5.16 Winter Weather

2023 SHMP Update Changes

- The hazard profile was significantly enhanced to include detailed descriptions of the following: hazard definition, location, extent, previous occurrences, and probability of future occurrences (including how future conditions may impact the hazard).
- Information was updated regarding the current population affected by severe winter weather.
- Winter weather events that occurred in the State of West Virginia (the State) from January 1, 2018, through December 31, 2022, were researched for this 2023 SHMP.
- New and updated figures from federal, state, and local agencies were incorporated.
- Local vulnerabilities were assessed, and a consequence analysis was conducted to address hazard impacts on the public, responders, continuity of operations, property and infrastructure, environment, economic conditions of the state, and public confidence in state governance.

5.16.1 Hazard Profile

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of future conditions) and vulnerability assessment for the winter weather hazard in West Virginia.

Hazard Description

Winter weather is classified as snow, ice, and extremely cold conditions; the dominant forms of precipitation for these events occur only at cold temperatures. For this 2023 hazard mitigation plan update, winter weather hazards include heavy snow, blizzards, sleet, ice storms, and nor'easters. Types of winter weather events or conditions are further defined as follows:

- **Heavy snow** is the accumulation of 4 inches or more of snow within 12 hours or less or the accumulation of 6 inches or more of snow within 24 hours (NWS n.d.).
- **Blizzards** are dangerous winter storms that are a combination of blowing snow and wind, resulting in very low visibility. While heavy snowfalls and severe cold often accompany blizzards, they are not required. Sometimes strong winds pick up snow that has already fallen, creating a ground blizzard (NSSL 2023).
- **Sleet** occurs when snowflakes only partially melt when they fall through a shallow layer of warm air. These slushy drops refreeze as they next fall through a deep layer of freezing air above the surface and eventually reach the ground as frozen raindrops that bounce on impact (NSSL 2023).
- **Ice storms** result in the accumulation of at least.25" of ice on exposed surfaces. They create hazardous driving and walking conditions. Tree branches and powerlines can easily snap under the weight of the ice (NSSL 2023).

- **Nor'easters** are low-pressure systems that form and travel along the eastern coast of the United States. While the storms often affect the Northeast, the term nor'easter is derived from the fact that the winds around the low-pressure system blow from the northeast. These storms are more common from September to April and may bring snow and high winds to the regions they affect (National Geographic 2022).

LOCATION

All regions of West Virginia are subject to winter weather. The mountains of West Virginia see some of the highest snowfall totals east of the Mississippi River, with an annual average of 100 inches. A record snowfall of more than 200 inches occurred during the winter of 2009–10, with more than 100 inches falling in the month of February, when the region was impacted by three major storms (NOAA 2022).

EXTENT

The magnitude or severity of a winter storm depends on several factors, including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) produces the Regional Snowfall Index (RSI) for significant snowstorms that affect the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5 and is based on the spatial extent of the storm, amount of snowfall, and the interaction of the extent and snowfall totals with the population based on the 2010 Census (see Table 5.16-1). The NCEI has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2022).

Table 5.16-1. RSI Snowstorm Impacts

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	10+

Source: NOAA 2022
Note: RSI Regional Snowfall Index

The National Weather Service (NWS) operates a widespread network of observing systems, such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists, who then write and disseminate forecasts. According to NWS (NWS 2021), the magnitude of a severe winter storm can be qualified into five main categories by event type.

Table 5.16-2. Winter Storm Category Thresholds

Storm Type	Description
Heavy Snowstorm	Accumulations of 4 inches or more of snow in a 6-hour period or 6 inches of snow in a 12-hour period.
Sleet Storm	Significant accumulations of solid pellets that form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists.
Ice Storm	Significant accumulation of rain or drizzle freezing on objects (trees, power lines, roadways) as it strikes them, causing slippery surfaces and damage from sheer weight of ice accumulations.
Blizzard	Wind velocity of 35 mph or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period.
Severe Blizzard	Wind velocity of 45 mph, temperatures of 10 °F or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period.

