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 Tompkins County.

The hazard profile is organized as follows:	The vulnerability assessment is organized as follows:
• Description • Extent • Previous Occurrences and Losses • Probability of Future Occurrences • Climate Change Impacts	• Impact on Life and Safety • Impact on General Building Stock • Impact on Community Lifelines • Impact on Economy • Impact on Environment • Cascading Impacts on Other Hazards • Future Change that may Impact Vulnerability • Changes Since 2014 HMP • Identified Issues

5.4.8.1 Hazard 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.

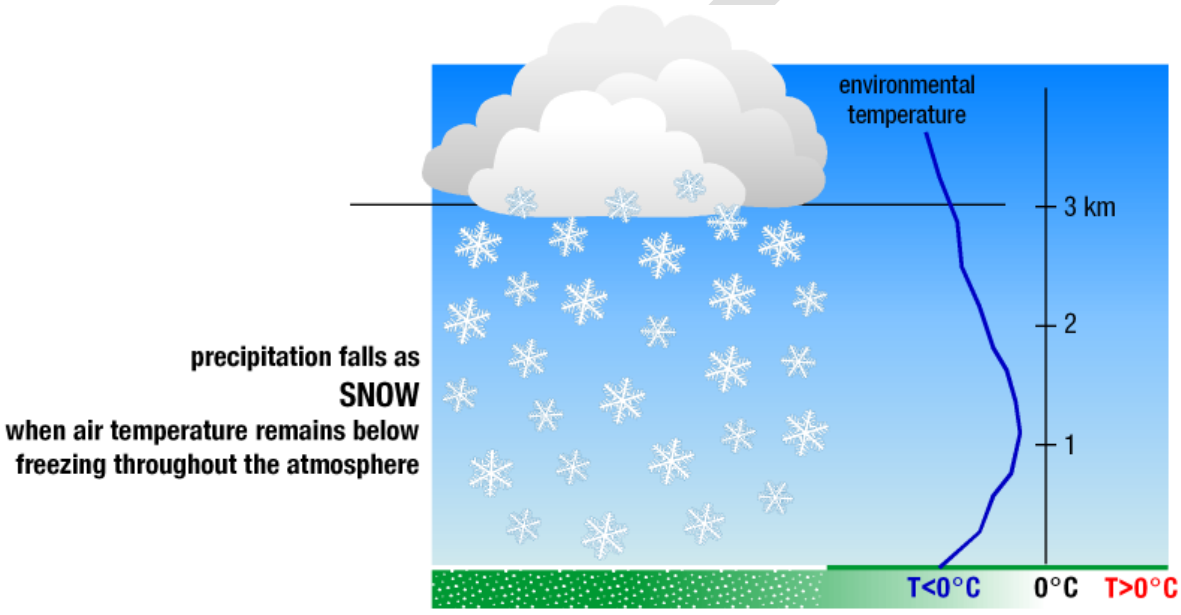
Some winter storms are large enough to immobilize an entire region while others might only affect a single community. Winter storms typically are accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community 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.

In Tompkins County, winter storms include blizzards, Nor'Easters, snowstorms, and ice 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.

