4.8 Severe Winter Storm

4.8.1 Hazard Profile

A severe winter storm is a prolonged storm event in which the varieties of precipitation are formed that only occur at low temperatures, such as snow or sleet, or a rainstorm where ground temperatures are low enough to allow ice to form (*i.e.* freezing rain). The characteristics of severe winter storms are determined by the amount and extent of snow or ice, air temperature, wind, and event duration (National Weather Service, 2009).

The common types of winter precipitation are snow, sleet, and freezing rain. [49]

- **Snow** is precipitation in the form of ice crystals, mainly of intricately branched, hexagonal form and often agglomerated into snowflakes, formed directly from the freezing of the water vapor in the air. There are different types of snow precipitation, including *snow showers*, *snow squalls*, and *blizzards*. Snow storms can amount to light flurries to blizzards with blinding wind driven snow. Blizzards are a combination of blowing snow and wind resulting in very low visibilities. While heavy snowfalls and severe cold often accompany blizzards, this is not always the case. Sometimes strong winds pick up snow that has already fallen, creating a ground blizzard.
- **Sleet** is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes before reaching the ground. It usually bounces when hitting a surface and does not stick to objects; however, sleet can accumulate like snow and cause a hazard to motorists.
- **Freezing rain** is precipitation that falls as rain, but freezes on contact with the surface, forming a glaze of ice. A significant accumulation of freezing rain lasting several hours or more is called an ice storm. Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

4.8.1.1 Geographic Location/ Extent

A winter storm is a combination of heavy snow, blowing snow, and/or dangerous wind chills. Winter weather generally impacts Virginia between the months of November and April, with varied intensities from east to west.

The CVPDC area's maximum 1-day snowfall of 21.8 inches on March 6, 1962 was recorded by Pedlar River Dam weather station in Amherst County. Table 4-126 lists the 1-, 2-, and 3-day snowfall maximums from each county in the region.

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[49] https://www.nssl.noaa.gov/education/svrwx101/winter/types/

Table 4-126 Snowfall extremes in the CVPDC area

Locality	1-Day Extremes		2-Day Extremes		3-Day Extremes	
	Value	Date	Value	Date	Value	Date
Amherst County	21.8	1962/03/06	25.3	1962/03/06	28.3	1962/03/07
Appomattox County	18	1996/01/07	30	1996/01/07	30	1996/01/07
Bedford County	18	1996/01/07	25	1996/01/08	25	1996/01/09
Campbell County	16.4	1922/01/27	23	1987/01/23	23	1987/01/23
Lynchburg City	16.4	1922/01/27	21.4	1996/01/08	21.4	1996/01/08

(1-, 2-, and 3-day snowfall maximums from each county. Values are in inches. Data were last updated on October 22, 2018 to accommodate data through June 30, 2018.) [50]

4.8.1.2 Magnitude/ Severity

The National Weather Service developed the *Northeast Snowfall Impact Scale* (NESIS) to characterize and rank high-impact snowstorms that impact the northeast corridor (Kocin and Uccellini, 2004) (Figure 4-114). NESIS provides a relative measure of Northeast winter storm impact based on total snowfall amount, its geographic distribution, and population density. The scale was developed because of the economic and transportation impact Northeast snowstorms can have on the rest of the country. The NESIS has five categories, ranging from Notable to Extreme (Table 4-127), and is frequently used to describe snowstorms with large areas of 10 inch snowfall accumulations. The index is unique in that it uses population information as well as meteorological measurements, which results in an indication of a storm's societal impacts.

The National Climatic Data Center (NCDC) computes NESIS values when a significant snowstorm hits the 13-state Northeast region—defined as West Virginia, Virginia, and northeastward through New York and the New England states. To capture the entire storm history, NESIS values are computed using total snowfall distributed east of the Rocky Mountains. The CVPDC area is part of the Northeast urban corridor and is therefore included in the NESIS ranking system. Please see Squires and Lawrimore (2006) for more information.

Table 4-127 NESIS Categories and Corresponding Value.

Category	NESIS Value	Descriptions
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

(Source: NOAA)

The NESIS scale was calibrated based on an analysis of thirty Northeast snowstorms that occurred from 1956 to 2000, using the average area covered by at least 10 inches or more of snowfall accumulation and the average population (as of the 2000 census) within the affected area. The mean NESIS value for these calibration events is 5.0 (Category 3). Table 4-128 shows the top ten most severe storms on record are ranked by NESIS value.

[50] https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/VA/1

The highest snow storm impact that affected the Northeast urban corridor was recorded on March 12-14, 1993 (Figure 4-115).

