5.4.6 SEVERE STORM

This section provides a profile and vulnerability assessment for the severe storm hazards.

5.4.6.1 Hazard Profile

Hazard profile information is provided in this section, including information on description, extent, location, previous occurrences and losses and the probability of future occurrences within Chenango County.

Description

For the purpose of this HMP and as deemed appropriated by Chenango County, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and tropical cyclones (e.g. hurricanes, tropical storms, and tropical depressions), which are defined below. Since most northeasters, (or Nor'Easters) a type of an extra-tropical cyclone, generally take place during the winter weather months, Nor'Easters have been grouped as a type of severe winter weather storm, further discussed in Section 5.4.8 (Severe Winter Storm).

Hailstorm: According to the National Weather Service (NWS), hail is defined as a showery precipitation in the form of irregular pellets or balls of ice more than five millimeters in diameter, falling from a cumulonimbus cloud (NWS, 2009). Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation, in the form of balls or irregularly shaped masses of ice. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstorms are a potential damaging outgrowth of severe thunderstorms (Northern Virginia Regional Commission [NVRC], 2006). They cause over $1.6 billion in crop and property damages each year in the U.S., making hailstorms one of the most costly natural disasters (Federal Alliance for Safe Homes, Inc., 2013).

Windstorm: According to the Federal Emergency Management Agency (FEMA), wind is air moving from high to low pressure. It is rough horizontal movement of air (as opposed to an air current) caused by uneven heating of the Earth's surface. It occurs at all scales, from local breezes generated by heating of land surfaces and lasting tens of minutes to global winds resulting from solar heating of the Earth (FEMA, 1997). A type of windstorm that is experienced often during rapidly moving thunderstorms is a derecho. A derecho is a widespread and long-lived windstorm associated with thunderstorms that are often curved in shape (Johns et al., 2011). The two major influences on the atmospheric circulation are the differential heating between the equator and the poles, and the rotation of the planet. Windstorm events are associated with cyclonic storms (for example, hurricanes, thunderstorms and tornadoes (FEMA, 1997).

Lightning: According to the NWS, lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds or between a rain cloud and the ground (NWS, 2005). The discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm creates a "bolt" when the buildup of charges becomes strong enough. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit (°F). Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. Annually, on average, 300 people are injured and 89 people are killed due to lightning strikes in the U.S. (NVRC, 2006).

Thunderstorm: According to the NWS, a thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS, 2005). A thunderstorm forms from a combination of moisture, rapidly rising warm air and a force capable of lifting air such as a warm and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. These storms occur most commonly in the tropics. Many tropical land-based locations experience over 100 thunderstorm days each year (Pidwirny, 2007). Although thunderstorms generally affect a small area when they occur, they are very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. A thunderstorm produces wind gusts less than 57 miles per hour (mph) and hail, if any, of less than 3/4-inch diameter at the surface. A severe thunderstorm has thunderstorm related surface winds (sustained or gusts) of 57 mph or greater and/or surface hail 3/4-inch or larger (NWS, 2005). Wind or hail damage may be used to infer the occurrence/existence of a severe thunderstorm (Office of the Federal Coordinator for Meteorology, 2001).

Tornado: A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Tornado season is generally March through August, although tornadoes can occur at any time of year. Tornadoes tend to strike in the afternoons and evening, with over 80 percent (%) of all tornadoes striking between noon and midnight (New Jersey Office of Emergency Management [NJOEM], 2012). The average forward speed of a tornado is 30 mph, but can vary from nearly stationary to 70 mph (NWS, Date Unknown). The NOAA Storm Prediction Center (SPC) indicates that the total duration of a tornado can last between a few seconds to over one hour; however, a tornado typically lasts less than 10 minutes (Edwards, 2012). High-wind velocity and wind-blown debris, along with lightning or hail, result in the damage caused by tornadoes. Destruction caused by tornadoes depends on the size, intensity, and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential homes and mobile homes, and tend to remain localized during impact (NVRC, 2006).

Tropical Cyclone: Tropical cyclone is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters (National Atlas, 2011); containing a warm core of low barometric pressure which typically produces heavy rainfall, powerful winds and storm surge (New York City Office of Emergency Management [NYCOEM], Date Unknown). It feeds on the heat released when moist air rises and the water vapor in it condenses (Dorrego, Date Unknown). Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression (Pacific Disaster Center, 2006). While tropical cyclones begin as a tropical depression, meaning the storm has sustained winds below 38 miles per hour (mph), it may develop into a tropical storm (with sustained winds of 39 to 73 mph) or a hurricane (with winds of 74 mph and higher). See below for descriptions of tropical storms and hurricanes.

Tropical Depression: A tropical depression is an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained winds of less than 38 mph. It has no “eye” (the calm area in the center of the storm) and does not typically have the organization or the spiral shape of more powerful storms (Emanuel, Date Unknown; Miami Museum of Science, 2000).

Tropical Storm: A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 39 and 73 mph (FEMA, 2013). Once a storm has reached tropical storm status, it is assigned a name. During this time, the storm itself becomes more organized and begins to become more circular in shape, resembling a hurricane. The rotation of a tropical storm is more recognizable than a tropical depression. Tropical storms can cause a lot of problems, even without becoming a hurricane; however, most of the problems stem from heavy rainfall (University of Illinois, Date Unknown).

Hurricane: A hurricane is an intense tropical cyclone with wind speeds reaching a constant speed of 74 mph or more (FEMA, 2013). It is a category of tropical cyclone characterized by thunderstorms and defined surface wind circulation. They are caused by the atmospheric instability created by the collision of warm air with cooler air. They form in the warm waters of tropical and sub-tropical oceans, seas, or Gulf of Mexico (NWS, 2009). Most hurricanes evolve from tropical disturbances. A tropical disturbance is a discrete system of organized convection (showers or thunderstorms), that originate in the tropics or subtropics, does not migrate along a frontal boundary, and maintains its identity for 24 hours or more (NWS, 2004). Hurricanes begin when areas of low atmospheric pressure move off the western coast of Africa and into the Atlantic, where they grow and intensify in the moisture-laden air above the warm tropical ocean. Air moves toward these atmospheric lows from all directions and circulates clock-wise under the influence of the Coriolis Effect, thereby initiating rotation in the converging wind fields. When these hot, moist air masses meet, they rise up into the atmosphere above the low pressure area, potentially establishing a self-reinforcing feedback system that produces weather systems known to meteorologists as tropical disturbances, tropical depressions, tropical storms, and hurricanes (Frankenberg, Date Unknown).

Almost all tropical storms and hurricanes in the Atlantic basin, which includes the Gulf of Mexico and Caribbean Sea, form between June 1st and November 30th. This time frame is known as hurricane season. August and September are peak months for hurricane development. The threats caused by an approaching hurricane can be divided into three main categories: storm surge, wind damage and rainfall/flooding:

- *Storm Surge* is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. Storm surge is responsible for nearly 90-percent of all hurricane-related deaths and injuries.
- *Wind Damage* is the force of wind that can quickly decimate the tree population, down power lines and utility poles, knock over signs, and damage/destroy homes and buildings. Flying debris can also cause damage to both structures and the general population. When hurricanes first make landfall, it is common for tornadoes to form which can cause severe localized wind damage.
- *Rainfall / Flooding* the torrential rains that normally accompany a hurricane can cause serious flooding. Whereas the storm surge and high winds are concentrated around the "eye", the rain may extend for hundreds of miles and may last for several days, affecting areas well after the hurricane has diminished (Mandia, 2011).

Extent

The extent (that is, magnitude or severity) of a severe storm is largely dependent upon sustained wind speed. Straight-line winds, winds that come out of a thunderstorm, in extreme cases, can cause wind gusts exceeding 100 mph. These winds are most responsible for hailstorm and thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado (NVRC, 2006).

Hail

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail is estimated by comparing it to a known object. Most hail storms are made up of a variety of sizes, and only the very largest hail stones pose serious risk to people, if exposed (NYS DHSES, 2011). Table 5.4.6-1 shows the different types of hail and the comparison to real-world objects.

Table 5.4.6-1. Hail Size

Description	Diameter (in inches)
Pea	0.25

Description	Diameter (in inches)
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88
Quarter	1.00
Half Dollar	1.25
Walnut or Ping Pong Ball	1.50
Golf ball	1.75
Hen's Egg	2.00
Tennis Ball	2.75
Baseball	2.75
Tea Cup	3.00
Grapefruit	4.00
Softball	4.50

Source: NYS HMP, 2011

Tornado

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971, based on a relationship between the Beaufort Wind Scales (B-Scales) (measure of wind intensity) and the Mach number scale (measure of relative speed). It is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure (Tornado Project, Date Unknown). The F-Scale categorizes each tornado by intensity and area. The scale is divided into six categories, F0 (Gale) to F5 (Incredible) (Edwards, 2012). Table 5.4.6-2 explains each of the six F-Scale categories.

Table 5.4.6-2. Fujita Damage Scale

Scale	Wind Estimate (MPH)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.

Scale	Wind Estimate (MPH)	Typical Damage
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: SPC, 2012

Although the F-Scale has been in use for over 30 years, there are limitations of the scale. The primary limitations are a lack of damage indicators, no account of construction quality and variability, and no definitive correlation between damage and wind speed. These limitations have led to the inconsistent rating of tornadoes and, in some cases, an overestimate of tornado wind speeds. The limitations listed above led to the development of the Enhanced Fujita Scale (EF Scale). The Texas Tech University Wind Science and Engineering (WISE) Center, along with a forum of nationally renowned meteorologists and wind engineers from across the country, developed the EF Scale (NOAA, 2008).

The EF Scale became operational on February 1, 2007. It is used to assign tornadoes a 'rating' based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale has to do with how most structures are designed (NOAA, 2008). Table 5.4.6-3 displays the EF Scale and each of its six categories.

Table 5.4.6-3. Enhanced Fujita Damage Scale

F-Scale Number	Intensity Phrase	Wind Speed (mph)	Type of Damage Done
EF0	Light tornado	65–85	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	Moderate tornado	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	Significant tornado	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	Devastating tornado	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	Incredible tornado	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: SPC, Date Unknown

In the Fujita Scale, there was a lack of clearly defined and easily identifiable damage indicators. The EF Scale takes into account more variables than the original F-Scale did when assigning a wind speed rating to a tornado. The EF Scale incorporates 28 DIs, such as building type, structures, and trees. For each damage indicator, there are eight DODs, ranging from the beginning of visible damage to complete destruction of the damage indicator. Table 5.4.6-4 lists the 28 DIs. Each one of these indicators has a description of the typical construction for that category of indicator. Each DOD in every category is given an expected estimate of wind speed, a lower bound of wind speed, and an upper bound of wind speed.

