5.4.6 SEVERE STORM

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

HAZARD PROFILE

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

Description

For the purpose of this HMP and as deemed appropriated by Burlington County, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and tropical cyclones (e.g. hurricanes, tropical storms, and tropical depressions), which are defined below. Since most northeasters, (or Nor'Easters) a type of an extra-tropical cyclone, generally take place during the winter weather months, Nor'Easters have been grouped as a type of severe winter weather storm, further discussed in Section 5.4.6 (Severe Winter Storm).

Hailstorm: According to the National Weather Service (NWS), hail is defined as a showery precipitation in the form of irregular pellets or balls of ice more than five millimeters in diameter, falling from a cumulonimbus cloud (NWS, 2009). Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation, in the form of balls or irregularly shaped masses of ice. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstorms are a potential damaging outgrowth of severe thunderstorms (Northern Virginia Regional Commission [NVRC], 2006). They cause over $1 billion in crop and property damages each year in the U.S., making hailstorms one of the most costly natural disasters (Federal Alliance for Safe Homes, Inc., 2006).

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

Destructive Wind: Destructive wind is a windstorm that poses a significant threat to life and property and destroying everything in its path. Destructive wind can also cause damage by flying debris, such as rocks, lumber, fuel drums, sheet metal and loose gear of any type which can be picked up by the wind and hurled with great force (Burlington County HMP, 2008).

Lightning: According to the NWS, lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds or between a rain cloud and the ground (NWS, 2009). The discharge of electrical energy resulting from the buildup of positive and negative charges within a

thunderstorm creates a "bolt" when the buildup of charges becomes strong enough. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit (°F). Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. Annually, on average, 300 people are injured and 89 people are killed due to lightning strikes in the U.S. (NVRC, 2006).

Thunderstorm: According to the NWS, a thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS, 2009). A thunderstorm forms from a combination of moisture, rapidly rising warm air and a force capable of lifting air such as a warm and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. These storms occur most commonly in the tropics. Many tropical land-based locations experience over 100 thunderstorm days each year (Pidwirny, 2007). Although thunderstorms generally affect a small area when they occur, they are very dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. A thunderstorm produces wind gusts of less than 57 miles per hour (mph) and hail, if any, of less than 3/4-inch diameter at the surface. A severe thunderstorm has thunderstorm-related surface winds (sustained or gusts) of 57 mph or greater and/or surface hail 3/4-inch or larger (NWS, 2005). Wind or hail damage may be used to infer the occurrence/existence of a severe thunderstorm (Office of the Federal Coordinator for Meteorology, 2001).

Tornado: A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Tornado season is generally March through August, although tornadoes can occur at any time of year. Tornadoes tend to strike in the afternoons and evening, with over 80 percent (%) of all tornadoes striking between noon and midnight (New Jersey Office of Emergency Management [NJOEM], 2011). The average forward speed of a tornado is 30 mph, but can vary from nearly stationary to 70 mph (NWS, 1995). The NOAA Storm Prediction Center (SPC) indicates that the total duration of a tornado can last between a few seconds to over one hour; however, a tornado typical lasts less than 10 minutes (Edwards, 2011). High-wind velocity and wind-blown debris, along with lightning or hail, result in the damage caused by tornadoes. Destruction caused by tornadoes depends on the size, intensity, and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential homes and mobile homes, and tend to remain localized during impact (NVRC, 2006).

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

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

Tropical Storm: A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 39 and 73 mph (FEMA, 2011). Once a storm has reached tropical storm status, it is assigned a name. During this time, the storm itself becomes more

organized and begins to become more circular in shape, resembling a hurricane. The rotation of a tropical storm is more recognizable than a tropical depression. Tropical storms can cause a lot of problems, even without becoming a hurricane; however, most of the problems stem from heavy rainfall (University of Illinois, Date Unknown).

Hurricane: A hurricane is an intense tropical cyclone with wind speeds reaching a constant speed of 74 mph or greater (FEMA, 2011). It is a category of a tropical cyclone characterized by thunderstorms and defined surface wind circulation. They are caused by the atmospheric instability created by the collision of warm air with cooler air. They form in the warm waters of tropical and sub-tropical oceans, seas, or Gulf of Mexico (NWS, 2011). Most hurricanes evolve from tropical disturbances. A tropical disturbance is a discrete system of organized convection (showers or thunderstorms), that originate in the tropics or subtropics, does not migrate along a frontal boundary, and maintains its identity for 24 hours or more (NWS, 2009). Hurricanes begin when areas of low atmospheric pressure move off the western coast of Africa and into the Atlantic, where they grow and intensify in the moisture-laden air above the warm tropical ocean. Air moves toward these atmospheric lows from all directions and circulates clock-wise under the influence of the Coriolis Effect, thereby initiating rotation in the converging wind fields. When these hot, moist air masses meet, they rise up into the atmosphere above the low pressure area, potentially establishing a self-reinforcing feedback system that produces weather systems known to meteorologists as tropical disturbances, tropical depressions, tropical storms, and hurricanes (Frankenberg, Date Unknown).

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

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

Extent

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

Hail

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail varies related to the severity and size of the thunderstorm that produced it, and is

estimated by comparing it to a known object. Most hail storms are made up of a variety of sizes, and only penny size (.75″ in diameter) or larger hail is considered severe (NJ HMP, 2011; NSSL, 2003). Table 5.4.6-1 shows the different types of hail and the comparison to real-world objects.

Table 5.4.6-1. Hail Size

Description	Diameter
Pea	1/4”
Plain M&M	1/2”
Dime/Penny	3/4”
Nickel	7/8”
Quarter	1”
Half Dollar	1.25”
Walnut or Ping Pong Ball	1.50”
Golf ball	1.75”
Hen’s Egg	2”
Tennis Ball	2.25
Baseball	2.75
Tea Cup	3”
Softball	4”
Grapefruit	4.5”
Computer CD/DVD	4.75 – 5”

Source: NWS, 2012

Tornado

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

Table 5.4.6-2. Fujita Damage Scale

Scale	Wind Estimate (MPH)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.

Scale	Wind Estimate (MPH)	Typical Damage
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 will occur.

Source: SPC, 2012

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

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

Table 5.4.6-3. Enhanced Fujita Damage Scale

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

F-Scale Number	Intensity Phrase	Wind Speed (mph)	Type of Damage Done
EF5	Incredible tornado	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: SPC, Date Unknown

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

Table 5.4.6-4. EF Scale Damage Indicators

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

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
12	Large, isolated ("big box") retail bldg.	LIRB	26	Free standing pole (light, flag, luminary)	FSP
13	Automobile showroom	ASR	27	Tree - hardwood	TH
14	Automotive service building	ASB	28	Tree - softwood	TS

Source: SPC, Date Unknown

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

Hurricanes

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

Table 5.4.6-5. The Saffir-Simpson Scale

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

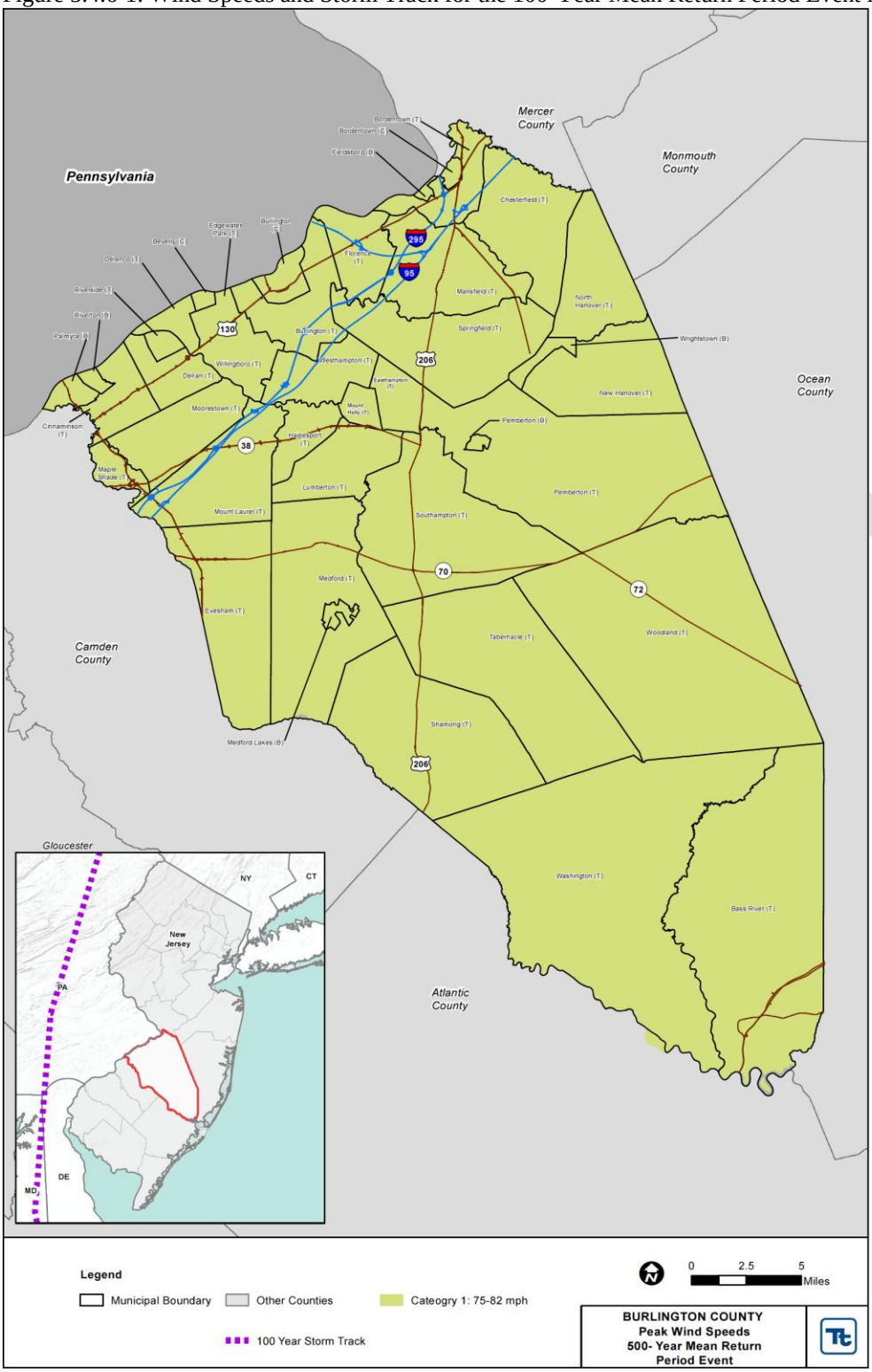
Category	Sustained Winds	Expected Damage
5 (major)	157 mph or higher	**Catastrophic damage will occur**: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA, 2013
mph = Miles per hour