Source: NWS 2021

Additionally, the NWS uses winter weather watches, warnings, and advisories to help people anticipate what to expect in the days and hours prior to an approaching storm (NWS 2021). Refer to Figure 5.16-1 for the warning thresholds.

Figure 5.16-1. Winter Storm Warning Thresholds

Source: NOAA n.d.

Warning Time

It is unusual for a winter storm to occur without warning. Forecasts of incoming winter weather are generally available several days ahead of winter storms. Winter weather warnings and watches are issued by the local NWS office. The NWS will update the watches and warnings and will notify the public when they are no longer in effect.

The NWS issues the following winter weather advisories, watches, and warnings (National Weather Service n.d.):

- **Winter Weather Advisory**—A Winter Weather Advisory means that there is a high probability of enough snow, sleet, or ice to inconvenience people, but not enough to warrant a Winter Storm Warning.
- **Winter Storm Watch**—A Winter Storm Watch is issued when a significant winter storm is possible. People can expect two or more inches of snow, 1/2 inch or more of sleet, or 1/4 inch or more of freezing rain. Winter Storm Watches may be issued 12-48 hour before the winter storm is expected.
- **Winter Storm Warning**—A Winter Storm Warning means that there is a high probability of a winter weather event that includes two or more inches of snow, 1/2 inch or more of sleet, or 1/4 inch or more of freezing rain. The Winter Storm Warning may be issued at the discretion of the forecaster or an emergency manager when significant impacts are expected but the precipitation criteria are not necessarily met.
- **Ice Storm Warning**—An Ice Storm Warning is issued when there is a high probability of 1/4 inch or more of freezing rain, or when a forecaster or emergency manager expects significant impacts but the freezing rain criteria is not necessarily met.
- **Blizzard Warning**—A Blizzard Warning is issued when there is a high probability that blizzard conditions (sustained wind speeds or gust of at least 35 mph and visibility reduced to less than 1/4 mile for at least 3 hours) will exist within the next 36 hours.

Previous Occurrences and Losses

Federal Emergency Management Agency (FEMA) Disaster Declarations

Between 1953 and 2022, the State was included in five disaster (DR) or emergency (EM) declarations for winter weather-related events. Generally, these disasters cover a wide region of the state; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2023).

Table 5.16-3. Winter Storm Events in the State (1993 to 2022)

Date(s) of Event	Event Type	Federal Designation	Counties Affected
March 13-17, 1993	Severe Snowfall and Winter Storm	EM-3109-WV	Statewide
January 6-12, 1996	Blizzard	DR-1084-WV	Statewide
December 18-20, 2009	Severe Winter Storm and Snowstorm	DR-1881-WV	Boone, Calhoun, Clay, Fayette, Greenbrier, Jefferson, Kanawha, McDowell, Mercer, Mingo, Nicholas, Pendleton, Pocahontas, Raleigh, Randolph, Ritchie, Roane, Wyoming
February 5-11, 2010	Severe Winter Storms and Snowstorms	DR-1903-WV	Berkeley, Brooke, Doddridge, Grant, Hampshire, Hancock, Hardy, Jefferson, Merion, Marshall, Mineral, Monongalia, Morgan, Ohio, Pocahontas, Preston, Ritchie, Tucker, Tyler, Wetzel
February 10-16, 2021	Severe Winter Storms	DR-4603-WV	Cabell, Lincoln, Mason, Putnam, Wayne

Source: FEMA 2023

U.S. Department of Agriculture (USDA) Disaster Declarations

The Secretary of Agriculture from the USDA is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, the State was not included in any agricultural disaster declarations pertaining to winter weather (USDA 2023).

