# Section 5. Risk Assessment

## 5.10 Severe Weather

The 2014 Plan update includes new and relevant data related to severe weather in New Jersey. The high winds, tornado, thunderstorms, hailstorms, and extreme temperatures profiles were enhanced to incorporate new information about these hazards including pertinent past occurrences and descriptions of major incidents. Past occurrences were updated using both reports of recent incidents and new data available through various agencies, including the Federal Emergency Management Agency (FEMA), the National Weather Service (NWS), and the Office of the New Jersey State Climatologist (ONJSC). Also, the potential impact of future climate change is discussed as it relates to the hazard and New Jersey communities. Finally, the exposure and vulnerability to severe weather has been updated and enhanced to reflect best available data.

### 5.10.1 Profile

#### Hazard Description

Severe weather events in New Jersey are very common and can occur at any time. For this 2014 Plan update, the severe weather profile will include high winds, tornadoes, thunderstorms, hailstorms, and extreme temperatures. In 2012, the United States Natural Hazards Statistics provided statistical information on fatalities, injuries, and damages caused by weather-related hazards. These statistics were compiled by the Office of Services and the National Climatic Data Center (NCDC) from information contained in in the publication *Storm Data*. According to this 2012 data, New Jersey had 24 fatalities, 21 injuries, and over $24 million in property and crop damages. This data includes statistics on cold, flood, heat, lightning, tornado, tropical cyclone, wind, and winter storm events. In relation to severe weather, New Jersey experienced one heat-related fatality, three lightning-related fatalities, and 11 wind-related fatalities in 2012 (National Oceanic and Atmospheric Administration [NOAA] 2013). Details regarding high winds, tornadoes, thunderstorms, hailstorms, and extreme temperatures (heat and cold) are discussed below.

##### High Winds

High winds, other than tornadoes, are experienced in all parts of the United States. Areas that experience the highest wind speeds are coastal regions from Texas to Maine, and the Alaskan coast; however, exposed mountain areas experience winds at least as high as those along the coast (FEMA 1997; Robinson 2013). In New Jersey, the northwest ridge tops most often experience the highest winds in the State, followed by the coastal locations (Robinson 2013). 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. Effects from high winds can include downed trees and power lines, and damages to roofs, windows, etc. (Ilicak 2005). The following table provides the descriptions of winds used by the NWS.

**Table 5.10-1. NWS Wind Descriptions**

| Descriptive Term | Sustained Wind Speed (mph) |
|---|---|
| Strong, dangerous, or damaging | ≥40 |
| Very Windy | 30-40 |
| Windy | 20-30 |
| Breezy, brisk, or blustery | 15-25 |
| None | 5-15 or 10-20 |
| Light or light and variable wind | 0-5 |

*Source: NWS 2010*
*mph miles per hour*

Extreme windstorm events are associated with extra-tropical and tropical cyclones, winter cyclones, severe thunderstorms, and accompanying mesoscale offspring such as tornadoes and downbursts. Winds vary from zero at ground level to 200 miles per hour (mph) in the upper atmospheric jet stream at six to eight miles above the earth's surface (FEMA 1997).

A type of windstorm that is experienced often during rapidly moving thunderstorms is a derecho. A derecho is a long-lived windstorm that is associated with a rapidly moving squall line of thunderstorms. It produces straight-line winds gusts of at least 58 mph and often has isolated gusts exceeding 75 mph. This means that trees generally fall and debris is blown in one direction. To be considered a derecho, these conditions must continue along a path of at least 240 miles. Derechos are more common in the Great Lakes and Midwest regions of the United States, though, on occasion, can persist into the mid-Atlantic and northeast United States (ONJSC Rutgers University 2013a).

## Tornadoes

Tornadoes are nature's most violent storms and can cause fatalities and devastate neighborhoods in seconds. A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 mph. Damage paths can be greater than one mile in width and 50 miles in length. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate internal winds exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997).

Tornadoes do occur in New Jersey, although generally they are relatively weak and short lived. Climatologically, past occurrences indicate that the State experiences about two tornadoes per year. Tornado season in New Jersey is generally March through September/October, though tornadoes can occur at any time of the year. Over 80% of all tornadoes strike between noon and midnight.

## Thunderstorms

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS 2009d). 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 have the potential to become dangerous due to their ability in generating tornadoes, hailstorms, strong winds, flash flooding, and lightning. The 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 2010).

The rising air in a thunderstorm cloud causes various types of frozen precipitation to form within the cloud, which includes very small ice crystals and larger pellets of snow and ice. The smaller ice crystals are carried upward toward the top of the clouds by the rising air while the heavier and denser pellets are either suspended by the rising air or start falling towards the ground. Collisions occur between the ice crystals and the pellets, and these collisions serve as the charging mechanism of the thunderstorm. The small ice crystals become positively charged while the pellets become negatively charged, resulting in the top of the cloud becoming positively charged and the middle to lower part of the storm becoming negatively charged. At the same time, the ground below the cloud becomes charged oppositely. When the charge difference between the ground and the cloud becomes too large, a small amount of charge starts moving toward the ground. When it nears the ground, an upward leader of opposite charge connects with the step leader. At the instant this connection is made, a powerful discharge occurs between the cloud and ground. The discharge is seen as a bright, visible flash of lightning (NOAA 2012). Thunder is the sound caused by rapidly expanding gases in a lightning discharge (NWS 2009c).

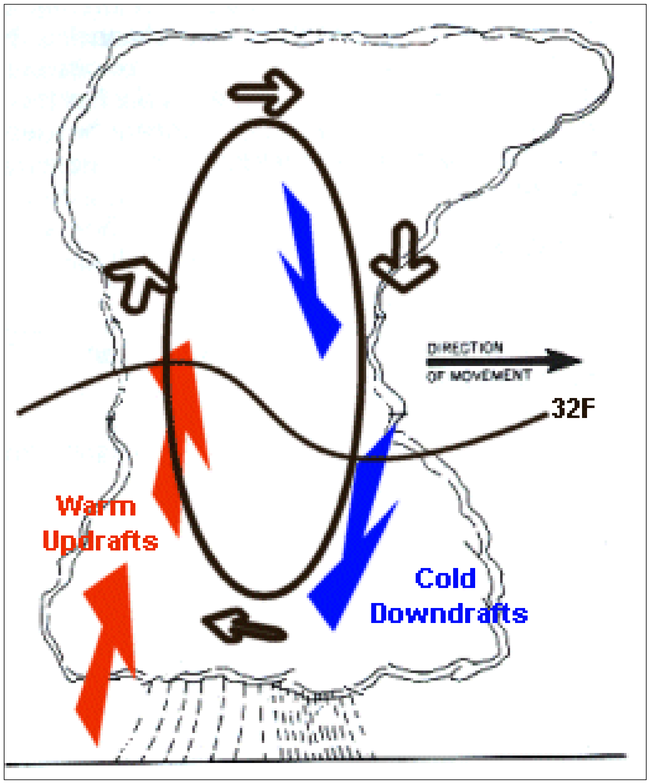
In the United States, an average of 300 people are injured and 80 people are killed by lightning each year. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. An estimated 100,000 thunderstorms occur each year in the United States, with approximately 10% of them classified as severe. During the warm season, thunderstorms are responsible for most of the rainfall.

## 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 may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and 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. Most hail is small and typically less than two inches in diameter (NWS 2010). Figure 5.10-1 illustrates the process that occurs in hail formulation.

The size of hailstones is a direct function of the size and severity of the storm. The size varies and is related to the severity and size of the thunderstorm that produced it. The higher the temperatures at the earth's surface, the greater the strength of the updrafts, and the greater the amount of time the hailstones are suspended, giving them more time to increase in size. Damage to crops and vehicles are typically the most significant impacts of hailstorms.

**Figure 5.10-1. Hail Formation**




*Source: NOAA 2012*
*°F degrees Fahrenheit*

## Extreme Temperatures

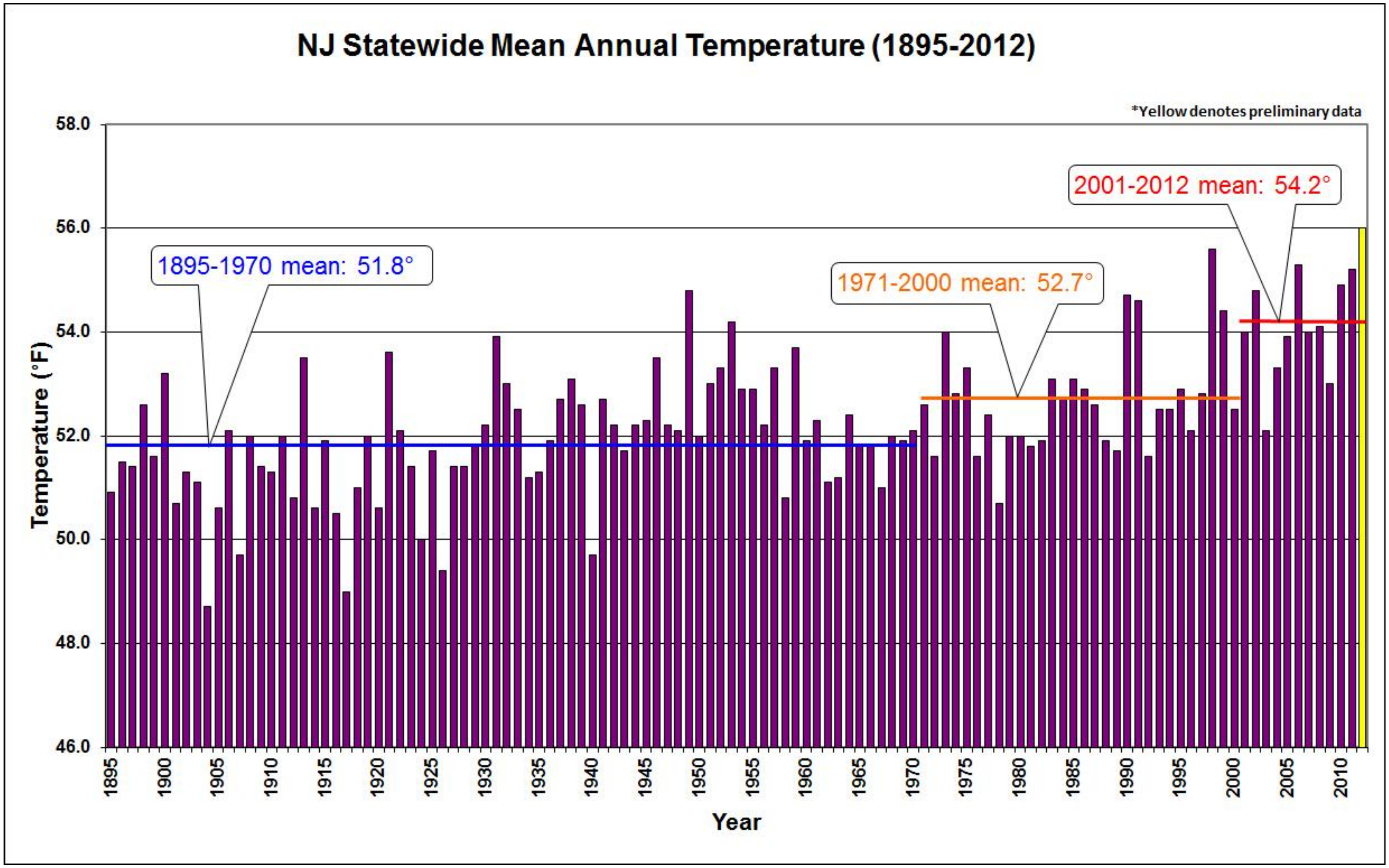
Extreme temperature includes both heat and cold events, which can have significant impact to human health, commercial/agricultural businesses, and primary and secondary effects on infrastructure (e.g., burst pipes and power failures). What constitutes as extreme cold or extreme heat can vary across different areas of the United States, based on what the population is accustomed to.

New Jersey has four well-defined seasons. The seasons have several defining factors, with temperature one of the most significant. Extreme temperatures can be defined as those that are far outside the normal ranges for the season. Figure 5.10-2 illustrates long-term average temperatures in the State and departures from the mean. The values were calculated from a spatially weighted average of numerous weather stations throughout the State and measured in degrees Fahrenheit (°F). Between 1895 and 1970, the Statewide mean temperature was 51.8°F. The mean increased to 52.7°F between 1971 and 2000. It increased again to 54.2°F between 2001 and 2012.

Figure 5.10-3 illustrates the distribution of the top five warm/cold and wet/dry months since 1895. As noted in the figure, the extreme warmest months tend to occur after 1990 and the extreme coldest months tend to be before 1930. For 2012, the figure indicates that five months (February, March, May, July, and December) were one of the top five warmest for those months.

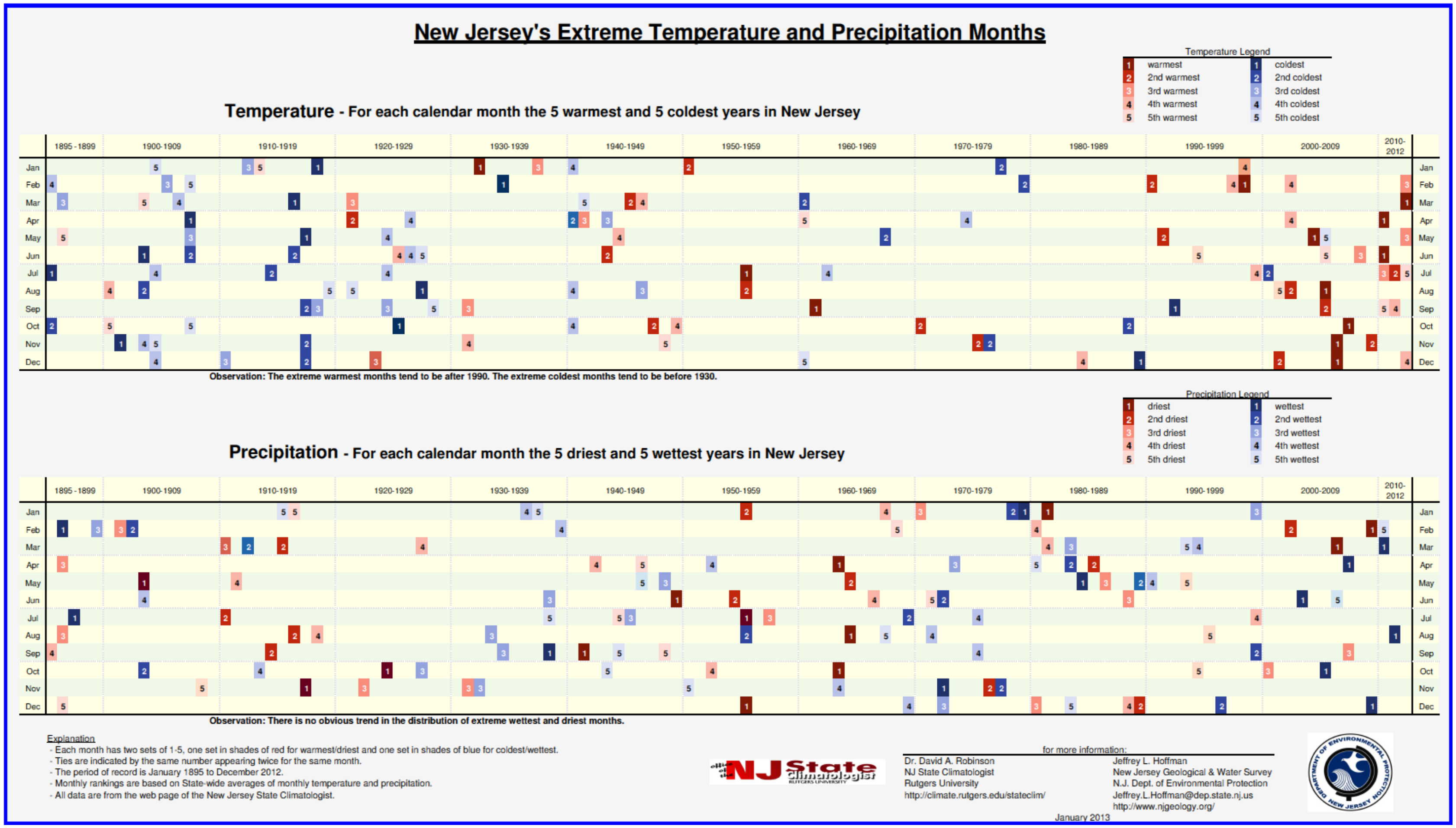
The average temperatures for New Jersey are listed in Table 5.10-2 below.

**Figure 5.10-2. Historical Annual Temperatures**




*Source* *ONJSC Rutgers University 2013b*
*°F* *degrees Fahrenheit*

**Figure 5.10-3. Historical Extreme Temperatures**




*Source: ONJSC Rutgers University 2013c; New Jersey Geological and Water Survey (NJGWS), 2013*

### Table 5.10-2. Average Temperatures in New Jersey

| Month | Old Normal* | New Normal** | Mean |
|---|---|---|---|
| January | 30.6 | 31.2 | 30.6 |
| February | 32.9 | 33.8 | 31.5 |
| March | 41.0 | 41.1 | 40.1 |
| April | 50.5 | 51.2 | 50.1 |
| May | 60.5 | 60.8 | 60.4 |
| June | 69.4 | 70.1 | 69.3 |
| July | 74.5 | 75.0 | 74.2 |
| August | 72.8 | 73.4 | 72.5 |
| September | 65.5 | 66.2 | 65.3 |
| October | 54.2 | 54.8 | 54.7 |
| November | 44.9 | 45.6 | 44.4 |
| December | 35.4 | 35.6 | 34.4 |

*Source: ONJSC Rutgers University 2013d*
*Note: All temperatures are in degrees Fahrenheit*
**Old normal is based on values from 1971-2000*
***New normal is based on values from 1981-2010 and are preliminary*

In New Jersey, temperatures fall below freezing on as many as 150 days each year in the coldest portions of the northwest portion of the State, while less than 75 days below freezing occur along the southern coast. The average lies between 90 and 100 days over two-thirds of the State. Minimal temperatures during the three core winter months of December, January, and February average below freezing (≤32°F) over the entire State, with the exception of some southern coastal locations in December. Generally, the minimal temperature averages 20°F during these months, with the exception of northwest, where January and February averages can drop into the teens. March temperatures run in the upper 20°F to low 30°F in the northern half of the State and the low to mid 30°F in the southern portion. The Pinelands are somewhat colder than the adjacent coast and southwest farmland, and an urban heat island bias was identified near Newark (ONJSC Rutgers University 2013d).

Lows equal to or below 20°F occur on more than 60 days annually in the northwest, while only one-third of that number are found in southern coastal locations. A majority of the State experiences these temperatures on 20 to 30 days of the year. Below 0°F lows, on average, occur only a day or two a year over most of the State. Exceptions are the northwest where as many as six days or slightly more, on average, exhibit these temperatures (ONJSC Rutgers University 2013d).

The following are some of the lowest temperatures recorded for the period from 1893 to 2012:

- Atlantic City International Airport: -11 °F (February 1979)
- Atlantic City Station: -4°F (January 1893)
- Newark: -8°F (January 1985)

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0°F or below (Centers of Disease Control and Prevention [CDC] 2005).

Exposure to cold temperatures, whether indoors or outside, can lead to serious or life-threatening health problems such as hypothermia, cold stress, frostbite or freezing of the exposed extremities such as fingers, toes, nose, and ear lobes. Hypothermia occurs when the core body temperature is <95ºF. If persons exposed to excessive cold are unable to generate enough heat (e.g., through shivering) to maintain a normal core body temperature of 98.6ºF, their organs (e.g., brain, heart, or kidneys) can malfunction. When brain function deteriorates, persons with hypothermia are less likely to perceive the need to seek shelter. Signs and symptoms of hypothermia (e.g., lethargy, weakness, loss of coordination, confusion, or uncontrollable shivering) can increase in severity as the body's core temperature drops (CDC 2005).

Extremely cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2007).

Excessive summer temperatures in New Jersey are often identified through counts of days with maximum temperatures greater than or equal to 90°F and greater than or equal to 100°F. Interior lowlands of the State have the largest number of such days, experiencing, on average, 20 to 30 days of greater than or equal to 90°F. Fewer than 10 days of temperatures greater than or equal to 90°F occur each summer along the coast and at higher elevations. Days when temperatures are equal to or greater than 100°F are rare throughout New Jersey and average one day or less each year (ONJSC Rutgers University 2013d).

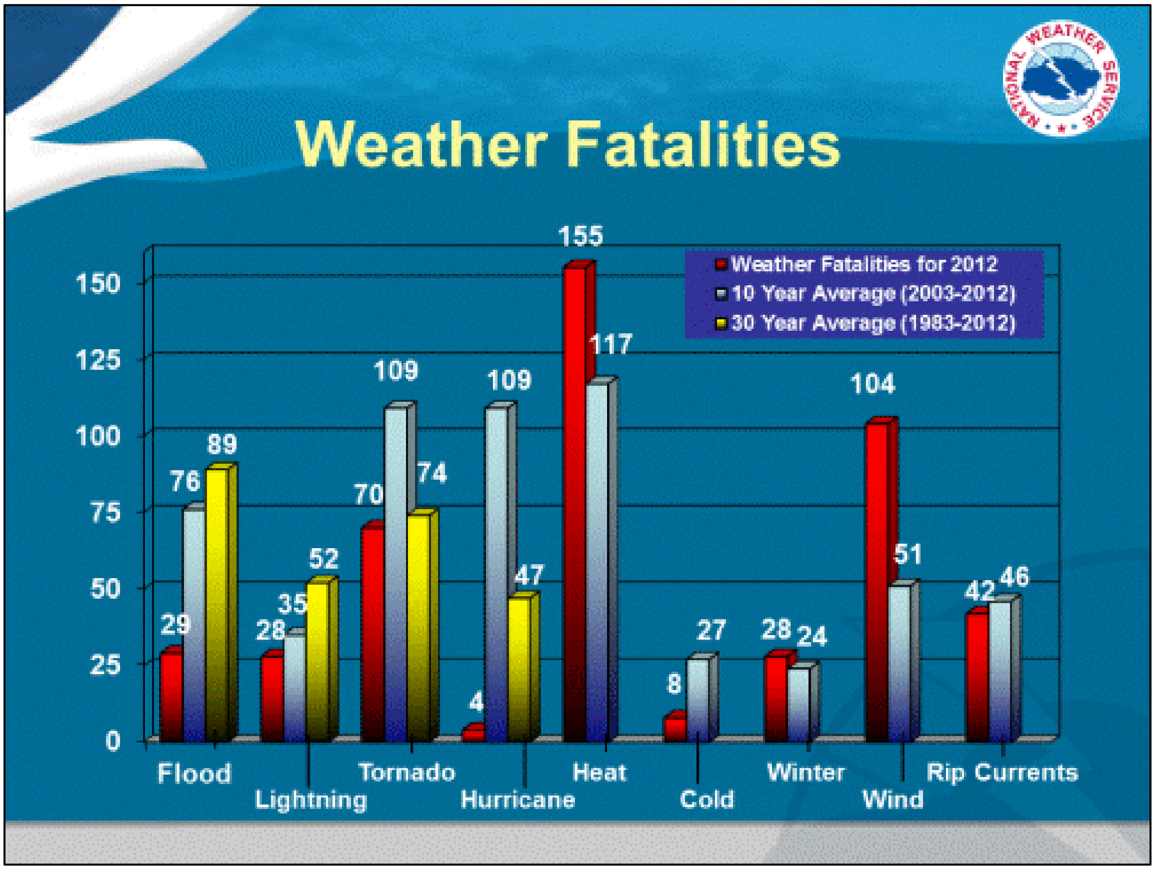
The following are some of the highest temperatures recorded for the period from 1893 to 2012:

- Atlantic City International Airport: 106°F (June 1967)
- Atlantic City Station: 104°F (August 1918)
- Newark: 108°F (August 2001)

Conditions of extreme heat are defined as summertime temperatures that are substantially hotter and/or more humid than average for a location at that time of year (CDC 2009). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (NWS 2005). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi 2004). A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population (Robinson, 2000). A heat wave is defined has three consecutive days of temperatures ≥90°F.

NOAA indicates that extreme heat is the number one weather-related cause of death in the United States. On average, excessive heat claims more lives each year than floods, lightning, tornadoes, and hurricanes combined. In 2012, New Jersey reported one heat-related fatality (NOAA 2012). As seen in Figure 5.10-4, heat had the highest average of weather related fatalities nationally in 2012 (155 fatalities), with one of those fatalities occurring in New Jersey.

**Figure 5.10-4. Weather Fatalities for 2012 in the U.S.**




*Source: NWS 2013*

Urbanized areas and urbanization creates an exacerbated type of risk during an extreme heat event, compared to rural and suburban areas. As defined by the United States Census Bureau, urban areas are classified as all territory, population, and housing units located within urbanized areas and urban clusters. The term urbanized area denotes an urban area of 50,000 or more people. Urban areas under 50,000 people are called urban clusters. The United States Census delineates urbanized area and urban cluster boundaries to encompass densely settled territory, which generally consists of:

- A cluster of one or more block groups or census blocks each of which has a population density of at least 1,000 people per square mile at the time.
- Surrounding block groups and census blocks each of which has a population density of at least 500 people per square mile at the time.
- Less densely settled blocks that form enclaves or indentations, or are used to connect discontiguous areas with qualifying densities (United States Census 2003).

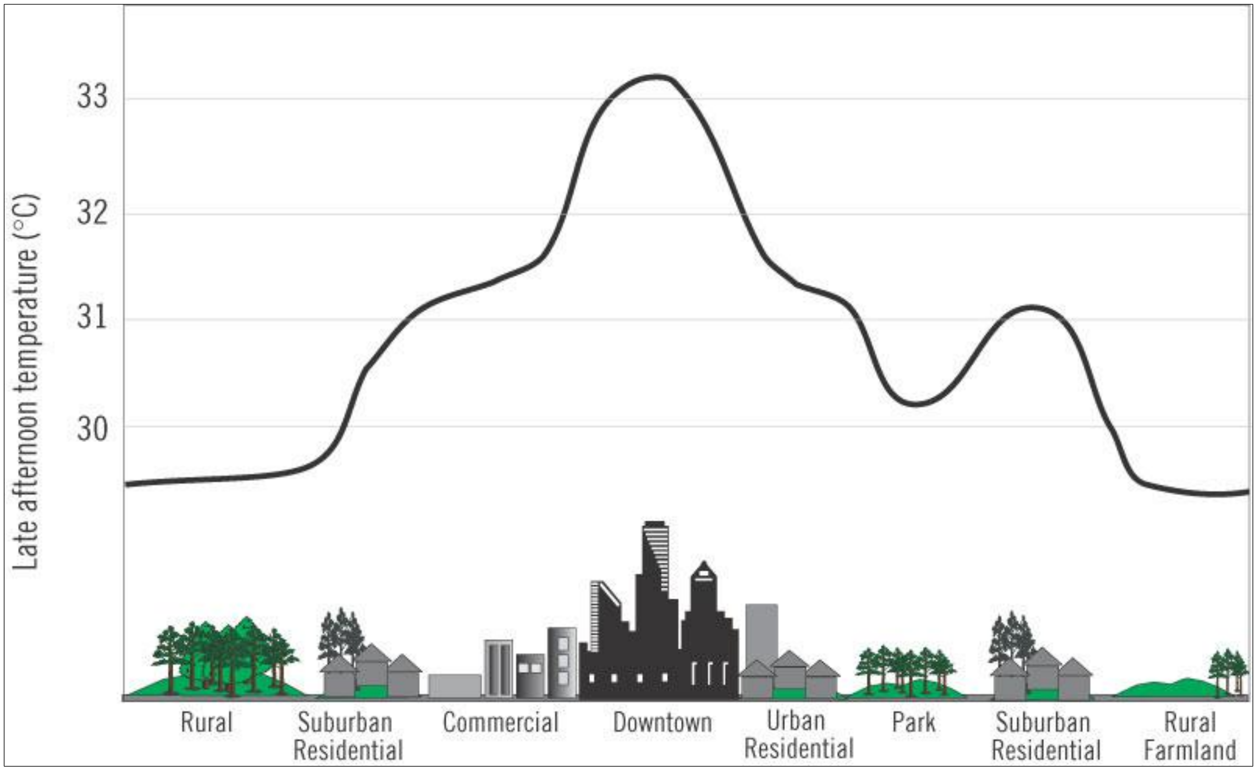
As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas. This forms an 'island' of higher temperatures (United States Environmental Protection Agency [EPA] 2009).

The term 'heat island' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with more than one million people can be between 1.8ºF and 5.4ºF warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22ºF. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50ºF to 90ºF hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA 2010 and 2011). Detailed information regarding the effects of heat islands is described below.

- Elevated summer temperatures increase the energy demand for cooling. Research has shown that for every 1ºF, electricity demand increases between 1.5% and 2%, starting when temperatures reach between 68ºF and 77ºF. Urban heat islands increase overall electricity demand, as well as peak demand. This generally occurs during hot, summer afternoons when homes and offices are running cooling systems, electricity, and appliances. During extreme heat events, the demand for cooling can overload systems and require utility companies to institute controlled brownouts or blackouts to prevent power outages (EPA 2011).
- Urban heat islands raise the demand for electricity during the summer. Companies that provide the electricity generally rely on fossil fuel power plants to meet the demand. This can lead to an increase in air pollution and greenhouse gas emissions. The primary pollutants include sulfur dioxide ($SO_2$), nitrogen oxides (NOx), particulate matter (PM), carbon monoxide (CO), and carbon dioxide ($CO_2$). These could all contribute to future global climate change. Elevated temperatures can also directly increase the rate of ground-level ozone formation. Ground-level ozone is formed when NOx and volatile organic compounds (VOC) react to the presence of sunlight and hot weather (EPA 2011).
- Increased temperatures and higher air pollution levels can affect human health by causing discomfort, respiratory difficulties, heat cramps and exhaustion, heat stroke, and mortality. Heat islands can also intensify the impact of heat waves. High risk populations are at particular risk from extreme heat events (EPA 2011).
- Urban areas often have many buildings and paved areas. During the hot summer months, high pavement and rooftop surface temperatures can heat stormwater runoff. Pavements that are 100ºF can elevate initial rainwater temperature from approximately 70ºF to over 95ºF. The heated stormwater usually becomes runoff and drains into storm sewers and raises water temperatures of streams, rivers, ponds, and lakes. Water temperature affects aquatic life. Rapid temperature changes in aquatic ecosystems from stormwater runoff can be stressful and sometimes fatal to aquatic habitats (EPA 2011).