Table 5.4.6-4. EF Scale Damage Indicators

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
1	Small barns, farm outbuildings	SBO	15	School - 1-story elementary (interior or exterior halls)	ES
2	One- or two-family residences	FR12	16	School - jr. or sr. high school	JHSH
3	Single-wide mobile home (MHSW)	MHSW	17	Low-rise (1-4 story) bldg.	LRB
4	Double-wide mobile home	MHDW	18	Mid-rise (5-20 story) bldg.	MRB
5	Apt, condo, townhouse (3 stories or less)	ACT	19	High-rise (over 20 stories)	HRB
6	Motel	M	20	Institutional bldg. (hospital, govt. or university)	IB
7	Masonry apt. or motel	MAM	21	Metal building system	MBS
8	Small retail bldg. (fast food)	SRB	22	Service station canopy	SSC
9	Small professional (doctor office, branch bank)	SPB	23	Warehouse (tilt-up walls or heavy timber)	WHB
10	Strip mall	SM	24	Transmission line tower	TLT
11	Large shopping mall	LSM	25	Free-standing tower	FST
12	Large, isolated ("big box") retail bldg.	LIRB	26	Free standing pole (light, flag, luminary)	FSP
13	Automobile showroom	ASR	27	Tree - hardwood	TH
14	Automotive service building	ASB	28	Tree - softwood	TS

Source: SPC, Date Unknown

Since the EF Scale recently went into effect in February 2007, previous occurrences and losses associated with historic tornado events, described in the next section (Previous Occurrences and Losses) of this hazard profile, are based on the former Fujita Scale. Events after February 2007 are based on the Enhance Fujita Scale.

Hurricanes and Tropical Storms

The extent of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NHC, 2013). Table 5.4.6-5 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes land fall.

Table 5.4.6-5. The Saffir-Simpson Scale

Category	Wind Speed (mph)	Expected Damage
1	74-95 mph	Very dangerous winds will produce some damage: Homes with well-constructed frames could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Homes with well-constructed frames could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph	Devastating damage will occur: Homes with well-built frames may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	Catastrophic damage will occur: Homes with well-built frames can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	>157 mph	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

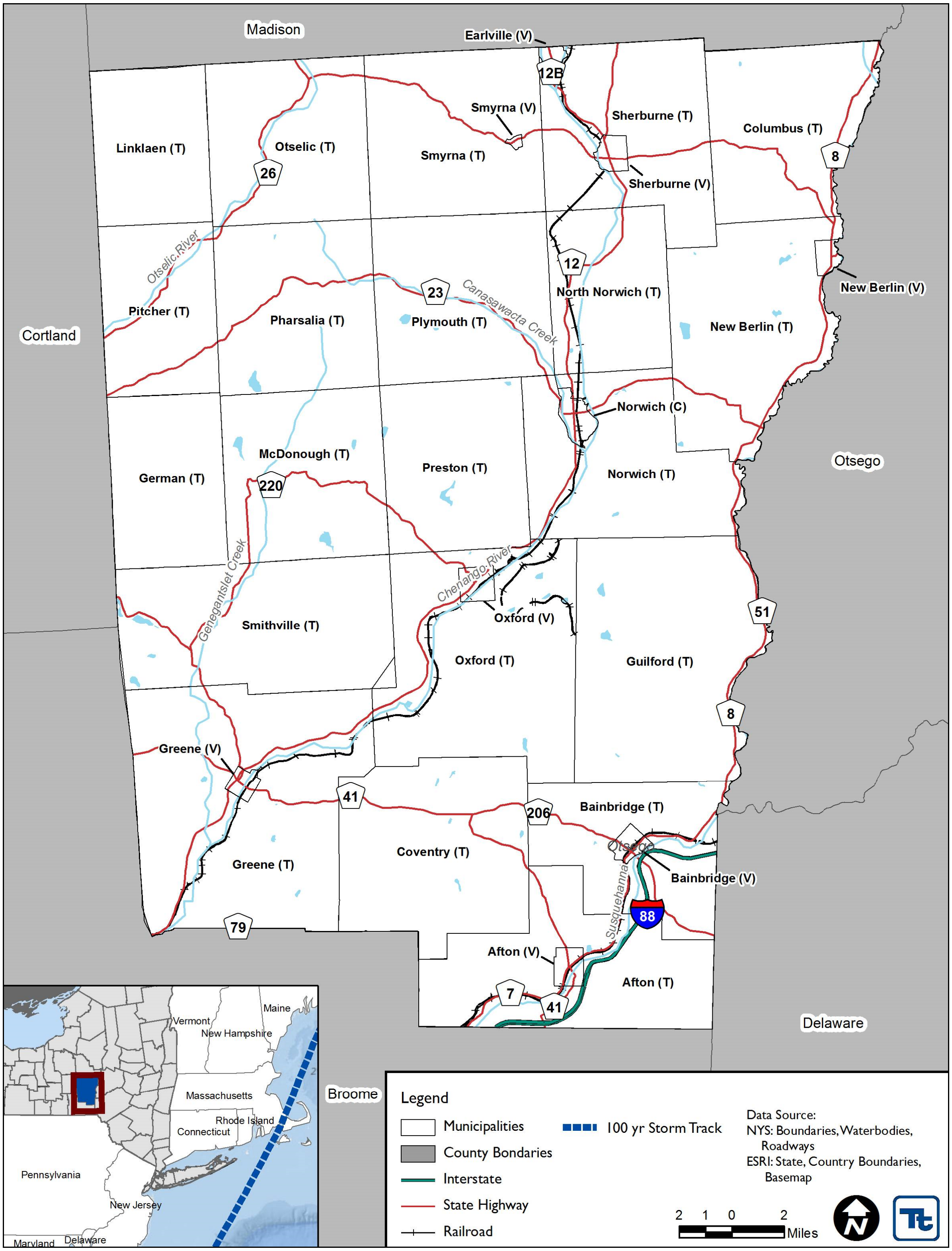
Source: NHC, 2013
mph = Miles per hour
> = Greater than

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event (equal to the inverse of the annual frequency of exceedance). For example, a flood that has a 1-percent chance of being equaled or exceeded in any given year is also referred to as the base flood and has a MRP of 100. This is known as a 100-year flood. The term "100-year flood" can be misleading; it is not the flood that will occur once every 100 years. Rather, it is the flood elevation that has a one-percent chance of being equaled or exceeded each year. Therefore, the 100-year flood could occur more than once in a relatively short period of time or less than one time in 100 years (Dinicola, 2009).

Figure 5.4.6-1 shows the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP HAZUS-MH model runs. The estimated hurricane track for the 100- and 500-year event is also shown. For the 100-year MRP event, the maximum 3-second wind speeds are less than 50 miles per hour (mph), characteristic of a tropical storm and tropical depression. For the 500-year MRP event, the maximum 3-second gust wind speeds for the county range from 61 to 63 mph, characteristic of a tropical storm. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment later in this section.

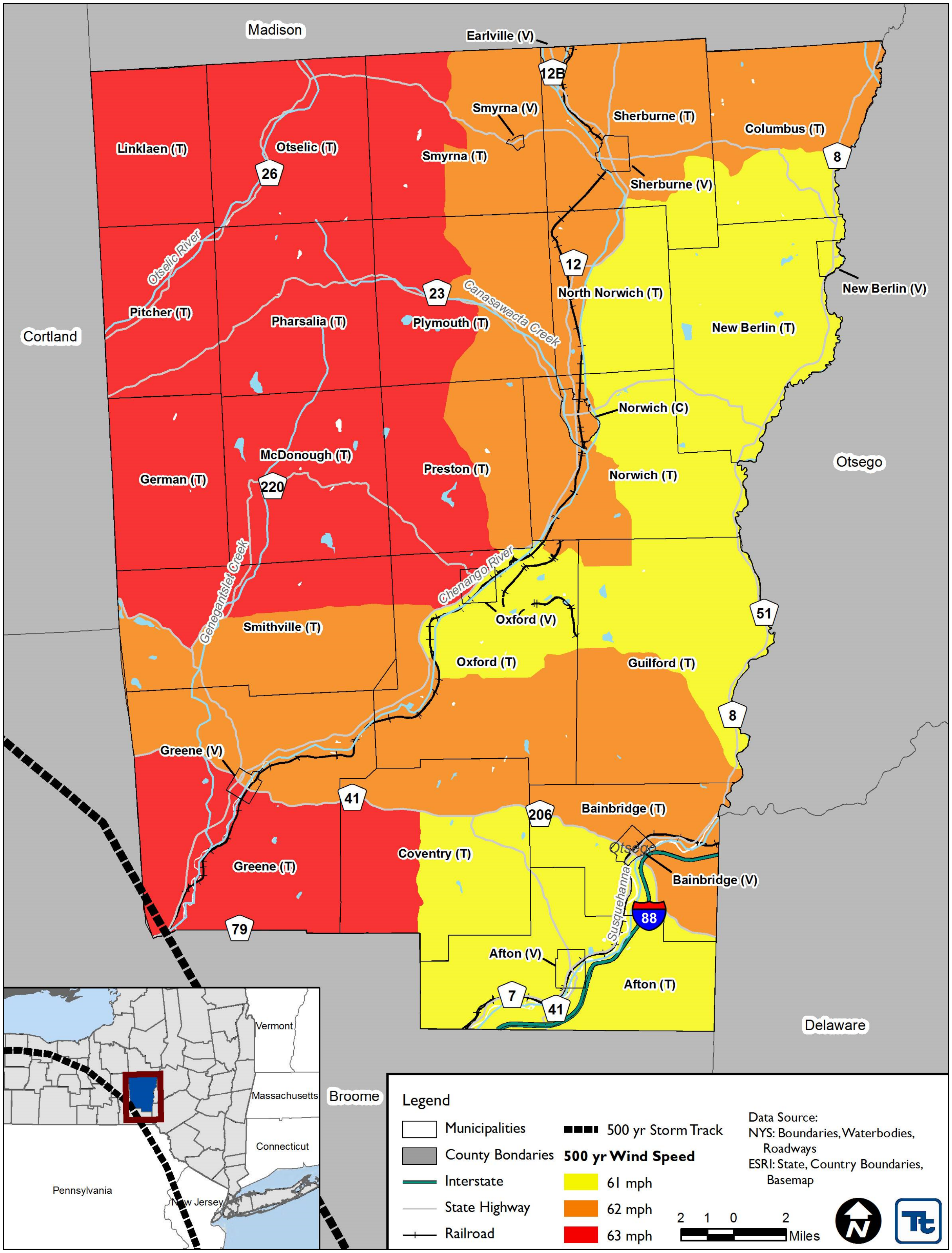
Figure 5.4.6-1. Wind Speeds and Storm Track for the 100-Year Mean Return Period Event in Chenango County



Source: *HAZUS-MH 2.1*

Note: *Wind speeds are less than 50mph for the 100-year storm track*

Figure 5.4.6-2. Wind Speeds and Storm Track for the 500-Year Mean Return Period Event in Chenango County



