5.4.9 SEVERE WINTER WEATHER

2016 HMP UPDATE CHANGES

- For the 2016 HMP update, the severe winter weather hazard groups together heavy snow, blizzards, and ice storms. The Nor'Easter hazard is discussed separately in the 2016 HMP (Section 5.4.7) to align with the hazards in the 2014 State of New Jersey HMP.
- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the severe winter weather hazard is discussed. The severe winter weather hazard is now located in Section 5 of the plan update (previously Section 3).
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2008 and 2015.
- A vulnerability assessment was conducted for the severe winter weather hazard; it now directly follows the hazard profile.

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the severe winter weather hazard in Sussex County.

5.4.9.1 PROFILE

Hazard Description

A winter storm is a weather event in which the main types of precipitation are snow, sleet or freezing rain. They can be a combination of heavy snow, blowing snow, and/or dangerous wind chills. There are three basic components needed to make a winter storm. Below freezing temperatures (cold air) in the clouds and near the ground are necessary to make snow and ice. Lift, something to raise the moist air to form clouds and cause precipitation, is needed. Examples of this is warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside. The last thing needed to generate a winter storm is moisture to form clouds and precipitation such as air blowing across a body of water (e.g., a large lake or the ocean) (National Severe Storms Laboratory 2014).

Some winter storms are large enough to immobilize an entire region while others may only affect a single community. Winter storms are typically accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and/or blocked roadways, downed utility lines, and power outages. In Sussex County, winter storms include blizzards, snow storms, Nor'Easters and ice storms. Extreme cold temperatures, wind chills and Nor'Easters are also associated with winter storms; however, based on input from the Planning Committee, these events are further discussed in this Plan in Section 5.4.7 (Nor'Easters) and Section 5.4.8 (Severe Weather) to align with the New Jersey HMP. Winter storms in Sussex County have led to localized damage, most notably, power outages, trees and vegetative debris, and snow-covered roads that require DPW overtime to clear.

Heavy Snow

According to the National Snow and Ice Data Center (NSIDC), snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32°F), when water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into a snow crystals or snow

pallet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. Sleet is made up of drops of rain that freeze into ice as they fall through colder air layers. They are usually smaller than 0.30 inches in diameter (NSIDC 2013).

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be the predominant over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (The Weather Channel 2012).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are typically accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines and utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2008).

Location

Snow and Blizzards

The trajectory of the storm center—whether it passes close to the New Jersey coast or at a distance—largely determines both the intensity and the duration of the snowfall over the State. Winter storms tend to have the heaviest snowfall within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. Depending on whether all or a portion of New Jersey falls within this swath, the trajectory determines which portion of the State (or all of the State) receives the heaviest amount of snow.

Normal seasonal snowfall in New Jersey varies from 14.9 inches annually in Cape May County to over 40 inches in Sussex County. However, there is great variability from year to year. Normal seasonal snowfall in Sussex County ranges from approximately 38.9 inches to 40.7 inches (ONJSC 2013).

Ice Storms

Sussex County, like all regions of New Jersey, are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the State. A cold rain may be falling over the southern portion of the State, freezing rain over the central region, and snow over the northern counties as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm.

Extent

The magnitude or severity of a severe 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, and 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. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2015). Table 5.4.9-1 presents the five RSI ranking categories.

Table 5.4.9-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA 2015
Note: RSI = Regional Snowfall Index

The 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 (NWS 2013).

The NWS uses winter weather watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location and timing are uncertain. A watch is issued to provide 12 to 48 hour notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS 2013).

Previous Occurrences and Losses

Many sources provided winter storm information regarding previous occurrences and losses associated with winter storm events throughout Sussex County. With so many sources reviewed for the purpose of this Hazard Mitigation Plan (HMP), loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1954 and 2015, FEMA declared that the State of New Jersey experienced eight winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storm, severe storm, snowstorm, blizzard, and ice conditions. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Sussex County was included in four of

these declarations since 1954. Since the original 2011 HMP, Sussex County was included in one FEMA disaster declaration: October 29, 2011 event. Table 5.4.9-2 lists the FEMA DR and EM declarations, between 2008 and 2015, in which Sussex County was included.