Figure 5.10-5 below illustrates an urban heat island profile. The graphic demonstrates that heat islands are typically most intense over dense urban areas. Further, vegetation and parks within a downtown area may help reduce heat islands (EPA 2008).

**Figure 5.10-5. Urban Heat Island Profile**



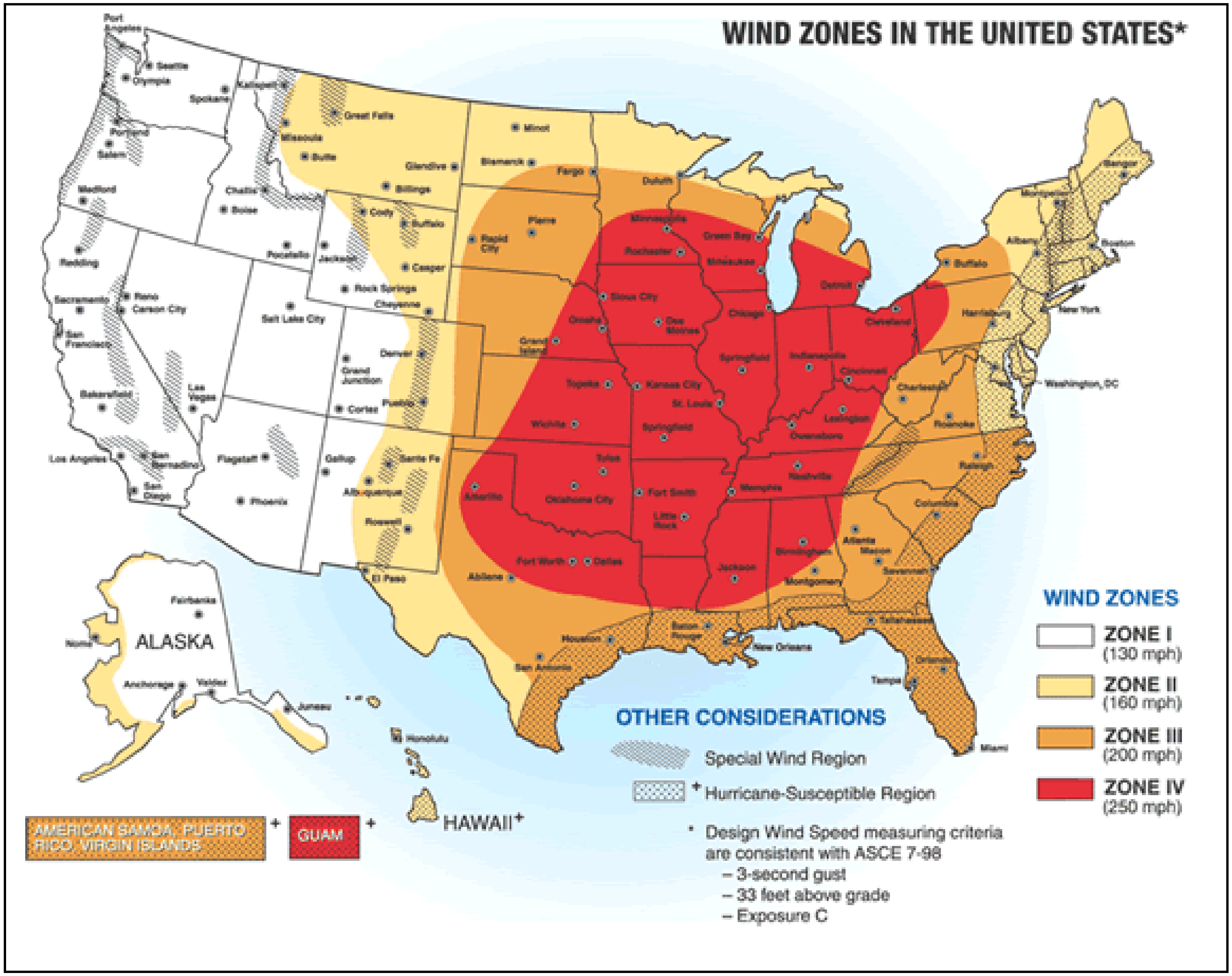

*Source: EPA 2008*
*ºC degrees Celsius*

## Location

### High Winds

Figure 5.10-6 indicates how the frequency and strength of windstorms impacts the United States and the general location of the most wind activity. This is based on 40 years of tornado data and 100 years of hurricane data, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes. New Jersey is located within Wind Zone II, which may experience wind speeds up to 160 mph. The entire State is also located within the hurricane-susceptible region. Table 5.10-3 describes the areas affected by the different United States wind zones.

**Figure 5.10-6. Wind Zones in the United States**




*Source: FEMA, 2012*
*mph miles per hour*

**Table 5.10-3. Wind Zones in the United States**

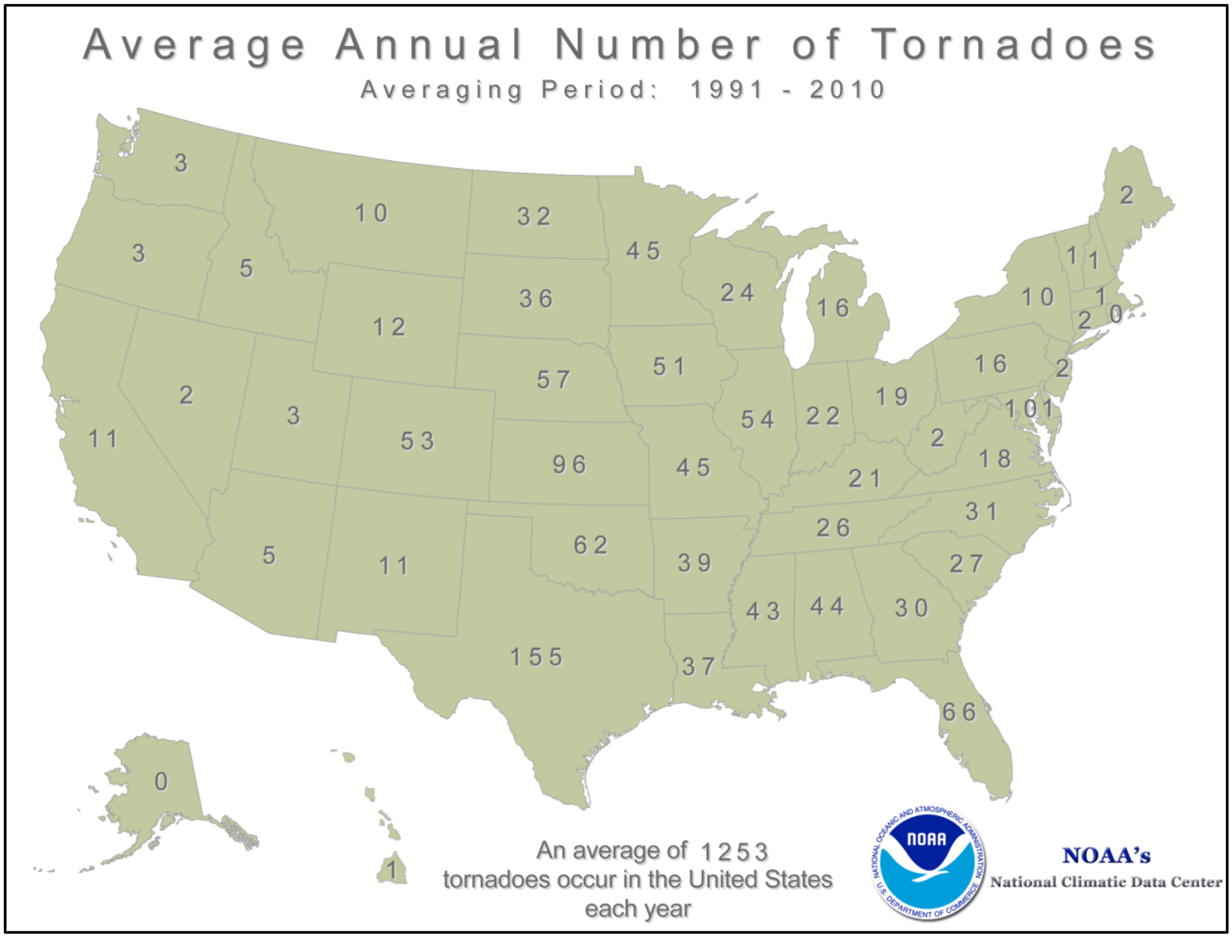
| Wind Zone | Areas Affected |
|---|---|
| Zone I (≤130 mph) | All of Washington, Oregon, California, Idaho, Utah, and Arizona. Western parts of Montana, Wyoming, Colorado, and New Mexico. Most of Alaska, except the east and south coastlines. |
| Zone II (131 - 160 mph) | Eastern parts of Montana, Wyoming, 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. All of New Jersey, Delaware, and Washington, DC. |
| Zone III (161 - 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, and West Virginia. All of American Samoa, Puerto Rico, and Virgin Islands. |
| Zone IV (201 - 250 mph) | Mid United States 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; between Tennessee and North Carolina. |
| Hurricane Susceptible Region | Southern United States 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, New Jersey, Delaware, and Washington DC. All of Hawaii, Guam, American Samoa, Puerto Rico and Virgin Islands. |

*mph miles per hour*

## Tornadoes

The United States experiences more tornadoes than any other country. In a typical year, approximately 1,000 tornadoes affect the United States. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central United States. The potential for a tornado strike is about equal across locations in New Jersey, except in the northern section of the State which typically has steeper terrain and therefore is less likely to experience tornadoes. Figure 5.10-7 shows the annual average number of tornadoes between 1991 and 2010. New Jersey experienced an average of two tornadoes annually between 1991 and 2010. However, based on the number of tornadoes that have occurred in New Jersey between 1951 and 2012 (144 events); New Jersey can expect to experience an average of two to three tornadoes each year.

**Figure 5.10-7. Annual Average Number of Tornadoes in the United States, 1991 to 2010**

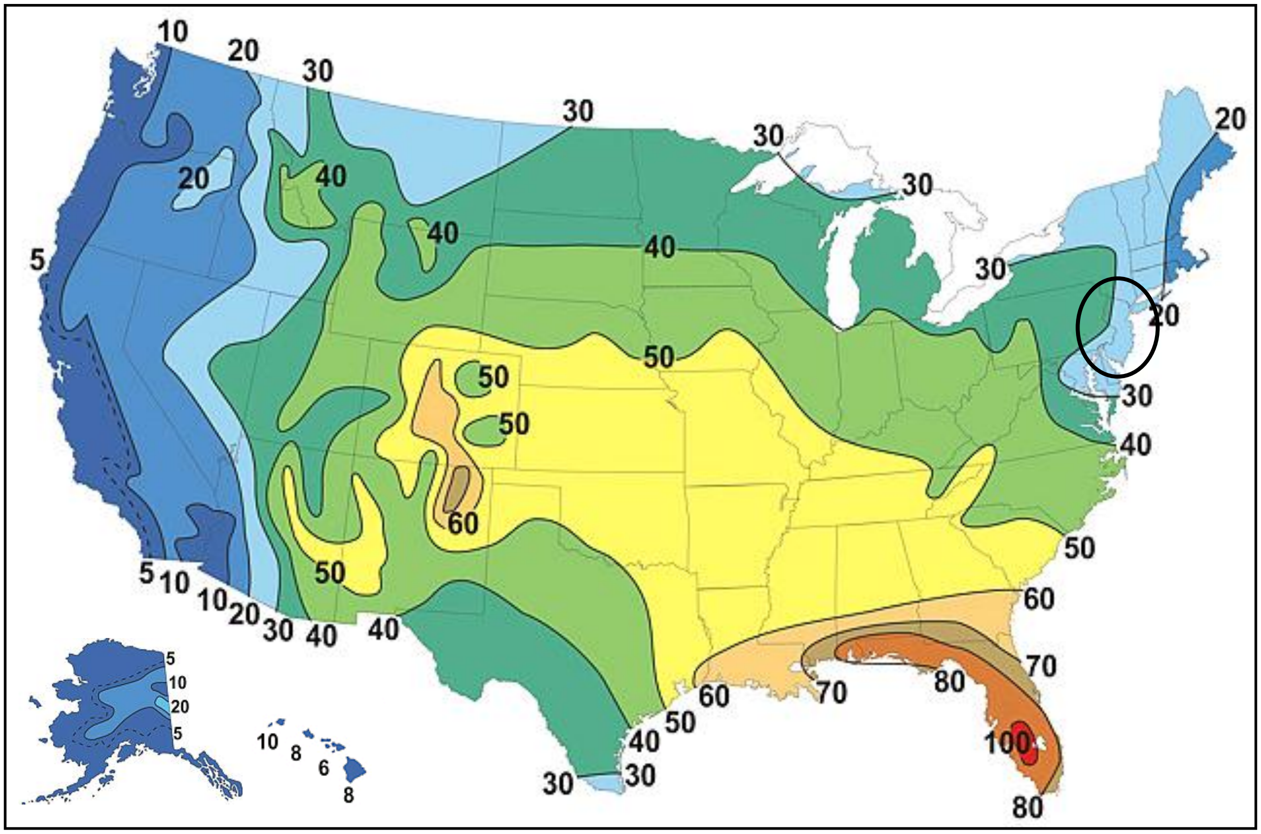



*Source: NCDC 2013*

## Thunderstorms

Thunderstorms affect relatively small localized areas, rather than large regions like winter storms and hurricane events. Thunderstorms can strike in all regions of the United States; however, they are most common in the central and southern states. 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. Figure 5.10-8 shows the average number of thunderstorm days throughout the United States. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year). Figure 5.10-8 illustrates that locations in New Jersey experience between 20 and 30 thunderstorm days each year (NWS 2009d; NWS 2010).

**Figure 5.10-8. Annual Average Number of Thunderstorm Days in the United States**




*Source: NWS 2010*

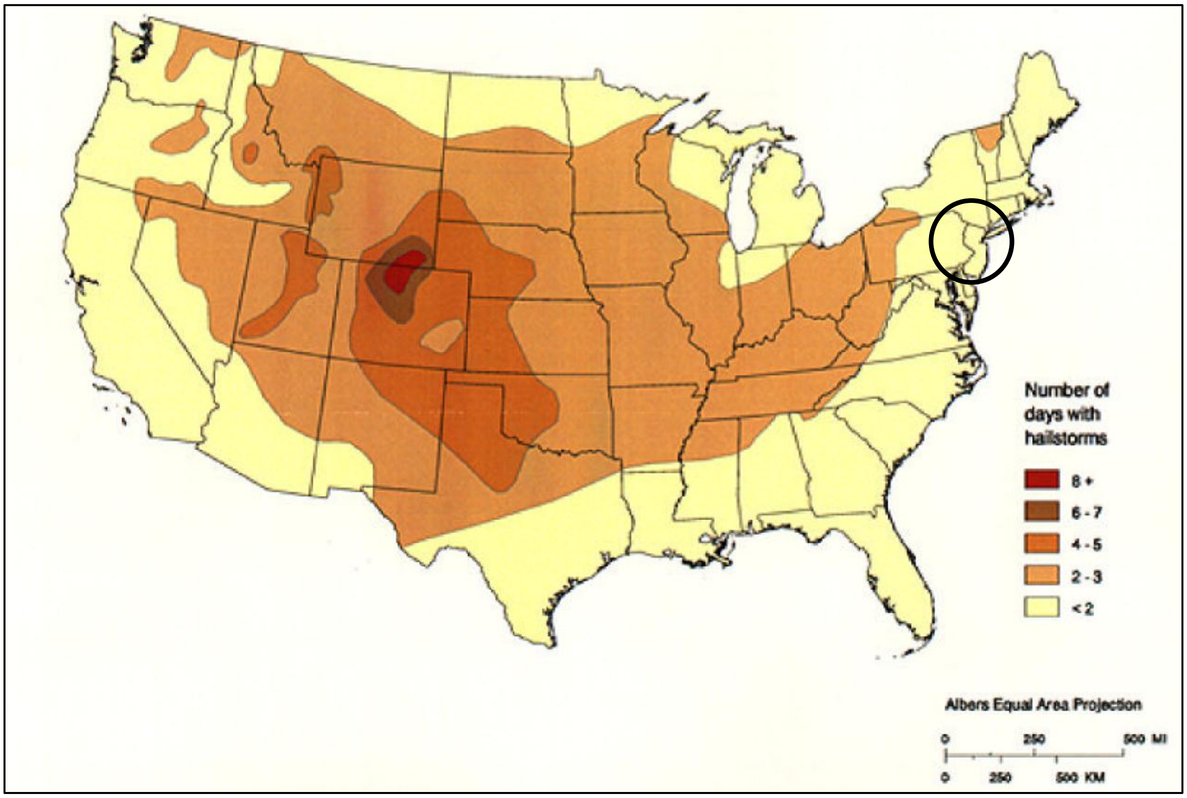
*Note: The black circle indicates the approximate location of New Jersey. According to this figure, New Jersey experiences an average between 20 and 30 thunderstorms annually.*

Thunderstorms spawned in Pennsylvania and New York State often move into northern New Jersey, where they usually reach maximum development during the evening hours. This region of the State has about twice as many thunderstorms as the coastal zone. The conditions most favorable to thunderstorm development occur between June and August, with July being the peak month for all weather stations in New Jersey.

## Hailstorms

Hail causes nearly $2 billion in crop and property damages, on average, each year in the United States. Hail occurs most frequently in the southern and central plain states; however, since hail occurs with thunderstorms, the possibility of hail damage exists throughout the entire United States (Federal Alliance for Safe Homes, 2006). Figure 5.10-9 indicates that New Jersey experiences less than two hailstorms a year, on average.

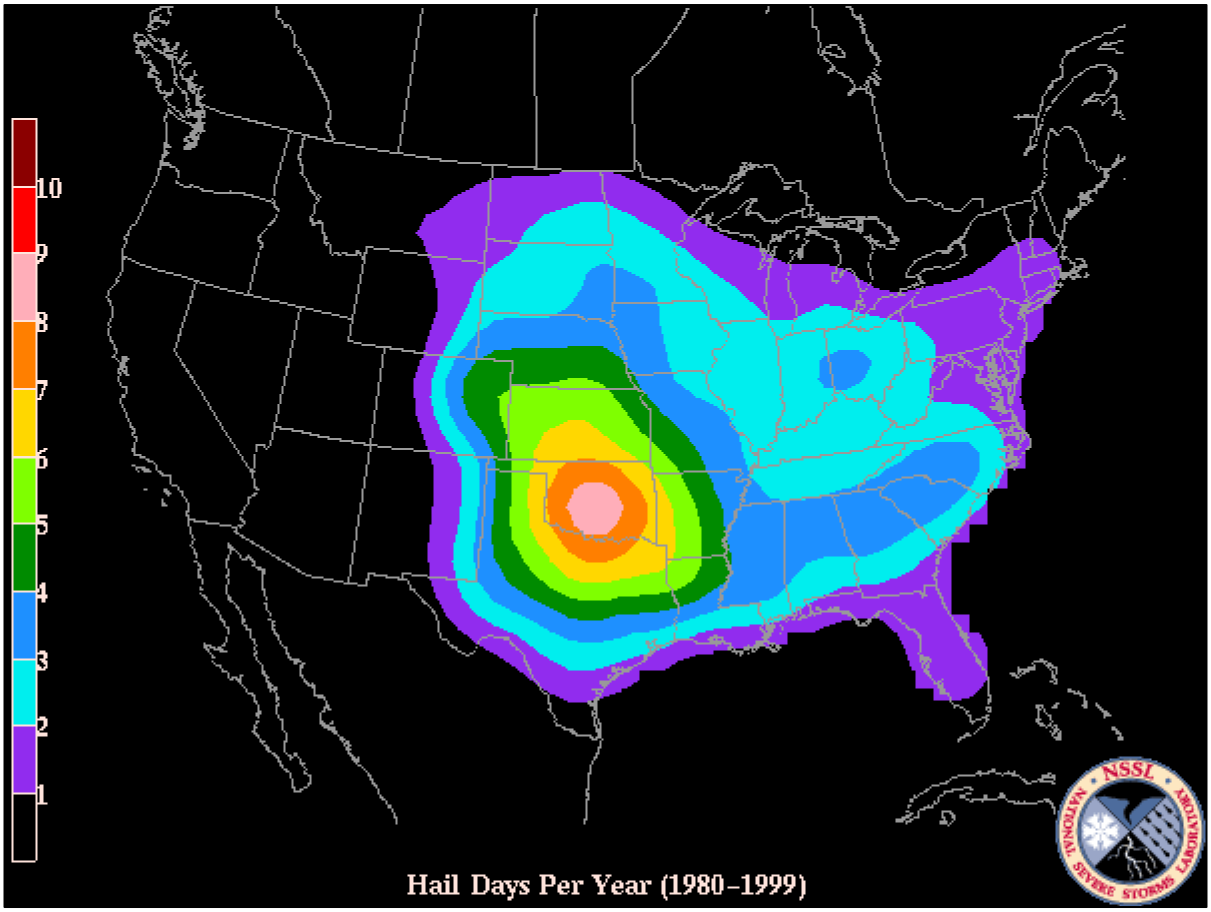
**Figure 5.10-9. Annual Frequency of Hailstorms in the United States**




*Source: FEMA, 1996*
*Note: The black circle indicates the approximate location of New Jersey.*

NOAA's National Severe Storms Laboratory (NSSL) started a project that estimates the likelihood of severe weather hazards in the United States. Severe thunderstorms were defined in the United States as having either tornadoes, gusts at least 58 mph, or hail at least 0.75-inch in diameter. Figure 5.10-10 illustrates the average number of days per year of hail events occurring within 25 miles of any point. In New Jersey, the figure shows an average of one to two days per year of hail events at least 0.75-inch diameter.

**Figure 5.10-10. Total Annual Threat of Hail Events (0.75-inch diameter or greater) in the United States, 1980 to 1999**



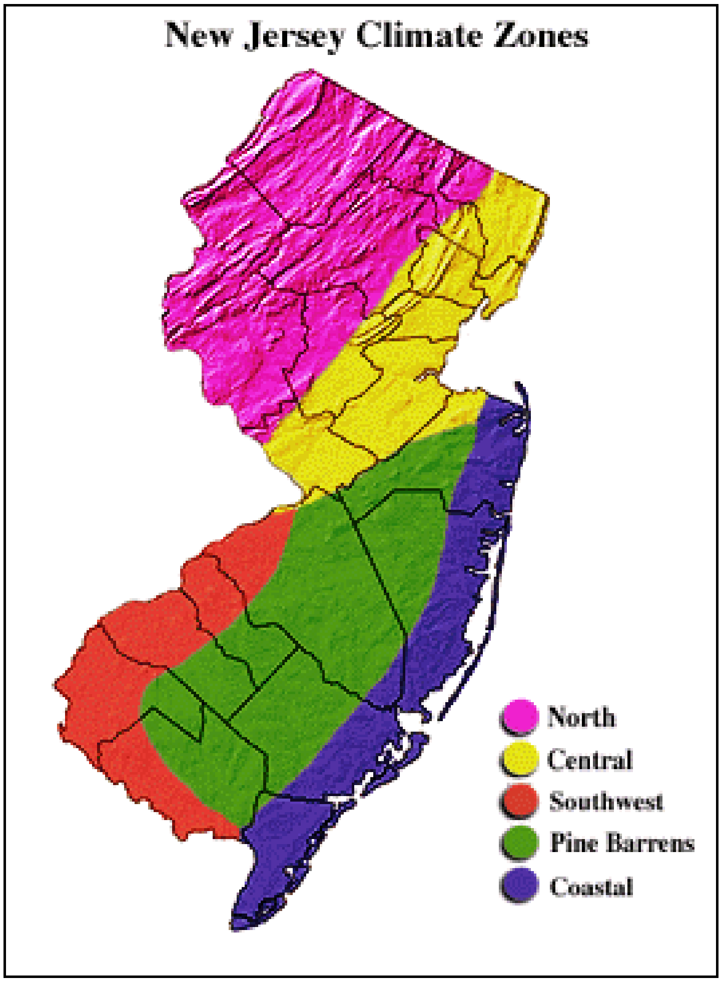

*Source: NSSL, 2003*

*Note: The mean number of days per year with one or more events within 25 miles of a point is shown here. The fill interval for hail days is 0.2, with the purple starting at 0.2 days. For the non-hail threats, the fill interval is 1, with the purple starting at 1. For the significant (violent), it's 5 days per century (millennium)*

## Extreme Temperatures

The location of extreme temperatures throughout the State are further identified below. For a discussion regarding drought locations, refer to Section 5.4 (Drought). According to the ONJSC, New Jersey has five distinct climate regions. Elevations, latitude, distance from the Atlantic Ocean, and landscape (e.g. urban, sandy soil) produce distinct variations in the daily weather between each of the regions. The five regions include: Northern, Central, Pine Barrens, Southwest, and Coastal. Figure 5.10-11 depicts these regions. Further descriptions regarding each of the climate divisions can be found in Section 4 (State Profile).

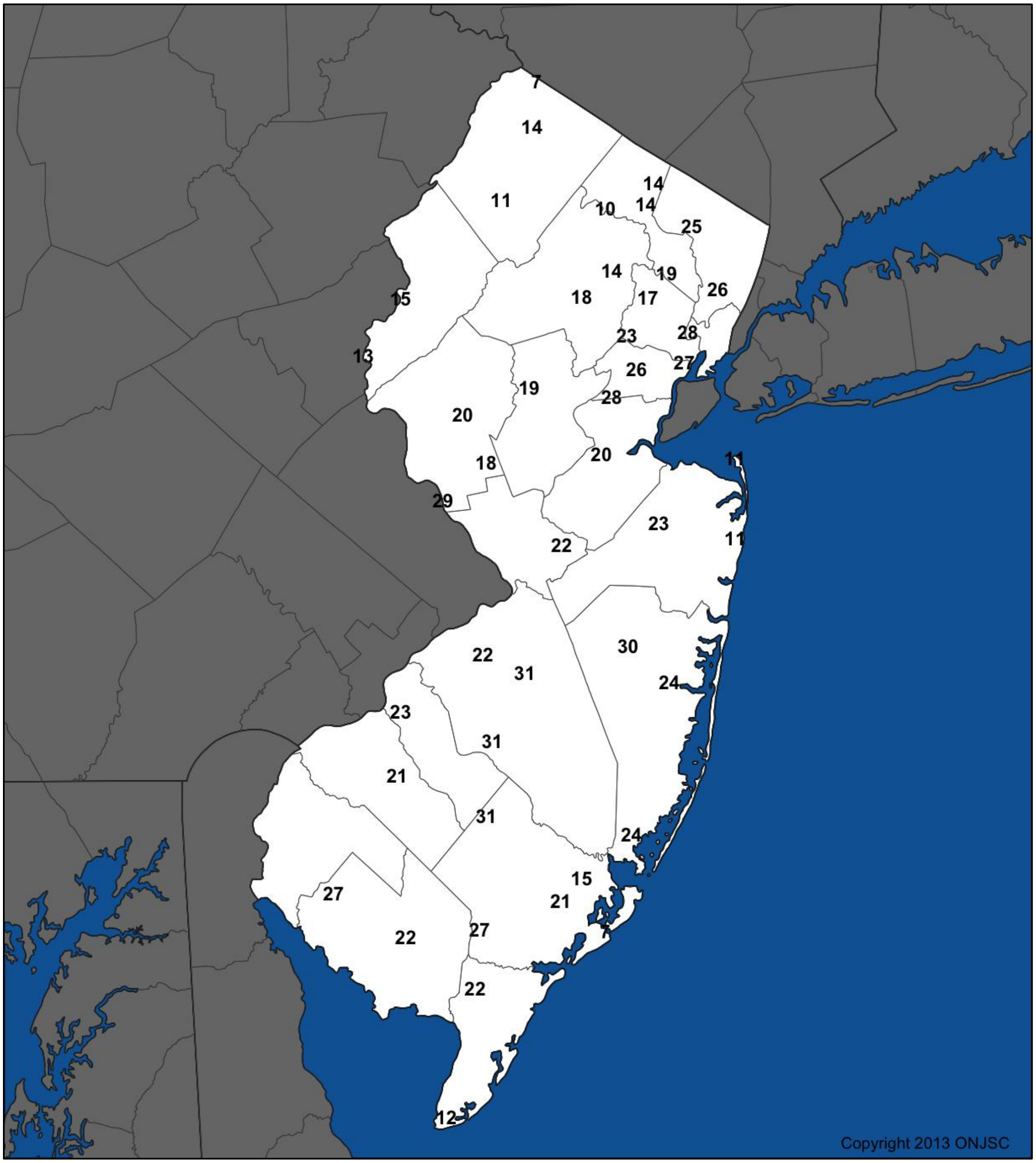
**Figure 5.10-11. Climate Regions of New Jersey**




*Source: ONJSC Rutgers University*

Temperature extremes can occur throughout the entire State. In New Jersey, average days per year where temperatures reach 90°F or higher range from five days to over 30 days, depending on location. Figure 5.10-12Figure 5.10-12. shows the average number of days per year, from 1981 to 2010, when temperatures were in excess of 90°F. The figure indicates that the central and northeastern areas of the State experience more days of 90°F or higher temperatures.

