4.3.10 NOR'EASTER

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 Nor'Easter hazard in Mercer County.

2021 HMP UPDATE CHANGES

- Previous occurrences were updated with events that occurred between 2015 and 2021.

A qualitative vulnerability assessment was conducted and updated for the Nor'Easter hazard Profile

Hazard Description

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 (NOAA 2013). 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.

In order to be called a Nor'Easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

- Must persist for at least a 12-hour period
- Have a closed circulation
- Be located within the quadrilateral bounded at 45°N by 65°W 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 miles per hour (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 20 to 40 Nor'Easters occur in the northeastern United States every year, with at least two considered severe (Storm Solution 2014). New Jersey can be impacted by 10 to 20 Nor'Easters each year, with approximately five to 10 of those having significant impact on the State. 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.

For the purpose of this HMP, only Nor'Easter events are being further discussed within this hazard profile, due to their significant historical impact on Mercer County. For information flooding related to Nor'Easters, refer to Section 4.3.5 (Flood) and Section 4.3.8 (Hurricane). For information on snow and ice storms, refer to Section 4.3.12 (Severe Winter Storm).

Location

The entire State of New Jersey, including Mercer County, is susceptible to the effects of Nor'Easters; however, coastal communities and other low-lying areas are particularly vulnerable. Nor'Easters usually form off the east coast near the Carolina, and then follow a track northwards along the coast until they blow out to sea. Mercer County is bordered to the west by the Delaware River which is considered a coastal boundary in New Jersey. Therefore, the County is exposed to the direct and indirect impacts of a Nor'Easter.

Extent

The magnitude or severity of a severe winter storm or 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, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. 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. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 4.3.10-1 presents the five RSI ranking categories.

Table 4.3.10-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA-NCDC 2011
Note: RSI = Regional Snowfall Index

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with Nor'Easters throughout the State of New Jersey and Mercer County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, Mercer County has been included in three Nor'Easter-related FEMA disaster declarations. Table 4.3.10-2 lists FEMA DR and EM declarations for Mercer County.

Table 4.3.10-2. FEMA Declarations for Nor'Easter Events in Mercer County

FEMA Declaration Number	Date(s) of Event	Date Declared	Event Type
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storms and Inland and Coastal Flooding

FEMA Declaration Number	Date(s) of Event	Date Declared	Event Type
DR-1897	March 12-April 15, 2010	May 7, 2010	Severe Storms and Flooding
DR-4264	January 22-24, 2016	March 14, 2016	Severe Winter Storm and Snowstorm

Source: FEMA 2021; NJ OEM 2019

USDA Disaster Declarations

The USDA Secretary of Agriculture 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. Mercer County was not included in declarations related to infestation or invasive species from 2015 to 2021 (USDA 2021).

Nor'Easter Events

Nor'Easter events that have impacted Mercer County between 2015 and 2021 are identified in Table 4.3.10-3. Refer to Appendix E (Risk Assessment Supplement) for events identified prior to 2015. For detailed information on damages and impacts to each municipality, refer to Section 9 (jurisdictional annexes).

Table 4.3.10-3. Nor'Easter Events in Mercer County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
January 22-24, 2016	Winter Storm	DR-4264	No	Mercer County	An impulse from the west coast traversed the midsection of the country, then developed into a low pressure system as it tracked across the Gulf states before intensifying along the Carolina coast into a major nor'easter, producing record snowfall in parts of New Jersey on January 23rd. It then moved out to sea after passing by the mid-Atlantic coast early on January 24th. Snow began during the evening hours on the 22nd, then continued, heavy at times through the 23rd before ending early on the 24th. Snowfall totals included 24.0 inches in Hamilton Township, 23.0 inches in Hopewell, 22.5 inches in Princeton, 22.0 inches in Trenton, and 18.5 inches in Ewing.
March 14, 2017	Blizzard	N/A	N/A	Mercer County	Low pressure systems across the Ohio Valley and Carolinas phased. This led to a rapidly developing storm which tracked just offshore. Wind and a foot of snow were reported across Mercer County.
January 4, 2018	Winter Storm	N/A	N/A	Mercer County	An area of low pressure tracked up the east coast interacting with a cold front which lead to rapid development of a winter storm across the state. This storm quickly moved out by the 5th. However, snowfall accumulations and gusty winds occurred with the storm. Blizzard conditions occurred along many coastal locations. Top wind gusts were generally around 40 mph across the state but were highest in Ocean County, closer to 60 mph. Snow amounts were highest in southern and coastal New Jersey with over 6 inches, totals were only a few inches further northwest. A state of Emergency was declared during the height of the storm. Several hundred vehicles were stranded and hundreds of thousands were without power at some point. Severe cold continued for the next week leading to many locations going to code blue operations. Snowfall was around 6 inches in the county.
March 7, 2018	Winter Storm	DR-4368	No	Mercer County	Narrative A broad area of low pressure extending from the Ohio Valley to the Piedmont of South Carolina consolidated off the Virginia Capes during the early morning of March 7th. This new primary low moved northeast and gradually deepened as it passed east of the Delaware and New Jersey coasts on March 7th. The snow contained large amounts of liquid, making it heavy and wet. This resulted in downed trees, limbs, and wires, leading to numerous power outages across portions of New Jersey, especially where the heaviest snow was reported. Many customers were still without power from the previous