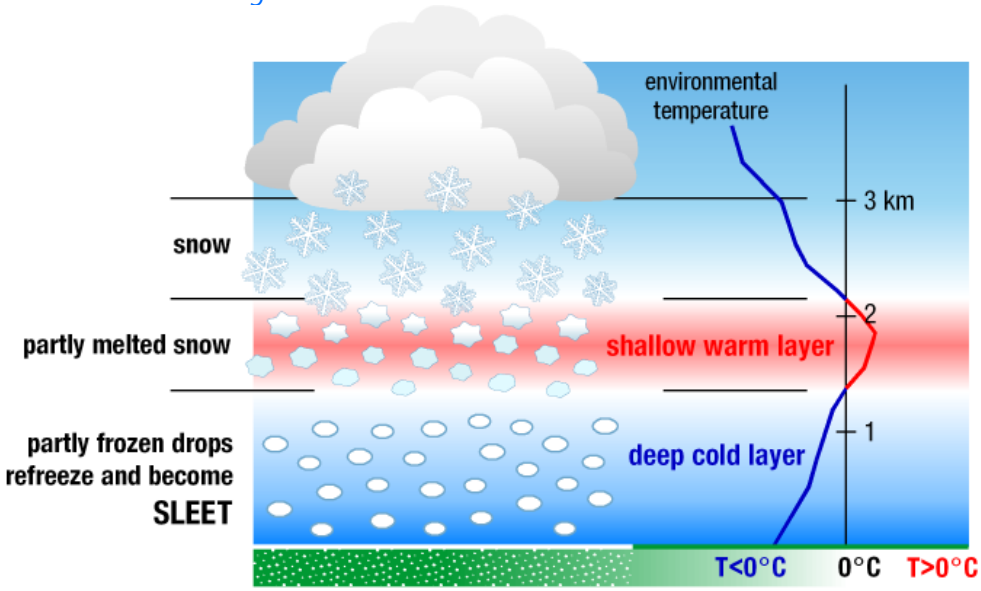
Figure 5.4.8-1. Snow Creation



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 2013). Figure 5.4.8-2 indicates the process of sleet creation.

Figure 5.4.8-2. Sleet Creation



Source: NOAA-NSSL 2015

Nor'easters

Nor'easters are storms that occur along the East Coast of North America and thus have been named accordingly based on the winds which are typically from the northeast. While these storms may occur at any given time of the year, they are most frequent and violent between the months of September and April. Some notable Nor'easter events include the New England Blizzard of 1978, the 1993 Superstorm, and the 2015 Boston snowstorm. These severe snow events have been responsible for billions of dollars in damage, and have caused significant economic, transportation and human disruption. In some instances, these events have also led to coastal flooding and subsequent damages.

These extreme snow events are triggered by polar jets from the north moving south towards the Atlantic and colliding with warm air from the Gulf of Mexico which the creates heavy amounts of precipitation along the East Coast. As a result of this collision, the coastal waters are relatively mild during the winter, which in turn helps warm the cold winter air over the water.

Blizzards

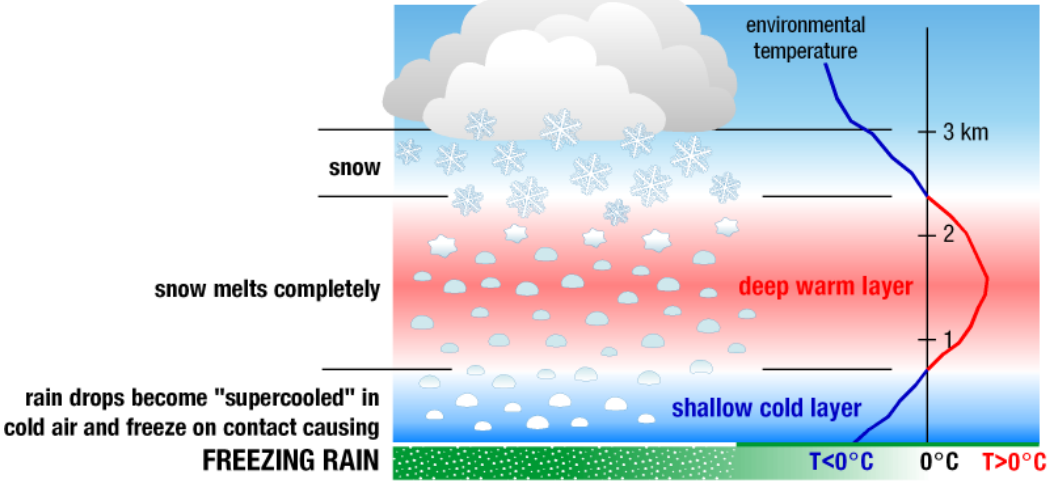
A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard 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 2012).