Previous Events

For this 2023 SHMP, winter weather events were summarized between January 1, 2018, and December 31, 2022. Table 5.16-4 includes details of winter weather events that occurred in the state between 2018 and 2022. Major events include those that resulted in losses or fatalities, as reported by the NOAA NCEI, events that led to a FEMA disaster declaration, and/or event that led to a USDA declaration. Due to over 900 events having been recorded between 2018 and 2022, the following criteria was used to narrow the events shown in Table 5.16-4:

- Events searched for in the NOAA NCEI Storm Events Database included blizzard, heavy snow, ice storm, sleet, winter storm, and winter weather
- Episode narratives are used for the event description
- Event narratives are not included in the event description
- Events with no property and/or crop damages are not included in Table 5.16-4
- Events with a fatality are included in Table 5.16-4

Table 5.16-4. Winter Weather Events in West Virginia, 2018 to 2022

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
January 16-17, 2018	Winter Weather, Heavy Snow	N/A	Barbour, Berkeley, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Grant, Hampshire, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mineral, Mingo, Morgan, Nicholas, Pendleton, Pleasants, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming	A weather system crossed the middle Ohio River Valley and central Appalachians on the morning of the 16th. Light snow began just after midnight, and picked up toward sunrise as colder air surged in. A band of moderate to heavy snowfall along and just south of I-64 from Huntington to Charleston; this area received 4 to 6 inches of snow. Cabell, Putnam, and Kanawha Counties received 4.5 to 5.5 inches of snow. Just as the heaviest snow started, roads quickly deteriorated, leading to multiple accidents. A four-vehicle accident on I-64 in Cabell County near Milton resulted in the death of a 19-year-old woman. Outside of the heavier snow, a persistent light to moderate snow fell from the pre-dawn through late afternoon or evening, with generally two to four inches across the lowlands and three to six inches across the mountains. No monetary damages were incurred from this event.
March 8-9, 2018	Winter Weather, Heavy Snow	N/A	Grant, Mineral, Pendleton, Preston, Randolph, Tucker	Snowfall began during the afternoon of the 8th. In general, these were quick-moving systems that produced brief visibility less than one mile and a quick coating of snow. One heavier system played a role in 17 vehicle pileup in the northbound lanes of I-77 near Beckley. The interstate was closed for several hours. Travelers on the interstate stated that visibility was very poor, and that the road had a light coating of snow. Seven injuries were reported as a result of the accident. $500,000 in property damages were incurred from this event.
March 20-22, 2018	Winter Weather, Winter Storm, Heavy Snow	N/A	Barbour, Berkeley, Braxton, Clay, Fayette, Grant, Greenbrier, Hampshire, Hardy, Harrison, Mercer, Mineral, Monroe, Morgan, Nicholas, Pocahontas, Raleigh, Randolph, Summers, Upshur, Webster	Rain changed to a wintry mix on the 20th. There was enough cold air for a period of heavier snow around midday. A light wintry mix continued the night of the 20th. On the 21st, a round of heavier precipitation to fall mainly in the form of snow. The snow tapered off later in the day as the low moved off to the north and east. $58,000 in property damages were incurred from this event.
November 14-16, 2018	Winter Weather, Winter	N/A	Berkeley, Brooke, Fayette, Grant, Greenbrier, Hampshire, Hancock, Hardy, Jefferson, Marshall, Mercer,	Warm and moist air entered the region the night of November 14th into the morning of November 15th. This warm and moist air resulted in rain falling across the area but falling through a shallow layer of below freezing air just above and at ground level, and onto surfaces also below freezing. The result