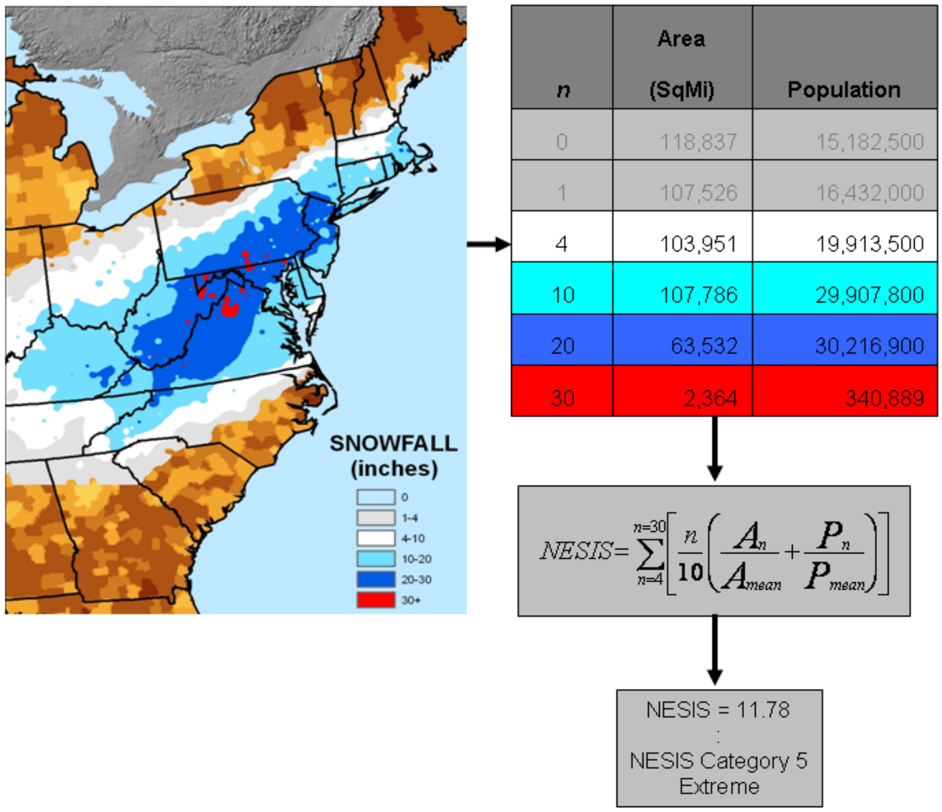


Figure 4-114 North Eastern Snowfall Impact Scale (NESIS)

Table 4-128 Ten highest-impact snowstorms that affected the Northeast urban corridor, ranked by severity

Rank	Start	End	NESIS	Category	Description
1	3/12/1993	3/14/1993	13.20	5	Extreme
2	1/6/1996	1/8/1996	11.78	5	Extreme
3	2/3/1960	3/5/1960	8.77	4	Crippling
4	1/22/2016	1/24/016	7.66	4	Crippling
5	2/15/2003	2/18/2003	7.50	4	Crippling
6	2/2/1961	2/5/1961	7.06	4	Crippling
7	1/11/1964	1/14/1964	6.91	4	Crippling
8	1/21/2005	1/24/2005	6.80	4	Crippling
9	1/19/1978	1/21/1978	6.53	4	Crippling
10	12/25/1969	12/28/1969	6.29	4	Crippling

(Source: NOAA) [51]

[51] https://www.ncdc.noaa.gov/snow-and-ice/rsi/nesis

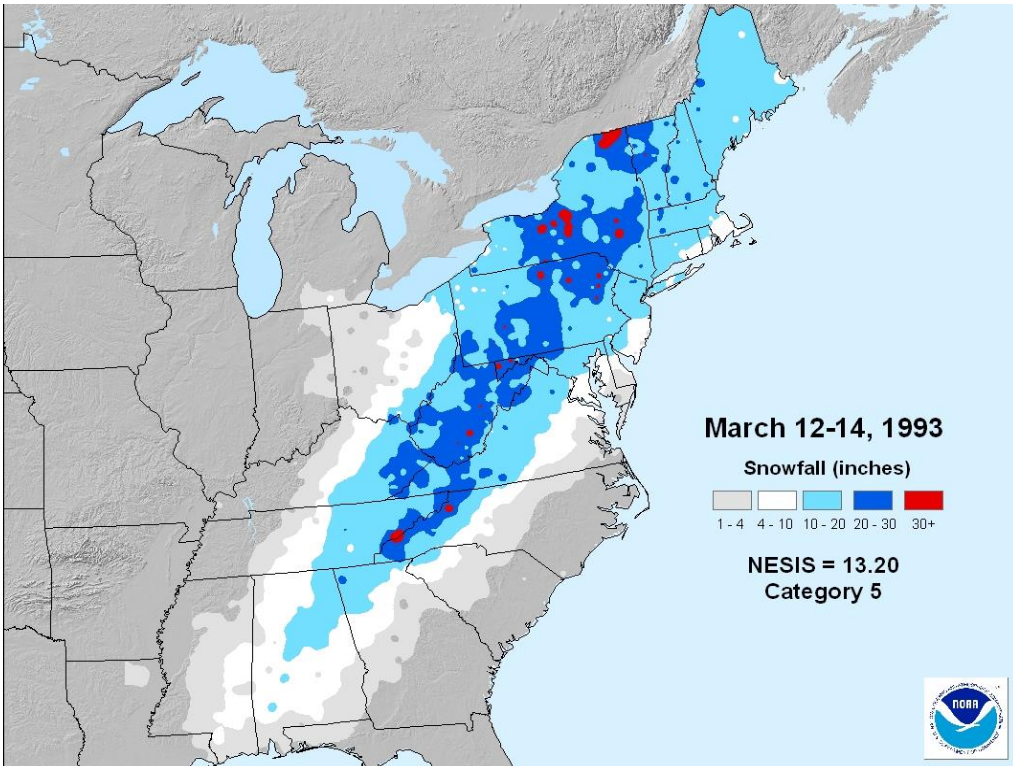


Figure 4-115 The Highest Impact Snow Storms that Affected the Northeast Urban Corridor, March 12-14, 1993

4.8.1.3 Previous Occurrences

The hazard history of major winter storm events that have occurred in the CVPDC area can be found in Appendix H: Hazard Events. Events have been broken down by the date of occurrence and, when available, by individual community descriptions. A large percentage of the region's federal declared disasters were due to severe winter weather. When no community specific description is available, the general description should be used as representing the entire planning area.

4.8.1.4 1.5 Relationship to Other Hazards

Figure 4-116 shows the interrelationship (causation, concurrence, *etc.*) between this hazard and other hazards discussed in this plan update.

4.8.2 Impact and Vulnerability

Heavy snowfall, ice storms, and extreme cold can immobilize an entire region. Areas that normally experience mild winters can experience a major snowstorm or extreme cold. The four characteristics of a winter storm that occur separately or together are snow, wind, ice, and cold temperatures.

