Chapter 4. Hazard Identification and Risk Assessment (HIRA)

4.1 Introduction

Common Hazard Mitigation Terms Defined

Hazard: an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural loss, damage to the environment, interruption of business, or other types of harm or loss.
Mitigation: sustained action taken to reduce or eliminate the long-term risk to human life and property from natural hazards and their effects; the emphasis on long-term risk distinguishes mitigation from actions geared primarily to emergency preparedness and short-term recovery.
Natural hazard: hurricanes, tornados, storms, floods, high or wind-driven waters, earthquakes, snowstorms, wildfires, droughts, landslides, and mudslides.
Hazard identification: the process of defining and describing a hazard, including its physical characteristics, magnitude and severity, probability and frequency, causative factors, and locations or areas affected.
Risk: The potential losses associated with a hazard, defined in terms of expected probability and frequency, exposure, and consequences.
Vulnerability: The level of exposure of human life and property to damage from natural hazards.

Source: Planning for Post-Disaster Recovery and Reconstruction, FEMA and APA, 1998.

The New River Valley is susceptible to a wide range of natural hazards. This chapter discusses each of the natural hazards possible in the region, including history, risk assessment and vulnerability, and past or existing mitigation. The hazard risk assessment and vulnerability looks specifically at two criteria: locations where the hazard is most likely to have negative impacts and the probability and severity of the hazard should it occur. When information is available, the specific impacts of a hazard is discussed, sometimes based on the usual impact in the region. These sections have been updated from the 2011 plan with the best available data.

4.1.1 Hazard Identification

Although hazards are classified in various ways, this plan places hazards into one of six categories: drought, geologic, flooding, severe weather, wildfire, and human-caused. Both geologic and severe weather hazards cover more than one specific event or situation. Geologic hazards include landslides, earthquakes, rockfall and karst. Severe weather hazards include freezing temperatures, non-rotational winds, snowfall, ice storms and tornados. Each hazard section includes mapping to identify areas with potential impacts.

4.1.2 Risk Assessment

Risk assessment seeks to define the probability of events and the likely consequences of events. The risk assessment and vulnerability presented herein is a result of an extensive analysis of historic event data, scholarly research and field work. The risk assessment and vulnerability portion of this update was conducted by the NRVRC.

4.1.3 Mitigation

Many times mitigation seeks to prevent the impacts of hazards on life and property. The primary goal of mitigation is to learn to live within the natural environment. This plan reviews past mitigation efforts in the New River Valley and identifies both strategies and specific projects that could further mitigate these impacts.

Mitigation options fall generally into six categories: prevention, property protection, natural resource protection, emergency services, structural projects and public information. Prevention projects are those activities that keep hazard areas from getting worse through effective regulatory planning efforts, such as comprehensive planning, building code update and enforcement, burying utility lines and water source planning. Property protection activities are usually undertaken on individual properties or parcels with coordination of the property owner, such as elevation, relocation and acquisition of frequently flooded or damaged structures, eliminating fuel sources surrounding the property, installing rain catchment systems and purchasing additional insurance. Natural resource protection activities seek to preserve or restore natural areas or natural functions of floodplain and watershed areas. They are often implemented by parks, recreation, or conservation agencies or organizations. Emergency services measures are taken during a hazard event to minimize its impact. These measures can include response planning, regional coordination and collaboration and critical facilities protection. Structural projects include activities associated with building new or additional infrastructure or features to minimize impacts from a hazard. The final category of public information is possibly the most important, empowering residents to take action to protect themselves and their property in the event of a hazard event. This category can include additional information available to the public, such as maps, brochures, and workshops, as well as property specific information included in parcel records.

4.2 Overview of Assessments

Each hazard assessment follows a similar format: introduction, history, risk assessment and vulnerability, past or existing mitigation, and mitigation goals, objectives and strategies. Some hazards include a brief discussion of special hazards areas that may be more prone to experiencing a certain hazard or more likely to be severely impacted by a specific hazard event.

Each identified hazard was prioritized by the steering committee using a standardized worksheet (see Appendix 1). Each hazard was evaluated on a 1-5 scale for frequency and a 1-4 scale for both intensity and area affected. Relative risk was then calculated using these ratings. Table 4.1 below illustrates how the hazards ranked in their relative risk to the region. A more detailed discussion of this risk assessment is included with each hazard section.

Table 4.1. New River Valley Regional Assessment of Relative Risk of Natural Hazards

High	**Medium**	**Low**
Freezing Temperatures	Snowfall	Karst
High Winds	Human-caused	Landslide
Flooding	Drought	Tornado
	Ice Storms	Earthquake
	Wildfire	Rockfall

4.3 Drought

Drought is the deficiency of precipitation over a protracted period of time. While this is a normal variable of climate, additional factors such as local degree of usual dryness, water demand, and water management can generate significant impacts to the population and economic activity.

A number of state and federal agencies monitor drought conditions in Virginia. At the federal level, NOAA leads an interagency partnership known as National Integrated Drought Information System that produces the weekly US Drought Monitor map and other resources on drought. The monitor synthesizes multiple indices and impacts to represent a consensus of federal and academic scientists. The Drought Monitor archived data is available dating to 2000. The Virginia Drought Monitoring Task Force led by DEQ uses four indicators – groundwater levels, precipitation deficits, reservoir storage, and streamflows – to assess drought and advise if drought stage declarations should be made.

4.3.1 History

According to the database from the National Climatic Data Center, there have been 14 reported drought events since 1996, including several months in 1998, 1999, 2007 and 2008. Four of these reports also include crop damage estimates, particularly in 1998 and 2007.

While not in a declared drought stage, the NRV has been experiencing very dry conditions during the winter 2016/2017 which have contributed to heightened wildfire risk. No significant droughts have occurred in the past decade, but the New River Valley has experienced two significant droughts that have affected agriculture and water supply in the region since 2000. The first of these two recent droughts began in 2000 and continued through the early fall of 2002. The second notable drought in recent years began in early 2007 and ended in early 2009.

Figure 4.1 below depicts the extent of the drought in September 2002, when portions of the region were under extreme and exceptional droughts with impacts predicted for agriculture, water supply and increased fire dangers. The accumulated rainfall deficit was at least 20 inches before precipitation resumed in the fall. The effects of this drought were more dramatic because precipitation deficits occurred in the summer, when vegetation used the moisture before it could recharge the groundwater. Table 4.2 defines the terms used in the Drought Monitor graphics.

Figure 4.1. Impact Extent during 2000-2002 Drought

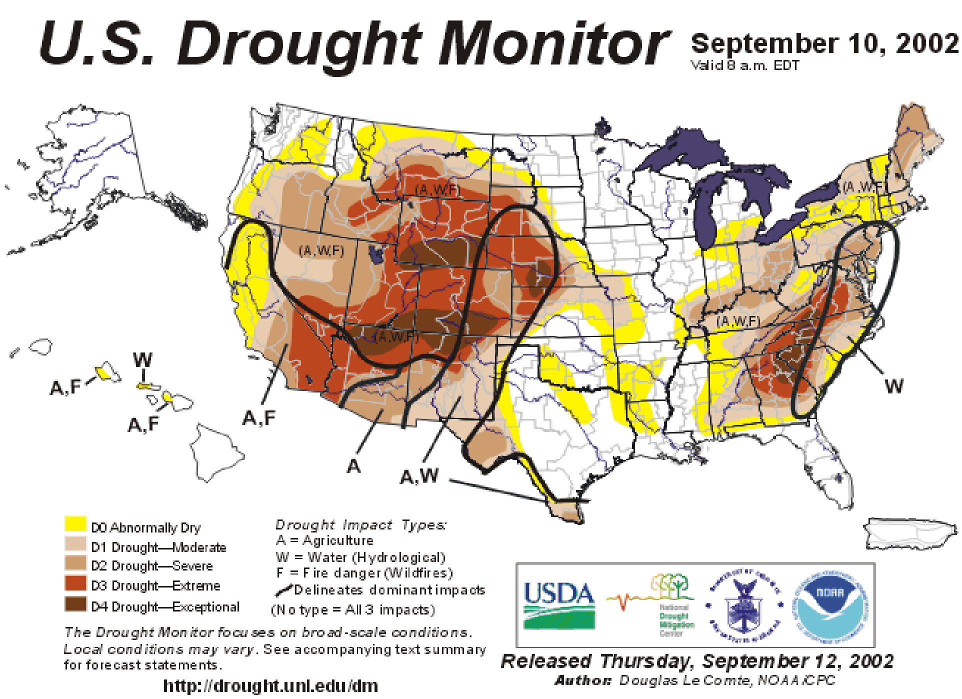


Table 4.2. Drought Monitor Status Descriptions

Description	Possible Impacts
Abnormally Dry – D0	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.

Description	Possible Impacts
Moderate Drought – D1	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested.
Severe Drought – D2	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed.
Extreme Drought – D3	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions.
Exceptional Drought – D4	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies.

The second notable drought in recent years began in early 2007 and ended in early 2009. Figure 4.2 below shows the drought at its most severe for the region. At the time of this map, most of the region is in either severe or extreme drought with impacts predicted for both agriculture and water supplies.

Figure 4.2. Impact Extent during 2007-2009 Drought

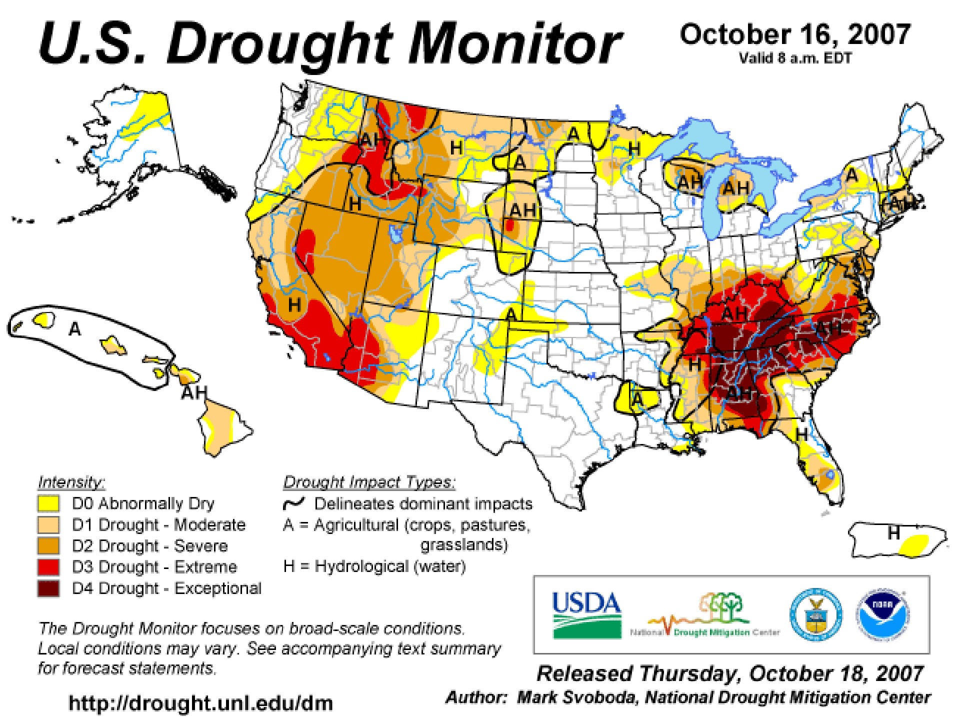
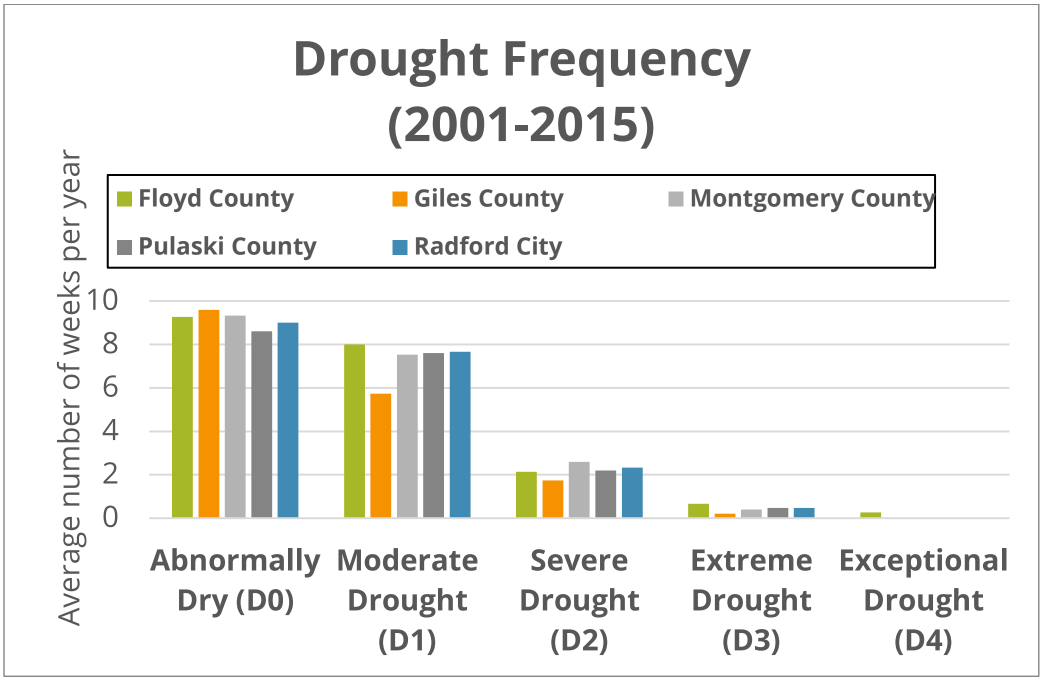


Figure 4.3 tracks the regional Drought Monitor levels from 2001 to 2015. The two previously discussed droughts are easily observed in this time series data showing a 3-year moving

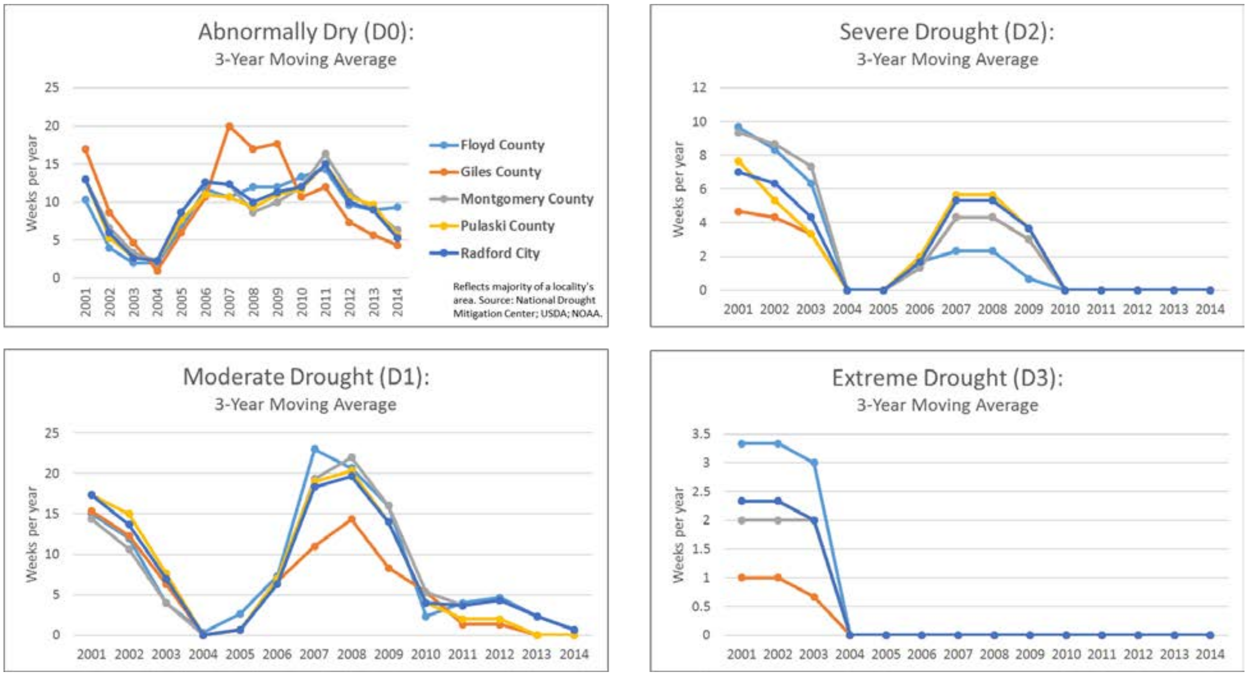
average for D0 and D1 conditions. While D2 conditions were recorded for the 2002 and 2007 droughts, they were not sustained for as many weeks as the D0 and D1 conditions indicating the severity of the drought was related to extended period of dryness rather than the intensity of dryness.

Figure 4.3. Drought Frequency



Reflects majority of a locality's area.
Source: National Drought Mitigation Center; USDA; NOAA.

Figure 4.4. Drought Monitor Data: 2001 to 2014*



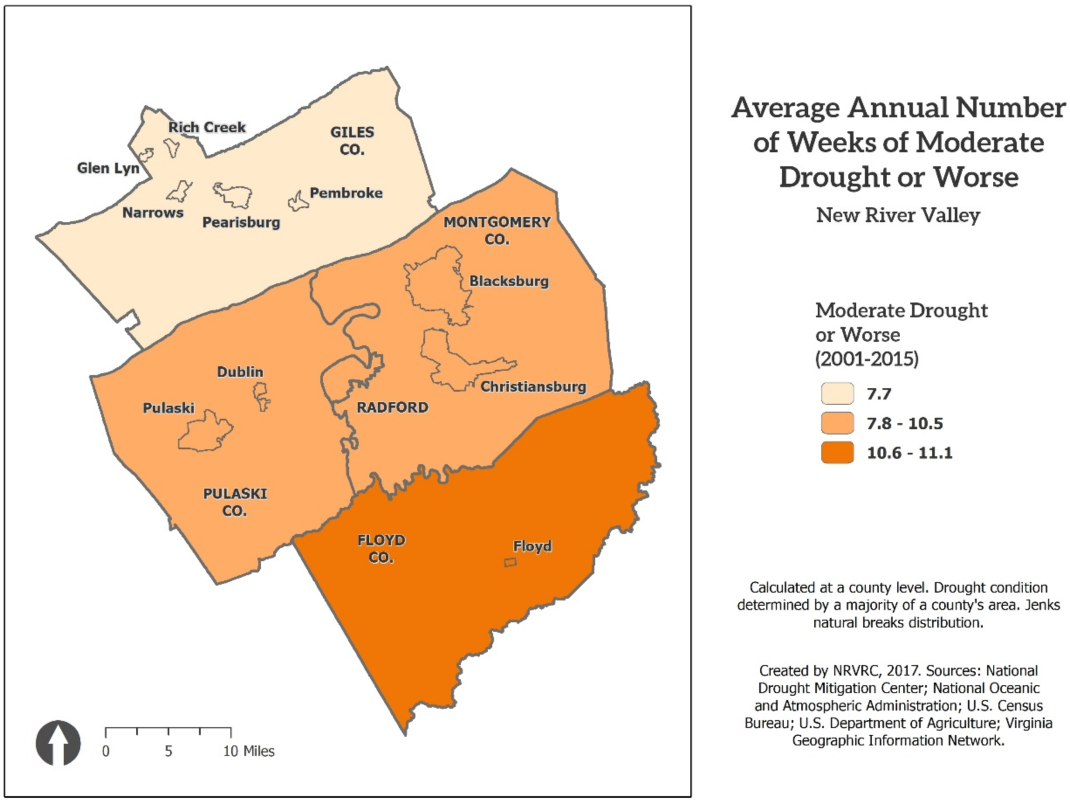
*Includes data through 2015 to create the three-year moving average.

4.3.2 Risk Assessment and Vulnerability

No place in the world is immune to drought. Rainfall fluctuates year to year, and to experience a year of "below average" precipitation is not uncommon. Recently, a study of drought was published by researchers from Columbia University. Specifically, these scientists were looking for causes of drought in the southeastern United States. Based on climate data, there is a very weak relationship between La Niña events and dry winters in the southeast. Dry summers appear to be caused by more local atmospheric variability that is very difficult to predict. Additionally, these researchers looked at historical precipitation records (i.e., tree-ring records) and found several multi-year droughts, including a 21-year drought in the mid-1700s. The historic drought record indicates that while there have been several notable droughts in recent years, overall the 20th century has been unusually moist.

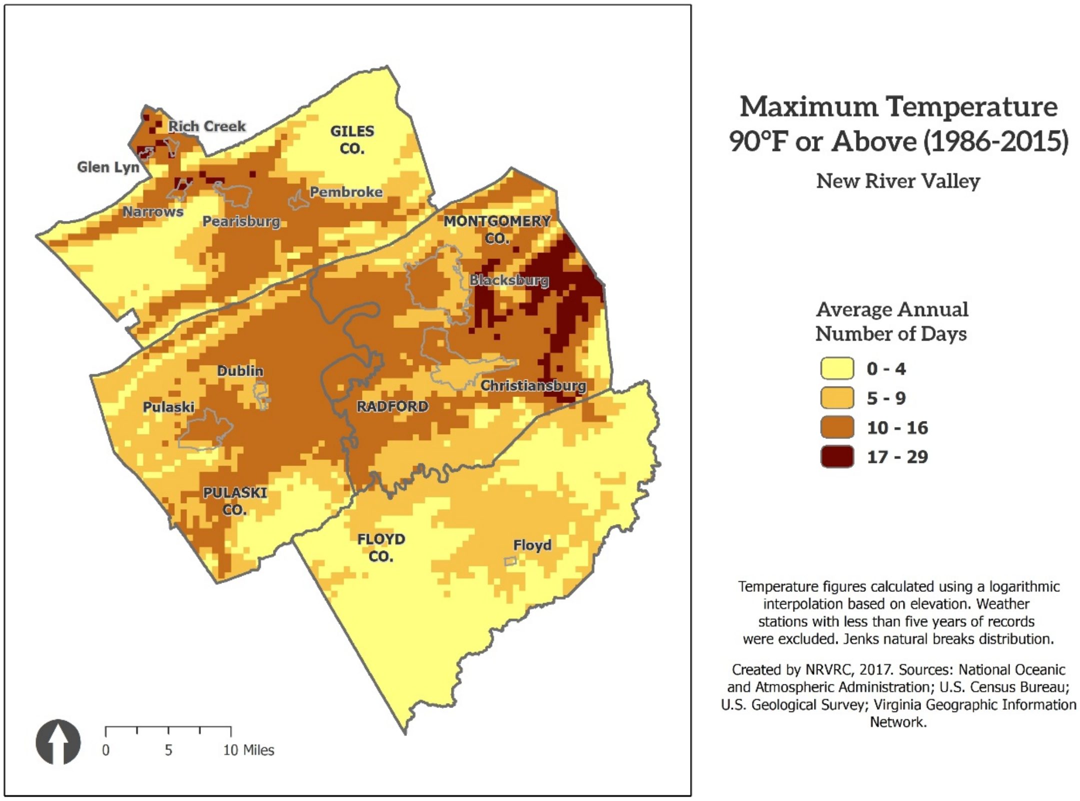
Map 1 shows the average annual weeks of moderate drought in the NRV for the last 15 years. Floyd has been most dramatically affected by drought; this is discussed in more detail in the Special Hazard Area section below.

Map 1. Average Annual Number of Weeks of Moderate or Worse Drought



Map 2 shows the average number of days where maximum temperatures reached 90 degrees or more. This includes data from 1986 through 2015 from weather stations that have been collecting data for five years or more. Areas most affected included the eastern area of Montgomery County and a few isolated locations in Giles County. The region in general is experiencing between five and 16 days a year of 90 degree plus temperatures.

Map 2. Average Annual Days of 90 Degrees or More



While considering the relative risk of all hazards possible in the New River Valley, the steering committee considered frequency of the event and severity, as well as the area affected by the hazard. using these considerations, drought was ranked as a moderate risk in the region. the steering committee noted that relative to other hazards, drought occurs occasionally, on average every three to five years, though more severe droughts have been known to last through several consecutive years. In many cases, precipitation deficits occurring during the summer months leading to a drought status are remedied by winter precipitation.

While recent droughts may not be of the magnitude of some historical droughts, it is clear that precipitation shortfalls in the region can pose a serious threat to water supplies, agriculture, and increase wildfire dangers. Wildfire will be discussed in a separate section.

4.3.3 Water Supplies

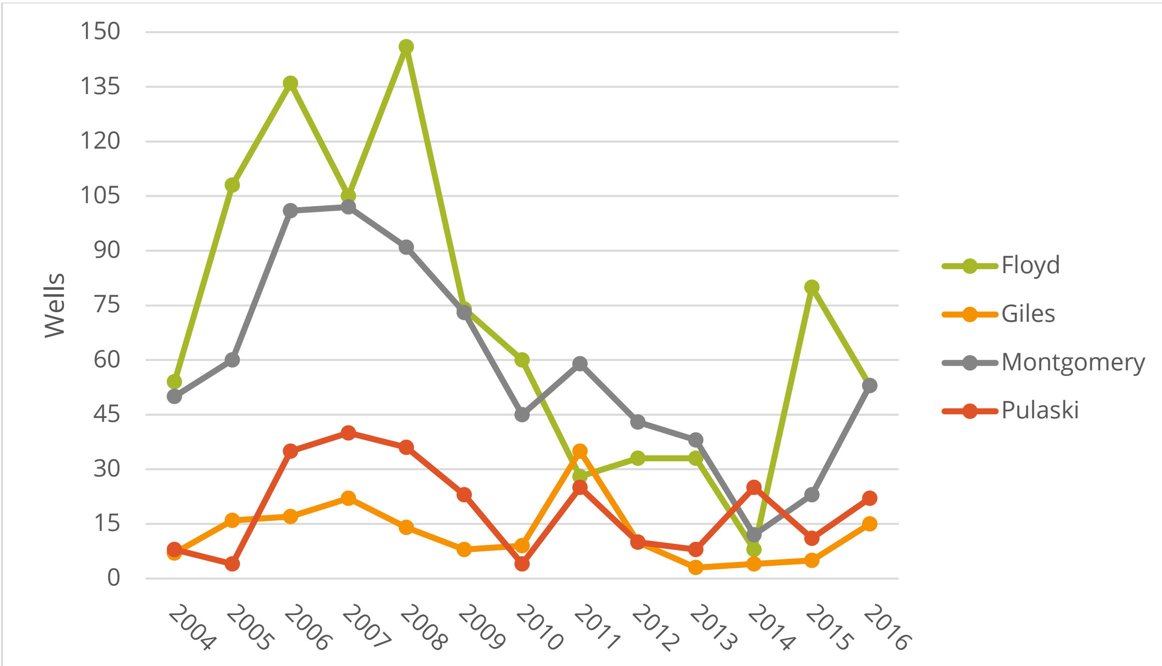
About 70% of NRV residents receive their water from a public water system; therefore, about 52,000 people are dependent on private springs and wells (see Table 4.3). Based on discussions with local PSA directors, it is assumed that most residents within town limits are on public water supplies and the exceptions to that assumption likely are less than 10 residences in a given town. The public water systems across the NRV are not generally interconnected, leaving systems vulnerable to inadequate supplies. For example, the Giles County Public Service Authority system, which supplies five towns and much of the unincorporated area, has only one primary source (wells).

Table 4.3. Populations with Public and Private Water Sources

Locality	Population	Public Water	Private Water (Well or Spring)	% On Private Water
Floyd	15,279	2,360	12,919	84.6%
Giles	17,286	9,809	7,477	43.3%
Montgomery	94,392	71,024	23,368	24.8%
Pulaski	34,872	26,808	8,064	23.1%
Radford City	16,408	15,859	549	3.3%
New River Valley	178,237	125,860	52,377	29.4%

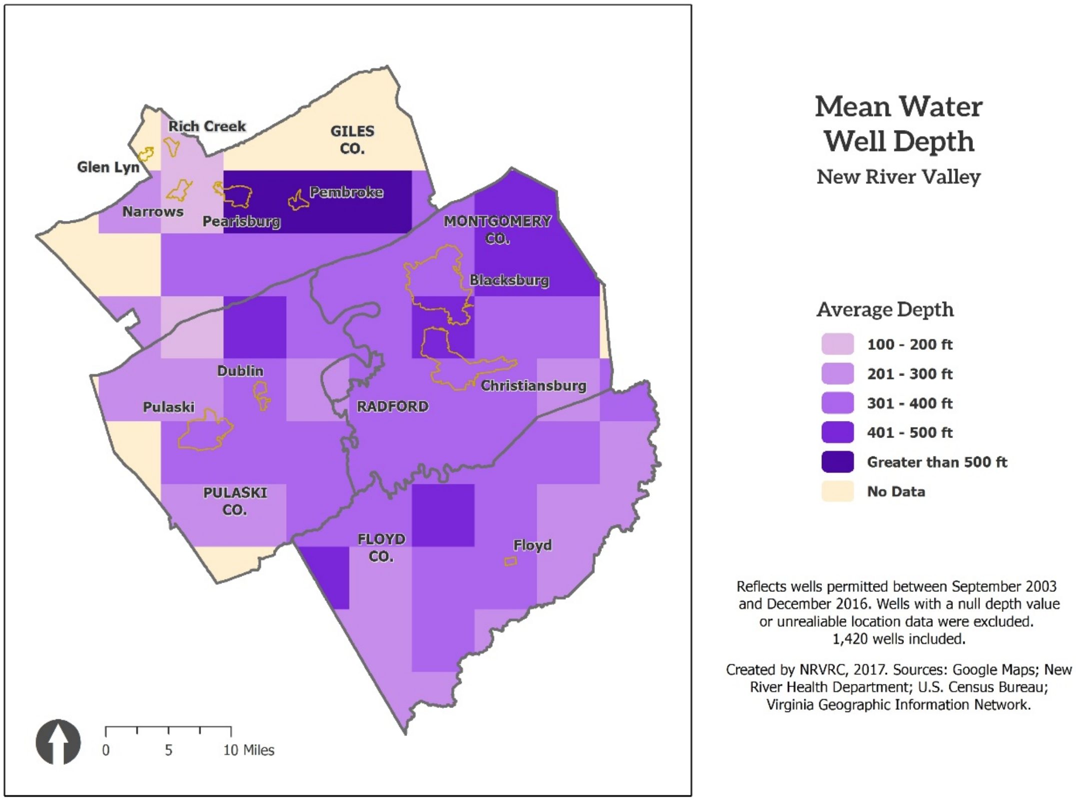
According to Virginia Department of Health well permits dated between 2004 and 2016, 2084 wells were drilled in the NRV for domestic drinking water purposes. As Figure 4.5 illustrates, there is a sharp spike in the number of permits filed for wells in 2007 and 2008. The numbers appear to fall in 2009, with a small spike in 2011.

Figure 4.5. Well Permits in the NRV

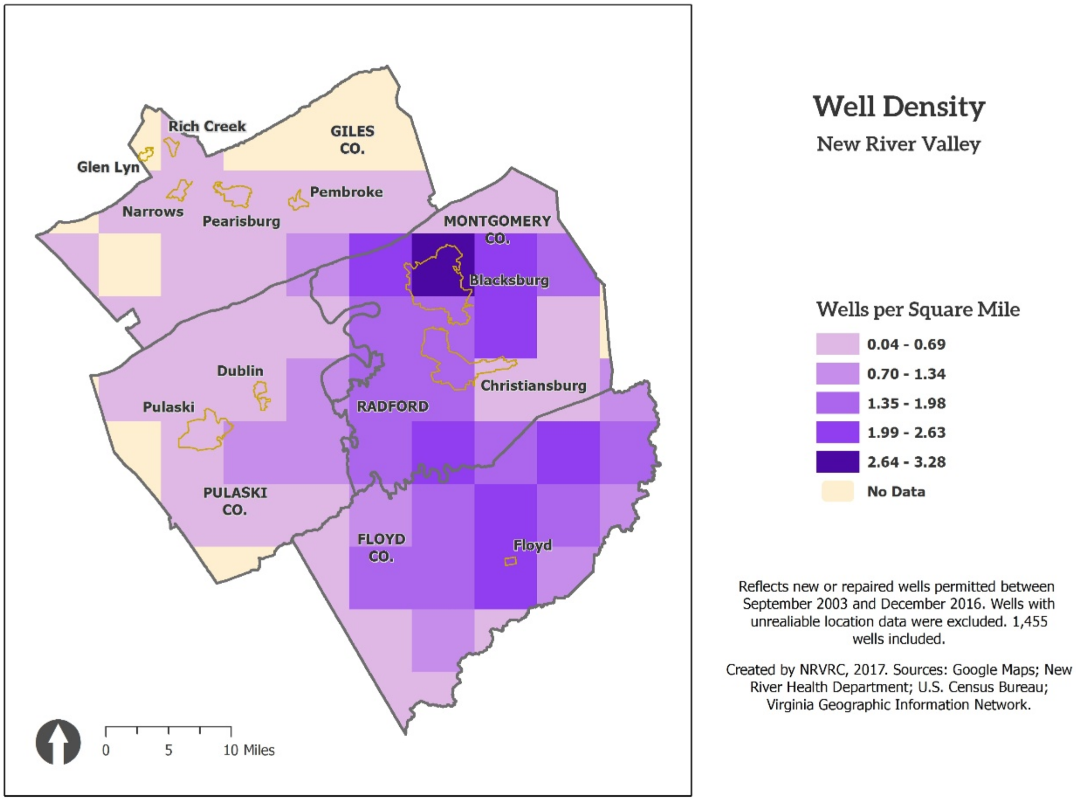


Map 3 illustrates the depths of the wells as reported on well permits to VDH. Map 4 illustrates the densities of wells per square mile throughout the region. The densities were calculated two ways. First, the density of wells within town boundaries was calculated based on the square miles in town. Second, the density of wells in census tracts throughout the counties was calculated. In areas where census tracts overlapped town boundaries, wells within town and the overlapping area were subtracted from the census data.

Map 3. NRV Mean Water Well Depths



Map 4. NRV Well Density



4.3.4 Special Hazard Area

About 63% of the replacement wells in the NRV from August 1999 to November 2002 were in Floyd County, which is the only NRV jurisdiction in the Blue Ridge physiographic region. Throughout the period more than 43% of well permits in Floyd County were for replacement wells. This trend of increased well permits during the 2007 drought is also illustrated in Figure 4.5 above. The current data available does not specify replacement wells, but given the timing of these well permits, it seems reasonable to believe the drought had an impact on the numbers.

Floyd County had the most total number of well permits filed between 2004 and 2016, exceeded by Montgomery and Giles Counties only in 2011. Based on the proportion of Floyd County's population dependent on private wells for their drinking water (84.6%), this county's residents require additional consideration in times of drought when their wells might be most susceptible.

4.3.5 Agricultural Losses

Beyond threats to water supplies, the agricultural losses due to drought can be significant in the region. According to the NCDC database, the drought events recorded since 1990 have caused approximately $17 million in agricultural damages. Agricultural losses for the drought of 2000-2002 were $10 million. Fortunately, the USDA classified all four counties in the NRV as federal drought disaster areas following the 2000-2002 drought. A Secretarial Designation (by the Secretary of Agriculture) requires several very specific conditions be met, specifically that the damages and losses must be due to a natural disaster; and a minimum 30-percent production loss of at least one crop in the county must have occurred. Following this designation, several programs from the Farm Service Agency are initiated including the Disaster Debt Set-Aside Program and a low-interest emergency loan program for producers. Floyd County is again the most vulnerable to drought of the NRV localities, based on the estimates of loss from the USDA shown in Table 4.4.

Table 4.4. Agricultural Losses 2000-2002 Drought

County	# Farm Facilities (developed springs, wells)	Value of Farm Facilities Lost	$ Livestock, Loss of Weight Gain	Total $ Loss
Floyd	560	$300,000	$3,700,000	$4,000,000
Giles	100	$100,000	$1,000,000	$1,100,000
Montgomery	370	$200,000	$2,500,000	$2,700,000
Pulaski	200	$200,000	$2,000,000	$2,200,000
Total	1230	$800,000	$9,200,000	$10,000,000

4.3.6 Other Economic Losses

Beyond the risks posed to water supply and agriculture, the region's tourism industry can be vulnerable to drought conditions. The New River draws tourists from around the area, as well as from outside the region to participate in various water-based activities. Additionally, Mountain Lake (the set for the movie Dirty Dancing) attracts tourists during the summer season. Mountain Lake is located on a fault line and periodically empties, especially during drought conditions. In both 2002 and 2008, the lake was virtually empty (Figure 4.6). During the 2008 season, the owners of Mountain Lake placed an emphasis on recreational activities around the resort area that were not water-centered. Despite these efforts, the low lake levels had a significant effect on revenue. Hotel management has reported an uptick in revenue and bookings over the last several years with major renovations, new recreational amenities, and new marketing strategies to offset a former reliance on the lake as an attraction.

Water levels have receded and returned (though not to historically fuller levels) and receded again. To address the nearly-dry pond at Mountain Lake in 2002, the private owners attempted to pump water back into the lake. They found this to be ineffective, however. For three days in 2008, the lake dried up completely and has remained at a very low level since then.

Figure 4.6. Mountain Lake, 2002

During the drought of 2000-2002, Chateau Morrisette, a winery and fine dining establishment in Floyd County, suffered the loss of its principal spring.

4.3.7 Past or Existing Mitigation

The existing public water systems themselves, especially those with multiple sources, are one measure of mitigation, adding versatility and reliability to local public water supplies. Four years of water study has explored the possibility of a regional water authority, transmitting water from treatment facilities to users in a large portion of the valley. The City of Radford's water treatment facility and other current sources produce enough water to provide public water to not only the residents of the city, but also to parts of Pulaski, Montgomery, and Floyd Counties. These water systems are either totally unconnected or under-connected. In 2012, the City of Radford and Pulaski County interconnection became operational, providing capacity for improved reliability of water service in the eastern part of the county. By interconnecting systems, these localities can reliably provide their customers with access to public water, with abundant backup sources of drinking water.

Other mitigation efforts include conservation and rainwater catchment systems. Conservation efforts were largely voluntary until the State Emergency Declaration in September 2002. Rainwater catchment systems have traditionally been personal efforts to provide additional water supply during "normal" years (Figure 4.7). During extended periods without rain, many of the systems can serve as cisterns, with water being delivered by truck from other sources.

Figure 4.7. Rain barrel

(Photo Courtesy of Rainwater Harvesting, Inc.)

Rainwater systems can also be applied in larger-scale projects. The Carillion New River Valley Medical Center in Montgomery County constructed a rainwater catchment system to simultaneously reduce stormwater run-off and supply re-use needs. This clay-lined pool collects all stormwater run-off from the medical center and some from the adjacent surgical center to supply recycled water for cooling the building and can recycle five million gallons of water a year. These large systems are based on the same principals as the traditional "rain barrels."

4.3.8 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Below are the goals, objectives, and strategies identified by the drought working group to specifically lessen the impacts of drought in the region.

Goal: Minimize economic losses and health risks during droughts.

a) Develop a set of planning tools that mitigate the impacts of drought.
    i. Improve data and inventory of water users to better assess the vulnerability of water supplies to drought and increase accessibility to public water systems.
    ii. Identify back-up water sources or increase storage capacity for public water systems.
    iii. Develop a system of notification of precipitation predictions that will assist agricultural producers in short-term decision making.
    iv. Pursue Memorandums of Understanding between localities and companies to haul in water as an alternative source of water during drought conditions.
    v. Encourage water providers in the region to take advantage of programs designed to prevent leaks and water losses in their systems.

vi. Continue efforts to promote interconnections of municipal water systems for use should an emergency situation arise.
vii. Encourage the use of notification emails regarding drought alerts from the National Weather Service to water resource managers and emergency service managers.

b) Encourage research and development of prediction capabilities that will assist in decision-making during drought conditions.
   i. Support the improvement of drought forecasting ,predictions, and resource monitoring (e.g. wells) available from government sources (i.e., NOAA, NWS).
   ii. Support efforts to develop and improve simulation modeling that provides information regarding all potential impacts and outcomes for decision-makers.

c) Promote educational efforts to assist residents in dealing with the impacts of drought.
   i. Provide information to residents of existing conservation measures and the sliding scale of prescriptive measures, as found in local water supply plan and drought ordinances, to assist in mitigating the impacts of drought.
   ii. Promote educational efforts developed for private well owners about proper care and maintenance of their well, as well as the potential impacts associated with drought.

4.4 Geologic Hazards: Landslides, Rockfall, Karst, and Earthquakes

Geologic hazards, including landslides, rockfall, karst, and earthquakes occur frequently within the New River Valley. In 1897, the region experienced a magnitude 5.8 earthquake centered in Giles County. In this section, each type of geologic hazard will be discussed individually, their history, risk assessment and vulnerability, past mitigation, and mitigation opportunities. At the end of the section goals and objectives specific to geologic hazards will be presented.

4.4.1 Landslides

Two types of sudden and often catastrophic landslide events are common in mountainous areas in Virginia: 1) storm-generated mudslides and debris flows; and 2) highway landslides, rockfalls, and rockslides. Both can have serious potential economic impact and public safety consequences.

1) Storm-generated debris flows occur when hurricanes or other storms of high precipitation intensity saturate mountainsides in areas of unstable soil and rock. Once movement is initiated at higher elevations, mud, rock, and other debris rushes down first order mountain streams growing in size and destructive energy. Debris flows are known to have occurred in the New River Valley, as evidenced by ancient debris flow deposits found in many of its tributary drainage systems.

2) Highway landslides, rockfalls, and rockslides can be a hazard anywhere that terrain has been modified for the construction of transportation corridors including roads, railroads, and canals. Terrain modifications include cuts which create unnaturally steep slopes in both soil and rock that are subject to weathering and the pull of gravity. Older cuts are especially prone to instability because construction methods have changed through the years and landslide mechanics were not as well understood in the past as they are today and older cuts have had more time for rock and soil materials to weather and weaken.

4.4.1.1 History

Western Virginia was the site of one of the most devastating landslides in US history. Nelson County and its vicinity had 150 deaths and $133 million in damage from Hurricane Camille remnants in 1969. The catastrophic debris flows occurred following 20+ inches of rain.

While no devastating landslides have occurred in the NRV, significant landslides have occurred. The 1897 earthquake triggered significant rockslides in Giles County, though little information is available on damage. Major flooding in 1940 resulted in landslides that temporarily closed rail lines and roads. The most significant slide on recent record was in the Draper community of Pulaski County in June 1994, when six inches of rain in three hours produced landslides that knocked at least one home from its foundation and blocked five miles of roads. Narrows in Giles County has periodic landslides that affect Route 460. In February 2003, winter storms and flooding caused landslides in the NRV like the one shown in Figure 4.8.

Figure 4.8. Minor landslide in Elliston, February 2003

In March 2010, a rockfall event in Pulaski County on Route 11 between Dublin and Fairlawn closed the road for approximately two hours (Figure 4.9). The rockfall occurred in the afternoon with no apparent cause, such as precipitation or immediate disturbance to the area. As discussed below in the risk assessment and vulnerability section, this particular road cut had been rated as an "A" site indicating a high potential for a rockfall event that could impact traffic flow and/or result in property damage and/or injury.