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
	Storm, Ice Storm		Mineral, Monongalia, Monroe, Pendleton, Pocahontas, Preston, Raleigh, Randolph, Summers, Tucker	was a freezing rain event that deposited up to one-quarter of an inch of ice on trees, power lines, and roads. At least 12,000 customers were out of power because of the ice. Widespread precipitation was brought to the region, including heavy snow and mixed precipitation. Four to seven inches of snow was measured north of I-80 and in the higher elevations; meanwhile, 1 to 3 inches of snow happened elsewhere. $105,000 in property damages were incurred from this event.
December 11, 2019	Winter Weather	N/A	Mercer	A weather system passing over West Virginia produced rain showers that turned to snow as temperatures dropped, with accumulations reaching about one inch in spots around Mercer County. With the colder temperatures, liquid water on the roads froze and created hazardous road conditions. Icy road conditions caused a school bus to slide down a road and collide with a storage building. $6,000 in property damages were incurred from this event.
December 13, 2019	Winter Weather	N/A	Berkeley, Braxton, Grant, Hampshire, Hardy, Jefferson, Lewis, Marion, Mineral, Morgan, Pendleton, Preston, Tucker, Upshur	A period of freezing rain occurred on the morning of the 13th. Ice accretion amounts ranged from a trace to about a tenth of an inch across portions of central West Virginia. Light icing caused multiple accidents along I-79 in Braxton and Lewis Counties. The interstate was closed for several hours as crews worked to clean up the crashes and treat the road. One driver was taken to the hospital following one of the accidents in Braxton County. In Upshur County, there were 13 separate weather-related accidents. $180,000 in property damages were incurred from this event.
December 16-17, 2019	Winter Weather, Ice Storm	N/A	Berkeley, Grant, Hampshire, Hardy, Jefferson, Mineral, Morgan	A period of snow occurred on the morning of the 16th. Warmer air entered the area and caused the snow to change to rain with pockets of freezing rain on the 16th into the morning of the 17th. Ice amounts from freezing rain were around a quarter to a half inch across western Mineral County. Multiple trees were reported down across roads over western Mineral County due to ice accretion. $15,000 in property damages were incurred from this event.
February 10-12, 2021	Winter Weather, Winter Storm	DR-4603-WV	Berkeley, Boone, Braxton, Cabell, Clay, Grant, Hampshire, Hardy, Harrison, Jackson, Jefferson, Kanawha, Lewis, Lincoln, Logan, Marion, Mason, McDowell, Mineral, Mingo, Monongalia, Morgan, Ohio,	Winter precipitation crossed the area on February 10th with significant ice and snowfall accumulations. Snowfall totals of 3 to 6 inches were observed to the north and east of Charleston, with six inches being reported four miles northeast of Rock Cave. Ice accumulations greater than a quarter of an inch were observed throughout the southern portions of the state, with up to 0.33 inches of ice from freezing rain reported 2 miles south of Ceredo, West Virginia. This resulted in significant tree damage across the hard-hit regions, with more than 45,000 customers in West Virginia losing power. The

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
			Pendleton, Pocahontas, Preston, Putnam, Raleigh, Ritchie, Roane, Taylor, Tucker, Upshur, Wayne, Wetzel, Wirt, Wood, Wyoming	Huntington airport was shut down for a time on the 11th due to slippery runways and a power outage. The westbound lanes of I-64 were shut down during the morning commute on the 11th due to a tractor trailer sliding off the roadway near Nitro. $66,000 in property damages were incurred from this event.
February 15-16, 2021	Winter Weather, Winter Storm, Ice Storm	DR-4603-WV	Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Marion, Marshall, Mason, Mineral, Mingo, Monongalia, Nicholas, Ohio, Pleasants, Putnam, Raleigh, Ritchie, Roane, Tyler, Wayne, Wetzel, Wirt, Wood	On the afternoon of the 15th, freezing rain was observed around the Charleston metro area and the western borders of the state. Major power outages around the Huntington area and other portions of southwestern West Virginia were reported in response to ice laying along and eventually knocking down power lines, which would continue to take a toll on the area as a third winter storm arrived only three days later. With trees and powerlines down along the roadways, many ambulances were unable to reach the hospital with injured patients. $189,000 in property damages were incurred from this event.
February 17-18, 2021	Winter Weather, Winter Storm, Heavy Snow	N/A	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis Wirt, Lincoln, Logan, Mason, McDowell , Mingo, Nicholas, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Wyoming	A winter storm impacted West Virginia with snow and freezing rain on February 17th through the 18th. Between 3 and 6 inches of snow fell across Central and Northern West Virginia, with the highest accumulations falling in the Sutton Lake area of Braxton County. Freezing rain fell in portions of southeastern West Virginia and down into Virginia and North Carolina. This weather pattern hindered efforts to restore power across the region from the previous winter storms and caused hazardous travel conditions across the region. The snow accumulating on top of ice from previous storms caused additional tree damage and power outages. According to Appalachian Power, the weight of the snow and ice from these storms caused trees to collapse onto wires and transmission towers to buckle. An estimated 550 broken power poles needed to be replaced, and roughly 2,400 spans of wire needed to be put back up. $61,000 in property damages were incurred from this event.
January 2-4, 2022	Winter Weather	N/A	Barbour	A quick-moving system brought a dusting of snow during the overnight hours of January 2nd-3rd. Colder air filtered into the area, which froze the roadways overnight on the 3rd and into the morning of January 4th. This resulted in hazardous conditions due to black ice and caused several vehicle accidents. $15,000 in property damages were incurred from this event.

