5.4.10 Severe Winter Storm

This section provides a profile and vulnerability assessment of the severe winter storm hazard for Monroe County.

5.4.10.1 Hazard Profile

This section provides information regarding the description, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences for the severe winter storm hazard.

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:

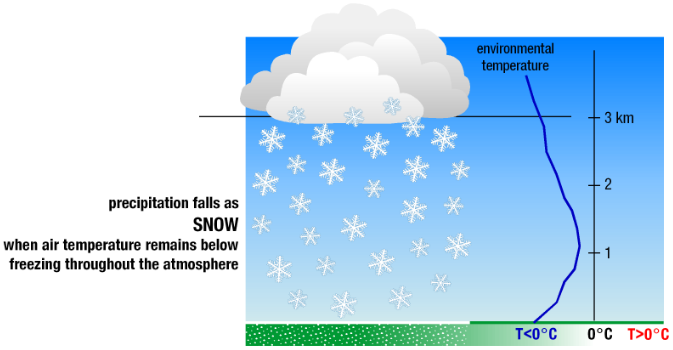
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean (NOAA 2021).

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. Monroe County's winter storms include blizzards, snowstorms, and ice storms. Extreme cold temperatures and wind chills are associated with winter storms. For more information on extreme cold temperatures, refer to the Section 5.4.4. (Extreme Temperature).

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 5.4.10-1 depicts snow creation.

Figure 5.4.10-1. Snow Creation



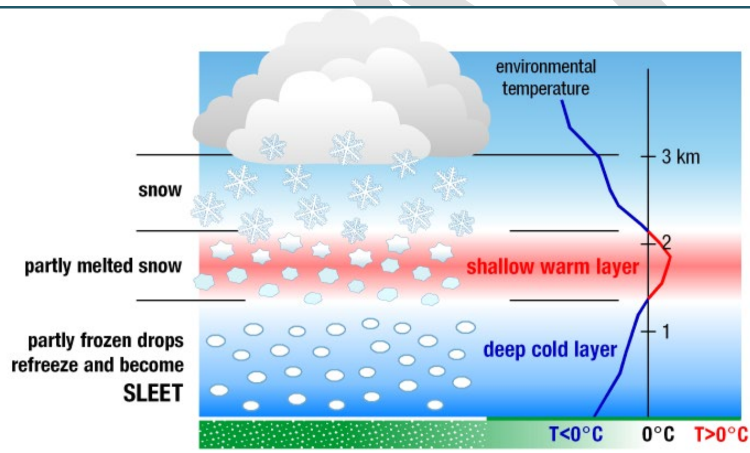
Source: NOAA-NSSL 2015

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

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 (NSSL 2021). Figure 5.4.10-2 depicts snow creation.

Figure 5.4.10-2. Sleet Creation



Source: NOAA-NSSL 2020

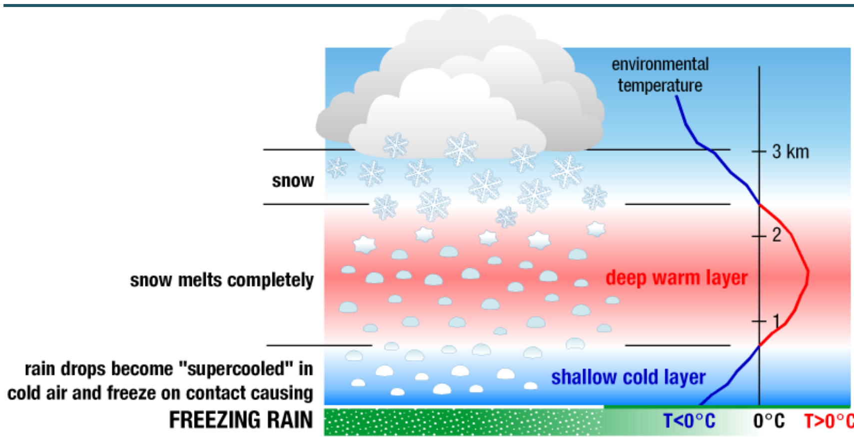
Blizzards

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 (Lam 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 (Dolce 2012). Figure 5.4.10-3 depicts freezing rain creation.