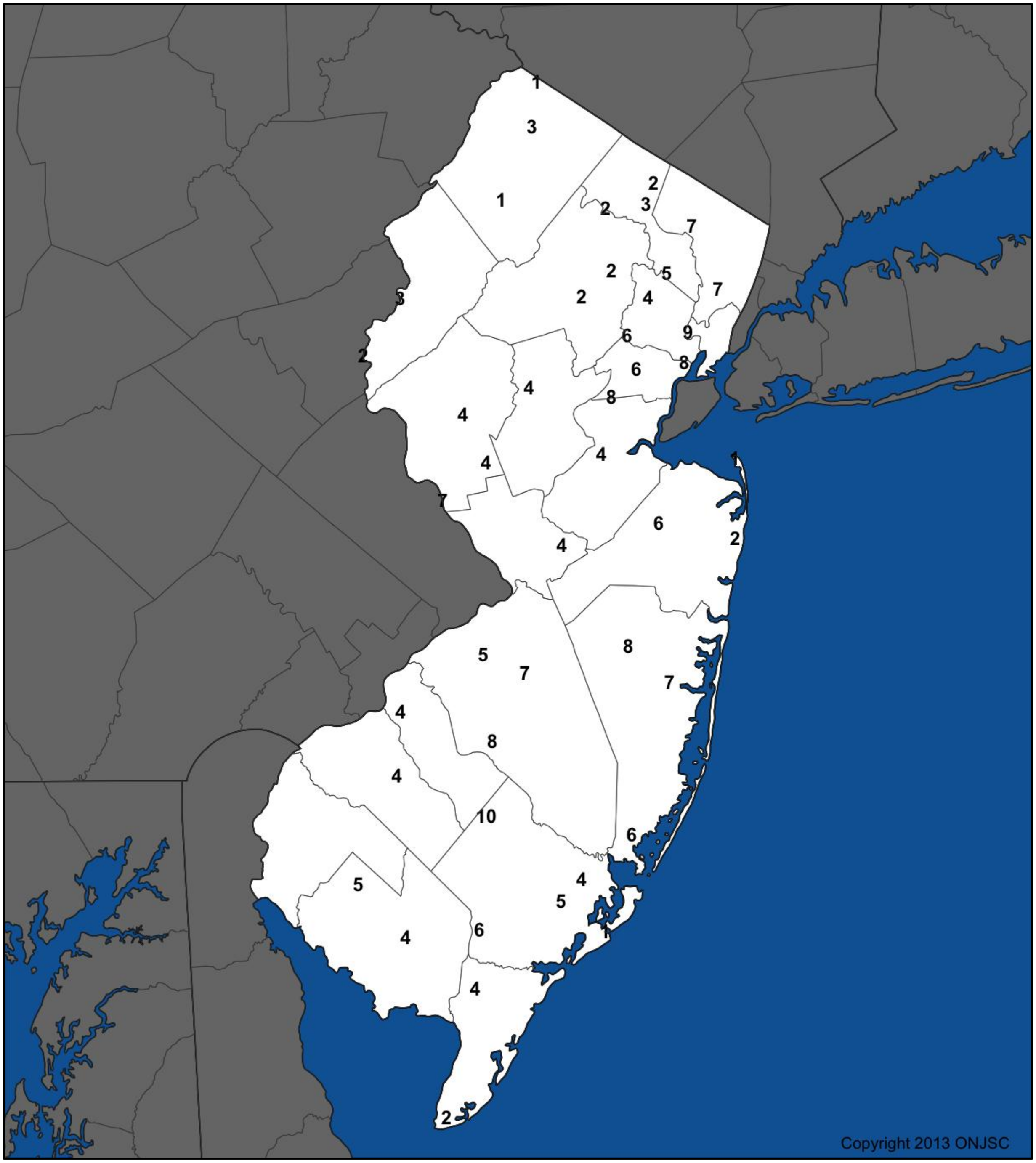
**Figure 5.10-12. Average Number of Days per Year in Excess of 90°F (1981 to 2010)**




*Source:* *ONJSC Rutgers University 2013a*
*°F* *degrees Fahrenheit*

In New Jersey, average days per year where temperatures reach 95°F or higher range from one day to over nine days, depending on location. Figure 5.10-13 shows the average number of days per year, from 1981 to 2010, when temperatures were in excess of 95°F. The figure indicates that northwestern and southern New Jersey experiences fewer 95°F or greater days than the northeastern or central areas.

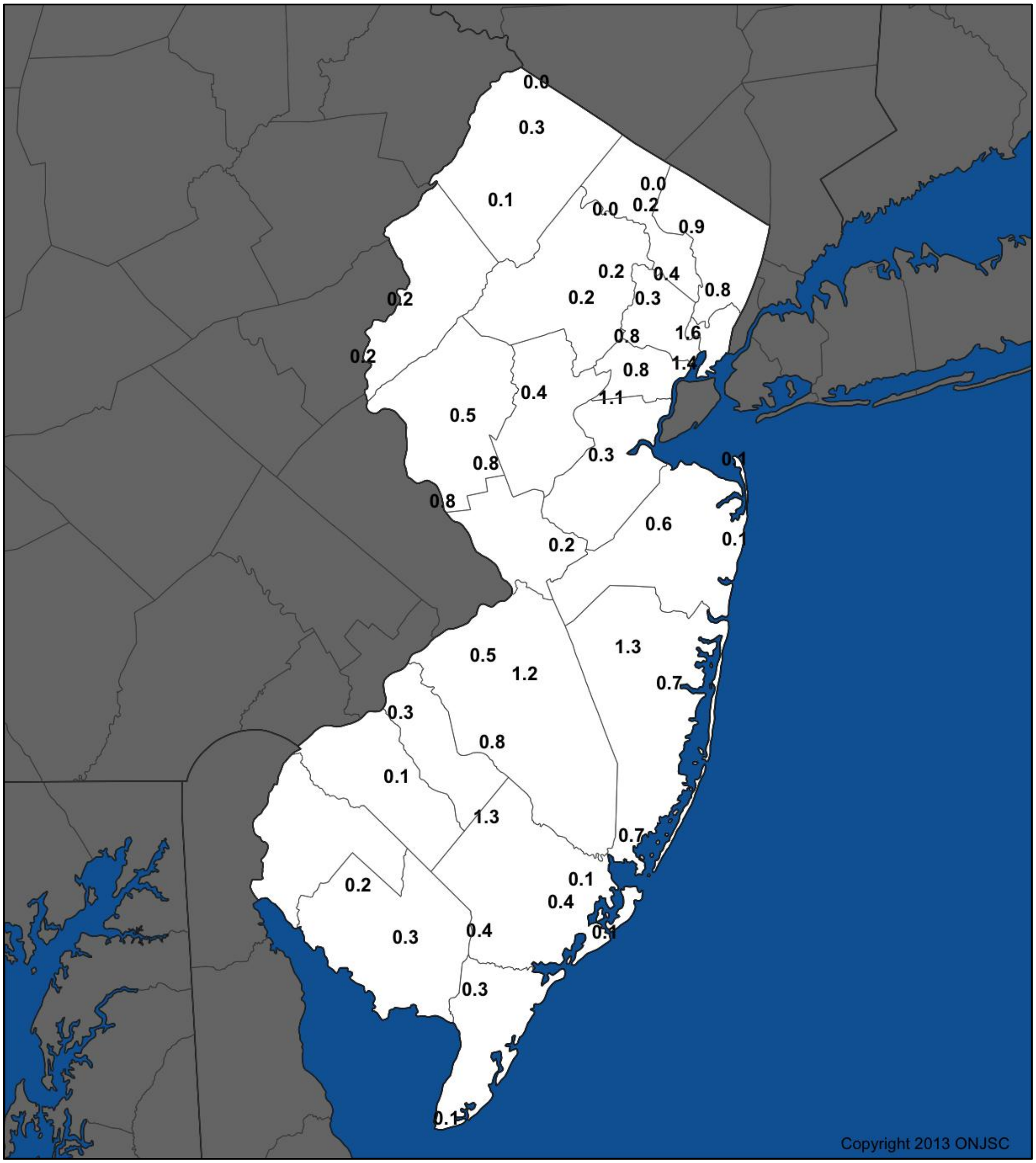
**Figure 5.10-13. Average Number of Days per Year in Excess of 95°F (1981 to 2010)**




*Source: ONJSC Rutgers University 2013a*
*°F degrees Fahrenheit*

In New Jersey, average days per year where temperatures reach 100°F or higher range from less than one day to over one day, depending on location. Figure 5.10-14 shows the average number of days per year, from 1981 to 2010, when temperatures were in excess of 100°F. The figure indicates that northwestern, coastal and southern New Jersey experience fewer 100°F or greater days than northeastern and central areas.

**Figure 5.10-14. Average Number of Days per Year in Excess of 100°F (1981 to 2010)**




*Source: ONJSC Rutgers University 2013a*
*°F degrees Fahrenheit*

Locations that are more prone to heat include inland urban areas. Cities are the most susceptible to the stresses of heat waves. Urban areas tend to have the largest populations and therefore, amplify the effects of heat. ONJSC conducted a study from 1997 to 2010 on summer heat at the NWS observing station located at Newark Liberty International Airport. The frequency of hot days, those with a maximum air temperature of 90°F or greater, or a heat index of that magnitude, was recorded during the study. Conditions were observed and recorded daily and hourly and also included information for 100°F. During the 14-year study, there was an average of 26 days each year with maximum temperatures ≥90°F. This ranged from 13 days in 2004, to 54 days in 2010. On average, the heat index was ≥90°F for 30 days each year. The temperature was ≥90°F for 124 hours in an average year, with a maximum of 319 hours in 2010. The average was 197 hours per year for the heat index. On ≥90°F days, the temperature remained at that level for an average of 4.4 hours and the heat index for 6.7 hours. Heat waves were also scrutinized during the ONJSC study. The maximum number of consecutive days of ≥90°F was 14 from July 16 to 29, 2010 (ONJSC Rutgers University 2010).

The NWS Automated Surface Observing Station (ASOS) was installed in 1996 in a grassy field between the outermost runway and the New Jersey Turnpike, roughly opposite of Terminal A of Newark Airport. The terrain in the area is flat and marshy, and there is a drainage canal between the station and the Turnpike. Less than a mile to the east is the Newark Bay and just beyond that is the New York Harbor. The majority of the land within a mile of the airport is covered with pavement or rooftops. Downtown Newark is located several miles to the north, and the City of Elizabeth is located to the south of the ASOS. To the northwest are ridges oriented roughly in a south-southwest to north-northwest direction. They rise to an elevation of approximately 200 feet at 4.5 to 5 miles and to 500 to 600 feet at seven to eight miles. The land up to the ridges is heavily developed urban/suburban (ONJSC Rutgers University 2010).

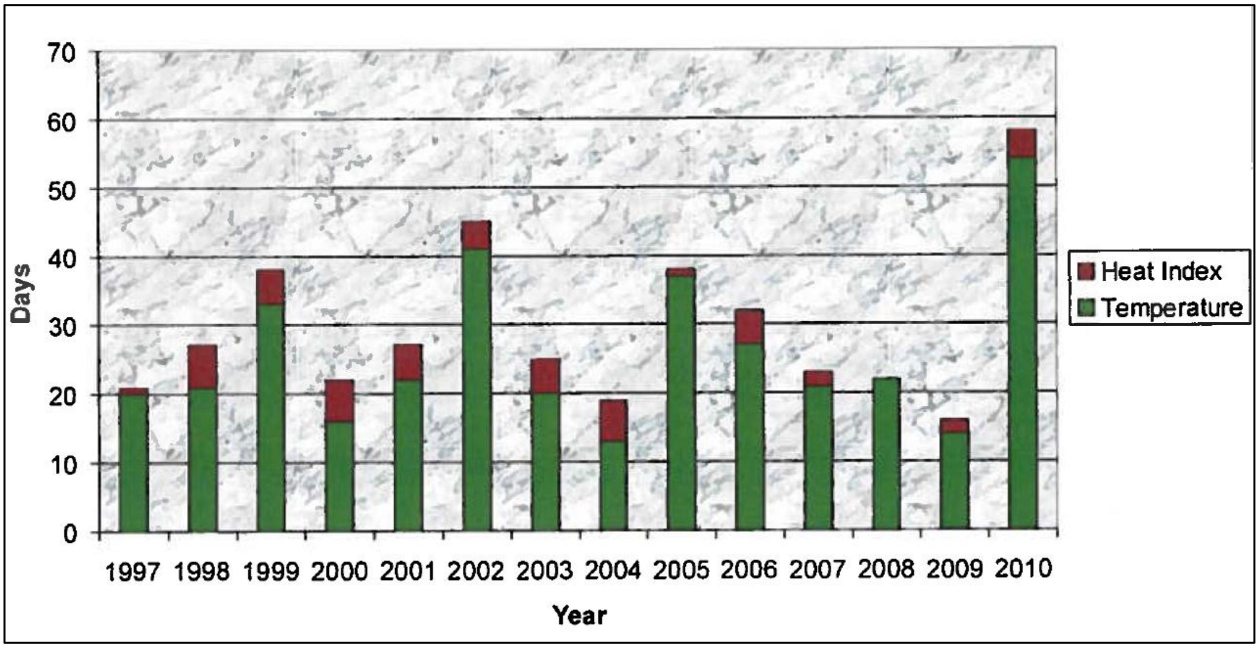
The ASOS weather station records temperature approximately five feet above the grassy surface. While Newark Airport observations date back to the early 1930s, the most recent 14 years were evaluated due to the change in landscape, relocation of the weather station, and the determination that the thermistor at Newark was faulty and read a degree or more too high from June 1992 through November 1994 (ONJSC Rutgers University 2010).

The results from the study provided the following:

- **Maximum temperature ≥90°F** – on average, there were 124 hours ≥90°F annually, with a maximum of 319 hours in 2010 and a minimum of 30 hours in 2004. On average, ≥90°F was reached 26 days each year, with a maximum of 54 days ≥90°F in 2010 and a minimum of 13 days ≥90°F in 2004.
- On days where the temperature was ≥90°F, the average maximum temperature for the day was 93°F, with a maximum of 105°F on August 9, 2001. On days where the temperature was ≥90°F, the average maximum heat index for the day was 95°F, with a maximum temperature of 112°F on July 5, 1999.
- Days where the temperature was ≥90°F, the temperature stayed at ≥90°F for an average of 4.4 hours. The annual maximum was 5.6 hours/day in 1999 and the daily maximum was 15 hours on July 5-6, 1999 and July 5-6, 2010. On days where the temperature was ≥90°F, the heat index was ≥90°F for 2.3 hours longer than the temperature was at or above this mark. The daily maximum was 21 hours on July 5, 1999, August 1, 2006, and August 2, 2006.

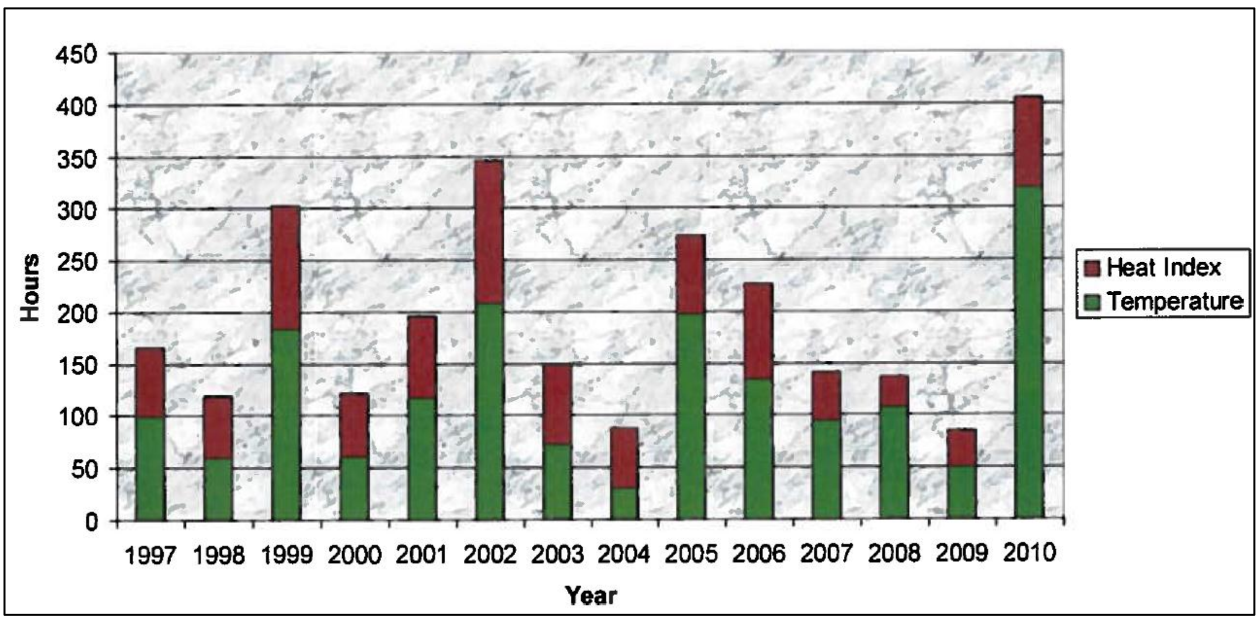
Figure 5.10-15 through Figure 5.10-17 illustrates these observations.

**Figure 5.10-15. ≥90°F Days Per Year in Newark, 1997 through 2010**



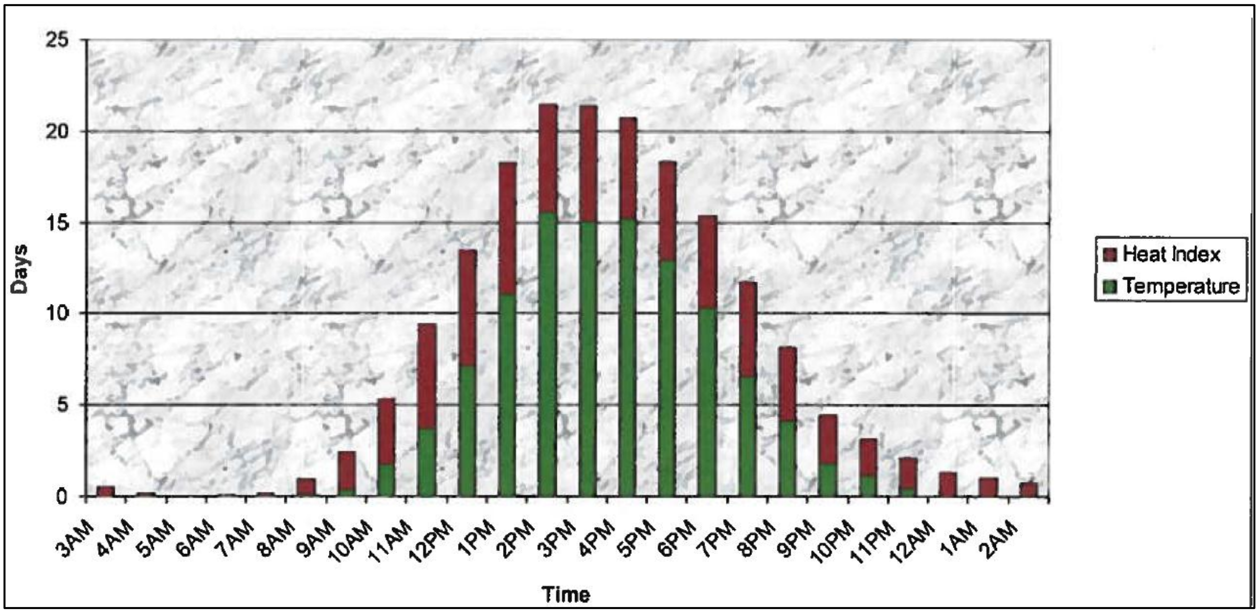

*Source: ONJSC Rutgers University 2010*
*°F degrees Fahrenheit*

**Figure 5.10-16. ≥90°F Hourly Observations Per Year in Newark, 1997 through 2010**




*Source: ONJSC Rutgers University 2010*
*°F degrees Fahrenheit*

**Figure 5.10-17. Average Days Per Year ≥90°F by Hour in Newark, 1997 through 2009**



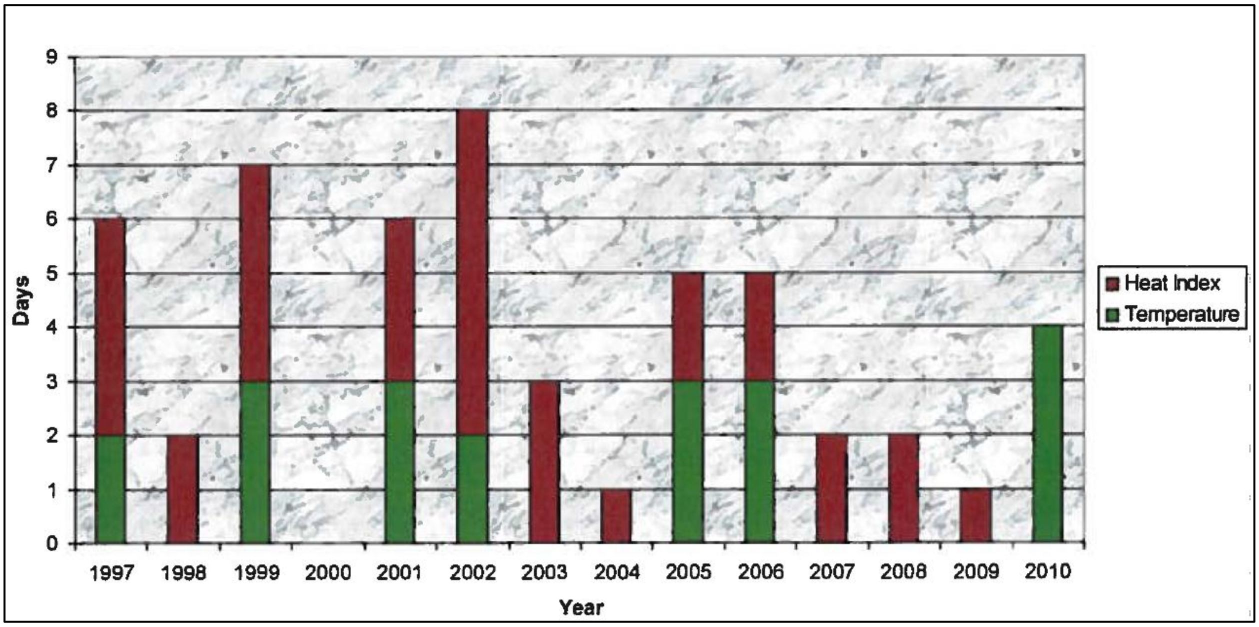

*Source: ONJSC Rutgers University 2010*
*Note: 2010 observations were not included in this calculation*
*°F degrees Fahrenheit*

Additional results from the study provided the following:

- **Heat Waves** – on average, heat waves lasted five days, with a maximum of 14 from July 16 to 29, 2010. On average, there were four heat waves per year, with a maximum of seven in 1999 and 2010 and a minimum of zero in 2004. The average duration of heat waves was 93 hours (from the first hourly reading ≥90°F until the last one), with a maximum of 317 hours during the July 2010, heat wave. From the start to the end of heat waves, approximately 26% of hours were spent below 80°F, with a minimum of 4% from August 11 to 14, 2005.
- **Heat Index ≥90°F** – on average, approximately 197 hours were spent with the heat index ≥90°F annually, with a maximum of 406 hours in 2010 and a minimum of 85 hours in 2009. On average, a heat index of ≥90°F was reached on 30 days annually, with a maximum of 58 in 2010 and a minimum of 16 in 2009. On days where the heat index was ≥90°F, the average maximum heat index for the day was 95°F, with a maximum of 112°F on July 5, 1999.
- **Temperatures ≥100°F** – on average, 2.4 hours were spent at ≥100°F annually. The following table summarizes the number of days each year that had temperatures ≥100°F.

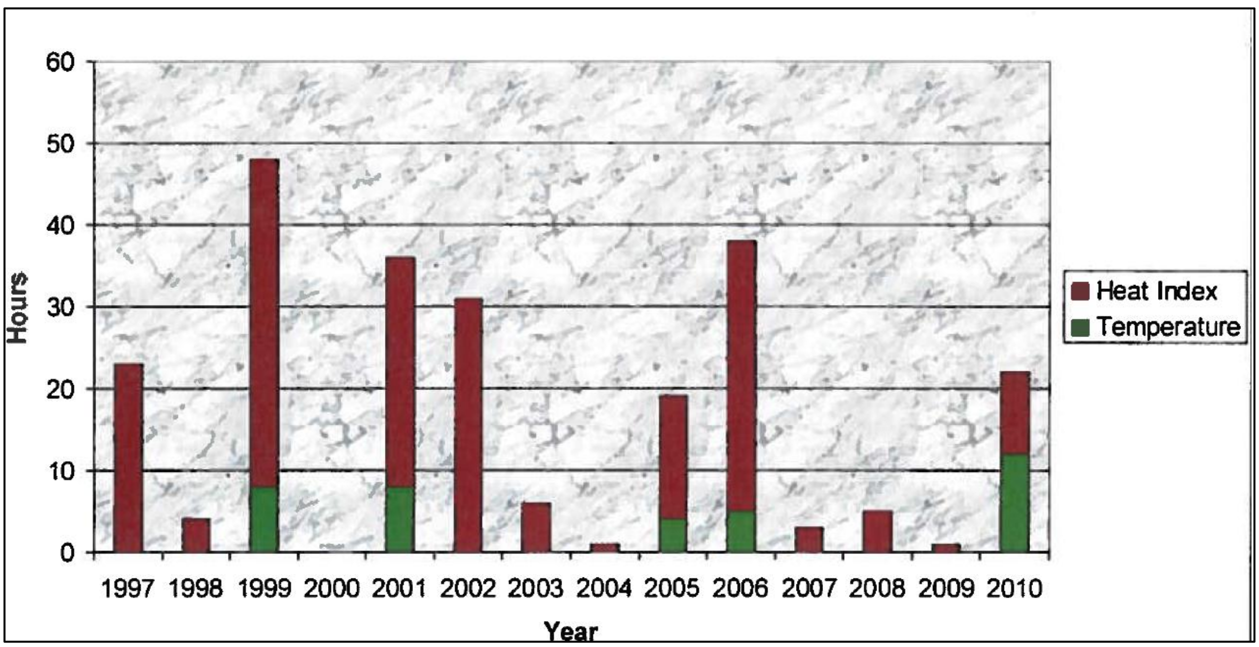
Figure 5.10-18 through Figure 5.10-20 further illustrates these observations.