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					storm when this storm struck. Governor Murphy estimated about 350,000 customers state-wide lost power as a result of this second storm. Banding and thundersnow produced pockets of heavier snow around the county. Some reported snowfall totals include: 11.5 inches in Hamilton Township, 11.0 inches in Princeton Junction, 10.5 inches in Hopewell, 10.0 inches in East Windsor Township, 9.0 inches in Yardville, 7.5 inches in Lawrenceville, 7.0 inches in Robbinsville, and 6.1 inches in Ewing.
March 21-22, 2018	Winter Storm	N/A	N/A	Mercer County	A complex area of low pressure over the middle Atlantic, which involved several individual centers, slowly consolidated off the Virginia Capes Tuesday morning, March 20th into Wednesday March 21st along a frontal boundary. This primary low, the fourth nor'easter of March, gradually moved northeast Wednesday night, to a position southeast of the 40 North/70 West Benchmark coordinates on Thursday morning. Precipitation began as a wet, heavy snow during the evening hours on March 20th. After a lull during the overnight hours, a drier snow began falling. The main winter storm snowfall began in the early morning hours of the 21st and continued into the early morning hours on the 22nd. Some reported snowfall amounts include: 10.2 inches in Hamilton Township, 9.1 inches near Hightstown, 9.0 inches near Washington Crossing, 8.8 inches near Hopewell Township, 7.8 inches in Ewing Township, and 7.3 inches just north of Trenton.
March 3-4, 2019	Winter Storm	N/A	N/A	Mercer County	An offshore low pressure system brought a period of heavy precipitation to the mid-Atlantic. A mix of rain, sleet, and snow was observed, with snow confined mainly to interior areas and sleet and rain more abundant near the coast. Snowfall totals inland approached 10, with snowfall rates exceeding one inch per hour for several hours. A sharp gradient in snowfall with a steep drop in snow totals was observed just west of the Interstate 95 corridor. A trained spotter in Highland Lakes reported 8.2 inches of snow.

Source: NOAA NCEI 2021, NJOEM 2019, FEMA 2021

Probability of Future Occurrences

Mercer County will continue to experience the direct and indirect impacts of Nor'Easters. Secondary hazards may include flooding, extreme wind, erosion, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

As with any weather phenomenon, it is nearly impossible to assign probabilities to Nor'Easters, except over the long-term. High activity seasons are when storm activity exceeds the historical 75th percentile. This means that seasons with this number of storms are expected to occur during one out of four years. Lower activity seasons are defined as when storm activity falls below the historical 75th percentile; meaning this number of storms are expected to occur during three out of four years (East Coast Winter Storms 2013).

In Section 4.4, the identified hazards of concern for Mercer County were ranked. 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 Committee, the probability of occurrence for Nor'Easters in the County is considered 'frequent'

Climate Change Impacts

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015).

Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9% increase. By 2050, annual precipitation in New Jersey could increase by 4% to 11% (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

Climate change may result in changes to the frequency of coastal storms. A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71% (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

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

Vulnerability Assessment

For the Nor'Easter hazard, all of Mercer County has been identified as potentially exposed or vulnerable. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in Section 3, are vulnerable to a Nor'Easter.

Impact on Life, Health and Safety

The impact of a Nor'Easter 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. Typically, a Nor'Easter has a longer duration (potentially lasting days) than a hurricane or tropical storm event, which normally pass through an area in a matter of hours; although the impacts from all stated storm events are long-lasting. It is assumed that the entire County's population (i.e., 367,922 total persons, ACS 2019) could be exposed to this hazard (wind and rain/snow) and secondary impacts discussed earlier associated with a Nor'Easter. Further, residents may be displaced or require temporary to long-term sheltering. Refer to Section 4.3.8 (Hurricanes and Tropical Storms) which display the peak gust wind speeds of the 100- and 500-year mean return period probabilistic wind events modeled in Hazus v4.2.

Impact on General Building Stock

The entire County's building stock is exposed to the wind and/or rain/snow from the Nor'Easter hazard. Mercer County is estimated to have 103,579 buildings, with a replacement cost value (structure and content) of approximately $155.9 billion. Refer to Section 4.3.5 (Flood), Section 4.3.8 (Hurricane and Tropical Storm), Section 4.3.11 (Severe Weather), and Section 4.3.12 (Severe Winter Weather) for more information about the wind, rain, and snow hazard impacts to the building stock in Mercer County.

Impact on Critical Facilities

All of Mercer County's critical facilities are exposed to the wind and/or rain/snow from the Nor'Easter hazard.

Impact on the Economy

Nor'Easter events can greatly impact the economy including loss of business function, damage to inventory (utility outages), relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Damages to buildings can impact a community's economy and tax base. In addition, damages to buildings and critical infrastructure, as well as road closures, can delay emergency response services during these events.

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. Several factors are examined in this section to assess hazard vulnerability.

Projected Development and Changes in Population

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by a Nor'Easter event if structures do not consider current mitigation measures against flooding, rain, wind, and snow. Therefore, it is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events like hurricanes. While predicting changes to the prevalence or intensity of Nor'Easter events and their affects under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA] 2020).

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed; the entire County continues to be exposed and vulnerable to the Nor'Easter hazard. Spatial analyses were conducted on the hazard related to a Nor'Easter (wind, flood) using updated inventories (building stock and critical facilities/lifelines). Further, updated demographic data was used for the plan update. This HMP provides an updated assessment on the County's vulnerability to Nor'Easter events and associated hazards.