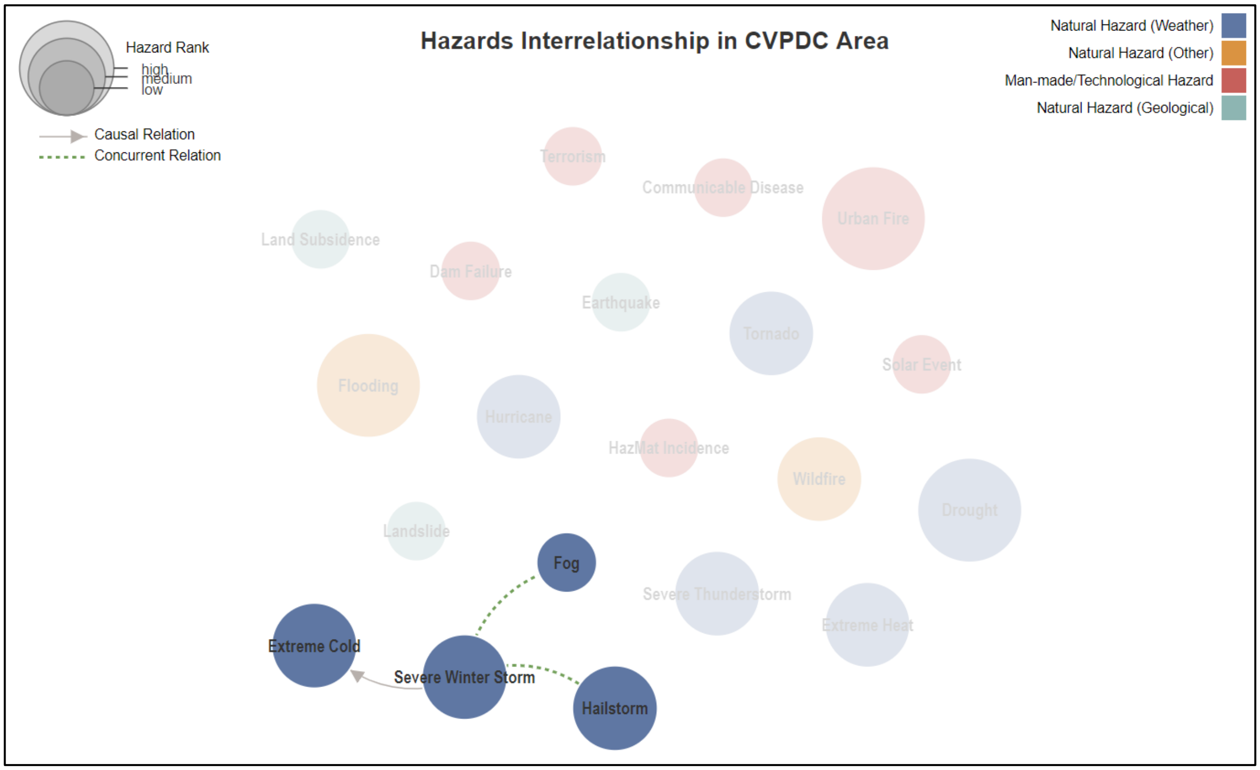


Figure 4-116 Hazards interrelationship

Biggest threats to the public:

- Critical facilities: loss of utilities due to power outages
- Transportation: icing conditions, vehicle crash, road blockage, and highway closure
- Property damage

The most notable impact from winter storms is the damage to power distribution networks and utilities. Ice storms pose particular danger, as the weight of the ice can knock down power lines and weaken telephone poles. The impacts of winter storms are minimal in terms of property damage and long-term effects. Power outages during the winter months can be dangerous if residents do not have an alternate heat source. Homes and businesses suffer damage when electric service is interrupted for long periods of time. Excessive snowfall can lead to roof collapses if roofs are not cleared of snow. As snow melts, an ice dam (a buildup of ice that typically forms along the eaves) prevents snow melt from flowing into the gutters and can eventually cause major damage to the roof and water leaks to the interior of homes.

Severe winter storms have the potential to inhibit normal functions of the community. Governmental costs for this type of event are a result of the needed personnel and equipment for clearing streets. Private sector losses are attributed to lost work when employees are unable to travel. All types of winter storms contribute to hazardous travel conditions, especially freezing rain, which is the most treacherous.

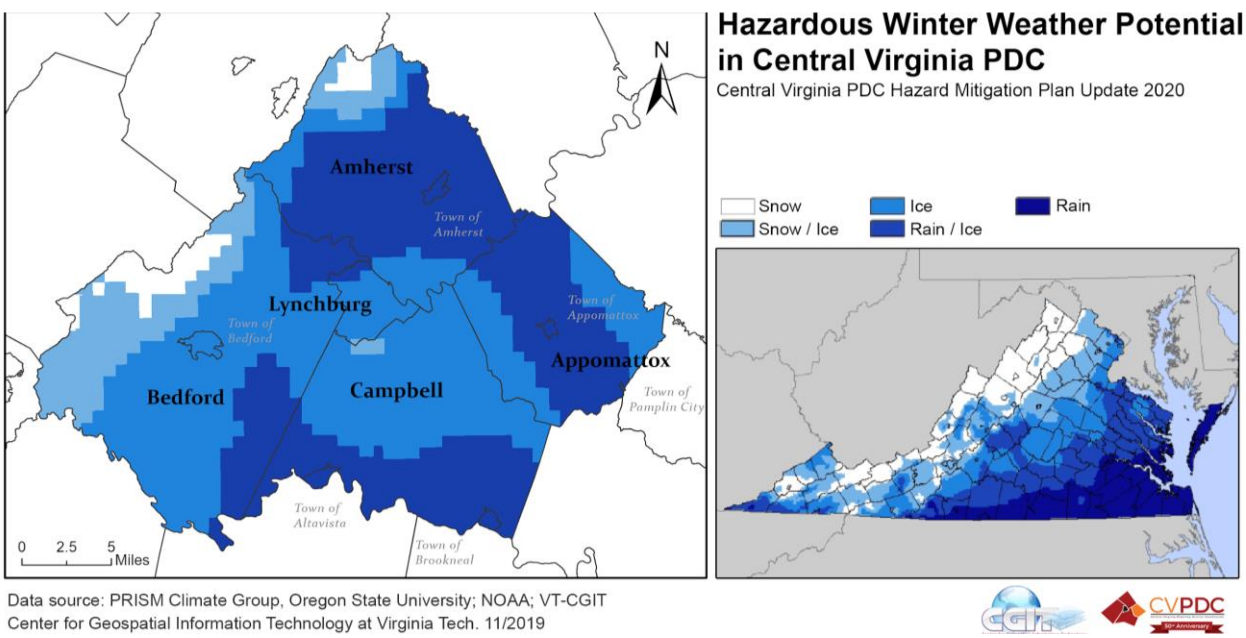
Health threats can become severe when frozen precipitation makes roadways and walkways very slippery, due to prolonged power outages, and if fuel supplies are jeopardized. Occasionally, buildings may be damaged when snow loads exceed the design capacity of their roofs or when trees fall due to excessive ice accumulation on branches.

