4.3.8 Severe Storm

Hazard Profile

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

Hazard Description

For the purpose of this 2024 plan update and as deemed appropriated by the Rockland County Steering and Planning Committees, the severe storm hazard includes hail, high winds, thunderstorms, tornadoes, Nor'easters, and hurricanes/tropical storms, which are defined below.

Hailstorms

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32°F or colder. As the frozen droplet begins to fall, it might thaw as it moves into warmer air toward the bottom of the thunderstorm, or the droplet might be picked up again by another updraft and carried back into the cold air to re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail (NSSL 2021).

High Winds

Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth. High winds are often associated by other severe weather events such as thunderstorms, tornadoes, hurricanes, and tropical storms (NWS 2012). The following are descriptions of types of damaging winds:

- **Straight-line Wind**: Used to define thunderstorm wind which is not linked with rotation and is mainly used to differentiate from tornadic winds (NOAA n.d.)
- **Down Draft**: A small scale column of air that sinks towards the ground (NOAA n.d.)
- **Macroburst**: An outward burst of strong winds that are more than 2.5 miles in diameter (NOAA n.d.)
- **Microburst**: A small, concentrated downburst which produces an outward burst of relatively strong winds near the surface (NOAA n.d.)
- **Downburst:** General term to describe macro and microbursts (NOAA n.d.)
- **Gust Front:** Leading edge of rain-cooled air which clashes with a warm thunderstorm inflow (NOAA n.d.)
- **Derecho:** Long lived windstorm associated with rapidly moving precipitation or thunderstorms. If wind damage swatch is more than 240 miles and includes gusts of wind that reach 58 mph or greater, then the event can be classified as a derecho (NOAA n.d.)

Tornadoes

NOAA defines a tornado as a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground (NOAA 2011). Because wind is invisible, it is hard to see a tornado unless it forms a condensation funnel made up of water droplets, dust, and debris. Tornadoes are the most violent of all atmospheric storms and the most hazardous when they occur in populated areas. Tornadoes can topple mobile homes, lift cars, snap trees,

and turn objects into destructive missiles. Among the most unpredictable of weather phenomena, tornadoes can occur at any time of day, in any state in the union, and in any season. While the majority of tornadoes cause little or no damage, some are capable of tremendous destruction, reaching wind speeds of 200 mph or more (NOAA 2023).

Thunderstorms

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NOAA-NSSL n.d.). 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 at the equator to as far north as Alaska. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and lightning.

Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. The National Weather Service (NWS) considers a thunderstorm severe only if it produces damaging wind gusts of 58 mph or higher or large hail one inch (quarter size) in diameter or larger or tornadoes (NWS n.d.). An estimated 100,000 thunderstorms occur each year in the U.S., with approximately 10% of them classified as severe (U.S. Department of Commerce; NOAA; NWS 1994). During the warm season, thunderstorms are responsible for most of the rainfall.

Lightning is a bright flash of electrical energy produced by a thunderstorm. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning, which can be very dangerous. It ranks as one of the top weather killers in the nation and kills approximately 20 people and injures hundreds each year (NWS n.d.). Lightning can occur anywhere there is a thunderstorm.

Nor'Easters

A Nor'easter is a cyclonic storm that moves along the East Coast of North America. It is called a Nor'easter because the damaging winds over coastal areas blow from a northeasterly direction. Nor'easters can occur any time of the year but are most frequent and strongest between September and April. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and typically move from southwest to northeast along the Atlantic Coast of the United States (NWS n.d.). To be classified as a Nor'easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

- Persist for at least a 12-hour period
- Have a closed circulation
- Be located within the quadrilateral bounded at 45°N by 65° and 70°W and at 30°N by 85°W and 75°W
- Show general movement from the south-southwest to the north-northeast
- Contain wind speeds greater than 23 mph)

A Nor'easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'easter is usually much slower than a hurricane, so with the slower speed, a Nor'easter can linger for days and cause tremendous damage to those areas impacted. Approximately 40 Nor'easters occur in the northeastern US every year (NPS 2023). The intensity of a Nor'easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds.

Hurricanes/Tropical Storms

A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 or more mph. Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic coast and impact the eastern seaboard or move into the US through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving offshore and heading east.

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Compared to a hurricane, these storms tend to have slower wind speeds. Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings, a phenomenon called "warm core" storm systems (NOAA 2023).

Location

Severe storm events occur throughout the State of New York and are not bound by geographic extent. The likelihood of these events affecting certain parts of Rockland County depends on storm conditions.

Hailstorms

Hailstorms can form anywhere; however, they are more likely to fall in areas that have the most thunderstorms. The longer a hailstone spends in the clouds, the larger it becomes as more droplets continue to freeze. Hail falls when it becomes heavy enough to overcome the strength of the thunderstorm updraft and is pulled to the earth by gravity. Smaller hailstones may be blown away from the updraft by horizontal winds, so larger hail typically falls closer to the updraft than smaller hail (NOAA n.d.).

According to the National Risk Index, on the county scale, the County has a relatively low risk to hail; on the census tract scale, the County ranges from a very low risk to a relatively low risk (FEMA 2019).

High Winds

All of Rockland County is subject to high winds from thunderstorms, hurricanes/tropical storms, tornadoes, and other severe weather events. According to FEMA Winds Zones of the United States map, Rockland County is located in Wind Zone II, where wind speeds can reach up to 160 mph. The County is also located in the Hurricane Susceptible Region, which extends along the entire east coast from Maine to Florida, the Gulf Coast, and Hawaii.

According to the National Risk Index, on the county scale, the County has a relatively high risk to strong winds; on the census tract scale, the County ranges from a relatively moderate risk to a relatively high risk (FEMA 2019).

Tornadoes

Approximately 1,200 tornadoes occur in the US each year, with the central portion of the country experiencing the most (NOAA-NSSL n.d.). Tornadoes can occur at any time of the year, with peak seasons at different times for different states. The peak season for southern Plains (Texas, Oklahoma, Kansas, etc.) is from May into early June. The Gulf coast experiences tornado seasons during the spring. For the northern Plains and upper Midwest region (North and South Dakota, Nebraska, Iowa, etc.) tornado seasons are generally seen June through July (NOAA-NSSL n.d.).

The entire State of New York is susceptible to tornado activity and vulnerable to tornado impacts. Based on statistics from 1996 to 2018, it was found that on average eight tornadoes ranging from F0 to F4, occurred each year in the State (NYS 2019). This resulted in an average of $6.4 million in annualized loss from tornadoes for the State of New York. Approximately 143 injuries and six fatalities were recorded from 1996 to 2018 as a result of tornado impacts (NYS 2019). The entirety of Rockland County is vulnerable to tornado impacts and can experience a tornado at any time when suitable conditions are present.

According to the National Risk Index, on the county scale, the County has a relatively moderate risk to tornadoes; on the census tract scale, the County ranges from a very low risk to a relatively moderate risk (FEMA 2019).

Thunderstorms

Thunderstorms affect relatively small, localized areas, rather than large regions like winter storms and hurricane events. Thunderstorms can strike anywhere, but they are most common in the central and southern US. The atmospheric conditions in these regions of the country are ideal for generating these powerful storms. It is estimated that there are as many as 40,000 thunderstorms each day worldwide (NOAA 2023). The most thunderstorms are seen in the southeast United States, with Florida having the highest incidences (80 to over 100 thunderstorm days each year).

Nor'easters

According to the New York State Hazard Mitigation Plan, the coastal region of the State of New York is extremely vulnerable to Nor'easters; however, these storms can impact the entire state. Therefore, the entire County is exposed and vulnerable to Nor'easters.