**Figure 5.10-18. ≥100°F Days per Year in Newark, 1997 to 2010**



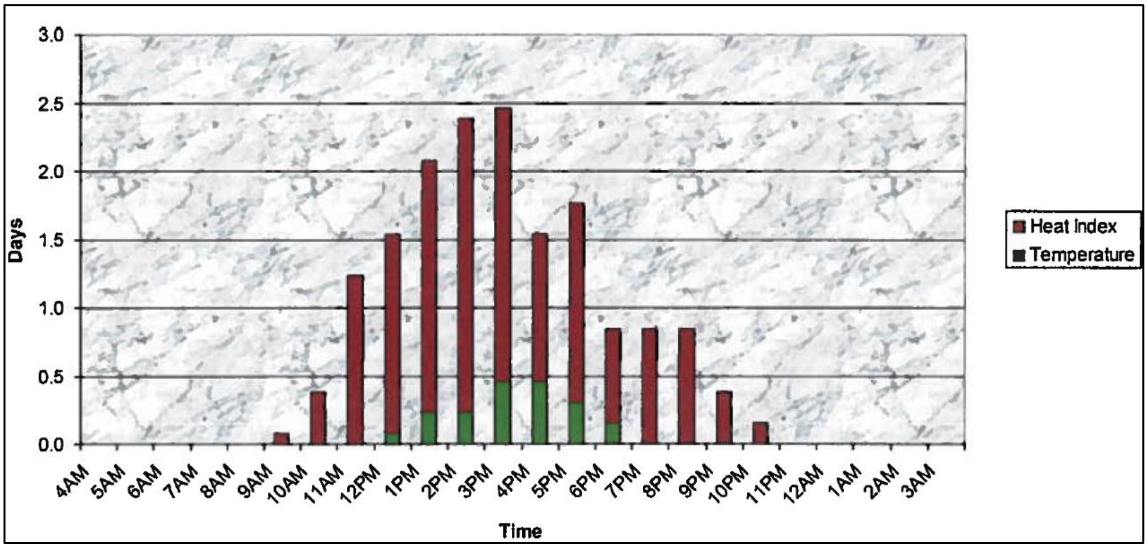

*Source:* *ONJSC Rutgers University 2010*
*°F* *degrees Fahrenheit*

**Figure 5.10-19. 100°F Hourly Observations by Year in Newark, 1997 to 2010**




*Source:* *ONJSC Rutgers University 2010*
*°F* *degrees Fahrenheit*

**Figure 5.10-20. Average Days per Year ≥100°F by Hour in Newark, 1997 to 2009**

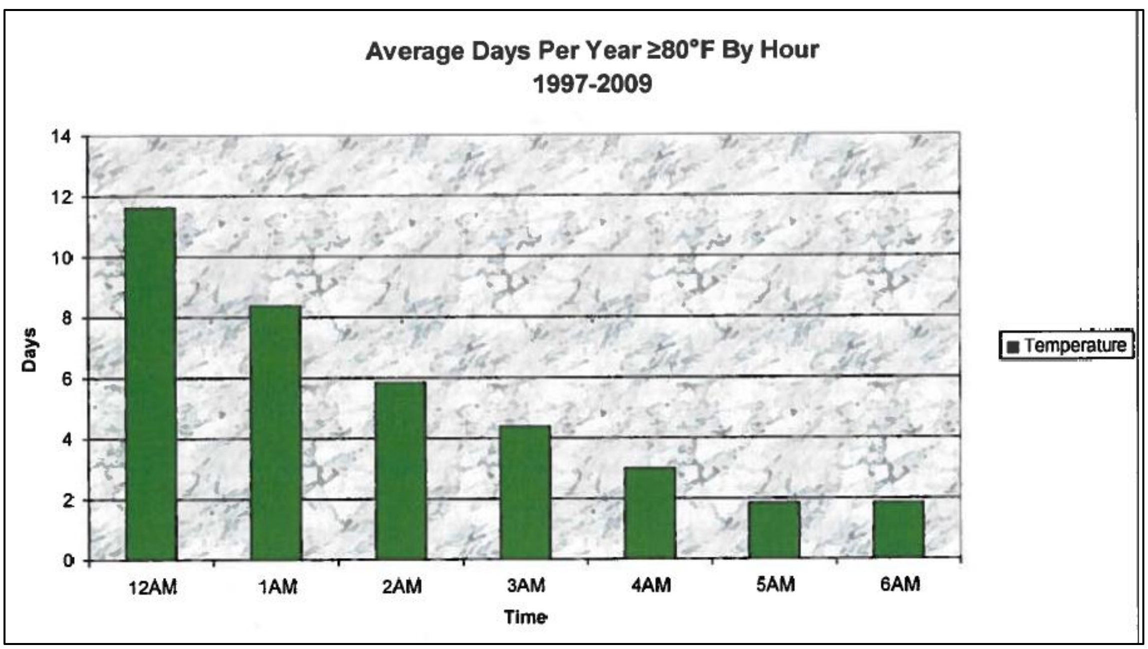



*Source: ONJSC Rutgers University 2010*
*°F degrees Fahrenheit*

Additional results from the study provided the following:

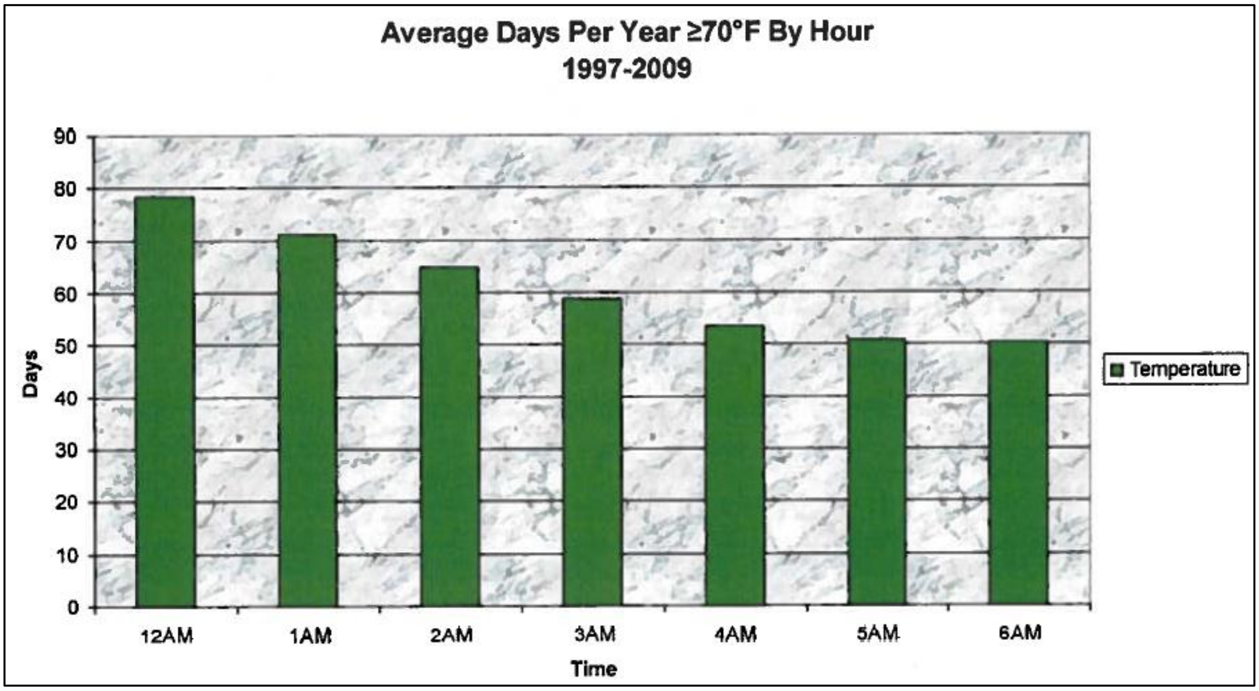
- **Warm nighttime temperatures** – On average, two days per year had 5 a.m. and 6 a.m. temperatures ≥80°F (Figure 5.10-21) and average of 50 days per year had 5 a.m. and 6 a.m. temperatures ≥70°F (Figure 5.10-22).

**Figure 5.10-21. Average Days Per Year ≥80°F by Hour in Newark**




*Source: ONJSC Rutgers University 2010*
*°F degrees Fahrenheit*

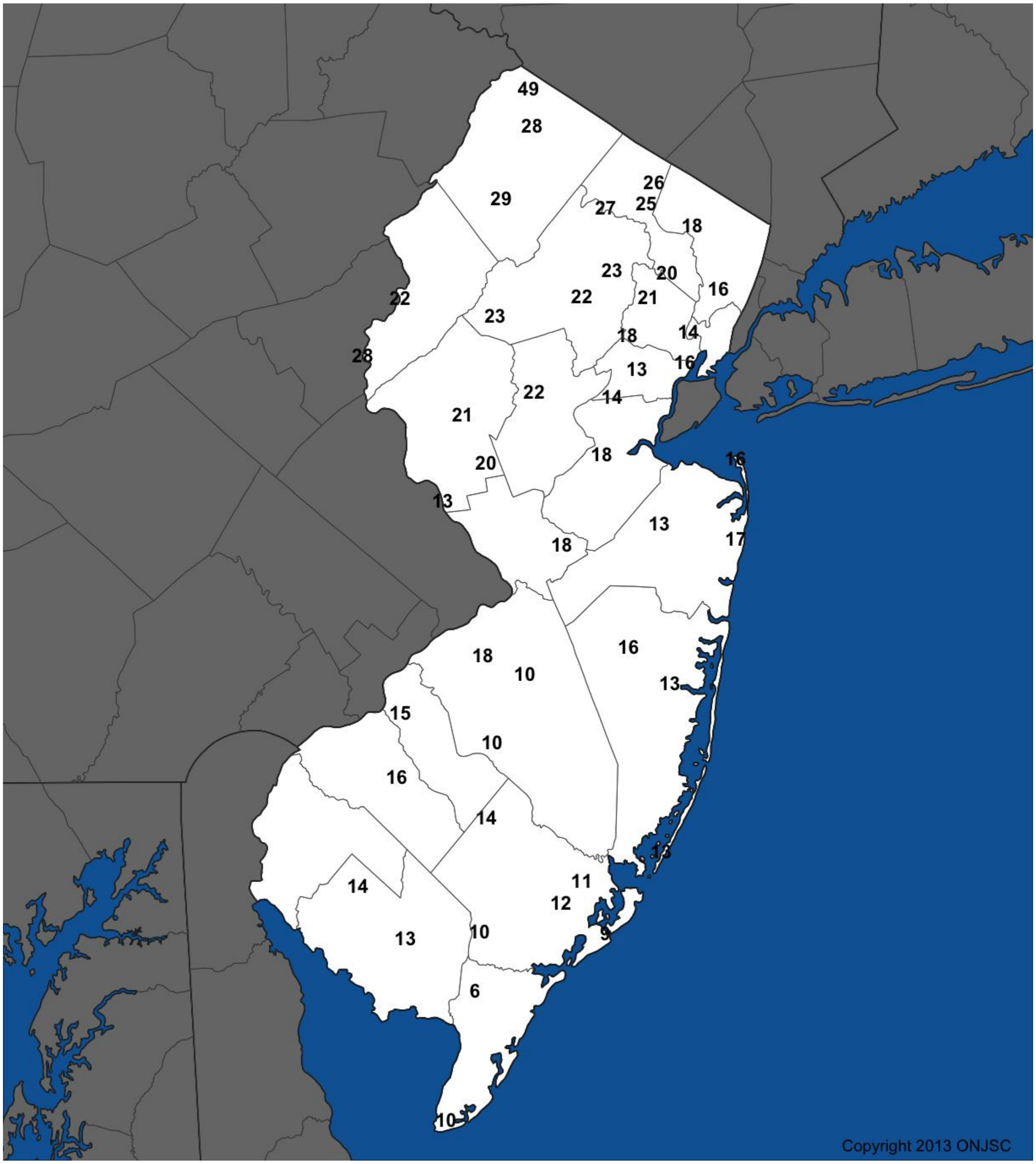
**Figure 5.10-22. Average Days Per Year ≥70°F by Hour in Newark, 1997 to 2009**




*Source: ONJSC Rutgers University 2010*
°F degrees Fahrenheit

In New Jersey, average days per year when temperatures reached less than 32°F range from six days in southern New Jersey to over 45 days in northern New Jersey. Figure 5.10-23 shows the average number of days below 32°F. The figure indicates northwestern New Jersey experiences more days of 32°F or colder than the rest of the State.

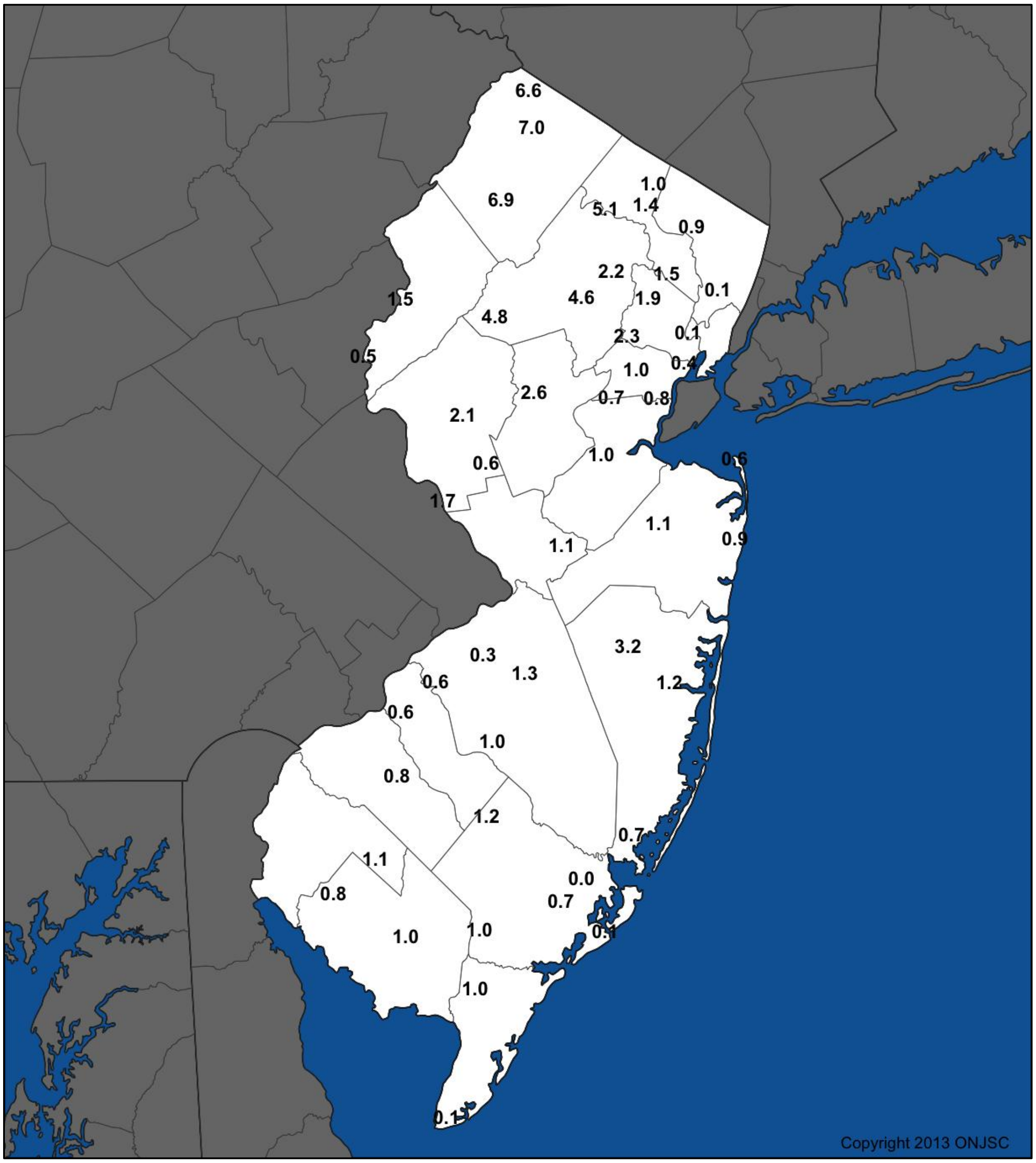
**Figure 5.10-23. Average Number of Days Each Year of Daily Maximum Temperature of Less than 32°F (1981 to 2010)**




*Source: ONJSC Rutgers University 2013a*
*Note: This figure shows the average number of days each year when the daily maximum temperature fails to exceed 32°F*
*°F degrees Fahrenheit*

In New Jersey, average days per year when temperatures reached less than 0°F range of less than one day in southern New Jersey to seven days in northern New Jersey. Figure 5.10-24 shows the average number of days below 0°F. The figure indicates northwestern New Jersey experiences more days below 0°F than the rest of the State.

**Figure 5.10-24. Average Number of Days Each Year of Daily Minimum Temperature of Less than 0°F (1981 to 2010)**




*Source: ONJSC Rutgers University 2013a*
*Note: This figure shows the average number of days each year when the daily minimum temperature fails to exceed 0°F*
*°F degrees Fahrenheit*

## Extent

### High Winds

The extent 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 (Northern Virginia Regional Commission [NVRC], 2006).

Windstorms have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the NWS is for a one-minute average; gusts may be 25% to 30% higher.

The NWS issues advisories, watches, and warnings for winds. A wind advisory is defined as sustained winds 25 to 39 mph and/or gusts of 46 to 57 mph. 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 are life threatening. The criterion for each of these varies from state to state (NWS 2010).

### Tornadoes

According to the Tornado Project, 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. 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 5.10-4 explains each of the six F-Scale categories.

**Table 5.10-4. 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. |
| 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 occur. |

*Source: Storm Prediction Center (SPC) 2011*
*mph miles per hour*

Although the F-Scale has been in use for over 30 years, there are limitations to 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 (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 (NOAA 2008). Table 5.10-5 displays the EF-Scale and each of its six categories.

**Table 5.10-5. Enhanced Fujita Damage Scale**

| EF-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 meters (109 yards); high-rise buildings have significant structural deformation; incredible phenomena occur. |

*Source: SPC 2011*
*EF-Scale Enhanced Fujita Scale*
*mph miles per hour*

In the F-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 5.10-6 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 5.10-6. 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 (one to four story) bldg. | LRB |
| 4 | Double-wide mobile home | MHDW | 18 | Mid-rise (five to 20 story) bldg. | MRB |
| 5 | Apartment, condo, townhouse (3 stories or less) | ACT | 19 | High-rise (over 20 stories) | HRB |
| 6 | Motel | M | 20 | Institutional bldg. (hospital, government, or university) | IB |
| 7 | Masonry apt. or motel | MAM | 21 | Metal building system | MBS |
| 8 | Small retail building (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 building | 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 2011*
*EF-Scale Enhanced Fujita Scale*

## Thunderstorms

Observational methodology of thunderstorms has varied over the years. In the 1990s there was the transition to the Automated Surface Observing Stations (ASOS) at NWS and Federal Aviation Administration (FAA) weather stations, mainly situated at airports. With ASOS deployment, an Automated Lightning Detection and Ranging System (ALDARS) took the place of human observers for identifying thunderstorms. Human observations appear to have caused major inconsistencies regarding thunderstorm days based on comparing pre-ASOS records to those gathered since the ASOS network was deployed. In many cases, the number of thunderstorm days dropped by as much as 50% from the past to present periods, though this was not apparent at all Mid-Atlantic stations (ONJSC Rutgers University 2013a).

These inconsistencies make it impossible to produce a useful map of thunderstorm days across New Jersey and nearby environs. Based on human observation, approximately 30 thunderstorm days per year occur in this region. This includes some sub-regional aspects, such as there being more inland storms than coastal thunderstorms (ONJSC Rutgers University 2013a).

With time, lightning detection climatology may prove more valuable than the former manual methodology. This should continue to be evaluated as future updates to the hazard mitigation plan are generated (ONJSC Rutgers University 2013a).

## Hailstorms

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 hailstorms are made up of a variety of sizes, and only the very largest hail stones pose serious risk to people, when exposed. Table 5.10-7 shows the different sizes of hail and the comparison to real-world objects.

**Table 5.10-7. Hail Size**

| Size | Inches in Diameter |
|---|---|
| Pea | 0.25 inch |
| Marble/mothball | 0.50 inch |
| Dime/Penny | 0.75 inch |
| Nickel | 0.875 inch |
| Quarter | 1.0 inch |
| Ping-Pong Ball | 1.5 inches |
| Golf Ball | 1.75 inches |
| Tennis Ball | 2.5 inches |
| Baseball | 2.75 inches |
| Tea Cup | 3.0 inches |
| Grapefruit | 4.0 inches |
| Softball | 4.5 inches |

*Source: NOAA 2012*

## Extreme Temperatures

NOAA's heat alert procedures are based mainly on Heat Index values. The Heat Index is given in degrees Fahrenheit. The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the Heat Index temperature, the temperature and relative humidity need to be known. Once both values are known, the Heat Index will be the corresponding number with both values (Figure 5.10-25). The Heat Index indicated the temperature the body feels. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. Strong winds, particularly with very hot dry air, can also be extremely hazardous (NWS 2013).

### Figure 5.10-25. NWS Heat Index Chart

Temperature (°F)

| Relative Humidity (%) | 80 | 82 | 84 | 86 | 88 | 90 | 92 | 94 | 96 | 98 | 100 | 102 | 104 | 106 | 108 | 110 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | 80 | 81 | 83 | 85 | 88 | 91 | 94 | 97 | 101 | 105 | 109 | 114 | 119 | 124 | 130 | 136 |
| 45 | 80 | 82 | 84 | 87 | 89 | 93 | 96 | 100 | 104 | 109 | 114 | 119 | 124 | 130 | 137 | |
| 50 | 81 | 83 | 85 | 88 | 91 | 95 | 99 | 103 | 108 | 113 | 118 | 124 | 131 | 137 | | |
| 55 | 81 | 84 | 86 | 89 | 93 | 97 | 101 | 106 | 112 | 117 | 124 | 130 | 137 | | | |
| 60 | 82 | 84 | 88 | 91 | 95 | 100 | 105 | 110 | 116 | 123 | 129 | 137 | | | | |
| 65 | 82 | 85 | 89 | 93 | 98 | 103 | 108 | 114 | 121 | 128 | 136 | | | | | |
| 70 | 83 | 86 | 90 | 95 | 100 | 105 | 112 | 119 | 126 | 134 | | | | | | |
| 75 | 84 | 88 | 92 | 97 | 103 | 109 | 116 | 124 | 132 | | | | | | | |
| 80 | 84 | 89 | 94 | 100 | 106 | 113 | 121 | 129 | | | | | | | | |
| 85 | 85 | 90 | 96 | 102 | 110 | 117 | 126 | 135 | | | | | | | | |
| 90 | 86 | 91 | 98 | 105 | 113 | 122 | 131 | | | | | | | | | |
| 95 | 86 | 93 | 100 | 108 | 117 | 127 | | | | | | | | | | |
| 100 | 87 | 95 | 103 | 112 | 121 | 132 | | | | | | | | | | |

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

*Source: NWS 2013*
*°F degrees Fahrenheit*
*% percent*

### Figure 5.10-26. Adverse Effects of Prolonged Exposures to Heat on Individuals

| Category | Heat Index | Health Hazards |
|---|---|---|
| Extreme Danger | 130 °F – Higher | Heat Stroke / Sunstroke is likely with continued exposure. |
| Danger | 105 °F – 129 °F | Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity. |
| Extreme Caution | 90 °F – 105 °F | Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity. |
| Caution | 80 °F – 90 °F | Fatigue possible with prolonged exposure and/or physical activity. |

*Source: NWS 2009*
*°F degrees Fahrenheit*

The NWS states that the extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop.

On November 1, 2001, the NWS implemented a new WCT Index. It was designed to more accurately calculate how cold air feels on human skin. The table below shows the new WCT Index. The WCT Index includes a frostbite indicator, showing points where temperature, wind speed, and exposure time will produce frostbite to humans. Figure 5.10-27 shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS 2013).

**Figure 5.10-27. NWS Wind Chill Index**

**NWS Windchill Chart**

Temperature (°F)

| Wind (mph) / Calm | 40 | 35 | 30 | 25 | 20 | 15 | 10 | 5 | 0 | -5 | -10 | -15 | -20 | -25 | -30 | -35 | -40 | -45 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 36 | 31 | 25 | 19 | 13 | 7 | 1 | -5 | -11 | -16 | -22 | -28 | -34 | -40 | -46 | -52 | -57 | -63 |
| 10 | 34 | 27 | 21 | 15 | 9 | 3 | -4 | -10 | -16 | -22 | -28 | -35 | -41 | -47 | -53 | -59 | -66 | -72 |
| 15 | 32 | 25 | 19 | 13 | 6 | 0 | -7 | -13 | -19 | -26 | -32 | -39 | -45 | -51 | -58 | -64 | -71 | -77 |
| 20 | 30 | 24 | 17 | 11 | 4 | -2 | -9 | -15 | -22 | -29 | -35 | -42 | -48 | -55 | -61 | -68 | -74 | -81 |
| 25 | 29 | 23 | 16 | 9 | 3 | -4 | -11 | -17 | -24 | -31 | -37 | -44 | -51 | -58 | -64 | -71 | -78 | -84 |
| 30 | 28 | 22 | 15 | 8 | 1 | -5 | -12 | -19 | -26 | -33 | -39 | -46 | -53 | -60 | -67 | -73 | -80 | -87 |
| 35 | 28 | 21 | 14 | 7 | 0 | -7 | -14 | -21 | -27 | -34 | -41 | -48 | -55 | -62 | -69 | -76 | -82 | -89 |
| 40 | 27 | 20 | 13 | 6 | -1 | -8 | -15 | -22 | -29 | -36 | -43 | -50 | -57 | -64 | -71 | -78 | -84 | -91 |
| 45 | 26 | 19 | 12 | 5 | -2 | -9 | -16 | -23 | -30 | -37 | -44 | -51 | -58 | -65 | -72 | -79 | -86 | -93 |
| 50 | 26 | 19 | 12 | 4 | -3 | -10 | -17 | -24 | -31 | -38 | -45 | -52 | -60 | -67 | -74 | -81 | -88 | -95 |
| 55 | 25 | 18 | 11 | 4 | -3 | -11 | -18 | -25 | -32 | -39 | -46 | -54 | -61 | -68 | -75 | -82 | -89 | -97 |
| 60 | 25 | 17 | 10 | 3 | -4 | -11 | -19 | -26 | -33 | -40 | -48 | -55 | -62 | -69 | -76 | -84 | -91 | -98 |

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

*Effective 11/01/01*

*Source: NWS 2009b*
*°F degrees Fahrenheit*
*mph miles per hour*

## Previous Occurrences and Losses

### High Winds

Many sources provided historical information regarding previous occurrences and losses associated with thunderstorm events throughout the State of New Jersey. Numerous sources were reviewed for this Hazard Management Plan (HMP), therefore, loss and impact information for many events could vary depending on the source. The accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

The 2011 Plan did not discuss specific high wind events; however, for this 2014 Plan update, high wind events that occurred in the State between January 1, 2010 and December 31, 2012 will be further discussed. Table 5.10-8 outlines these wind events in the State but does not include all incidents. Events in the table prior to 2010 were provided by ONJSC.

### Table 5.10-8. High Wind Incidents in New Jersey

| Date(s) of Event | Event Type | Counties Affected | Description |
|---|---|---|---|
| November 20, 1989 | Derecho | Statewide | A line of thunderstorms formed along a cold front over north-central Pennsylvania in the late afternoon on November 20. The storms built south along the front as it moved across Pennsylvania, southeastern New York State, New Jersey, and adjacent portions of Maryland and Delaware. The squall line produced a continuous swath of damaging wind that extended more than 250 miles from the Allegheny Mountains to the New Jersey coast and Long Island. Maximum wind gusts exceeded 58 mph and there were numerous gusts measuring at greater than 70 mph. In New Jersey, wind gusts of 86 mph were recorded in the southern portion. A steeple was blown off a church in Trenton and a roof was blown off of a high-rise apartment building in Burlington County. A falling tree seriously injured a man in Princeton. Overall, this event caused more than $20 million in damages to Pennsylvania, New Jersey, and New York. |
| September 7, 1998 | Derechos ("The Labor Day Derechos of 1998") | Northern New Jersey | A derecho formed over western New York State and moved east in the early morning on September 7. Wind damage occurred in much of the area, with some of the worst storm damage occurring in a band across western and central New York State. Along the path of the derecho, tens of thousands of trees were blown down and over 1,000 homes and businesses were damaged. Damage was estimated at approximately $130 million. Many homes and businesses were without power. |
| January 3, 2010 | Strong Winds | Statewide | Strong and gusty west to northwest winds occurred for nearly twenty-four hours across New Jersey. Peak wind gusts averaged around 50 mph, with some gusts of 70 mph in the higher terrain of Sussex County. Strong winds downed weak trees, tree limbs, and power lines resulting in power outages. About 1,000 homes and businesses lost power in Monmouth and Ocean Counties. |
| January 25, 2010 | Strong Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Ocean, Salem, Somerset | Strong to high southerly winds affected central and southern New Jersey in the morning of January 25. Peak wind gusts averaged around 55 mph, with the strongest winds in the southern half of the state. About 80,500 homes and businesses lost power. Most power was restored by the next afternoon. The high winds also caused structural and property damage in Cumberland and Gloucester Counties. |
| March 13, 2010 | High Winds | Statewide | Strong to high winds downed thousands of trees and tree limbs, hundreds of telephone poles. Over half a million utility customers throughout the state lost power. Dozens of homes were damaged by fallen trees, a few other homes were damaged by the high winds themselves and crane damage occurred in Atlantic City. There were three reported injuries. A 78 mph wind gust was reported at Robbins Reef at 7:18 pm. |
| December 1, 2010 | Wind Gusts | Bergen, Passaic | A wind gust to 59 mph was reported at Teterboro airport in the early afternoon of December 1. Strong winds knocked down some trees and tree limbs which caused scattered power outages across the region. |

| Date(s) of Event | Event Type | Counties Affected | Description |
|---|---|---|---|
| December 18, 2010 | High Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, Sussex, Warren | Strong to high west to northwest winds affected New Jersey in the evening of January 18 into the evening of January 19. Peak wind gusts averaged around 55 mph. The winds tore down trees, tree limbs, and wires, and caused power outages. Most of the highest winds and damage occurred in the central and southern part of the state. About 22,000 homes and businesses lost power. |
| December 26, 2010 | High Winds | Statewide | Strong to high winds that started in the afternoon of the winter storm on December 26 persisted into the next evening. Peak wind gusts were around 50 mph, except along some shore points and in the higher terrain of Sussex County where gusts reached 60 mph and greater. |
| February 25, 2011 | High Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, Sussex, Warren | A very strong cold frontal passage produced strong to high winds across New Jersey in the afternoon and early evening of February 25. Peak wind gusts averaged 50 to 60 mph, with most of the highest gusts in the southern half of the state. The winds downed numerous trees, tree limbs, and power lines, and also caused some structural damage. |
| April 16, 2011 | High Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, Sussex, Warren | Strong to high southeast to south winds affected central and southern New Jersey in the afternoon and evening on April 16. Peak wind gusts averaged around 50 to 55 mph with some isolated wind gusts around 60 mph. The highest wind gusts occurred during the evening and the worst reported wind damage occurred in Cumberland County. The strong to high winds coupled with the heavy rain, knocked down weak trees, tree limbs, and wires. The strong to high gradient winds were exacerbated further by isolated severe thunderstorms. |
| January 13, 2012 | High Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, Sussex, Warren | Strong westerly winds were recorded early in the morning and again later in the day on January 13, across New Jersey, following a cold frontal passage. Peak wind gusts averaged between 45 and 55 mph, resulting in downed tree limbs and isolated power outages. Atlantic City Electric reported about 3,000 of its customers lost power in southern New Jersey. |
| February 25, 2012 | Strong Winds | Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Salem, Somerset, Sussex, Warren | Strong winds downed weak trees, tree limbs, and power lines and caused scattered outages. Peak wind gusts included 62 mph in Wantage (Sussex County), 61 mph in Seaside Park (Ocean County), 56 mph in Brick (Ocean County). |
| June 29, 2012 | Derecho (“The Ohio Valley/Mid-Atlantic Derecho of June 2012”) | Southern New Jersey | This event produced the all-time highest recorded June or July wind gusts at several official observing sites, in addition to widespread, significant wind damage. Five million people lost power from Chicago to the mid-Atlantic coast and 22 people were killed. In New Jersey, the storms produced continuous damage that extended east across the Delaware Bay to Atlantic City, where a 74 mph wind gust was reported. Two children were killed in Salem County. |

| Date(s) of Event | Event Type | Counties Affected | Description |
|---|---|---|---|
| December 26, 2012 | High Winds | Atlantic, Burlington, Cape May, Mercer, Monmouth, Ocean | An intense low pressure system brought strong to high northeast winds into central and eastern New Jersey mainly during the evening on December 26. Peak wind gusts reached hurricane force gusts in Ocean County. The strong to high winds caused some structural damage as well as knocking down trees, tree limbs, and wires and causing power outages. Jersey Central Power and Light reported about 7,000 of its customers lost power in Ocean and Monmouth Counties.<br><br>Peak wind gusts included 74 mph in Brick (Ocean County), 70 mph in Tuckerton and Barnegat (Ocean County), 68 mph in Harvey Cedars (Ocean County), 61 mph in Sandy Hook (Monmouth County), 58 mph in Monmouth Beach (Monmouth County), 57 mph in Oceanport (Monmouth County), 54 mph in Florence (Burlington County), Point Pleasant and Seaside Heights (Ocean County), 51 mph at the Atlantic City International Airport (Atlantic County), 49 mph in West Cape May (Cape May County), 48 mph in Oceanville (Atlantic County) and 46 mph in Trenton (Mercer County) and the Marina in Atlantic City (Atlantic County). Overall, the State experienced $150,000 in property damages. |

*Source: NCDC 2013; ONJSC Rutgers University 2013; SPC 1998; SPC 2012*
*mph miles per hour*

## Tornadoes

Table 5.10-9 displays the annual tornado summary for the State between 1950 and 2012 based on best available data.