Figure 5.4.10-3. Freezing Rain Creation



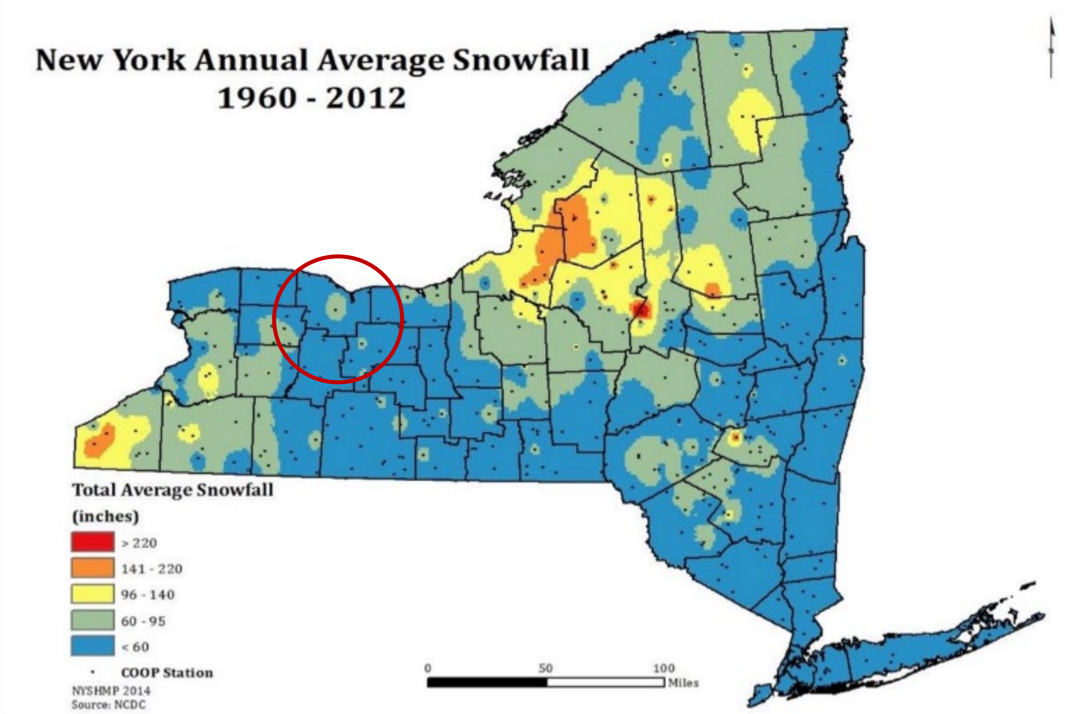
Source: NOAA-NSSL 2020

Location

The climate of New York State is marked by abundant snowfall. Winter weather can reach New York State as early as October and is usually in full force by late November with average winter temperatures between 20 and 40 F. The inland regions of New York State receive more snow than most other communities in the nation. Although the entire state is subject to winter storms, the easternmost and west-central portions of the state are more likely to suffer under winter storm occurrences than any other location (NYS DHSES 2019). With the exception of coastal New York State, the state receives an average seasonal amount of 40 inches of snow or more. The average annual snowfall is greater than 70 inches over 60 percent of New York State's area, with Monroe County's averages less than 60 to 95inches annually. The City of Rochester is typically in the top ten cities in the nation in annual snowfall (NYS DHSES 2019). According to the Northeast Regional Climate Center, average annual snowfall in Rochester is 93.4 inches (Northeast Regional Climate Center 2009).

Figure 5.4.10-4, an annual average snowfall map, illustrates the annual average snowfall totals over a 50-year period for New York State.

Figure 5.4.10-4. New York Annual Average Snowfall, 1960-2012



Source: NYS DHSES 2014
Note: The red circle indicates the location of Monroe County

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. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA n.d.). Table 5.4.10-1 presents the five RSI ranking categories.

Table 5.4.10-1. 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. According to NWS (NWS 2021), the magnitude of a severe winter storm can be qualified into five main categories by event type:

Table 5.4.10-2. Winter Storm Category Thresholds

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 5.4.10.1-5 for the warning thresholds.

Figure 5.4.10.1-5. Winter Storm Warning Thresholds

Source: NWS 2021

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe winter storms throughout New York State and Monroe County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based on the available information in cited sources.

