5.4.8 Severe Winter Storm

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 storm hazard in Putnam County.

5.4.8.1 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 dangerous wind chills. According to the National Severe Storms Laboratory (n.d.), the three basic components needed to make a winter storm include the following:

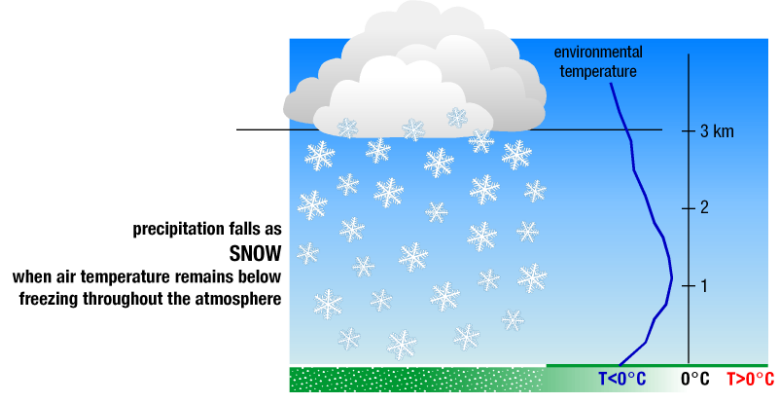
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

Some winter storms can immobilize an entire region, while others might only affect a single community. Winter storms typically are 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 blocked roadways, downed utility lines, and power outages. Putnam County's winter storms include blizzards, snowstorms, Nor'Easters, and ice storms. Extreme cold temperatures and wind chills are associated with winter storms.

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) and 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 snow crystals or a snow pellet, 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. Figure 5.4.8-1 depicts snow creation.

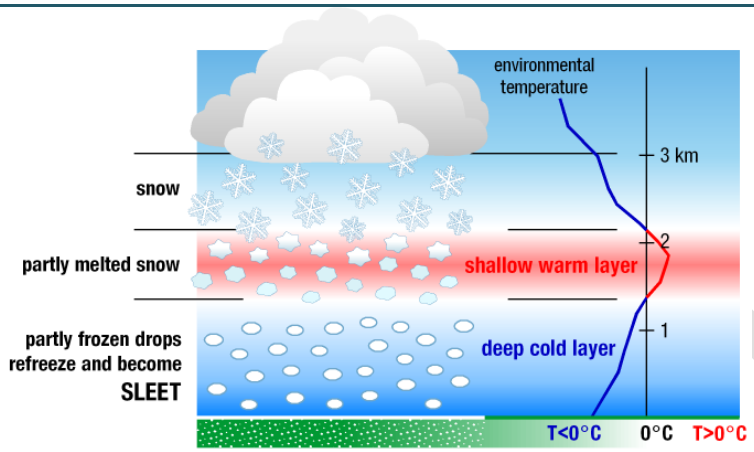
Figure 5.4.8-1. Snow Creation



Source: NOAA-NSSL, 2015

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 2020).

Figure 5.4.8-2. Sleet Creation



Source: NOAA-NSSL 2020

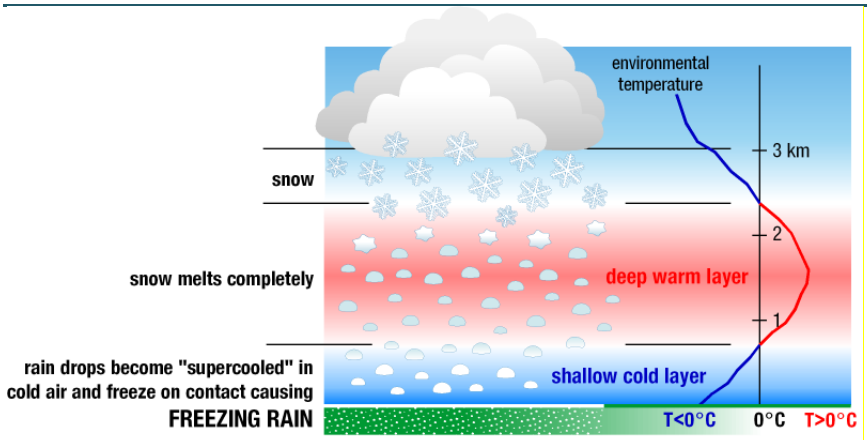
Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are 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 2019).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, 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 2020).