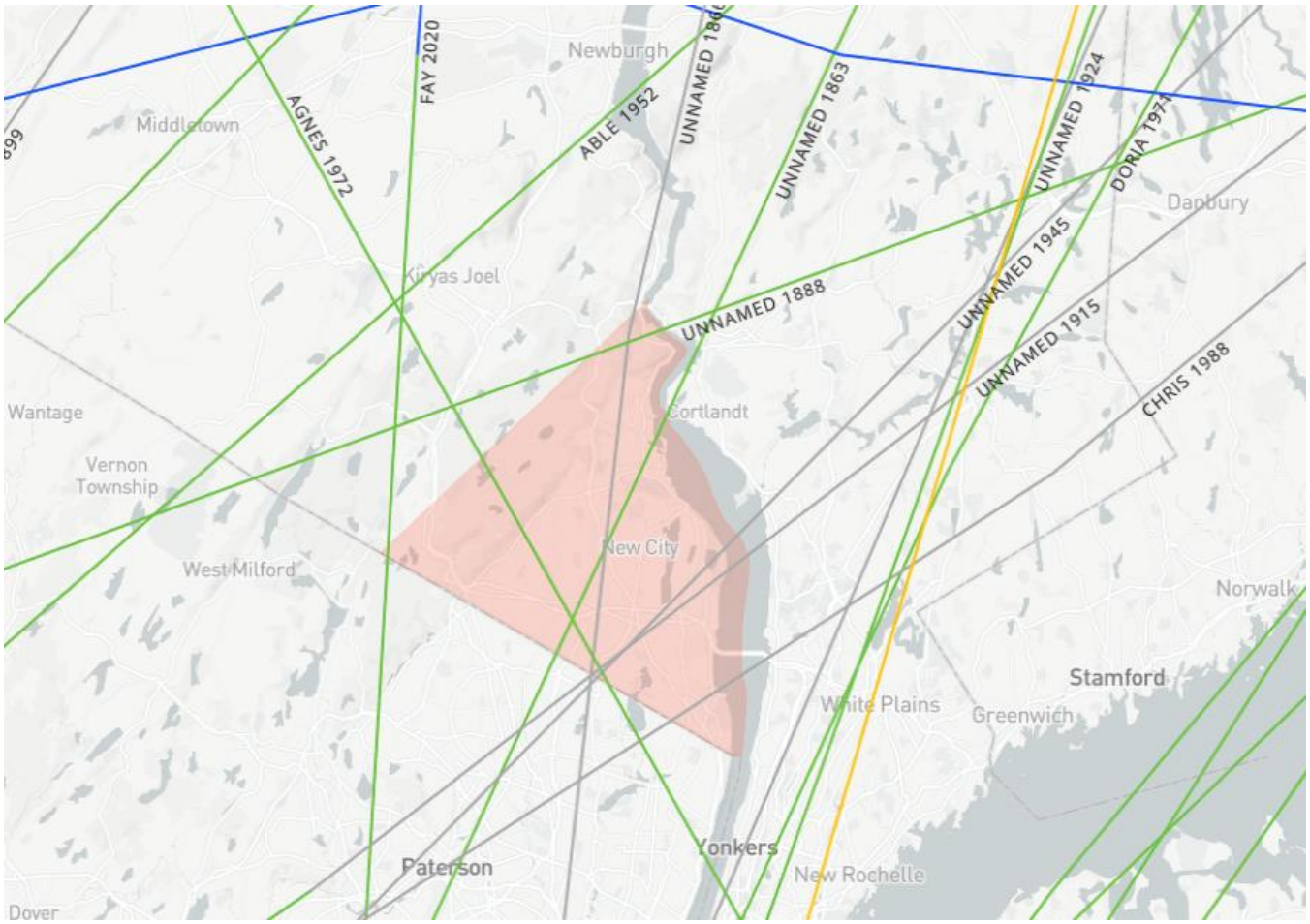
Hurricanes/Tropical Storms

The official hurricane season for the eastern US, including the State of New York, is from June to November. Hurricanes and tropical storms are most likely to affect the State between late July to early due to the coolness of the Atlantic Ocean (NYS 2019).

Rockland County is vulnerable to the impacts of hurricanes and tropical storms. However, it depends on the storm's track. Inland areas, like western Rockland County, are at risk for flooding due to the heavy rain and winds produced by hurricanes and tropical storms. The majority of damage from these events often results from residual wind damage and inland flooding, most recently experienced during Hurricane Irene in August 2011. Additionally, areas of Rockland County bordered by the Hudson River are susceptible to flooding from tidal-influenced storm surge associated with hurricanes and tropical storms.

NOAA's 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 catalogs tropical cyclones that have occurred from 1950 to 2023 (latest date available from data source). Between 1950 and 2023, 52 tropical cyclones tracked within 60 nautical miles of Rockland County (NOAA 2021). Figure 4.3.8-1 displays the tropical cyclone tracks for Rockland County that tracked with 60 nautical miles.

Figure 4.3.8-1. Historical Tropical Storm and Hurricane Tracks 1950 to 2023



Source: NOAA NHC 2023

According to the National Risk Index, on the county scale, the County has a relatively moderate risk to hurricanes; on the census tract scale, the County ranges from a very relatively low risk to a relatively moderate risk (FEMA 2019).

Extent

Hailstorms

The severity of hail is measured by duration, hail size, and geographic extent. Hail can exhibit a variety of sizes, though only the very largest hail stones pose serious risk to people, if exposed. It is often estimated by comparing

it to a known object (Figure 4.3.8-2). Most hailstorms are made up of a mix of different sizes, and only the very largest hail stones pose serious risk to people caught in the open (NSSL 2021).

Figure 4.3.8-2. Hail Size Chart

Source: NOAA

High Winds

The NWS issues advisories and warnings for winds. Issuance is normally site-specific. High wind advisories, watches and warnings are products issued by the NWS when wind speeds may pose a hazard or is life threatening. The criterion for each of these varies from state to state. Wind warnings and advisories for the State of New York are as follows:

- **High Wind Warnings** are issued when sustained wind speeds of 40 mph or greater lasting for one hour or longer or for winds of 58 mph or greater for any duration or widespread damage are possible.
- **Wind Advisories** are issues when sustained winds of 30 to 39 mph are forecast for one hour or longer, or wind gusts of 46 to 57 mph for any duration (NWS 2011).

Tornadoes

The Enhanced Fujita Scale (EF-Scale) is the standard used to measure the strength of a tornado. 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 (DI) 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 considers how most structures are designed (NWS n.d.). Figure 4.3.8-3 illustrates the relationship between EF ratings, wind speed, and expected tornado damage. Rockland County typically experience tornadoes ranging from EF0 to EF1.

NOAA Storm Prediction Center issues watch and warning alerts for tornado activities. A tornado watch is when conditions are favorable for a tornado to form. A watch can cover parts of a state or span several states (NOAA-NSSL n.d.). A tornado warning is when a tornado is spotted by a radar and indicated action should we taken to ensure safety and shelter. Warnings can cover parts of counties or several counties, depending on the tornadoes path (NOAA-NSSL n.d.). The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NWS n.d.).

Figure 4.3.8-3. Explanation of EF-Scale Ratings

Source: NWS n.d.