FEMA Major Disaster and Emergency Declarations

Between 1953 and 2022, New York State was included in 22 FEMA declared disasters (DR) or emergency declarations (EM) that involved snow or ice storms. Monroe County was included in six of these 22 severe winter weather-related declarations (Table 5.4.10-1).

Table 5.4.10-3. FEMA DR and EM Declarations for Severe Winter Storm Events in Monroe County, 1954 to 2022

FEMA Declaration Number	Date(s) Of Event	Event Type	Details
DR-494	March 19, 1976	Ice Storm, Severe Storms, Flooding	New York Ice Storm, Severe Storms, Flooding
DR-898	March 3-4, 1990	Severe Winter Storm	New York Severe Storm, Winter Storm
EM-3107	March 13-17, 1993	Severe Blizzard	New York Severe Blizzard
DR-1196	January 5-17, 1998	Severe Storms and Flooding	New York Severe Winter Storms
EM-3138	March 3-6, 1999	Snow	New York Winter Storm
DR-1467	April 3-5, 2003	Ice Storm	New York Ice Storm

Source: FEMA 2022

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (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 2015 and 2022, Monroe County was not included in any USDA-designated agricultural disasters that included severe winter storm events (USDA 2022).

Previous Events

Table 5.4.10-4 identifies the known severe winter storm events that impacted Monroe County between 2015 and 2022. 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 5.4.10-4. Severe Winter Storm Events in Monroe County, 2015 to 2022

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
February 1-2, 2015	Winter Storm	Monroe County	N/A	N/A	Low pressure brought a general eight to fourteen inches of snow to the entire region. Heaviest amounts were along the southern tier counties and over the counties along the south shore of Lake Ontario. Northeast winds became quite strong near Lake Ontario with near blizzard conditions occurring closer to the shore. While the snow did not result in many closings the general snow across the entire region did result in many delays and late openings. Specific snowfall reports included: 17 inches at Webster; and 16 inches at Greece and Oswego
February 9, 2015	Winter Storm	Monroe County	N/A	N/A	Low pressure brought a light general snowfall to the area. The northerly flow crossing the warmer waters of Lake Ontario and higher elevations resulted in enhanced snowfall amounts across parts of the Genesee Valley and northern Finger Lakes. Given the harsh winter conditions, the effects of this storm on the region were generally minimal with just some delays and longer travel times. Specific snowfall reports included 12 inches near Rochester.
February 14-15, 2015	Winter Storm	Monroe County	N/A	N/A	A strong clipper crossed the Great Lakes and brought snow and blowing snow to the region and some of the coldest air of the season. The snowfall amounts were enhanced downwind of Lake Ontario and upslope east of Lake Erie where snowfall amounts around a foot were recorded. Gusty winds accompanied the system and produced reduced visibilities in blowing snow. On the back side of the system, temperatures plummeted and struggled to reach zero on Sunday the 15th. Combined with the winds, wind chill temperatures of minus 25 to minus 35 degrees F were recorded.
January 18-19, 2016	Lake-Effect Snow	Monroe County	N/A	N/A	Lake effect snow, arctic air flowed over the eastern Great Lakes Sunday, January 17th, with early weekend air temperatures in the 40s plummeting back below freezing. The lake effect snows began during the morning. This northwest flow over Lake Ontario continued varying intensity to the snow bands through the night and into Tuesday, with subtle variations in the wind flow carrying the snows over the southern and southeastern shorelines Specific storm totals off Lake Ontario included 13 inches at Irondequoit.
February 10-11, 2016	Lake-Effect Snow	Monroe County	N/A	N/A	A west wind brought the steadiest snows east of Lake Erie across ski country through the day, while on the southwestern shoreline of Lake Ontario a band of snow hugged the shoreline, dropping upwards of a half a foot of snow.
February 15-16, 2016	Winter Storm	Monroe County	N/A	N/A	Low pressure moved north across central Pennsylvania and central New York. It was on the only major synoptic event of the winter. This brought all snow to western New York. Across central New York what started initially as snow changed to rain Tuesday morning (16th) then back to snow for the evening hours. Across the north country minor snow accumulations accompanied up to a half inch of ice. The axis of heaviest snow (eighteen to twenty-two inches) fell across the Monroe county and the City of Rochester. The heavy snow began to fall during the early morning hours bringing the morning commute to a standstill.
November 20-22, 2016	Lake-Effect Snow	Monroe County	N/A	N/A	A strong cold front moved across the Lower Great Lakes creating marginally cold temperatures. Lake enhanced snow covered a much larger area than typical lake effect snow events. The most persistent lake enhanced snow was found east and southeast of Lake Ontario with storm totals of over one foot in a large area from Rochester eastward to the Tug Hill region. Snowfall reports off Lake Ontario included 16 inches at Fairport and 15 inches at Rochester.