Figure 5.4.8-3. Freezing Rain Creation



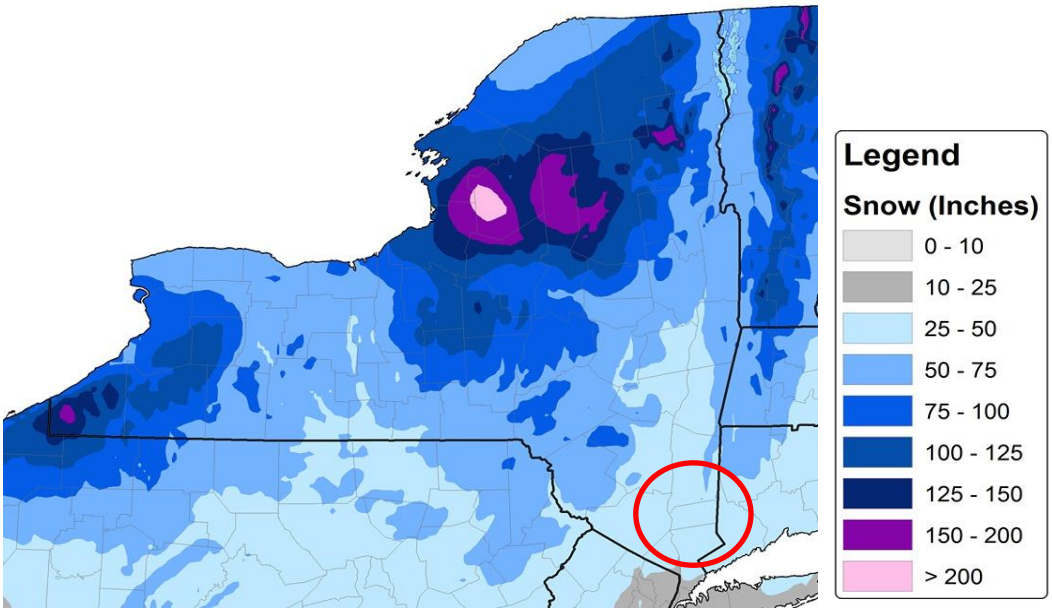
Source: NOAA-NSSL 2020

Location

Snow and Blizzards

Snowfall in New York State is highly variable. The inland regions of the State see an average seasonal amount of 40 inches or more, whereas the coastal regions typically see 25 to 35 inches. More than half of New York State's land area sees more than 70 inches of snow each season (NDC 2016). According to data from Cornell University, snowfall in Putnam averages between 25 and 50 inches a year. In terms of snowfall totals across the state, this is on the lower end of the spectrum. Much of the lower Hudson Valley experiences similar snowfall totals, whereas New York City and Long Island see approximately 10-25 inches/year. Much of the northern and western parts of the State (particularly those in higher elevations and near the lakes) can see at least 75 to 100 inches per year.

Figure 5.4.8-4. New York Annual Average Snowfall, 1960-2012



Source: Cornell University, NYSkiBlog.com
Note: The red circle indicates the location of Putnam County.

Ice Storms

The Midwest and Northeast United States are prime areas for freezing rain and ice storm events. These events can occur anytime between November and April, with most events occurring during December and January. Based on data from 1948 to 2000, the average annual number of days with freezing rain for Putnam County is five to six days, and the average annual number of hours is nine to fifteen hours (Midwest Regional Climate Center 2020).

Extent

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

The extent of a severe winter storm can be classified both by meteorological measurements and by evaluating societal impacts. The National Oceanic and Atmospheric Administration's (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 and 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 5.4.8-1 presents the five RSI ranking categories.

Table 5.4.8-1. 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 2020
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).

According to NWS (2018), the magnitude of a severe winter storm can be qualified into five main categories by event type:

- 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.