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

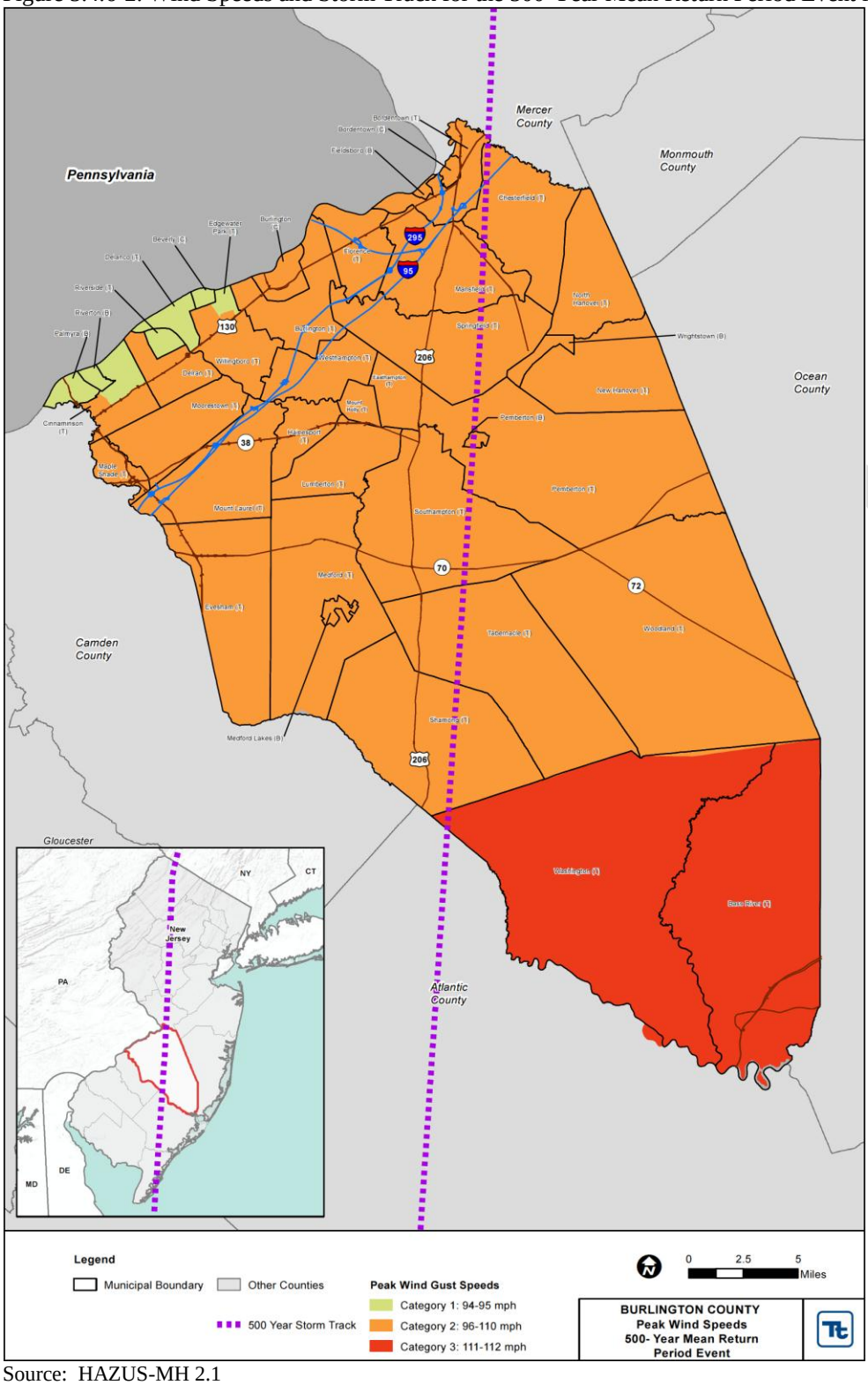
Figure 5.4.6-1 and Figure 5.4.6-2 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP HAZUS-MH model runs. The estimated hurricane track for the 100- and 500-year event is also shown. For the 100-year MRP event, the maximum 3-second gust wind speeds for the County range from 75 to 82 mph, characteristic of a Category 1 hurricane or tropical storm. For the 500-year MRP event, the maximum 3-second gust wind speeds for the County range from 94 to 112 mph, characteristic of a Category 1, Category 2, and Category 3 hurricane. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment later in this section.

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



Source: HAZUS-MH 2.1

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



Source: HAZUS-MH 2.1

Location

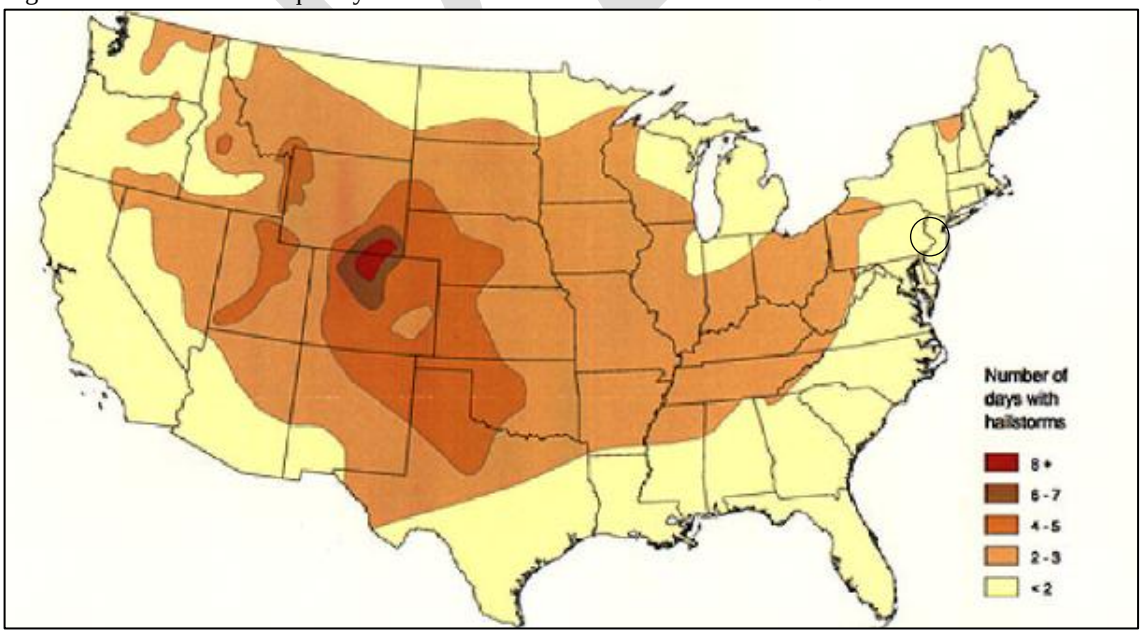
New Jersey is located in the path of precipitation-producing weather systems ("storm paths") that move across the U.S. from all directions. These systems commonly produce thunderstorms during the warm season and snow during the cold season. Occasional hurricanes, tropical storms, and Nor'Easters approach New Jersey from the southeast and northeast. Severe storms are a common occurrence throughout New Jersey and can affect the entire study area of Burlington County.

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

Hailstorms

Hailstorms are more frequent in the southern and central plain states, where the climate produces violent thunderstorms. However, hailstorms have been observed in almost every location where thunderstorms occur (Federal Alliance for Safe Homes, Inc., 2006). Figure 5.4.6-3 illustrates that Burlington County and all other areas in New Jersey experience less than two hailstorms per year.

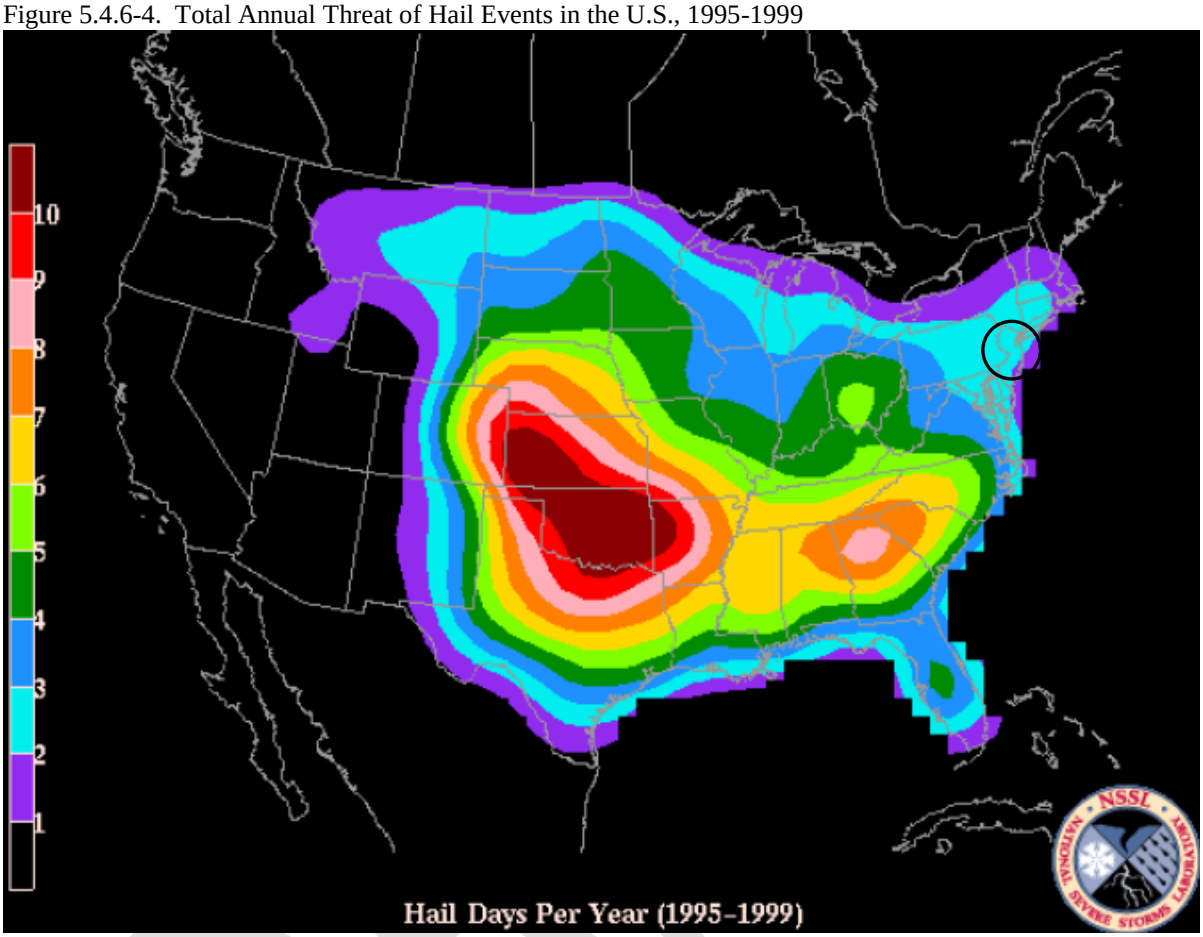
Figure 5.4.6-3. Annual Frequency of Hailstorms in the U.S.



Source: FEMA, 1997
Note: The black circle indicates the approximate location of Burlington County; the County experiences less than two hailstorms annually.

Figure 5.4.6-4 illustrates the number of hail days, per year, between 1995 and 1999 in the U.S. According to this figure, New Jersey experiences between one and three days of hail each year, with Burlington County experiencing between one and three days.

Figure 5.4.6-4. Total Annual Threat of Hail Events in the U.S., 1995-1999



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 tornadoes is 0.2, with the purple starting at 0.2 days. For the nontornadic threats, the fill interval is 1, with the purple starting at 1. For the significant (violent), it's 5 days per century (millennium)
The black circle indicates the approximate location of Burlnigton County.