Date(s) of Event	Event Type	FEMA/USDA Declaration	Counties Affected	Description
January 6-7, 2022	Winter Weather, Heavy Snow	N/A	Barbour, Boone, Braxton, Cabell, Calhoun, Clay, Doddridge, Fayette, Gilmer, Harrison, Jackson, Kanawha, Lewis, Lincoln, Logan, Mason, McDowell, Mingo, Nicholas, Pleasants, Pocahontas, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Webster, Wirt, Wood, Wyoming	A system crossed into the area on January 6th, resulting in snowfall throughout the afternoon and evening hours. Snowfall totals ranged from 8 to 12 inches around the Charleston metro area and up to 14 inches of snow in the mountains and adjacent foothills. Snow began to fall around 2 PM that afternoon with 1 to 2 inches per hour snowfall rates. All major highways in West Virginia observed longer than normal travel times and eventual closures due to slick spots and vehicle accidents. Overnight freezing temperatures and light lake-effect snow showers also resulted in a slow morning commute on the 7th. Between 6 and 12 inches of snow covered most areas from south of I-64 in northeast Kentucky northeastward across a large portion of West Virginia. $10,000 in property damages were incurred from this event.
December 15, 2022	Winter Weather, Ice Storm	N/A	Greenbrier, Preston, Tucker	The combination of sleet and freezing rain resulted in slick road surfaces on I-64 near the border with Virginia, the White Sulphur Springs, WV area. A west bound minivan collided with a WVDOH work truck between mile markers 180 and 181. The accident led to the closure of both westbound lanes of I-64. $75,000 in property damages were incurred from this event.
December 22, 2022	Winter Weather	N/A	Braxton, Fayette, Gilmer, Nicholas, Pocahontas, Raleigh, Randolph, Webster	A system entered the area during the morning hours of December 22nd. Cold temperatures that were in place at the time of precipitation resulted in wintry precipitation across northern West Virginia and along the higher terrain. Freezing rain was observed just after midnight on the 22nd, with instances of black ice leading to slippery spots in time for the morning commute. Several vehicle crashes in Raleigh, Fayette, and Gilmer Counties occurred due to the icy roadways. $10,000 in property damages were incurred from this event.

Source: FEMA 2023; NOAA NCEI 2023
Notes:
DR Federal Disaster Declaration
EM Emergency Management
EMA Emergency Management Agency
FEMA Federal Emergency Management Agency
NCEI National Centers for Environmental Information
NOAA National Oceanic Atmospheric Administration
N/A Not applicable/not available

Probability of Future Hazard Events

Overall Probability

According to FEMA's list of disaster declarations, the USDA's list of disaster declarations, the NOAA NCEI Storm Events Database, and the 2018 SHMP, the State experienced over 900 winter weather events between 1950 and 2022, as summarized in Table 5.16-5.