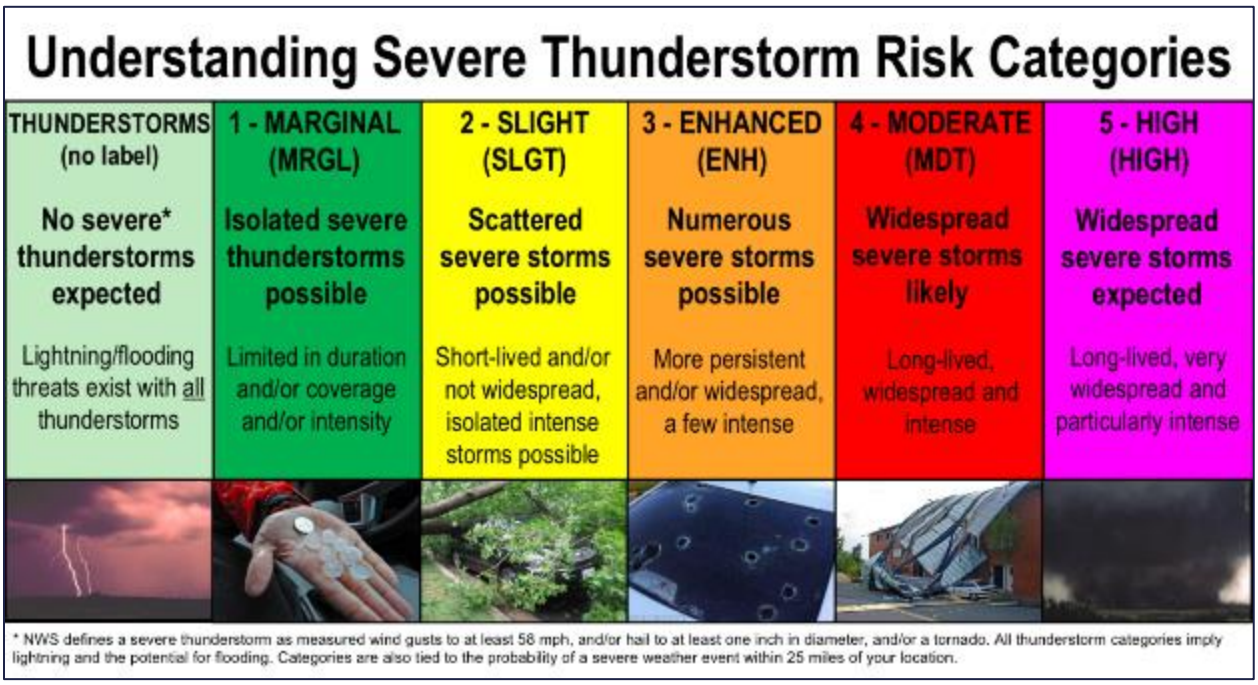
Thunderstorms

Severe thunderstorm statements, watches, and warnings are issued by the local NWS office and the Storm Prediction Center (SPC). The NWS and SPC will update the watches and warnings and notify the public when they are no longer in effect. NWS issues statements, watches, and warnings for thunderstorms:

- **Special Weather Statement:** Issued for strong storms that are below severe levels but may have impacts. Usually reserved for the threat of wind gust of 40–57 mph or hail of 0.5-inches to 0.99-inches in diameter (NWS 2023).
- **Severe Thunderstorm Watches:** A severe thunderstorm watch is issued when severe thunderstorms are possible in and near watch areas (NWS 2023).
- **Severe Thunderstorm Warning:** A severe thunderstorm is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A severe thunderstorm is one that produces winds 58 mph or stronger and/or hail 1 inch in diameter or larger. A warning means to take shelter (NWS 2023).

The NWS has five risk categories for severe weather: marginal, slight, enhanced, moderate, and high. The probabilistic forecast directly expresses the best estimate of a severe weather event occurring within 25 miles of a point (NWS 2022). Figure 4.3.8-4 details the thunderstorm risk categories.

Figure 4.3.8-4. Thunderstorm Risk



Source: NOAA

Nor'Easters

Nor'Easters have the potential to impact society to a greater extent than hurricanes and tornadoes. These storms often have a diameter three to four times larger than a hurricane and therefore, impact much larger areas. The severity of a Nor'Easter 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 (e.g., weekday versus weekend), and season.

NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5 and is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA n.d.). Table 4.3.8-1 lists the five categories.

Table 4.3.8-1. Regional Snowfall Index 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+

Source: NOAA-NCDC 2011
RSI Regional Snowfall Index

Hurricanes/Tropical Storms

Hurricanes are classified according to the Saffir-Simpson Hurricane Wind Scale from a Category 1 to Category 5 by sustained wind intensity. Figure 4.3.8-5 below shows the categories and the type of damage they produce.

Figure 4.3.8-5. Saffir-Simpson Hurricane Wind Scale

Source: NWS 2022

The NWS issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center (NHC) to issue advisories during the post-tropical stage (NHC NOAA 2010).

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. Figure 4.3.8-6 and Figure 4.3.8-7 show the estimated maximum three-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using Hazards U.S. Multi-Hazard (HAZUS-MH) model runs for the 100- and 500-year event. The maximum 3-second gust wind speeds for Rockland County range from 74 to 95 mph for the 100-year MRP event. The maximum 3-second gust wind speeds for Rockland County range from 74 to 110 mph for the 500-year MRP event. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment.