Figure 4.9. Rockfall in Pulaski County, March 2010

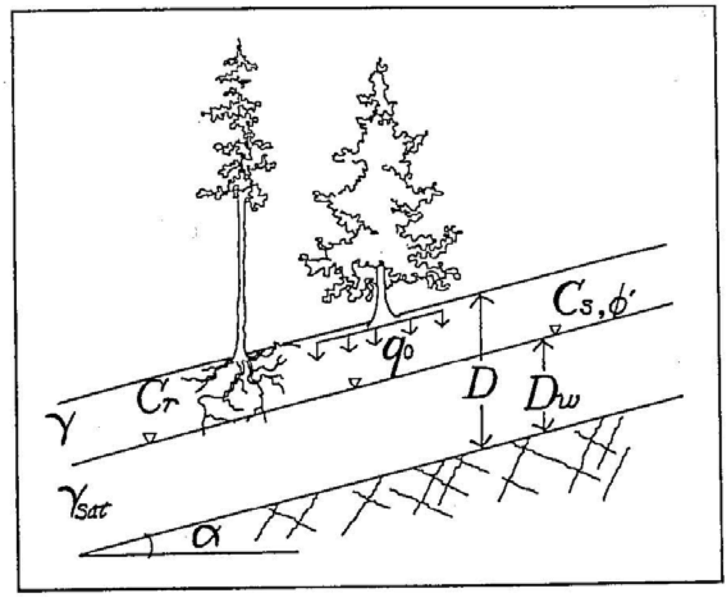
4.4.1.2 Risk Assessment and Vulnerability

Two sets of risk assessment mapping were developed for this updated hazard mitigation plan. These maps are 1) storm-generated debris flow safety factor maps, and 2) highway landslide, rockfall, and rockslide hazard potential inventory. The methods for both maps are discussed below.

Storm-generated debris flow safety factor map (Map 5) was created using digital elevation models (DEMs) overlain by USDA soils maps. The DEMs were manipulated using GIS mapping techniques to generate slope maps from which slope inclination and slope direction can be determined within 10 meter cells across the landscape. The USDA soils maps and accompanying reports provide information about the physical characteristics and thicknesses of the soil layers within each of the slope map cells.

The Level I Stability Analysis (LISA) safety factor equation (Figure 4.10) is applied to each cell and assigned a color based on the relative stability of the soil within the cell when saturated by a major storm event. The exact magnitude of the storm is not required since the safety values for individual cells are evaluated relative to safety values of the surrounding cells. Those most likely to be unstable for a moderate storm will be the same as those most likely to be unstable for a major storm and vice-versa.

Figure 4.10. Level I Stability Analysis (LISA) model

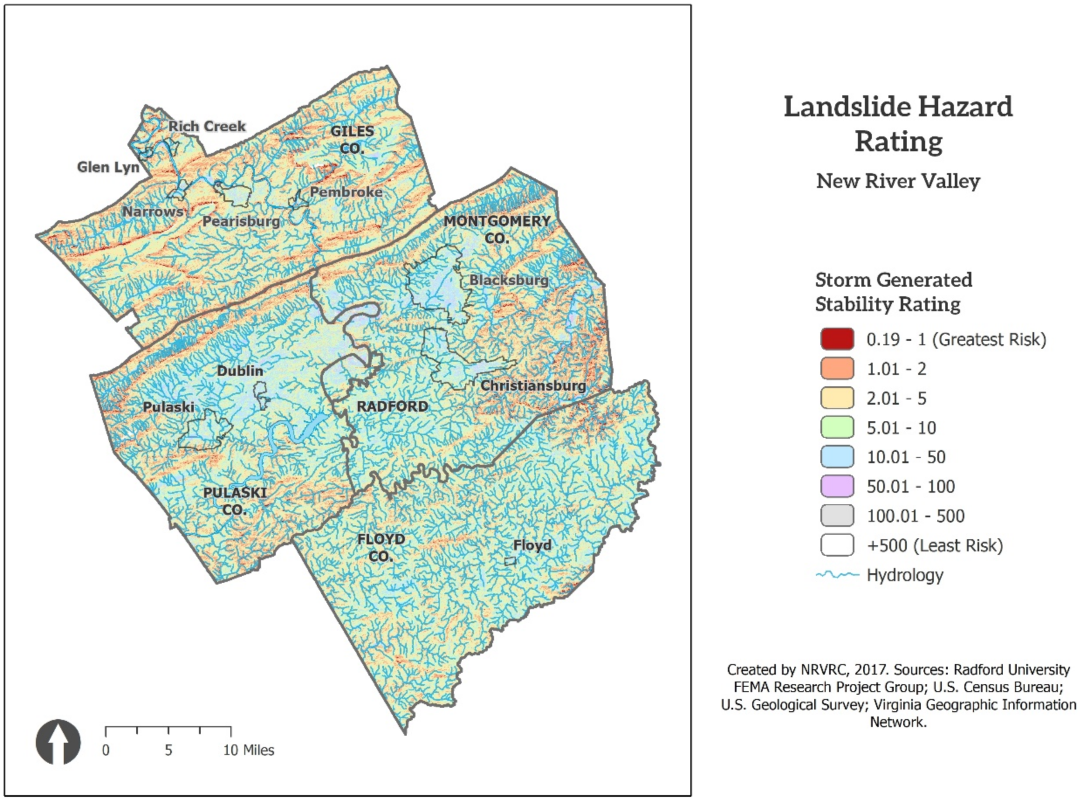


$$FS = \frac{C_r + C_s' + \cos^2\alpha[q_0 + \gamma(D - D_w) + (\gamma_{sat} - \gamma_w)D_w]\tan\phi'}{\sin\alpha\cos\alpha[q_0 + \gamma(D - D_w) + \gamma_{sat}D_w]}$$

where FS = factor of safety
α = slope of the ground surface, degrees
D = total soil thickness, ft
D_w = saturated soil thickness, ft
C_r = tree root strength expressed as cohesion, psf
q_0 = tree surcharge, psf
C_s' = soil cohesion, psf
ϕ' = effective internal angle of friction, degrees
γ_d = dry soil unit weight, pcf
γ = moist soil unit weight, pcf
γ_{sat} = saturated soil unit weight, pcf
γ_w = water unit weight, pcf

The red end of the storm-generated stability rating spectrum (reds and oranges) indicates probable landslide initiation points during storms. Communities and infrastructure down slope from initiation points following the first order tributary drainage systems will be at greatest risk. The blue end of the spectrum and neutral colors indicate areas least likely to initiate landslides according to the LISA stability calculations.

Map 5. Landslide Hazard Rating



Highway landslide, rockfall, and rockslide hazard potential is shown on the following figure by colored "pins" marking the starting points of measured road cuts. Red pins indicate the most hazardous A-rated slopes, blue pins indicate the least hazardous C-rated slopes, and green pins indicate slopes of moderate hazard according to the FHWA rating guidelines. These points were joined to show the cumulative rockfall hazard rating per mile of roadway on the region's primary roads to show a broader indication of risk when developing mitigation strategies (Figure 4.11).

All A and B-rated slopes have associated field data collection forms available for reference. These field sheets provide information about each road cut and the basis for its preliminary rating (Figure 4.11). Each field sheet has spaces available for detailed rating parameters and scoring should it be necessary to return to the site at some time in the future to perform a detailed numerical evaluation for remediation or ranking purposes. In Map 6, the data has been created by joining road segments within 50 feet of each other to identify the extent of rockfall hazard along a given area, which can be useful in determining resource deployment to mitigate vulnerable sections, rather than only individual points that may vary in size and degree.

Figure 4.11. NRV Rockfall Hazard

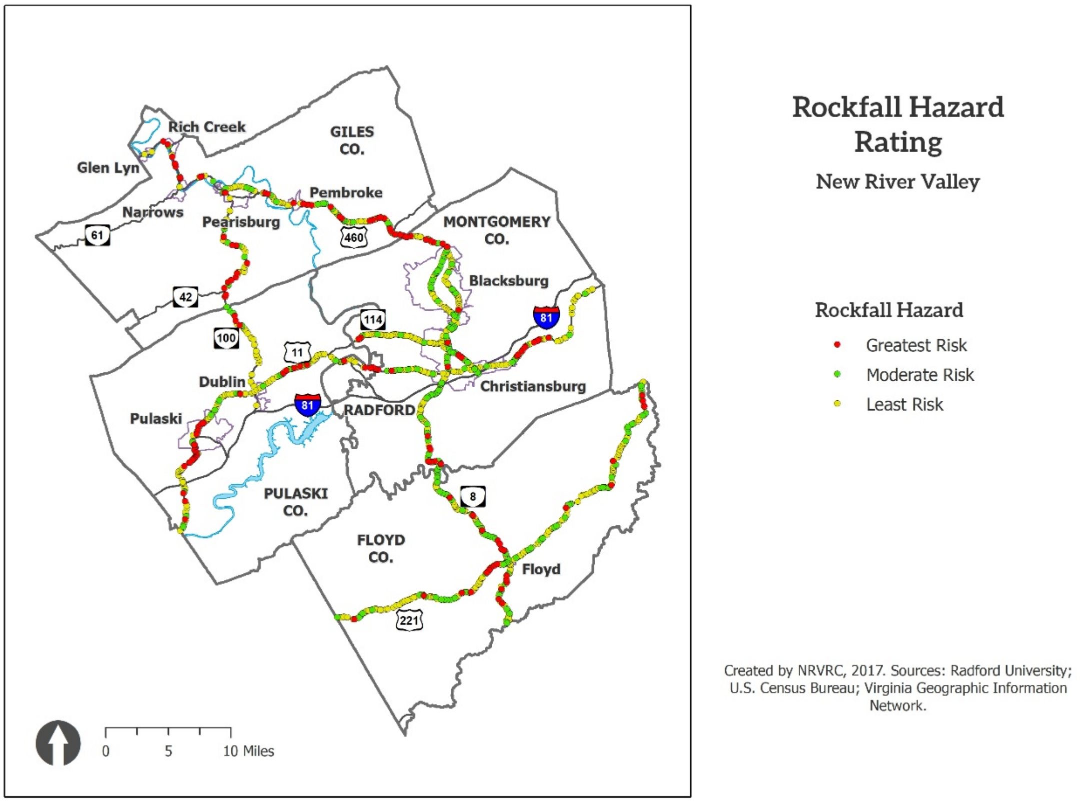


Figure 4.12. Sample field data collection sheet for rating highway rockfall hazards

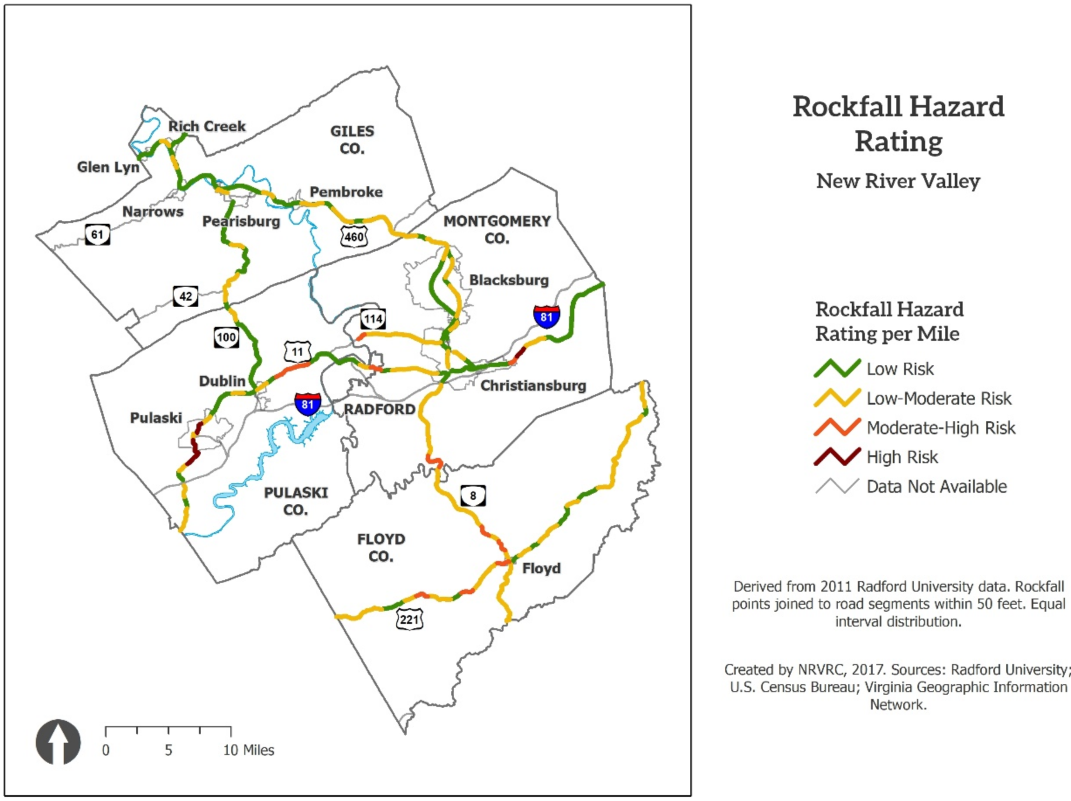
RHRS FIELD DATA SHEET

HIGHWAY: 99E REGION: 1

HIGHWAY # 1E	Beginning M.P. 12.62	[L] / R	Ending M.P. 12.94
COUNTY # 3	DATE 91 08 07	NEW	Rated By Siel
CLASS [A] B	ADT 18,300	UPDATE	Speed Limit 30

CATEGORY	REMARKS	CATEGORY SCORE	
Slope Height 116 ft °/ °/	Access to top of slope. Height measured with tape.	SLOPE HEIGHT	100
Ditch Effectiveness G M L [N]	None	DITCH EFFECT	100
Average Vehicle Risk 813 %		AVR	100
Sight Distance 450 ft Percent Decision Site Distance 100 %		SIGHT DISTANCE	3
Roadway Width 48 ft		ROADWAY WIDTH	2
GEOLOGIC CHARACTER		GEOLOGIC CHARACTER	
CASE 1		CASE 1	
Structural Condition D [C]/F R [A]	Toppling	STRUCT COND	81
Rock Friction R I [U] P C - S		ROCK FRICTION	9
CASE 2		CASE 2	
Differential Erosion Features F O N M		DIF ER FEATURES	
Difference in Erosion Rates S M L E		DIF ER RATES	
Block Size/Volume 3 ft ft/yd³	Up to 8 yd³	BLOCK SIZE	27
Climate Precipitation L M [H] Freezing Period N [S] L Water on Slope N I [C]		CLIMATE	50
Rockfall History F O M [C]		ROCKFALL HISTORY	75
COMMENTS: History of accidents. Road patrols required year round.		TOTAL SCORE	547

Map 6. NRV Rockfall Hazard Rating Per Mile



While considering the relative risk of all hazards possible in the New River Valley, the Steering Committee considered frequency of the event and severity, as well as the area affected by the hazard. Using these considerations, landslide was ranked as a low risk in the region. The Steering Committee noted that relative to other hazards, landslides occur occasionally, on average every three to five years. Relatively speaking though, landslides are relatively isolated and their intensity is moderate in comparison to other hazards.

4.4.1.3 Past or Existing Mitigation

Most zoning and subdivision ordinances in the NRV have only weak language stating that "size, location, shape, slope and condition of land shall be suitable" for development. Generally, no specific parameters are set. So, development on steep or unstable slopes is largely unrestricted in the NRV. The one exception is the Town of Blacksburg which requires that "primary conservation areas" such as floodplains, wetlands, and steep slopes "shall be dedicated as open space" (where slopes are 25% or greater.) Also, the Virginia Department of Transportation

(VDOT) does utilize safety fences to help protect against minor rockfalls into traffic along primary roads (Figure 4.13).

Figure 4.13. Safety fence along I-81 near Christiansburg Mountain

4.4.2 Karst

The term "karst topography" is derived from the surface topography of a limestone region in Slovakia where these landscapes were first studied. Limestone is a very common type of rock in the upper crustal sections of the earth. All of the numerous types of limestone are highly susceptible to chemical weathering mostly brought about by the presence of acids, foremost of which is carbonic acid (carbonation). Karst is typified by landscapes of pitted bumpy surface topography, poor surface drainage, and the common presence of underground solution channels in the form of cavern systems which, in turn, often form labyrinths of far-reaching underground networks.

Karst can only develop under the following conditions:

a) The geologic formations must consist of limestone containing at least 80% calcium carbonate for solution processes for this development to occur effectively;
b) The limestone formations must be jointed (fractures by warping, lifting, lateral tectonic pressure) to allow for passages along which water can travel through the otherwise impermeable limestone;
c) There must be aeration between the surface of the rock formation and the water table; and
d) A variety of different additional acids may be derived from the vegetation cover, enhancing the solution processes.

One of the dominant signs of karst is the presence of sinkholes. These are typified by circular or semi-circular surface depressions with depths from 7 to 330 feet and diameters ranging from 33 to 3300 feet. When the bottom of a sinkhole collapses into an underlying cave system, these sinkholes can become quite large. Figure 4.14 and Figure 4.15 below illustrate two different types of sinkholes possible in karst areas.

Figure 4.14. Cover Collapse Sinkhole

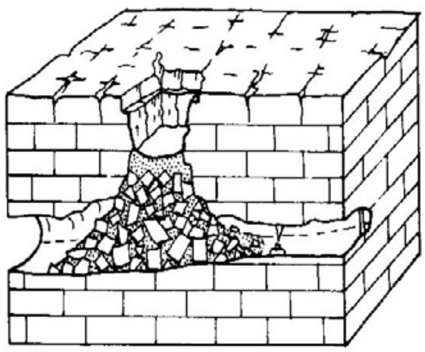
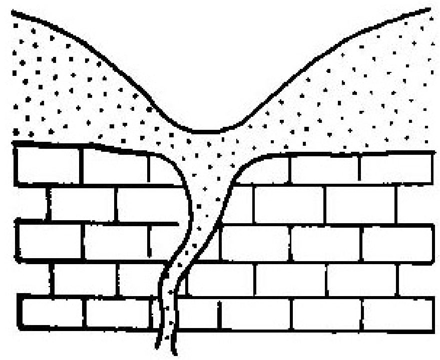


Figure 4.15. Subsidence Sinkhole



Surface water in karst areas typically flows into sinkholes and through the bottom into underlying cavern systems. This water often travels for significant distances in these underground drainage channels, to re-emerge from caves that surface streams have cut into, or it becomes part of the local water table, flowing through the limestone formations along fractures.

4.4.2.1 History

Much of the NRV rests on karst topography, and therefore the landscape is dotted with sinkholes (Figure 4.16). While there are no records of major structural damage caused by sinkholes in the NRV, such incidents have occurred in other karst regions. Major highway collapses are a recurring event for example. On the contrary, sinkholes opened up in Pearisburg during the 2002 flooding which provided sufficient temporary drainage to avoid significant flood damage to structures. Sinkholes are always challenging, however, as there is potential for direct groundwater contamination.

Figure 4.16. Sinkhole in Castle Rock Recreation Area, Giles County

4.4.2.2 Risk Assessment and Vulnerability

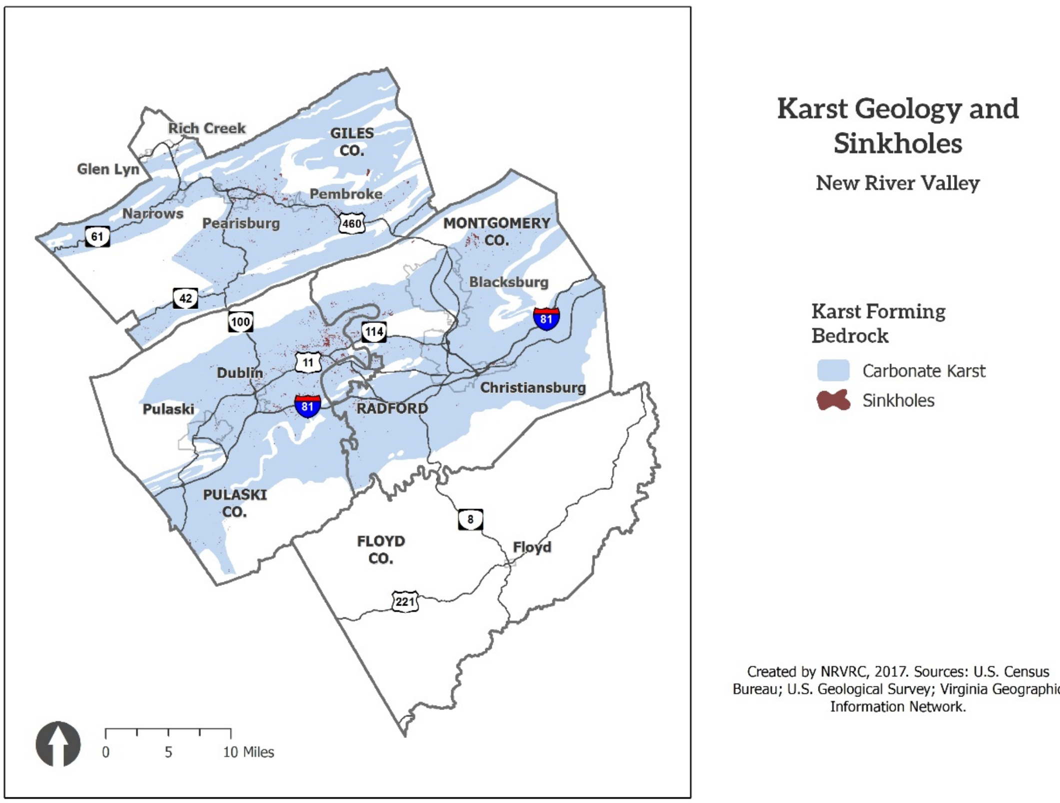
The distribution of karst-forming bedrock throughout the NRVRC area is shown on Map 7. Of note is the fact that Floyd County has no karst-forming bedrock formations. The county is underlain by igneous rocks do not lend themselves to karst and the formation of sinkholes.

Pulaski and Montgomery Counties have karst-forming bedrock beneath more than 60% of their respective land areas. The percentage for Giles County is slightly less: nearly 50%. Map 8 illustrates the density of karst by square feet across the region, showing the concentrations of karst in these three counties. The City of Radford is completely underlain by karst-forming bedrock. Sinkholes, cave entrances, and the occasional subsidence of surface areas due to collapse of underlying cavern systems are common throughout all areas where these karst-forming formations (mostly limestone formations) are encountered.

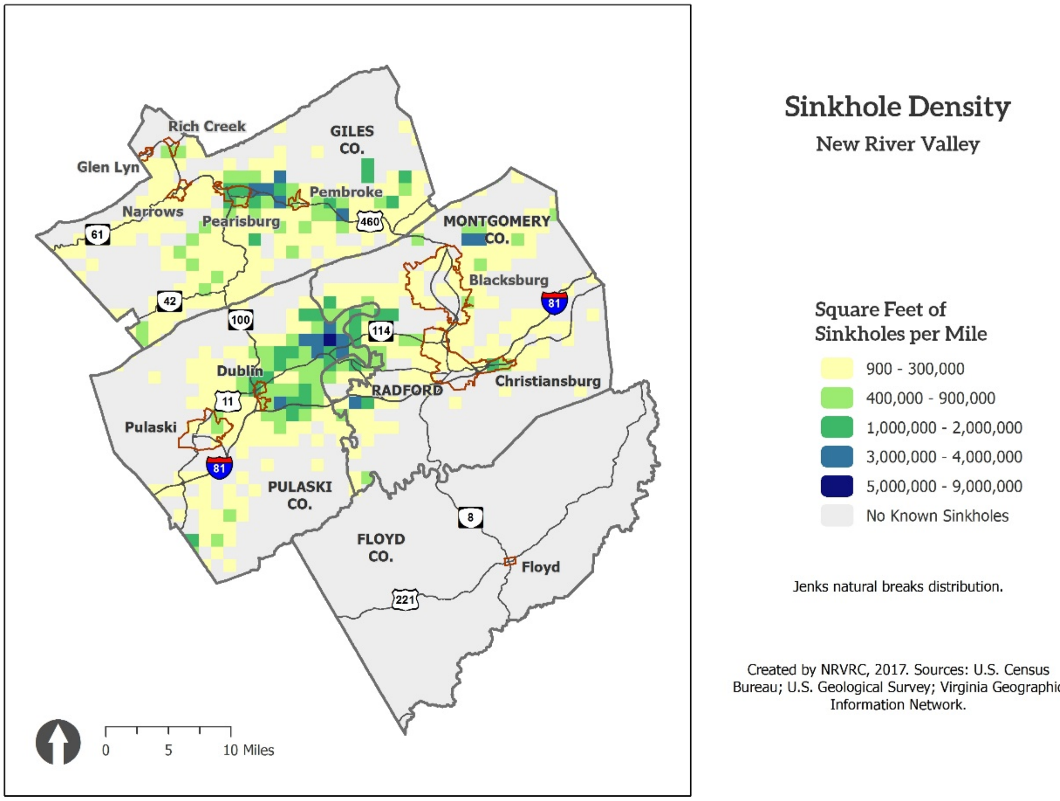
The principal event associated with karst is subsidence, or sinkholes, which may open up under structures such as a home. The risk of new sinkholes developing is highest during times of flooding or drought. In terms of structural damage, a new sinkhole would likely impact only one property.

Sinkholes also literally open up a direct avenue for potential groundwater contamination, which can occur naturally through run-off or when people dump waste or dead animals into them. Surface contaminations typically percolate into the sub-surface cavern systems. Here they commonly travel for significant distances (several dozen miles at times) with the sub-surface water-flow, and the contaminated water then re-emerges to the surface along stream-cut valleys or simply becomes part of the contamination of the water table. Such movement of subsurface-water-borne contaminants is not easily traceable (or visible), and the impact can be truly regional. The risk for the population is associated with the unconscious use of such contaminated water pumped from private wells. While all wells in all areas are as risk of contamination, it is the presence of wells in the karst regions that are of particular concern, due to the significant distance which sub-surface water travels here. While fecal coliform has been found in 25-30% of wells in some areas, expensive dye tracing is necessary to trace paths from sinkholes, so no cases of direct contamination have been discovered.

Map 7. NRV Karst Geology



Map 8. Karst Density per Square Feet



While considering the relative risk of all hazards possible in the New River Valley, the Steering Committee considered frequency of the event and severity, as well as the area affected by the hazard. Using these considerations, karst was ranked as a low risk in the region. The Steering Committee noted that relative to other hazards, land subsidence related to karst occurs seldom, with negligible and isolated effects.

4.4.2.3 Past or Existing Mitigation

Most land use ordinances in the NRV, including zoning and subdivision ordinances, have only weak language regarding karst, such as “land deemed to be topographically unsuitable shall not be platted for residential use.”

Most karst mitigation efforts to date have been made by the Virginia Department of Conservation and Recreation (DCR), which has an office in the NRV, or the Senior Environmental

Corp, or the Cave Conservancy. DCR has sponsored local workshops for planners and local officials.

Also, VDOT requires the locality and developer to make additional stormwater management provisions in areas with karst topography prior to the acceptance of subdivision streets.

4.4.3 Earthquake

As the name implies, an earthquake is the trembling at the Earth's surface or below, resulting from the release of energy or strain on the Earth's tectonic plates. The shaking and movement can cause serious damage to buildings and structures. There are four hazards associated with earthquakes (from Planning for Post-Disaster Recovery):

- Ground motion: waves of vibration
- Seismic activity: energy transferred, measured by magnitude (total energy) and intensity (subjective description at a particular place)
- Surface faulting: visible, lasting ground changes
- Ground failure: weak or unstable soils can liquefy and move

The most familiar terminology associated with earthquakes are magnitude and intensity. Table 4.5 below provides explanation of the Modified Mercalli Intensity Scale (MMI) and relates it to likely magnitude and damages at the epicenter. The value on MMI Scale recorded for the same event can vary based on the distance from the epicenter.

Table 4.5. Richter/Modified Mercalli Scales for Earthquakes

Richter Scale Magnitude	Typical Modified Mercalli Intensity	Type	Damage Description
1.0 – 3.0	I	Instrumental	– Not felt by many people unless in favorable conditions.
3.0 – 3.9	II – III	Weak – Slight	– Felt only by a few people at best, especially on the upper floors of buildings. Delicately suspended objects may swing. – Felt quite noticeably by people indoors, especially on the upper floors of buildings. Many do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration similar to the passing of a truck. Duration estimated.

Richter Scale Magnitude	Typical Modified Mercalli Intensity	Type	Damage Description
4.0 – 4.9	IV – V	Moderate – Rather Strong	– Felt indoors by many people, outdoors by few people during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. Dishes and windows rattle alarmingly. – Felt outside by most, may not be felt by some outside in non-favorable conditions. Dishes and windows may break and large bells will ring. Vibrations like large train passing close to house.
5.0 – 5.9	VI – VII	Strong – Very Strong	– Felt by all; many frightened and run outdoors, walk unsteadily. Windows, dishes, glassware broken; books fall off shelves; some heavy furniture moved or overturned; a few instances of fallen plaster. Damage slight. – Difficult to stand; furniture broken; damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by people driving motor cars.

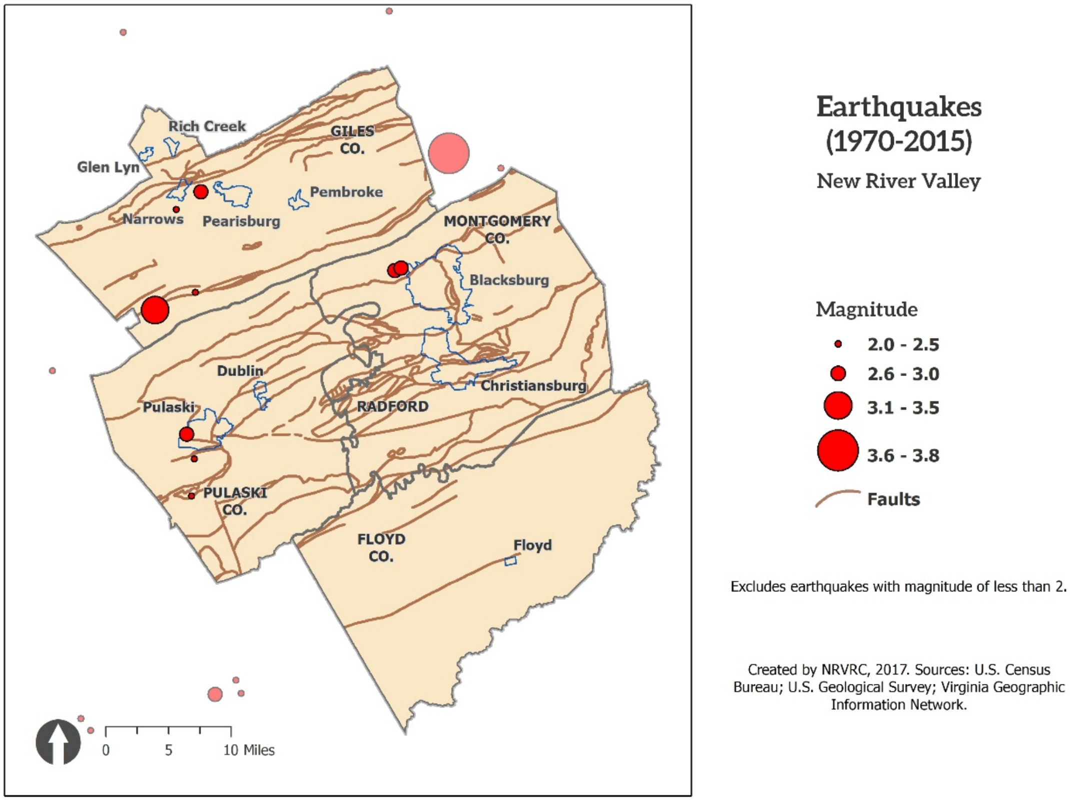
Richter Scale Magnitude	Typical Modified Mercalli Intensity	Type	Damage Description
6.0 – 6.9	VII – IX	Very Strong – Destructive – Violent	– Difficult to stand; furniture broken; damage negligible in building of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. Noticed by people driving motor cars. – Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved. – General panic; damage considerable in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.

Richter Scale Magnitude	Typical Modified Mercalli Intensity	Type	Damage Description
7.0 +	VIII or higher	Destructive – Violent – Intense – Extreme – Cataclysmic	– Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture moved. – General panic; damage considerable in specially designed structures, well designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. – Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundation. Rails bent. – Few, if any masonry structures remain standing. Bridges destroyed. Rails bent greatly. – Total destruction - Everything is destroyed. Lines of sight and level distorted. Objects thrown into the air. The ground moves in waves or ripples. Large amounts of rock move position. Landscape altered, or leveled by several meters. In some cases, even the route of rivers is changed.

4.4.3.1 History

In the New River Valley, earthquakes are common, although typically of such a minor scale that the movements are not felt by residents, but rather recorded by instruments at Virginia Tech's Seismic Observatory. There are three types of faults present in the NRV: 1) surface faults (most have strong vertical movements), 2) reverse faults (with horizontal movements and can involve sections of the crust rolling over either partially or completely), and 3) ground failure (involving primarily unconsolidated rock debris and soil). Map 9 shows the incidence of earthquakes from 1975 to 2015 as well as the known faults in the region.

Map 9. Earthquake History



On May 31, 1897 an earthquake estimated at 5.8 on the Richter scale occurred in the NRV. The epicenter was in Pearisburg, but it was felt as far north as Cleveland, Ohio and as far south as Atlanta, Georgia. In the Giles County area, chimneys fell, brick homes were damaged, streams changed course, and rockslides and landslides covered railroad tracks. This is the one of the largest recorded earthquake in the state of Virginia, second only to the August 2011 earthquake centered in Louisa County, though smaller earthquakes frequently occur throughout the state.

4.4.3.2 Risk Assessment and Vulnerability

Map 10 below illustrates the estimated damages in 2010 dollars if the earthquake of 1897 were to occur presently. The results of modeling using FEMA's HAZUS-MH 3.1 is indicated on Map 11. The model assumption is an earthquake with a magnitude of 7.0 striking the area and the resultant loss as annualized costs. FEMA defines annualized loss as the estimated long-term value of losses to the general building stock averaged on an annual basis for a specific hazard type. Annualized loss considers all future losses on return periods averaged on a "per year" basis. Like other loss estimates, annualized loss is an estimate based on available data and models. Therefore, the actual loss in any given year can be substantially higher or lower than the estimated annualized loss. Table 4.6 shows the estimated direct economic loss for buildings based on HAZUS-MH 3.1 modeling.

Table 4.6. HAZUS Earthquake Total Annualized Loss

Locality	**Annualized Loss Amount**
Floyd County	$49,114
Giles County	$77,960
Montgomery County	$401,496
Pulaski County	$176,658
City of Radford	$75,955

According to Martin Chapman, PhD, a seismologist at Virginia Tech, a 6 to 6.5 magnitude earthquake is estimated to be a 1-in-2,500-year event in the New River Valley. Specifically, he suggests that the region within 30 kilometers of the epicenter of the 1897 earthquake is most likely to see the next significant event.

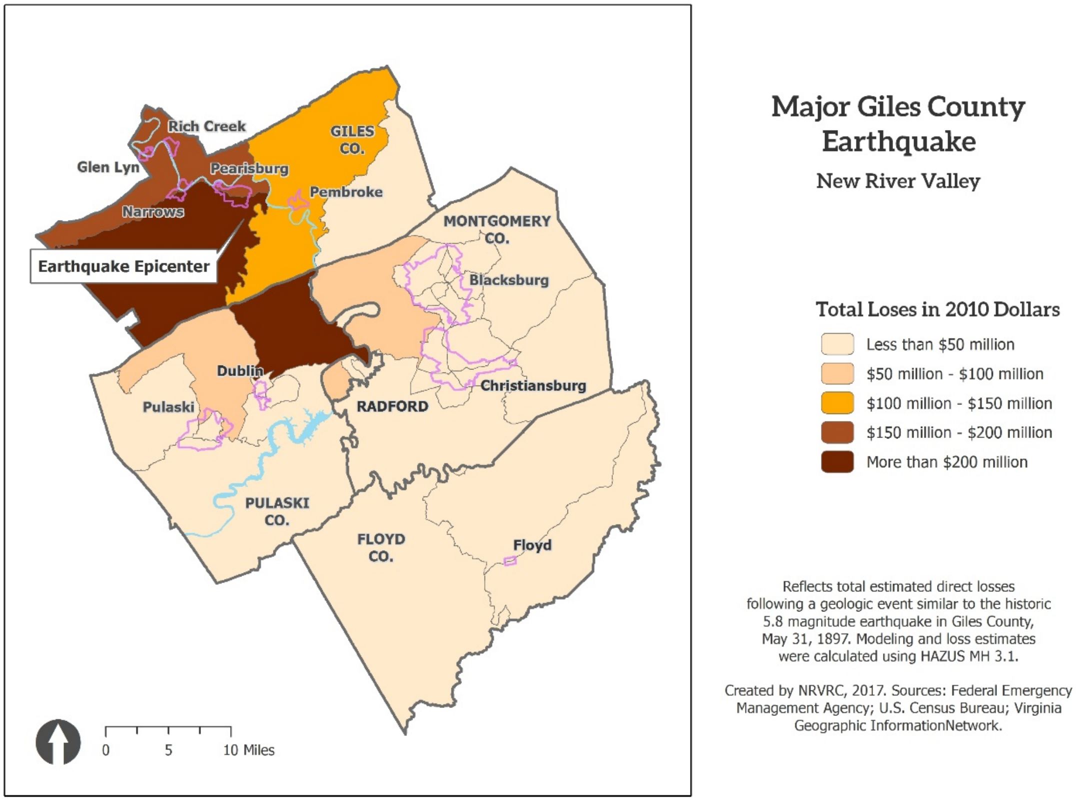
The probability of an earthquake with a significant force striking the NRVRC is highly unlikely in the near future. However, one has to keep in mind that earthquakes are unpredictable, both in occurrence as well as in magnitude.

Also according to Dr. Chapman, old brick and block construction results in the most death and injuries during this level of earthquake. Specifically, he mentioned that firehouse doors and hospital equipment not restrained may be rendered inoperable. There are four hospitals in this high hazard area, and there are approximately 15 firehouses. A major earthquake could damage medical and rescue equipment, as well as major bridges—causing millions of dollars in damage.

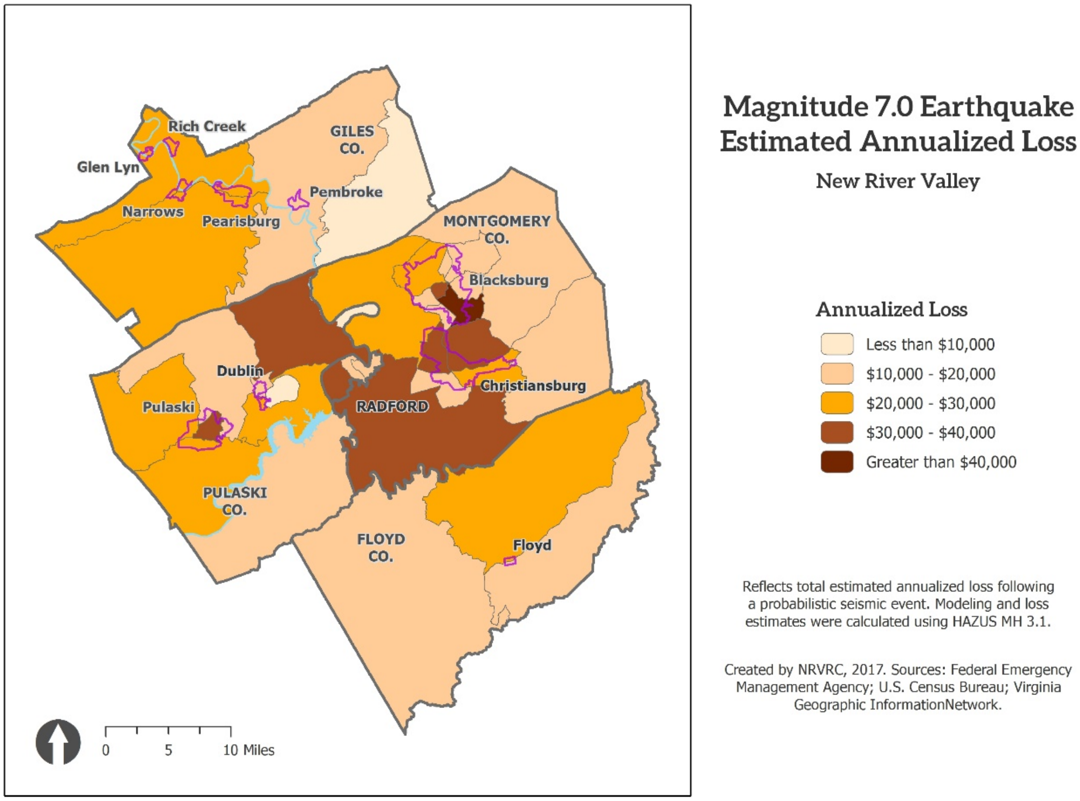
There is also one major underground natural gas transmission line (through Pulaski and Montgomery Counties) and a major hydroelectric dam (Claytor Dam in Pulaski County) that could be affected by a major quake. Given the very low probability of this type event, however, no additional assessment was deemed necessary at this time.

While considering the relative risk of all hazards possible in the New River Valley, the Steering Committee considered frequency of the event and severity, as well as the area affected by the hazard. Using these considerations, earthquake was ranked as a low risk in the region. Though a significant earthquake event could be catastrophic for the region, it is unlikely to occur frequently.

Map 10. NRV 1897 Earthquake Loss Estimates



Map 11. NRV Magnitude 7.0 Earthquake Estimate Annualized Loss



4.4.3.3 Past or Existing Mitigation

The only earthquake mitigation currently in effect is the statewide building code. The building standards in earthquake hazard areas may be further increased in subsequent updates to the with International Building Code.

4.4.3.3.1 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Below are the goals, objectives, and strategies identified by the geologic working groups to specifically lessen the impacts of geologic hazards in the region.

Goal: Minimize structural damage due to landslides.

a) Develop strategies to protect existing structures from the impacts of landslides and debris flows.

i. Identify areas where potential debris flow could be diverted to avoid existing structures.
ii. Re-vegetate areas in danger of becoming slides.
iii. Collect data on landslides at locality level.
iv. Prevent landslide damage at sites with known risks [by implementing projects such as completing feasibility studies and determining a suite of solutions].

b) Develop educational materials and notification systems to better inform residents of landslide hazards.
i. Create a database or reporting system for landslides.
ii. Notify permit applicants of site vulnerability to landslide and debris flow.
iii. Develop appropriate signage that warns of the danger of landslide and rockfall, especially during heavy rain periods.
iv. Install warning devices on extremely vulnerable sites that have remote notification for emergency and response personnel.

c) Encourage planning practices that mitigate the impacts of landslides and rockfall on new and existing developments.
i. Ensure that the most accurate data is available and incorporated while making planning decisions (i.e., zoning, subdivisions).
ii. Restrict future development in landslide prone areas.
iii. Continue to improve data available for future planning and mitigation.
iv. Incorporate additional language into ordinances to mitigate impacts from landslides.
v. Continue to monitor A-rated rockfall cuts for future slope movement.
vi. Encourage projects that expand catchment areas (i.e., ditches and shoulders) in potential rockfall areas of roads.
vii. Encourage slope protection, reinforcement and reconstruction projects to prevent future rockfall events.
viii. Engage in pre-demolition activities that control rockfall events.

d) Engage in activities to plan for and avoid future landslide and rockfall impacts.
i. Gather existing route information for detours that may be necessary in the event of a rockfall event.

Goal: Minimize risks to developments and structures in areas prone to earthquakes and new sinkholes.

a) Encourage activities to protect structures from future events.
i. Continue to ensure that seismic requirements are included in building codes.

ii. Identify and reinforce existing structures and critical facilities to withstand seismic events.
iii. Within site plan development, address topography and karst risk.

b) Develop educational programs to increase residents' awareness of likelihood of geologic events.
   i. Develop and coordinate training/education activities for all interested and responsible parties (including government staff, non-profits, and other organizations involved in hazard response activities) on appropriate response for geologic events.
   ii. Maintain awareness of regional seismic activity.
   iii. Develop informational materials about potential for sinkholes in vulnerable areas.
   iv. Encourage participation in preparedness events.