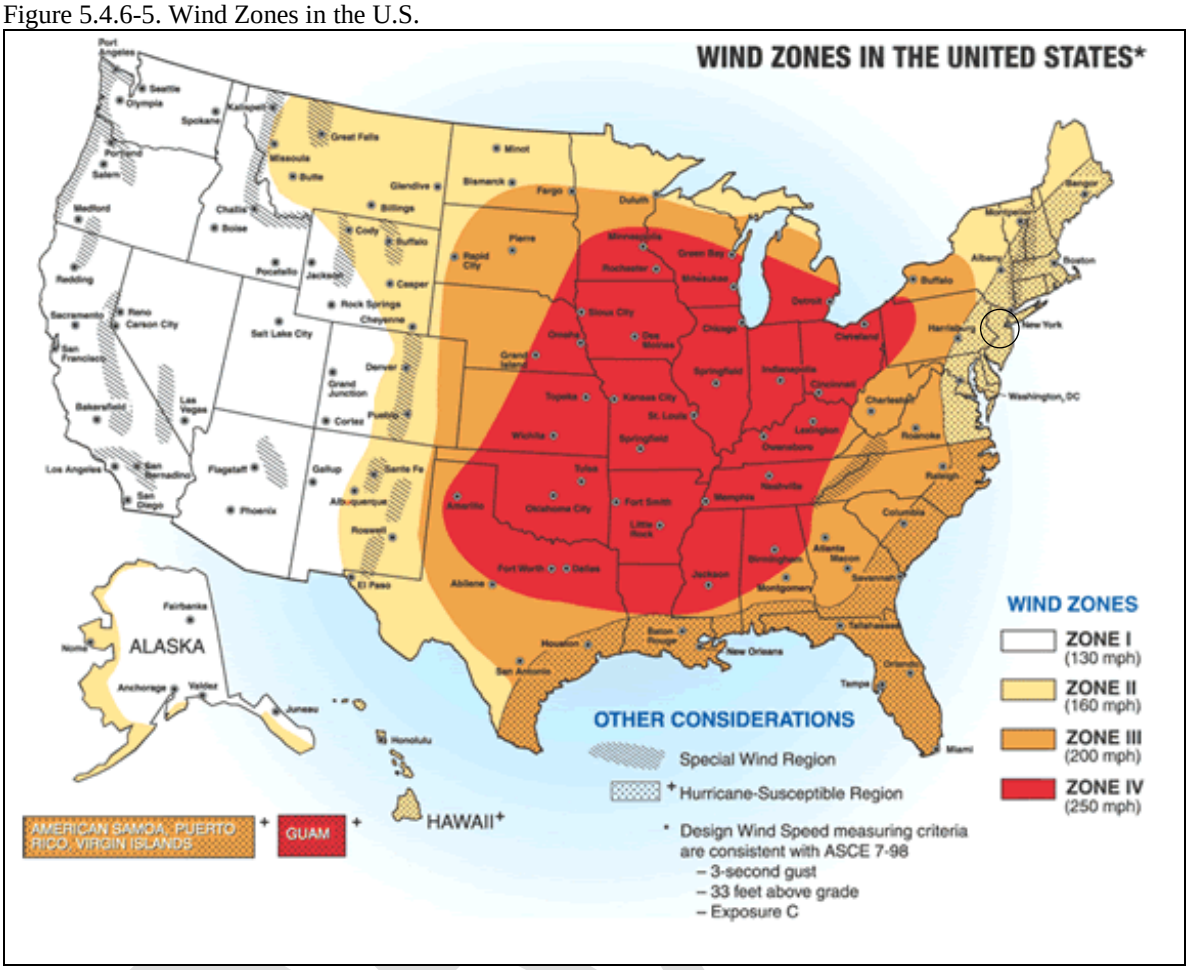
Windstorms

In New Jersey, new construction must be built in accordance with the state-adopted International Building Code (IBC). For Burlington County, the IBC's design wind speeds (according to the ASCE 7-98, 3 second gust, 33 feet above grade, Exposure Category C) range from a low of 90 miles per hour in areas nearest the Delaware River to a maximum of 120 miles per hour in areas nearest to Great Bay. While building codes require that a building withstand a "design" event, extreme wind events can cause wind speeds in excess of those on which local code requirements are based (Burlington County HMP, 2008).

Figure 5.4.6-5 indicates how the frequency and strength of windstorms impacts the U.S. and the general location of the most wind activity. This is based on 40 years of tornado history and 100 years of hurricane history, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes (NVRC, 2006). Burlington County is located in Wind Zone II with speeds up to 160 miles per hour (FEMA, 2012). The entire state of New Jersey is also

categorized as the Hurricane Susceptibility Region, which extends along the northeastern coastline of the U.S.

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



Source: FEMA, 2012

Note: The black circle indicates the approximate location of Burlington County; the County is located within Wind Zone II and in the hurricane susceptible region.

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

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

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

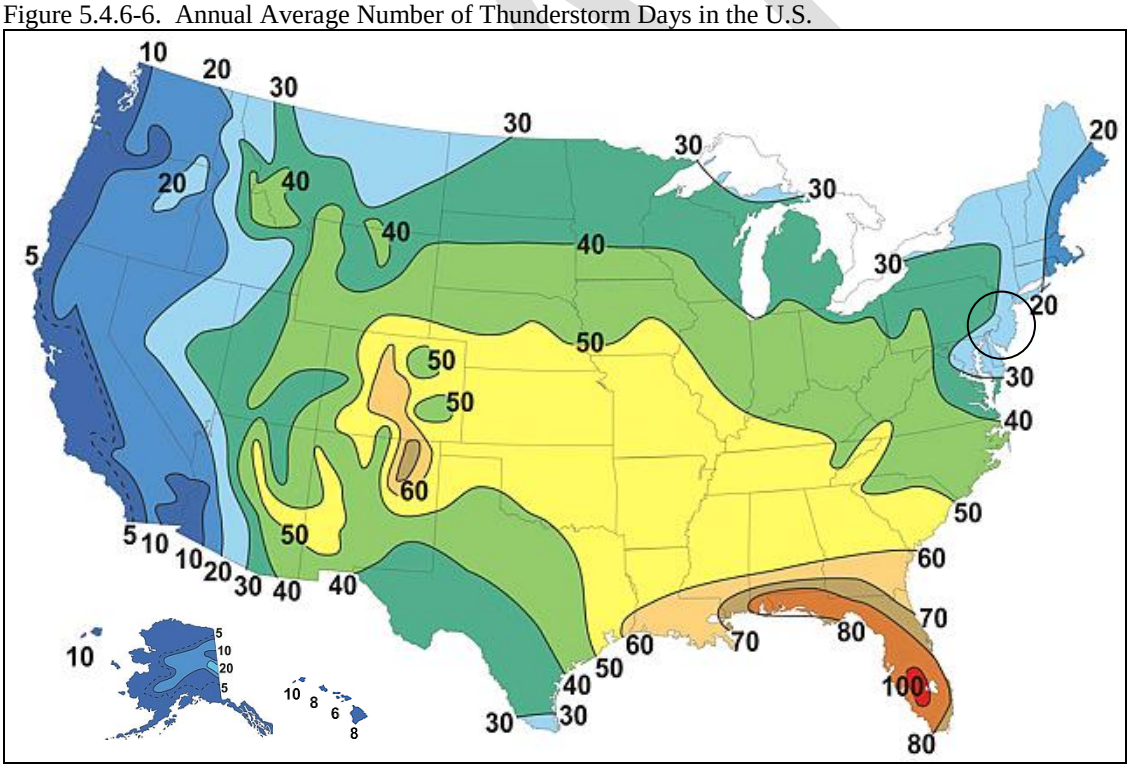
Source: FEMA, 2012

Thunderstorms

Thunderstorms affect relatively small localized areas, rather than large regions much like winter storms, and hurricane events (NWS, 2010). Thunderstorms can strike in all regions of the U.S.; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms (NVRC, 2006). It is estimated that there are as many as 40,000 thunderstorms each day world-wide.

Figure 5.4.6-6 shows the average number of thunderstorm days throughout the U.S. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year) (NWS, 2010). This figure indicates that most of New Jersey, including Burlington County, experiences approximately 20 thunderstorm days each year.

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

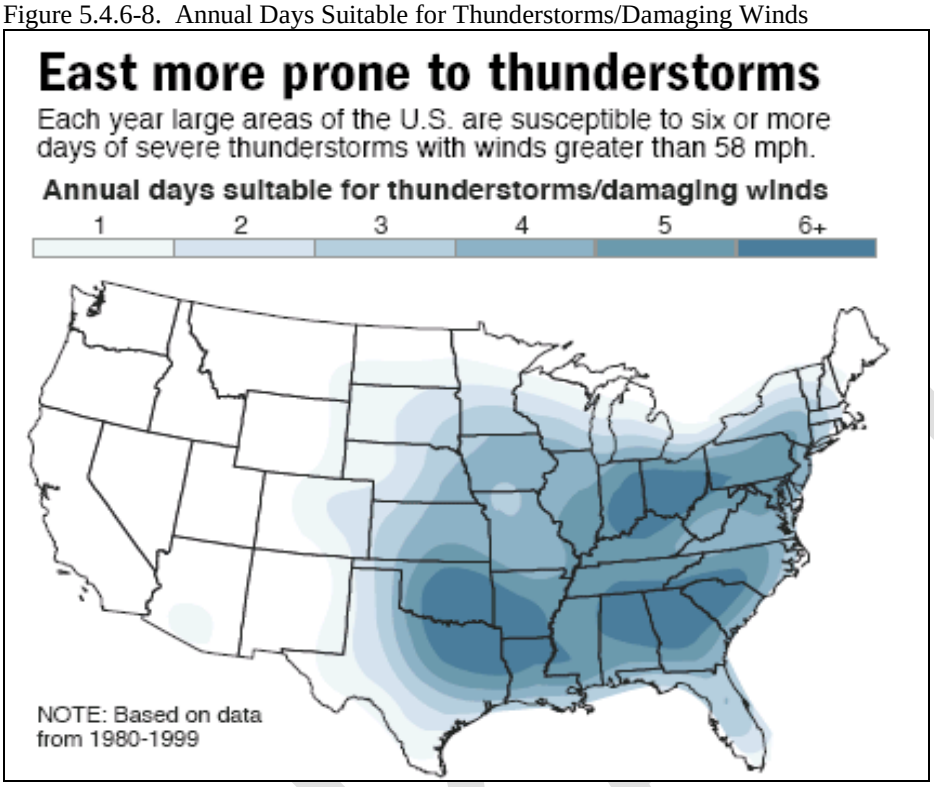


Source: NWS, 2010
Note: The black circle indicates the approximate location of New Jersey; Burlington County experiences approximately 20 thunderstorms annually, on average.

NASA scientists suggest that the U.S. will face more severe thunderstorms in the future, with deadly lightning, damaging hail and the potential for tornadoes in the event of climate change (Borenstein, 2007).

A recent study conducted by NASA predicts that smaller storm events like thunderstorms will be more dangerous due to climate change (Figure 5.4.6-8). As prepared by the NWS, Figure 5.4.6-8 identifies those areas, particularly within the eastern U.S. that are more prone to thunderstorms, which includes all of the state of New Jersey.