Source: HAZUS-MH 2.1

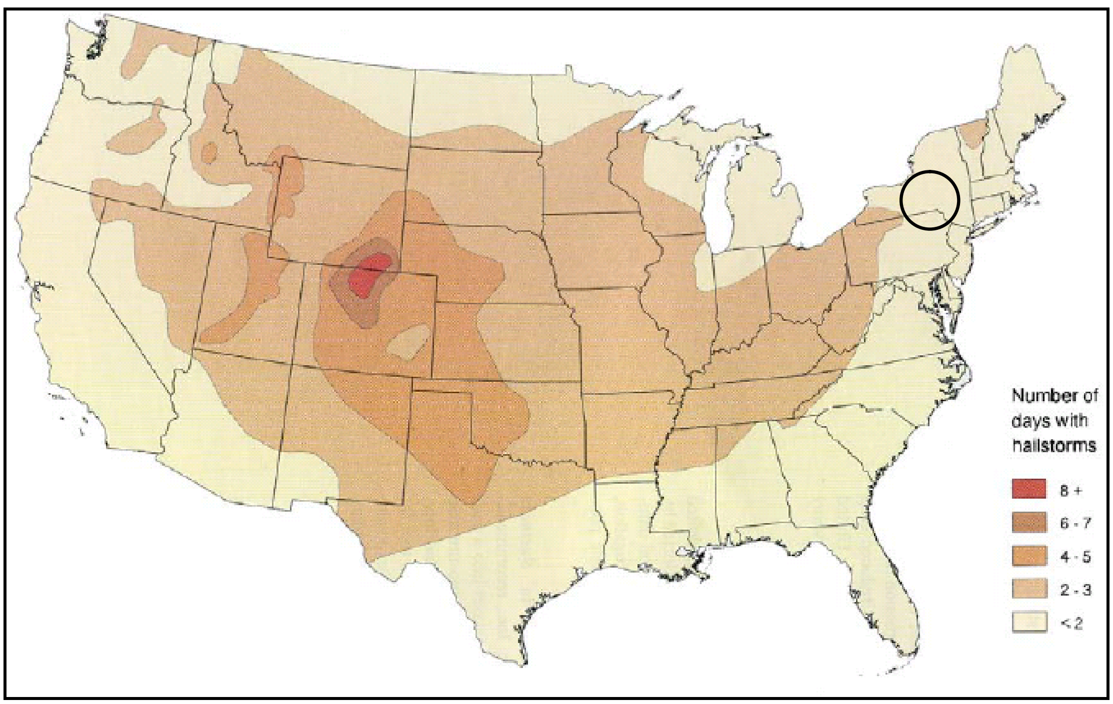
Location

Severe storms are a common natural hazard in New York State because the State exhibits a unique blend of weather (geographically and meteorological) features that influence the potential for severe storms and associated flooding. Factors include temperature, which is affected by latitude, elevation, proximity to water bodies and source of air masses; and precipitation which includes snowfall and rainfall. Precipitation intensities and effects are influenced by temperature, proximity to water bodies, and general frequency of storm systems. The Cornell Climate Report also indicates that the geographic position of the State (Northeast U.S.) makes it vulnerable to frequent storm and precipitation events. This is because nearly all storms and frontal systems moving eastward across the continent pass through, or in close proximity to New York State. Additionally, the potential for prolonged thunderstorms or coastal storms and periods of heavy precipitation is increased throughout the state because of the available moisture that originates from the Atlantic Ocean (NYS DHSES, 2011).

Hailstorms

Hailstorms are more frequent in the southern and central plain states, where the climate produces violent thunderstorms. However, hailstorms have been observed in almost every location where thunderstorms occur (Federal Alliance for Safe Homes, Inc., 2013). Hailstorms can occur anywhere in New York State, either independently or during a tornado or thunderstorm event (NYS DHSES, 2013). Figure 5.4.6-3 illustrates that Chenango County and most of New York State experience less than two hailstorms per year.

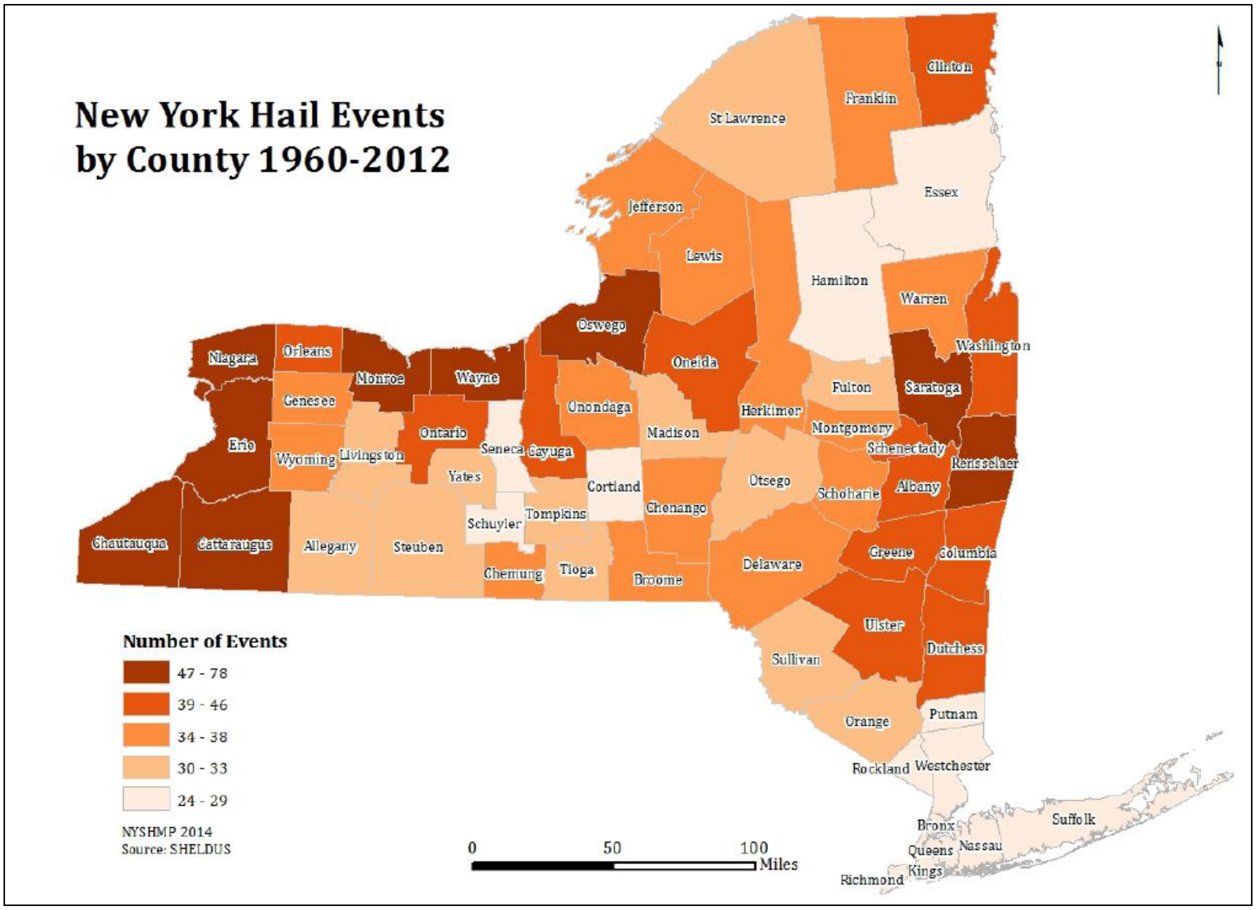
Figure 5.4.6-3. Annual Frequency of Hailstorms in the U.S.



Source: NVRC, 2006
Note: The black circle indicates the approximate location of Chenango County.

Figure 5.4.6-4 shows the number of hail events from 1960 to 2012 across New York State. The figure indicates that Chenango County has experienced between 34 and 38 events during this timeframe (NYS DHSES, 2013).

Figure 5.4.6-4. New York Hail Events by County, 1960 to 2012

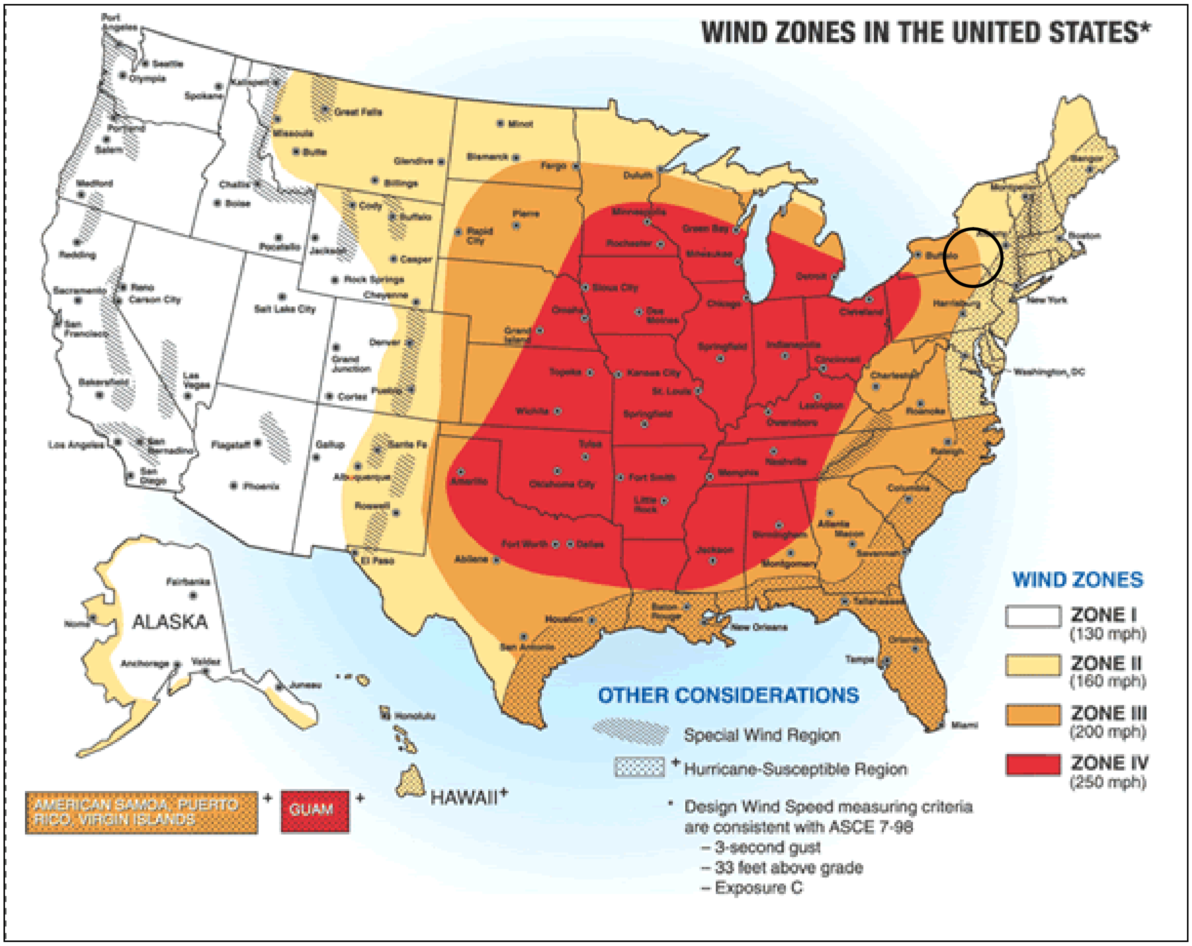


Source: *NYS DHSES, 2013*

Windstorms

Figure 5.4.6-5 indicates how the frequency and strength of windstorms impacts the U.S. and the general location of the most wind activity. This is based on 40 years of tornado history and 100 years of hurricane history, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes (NVRC, 2006). Chenango County is located in Wind Zone III with speeds up to 200 miles per hour (NYS HMP, 2011; FEMA, 2012). The NYS HMP identifies counties most vulnerable to wind, as determined by a rating score. Counties accumulate points based on the value of each vulnerability indicator, the higher the indication for wind exposure the more points assigned, resulting in a final rating score. Chenango County was given a rating score of 11 (NYS DHSES, 2011).

Figure 5.4.6-5. Wind Zones in the U.S.



Source: FEMA, 2012

Note: The black circle indicates the approximate location of Chenango County.

Table 5.4.6-6. Wind Zones in the U.S.