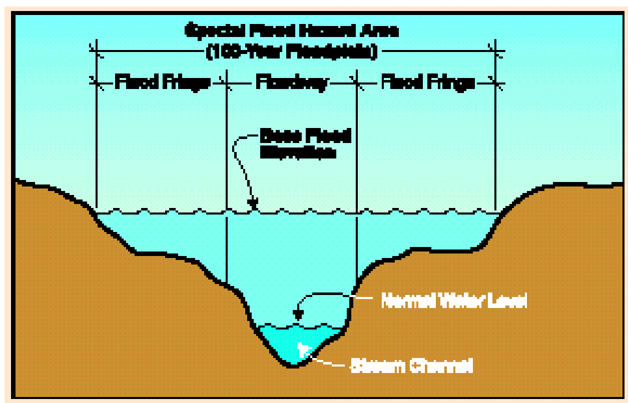
c) Engage in planning activities to minimize impacts of earthquakes and sinkholes.
   i. Identify and mark known sinkholes.
   ii. Conduct aerial surveys of hazardous conditions resulting from sinkholes.
   iii. Survey local surveyors, well drillers, septic installers, soil scientists and other local experts to identify new sinkhole locations.
   iv. Ensure that identified sinkholes are marked on plats, easements, and building permits.
   v. Conduct water quality assessments to determine impacts of sinkholes on water sources.
   vi. Encourage further dye tracing to track water as it moves between the surface and below ground.
   vii. Ensure that groundwater sources are protected from contamination by requiring septic drainfields to be a minimum distance from a known sinkhole.
   viii. Ensure structures are not placed near known sinkholes.
   ix. Pursue more detailed karst mapping for localities.

4.5 Flooding: Riverine, Flash Flooding and Dam Inundation

Flooding is perhaps the most common and widespread hazard within the New River Valley, as it is across the nation. FIRMs from the NFIP are available for all counties and the city in the NRV. These are digitized versions of the paper maps created in the 1970s at the origination of the NFIP. The FIRMs locate the 100-year floodplain, meaning the area that has a 1% chance of flooding in any given year. Property owners living within a community that participates in the NFIP can purchase flood insurance through the federal program, regardless of their location in or outside of the floodplain. Insurance rates do increase as the predicted risk of flooding increases, as based off the FIRMs.

Figure 4.17 below shows a generalized depiction of a 100-year floodplain. The base flood is also called the 100-year flood which has a 1% probability of being equaled or exceeded in any given year. The floodplain is defined as any land area susceptible to partial or complete inundation by water from any source. The floodway is the central channel and that portion of the adjacent floodplain which must remain open to permit passage of the base flood. The greatest intensity floodwaters are generally in the floodway, and anything in this area is at greatest risk during a flood. The remainder of the 100-year floodplain is called the "fringe" where water may be shallower and slower. The depth and intensity of the water flow here is determined by existence of obstructions.

Figure 4.17. Generalized 100-Year Floodplain



It is important to note that on the FIRMs and in the supporting Flood Insurance Studies "the hydraulic analysis…is based on the effects of unobstructed flow. The flood elevations as shown are considered valid only if the hydraulic structures in general remain unobstructed and do not fail." When flow is obstructed, as often happens with debris, the impacted area is wider and/or the depths of the water are greater.

Table 4.7 below describes the flood hazard areas as depicted by the FIRMs and their associated probabilities.

Table 4.7. FEMA Special Flood Hazard Area designations and probabilities

Probability	Zone	Description
Annual probability of Flooding of 1% or Greater	A	Subject to 100-year flood. Base flood elevation undetermined.
	AE or A1-A30	Both AE and A1-A30 represent areas subject to 100-year flood with base flood determined.
	AH	Subject to 100-year shallow flooding (usually areas of poundings) with average depth of 1-3 feet. Base flood elevation determined.

Probability	Zone	Description
	AO	Subject to 100-year shallow flooding (usually sheet flow on sloping terrain) with average depth of 1-3 feet. Base flood elevation undetermined.
	V	Subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation undetermined.
	VE or V1-V30	Both VE and V1-V30 represent areas subject to 100-year flood and additional velocity hazard (wave action). Base flood elevation determined.
Annual Probability of Flooding of 0.2% to 1%	B or X500	Both B and X500 represent areas between the limits of the 100-year and 500-year flood; or certain areas subject to 100-year flood with average depths less than 1 foot or where the contributing drainage area is less than 1 square mile; or areas protected by levees from the 100-year flood.
Annual Probability of Flooding of Less than 0.2%	C or X	Both C and X represent areas outside the 500-year flood plain with less than 0.2% annual probability of flooding.
Annual Probability of Flooding of Less than 1%	No SFHA	Areas outside a "Special Flood Hazard Area" (or 100-year flood plain). Can include areas inundated by 0.2% annual chance flooding; areas inundated by 1% annual chance flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; areas protected by levees from 1% annual chance flooding; or areas outside the 1% and 0.2% annual chance floodplains.

In the NRV there are multiple properties that are defined as either Repetitive Loss or Severe Repetitive Loss by the NFIP. Table 4.8 summarizes these properties.

Table 4.8. Repetitive and Severe Repetitive Loss Properties by Locality

Locality	Repetitive Loss Properties	Severe Repetitive Loss Properties	Type of Properties
Town of Christiansburg	2	0	1 non-residential, 1 residential
Floyd County	1	1	All residential
Giles County	5	1	All residential
Montgomery County	15	1	All residential
Pulaski County	6	0	All residential
Town of Pulaski	2	0	All residential
Town of Narrows	2	0	All residential

The Town of Pulaski acquired two repetitive loss properties in 2002 and have successfully utilized five structural acquisitions for community greenspace. In 2004, Giles County acquired a home in Pembroke that was frequently flooded by Little Stony Creek. This property was turned to green space to avoid flooding impacts to the residents and their property.

4.5.1 History

The New River Valley is prone to riverine and flash flooding. The history of each is delineated next.

4.5.1.1 Riverine

Riverine flooding is the more gradual flooding that occurs on major waterways such as the New River following many days of rain. There is typically advance notice for this type of flooding. Riverine flooding occurred along the New River in 1878, 1916 and 1940. All three events were deemed "100-year event." Notably, all of these events occurred prior to the completion of the power-generating dam on the New River, though it was not built for flood control purposes. Riverine flooding not only affects the development on the river, including that in Radford, Pearisburg and Narrows, but it also causes backwater effects into the downstream portions of tributaries like Little Stony and Doe Creeks.

In addition to these notable flood events, 17 flood events have been recorded in the National Climatic Data Center (NCDC) database from 1996 to 2016. These recorded events have cost just over $2 million in damages and resulted in one death and one injury. Unfortunately these records do not indicate the magnitude of the flooding, so it is impossible to tell if these were 100-year floods, or more common flooding that occurs regularly in some portions of the region.

4.5.1.2 Flash Flooding

The more frequent and damaging type of flooding in the NRV is flash flooding. The mountains of western Virginia are among the most dangerous flash flood-prone areas in the U.S., due to the strong storms created by the collision of warm, moist Gulf air and cold fronts from the North (Water News, Virginia Tech, 1987). Often this flooding occurs from localized thunderstorms or tropical storm-related events. For example, in June, 1972, Tropical Storm Agnes became a hurricane in the Gulf, deteriorated to a tropical depression, then surged to a tropical storm force again in Georgia traveling north before continuing further north. It never made landfall in Virginia, moving over the ocean in North Carolina. Yet, its impacts reached into western Virginia where it wreaked havoc.

Since 1996, approximately 145 flash floods have been reported throughout the NRV in the NCDC database. Even though these events were reported much more frequently than riverine flooding, the damages reported were just over $5 million, with no deaths or injuries reported.

4.5.1.3 Dam Inundation

Various types of dams exist to serve a multitude of functions within the NRV area. These include farm use, recreation, hydroelectric power generation, flood and storm-water control, water supply and fish or wildlife ponds. In some cases, a single dam structure serves multiple functions, such as generating hydroelectric power and providing recreational opportunities to boaters and fishermen.

State and federal governments regulate dam construction, maintenance and repair. The federal government regulates power-producing dams (through Federal Energy commission) and federally-owned dams. On the state level, the Virginia Dam Safety Act of 1982 (and as amended effective December 22, 2010) serves as the guiding legislation. Virginia's regulations were last updated in March 2016. Within the NRV there are 15 dams that are of a class that is regulated. Table 4.9 below describes these dams.

Table 4.9. Regulated Dams in the NRV

Dam Name	County	River/Stream	Owner	Regulatory Authority	Hazard Rating
Mabry Mill Pond Dam	Floyd	Mabry Mill Pond	DOI NPS SER RLRI	Federal	
Park Ridge Dam	Floyd		Park Ridge Development of Floyd and Franklin	DCR	Significant
Rakes Mill Dam	Floyd	Dodd Creek	DOI NPS SER RLRI	Federal	
Celanese Dam 1	Giles	New River	Celanese	DCR	High
Glen Lyn Bottom Ash Dam	Giles	New River	AEP Service Corp.	DCR	High
Glen Lyn Flyash Dam (recently closed)	Giles	New River (off stream)	AEP Service Corp.	DCR	Low
Glen Lyn West Pond Dam	Giles	New River	AEP Service Corp.	DCR	High
Little River Dam	Montgomery	Little River	City of Radford	Federal - FERC	High
Teel Dam	Montgomery		Dale Teel		High

Dam Name	County	River/Stream	Owner	Regulatory Authority	Hazard Rating
Claytor Dam	Pulaski	New River	Appalachian Power Co, American Electric Power	Federal - FERC	High
Gatewood Dam	Pulaski	Peak Creek	Town of Pulaski	DCR	High
Hogan's Dam	Pulaski	Hogan Branch	Thornsprings Group LLC	DCR	High
Lake Powhatan Dam	Pulaski	Big Macks Creek	B.S.A., Blue Ridge Mountain	DCR	High
Ottari Scout Camp #2 Dam	Pulaski	Little Laurel Creek	B.S.A., Blue Ridge Mountain	DCR	Low

The federal government maintains an inventory of dams through the National Dam Inspection Act of 1972 and, more recently, the Water Resources Development Act of 1996. Maintained by the U.S. Army Corps of Engineers, the National Inventory of Dams has been available on-line since January 1999 (https://nid.usace.army.mil).

The current online database does not list the hazard rating for the dams. However, DCR does maintain the details that are submitted to this database and rate the regulated dams. Dams classified as a high hazard indicate that there is a probable loss of one human life is likely if the dam fails, while dams classified as significant hazards indicate that possible loss of human life and likely significant property or environmental destruction should the dam fail. Low hazard indicates loss of life is unlikely. These dams are rated based on dam break inundation studies based on DCR's Dam Safety regulations (http://www.dcr.virginia.gov/dam-safety-and-floodplains/dam-safety-index).

4.5.2 Risk Assessment and Vulnerability of Flooding[1]

FEMA's HAZUS-MH 3.1 was also used to assess the flood vulnerability for New River Valley region using the databases provided in the risk assessment tool. The potential for loss, or the degree of vulnerability, was measured using three different factors:

[1] *Disclaimer*:
The estimates of social and economic impacts contained in this report were produced using HAZUS-MH 3.1 loss estimation methodology software which is based on current scientific and engineering

1. Amount of county land area susceptible to a 100-year flood.
2. Amount of potential damage by square footage of buildings (by construction type and by occupancy).
3. Amount of direct economic losses related to buildings.

The three measures of loss give a general picture of the very complex issue of vulnerability to floods.

4.5.2.1 Location and Aerial Extent

HAZUS-MH 3.1 was used to generate the flood depth grid for 100-year and 500-year return periods (Map 12) calculated for one square mile drainage areas. The riverine model was determined from a user provided US Geological Survey (USGS) 10 meter digital elevation model (DEM) and peak discharge values obtained for reaches so generated.

The majority of flooding in the New River Valley is along the New River itself. Other feeder streams were also modeled but their contribution and impact is minimal. Complete vulnerability scenario modeling for every county (and Radford City) yielded a picture of varying degrees of vulnerability to flooding (Table 4.10). Pulaski County has the largest flood zone (24.9 square miles) while Floyd County has the smallest flood zone (9.37 sq. miles). Floyd County, far removed from the main course of the New River, has the lowest percentage of its land in floodplains. In contrast, Radford City, which is the smallest in area, lies directly along the New River and as such it has the highest percentage (12%) of land area within the floodplain. Overall, 69.75 square miles of the planning district's 1,470.84 square miles fall within the 100-year floodplain. In other words, 4.74% of the land area of the planning district is vulnerable to a 100-year flood event.

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knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific flood. These results can be improved by using enhanced inventory data and flood hazard information.

Map 12. NRV Floodplains

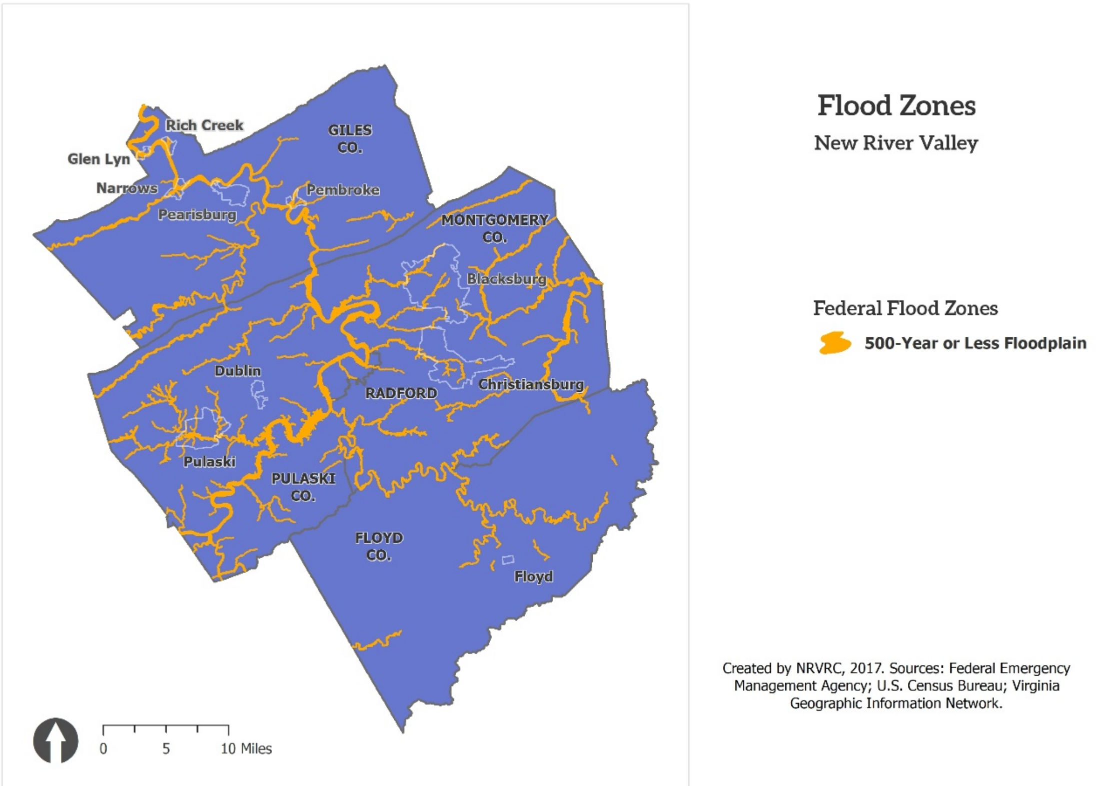


Table 4.10. 100-year Flood Zone Area

Locality	Flood zone Area (sq. mi)	Total Area (sq. mi)	% of Total
Floyd	7.39	381.78	1.94%
Giles	11.92	360.38	3.31%
Montgomery	11.37	388.72	2.92%
Pulaski	15.36	329.57	4.66%
Radford	0.84	10.21	8.22%
NVRPDC Total	46.87	1470.66	3.19%

The size of the flood zone is a convenient and more general measure of flood vulnerability. A more accurate method for expressing the level of vulnerability is loss estimation based on potential damage from a 100-year flood event. HAZUS-MH processing capability accounts for five flood events (10, 20, 50, 100, and 500 years) per return period. The following estimations are based on a 100-year flood event and reflect the damage estimates within the defined 100-year flood zone area.

4.5.2.2 Loss Estimation Analysis

The HAZUS-MH loss estimation results (average expected value per year) can be obtained for deterministic and probabilistic scenarios. The flood risk assessment presented herein was based on probabilistic analysis since no specific flood event was modeled. Deterministic analyses are based on the laws of physics and correlations among experience or tests to predict a particular outcome. One or more worst credible possible scenarios can be developed, but the frequency of events must be evaluated.

Probabilistic analyses are used to develop loss estimations and annualized losses due to potential damage. HAZUS standardized hazard outputs can be in the form of direct economic losses, induced, social and business interruptions. The analyses consider the likelihood of occurrence of a specific event, its resulting losses and consequences. The likelihood estimates are based on both statistics and historical information.

4.5.2.3 Building Damage and Stock Exposure by Building Type

One common measure in loss estimation is the amount of square feet of damage to buildings by construction type and/or by occupancy in the event of a flood. A simplified statistic can be derived by setting a threshold on a specified level of damage. One such a statistic is substantial damage. The NFIP defines substantial damage as damage of any origin sustained by a structure that would equal or exceed 50% of the market value of the structure before the damage occurred. This also applies to improvements to the structure that equal or exceed 50% of the market value of the structure.

Substantial damage is a key indicator of vulnerability because NFIP requires any substantially damaged structure must be brought into compliance with current local floodplain management regulations which will likely require elevation, relocation, floodproofing or demoltion of the structure. For instance it can be observed from Table 4.11 that in Floyd County the overall square footage of building damage by construction type is 75%. This means that a 100-year flood event will most likely cause substantial damage in 75% of the buildings at risk. The table also provides specific breakdown by construction type. For Floyd County the total square footage of wood buildings in the flood zone – the largest amount of building type at risk – is 34,000 square feet, and of these, 14,000 square feet will most likely experience damage of 50% or greater of its market value.

Given that Floyd County averages significant damage in 86.7% of its wood structures, it is clear therefore they will have proportionately greater damage than any other type. It is also apparent that based on this statistic, Montgomery County structures along the 100-year floodplain are more vulnerable with 38.4% receiving substantial damage. Pulaski County is the least vulnerable with only 31.7% of structures likely to experience substantial damage . The average for the planning district is 33.3% receiving substantial damage.

Overall, Floyd County has the least amount of square footage receiving substantial damage in almost all categories. In part this is due to the limited amount of area subject to flooding. For instance, the County has no concrete, masonry, or manufactured housing in the floodplains.

Manufactured housing tends to be extremely vulnerable because it takes less flooding than a other building types to create substantial damage. In the event of a 100-year flood, substantial damage to manufactured housing will be 83% of square footage in Montgomery, 70.6% in Giles, and 93.6% in Pulaski.

Although construction types are spatially much more widespread than occupancy categories, damage to manufactured housing (82.4%) dominates wood (33.27%), concrete (6.72%), masonry (16.2%) and steel (6.7%) structures.

Table 4.11. Building Damage by Building Type

Building Type	Damage	Floyd	Giles	Montgomery	Pulaski	Radford	NRV
Concrete	Any damage	0	0	29	75	15	119
Concrete	Substantial damage	0	0	1	4	3	8
Concrete	At risk for total loss	0	0	3.45%	5.33%	20.00%	6.72%
Manufactured Housing	Any damage	0	34	94	31	0	159
Manufactured Housing	Substantial	0	24	78	29	0	131
Manufactured Housing	At risk for total loss	0	70.59%	82.98%	93.55%	0	82.39%
Masonry	Any damage	0	49	134	274	32	489
Masonry	Substantial	0	10	28	37	4	79
Masonry	At risk for total loss	0	20.41%	20.90%	13.50%	12.50%	16.16%
Steel	Any damage	6	24	112	442	44	628
Steel	Substantial	1	7	4	25	5	42
Steel	At risk for total loss	16.67%	29.17%	3.57%	5.66%	11.36%	6.69%
Wood	Any damage	30	272	508	467	58	1335
Wood	Substantial	26	65	195	148	10	444
Wood	At risk for total loss	86.67%	23.90%	38.39%	31.69%	17.24%	33.26%
All structure types	At risk for total loss	75.00%	27.97%	34.89%	18.85%	14.77%	25.79%

**In thousands of square feet; Substantial damage = damage 50% or greater of market value*

4.5.2.4 Building Damage and Stock Exposure by Occupancy

A breakdown of the total square feet of potential building damage by county into different categories of occupancy, provide a different perspective of flood vulnerability (Table 4.12). As in the case of damage by building type, damage by occupancy was also analyzed at ≥50% as substantial damage.

The occupancy categories tracked by HAZUS-MH are agricultural, commercial, educational, governmental, industrial, religious/non-profit and residential. The overall substantial damage for the NRV is 27.5% of structures, with a fairly wide range of impact. Government and religious/non-profit structures are not at risk; commercial, residential, agricultural, and educational are. However, it is noteworthy that the majority of the potential substantial damage to buildings in the NRV is to residential buildings. In both absolute (608,000 square feet) and percentage (39%) terms, residential buildings are more vulnerable than any other category. Only 2,000 square feet of educational facilities (mainly schools) are found within the floodplain. Therefore, substantial damage to education buildings is generally very low in the NRV; it is only in Montgomery County that 10.5% of educational facilities stand a chance for substantial damage from a 100-year flood event. This trend demonstrates the importance of the public service sector in the NRV.

The distribution of agricultural damage shows two counties at risk: Giles County with the highest vulnerability with approximately 100% of 1,000 square feet receiving substantial damage and Pulaski County with 20% of its square footage receiving substantial damage. The rest of the counties' agricultural structures are not vulnerable. Radford City stands out as the one with the largest square footage of commercial (14,000 sf or 25%) and significant industrial (16.7%) flood vulnerability.

Table 4.12. Building Damage by General Occupancy

Occupancy Type	Damage	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Residential	Any damage	30	326	668	460	72	1556
	Substantial damage	26	96	288	189	9	608
	At risk for total loss	86.67%	29.45%	43.11%	41.09%	12.50%	39.07%
Commercial	Any damage	2	29	22	207	56	316
	Substantial	1	6	0	1	14	22
	At risk for total loss	50.00%	20.69%	0.00%	0.48%	25.00%	6.96%
Industrial	Any damage	4	4	141	534	18	701
	Substantial	0	2	3	39	3	47

Occupancy Type	Damage	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
	At risk for total loss	0.00%	50.00%	2.13%	7.30%	16.67%	6.70%
Agricultural	Any damage	0	1	2	5	0	8
	Substantial	0	1	0	1	0	2
	At risk for total loss	0.00%	100.00%	0.00%	20.00%	0.00%	25.00%
Religion	Any damage	0	11	12	37	0	60
	Substantial	0	0	0	0	0	0
	At risk for total loss	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Government	Total	0	0	0	52	0	0
	Substantial	0	0	0	0	0	52
	Percentage	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Education	Total	0	0	19	3	0	22
	Substantial	0	0	2	0	0	2
	Percentage	0.00%	0.00%	10.53%	0.00%	0.00%	9.09%
All occupancy types	At risk for total loss	75.00%	28.30%	33.91%	22.63%	17.81%	27.53%

**In thousands of square feet; Substantial damage = damage 50% or greater of market value*

4.5.2.5 Dollar Exposure

Unless floodwaters flow at a high velocity and the structure and the foundation become separated or the structure is impacted by flood-borne debris, it is unlikely that a building will suffer structural failure in a flood (HAZUS-MH MR4 Technical Manual, 2010). Therefore, the way HAZUS-MH works is that building type, design level and quality of construction do not play a major role in damage resistance to flooding. In general, it is expected that the major structural components of a building will survive a flood, but that the structural finishes and contents/inventory may be severely damaged due to inundation.

HAZUS-MH models general building stock dollar exposure which can be viewed by general occupancy, general building type or specific building type. This option provides estimates of direct physical damages to buildings and contents and the exposure of essential facilities to flooding, as well as the consequential direct economic losses and the number of people displaced by evacuation and inundation. The latter is not examined in this report.

Table 4.13 and Table 4.14 provide summary statistics for building stock exposure by type and occupancy for the NRV.

Table 4.13. Building Stock Exposure by Building Type

Building Type	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Concrete	$28,079	$47,382	$590,158	$128,264	$144,294	$938,177
Manufactured Housing	$65,268	$67,172	$179,913	$112,167	$6,988	$431,508
Masonry	$349,792	$436,242	$2,670,503	$929,766	$449,135	$4,835,438
Steel	$97,169	$154,339	$1,017,689	$418,220	$206,119	$1,893,536
Wood	$891,975	$1,048,303	$5,471,214	$2,127,136	$807,090	$10,345,718
Total	$1,432,283	$1,753,438	$9,929,477	$3,715,553	$1,613,626	$18,444,377

All values in thousands of dollars

Table 4.14. Building Stock Exposure by Occupancy

Occupancy Type	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Residential	$1,223,547	$1,427,841	$8,002,162	$2,881,329	$1,271,948	$14,806,827
Commercial	$106,426	$197,759	$1,214,356	$345,104	$222,893	$2,086,538
Industrial	$51,214	$65,504	$217,128	$354,706	$67,246	$755,798
Agricultural	$11,162	$6,546	$28,791	$11,211	$1,294	$59,004
Religion	$18,209	$35,530	$163,600	$63,152	$29,191	$309,682
Government	$8,476	$7,874	$45,935	$27,498	$7,207	$96,990
Education	$13,183	$12,315	$257,360	$32,396	$13,825	$329,079
Total	$1,432,217	$1,753,369	$9,929,332	$3,715,396	$1,613,604	$18,443,918

All values in thousands of dollars

Table 4.13 shows the dollar exposure by building construction type. The overall picture presents a typical expected outcome based on the quality and durability of the construction. Within the NRV the most likely damage in order of magnitude range from manufactured housing ($431,508,000) to concrete ($938,177.000) to steel ($1,839,536,000) to masonry ($4,835,438,000) to wood ($10,345,718,000) for an estimated total of $18,444,377,000. Notice that that wood damage is the highest in part because it is common, but also because it is more vulnerable. Steel has one of the lowest damage values because it is rare and also less vulnerable. Manufactured housing which dominates the percentage of square footage receiving substantial damage (see Table 4.11) has a low dollar exposure mainly because of their value and cheaper construction.

As can be seen in Table 4.14, the agriculture category has the least exposure in terms of dollar value. This is expected since land designated as agriculture has the least number of standing buildings. The major damage is in residential and commercial buildings. Government buildings also have a low exposure risk for the simple reason that public facilities are seldom in flood-prone areas.

The key difference in the dollar exposure values provided is the issue of spatial location. Consistently Radford City tends to show high risks primarily due to its proximity to the New River. The same can be said about Giles County. At the same time, Montgomery and Pulaski are both large counties but ones with few buildings within the floodplains.

One key parameter not considered in this estimation of expected flood damage is building age. Age is an issue because building codes (and expected building performance) change over time, and because development regulations change when a community enters the NFIP. In cases where the building floor data was developed prior to entrance in the NFIP, it can be assumed that this portion of data in the exposure analysis will be more susceptible to damage resulting from a 100-year flood event. In the final analysis, the interpretation of the statistics generated depends not only on the type and occupancy of the buildings but also the age of the buildings in question.

4.5.2.6 Transportation System Dollar Exposure

The broad transportation systems included in HAZUS-MH program are highways, railways, light rail, bus, ports, ferries and airports.

The following are the characteristics of the categories under consideration in this analysis:

- Highways - consists of roadways, bridges and tunnels. HAZUS-MH 3.1 as is does not include assessment of losses to street segments and other highway components.
- Railways - consists of tracks, bridges, tunnels, stations, fuel, dispatch and maintenance facilities. The HAZUS-MH 3.1 flood model does not account for flood-borne debris impact or the loads resulting from flood-borne debris trapped against transportation features such as bridges. Also the model does not assess losses to railway segments and other railway components, but will produce an estimate of the percent damage to a bridge and the probability of the bridge being functional, depending on the estimated damage.
- Bus - bus transportation system consists of urban stations fuel facilities, dispatch and maintenance facilities. In the NRV there are three functional bus systems: Blacksburg Transit (BT) that operates fixed-routes mainly in the Towns of Blacksburg and Christiansburg, Pulaski Area Transit which operates primarily in the Town of Pulaski, and Radford Transit that operates fixed-routes mainly in the City of Radford. Both BT and Pulaski Area Transit also provide an on-demand service for qualifying disabled residents. The BT system was included in the present modeling, but the other two were not.
- Airport - an airport transportation system consists of control towers, runways, terminal buildings, parking structures, fuel facilities and maintenance and hangar facilities. There are two facilities within the NRV namely the New River Valley Airport (NRV Airpark) in Dublin (Pulaski County) and the Virginia Tech Montgomery Executive Airport in Blacksburg (Montgomery County).

Overall the most impact in the event of a 100-year flood, highways will experience the largest loss followed by railways and airports. Montgomery County will bear most of the brunt and in all categories (Table 4.15).

Note that light rail, ports and ferry categories are not included in the analysis because they do not exist in the NRV.

Table 4.15. Transportation System Dollar Exposure

Transportation	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Highway	$503,645	$574,442	$1,092,269	$525,035	$154,904	$2,850,295
Railway	$0	$82,540	$102,954	$51,029	$15,254	$251,777
Bus Facility	$0	$0	$2,027	$0	$0	$2,027
Airport	$0	$0	$48,615	$48,615	$0	$97,230
Total	$503,645	$656,982	$1,245,866	$624,679	$170,158	$3,201,329

All values in thousands of dollars

4.5.2.7 Utility Dollar Exposure

The inventory classification scheme for lifeline systems separates components that make up the system into a set of pre-defined classes. The classification system includes potable water, wastewater, oil, natural gas, electric power and communication systems. Oil systems and natural gas are not included in the report because they do not exist in the form described within the NRV. The following is a brief description of the utility systems:

- Potable water – this system consists of pipelines, water treatment plants, control vaults and control stations, wells, storage tanks and pumping stations. The model estimates damage, losses and functionality for select vulnerable components of the potable water system. These include treatment plants, control vaults and control stations and pumping stations.
- Wastewater – wastewater system consists of pipelines, wastewater treatment plants, control vaults and control stations and lift stations. The model will estimate damage, losses, and functionality for select vulnerable components within the wastewater system including treatment plants, control vaults and control stations and lift stations.
- Electric power – electric power system consists of generating plants, substations, distribution circuits and transmission towers. The flood model as is only performs a limited analysis on select vulnerable electric power system components vis-à-vis generating plants and substations.
- Communication – a communication system consists of communications facilities, communications lines, control vaults, switching stations, radio/TV station, weather station or other facilities. At this time HAZUS-MH 3.1 flood model has deferred estimating damage and losses for communications facilities.

The inventory data used to estimate utility dollar exposure in each case includes the geographical location and classification of system components, replacement cost for facilities and the repair costs for the system components.

At the moment wastewater systems are more vulnerable than any of the other categories in part because collecting points for wastewater is always located downhill, coinciding with river flood zones. Potable water systems are significantly at risk at a distant second to wastewater in all localities except the City of Radford, which has no wastewater treatment facility exposure and Floyd County which has no potable water exposure (Table 4.16). After the September 2015 flood in Floyd County, the wastewater system experience infiltration for months, prompting major replacement work.

At this time, the flood model does not account for flood borne debris impact, or water borne debris loads which can cause significant clean-up efforts for utility systems. The flood model analyzes those system components that are more vulnerable or costly to clean-up, repair or replace since they are likely to control the overall recovery costs and time.

Table 4.16. Utility System Dollar Exposure

Utility	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Potable Water	$0	$30,969	$30,969	$61,938	$30,969	$154,845
Waste Water	$61,938	$309,690	$309,690	$123,876	$0	$805,194
Oil Systems	$0	$93	$0	$0	$0	$93
Electric Power	$0	$102,300	$0	$0	$0	$102,300
Communication	$93	$186	$651	$744	$93	$1,767
Total	$62,031	$443,238	$341,310	$186,558	$31,062	$1,064,199

All values in thousands of dollars

4.5.2.8 Vehicle Dollar Exposure

Vehicle dollar exposure is the estimated dollar value within any given census block, based on home address. Vehicle valuation is based on distributions of new and used vehicles provided by the Virginia Department of Motor Vehicles, and the average sale price of those vehicles. The flood model looks at passenger cars, light trucks (including SUVs) and heavy trucks (commercial/industrial vehicles including 18-wheelers). The HAZUS estimation procedure for flood damage of motor vehicles (vehicle dollar exposure) is based on vehicle inventory within a study area, allocation of vehicles by time of day to different locations, estimated value of vehicles and the percent loss damage function according to the flood depth.

Generally, vehicle dollar exposure is higher for night – when registered vehicles are assumed to be at the registered residence – than day. If the day dollar exposure is high then the model assumes that the locality records more day into-locality traffic (commuters) than out-of-locality traffic. Giles County has such traffic flow, recording more vehicles during the day than at night.

Table 4.17. Vehicle Dollar Exposure – Day

	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Cars	$74,827,732	$101,016,049	$538,161,128	$216,066,124	$95,900,280	$1,025,971,313
Light Trucks	$52,139,182	$70,169,391	$373,194,503	$50,045,529	$66,463,996	$612,012,601
Heavy Trucks	$15,658,979	$20,543,850	$99,203,969	$67,018,604	$18,489,465	$220,914,867
Total	$142,625,893	$191,729,290	$1,010,559,600	$433,130,257	$180,853,741	$1,858,898,781

All values in dollars

Table 4.18. Vehicle Dollar Exposure – Night

	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC
Cars	$107,380,030	$128,305,138	$559,331,123	$259,181,725	$98,463,228	$1,152,661,244
Light Trucks	$74,624,762	$88,953,608	$387,470,965	$179,381,047	$68,067,905	$798,498,287
Heavy Trucks	$16,298,121	$21,867,787	$105,275,818	$70,807,803	$19,493,831	$233,743,360
Total	$198,302,913	$239,126,533	$1,052,077,906	$509,370,575	$186,024,964	$2,184,902,891

All values in dollars

4.5.2.9 Direct Economic Annualized Losses for Buildings

Annualized loss provided an estimate of the maximum potential annual loss. Annualized losses are essentially the summation of losses over all return periods multiplied by the probability of those floods occurring. In mathematical terms, the analysis essentially looks like this:

Annual Loss = Sum of (Probability of Occurrence) * ($ loss)

These loss estimates document the magnitude of the natural hazards problems, as well as provide a benchmark against which progress toward reducing losses due to natural hazards through public policy can be assessed. Annualized direct economic losses estimates are only available for buildings because HAZUS-MH focuses on building assets using a more complete inventory and analysis.

Table 4.19. Direct Economic Annualized Capital Stock Losses for Buildings in the NRV

Locality	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC Total
Capital Stock Losses						
Cost Building Damage	$11,024	$27,814	$65,762	$60,522	$9,272	$174,394

Locality	Floyd	Giles	Montgomery	Pulaski	Radford	NRVRC Total
Cost Content Damage	$7,295	$20,196	$54,208	$102,312	$16,156	$200,167
Inventory Loss	$206	$246	$1,406	$9,872	$420	$12,150
Building Loss Ratio	2.9	4.4	5	4.7	2.2	19.2
Income Losses						
Relocation Loss	$ -	$7	$34	$60	$19	$120
Capital Related Loss	$ -	$21	$64	$104	$27	$216
Wages Loss	$26	$123	$122	$886	$67	$1,224
Rental Income Loss	$ -	$3	$11	$10	$ -	$24
Total Loss	$18,551	$48,410	$121,607	$173,766	$25,961	$388,295

All values in thousands of dollars

Although only about 5% of the New River Valley is predicted to be vulnerable to flooding impacts, it is evident that estimated losses can easily run into several million dollars.

4.5.3 A Newer Summary of Total Exposure in the Floodplain

A second method was used to assess flood vulnerability of structures with footprints absolutely located in the floodplain the NRV. Total Exposure in the Floodplain 2.0 (TEIF 2.0) creates a total exposure value based on building footprints in the SHFA rather than distributing the risk across the census block regardless of how much of the block is within the flood zone. HAZUS provides more detailed information on vulnerability than TEIF 2.0 by structure types and other assets in the floodplain, but as Table 4.20 and Figure 4.18 show, TEIF can give a more accurate view of floodplain risk to fixed structures.

Table 4.20. TEIF modeling of SFHA and Building Exposure

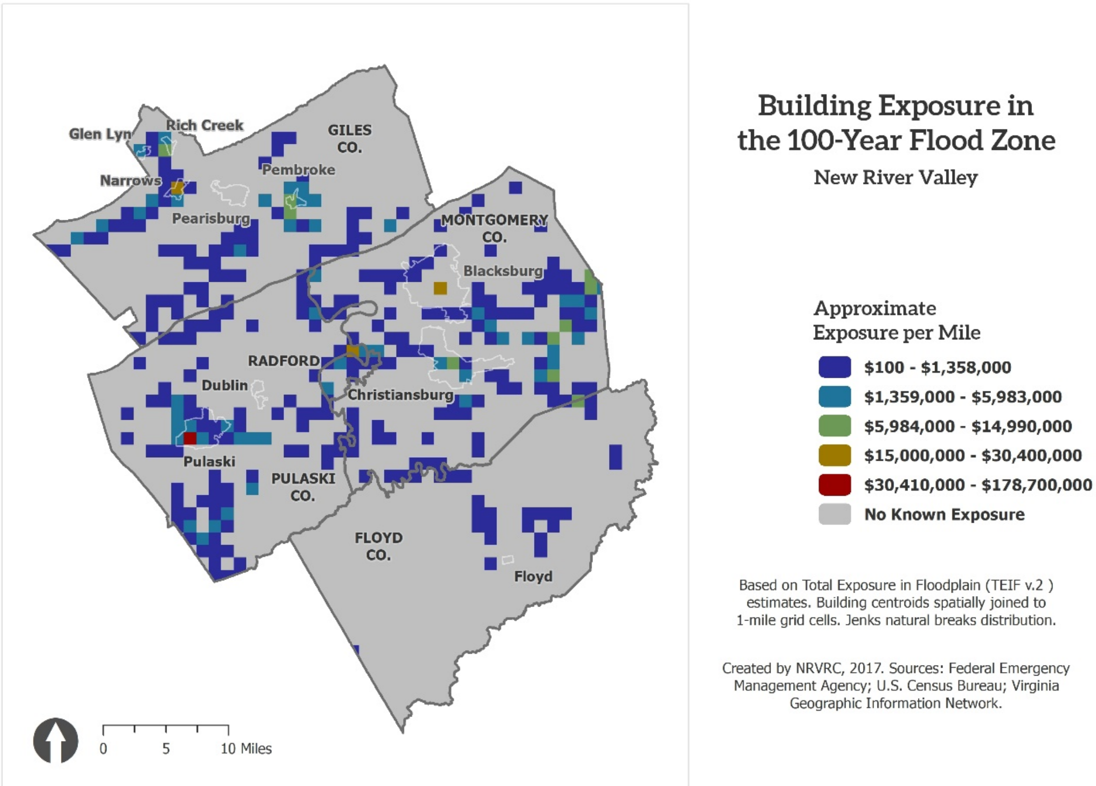
	Special Flood Hazard Area (SFHA) (acres)	% of Total Jurisdiction Area	Total Potential Building Exposure to Flooding in SFHA*	% of Total Potential Building Exposure
Floyd County	2,351	1.0%	$5,172,000	0.4%
Giles County	7,711	3.3%	$113,386,000	6.5%
Montgomery County	10,278	4.1%	$180,285,000	1.8%
Pulaski County	12,265	5.8%	$250,041,000	6.7%
Radford City	766	11.9%	$28,521,000	1.8%
Blacksburg	348	2.8%	$31,650,000	0.7%
Christiansburg	175	2.0%	$16,575,000	0.6%
Floyd	0	0.0%	$0	0.0%
Glen Lyn	153	35.4%	$1,568,000	12.5%
Narrows	190	22.7%	$21,821,000	9.4%
Pearisburg	19	0.9%	$0	0.0%
Pembroke	126	18.1%	$17,750,000	19.0%
Pulaski	431	8.5%	$189,973,000	18.3%
Rich Creek	74	14.7%	$14,359,000	14.5%

County figures are inclusive of municipalities. Color reflects relative value compared to other cities/towns or counties.

*figures rounded to thousands

Source FEMA TEIF v. 2.0

Figure 4.18. Building Exposure in the 100-Year Flood Zone



The following sections contain locality specific information and mapping for flooding. Original information was compiled from FEMA reports, National Flood Insurance Studies, Army Corps of Engineer studies, Natural Resources Conservation Service reports, newspaper accounts and local records. Each localities' 100-year and 500-year floodplains are included in Map 13 through Map 27. Larger displays of the maps can be found in Appendix 6.

4.5.3.1 Floyd County

Floyd County is situated atop a high plateau of the Blue Ridge Mountains that divides eastward flowing waters from westward flowing waters. Essentially no water flows into Floyd County; all flowing water begins in the county and drains to other areas. A number of important streams originate in Floyd County, including Big Reed Island Creek and Little River (tributaries of the New) and headwater streams of the Dan, Smith, Pigg, Backwater and Roanoke Rivers. The following were studied in detail by the Flood Insurance Study performed by FEMA to identify and prioritize flood hazards (1989):

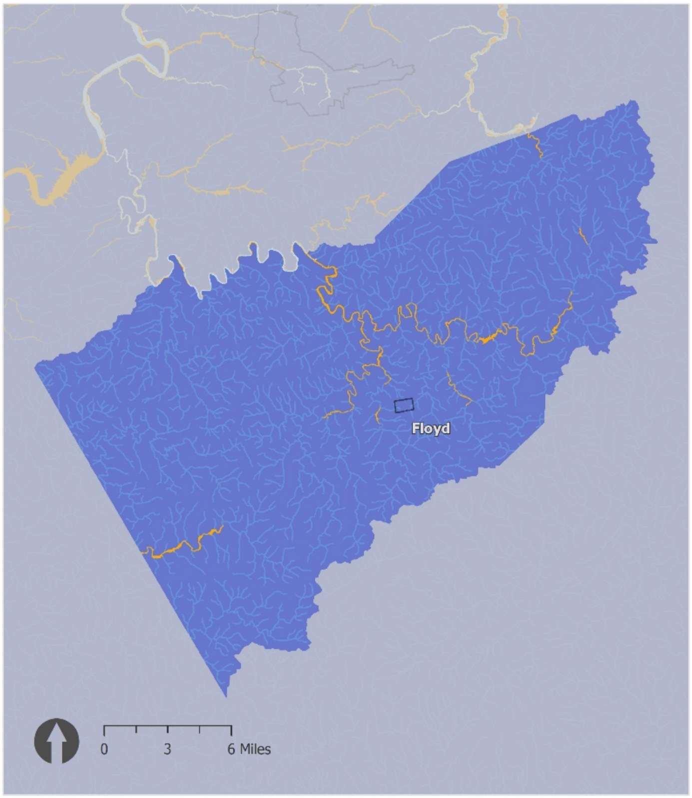
- Little River
- Dodd Creek
- West Fork of Little River
- Pine Creek
- Meadow Run

Flooding has been recorded in these areas of the county in 1940, 1959, 1972, 1985, and 2003. The floods are primarily due to heavy rains from localized storms and tropical storms in this area and cause significant economic damage to private, commercial, and public property, especially roads and bridges. NWS Blacksburg noted the storm in fall 2015 as one of its top five weather and climate events of the year. Flooding from a tropical moisture plume on September 28th through October 1st) occurred from significant rain that fell in a 6-day period. At least 24 homes were completely destroyed along the Little River basin in Floyd County. Up to $10 million damage occurred in Floyd, Patrick, and Montgomery counties alone. Floyd County officials described it as one of the worst natural disasters in recent memory there.