Figure 4.3.8-6. Wind Speeds for the 100-Year Mean Return Period Event

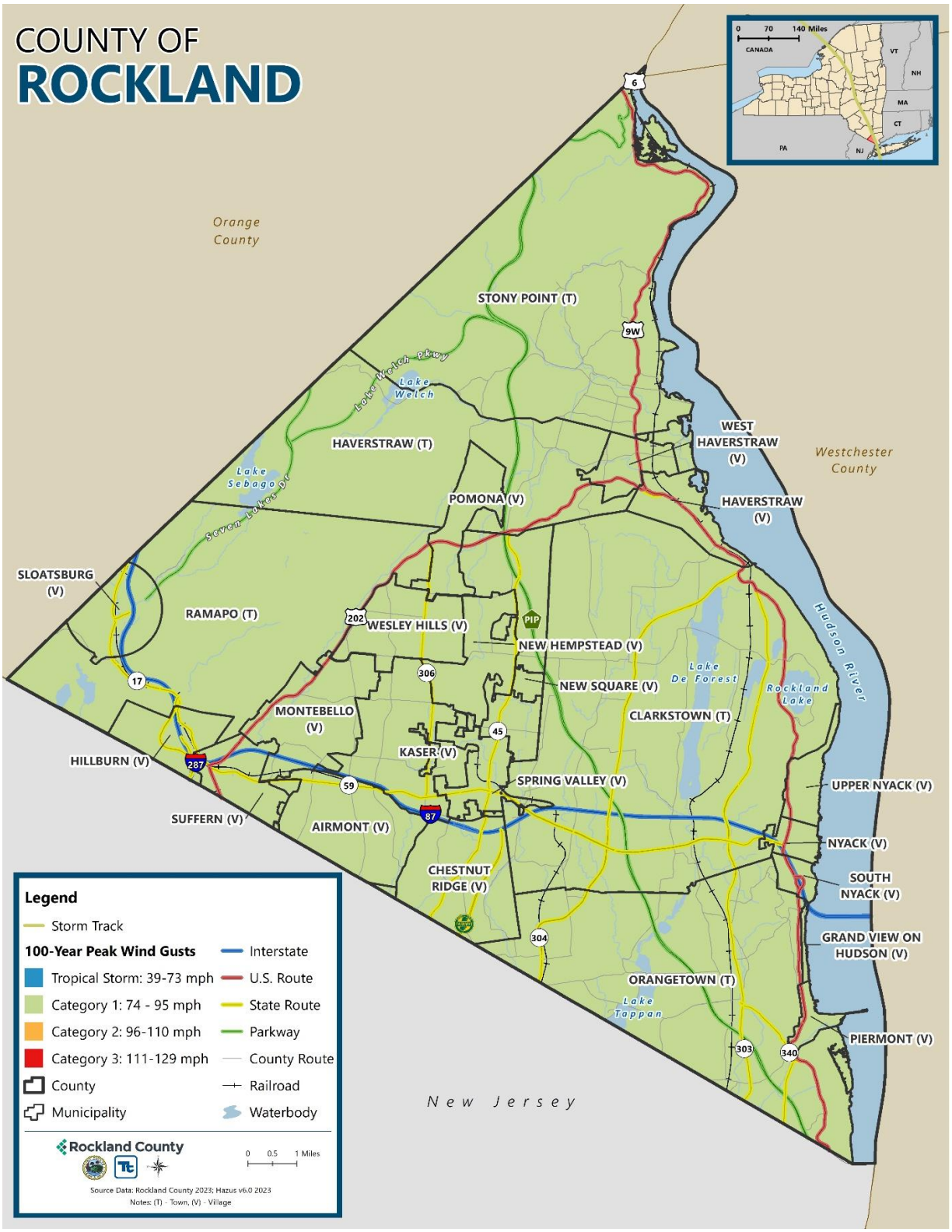
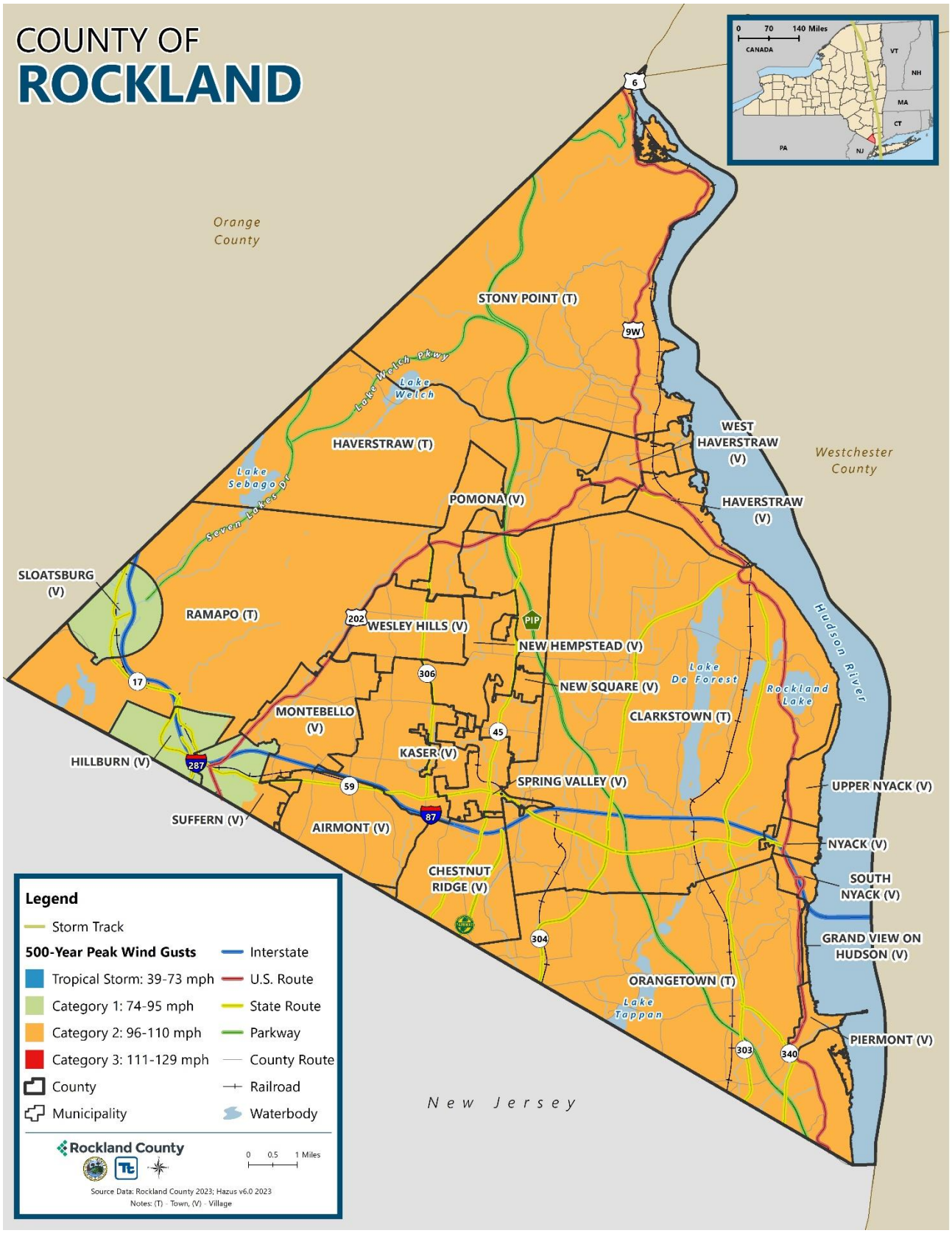


Figure 4.3.8-7. Wind Speeds for the 500-Year Mean Return Period Event



Previous Occurrences

FEMA Major Disaster and Emergency Declarations

Between 1954 and 2023, Rockland County was included in 16 major disaster (DR) or emergency (EM) declarations for severe storm-related events (FEMA 2023). These declarations involved events classified as one or a combination of the following hazards: hurricane, flood, severe ice storm, severe storm, and tornado (FEMA 2023). Generally, these disasters cover a wide region of the State and may have impacted many counties. For declarations that occurred between 2017 and 2023, refer to Table 4.3.8-2. Detailed information about the declared disasters since 1954 is provided in Section 3 (County Profile).

Table 4.3.8-2. FEMA Declarations for Severe Storm Events in Rockland County (2017 to 2023)

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Rockland County included in declaration?	Location Impacted	Description
October 2, 2020	Hurricane	DR-4567	Yes	Nassau, Suffolk, Putnam, Queens, Richmond, Rockland, and Westchester Counties	Tropical Storm Isaias impacted the East Coast of the United States, claiming the lives of over 12 people and leaving millions without power. This severe storm event resulted in approximately $5.025B in damage, making it the costliest tropical cyclone to impact the Northeastern United States since Hurricane Sandy in 2012.
August 22, 2021	Hurricane	EM-3565	Yes	Countywide	Tropical Storm Henri (downgraded to a tropical storm at landfall) impacted New York and neighboring states, causing thousands of residents to lose power. While Rockland County was spared from the heaviest wind gusts, substantial rainfall and flooding affected the area.
September 2, 2021	Hurricane	EM-3572	Yes	Bronx, Dutchess, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk, Sullivan, Westchester, and Ulster Counties	The remnants of Hurricane Ida impacted New York State, bringing heavy rain, severe wind, and widespread urban flooding. Approximately 31 roadways were closed in Rockland, 212 emergency calls were received by the local fire department, and 1,481 power outages were reported. Additionally, 85 people were rescued from vehicles that were swept away by the floodwaters.
September 5, 2021	Hurricane	DR-4615	Yes	Bronx, Dutchess, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk, Sullivan, Westchester, and Ulster Counties	Remnants of Hurricane Ida impacted New York State, bringing heavy rain, high winds, and severe flooding. Hundreds of millions of dollars in damage resulted from this storm, and more than 40 people lost their lives.
July 22, 2023	Severe Storm	DR-4723	Yes	Clinton, Dutchess, Essex, Frankin, Hamilton, Ontario, Orange, Putnam, and Rockland Counties	Severe storms and flooding impacted multiple counties across New York State, bringing record-breaking levels of precipitation, landslides, and widespread road closures.

Sources: FEMA, 2023; (Childs 2020, Korn 2021, FEMA 2022, NBC4 New York 2021, CBS4 New York 2021)

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2018 and 2023, Rockland County was included in two Severe Storm-related agricultural disaster declarations. For declarations that occurred between 2017 and 2023, refer to Table 4.3.8-3.

Table 4.3.8-3. USDA Declarations for Severe Storm Events in Rockland County (2017 to 2023)

Event Date	Event Type	USDA Declaration Number	Description
April 10, 2019	Excessive Precipitation	S4479	Thunderstorms in Rockland brought heavy rain and lightning that resulted in power outages for over 42,000 residents.
July 31, 2023	Flash Flooding and Excessive Rain	S5607; S5641	Severe storms struck multiple counties in Upstate New York, resulting in an estimated $50 million in damage.

Sources: CBS New York 2019, USDA 2024, ABC7 New York 2023

Previous Events

For this 2024 HMP update, known hazard events that impacted Rockland County between January 2017 and December 2023 are discussed in Table 4.3.8-4. For events prior to 2017, refer to the 2018 Rockland County HMP.