Wind Zones	Areas Affected
Zone I (130 mph)	All of Washington, Oregon, California, Idaho, Utah, and Arizona. Western parts of Montana, Wyoming, Colorado and New Mexico. Most of Alaska, except the east and south coastlines.
Zone II (160 mph)	Eastern parts of Montana, Wyoming, Colorado, and New Mexico. Most of North Dakota. Northern parts of Minnesota, Wisconsin and Michigan. Western parts of South Dakota, Nebraska and Texas. All New England States. Eastern parts of New York, Pennsylvania, Maryland, and Virginia. Washington, DC.
Zone III (200 mph)	Areas of Minnesota, South Dakota, Nebraska, Colorado, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, Tennessee, Kentucky, Pennsylvania, New York, Michigan, and Wisconsin. Most or all of Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia. All of American Samoa, Puerto Rico, and Virgin Islands.
Zone IV (250 mph)	Mid US including all of Iowa, Missouri, Arkansas, Illinois, Indiana, and Ohio and parts of adjoining states of Minnesota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, Tennessee, Kentucky, Pennsylvania, Michigan, and Wisconsin. Guam.
Special Wind Region	Isolated areas in the following states: Washington, Oregon, California, Idaho, Utah, Arizona, Montana, Wyoming, Colorado, New Mexico. The borders between Vermont and New Hampshire; between New York, Massachusetts and Connecticut;

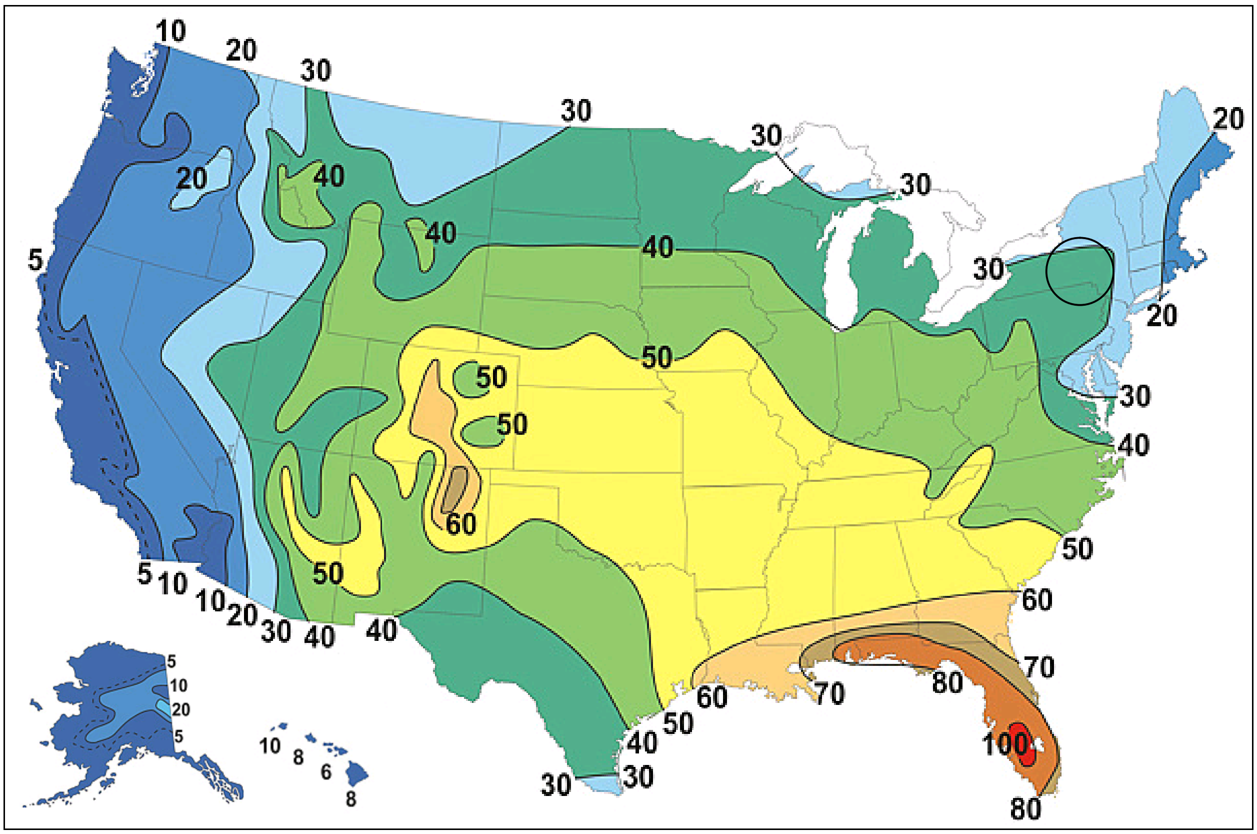
Wind Zones	Areas Affected
	between Tennessee and North Carolina.
Hurricane Susceptible Region	Southern US coastline from Gulf Coast of Texas eastward to include entire state of Florida. East Coastline from Maine to Florida, including all of Massachusetts, Connecticut, Rhode Island, Delaware, and Washington DC. All of Hawaii, Guam, American Samoa, Puerto Rico and Virgin Islands.

Source: NYS HMP, 2011

Thunderstorms

Thunderstorms affect relatively small localized areas, rather than large regions much like winter storms, and hurricane events (NWS, 2005). Thunderstorms can strike in all regions of the U.S.; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms (NVRC, 2006). It is estimated that there are as many as 40,000 thunderstorms each day world-wide. Figure 5.4.6-6 shows the average number of thunderstorm days throughout the U.S. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year) (NWS, 2010). This figure indicates that Chenango County experiences between 30 and 40 thunderstorm days each year.

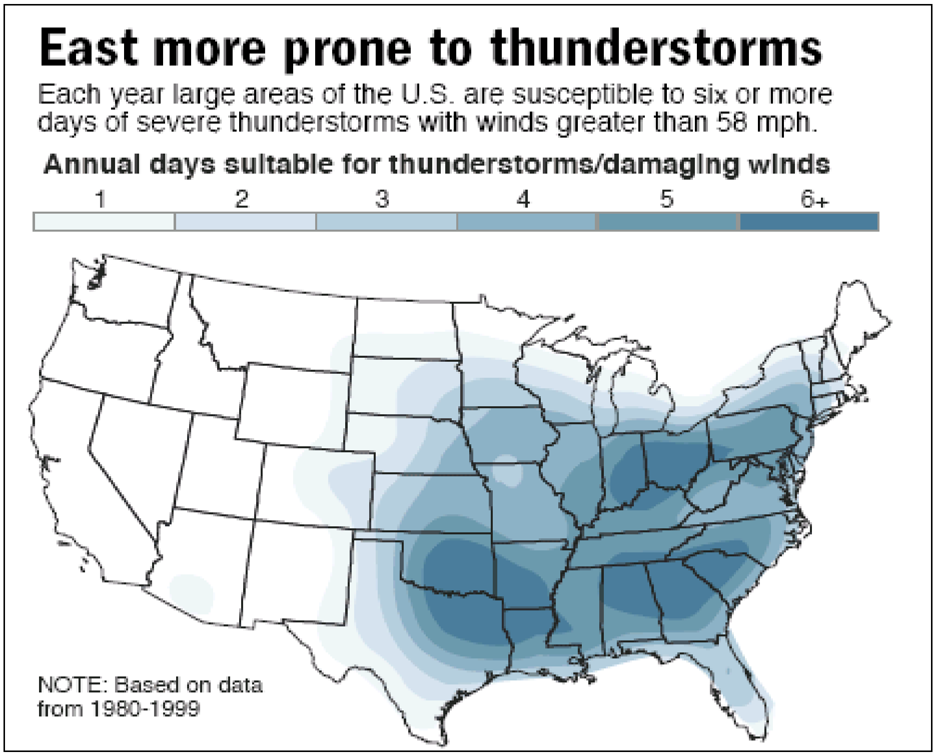
Figure 5.4.6-6. Annual Average Number of Thunderstorm Days in the U.S.



Source: NWS, 2010
Note: The black circle indicates the approximate location of Chenango County.

NASA scientists suggest that the U.S. will face more severe thunderstorms in the future, with deadly lightning, damaging hail and the potential for tornadoes in the event of climate change (Borenstein, 2007). A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change. As prepared by the NWS, Figure 5.4.6-7 identifies those areas, particularly within the eastern U.S., that are more prone to thunderstorms, which includes New York State.

Figure 5.4.6-7. Annual Days Suitable for Thunderstorms/Damaging Winds

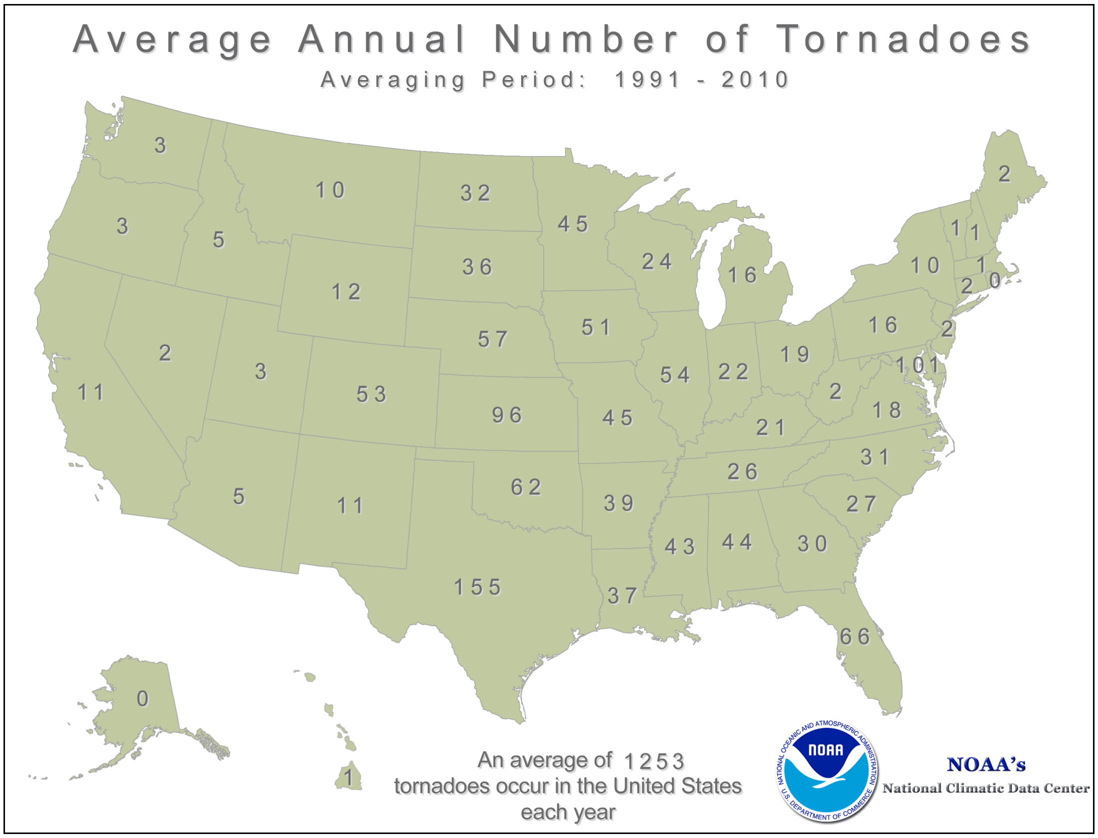


Source: NBCNEWS.com, 2007

Tornado

The U.S. experiences more tornadoes than any other country. In a typical year, an average of 1,253 tornadoes occurs in the U.S. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central U.S. Figure 5.4.6-8 shows the annual average number of tornadoes between 1991 and 2010 (NWS, 2011). New York State experienced an average of 10 tornado events annually between 1991 and 2010.