Figure 5.4.6-8. Annual Days Suitable for Thunderstorms/Damaging Winds

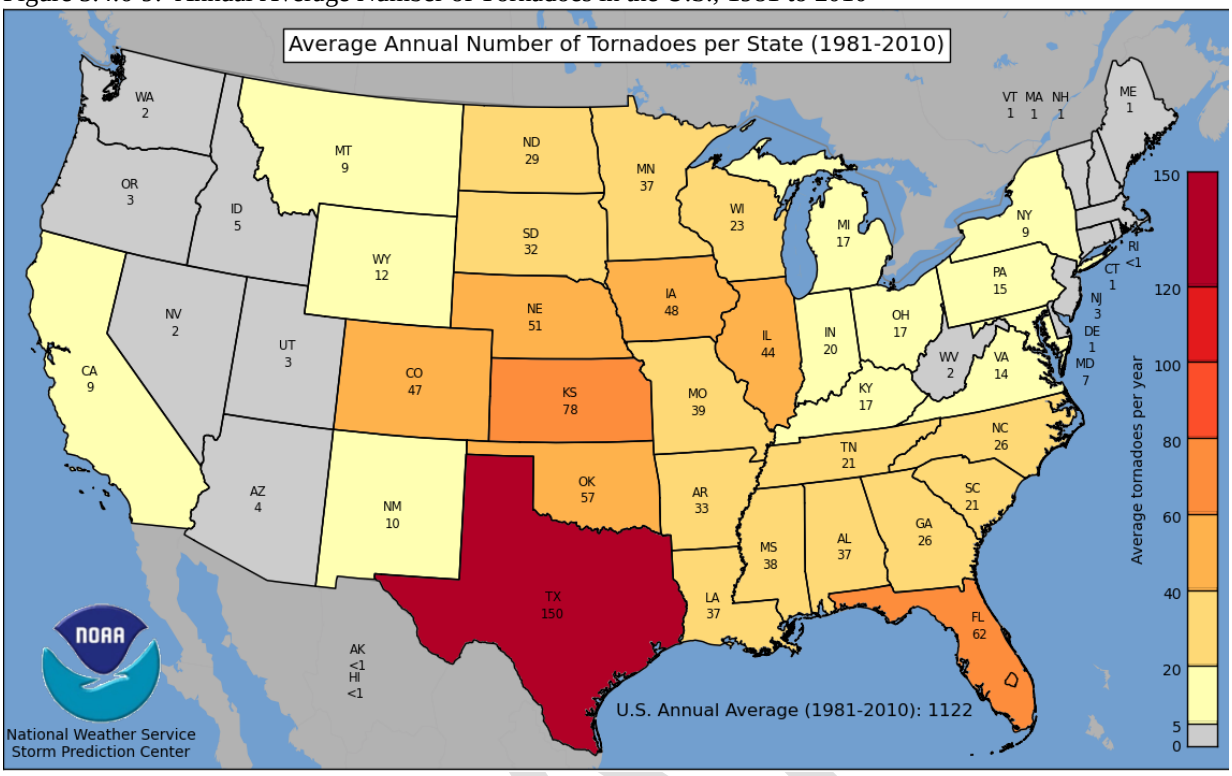


Source: MSNBC.com, 2007

Tornado

The U.S. experiences more tornadoes than any other country. In a typical year, approximately 1,000 tornadoes affect the U.S. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central U.S. Figure 5.4.6-9 shows the annual average number of tornadoes between 1981 and 2010 (NWS, 2012). New Jersey experienced an average of three tornado events annually between 1981 and 2010.

Figure 5.4.6-9. Annual Average Number of Tornadoes in the U.S., 1981 to 2010

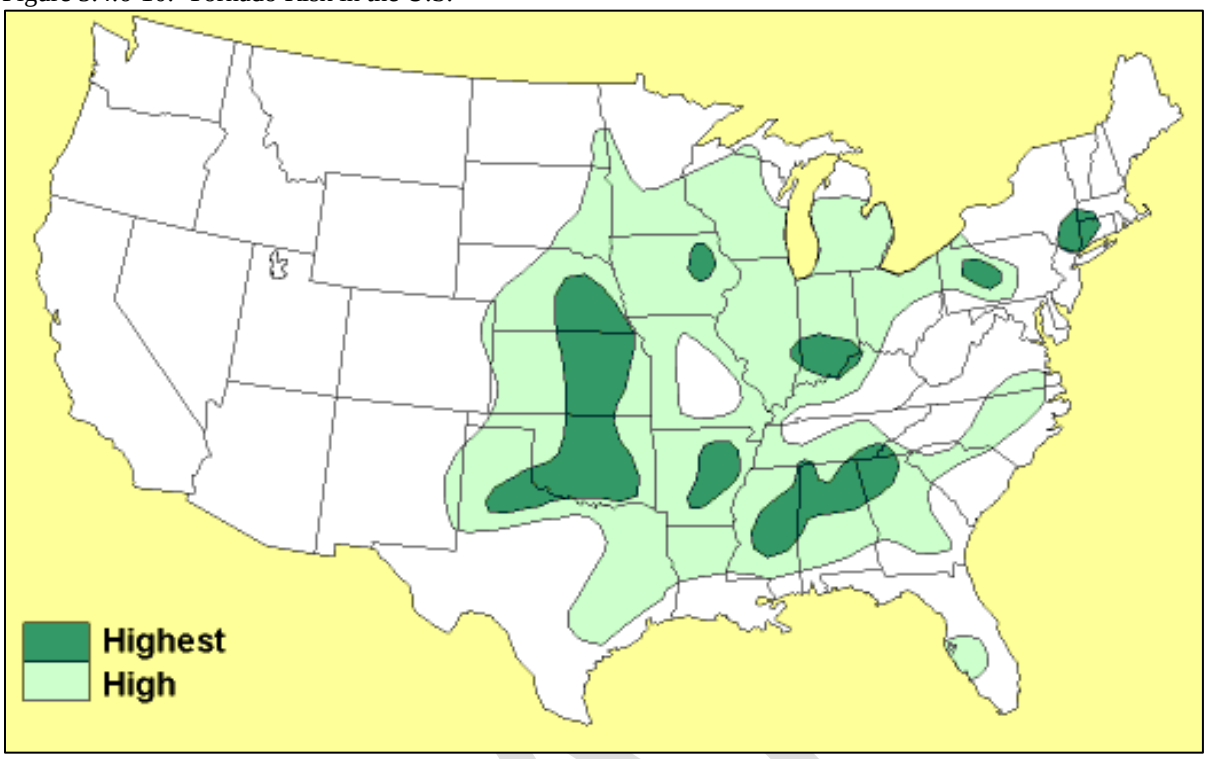


Source: NWS, 2012
Note: Between 1981 and 2010, New Jersey experienced an average of three tornadoes annually.

New Jersey ranks 37th in the U.S. for frequency of tornadoes, 30th for injuries per area and 23rd for cost per area. When compared to other states on the frequency of tornadoes per square mile, New Jersey ranks 20th (NJOEM, 2011).

Figure 5.4.6-10 indicates that a majority of the State, with the exception of the northern-most border, has an overall low risk of tornado activity. Burlington County is located in central New Jersey, which according to the figure, has a low risk of tornadoes.

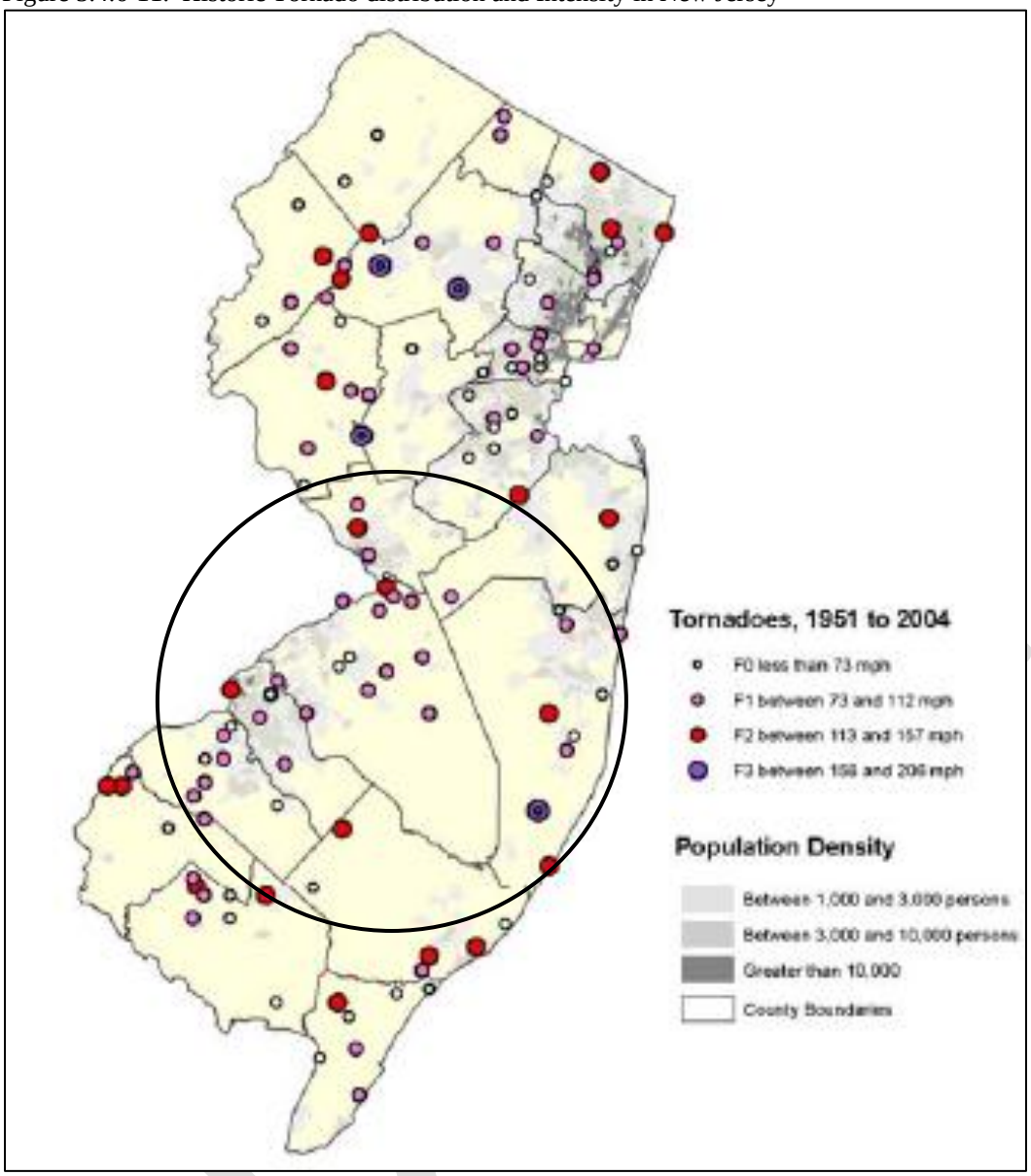
Figure 5.4.6-10. Tornado Risk in the U.S.



Source: The Physical Environment, 2012
Note: Burlington County is shown has having a low risk of tornado occurrences.

According to Figure 5.4.6-11, every county in New Jersey has experienced a tornado between 1951 and 2004 (NJOEM, 2011). No tornados have been reported in Burlington County since the publication of the initial HMP, dated 2008.