The largest flood occurred on June 21, 1972 when Little River's discharge at Graysontown reached 22,800 cubic feet per second (cfs). This flood has an approximate recurrence interval of 50 years. Map 13 illustrates the 100-year and 500-year floodplains in the county, while Map 14 illustrates the same for the Town of Floyd.

It is believed that the number of homes with significant flooding risk to primary living areas is limited in Floyd County. Only 19 properties in Floyd County participate in the National Flood Insurance Program and only one is a severe repetitive loss property. Floyd County is experiencing substantial housing and population growth, but it is not currently believed to be occurring in the flood hazard area.

Map 13. Floyd County Floodplains

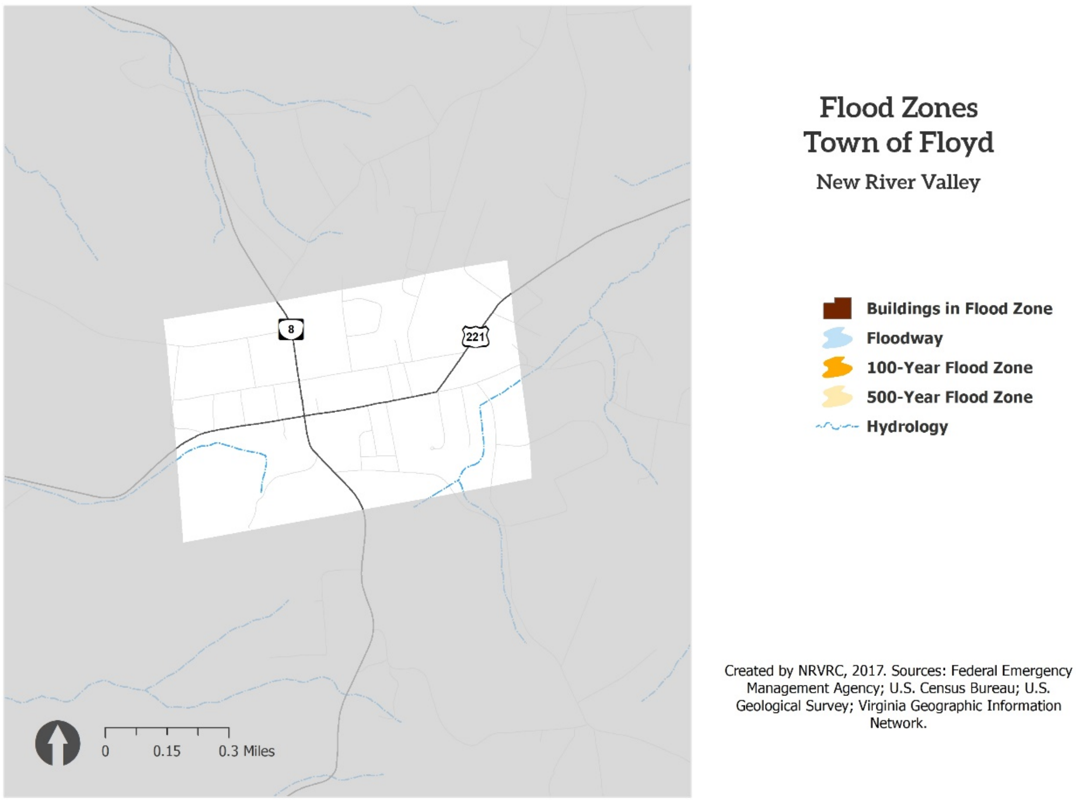


Flood Zones
Floyd County
New River Valley

Floodway
100-Year Flood Zone
500-Year Flood Zone
Hydrology

Created by NRVRC, 2017. Sources: Federal Emergency Management Agency; U.S. Census Bureau; U.S. Geological Survey; Virginia Geographic Information Network.

Map 14. Town of Floyd Floodplains



4.5.3.2 Giles County

The unincorporated areas of Giles County can be affected by flooding from 19 different streams or stream segments. The Flood Insurance Study by FEMA breaks these into two groups. One group was studied in detail, the other in approximate methods. The following streams studied in detail were done so due to known history of flood hazard and the projected growth in area:

- New River (in or near towns)
- Doe Creek
- Greenbrier Branch
- Laurel Branch
- Little Stony Creek
- Piney Creek
- Sinking Creek

- Spruce Run
- Stony Creek
- Wolf Creek

These were studied using approximate methods

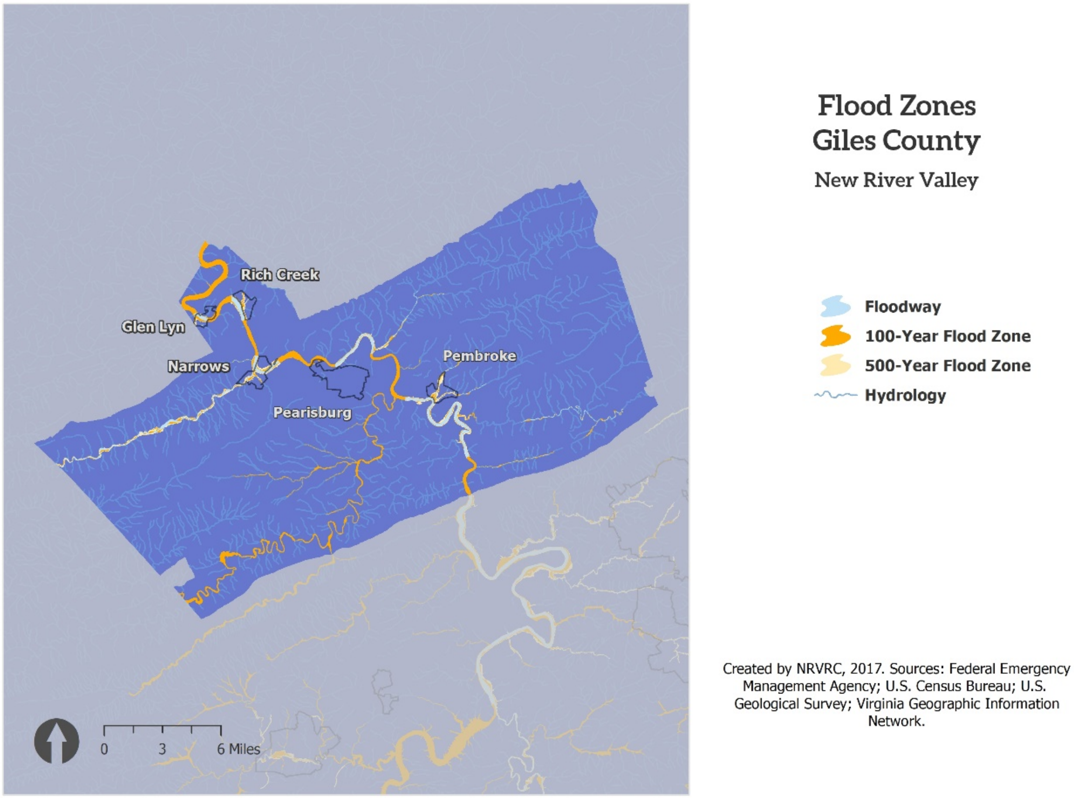
- New River (remainder)
- Bluestone Lake
- Broad Hollow Creek
- Cecil Branch
- Dry Branch
- Little Sugar Run
- Sugar Run
- Tributary to Sugar Run
- Walbash Creek
- Walker Creek

Giles County is fairly rugged, with high mountains and narrow valleys with some rolling hills and small, flat plateaus. Many of the streams are characterized by large boulders and high-velocity flows during storms. This results in rapid and dangerous flash-flooding in several areas, threatening life and property with little time for warning and preparation (and thus the later identified needs of better warning mechanisms and swift-water rescue capabilities). Flowing through the middle of the county is the New River. Flowing northwest through Virginia and into West Virginia, the New River divides Giles County into almost two equal parts.

Low-lying areas of the county in the proximity of the above streams are the most subject to flooding (see maps below). Tropical storms and isolated storms are the main causes of flooding in the area. The largest flood recorded for the New River was in 1940 where the waters were almost to the 100-year flood elevation. A limited portion of the Celanese Acetate, LLC property, the largest employer in Giles County, is located along the New River, in the 100-year floodplain, so a 100-year storm or greater could have a dramatic indirect economic costs as well (in terms of work days lost). Doe Creek, Little Stony, and Sinking Creek all experienced their largest flood elevations in May 1973. Damages to property, road, bridges and utilities were reported to be between $600,000 and $800,000 ($1.5 million+ in 2003 dollars.) Detailed analysis on local flood-prone areas is provided next for Glen Lyn, Narrows, Pearisburg, Pembroke and Rich Creek.

There are a number of homes with flooding risk in Giles County; 78 properties in the county (outside of incorporate towns) participate in the National Flood Insurance Program. Four are repetitive loss properties and one is a severe repetitive loss.

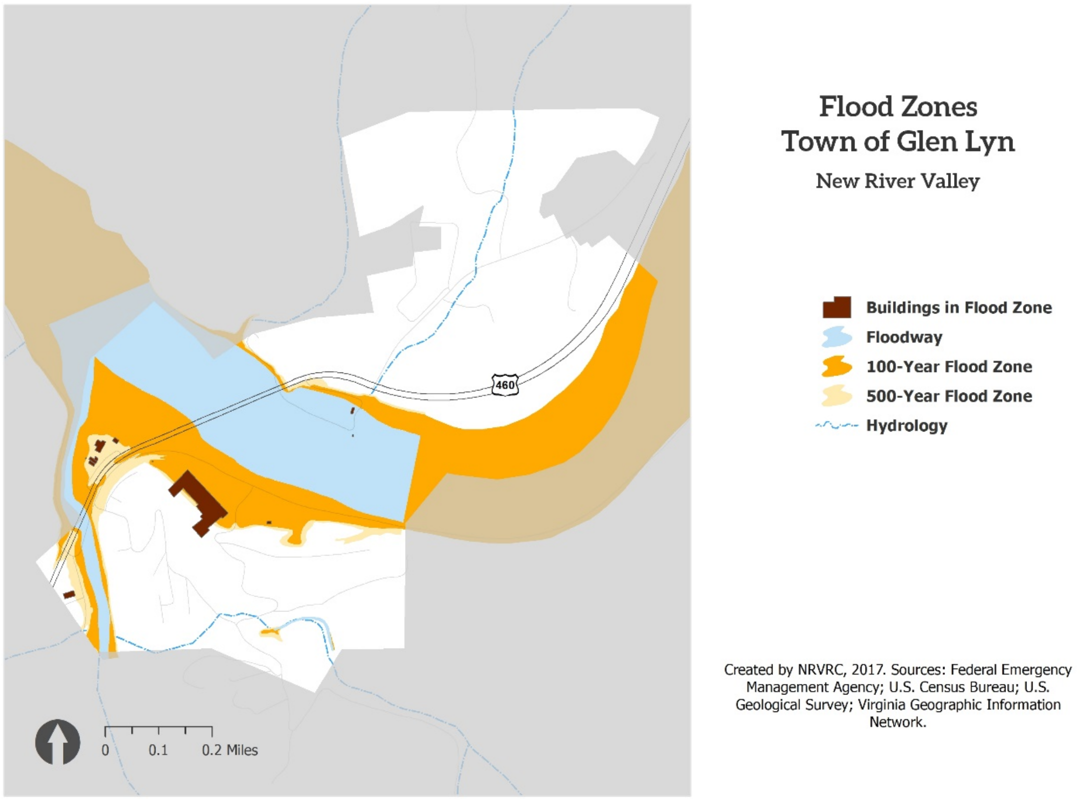
Map 15. Giles County Floodplains



4.5.3.3 Town of Glen Lyn

The Town of Glen Lyn lies alongside the New River as it flows north into West Virginia. Located within the floodplain and partially within the Town of Glen Lyn is the American Electric Power Plant. Otherwise, the majority of the Town is located on a hillside, and therefore only a few structures are at risk in the event of a flood. The largest recorded flood in the area was in 1940. The power plant became flooded, but only received minor damages. The 1940 event along with an event of 1916 and 1972 are the only recorded flood events for the Town of Glen Lyn. Glen Lyn participates in the National Flood Insurance Program, but there are currently no policies in effect.

Map 16. Town of Glen Lyn Floodplains

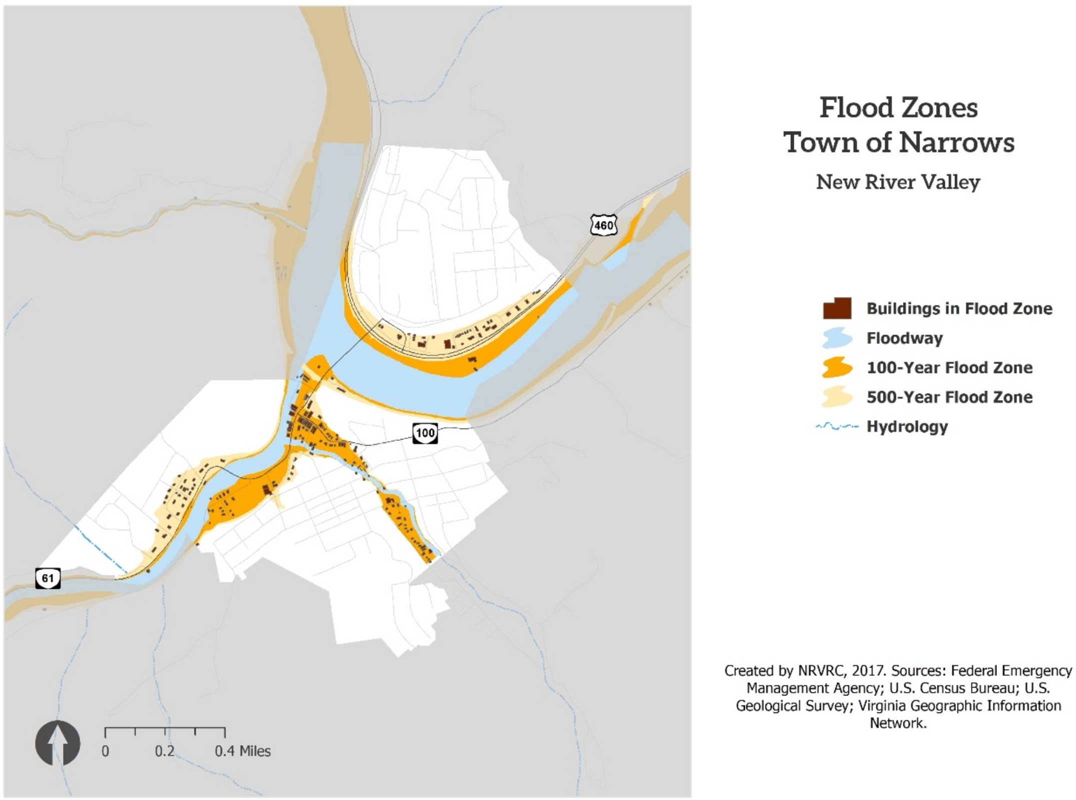


4.5.3.4 Town of Narrows

The Town of Narrows is located along a New River bend. The confluence of Wolf Creek and the New River occurs in the Town limits so flooding on the New has dramatic effects on the Town. Mill Creek, a tributary of Wolf, also contributes to flood problems. During the 1940 New River flood (estimated at 100-year flood), virtually the entire business section of the Town of Narrows was flooded. The local sewage treatment plant, still located in the New River floodplain, was damaged. Subsequent floods, including 1956 and 1972, caused significant property damage along Wolf Creek. Water entered homes and businesses peaking at a height of four feet in a local power substation.

The Town of Narrows is very vulnerable to flooding. Nineteen properties participate in the National Flood Insurance Program. There are two reported Repetitive Loss Properties in Narrows.

Map 17. Town of Narrows Floodplains



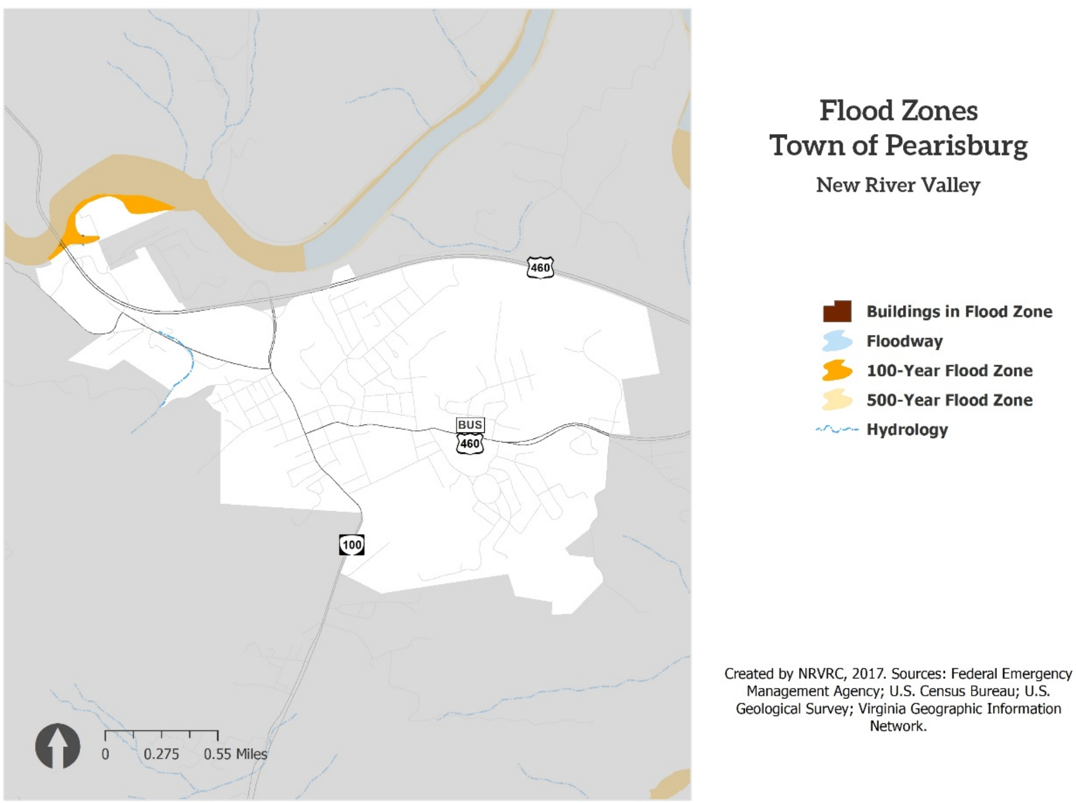
4.5.3.5 Town of Pearisburg

The Town of Pearisburg has experienced flood problems in the downtown area and on the east end. Most recently, the downtown experienced flooding in 1995, and the east end flooded in 2002. There has apparently been no federal flood insurance study in Pearisburg, though the Town conducted a study of downtown flooding issues in 1998. Stormwater drainage improvements were completed recently, which has reduced flooding in the east end of town.

Wenonah Street is affected by flooding in Pearisburg, as is the Bunker Hill area (Preliminary Engineering Report, 1998). Clifford and Chestnut streets experience minor stormwater flooding in backyards. Since no flood insurance studies or mapping have been done in the town, the risk factors are unknown. The west end of Town experiences some small amount of flooding, though debris collecting at a culvert during rain events has been identified as the source and has not created a problem for several years.

Located inside the Town limits, the town's sewage treatment plant and a portion of the Hoechst-Celanese property (a major employer) are in the 100-year floodplain. The treatment plant facilities are elevated to a height of at least six inches above the base flood elevation. The treatment plant is valued at over $1 million. As of 2016, there was one flood insurance policy in Pearisburg. Pearisburg has no repetitive loss properties.

Map 18. Town of Pearisburg Floodplains



4.5.3.6 Town of Pembroke

The Town of Pembroke is located in the center of Giles County. The town became incorporated in 1948 and had a population of 1,134 in 2000. Mays Hollow, Little Stony Creek, Doe Creek and the New River are all threats of flooding to the town and were the subjects of a flood insurance study in 1978.

Mays Hollow, Little Stony Creek and Doe Creek flow through the town while the New River flows along the town’s southern border. The worst flooding on record of the New River was in August 1940. The flooding caused backwater effects that affected the lower lying areas and filled Little Stony and Doe Creek, causing damages to many residents.

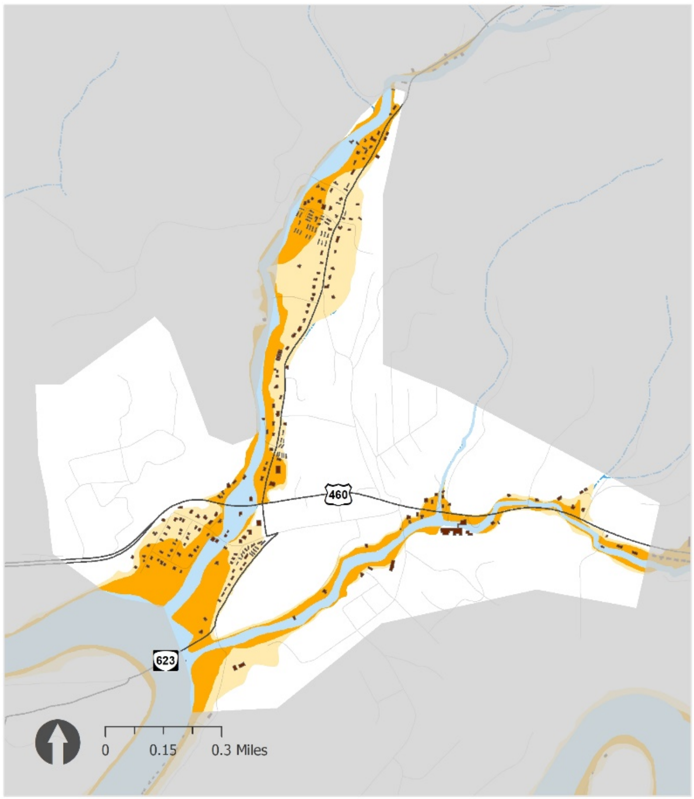
Localized thunderstorm events and tropical storm related precipitation are the primary cause of flooding in the area. A recent flood event occurred in July 2002, as already discussed, after a localized storm dropped 5.5+ inches of precipitation in less than four hours. This event caused flooding of Doe Creek, the temporary closing US Route 460, and substantial flood damage to residents and businesses.

Local residents point to the construction of US Route 460 and subsequent channelization of Doe Creek and Little Stony Creek as part of the problem. The small culverts are easily overwhelmed, and debris further exacerbates the problems.

The 2002 “Doe Creek” flood revealed part of Pembroke’s vulnerability to flash-flooding. As Map 19 demonstrates, though, the Little Stony 100-year floodplain (flowing north to south) through the town is much larger than the Doe Creek 100-year floodplain (flowing east to west). If the 2002 event had been centered just slightly north and west, much more damage would have likely occurred, as there are many more structures close to the streambed along Little Stony.

Despite the high number of at-risk properties, there are only 25 flood insurance policies in the town, covering about $3.6 million in property.

Map 19. Town of Pembroke Floodplains



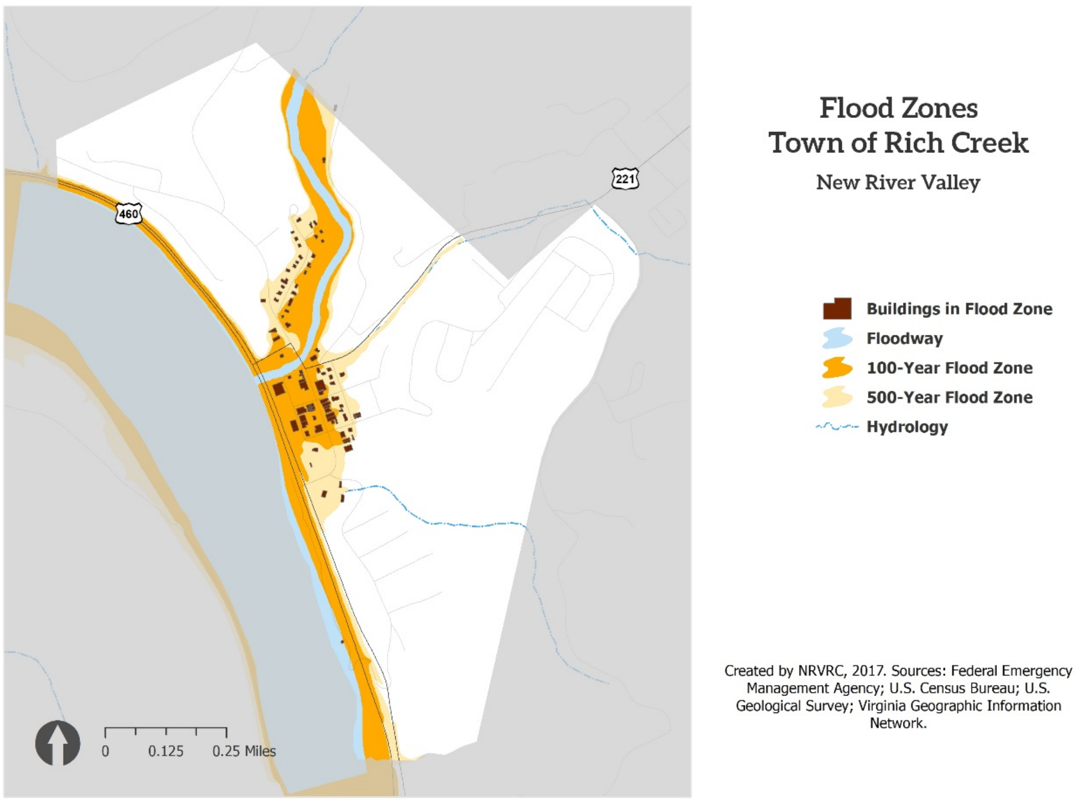
4.5.3.7 Town of Rich Creek

Incorporated in 1947, the Town of Rich Creek is located in Giles County only a few miles from West Virginia. The New River is the western boundary of the Town and is the primary source of periodical flooding. Another source of flooding is the Town's namesake, Rich Creek, a tributary to the New River.

Flooding in the Town of Rich Creek has been primarily due to heavy rains resulting from a tropical storm, or localized thunderstorm or frontal system. Flood events which resulted in property damage (including commercial) occurred in July 1916 and August 1940, but there is no data available on an estimation of damages. Both of these flood events were recorded as 100-year flood events.

Located on its namesake, much of Rich Creek is in the floodplain. There are a number of homes with flooding risk in Rich Creek; 8 properties participate in the National Flood Insurance Program. No repetitive loss properties are known to be located in Rich Creek.

Map 20. Town of Rich Creek Floodplains



4.5.3.8 Montgomery County

Montgomery County is bordered on the north by Giles and Craig Counties, on the south by Floyd County, on the east by Roanoke County, and on the west by Pulaski County. Urbanized areas within the county experience fairly frequent flooding. These high risk areas will be discussed in more detail later.

The unincorporated areas of Montgomery County may be affected by flooding from many streams in the area. In the past, the most severe flooding of the major streams has been the result of heavy rains from tropical storms, while flooding of the smaller creeks has been primarily due to localized thunderstorms. Also, flooding is sometimes associated with heavy rains on top of snowmelt or frozen ground.

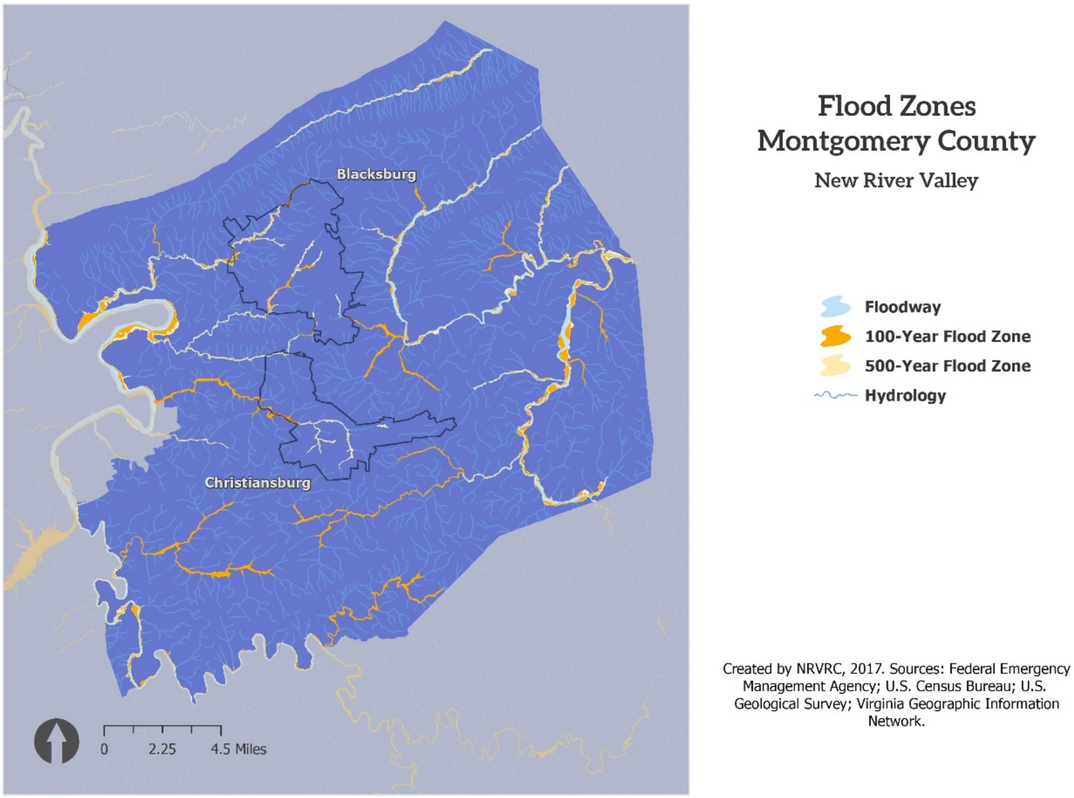
Flooding sources identified in the unincorporated areas of Montgomery County:

- Roanoke River
- North Fork Roanoke River
- South Fork Roanoke River
- Bottom Creek
- Bradshaw Creek
- Craig Creek
- Elliott Creek
- Goose Creek
- Indian Run
- Little River
- New River
- Plum Creek
- Slate Branch
- Spring Branch
- Stroubles Creek
- Toms Creek

The communities of Shawsville, Elliston, Lafayette, Alleghany Springs (Roanoke River basin) and Plum Creek, plus the towns of Blacksburg and Christiansburg are the primary areas affected. In June 1972, the elevations of the South Fork Roanoke and Roanoke River were at approximate 50-year frequency levels due to rainfall from tropical storm Agnes. This caused extensive damage to the adjacent communities in excess of one million dollars. This area also experienced flooding during the 1980s and 1990s and as recently as 2003. Many of these areas are zoned for growth, including not only Blacksburg and Christiansburg, but also much of Shawsville, Elliston and Plum Creek as evidenced by the village designation in the future land use map. The goals of the comprehensive plan are formulated to protect these communities from flooding impacts.

As of November 2016, there were 146 NFIP policies in-force in the unincorporated areas of Montgomery County, covering $29.2 million in structures. This areas includes eastern Montgomery and Plum Creek, but not the Towns of Blacksburg and Christiansburg, where 59 policies in-force total $7.8 million and $6.9 million, respectively (November 2016). There are 15 repetitive loss properties and one severe repetitive loss property in the county.

Map 21. Montgomery County Floodplains



4.5.3.9 Shawsville, Elliston, Lafayette and Alleghany Springs

Major flooding occurred in the Eastern Montgomery communities of Shawsville, Elliston, Lafayette and Alleghany Springs in 1940, 1972 and 1985. In June 1972, the elevations of the South Fork Roanoke and Roanoke River were at approximate 50-year frequency levels. This caused extensive damage to the above communities in excess of one million dollars. This area also experienced flooding in the early 1990's and as recently as 2003.

In relatively mild downpours, communities in eastern Montgomery County experience flooded roads and hampered mobility. When serious rainfall occurs, as seen in the February 2003 event, substantial threats to life exist. Roads and bridges flood, as do homes, resulting in substantial damage.

4.5.3.10 Plum Creek

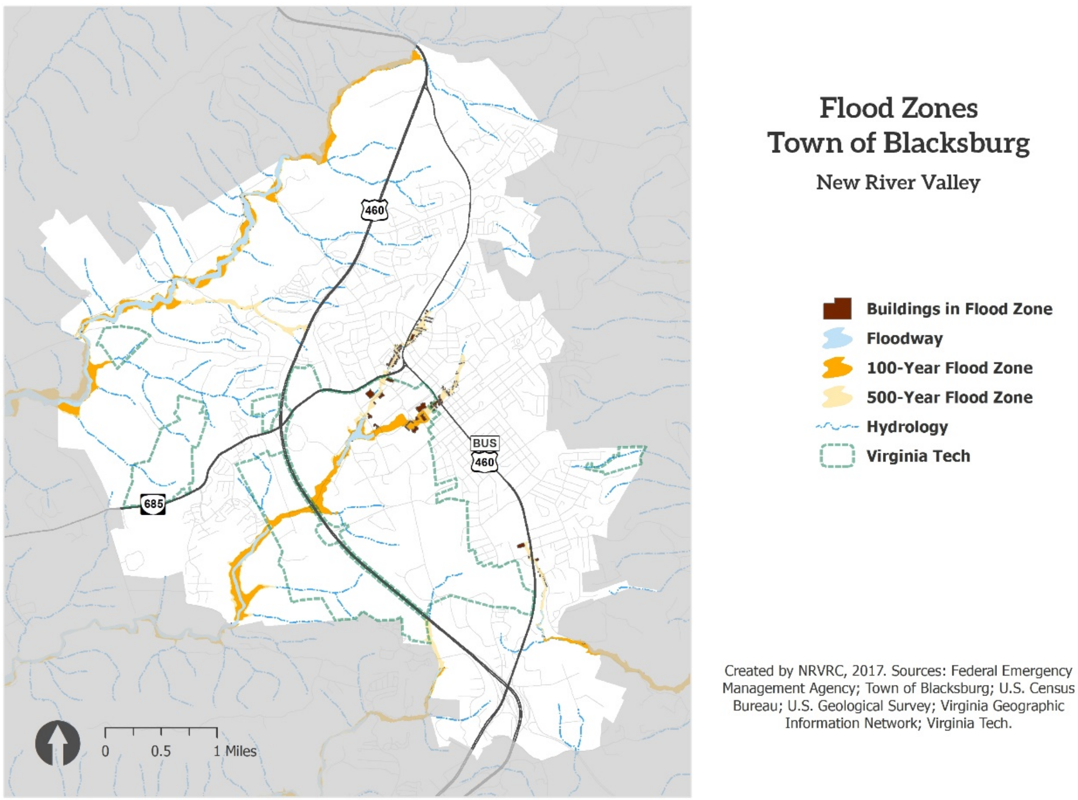
The Plum Creek section of Montgomery County is located largely along the Route 11 corridor between Christiansburg and Radford. While most flood hazard areas in unincorporated Montgomery County are zoned for agriculture, the Plum Creek area is largely zoned for growth.

4.5.3.11 Town of Blacksburg

The Town of Blacksburg supports a population of 40,620 residents, the largest urban area in the New River Valley. The Town of Blacksburg was incorporated in 1871. Growth of the town has been as a result of the establishment and growth of Virginia Polytechnic Institute and State University (Virginia Tech) as a land grant college. The university began as an agriculture and mechanical college and has expanded to a leading university in such programs as engineering, architecture, business, and the arts. Currently home to approximately 25,000 students, the university is an enormous asset to the town.

Blacksburg is located atop the eastern continental divide where Toms and Stroubles Creeks flow into the New River. These two creeks along with Cedar Run, a tributary of the Roanoke River and Slate Branch are of the most concern for flood conditions. Flooding primarily occurs in the low-lying areas of the town and is the result of heavy rains of a localized storm, tropical storm, or combination rain and snowmelt in the area. Past history reports of severe flooding include 1940, 1972, 1978, 1985, and 1991. The 1991 flood caused $4.5 million in damage on the Virginia Tech campus, including major damage to the Donaldson Brown Center (per Virginia Tech Environmental Health and Safety Services). Flood-protection methods for the residents and property of the town are controlled by the Town of Blacksburg in the form of zoning regulations, building codes and availability of FIRMs.

There are 30 flood insurance policies in force in Blacksburg, covering about $7.8 million in property. There are no repetitive loss properties in Blacksburg.



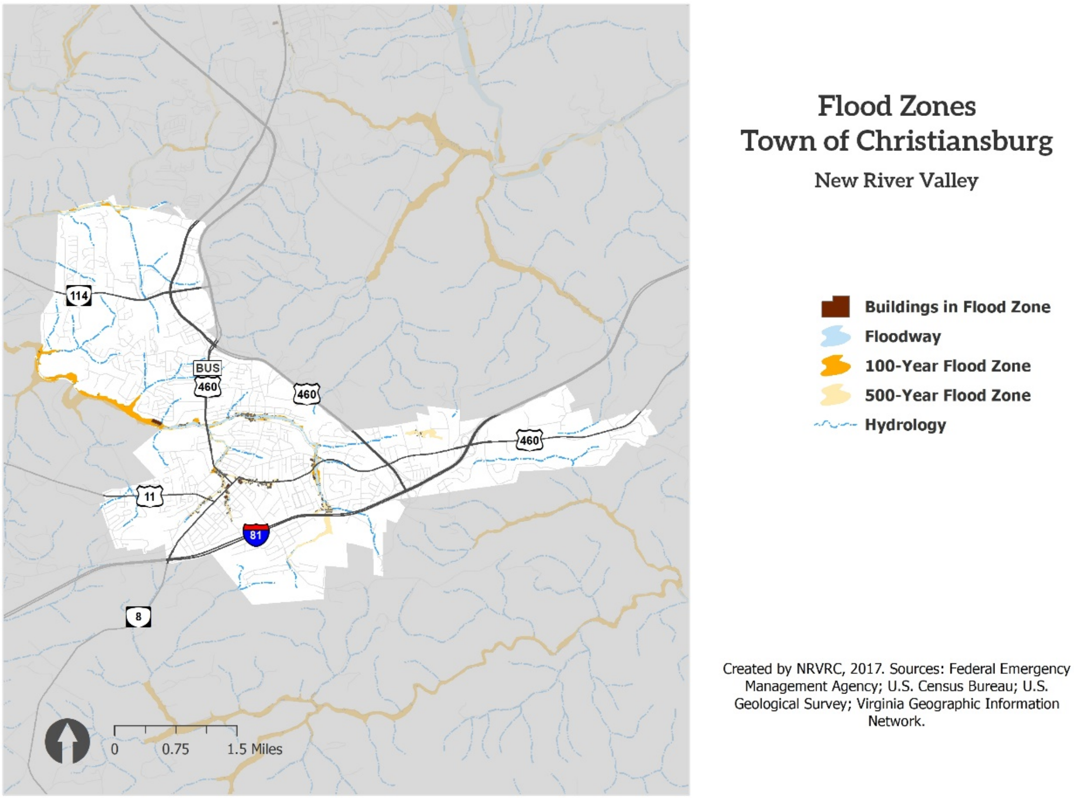
4.5.3.12 Town of Christiansburg

The Town of Christiansburg is located in central Montgomery County and serves as the county seat and commercial center for the entire New River Valley. Christiansburg was incorporated in 1792 and boasts a population, in the 2010 census, of 21,041 residents. The town, located in the Valley and Ridge Physiographic Province, is characterized by rolling hills cut by rugged valleys. The floodplains are narrow, as the streams have small drainage areas and steep slopes. Development primarily lies above flood elevations, but floodplain regulations mitigate flood damage to future development.

Low-lying areas of Christiansburg may be subject to periodic flooding from Crab Creek, Walnut Branch and other small tributaries. The most severe flooding occurred in 1940, 1972, and 1978 as a result of localized thunderstorms and major weather fronts. Due to these floods, the area experienced large economic losses, but no loss of life was reported.

There are 29 flood insurance policies in force in Christiansburg, covering about $6.9 million in property. There are two repetitive loss properties in Christiansburg.

Map 23. Town of Christiansburg Floodplains



4.5.3.13 Pulaski County

Pulaski County is bordered by the Counties of Bland, Floyd, Giles, Montgomery, Carroll and Wythe. There are two towns in the county, Dublin and Pulaski, which is the county seat. the New River bisects the county from southwest to northeast. American Electric Power has a hydroelectric reservoir on the New River (built in 1939) within the county as well. Significant tributaries of the New River in Pulaski County include Peak Creek, Little Walker Creek and Big Reed Island Creek. These plus Peak Creek's two tributaries, Tract Fork and Sproules Run, are the principal sources of flooding in the county.

The most significant flood history and risks exist in and around the Town of Pulaski. In the last 90 years, the town has experienced at least 11 100-year floods, plus a 500-year flood in 1929. Based on the frequency of 100+-year floods in the last century, there is a 10-13% chance every year that the town will experience this level of flooding, rather than the anticipated 0.2-1% chance anticipated.

Tropical storms, including Hurricanes Donna (1960), Camille (1969) and Agnes (1972) are one cause of flooding. Localized thunderstorms from May to September tend to cause localized flooding. Rainstorms of longer duration tend to occur in colder months; these can also be exacerbated by snow/ice melts, as in February 2003.

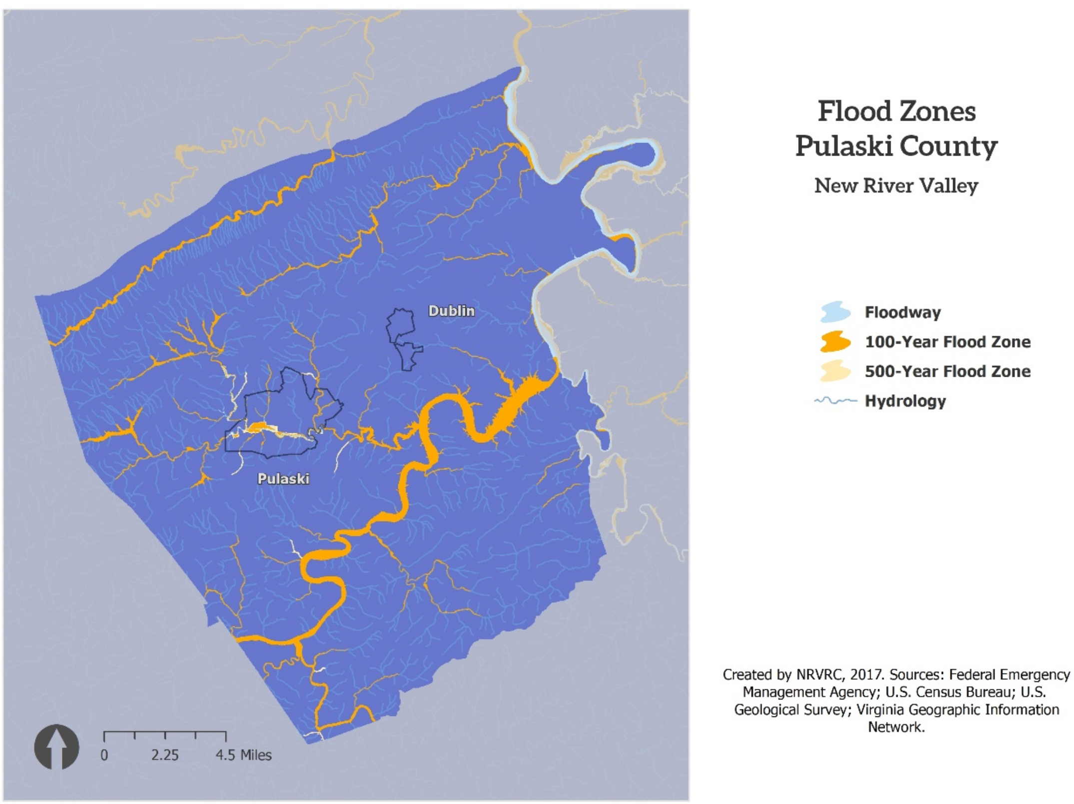
4.5.3.14 Big Reed Island Area

In the very southwest corner of Pulaski County, the Big Reed Island Creek flows from Floyd County to the New River at Allisonia. In the early 1990's, flooding destroyed two bridges in this area and damaged other structures.