Figure 5.4.6-8. Annual Average Number of Tornadoes in the U.S., 1991 to 2010

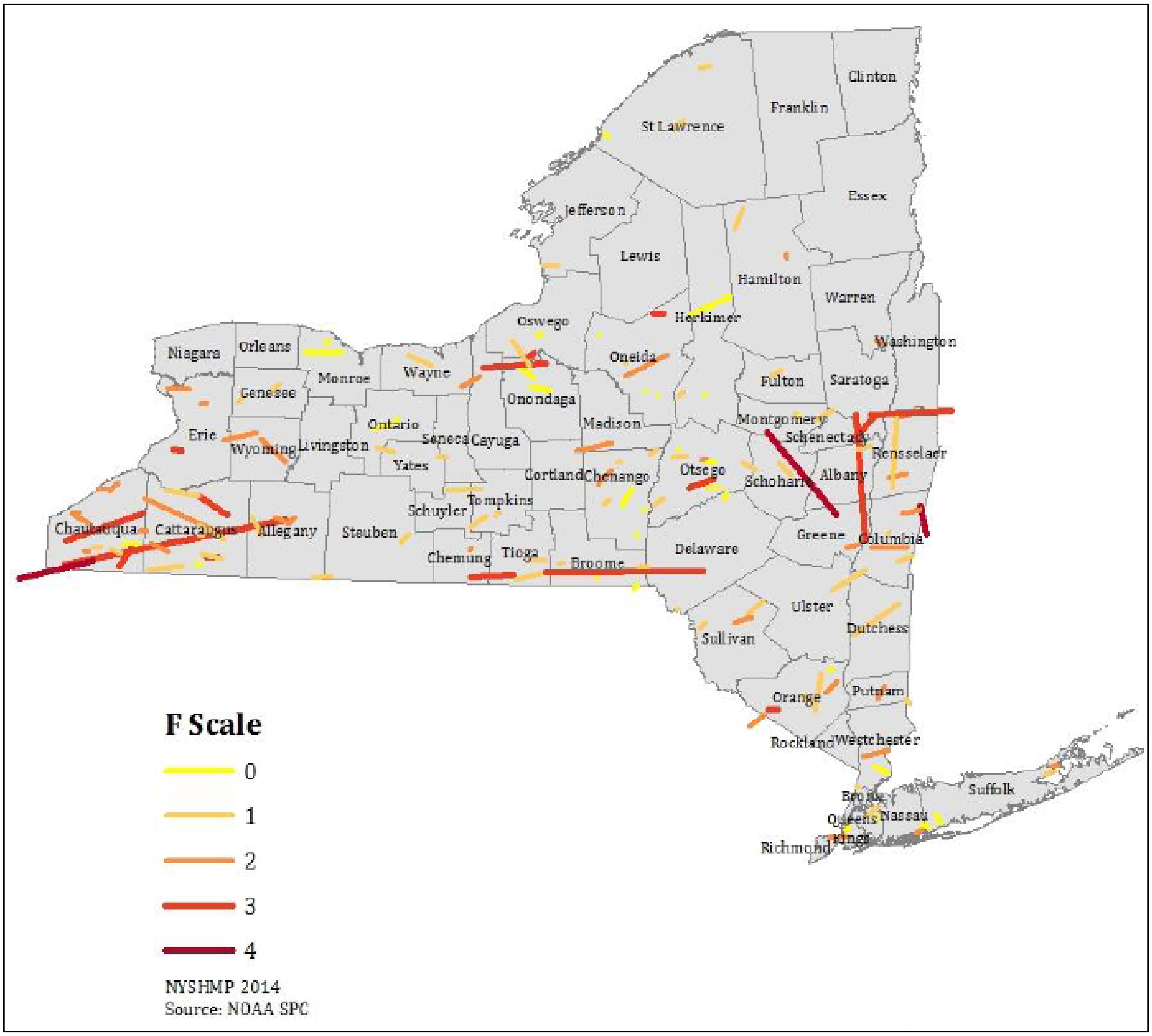


Source: *NCDC, 2013*

Note: *Between 1991 and 2010, New York State experienced an average of 10 tornadoes each year.*

New York State ranks 30th in the U.S. for frequency of tornadoes. When compared to other states on the frequency of tornadoes per square mile, the State ranks 35th (The Disaster Center, Date Unknown). New York State has a definite vulnerability to tornadoes and can occur, based on historical occurrences, in any part of the State. Figure 5.4.6-9 shows historical straight-path tornado tracks for New York State between 1960 and 2012. The figure indicates that Chenango County has experienced F0, F1, and F2 tornadoes (NYS DHSES, 2013).

Figure 5.4.6-9. Historical Tornado Tracks in New York State, 1960-2012



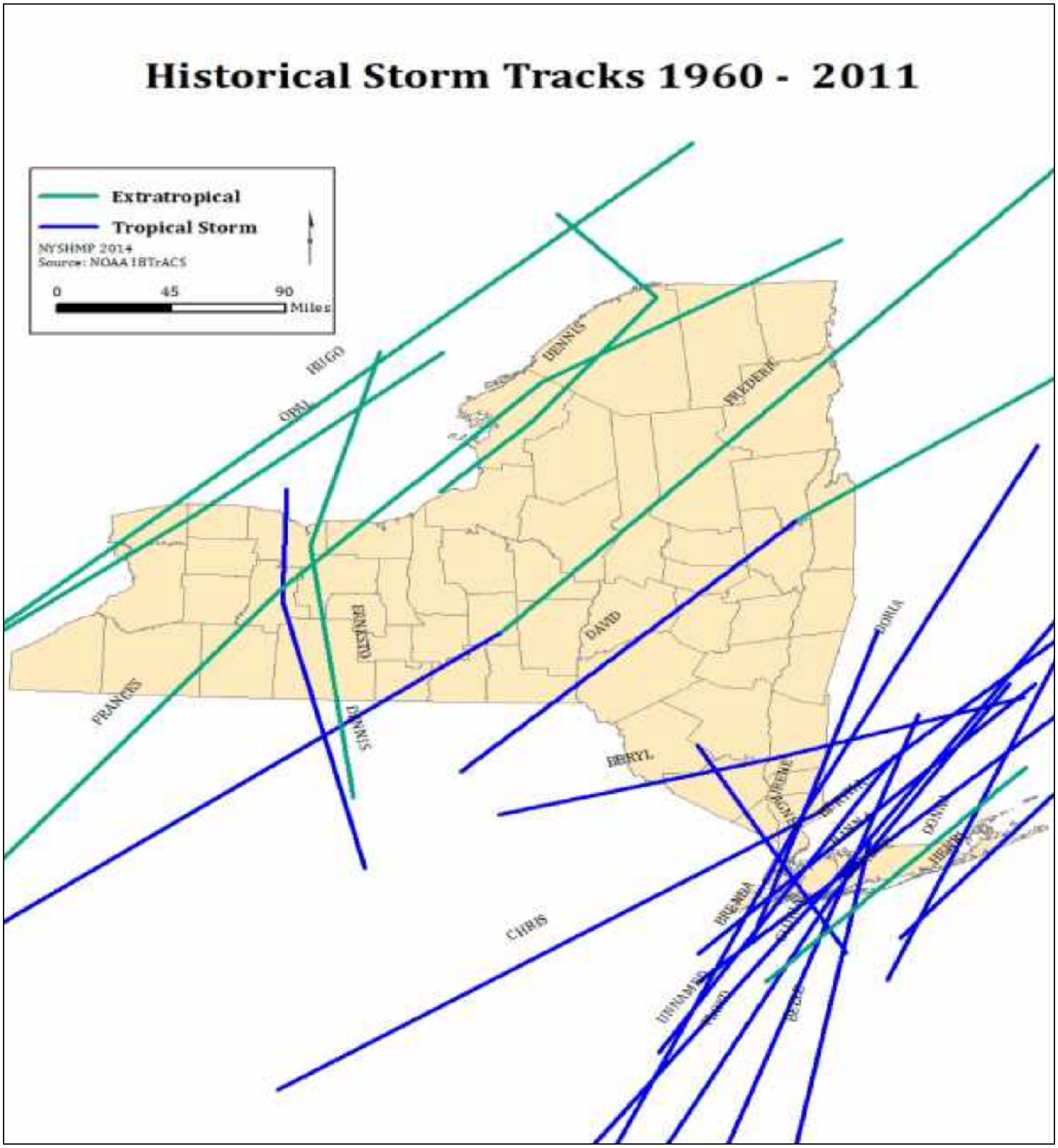
Source: NYS DHSES, 2013

Hurricanes/Tropical Storms

Due to Chenango County's inland location, hurricanes do not appear to make direct landfall on the mitigation study area. However, the County has been known to experience the indirect landward effects, including high winds, heavy rains, and major flooding associated with hurricane and/or tropical storm events. Hurricanes and tropical storms can impact New York State from June to November, the official eastern U.S. hurricane season. However, late July to early October is the period hurricanes and tropical storms are most likely to impact New York State, due to the coolness of the North Atlantic Ocean waters (NYS DHSES, 2011).

Figure 5.4.6-10 from the NYS HMP, illustrates the storm tracks for storms between 1960 and 2011 for the State. The vast majority of these storms have been over the eastern part of the State, specifically in the southeastern corner. This area includes the New York City metropolitan area and the mid and lower Hudson Valley areas (NYS DHSES, 2013).

Figure 5.4.6-10. Hurricane Tracks in New York State, 1960 to 2011.