Another challenge with winter weather in Virginia and in the region is the amount of ice that often comes as part of winter weather. Snowfall and ice potential are generated based on the percentage difference between the total precipitation from November to April and the corresponding liquid equivalent snowfall depth. Since snow falls in a frozen state, it does not accumulate on the surface the same way as rainfall would. In order to account for this difference, there are characteristic snow/rain relationships that have been created.

For example, a value of 1 would mean that all of the precipitation at the location falls as liquid rainfall, and a value of 0.5 would mean that half of the precipitation falls as liquid rainfall and half falls as frozen precipitation. It is assumed that the lower the percentage, the greater potential that precipitation within these months is falling as snow. The values in the middle of the two extremes would represent regions that favor ice conditions over rain and snow. A five quintile distribution was applied to the output statewide grid to split the percentages into five characteristic climatological winter weather categories (snow, snow/ice, ice, rain/ice, and rain). (Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-117 shows the statewide map of the CVPDC area for likelihood of future occurrences. The planning team agreed that these maps accurately depicted the level of risk of future events for their respective localities. The trend of ice potential in Virginia is highest in the area between the eastern edge of the Blue Ridge Mountains and the Piedmont Plateau, since it usually snows in the mountains and rains on the coast. (Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-117 illustrates, the mountains in Amherst and Bedford Counties get a majority of the snow, while the southeast portion of the region receives a winter sleet mix.



(Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-117 Hazardous Winter Weather Potential Based on LEQ Precipitation in CVPDC Area

4.8.3 Risk Assessment and Jurisdictional Analysis

4.8.3.1 Snowfall and Ice Risks

The maps for the ice and snowfall risks from the previous Hazard Mitigation Plan are still viable. There has been no increasing or decreasing trend in snowfall amounts since the original plan was passed.(Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-117 illustrates the overall winter weather and ice potential for the region. Figure 4-118 and Figure 4-119 show the relative risk or vulnerability based on these previous maps. These were developed by assigning a high risk to those census blocks within the regions with the greatest potential for snowy days (> 1 in of snow) or ice. Division into high, medium, and low were based on the levels predicted from potential maps. Table 4-129 and Table 4-130 show the population (from 2010 Census) in each locality impacted by the overall snowfall and ice risks.

Note that Table 4-129 and Table 4-130 indicate the town populations impacted; the county totals include the populations of the towns. Future revisions of this plan will need to develop a method to calculate the potential loss from these winter storms. Areas of high susceptibility for snowfall (Figure 4-118) are centralized around the foothills of the Blue Ridge Mountains, with the highest snowfall risk around the Peaks of Otter in Bedford County. Relative ice potential (Figure 4-119) for the region has a slightly different trend of potential risk. The northern portion of Amherst County follows a similar pattern as the snowfall risk. There is a band of high ice potential starting in Lynchburg City south into the majority of Campbell County and a southwest band of ice risk in Bedford County.

The winter weather mapping resolution does not support town based analysis, since most towns in the CVPDC area would be represented by one or two pixels at this resolution. As weather data has better spatial resolution in the future, the ability to create practical town based analysis will be improved. While Table 4-129 and Table 4-130 show town based vulnerability, the analysis method was designed to derive broad regional vulnerability comparisons, not pinpoint location comparisons. Also, the nature of winter storm preparedness and impact cannot be represented with snow or ice potential maps. Even though Bedford County may receive more snow than other localities, the county may have more VDOT and power company resources prepared to address winter weather than other communities.

The northern portion of Bedford County has the highest relative snowfall risk for the region. Relative ice risk for the region is scattered in each of the localities, with high potential being in the northern portion of Amherst County, Lynchburg City, northern Campbell County, and southeast Bedford County.

4.8.3.2 Steep Slopes

Lack of extensive GIS data throughout the region limited any other additional winter storm vulnerability assessment except in Lynchburg. The Lynchburg City GIS department was able to provide detailed streets and terrain data that could be used to identify streets that would be of a higher risk during ice storm events. A GIS analysis was performed to identify streets throughout with slopes greater than 15%, which would have vehicle traction issues during ice storms. Table 4-132 and Figure 4-120 illustrate selected roadways in the City of Lynchburg that have a slope greater than 15%. These areas should be identified as having a higher potential for accidents. The eastern portion of the city has several roads with a slope greater than 15%.