4.5.3.15 Little Walker Creek Area

Located in the very northwest corner of Pulaski County, Little Walker Creek flows from Wythe County toward Giles County and the New River.

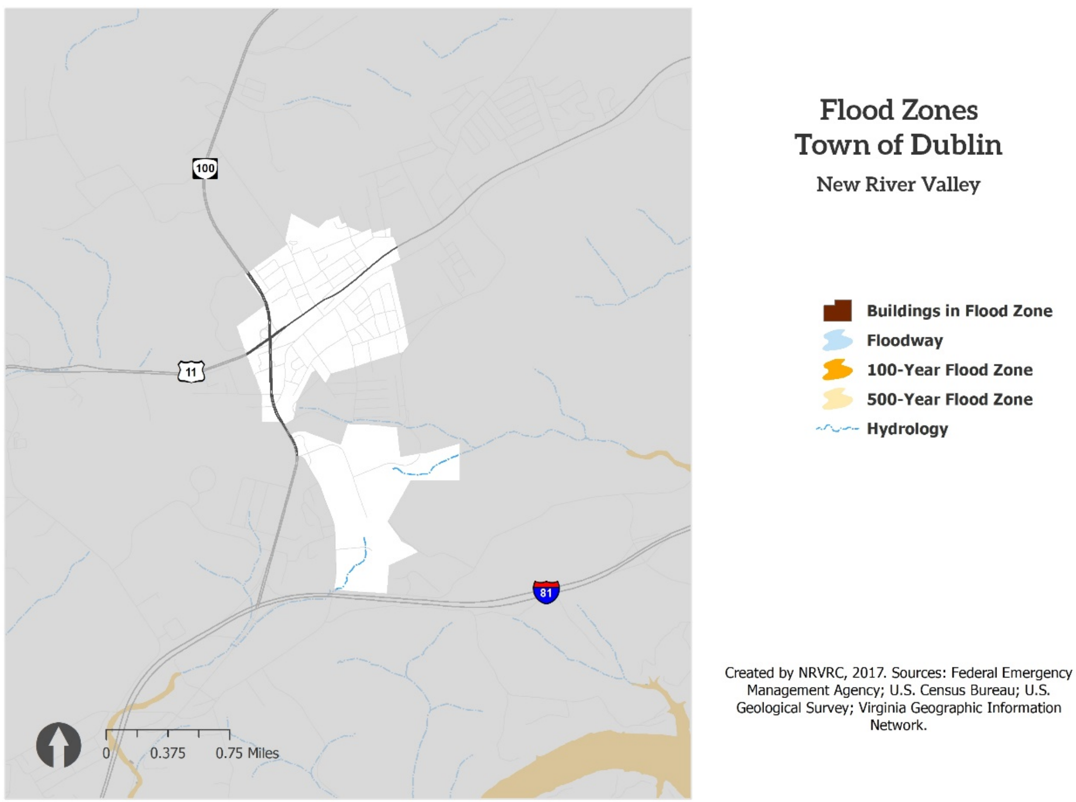
Map 24. Pulaski County Floodplains



4.5.3.16 Town of Dublin

There are also flooding problems reported in the downtown area of the Town of Dublin, according to the 1999 comprehensive plan, but Dublin did not participate in this planning process. There is no FIRM for Dublin, and they do not participate in the program. However, their comprehensive plan lists flood mitigation in high hazards areas as a top concern.

Map 25. Town of Dublin Floodplains



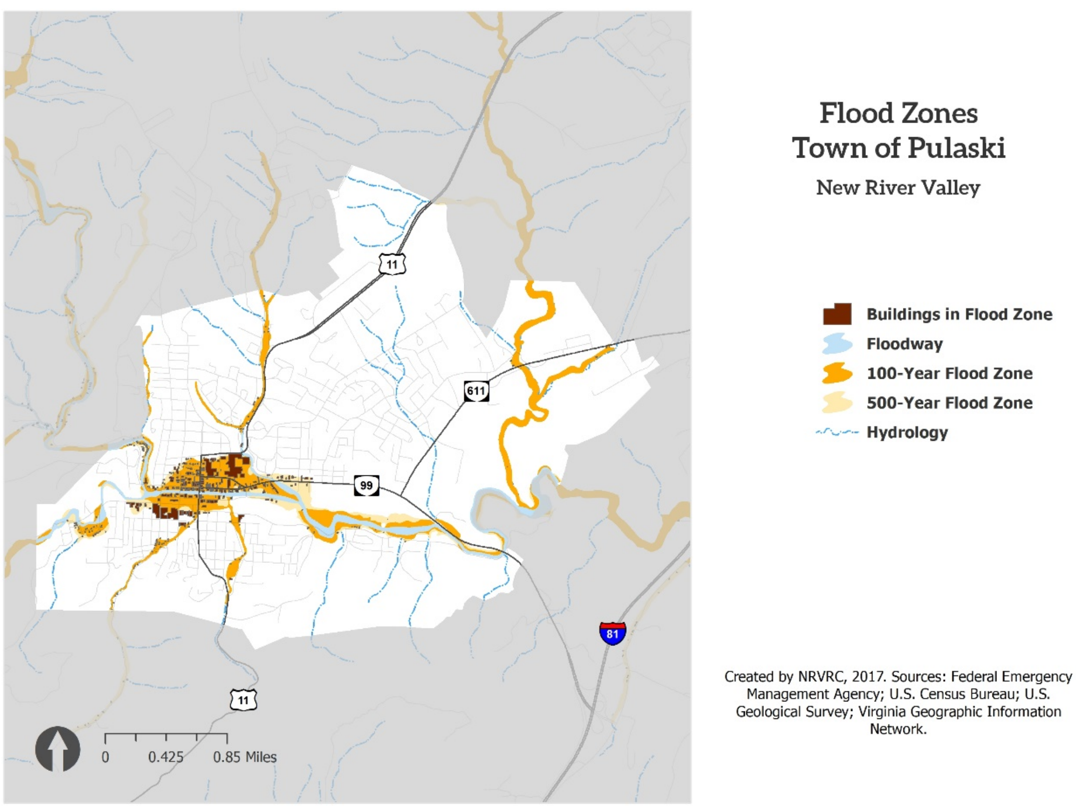
4.5.3.17 Town of Pulaski

The Town of Pulaski is subject to flooding from the main channel of Peak Creek. Peak Creek is a tributary to the New River with its confluence into Claytor Lake. Sproules Run and Tract Fork are also sources of flooding for the town, both are tributaries to Peak Creek. The Town's flooding is exacerbated by very steep terrain above the Town and the relatively flat terrain from the town to Claytor Lake (limiting more rapid drainage). Peak Creek has been channelized through the town, but the value of this is unclear. Analysis with the Virginia Department of Conservation (DCR) reveals that the flooding is also exacerbated by the channel obstructions, both man-made and natural. One man-made obstruction is the railroad trestle which acts as a dam and causes greater water depths and flooding during major storm events. Natural obstructions can include logjams.

The 100-year floodplain in the Town of Pulaski is fairly flat terrain and varies from 2,000 feet in width in the downtown area to 100 feet in the west end. Within the floodplain are roadways, educational and recreational facilities, business and commercial structures, scattered residences, and municipal facilities. Flood problems in the community can be separated into three distinct areas. These areas include the downtown area, the downstream, “Dora Highway” (east side) area, and the upstream, Kersey Bottom (west side) area. During the flood on May 28, 1973, 12 homes and two commercial establishments were inundated. Since that time, a few of those homes along Dora Highway have been bought out through FEMA and demolished. The last significant flood in the town occurred in March 2010. Flood waters rose into the downtown area, causing damage in several businesses and the sheriff’s office.

There are 37 flood insurance policies in force in Pulaski, covering about $11.5 million in property, including two repetitive loss properties.

Map 26. Town of Pulaski Floodplains



4.5.3.18 City of Radford

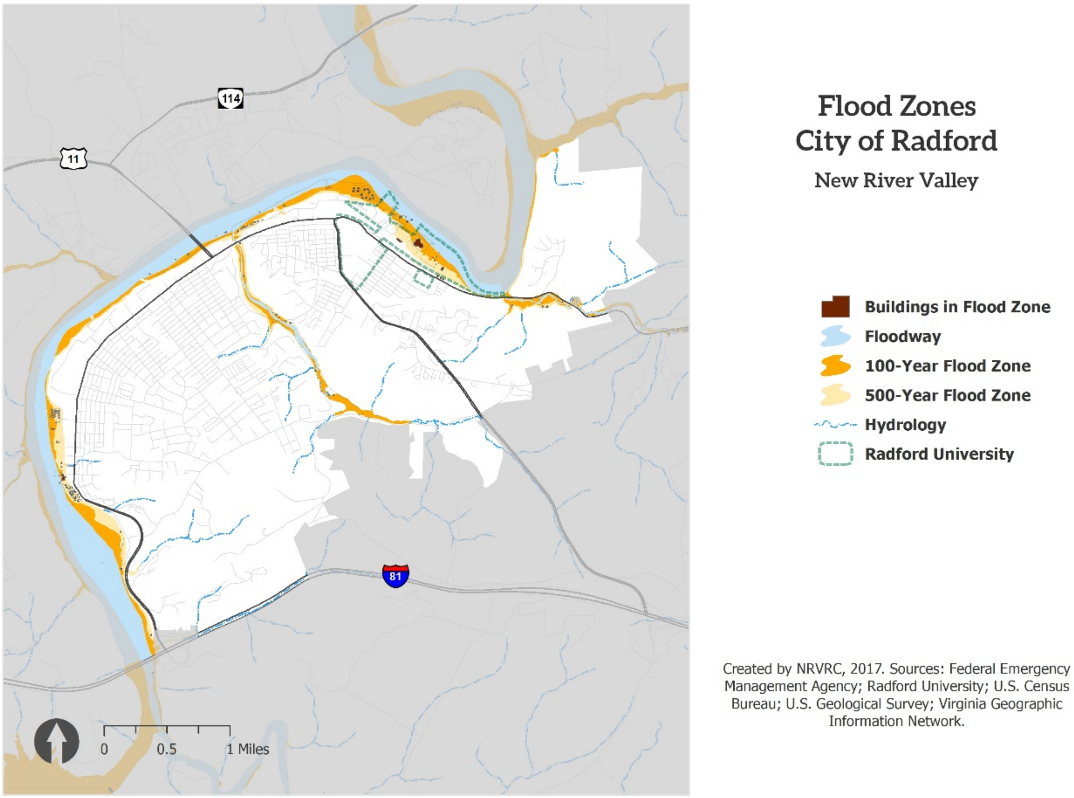
The City of Radford is located within southwestern Virginia and is bounded by Montgomery and Pulaski Counties. The area became an independent city in 1892. Located within the City of Radford is Radford University, a comprehensive institution with undergraduate and graduate programs. Radford University first began as an all-women's school in 1910 and then received affiliation from the General Assembly in 1964.

The New River creates Radford's western and northern corporate limits, fully eight miles of its border. The New River flows in a northern direction through the state of Virginia and is Radford's main cause of flooding. Major flooding of the New River has been recorded in 1914, 1940, and 1972 and is primarily the result of tropical storms. Connelly's Run is also a cause of concern for flooding in the area. Low-lying areas near this creek are likely to experience flooding due to a localized storm or frontal system. Located up stream in Pulaski County, Claytor Lake Dam controls most flood elevations. Radford's hydroelectric dam on Little River also has minimal effects on flood elevations.

Radford is essentially built upon the terraces of the New River. The first terrace, just a few feet above the river, is about one-quarter mile wide. Upon the next terrace, more than 50 feet above the first, are the main downtown businesses.

There are 27 flood insurance policies in force in Radford, covering about $11.2 million in property. There are no repetitive loss properties in Radford.

Map 27. City of Radford Floodplains



4.5.3.19 Drowning Risks

Even more important than the risk to structures are the risks to personal safety. Due to the rural, mountainous terrain of much of the New River Valley, many homes are precariously perched along streams. Often the only access is across private bridges. Likewise, many public roads and bridges are impacted by floodwaters. One of the greatest risks to personal safety from flooding comes as people try to drive onto flooded roadways or bridges. Nationally, nearly half of the flood or flash-flood related fatalities are auto-related. An auto will float in less than six inches of moving water and can be swept downstream into deeper waters. Victims of floods have often put themselves in perilous situations by ignoring warnings about travel or mistakenly thinking that a washed-out bridge is still open. This risk is largely preventable when people learn to respect the dangerous power of floodwaters.

4.5.3.20 Dam Inundation

There is, in reality, no way to predict the likelihood of dam failure, and the classification of "significant" and "high" hazards are, at least in part, rather random. The classification into a risk category also changes from one database to another over the period of a year or so. Generally speaking, the possibility of failure generally increases with age. Dams in the NRV are between 110 and 62 years of age. Considering that many dams were designed for an effective life of 50 years, this indicates that dam failure may eventually occur.

There is no history in the NRV of a dam failure among the registered and inspected dams. Thus, an assessment of damages is not probable. Preliminary research results on the areas affected by potential dam failures are still in a preliminary stage for the NRV. All dams in the region have a plan kept by DCR, but those plans are of varying quality and information. Only Claytor Lake has a downstream inundation map should the hydroelectric dam there fail, either partially or fully.

4.5.4 Past or Existing Mitigation

While the risk to lives and property from flooding is substantial in the New River Valley, the opportunities to mitigate those risks are also substantial. Some are as simple as recognizing and valuing the contribution of natural components (such as trees) and functions.

Most jurisdictions have already acted upon some of these opportunities. The level of flood mitigation across the New River Valley varies widely. All of the Counties, the City and most of the Towns participate in the NFIP. Participation requires the jurisdictions to regulate development in the floodway and the flood fringe through zoning or a separate ordinance. This means that in the designated floodway, no expansion of structures may occur. In a designated floodplain, substantial improvements (greater than 50% of current value) must be elevated or floodproofed. Also, floatable objects should be restrained in some manner to help avoid the obstruction of drainage structures. Local government participation means that citizens may then buy flood insurance. Based on preliminary assessment, it appears that from 10 to 50 percent of high-risk property is insured.

Jurisdictions such as the Towns of Blacksburg and Pulaski with major flood losses and large town staffs have been more active and pro-active in flood mitigation. Also some private citizens around the area are demonstrating basic mitigation techniques.

4.5.4.1 Town of Blacksburg

Blacksburg has more stringent stormwater management ordinances than Virginia requires. Blacksburg has initiated studies along Stroubles Creek and identified a series of stormwater detention ponds that would reduce flood elevations. Blacksburg has also digitized its floodplain maps and strictly prohibits any additional floodplain development. Blacksburg is also one of the first localities in the nation to implement a broad community communication network. This system can notify registered users of news through their home phone, cell phone, e-mail, pager, and/or fax.

4.5.4.2 Town of Christiansburg

The Town's Floodplain Ordinance governs the uses, activities, and development of land within the floodplain. A number of properties—including industrial, commercial, and residential uses—were developed prior to the FEMA floodplain regulation existing along Crab Creek and two branches within Town. The 100-year floodplain is unsuitable for development and is targeted for green space protection and recreational uses. The Town's Engineering Department has two full-time staff dealing with environmental programming related to the MS-4 (Municipal Separate Sewer System) permit. These efforts have yielded positive impacts on flood mitigation within the Town including stream restoration projects, encouraging maintenance of private stormwater facilities, and promoting public education regarding watershed protection.

4.5.4.3 Town of Pulaski

Pulaski initiated flood mitigation planning in 2001. It organized a committee composed of citizens, business owners and Town staff. Town staff digitized floodplain maps. Building upon prior Flood Insurance Studies, Corps of Engineer reports, and new analysis by DCR and the NRVRC, a mitigation plan was drafted. So far, in accordance with that plan, the Town has

- Completed the removal of six houses from the floodplain using hazard mitigation grant funding,
- Established a flood mitigation section at the local library, and
- Created and mailed a flood mitigation newsletter to all residents in the floodplain.

The Town also wishes to apply to the Community Rating System to help reduce the cost of flood insurance and increase local participation.

4.5.4.4 Montgomery County

In the 1980s and 1990s, Montgomery County pursued federal assistance in the eastern portion of the county. The Corps of Engineers did analysis along Brake Branch, and the Natural Resource Conservation Service provided some streambank clearance assistance. In its current comprehensive planning process, Montgomery County staff and citizens are focusing intensely on environmental elements. The county zoning ordinance has been updated to require new construction to be at least one foot above base flood elevation. New structures must also have elevation certificates to show they meet this requirement. Staff also receive floodplain management training, including the Certified Floodplain Manager qualification. The county's FIRMs were updated in September 2009. In addition to local government action, citizens are increasing demonstrating mitigation propensities.

4.5.4.5 Giles County and the Town of Pembroke

Since the 2002 flooding in Pearisburg and Pembroke, Giles County has successfully sought streambank clearance assistance from the Natural Resource Conservation Service. Also since that flooding, the Town of Pembroke has increased its attention to drainage-system components and maintenance. The Town and County are seeking help from VDOT to assess culvert sizes and maintenance programs along primary and secondary roads in flood-prone areas. The Town also makes regular drainage system maintenance checks before and after flood events. Also, the Town of Pembroke hosted a special flood hazard and mitigation meeting as part of its comprehensive plan update in 2003. The Town is also including a sizable hazard mitigation section in the comprehensive plan.

4.5.4.6 City of Radford

In part due to the City's enforcement of the floodplain zones, other entities in Radford are mitigating against flood damage. Hunter Ridge Apartments were built upon a mound, to ensure elevation out of the flood elevation levels. Radford University built a berm along the river to help protect the parking lot at the Dedmon Center.

4.5.4.7 Other Existing Mitigation Programs

The region also benefits from another federal program, the National Weather Service (NWS). With a local office in Blacksburg, the NWS distributes forecasts, statements, severe weather watches and warnings through local media outlets and the Emergency Alert System. The NWS also coordinates and monitors the Automated Flood Warning System (also Integrated Stream Flows (IFLOWs), a network of rain gauges in the eastern U.S. including the New River Valley. The system is automated and updated every 15 minutes and is available online at www.afws.net.

Additionally, the NWS and the National Oceanic and Atmospheric Administration (NOAA) operate NOAA Weather Radio, which makes statements and warnings ever-accessible. Moreover, new technology has enabled the "Specific Area Message Encoder" (SAME) program, which activates special radios in only the affected area when there is an imminent threat. These radios are available on the market for $30-40. Unfortunately, reception is spotty in the mountainous areas of the NRV. There are similar services available from private vendors for cell phones, fax machines, etc., including "Notify!" from the Weather Channel. In these and the new Town of Blacksburg service, people may choose which the types of events for which they wish to be notified.

4.5.5 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Below are the goals, objectives, and strategies identified by the flooding working group to specifically lessen the impacts of flooding in the region.

Goal: Minimize flood-related deaths and losses of existing and future structures.

a) Save lives at imminent risk.
    i. Seek grant funding to develop early warning systems in high-risk areas utilizing new technology.
    ii. Enhance regional capacity for swift-water rescue, including training and equipment purchase.

iii. Encourage localities to participate in the Weather Ready Ambassador Program offered by the National Weather Service (NWS).
iv. Promote Virginia Department of Transportation flood signage and other awareness activities.
v. Increase 2-way communication between NWS and emergency managers during flooding events, as well as communication with residents potentially affected by flooding.
vi. Improve regional communication to improve flood response.
vii. Increase awareness to public or high-hazard dams.

b) Reduce risks to critical facilities.
i. Do not build new critical facilities in high hazard areas (preferred in ordinance format but could be a general policy decision).
ii. Identify critical facilities in high-risk areas.
iii. Identify measures to reduce risk of critical facilities in high hazard areas.
iv. Relocate or mitigate critical facilities currently located in high-risk areas.

c) Offer mitigation assistance to owners of flood-prone properties, especially repetitive loss properties.
i. Pursue mitigation grant opportunities or other funding to buy out, elevate, relocate or water-proof flood-prone properties through Federal Emergency Management Agency (FEMA), Virginia Department of Emergency Management (VDEM), and Community Development Block Grants and other sources.
ii. Study feasibility of mitigation and other similar opportunities in historic districts or with historic properties.

d) Educate citizens about the inevitability of flooding, the dangers it poses to life and property, and the opportunities for mitigation.
i. Seek to update flood insurance studies and maps to understand risks more accurately and provide simplified maps. Educate public on letter of map change procedures.
ii. Encourage the development of statewide databases and geographic information systems layers to assist local government planning efforts. Encourage state agencies to acquire and use elevation data that is accurate and compliant with regulations.
iii. Encourage collection and development of better hazard history locally and incorporate into geographic information systems. Encourage citizen reporting through smartphone photos and apps.
iv. Incorporate hazard mitigation information in the future in the local comprehensive planning process.
v. Utilize existing documents and programs from FEMA, the National Flood Insurance Program (NFIP), VDEM, and the NWS to educate the public about hazards and mitigation opportunities.

vi. Produce and distribute mitigation information to residents in high-hazard areas.
vii. Coordinate with and support Community Emergency Response Team (CERT) information distribution activities in the community.
viii. Provide grant-based community workshops along with partnerships with local resources.
ix. Educate citizens about the availability and value of NFIP policies and encourage greater participation.
x. Educate property owners of structures in floodplain [keep] and how to become more flood resistant.
xi. Include a notice that property is in floodplain in deed or plat.

e) Encourage flood-wise education opportunities for builders and developers. Limit future development in floodplains.
   i. Utilize zoning ordinances to further restrict undeveloped floodplains. Encourage localities to review floodplain disclosures in floodplain ordinances.
   ii. Encourage standards above NFIP standards when considering floodplain development.

f) Develop adequate drainage structures and maintenance procedures to prohibit “back-up” flooding in high-hazard areas.
   i. Identify inappropriate sized culverts and drainage and seek grant and/or state funding for replacement.
   ii. Pursue streambed clearance through citizen groups and/or Natural Resources Conservation Service as needed to eliminate bottlenecks.
   iii. Encourage bottomland farm fences to catch debris before reaching culverts.
   iv. Schedule regular drainage system maintenance including before and after storms.
   v. Work with VDOT to inventory culverts in the region.
   vi. Ensure that future culverts are adequately sized for the estimated run-off from storms.
   vii. Educate landowners about culvert maintenance to ensure culverts continue to efficiently handle stormwater.
   viii. Pursue multiple funding opportunities to combine stream restoration projects with flood mitigation projects.

g) Develop stormwater facilities or upgrades as needed to limit flooding in high hazard areas.
   i. Seek grant funding for regional stormwater detention facilities as needed. Reconsider design frequency of occurrence.
   ii. Seek channel improvements or upgrades as needed to reduce peak flood flows.
   iii. Pursue combinations of regional stormwater management strategies and onsite strategies.

iv. Encourage alternative stormwater management options in both new and existing facilities, such as pervious development choices.
v. Inventory stormwater infrastructure to ensure adequate future maintenance.
vi. Utilize floodplains as community assets such as parks or other open spaces.
vii. Develop strategies for addressing impervious surfaces and their impact on stormwater.
viii. Review current parking and development standards to minimize negative stormwater impacts.

h) Pursue mitigation projects that achieve multiple community goals.
i. Pursue partnerships with land trusts to promote conservation easements on undeveloped floodplains and wetlands to aid flood mitigation.
ii. Pursue the affordable housing alternatives for low-income families now living in floodplains.
iii. Seek economic development opportunities, such as brownfields, which turn current "liabilities" into community assets. Examples could include recreational area development or green infrastructure stormwater projects.

4.6 Severe Weather: Severe Winter Weather, High Winds, and Tornados

The New River Valley experiences a variety of severe weather events. Most of these do not cause catastrophic damages, however. Rather, most threats to life can generally be minimized through attention to personal safety. Threats to property may be minimized in a variety of ways. Most of these hazard events are not associated with particular places. This section of the HIRA includes severe winter weather (freezing temperatures and significant snowfall), high non-rotational winds, and tornados. Severe winter weather and high non-rotational winds are common hazards in the NRV.

4.6.1 Severe Winter Weather

Severe winter weather in the New River Valley includes freezing temperatures, snowfall, and ice storms. These three events can occur independently or concurrently when the right atmospheric conditions exist. The NRV can have relatively mild winters with little snowfall and only moderately frosty days; it can have relatively severe winters with long periods of moderate to severe frost and significant snow accumulations; or it can have what statistically would be "average winters" with a little of everything. There is no definite character for winter weather in this region due to the geographic location and the typical weather patterns that occur over the winter period.

The New River Valley is a mountainous region that is subject to weather systems entering predominantly from the west and the northwest (moisture from the west, sometimes from the southwest, e.g., Gulf influence). Arctic fronts with cold and dry air come in from the northwest (Upper Midwest and Canada), and moist air masses are brought in by Atlantic Coastal storms that are moving in a north-westerly direction. The moist Atlantic air that is pushed upwards from the coastal plains and the Piedmont into this region loses its capacity to hold moisture due to orographic uplifting, causing the air mass to cool and release its moisture as precipitation. When this occurs, the region will experience anything from a severe snow storm, to a severe ice storm, to high volumes of precipitation consisting of near-freezing rain (which can locally then turn into ice-rain). Heavy snow storms followed almost immediately by a thaw resulting in flooding of local streams are relatively common. This is particularly sudden when prolonged periods of frost have preceded the snow, rendering the soil impermeable due to freezing. In such cases, the melt water cannot filter through the soil, but has to run off across the surface, resulting in rapid peak-flows and flooding.

4.6.1.1 History

Severe winter weather is not unusual in the New River Valley, but the region can have back-to-back mild winters with no significant weather events. Since the early 1996, the NRV has recorded 84 winter weather events, including extreme cold, ice storms, and heavy snows, with just under $6.6 million reported in damages, as recorded by the National Climatic Data Center.

The NRV does have a history of memorable winter storm events, such as the Blizzard of 1993, the Ice Storm of 1994, the Blizzard of 1996, the flooding as a result of rapid snow melt of 1996, the Winter Storm of 1998, the Ice Storm of 1998, the Winter Storm of February 2000, the Ice Storm of December 2002, the flooding from rapid melting in February 2003, and the extreme cold in the winter of 2001/2002. Impacts from a few of those storms can be seen in Figure 4.19 and Figure 4.20.

Figure 4.19. Heavy Ice, Floyd County, December 2002

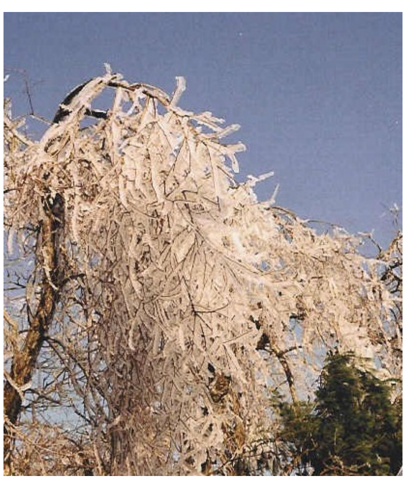


Figure 4.20. Wind Damage, Pembroke, February 2003

Significant snowfall levels, such as in 2009, do not necessarily imply an emergency. As in 2009, the cumulative snowfalls that year were sufficiently spread out to allow for clearing of the roads in between. The winter of 2009-2010 brought several significant snowfall events to the region. Due to a December 2009 snowfall that left 12-16" of snow across the region, Montgomery County was part of a Presidential Disaster Declaration. In addition to that event, February 2010 brought more snow to the region. On February 5, 2010, approximately 8-11" of snow fell across the region. February 2015 brought an Arctic weather front creating the third coldest February on record in Blacksburg accompanied by a snowstorm February 12-13 with snowfall as high as 11 inches across the NRV and another on February 20th and 21st with 4 to 8 inches reported across the region. 2016 winter storms included snowfall January 22-23 with accumulation of 6 to 12 inches in the NRV.

Similar to the Fujita and Saffir-Simpson scales used to characterize the magnitude of tornadoes and hurricanes, Paul Kocin and Louis Uccellini of the National Weather Service developed the Northeast Snowfall Impact Scale (NESIS) to characterize the impact of snow events of 10 inches snowfall accumulation or more (https://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis). The NESIS characterizes and ranks high-impact snowstorms occurring in the northeastern United States. NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. Table 4.21 below summarizes the NESIS categories. A number of storms that occurred in the NRV were categorized by this system: December 2009 (Significant), February 2010 (Major), February 2015 (Notable), and January 2016 (Crippling).

Table 4.21. NESIS Categories

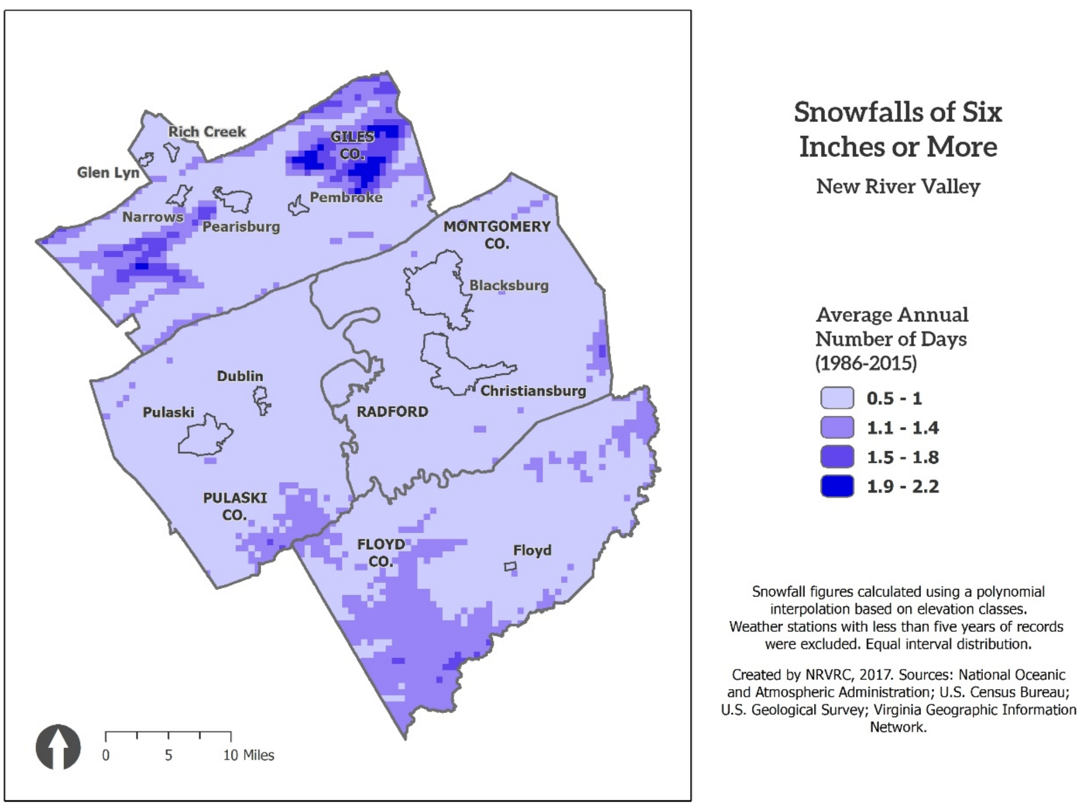
Category	NESIS Value	Description
1	1-2.499	Notable
2	2.5-3.99	Significant
3	4-5.99	Major
4	6-9.99	Crippling
5	10.0+	Extreme

Map 28 shows the average number of days with at least 6 inches of snow, while Map 29 illustrates the average annual days with temperatures below 32° F. High snowfall levels as well as low temperatures are particularly common in the mountainous areas of the NRV. A trend of warming winter weather at mostly higher elevations was found when dividing the reporting period in half (between 1960-1987 and 1988-2015), with fewer days below freezing particularly noted in areas of Giles County where forest cover is most prevalent (Map 30).

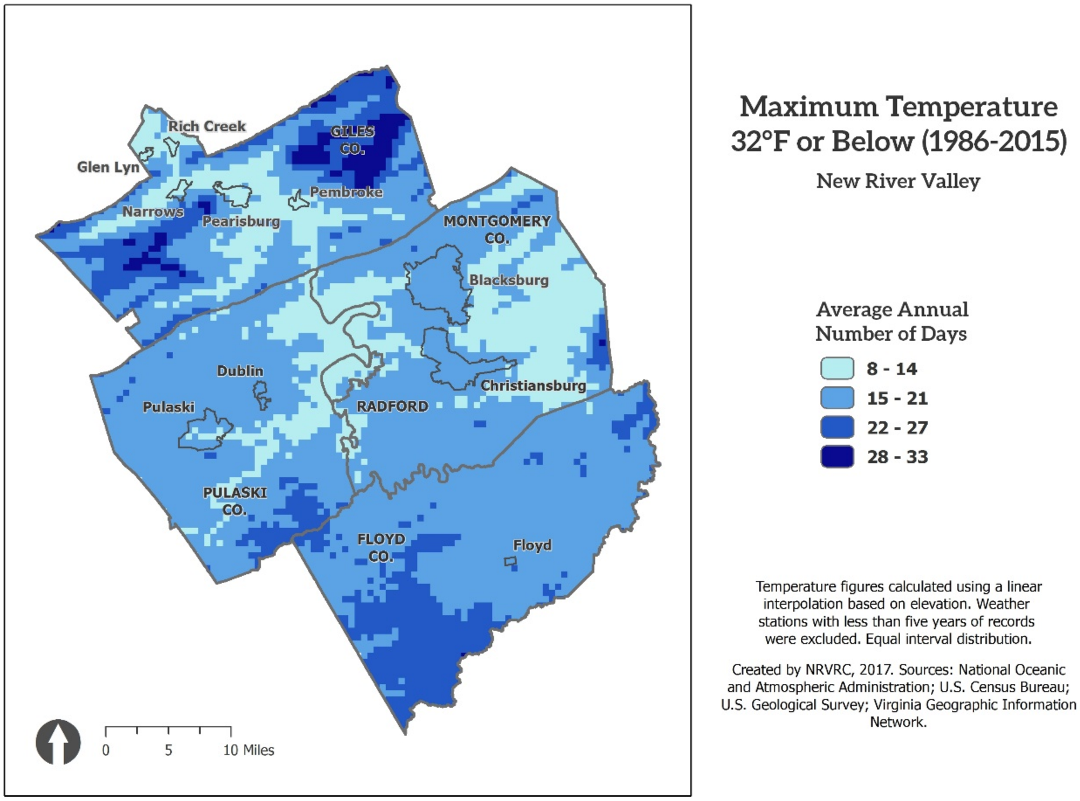
4.6.1.2 Risk Assessment and Vulnerability

Ice storms are of high concern in the region. Damage to trees can significantly increase the fire-danger in subsequent years, as dead biomass accumulates on the forest floor. Damage to infrastructure from ice storms (roads rendered impassable because of ice, fallen trees, accidents; power lines downed because of ice buildup or because of trees/branches falling on lines after breakage due to ice build-up; failure of communication systems due to breakage of lines) do occur frequently. Since the temperature that leads to ice storms rather than rain are often only a degree or two different and with local variations in conditions conducive to a build-up of ice (e.g., cold valleys, areas where cold air falls from higher elevations) predicting the effect of ice storms for specific areas of the NRV is difficult at best. Observations have been made where one valley had ice build-up, while the next valley had rain, and another had snow. Locally, there are tremendous differences in microclimatic situations causing these variations from place to place.

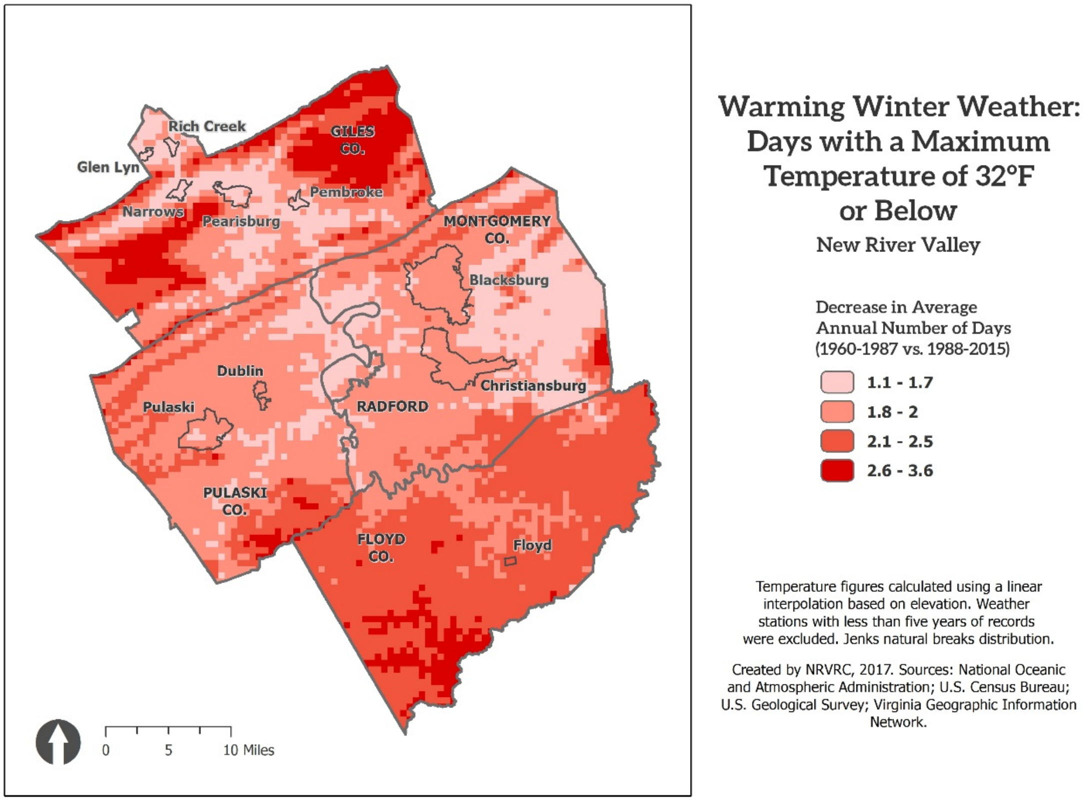
Map 28. NRV Six-inch Snowfalls



Map 29. NRV Freezing Temperature



Map 30. Warming Winter Weather Trend



Whenever a major winter storm occurs, it is likely to severely affect the highways and power lines. Heavy snowfall and ice storms can immobilize an entire region such as the NRV and adjoining areas. Snow and ice storm-related deaths are typically the result of accidents, overexertion, and exposure. Flooding may follow major winter storms. Heavy snow built-up on some roofs may lead to their collapse, resulting in structural damage. There is no known way to predict damage from winter storms to a particular region, nor is there data to support such predictions. The National Climatic Data Center reports damage by storm events, but not by locality.

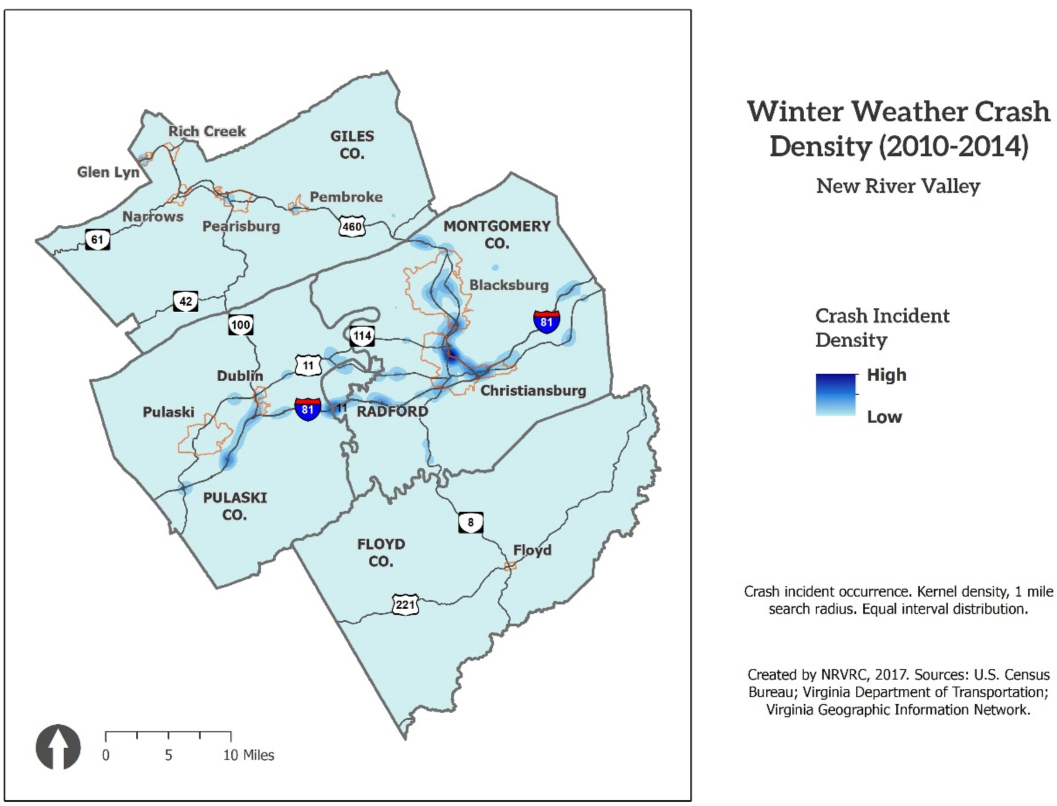
The occurrence of winter storms and ice can cause death and injury. Such storms can trap people in their vehicles or in their homes due to impassable roads. Downed power lines may further exasperate the situation by limiting the access of residents to heat and potentially also to clean water.

Map 31 and Map 32 show the density of crashes during winter weather events along major roads; all crashes reported during the winter season where road conditions demonstrated winter weather such as ice or snow are shown on Map 31. Map 32 shows the density normalized by functional class to more readily identify hot spots such as the Route 460 corridor in Montgomery County, which, outside of I-81, serves as the most significant corridor for the region's traffic.