**Table 5.10-9. Annual Tornado Summary, State of New Jersey, 1951 to 2012**

| Year | Tornadoes | Deaths | Injuries | Total Damages |
|---|---|---|---|---|
| 1951 | 1 | 0 | 2 | $25,000 |
| 1952 | 4 | 0 | 1 | $78,000 |
| 1953 | No incidents reported | | | |
| 1954 | No incidents reported | | | |
| 1955 | 1 | 0 | 0 | N/A |
| 1956 | 4 | 0 | 8 | $50,000 |
| 1957 | 1 | 0 | 0 | $250,000 |
| 1958 | 3 | 0 | 0 | $277,500 |
| 1959 | No incidents reported | | | |
| 1960 | 5 | 0 | 0 | $302,750 |
| 1961 | No incidents reported | | | |
| 1962 | 3 | 0 | 1 | $500,000 |
| 1963 | No incidents reported | | | |
| 1964 | 6 | 0 | 10 | $775,000 |
| 1965 | No incidents reported | | | |
| 1966 | No incidents reported | | | |
| 1967 | 1 | 0 | 0 | $25,000 |
| 1968 | No incidents reported | | | |
| 1969 | No incidents reported | | | |
| 1970 | 2 | 0 | 0 | $275,000 |
| 1971 | 3 | 0 | 0 | $750,000 |
| 1972 | No incidents reported | | | |
| 1973 | 8 | 0 | 12 | $530,500 |
| 1974 | 2 | 0 | 0 | $250 |
| 1975 | 3 | 0 | 0 | $25,275,000 |
| 1976 | 1 | 0 | 0 | $250,000 |
| 1977 | 2 | 0 | 1 | $50,000 |

| Year | Tornadoes | Deaths | Injuries | Total Damages |
|---|---|---|---|---|
| 1978 | No incidents reported | | | |
| 1979 | 2 | 0 | 1 | $252,500 |
| 1980 | 1 | 0 | 0 | $25,000 |
| 1981 | 3 | 0 | 0 | $250,000 |
| 1982 | 1 | 0 | 0 | $2,500,000 |
| 1983 | 1 | 0 | 0 | $2,500,000 |
| 1984 | No incidents reported | | | |
| 1985 | 2 | 0 | 8 | $250 |
| 1986 | 1 | 0 | 0 | $250,000 |
| 1987 | 9 | 0 | 3 | $257,500 |
| 1988 | 6 | 0 | 1 | $3,252,500 |
| 1989 | 17 | 0 | 2 | $10,827,500 |
| 1990 | 7 | 0 | 11 | $6,000,000 |
| 1991 | 1 | 0 | 0 | $2,500 |
| 1992 | 4 | 0 | 0 | $500,000 |
| 1993 | 5 | 0 | 0 | $505,000 |
| 1994 | 8 | 0 | 0 | $10,575,000 |
| 1995 | 5 | 0 | 0 | N/A |
| 1996 | 2 | 0 | 0 | $10,000 |
| 1997 | 2 | 0 | 0 | $103,000 |
| 1998 | 3 | 0 | 0 | $2,050,000 |
| 1999 | 2 | 0 | 0 | $100,000 |
| 2000 | No incidents reported | | | |
| 2001 | 2 | 0 | 0 | $1,015,000 |
| 2002 | No incidents reported | | | |
| 2003 | 7 | 1 | 2 | $2,100,000 |
| 2004 | 2 | 0 | 2 | $600,000 |
| 2005 | No incidents reported | | | |
| 2006 | 1 | 0 | 0 | $100,000 |
| 2007 | No incidents reported | | | |
| 2008 | No incidents reported | | | |

| Year | Tornadoes | Deaths | Injuries | Total Damages |
|---|---|---|---|---|
| 2009 | 2 | 0 | 0 | $1,000,000 |
| 2010 | 1 | 0 | 0 | $25,000 |
| 2011 | 4 | 0 | 0 | $250,000 |
| 2012 | 1 | 0 | 0 | $25,000 |

*Source: SPC 2012; NOAA-NCDC 2013; ONJSC Rutgers University 2013e*
*N/A Not available*

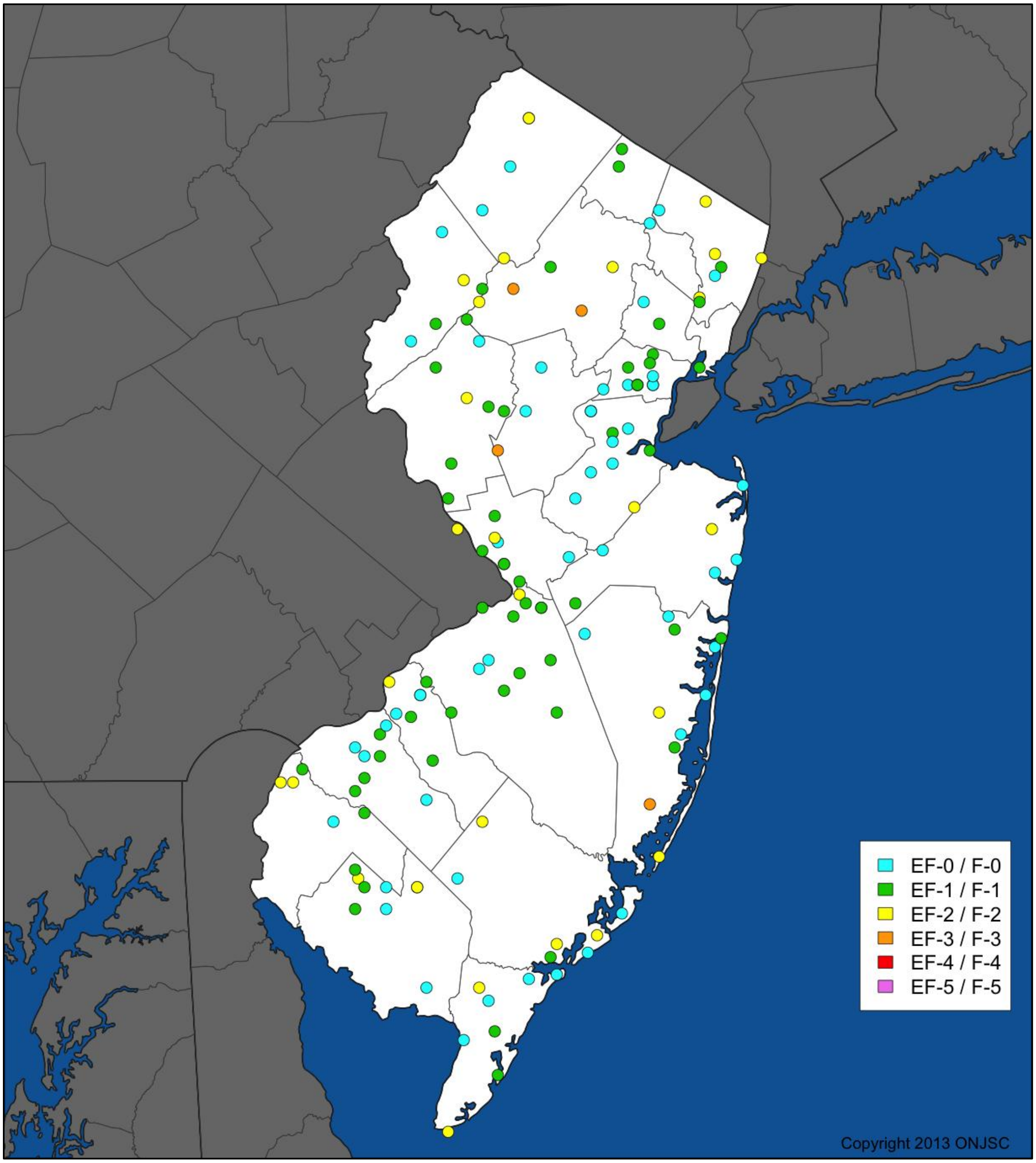
Over the course of the last 20 years, the State of New Jersey has experienced 51 tornadoes, with an annual frequency of 2.5 per year. ONJSC developed Figure 5.10-28 that illustrates the locations of confirmed tornadoes in the State of New Jersey between 1950 and 2012. According to this figure, there have been 144 tornadoes in New Jersey. Of those 144 tornadoes:

- 51 were EF-0/F-0
- 56 were EF-1/F-1
- 29 were EF-2/F-2
- Four were EF-3/F-4and
- Four were unknown

These tornado events resulted in 77 injuries and one fatality, and they resulted in $77,884,250.00 in damages. The map figure indicates that northern and western parts of the State experience more tornadoes than southern and coastal areas.

The 2011 Plan did not discuss specific tornado events. For this 2014 Plan update, tornado events that occurred in the State between January 1, 2010 and December 31, 2012 will be further discussed. Table 5.10-10 lists all available data on tornadoes in New Jersey from 1950 to 2012. Tornado events occurring prior to 2010 are based on other research and information provided by the SPC and ONJSC.

**Figure 5.10-28. Confirmed Tornadoes in New Jersey, 1950 to 2012**




*Source: ONJSC Rutgers University 2013*
*EF Enhanced Fujita (Scale)*
*F Fujita (Scale)*

**Table 5.10-10. Tornado Incidents in New Jersey, 1950 to 2012**

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| April 29, 1951 | F1 | N/A | $25,000 in property damage; two injuries |
| April 5, 1952 | F1 | N/A | $2,500 in property damage |
| August 10, 1952 | F1 | N/A | $25,000 in property damage |
| October 16, 1955 | F2 | N/A | Unknown |
| May 6, 1956 | F2 | N/A | $25,000 in property damage |
| July 13, 1956 | F1 | N/A | 8 injuries |
| July 13, 1956 | F1 | N/A | $2,500 in property damage |
| September 6, 1956 | F2 | N/A | Unknown |
| November 19, 1957 | F1 | N/A | $250,000 in property damage |
| June 13, 1958 | F2 | N/A | $250,000 in property damage; one injury |
| June 13, 1958 | Unknown | N/A | $2,500 in property damage |
| July 14, 1958 | F1 | N/A | $25,000 in property damage |
| April 18, 1960 | F1 | N/A | $250 in property damage |
| June 24, 1960 | Unknown | N/A | $25,000 in property damage |
| July 1, 1960 | F1 | N/A | $2,500 in property damage |
| July 14, 1960 | F2 | N/A | $250,000 in property damage; six injuries |
| November 29, 1960 | Unknown | N/A | $25,000 in property damage |
| May 24, 1962 | F2 | N/A | $250,000 in property damage; one injury |
| July 21, 1962 | F0 | N/A | Unknown |
| August 7, 1962 | F2 | N/A | $250,000 in property damage |
| March 10, 1964 | F1 | N/A | $250,000 in property damage; five injuries |
| March 26, 1964 | F0 | N/A | $25,000 in property damage |
| October 18, 1967 | F1 | N/A | $25,000 in property damage |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| July 15, 1970 | F2 | N/A | $25,000 in property damage |
| November 4, 1970 | F2 | N/A | $250,000 in property damage |
| July 19, 1971 | F2 | N/A | $250,000 in property damage |
| July 19, 1971 | F2 | N/A | $250,000 in property damage |
| August 27, 1971 | F2 | N/A | $250,000 in property damage |
| February 2, 1973 | F2 | N/A | $2,500 in property damage |
| February 2, 1973 | F1 | N/A | $250 in property damage |
| February 2, 1973 | F1 | N/A | $250 in property damage |
| May 28, 1973 | F3 | N/A | $250,000 in property damage |
| May 28, 1973 | F3 | N/A | $250,000 in property damage; 1two injuries |
| June 29, 1973 | F1 | N/A | $2,500 in property damage |
| June 29, 1973 | F1 | N/A | $25,000 in property damage |
| November 28, 1973 | F0 | N/A | Unknown |
| April 14, 1974 | F2 | N/A | $250 in property damage |
| July 24, 1974 | F1 | N/A | Unknown |
| April 3, 1975 | F0 | N/A | $25,000 in property damage |
| July 13, 1975 | F2 | N/A | $25 million in property damage |
| July 13, 1975 | F1 | N/A | $250,000 in property damage |
| July 7, 1976 | F1 | N/A | $250,000 in property damage |
| August 10, 1977 | F0 | N/A | $25,000 in property damage; one injury |
| September 26, 1977 | Unknown | N/A | $25,000 in property damage |
| September 6, 1979 | F1 | N/A | $250,000 in property damage; one injury |
| November 26, 1979 | F1 | N/A | $2,500 in property damage |
| June 3, 1980 | F1 | N/A | $25,000 in property damage |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| June 21, 1981 | F1 | N/A | $250,000 in property damage |
| July 20, 1981 | F2 | N/A | Unknown |
| October 26, 1981 | F2 | N/A | Unknown |
| June 29, 1982 | F2 | N/A | $2.5 million in property damage |
| July 21, 1983 | F3 | N/A | $2.5 million in property damage |
| September 27, 1985 | F0 | N/A | $250 in property damage |
| October 5, 1985 | F1 | N/A | 8 injuries |
| September 23, 1986 | F0 | N/A | $250,000 in property damage; eight injuries |
| July 2, 1987 | F1 | N/A | $250,000 in property damage |
| July 12, 1987 | F1 | N/A | $2,500 in property damage |
| July 14, 1987 | F0 | N/A | Unknown |
| July 21, 1987 | F2 | N/A | $2,500 in property damage |
| July 26, 1987 | F0 | N/A | Unknown |
| July 26, 1987 | F1 | N/A | Unknown |
| August 5, 1987 | F0 | N/A | $2,500 in property damage |
| May 23, 1988 | F0 | N/A | Unknown |
| July 20, 1988 | F1 | N/A | Unknown |
| July 23, 1988 | F1 | N/A | $250,000 in property damage; one injury |
| August 17, 1988 | F2 | N/A | $2.5 million in property damage |
| August 17, 1988 | F0 | N/A | $2,500 in property damage |
| August 17, 1988 | F2 | N/A | $250,000 in property damage |
| March 18, 1989 | F1 | N/A | $25,000 in property damage |
| March 18, 1989 | F1 | N/A | $25,000 in property damage |
| March 18, 1989 | F1 | N/A | Unknown |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| May 27, 1989 | F0 | N/A | $2,500 in property damage |
| June 9, 1989 | F2 | N/A | $250,000 in property damage |
| July 10, 1989 | F1 | N/A | $2.5 million in property damage |
| July 10, 1989 | F0 | N/A | $2.5 million in property damage |
| July 10, 1989 | F0 | N/A | $2.5 million in property damage |
| August 29, 1989 | F0 | N/A | one injury |
| November 16, 1989 | F0 | N/A | $250,000 in property damage; one injury |
| November 16, 1989 | F1 | N/A | $250,000 in property damage |
| November 16, 1989 | F0 | N/A | one injury |
| November 16, 1989 | F0 | N/A | one injury |
| November 16, 1989 | F0 | N/A | one injury |
| November 16, 1989 | F1 | N/A | one injury |
| November 16, 1989 | F0 | N/A | one injury |
| November 20, 1989 | F0 | N/A | $2.5 million in property damage |
| May 10, 1990 | F0 | N/A | $250,000 in property damage |
| May 10, 1990 | F2 | N/A | $250,000 in property damage |
| August 13, 1990 | F0 | N/A | Unknown |
| October 18, 1990 | F3 | N/A | $2.5 million in property damage; eight injuries |
| October 18, 1990 | F1 | N/A | $250,000 in property damage |
| October 18, 1990 | F0 | N/A | $2.5 million in property damage; three injuries |
| October 18, 1990 | F0 | N/A | $250,000 in property damage |
| August 19, 1991 | F0 | N/A | $2,500 in property damage |
| June 24, 1992 | F1 | N/A | $250,000 in property damage |
| July 15, 1992 | F0 | N/A | Unknown |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| July 31, 1992 | F1 | N/A | $250,000 in property damage |
| July 31, 1992 | F1 | N/A | Unknown |
| June 9, 1993 | F0 | N/A | Unknown |
| June 21, 1993 | F0 | N/A | Unknown |
| July 10, 1993 | F0 | N/A | Unknown |
| August 21, 1993 | F2 | N/A | $250,000 in property damage |
| September 8, 1993 | F0 | N/A | $2,500 in property damage |
| April 13, 1994 | F1 | N/A | $2.5 million in property damage |
| May 25, 1994 | F1 | N/A | $2.5 million in property damage |
| June 29, 1994 | F1 | N/A | Unknown |
| July 3, 1994 | F1 | N/A | $250,000 in property damage |
| July 26, 1994 | F1 | N/A | $2.5 million in property damage |
| August 2, 1994 | F1 | N/A | Unknown |
| August 17, 1994 | F1 | N/A | Unknown |
| November 1, 1994 | F0 | N/A | $250,000 in property damage |
| May 29, 1995 | F1 | N/A | Unknown |
| July 16, 1995 | F1 | N/A | Unknown |
| July 16, 1995 | F1 | N/A | Unknown |
| July 22, 1995 | F0 | N/A | $2.5 million in property damage |
| October 21, 1995 | F0 | N/A | Unknown |
| June 22, 1996 | F0 | N/A | Unknown |
| September 8, 1996 | F0 | N/A | $10,000 in property damage |
| August 13, 1997 | F0 | N/A | $50,000 in property damage |
| September 11, 1997 | F1 | N/A | $530,000 in property damage |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| September 2, 1998 | F0 | N/A | Unknown |
| September 7, 1998 | F0 | N/A | $1.5 million in property damage |
| September 7, 1998 | F1 | N/A | $5,500 in in property damage |
| February 12, 1999 | F1 | N/A | $10,000 in property damage |
| August 20, 1999 | F2 | N/A | $4.2 million in property damage; one injury |
| May 27, 2001 | F2 | N/A | $1 million in property damage |
| July 5, 2001 | F1 | N/A | $10,000 in property damage |
| July 3, 2003 | F0 | N/A | None |
| September 23, 2003 | F1 | N/A | $500,000 in property damage |
| September 23, 2003 | F1 | N/A | $600,000 in property damage |
| September 23, 2003 | F1 | N/A | $1 million in property damage; two injuries |
| October 27, 2003 | F0 | N/A | $2,500 in property damage; 1 fatality |
| October 27, 2003 | F0 | N/A | Unknown |
| October 27, 2003 | F0 | N/A | Unknown |
| July 27, 2004 | F1 | N/A | $500,000 in property damage; two injuries |
| September 28, 2004 | F0 | N/A | $100,000 in property damage |
| June 2, 2006 | F0 | N/A | $10,000 in property damage |
| July 29, 2009 | EF2 | Sussex | An EF2 tornado touched down in Wantage Township at about 2:48 p.m. on July 29. It was the first confirmed tornado in Sussex County since August 1990, the first tornado of F2 or EF2 strength ever in the county since records started in 1950 and the first tornado to reach EF2 or F2 strength in New Jersey since the Manalapan tornado of May 27, 2001. The tornado remained on the ground for 6.6 miles before it crossed the border into New York State. Its maximum width was about 100 yards and its highest estimated wind speed was 120 mph. Approximately $800,000 in property damage and $200,000 in crop damage. |
| July 29, 2009 | EF2 | N/A | $960,000 in property damage |
| July 29, 2009 | EF2 | N/A | $875,000 in property damage |

| Date(s) of Event | Magnitude | Counties Affected | Impacts |
|---|---|---|---|
| September 16, 2010 | EF1 | Middlesex, Ocean | An EF1 tornado touched down in Plumsted Township in Ocean County at about 6:05 p.m. on September 16. The tornado remained on the ground for about 2.2 miles. The tornado touched down just north of the intersection of Long Swamp Road and Archertown Road. The tornado traveled east-northeast crossing Ocean County Route 539 and lifted near Hawkins Road or Prospertown-Colliers Mills Road near Colliers Lake. Approximately $25,000 in property damage. |
| August 9, 2011 | EF0 | Monmouth | An EF0 tornado touched down in Millstone Township in Monmouth County. The tornado initially touched down north of Buono Farm and tracked northeast where it crossed New Jersey State Route 33. Approximately $10,000 in property damage. |
| August 28, 2011 | EF0 | Mercer | Tropical Storm Irene produced torrential downpour rains that resulted in major flooding and a number of record breaking crests on area rivers, tropical storm force wind gusts with record breaking outages for New Jersey utilities, one confirmed tornado, and a three to five foot storm surge. There was one confirmed tornado in Mercer County. Overall, $25,000 in property damage. |
| September 4, 2012 | EF0 | Burlington, Camden | A weak EF0 tornado touched down in Mount Ephraim at 6:31 p.m. on September 4. The tornado initially touched down on the west side of Cleveland Avenue. It then moved east northeast, crossed Jefferson Avenue and lifted as it approached Kings Highway. (County Route 551). Several homes in the area experienced roof damage, mainly from fallen tree limbs.<br><br>A weak tornado (F0 on the Fujita Scale) touched down in a wooded area between Marne Highway and the Holly Bowl bowling alley in Hainesport Township. It moved east and lifted just before crossing New Jersey State Route 38.<br><br>A weak tornado (F0 on the Fujita Scale) briefly touched down in eastern Bedminster Township on Miller Lane near the split of U.S. Routes 202 and 206. The tornado remained on the ground for only a couple of tenths of a mile before it lifted in a wooded area east of the public works building in the township.<br><br>Overall, $25,000 in property damage |

*Source: NOAA-NCDC 2013; SPC 2013; ONJSC Rutgers University 2013a*
*EF Enhanced Fujita (Scale)*
*F Fujita (Scale)*
*mph miles per hour*

## Thunderstorms

Thunderstorms occur regularly in New Jersey, primarily during the summer months. Of particular concern are the effects of lightning strikes to individuals and homes in the State. Most areas receive between 25 and 30 thunderstorms each year.

Many sources provided historical information regarding previous occurrences and losses associated with thunderstorm events throughout the State of New Jersey. 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.

The 2011 Plan did not discuss specific thunderstorm events; however, for this 2014 Plan update, thunderstorm events that occurred in the State between January 1, 2010 and December 31, 2012 will be further discussed. Table 5.10-11 outlines these thunderstorm events in the State but does not include all incidents.

### Table 5.10-11. Thunderstorm and Lightning Incidents in New Jersey, 2010 to 2012

| Date(s) of Event | Event Type | Counties Affected | Impacts |
|---|---|---|---|
| May 14, 2010 | Thunderstorm | Burlington, Cape May, Cumberland Gloucester, Monmouth, Ocean | An Appalachian lee side meteorological trough and an approaching cold front both helped produce thunderstorms, some locally severe, across central and southern New Jersey in the evening of May 14. |
| May 31, 2010 | Severe Thunderstorm | Mercer | A severe thunderstorm formed near a warm front in Mercer County in the afternoon and early evening on May 31. A lightning strike caused a power failure at the Lawrence Township Police Department. |
| June 1, 2010 | Lightning Strike | Monmouth | The Shores High Rise Condominium (two twelve-story buildings) were evacuated for three days after a lightning strike struck one of the towers and knocked out the sprinkler system pump. |
| June 24, 2010 | Severe Thunderstorm | Atlantic, Burlington, Cumberland, Gloucester, Salem | Severe thunderstorms caused considerable tree damage during the afternoon into the early evening on June 24, across the southern third of New Jersey and claimed the life of one woman and injured two other persons in Burlington County. About 130,000 PSE&G and 65,000 Atlantic City Electric customers lost power. A lightning strike caused an apartment fire at the Campus Crossings Apartments in Glassboro. |
| June 28, 2010 | Lightning Strike | Cape May, Ocean | A lightning strike damaged a chimney in Lavallette. A lightning strike set a pole on fire in Ship Bottom. The combination of lightning strikes and strong winds caused numerous outages on Long Beach Island. |
| July 10, 2010 | Lightning Strike | Morris | Lightning struck a power line in Jefferson Township and caused about 2,000 homes to lose power at around 9 a.m. |
| July 13, 2010 | Lightning Strike | Monmouth | Two lightning strikes caused about 8,200 homes and businesses to lose power in Ocean Township. |
| July 14, 2010 | Lightning Strike | Burlington | A 46-year-old and a 37-year-old man camping in Rancocas State Park were injured after being struck by lightning. |
| July 19, 2010 | Severe Thunderstorm | Bergen, Camden, Monmouth | A lee side trough triggered and maintained a line of severe thunderstorms across central and southern New Jersey in the morning of July 19. A 49-year-old man was struck and killed by lightning on Linden Avenue in Middletown. A lightning strike set the attic of a house on fire on Monmouth Parkway in Middletown Township and struck an attached garage on a house along Colonial Road in Emerson. |
| July 23, 2010 | Thunderstorm | Bergen, Passaic | Severe storms, including an isolated supercell moved southeast into the region. These thunderstorms produced heavy rain and flash flooding and impacted most of Northeast New Jersey. |
| July 29, 2010 | Lightning Strike | Ocean | A lightning strike caused two pole fires and power outages on Long Beach Island in Harvey Cedars. |
| August 12, 2010 | Thunderstorm | Salem | A shower and thunderstorm complex that moved through the southern part of New Jersey caused a barn fire. |

| Date(s) of Event | Event Type | Counties Affected | Impacts |
|---|---|---|---|
| August 16, 2010 | Thunderstorm | Bergen, Hudson | An approaching cold front triggered isolated severe thunderstorms, which impacted Bergen and Hudson Counties. |
| September 22, 2010 | Severe Thunderstorm | Hunterdon, Mercer, Middlesex, Monmouth, Somerset, Warren | A complex of showers and strong to locally severe thunderstorms preceding a cold frontal passage caused wind damage mainly in the central and northern part of New Jersey. A lightning strike caused a transformer fire on Easton Avenue in Montgomery Township. A lightning strike caused a transformer fire on Easton Avenue in Montgomery Township. |
| October 11, 2010 | Severe Thunderstorm | Camden, Morris, Sussex | Severe thunderstorms formed in the evening of October 11, in central and northern New Jersey. Lightning struck the electrical box in the front of one home in Hopatcong and ignited a fire that engulfed the unoccupied dwelling. |
| February 25, 2011 | Thunderstorm | Burlington, Camden, Gloucester, Ocean | A strong cold frontal passage in the afternoon of February 25, triggering a squall line of strong to severe thunderstorms that moved through central and southern New Jersey. |
| April 12, 2011 | Thunderstorm | Essex | A cold pool of air triggered thunderstorms across northeast New Jersey, with one lightning strike near Newark. |
| April 16, 2011 | Thunderstorm | Cape May, Cumberland, Ocean | Thunderstorms that moved across extreme southern New Jersey exacerbated the ongoing strong synoptic scale southeast winds already in place in the evening of April 16 and produced wind damage. In addition, a lightning strike caused damage to a home in Ocean County. |
| May 30, 2011 | Lightning Strike | Monmouth | A lightning strike in Brielle downed some wires. Five hundred homes and businesses lost power for six and a half hours. |
| June 17, 2011 | Lightning Strike | Middlesex, Monmouth, Somerset | Lightning caused about 8,300 homes and businesses to lose power during the morning in Somerset and Middlesex Counties. |
| June 24, 2011 | Severe Thunderstorm | Mercer, Middlesex, Monmouth, Ocean | An approaching cold front triggered scattered strong to locally severe thunderstorms in central New Jersey in the afternoon and early evening of June 24. One person was struck and injured by lightning in Ocean Township. Two people were struck and injured by lightning in Plainsboro Township. |
| July 3, 2011 | Severe Thunderstorm | Atlantic, Hunterdon, Middlesex, Monmouth, Ocean, Sussex | A warm front acted as a focus for strong to severe thunderstorms in the early morning of July 3 in northwestern New Jersey and in the late afternoon and early evening of July 3 across central New Jersey. A 54-year-old male was struck and killed by lightning while ducking under a tree during a thunderstorm to light a cigar in Hammonton. |
| July 6, 2011 | Severe Thunderstorm | Burlington, Mercer, Middlesex, Monmouth, Ocean | Scattered strong to severe thunderstorms developed along a lee side trough and affected central New Jersey in the late afternoon and early evening on July 6. A lightning strike took down two wires on the property of the Crystal Springs Aquatic Center in East Brunswick Township. |