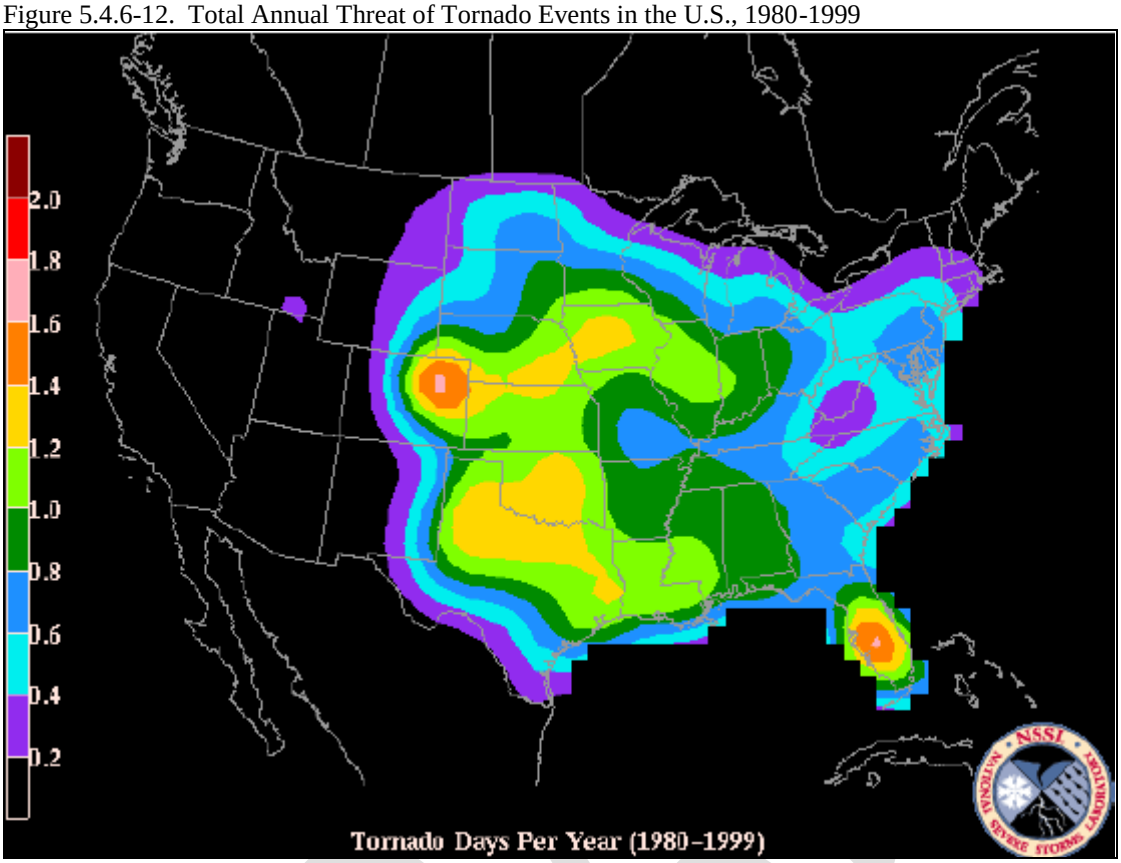
Figure 5.4.6-11. Historic Tornado distribution and Intensity in New Jersey



Source: NJOEM, 2011
Note: The black circle indicates the approximate location of Burlington County.

A study from NOAA's National Severe Storms Laboratory (NSSL) provided estimates of the long-term threat from tornadoes. The NSSL used historical data to estimate the daily probability of tornado occurrences across the U.S., no matter the magnitude of the tornado. Figure 5.4.6-12 shows the estimates prepared by the NSSL. In the State of New Jersey, it is estimated that the probability of a tornado occurring is 0.4 and 0.8 days per year. In Burlington County, it is estimated that the probability of tornado occurring is 0.6 to 0.8 days per year (NSSL, 2003; NJOEM, 2011).

Figure 5.4.6-12. Total Annual Threat of Tornado Events in the U.S., 1980-1999



Source: NJOEM, 2011; NSSL, 2003

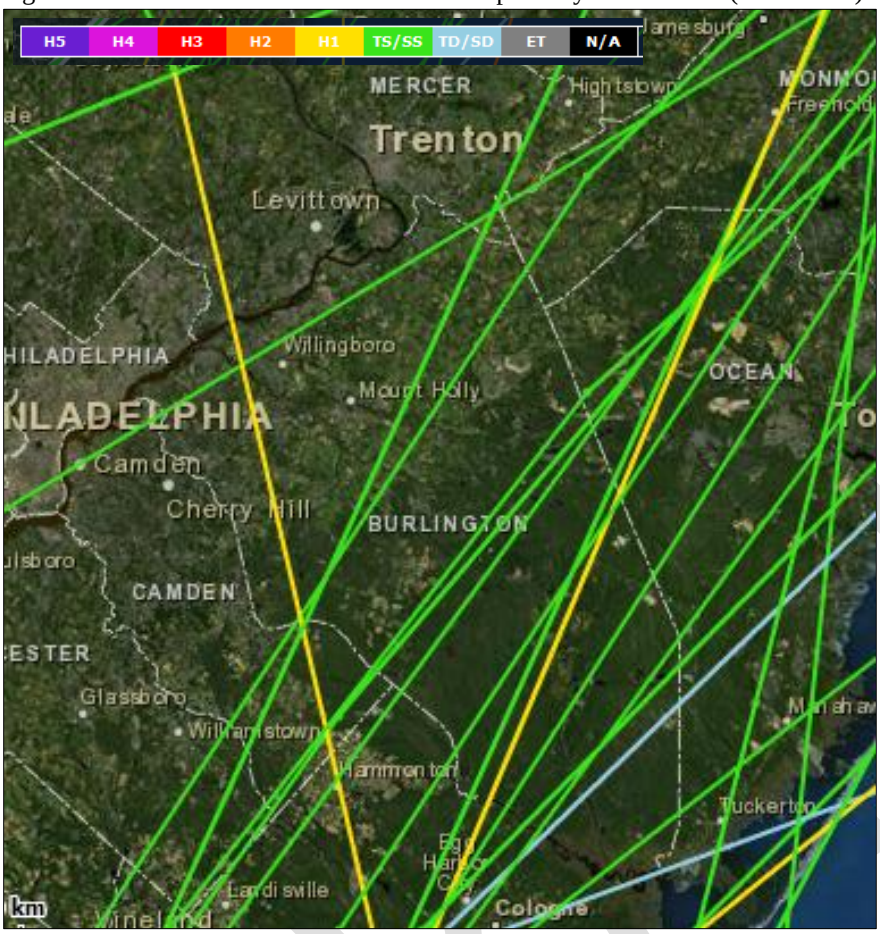
Note: The mean number of days per year with one or more events within 25 miles of a point is shown here. The fill interval for tornadoes is 0.2, with the purple starting at 0.2 days. For the nontornadic threats, the fill interval is 1, with the purple starting at 1. For the significant (violent), it's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

Hurricanes/Tropical Storms

Hurricanes and tropical storms can impact the state of New Jersey and Burlington County from June to November, the official eastern U.S. hurricane season. However, late July to early October is the period hurricanes and tropical storms are most likely to impact the state, due to the coolness of the North Atlantic Ocean waters (NYS HMP, 2011).

The Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1842 to 2013. Figure 5.4.6-14 displays specific tropical cyclone tracks for Burlington County. Between 1842 and 2012, 34 tropical cyclone events have passed through Burlington County within 65 nautical miles (NOAA, 2012).

Figure 5.4.6-14. Historical North Atlantic Tropical Cyclone Tracks (1842-2013)



Source: NOAA, 2012

Input from Planning Committee

Specific items identified by Planning Committee members include:

- Moorestown Township has many large older trees that have been brought down by high winds in the past. This trend is expected in the future, causing power outages and traffic obstructions, etc. They also noted numerous nursing homes and assisted care facilities in their area that would be of concern for damage to electric power distribution systems (Burlington County HMP, 2008).
- Tabernacle noted that it is highly susceptible to extreme winds in its most flat areas made up of farm tracts and open lands (Burlington County HMP, 2008).
- Florence indicated that extreme winds have caused damage in the Township throughout the past few years, where windstorms have caused emergency situations resulting in power outages due to overgrown trees knocking down power lines and structure damage due to winds and debris (Burlington County HMP, 2008).
- Mount Laurel noted that their major concerns regarding extreme winds include tree damage, downed wires, traffic problems, power outages, and communication problems (Burlington County HMP, 2008).
- Cinnaminson has been impacted by extreme winds in the past, which have caused emergency situations, power outages, and structural damages. They note recent tornado touchdowns in

neighboring townships causing severe damage, and in their community, damages in recent years from wind downdrafts (Burlington County HMP, 2008).

- Mansfield Township recalls a past extreme wind event in the early 1990's which downed trees and damaged dwellings (Burlington County HMP, 2008).
- Wrightstown Borough reports that the extent of the extreme wind hazard in their community has been observed by a straight line wind even in 1995 which destroyed 19 mobile homes and damaged over 100 other structures (Burlington County HMP, 2008).

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe storm events throughout the State of New Jersey and Burlington County. With so many sources reviewed for the purpose of this HMP Update, 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 update.

According to NOAA's National Climatic Data Center (NCDC), 554 severe storm events (hurricane/tropical storms, tornadoes, thunderstorm/wind, lightning, funnel clouds, hail, heavy rain, and high wind) have been reported in Burlington County between January 1, 1950 and April 30, 2013. These events resulted in six fatalities, 45 injuries, $69.8 million in property damages and $1 million in crop damages. For most events affecting Burlington County, downed trees and power lines were common effects of high winds, which ranged from a minimum of 58 miles per hour to a maximum of 102 miles per hour, with most events being in the range of approximately 58 to 74 miles per hour and often were the result of severe thunderstorms or strong pressure systems moving through the area between the months of May and August. The first 78 events in the database (from July 1956 through July 1992) do not include descriptions. The majority of the remaining reported wind events included downed trees and power lines, and associated power outages and road closures.

Between 1955 and 2012, FEMA declared that the state of New Jersey experienced 32 severe storm-related disasters (DR) and/or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, flooding, coastal storms, heavy rains, remnants of tropical storm, hurricane, high tides, and straight-line winds. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, sources indicate that Burlington County has been declared as a disaster area as a result of 10 of these severe storm events (FEMA, 2012).

Based on all sources researched, known severe storm events that have affected Burlington County and its municipalities since the original HMP was published are identified in Table 5.4.6-7. With severe storm documentation for New Jersey being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.6-7 may not include all events that have occurred throughout the County and region. Many severe storm events resulted in major flooding throughout the county, therefore, the flood impact of these events are further mentioned in Section 5.4.6 (Flood). According to many sources, certain severe storm events have actually been classified as Nor'Easters; therefore, further discussed in Section 5.4.6 (Severe Winter Storm) and the flooding impact of the events are further discussed in Section 5.4.6 (Flood). Events previously reported in the 2008 County HMP are sourced as "Burlington County HMP".