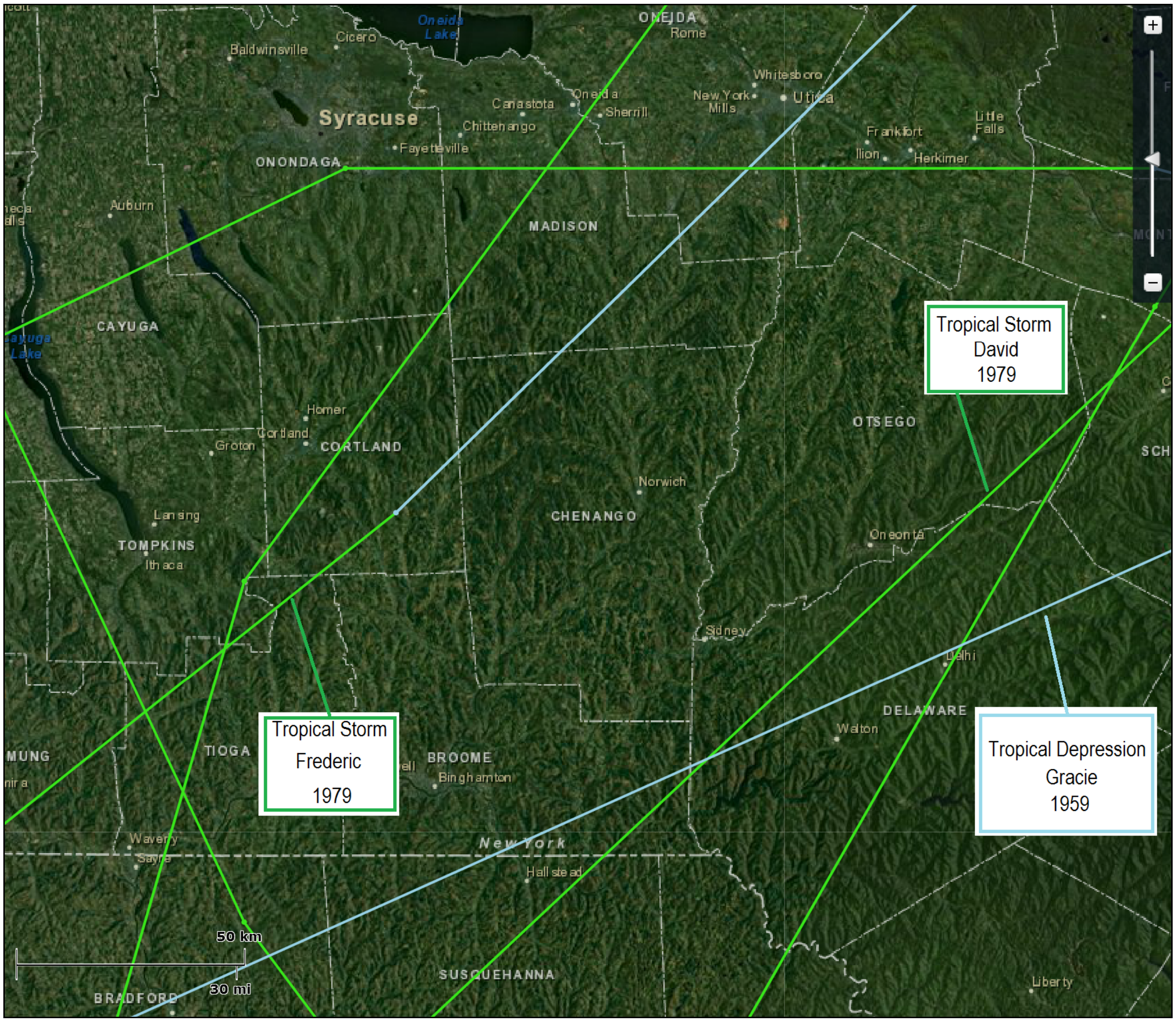


Source: NYS DHSES, 2013

Multiple sources have indicated that Chenango County has been impacted by hurricanes, tropical storms and tropical depressions. The County has felt the direct and indirect landward effects associated with several hurricanes and tropical storms in recent history. These storms are based on the Historical Hurricane Tracker, which includes storms through 2012. More recently, the County felt the effects of Hurricane Irene and Tropical Storm Lee. In 2012, Hurricane Sandy, which did significant damage to the southeastern portions of New York State, did minor damage to Chenango County, resulting in some closed roads and approximately 280 residences without power (WBNG, 2013).

The Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2012. Figure 5.4.6-11 displays tropical cyclone tracks for Chenango County; however, the associated names for some of these events are unknown. Between 1842 and 2012, Chenango County has experienced seven tropical cyclone occurrences within 65 nautical miles of the County (NOAA, 2013).

Figure 5.4.6-11. Historical North Atlantic Tropical Cyclone Tracks (1842-2012)



Source: NOAA, 2013

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe storm events throughout New York State and Chenango County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1954 and 2015, New York State was included in 55 severe storm-related major disaster (DR) or emergency (EM) FEMA declarations. The events were classified as one or a combination of the following event types: winter storms, severe storms, coastal storms, flooding, heavy rain, tropical storm, hurricane, high winds and tornado. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, FEMA, the NYS DHSES and other sources indicated that Chenango County has been declared as a disaster area as a result of 15 severe storm events (FEMA, 2015).

For this 2015 Plan Update, known severe storm events that have impacted Chenango County between 2008 and 2015 are identified in Table 5.4.6-6. For events prior to 2008, refer to the 2007 HMP. With severe storm documentation for New York State and Chenango County being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.6-6 may not include all events that have occurred in the County.

Table 5.4.6-6. Severe Storm Events Between 2008 and 2015

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
June 16, 2008	Hail	N/A	N/A	Widespread thunderstorms developed in front of a cold front, many producing large hail. 1.75 inch diameter hail caused $15K in crop damages in the Town of North Norwich.
June 25, 2009	TSTM Winds	N/A	N/A	Showers and thunderstorms, some severe, caused $14 K in property damages from downed trees and power lines in the Towns of Greene, Plymouth, Oxford, and Bainbridge, and the City of Norwich.
July 24, 2010	TSTM Winds	N/A	N/A	Showers and thunderstorms caused $10 K in property damages in the Town of South Otselic. 10 buildings were damaged, with one roof blown off.
August 16, 2010	TSTM Winds	N/A	N/A	Thunderstorms caused $2 K in property damages due to downed trees blocking roads in the City of Norwich.
April 27, 2011	TSTM Winds	DR-1993	Yes	Severe thunderstorms caused $5 K in property damages due to downed trees and wires in the Town of New Berlin.
April 28, 2011	TSTM Winds; Tornado (EF1-EF2)	DR-1993	Yes	A tornado touched down in Pharsalia and produced EF1 damage to a few barns and some trees. The tornado traveled northeast approximately 8 miles before dissipating on Pigeon Hill Road in Pharsalia. Intensity for most of the path was estimated at EF1, however EF2 intensity was estimated along North Road and Center Road in Pharsalia. In those areas hundreds of large trees were snapped and uprooted leveling a dense forest. Over the hill a house trailer was lifted and demolished, a two story barn was demolished, a small pond had its water sucked out, and a jeep was moved several feet and hit with debris. Outbuildings were also destroyed. the Town of Pharsalia suffered $625 K in property damages. Other damages to the Towns of Columbus, Bainbridge, McDonough, and Afton, as well as Lambs Corner and Smithville Center brought the total damages in Chenango County to approximately $880 K.
May 26-27, 2011	TSTM Winds	N/A	N/A	$20 K in property damages due to downed trees were reported in the Towns of McDonough, Greene, and Pharsalia, and Smithville Flats
June 28, 2011	TSTM Winds	N/A	N/A	Thunderstorms caused $11 K in property damages due to downed trees blocking roads in Genegantslet and the Town of Bainbridge.
July 26, 2011	TSTM Winds	N/A	N/A	$5 K in property damages due to downed trees and wires were reported in the Town of South Otselic and Amblerville (Town of New Berlin)
July 29, 2011	Tornado (EF0)	N/A	N/A	A tornado briefly touched down in the Town of Guilford, damaging a shed, paddle boat, and some trees. $5 K in property damages
August 19, 2011	TSTM Winds	N/A	N/A	Severe thunderstorms caused $4 K in property damages due to downed trees and wires in the Town of Smyrna.
September 7-11, 2011	Tropical Storm Lee	DR-4031	Yes	The remnants of Tropical Storm Lee interacted with a frontal system to the west and moisture from Hurricane Katia to the east, resulting in an extreme amount of rain over a 48-hour period from September 6-8, 2011. Rainfall from 6-12 inches fell over most of the upper Susquehanna River basin in New York and northeast Pennsylvania, causing massive, record-breaking flooding on small streams, creeks, and the Susquehanna River and its tributaries. Damages in the upper Susquehanna River Basin in New York and Pennsylvania approached $1 billion.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
				Flooding associated with Tropical Storm Lee broke the existing record for the Chenango River at Sherburne, NY. The Unadilla River near Rockdale also broke its flood record. Moderate to major flooding also occurred on the Chenango River at Greene and Bainbridge. Major flash flooding occurred throughout the area, including in and around Brisben, the Villages of New Berlin and Afton, and Smithville Center. The storm caused over $2.1 million in property damages in the county.
May 29, 2012	TSTM Winds	N/A	N/A	Severe thunderstorms caused $3K in property damages due to downed trees in Smithville Flats.
July 23, 2012	TSTM Winds; Hail	N/A	N/A	$6 K in property damages due to downed trees and wires were reported in the Town of McDonough, Amblerville (Town of New Berlin), and Smithville Center (Town of Smithville)
July 28, 2012	TSTM Winds	N/A	N/A	$5 K in property damages caused by thunderstorm winds blowing part of a roof off In the Town of North Norwich
October 27, 2012	Hurricane Sandy	DR-3351	Yes	280 residences without power; some road closures
April 19, 2013	Tornado (EF0)	N/A	N/A	A tornado touched down south southeast of the Village of Bainbridge and tracked northeast. Two power poles were snapped, a car was destroyed by a large tree branch, several homes and other structures were significantly damaged. $110 K in property damages to Bennettsville and Ambierville.
May 22, 2014	Hail	N/A	N/A	Severe thunderstorms impacted central New York State, bringing hail up to two inches in diameter. The storms also produced a tornado in Schenectady and Albany Counties. In Chenango County, hail ranged from 0.75 inches in diameter in Greene to one inch in diameter in Bainbridge.
June 17, 2014	Thunderstorms and Lightning	N/A	N/A	Severe thunderstorms developed in central New York State, brining rain, strong winds and lightning. In Chenango County, the wind downed trees in McDonough and had wind gusts of 58 mph. In Preston, lightning struck a church steeple. In Plymouth, lightning struck a tree which fell through a home. Strong winds downed a tree which fell onto a house and resulted in heavy damage on County Route 16. In Smyrna, a lightning strike set a house on fire. In North Norwich, winds downed trees on Hemlock Hill and Kales Hill Roads. Overall, the County had approximately $45,000 in damages from this event.

Sources: *NYS DHSES, 2013; FEMA, 2014; NOAA-NCDC, 2014; NWS, 2014; WBNG; SHELDUS, 2013*

Note: *Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.*

DR	*Federal Disaster Declaration*
EM	*Federal Emergency Declaration*
FEMA	*Federal Emergency Management Agency*
K	*Thousand ($)*
M	*Million ($)*
Mph	*Miles Per Hour*
NCDC	*National Climate Data Center*
NOAA	*National Oceanic Atmospheric Administration*
NYS	*New York State*
NWS	*National Weather Service*
SHELDUS	*Spatial Hazard Events and Losses Database for the U.S.*
TSTM	*Thunderstorms*

Probability of Future Events

Predicting future severe storm events in a constantly changing climate has proven to be a difficult task. Predicting extremes in New York State is particularly difficult because of the region's geographic location. It is positioned roughly halfway between the equator and the North Pole and is exposed to both cold and dry airstreams from the south. The interaction between these opposing air masses often leads to turbulent weather across the region (Keim, 1997).

It is estimated that Chenango County will continue to experience direct and indirect impacts of severe storms annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences. Table 5.4.6-7 summarizes the occurrences of severe storm events and their annual occurrence (on average).

Table 5.4.6-7. Occurrences of Flood Events in Chenango County, 1950 - 2013

Event Type	Total Number of Occurrences	Annual Number of Events (average)
Hail	97	1.5
Thunderstorm Winds	237	3.7
Tornadoes	18	0.3
Tropical Cyclones	7	0.1
Total:	**359**	**5.6**

Source: NOAA-NCDC, 2013
Note: On average, Chenango County experiences 5.6 severe storm events each year.

In Section 5.3, the identified hazards of concern for Chenango County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the County is considered 'frequent (likely to occur within 25 years, as presented in Table 5.3-3); however, impacts only related to severe storms, excluding those associated with hurricanes, tropical storms and flooding, are expected to be minimal.

Climate Change Impacts

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt 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 (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Chenango County is part of Region 3, Southern Tier. Some of the issues in this region, affected by climate change, include: dairy dominates the agricultural economy and milk production losses are projected, Susquehanna River flooding increases, and this region is one of the first parts of the State hit by invasive insects, weeds and other pests moving north (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° F to 3.4° F by the 2020s, 4.1° F to 6.8° F by the 2050s, and 5.3° F to 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).