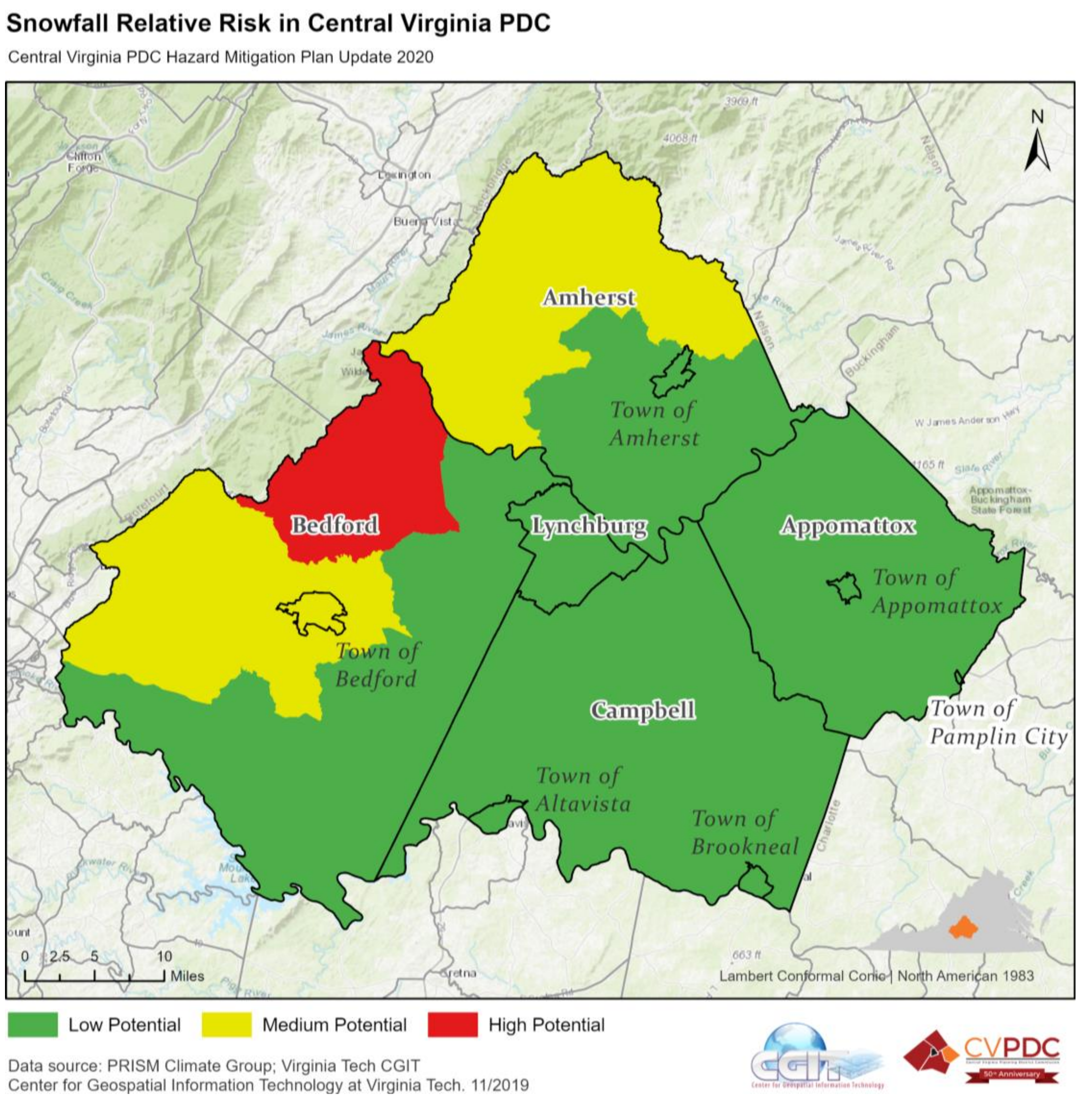


Figure 4-118 Snowfall Relative Risk in CVPDC Area

Table 4-129 Population in Snowfall Relative Risk in CVPDC Area

Community	Low	Medium	High	Total
Amherst County	27,065	5,288	-	32,353
*Town of Amherst	2,231	-	-	2,231
Appomattox County	14,973	-	-	14,973
*Town of Appomattox	1,733	-	-	1,733
*Town of Pamplin City	219	-	-	219
Bedford County	46,558	24,601	3,739	74,898
*Town of Bedford	-	6,222	-	6,222
Campbell County	54,842	-	-	54,842
*Town of Altavista	3,450		-	3,450
*Town of Brookneal	1,112		-	1,112

Community	Low	Medium	High	Total
Lynchburg City	75,568		-	75,568
Total	**227,751**	**36,111**	**3,739**	**267,601**

*(*denotes town values that are also included in the totals for the perspective county.)*