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 2008). Figure 5.4.8-3 shows the process of freezing rain creation,

Figure 5.4.8-3. Freezing Rain Creation



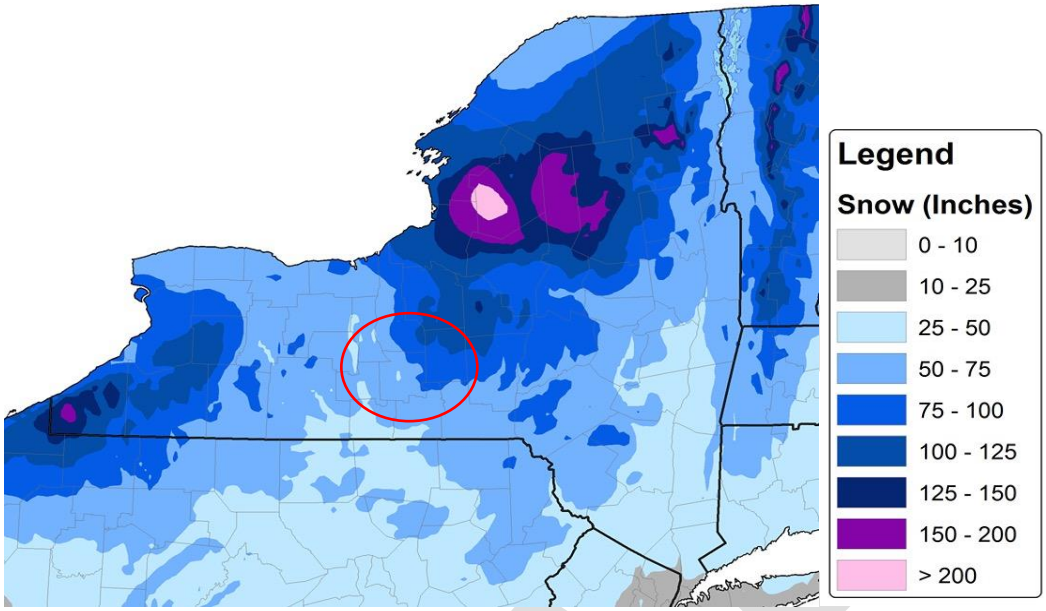
Source: NOAA-NSSL 2015

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 Tompkins County averages between 50 and 100 inches a year. The Southern Tier and Hudson Valley region of the State generally receives less snowfall than the northern and lakeshore portions. Much of the northern and western parts of the State (particularly those in higher elevations and near the lakes) can experience in excess of 125 inches per year. Figure 5.4.8-4 provides the historical annual average snowfall in New York State through 2012.

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 Tompkins County.

Ice Storms

The Northeast United States is a prime area 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 Tompkins County is six to seven days, and the average annual number of hours with freezing rain is between nine and twenty-one (Midwest Regional Climate Center 2020).

Nor'easters

Based on historical records, there was one event in 2014 that was categorized as a Nor' Easter, according to NOAA.

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, 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 by meteorological measurements and by evaluating its 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) as noted in Table 5.4.8-1. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2015).

Table 5.4.8-1. Regional Snow Index (RS)I 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+

Figure 5.4.8-5. 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.

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 listed in

Figure 5.4.8-5

Figure 5.4.8-6. Winter Storm Warning Thresholds

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 as noted in Figure 5.4.8-7.

Previous Occurrences and Losses

Based on a review of historic weather events and losses, Tompkins County was found to have frequent winter storm occurrences. According to the NOAA-NCEI storm events database, Tompkins County has been impacted by 71 winter weather events between 1996 and April 2020, including 42 heavy snow events, 7 ice storms, 3 lake effect snow events, 16 winter storms, and 3 winter weather events. Table 5.4.8-2 summarizes these statistics. Note that these also account for previous Nor'easter occurrences which are categorized under Winter Storm.

Table 5.4.8-2. Severe Winter Events 1996-May 2020

Hazard Type	Number of Occurrences Between 1996 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Blizzard	0	0	0	$0	$0
Heavy Snow	42	3	2	$650,000	$0
Ice Storm	7	0	0	$105,000	$0
Lake Effect Snow	3	0	0	$0	$0
Sleet	0	0	0	$0	$0
Winter Storm	16	0	0	$30,000	$0
Winter Weather	3	0	0	$20,000	$0
Total	**71**	**3**	**2**	**$775,000**	**$0**

Source: NOAA-NCEI 2020
Note: NOAA-NCEI database includes winter-related events starting in 1996. Events that occurred prior to 1996 are not included in the table.