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
December 15-16, 2016	Lake-Effect Snow	Monroe County	N/A	N/A	A cold front moved through the region, with the wind direction from the southwest initially developing lake effect snow. Lake Ontario experiences the heaviest snow period during the morning of the 15th. Following the passage of the arctic front, winds become more northwest, with a band of heavy snow settling south into the Rochester area during the late afternoon and evening. The combination of heavy snow and gusty winds brought a difficult afternoon and evening drive in the Rochester area. Heavy lake effect snow persisted through much of the night on the 15th for Rochester. Lake Ontario, specific snowfall reports included: 14 inches at Rochester Airport, 10 inches at Irondequoit and Webster.
February 9-10, 2017	Lake-Effect Snow	Monroe County	N/A	N/A	Lake effect snow developed behind a departing coastal nor'easter as cold air spilled across the region on a northwesterly flow. The northwesterly flow became perfectly aligned from Lake Superior across the Georgian Bay to Lake Ontario Thursday night into Friday morning. This helped to organize and lock-in an intense single band of lake effect snow that came on shore in northeast Monroe County. Specific snowfall reports included 8 inches in Webster.
December 12-13, 2017	Winter Storm	Monroe County	N/A	N/A	A general snow across the region was enhanced by the Great Lakes before transitioning to lake effect snow bands east and southeast of the lakes. The lake effect snow taper off and ended by late Wednesday. Off Lake Ontario, synoptic snow became lake enhanced on Tuesday and Tuesday night, before transitioning to purely lake effect snow by late Tuesday night through Wednesday. A robust lake effect snow plume was centered on the Tug Hill under a westerly flow with snowfall rates exceeding 2 inches per hour. Overnight, winds became northwest and pushed this band to the south, breaking it apart into multi-bands on a northwest flow. The lake effect snow ended Wednesday night. Snowfall amounts were generally highest toward the southeast corner of Lake Ontario, which saw the most persistent lake enhancement of snowfall.
December 29-30, 2017	Lake-Effect Snow	Monroe County	N/A	N/A	Tea kettle bands of lake effect snow developed offshore over Lake Erie and Lake Ontario for an extended period of time prior to moving onshore, first on Lake Erie and eventually on Lake Ontario. By early evening, the entire band moved onshore as an arctic front crossed the lake. The lake effect snow diminished to flurries and light snow showers by midday on the 31st. Specific snowfall reports included: 8 inches at Greece.
January 4-6, 2018	Lake-Effect Snow	Monroe County	N/A	N/A	The heaviest lake effect snow fell at the beginning of this event during the evening of the 4th as an arctic front slowly crossed Lake Ontario and merged with a band of lake effect snow from Rochester to southern Oswego County. Snowfall rates reached 2 inches per hour at times for a few hours during the evening from the Monroe County shoreline. Specific snowfall reports included:12 inches at Webster and 8 inches at Irondequoit.
January 12-13, 2018	Winter Storm	Monroe County	N/A	N/A	A developing winter storm brought first a wintry mix of precipitation during the evening of the 12th and then heavy snow through the morning of the 13th. Rain changed to a mix of freezing rain and snow during the evening. Ice accumulations up to a tenth of an inch were reported along the lake shore counties. Once the precipitation changed to snow, the heavy snow fell at one to two inches an hour during the overnight hours. Travel was difficult especially on untreated roads as the snow covered the ice below. Winds gusting to 35 mph at times caused areas of blowing and drifting snow.
November 15-16, 2018	Winter Storm	Monroe County	N/A	N/A	A complex system moved into the area with wildly varying thermal profiles. An initial mid-level trough and surface low moved across the southeast United States that gave way to secondary cyclogenesis near the southern tip of the Delmarva. The secondary low then moved northward along the east coast to the Gulf of Maine. The system had very marginal cold air to work with, particularly in western New York. As