Table 5.4.6-7. Severe Storm Events between 1903 and 2013

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
September 16, 1903	Hurricane	N/A	N/A	This storm made landfall on September 16, 1903 at Atlantic City as an 80 mph Category 1 hurricane, making it the most recent hurricane to directly strike the State of New Jersey. The storm track crossed over Burlington County in a north-northwesterly direction. The storm reportedly caused some damage to coastal areas, with most significant impacts inland particularly in the Passaic River Basin in northern New Jersey due to significant rainfall of up to 15 inches in some areas.	Burlington County HMP
August 26, 1924	Hurricane	N/A	N/A	This unnamed storm was a Category 2 storm when it passed approximately 150 nautical miles off the southeastern corner of Burlington County with winds of 100 to 105 mph.	Burlington County HMP
September 19, 1936	Hurricane	N/A	N/A	This storm was a Category 2 hurricane when it passed by Burlington County, roughly paralleling the New Jersey shoreline. Coastal areas incurred flooding and beach erosion.	Burlington County HMP
September 21, 1938	Hurricane	N/A	N/A	The New England Hurricane of 1938 passed to the east of New Jersey. Coastal areas saw heavy winds and wave action. Statewide, tomato crops and apple harvests suffered.	Burlington County HMP
August 1, 1944	Tropical Storm of August 1944	N/A	N/A	This tropical storm passed through the Delmarva Peninsula and subsequently made landfall in New Jersey at Cape May. Severe beach erosion and high tides were noted in coastal areas.	Burlington County HMP
September 14, 1944	Great Atlantic Hurricane	N/A	N/A	This storm was a Category 3 when it passed off the coast of New Jersey. It caused damages primarily in northern New Jersey, New York City, Long Island, and portions of the Mohawk and Hudson watersheds. Burlington City received 4.75 inches of rain. Severe flooding occurred statewide, particularly in coastal areas which saw storm surges of up to nearly ten feet, waves of up to 40 feet, and strong winds gusting to 125 mph.	Burlington County HMP
August 10, 1952	Tornado (F0)	N/A	N/A	2 miles in length; 100 yards in width; approximately $25 K in damages. Location of the tornado was not reported.	Burlington County HMP
August 1955	Tropical Storms Connie and Diane	DR-41	N/A	Tropical storm Connie saturated much of New Jersey when it passed through the Delmarva Peninsula on August 13, 1955. When Tropical Storm Diane arrived on August 19, 1955, significant rain fell on already saturated ground, causing significant flooding particularly in the Delaware River Basin (including western Burlington County). In Burlington City, this event flooded more structures than any other community along the Delaware River, leaving the Township with 875 residential, 77 commercial, and 4 industrial structures damaged by the floodwaters. Within the Delaware River Basin as a whole, this event was one of the most destructive along the main stem.	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
July 13, 1956	Tornado (F1)	N/A	N/A	1 mile in length; 150 yards in width; approximately $25 K in damages. Location of the tornado was not reported.	Burlington County HMP
June 13, 1958	Tornado (F1)	N/A	N/A	The length, width and location of this tornado were not reported. It caused $250 K in damages and one injury was reported.	Burlington County HMP
September 12, 1960	Hurricane Donna	N/A	N/A	Hurricane Donna passed New Jersey as a Category 3 hurricane while moving at a high forward speed. Damage was significant along the coastline, but was minimized because Donna was not a direct hit in New Jersey. The hurricane caused winds gusts of up to 109 mph, heavy rainfall, and a storm surge of 6 feet.	Burlington County HMP
March 10, 1964	Tornado (F1)	N/A	N/A	25 miles in length; 200 yards in width; approximately $250 K in damages and five injuries. Location of the tornado was not reported.	Burlington County HMP
September 1971	Heavy Rains and Flooding	DR-310	Yes	No reference and/or no damage reported.	FEMA
July 1975	Heavy Rains, High Winds, Hail, Tornadoes	DR-477	Yes	No reference and/or no damage reported.	FEMA
June 3, 1980	Tornado (F0)	N/A	N/A	One mile in length; 30 yards in width; approximately $25 K in damages. Location of the tornado was not reported.	Burlington County HMP
June 21, 1981	Tornado (F1)	N/A	N/A	The length, width and location of this tornado were not reported. It caused $250 K in damages.	Burlington County HMP
September 27, 1985	Hurricane Gloria			Hurricane Gloria passed just east of Burlington County, before making landfall on Long Island.	Burlington County HMP
July 2, 1987	Tornado (F0)	N/A	N/A	One mile in length; 30 yards in width; approximately $250 K in damages. Location of the tornado was not reported.	Burlington County HMP
July 12, 1987	Tornado (F1)	N/A	N/A	2 miles in length; 10 yards in width; approximately $3 K in damages. Location of the tornado was not reported.	Burlington County HMP
1990	Wind Shear	N/A	N/A	City of Burlington experienced a wind shear event that downed 200 year old trees, powerlines and close off roadways in the City.	Burlington County HMP
October 18, 1990	Tornado (F1)	N/A	N/A	One mile in length; 100 yards in width; approximately $250 K in damages. Location of the tornado was not reported.	Burlington County HMP
August 19, 1991	Tornado (F1)	N/A	N/A	Two miles in length; 70 yards in width; approximately $3 K in damages. Location of the tornado was not reported.	Burlington County HMP
June 27, 1994	Microburst	N/A	N/A	A severe microburst (estimated wind gusts to 70 mph) affected most of the downtown and lake shore areas of Pemberton with at least a dozen large trees uprooted with numerous limbs down. The greatest damage was done on East Lake Shore Drive. Damaging wind gusts continued in McGuire Air Force Base where a roof blew off and knocked down an adjoining wall of the same building. Numerous trees were downed at the base.	Burlington County HMP
July 25, 1994	TSTM	N/A	N/A	In Burlington City, thunderstorm winds caused the partial collapse	Burlington County