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. Tompkins County was included in two of these declarations.

Table 5.4.8-3. FEMA Major Snow-Related Disasters and Emergency Declarations in Tompkins County since 1953

Disaster Number	Incident Duration	Declaration Date	Incident Type	Title
DR-4322	March 14-- March 15, 2017	7/12/2017	Snow	Severe Winter Storm and Snowstorm
EM-3107	March 13-- March 17, 1993	3/17/1993	Snow	Severe Blizzard

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

USDA Disaster Designations

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 agricultural producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2020, Tompkins County was included in 2 USDA declarations related to severe winter weather, and 7 severe frosts/ freezes.

The USDA crop loss data provide another indicator of the severity of previous events. Additionally, crop losses can have a significant impact on the economy by reducing produce sales and purchases. Such impacts may have long-term consequences, particularly if crop yields are low the following years as well. Fortunately, USDA records indicate that Tompkins County has not experienced crop loss from severe winter storm events between 2000 and 2020.

Previous Events

Table 5.4.8-4 identifies the known severe winter storm events that impacted Tompkins County between 2012 and 2020. For events prior to 2012, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.8-4. *Severe Winter Weather Events in Tompkins County, 2012 to 2020*

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
January 13-14, 2012	Heavy Snow	N/A	No	A low-pressure system coming from Lake Ontario brought a cold front to the region. Snowfall totals in Tompkins County ranged from four to twelve inches. Groton saw nearly a foot of snow, whereas Etna saw 7.4 inches.
December 26-27, 2012	Winter Storm	N/A	No	Six to eight inches of snow fell in Tompkins County following a low-pressure system coming across the Tennessee Valley to off of the New Jersey coast.

Table 5.4.8-4. *Severe Winter Weather Events in Tompkins County, 2012 to 2020*

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
December 29-30, 2012	Winter Storm	N/A	No	A low-pressure system coming from the Mid-West brought five to eight inches of snow to the county.
February 8-9, 2013	Heavy Snow	N/A	No	A coastal storm merged with a system coming from the north, resulting in five to ten inches of snow, including nearly 10 inches in Groton, 9.5 inches in Etna, and nine inches in Dryden.
January 1-3, 2014	Winter Storm	N/A	No	Eight to thirteen inches of snow fell in the county due to a stalled frontal boundary. Winds exacerbated the winter storm conditions.
February 5, 2014	Winter Storm	N/A	No	Snowfall between six and ten inches fell across Tompkins County, with the highest amount recorded in North Lansing.
December 9-11, 2014	Winter Storm	N/A	No	A low-pressure system developing over the East Coast brought significant snowfall to the area. Tompkins County saw between six and 17 inches of snow, with the highest amount seen in Groton.
February 1-2, 2015	Heavy Snow	N/A	No	A winter storm originating from the Central Plains brought snow to Central New York, including Tompkins County where between five to nine inches of snow fell.
November 19-22, 2016	Lake-Effect Snow	N/A	No	A strong cold front entering the region encountered moist air from the Great Lakes and brought unusually high snowfall to the Southern Tier region. In Tompkins County, snowfall generally ranged between eight and sixteen inches of snow. Caroline, in the southeastern corner of the County, saw 28 inches of snow.
March 14-15, 2017	Heavy Snow	DR-4322	Yes	A northeast-moving storm that developed off of North Carolina brought blizzard conditions to parts of the State and strong winter storm conditions to Tompkins County. The highest amounts of snow were seen in the southeastern section of the county, whereas the county overall saw between one and two feet of snow.
March 13-15, 2018	Heavy Snow	N/A	No	Central New York and northeastern Pennsylvania were impacted by unseasonably cold and moist air that led to five to nine inches of snow in Tompkins County.
November 15-16, 2018	Heavy Snow	N/A	No	A heavy early-season snowstorm impacted much of the Southern Tier region, bringing up to one foot of snow to the county.
January 19-20, 2019	Heavy Snow	N/A	No	A low-pressure system approaching from the southeast brought 10 to 14 inches of snow to Tompkins County.