Table 5.4.9-2. FEMA Declarations since 2008 for Severe Winter Weather Events in Sussex County

FEMA Declaration Number	Date(s) of Event	Event Type	Counties Included
DR-4048	October 29, 2011	Severe Weather (Snowstorm / Nor'Easter)	Bergen, Cape May, Essex, Hunterdon, Middlesex, Morris, Passaic, Somerset, Sussex, Union, and Warren Counties

Source: FEMA 2015

For this 2016 HMP update, winter weather events were summarized from 2008 to 2015. Known severe winter weather events, including FEMA disaster declarations, which impacted Sussex County between 2008 and 2015 are identified in Appendix E. For information regarding severe winter weather events prior to 2008, refer to the 2011 Sussex County HMP. For detailed information on damages and impacts to each municipality, refer to Section 9 (jurisdictional annexes).

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter season in New Jersey. The majority of the State will receive at least one measureable snow event during the winter months. The months of January, February, March, April, October, November and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region. It is estimated that Sussex County will continue to experience the direct and indirect impacts of severe winter weather events annually that many induce secondary hazards such as: structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

According to the NOAA-NCDC storm events database, Sussex County has been impacted by 138 winter weather-related events (blizzard, ice storm, heavy snow, winter storm, and winter weather) between 2008 and 2015; this number increases to 310 winter weather-related events when traced back to 1950. These events resulted in $1.15 million in property damage. The table below lists the probability of future occurrences for each type of severe winter weather event to occur in Sussex County. Based on data from NOAA-NCDC, Sussex County can expect an average of 4.77 winter storm-related events each year.

Table 5.4.9-3. Probability of Future Severe Winter Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Annual Number of Events (average)	Recurrence Interval* (in years)	Probability of Event Occurring in Any Given Year	Percent Chance of Occurring in Any Given Year
Blizzard	1	0.02	66.00	0.02	1.5%
Heavy Snow	46	0.71	1.43	0.70	69.7%
Ice Storm	10	0.15	6.60	0.15	15.2%
Sleet	5	0.08	13.20	0.08	7.6%
Winter Storm	60	0.92	1.10	0.91	90.9%
Winter Weather	188	2.89	0.35	1.0	100%

Source: NOAA-NCDC Storm Events Database 2015
**Estimate of the likelihood of an event to occur*

In Section 5.3, the identified hazards of concern for Sussex County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe winter weather in the county is considered 'frequent' (likely to occur within 25 years, as presented in Table 5.3-3).

Climate Change Impacts

In terms of snowfall and ice storms, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013). Due to the increase in temperature, snow cover and sea ice extent are predicted to likely decrease over the next century and the snow season length is very likely to decrease over North America. However, warming of the lower atmosphere could potentially lead to more ice storms by allowing snow to more frequently melt as it falls and then refreeze near or at surface (NPCC 2010).

5.4.9.2 VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. For the severe winter weather hazard, all of Sussex County is exposed. Therefore, all assets in the county (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are exposed and potentially vulnerable to a winter storm. The following text evaluates and estimates the potential impact of the severe winter weather hazard on the county including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2011 Sussex County HMP
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Severe winter storms are of significant concern to Sussex County because of the frequency and magnitude of these events in the region. In addition, the impacts from these events can be great, for example: direct and indirect costs associated with preparation, response and recovery stressing community resources; transportation delays; impacts on the people and facilities of the region related to snow and ice removal; health problems; and cascade effects such as utility failure (power outages) and traffic accidents.

Data and Methodology

Updated population and general building stock data were used to support an evaluation of assets exposed and potentially impacted by this hazard. Additionally, economic losses provided by the Planning Committee to support this vulnerability assessment were included.

Impact on Life, Health and Safety

According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. Heavy accumulations of ice can bring down trees and power lines, disabling electric power and communications for days or weeks. Heavy snow can immobilize a region and paralyze a city, shutting down all air and rail transportation and disrupting medical and emergency services. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The economic impact of winter weather each year is huge, with costs for snow removal, damage and loss of business in the millions (NSSL 2015; Disaster Center 1999).

Heavy snow can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches. The cost of snow removal, repairing damages, and loss of business can have large economic impacts on cities and towns (NWS 2015).

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 may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL, 2006).

For the purposes of this HMP, the entire population of Sussex County (149,265 people) is exposed to severe winter storm events (U.S. Census, 2010). Snow accumulation and frozen/slippery road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries. Refer to Section 4 (County Profile) for population statistics for each participating municipality.

The elderly are considered most 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, severe winter storm events 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).

Impact on General Building Stock

The entire general building stock inventory is exposed and vulnerable to the severe winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Table 5.4.9-4 presents the total exposure value for general building stock for each participating municipality.

Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percentage damages that could result from severe winter storm conditions. Table 5.4.8-2

below summarizes percent damages that could result from severe winter storm conditions for the Planning Area's total general building stock. Given professional knowledge and the currently available information, the potential loss for this hazard is many times considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

Table 5.4.9-4. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Municipality	Total (All Occupancies)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Borough of Andover	$110,720,294	$1,107,202.94	$5,536,014.70	$11,072,029.40
Township of Andover	$797,432,934	$7,974,329.34	$39,871,646.70	$79,743,293.40
Borough of Branchville	$105,787,947	$1,057,879.47	$5,289,397.35	$10,578,794.70
Township of Byram	$1,001,139,850	$10,011,398.50	$50,056,992.50	$100,113,985.00
Township of Frankford	$1,028,566,798	$10,285,667.98	$51,428,339.90	$102,856,679.80
Borough of Franklin	$555,083,580	$5,550,835.80	$27,754,179.00	$55,508,358.00
Township of Fredon	$524,017,917	$5,240,179.17	$26,200,895.85	$52,401,791.70
Township of Green	$617,892,936	$6,178,929.36	$30,894,646.80	$61,789,293.60
Borough of Hamburg	$478,777,394	$4,787,773.94	$23,938,869.70	$47,877,739.40
Township of Hampton	$898,127,786	$8,981,277.86	$44,906,389.30	$89,812,778.60
Township of Hardyston	$1,058,804,064	$10,588,040.64	$52,940,203.20	$105,880,406.40
Borough of Hopatcong	$1,459,447,874	$14,594,478.74	$72,972,393.70	$145,944,787.40
Township of Lafayette	$484,326,532	$4,843,265.32	$24,216,326.60	$48,432,653.20
Township of Montague	$550,631,281	$5,506,312.81	$27,531,564.05	$55,063,128.10
Town of Newton	$926,551,970	$9,265,519.70	$46,327,598.50	$92,655,197.00
Borough of Ogdensburg	$250,464,374	$2,504,643.74	$12,523,218.70	$25,046,437.40
Township of Sandyston	$359,643,031	$3,596,430.31	$17,982,151.55	$35,964,303.10
Township of Sparta	$3,083,993,131	$30,839,931.31	$154,199,656.55	$308,399,313.10
Borough of Stanhope	$557,098,000	$5,570,980.00	$27,854,900.00	$55,709,800.00
Township of Stillwater	$581,254,607	$5,812,546.07	$29,062,730.35	$58,125,460.70
Borough of Sussex	$259,651,457	$2,596,514.57	$12,982,572.85	$25,965,145.70
Township of Vernon	$3,063,072,948	$30,630,729.48	$153,153,647.40	$306,307,294.80
Township of Walpack	$8,710,816	$87,108.16	$435,540.80	$871,081.60
Township of Wantage	$1,396,272,081	$13,962,720.81	$69,813,604.05	$139,627,208.10
Sussex County Total	**$20,157,469,603**	**$201,574,696.03**	**$1,007,873,480.15**	**$2,015,746,960.30**

Source: Sussex County
Values represent estimated replacement cost.

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At-risk residential infrastructures are presented in the flood hazard profile (Section 5.4.4). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the Severe Weather (Section 5.4.8) profile for losses resulting from high winds which may also accompany severe winter weather.

Impact on Critical Facilities

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the county.

Future Growth and Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Sussex County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12 percent) greater than the average from 1895-1970. Southern New Jersey became two inches (5 percent) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5 percent by the 2020s and up to 10 percent by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NPCC] 2009).

In terms of snowfall and ice storms in New Jersey, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013). Future enhancements in climate modeling will provide an improved understanding of how the climate will change and impact the Northeast.

Change of Vulnerability

The entire county continues to be vulnerable to the severe winter weather hazard. The 2011 HMP used data from SHELDUS 7.0, the NCDC, and the NWS that was collected between 1960 and 2008 to determine the risk potential. The 2016 HMP update provided damage estimates using an update custom building stock based on 2015 MODIV tax assessment data and estimated replacement cost. The updated vulnerability assessment provides a more current assessment for the county.

Additional Data and Next Steps

The assessment above identifies vulnerable populations and economic losses associated with this hazard of concern. Historic data on structural losses to general building stock are not adequate to predict specific losses to this inventory; therefore, the percent of damage assumption methodology was applied. This methodology is based on FEMA's How to Series (FEMA 386-2), Understanding Your Risks, Identifying and Estimating Losses (FEMA, 2001) and FEMA's Using HAZUS-MH for Risk Assessment (FEMA 433) (FEMA, 2004). The collection of additional/actual valuation data for general building stock and critical infrastructure losses would further support future estimates of potential exposure and damage for the general building stock inventory. Mitigation strategies addressing early warning, dissemination of hazard information, provisions for snow removal and back-up power are included in Volume II, Section 9 of this plan.