Table 4.3.8-4. Hazard Events in Rockland County (2017 to 2023)

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Rockland County included in declaration?	Location Impacted	Description
March 2, 2018	High Winds	N/A	N/A	Countywide	Strong winds caused several trees to be downed along Treack Road, Palisades Parkway, and Hasting Lane blocking several roadways. One tree was downed on a house and car on a school street in Upper Nyack. Power outages were seen in some neighborhoods in the area.
May 15, 2018	Thunderstorm Wind	N/A	N/A	Nanuet, Nyack, West Nyack, Congers, Doodletown, and Spring Valley, NY	A tree was downed on Red Schoolhouse Road due to thunderstorm winds, resulting in one fatality. The victim was an 80-year-old woman who was inside a car that the tree fell on.
July 3, 2018	Thunderstorm Wind	N/A	N/A	New City, NY	A tree was downed on a car located on Laurel Road due to thunderstorm winds. One victim was injured as a result of being inside the car.

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Rockland County included in declaration?	Location Impacted	Description
October 2, 2018	Tornado	N/A	N/A	Stony Point, NY	A tornado made landfall in Harriman State Park and ended near Wilderness Drive in Stony Point. Several trees were uprooted and downed in the tornado path. Maximum wind speeds were recorded around 100 mph, indicating an EF1 rating. The maximum path width was approximately 100 yards. The tornado covered a length of approximately one and one-half miles for its total duration.
February 25, 2019	High Winds	N/A	N/A	Valley Cottage, NY	A large tree was downed in the afternoon in Valley Cottage. The downed tree knocked out wires and started a small fire on Carlann Lane.
April 13, 2020	High Winds	EM-3434-NY (Unrelated due to COVID-19)	N/A	New Hempstead, NY	Several large trees were downed in the New Hempstead area blocking roadways. Wires were downed by several trees, causing further road closures due to power outages for traffic lights.
June 29, 2020	Thunderstorm Wind	N/A	N/A	Pearl River, NY	A large tree was downed due to high thunderstorm winds and resulted in crushing a car. No one was inside the car.
July 11, 2020	Thunderstorm Wind	N/A	N/A	Upper Nyack, NY	Several trees and power lines were downed due to severe thunderstorm winds in the Town of Valley Cottage.
August 4, 2020	Tropical Storm	N/A	N/A	Countywide	Maximum winds were recorded at 42 mph, with peak wind gusts up to 57 mph. 1 to 3 inches of rainfall was also recorded across the county. Several trees were downed which resulted in power outages and damages seen to homes, cars, and transit systems.
November 15, 2020	Thunderstorm Wind	N/A	N/A	Garnersville, NY	A large tree was downed onto a house on Bloom Street. No injuries or fatalities were reported.
June 8, 2021	Thunderstorm Wind	N/A	N/A	Sparkill, NY; Palisades, NY	A surface trough (region of low-pressure air) in a warm air mass triggered multiple thunderstorms across southeastern New York. One tree and other large branches blocked lanes on NY 303 Northbound, and $2,000 in property damage was reported. No injuries or deaths were reported as a result of this storm event.
July 6, 2021	Thunderstorm Wind	N/A	N/A	Orangeburg, NY	A region of low-pressure air in a hot and humid air mass triggered severe thunderstorms across southeastern New York. A downed tree on Palisades Interstate Parkway blocked the right lane of traffic, and $1,000 in property damage resulted from this storm event. No injuries or deaths were reported in this incident.

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Rockland County included in declaration?	Location Impacted	Description
August 12, 2021	Thunderstorm Wind	N/A	N/A	Doodletown, NY	A region of low-pressure air in a hot and humid air mass triggered severe thunderstorms across southeastern New York. Multiple trees were destroyed as a result of these storms, bringing $3,000 in property damage. No injuries or deaths were reported as a result of this storm event.
July 25, 2023	Thunderstorm Wind	N/A	N/A	Central Nyack, NY	Multiple severe thunderstorms impacted southeastern New York, producing severe wind gusts that resulted in $1,000 in property damage. No injuries or deaths were reported as a result of this storm event.
September 8, 2023	Thunderstorm Wind	N/A	N/A	Monsey, NY	Thunderstorms moved through southeastern New York bringing severe wind and hailstorms to the area. Hailstones up to one inch in diameter were reported. $3,000 in property damage resulted from this storm event, and no injuries or deaths were reported.

Sources: NOAA, 2023
FEMA Federal Emergency Management Agency
NOAA National Oceanic and Atmospheric Administration
NYS New York State

Probability of Future Occurrences

For the 2024 HMP update, best available data was used to collect hazard event details. These details were used to calculate the probability of future occurrence of hazard events in the County. Information from the National Oceanic and Atmospheric Administration (NOAA) Storm Events Database, the U.S. Department of Agriculture (USDA) Disaster Designations database, the 2019 State of New York HMP, the 2018 Rockland County HMP, and FEMA were used to identify the number of events that occurred between 1954 and 2023. Table 4.3.8-5 provides the calculated probability of future severe storm events in Rockland County.

Table 4.3.8-5. Probability of Future Severe Storm Events in Rockland County

Hazard Type	Number of Occurrences Between 1954 and 2023	Percent Chance of Occurring in Any Given Year
Severe Storm	196	100%

Sources: FEMA 2023, USDA 2024, NOAA 2024
Notes: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected severe storm events since 1968. Due to limitations in data, not all severe 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.

In Section 4.4, the identified hazards of concern for Rockland County were ranted. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for severe storm in the County is considered 'frequent.'

Climate Change Projections

Climate change affects the State of New York's residents and resources, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt in the State.

According to the 2023 Climate Projections Report by NYSERDA (ClimAID), temperatures in the State of New York 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 the State of New York 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 2023).

Regional precipitation across the State of New York is projected to increase by approximately one to eight percent by the 2020s, 3 to 12 percent by the 2050s, and 4 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 2023).

The region encompassing Rockland County, which includes the Catskill Mountains and the West Hudson River Valley, is estimated that temperatures will increase by 3.1°F to 6.9ºF by the 2050s and 4.0ºF to 10.7ºF by the 2080s (baseline of 50.0ºF). Precipitation totals will increase between 1 and 14 percent by the 2050s and 2 to 18 percent by the 2080s (baseline of 46.0 inches). Table 4.3.8-6 displays the projected seasonal precipitation change for the Catskill Mountains and West Hudson River Valley ClimAID Region (NYSERDA 2023).

Table 4.3.8-6. Projected Seasonal Precipitation Change in the Catskill Mountains and West Hudson Iver Valley, 2050s (% change)

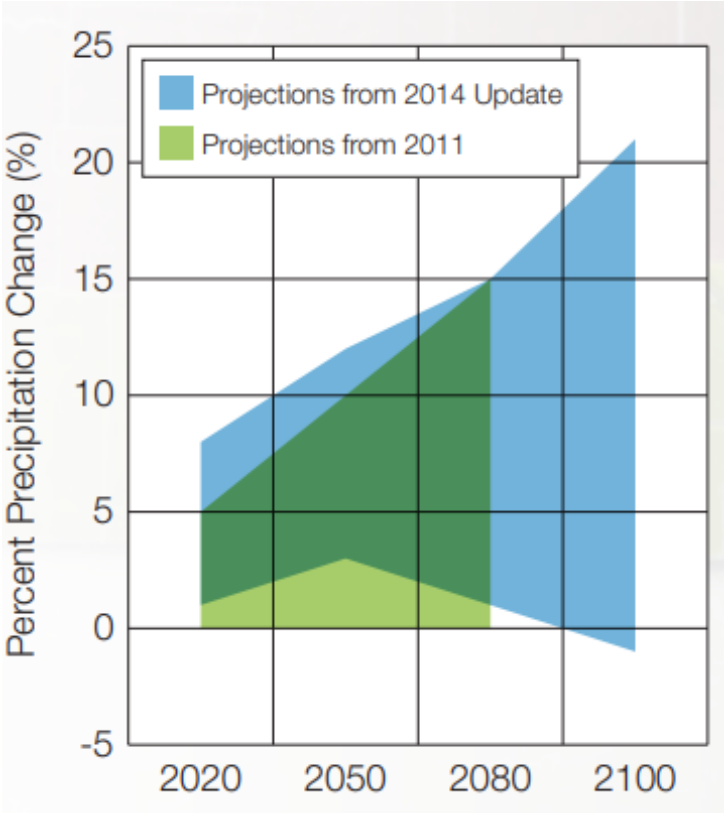
Winter	Spring	Summer	Fall
0 to +15	0 to +10	-5 to +10	-5 to +10

Source: NYSERDA 2011

The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. Downpours are very likely to increase in frequency and intensity, a change which 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 2023). 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 2023).