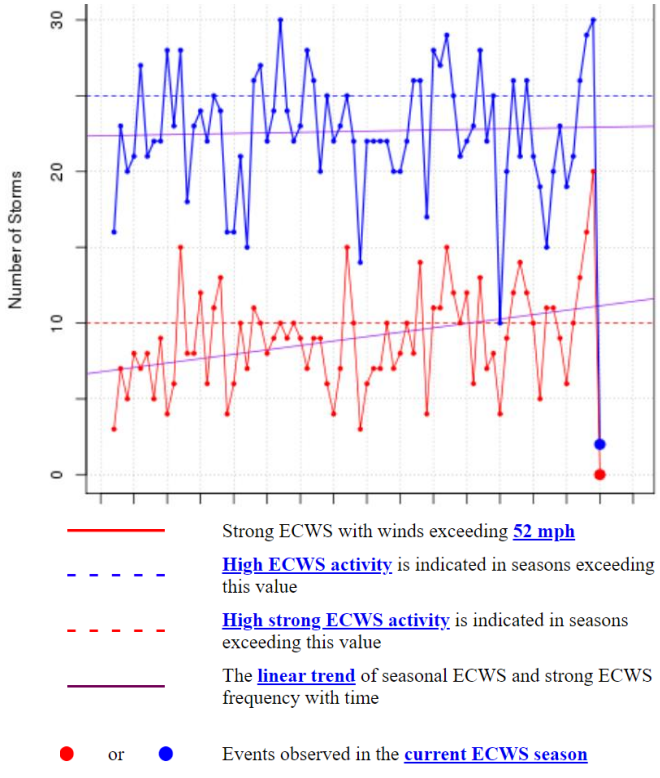
Table 5.4.8-4. *Severe Winter Weather Events in Tompkins County, 2012 to 2020*

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
December 1-2, 2019	Heavy Snow	N/A	No	A complex winter storm event resulted in mixed precipitation events to the Southern Tier and Central New York region. In Tompkins County, snow accumulate between nine and thirteen inches.
February 6-7, 2020	Heavy Snow	N/A	No	An intensifying winter storm developed along a frontal boundary brought eight to fourteen inches of snow to the county.

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 Impacts

Figure 5.4.8-7 Severe Winter Storm Trends



Climate change is affecting both people and resources in New York State, and these impacts are likely 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).

According to NRCC, in Tompkins County and its surrounding region, overall weather is expected to become warmer. In general, that means milder winters on average. However, based on historical trends (Figure 5.4.8-8 the blue depicts the overall number of winter storms that are expected to stay constant, while the number of severe winter storms is projected to

increase (red line). Therefore, in Tompkins County, while overall winter weather is expected to become warmer and milder, the number of severe winter storms is also projected to increase.

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. Tompkins County is part of Region 3, the Southern Tier, where temperatures are estimated to increase by 4.4–6.3 ºF by the 2050s and 5.7–9.9 ºF by the 2080s (baseline of 47.5 ºF, middle range projection) as indicated. Precipitation totals are estimated to increase between 4–10 percent by the 2050s and 6–14 percent by the 2080s (baseline of 35.0 inches, middle range projection).

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 Tompkins County based on the historic record. In Tompkins County, heavy snowstorms are the most common

event, following by winter storms. 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 Tompkins County

Hazard Type	Number of Occurrences Between 1954 and 2018	% chance of occurrence in any given year
Blizzard	0	0
Heavy Snow	42	62.7%
Ice Storm	7	10.5%
Lake Effect Snow	3	4.5%
Sleet	0	0%
Winter Storm	16	23.9%
Winter Weather	3	4.5%
Total	71	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 severe winter storm events since 1996. Due to limitations in data, not all severe 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, Tompkins 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 Tompkins 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 Tompkins County (102,962 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).