Table 5.16-5. Probability of Future Winter Weather Events in West Virginia

Hazard Type	Number of Occurrences Between 1950 and 2022	Percent Chance of Occurrence in Any Given Year
Blizzard	9	12.5%
Heavy Snow	247	100%
Ice Storm	50	100%
Sleet	0	0%
Winter Storm	216	100%
Winter Weather	417	100%
Total	**939**	**100%**

Source: NOAA NCEI 2023

Projected Future Conditions

Temperatures in West Virginia have risen 1°F since the beginning of the 20th century and are projected to continue rising in all seasons of the year (NOAA 2022). This overall increase in temperature leads to more water vapor being stored in the atmosphere. During winter months, despite a warmer temperature, this increase in water vapor can spur more frequent, intense winter weather. The frequency of large snowfall years has increased in the northern United States. Analysis of storm tracks indicates that there has been an increase in winter storm frequency and intensity since 1950, with a slight shift in tracks toward the poles (U.S. Global Change Research Program 2018). If current projections remain, the State can expect more frequent and intense winter weather events.

5.16.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For severe winter weather, the entirety of West Virginia has been identified as the hazard area. Therefore, all assets in the state (population, structures, critical facilities, and lifelines), as described in the State Profile, are vulnerable. The impacts on population, existing structures, critical facilities, and the economy are presented below.

State Assets

For the purposes of this risk assessment, an asset is considered potentially vulnerable if it is in an identified hazard area. As stated previously, for the winter weather hazard the entire area of the State is the hazard area. Therefore, a total of 1,117 state facilities are vulnerable to winter weather. The total replacement cost value for all 1,117 facilities is $6,103,990,956. Kanawha County has the most facilities (200) while Monongalia County has the highest

total RCV ($1,605,027,842) of state facilities in comparison to all the counties in the state. See Section 2 (State Profile) for tables identifying the numbers and replacement cost value of state facilities in each county.

All State roads are also vulnerable to the winter weather hazards. Snow and ice can fully cover roads for extended periods of time, resulting in closures and cutting off critical access to communities. In addition, freezing, melting, and refreezing of the roads can create potholes and degrade the quality of the roads. See Section 2 (State Profile) for tables identifying the miles of roadway in each county.

Critical Facilities and Community Lifelines

Transportation routes are vulnerable to winter weather and have the potential to be inaccessible, creating isolation issues. This includes all roads and bridges affected by winter weather. Those that are most vulnerable are those that are already in poor condition and would not be able to withstand refreezing. Utility infrastructure is also vulnerable; interruption of services may not only impact vulnerable populations but may also impact facilities that need to be in operation during a disaster. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Full functionality of critical facilities such as police, fire, and medical services is essential for response during and after a winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, these should undergo only minimal structural damage from severe winter weather events.

In total, there are 185 critical facilities that may be impacted by winter weather, with Kanawha County having the greatest number of critical facilities (75). The total replacement cost value of all the critical facilities that have the potential to be impacted by winter weather is $658,480,508. See Section 2 (State Profile) for tables identifying the numbers of critical facilities and their replacement cost value in each county.

Population

For the purpose of this SHMP, the entire population of the State (1,807,426) is exposed to the winter weather hazard. Residents may be displaced or require temporary and long-term housing and sheltering. In addition, damages caused by severe winter weather can lead to severe injuries and loss of life. Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during extreme winter weather. Kanawha County has a population of 181,014, which makes it the most populous county in the state and extremely vulnerable to severe winter weather. This analysis does not include the number of tourists and visitors in the state; therefore, this estimate may be underestimating exposure and vulnerability. Section 2 (State Profile) identifies the population of each county vulnerable to the winter weather hazard.

Impacts on Socially Vulnerable Populations

Socially vulnerable populations are susceptible based on many factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Economically disadvantaged populations are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to prepare for or respond to a winter weather event.

In relation to the hazard of winter weather, socially vulnerable populations will experience a disproportionate disadvantage. For example, the elderly are considered susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. In

addition, winter weather can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing, or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Populations with physical disabilities may not be able to leave their houses or maneuver outdoors due to covered walkways and ramps.

The aftermath of winter weather events present numerous threats to public health and safety, including weighted powerlines and tree branches, power outages, snow- and ice-covered walkways and roadways, and cold temperatures. Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best preparation for these effects includes awareness that they can occur, education of the public on prevention, and planning to deal with them during responses to winter weather events.