| Date(s) of Event | Event Type | Counties Affected | Impacts |
|---|---|---|---|
| July 7, 2011 | Severe Thunderstorm | Atlantic, Burlington, Camden, Cape May, Hunterdon, Monmouth, Ocean | A cold front helped trigger numerous severe thunderstorms in the afternoon and into the evening on July 7. A lightning strike started a house fire in Ocean View (Dennis Township). Lightning struck and injured a man standing on a porch during a thunderstorm on Townhouse Lane in Little Egg Harbor Township. For the third time in 2011, the water treatment plant in Allentown Borough was struck by lightning. |
| July 19, 2011 | Severe Thunderstorm | Atlantic, Camden, Cumberland, Gloucester, Salem | Strong to locally severe thunderstorms occurred in the late afternoon and into the evening on July 19 in southern New Jersey. Hardest hit by the severe thunderstorms were Cumberland and Gloucester Counties. Lightning struck and the ensuing fire damaged a home in Folsom Borough. Lightning struck a home in Franklin Township. |
| July 29, 2011 | Severe Thunderstorm | Atlantic, Burlington, Mercer, Monmouth, Ocean | An approaching cold front helped trigger strong to severe thunderstorms across central and northern New Jersey in the early evening on July 29. Hardest hit were Sussex, Burlington and Ocean Counties. About 37,000 PSE&G customers lost power. A pair of lightning strikes caused house fires in Willingboro Township. A lightning strike started an attic fire at a house on Melissa Court in Moorestown. A lightning strike started a fire at an occupied structure at the intersection of Ford Road and U.S. Route 9 in Howell Township. |
| August 1, 2011 | Severe Thunderstorm | Atlantic, Burlington, Camden, Cumberland, Gloucester, Monmouth, Salem | An approaching cold front triggered strong to severe thunderstorms mainly across the southern half of New Jersey in the late afternoon and early evening on August 1. A 32-year-old man was struck and seriously injured by lightning while on a beach in Sandy Hook. |
| August 9, 2011 | Severe Thunderstorm | Gloucester, Monmouth, Salem | A warm front helped trigger some strong to locally severe thunderstorms and also one confirmed tornado across central and southern New Jersey in the afternoon on August 9. Lightning struck the television antenna of a home on Ayers Avenue in North Plainfield. |
| August 14, 2011 | Thunderstorm | Camden, Cumberland, Monmouth, Salem | In addition to the flash flooding rains, thunderstorms affected New on August 14. A lightning strike and ensuing fire badly damaged a Maxim Road home in Howell. |
| August 18, 2011 | Severe Thunderstorm | Cape May, Cumberland, Gloucester, Morris, Ocean, Monmouth | An upper air disturbance coupled with a surface trough helped trigger strong to locally severe thunderstorms from the late afternoon through the night in New Jersey. A house was struck by lightning in Brick Township. |
| August 19, 2011 | Severe Thunderstorm | Bergen, Burlington, Camden, Essex, Hunterdon, Mercer, Middlesex, Morris, Passaic, Somerset, Warren | A passing mid-level disturbance triggered severe thunderstorms that produced large hail, damaging winds and lightning strikes across Bergen, Essex, Hudson, and Passaic Counties. Several homes were reported struck by lightning in the town of Bergenfield. A lightning strike ignited a fire at a house on York Street in Lambertville. |
| August 21, 2011 | Thunderstorm | Burlington, Monmouth, Morris, Warren | A series of thunderstorms that preceded and accompanied a lee side trough and a cold front produced strong to locally severe thunderstorms mainly during the afternoon in New Jersey. A lightning strike to one of its water towers on Union Lane caused Brielle Borough to declare an emergency on August 21. |
| September 15, 2011 | Lightning Strike | Atlantic County | A 40-year-old male construction worker was killed and two others were injured after they were struck by lightning while working on the Revel Casino Project in Atlantic City |

| Date(s) of Event | Event Type | Counties Affected | Impacts |
|---|---|---|---|
| | | | off of Connecticut Avenue. |
| June 7, 2012 | Thunderstorm | Atlantic County | A thunderstorm with small hail started after the outdoor graduation ceremony began at Absegami High School in Galloway Township causing panic as people left the ceremony and made dashes for shelter. |
| June 22, 2012 | Severe Thunderstorm | Atlantic, Burlington, Cumberland, Hunterdon, Middlesex, Monmouth, Morris, Ocean, Sussex, Warren | Scattered strong to severe thunderstorms developed along a sea breeze front and also ahead of an approaching cold front, producing pockets of very heavy rain and some wind damage across parts of New Jersey. Lightning from a thunderstorm struck and injured a person at Fort Hancock at 2:30 pm on June 22. Lightning struck ten other buildings at the Gateway National Recreational Area at Sandy Hook, but no serious damage was reported. |
| June 25, 2012 | Severe Thunderstorm | Mercer, Middlesex, Monmouth, Ocean | An approaching cold front helped trigger strong to locally severe thunderstorms in two waves across central and southern New Jersey. Lightning struck a house on Washington Avenue in Middletown Township. The homeowner smelled an odor after the lightning struck a metal french door. |
| June 30, 2012 | Lightning Strike | Atlantic, Cape May, Cumberland, Gloucester, Ocean, Salem | In the early morning hours on June 30, a severe line of storms packing intense lightning and damaging winds swept through Southern New Jersey. The storms, known as derechos, are essentially an intense line of storms characterized by a bowed “C” shape. This particular derecho began in Chicago and grew in intensity as it moved east. The storms packed intense lightning and high winds gusting to 74 miles per hour. The hardest hit counties were Atlantic and Salem where widespread damage was reported. |
| July 4, 2012 | Lightning Strike | Burlington, Monmouth, Ocean | Lightning struck a transformer and downed a couple of wires. The downed wires caused a brief fire. |
| July 7, 2012 | Severe Thunderstorm | Hunterdon, Middlesex, Monmouth, Ocean, Somerset | A complex of strong to severe thunderstorms moved through the central third of New Jersey in the early evening on July 7. Lightning strikes on Long Beach Island resulted in about 8,000 homes and businesses losing power in Barnegat Light, Loveladies, Harvey Cedars and Beach Haven |
| July 18, 2012 | Lightning Strike | Hunterdon, Middlesex, Monmouth, Sussex | A lightning strike and subsequent fire forced the evacuation of six condominium units in the Hunters Crossing Development on Nuthatch Court in Readington Township. |
| July 23, 2012 | Lightning Strike | Morris, Somerset, Sussex | A lightning strike injured two campers in Sandyston Township. The bolt struck a pine tree and traveled into the foundation of a cabin at the Lindley C. Cook 4H Camp in Stokes State Forest. |
| July 24, 2012 | Lightning Strike | Cape May, Salem | Lightning struck and damaged a transformer in Pennsville Township. |
| July 28, 2012 | Severe Thunderstorm | Atlantic, Burlington, Cape May, Cumberland, Mercer, Middlesex, Monmouth, Morris, Salem, Warren | Pulse-type severe thunderstorms caused scattered wind damage in New Jersey in the afternoon and evening of July 28. Over 43,000 homes and businesses lost power in the state. A lightning strike and ensuing fire damaged a house on West 25th Avenue in North Wildwood. |

| Date(s) of Event | Event Type | Counties Affected | Impacts |
|---|---|---|---|
| August 1, 2012 | Lightning Strike | Cape May | A family of four people suffered minor injuries from a lightning strike on the beach in Wildwood off of East Cedar Avenue. They were under a beach umbrella when lightning struck nearby. |
| August 5, 2012 | Lightning Strike | Burlington, Middlesex, Monmouth, Sussex | A house was struck by lightning on Madison Avenue. No serious damage or injuries were reported. |
| August 9, 2012 | Lightning Strike | Hunterdon, Mercer, Middlesex | A lightning strike and ensuing fire damaged an attic of a home under construction on Jefferson Road in Princeton. |
| August 9, 2012 | Severe Thunderstorm | Atlantic, Camden, Cumberland, Gloucester, Salem | A storm knocked out power to thousands, and killed two people. Atlantic County, Vineland and other New Jersey towns and counties declared states of emergency, which restricted travel in some areas so crews could clear debris and assess damage caused by the storm. The hardest counties were: Atlantic, Camden, Cumberland, Gloucester, and Salem Counties in Southern New Jersey. |
| August 15, 2012 | Lightning Strike | Cumberland, Monmouth, Passaic, Sussex | A 41-year-old male was struck and died the next day from a lightning strike while fishing with his 10-year-old son on Takanassee Lake Beach in Long Branch. His son was not injured. |
| September 4, 2012 | Lightning Strike | Burlington, Camden, Morris, Sussex | A lightning strike caused 700 homes to lose power in Parsippany. |
| September 7, 2012 | Lightning Strike | Bergen | A 71-year-old man was injured by lightning at Northern Valley Regional High School. |

*Source: NCDC 2013; Chang 2012; Giambusso 2012*
*PSE&G Public Service and Electric*

## Hailstorms

Hailstorms, like thunderstorms, occur as a routine part of severe weather in New Jersey. The potential for hail exists all over New Jersey. There are at least a few incidences each year, but they are minor. New Jersey has a relatively low potential for significant hail events, based on previous records.

Many sources provided historical information regarding previous occurrences and losses associated with hail events throughout the State. 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.

The 2011 Plan did not discuss specific hailstorm events; however, the Plan did summarize hailstorm events between 1950 and 2009. For this 2014 Plan update, hailstorm events in New Jersey that occurred between January 1, 2010, and December 31, 2012 were summarized. Table 5.10-12 summarizes the events from the 2011 Plan and incorporates events from 2010 to 2012, by county. The tables may not include all incidents. There were no deaths or injuries associated with these hailstorm events.

**Table 5.10-12. Hailstorm Events Summary, 1950 to 2012**

| County | # Reported Incidents | Property Damage | Crop Damage |
|---|---|---|---|
| Atlantic | 35 | $10,000 | $5,010,000 |
| Bergen | 32 | $0 | $0 |
| Burlington | 83 | $0 | $0 |
| Camden | 40 | $0 | $2,000 |
| Cape May | 26 | $0 | $0 |
| Cumberland | 23 | $75,000 | $0 |
| Essex | 23 | $0 | $0 |
| Gloucester | 37 | $0 | $5,000,000 |
| Hudson | 18 | $0 | $0 |
| Hunterdon | 32 | $0 | $100,000 |
| Mercer | 36 | $0 | $0 |
| Middlesex | 30 | $10,000 | $0 |
| Monmouth | 35 | $0 | $0 |
| Morris | 35 | $0 | $0 |
| Ocean | 55 | $1,000 | $0 |
| Passaic | 24 | $0 | $0 |
| Salem | 18 | $250,000 | $5,000,000 |
| Somerset | 29 | $100,000 | $1,000 |
| Sussex | 40 | $0 | $1,000 |
| Union | 19 | $0 | $0 |

| County | # Reported Incidents | Property Damage | Crop Damage |
|---|---|---|---|
| Warren | 22 | $0 | $0 |
| Statewide Total | 692 | $446,000 | $15,114,000 |

*Source: NOAA-NCDC 2013*

## Extreme Temperatures

New Jersey has been experiencing an increase in extreme temperatures across the State. Historically, there has been an increase in temperature during the warmest months in New Jersey, with the majority of the extreme heat months occurring after 1990. Conversely, the months which set records for extreme cold temperatures tended to occur prior to 1930.

Many sources provided historical information regarding previous occurrences and losses associated with extreme temperature events throughout the State. 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.

The 2011 Plan did not discuss specific extreme temperature events; therefore, for this 2014 Plan update, extreme heat and cold events were summarized for events that occurred in the three years between January 1, 2010, and December 31, 2012. Table 5.10-13 summarizes the events from data provided by the ONJSC and events from 2010 to 2012. The table may not include all incidents.

The extreme temperature events of the three years from January 2010 through December 2012 show 21 incidences of temperature extremes that occurred Statewide and one six-day heat and humidity incident that affected Central and Southern New Jersey. Of the 22 incidents, 19 were extreme heat related and covered 49 total days of high temperatures plus a record-heat month. Three incidents involved six days of extreme cold are cited Statewide over the past three years.

**Table 5.10-13. Extreme Temperature Events in New Jersey**

| Date(s) of Event | Event Type | Counties Affected | Description |
|---|---|---|---|
| July 15, 1995 | Excessive Heat | Statewide | Heat index reached 128°F in Newark when the temperature reached 103°F and the dew point reached 84°F. There were 16 hours with the heat index ≥100°F, 12 hours of ≥110°F, and three hours of ≥120°F. ONJSC stated that this was the most uncomfortably hot day at Newark since weather observations began to be collected in the early 1930s. |
| July 5, 1999 | Excessive Heat | Statewide | The index was ≥100°F for 14 hours, ≥105°F for nine hours, and ≥110°F for four hours. This culminated with the July 4 to 7 period of having 58 hours with a heat index ≥90°F, with never more than four consecutive hours of less than 90°F. |
| January 27 to 28, 2000 | Extreme Cold | Statewide | Temperatures ranged from 9°F to 14°F |
| May 2 to 4, 2001 | Extreme Heat | Statewide | Temperatures ranged from 89°F to 96°F |
| February 5 to 7, 2007 | Extreme Cold | Statewide | Temperatures ranged from -4°F to 12°F |
| June 26 to 28, 2007 | Extreme Heat | Statewide | Temperatures ranged from 92°F to 96°F |
| July 8 to 10, 2007 | Extreme Heat | Statewide | Temperatures ranged from 93°F to 100°F |
| August 7 to 8, 2007 | Extreme Heat | Statewide | Temperatures ranged from 93°F to 101°F |
| August 25, 2007 | Extreme Heat | Statewide | Temperatures ranged from 91°F to 94°F |
| June 7 to 10, 2008 | Extreme Heat | Statewide | Temperatures ranged from 92°F to 100°F |
| July 16 to 22, 2008 | Extreme Heat | Statewide | Temperatures ranged from 93°F to 98°F |
| August 10, 2009 | Extreme Heat | Statewide | Temperatures ranged from 93°F to 104°F |
| June 23 to 24, 2010 | Extreme Heat | Statewide | Temperatures ranged from 97°F to 99°F |
| June 27 to 28, 2010 | Extreme Heat | Statewide | Temperatures ranged from 95°F to 99°F |
| July 4 to 7, 2010 | Extreme Heat | Statewide | Temperatures ranged from 90°F to 105°F. One fatality was reported from this event. In Newark, four straight days of temperatures ≥100°F (101°F, 102°F, 103°F, and 101°F respectively). This led to 65 consecutive hours of temperatures of ≥80°F. The low temperature on July 6 was 84°F. |
| January 24, 2011 | Extreme Cold/Windchill | Statewide | An arctic high pressure system brought in the coldest air mass of the season to New Jersey. Many places saw morning lows that were the coldest during that winter. Northwest winds produced wind chill factors below zero in most of the State. Sussex County experienced a wind chill of -15°F. Actual low temperatures in the Raritan Basin and northwest New Jersey were below 0°F. Temperatures throughout the State ranged from -14°F in Warren County to 9°F in Cape May County. |

| Date(s) of Event | Event Type | Counties Affected | Description |
|---|---|---|---|
| July 21 to 24, 2011 | Heat Wave | Statewide | One of the most oppressive heat waves since July 1995. It caused two deaths and hundreds of heat-related injuries. Many locations had high temperatures that were in excess of 100°F. July 22 was the hottest, with heat index values of 110°F to 120°F. Many counties and municipalities opened cooling centers for its residents. Temperatures ranged from 100°F in Cumberland and Cape May Counties, to 106°F in Mercer County. |
| March 2012 | Record Warmth | Statewide | The warmest March in history, breaking nearly 15,000 warm temperature records. |
| June 20 to 22, 2012 | Heat Wave | Statewide | A three-day heat wave occurred throughout the entire State, bringing temperatures between 94°F and 99°F. The heat wave broke dramatically when a series of severe thunderstorms impacted New Jersey. |
| June 29, 2012 | Extreme Heat | Statewide | An unseasonably hot and humid day produced high temperatures in the mid to upper 90s in most of New Jersey. Maximum hourly heat indices reached between 100°F and 105°F. High temperatures ranged from 93°F in Hunterdon, Warren, Cape May and Atlantic Counties, to 99°F in Burlington County. |
| July 2 to 7, 2012 | Excessive Heat and High Humidity | Central and Southern New Jersey | Temperatures ranged from 90°F to 101°F between July 2 and 7, peaking on July 7 with high temperatures around 100°F and afternoon hourly heat indices peaking around 105°F. |
| July 17 to 18, 2012 | Extreme Heat | Statewide | Temperatures ranged from 97°F in Sussex County, to 102°F in Morris, Ocean and Camden Counties. |

*Source: NOAA-NCDC 2013; ONJSC Rutgers University 2013a*
*°F degrees Fahrenheit*

## FEMA Disaster Declarations

Between 1954 and 2012, FEMA declared that the State of New Jersey experienced 14 severe storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, high tides, flooding, high winds, heavy rain, hail, tornadoes, and mudslides. Generally, these disasters cover a wide region of the State; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2013).

Table 5.10-14 identifies known severe storm events that have affected New Jersey and were declared a FEMA disaster. This table provides information on the FEMA disaster declarations for severe storms, including the disaster number, disaster type, declaration and incident dates, and counties included in the declaration. Figure 5.10-29 illustrates the number of FEMA declared disasters by county.

Detailed information about the declared disasters is provided in Appendix D of this Plan.

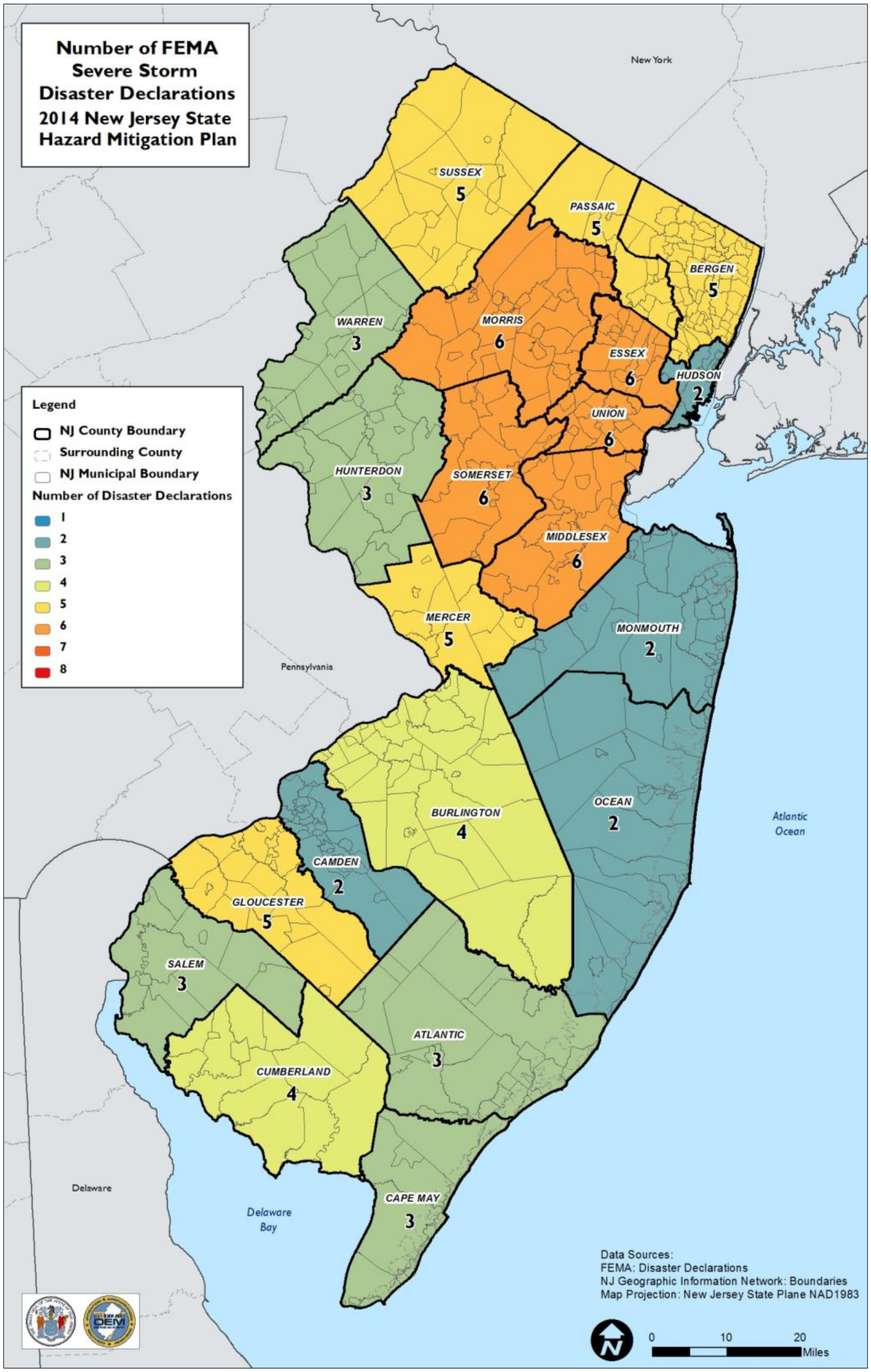
## Table 5.10-14. Severe Weather-Related FEMA Disaster Declarations by County (1954 to 2012)

| Disaster # | Disaster Type | Declaration Date | Incident Period | Atlantic | Bergen | Burlington | Camden | Cape May | Cumberland | Essex | Gloucester | Hudson | Hunterdon | Mercer | Middlesex | Monmouth | Morris | Ocean | Passaic | Salem | Somerset | Sussex | Union | Warren | Number of Counties Impacted Per Disaster |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DR-142 | Severe Storms, High Tides, Flooding | 3/9/1962 | 3/9/1962 | Unknown | | | | | | | | | | | | | | | | | | | | | |
| DR-402 | Severe Storms, Flooding | 8/7/1973 | 8/7/1973 | | | | | | | X | | | | | X | | | | | | X | | X | | 4 |
| DR-477 | Heavy Rains, High Winds, Hail, Tornadoes | 7/23/1975 | 7/23/1975 | | X | X | | | X | X | X | | | X | X | | X | | X | X | X | X | X | | 13 |
| DR-519 | Severe Storms, High Winds, Flooding | 8/21/1976 | 8/21/1976 | X | | | | X | | | | | | | | X | | X | | | | | | | 4 |
| DR-1145 | Severe Storms/Flooding | 11/19/1996 | 10/18/1996 – 10/23/1996 | | | | | | | | | X | | | X | | X | | | | X | | X | | 5 |
| DR-1337 | Severe Storms, Flooding, and Mudslides | 8/17/2000 | 8/12/2000 – 8/21/2000 | | | | | | | | | | | | | | X | | | | | X | | | 2 |
| DR-1530 | Severe Storms and Flooding | 7/16/2004 | 7/12/2004 – 7/23/2004 | | | X | X | | | | | | | | | | | | | | | | | | 2 |
| DR-1588 | Severe Storms and Flooding | 4/19/2005 | 4/1/2005 – 4/3/2005 | | X | | | | | X | X | | X | X | | | X | | X | | | X | | X | 9 |
| DR-1653 | Severe Storms and Flooding | 7/7/2006 | 6/23/2006 – 7/10/2006 | | | | | | | | | | X | X | | | | | | | | X | | X | 4 |
| DR-1694 | Severe Storms and Inland Coastal Flooding | 4/26/2007 | 4/14/2007 – 4/20/2007 | | X | X | X | | | X | X | X | | X | X | | X | | X | | X | | X | | 12 |
| DR-1897 | Severe Storms and Flooding | 4/2/2010 | 3/12/2010 – 4/15/2010 | X | X | X | | X | X | X | X | | | X | X | X | X | X | X | | X | | X | | 15 |
| DR-4033 | Severe Storms and Flooding | 8/15/2011 | 8/13/2011 | | | | | | X | | X | | | | | | | | | X | | | | | 3 |
| DR-4048 | Severe Storm | 11/30/2011 | 10/29/2011 | | X | | | X | | X | | | X | | X | | | | X | | X | X | X | X | 10 |
| DR-4070 | Severe Storms and Straight Line Winds | 7/19/2012 | 6/30/2012 | X | | | | | X | | | | | | | | | | | X | | | | | 3 |

*Note: Disaster number is issued by FEMA*

*FEMA Federal Emergency Management Agency*

**Figure 5.10-29. Number of FEMA Severe Weather-Related Disaster Declarations (1954 to 2012)**




*Source: FEMA 2013*

*FEMA Federal Emergency Management Agency*

## Probability of Future Occurrences

### High Wind

High wind events will occur regularly as part of severe weather events in the State. As noted in the previous occurrences section, high wind events occur annually, and in most cases several times per year across the State.

### Tornadoes

Tornadoes occur approximately one to three times per year in New Jersey. Generally these events will be rather minor and will not cause significant damage.

### Thunderstorms

Like high wind storms, thunderstorms occur in regular intervals as part of normal weather systems in New Jersey. During the summer months some thunderstorms may be severe and could cause significant damage. Thunderstorms often occur in conjunction with other severe hazards such as hail and damaging winds.

### Hailstorms

Hailstorms occur regularly but not at the frequency or intensity of thunderstorms across the State. Furthermore, damaging storms that produce golf ball or larger sized hail do not occur every year in New Jersey like they do in many central United States.

### Extreme Temperatures

Extreme temperatures are predicted to occur more frequently as part of regular seasons. Specifically, extreme heat may continue to impact New Jersey and, based upon data presented, may increase in the next several decades. Figure 5.10-3 indicates that many heat records have been set in the last 10 to 15 years. This trend is predicted to continue. On the other hand, record-setting cold temperatures are decreasing. This trend may likely continue.

## Severity

### High Wind

High wind storms cause disruptions to power and have the potential to damage structures in the State. High winds storms also have the potential to knock down tree limbs which subsequently damage power and other utility lines thus contributing to widespread power outages. High wind storms are often accompanied by other events such as thunderstorms, or part of hurricane and tropical storms. The worst case scenario for a high wind event includes widespread power outages to populated cities and municipalities.

### Tornadoes

Tornadoes are nature’s most violent storms. They are spawned from thunderstorms and can cause fatalities and devastate a neighborhood in seconds. Winds can reach 300 mph and damage paths can be in excess of one mile wide and 50 miles long. Every state in the United States is at some risk from tornadoes (FEMA 2013).

### Thunderstorms

The most common problems associated with severe storms are immobility and loss of utilities. Fatalities are uncommon, but can occur due to lightning strikes. Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may be disrupted. Lightning can cause severe damage and injury. Wind storms can be a frequent problem and have caused damage to utilities. Wind storms, as mentioned previously, may occur as part of thunderstorms or independently. The predicted wind speed given in wind warnings issued by the NWS is for a one-minute average; gusts may be 25 to 30% higher.

### Hailstorms

The severity of hail is measured by duration, hail size, and geographic extent. All of these factors are directly related to thunderstorms, which creates hail. There is wide potential variation in these severity components. The most significant impact of hail is damage to crops. Hail also has the potential to damage structures and vehicles during hailstorms. The State has a relatively low potential for significant hail events, based on previous records.

### Extreme Temperatures

The Wind Chill Temperature (WCT) Index is one of the means used to measure the severity of cold temperatures. Wind Chill Temperature is the temperature that people and animals feel and it is based on the rate of heat loss from exposed skin from the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop. The severity of extreme heat temperatures are generally measured through the Heat Index. The Heat Index can be used to determine what effects the temperature and humidity can have on the population. Detailed information regarding the WCT and Heat Index is discussed earlier in this section.

## Warning Time

### High Winds

The NWS issues watches and warning for high wind storms and also severe thunderstorms that may cause damaging winds. Additionally, the NWS issues marine weather messages consisting of small craft advisories when conditions are suitable for producing high wind incidents. Like the prediction of thunderstorms and other severe weather events, the NWS can provide accurate forecasts several days prior to an event.

### Tornadoes

A tornado watches and warning is issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes; however, warning times for New Jersey may be shorter due to the fact that the State experiences smaller tornadoes that are difficult to warn for. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NOAA 2013; FEMA, 2013; Robinson 2013).

### Thunderstorms

Meteorologists can often predict the likelihood of a severe thunderstorm. This can give several days warning. However, meteorologists cannot predict the exact time of onset, specific location, or the severity of the storm. Some storms may come on more quickly and have only a few hours of warning time.

### Hailstorms

Like high wind events and thunderstorms, meteorologists can forecast the potential of hailstorms, often giving several hours of notice that hail may form. In addition, meteorologists can give live updates during severe weather to indicate areas that are experiencing or will experience hail. Since hailstorms often occur as part of other events, such as thunderstorms, forecasts for hailstorms may be available several days in advance.

### Extreme Temperatures

Meteorologists can accurately forecast extreme temperature event development and the severity of the associated conditions with several days lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations. For heat events, the NWS issues excessive heat outlooks when the potential exists for an excessive heat event in the next three to seven days. Watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. Excessive heat warning/advisories are issued when an excessive heat event is expected in the next 36 hours (NWS 2013). Winter temperatures may fall to extreme cold readings with no wind occurring. Currently, the only way to headline very cold temperatures is with the use of the NWS-designated Wind Chill Advisory or Warning products. When actual temperatures reach Wind Chill Warning criteria with little to no wind, extreme cold warnings may be issued (NOAA 2013).

## Secondary Hazards

### High Winds

The most significant secondary hazard of high wind storms is utility failure resulting from downed power lines and tree branches. As noted, high wind storms can cause localized or regional power outages, thus leading to exposure extreme temperatures for vulnerable populations. An example was the widespread power outages following Superstorm Sandy and the exceptionally cold temperatures which led counties to open additional shelter place for displaced residents. An additional secondary hazard is traffic accidents that may occur when power to traffic control devices is disrupted.