Figure 4.3.8-8 displays the precipitation projections for the State of New York, comparing the 2011 data to the most recent 2014 data. The percent precipitation change is projected to increase exponentially as updated information and data has been gathered during the 2014 report (NYSERDA 2023). Rainstorms and other precipitation events will increase in severity and frequency.

Figure 4.3.8-8. Comparison of 2011 and 2014 Precipitation Projections



Source: NYSERDA 2014

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the hazard area identified. The entire County has been identified as exposed for severe storms. Therefore, all assets in the County (population, structures, critical facilities, and lifelines), as described in the County Profile (Section 3), are exposed and vulnerable to severe storm events.

Impact on Life, Health, and Safety

The entire population of Rockland County (461,860) is exposed to this hazard; however, however, the impact of these events can have on life, health, and safety are dependent upon several factors, including the severity of the event and whether adequate warning time was provided to residents.

Outdoor workers are vulnerable to severe weather events. Employers should prepare for the hazards associated with adverse weather conditions that may require special facilities and safety equipment being provided to employees, or in some instances, work stoppage to ensure the safety and health of workers. Wet weather and high wind conditions can pose a greater threat to employees working in the construction, and shipbuilding industries. For instance, workers in the construction industry are bound to work in open spaces, at heights, with electrical equipment and metals, in excavation areas and trenches, and may handle hazardous materials as a work task, thereby causing exposure to a myriad of safety hazards (Hazwoper OSHA 2020).

As a result of a significant hurricane event, residents may be displaced or require temporary to long-term sheltering. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Hazus estimates that there will not be any displaced households or persons seeking short-term shelter from the 100-year MRP event. Further, Hazus estimates that there will be 124 households displaced and 98 persons seeking short-term sheltering caused by the 500-year MRP event (Table 4.3.8-7).

Table 4.3.8-7. Estimated Displaced Households and Persons Seeking Shelter Caused by the 100-Year and 500-Year MRP Hurricane Events

Jurisdiction	100-Year MRP Hurricane		500-Year MRP Hurricane	
	Displaced Households	Persons Seeking Short-Term Sheltering	Displaced Households	Persons Seeking Short-Term Sheltering
Airmont, Village of	0	0	1	1
Chestnut Ridge, Village of	0	0	0	0
Clarkstown, Town of	0	0	42	29
Grand View on Hudson, Village of	0	0	0	0
Haverstraw, Town of	0	0	5	4
Haverstraw, Village of	0	0	6	11
Hillburn, Village of	0	0	0	0
Kaser, Village of	0	0	0	0
Montebello, Village of	0	0	0	0
New Hempstead, Village of	0	0	1	1
New Square, Village of	0	0	1	2
Nyack, Village of	0	0	11	5
Orangetown, Town of	0	0	22	12
Piermont, Village of	0	0	3	0
Pomona, Village of	0	0	0	0
Ramapo, Town of	0	0	7	8
Sloatsburg, Village of	0	0	0	0
South Nyack, Village of	0	0	3	2
Spring Valley, Village of	0	0	10	12
Stony Point, Town of	0	0	5	4
Suffern, Village of	0	0	3	2
Upper Nyack, Village of	0	0	**1**	**1**
Wesley Hills, Village of	0	0	0	0
West Haverstraw, Village of	0	0	3	4
Rockland County (Total)	**0**	**0**	**124**	**98**

Source: Hazus v6.0
Note: These values are rounded down.

Socially Vulnerable Population

The vulnerable population also includes those who would not have adequate warning from an emergency warning system (e.g., television or radio); this would include residents and visitors. The population adversely affected by severe summer weathers may also include those beyond the disaster area that rely on affected roads for transportation.

Socially vulnerable populations are most susceptible due to their physical and financial ability to react and respond during extreme severe summer weathers. This population includes the elderly, young, and individuals with disabilities or access or functional needs who may be unable to evacuate in the event of an emergency. 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 that might not be readily available due to isolation during a storm event. Section 3 (County Profile) provides statistics of these populations.

Economically disadvantaged people are at high risk for bracing severe summer weathers because of the potential inability to afford up-to-code homes and buildings that are deemed safe from storms passing through. They also may pose health issues, such as exposure to mold and other health issues that water seepage may cause. These populations may also lack access to vehicles for any necessary evacuations.

According to the 2021 ACS, there are 52,060 persons over the age of 65 years, 27,605 persons under the age of five years, 26,990 non-English speakers, 29,008 persons with a disability, 49,451 living in poverty, and 109,704 living below ALICE in Rockland County.

Impact on General Building Stock

All buildings are exposed to severe weather hazards such as hailstorms and lightning strikes. Refer to Section 3 (County Profile) for summaries of the building inventory in Rockland County.

An extreme hailstorm event can carry hail stones traveling at speeds greater than 100 miles per hour (NWS 2019). This could cause structural damage for the general building stock in the County.

Severe summer weather that causes lightning could be a threat to the County's general building stock if the lightning starts a fire. Over 22,000 fires caused by lightning occurred annually throughout the U.S. between 2007 and 2011, which was valued at approximately $450 million of damages per year (NFPA 2013).

Potential building damage was evaluated by Hazus across the following damage categories: none, slight, moderate, extensive, and complete. Table 4.3.8-8 provides definitions of these five categories of damage for a light wood-framed building. Definitions for other building types are included in the Hazus technical manual documentation. The results of potential damage states for buildings in Rockland County categorized by general occupancy classes (i.e., residential, commercial, industrial, etc.) from Hazus are summarized in Table 4.3.8-9 for the 100-year MRP event. Hazus estimates that there will be $98,810,365 in damages to structures caused by the 100-year MRP event, with the estimated residential damage being the most expensive at $91,389,486, or 98.5 percent of the total damages. Table 4.3.8-10 summarizes the damages to structures for the 500 MRP event, which estimates that there will be $381,159,445 in damages to structures caused by the 500-year MRP event, with the estimated residential damage being the most expensive at $314,987,540, or 82.6 percent of the total damages.

Table 4.3.8-8. Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple-wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: FEMA 2022

Table 4.3.8-9. Estimated Building Losses Caused by the 100-Year MRP Hurricane by Occupancy

Jurisdiction	100-Year MRP Hurricane	100-Year MRP for Residential Structures Only	100-Year MRP Hurricane for Commercial Structures Only	100-Year MRP Hurricane for All Other Occupancies Structures Only
Airmont, Village of	$3,875,540	$3,758,302	$78,668	$38,569
Chestnut Ridge, Village of	$3,438,961	$3,304,582	$52,991	$81,388
Clarkstown, Town of	$31,171,222	$29,746,267	$905,322	$519,633
Grand View on Hudson, Village of	$257,798	$236,319	$13,248	$8,231
Haverstraw, Town of	$4,772,796	$3,453,670	$311,083	$1,008,044
Haverstraw, Village of	$1,157,497	$1,052,778	$54,264	$50,455
Hillburn, Village of	$204,894	$185,896	$5,819	$13,179
Kaser, Village of	$154,562	$140,436	$1,500	$12,626
Montebello, Village of	$1,980,608	$1,864,265	$74,109	$42,234
New Hempstead, Village of	$1,917,328	$1,811,027	$64,025	$42,276
New Square, Village of	$305,532	$254,426	$22,733	$28,373
Nyack, Village of	$1,628,991	$1,431,518	$156,759	$40,713
Orangetown, Town of	$20,397,281	$18,085,335	$1,720,006	$591,940
Piermont, Village of	$1,008,154	$954,269	$29,276	$24,608
Pomona, Village of	$1,396,339	$1,109,834	$142,946	$143,559
Ramapo, Town of	$8,530,928	$8,092,705	$237,904	$200,320
Sloatsburg, Village of	$760,652	$744,849	$10,048	$5,756
South Nyack, Village of	$850,021	$808,187	$8,920	$32,915
Spring Valley, Village of	$2,098,454	$1,901,980	$90,194	$106,280
Stony Point, Town of	$5,941,060	$5,777,318	$77,453	$86,288
Suffern, Village of	$1,689,762	$1,603,500	$39,843	$46,419
Upper Nyack, Village of	$1,210,340	$1,168,919	$19,546	$21,876
Wesley Hills, Village of	$2,414,000	$2,370,359	$11,574	$32,067
West Haverstraw, Village of	$1,647,645	$1,532,744	$61,321	$53,579
Rockland County (Total)	**$98,810,365**	**$91,389,486**	**$4,189,551**	**$3,231,329**

Source: Hazus v6.0
Note: These values are rounded to the nearest dollar/whole value.