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
					the event unfolded, precipitation type was mostly snow from Rochester eastward, with just a few brief periods of sleet. More sleet and some freezing rain mixed in through the first half of the event across far western New York, cutting back on snow accumulation there.
April 14-15, 2018	Ice Storm	Monroe County	N/A	N/A	Two rounds of mixed winter precipitation moved over the area with warm air aloft overriding a deep layer of cold air at the surface. This resulted in sleet initially that transitioned to freezing rain before temperatures eventually increased above freezing. Several areas saw nearly an inch of sleet combined with around one half of an inch of freezing rain. This resulted in thousands of power outages and substantial tree damage.
January 1-20, 2019	Winter Storm	Monroe County	N/A	N/A	A system tracked along the New York/Pennsylvania line and spread heavy snow across our region over the weekend. The low pressure track fit perfectly with climatology for widespread heavy snow in our area. The heaviest amounts that model solutions generally had across the western Southern Tier ended up being across the entirety of the Thruway corridor, resulting in over a foot of snow for much of the area. Northeasterly flow off of Lake Ontario resulted in localized maxima along the southwestern shore of the lake, as well. Even with more than a foot of snow, impacts were not as severe as they would otherwise have been because all of the snow fell over a weekend, resulting in lower impacts to transportation.
February 27, 2019	Winter Storm	Monroe County	N/A	N/A	Snow developed across the area south of Lake Ontario as a surface low translated across Pennsylvania. The heaviest snow generally fell along the Thruway corridor during the daytime hours of February 27. This snow impacted both the morning and evening commutes with up to 1 inch per hour snowfall rates. Most areas received between 4 and 7 inches, however local daytime accumulation in the northern Finger Lakes and Rochester area slightly exceeded these values.
November 11-12, 2019	Winter Storm	Monroe County	N/A	N/A	A cold front moved slowly south across the area and stalled just south of the area. A deep upper level trough became carved out in the flow over the Upper Great Lakes, which forced a strong wave to develop along the stalled frontal zone just south of our area. Frontogenesis to the north of the low track and just north of the stalled frontal zone acted as a focus for moderate to heavy snow. Model guidance with this system trended south and weaker before trending back north and stronger. Winter storm watches and warnings were issued for much of the area, but the heavy snow ended up being a bit farther north and west than had been warned for.
January 22-23, 2021	Lake-Effect Snow	Monroe County	N/A	N/A	Weakening low pressure system passed to our north across Ontario and Quebec. This provided large scale moisture that when combined with pre-frontal temps aloft just cold enough to support lake effect resulted in snow east of Lake Ontario. Upslope initially aided the combined synoptic moisture and lake-induced instability to generate heavy snow in the Tug Hill region. This resulted in heavy snow sinking southward in the Monroe County to Cayuga County shoreline. Selected snow totals included 10 inches in Gates and 9 inches in Webster.
February 2-3, 2021	Winter Storm	Monroe County	N/A	N/A	A stacked coastal storm threw Atlantic moisture back across western and north central New York Tuesday (Groundhog Day) and into Wednesday. Strong mesoscale banding occurred over the North Country and on the western edge of the mid-upper level low. Later, banding within the shield of synoptic snow enhanced snowfall rates to over an inch an hour for sites Rochester and eastward with total snowfall approaching 10 -12 inches in some areas. The Rochester evening commute was slow with snow covered roads.

Dates of Event	Event Type	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
February 15-16, 2021	Winter Storm	Monroe County	N/A	N/A	A deep trough dug across the nation's midsection with an outbreak of Arctic air from the Great Plains to Texas. Low pressure developed near Louisiana and tracked across Pennsylvania toward southern New England on the eastern fringe of the cold air mass. A weaker initial wave of precipitation produced 1-3 inches of snow with a lull before the main event with deeper moisture, isentropic lift, and favorable jet dynamics arrived later in the day on February 15. While most of the area was originally forecast to see heavy snow, large scale drying aloft encroached from the south. This resulted in far less snow over the Southern Tier and from the Genesee Valley eastward.
January 16-17, 2022	Winter Storm	Monroe County	N/A	N/A	Low pressure across the Carolinas rapidly intensified to 980 hPa as it tracked across eastern Pennsylvania and New York. This brought a deepening surface low track inland of the coast and the climatologically favored baroclinic zone along the periphery of the Gulf Stream. Other than the unusual track, it was a classic Nor'easter driven by a strong closed low across the southeast interacting with a longwave trough. Forcing for ascent was supported by strong differential vorticity advection ahead of the sharp mid-level closed low, impressive upper level coupled jet structure, and strongly diffluent flow aloft. A very strong southeasterly low level jet supported a strong warm conveyor belt, which resulted in a clearly defined deformation zone developing northwest of the storm early on January 17 and lingering over much of western New York with extreme snowfall rates for several hours.
February 2-4, 2022	Winter Storm	Monroe County	N/A	N/A	A frontal boundary slowly sagged southward through the area. This allowed for deep cold air to make its way south of the Pennsylvania state line. A series of weak disturbances then worked down this front bringing several rounds of moderate to heavy snow. The heaviest snow fell in the evening of February 3 for most areas. This occurred after a slow changeover from rain to snow as the front sagged southward. By the end of the event, many portions of the area received more than a foot of snow.