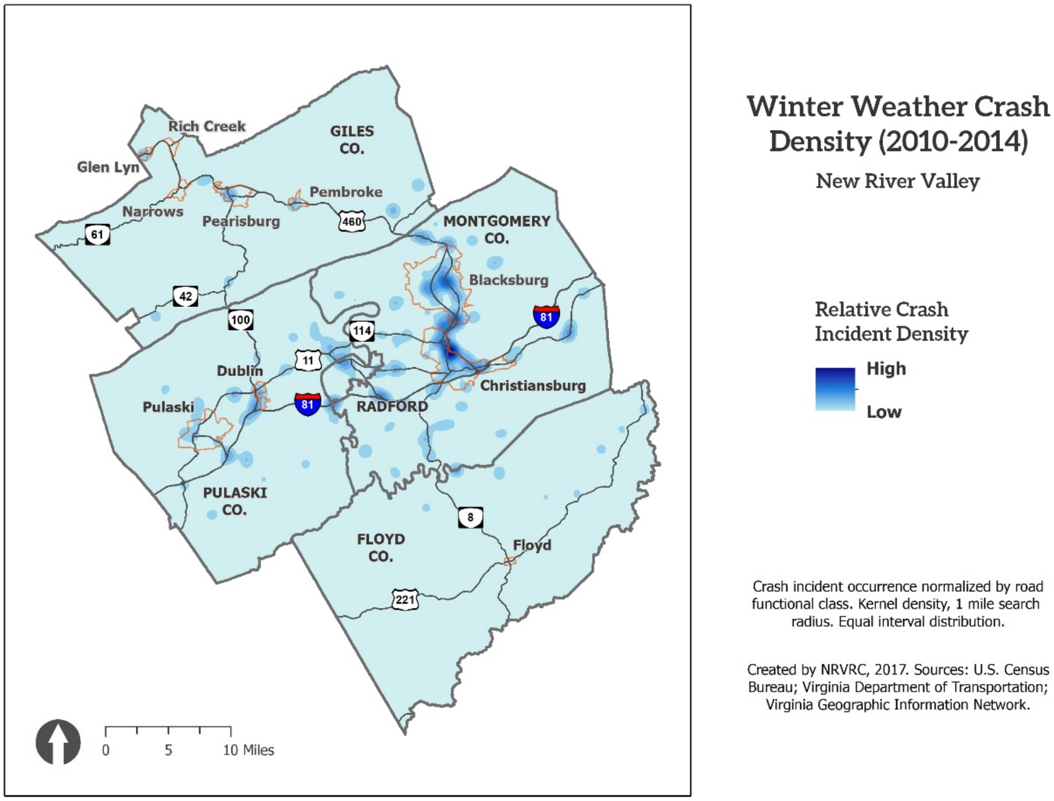
4.6.1.3 Past or Existing Mitigation

Winter storms (snow and ice) regularly result in closure of schools. Storm forecasts commonly result in early school closings to reduce the risk from accidents that may occur with buses on snow covered or icy roads. Business activities are regularly affected by winter storms, in part because customers and clients chose to stay home rather than venture out during or right after winter storms. VDOT deals directly with the effect of winter storms. Clearing of primary roads is a major concern (Interstate, US highways), before secondary roads and residential areas are cleared. VDOT has been pro-active by applying liquid chloride when storms are forecast and deploying snowplows to strategic positions in advance of severe storms.

Map 31. Winter Weather Crash Density



Map 32. Winter Weather Crash Density (Normalized)



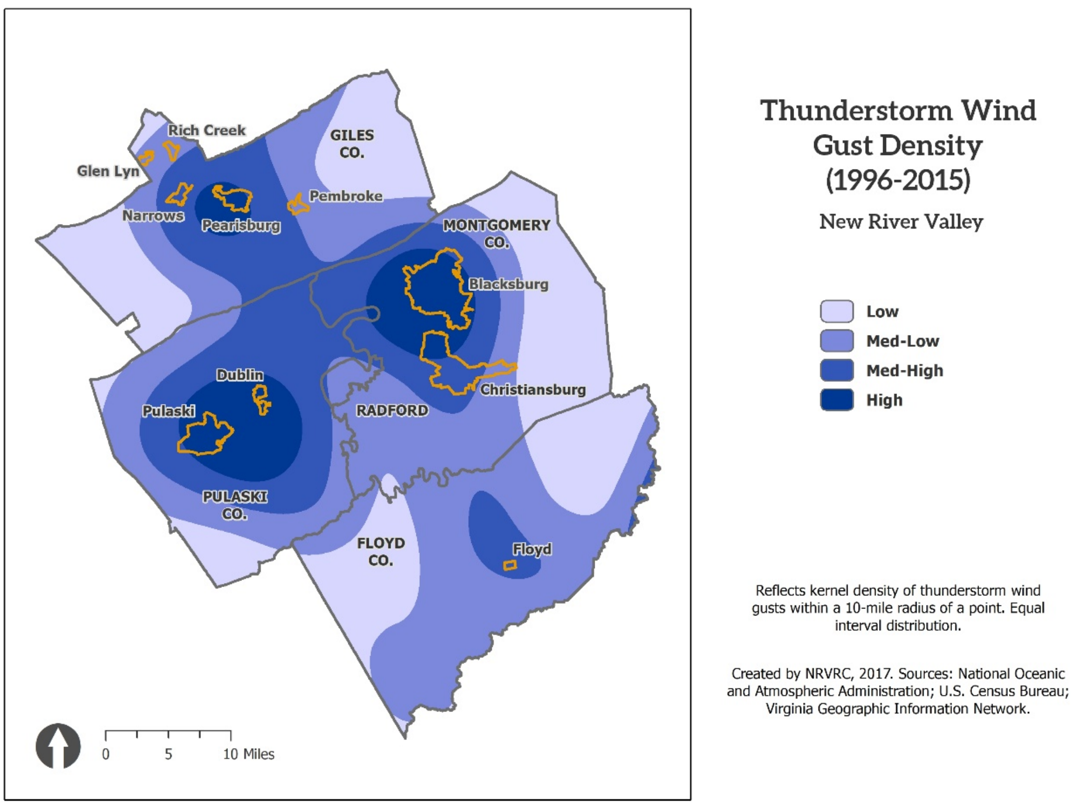
4.6.2 High Winds (Non-Rotational)

High winds occurring in the New River Valley are of two primary types: winter high winds and high winds associated with thunderstorms. High winds can be particularly damaging to structures, pulling off roofing or siding. Additionally, high winds can cause objects to become airborne, causing additional damage to structures and property loss. In particularly wet conditions, high winds can cause trees to fall. Downed trees can cause damage to property and disruptions in utility services to surrounding areas should the tree fall on a utility line.

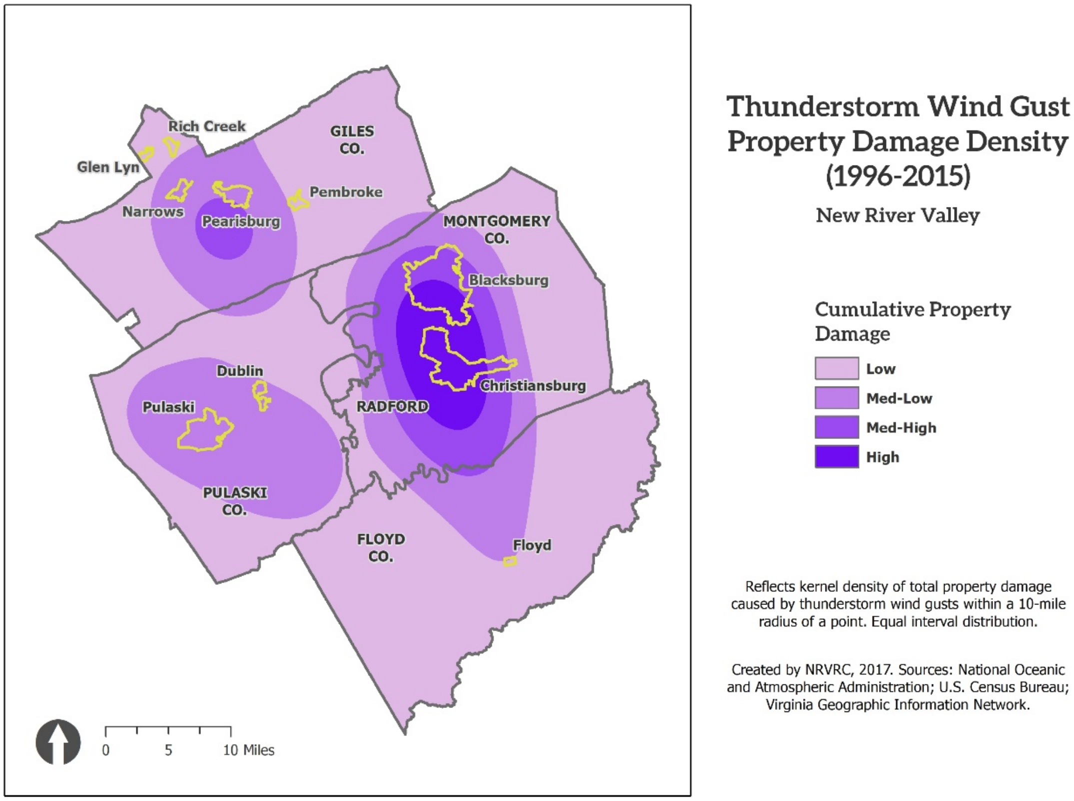
Wind events generally do not cause death, but 10 injuries were reported during wind events in the NRV since 1996, none of which were associated with winter wind events; the other injuries were associated with a thunderstorm event and the 2011 tornado.

Sporadic reports from the 1960s, 1970s, and 1980s, and more consistent records from 1990 to the present indicate that there have been over 200 notable wind events in the NRV. Approximately 172 of the recorded events are associated with thunderstorms, predominately in the summer months. Severe thunderstorms are storms with wind gusts in excess of 58 mph and hail stones larger than ¾ of an inch. The remaining 42 high wind events were recorded during the winter months as individual events, generally not associated with a winter storm event. Reported damages for historical wind events total $11.5 million dollars. Map 33 and Map 34 display the density of reported thunderstorm wind gusts for the years 1996 to 2015 and the value of property damage created by those events. Such events are more likely to be reported in higher population locations and to have more impact in terms of property damage. Historical records show that wind events occur multiple times a year, so the probability of future occurrences is high.

Map 33. Wind Gust Density



Map 34. Wind Gust Property Damage Density



The Beaufort Wind Scale estimates the speed and strength of high winds on a scale of F0 through F12 (from http://www.spc.noaa.gov/faq/tornado/beaufort.html) (Table 4.22).

Table 4.22. Beaufort Wind Scale

Force	**Wind (Knots)**	**WMO Classification**	**Appearance of Wind Effects**	
			On the Water	**On Land**
0	Less than 1	Calm	Sea surface smooth and mirror-like	Calm, smoke rises vertically
1	1-3	Light Air	Scaly ripples, no foam crests	Smoke drift indicates wind direction, still wind vanes
2	4-6	Light Breeze	Small wavelets, crests glassy, no breaking	Wind felt on face, leaves rustle, vanes begin to move

Force	Wind (Knots)	WMO Classification	Appearance of Wind Effects	
3	7-10	Gentle Breeze	Large wavelets, crests begin to break, scattered whitecaps	Leaves and small twigs constantly moving, light flags extended
4	11-16	Moderate Breeze	Small waves 1-4 ft. becoming longer, numerous whitecaps	Dust, leaves, and loose paper lifted, small tree branches move
5	17-21	Fresh Breeze	Moderate waves 4-8 ft. taking longer form, many whitecaps, some spray	Small trees in leaf begin to sway
6	22-27	Strong Breeze	Larger waves 8-13 ft., whitecaps common, more spray	Larger tree branches moving, whistling in wires
7	28-33	Near Gale	Sea heaps up, waves 13-20 ft., white foam streaks off breakers	Whole trees moving, resistance felt walking against wind
8	34-40	Gale	Moderately high (13-20 ft.) waves of greater length, edges of crests begin to break into spindrift, foam blown in streaks	Whole trees in motion, resistance felt walking against wind
9	41-47	Strong Gale	High waves (20 ft.), sea begins to roll, dense streaks of foam, spray may reduce visibility	Slight structural damage occurs, slate blows off roofs
10	48-55	Storm	Very high waves (20-30 ft.) with overhanging crests, sea white with densely blown foam, heavy rolling, lowered visibility	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	56-63	Violent Storm	Exceptionally high (30-45 ft.) waves, foam patches cover sea, visibility more reduced	
12	64+	Hurricane	Air filled with foam, waves over 45 ft., sea completely white with driving spray, visibility greatly reduced	

4.6.2.1 Risk Assessment and Vulnerability

High wind events are generally common in the region and can cause significant structural damage; wind events can be highly unpredictable. Figure 4.21 below illustrates the overall risk assessment for the state. The state ranks risk according to speeds show in Table 4.23.

Table 4.23. Wind speeds and risk categories

Hurricane Risk	Wind Speed (mph)	Category
Low	≤ 59.9	High Wind
Medium-Low	60.0-73.9	Tropical Storm

Hurricane Risk	Wind Speed (mph)	Category
Medium-High	74.0-94.9	Category 1 Hurricane
High	≥ 95.0	Category 2+

NRV localities have varying risk; Giles, Pulaski and Floyd counties and the City of Radford are at low risk, while Montgomery County has a medium risk rating.

Figure 4.21. Non-Rotation Wind Risk Assessment

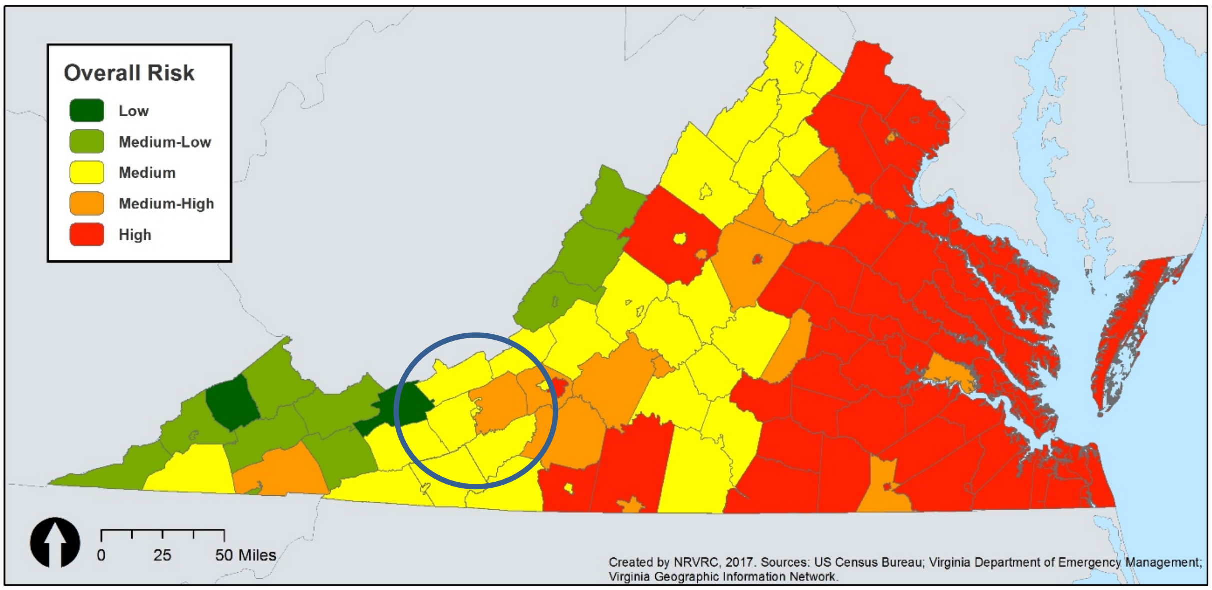
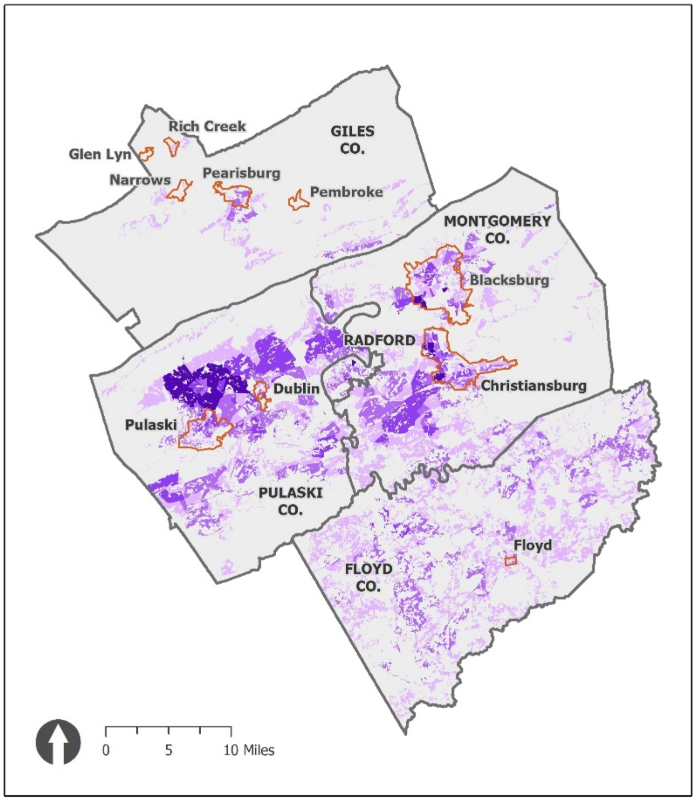


Table 4.24 shows the annualized loss estimates for the region as determined through the HAZUS analysis conducted for this plan for a 100-year event along with a distribution of the losses by census block in Map 35. The total amounts include potential damage to residential, commercial and industrial buildings. The loss estimates show that even where risk may be low, damage to in the event of a severe windstorm will have significant impact to the structures in the region.

Table 4.24. HAZUS-MH 3.1 Hurricane Wind Annualized Losses

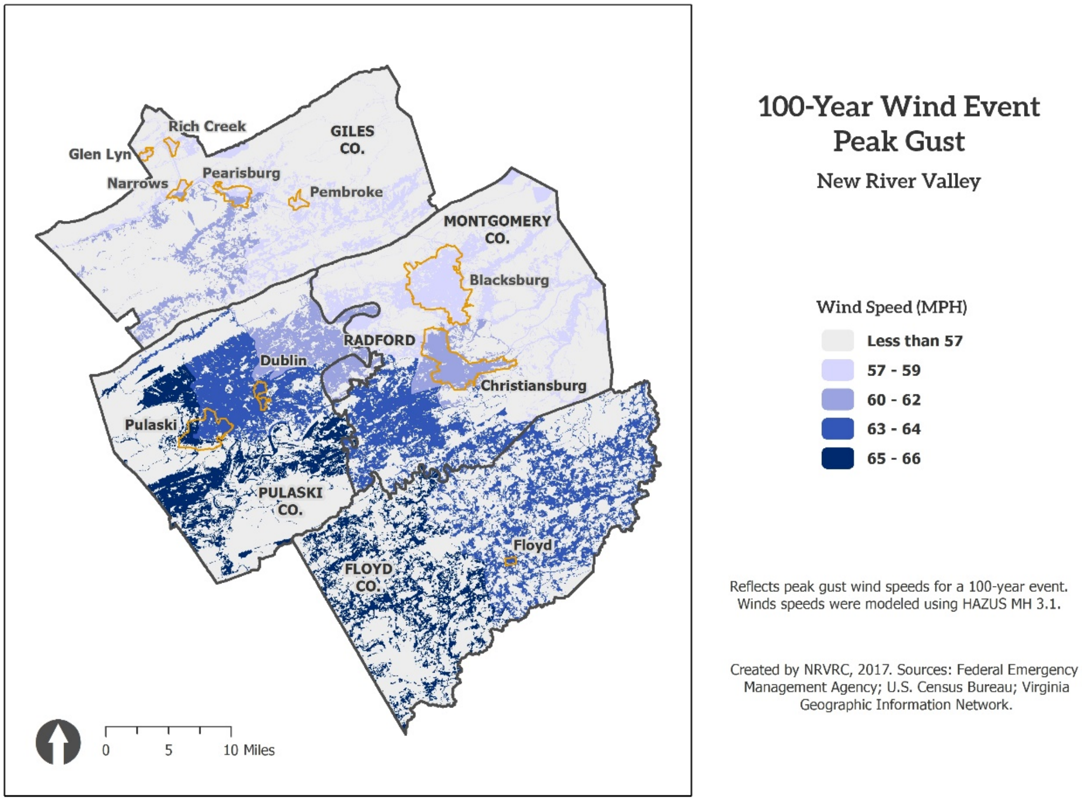
Locality	Annualized Loss Amount
Floyd County	$37,000
Giles County	$24,000
Montgomery County	$199,000
Pulaski County	$88,000
City of Radford	$26,000

Map 35. 100-Year Wind Event Annualized Loss



Map 36 shows the peak wind for a 100-year event and where the highest speeds are likely to occur. Whiles annualized loss does show current potential risk, Map 36 demonstrates areas where risk could rise if future development occurred in the darker blue areas.

Map 36. 100-Year Wind Event Peak Gust



4.6.3 Tornado

A tornado is a highly intense, destructive cyclonic rotation of air that develops in response to extremely low air pressure, often associated with a cumulonimbus cloud. A tornado is commonly associated with a mesocyclone formation. As more moisture-laded air is drawn up into the circulation of a mesocyclone, more energy is liberated, and the rotation becomes more rapid. A tornado can then develop as the dark funnel cloud that pulses from the bottom side of the parent cloud. When and where this funnel cloud reaches down to the surface, tremendous destructive winds that can reach speeds of over 300 mph have been measured. The destructive force of tornadoes is measured in the Enhanced Fujita Tornado Measurement Scale (http://www.spc.noaa.gov/faq/tornado/ef-scale.html) (Table 4.25).

Table 4.25. Enhanced Fujita Scale

EF Number	3 Second Gust Speed (MPH)
0	65-85
1	86-110

EF Number	3 Second Gust Speed (MPH)
2	111-135
3	136-165
4	166-200
5	Over 200

4.6.3.1 History

The New River Valley does not have an extensive record of tornados in the region. Between 1980 and 2010, four tornados had been recorded in the NRV. Table 4.26 below describes these events as well as the most recent EF-1 and EF-2 tornadoes that struck two different areas of Pulaski County on April 8, 2011. They affected Draper and the Town of Pulaski, damaging or destroying as many as 400 homes, at an estimated value of $5.25 million. The associated storm left 4,600 customers without power and water system users were advised to boil water. Recovery from this event included repairing 75 homes, rebuilding 4, and replacing 15, as well as acquisition of four lots (Figure 4.22).

Figure 4.22. Rebuilding Homes Post-tornado in Pulaski County

Table 4.26. NRV Tornados 1987-2011

Location	Date	Intensity	Property Damage
Montgomery County	3/30/1987	F1	$2.5 Million
Radford	6/11/1998	F0	$0
Indian Valley, Floyd County	1/23/1999	F1	$12,000
Indian Valley, Floyd County	5/2/2009	F0	$10,000
Draper, Pulaski County	4/8/2011	EF-1	$3.57 Million
Town of Pulaski, Pulaski County	4/8/2011	EF-2	$1.68 Million

4.6.3.2 Risk Assessment and Vulnerability

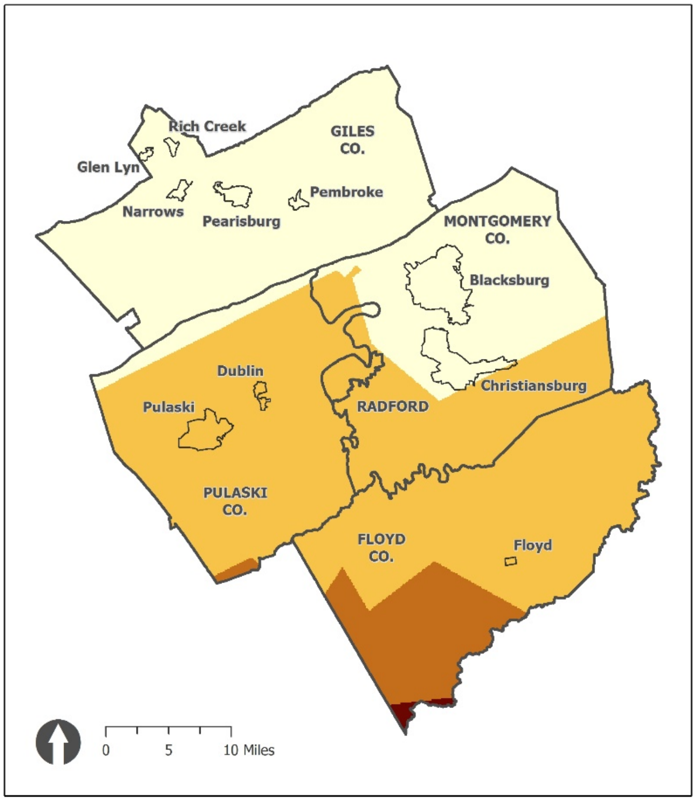
F0 and F1 tornados are considered weak and generally are short lived. Tornados of these intensities make up approximately 80% of all tornado reports nationwide.

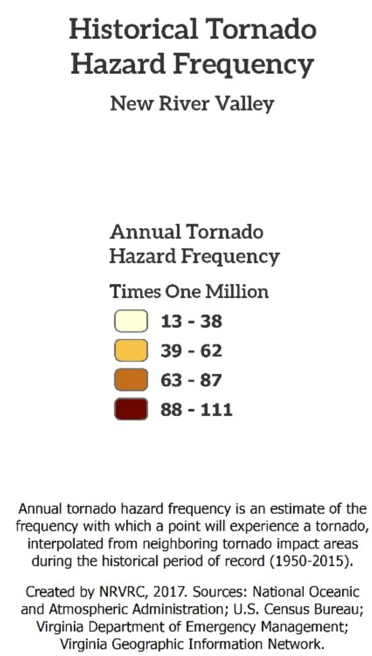
During an F0 tornado, damage is characterized by superficial damage to structures and vegetation. Well-built structures are typically unscathed, sometimes sustaining broken windows, with minor damage to roofs and chimneys. Billboards and large signs can be knocked down. Trees may have large branches broken off and can be uprooted if they have shallow roots.

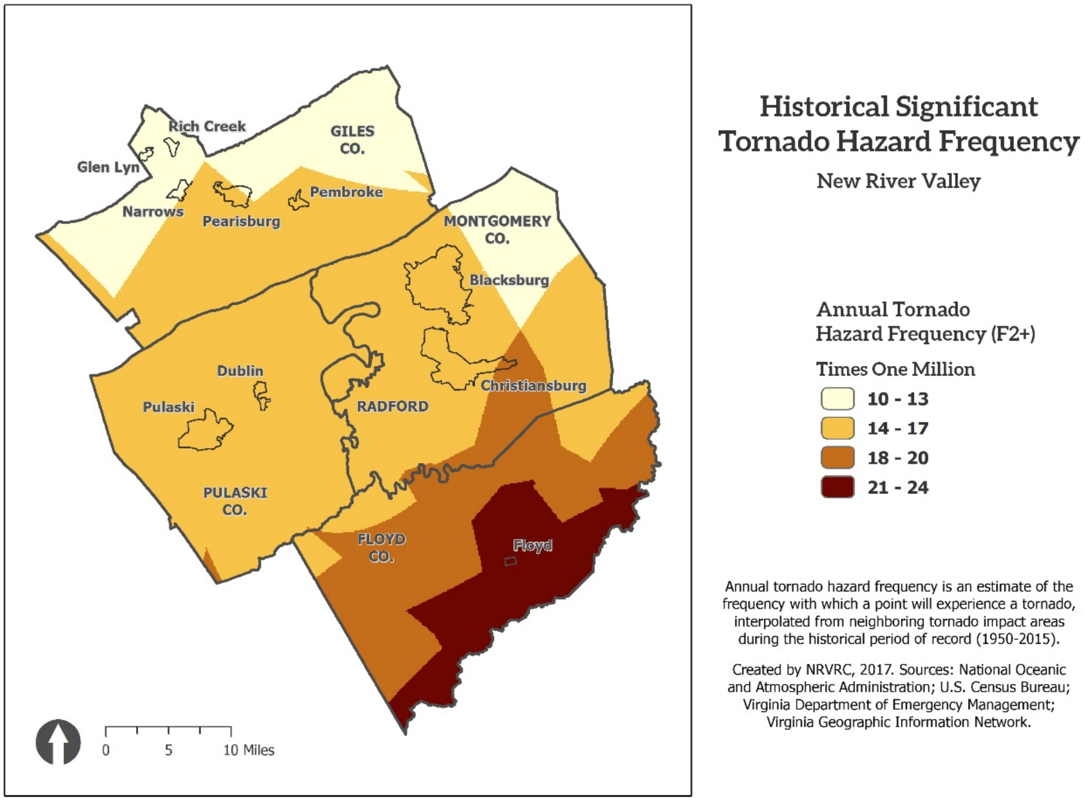
During an F1 tornado, damage has caused significantly more fatalities than that caused by EF0 tornadoes. At this level, damage to mobile homes and other temporary structures becomes significant, and cars and other vehicles can be pushed off the road. Permanent structures can suffer major damage to their roofs.

Map 37 shows the NRV's probability of experiencing any tornado in a given year in the state, while Map 38 shows a slightly reduced probability of experiencing an F2+ tornado event. Map 39 shows the locations of tornado events in the region since 1950. Figure 4.23 below shows a statewide model for tornado probability. The unpredictable nature of these storms, and the fact that they typically involve relatively small areas at a time, makes a prediction of costs highly unrealistic. The map does show, however, that along the eastern edge of the NRV there is a higher probability for tornadoes than in the western half of the region. This is related to the extent of tornados adjacent to the region (which can be a far away as 100 miles).

Map 37. NRV Tornado Hazard






Historical Significant
Tornado Hazard Frequency
New River Valley
Annual Tornado
Hazard Frequency (F2+)
Times One Million
10 - 13
14 - 17
18 - 20
21 - 24
Annual tornado hazard frequency is an estimate of the frequency with which a point will experience a tornado, interpolated from neighboring tornado impact areas during the historical period of record (1950-2015).
Created by NRVRC, 2017. Sources: National Oceanic and Atmospheric Administration; U.S. Census Bureau; Virginia Department of Emergency Management; Virginia Geographic Information Network.
Rich Creek
GILES CO.
Glen Lyn
Narrows
Pearisburg
Pembroke
MONTGOMERY CO.
Blacksburg
Dublin
Pulaski
RADFORD
Christiansburg
PULASKI CO.
FLOYD CO.
Floyd
0
5
10 Miles

Map 39. NRV Tornado History

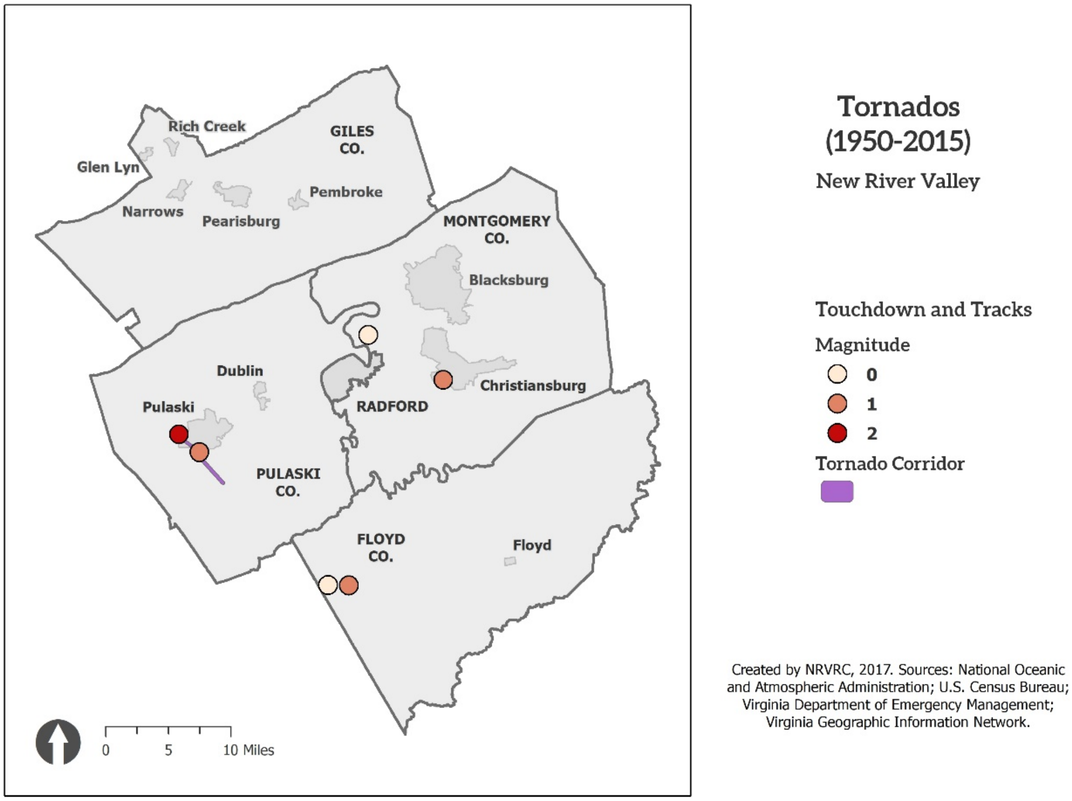
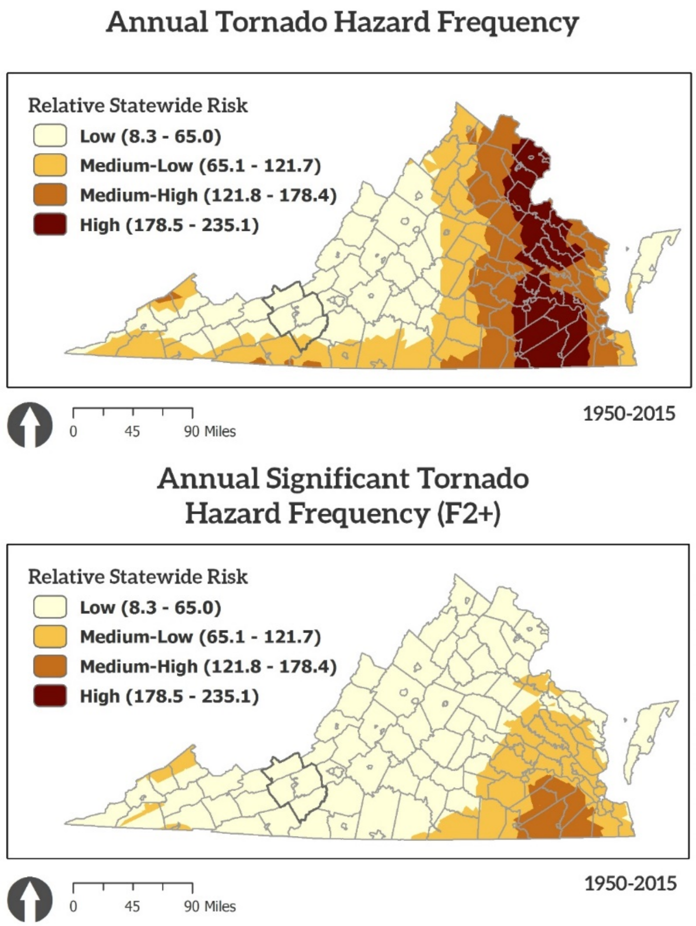


Figure 4.23. Virginia Tornado Hazard Frequency and F2+ Hazard Frequency



Annual tornado hazard frequency is an estimate of the frequency with which a point will experience a tornado, interpolated from neighboring tornado impact areas during the historical period of record. Classifications reflect equal interval distribution of frequency of tornados of any strength in Virginia.

Created by NRVRC, 2017. Sources: National Oceanic and Atmospheric Administration; U.S. Census Bureau; Virginia Department of Emergency Management; Virginia Geographic Information Network.

Table 4.27 below describes the probability and risk of tornado based on the updated analysis.

Table 4.27. Tornado Hazard and Frequency

Tornado Hazard	Annual Tornado Hazard Frequency (times 1 million)
Low	8.3-65.0
Medium-Low	65.1-121.7
Medium-High	121.8-178.4
High	178.5-235.1

4.6.3.3 Past or Existing Mitigation

The only tornado mitigation currently in effect is the statewide building code and notifications of tornado watches and warnings issued by the National Weather Service.

4.6.3.4 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Below are the goals, objectives, and strategies identified by the winds and winter weather working groups to specifically lessen the impacts of severe weather hazards in the region.

Goal: Minimize impacts of significant weather events, such as winter weather and severe weather events in the NRV.

a) Encourage activities to reduce impacts during storm events.
   i. Promote the installation and maintenance of drift fences to maintain access during snow events.
   ii. Emphasize that all treatment of roads be done prior to storms to prevent access issues.
   iii. Ensure necessary resources are available in advance of storms and weather events.
   iv. Improve collaboration and coordination with VDOT to create opportunities for dialogue on treatment and clearing of roads.

b) Develop educational materials and events to prevent loss of life and property in severe weather events.
   i. Continue educational efforts during times when events are not occurring (i.e., brochures, websites, social media, awareness weeks-promotions coordination).
   ii. Emphasize what should be done during a storm event (i.e., lightning) to maintain safety.
   iii. Educate landowners about how overhanging utility lines and trees can cause property damage during a storm.
   iv. Create a brochure or handout of local hazards to provide to the community.
   v. Pursue and/or maintain Storm Ready designation for the region's communities.

c) Encourage preparation and planning activities that minimize impacts to life and property.
   i. Encourage personal planning for storm events and their impacts.
   ii. Inventory public and critical facilities to determine the need for back-up power generation.
   iii. Inventory and assess critical facilities for possible roof collapses to determine need for future mitigation efforts.
   iv. Engage in regional emergency management exercises (table-top and field) to train responders.

Goal: Minimize impacts of significant weather events, such as winter weather and severe weather events in the NRV.

a) Encourage activities to prevent impacts during storm events.
    i. Promote the installation and maintenance of drift fences to maintain access during snow events.
    ii. Emphasize that all road maintenance be done prior to storms to prevent access issues.

b) Develop educational materials and events to prevent loss of life and property in severe weather events.
    i. Emphasize what should be done during a storm event (i.e., lightning) to maintain safety.
    ii. Educate landowners about how overhanging utility lines and trees can cause property damage during a storm.
    iii. Continue educational efforts during times when events are not occurring (i.e., brochures, websites, awareness weeks-promotions coordination).
    iv. Create a brochure or handout of local hazards to provide to the community.
    v. Pursue and maintain Storm Ready designation for the region's communities.

c) Encourage preparation and planning activities that ensure minimal impacts to life and property.
    i. Encourage personal planning for storm events and their impacts.
    ii. Inventory public facilities to determine the need for back-up power generation.
    iii. Inventory of possible roof collapses through an analysis of building permits to determine need for future mitigation efforts.
    iv. Engage in regional emergency management exercises (table-top and field) to train responders.
    v. Look into technology to be applied on a regional level (damage assessment software such as Crisis Track)

4.7 Wildfire

This section of the HIRA has been updated from the previous New River Valley Hazard Mitigation Plan. New information has been provided for the risk assessment and vulnerability section, as well as the past or existing mitigation section by the Virginia Department of Forestry (DOF). Specific communities have been identified by DOF as being at risk on the urban-wildland interface and are discussed as special hazard areas below.

4.7.1 History

The New River Valley has not suffered any devastating fires of the scale that now seem frequent in the western U.S. Yet, small fires are relatively frequent in the New River Valley. For the years

2002-2016, Table 4.28 illustrates the average acreage involved in wildfires based on data from DOF.

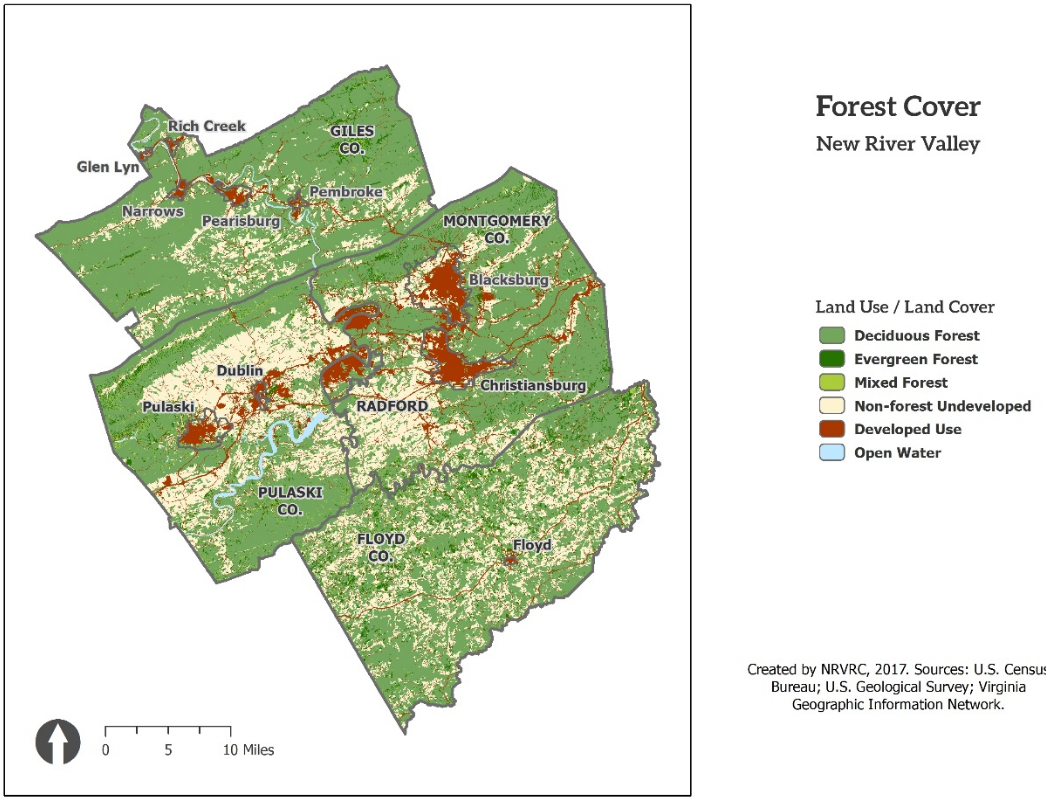
Table 4.28. Acreages and Averages for Wildfires 2002-2016

County	Total Fires	Total Acreage	Average Acreage	Max Acreage
Floyd	35	165	4.71	26
Giles	53	592	11.17	300
Montgomery	91	1286	14.13	300
Pulaski	78	1077	13.81	457
New River Valley	257	3120	12.14	457

Source: Virginia Department of Forestry

Approximately 65% of the New River Valley is forested. Figure 4.24 below illustrates the various general land uses in the region. Additionally, there is a significant portion of the Jefferson National Forest in the region, also indicated in Figure 4.24.

Figure 4.24. Forest Cover in the New River Valley



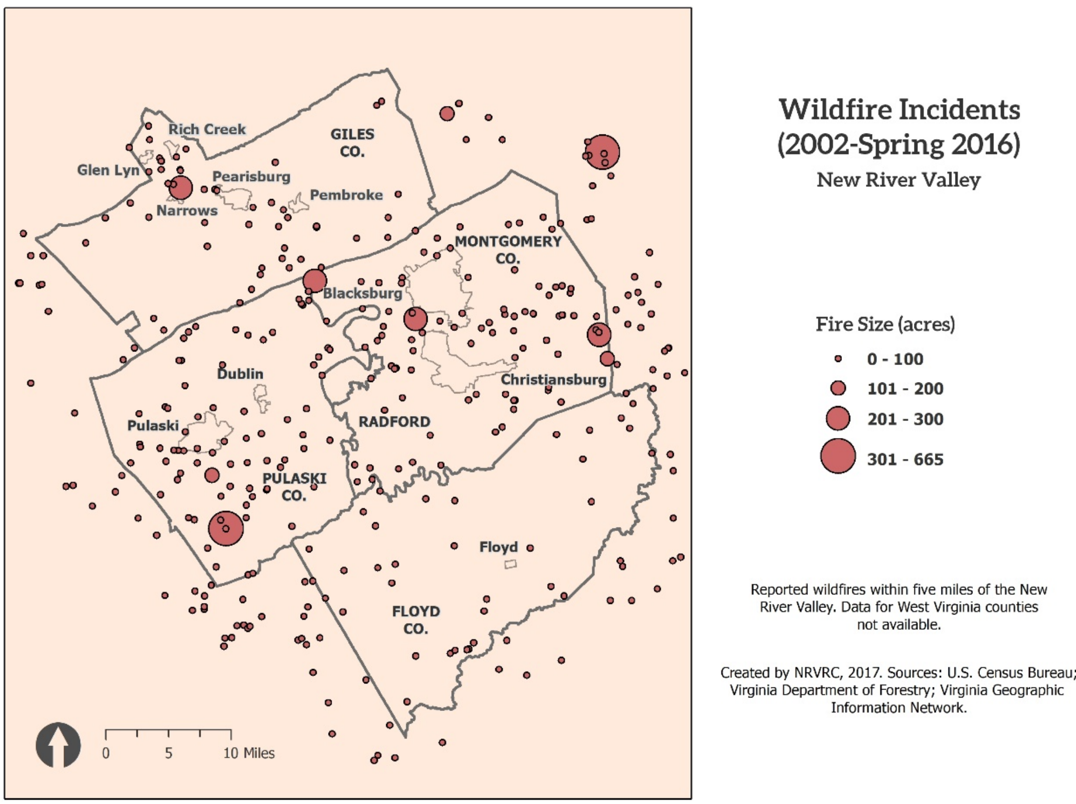
Between 2002 and 2016, there were 257 recorded wildfires in the New River Valley. On average, that is approximately 18 fires each year throughout the region. Map 40 below indicates the location of all these fires.