Individuals most vulnerable to severe winter storm events include those: Over 65 years old and homeless

The homeless and elderly are considered most susceptible to this hazard. 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 Tompkins County, the Town of Dryden has the highest concentration of population below the poverty level (i.e., 17-percent). Refer to Section 4 (County Profile) that displays the densities of low-income populations in Tompkins County.

The elderly are also 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 13,561 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.

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. Table 5.4.8-6 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
Caroline (T)	$2,523,108,347	$25,231,083	$126,155,417	$252,310,835
Cayuga Heights (V)	$1,548,665,909	$15,486,659	$77,433,295	$154,866,591
Danby (T)	$2,188,454,321	$21,884,543	$109,422,716	$218,845,432
Dryden (T)	$8,740,906,102	$87,409,061	$437,045,305	$874,090,610
Dryden (V)	$1,135,109,100	$11,351,091	$56,755,455	$113,510,910
Enfield (T)	$2,736,468,231	$27,364,682	$136,823,412	$273,646,823
Freeville (V)	$356,699,295	$3,566,993	$17,834,965	$35,669,929
Groton (T)	$2,804,801,342	$28,048,013	$140,240,067	$280,480,134
Groton (V)	$1,203,171,190	$12,031,712	$60,158,560	$120,317,119
Ithaca (C)	$19,712,305,674	$197,123,057	$985,615,284	$1,971,230,567
Ithaca (T)	$10,868,181,586	$108,681,816	$543,409,079	$1,086,818,159
Lansing (T)	$6,270,191,033	$62,701,910	$313,509,552	$627,019,103
Lansing (V)	$3,436,043,635	$34,360,436	$171,802,182	$343,604,364
Newfield (T)	$3,848,204,673	$38,482,047	$192,410,234	$384,820,467
Trumansburg (V)	$1,241,549,970	$12,415,500	$62,077,498	$124,154,997
Ulysses (T)	$3,372,144,448	$33,721,444	$168,607,222	$337,214,445
Tompkins County (Total)	**$71,986,004,856**	**$719,860,049**	**$3,599,300,243**	**$7,198,600,486**

Source: Tompkins County GIS 2020; 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 5.4.4 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 Community Lifelines

Full functionality of critical facilities lifelines such as police, fire and medical facilities is essential for response during and after a severe winter storm event. These 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).

Further, 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 Tompkins County, the Towns of Lansing, Groton, Dryden, Caroline, Danby, Ithaca, and Ulysses all assist in snow and ice maintenance on County roads (Tompkins County 2020). The Tompkins County 2020 Budget indicates that snow and ice removal in 2019 was t budgeted at $665,000 (Tompkins County Administration 2019). This budget has increased every year since 2017 and is expected to increase to $782,000 for the 2020 fiscal year. Further, 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 storms can have a major impact on the environment. Not only does severe winter storms 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.

Furthermore, chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry deicing chemicals and salt 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

As noted , 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 Section 5.4.4 (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 population projections from the Cornell Program on Applied Demographics, Tompkins County will experience a continual population increase from 2020 through 2040 (over 6,040 people in total by 2040). The U.S. Census Bureau also shows that the population in Tompkins County has increased 0.6-percent between 2010 and 2019 (U.S. Census Bureau 2020). 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 Impacts

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 2014 HMP

Since the 2014 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, the vulnerability assessment in this plan update uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Tompkins County.

Identified Issues

- Important issues associated with a severe winter storm in the planning area include the following:
- Windblown snow can create challenges in maintain open travel routes in areas where there are limited natural or man-made wind breaks to limit the accumulation of drifting snow on roadways.
- Older building stock in the County might be more vulnerable to aftermath of a winter storm event. Heavy snow loads on the roofs of buildings might not be able to withstand the extra weight.
- Ice and freezing temperatures can lead to frost heaving and damage to roads, bridges, buildings, home foundations, and railroad tracks.
- During snowstorms, the homeless population is exposed and vulnerable to the health impacts of such events.
- The impacts of drought and invasive species can lead to dead or dying trees. These trees are more susceptible to falling during winter storm events from the weight of snow and ice causing power outages, closed roadways, and damage to buildings and property.
- Downed power lines from the weight of snow and ice lead to power outages, leaving many homes without a source of heat.