### Tornadoes

Like high wind storms, tornadoes have the potential to lead to widespread utility failure, thus exposing vulnerable populations to extreme temperatures. Tornado events may also be accompanied by strong thunderstorms, straight line winds, and hail.

### Thunderstorms

Severe thunderstorms, like tornadoes are often accompanied by strong winds and hail. Both of these hazards have the potential to damage critical infrastructure. Additionally, flash flooding, particularly in low lying areas, is a secondary effect of thunderstorms as intense rain often accompanies thunderstorms.

### Hailstorms

Hailstorms, like many of the other hazards discussed, are often accompanied by other severe weather. One secondary effect of hailstorms is the damage to critical infrastructure which in turn may lead to utility failure. Additionally, extreme hailstorms impact traffic route and may lead to transportation accidents.

## Extreme Temperatures

Prolonged extreme temperatures can radically affect the State and cause numerous secondary hazards. Depending on severity, duration and location; extreme heat events can create or provoke secondary hazards including, but not limited to: dust storms, droughts, wildfires, water shortages, and power outages (FEMA, 2006; CDC, 2006). This could result in a broad and far-reaching set of impacts throughout a local area or entire region. Impacts could include: significant loss of life and illness; economic costs in transportation, agriculture, production, energy and infrastructure; and losses of ecosystems, wildlife habitats, and water resources (Meehl and Tebaldi, 2004; CDC, 2006). Extreme cold temperatures create the conditions for secondary effects such as the possibility of snow, ice, and freezing rain.

## Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

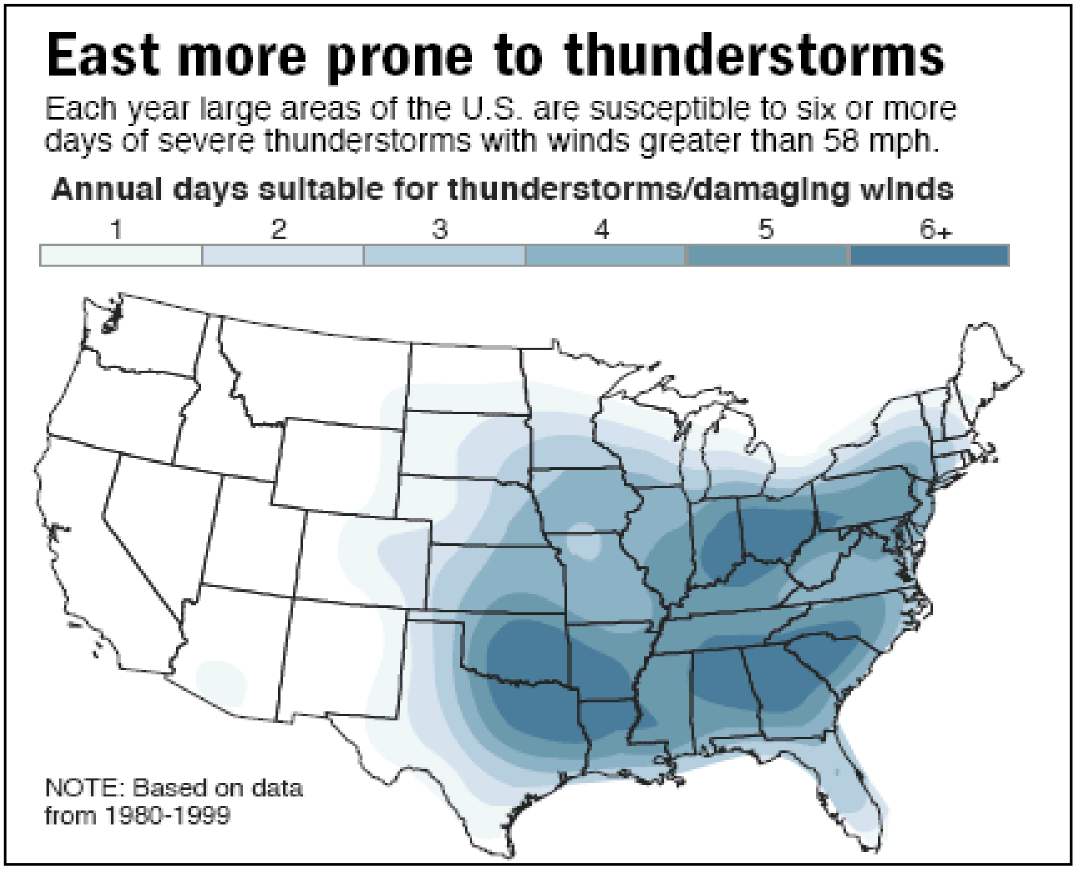
The New Jersey Climate Adaptation Alliance is a network of policymakers, public and private-sector practitioners, academics, non-governmental organizations (NGO), and business leaders aligned to build climate change preparedness in the state of New Jersey. The Alliance is facilitated by Rutgers University, which provides science and technical support, facilitates the Alliance's operations and advances its recommendations. A document titled *Change in New Jersey: Trends and Projections* was developed to identify recommendations for State and local public policy that will be designed to enhance climate change preparedness and resilience in New Jersey (Rutgers 2013).

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12%) greater than the average from 1895-1970. Southern New Jersey became two inches (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by five-percent by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NYCPCC] 2009).

National Aeronautics and Space Administration (NASA) scientists suggest that the United States will face more severe thunderstorms in the future, with deadly lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change (NASA 2007). As prepared by the NWS Figure 5.10-30 identifies those areas, particularly within the eastern United States, that are more prone to thunderstorms, including New Jersey (NWS 2010).

**Figure 5.10-30. Annual Days Suitable for Thunderstorms/Damaging Winds**




*Source:* *Borenstein, 2007*
mph miles per hour

The increase in the number of extreme heat days will lead to more heat related illness. Also, with an increase in severe storms there will be an increase in stormwater runoff which may be polluted and sicken individuals (Kaplan and Herb 2012). The effect on public health will likely increase the need for vulnerable population planning and may place heavier burdens on the healthcare system.

## 5.10.2 Vulnerability Assessment

To understand risk, the assets exposed to hazards must be identified. Certain areas are more vulnerable to specific severe weather events than others due to geographic location and local weather patterns. For severe weather, the entire State of New Jersey may be exposed. Therefore, all State assets are potentially vulnerable.

### Assessing Vulnerability by Jurisdiction

Historically, severe weather events have impacted all 21 New Jersey counties. All local hazard mitigation plans identified severe weather as a hazard of concern. Refer to Table 5.1-2 in Section 5.1 (State Risk Assessment Overview) for further information on the local mitigation plans. Of the five local mitigation plans that ranked risk into high/medium/low categories for this hazard, all considered the severe weather hazard to be high risk. These plans were for the following counties: Cape May, Essex, Hudson, Monmouth, and Somerset counties.

For the purposes of this 2014 Plan update, the entire population of New Jersey is exposed to severe weather events. Residents may be displaced or require temporary to long-term sheltering due to severe weather events. 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.

The continued development of the state will increase the overall vulnerability to severe storm hazards. Any new development in Atlantic, Bergen, Burlington, Cape May, Camden, Cumberland, Essex, Hudson, Gloucester, Middlesex, Monmouth, and Union Counties are vulnerable to winds over 100 mph. The development of new buildings in these areas must meet or exceed the standards in Section R301.2.1.1 of the International Building Code (IBC). Based on previous occurrences of tornado touchdowns, generally the Interstate 95 corridor in New Jersey may be more vulnerable to tornado activity than other areas. New development in close proximity to this corridor has the potential to increase the number of people vulnerable to the hazards associated with tornadoes. Development that expands the densely developed urban centers has the potential to increase the vulnerability to extreme heat events due to the heat island effect.

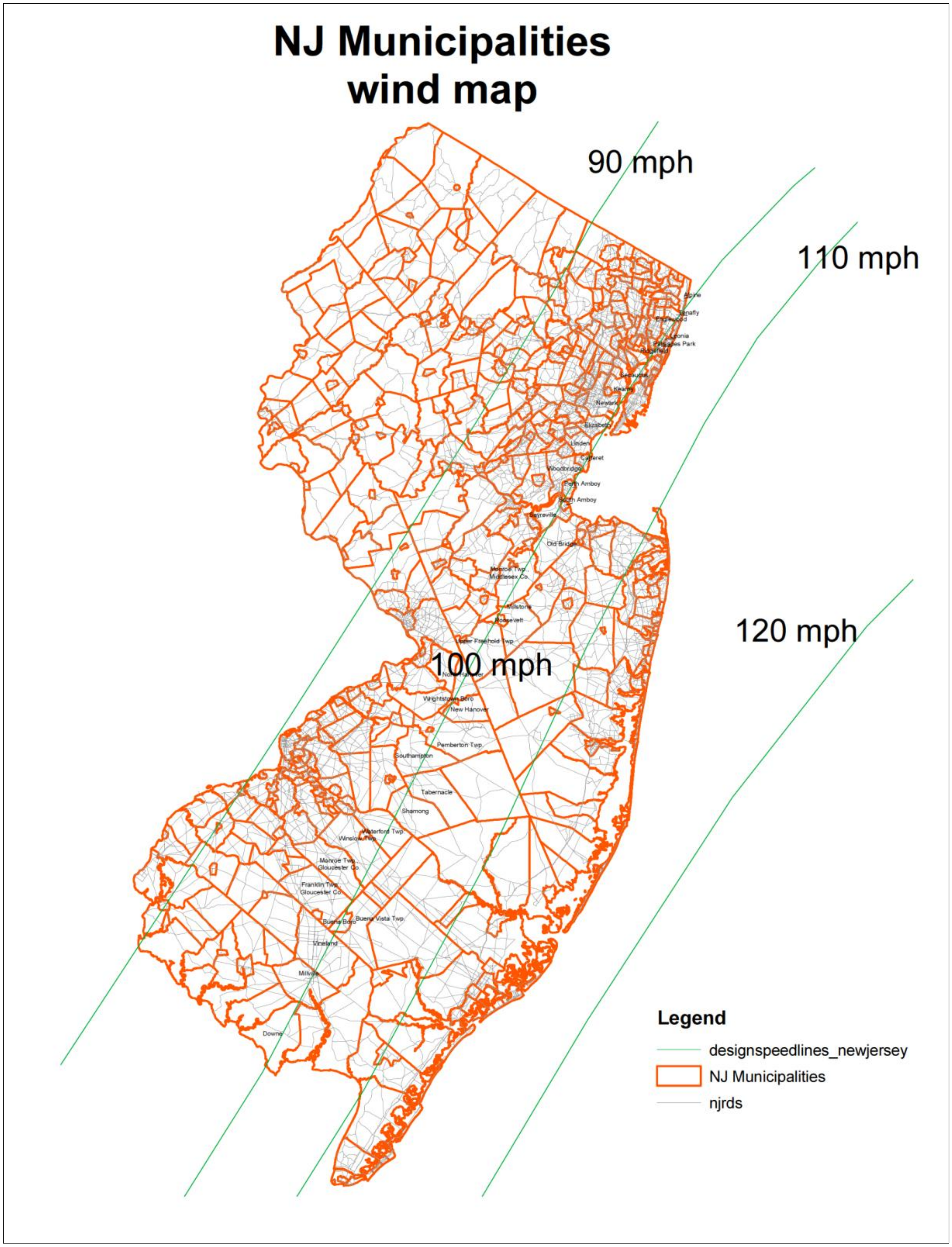
The summary below describes the vulnerability for each severe weather type.

#### High Winds

The entire population of the State is considered exposed to high wind events. Wind speeds for the 50-year mean recurrence interval were determined based on three-second gusts in mph at 33 feet above the ground. Refer to Figure 5.10-31 below. For the 50-year wind event, the portions of the following 12 coastal counties may experience wind speeds greater than 100 miles per hour: Atlantic, Bergen, Burlington, Cape May, Camden, Cumberland, Essex, Hudson, Gloucester, Middlesex, Monmouth, and Union Counties.

According to the Department of Community Affairs, Division of Codes and Standards, the isolines should be used to determine the wind loads used for a structure that would be IBC-compliant. Further, Section R301.2.1.1 (design criteria) of the International Residential Code/2006, as it applies to the New Jersey, requires specific construction design requirements in regions where the basic wind speeds equal or exceed 100 mph (NJDCA 2007).

**Figure 5.10-31. Wind Load Zones in New Jersey for the 50-Year Mean Recurrence Interval**




*Source* *New Jersey Department of Community Affairs 2013*
*mph* miles per hour

## Tornadoes

According to historic record, there have been 144 tornado touch-downs in New Jersey from 1950 to 2012. There has been at least one confirmed tornado touch-down in every county. Table 5.10-15 below summarizes the number of historic confirmed tornado touch-downs in New Jersey from 1950 to 2012.

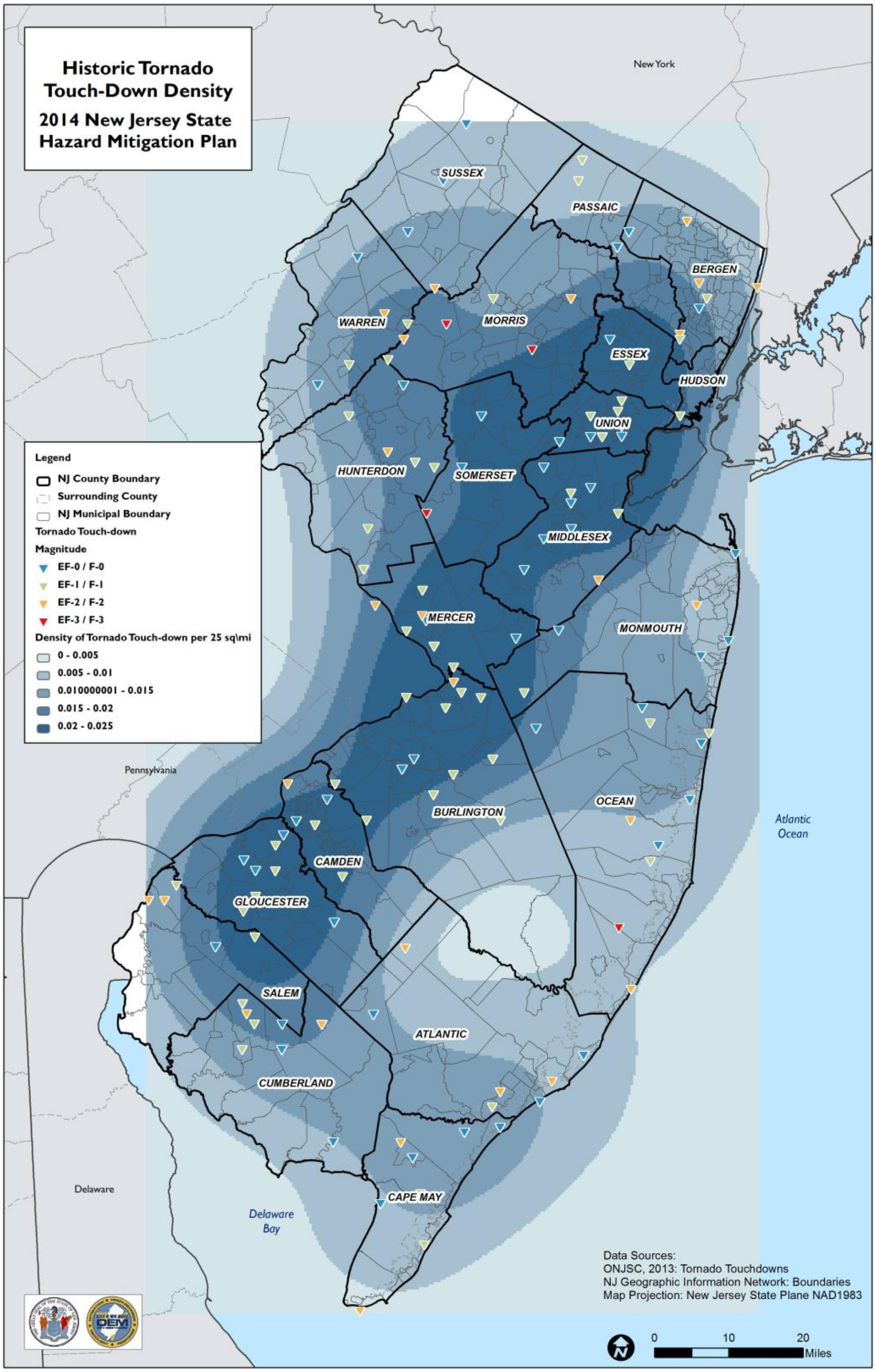
**Table 5.10-15. Number of Historic Confirmed Tornado Touch-Downs in New Jersey (1950 – 2012) by County**

| County | Number of Tornado Touch-downs |
|---|---|
| Atlantic | 7 |
| Bergen | 8 |
| Burlington | 15 |
| Camden | 6 |
| Cape May | 8 |
| Cumberland | 9 |
| Essex | 2 |
| Gloucester | 8 |
| Hudson | 1 |
| Hunterdon | 7 |
| Mercer | 8 |
| Middlesex | 10 |
| Monmouth | 6 |
| Morris | 6 |
| Ocean | 11 |
| Passaic | 3 |
| Salem | 5 |
| Somerset | 4 |
| Sussex | 5 |
| Union | 10 |
| Warren | 5 |
| **Total** | **144** |

*Source: ONJSC Rutgers University 2013a*

Tornado risk and vulnerability for the 2014 Plan update is based on probability of occurrence of past events. As shown in Figure 5.10-32 below, the density per 25 square miles indicates the probable number of tornado touchdowns for each 25 square mile cell within the contoured zone that can be expected over a similar period of record (approximately 60 years). The highest frequency of touch-downs has occurred in a southwest to northeast band across the State. The frequency of tornado touch-downs in New Jersey is heavily biased toward areas where the population density is greatest, as seen in Figure 5.10-32.

## Figure 5.10-32. Total Tornado Events per 25-Square Miles in New Jersey




*Source: ONJSC Rutgers University 2013a*

### Thunderstorms

Lightning strikes primarily occur during the summer months. People outside are considered at risk and more vulnerable to a lightning strike than those inside a shelter. This could be particularly true for the State's shore community, as many lightning strikes occur at the beach.

### Hailstorms

Hail causes considerable damage to United States crops and property, occasionally causes death to farm animals, but seldom causes loss of human life. All counties are considered vulnerable to the effects of hailstorms, but those with farmland and high agricultural yields are more likely to be impacted. According to the 2007 United States Department of Agriculture's Agricultural Census, the counties with the greatest number of farms are: Burlington (922 farms); Hunterdon (1,623 farms); Monmouth (932 farms); Sussex (1,060 farms) and Warren (933 farms) (United States Department of Agriculture 2007). Refer to Section 4 (State Profile) for additional statistics on agriculture in New Jersey.

### Extreme Temperature

In terms of extreme temperature, both extreme heat and extreme cold were examined for this 2014 Plan update. Whether for extreme heat or extreme cold, vulnerable populations include the homeless population, elderly, low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads.

As discussed earlier, extreme heat events account for more loss of life than any other weather event. Those at greatest risk are located in urban areas due to the urban heat island effect. Cities are the most susceptible to the stresses of heat waves due to their large populations, which amplify the effects of heat. The population living in urban areas are also at high risk to poor air quality which may accompany extreme heat events.

Rowan University's Geospatial Research Lab compared and displayed the percent impervious surface across the State in 1986 and 2007. According to this study the amount of urban land has been increasing substantially through 2007. The increases in impervious surfaces associated with urban development have the potential to exacerbate the urban heat island effect.

Prolonged periods of extreme heat may be associated with drought conditions and impact ground and surface water supplies. A discussion on impacts to water resources is discussed further in Section 5.4 (Drought).

Both extreme heat and cold temperature events can negatively impact the agricultural industry. As summarized in Section 4 (State Profile), New Jersey has more than 10,000 farms that produce products valued at $1 billion annually. The counties with the greatest number of farms were discussed above for the hailstorm severe weather type.

As discussed earlier, northwestern, coastal and southern New Jersey experience fewer 100°F or greater days than northeastern and central areas. In terms of extreme cold events, northwestern New Jersey experiences more days of 32°F or colder than the rest of the State.

## Assessing Vulnerability to State Facilities

As the state of New Jersey continues to become more urbanized; the state facilities will need to be developed in locations that will serve the growing population. As discussed above, the development of new state facilities in Atlantic, Bergen, Burlington, Cape May, Camden, Cumberland, Essex, Hudson, Gloucester, Middlesex, Monmouth, and Union Counties could be vulnerable to winds over 100 mph. The development of new state facilities in these areas must meet or exceed the standards in Section R301.2.1.1 of the IBC. Based on previous occurrences of tornado touchdowns, the Interstate 95 corridor in the state may be vulnerable to tornado activity. The development of new state facilities proximate to this corridor has the potential to be more vulnerable to the hazards associated with tornadoes based on historical data. Development of new state facilities in densely developed urban centers may be vulnerable to extreme heat events due to the heat island effect.

## High Winds

Damage to buildings is dependent upon several factors including wind speed and duration, and building construction. Refer to Section 5.8 (Hurricanes/Tropical Storms) for a presentation on potential wind losses associated with 100- and 500-year mean return period events. To assess the vulnerability of high winds to state facilities, a spatial analysis was conducted using the four wind load zones. Generally speaking, structures should be designed to withstand the total wind load of the zone in which they are located. Refer to the State Building Code for appropriate reference wind pressures, wind forces on roofs, and other required codes. The state facilities, critical facilities and infrastructure located in each zone are noted in Tables 5.10-16 through 5.10-18. Table 5.10-19 presents only the critical facilities located in the 110 to 120 mph zone.

**Table 5.10-16. Number of State-Owned and -Leased Buildings in Wind Load Zones by County**

| County | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|
| | Lease | Own | Lease | Own | Lease | Own | Lease | Own |
| Atlantic | 0 | 0 | 0 | 0 | 7 | 33 | 9 | 38 |
| Bergen | 0 | 0 | 8 | 35 | 0 | 3 | 0 | 0 |
| Burlington | 0 | 0 | 11 | 201 | 0 | 129 | 1 | 3 |
| Camden | 0 | 0 | 8 | 61 | 0 | 0 | 0 | 0 |
| Cape May | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 109 |
| Cumberland | 0 | 0 | 4 | 153 | 1 | 209 | 0 | 0 |
| Essex | 0 | 0 | 13 | 61 | 0 | 0 | 0 | 0 |
| Gloucester | 0 | 6 | 4 | 36 | 0 | 0 | 0 | 0 |
| Hudson | 0 | 0 | 0 | 5 | 7 | 10 | 0 | 0 |
| Hunterdon | 3 | 330 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mercer | 0 | 1 | 47 | 342 | 0 | 0 | 0 | 0 |
| Middlesex | 0 | 0 | 6 | 165 | 1 | 85 | 0 | 0 |
| Monmouth | 0 | 0 | 0 | 2 | 3 | 43 | 7 | 107 |
| Morris | 6 | 85 | 0 | 10 | 0 | 0 | 0 | 0 |
| Ocean | 0 | 0 | 0 | 0 | 0 | 15 | 8 | 80 |
| Passaic | 1 | 9 | 0 | 55 | 0 | 0 | 0 | 0 |
| Salem | 3 | 18 | 0 | 34 | 0 | 0 | 0 | 0 |
| Somerset | 0 | 13 | 0 | 22 | 0 | 0 | 0 | 0 |
| Sussex | 5 | 58 | 0 | 0 | 0 | 0 | 0 | 0 |
| Union | 0 | 0 | 0 | 26 | 0 | 0 | 0 | 0 |
| Warren | 3 | 117 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **21** | **637** | **101** | **1,208** | **19** | **527** | **30** | **337** |

*Source: NJOMB 2013*

*Notes* *All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary.*

*mph* *miles per hour*

### Table 5.10-17. Number of State-Owned and -Leased Buildings in Wind Load Zones by Agency

| Agency | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|
| | Lease | Own | Lease | Own | Lease | Own | Lease | Own |
| Agriculture | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Banking and Insurance | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Chief Executive | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Children and Families | 9 | 4 | 19 | 16 | 6 | 0 | 7 | 20 |
| Community Affairs | 2 | 0 | 0 | 1 | 2 | 0 | 0 | 0 |
| Corrections | 0 | 141 | 0 | 344 | 0 | 203 | 3 | 0 |
| Education | 1 | 1 | 0 | 55 | 0 | 3 | 0 | 0 |
| Environmental Protection | 1 | 130 | 0 | 65 | 2 | 40 | 2 | 70 |
| Health | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Human Services | 0 | 110 | 1 | 195 | 0 | 89 | 0 | 68 |
| Judiciary | 0 | | 4 | | 0 | 0 | 0 | 0 |
| Juvenile Justice Commission | 0 | 32 | 2 | 46 | 1 | 95 | 0 | 5 |
| Labor and Work Force Dev. | 0 | 0 | 1 | 1 | 0 | 0 | 2 | |
| Law And Public Safety | 0 | 0 | 4 | 4 | 0 | 0 | 1 | 1 |
| Legislature | 0 | 0 | 1 | 3 | 0 | 0 | 0 | |
| Military And Veterans Affairs | 0 | 27 | 3 | 118 | 0 | 30 | 0 | 82 |
| Miscellaneous Commissions | 0 | 0 | 1 | | 0 | 0 | 0 | 0 |
| Motor Vehicles Commission | 3 | 7 | 11 | 22 | 3 | 3 | 5 | 9 |
| Personnel | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| State | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 1 |
| State Police | 4 | 8 | 15 | 56 | 5 | 10 | 9 | 11 |
| Transportation | 0 | 177 | 0 | 263 | 0 | 53 | 0 | 72 |
| Treasury | 0 | | 6 | 8 | 0 | 0 | 1 | 0 |
| **Total** | **21** | **637** | **70** | **1208** | **19** | **527** | **30** | **339** |

*Source:* *NJOMB 2013*

*Notes:* *All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary.*

*mph* *miles per hour*

**Table 5.10-18. Number of Critical Facilities Exposed to 110 to 120 mph Wind Loads**

| County | Total Count | Airports | Special Needs | Communication | Correctional Institutions | Dams | Electric Power | EMS | EOC | Ferry | Fire | Highway Bridges | Highway Tunnels | Light Rail Facilities | Medical | Military | Natural Gas | Oil | Police | Ports | Potable Water | Rail Facilities | Rail Tunnels | Schools | Shelters | Storage of Critical Records | Wastewater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic | 388 | 1 | 15 | 0 | 0 | 19 | 2 | 33 | 1 | 0 | 37 | 9 | 0 | 0 | 6 | 1 | 0 | 0 | 16 | 0 | 1 | 2 | 0 | 71 | 30 | 0 | 2 |
| Bergen | 1,148 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Burlington | 747 | 1 | 0 | 0 | 0 | 6 | 0 | 1 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Camden | 701 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cape May | 229 | 2 | 10 | 0 | 6 | 6 | 0 | 30 | 1 | 1 | 34 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 14 | 1 | 1 | 0 | 0 | 42 | 58 | 0 | 6 |
| Cumberland | 251 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Essex | 784 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gloucester | 346 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hudson | 493 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hunterdon | 328 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mercer | 538 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Middlesex | 816 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Monmouth | 905 | 1 | 29 | 0 | 0 | 46 | 0 | 82 | 0 | 1 | 70 | 1 | 0 | 0 | 5 | 1 | 0 | 0 | 34 | 2 | 2 | 11 | 0 | 166 | 31 | 0 | 6 |
| Morris | 913 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ocean | 621 | 0 | 43 | 0 | 1 | 66 | 1 | 82 | 1 | 0 | 70 | 5 | 0 | 0 | 9 | 0 | 0 | 0 | 32 | 0 | 2 | 2 | 0 | 188 | 22 | 1 | 3 |
| Passaic | 648 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salem | 201 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Somerset | 539 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sussex | 542 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Union | 607 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Warren | 351 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **12,096** | **5** | **97** | **0** | **7** | **143** | **3** | **228** | **3** | **2** | **213** | **18** | **0** | **0** | **21** | **3** | **0** | **0** | **97** | **3** | **6** | **15** | **0** | **468** | **141** | **1** | **17** |

*Note: All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary.*

*EOC Emergency Operations Center EMS Emergency Medical Services mph miles per hour*

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. The impacted population can include the young and elderly, who are particularly vulnerable to temperature-related health impacts. Post-event, there is a risk of fire, electrocution or explosion.

### Tornadoes

To determine the vulnerability of state buildings, critical facilities and infrastructure to tornadoes, a spatial analysis was conducted using the historic tornado touch-down density. The number of state buildings in the zones of greatest historical tornado touch-down density (greater than 0.02) are presented in Tables 5.10-19 to 5.10-21 by county and agency.