Two significant wildfires occurred simultaneously in 2003 despite the heavy moisture in the winter and spring. From April 16-19, 2003, 142 acres burned on Draper Mountain in Pulaski County and about 100 acres burned on Poor Mountain in Montgomery County (Figure 4.25). In November 2016, a wildfire occurred in Giles County, burning over 100 acres during a season that included wildfires across 119,000 acres in eight Southeastern US states.

Wildfires sometimes damage homes and structures, as well as destroying wildlife habitat, merchantable timber and critical watersheds. While the NRV has been spared devastating fires, numerous fires have caused thousands of dollars of damage.

Figure 4.25. Helicopter flies over Poor Mountain Fire, 2003

Map 40. NRV Wildfires



4.7.2 Risk Assessment and Vulnerability

The DOF has created a very useful wildfire risk assessment map that illustrates areas of high, medium, and low risk for wildfire. When creating this model, DOF used six factors to determine the level of risk. These factors include land cover and railroad buffer, density of wildfires, aspect, percent slope, population density, road density and developed areas, and distance to roads. Land cover affected the wildfire risk as different fuels ignite more easily, burn with greater intensity and can facilitate more rapid fire advancement. Proximity to railroads increased fire risk as a small percentage of wildfires has been found to be ignited by railroad operation or maintenance. It was assumed that the density of historic wildfires would remain similar and risk was assessed using that assumption.

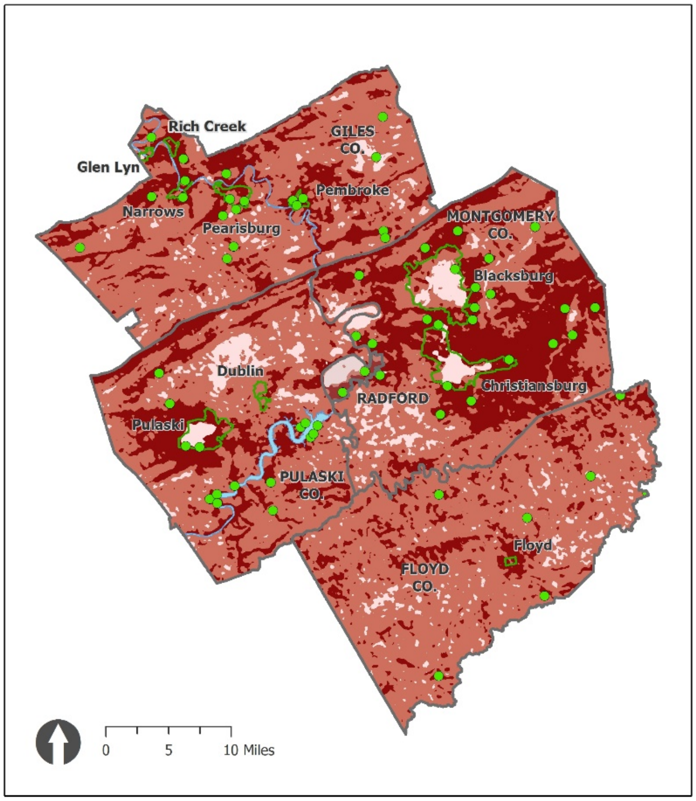
Slope can have an effect on wildfire in two regards, slope face and steepness. Slopes that face south receive more direct sunlight drying fuels and creating more favorable conditions for wildfires to ignite. Additionally, steeper slopes facilitate convective pre-heating for wildfires that can cause fires to advance uphill. Steeper slopes increase this pre-heating effect and thus increase the potential for wildfire ignition.

The greatest number of fires occur in February, March, April and May. This period is known as Spring Fire Season. Fall Fire Season in October, November and December. Human populations can also affect wildfire risk, as most of reported wildfires in Virginia were started by humans through arson, smokers, campfires, equipment use, and debris burning. Despite this, urban areas were considered to have a much lower risk of wildfires than rural areas. To account for at least some of the human cause of wildfires, areas in close proximity to road corridors were ranked with a higher risk of wildfire due to the higher probability of human presence.

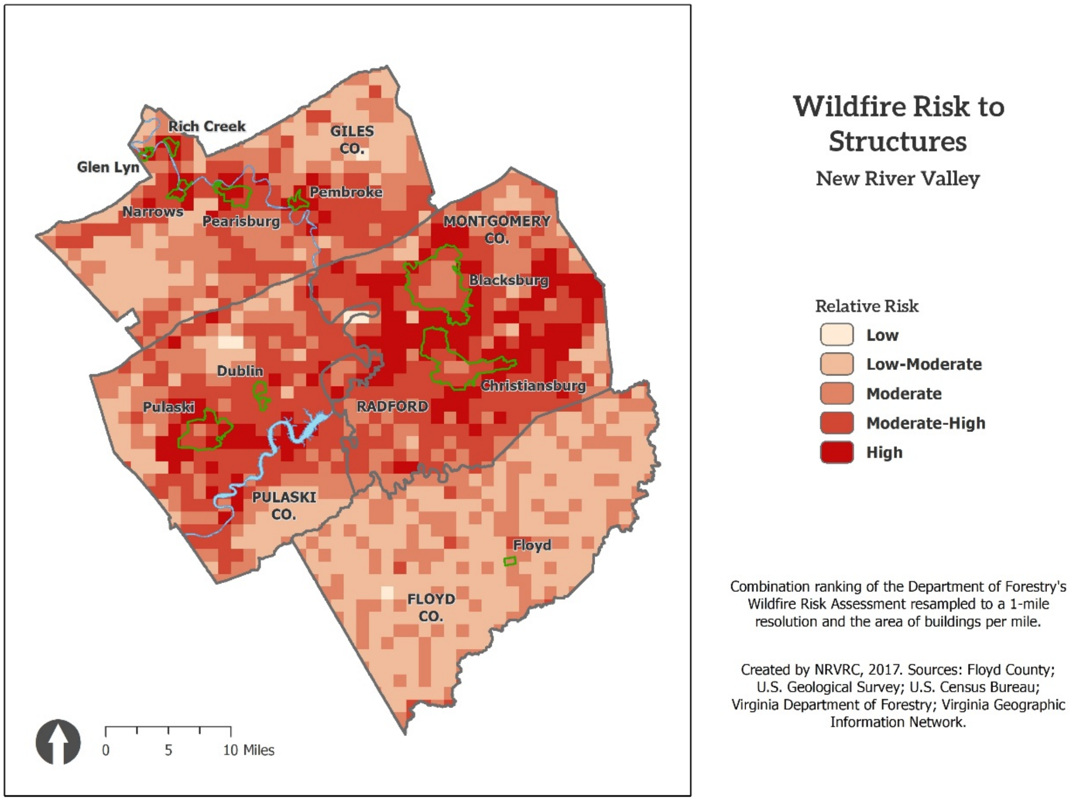
Map 41 below illustrates DOF's wildfire risk assessment for the New River Valley. Map 42 and Map 43 show more specific risk assessment to structures based on population density (risk to structures) and further analysis of the extent of risk to more densely clustered structures outside the urban areas of development (risk to exurban structures).

While considering the relative risk of all hazards possible in the New River Valley, the steering committee considered frequency of the event and severity, as well as the area affected by the hazard. Using these considerations, wildfire was ranked as a moderate risk in the region. The steering committee noted that relative to other hazards, wildfires are likely to occur, on average several occurring every year, where most have negligible to moderate impacts and occur in an isolated area.

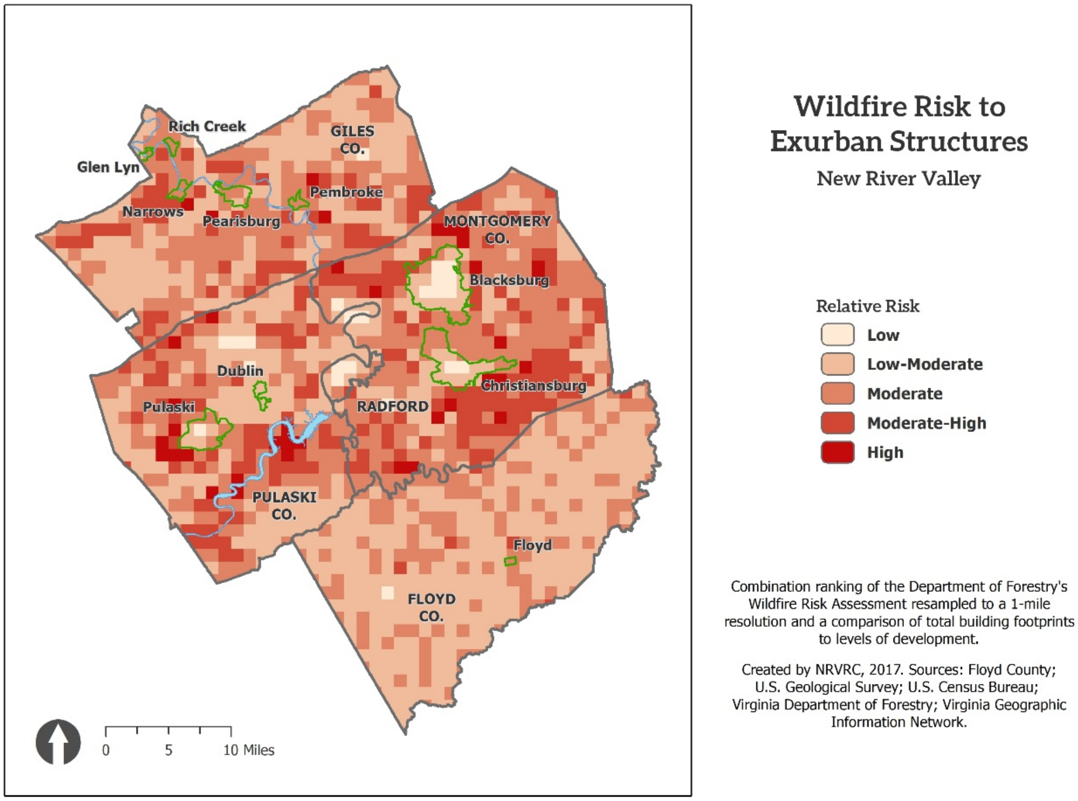
Map 41. NRV Wildfire Risk Assessment



Map 42. NRV Wildfire Risk to Structures



Map 43. NRV Wildfire Risk to Exurban Structures



4.7.3 Special Hazard Areas

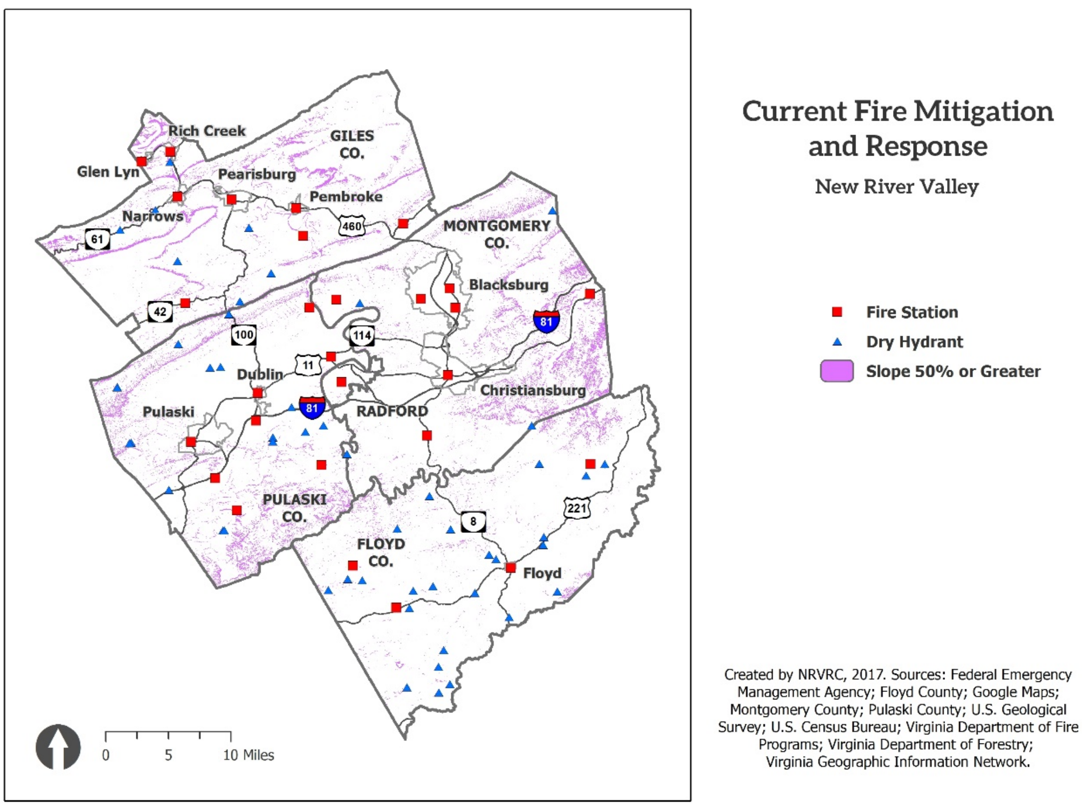
Several special hazard areas have been identified as well by DOF. The wildland-urban interface tends to be especially vulnerable to wildfire risks. DOF identified Woodland Home Communities where this interface could potentially put numerous homes and lives at risk during a wildfire. These communities are identified on Map 41 as part of the existing wildfire mitigation and response. In identifying the woodland home communities, DOF also prioritized these communities and their risk and has begun outreach efforts with those at the most risk of severe impacts from wildfires.

4.7.4 Past or Existing Mitigation

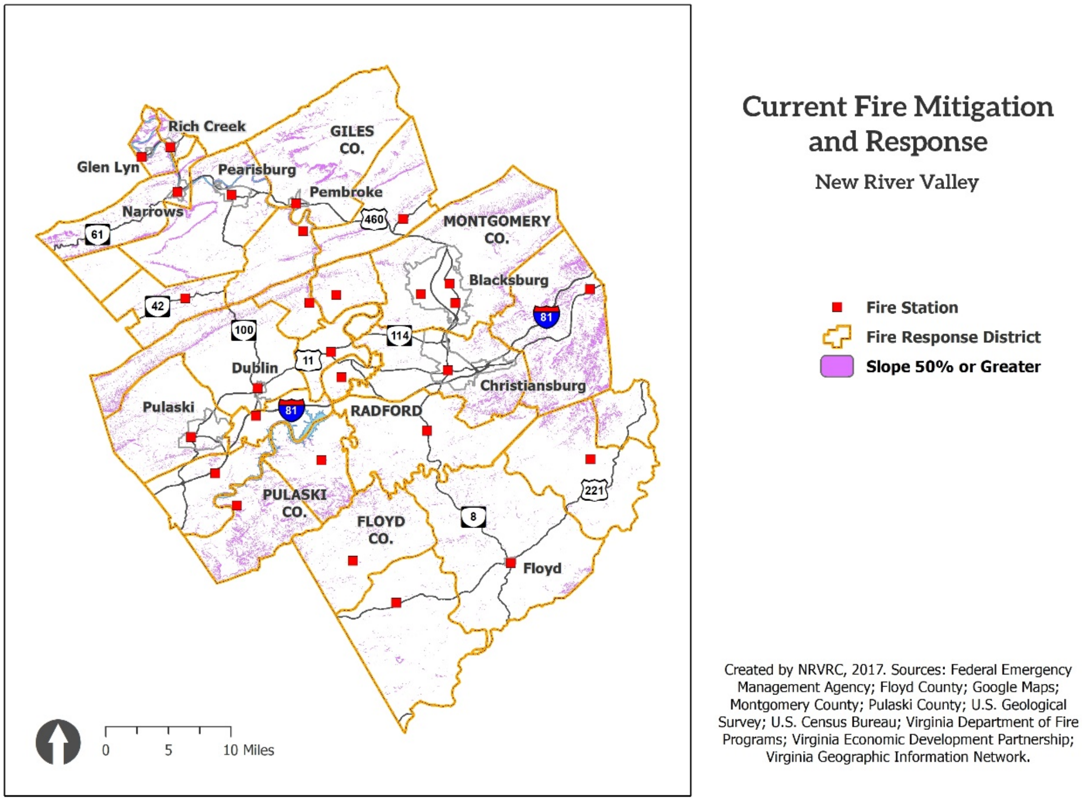
The NRV benefits from many national and state forestry initiatives. These include the Virginia Forestry Smokey the Bear program, the Fire Risk Index, outdoor burn laws, dry hydrant programs, the Firewise program and geographic information system development. Dry hydrants are a non-pressurized pipe system installed in a stream, pond or lake to provide a suction source for water to a fire truck. The Firewise program enables the DOF to work with communities to assess wildfire risk and create plans to reduce them. At time of the plan update, NRHC&D council, along with the DOF, was expanding the capacity of the Firewise program to work directly with localities and communities to encourage new development that mitigates wildfire risk through the council's membership in the Appalachian Community Coalition for Fire-adapted Communities.

Additionally, the US Forest Service's Federal Wildland Fire Policy emphasizes community initiatives including cross-training among structural and wildland (local, state and federal) firefighters. The U.S. Fire Administration and USDA's Rural Development program administer grant programs to help equip fire departments. Map 44 and Map 45 below outline some of these traditional mitigation techniques from fire and rescue districts to dry hydrant locations and areas with slopes greater than 50% than inhibit access for emergency response equipment.

Map 44. Current Fire Mitigation and Response (with dry hydrants)



Map 45. Current Fire Mitigation and Response (with fire response districts)



4.7.5 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Below are the goals, objectives, and strategies identified by the wildfire working group to specifically lessen the impacts of wildfire hazards in the region.

Goal: Minimize wildfire losses in the “urban wildland interface” areas.

a) Educate residents and landowners on possible wildfire mitigation techniques.
   - i. Educate the homeowners about the need to clear debris to prevent loss to wildfire.
   - ii. Facilitate public awareness of local fire notices.
   - iii. Conduct practice “tagging” exercises to educate homeowners about the realities of wildfire.
   - iv. Encourage the use of Firewise standards in new development and homeowner’s associations.
   - v. Engage with landscaping companies to encourage and utilize Firewise techniques on customers’ property.

b) Engage in mitigation and planning activities to minimize wildfire impacts.

   i. Ensure that new wildland communities are built to Firewise standards through inclusion in ordinances and building permits.
   ii. Consider limiting future development in areas with slopes greater than 50% that prevent access by fire equipment.
   iii. Work with insurance to improve incentives for homeowners engaging in Firewise activities.
   iv. Improve physical access to community for fire and rescue personnel and equipment.
   v. Encourage county-wide fire plans and Community Wildfire Protection Plans.
   vi. Search for funding to increase equipment, training, and personnel to fight wildfires.
   vii. Enforce existing regulations that home numbers at the road are easily visible for first responders.
   viii. Improve 911 mapping systems for improved access by first responders.
   ix. Work with land and home owners with gates or locks to improve fire access.
   x. Encourage mitigation activities that prevent wildfire damage to structures, including creating a defensible space around a vulnerable structure, structural protection through ignition resistant construction activities, and hazardous fuels reduction activities.

4.8 Human-caused Hazards

There are three primary types of human-caused hazards; accidental, criminal and terrorist. Accidental human-caused hazards occur due to human error with no intent to do harm. Criminal acts are events carried out by humans with the intent to do harm to either persons or property. Terrorist activities are similar to criminal activities, but are defined by FEMA 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. Though these hazards tend to be more difficult to predict due to the unpredictable nature of human actions, it is still important to understand the risks associated with them and plan to mitigate their potential impacts.

This section will briefly discuss community assets and infrastructure that can be negatively impacted by human activities. This section will also include a brief discussion of vulnerable populations within the community that can be impacted by all of the discussed hazards in very unique ways.

4.8.1 History

The most memorable human-caused event in recent memory in the New River Valley was the April 16, 2007 shooting at Virginia Tech. During this incident, a lone gunman killed 32 students and staff members at the university. Since that time, the university has put in many new procedures and tools to prevent another tragedy at the same scale.

Both universities in the region have completed a hazard mitigation plan to earn the designation as "Disaster Resistant University." Both plans include sections regarding human-caused events focusing on structural fires, hazardous materials and acts of terrorism. For more information about these plans, please contact the Radford University Office of Emergency Preparedness at (540) 831-7155 or the Virginia Tech Office of Emergency Management at http://www.emergency.vt.edu/.

Outside this notable criminal act, very few major human-caused incidents have been noted in the region. The region does serve as a major transportation corridor via both the interstate highway system and railways. As a major corridor, accidents involving hazardous materials are not uncommon, but rarely cause interruptions to the daily life of the region's citizens. Records of these accidents or incidents are scattered and very difficult to compile, thus there is no good historical record.

There is no notable historical record of additional criminal or terrorist activities focused on this region.

All localities except the Town of Glen Lyn are known to operate with an Emergency Operations Plan (EOP), though some towns are covered under their county's EOP. These plans address the need to prepare for, respond to, and recover from natural and manmade disasters. Because they address how operations will be directed and controlled during and after an event, they are an important piece of the emergency management environment in the NRV that will be called on to address human-caused events as much as natural disasters..

4.8.2 Risk Assessment and Vulnerability

4.8.2.1 Hazardous Materials

Hazardous materials are routinely stored and transported throughout the New River Valley. For planning purposes these storage sites could be impacted by any of the three types of human-cause hazards; accidental, criminal or terrorist. Additionally, these sites could be impacted by a variety of natural hazards based on their location. The Environmental Protection Agency (EPA) requires reporting of hazardous chemical storage for compliance with the Emergency Planning and Community Right-to-Know Act (EPCRA). Various facilities are required to report the hazardous chemicals used or stored in the workplace. Facilities that meet the thresholds below are required to report to annually to the Virginia Department of Environmental Quality, their Local Emergency Planning Committee, as well as the local fire department with jurisdiction for the storage facility. Facilities must report their hazardous materials storage if:

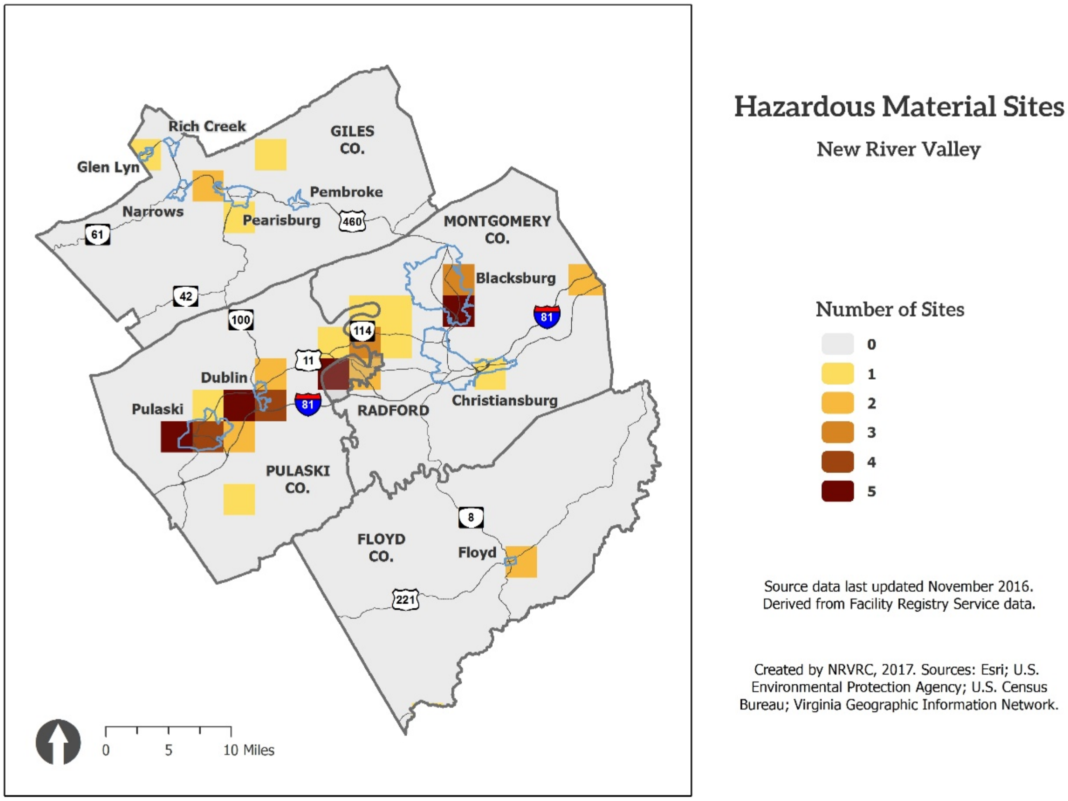
- They store either 500 pounds or the Threshold Planning Quantity (TPQ), whichever is lower, of Extremely Hazardous Substances (EHSs);

- For gasoline (all grades combined) at a retail gas station, they store 75,000 gallons (or approximately 283,900 liters), if the tank(s) was stored entirely underground and was in compliance at all times during the preceding calendar year with all applicable Underground Storage Tank (UST) requirements at 40 CFR part 280 or requirements of the State UST program approved by the agency under 40 CFR part 281;
- For diesel fuel (all grades combined) at a retail gas station, they store 100,000 gallons (or approximately 378,500 liters), if the tank(s) was stored entirely underground and the tank(s) was in compliance at all times during the preceding calendar year with all applicable UST requirements at 40 CFR part 280 or requirements of the State UST program approved by the agency under 40 CFR part 281;
- For all other hazardous chemicals, they store 10,000 pounds.

Map 46 below illustrates the density of facilities submitting Tier II reports in 2016. There is currently no data available for Giles or Floyd Counties. Typically these facilities include retail gas stations and public utility facilities, among others. These facilities are not hazardous material waste sites ("dumps"), but rather storage of hazardous materials. The facilities were mapped using their listed addresses and then buffered by a mile to prevent specific location identification. Density was calculated by combining overlapping buffers and then calculating the number of facilities per square mile inside the buffered area. It will be important in future revisions of this plan to obtain better and more complete data from all jurisdictions on locations storing these types of hazardous materials.

Additional future analysis of the risks associated with hazardous materials storage should include an analysis of the risks posed to these sites by natural hazards.

Map 46. Hazardous Materials



4.8.2.2 Critical Facilities and Utilities

Critical facilities and critical utilities both play key roles in mitigating hazards. Critical facilities are those identified in the community that provide key services to residents and would have significant detrimental effects should they be destroyed or disrupted. Critical facilities are most likely to be affected by natural hazards, but some may be targeted for criminal or terrorist activities. The facilities identified throughout the region include emergency shelters, government buildings, hospitals, schools and emergency communications tower locations. Map 47 and Map 48 below depicts the locations of these facilities throughout the region. Additional facilities may be identified in the future and mitigation actions could be taken to ensure their proper functioning throughout the course of a given hazard event.

Critical utilities include those utilities that provide essential functions to maintain the health and safety of residents. These utilities primarily consist of water and sewer infrastructure and major gas and electrical transmission lines (Map 49 and Map 50). Additional data for the next plan update, especially for water and sewer infrastructure, could improve the analysis of these community assets. Utilities are most likely to be impacted by natural hazards such as high winds or ice, but some may also be the targets of criminal or terrorist activities.

Over the past 70 years, a nationwide system of collection, transmission, and distribution pipelines has been constructed to transport almost 100 percent of the natural gas and about 66 percent of the ton-miles of oil and refined petroleum products consumed in the United States. Many portions of the transmission pipelines were originally constructed in sparsely populated areas; subsequent growth has transformed some of these previously rural and sometimes remote areas into urban and suburban areas with housing subdivisions, shopping centers, and business parks.

The goal of the Pipelines and Informed Planning Alliance (PIPA) is to reduce risks and improve the safety of affected communities and transmission pipelines through implementation of recommended practices related to risk-informed land use near transmission pipelines. The PIPA recommended practices describe actions that can be taken by key stakeholders relative to proposed changes in land use or new development adjacent to existing transmission pipelines. Local governments, property developers/owners, transmission pipeline operators, and state real estate commissions have key roles to enhance pipeline safety and ensure the protection of people, the environment and the pipeline infrastructure.

To address increasing trends of excavation damage to pipelines and to fulfill the requirements of the Transportation Equity Act for the 21st Century, the US Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) undertook a study of damage prevention practices associated with existing one-call notification systems. In 1999, PHMSA published the landmark Common Ground Study of One-call Systems and Damage Prevention Best Practices. Building on the success of the Common Ground Study, PHMSA facilitated the founding of the Common Ground Alliance to provide stewardship to help ensure acceptance and implementation of the damage prevention best practices across the country.

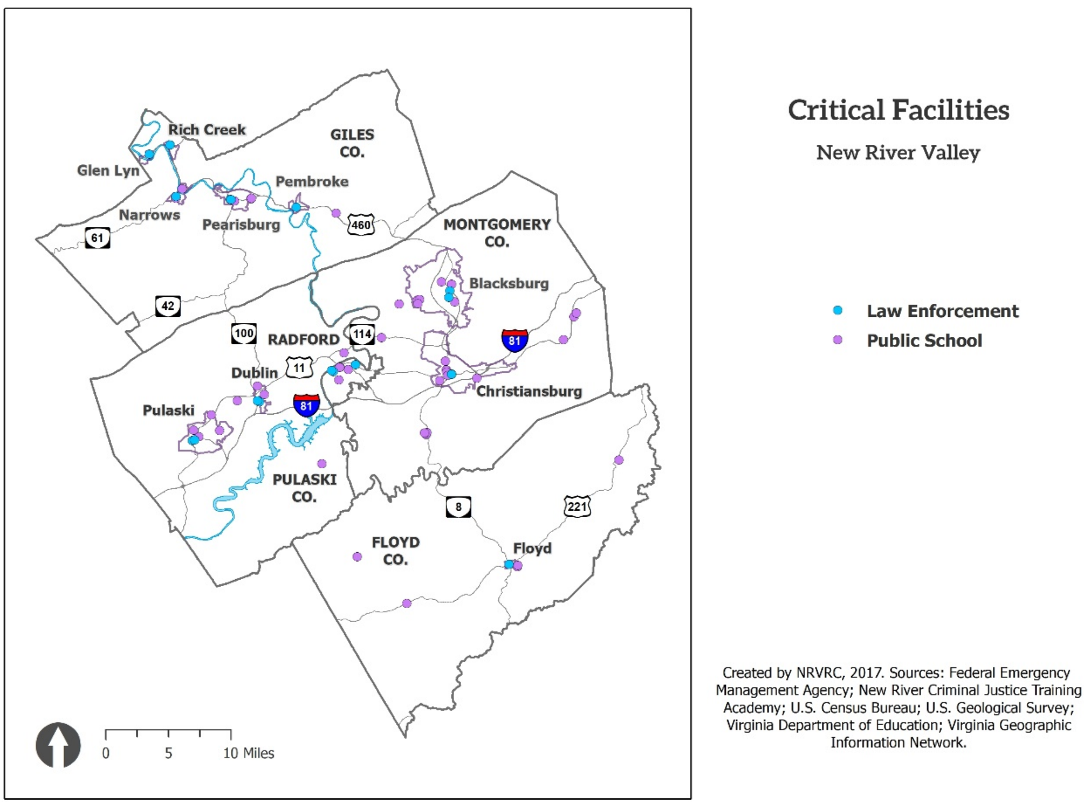
To further address the impact of community growth on pipeline safety, and the requirements of the Pipeline Safety Improvement Act of 2002, the Transportation Research Board (TRB) of the National Academies conducted a comprehensive study of pipeline safety and land use practices to better understand land use planning issues. The results, published in 2004 as TRB Special Report 281, "Transmission Pipelines and Land Use: A Risk-Informed Approach," included several recommendations for PHMSA. To address these recommendations, in August 2007 PHMSA facilitated the establishment of the PIPA.

The Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 reauthorized federal pipeline safety programs and includes 42 mandates the PHMSA is implementing for public safety with respect to the 2.6 million mile pipeline network across the country.

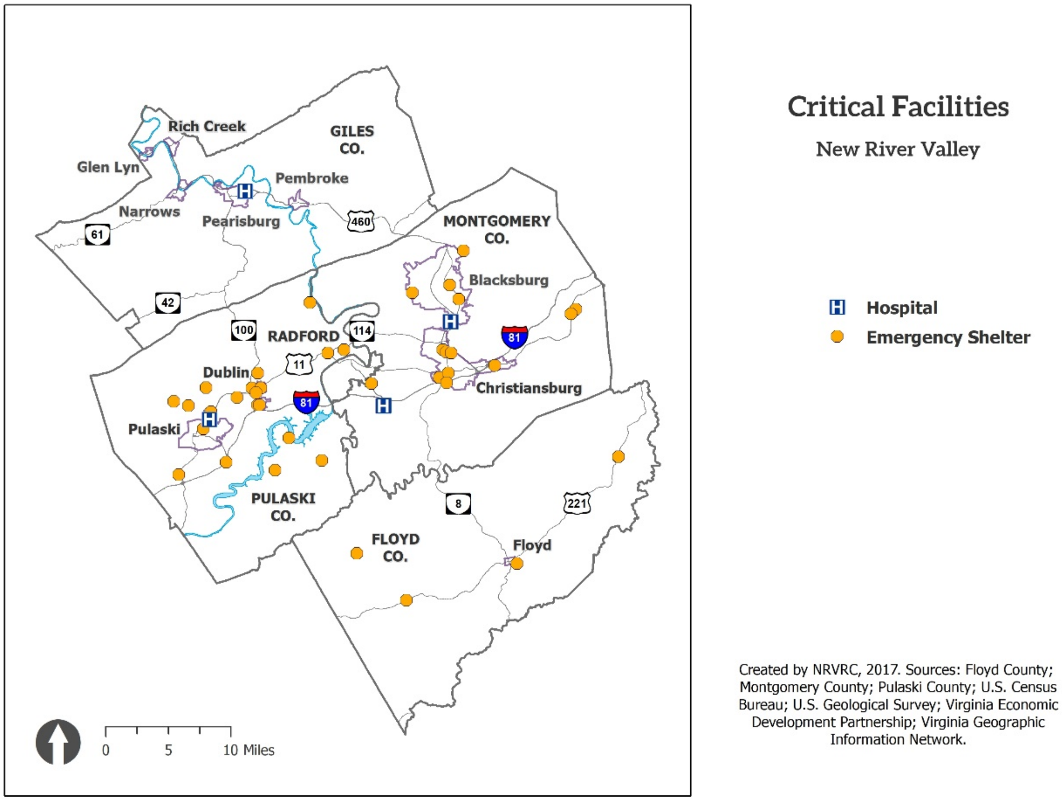
In January 2015, the PHMSA and FEMA released hazard mitigation guidance outlining best practices for reducing a community's risks from pipeline incidents.

Broadband infrastructure is another critical utility that is essential in the proper functioning of numerous community services, including policy and fire, as well as hospitals. Every day, society becomes more reliant upon broadband access to provide critical services to the community, outside individual access to the internet. While there is no publicly available data indicating the location of major fiber transmission lines, this does provide an opportunity for emergency services staff and planners to partner with the private broadband providers to discuss mitigation in the event of natural or human-caused hazard events. Similar to other public utilities, especially water and sewer, it is critical to include broadband providers in planning discussions for future community growth and how to provide critical services to residents.

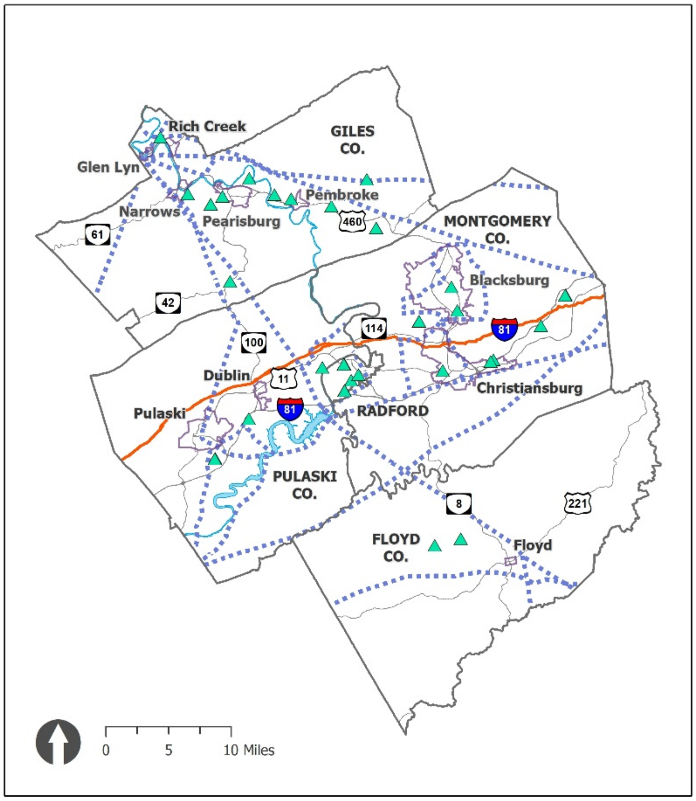
Map 47. Critical Facilities (law enforcement and schools)



Map 48. Critical Facilities (shelters and hospitals)



Map 49. Critical Utilities (power and cell towers)



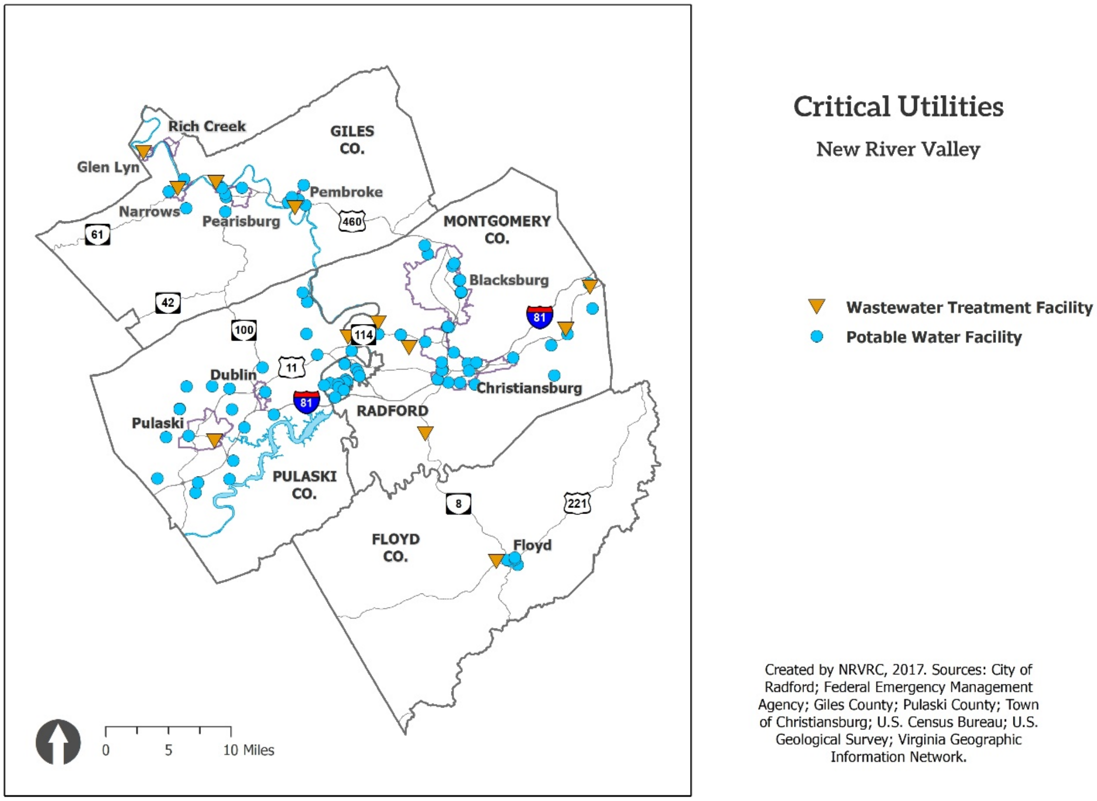
Critical Utilities

New River Valley

- Cell Tower
- Electricity Transmission Line
- Gas Transmission Pipeline

Created by NRVRC, 2017. Sources: City of Radford; Giles County; Esri; U.S. Census Bureau; U.S. Department of Transportation; U.S. Federal Communications Commission; U.S. Geological Survey; Virginia Economic Development Partnership; Virginia Geographic Information Network.

Map 50. Critical Utilities (water and wastewater)



4.8.2.3 Transportation Infrastructure

4.8.2.3.1 Evaluating Potential Hazards

The New River Valley has passenger and freight transportation modes inclusive of roadway, railway and aviation facilities. The region's transportation system is similar to that of many in Appalachia, featuring a variety of rolling topographical rural areas that integrate with a mixture of small urban communities. Typical hazards that may impact the existing transportation infrastructure are flooding, geologic failures, acts of terrorism and severe weather. The majority of the transportation network is located in predominately rural areas.

The region currently facilitates a mixture of passenger and freight traffic north-south by Interstate 81, US Route 11, US Route 221 and VA Primary Route 61 (roadway), Norfolk Southern's Crescent Corridor (railway), and the New River Valley Airport (airway-freight). East-west passenger and freight traffic is facilitated by US Route 460, US Route 8, VA Primary Route

114, VA Primary Route 42 and VA Primary Route 100 (roadway), Norfolk Southern's Heartland Corridor (railway), and the New River Valley Airport (airway-freight).

The future of these corridors includes a vast improvement schedule to advance the freight railway corridors and associated facilities. A passenger rail service as part of the TransDominion Express from Richmond, VA, to Bristol, NC, is also planned. Capacity improvements to Virginia Routes 114, 100 and 8 are planned.

The New River Valley also has mass public transportation fixed routes and on-demand services for several of the local communities. Currently fixed route services are provided in the Towns of Blacksburg, Christiansburg and Dublin and the City of Radford. Currently, on-demand services are provided in the Towns of Pulaski, Dublin, Blacksburg, Christiansburg and City of Radford. There are a limited number of fixed-route connections between Montgomery and Pulaski Counties and the City of Radford primarily serving the higher education population. There is also a multi-jurisdictional, fixed route that links Blacksburg and Christiansburg to Salem and Roanoke.

The future of transit in the New River Valley may include additional connections between Montgomery and Pulaski Counties and the City of Radford. Additionally, Giles and Floyd Counties have expressed interest in exploring rural transit options in the near future. These communities have been identified by the Virginia Department of Rail and Public Transportation as having characteristics to support transit.

4.8.2.3.2 Identifying Critical Roadways

The primary roadway network for the region consists of one interstate which bi-sects the region from north-east to south-west. Interstate 81 provides access to the Towns of Pulaski, Dublin, Christiansburg and the City of Radford. This corridor has been identified as a mobility corridor that will incorporate roadway, railway and airway modes of transportation as part of Virginia's long range plan. This corridor predominately facilitates transportation for passenger and freight traffic between Tennessee and Washington, D.C.

I-81 serves as the region's only freeway which is defined by the Highway Capacity Manual as a divided highway with full control access and two or more lanes for the exclusive use of traffic in each direction. A freeway is the only facility that provides completely uninterrupted traffic flow. Freeways are unique in that there are no signalized or stop-controlled at-grade intersections, and access is limited to ramp locations. All other roadways are classified as rural or suburban 2-4 lane highways that generally have posted speed limits between 25 and 65 mph. These highways generally have signalized intersections at widely spaced intervals, occurring at major junctions that are not grade separated.