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) might affect a certain area, but its occurrence, location, and timing are uncertain. A winter storm watch is issued when severe winter conditions (heavy rain or significant ice accumulations) are possible within in the next day or two. A winter storm warning is issued when severe winter conditions are expected (heavy snow 7 inches or greater in 12 hours or 9 inches or greater in 24 hours; ice storm with ½ inch or more). A winter weather advisory is used when winter conditions (i.e., snow, sleet, freezing rain, ice) are expected to cause significant inconvenience and could be hazardous (e.g., snow or sleet of 4–6 inches, freezing rain and drizzle in any accretion of ice on roads but less than ½ inch). A blizzard warning is issued when snow and strong winds will combine to produce a blinding snow, visibility near zero/whiteouts, and deep snow drifts (NWS, n.d.).

Previous Occurrences and Losses

Based on a review of historic weather events and losses, Putnam County was found to have frequent winter storm occurrences. According to the NOAA-NCEI storm events database, Putnam County has been impacted by 88 winter weather events between 1996 and April 2020, including 44 heavy snow events, 6 ice storms, 26 winter storms, and 9 winter weather events (NOAA NCEI 2020).

Figure 5.4.8-5. History of Severe Storm Events in Putnam County

FEMA Disaster Declarations

Between 1954 and April 2020, FEMA included New York State in 26 winter storm-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe winter storm, snowstorm, snow, ice storm, winter storm, blizzard, and flooding. Generally, these disasters cover a wide region of the state; therefore, they may have impacted many counties. Putnam County was included in five of these declarations.

Table 5.4.8-2 FEMA Major Disasters and Emergency Declarations in Putnam County

Disaster Number	Declaration Date	Event Date	Incident Type	Title
EM-3299	12/18/2008	December 11, 2008 -- December 31, 2008	Severe Storm(s)	Severe Winter storm
EM-3184	3/27/2003	February 17, 2003 -- February 18, 2003	Snow	Snow
DR-1083	1/12/1996	January 6, 1996 -- January 12, 1996	Snow	Blizzard of '96 (Severe Snow Storm)
EM-3107	3/17/1993	March 13, 1993 -- March 17, 1993	Snow	Severe Blizzard
DR-801	11/10/1987	October 4, 1987	Snow	Severe Winter Storm

Source: FEMA 2020
DR Major Disaster Declaration (FEMA)
EM Emergency Declaration (FEMA)
FEMA Federal Emergency Management Agency

Previous Events

Table 5.4.8-3 identifies the known severe winter storm events that impacted Putnam County between 2014 and April 2020. For events prior to 2015, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.8-3. Severe Winter Weather Events in Putnam County, February 2014 to April 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
February 5, 2014	Heavy Snow	N/A	No	Eight to ten inches of snow fell in Putnam County following an eastward moving low-pressure system that brought wintry precipitation to the region.
February 13-14, 2014	Winter Storm	N/A	No	Sixteen to eighteen inches of snow fell and up to two-tenths of an inch of freezing rain fell on the County following a coastal low-pressure system.
November 26, 2014	Heavy Snow	N/A	No	Up to seven inches of snow fell across the County after a low-pressure system moved across the Eastern Seaboard. The storm caused impacts for Thanksgiving holiday travel.
January 24, 2015	Heavy Snow	N/A	No	A low-pressure system originating in the Gulf of Mexico moved up the Eastern Seaboard, bringing six to seven inches of snow to the lower Hudson Valley.
February 1, 2015	Heavy Snow	N/A	No	Eight to ten inches of snow fell in Putnam County following an eastward-moving storm that brought wintry mix to the region.
March 1, 2015	Winter Weather	N/A	No	Five inches of snow fell in the County as a result of a weak low-pressure system from the Ohio Valley.
January 23-24, 2016	Winter Storm	N/A	No	Between eight and 14 inches of snow fell in Carmel and throughout the County during a strong winter storm that brought widespread disruption to regional transportation over the weekend.
December 17, 2016	Winter Weather	N/A	No	Up to five inches of snow fell in the region owing to a wave of low pressure off Long Island.
February 9, 2017	Winter Storm	N/A	No	A strong winter storm recorded approximately one foot of snowfall in Putnam County. Disruption to regional transportation systems resulted from blizzard conditions impacting the NYC metropolitan area.
March 14, 2017	Winter Storm/Blizzard	N/A	No	Between one and two feet of snowfall and some sleet was recorded as a low-pressure system moved up the Eastern Seaboard and brought blizzard conditions to the Lower Hudson Valley. At Poughkeepsie Airport, visibility was reduced to less than one-quarter mile and wind gusted over 35 mph.
January 4, 2018	Winter Storm	N/A	No	A winter storm/blizzard brought 10 inches of snow to Carmel and six to eight inches of snow elsewhere. Wind gusts of up to 40 mph were recorded at the Danbury Airport near Putnam County.
February 17-18, 2018	Heavy Snow	N/A	No	Six to seven inches of snowfall were reported in Putnam County resulting from a low-pressure system passing through southern New York and the Lower Hudson Valley.
March 1, 2018	Winter Weather	N/A	No	A low-pressure system bringing moderate amounts of snow to the region resulted in tragedy when associated winds fell a tree upon a house in Putnam Valley, killing an eleven-year-old boy.
March 7-8, 2018	Winter Storm	N/A	No	Between 15 and 20 inches of snow was reported to fall in Putnam County following a winter storm that brought down power lines and tree limbs owing to wet snow and wind gusts.
March 12-13, 2018	Winter Weather	N/A	No	Four to six inches of snow fell in the County following an area of low pressure that brought light snow to southern New York.
March 21-22, 2018	Winter Weather	N/A	No	A slow-moving low-pressure system brought minor amounts of snow to southern New York, with three to five inches in Putnam recorded. Blizzard-like conditions were recorded on Long Island.
April 2, 2018	Winter Weather	N/A	No	Five to six inches of snowfall were reported in Putnam County resulting from a stalled frontal boundary.
November 15-16, 2018	Winter Storm	N/A	No	Stationary cold air and a developing coastal low-pressure system produced significant snowfall and regional disruption in the Tri-