Source: NOAA NCEI 2022; FEMA 2022; NYS DHSES 2019

Climate Change Impacts

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 2011/2014).

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 2011/2014).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Monroe County is part of Region 1 (Western New York and the Great Lake Plains), where temperatures are estimated to increase by 4.3 to 6.3ºF by the 2050s and 5.7 to 9.6ºF by the 2080s (baseline of 47.7ºF, middle range projection). Precipitation totals are estimated to increase between four to ten percent by the 2050s and four to thirteen percent by the 2080s (baseline of 34.0 inches, middle range projection). Table 5.4.1010-44 displays the projected seasonal precipitation change for the region for 2050 (NYSERDA 2011/2014). The winter season is projected to have a precipitation increase of 5-15 percent.

Table 5.4.1010-4. Projected Seasonal Precipitation Change in Region 2, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	0 to +15	-10 to +10	-5 to +10

Source: NYSERDA 2014

New York State already is experiencing the effects of climate change during the winter season. Annual ice cover has decreased 71 percent on the Great Lakes since 1973. This decrease may lead to increased lake-effect snow in Erie County in the next two decades through greater moisture availability. By mid-century, however, lake-effect snow will generally decrease as temperatures below freezing become less frequent. 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 2011/2014). 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 2011/2014).

Probability of Future Occurrences

Based on geography, location, past event history, and climate projections, Monroe County will continue to experience winter storm events.

Table 5.4.10-5 summarizes data regarding the probability of occurrences of severe winter storm events in Monroe County based on the historic record. Heavy snow events and winter storms are the first and second most common in Monroe County, respectively. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5.4.10-5. Probability of Future Occurrence of Severe Winter Weather Events in Monroe County

Hazard Type	Number of Occurrences Between 1996 and 2022	% chance of occurrence in any given year
Blizzard	2	7.41%
Heavy Snow	39	100%
Ice Storm	4	14.8%
Winter Storm	30	100%
Winter Weather	1	3.7%
TOTAL	**76**	**100%**

Source: NOAA-NCEI 2022
Note: Disaster occurrences include federally declared disasters and selected winter storm events between January 1, 1996 and January 1, 2022. Due to limitations in data, not all winter storm events occurring between 1996 and June 2022 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

Based on historical data from NYSERDA (2014), 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.

Section 5.3 ranks the identified hazards of concern for Monroe County. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee, the probability of occurrence for severe winter storm in the County is considered 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year).

5.4.10.2 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 Monroe 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 Monroe County (753,109) is exposed to severe winter storm events (US Census 2020). 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 2021).

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 2020 American Community Survey 5-Year population estimate, there are 127,588 persons over 65 years old that reside in the County that are considered vulnerable to severe winter weather (16.9 percent of the County population). In addition, severe winter storm events can reduce the ability of these populations to access emergency services

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. 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.

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 from the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires clearing of roadways and alerting of 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. 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.

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 storm 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 DHSES 2019).

Projected Changes in Population

According to the 2020 Census, the population of the County has increased by approximately 1.2 percent since 2010. The County's population is anticipated to slightly increase over the next decade (0.7 percent increase by 2030). Any increase in 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 more thorough discussion about 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 2017 HMP

Monroe County remains vulnerable to severe winter storm events. Since the 2017 analysis, population statistics have been updated using the 2020 US Census. 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.

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