**Table 5.10-19. Number of State Buildings with the Greatest Historic Tornado Touch-Downs per Square Mile by County**

| County | Lease | Own | Total |
|---|---|---|---|
| Atlantic | 0 | 0 | 0 |
| Bergen | 0 | 0 | 0 |
| Burlington | 8 | 208 | 216 |
| Camden | 7 | 17 | 24 |
| Cape May | 0 | 0 | 0 |
| Cumberland | 0 | 0 | 0 |
| Essex | 13 | 61 | 74 |
| Gloucester | 4 | 31 | 35 |
| Hudson | 2 | 1 | 3 |
| Hunterdon | 0 | 0 | 0 |
| Mercer | 47 | 342 | 389 |
| Middlesex | 13 | 165 | 178 |
| Monmouth | 0 | 10 | 10 |
| Morris | 4 | 22 | 26 |
| Ocean | 0 | 0 | 0 |
| Passaic | 1 | 3 | 4 |
| Salem | 0 | 7 | 7 |
| Somerset | 3 | 35 | 38 |
| Sussex | 0 | 0 | 0 |
| Union | 9 | 26 | 35 |
| Warren | 0 | 0 | 0 |
| **Total** | **111** | **928** | **1,039** |

*Source: NJOMB 2013*

**Table 5.10-20. Number of State Buildings with the Greatest Historic Tornado Touch-Downs per Square Mile by Agency**

| Agency | Lease | Own | Total |
|---|---|---|---|
| Agriculture | 0 | 1 | 1 |
| Banking And Insurance | 0 | 1 | 1 |
| Children and Families | 23 | 11 | 34 |
| Community Affairs | 4 | 1 | 5 |
| Corrections | 3 | 319 | 322 |
| Education | 4 | 51 | 55 |
| Environmental Protection | 21 | 17 | 38 |
| Health | 1 | 2 | 3 |
| Human Services | 1 | 72 | 73 |
| Judiciary | 4 | 0 | 4 |
| Juvenile Justice Commission | 2 | 37 | 39 |
| Labor and Work Force Development | 3 | 1 | 4 |
| Law And Public Safety | 5 | 4 | 9 |
| Legislature | 1 | 3 | 4 |
| Military And Veterans Affairs | 2 | 103 | 105 |
| Motor Vehicles Commission | 14 | 15 | 29 |
| Personnel | 1 | 0 | 1 |
| State | 0 | 8 | 8 |
| State Police | 14 | 47 | 61 |
| Transportation | 0 | 227 | 227 |
| Treasury | 8 | 8 | 16 |
| **Total** | **111** | **928** | **1,039** |

*Source: NJOMB 2013*

**Table 5.10-21. Number of Critical Facilities with the Greatest Historic Tornado Touch-Downs per Square Mile**

| County | Total Count | Airports | Special Needs | Communication | Correctional Institutions | Dams | Electric Power | EMS | EOC | Ferry | Fire | Highway Bridges | Highway Tunnels | Light Rail Facilities | Medical | Military | Natural Gas | Oil | Police | Ports | Potable Water | Rail Facilities | Rail Tunnels | Schools | Shelters | Storage of Critical Records | Wastewater |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic | 388 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bergen | 1,148 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 2 | 0 | 14 | 0 | 0 | 0 |
| Burlington | 747 | 0 | 24 | 1 | 1 | 49 | 0 | 46 | 1 | 0 | 44 | 2 | 0 | 6 | 6 | 4 | 0 | 0 | 28 | 0 | 0 | 0 | 0 | 128 | 86 | 0 | 12 |
| Camden | 701 | 0 | 25 | 0 | 0 | 67 | 0 | 63 | 1 | 0 | 53 | 1 | 0 | 0 | 4 | 0 | 0 | 0 | 33 | 0 | 0 | 2 | 0 | 160 | 93 | 0 | 0 |
| Cape May | 229 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cumberland | 251 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Essex | 784 | 2 | 43 | 0 | 2 | 33 | 1 | 57 | 2 | 0 | 63 | 2 | 0 | 17 | 15 | 0 | 0 | 0 | 42 | 3 | 4 | 22 | 0 | 357 | 108 | 1 | 6 |
| Gloucester | 346 | 0 | 14 | 0 | 0 | 52 | 0 | 33 | 1 | 0 | 44 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 19 | 0 | 0 | 0 | 0 | 100 | 9 | 0 | 1 |
| Hudson | 493 | 0 | 2 | 0 | 1 | 0 | 1 | 11 | 0 | 0 | 12 | 2 | 0 | 3 | 2 | 0 | 0 | 0 | 5 | 0 | 0 | 1 | 0 | 34 | 21 | 0 | 0 |
| Hunterdon | 328 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mercer | 538 | 1 | 25 | 2 | 2 | 87 | 1 | 34 | 3 | 0 | 36 | 0 | 0 | 3 | 12 | 1 | 0 | 0 | 24 | 0 | 3 | 4 | 0 | 151 | 115 | 7 | 6 |
| Middlesex | 816 | 0 | 28 | 0 | 4 | 35 | 3 | 91 | 2 | 0 | 78 | 5 | 0 | 0 | 10 | 0 | 0 | 1 | 27 | 0 | 6 | 10 | 0 | 288 | 122 | 1 | 4 |
| Monmouth | 905 | 0 | 0 | 0 | 0 | 15 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 |
| Morris | 913 | 1 | 16 | 0 | 1 | 25 | 2 | 20 | 0 | 0 | 21 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 11 | 0 | 0 | 7 | 0 | 71 | 21 | 0 | 6 |
| Ocean | 621 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 0 |
| Passaic | 648 | 0 | 0 | 0 | 0 | 3 | 0 | 6 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 3 | 0 | 11 | 3 | 0 | 0 |
| Salem | 201 | 0 | 1 | 0 | 0 | 10 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 4 | 0 | 0 |
| Somerset | 539 | 0 | 28 | 1 | 1 | 87 | 0 | 49 | 1 | 0 | 47 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 21 | 0 | 2 | 11 | 0 | 145 | 98 | 0 | 3 |
| Sussex | 542 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Union | 607 | 0 | 26 | 0 | 1 | 29 | 1 | 53 | 1 | 0 | 45 | 2 | 0 | 0 | 9 | 0 | 0 | 0 | 26 | 5 | 3 | 16 | 0 | 244 | 141 | 0 | 5 |
| Warren | 351 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **12,096** | **4** | **232** | **4** | **13** | **493** | **9** | **471** | **12** | **0** | **457** | **14** | **0** | **29** | **70** | **5** | **0** | **1** | **242** | **8** | **24** | **78** | **0** | **1,714** | **825** | **9** | **43** |

### Thunderstorms

All of the state-owned and -leased buildings may be exposed to the effects of thunderstorms. Thunderstorms will often be accompanied by high winds and sometimes hail. Losses related to thunderstorms primarily will be structural when falling or projectile debris impacts state-owned buildings.

According to NOAA's Technical Paper on *Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959 - 1994*, monetary losses for lightning events range from less than $50 to greater than $5 million. The larger losses are associated with forest fires with homes destroyed and crop loss (NOAA 1997). Lightning can be responsible for damages to buildings; cause electrical, forest and/or wildfires; and damage infrastructure such as power transmission lines and communication towers. The total replacement cost value of all state-owned and -leased facilities in the State is approximately $10 billion (structure and contents). Of particular concern is radio towers used by the first responder community that are frequently struck by lightning.

### Hailstorms

Similar to thunderstorms, hailstorms may affect all State-owned and -leased buildings across New Jersey. Damages will result from the hail stones themselves and will have a specific impact on roofs of state facilities. The extent of damage will depend on the size and scope of the hailstorm. The primary impact of hailstorms is to crops and livestock.

### Extreme Temperature

All of the state-owned and -leased buildings are exposed to the extreme temperature hazard. Extreme heat generally does not impact buildings. Extreme heat events can sometimes cause short periods of utility failure commonly referred to as brownouts, due to increased usage from air conditioners, appliances, etc. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption. Backup power or distributed generation is recommended for critical facilities and infrastructure. In terms of utilities and infrastructure, both extreme heat and cold temperature events can cause impacts.

## Estimating Potential Losses to Jurisdictions

### High Winds

High wind events may impact the economy, including: loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Recovery and clean-up costs can also be costly and impact the economy as well.

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. High-rise buildings are also vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Table 5.10-22 summarizes the total replacement cost value of the residential general building stock (structure only) in the defined wind zones, by County. This is the default general building stock available in Hazards U.S. – Multi Hazard (HAZUS-MH) Version 2.1. The total structural replacement cost value for residential buildings in the State is greater than $552 billion or approximately 71.6% of all occupancy classes. Refer to

Section 5.8 (Hurricanes/Tropical Storms) which includes estimated potential losses to buildings due to high wind speeds associated with historic tropical storm and hurricane events.

## Table 5.10-22. Estimated Potential Losses to Residential Buildings in Wind Load Zones by County

| County | Total RCV | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|---|
| | | RCV | % of Total | RCV | % of Total | RCV | % of Total | RCV | % of Total |
| Atlantic | $17,550,464,000 | $0 | 0.0% | $47,178,000 | 0.3% | $2,929,352,000 | 16.7% | $14,768,397,000 | 84.1% |
| Bergen | $63,288,904,000 | $12,533,000 | 0.0% | $55,853,010,000 | 88.3% | $7,933,737,000 | 12.5% | $0 | 0.0% |
| Burlington | $27,709,770,000 | $0 | 0.0% | $24,784,889,000 | 89.4% | $3,269,950,000 | 11.8% | $111,450,000 | 0.4% |
| Camden | $30,189,818,000 | $0 | 0.0% | $30,089,736,000 | 99.7% | $241,150,000 | 0.8% | $0 | 0.0% |
| Cape May | $12,809,725,000 | $0 | 0.0% | $0 | 0.0% | $161,734,000 | 1.3% | $12,678,912,000 | 99.0% |
| Cumberland | $7,068,282,000 | $0 | 0.0% | $5,555,352,000 | 78.6% | $1,853,584,000 | 26.2% | $0 | 0.0% |
| Essex | $46,181,097,000 | $0 | 0.0% | $46,181,097,000 | 100.0% | $0 | 0.0% | $0 | 0.0% |
| Gloucester | $14,895,184,000 | $882,813,000 | 5.9% | $14,149,939,000 | 95.0% | $14,933,000 | 0.1% | $0 | 0.0% |
| Hudson | $32,048,386,000 | $0 | 0.0% | $3,831,479,000 | 12.0% | $28,486,360,000 | 88.9% | $0 | 0.0% |
| Hunterdon | $9,537,415,000 | $9,537,415,000 | 100.0% | $14,882,000 | 0.2% | $0 | 0.0% | $0 | 0.0% |
| Mercer | $23,159,272,000 | $366,189,000 | 1.6% | $22,958,164,000 | 99.1% | $0 | 0.0% | $0 | 0.0% |
| Middlesex | $47,528,835,000 | $0 | 0.0% | $41,218,609,000 | 86.7% | $7,154,402,000 | 15.1% | $0 | 0.0% |
| Monmouth | $44,372,513,000 | $0 | 0.0% | $353,247,000 | 0.8% | $21,896,119,000 | 49.3% | $22,988,654,000 | 51.8% |
| Morris | $36,382,527,000 | $25,062,700,000 | 68.9% | $12,212,841,000 | 33.6% | $0 | 0.0% | $0 | 0.0% |
| Ocean | $37,121,492,000 | $0 | 0.0% | $0 | 0.0% | $4,019,938,000 | 10.8% | $33,663,663,000 | 90.7% |
| Passaic | $26,889,201,000 | $4,246,553,000 | 15.8% | $22,829,712,000 | 84.9% | $0 | 0.0% | $0 | 0.0% |
| Salem | $3,629,553,000 | $1,869,106,000 | 51.5% | $1,842,625,000 | 50.8% | $0 | 0.0% | $0 | 0.0% |
| Sussex | $22,915,544,000 | $7,517,043,000 | 32.8% | $16,265,563,000 | 71.0% | $0 | 0.0% | $0 | 0.0% |
| Somerset | $9,749,907,000 | $9,749,907,000 | 100.0% | $0 | 0.0% | $0 | 0.0% | $0 | 0.0% |
| Union | $33,128,555,000 | $0 | 0.0% | $33,128,555,000 | 100.0% | $125,000 | 0.0% | $0 | 0.0% |
| Warren | $6,343,325,000 | $6,343,325,000 | 100.0% | $0 | 0.0% | $0 | 0.0% | $0 | 0.0% |
| **Total** | **$552,499,769,000** | **$65,587,584,000** | **11.9%** | **$331,316,878,000** | **60.0%** | **$77,961,384,000** | **14.1%** | **$84,211,076,000** | **15.2%** |

*Source: HAZUS-MH 2.1*

*Notes: All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary.*

*Replacement cost value (RCV) represents structural value only (excludes content value).*

| | |
|---|---|
| *%* | *percent* |
| *mph* | *miles per hour* |
| *RCV* | *Replacement cost value* |

### Tornadoes

Tornado events are typically localized; whereas high wind and thunderstorm events can be more widespread. The impacts of tornadoes on the environment may include severe damage to complete devastation to buildings, vegetation and anything in its path.

To estimate the potential losses to buildings, the default HAZUS-MH general building stock data was overlaid with the zone of greatest historical tornado touch-down density (greater than 0.02) in the State. The replacement cost value of buildings (all occupancy types) within this zone are presented in Table 5.10-23. The limitations of this analysis are recognized. This figure assumes 100% loss to each structure and its contents. This potential loss estimate is considered high given it is not likely that a tornado would occur across the entire area at the same time from one event. Nonetheless, the total replacement cost value of buildings within this area represents an estimated total loss value for these counties. As more current replacement cost data becomes available at the structure level, this section of the plan will be updated with new information.

**Table 5.10-23. Estimated Replacement Cost Value of Buildings with the Greatest Historic Tornado Touch-Downs per Square Mile**

| County | Total RCV | Total RCV in Greatest Historic Tornado Density | % Total |
|---|---|---|---|
| Atlantic | $38,043,171 | $0 | 0.0% |
| Bergen | $154,077,482 | $4,118,290 | 2.7% |
| Burlington | $62,700,794 | $45,949,190 | 73.3% |
| Camden | $70,467,051 | $50,418,110 | 71.5% |
| Cape May | $24,665,528 | $0 | 0.0% |
| Cumberland | $18,128,613 | $0 | 0.0% |
| Essex | $113,124,687 | $112,053,636 | 99.1% |
| Gloucester | $33,534,660 | $28,373,926 | 84.6% |
| Hudson | $82,290,184 | $19,206,577 | 23.3% |
| Hunterdon | $21,720,513 | $0 | 0.0% |
| Mercer | $56,194,660 | $55,272,646 | 98.4% |
| Middlesex | $119,947,782 | $109,959,088 | 91.7% |
| Monmouth | $96,235,266 | $1,261,970 | 1.3% |
| Morris | $86,634,810 | $25,619,706 | 29.6% |
| Ocean | $73,559,915 | $307,181 | 0.4% |
| Passaic | $66,705,864 | $5,963,827 | 8.9% |
| Salem | $8,092,037 | $939,787 | 11.6% |
| Somerset | $52,513,253 | $50,104,465 | 95.4% |
| Sussex | $20,979,595 | $0 | 0.0% |
| Union | $79,329,736 | $79,329,736 | 100.0% |
| Warren | $14,442,755 | $0 | 0.0% |
| **Total** | **$1,293,388,356** | **$588,878,135** | **45.5%** |

*Source: HAZUS 2.1*

*%* *percent*
*RCV* *Replacement cost value (structure and contents)*

## Thunderstorms

Agricultural losses can be devastating due to lightning and resulting fires. Table 5.10-24 below summarizes the potential monetary loss of crops in each county. The counties with the amount of high value crop types have the highest potential loss due to storms. Atlantic and Cumberland Counties have the highest amount of potential monetary crop loss. In 2010, Salem County experienced $1,000 in crop damage due to lightning. In 2012, Sussex County experienced $5,000 in crop damage due to lightning. Refer to Section 5.15 (Crop Failure) for additional details on these historic events and losses.

**Table 5.10-24. Agricultural Statistics in New Jersey**

| County | Number of Farms | % of Total Farms in State | Land in Farms (acres) | Market Value of Products Sold |
|---|---|---|---|---|
| Atlantic | 499 | 4.83% | 30,732 | $128,339,000 |
| Bergen | 89 | 0.86% | 1,177 | $8,694,000 |
| Burlington | 922 | 8.93% | 85,790 | $86,302,000 |
| Camden | 225 | 2.18% | 8,760 | $18,554,000 |
| Cape May | 201 | 1.95% | 7,976 | $14,586,000 |
| Cumberland | 615 | 5.96% | 69,489 | $156,939,000 |
| Essex | 13 | 0.13% | 184 | $710,000 |
| Gloucester | 669 | 6.48% | 46,662 | $93,883,000 |
| Hudson | N/A | N/A | N/A | N/A |
| Hunterdon | 1,623 | 15.72% | 100,027 | $69,745,000 |
| Mercer | 311 | 3.01% | 21,730 | $18,646,000 |
| Middlesex | 236 | 2.29% | 18,717 | $41,854,000 |
| Monmouth | 932 | 9.02% | 44,130 | $105,413,000 |
| Morris | 422 | 4.09% | 17,028 | $27,312,000 |
| Ocean | 255 | 2.47% | 9,833 | $11,515,000 |
| Passaic | 103 | 1.00% | 1,981 | $6,318,000 |
| Salem | 759 | 7.35% | 96,530 | $79,962,000 |
| Somerset | 445 | 4.31% | 32,721 | $18,911,000 |
| Sussex | 1,060 | 10.26% | 65,242 | $21,242,000 |
| Union | 15 | 0.15% | 126 | $2,483,000 |
| Warren | 933 | 9.03% | 74,975 | $75,477,000 |
| Total | 10,327 | 100% | 733,450 | $986,885,000 |

*Source:* *USDA 2007*
*%* *percent*
*N/A* *Not Available*

### Hailstorms

As discussed above, all counties are considered vulnerable to the effects of hailstorms, but those with farmland and high agricultural yields are more likely to be impacted. According to the 2007 United States Department of Agriculture's Agricultural Census, Atlantic and Cumberland Counties have the highest amount of potential monetary crop loss (USDA 2007). In 2011, Atlantic County experienced $10,000 in crop damage due to a hailstorm event (ping-pong sized hail). Refer to Section 5.15 (Crop Failure) for additional details on historic events and losses.

### Extreme Temperature

Extreme heat and cold temperature events can have significant impacts to human health and the local economy. As discussed earlier, extreme heat events account for more loss of life than any other weather event. Those at greatest risk are located in urban areas due to the urban heat island effect. Refer to Section 4 (State Profile), Figure 4-8 which displays population density across the State.

Business owners may be faced with increased financial burdens due to unexpected repairs such as pipes bursting, higher than normal utility bills or business interruption due to power failure (e.g.., loss of electricity, telecommunications). Increased demand for water and electricity may result in shortages and a higher cost for these resources. Industries that rely on water for business operations and services may be impacted the hardest during extreme heat events (e.g., landscaping businesses). Even though most businesses will still be operational, they may be impacted aesthetically. These aesthetic impacts are significant to the recreation and tourism industry.

As summarized in Section 4 (State Profile), New Jersey has more than 10,000 farms that produce products valued at $1 billion annually. This represents the total potential loss that can be experienced from extreme temperature events. Historic records indicate severe weather such as extreme temperature can damage crops throughout the State. Refer to Section 5.15 (Crop Failure) for additional details on historic events and losses.

## Estimating Potential Losses to State Facilities

### High Winds

As mentioned earlier, all buildings, critical facilities and infrastructure may be exposed and vulnerable to high winds. To estimate potential losses to state buildings from high winds, a spatial analysis was conducted using the four wind load zones. Generally speaking, structures should be designed to withstand the total wind load of the zone in which they are located. Refer to the State Building Code for appropriate reference wind pressures, wind forces on roofs, and other relevant codes. Tables 5.10-25 and 5.10-26 list the structural replacement cost value of all State facilities located in each zone by County and Agency, respectively. The limitations of this analysis are recognized. This figure assumes 100% loss to each structure. This potential loss estimate is considered high given it is not likely that all buildings will experience 100% loss from one event. Nonetheless, the total replacement cost value of buildings within these wind zones represents an estimated total loss value for these counties.

**Table 5.10-25. Estimated Potential Loss to State-Owned and -Leased Buildings in Wind Load Zones by County**

| County | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|
| | Lease | Own | Lease | Own | Lease | Own | Lease | Own |
| Atlantic | $0 | $0 | $0 | $0 | $13,370,005 | $21,799,046 | $131,031,644 | $13,505,880 |
| Bergen | $0 | $0 | $34,121,796 | $85,849,968 | $0 | $746,771 | $0 | $0 |
| Burlington | $0 | $0 | $76,307,865 | $320,093,638 | $0 | $113,655,304 | $323,273 | $1,252,718 |
| Camden | $0 | $0 | $141,414,541 | $172,404,799 | $0 | $0 | $0 | $0 |
| Cape May | $0 | $0 | $0 | $0 | $0 | $0 | $2,584,257 | $63,712,640 |
| Cumberland | $0 | $0 | $3,524,431 | $356,599,904 | $945,573 | $107,418,708 | $0 | $0 |
| Essex | $0 | $0 | $198,465,073 | $160,993,164 | $0 | $0 | $0 | $0 |
| Gloucester | $0 | $824,429 | $25,072,915 | $12,508,550 | $0 | $0 | $0 | $0 |
| Hudson | $0 | $0 | $0 | $2,452,809 | $41,978,058 | $38,817,579 | $0 | $0 |
| Hunterdon | $3,541,525 | $232,064,505 | $0 | $0 | $0 | $0 | $0 | $0 |
| Mercer | $0 | $254,676 | $385,738,794 | $1,405,976,862 | $0 | $0 | $0 | $0 |
| Middlesex | $0 | $0 | $18,606,814 | $272,066,482 | $7,568,254 | $58,661,549 | $0 | $0 |
| Monmouth | $0 | $0 | $0 | $811,089 | $7,999,157 | $28,938,594 | $14,580,098 | $72,950,606 |
| Morris | $34,821,607 | $181,561,198 | $0 | $5,263,728 | $0 | $0 | $0 | $0 |
| Ocean | $0 | $0 | $0 | $0 | $0 | $38,208,555 | $22,408,626 | $26,534,632 |
| Passaic | $64,799,700 | $3,653,336 | $0 | $65,112,172 | $0 | $0 | $0 | $0 |
| Salem | $15,267,601 | $4,083,233 | $0 | $9,083,368 | $0 | $0 | $0 | $0 |
| Somerset | $0 | $4,284,181 | $0 | $36,626,736 | $0 | $0 | $0 | $0 |
| Sussex | $7,318,677 | $18,539,425 | $0 | $0 | $0 | $0 | $0 | $0 |
| Union | $0 | $0 | $0 | $14,280,053 | $0 | $0 | $0 | $0 |
| Warren | $9,755,189 | $45,486,157 | $0 | $0 | $0 | $0 | $0 | $0 |
| **Total** | **$135,504,299** | **$490,751,140** | **$883,252,228** | **$2,920,123,321** | **$71,861,047** | **$408,246,106** | **$170,927,897** | **$177,956,476** |

*Source: NJOMB 2013*

*Notes: All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary. Replacement cost values represent structure only.*

*mph miles per hour*

**Table 5.10-26. Estimated Potential Loss to State-Owned and -Leased Buildings in Wind Load Zones by Agency**

| Agency | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|
| | Lease | Own | Lease | Own | Lease | Own | Lease | Own |
| Agriculture | $0 | $0 | $0 | $0 | $0 | $1,438,307 | $0 | $0 |
| Banking and Insurance | $0 | $0 | $0 | $41,888,820 | $0 | $0 | $0 | $0 |
| Chief Executive | $6,326,688 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| Children and Families | $96,059,208 | $1,484,436 | $198,040,032 | $4,955,090 | $27,562,382 | $0 | $24,955,095 | $11,952,960 |
| Community Affairs | $11,145,038 | $0 | $10,045,108 | $26,247,441 | $22,526,095 | $0 | $0 | $0 |
| Corrections | $0 | $106,918,094 | $5,686,417 | $780,483,336 | $0 | $129,515,990 | $4,397,087 | $0 |
| Education | $885,526 | $4,540,790 | $24,928,079 | $131,560,200 | $0 | $0 | $0 | $0 |
| Environmental Protection | $0 | $40,723,792 | $67,894,941 | $59,347,757 | $7,641,226 | $25,597,541 | $9,334,284 | $15,616,242 |
| Health | $0 | $0 | $20,584,392 | $52,632,460 | $0 | | $0 | $0 |
| Human Services | $0 | $237,216,398 | $2,825,013 | $547,354,087 | $0 | $71,603,457 | $0 | $52,400,639 |
| Judiciary | $0 | $0 | $57,010,526 | $0 | $0 | $0 | $0 | $0 |
| Juvenile Justice Commission | $0 | $7,391,583 | $13,222,175 | $69,008,480 | $0 | $61,607,211 | $0 | $1,481,979 |
| Labor and Work Force Dev. | $0 | $0 | $36,200,712 | $61,327,079 | $0 | $0 | $3,807,477 | $0 |
| Law And Public Safety | $0 | $0 | $119,491,056 | $111,346,779 | $0 | $0 | $12,916,988 | $738,784 |
| Legislature | $0 | $0 | $1,953,710 | $80,588,984 | $0 | $0 | $0 | $0 |
| Military And Veterans Affairs | $0 | $44,037,724 | $1,303,385 | $338,876,567 | $0 | $69,350,387 | $0 | $61,073,217 |
| Miscellaneous Commissions | $0 | $0 | $7,825,328 | $0 | $0 | $0 | $0 | $0 |
| Motor Vehicles Commission | $7,786,902 | $5,048,997 | $158,906,952 | $115,042,487 | $3,113,476 | $6,717,651 | $99,643,424 | $8,566,797 |
| Personnel | $0 | $0 | $4,256,708 | $0 | $0 | $0 | $0 | $0 |
| State | $0 | $0 | $0 | $96,143,325 | $0 | $0 | $0 | $8,265,027 |

| Agency | Less than 90 mph | | 90 – 100 mph | | 100 – 110 mph | | 110 – 120 mph | |
|---|---|---|---|---|---|---|---|---|
| | Lease | Own | Lease | Own | Lease | Own | Lease | Own |
| State Police | $2,342,275 | $4,432,666 | $37,674,219 | $151,457,068 | $10,122,078 | $15,160,036 | $4,462,204 | $5,053,013 |
| Transportation | $0 | $38,956,660 | $0 | $181,104,600 | $0 | $19,540,097 | $0 | $22,015,585 |
| Treasury | $0 | $0 | $111,264,468 | $70,758,761 | $0 | $0 | $11,411,339 | $0 |
| **Total** | **$124,545,636** | **$490,751,140** | **$879,113,222** | **$2,920,123,321** | **$70,965,257** | **$400,530,678** | **$170,927,897** | **$187,164,243** |

*Source:* *NJOMB 2013*

*Notes:* *All wind load zone boundaries prepared specific for this analysis are considered approximate and do not represent the regulatory boundary. Replacement cost values represent structure only.*

*mph* *miles per hour*

## Tornadoes

To estimate the potential losses to state buildings, the Land and Building Asset Management System (LBAM) data was overlaid with the zone of greatest historical tornado touch-down density in the State. The replacement cost values of the buildings within this zone are presented in Table 5.10-27. As discussed above, the limitations of this analysis are recognized. This figure assumes 100% loss to each structure and its contents. This potential loss estimate is considered high given it is not likely that a tornado would occur across the entire area at the same time. Nonetheless, the total replacement cost value of buildings within this area represents an estimated total loss value for these counties. As more current replacement cost data becomes available at the structure level, this section of the plan will be updated with new information.

**Table 5.10-27. Estimated Replacement Cost Value of State Buildings with the Greatest Historic Tornado Touch-Downs per Square Mile**

| County | Lease | Own | Total |
|---|---|---|---|
| Atlantic | - | - | - |
| Bergen | - | - | - |
| Burlington | $144,641,366 | $565,105,052 | $709,746,419 |
| Camden | $267,178,426 | $23,931,707 | $291,110,133 |
| Cape May | - | - | - |
| Cumberland | - | - | - |
| Essex | $396,930,146 | $277,537,642 | $674,467,788 |
| Gloucester | $50,145,830 | $24,217,508 | $74,363,338 |
| Hudson | $6,741,931 | $249,806 | $6,991,737 |
| Hunterdon | - | - | - |
| Mercer | $771,275,049 | $2,705,627,970 | $3,476,903,019 |
| Middlesex | $92,348,757 | $447,393,222 | $539,741,979 |
| Monmouth | $0 | $13,547,532 | $13,547,532 |
| Morris | $43,473,165 | $22,375,709 | $65,848,874 |
| Ocean | - | - | - |
| Passaic | $185,413 | $319,493 | $504,906 |
| Salem | $0 | $1,554,990 | $1,554,990 |
| Somerset | $152,137,964 | $81,193,734 | $233,331,698 |
| Sussex | - | - | - |
| Union | $57,259,610 | $27,997,974 | $85,257,584 |
| Warren | - | - | - |
| **Total** | **$1,982,317,655** | **$4,191,052,340** | **$6,173,369,996** |

*Source: NJOMB 2013*

*Notes:* *Replacement cost value for structure and contents.*

\- *There are no buildings located in the area of greatest historic tornado density.*

### Thunderstorms

Current modeling tools are not available to estimate specific losses for this severe weather type. As stated earlier, all state buildings, critical facilities, and infrastructure may be vulnerable.

### Hailstorms

Current modeling tools are not available to estimate specific losses for this severe weather type. As stated earlier, all state buildings, critical facilities, and infrastructure may be vulnerable.

### Extreme Temperatures

Current modeling tools are not available to estimate specific losses for this severe weather type. As stated earlier, all state buildings, critical facilities, and infrastructure may be vulnerable.

## Environmental Impacts

The environmental impacts of severe weather events, such as thunderstorms and tornadoes, are consistent with impacts of other hazards discussed in this plan (Section 5.8 [Hurricane and Tropical Storm] and Section 5.9 [Nor'Easter]). A tornado's area of impact tends to be smaller than a thunderstorm, tropical storm or hurricane but their higher wind speeds can cause much more destruction including uprooting trees, buildings and anything in its path. Hailstorm events and prolonged periods of extreme cold temperatures can damage vegetation and crops. Extreme heat events may be associated with drought conditions and impact ground and surface water supplies. A discussion on impacts to water resources is discussed further in Section 5.4 (Drought). Both extreme heat and cold temperature events can negatively impact the agricultural industry.