Regional precipitation across New York State is projected to increase by approximately one to eight-percent by the 2020s, three to 12-percent by the 2050s, and four to 15-percent by the 2080s. By the end of the century, the greatest increases in precipitation are projected to be in the northern areas of the State (NYSERDA, 2014).

In Region 3, it is estimated that temperatures will increase by 3.6ºF to 7.1ºF by the 2050s and 4.2ºF to 11.6ºF by the 2080s (baseline of 47.5ºF). Precipitation totals will increase between 2 and 15% by the 2050s and 3 to 16% by the 2080s (baseline of 35 inches). The changes in temperature and precipitation are likely to produce an increase in extreme heat, intense precipitation, and more occurrences of short-duration warm season droughts. Both heavy precipitation events and warm season droughts are projected to become more frequent and intense during this century. Table 5.4.6-8 displays the projected seasonal precipitation change for the Southern Tier ClimAID Region (NYSERDA, 2014).

Table 5.4.6-8. Projected Seasonal Precipitation Change in Region 3, 2050s (% change)

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

Source: NYSERDA, 2011

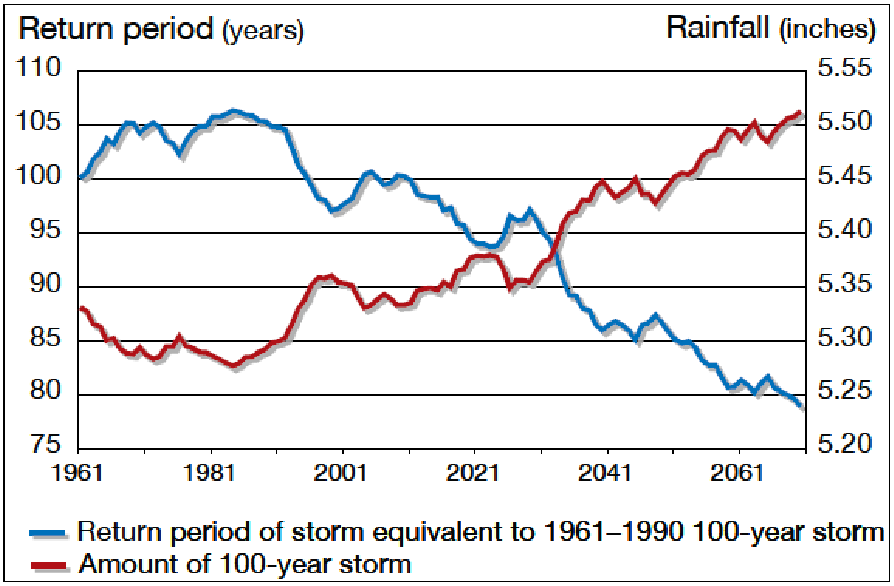
The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways and transportation hubs; and increase delays and hazards related to extreme weather events (NYSERDA, 2011).

Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA, 2011).

Over the past 50 years, heavy downpours have increased and this trend is projected to continue. This can cause an increase in localized flash flooding in urban areas and hilly regions. Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable facilities located within floodplains. Less frequent rainfall during the summer months may impact the ability of water supply systems. Increasing water temperatures in rivers and streams will affect aquatic health and reduce the capacity of streams to assimilate effluent wastewater treatment plants (NYSERDA, 2011).

Figure 5.4.6-12 displays the project rainfall and frequency of extreme storms in New York State. The amount of rain fall in a 100-year event is projected to increase, while the number of years between such storms (return period) is projected to decrease. Rainstorms will become more severe and more frequent (NYSERDA, 2011).

Figure 5.4.6-12. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA, 2011

Total precipitation amounts have slightly increased in the Northeast U.S., by approximately 3.3 inches over the last 100 years. There has also been an increase in the number of two-inch rainfall events over a 48-hour period since the 1950s (a 67-percent increase). The number and intensity of extreme precipitation events are increasing in New York State as well. More rain heightens the danger of localized flash flooding, streambank erosion and storm damage (DeGaetano et al [Cornell University], 2011).

5.4.6.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For hurricanes and tropical storms, the entire 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 2), are vulnerable. The following text evaluates and estimates the potential impact of hurricanes and tropical storms on the County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety and health of residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time

Overview of Vulnerability

The high winds and air speeds of a hurricane or any severe storm often result in power outages, disruptions to transportation corridors and equipment, loss of workplace access, significant property damage, injuries and loss of life, and the need to shelter and care for individuals impacted by the events. A large amount of damage can be inflicted by trees, branches, and other objects that fall onto power lines, buildings, roads, vehicles, and, in some cases, people. The risk assessment for hurricanes and tropical storms evaluates available data for a range of storms included in this hazard category.

Due to the inland location of the County, the potential losses associated with hurricanes and tropical storms would be from wind and rain. Secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a concern in the County.

The entire inventory of the County is at risk of being damaged or lost due to impacts of severe wind. Certain areas, infrastructure, and types of building are at greater risk than others due to proximity to falling hazards and/or their manner of construction. Potential losses associated with high wind events were calculated for the County for two probabilistic hurricane events, the 100-year and 500-year MRP hurricane events. The impacts on population, existing structures, critical facilities and the economy are presented below, following a summary of the data and methodology used.

Data and Methodology

After reviewing historic data, the HAZUS-MH methodology and model were used to analyze the hurricane and tropical storm hazard for Chenango County. Data used to assess this hazard include data available in the HAZUS-MH 2.1 hurricane model, professional knowledge, information provided by the Steering Committee and input from the public.

A probabilistic scenario was run for Chenango County for annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. These results are shown in Figure 5.4.6-1 and Figure 5.4.6-2 earlier in this section, which show the HAZUS-MH maximum peak gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP hurricane events. The estimated hurricane track for the 100- and 500-year events is also shown.

HAZUS-MH contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Hurricane and inventory data available in HAZUS-MH were used to evaluate potential losses from the 100- and 500-year MRP events (severe wind impacts). Other than updated data for the general building stock and critical facility inventories, the default data in HAZUS-MH 2.1 was the best available for use in this evaluation.

Impact on Life, Health and Safety

The impact of a severe storm on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire County's population (U.S. Census 2010 population of 51,844 people) is exposed to this storm hazard.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. HAZUS-MH estimates there will be 0 people displaced and zero people that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, HAZUS-MH estimates 0 households will be displaced and 0 require short-term sheltering. Refer to Table 5.4.6-9 which summarizes the sheltering estimates for the 500-year MRP event by municipality.

Table 5.4.6-9. Sheltering Needs for the 500-year MRP Hurricane Events for Chenango County

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Afton (T)	0	0
Afton (V)	0	0
Bainbridge (T)	0	0
Bainbridge (V)	0	0
Columbus (T)	0	0
Coventry (T)	0	0
Earlville (V)	0	0
German (T)	0	0
Greene (T)	0	0
Greene (V)	0	0
Guilford (T)	0	0
Lincklaen (T)	0	0
McDonough (T)	0	0
New Berlin (T)	0	0
New Berlin (V)	0	0
North Norwich (T)	0	0
Norwich (C)	0	0
Norwich (T)	0	0
Otselic (T)	0	0
Oxford (T)	0	0
Oxford (V)	0	0
Pharsalia (T)	0	0
Pitcher (T)	0	0
Plymouth (T)	0	0
Preston (T)	0	0
Sherburne (T)	0	0
Sherburne (V)	0	0
Smithville (T)	0	0

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Smyrna (T)	0	0
Smyrna (V)	0	0
Chenango County (Total)	**0**	**0**

Source: HAZUS-MH v 2.1 (U.S. Census 2000)
Note: Sheltering estimates are based on the default 2000 U.S. Census data in HAZUS-MH. Therefore, these are conservative estimates given the increase in population as indicated by the 2010 U.S. Census data.

Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. Please refer to Section 4 for the statistics of these populations in the County.

Impact on General Building Stock

After considering the population exposed to the severe storm hazard, the general building stock replacement value exposed to and damaged by 100- and 500-year MRP events was examined. Wind-only impacts from a severe storm are reported based on the probabilistic hurricane runs in HAZUS-MH 2.1. Potential damage is the modeled loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane (using the methodology described in Section 5.1).

It is assumed that the entire County's general building stock is exposed to the severe storm wind hazard (greater than $3.4 billion structure only). Expected building damage was evaluated by HAZUS across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.6-10 summarizes the definition of the damage categories.

Table 5.4.6-10. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little of no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.	≤ 2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	> 2% and ≤ 15%	One window, door, or garage door failure	No	< 5 Impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	> 15% and ≤ 50%	> the larger of 20% & 3 and ≤ 50%	1 to 3 Panels	Typically 5 to 10 Impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	> 50%	> one and ≤ the larger of 20% & 3	> 3 and ≤ 25%	Typically 10 to 20 Impacts	No	No
Destruction Complete roof failure and/or failure of wall frame. Loss of more than 50% of roof sheathing.	Typically > 50%	> 50%	> 25%	Typically > 20 Impacts	Yes	Yes

Source: HAZUS-MH Hurricane Technical Manual

As noted earlier in the profile, HAZUS estimates the 100-year MRP peak gust wind speeds for Chenango County to be less than 50 miles per hour (mph). For the 100-year MRP event, HAZUS-MH 2.1 estimates $0 in structure damages across the County. Residential buildings comprise the majority of the building inventory and are estimated to experience all of the damage.

HAZUS estimates the 500-year MRP peak gust wind speeds for Chenango County to range from 61 to 63 mph. This equates to a tropical storm and $1 Million in damages to the general building stock (structure only). This is less than one-percent of the County's building inventory. The residential buildings are estimated to experience the majority of the damage. Table 5.4.6-11 summarizes the building value (structure only) damage estimated for the annualized and 100- and 500-year MRP wind-only events by occupancy class.