Table 4.3.8-10. Estimated Building Losses Caused by the 500-Year MRP Hurricane by Occupancy

Jurisdiction	500-Year Mean Return Period Hurricane	500-Year Mean Return Period Hurricane for Residential Structures Only	500-Year Mean Return Period Hurricane for Commercial Structures Only	500-Year Mean Return Period Hurricane for All Other Occupancies Structures Only
Airmont, Village of	$11,662,752	$10,982,360	$479,887	$200,505
Chestnut Ridge, Village of	$11,267,075	$10,277,654	$457,302	$532,119
Clarkstown, Town of	$117,153,891	$104,468,941	$8,291,996	$4,392,954
Grand View on Hudson, Village of	$1,065,630	$855,468	$143,382	$66,780
Haverstraw, Town of	$20,166,985	$11,464,740	$3,062,332	$5,639,913
Haverstraw, Village of	$5,920,441	$4,827,029	$549,008	$544,405
Hillburn, Village of	$648,850	$542,181	$35,126	$71,543
Kaser, Village of	$662,576	$576,093	$12,719	$73,764
Montebello, Village of	$6,260,226	$5,552,022	$500,120	$208,084
New Hempstead, Village of	$6,393,804	$5,676,916	$487,666	$229,222
New Square, Village of	$1,439,521	$1,149,058	$129,466	$160,997
Nyack, Village of	$8,474,987	$6,607,973	$1,498,271	$368,743
Orangetown, Town of	$87,638,559	$61,055,386	$21,450,813	$5,132,360
Piermont, Village of	$4,135,157	$3,720,494	$243,494	$171,169
Pomona, Village of	$6,277,945	$3,609,961	$1,640,457	$1,027,526
Ramapo, Town of	$29,199,942	$26,350,338	$1,697,257	$1,152,347
Sloatsburg, Village of	$2,329,923	$2,248,809	$54,443	$26,671
South Nyack, Village of	$4,203,332	$3,781,666	$93,746	$327,919
Spring Valley, Village of	$9,494,963	$8,116,060	$665,470	$713,433
Stony Point, Town of	$21,851,314	$20,365,915	$783,940	$701,459
Suffern, Village of	$5,669,638	$5,123,461	$235,648	$310,529
Upper Nyack, Village of	$5,082,546	$4,631,026	$224,906	$226,615
Wesley Hills, Village of	$7,539,367	$7,246,714	$82,108	$210,546
West Haverstraw, Village of	$6,620,023	$5,757,277	$480,129	$382,617
Rockland County (Total)	**$381,159,445**	**$314,987,540**	**$43,299,684**	**$22,872,220**

Source: Hazus v6.0
Note: These values are rounded to the nearest dollar/whole value.

Building damage as a result of the 100-year and 500-year MRP hurricanes were estimated for each municipality using Hazus. Table 4.3.8-11 summarizes estimated total building and content losses caused by the 100-year and 500-year MRP events by building occupancy class. For the 100-year MRP event, up to 68 buildings will be moderately damaged by the 100-year MRP event and up to two will be severely damaged. The majority of the losses are estimated to the residential occupancy class. For the 500-year MRP event, up to 1,500 buildings will be moderately damaged by the 500-year MRP event and up to 61 will be severely damaged. The majority of the losses are estimated to the residential occupancy class.

Table 4.3.8-11. Estimated Building Damages (Structure and Contents) from the 100-year and 500-year MRP Hurricane Events

Occupancy Class	Total Number of Buildings Assessed in Occupancy	Severity of Expected Damage	100-Year MRP Hurricane		500-Year MRP Hurricane	
			Building Count	Percent of Buildings in Occupancy Class	Building Count	Percent of Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	104,229	NONE	101,953	97.8%	88,108	84.5%
		MINOR	2,222	2.1%	14,689	14.1%
		MODERATE	55	0.1%	1,378	1.3%
		SEVERE	0	0.0%	29	0.0%
		DESTRUCTION	0	0.0%	24	0.0%
Commercial Buildings	4,971	NONE	4,902	98.6%	4,436	89.2%
		MINOR	57	1.1%	414	8.3%
		MODERATE	12	0.2%	92	1.9%
		SEVERE	1	0.0%	29	0.6%
		DESTRUCTION	0	0.0%	0	0.0%
Industrial Buildings	1,154	NONE	1,136	98.5%	1,046	90.6%
		MINOR	17	1.5%	88	7.6%
		MODERATE	1	0.1%	17	1.4%
		SEVERE	0	0.0%	3	0.3%
		DESTRUCTION	0	0.0%	0	0.0%
Government, Religion, Agricultural, and Education Buildings	2,131	NONE	2,105	98.8%	1,916	89.9%
		MINOR	26	1.2%	202	9.5%
		MODERATE	0	0.0%	13	0.6%
		SEVERE	0	0.0%	0	0.0%
		DESTRUCTION	0	0.0%	0	0.0%

Source: Hazus v6.0

Impact on Critical Facilities and Community Lifelines

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. Emergency personnel such as police, fire, and emergency medical services (EMS) will not be able to effectively respond in a power loss event to maintain the safety of its citizens unless backup power and fuel sources are available. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored.

All critical facilities in the County are exposed to the severe weather hazard with similar risks as discussed for the general building stock. It is essential that critical facilities remain operational during natural hazard events. Backup

power is recommended for critical facilities and infrastructure. Where backup power is needed for critical facilities that provide essential services, municipalities identified mitigation actions in Section 9 (Jurisdictional Annexes).

The Hazus hurricane model was used to assign the range or average probability of each damage state category to the critical facilities and lifelines in Rockland County for the 100-year and 500-year MRP events. For percent probability of sustaining damage, the minimum and maximum damage estimated value for that facility type is presented.

As a result of a 100-year MRP event, Hazus estimates that police stations have the greatest chance of sustaining minor damage, at a range of 1.3 to 2.5 percent. Schools will have the greatest chance of moderate damages, ranging from 0.1 to 0.2 percent. As a result of a 500-year MRP event, Hazus estimates that police stations have the greatest chance of sustaining minor damage, at a range of 5.1 to 11.7 percent. Schools will have the greatest chance of moderate damages, ranging from 0.4 to 6.8 percent. Severe damages to all critical facilities is negligible, with the greatest chance of damages occurring to police stations, which range from 0.0 to 0.2 percent. Table 4.3.8-12 and Table 4.3.8-13 summarize the damage state probabilities for critical facilities during the 100-year and 500-year MRP events, respectively.