Future Changes That May Impact State Vulnerability

Understanding factors of change that impact vulnerability in the state can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The state considered the following factors to examine conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of future conditions

Potential or Projected Development

Although West Virginia has not experienced significant growth, any areas of growth could be impacted by the severe winter weather hazard because the entire state is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the hazard, while aging infrastructure will become increasingly vulnerable.

Projected Changes in Population

West Virginia is losing population faster than recent forecasts, which do not account for county-by-county increases. According to population projections in 2022 from the West Virginia University (WVU) Bureau of Business and Economic Research, West Virginia's population was projected to fall from 1,793,716 in 2020 to 1,705,509 in 2040 (West Virginia University 2022). As of July 1, 2019, according to estimates by the U.S. Census Bureau, West Virginia's total population is 1,792,147, representing a 3.3 percent decline since 2010 (approximately 60,487 fewer residents). West Virginia lost population both naturally, with 19,000 more deaths than births, and through migration, with 27,000 more people leaving the state than moving in (WVDOT 2020). Refer to Section 2 (County Profile), which includes a discussion on population trends for the county.

The overall anticipated decrease in population for West Virginia will potentially lower the threat of the winter weather hazard and its impact on life, but it will not eliminate the hazard. As the population leaves the state, the buildings and structures once resided in will remain standing, leaving the structural risk to the winter weather hazard the same as before. The groups most vulnerable to the hazard will remain the same, as will the geographic and topographic areas most vulnerable.

Other Factors of Change

The impacts of future conditions to the state have the potential to increase the probability of winter weather events as discussed in the Probability of Future Hazard Events section above. Overall projected temperature increases will lead to more water vapor being stored in the atmosphere. During winter months, despite a warmer temperature, this increase in water vapor can spur more frequent, intense winter weather (U.S. Global Change Research Program 2018).

5.16.3 Consequence Analysis

Impacts to the Public

According to the NOAA National Severe Storms Laboratory (NSSL), winter weather indirectly kills hundreds of people in the United States every year, primarily from automobile accidents, overexertion, and exposure. Winter storms are often accompanied by strong winds that may create blizzard-like conditions, drifting snow, extreme cold temperatures, and dangerous wind chills. Winter weather is considered to be deceptive because most deaths and other impacts or losses are indirectly related to the storms, as it is the temperature that can lead to hypothermia and frostbite, which require immediate medical attention. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or hypothermia from prolonged exposure to cold; however, vehicular accidents account for most of the injuries and deaths related to heavy snow (NSSL 2023). The mountainous terrain of West Virginia results in some areas of steep roadways, which can make it more difficult for the population to safely shovel or travel on snow-covered roads; bridges and overpasses are particularly dangerous because they freeze before other surfaces.

In addition, heavy accumulations of ice and snow can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. This endangers those that may need assistance evacuating, as well as those that need to call for help when injured. Even small accumulations of ice and snow may call for shutting down air and rail transportation which could disrupt medical and emergency services as well as the transportation of emergency supplies, endangering those that are in need of help even more (NWS 2019).

Impacts to Responders

In the aftermath of a winter weather event, workers may be involved in a variety of response and recovery operations. Emergency response to floods may several first response organizations, ranging from local police, fire and EMS departments, and public service workers. Assessments must be done to determine the current needs of the situation, including evacuation, plowing snow, salting or brining roads, search and rescue operations, distribution of resources, relocation of displaced individuals, firefighting, and utility repairs. In addition to the risks of responding to a winter weather event, emergency responders can be exposed to cold-related illnesses and injuries from winter weather, including chilblains, frostbite, trench foot, and hypothermia.

Heavy snow can immobilize a region and paralyze a city, shutting down air and rail transportation, stopping flow of supplies, and disrupting medical and emergency services. Accumulations of snow and ice can collapse buildings and knock down trees, communication, and power lines, making it difficult for responders to be able to pinpoint

those who need assistance and where they may be. In rural areas, homes and farms may be isolated for days due to snow and ice accumulations making roads impassable. In the mountains, heavy snow and snow drifts may hinder the delivery of emergency services and endanger the responders.