Table 5.4.6-11. Estimated Building Replacement Value (Structure Only) Damaged by the 100-Year and 500-Year Mean Return Period Hurricane-Related Winds for All Occupancy Classes

		Total Building Damage (All Occupancies)						Residential Buildings		Commercial Buildings	
		Annualized		100 Year		500 Year					
Municipality	Total Building Replacement Value (Structure Only)	Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	100 Year	500 Year	100 Year	500 Year
Afton (T)	$118,931,000	$814.50	0.00	0	0	$42,933.60	0.04%	0	$42,655.4	0	271.6
Afton (V)	$64,951,000	$254.35	0.00	0	0	$12,188.90	0.02%	0	$12,138.8	0	50.1
Bainbridge (T)	$153,224,000	$639.10	0.00	0	0	$43,286.10	0.03%	0	$42,853.9	0	337.1
Bainbridge (V)	$131,757,000	$425.51	0.00	0	0	$24,668.40	0.02%	0	$23,948.1	0	557.2
Columbus (T)	$56,165,000	$153.15	0.00	0	0	$13,847.90	0.02%	0	$13,478.8	0	312.8
Coventry (T)	$85,266,000	$509.79	0.00	0	0	$36,306.10	0.04%	0	$36,175.7	0	101
Earlville (V)	$16,323,000	$80.11	0.00	0	0	$9,156.20	0.06%	0	$8,997.7	0	141.9
German (T)	$24,195,000	$101.10	0.00	0	0	$12,364.70	0.05%	0	$12,041.5	0	74.9
Greene (T)	$224,771,000	$1,147.81	0.00	0	0	$108,438.80	0.05%	0	$105,555.1	0	2053.4
Greene (V)	$168,206,000	$512.22	0.00	0	0	$45,292.40	0.03%	0	$39,635.4	0	1188.4
Guilford (T)	$162,643,000	$744.75	0.00	0	0	$57,905.30	0.04%	0	$57,347.5	0	346.1
Lincklaen (T)	$21,095,000	$73.04	0.00	0	0	$10,003.50	0.05%	0	$9,890.8	0	48.5
McDonough (T)	$54,845,000	$206.70	0.00	0	0	$26,038.50	0.05%	0	$25,532.3	0	279.5
New Berlin (T)	$96,879,000	$475.60	0.00	0	0	$43,367.30	0.04%	0	$43,150.7	0	82.8
New Berlin (V)	$84,173,000	$248.27	0.00	0	0	$18,555.50	0.02%	0	$18,345.8	0	209.7
North Norwich (T)	$100,195,000	$365.36	0.00	0	0	$34,612.00	0.03%	0	$33,040.1	0	33.5
Norwich (C)	$624,530,000	$1,541.57	0.00	0	0	$119,759.00	0.02%	0	$119,759.0	0	0
Norwich (T)	$247,680,000	$730.13	0.00	0	0	$62,439.60	0.03%	0	$62,257.2	0	102.6
Otselic (T)	$57,767,000	$149.24	0.00	0	0	$21,550.80	0.04%	0	$19,550.9	0	565.8
Oxford (T)	$155,750,000	$624.56	0.00	0	0	$54,169.50	0.03%	0	$53,865.5	0	50.5
Oxford (V)	$107,102,000	$383.55	0.00	0	0	$37,727.70	0.04%	0	$36,918.9	0	342.5
Pharsalia (T)	$31,028,000	$92.96	0.00	0	0	$12,869.60	0.04%	0	$12,311.4	0	262.7
Pitcher (T)	$31,670,000	$110.17	0.00	0	0	$15,456.70	0.05%	0	$15,167.4	0	207.7
Plymouth (T)	$111,005,000	$307.16	0.00	0	0	$32,451.80	0.03%	0	$31,911.6	0	179
Preston (T)	$52,484,000	$163.90	0.00	0	0	$17,721.70	0.03%	0	$17,523.9	0	145.4
Sherburne (T)	$128,134,000	$395.02	0.00	0	0	$38,920.30	0.03%	0	$38,603.6	0	242.6

Municipality	Total Building Replacement Value (Structure Only)	Total Building Damage (All Occupancies)						Residential Buildings		Commercial Buildings	
		Annualized		100 Year		500 Year					
		Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	100 Year	500 Year	100 Year	500 Year
Sherburne (V)	$150,926,000	$275.94	0.00	0	0	$21,073.30	0.01%	0	$21,063.9	0	0
Smithville (T)	$72,864,000	$375.82	0.00	0	0	$34,239.40	0.05%	0	$34,207.0	0	26.1
Smyrna (T)	$57,712,000	$199.78	0.00	0	0	$22,966.60	0.04%	0	$22,319.3	0	300.3
Smyrna (V)	$12,576,000	$42.50	0.00	0	0	$4,128.60	0.03%	0	$3,983.8	0	138.3
Chenango County (Total)	**$3,404,847,000**	**$12,144**	**0.00**	**0**	**0**	**$1,034,440**	**0.03%**	**0**	**$1,014,231**	**0**	**8,652**

Municipality	Industrial Buildings		Agriculture Buildings		Religious Buildings		Government Buildings		Education Buildings	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Afton (T)	0	6.6	0	0	0	0	0	0	0	0
Afton (V)	0	0	0	0	0	0	0	0	0	0
Bainbridge (T)	0	59.7	0	0	0	35.4	0	0	0	0
Bainbridge (V)	0	76.1	0	0	0	74.8	0	12.2	0	0
Columbus (T)	0	49.8	0	0	0	0	0	6.5	0	0
Coventry (T)	0	29.4	0	0	0	0	0	0	0	0
Earlville (V)	0	16.6	0	0	0	0	0	0	0	0
German (T)	0	191.9	0	0	0	56.4	0	0	0	0
Greene (T)	0	194.8	0	4.6	0	314.8	0	316.1	0	0
Greene (V)	0	3801.4	0	0	0	302.3	0	86.5	0	278.4
Guilford (T)	0	160.5	0	0	0	38.1	0	13.1	0	0
Lincklaen (T)	0	33.2	0	31	0	0	0	0	0	0
McDonough (T)	0	43.9	0	0	0	140.4	0	42.4	0	0
New Berlin (T)	0	0	0	0	0	133.8	0	0	0	0
New Berlin (V)	0	0	0	0	0	0	0	0	0	0
North Norwich (T)	0	835.4	0	0	0	22.3	0	0	0	680.7
Norwich (C)	0	0	0	0	0	0	0	0	0	0
Norwich (T)	0	45.2	0	0	0	0	0	34.6	0	0
Otselic (T)	0	796.1	0	0	0	19.7	0	417.4	0	200.9

Municipality	Industrial Buildings		Agriculture Buildings		Religious Buildings		Government Buildings		Education Buildings	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Oxford (T)	0	159	0	0	0	0	0	94.5	0	0
Oxford (V)	0	235.4	0	0	0	230.9	0	0	0	0
Pharsalia (T)	0	40	0	0	0	0	0	164.7	0	90.8
Pitcher (T)	0	22	0	15.8	0	0	0	43.8	0	0
Plymouth (T)	0	90.7	0	0	0	99.7	0	170.8	0	0
Preston (T)	0	18	0	0	0	21.2	0	13.2	0	0
Sherburne (T)	0	41.3	0	0	0	32.8	0	0	0	0
Sherburne (V)	0	9.4	0	0	0	0	0	0	0	0
Smithville (T)	0	6.3	0	0	0	0	0	0	0	0
Smyrna (T)	0	156	0	0	0	40.7	0	150.3	0	0
Smyrna (V)	0	0	0	0	0	0	0	6.5	0	0
Chenango County (Total)	**0**	**7,118.7**	**0**	**51.4**	**0**	**1,563.3**	**0**	**1,572.6**	**0**	**1,250.8**

Source: HAZUS-MH 2.1

Notes: B = Borough; GBS = General Building Stock; RCV = Replacement Cost Value; T = Town

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. The damage counts include buildings damaged at all severity levels from minor damage to total destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level.

Of the exceeding $2.4 billion in total residential replacement value (structure) for the entire County, an estimated $0 in residential building damage can be anticipated for the 100-year event and $1.01 million in residential building damage can be anticipated for the 500-year event. Residential building damage accounts for 98-percent of total damages for the 500-year wind-only event. This illustrates residential structures are the most vulnerable to the wind hazard.

Annualized losses were also examined for Chenango County. A total of $12,000 is estimated as the annualized loss for the entire County; see Table 5.4.6-11 above. Please note that annualized loss does not predict what losses will occur in any particular year.

Impact on Critical Facilities

HAZUS-MH estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH estimates the loss of use for each facility in number of days. HAZUS-MH estimates a less than 1-percent chance that critical facilities in Chenango County will experience minor damage; and continuity of operations at these facilities will not be interrupted (loss of use is estimated to be zero days) as a result of a 100-year and 500-year MRP events.

At this time, HAZUS-MH 2.1 does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, falling debris etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

Utility structures could suffer damage associated with falling tree limbs or other debris. Such impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Impact on Economy

Severe storms also impact the economy, including: loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. HAZUS-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

For the 100-year MRP wind event, HAZUS-MH estimates $0 in relocation costs. For the 500-year MRP wind only event, HAZUS-MH estimates less than $1K in business interruption losses for Chenango County which includes loss of income, relocation costs, rental costs and lost wages. Further HAZUS-MH estimates $0in loss of inventory.

HAZUS-MH 2.1 also estimates the amount of debris that may be produced a result of the 100- and 500-year MRP wind events. Table 5.4.6-12 estimates the debris produced. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the HAZUS-MH Hurricane User Manual: '*The Eligible Tree Debris columns provide estimates of the weight and volume of downed trees that would likely be collected and disposed at public expense. As discussed in Chapter 12 of the HAZUS-MH Hurricane Model Technical Manual, the eligible tree debris estimates produced by the Hurricane Model tend to underestimate reported volumes of debris brought to landfills for a number of events that have occurred over the past several years. This indicates that that there may be other sources of vegetative and non-vegetative debris that are not currently being modeled in HAZUS. For landfill estimation purposes, it is recommended that the HAZUS debris volume estimate be treated as an approximate lower bound. Based on actual reported debris volumes, it is recommended that the HAZUS results be multiplied by three to obtain an approximate upper bound estimate. It is also important to note that the Hurricane Model assumes a bulking factor of 10 cubic yards per ton of tree debris. If the debris is chipped prior to transport or disposal, a bulking factor of 4 is recommended. Thus, for chipped debris, the eligible tree debris volume should be multiplied by 0.4*'.

Table 5.4.6-12. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Afton (T)	0	0	0	0	0	1,420	0	729
Afton (V)	0	0	0	0	0	31	0	98
Bainbridge (T)	0	0	0	0	0	822	0	474
Bainbridge (V)	0	0	0	0	0	14	0	104
Columbus (T)	0	0	0	0	0	627	0	299
Coventry (T)	0	0	0	0	0	1,553	0	628
Earlville (V)	0	0	0	0	0	18	0	54
German (T)	0	0	0	0	0	1,074	0	378
Greene (T)	0	0	0	0	0	2,354	0	1,145
Greene (V)	0	0	0	0	0	31	0	215
Guilford (T)	0	0	0	0	0	1,077	0	579
Lincklaen (T)	0	0	0	0	0	818	0	327
McDonough (T)	0	0	0	0	0	1,173	0	565
New Berlin (T)	0	0	0	0	0	1,220	0	526
New Berlin (V)	0	0	0	0	0	20	0	107
North Norwich (T)	0	0	0	0	0	725	0	404
Norwich (C)	0	0	0	0	0	45	0	446
Norwich (T)	0	0	0	0	0	676	0	556
Otselic (T)	0	0	0	0	0	1,175	0	442
Oxford (T)	0	0	0	0	0	1,334	0	667
Oxford (V)	0	0	0	0	0	47	0	192
Pharsalia (T)	0	0	0	0	0	1,504	0	530
Pitcher (T)	0	0	0	0	0	790	0	317
Plymouth (T)	0	0	0	0	0	730	0	328

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Preston (T)	0	0	0	0	0	544	0	219
Sherburne (T)	0	0	0	0	0	1,094	0	509
Sherburne (V)	0	0	0	0	0	24	0	116
Smithville (T)	0	0	0	0	0	1,754	0	730
Smyrna (T)	0	0	0	0	0	957	0	377
Smyrna (V)	0	0	0	0	0	4	0	15
Chenango County (Total)	0	0	0	0	0	23,655	0	12,077

Source: HAZUS-MH 2.1

Future Growth and Development

As discussed and illustrated in Section 2, areas targeted for future growth and development have been identified across Chenango County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire County is exposed and vulnerable to the wind hazard associated with severe storms.

Additional Data and Next Steps

Over time, Chenango County will obtain additional data to support the analysis of this hazard. Data that will support the analysis would include additional detail on past hazard events and impacts, specific building information such as type of construction and details on protective features (for example, hurricane straps). In addition, information on particular buildings or infrastructure age or year built would be helpful in future analysis of this hazard.