Table 5.4.8-3. Severe Winter Weather Events in Putnam County, February 2014 to April 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				State area. Seven to nine inches of snow were reported in Putnam County.
January 19-20, 2019	Winter Storm	N/A	No	Nearly a half-inch of ice and up to five inches of snow were reported in the Putnam County region due to a wintry mix of precipitation associated with a low-pressure system from the southeast. Hazardous travel conditions, downed power lines, and downed tree limbs were reported.
March 2, 2019	Winter Weather	N/A	No	A fast-moving low-pressure system brought two inches of snow to Carmel.
March 3-4, 2019	Heavy Snow	N/A	No	Over half a foot of snow fell in Putnam County as a low-pressure system brought wintry precipitation as it moved up the Eastern Seaboard.
December 1-3, 2019	Heavy Snow	N/A	No	Five to seven inches of snow was reported following an area of low pressure moving through the region from the coast.

Sources: FEMA 2020; NOAA-NCEI 2020; SPC 2020
** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
DR Major Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph Miles per Hour
NCEI National Centers for Environmental Information
NOAA National Oceanic and Atmospheric Administration
N/A Not Applicable

Climate Change Projections

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to increase. The impacts related to increasing temperatures and sea level rise are already causing complications in the state. *ClimAID: The Integrated Assessment for Effective Climate Change in New York State (ClimAID)* was undertaken to provide decision-makers with information on the state's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (NYSERDA 2011).

Temperatures in New York State are warming, with an average rate of warming over the past century of 0.25° F per decade. Average annual temperatures are projected to increase across New York State by 2–3.4 °F by the 2020s, 4.1–6.8 °F by the 2050s, and 5.3–10.1 °F by the 2080s. By the end of the century, the greatest warming is projected to be in the northern section of the state (NYSERDA 2014).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Putnam County is part of Region 5 (Hudson River and Mohawk River Valleys), where temperatures are estimated to increase by 4.5 to 6.2ºF by the 2050s and 5.6 to 9.7ºF by the 2080s (baseline of 47.6ºF, middle range projection). Precipitation totals are estimated to increase between four to twelve percent by the 2050s and five to fifteen percent by the 2080s (baseline of 38.6 inches, middle range projection). Table 5.4.8-4 displays the projected seasonal precipitation change for the region (NYSERDA 2014).