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				of an unused building at a private school on River Bank Road. Trees were uprooted in Burlington City and also in North Hanover. PSE&G reported thousands of customers were without power in Burlington County	HMP
August 2, 1994	Tornado (F0)	N/A	N/A	A rare westward moving tornado was formed from merging thunderstorms in northern Burlington County. The tornado touched down in Chesterfield Township and destroyed a brick barn, uprooted trees, damaged the roof of a home under construction and also damaged a couple of classic autos in a garage.	Burlington County HMP
May 29, 1995	Tornado (F1)	N/A	N/A	The same thunderstorm that produced the Norristown tornado and funnel clouds over the Burlington Bristol Bridge dropped another tornado on Chesterfield Township. The tornado (F1) touched down near the intersection of Old York and Bordentown-Chesterfield Road (County Road 528). The tornado paralleled Bordentown-Chesterfield Road for most of its lifetime. Four houses suffered damage from both the tornado and the hail. The remaining damage was toppled trees, twisted limbs and downed power lines. No injuries were reported.	Burlington County HMP
June 22, 1996	TSTM	N/A	N/A	A severe TSTM occurred on June 22nd in Burlington County and uprooted trees; downed powerlines; brought golf ball sized hail and caused considerable wind damage to most of the County. In Bordentown Township, the storms uprooted trees and downed wires. Most of the damage to structures and vehicles were caused by fallen trees. Hundreds of trees were damaged and approximately 20 to 30 trees between 200 and 300 years old were destroyed on the World Missionary grounds. In Fieldsboro Borough, golf ball sized hail fell and approximately 60 reports of wind-related damage was reported in the Browns Mills and Country Lakes sections of Pemberton Township. In North Hanover Township, the storms caused wind damage to farm crops and mobile homes in Spartan Village (nine homes destroyed, 70% of mobile homes suffered some damage). There was some wind damage reported at McGuire Air Force Base as well. A 26-year-old National Guardsman died during the clean-up on the base when he tried to move a downed tree and it collapsed on him on Pennsylvania Avenue. One-third of the County's total damages occurred in North Hanover Township.	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				Overall, in Burlington County, 10 homes were destroyed, 116 homes suffered severe damage, 374 homes had minor to moderate damage, and 22,000 homes were without power. Burlington County was declared a disaster area. Wind damages were reported throughout the County, with wind gusts reaching 84 mph in some locations. Entire fields of crops at 12 farms were destroyed from Chesterfield through North Hanover to Fort Dix. Countywide damage from the thunderstorms was estimated at $12 million ($11 million property damage and $1 million crop damage).	
July 18, 1997	High Winds	N/A	N/A	A gust front of damaging winds moved through northwestern Burlington County and knocked down power lines in Burlington City and in the Townships of Cinnaminson, Delran, Mansfield, Medford, Moorestown, Mount Holly, Southampton and Westampton. In Moorestown Township, downed wires on Kings Highway (State Route 41) closed the road for one hour. PSE&G reported 18,000 customers lost power due to the downed wires from the wind gusts that occurred throughout central New Jersey.	Burlington County HMP
June 1, 1998	Severe TSTMs	N/A	N/A	A squall line of severe thunderstorms caused pockets of wind damage throughout the northwest half of Burlington County. The riverfront townships were the hardest hit in the County. There was a second burst of wind damage inland in the Townships of Evesham, Medford, Pemberton and Southampton. Pemberton Township declared a local state of emergency as 12 roads were closed and most of the Township was without power. Eight school districts cancelled classes because of power outages. Power outages also affected two of the County's hospitals and cancelled the morning court session in Mount Holly. Peak wind gusts of 74 mph were reported at McGuire Air Force Base. In Palmyra Township, numerous trees were knocked down, especially along Morgan Avenue. A porch of one home was damaged by a fallen tree. In Willingboro Township, a tree crushed a garage and many trees were knocked down, mainly in the Martin's Beach area. In Burlington Township, at least one vehicle was damaged by fallen trees. The thunderstorm tore a metal roof away and knocked down wires in twenty different locations. In Springfield Township, a barn collapsed after its roof was blown off. Debris was scattered up to 3,000 feet. In Pemberton Township, an elderly couple was trapped in their	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				mobile home, several roofs were damaged in the Country Lakes area, the Browns Mills Fire Station was damaged and most of the downtown area was blacked out. Numerous trees were knocked down in the Hoot Owl section of Medford Township. Minor wind damage was also reported in Lumberton and Mount Laurel Townships. About 74,000 PSE&G customers lost power during the height of the storm throughout their service area. Most of the outages though were in Burlington, Camden and Gloucester Counties. There were still 32,500 customers without power the evening of the first. All power was restored the morning of the second.	
June 30, 1998	Strong Winds	N/A	N/A	A gust front the squall line moved through western Burlington County and produced scattered pockets of wind damage. In Medford Township, a 40 foot high cinderblock wall at a construction site in St. Mary of the Lakes School collapsed. The west wall of the planned gym was knocked down by the gust front. The gust front knocked over trees and power lines in Burlington, Chesterfield, Delanco, Edgewater Park, Mansfield, Medford, Mount Laurel, Springfield and Willingboro Townships. A tree crushed a vehicle in Edgewater Park.	Burlington County HMP
September 16-18, 1999	Hurricane Floyd	EM-3148	Yes	Tropical Storm Floyd passed roughly 10 miles east of Atlantic City. Bergen and Somerset Counties were the hardest hit in New Jersey. Across the southern half of New Jersey, the most widespread flooding occurred in townships along the Delaware River. In Burlington County, flooding was worst along the Rancocas Creek and along tidal sections of tributaries to the Delaware River. Some evacuations occurred in Riverside around the Delanco-Riverside Bridge. The bridge was also closed. Farther upstream along the Rancocas Creek the Centerton Bridge in Willingboro was closed. Voluntary evacuations also occurred along the Delaware River in Delran and roads near the Rancocas Creek were closed. Several evacuations also occurred along the Assicunk Creek in Burlington City. Creek flooding (mainly the Rancocas) occurred in Medford, Mount Holly, and Westampton Townships. About ten roads in the County were closed due to flooding. The North Branch of the Rancocas Creek in Pemberton crested at 3.2 feet at 9pm on the 17th; flood stage is 2.7 feet. Highest reported wind gusts were 62 mph in Browns Mills. The four highest precipitation storm totals for Burlington County were 7.07 inches in Mount Laurel, 6.48 inches in New Lisbon, 6.32	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				inches in Willingboro and 6.20 inches in Mount Holly.	
August 30, 2003	Severe TSTMs	N/A	N/A	A severe thunderstorm tore down trees and wires in Florence Township and large tree limbs and wires in Mansfield and North Hanover Townships. Downed trees closed the ramps at Exit 6 to the New Jersey Turnpike in Florence for a few hours. U.S. Route 130 in Florence was closed for about an hour because of downed utility poles.	Burlington County HMP
September 18-19, 2003	Tropical Storm Isabel			Hurricane Isabel made landfall on the outer banks of North Carolina on September 18, 2003. It quickly weakened over land and was a Tropical Storm by the time is passed over Pennsylvania. Tropical storm force winds were felt across much of the County, but rainfall was not terribly heavy. Moderate tidal flooding was observed; the high was 10.6 feet on the Delaware River in Burlington. Downed trees and powerlines were the most common type of damage.	Burlington County HMP
September 23, 2003	Severe TSTMs / Tornado (F0)	N/A	N/A	A powerful line of severe thunderstorms uprooted numerous trees and power lines throughout Burlington County. About 23,000 homes and business lost power in Mercer, Burlington, Camden and Gloucester Counties. All power was restored by the afternoon of the 24th. The combination of the Florence Township tornado and the line of severe storms produced an estimated property damage of $2.1 M throughout the County. An F1 tornado touched down in Florence Township and uprooted about 100 trees along its path. Some of the trees fell on and damaged homes. The maximum wind speeds were estimated at 85 mph. The tornado remained on the ground for about 1.75 miles and lifted in the Roebling Section of the Township. A state of emergency was declared in the Township. The worst wind damage occurred along Grove Street and Third Avenue. Trees up to three feet in diameter were snapped. A two ton central air conditioning unit was tossed into a home. At the Florence High School bleachers, concession stands and fences were badly damaged. Most of the wind damage was caused by trees falling on homes and vehicles. Other hard hit areas included Beverly, Bordentown, Burlington City, Burlington Township, Cinnaminson, Delanco, Delran, Edgewater Park, Palmyra, Riverside and Willingboro Townships. States of emergency were declared in Delanco, Riverside and Edgewater Park. The County 911 center received	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				770 weather related calls which included 130 reports of downed lines. In Cinnaminson, at the Mar-Khem Industrial site, the winds ripped the front half of a metal roof from a warehouse and office building. Several support beams were twisted and a trailer was blown over. In Beverly, part of a roof was torn from a trucking warehouse. In Edgewater Park, Colonial and Regency Roads were hit hard. Trees were removed from bedrooms and living rooms. Schools were closed. In Delanco, the steeple on the Abundant Life Fellowship Church was toppled. In Riverside, downed wires caused a fire that damaged the annex of the First Baptist Church. In Delran, two tractor-trailer boxes overturned on U.S. Route 130 and snarled it for hours. The leg of a plastic picnic table pierced the windshield of a vehicle. Numerous trees were downed including one that landed on a car. DPW staff finished the cleanup one day after the event occurred. The Fire Department responded to over 30 calls. In Burlington City, wind damage was concentrated on Riverbank Avenue, Wood Street, West Pearl Street and West Union Street.	
October 27, 2003	Tornado (F1)	N/A	N/A	A weak tornado 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. The tornado snapped large tree limbs and tossed them. A nine inch wide limb was tossed about 100 feet and struck and killed a 77-year-old woman who was about to enter her vehicle in the Holly Bowl parking lot. She suffered massive head trauma and spinal cord injuries. The same limb damaged her and two neighboring vehicles. The tornado caused small damage to the bowling alley's roof, smashed a fence and toppled a couple of light standards. It was the first tornado related death in New Jersey since August 25, 1941 in Gloucester County. The tornado was on the ground for about a half mile and its maximum path width was 30 yards. The strongest speed of the tornado was estimated at 70 mph.	Burlington County HMP
July 12-23, 2004	Severe Storms and Flooding	DR-1530	Yes	No reference and/or no damage reported.	FEMA
July 27, 2004	Tornado (F1)	N/A	N/A	An F1 tornado touched down in Woodland Township, injuring two people, damaged the New Lisbon Development Center and about 350 acres of trees in the Brendan T. Byrne State Forest. The tornado touched down in a wooded area about one mile south of the intersections of State Routes 70 and 72. A second	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				much smaller and weaker funnel also briefly touched down in that area. The tornado proceeded east through the New Lisbon Development Center where all the property damage and injuries occurred and crossed State Route 72 into the Brendan Byrne State Forest. Two staff members were injured. A thrift store on campus was destroyed and several apartments in the same attached building were also destroyed. None of the residents were injured. The roof and walls from the thrift shop were tossed more than one hundred yards. A metal bench was found in a tree. The tornado also badly damaged the administration center building. A tractor-trailer used for storage near the thrift shop was found in the woods. Several vehicles were overturned. The tornado uprooted and snapped trees, bent bird cage poles and ripped light poles from the ground. One-hundred-year-old trees were snapped. The tornado then proceeded into the Brendan Byrne State Forest where approximately 350 acres of trees were damaged or destroyed. Several hiking trails were closed through the 31st until the debris was cleared. Overall, the tornado closed down State Route 72 and 100 people were without power. Maximum wind speeds were approximately 110 mph. The tornado remained on the ground for about 2.6 miles and its path width was around 100 yards. The tornado caused approximately $500 K in damages.	
June 6, 2005	Severe TSTM	N/A	N/A	A severe thunderstorm produced a measured wind gust of 79 mph at the McGuire Air Force Base in Burlington County. Two army vehicles were struck by a wooden storage shed that had been blown over by the high winds. The shed damaged the front end of one vehicle and dented and scratched the trunk and lid of the other vehicle.	NOAA-NCDC
July 27, 2005	Severe TSTM	N/A	N/A	The gust front from a severe thunderstorm downed trees, tree limbs and wires in northwestern Burlington County including the townships of Willingboro, Maple Shade and Mount Laurel. At the Riverton Yacht Club, the gust front capsized eleven boats and sixteen people tumbled into the Delaware River. They were rescued without being injured. PSE&G reported about 16,000 of their customers, statewide, lost power including Burlington County. It took most of the night to restore power to all homes and businesses with homes in Willingboro the last to have their power restored.	NOAA-NCDC
August 2006	Extreme Wind	N/A	N/A	No reference and/or no damage reported.	Tabernacle