Table 4.3.8-12. Estimated Damage for Critical Facilities in Rockland County for the 100-Year MRP Hurricane Event

Facility Type	100-Year MRP Hurricane				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
Medical Facilities	0	0.4% - 1.4%	0.0% - 0.1%	0.0%	0.0%
Police Stations	0	1.3% - 2.5%	<0.1% - 0.1%	0.0%	0.0%
Fire Stations	0	0.4% - 1.1%	<0.1% - 0.1%	0.0%	0.0%
Schools	0	0.6% - 1.8%	<0.1% - 0.2%	0.0%	0.0%
EOC	0	1.3% - 1.9%	<0.1%	0.0%	0.0%

Source: Hazus v6.0

Table 4.3.8-13. Estimated Damage for Critical Facilities in Rockland County for the 500-Year MRP Hurricane Event

Facility Type	500-Year MRP Hurricane				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
Medical Facilities	0	1.7% - 8.8%	0.1% - 4.3%	0.0% - <0.1%	0.0%
Police Stations	0	5.1% - 11.7%	0.4% - 2.7%	0.0% - 0.2%	0.0%
Fire Stations	0	1.3% - 6.0%	0.1% - 1.8%	0.0% - 0.1%	0.0%
Schools	0 - 1	2.8% - 9.1%	0.4% - 6.8%	0.0% - 0.1%	0.0%
EOC	0	5.2% - 9.8%	0.4% - 1.7%	0.0% - 0.1%	0.0%

Source: Hazus v6.0

Impact on the Economy

Severe weather events can have short- and long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts include the 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. Impacts to transportation

lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population.

Hazus estimates building-related economic losses, including income losses (wage, rental, relocation, and capital-related losses) and capital stock losses (structural, non-structural, content, and inventory losses). Economic losses caused by the 100-year and 500-year hurricane MRP events were estimated by Hazus and are summarized in Table 4.3.8-14. Hazus estimates a difference in losses between the 100-year and 500-year MRP events. Income losses for the 100-year MRP event are $20,050 and $6,358,000 for the 500-year MRP event.

Table 4.3.8-14. Total Business Interruption Loss (in Thousands of Dollars)

MRP	Income Loss	Relocation Loss	Building Losses	Wages Losses	Rental Losses
100-Year	$20,050	$451,170	$98,810,370	$20,350	$1,345,990
500-Year	$6,358,000	$24,764,280	$381,159,440	$10,479,450	$9,287,850

Source: Hazus v6.0

Hazus also estimates the volume of debris that may be generated as a result of a hurricane event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: reinforced concrete and steel that require special equipment to break it up before it can be transported, and brick, wood, and other debris that can be loaded directly onto trucks with bulldozers (FEMA 2022).

For the 100-year MRP event, Hazus estimates that 179,625 tons of debris will be generated. For the 500-year MRP event, Hazus estimates a total of 510,740 tons of debris will be generated county-wide. Table 4.3.8-15 and Table 4.3.8-16 summarize the estimated debris generated because of these events by municipality, respectively.

Table 4.3.8-15. Estimated Debris Created During the 100-Year Mean Return Period Hurricane Wind Event

Jurisdiction	Estimated Debris Created During the 100-Year MRP Hurricane Wind Event			
	Brick and Wood (Tons)	Concrete and Steel (Tons)	Tree (Tons)	Eligible Tree Volume (Cubic Yards)
Airmont, Village of	300	0	543	4,240
Chestnut Ridge, Village of	287	0	846	6,482
Clarkstown, Town of	2,695	0	6,903	50,488
Grand View on Hudson, Village of	25	0	185	630
Haverstraw, Town of	502	0	1,562	4,914
Haverstraw, Village of	161	0	358	2,430
Hillburn, Village of	21	0	216	496
Kaser, Village of	24	0	22	209
Montebello, Village of	162	0	1,699	3,062
New Hempstead, Village of	152	0	462	2,685
New Square, Village of	56	0	54	537
Nyack, Village of	201	0	176	1,639
Orangetown, Town of	1,832	0	4,838	27,073
Piermont, Village of	119	0	150	1,499
Pomona, Village of	159	0	1,333	3,097
Ramapo, Town of	813	0	1,967	10,784

Jurisdiction	Estimated Debris Created During the 100-Year MRP Hurricane Wind Event			
	Brick and Wood (Tons)	Concrete and Steel (Tons)	Tree (Tons)	Eligible Tree Volume (Cubic Yards)
Sloatsburg, Village of	60	0	2	2
South Nyack, Village of	109	0	98	827
Spring Valley, Village of	347	0	355	3,394
Stony Point, Town of	493	0	3,541	9,379
Suffern, Village of	181	0	226	1,562
Upper Nyack, Village of	101	0	234	1,781
Wesley Hills, Village of	177	0	1,128	3,671
West Haverstraw, Village of	178	0	293	2,400
Rockland County (Total)	**9,154**	**0**	**27,191**	**143,280**

Source: Hazus v6.0
Note: These values are rounded to the nearest whole value.

Table 4.3.8-16. Estimated Debris Created During the 500-Year MRP Hurricane Wind Event

Jurisdiction	Estimated Debris Created During the 500-Year MRP Hurricane Wind Event			
	Brick and Wood (Tons)	Concrete and Steel (Tons)	Tree (Tons)	Eligible Tree Volume (Cubic Yards)
Airmont, Village of	1,354	0	1,648	12,954
Chestnut Ridge, Village of	1,345	0	1,784	13,624
Clarkstown, Town of	14,509	0	16,692	121,569
Grand View on Hudson, Village of	132	0	349	1,191
Haverstraw, Town of	2,589	0	4,614	16,722
Haverstraw, Village of	900	0	1,085	8,287
Hillburn, Village of	88	0	791	1,820
Kaser, Village of	114	0	67	646
Montebello, Village of	718	0	5,162	9,555
New Hempstead, Village of	765	0	1,326	7,753
New Square, Village of	255	0	190	1,895
Nyack, Village of	1,152	0	568	5,353
Orangetown, Town of	9,478	0	11,009	63,915
Piermont, Village of	579	0	342	3,427
Pomona, Village of	834	0	3,508	8,409
Ramapo, Town of	3,838	0	5,780	31,496
Sloatsburg, Village of	257	0	813	4,371
South Nyack, Village of	609	0	331	2,797
Spring Valley, Village of	1,644	0	1,250	11,927
Stony Point, Town of	2,664	0	11,021	32,011
Suffern, Village of	777	0	780	5,522
Upper Nyack, Village of	647	0	586	4,451
Wesley Hills, Village of	841	0	3,341	10,704
West Haverstraw, Village of	939	0	1,132	9,144
Rockland County (Total)	**47,028**	**0**	**74,169**	**389,543**

Source: Hazus v6.0
Note: These values are rounded to the nearest whole value.

Impact on the Environment

The impact of severe weather events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long-term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems (US EPA 2023). Researchers also believe that a greater number of diseases will spread across ecosystems because of impacts that severe weather and climate change will have on water supplies (U.S. Climate Resilience Toolkit 2016). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the entire ecosystem within Rockland County. Refer to Section 4.3.2 (Disease Outbreak) for more information about these stressors.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. 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

Potential or Projected Development

The ability of new development to withstand extreme summer weather hazard impacts lies in sound land use practices, building design considerations (e.g., Leadership in Energy and Environmental Design [LEED]), and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry, potentially making them more susceptible to fires caused by lightning. Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Projected Changes in Population

Rockland County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 8.5 percent between 2010 and 2020 (County of Rockland 2021). Cornell University's Program on Applied Demographics projects Rockland County will have a population of 356,758 by 2030 and 372,432 by 2040 (Cornell University 2018).

Changes in the density of population can increase the number of persons exposed to flooding and erosion. As areas continue to be cleared for new development and run-off persists, the population in the County will remain exposed to this hazard. Refer to Section 3 (County Profile), which includes a discussion on population trends for the County.

Other Identified Conditions

As discussed in previous sections, most studies project that the County will see an increase in average annual temperatures and precipitation. As the climate warms and other changes in climate continue to unfold, the intensity of summer weather may change, producing more ideal conditions for severe storms to form. It is anticipated that the County will continue to experience direct and indirect impacts of severe weather events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

Change of Vulnerability Since 2018 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to severe storm events. As existing development and infrastructure continue to age, they can be at increased risk to failed utility and transportation systems if they are not properly maintained and do not adapt to the changing environment. Since the 2018 HMP, an updated version of Hazus-MH was released. This updated model includes longer historical wind events to pull from to generate probabilistic events.