Highway critical facilities that are essential to the health and welfare of the whole population and are especially important following hazard events include: I-81, U.S. 460, U.S. 11, U.S. 221, U.S. 219, Virginia 114, Virginia 100, Virginia 8, Virginia 177, Virginia 232, Virginia 99, Virginia 61 and Virginia 42. Each of these facilities provide connectivity to emergency operations, public works facilities, schools, other special needs populations, major employers, financial centers, businesses, high density residential, institutional, industrial areas, as well as historical and natural resource areas. Traffic volume relative to capacity has been estimated and highlighted in Map 51 and Map 52 shows the estimated change in traffic capacity by 2025. A more detailed study should be considered along corridors of particular concern analyzing intersections, driveways, topography and other forms of delay for a more accurate capacity estimate.

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, maneuverability, delay, and safety. The level of service of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst. Map 53 demonstrates current levels of service on the major roads in the region and Map 54 illustrates the forecasted service levels in 2025.

4.8.2.3.3 Identifying Critical Bridges

The average year that critical roadway infrastructure was built in the NRV was 1968 and has an average value of $7,047,150.33. For the purpose of this plan, 95 critical bridges have been identified located along primary corridors and could cause substantial negative impacts following hazard events. The spans of these bridge structures range from 20 feet to nearly 1700 feet in length and provide crossings over waterways and railways and assist in navigating undulated terrain. The total estimated value of roadway bridges is nearly $670 million. It is recommended that 2,000 linear feet (LF) of temporary structure be kept on-hand by a regional authority to provide accessibility to primary corridors that could experience structure loss. Current research shows that there are numerous design alternatives that provide reliable alternatives to loss of structures in critical areas.

4.8.2.3.4 Identifying Critical Railways

The NRV is estimated to have over one million LF (nearly 200 miles) of active Class 1 freight rail track (multiple lines in parallel are accounted for separately), seven tunnels, and numerous bridge and culvert structures. Norfolk Southern is the area's railway operator. The Heartland (east-west) and Crescent (north-south) corridors cross in the center of the NRV. These alignments are major East Coast commodity shipment corridors that play a major role in the movement of goods on a national level. The total estimated value of railroad assets in the region exceeds $600 million. Nearly all railways follow valley bottoms alongside tributaries and steeply carved slopes. Flooding and slope failures are regular hazards for daily operations, but major damages have a ripple effect of delaying the movement of freight.

4.8.2.3.5 Identifying Critical Aviation

The NRV has two aviation facilities that accommodate a range of commodity shipments and private flights. The runway is currently 6,201 by 150 feet. The first is the NRV Airport in Dublin, constructed in 1962. The facility primarily serves general aviation, but is also an official U.S. Customs Service Port of Entry. The airport is estimated to have a net value of approximately $9 million.

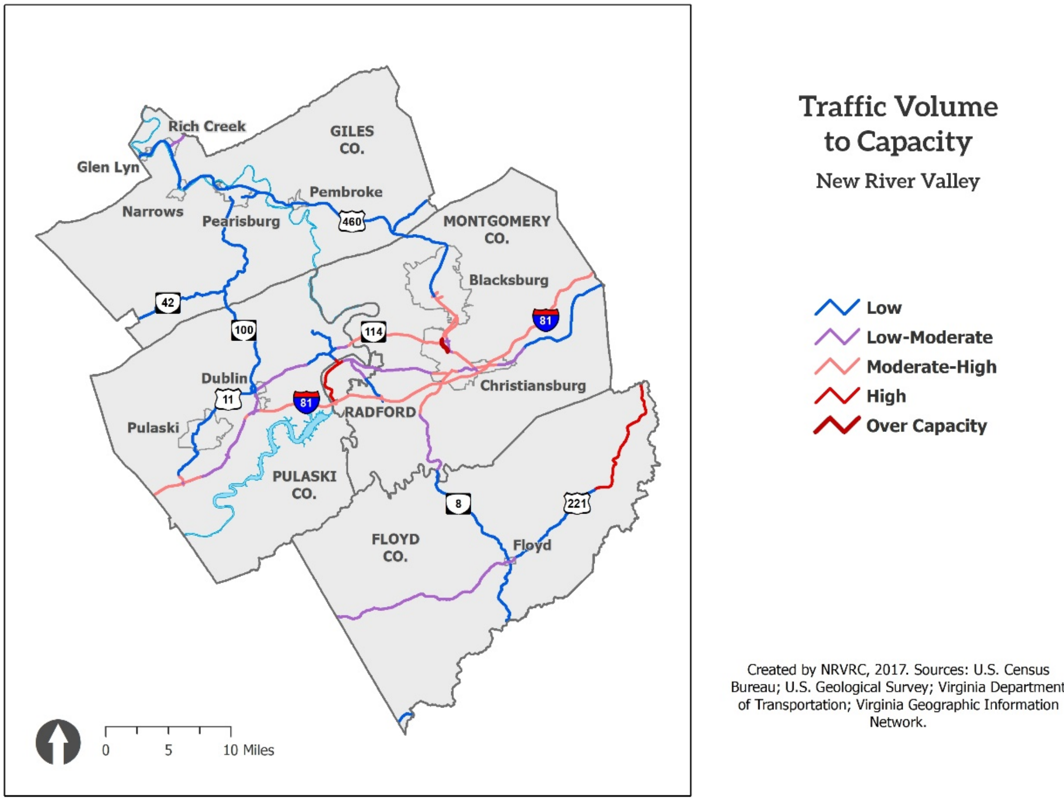
The second airport, Virginia Tech Montgomery Executive Airport was constructed in 1929 and is located on the Virginia Tech campus. The original airport was constructed to accommodate the large aircraft of the time. The facility officially opened in 1931. The purpose of the airport has changed over time from training cadets in the 1940s to primarily serving the community and corporate jets. The runway is currently 4,539 by 100 feet. The Virginia Tech Executive Airport and associated assets are valued at nearly $20 million.

4.8.2.3.6 Identifying Critical Public Transportation Systems

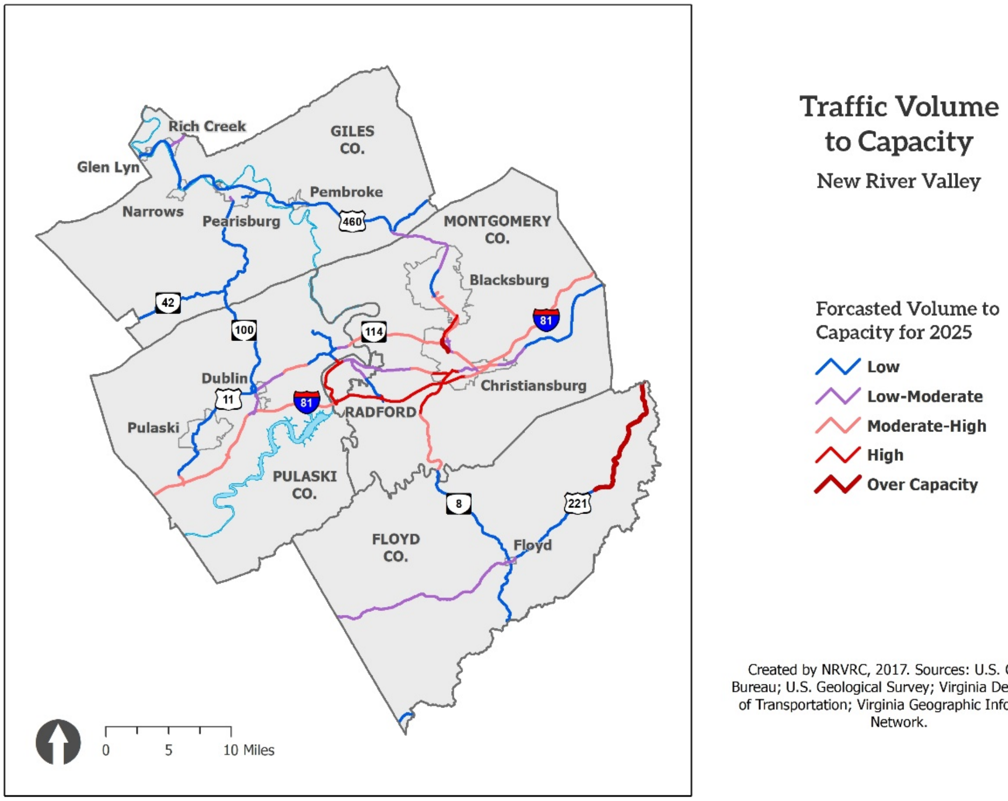
The NRV currently has a mixture of fixed route, paratransit, senior services and on-demand transit services. Transit providers are often used to assist emergency response agencies to evacuate the elderly, low income and persons with disabilities. Currently services are offered within the Counties of Montgomery and Pulaski and the City of Radford. Giles and Floyd Counties currently do not provide transit services. Critical infrastructure for local transit providers includes vehicles, maintenance and office facilities, and local roadway networks. The estimated value for the region’s public transportation assets is over $56 million.

The 2010 U.S. Census shows that 178,237 people live in the New River Valley. Population varies throughout the year because of the two universities in the region. The Town of Blacksburg is home to the Commonwealth’s largest institution, Virginia Tech, which has an enrollment of slightly more than 30,000 students and consists of about 70% of the community’s overall population each year. The City of Radford is home to Radford University which has an enrollment of 9,400 students that more than doubles the community population. The Town of Dublin is home to the New River Community College which has an enrollment of nearly 5,000 commuter students that more than doubles the community’s population any given day of the week. Each of these facilities has varying impacts on the local transportation system. For the purpose of this plan it is important to take into account the additional 45,000 persons that live in the NRV 75% of the year.

Map 51. Traffic Volume to Capacity

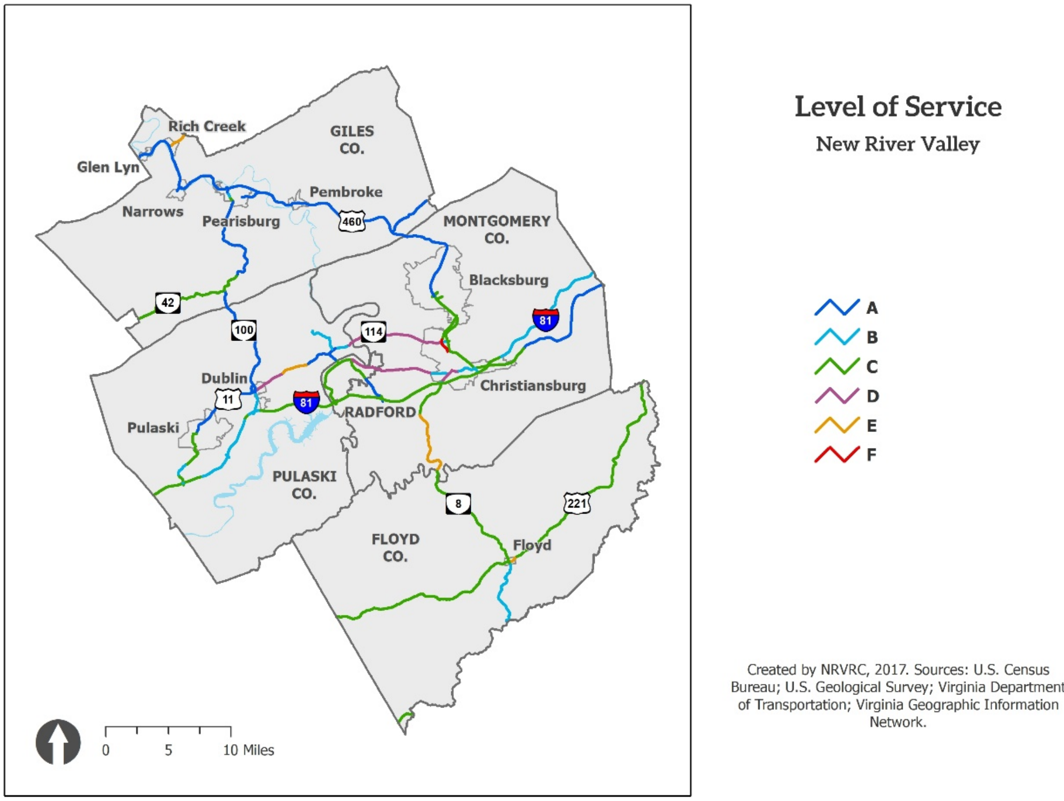


Map 52. Forecasted Traffic Volume to Capacity

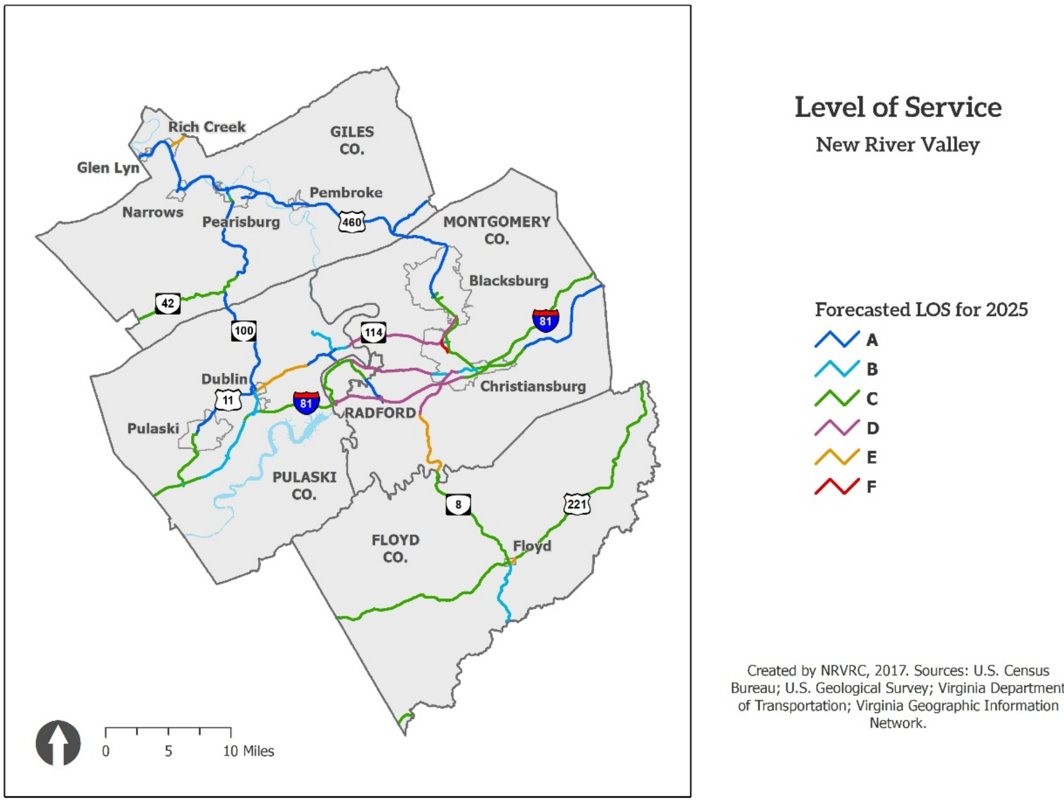


Created by NRVRC, 2017. Sources: U.S. Census Bureau; U.S. Geological Survey; Virginia Department of Transportation; Virginia Geographic Information Network.

Map 53. Level of Service for Principal Travel Corridors



Map 54. Level of Service Forecast for Principal Travel Corridors



4.8.2.4 Risk Assessment

Vulnerability is based on service losses as well as the interruption of service. For the purpose of mitigation planning these transportation assets are critical to emergency operations and accessibility.

In the NRV, there are a total of 95 identified roadway bridges on primary roads with a total linear length of 36,958 feet and an average length of 389 feet. The total estimated value of all identified bridges is $669,479,281 with an average value of $7,047,150 and on average built in 1968. Public transportation assets in the region have a total estimated value of $56 million. There are 10,740 linear feet of aviation runway at two airports in the NRV with a total estimated value of $29,000,000.

Railways are an important component of the transportation infrastructure in the NRV. There is approximately 1,030,000 feet of mainline track and 23,250 feet of sidings and spurs. The total estimated value of railway infrastructure in the NRV is $643,400,000 with the average structure's value being $17,872,222. There are 25 railway bridges in the region with lengths over 100 feet, the average being 280 feet. There is a total of 2,030 feet of bridges of less than 100 feet. Eight tunnels serve the NRV railway system, with an average length of 1,776 feet.

The following tables provide detailed 2010 data from VDOT, DRPT, and local transit agencies about specific and critical transportation assets and their estimated value and average daily use. Map 55 provides a basic illustration of the transportation infrastructure in the region.

Table 4.29. Floyd County Roadway Bridges

Route	Structure Number	Over	Year Built	Length*	Lanes	Width*	ADT**	Estimated Value
8	1001	Dodds Creek	1936	64.94	2	28.86	1807	$749,817.45
8	1002	Dodds Creek	1976	122.02	2	41.98	6788	$2,049,087.90
8	1003	W Fork Little River	1976	137.10	2	41.98	6788	$2,302,469.73
221	1017	W Fork Little River	1939	96.10	2	26.57	3436	$1,021,316.43
221	1019	Dodd Creek	1938	97.48	2	29.99	3436	$1,169,401.04
221	1021	Pine Creek	1938	112.47	2	26.29	2675	$1,182,894.13
221	1022	Little River	1998	320.78	2	37.72	8051	$4,839,988.99
221	1023	Beaverdam Creek	1936	127.92	2	26.57	2675	$1,359,431.42
221	1025	Big Run	1936	64.94	2	32.47	2152	$843,544.63
221	1026	Pine Branch	1936	112.83	2	32.47	2152	$1,465,552.28

** in Linear Feet*
*** ADT = Average Daily Traffic*

Table 4.30. Giles County Roadway Bridges

Route	Structure Number	Over	Year Built	Length (LF)	Lanes	Width (LF)	ADT	Estimated Value
42	1012	Sinking Creek	1941	84.95	2	30.83	1286	$1,047,696.03
61	1023	Dry Branch @ Narrows	1998	30.83	2	28.86	4586	$355,973.94
61	1037	New River & Rte. 460	1952	1266.74	2	46.00	4356	$23,307,942.40
61	1078	Wolf Creek @ Narrows	1963	221.07	2	37.39	2411	$3,306,529.69
61	1079	Wolf Creek	1969	440.83	2	27.22	538	$4,800,484.15
61	1080	Wolf Creek	1969	252.89	2	27.22	538	$2,753,849.16
100	1015	Big Walker Creek	1987	182.04	2	45.92	4262	$3,343,710.72
100	1017	Walker Creek	1977	246.00	2	41.98	2216	$4,131,225.60
100	1042	Walker Creek	1990	362.77	4	87.90	3897	$12,755,503.31
100	1050	Walker Creek @ Bane	1977	246.00	2	41.98	2216	$4,131,225.60
219	1929	Rich Creek	1931	98.07	2	24.93	8979	$977,895.53
219	6215	Rich Creek	1930	129.89	2	47.56	8979	$2,470,989.31
460	1001	NS Rwy/Prvt Ent Celanese	1978	170.89	2	41.98	6304	$2,869,824.72
460	1002	New River & N&W Railway	1978	1317.58	2	41.98	6304	$22,126,844.31
460	1010	New River/ Rt640/Ns Rwy.	2001	1300.00	2	48.87	6304	$25,413,440.00
460	1011	NS Rwy/Prv Ent To Plant	2001	1285.00	2	48.87	6304	$25,120,208.00
460	1019	East River	1986	276.83	2	40.02	4614	$4,431,083.72

Route	Structure Number	Over	Year Built	Length (LF)	Lanes	Width (LF)	ADT	Estimated Value
460	1020	New River	1986	1653.45	2	41.66	4614	$27,550,411.96
460	1021	Rich Creek	1973	118.08	4	92.82	6826	$4,384,263.17
460	1075	Sinking Creek	1977	216.81	2	41.98	4990	$3,640,986.83
460	1076	Stream	1932	5.90	4	85.00	12609	$200,736.00
460	1077	Sinking Creek	1961	220.09	2	33.13	4990	$2,916,430.11
460	1081	East River	1969	274.86	2	46.25	4614	$5,084,764.11
460	1082	New River	1969	1649.51	2	37.06	4614	$24,455,005.11
460	1083	New River/Ns Railway	1974	1272.64	2	38.05	5904	$19,368,562.69
460	1084	New River/Ns Railway	1974	1272.64	2	38.05	5904	$19,368,562.69
460	1085	Rte. 460 Bus	1981	212.87	2	41.66	5904	$3,546,958.41
460	1086	Rte. 460 Bus	1981	212.87	2	41.66	5904	$3,546,958.41

Table 4.31. Montgomery County Roadway Bridges

Route	Structure Number	Over	Year Built	Length (LF)	Lanes	Width (LF)	ADT	Estimated Value
8	1007	Mill Creek	1990	21.98	3	51.82	7359	$455,553.69
8	1902	Little River & Rte. 716	1984	312.91	2	41.98	7359	$5,254,918.96
11	1002	S Fork Roanoke River	1981	211.89	2	41.66	4044	$3,530,562.61
11	1006	S Fork Roanoke River	1926	143.99	2	24.93	3782	$1,435,773.03
11	1027	S Fork Roanoke River	1950	202.05	2	32.14	4044	$2,597,852.36
11	1028	S. Fork Roanoke River	1950	261.09	2	32.14	4044	$3,356,965.07
11	1029	South Fork Roanoke River	1950	259.78	2	32.14	4044	$3,340,095.90
11	1031	S Fork Roanoke River	1952	173.84	2	33.13	3782	$2,303,588.61
81	2004	NS Railway & Rte. 641	1970	173.84	2	41.98	22672	$2,919,399.42
81	2005	NS Rwy, Den Hill Rd/641	1970	165.97	2	41.98	19500	$2,787,200.20
81	2006	NS Railway & Roanoke Rv	1970	345.06	3	56.09	22728	$7,741,400.37
81	2007	NS Railway & Roanoke Rv	1970	326.03	2	43.95	19500	$5,731,903.39
81	2900	New River, Ns Rwy, Rt605	1965	1657.71	2	41.98	14500	$27,838,952.24
81	2901	New River, Ns Rwy, Rt605	1965	1599.66	2	41.98	19455	$26,863,983.00
114	1045	New River	1990	1036.81	2	45.92	7942	$19,044,089.34
114	1046	NS Railway	1990	147.93	2	45.92	7471	$2,717,141.50
114	1092	Rte. 460 Bypass	2003	194.83	4	111.52	13324	$8,691,065.86
177	1062	Rte. I 81	1965	306.02	2	35.10	5274	$4,296,087.32
177	1065	Rte. I 81	1965	306.02	2	35.10	5274	$4,296,087.32
232	1044	Rte. I-81	1965	293.89	2	46.90	6647	$5,513,809.10
460	1032	Toms Creek	1978	18.04	4	85.00	12437	$613,360.00
460	1067	Rte. 723	1969	98.07	2	42.64	15989	$1,672,716.03
460	1068	Rte. 723	1969	98.07	2	42.64	15989	$1,672,716.03
460	1074	Jennelle Rd./Rt642	2002	360.80	2	42.64	17734	$6,153,804.80
460	1075	Rte. 642/ Jennelle Rd.	2002	450.02	2	42.64	17734	$7,675,472.90
460	1086	Ramp C 460 W Bus	2002	369.00	2	42.64	15989	$6,293,664.00

Table 4.32. Pulaski County Roadway Bridges

Route	Structure Number	Over	Year Built	Length (LF)	Lanes	Width (LF)	ADT	Estimated Value
11	1904	New River & Ns Railway	2005	1494.70	3	55.76	13562	$33,337,699.58
11	1905	New River & Ns Railway	2002	1494.70	3	55.76	13562	$33,337,699.58
81	2000	Rtes. 100 & 11	1959	194.83	3	44.94	17071	$3,501,988.30
81	2001	Rtes. 100 & 11	1959	194.83	3	44.94	14500	$3,501,988.30
81	2002	Rt99/Count Pulaski Dr.	1960	246.98	3	45.92	17774	$4,536,602.11
81	2003	Rt99/Count Pulaski Dr.	1960	225.99	2	43.95	14500	$3,973,120.15
81	2004	Peak Creek	1960	371.95	2	42.64	17774	$6,344,013.31
81	2005	Peak Creek	1960	371.95	2	42.64	14500	$6,344,013.31
81	2006	New River Trail St. Park	1960	175.81	2	43.95	17774	$3,090,845.29
81	2007	New River Trail S. P.	1960	175.81	2	43.95	14500	$3,090,845.29
81	2024	Rte. 644_Miller Lane	1965	123.98	2	43.95	17774	$2,179,737.91
81	2025	Rte. 644_Miller Lane	1965	123.98	2	43.95	14500	$2,179,737.91
81	2026	Rte. 611_Newbern Rd.	1965	129.89	2	43.95	17774	$2,283,534.95
81	2027	Rte. 611_Newbern Rd.	1965	125.95	2	43.95	14500	$2,214,336.92
81	2028	Rte. 100	1965	253.87	2	42.31	19215	$4,296,732.83
81	2029	Rte. 100	1965	247.97	2	42.31	14500	$4,196,808.81
81	2030	Rte. 799	1965	136.12	2	43.95	19455	$2,393,098.50
81	2031	Rte. 799	1965	130.87	2	43.95	14500	$2,300,834.46
99	1009	Branch Peak Creek	1960	5.90	4	85.00	6892	$200,736.00
100	1015	Back Creek	1936	127.92	2	30.83	2506	$1,577,611.78
100	1016	Little Walker Creek	2001	275.00	5	89.22	5012	$9,813,760.00
100	1018	Back Creek	1974	140.06	2	41.98	2506	$2,352,044.44
100	1022	Rte. 11 @ Dublin	1950	88.89	2	39.03	2756	$1,387,790.57
100	1024	Ns Railway & Rte. 689	1952	195.82	2	38.05	8943	$2,980,162.87
100	1041	Rte. 11 @ Dublin	1966	86.92	3	46.90	2881	$1,630,758.27
100	1042	Ns Railway & Rte. 689	1966	193.85	2	36.41	8943	$2,823,047.19

Table 4.33. City of Radford Roadway Bridges

Route	Structure Number	Over	Year Built	Length (LF)	Lanes	Width (LF)	ADT	Estimated Value
Univ Blvd	NA	Ns Railway	NA	450.00	4	62.00	NA	$11,160,000.00
11	NA	New River & Railway	NA	1505.00	3	55.00	NA	$33,110,000.00
11	NA	New River & Railway	NA	1525.00	3	55.00	NA	$33,550,000.00
11	NA	Tributary	NA	180.00	2	50.00	4600	$3,600,000.00
11	NA	Tributary	NA	150.00	2	50.00	4600	$3,000,000.00

Table 4.34. NRV Aviation Infrastructure

Asset Description	Year Built	Length (LF)	Strips	Width (LF)	Annual Average Daily Operations
NRV Airport, Dublin, VA	1962	6201	1	150	30
Virginia Tech Airport, Blacksburg, VA	1929	4539	1	100	55

Table 4.35. NRV Railway Infrastructure

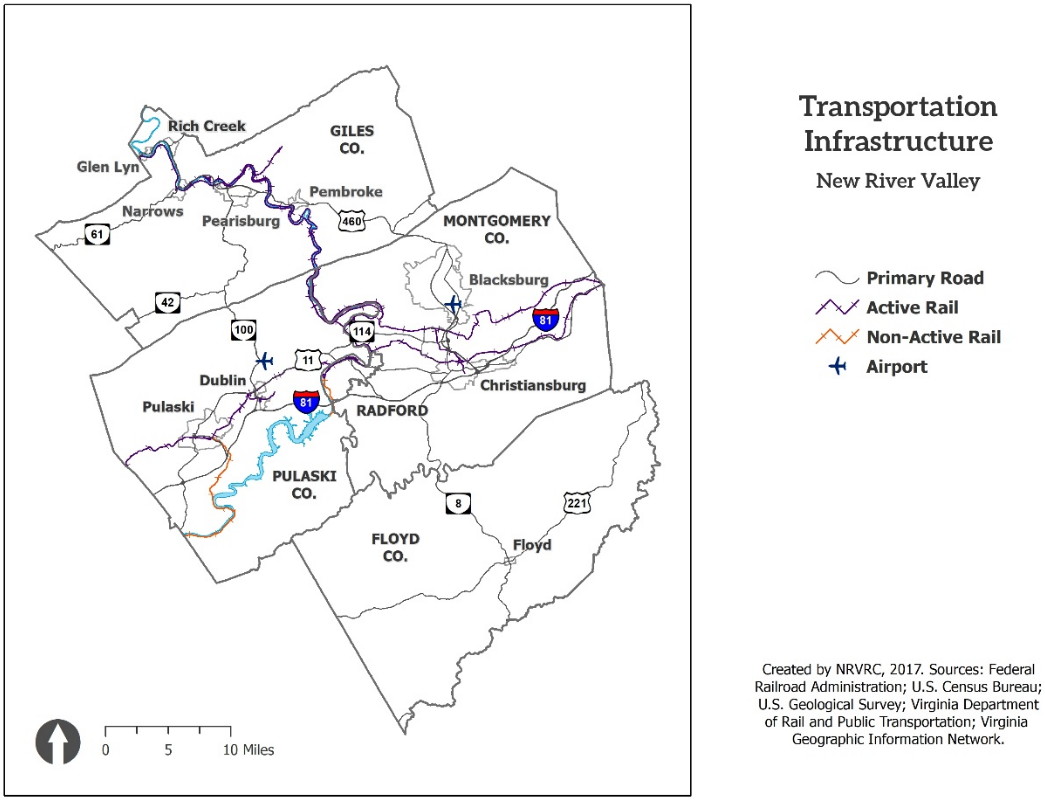
Asset Description	Length (LF)	Lines	Estimated Value
Estimated Norfolk Southern Doublestack Mainline Track	665000	1-3	$232,750,000.00
Estimated Norfolk Southern Mainline Track	365000	1-2	$127,750,000.00
Norfolk Southern Cowan Tunnel	3650	1	$18,250,000.00
Norfolk Southern Tunnel (Giles Co.)	575	1	$2,875,000.00
Norfolk Southern Tunnel (Giles Co. 2)	1285	1	$6,425,000.00
Norfolk Southern Tunnel (Giles Co. 3)	1700	1	$8,500,000.00
Norfolk Southern Tunnel (Montgomery Co./Prices Fork Rd.)	500	1	$2,500,000.00
Norfolk Southern Tunnel (Montgomery Co. Merrimac)	4850	1	$24,250,000.00
Norfolk Southern Tunnel (Montgomery Co.)	750	2	$7,500,000.00
Norfolk Southern Tunnel (Montgomery Co./N Fork Rd.)	900	1	$4,500,000.00
Norfolk Southern Estimated Total of Bridges 100 ft. or less	2030	1	$40,600,000.00
Norfolk Southern Bridge (Giles Co. West of Narrows)	225	2	$9,000,000.00
Norfolk Southern Bridge (Giles Co. Narrows/New River)	1300	1	$26,000,000.00
Norfolk Southern Bridge (Giles Co. Ripplemead/New River)	650	1	$13,000,000.00
Norfolk Southern Bridge (Giles Co.)	325	2	$13,000,000.00
Norfolk Southern Bridge (Giles Co./Pembroke)	135	1	$2,700,000.00
Norfolk Southern Bridge (Pulaski Co. West of RAAP)	150	1	$3,000,000.00
Norfolk Southern Bridge (Pulaski Co. South of Gatewood Reservoir)	215	1	$4,300,000.00
Norfolk Southern Bridge (Pulaski Co. East of Hogan Lake)	125	1	$2,500,000.00
Norfolk Southern Bridge (Pulaski Co. East of Hogan Lake 2)	180	1	$3,600,000.00
Norfolk Southern Bridge (Pulaski Co. West of Town)	175	1	$3,500,000.00
Norfolk Southern Bridge (Pulaski Co. West of Town 2)	200	1	$4,000,000.00
Norfolk Southern Bridge (Pulaski Co. West of Town 2)	180	1	$3,600,000.00
Norfolk Southern Bridge (Town of Pulaski)	140	1	$2,800,000.00
Norfolk Southern Bridge (Town of Pulaski 2)	150	1	$3,000,000.00
Norfolk Southern Bridge (Town of Pulaski 3)	150	1	$3,000,000.00
Norfolk Southern Bridge (City of Radford)	960	1	$19,200,000.00
Norfolk Southern Bridge (Montgomery Co./East of Christiansburg)	120	1	$2,400,000.00

Asset Description	Length (LF)	Lines	Estimated Value
Norfolk Southern Bridge (Montgomery Co./East of Christiansburg 2)	200	1	$4,000,000.00
Norfolk Southern Bridge (Montgomery Co./N Fork Road)	215	1	$4,300,000.00
Norfolk Southern Bridge (Montgomery Co./North of Elliston)	150	1	$3,000,000.00
Norfolk Southern Bridge (Montgomery Co./North of Elliston 2)	125	1	$2,500,000.00
Norfolk Southern Bridge (Montgomery Co./North of Elliston 3)	125	1	$2,500,000.00
Norfolk Southern Bridge (Montgomery Co./West of Elliston)	415	2	$16,600,000.00
Norfolk Southern Bridge (Montgomery Co./West of Elliston 2)	185	2	$7,400,000.00
Norfolk Southern Bridge (Montgomery Co./Elliston)	215	2	$8,600,000.00

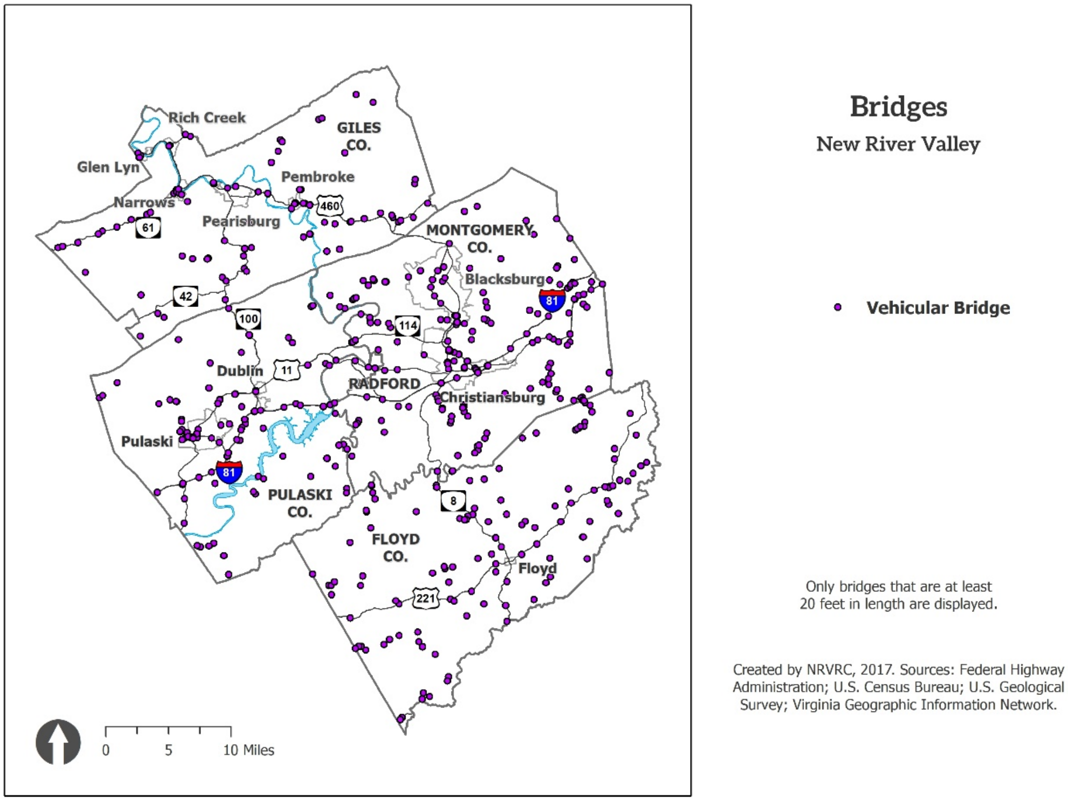
Table 4.36. NRV Public Transportation Assets

Asset Description	Annual Passengers	Estimated Value
Blacksburg Transit Vehicles and Facilities	3,513,538	$35,150,470
Community Transit Vehicles and Facilities	25,172	$1,255,000
Pulaski Area Transit Vehicles and Facilities	133,696	$781,000
Smart Way Vehicles	60,000	$1,5000,000
Radford Transit Vehicles and Facilities	330,848	$3,910,000

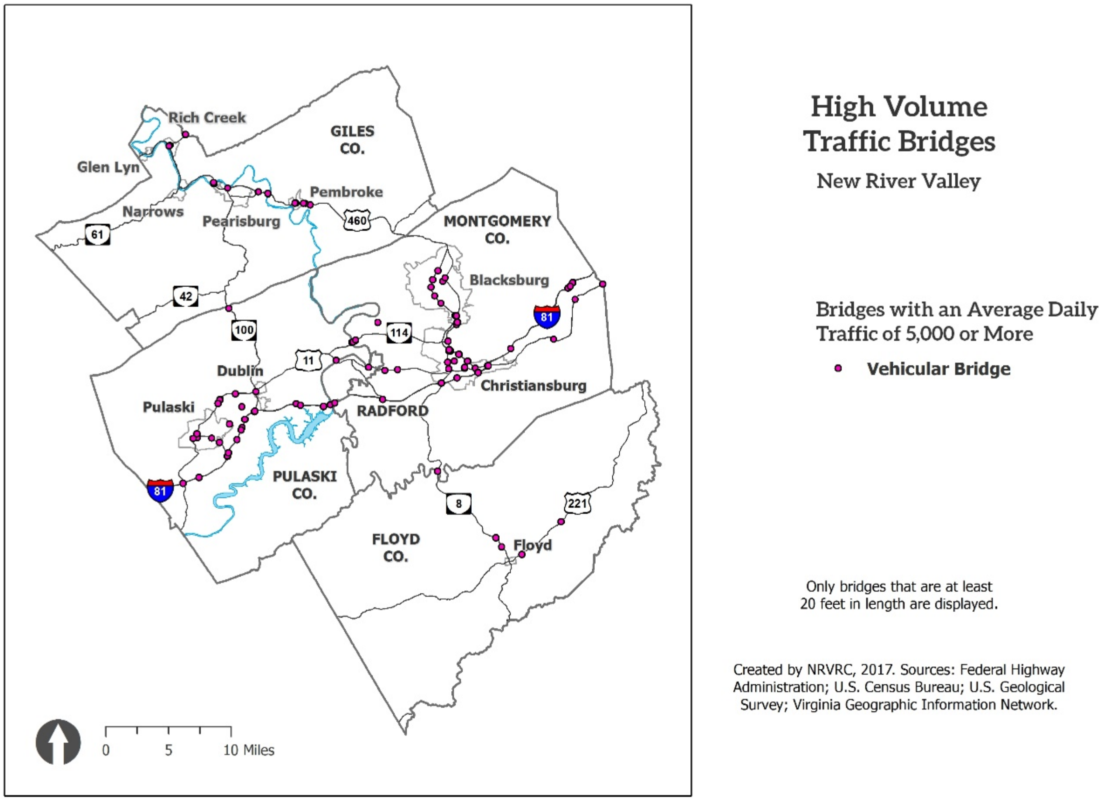
Map 55. Transportation Infrastructure



Map 56. Traffic Bridges in the NRV



Map 57. High Volume Traffic Bridges



4.8.2.5 Vulnerable Populations

For the purposes of this plan, vulnerable populations are generally defined as persons with either short-term or long-term disabilities and elderly persons. These populations may be particularly susceptible to the impacts of hazard events and have very specific needs in the event of a hazard event. To begin evaluating those specific needs, the NRVRC attended and led a facilitated discussion with the region's Disability Services Board (DSB). The DSB provides input to state and local agencies on service needs and priorities of persons with physical and sensory disabilities, to provide information and resource referral to local governments regarding the Americans with Disabilities Act and to provide such other assistance and advice to local governments as may be requested. The DSB is comprised of individuals representing businesses, consumers, each locality and liaisons. A primary activity of the DSB is to conduct a region-wide needs assessment focused on the disabled population, from transportation and housing to services.

During this facilitated discussion, the group identified numerous needs of these communities and how those needs could be addressed. The two main themes emerging from this discussion were that communication is a critically unaddressed issue, as well as the need for access to resources and supplies during a hazard event.

Communication during a hazard event, whether natural or human-caused, is critical in the mitigation of negative impacts in vulnerable populations. This communication must be two-way, both from the authorities to the population in a way that they can access the information, as well as from the population to the authorities to express their needs. As the group identified this need, it became evident that there is a fine line to be balanced between identifying vulnerable populations and not violating their right to privacy. To prevent many of the potentially negative impacts of hazard events, it is critical for government agencies and service providers to conduct outreach and provide persons within these populations the opportunity to self-identify themselves. Maintaining a database of these individuals should assist authorities in providing the necessary assistance to those who want it. A self-maintained database of the location and needs of permanently disabled or elderly persons should be adequate, but additional staff support at either a government agency or other service provider may be necessary to keep track of the self-reported individuals with short-term disabilities or needs.

Communication during a hazard event is also critical to ensure that vulnerable populations are aware of the situation and what they need to do to maintain their personal safety. Typically, notifications are sent to the general public through crawlers on TV screens or announcements on radio stations. The crawlers are not sufficient for the visually impaired or those with cognitive disabilities that limit their ability to read the information provided. This communication also needs to be in multiple forms, beyond TV, radio and the internet to be sure that the necessary information is reaching all the concerned individuals. Some alternative communications methods, especially for critical situations, include door-to-door notifications as well as working with church groups to get information distributed. Reverse 911 with an option to receive a text message would enable a good portion of these vulnerable populations to receive notifications.

Access to resources and supplies can be critical for vulnerable populations during a hazard event. Many times these individuals rely on specific medical devices and/or medications that may be difficult to access or transport in emergency situations. It is important for both emergency sheltering authorities and individuals to identify where to obtain necessary equipment and/or medications prior to an emergency or to identify a storage location if the resource can be stored for periods of time. The group emphasized the need to individuals with disabilities to create and maintain their own personalized "To Go" kit, and possibly a back-up kit, with all necessary medications and equipment. A suggested strategy to further this idea was to propose training sessions at agencies and service providers for individuals on how to create and maintain their own kit. One idea for ensuring that all necessary equipment and medications are available to disabled populations is to shelter these individuals directly in hospitals or other care facilities during emergency events.

In addition to these resources, access to transportation is critical for many in the disabled population. For evacuation situations, it is necessary that all regional authorities know what accessible vehicles are available and where they are to provide a means for evacuation for disabled populations. The group identified the need to establish community locations for evacuation pick-up that are available for disabled persons and would facilitate their timely egress from a potentially dangerous situation.

A primary strategy identified to help address these identified needs was to increase outreach by government agencies and other service providers to these vulnerable populations that may not be currently receiving aid or assistance. Providing a workshop with clients at agencies and working directly with clients will create an awareness of how to respond in time and promote readiness within the vulnerable populations.

4.8.2.5.1 Mitigation Opportunities

A complete listing of NRV hazard mitigation goals, objectives, and strategies can be found in Chapter 5: Mitigation Strategy. Because so little information is available on human-caused hazards and is a relatively new hazard being considered, the Steering Committee developed a mitigation goal. The Steering Committee elected to delay developing specific objectives and strategies until the next revision of this plan.

Goal: Support existing efforts in addressing potential impacts of future human-caused events.

a) Develop information on man-made hazards that impact human health and quality of life, e.g., air, water and soil quality in the NRV.
b) Encourage the development and coordination of a regional evacuation plan.
c) Encourage the development of added capacity to regional communication systems.
d) Support furthering regional response efforts.