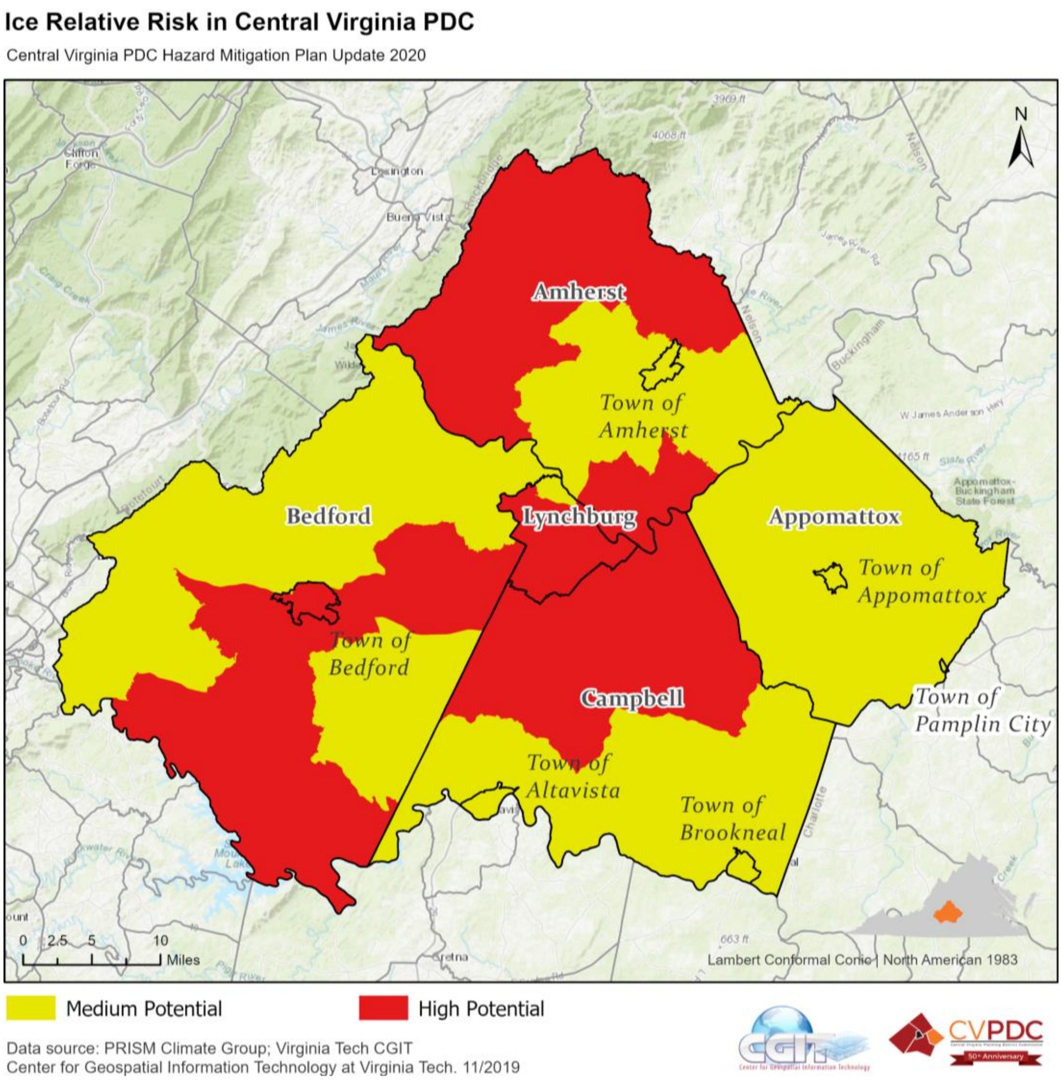


Figure 4-119 Ice Relative Risk in CVPDC Area

Table 4-130 Population in Ice Relative Risk in CVPDC Area

Community	Low	Medium	High	Total
Amherst County	-	14,090	18,263	32,353
**Town of Amherst*	-	2,231	-	2,231
Appomattox County	-	14,973	-	14,973
**Town of Appomattox*	-	1,733	-	1,733
**Town of Pamplin City*	-	219	-	219
Bedford County	-	31,227	43,671	74,898
**Town of Bedford*	-	-	6,222	6,222
Campbell County	-	14,608	40,234	54,842

Community	Low	Medium	High	Total
**Town of Altavista*	-	3,450	-	3,450
**Town of Brookneal*	-	1,112	-	1,112
Lynchburg City	-	4,490	71,078	75,568
Total	**-**	**88,133**	**179,468**	**267,601**

*(*denotes town values that are also included in the totals for the perspective county.)*

Table 4-131 Winter Weather Events Occurring during January 2000 and June 2018

	Winter Storm	Blizzard	Frost/ Freeze	Ice Storm	Winter Storm	Heavy Snow	Winter Weather
Amherst County	23	1	15	10	23	15	18
Appomattox County	15	0	3	7	15	14	1
Bedford County	0	0	6	11	17	14	7
Campbell County	20	0	7	5	18	10	2
Lynchburg City	2	0	0	2	2	3	0

(Source: NOAA Storm Event Database)