Impacts to Continuity of Operations

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice have the ability to be life-threatening and can inhibit transportation of goods and services. Heavy snow and ice may collapse, old, yet relied upon infrastructure which can inhibit continuity of operations for businesses. Excessive amounts of snow impact airports and roadways, sometimes even closing them completely, stopping the flow of international and national supplies.

Impacts to Property, Facilities, and Infrastructure

All facilities in West Virginia are exposed and vulnerable to the winter storm hazard. High snow accumulation may make infrastructure vulnerable to structure failure and possible collapse. In general, structural impact damage may include damage to roofs and building frames, as well as damage to building contents. Structural failure from increased snow accumulation on roofs can be linked to several different causes, including but not limited to:

- Actual snow load significantly exceeds design snow load
- Drifting and sliding snow conditions
- Deficient workmanship
- Insufficient operation and maintenance
- Improper design
- Inadequate drainage design
- Insufficient design: in older buildings, insufficient design is often related to inadequate snow load design criteria in the building code in effect when the building was designed (FEMA 2020).

Winter weather can also impact and damage utilities and above-ground wires and towers by freezing infrastructure, falling tree limbs, and weighing down above-ground infrastructure. Loss of power can also impact potable water and wastewater treatment facilities.

Impacts to the Environment

Environmental impacts from winter weather often includes damage to trees and shrubs caused by heavy snow loading, ice buildup, and/or high winds, which can break limbs and down large trees. Environmental resources, including critical habitat (or habitats that are known to be essential for an endangered or threatened species), wetlands, parks, and reserves are particularly vulnerable to severe winter weather. Destroyed habitats could displace and kill organisms reliant on these habitats to survive and reproduce. An indirect effect of winter storms is impairment of surface and groundwater adjacent to roadway surfaces treated with salt, chemicals, and other de-icing materials. These added pollutants can runoff into bodies of water and cause eutrophication, creating issues for ecosystems present in those water bodies (Columbia Climate School 2018).

Winter storms can also have a positive environmental impact: gradual melting of snow and ice provides groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause accelerated snowmelt, rapid surface water runoff, and severe flooding (USGS 2019).

Impacts to the Economic Condition of the State

Potential economic impacts include loss of agriculture, business, and tourism (though tourism could also be *increased* due to winter weather events, particularly at the State's ski resorts and other snow-dependent activities). In addition, losses of buildings and infrastructure also take a toll on the economic condition of West Virginia. Similarly, damages to buildings can displace people from their homes, threaten life safety, and impact a community's economy and tax base. Severe winter weather can also damage utilities and communication towers, which are costly because they need to be repaired almost immediately after damages occur and these repairs can cost millions of dollars to fix for a singular event. Infrastructure at risk from the winter weather hazard also includes roadways that could be damaged by application of salt and intermittent freezing and warming conditions that can damage roads over time and cause potholes. Costs of snow and ice removals, as well as repairs of roads undergoing freeze/thaw cycles, can drain local financial resources quickly. A quick thaw or rain event after a heavy snow can cause substantial flooding, especially along small streams and in urban areas, which can become expensive to mitigate. Potential secondary impacts from winter storms also impact the local economy, including the interruption of transportation corridors and loss of business function for the duration of the event. Finally, extensive damage to forests can affect timber values and create flammable woody debris, exacerbating wildfire vulnerability.

Impacts to Public Confidence in State Governance

The public confidence in state governance would primarily depend on how effective the State has been preparing for and responding to winter events. Public confidence also depends on the size of the event and the preparation the State takes for each event. In general, if the State is transparent in sharing relevant information with the public, then the public is more apt to trust the State and feel as if it has the capability to support the residents of West Virginia if a winter weather event occurs. The State also demonstrates its reliability to the public through availability of programs and services relevant to winter weather assistance (Chew, et al. 2021).