Table 5.4.8-4. Projected Seasonal Precipitation Change in Region 5, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	-5 to +10	-5 to +5	-5 to +10

Source: NYSERDA 2011

New York State already is experiencing the effects of climate change during the winter season. Winter snow cover is decreasing, and spring comes, on average, about a week earlier than it did a few years ago. Nighttime temperatures are measurably warmer, even during the colder months. Overall winter temperatures in New York State are almost 5 degrees warmer than in 1970 (NYSERDA 2011; NYSDEC, n.d.). The state has experienced a decrease in the number of cold winter days (below 32 °F) and can expect to see a decrease in snow cover by as much as 25–50 percent by end of the next century. The lack of snow cover may jeopardize opportunities for skiing, snowmobiling, and other types of winter recreation; and natural ecosystems will be affected by the changing snow cover (Cornell University College of Agriculture and Life Sciences 2011). As the century progresses, snowfall is likely to become less frequent, with the snow season decreasing in length. It is uncertain if there will be changes in the intensity of snowfall during each storm; however, it is possible that higher temperatures in colder parts of New York State could support higher snowfall totals during snowstorm events (NYSERDA 2014).

Some climatologists believe that climate change could play a role in the frequency and intensity of Nor'Easters. Two ingredients are needed to produce strong Nor'Easters and intense snowfall: (1) temperatures which are just below freezing and (2) massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As temperatures increase in the winter months, they will be closer to freezing rather than frigidly cold. Climate change is expected to produce more moisture, thus increasing the likelihood that these two ingredients (temperatures just below freezing and intense moisture) will cause more intense snow events.

Probability of Future Occurrences

Table 5.4.8-5 summarizes data regarding the probability of occurrences of severe winter storm events in Putnam County based on the historic record. Heavy snow events and winter storms are the first and second most common in Putnam County, respectively. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5.4.8-5. Probability of Future Occurrence of Severe Winter Weather Events in Putnam County

Hazard Type	Number of Occurrences Between 1954 and 2019	% Chance of Occurring in Any Given Year
Blizzard	0	N/A
Heavy Snow	49	100
Ice Storm	5	20.8
Lake Effect Snow	2	8.3
Sleet	0	N/A
Winter Storm	18	75.0
Winter Weather	5	20.8
TOTAL	**79**	100

Source: NOAA-NCEI 2020
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act (Public Law 81-875), and selected winter storm events since 1996. Due to limitations in data, not all winter storm events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated

Based on historical data from NYSERDA (2011), it is expected that the following will occur at least once per 100 years:

- Up to four inches of freezing rain in the ice band near central New York State of which between 1–2 inches of accumulated ice will occur over a 24-hour period.

- Up to two feet of accumulated snow in the snow band in northern and western New York State over a 48-hour period.

Based on geography, location, past event history, and climate projections, Putnam County will continue to experience winter storm events. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings; refer to Section 5.3 (Hazard Ranking) for additional information on the hazard ranking methodology and probability criteria. The probability of occurrence for severe winter storms in the county is considered frequent (event has a 100 percent annual probability and might occur multiple times in the same year).

5.4.8.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the severe winter storm hazard, all of Putnam County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable to a winter storm event.

Impact on Life, Health and Safety

The entire population of Putnam County (99,070 people) is exposed to severe winter storm events (American Community Survey 2018). 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 (NSSL 2020).

The homeless and elderly are considered most susceptible to this hazard. 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. According to the 2018 American Community Survey 5-Year population estimate, there are 16,053 persons over 65 years old that reside in the County that are considered vulnerable to severe winter weather. In addition, severe winter storm events can reduce the ability of these populations to access emergency services.

Additionally, the homeless and residents below the poverty level may not have access to housing or their housing could be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Putnam County, the Town of Carmel has the highest population below the poverty level (i.e., 1,144 persons). Refer to Section 4 (County Profile) that displays the distribution of low-income populations in Putnam County.