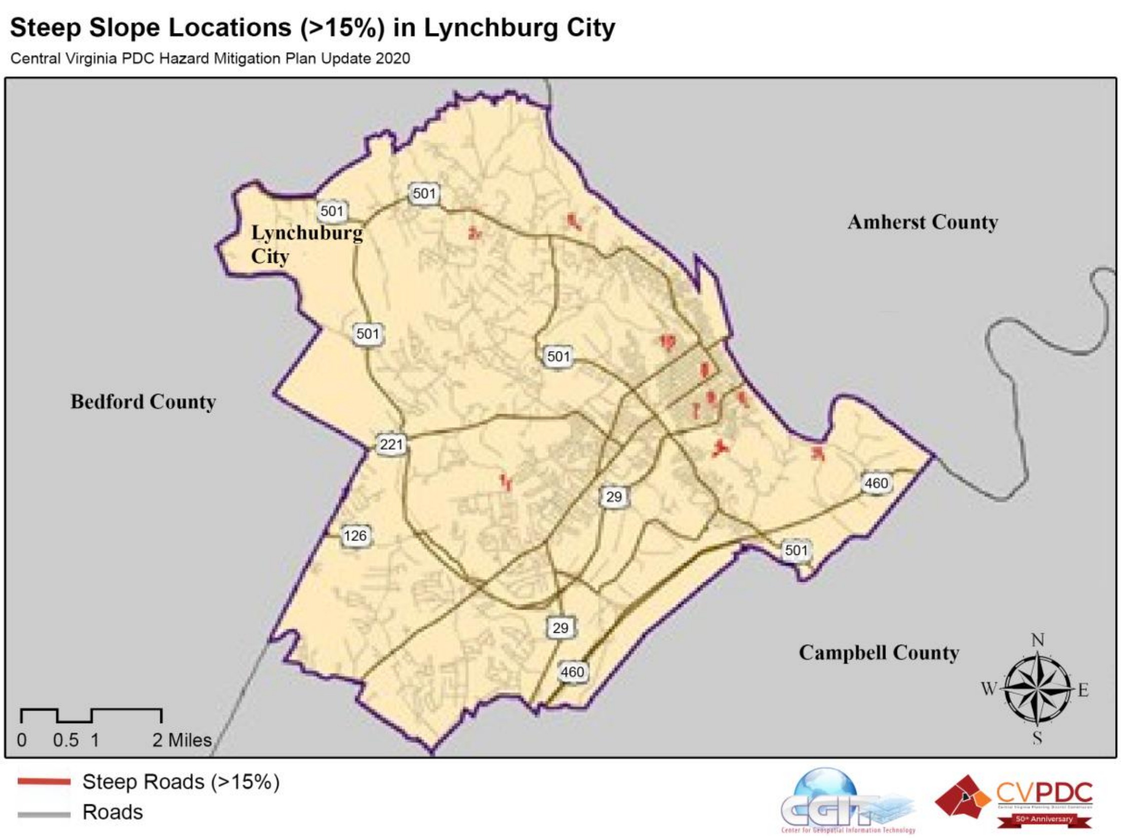


Figure 4-120 Steep Slope Locations (>15%) in Lynchburg City

Table 4-132 Lynchburg City Steep Slope Locations (>15%)

Ranking	Steep Slope Location	Slope
1	500 Sandusky Dr.	15%
2	1700 Clayton Ave.	15%

Ranking	Steep Slope Location	Slope
3	130 Rockwell Rd.	15.3%
4	1400 Augusta St.	15.8%
5	N/A Paxton Ave.	16.8%
6	2000 Rose St.	17.3%
7	1220 17th St.	18.3%
8	600 11th St.	18.5%
9	1700 Locust St.	18.6%
10	200 Polk St.	19.2%

4.8.4 Probability of Future Occurrences

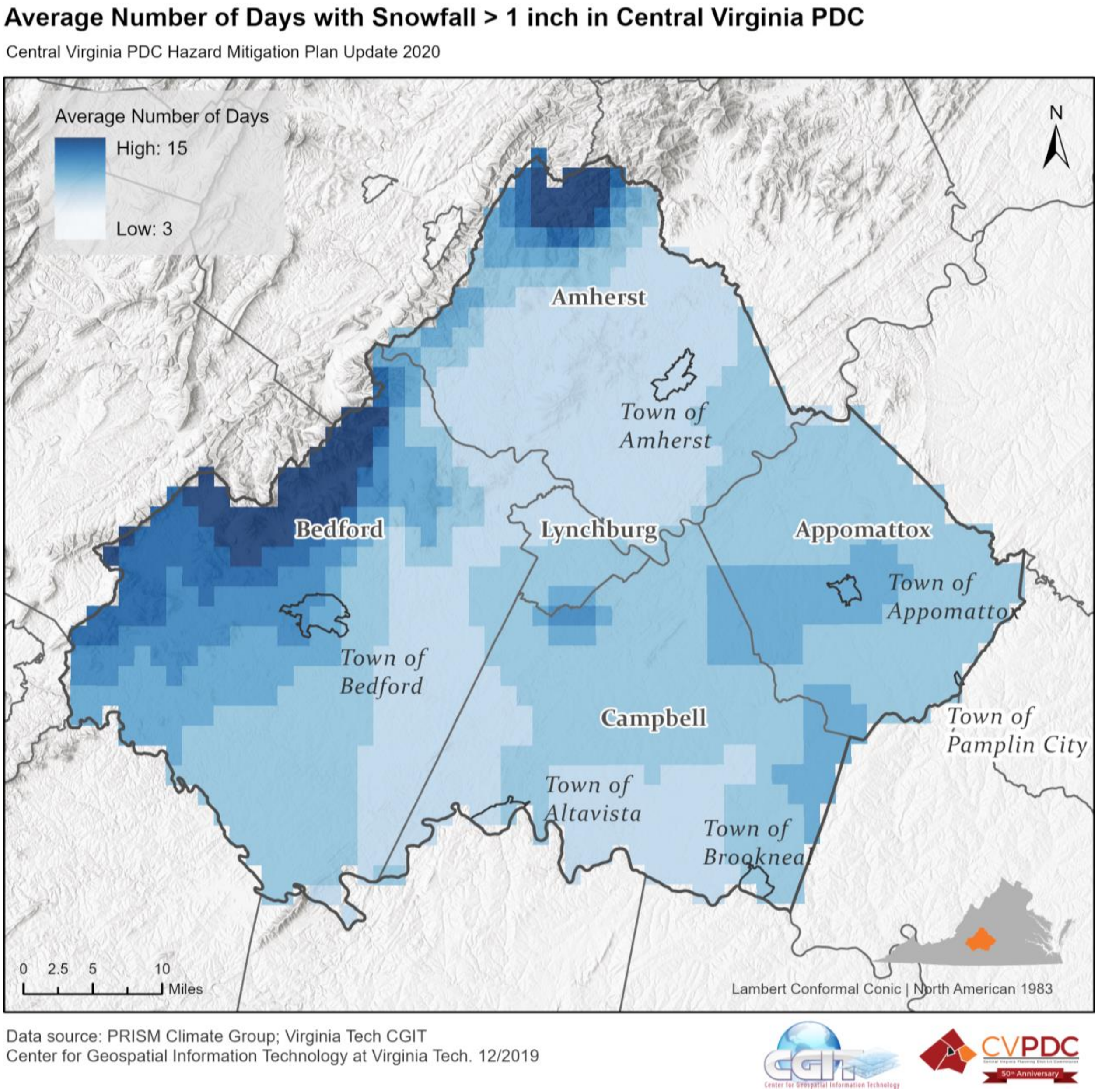
In order to create a statewide winter weather hazard potential map that captures this variability, gridded climate data was obtained from the Climate Source and through the VirginiaView program. This data was developed by the Oregon State University Spatial Climate Analysis Service (SCAS) using PRISM (Parameter-elevation Regressions on Independent Slopes Model). This climate mapping system is an analytical tool that uses point weather station observation data, a digital elevation model, and other spatial data sets to generate gridded estimates of monthly, yearly, and event-based climatic parameters. The project management team for the 2013 plan update agreed that this analysis would suffice for the update. There is no updated data for the 2020 update.

PRISM data was selected for this analysis because it is an interpolation system that incorporates elevation fluctuation into the regression equations that are used to predict the gridded variation of each climate parameter. This winter weather risk assessment uses monthly normal precipitation, mean annual days with snowfall greater than 1 inch, and mean monthly snowfall PRISM data to develop snow and ice potential maps for the state.

These datasets have been generated to incorporate topographic effects on precipitation, capture orographic rain shadows, and include coastal and lake effect influences on precipitation and snowfall. The monthly precipitation grid provides a 30-year climatological average of total precipitation in inches. The mean monthly snowfall grid provides a 30-year climatological average depth of freshly fallen snow in inches. The mean annual days map reveals the 30-year average of the number of days that a location will receive greater than 1 inch of snowfall in a 24-hour period in a given year.

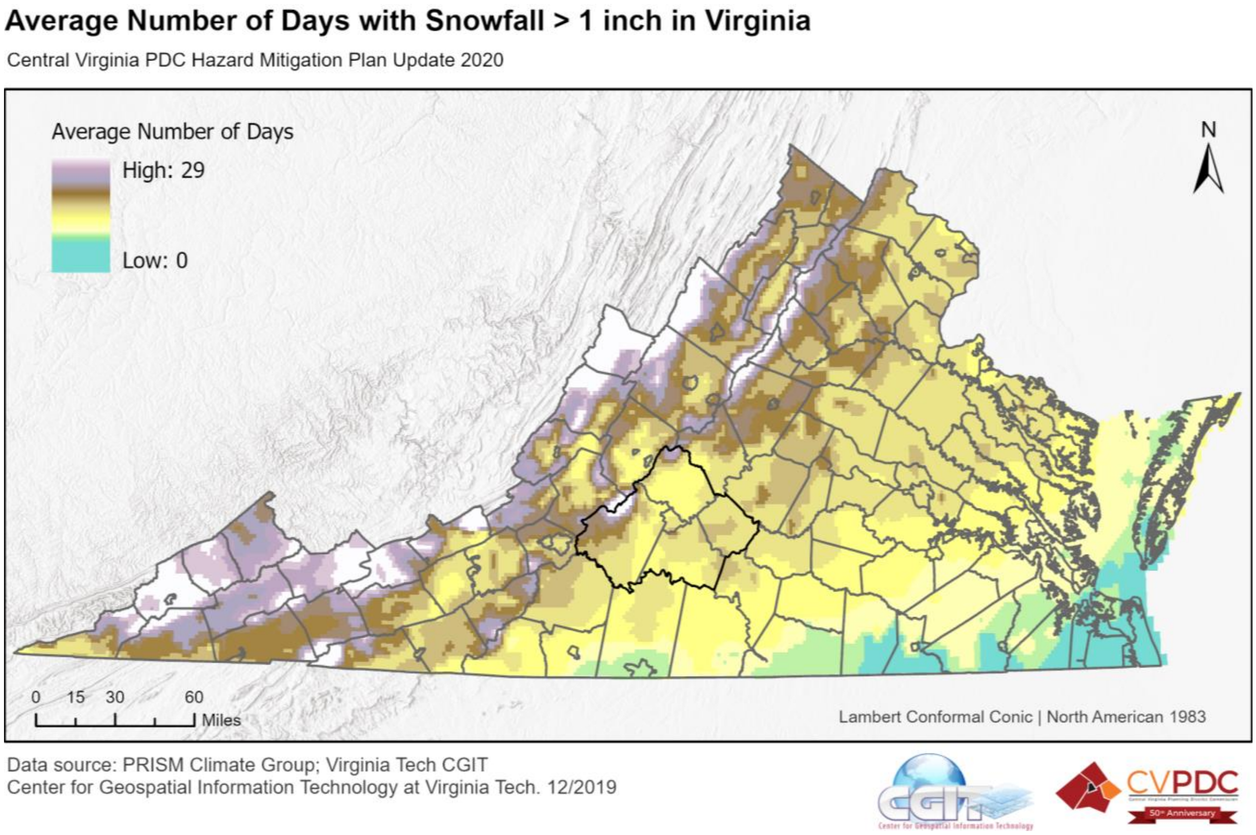
A criterion of “greater than 1 inch” was selected for winter snowfall severity assessment because this depth will result in complete road coverage that can create extremely dangerous driving conditions that will require removal by the local community. This amount of snowfall in a 24-hour period can also lead to business closure and school delays or cancellations. (Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-122 shows the average number of days with snowfall greater than one inch for the state and Figure 4-121 shows the average number of days with snowfall greater than one inch for the CVPDC area. These assessments can act as indicators of the likelihood of future occurrences. Average number of days with snowfall greater than one-inch increases dramatically near the mountain ranges. In the CVPDC area, the Blue Ridge Mountains in the northern portions of Amherst and Bedford counties receive the greatest amount of snowfall.



(Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-121 Average Number of Days with Snowfall > 1 inch in CVPDC Area



(Source: PRISM Climate Group; Virginia Tech CGIT)

Figure 4-122 Average Number of Days with Snowfall > 1 inch in Virginia

4.8.5 References

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- NOAA National Severe Storms Laboratory. *Severe weather 101.* https://www.nssl.noaa.gov/education/svrwx101/winter/ (Accessed Feb 14 2019)
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