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. Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percent damages that could result from severe winter storm conditions. This allows planners and emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. **Error! Reference source not found.** Table below summarizes the estimated loss based on 1-, 5-, and 10-percent losses. 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 5.4.8-6. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Brewster (V)	$665,633,363	$6,656,334	$33,281,668	$66,563,336
Carmel (T)	$9,304,370,987	$93,043,710	$465,218,549	$930,437,099
Cold Spring (V)	$790,405,963	$7,904,060	$39,520,298	$79,040,596
Kent (T)	$2,983,284,562	$29,832,846	$149,164,228	$298,328,456
Nelsonville (V)	$209,404,256	$2,094,043	$10,470,213	$20,940,426
Patterson (T)	$2,927,865,178	$29,278,652	$146,393,259	$292,786,518
Philipstown (T)	$2,629,391,554	$26,293,916	$131,469,578	$262,939,155
Putnam Valley (T)	$3,314,750,529	$33,147,505	$165,737,526	$331,475,053
Southeast (T)	$4,717,511,487	$47,175,115	$235,875,574	$471,751,149
Putnam County (TOTAL)	**$27,542,617,878**	**$275,426,179**	**$1,377,130,894**	**$2,754,261,788**

Source: Putnam GIS 2014; RS Means 2019

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 5.4.5 Flood). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with the 1-percent annual chance flood.

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 (NSSL 2020).

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 2020).

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. According to Putnam County, the projected costs in 2020 for snow removal throughout the County is approximately $4.56 million (Putnam County 2018). The County has partnered with the Town of Kent, the Town of Patterson, the Town of Philipstown, the Town of Putnam Valley, and the Town of Southeast along with several school districts to coordinate with snowplow efforts. In addition to snow removal costs, severe winter

weather affects the ability of persons to commute into and 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 and may cause a loss in economic productivity.

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020). Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals.

Chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry de-icing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth.

Cascading Impacts on Other Hazards

Severe winter weather events may exacerbate flooding. As discussed, the freezing and thawing of snow and ice associated with winter weather events can create major flooding issues in the County. Maintaining winter weather hazards through snow and ice removal could minimize the potential risk of flooding during a warming period. Refer to 5.4.5 (Flood) for more information about the flood hazard of concern.

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential 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 climate change.

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located could be potentially impacted by severe winter weather events. Current New York State land use and building codes incorporate standards that address and mitigate snow accumulation. Some local municipalities in the State have implemented the following activities to eliminate loss of life and property and infrastructure damages during winter storm events:

- Removal of snow from roadways
- Removal of dead trees and trim trees/brush from roadways to lessen falling limbs and trees
- Ensure proper road signs are visible and installed properly
- Bury electrical and telephone utility lines to minimize downed lines
- Removal of debris/obstructions in waterways and develop routine inspections/maintenance plans to reduce potential flooding
- Replace substandard roofs of critical facilities to reduce exposure to airborne germs resulting from leakage

- Purchase and install backup generators in evacuation facilities and critical facilities to essential services to residents
- Install cell towers in areas where limited telecommunication is available to increase emergency response and cell phone coverage (NYS HMP 2019, NYS DHSES 2020)

Projected Changes in Population

According to the U.S. Census Bureau, the population in Putnam County has decreased by approximately 0.7-percent between 2010 and 2018 (US Census Bureau 2020). However, estimated population projections provided by the 2017 Cornell Program on Applied Demographics indicates that the County's population will increase slowly into 2040, increasing the total population to approximately 100,435 persons (Cornell Program on Applied Demographics 2017). Any growth can create changes in density throughout the County, which may impact the ability of persons in the County to mobilize or receive essential services during severe winter storm events. Historically, winter weather events with associated snowfall and ice accumulation have severely impacted transportation corridors as well as infrastructure. Refer to Section 4 (County Profile), which includes a discussion on population trends for the County.

Climate Change

As discussed above, most studies project that the State of New York will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to freeze into heavy snowfall and icing. This increase in snow and ice could result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by severe winter events due to loss of service or access.

Change of Vulnerability Since 2015 HMP

Since the 2015 analysis, population statistics have been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. Additionally, this updated analysis estimated exposure and losses at the structure level with updated building stock data. The general building stock was updated using building stock data provided by the County to update the user-defined facility inventory and critical facility inventory dataset. The replacement cost value of these structures was updated using RS Means 2019 building valuations.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Putnam County.

Identified Issues

Placeholder