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
					Township
April 14-20, 2007	Severe Storms and Inland and Coastal Flooding	DR-1897	Yes	One of the worst Nor'Easters to hit New Jersey in several decades. Governor Codey indicated that the storm caused over $180 M in damages, making it the second worst rain storm in history.	FEMA, NJ HMP
October 28, 2008	Strong Winds	N/A	N/A	Gusty northwest winds combined with heavy wet snow and trees wet with leaves caused widespread utility outages throughout New Jersey. In central New Jersey, about 9,000 homes and businesses lost power. Peak wind gusts in Burlington County were recorded at 32mhr in Mount Holly Township. SHELDUS reported over $207K in damages.	NOAA-NCDC, SHELDUS
February 12, 2009	High Winds	N/A	N/A	After a cold front passed through, strong to high winds affected the State of New Jersey during the day on the 12th. Peak wind gusts averaged between 50 and 60 mph, knocking down trees, tree limbs, power lines and signs. The New Jersey Turnpike Authority banned motorcycles and car-pulled trailers. About 86,000 homes and businesses lost power in the State, with the strongest winds and most damage occurring in the central and northern parts of the state. Peak wind gusts in Burlington County included 52 mph in Chatsworth (Woodland Township and Lumberton Township. SHELDUS reported over $38K in damages.	NOAA-NCDC, SHELDUS
July 29, 2009	Severe TSTMs	N/A	N/A	A pair of severe thunderstorms moved through Burlington County in the afternoon and evening, leaving approximately 20,000 homes and businesses without power. The storms tore down scores of trees in Willingboro Township, damaging vehicles and telephone wires and displacing at least one family. Some trees and wires were also knocked down in neighboring Burlington Township and Burlington City. Gusts of up to 59 mph were recorded. The County experienced approximately $100K in damages.	NOAA-NCDC
July 31, 2009	Severe TSTMs	N/A	N/A	Severe thunderstorms moved throughout the state in the late afternoon of the 31st. Most of the wind damage occurred as a line of severe thunderstorms moved across the southern half of the state, leaving about 67,000 homes and businesses without power. In Burlington County, a damaging microburst knocked down hundreds of trees and damaged dozens of homes in Medford Lakes Borough and Medford Township. Both municipalities declared states of emergency as there were approximately a combined 1,200 weather related calls in both municipalities. Two	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				men were injured: a firefighter clearing debris and another who tried to secure a carnival float as the damaging winds began. In Medford Lakes Borough, approximately 400 trees were knocked down. About 25 homes were damaged by downed trees. Downed trees blocked 22 roadways. A tree fell on a vehicle on Lenape Trail. The hardest hit areas within the borough included Tabernacle Road, Chippewa Trail and Stokes Road near Upper Aetna Lake. Half the borough lost power. In Medford Township, a downed tree created a four foot wide hole in a home on McKendimen Road, displacing the family. Another downed tree punctured a hole in a home on Sunset Trail. The Tamarac section of the township was hardest hit. Six roadways were closed by downed trees. Power was restored the night of the 1st. Gusts of up to 85 mph were recorded. The County experienced approximately $500K in damages.	
September 10-11, 2009	Strong Winds	N/A	N/A	Peak wind gusts in Burlington County were recorded at 50 km/h in Mount Holly Township. SHELDUS reported over $23K in damages.	NOAA-NCDC, SHELDUS
March 12 - April 15, 2010	Series of Severe Storms, Nor'Easters and High Winds	DR-1897	Yes	A Nor'Easter moved into the area on March 12. On March 13, strong to high winds downed thousands of trees and tree limbs, hundreds of telephone poles, and caused utility outages throughout the state. The strongest winds occurred during the afternoon on the 13th. Governor Chris Christie declared a state of emergency on March 14th, and on March 26 requested a major disaster declaration. A state-wide federal disaster declaration was announced on April 2, making IA and PA available for affected areas. At the time of this report, a total $16.9M in IA had been approved and $30.7M in PA had been obligated throughout the State of New Jersey. Peak wind gusts included 65 mph in Woodland Township at Chatsworth, 63 mph at McGuire AFB, and 61 mph in Burlington (City). SHELDUS reported $100K in damages.	NOAA-NCDC, SHELDUS, FEMA
June 24, 2010	Severe TSTMs	N/A	N/A	Severe thunderstorms caused considerable tree damage during the afternoon into the early evening of the 24th across the southern third of New Jersey and claimed the life of one woman and injured two other persons in Burlington County. Peak wind gusts in Burlington County included 50 knts in Shamong	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				Township at Atsion. The storm knocked down trees and tree limbs in Shamong Township. A 47-year-old woman died while camping at the Atsion Recreation Area within the township. A tree snapped and fell on top of a tent she as well as a 51-year-old man and 31-year-old woman were taking shelter within. The latter two suffered minor injuries. Another downed tree damaged a vehicle within the town. About 130,000 Public Service Electric & Gas and 65,000 Atlantic City Electric customers lost power.	
July 25, 2010	Severe TSTMs	N/A	N/A	A strong cold frontal passage triggered strong to severe thunderstorms across New Jersey during the second half of the afternoon on the 25th. Numerous trees and wires were knocked down and approximately 66,000 homes and businesses lost power. Power was not fully restored until after the evening of the 26th. In Burlington County, the gust front from a severe thunderstorm knocked down a couple of trees in Mount Laurel Township. Wind gusts in the Township were recorded at 57 mph, and $1K in damage was reported.	NOAA-NCDC
September 16, 2010	Severe TSTMs	N/A	N/A	A squall line of strong to severe thunderstorms moved across most of New Jersey during the late afternoon and early evening on the 16th. At the same time, a warm front was advancing north through the state. About 50,000 homes and businesses lost power until the evening of the 17th. Many shore high school football games were postponed because of the dangerous weather. In Burlington County, a severe thunderstorm knocked down a telephone pole in Southampton Township. A Skywarn spotter's anemometer was broken by the damaging winds. At nearby South Jersey Regional Airport in Lumberton Township, a measured wind gust of 55 mph occurred. Wind gusts were recorded at 59 mph in Southampton Township, and $1K in damage was reported.	NOAA-NCDC
February 19, 2011	Strong Winds	N/A	N/A	Strong to high west to northwest winds affected New Jersey from the evening of the 18th into the evening of the 19th. 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. While more than two-thirds of the outages were resolved by the evening of the 19th, full power restoration did not occur until the evening of	NOAA-NCDC, SHELDUS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				the 20th. In Burlington County, a downed century old oak tree damaged the back of a home in Cinnaminson Township. In Edgewater Park, a greater than 200-year-old white pine tree was split in half. Peak wind gusts in Burlington County included 54 mph Florence Township, 51 mph at Lumberton Township, 50 mph in Chatsworth, Woodland Township. SHELDUS reported over $75K in damages.	
February 25, 2011	TSTMs	N/A	N/A	A strong cold frontal passage during the afternoon on the 25th triggered a squall line of strong to severe thunderstorms that moved through central and southern New Jersey. A severe thunderstorm knocked down a couple of trees in Westampton Township. Peak wind gusts in Burlington County were recorded at 57 mph in Timbuctoo, Westhampton Township. SHELDUS reported over $25K in damages.	NOAA-NCDC, SHELDUS
July 6, 2011	TSTMs	N/A	N/A	Scattered strong to severe thunderstorms affected central New Jersey during the second half of the afternoon into the early evening of the 6th. In Burlington County the storms uprooted a very large pine tree onto and damaged a fence in Wrightstown Borough. Neighboring McGuire Air Force Base recorded a wind gust of 54 mph. $1K in damages were reported.	NOAA-NCDC
July 24, 2011	TSTMs	N/A	N/A	Strong thunderstorms occurred during the afternoon and early evening of the 24th across New Jersey, with isolated severe thunderstorms in the southern half of the state. In Burlington County, a severe thunderstorm produced a strong wet microburst and knocked down numerous trees in Jenkins, Washington Township including one that fell onto a moving vehicle. The driver was not injured. The severe thunderstorm also caused the partial collapse of a couple of buildings. In Washington Township, gusts of up to 74 mph were reported in the Jenkins area of the Township and 59 mph in Buddtown (Southampton Township). $100K in damages was reported.	NOAA-NCDC
July 29, 2011	TSTMs	N/A	N/A	An approaching cold front helped trigger strong to severe thunderstorms across central and northern New Jersey during the early evening of the 29th. Hardest hit were Sussex, Burlington and Ocean Counties. About 37,000 Jersey Central Power and Light and PSE&G customers lost power in the state. Full power restoration did not occur until the 31st. In Willingboro Township of Burlington County, the storm	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				knocked down numerous trees, tree limbs and wires, and westbound Garfield road was closed. One downed tree on Twig Court fell through a home and damaged a vehicle. In Mount Laurel Township, lightning strikes were reported and one downed tree on Rancocas Boulevard fell through the roof of a house. A lightning strike started an attic fire at a house on Melissa Court in Moorestown Township. The fire was contained in the attic and no injuries were reported. Recorded wind speeds in Burlington County included 59 mph in Cinniminson Township, 64 mph in Centerton, Mount Laurel Township, 59 mph in Marlton, Evesham Township, and 59 mph in Buddtown, Washington Township. In total, the County incurred $325K in damages.	
August 13-19, 2011	TSTMs	DR-4033	No	A series of thunderstorms preceding a cold front dropped three to seven inches of rain across a wide area of the State of New Jersey from overnight on the 13th into the day on the 14th. Another series of strong to severe thunderstorms affected the State on the 18th and 19th. In Burlington County, penny size hail fell in Mount Laurel Township on the 18th. The next day, a few trees and large limbs fell in Medford Township, causing some damage to houses. Wind speeds included 59 mph in Maple Shades Township, 59 mph in Ramblewood (Mount Laurel Township), and 59 mph in Medford Lakes Borough, causing $10K in damages.	NOAA-NCDC, FEMA
August 27 – September 5, 2011	Hurricane Irene	DR-4021 EM-3332	Yes	Hurricane Irene hit the State of New Jersey on August 27th, resulting in a state disaster declaration August 29th and a presidential disaster declaration August 31st. Approximately 1.6 million customers of JCP&L and PSE&G throughout the State lost power, which was not fully restored until September 5th. Widespread tree wind damage (and damage to homes and vehicles when trees fell on them) occurred in every county. The highest wind gusts recorded in Burlington County during Hurricane Irene were 51 mph at Ft Dix-Wrightstown in New Hanover Township, and 47 mph in Mount Holly Township. Thousands of homes were flooded, including about 300 reported basement floods in Burlington City. Damage from the storm was so widespread that for the first time in state history, all 21 counties became eligible for both Individual	NOAA-NCDC, FEMA

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				Assistance (IA) and Public Assistance (PA). At the time of this report, a total $176.6M in IA had been approved and $111.9M in PA had been obligated throughout the state of New Jersey. Burlington County had approximately $500K in damage due to the storm.	
September 28 – October 6, 2011	Remnants of Tropical Storm Lee	DR-4039	No	Remnants of Tropical Storm Lee brought a series of thunderstorms with torrential downpours the State of New Jersey. The thunderstorms caused small stream and poor drainage flash flooding across northwest New Jersey. No damage was reported in Burlington County.	NOAA-NCDC, FEMA
June 1, 2012	TSTMs	N/A	N/A	Scattered strong thunderstorms moved over central parts of New Jersey during the afternoon and early evening of the 3rd. These thunderstorms dropped penny to nickel-size hail in Hunterdon County and produced minor wind damage in Burlington county. In Burlington County, storms knocked down one tree onto a house on Montrose Lane in the Millbrook Park section of Willingboro Township. Doppler Radar suggested the wind gusts were around 45 mph. No injuries and $10K in damages were reported.	NOAA-NCDC
June 22, 2012	TSTMs	N/A	N/A	Scattered strong to severe thunderstorms produced pockets of very heavy rain and some wind damage across parts of New Jersey, eastern Pennsylvania, and Delaware during the afternoon and evening of the 22nd. Atlantic City Electric reported that roughly 16,000 of its customers lost power at the height of the storm. In Burlington County, wind gusts knocked down trees in Chesterfield Township, and trees and wires fell in Southampton Township. In Palmyra Borough, trees fell on West Broad Street and Washington Avenue and in Moorestown Township numerous large tree limbs fell on East Main Street. Recorded wind speeds included 50knts in Chesterfield Township, Riverton Borough, Mount Laurel Township at Ramblewood, and Southampton Township at Vincentown. Hail was reported of 1 inch in Jacobstown and .75 inch in Willlingboro Township. The County experienced a total of $2K in damages.	NOAA-NCDC
July 4, 2012	TSTMs	N/A	N/A	Strong to severe thunderstorms developed during the late evening and overnight across the central part of New Jersey. In Burlington County, lightning struck a transformer, downing wires and causing a brief fire near Old York Road in Burlington Township. Penny-size hail as well as a peak wind gust of 48 mph was reported in	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				Florence Township. Another thunderstorm produced estimated wind gusts of 40 to 50 mph in Willingboro Township and knocked down a 150-year-old tree in Westhampton Township. It also caused some minor wind damage to a couple of homes. Wind speeds of 57 mph were reported in Timbuctoo (Westhampton Township). The County experienced a total of $2K in damages.	
October 26 – November 8, 2012	Hurricane Sandy	DR-4086 EM-3354	Yes	Hurricane Sandy made landfall in New Jersey on October 28, causing widespread damage. However, since the storm merged with a cold-air system, it was no longer considered a tropical cyclone by the time of landfall, even though it still had hurricane-force winds. Sustained winds were well over tropical storm force in northern and central New Jersey, and gusts exceeded hurricane force (74 mph) at many coastal locations and at some exposed inland sites. The result of the storm was devastation to homes and infrastructure along the Delaware River and near the Atlantic coast in Burlington County, thousands of trees falling on homes, automobiles, and power lines across the state, unprecedented damage to the power grid, the loss of power to over 75% of customers, and record disruptions of transportation and communications. In Burlington County, a 73-year-old man and his 70-year-old wife died from a generator related house fire in Willingboro Township, and a Mount Holly Township resident was trapped inside their home after a tree landed on it. Indicative of further tree damage in the county, seven roadways were closed in Medford Township. Along the Delaware River, tidal flooding occurred in the Columbus Park Development along the Assiscunk Creek in Burlington City. The most widespread damage (mainly tidal and flood related) was reported in Bass River Township. Recorded wind speeds in the county include gusts of up to 70 mph in Florence Township, 66 mph at the McGuire Air Force Base in New Hanover Township, 60 mph in Lumberton Township, and 56 mph in Woodland Township (Burlington County). Event precipitation totals included 4.10 inches in Medford Township, 3.51 inches in Woodland Township at Chatsworth, 3.15 inches in Medford Lakes Borough, 2.92 inches in Mount Laurel Township, 2.82 inches in Morrestown Township, and 2.42 inches in Westampton Township. A federal emergency declaration was announced for New Jersey	NOAA-NCDC, FEMA

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source (s)
				on October 29, and a major disaster declaration followed the next day, making IA and PA funds available to affected residents. At the time of this report, a total $274.9M in IA had been approved and $81M in PA had been obligated throughout the State of New Jersey.	

Sources: FEMA, NOAA-NCDC, NWS, SHELDUS, ONJSC, NJWCN , Weather Underground

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

DR	Federal Disaster Declaration	Mph	Miles Per Hour
EM	Federal Emergency Declaration	NCDC	National Climate Data Center
FEMA	Federal Emergency Management Agency	NOAA	National Oceanic Atmospheric Administration
HMP	Hazard Mitigation Plan	NWS	National Weather Service
IA	Individual Assistance	PA	Public Assistance
K	Thousand ($)	SHELDUS	Spatial Hazard Events and Losses Database for the U.S.
M	Million ($)	TSTM	Thunderstorms

Probability of Future Events

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

In Section 5.2, the identified hazards of concern for Burlington County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the County is considered 'frequent' (likely to occur within 25 years, as presented in Table 5.3-3); however, impacts only related to severe storms, excluding those associated with hurricanes, tropical storms, Nor'Easters and flooding, are expected to be minimal.

It is estimated that Burlington County will continue to experience direct and indirect impacts of severe storms annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

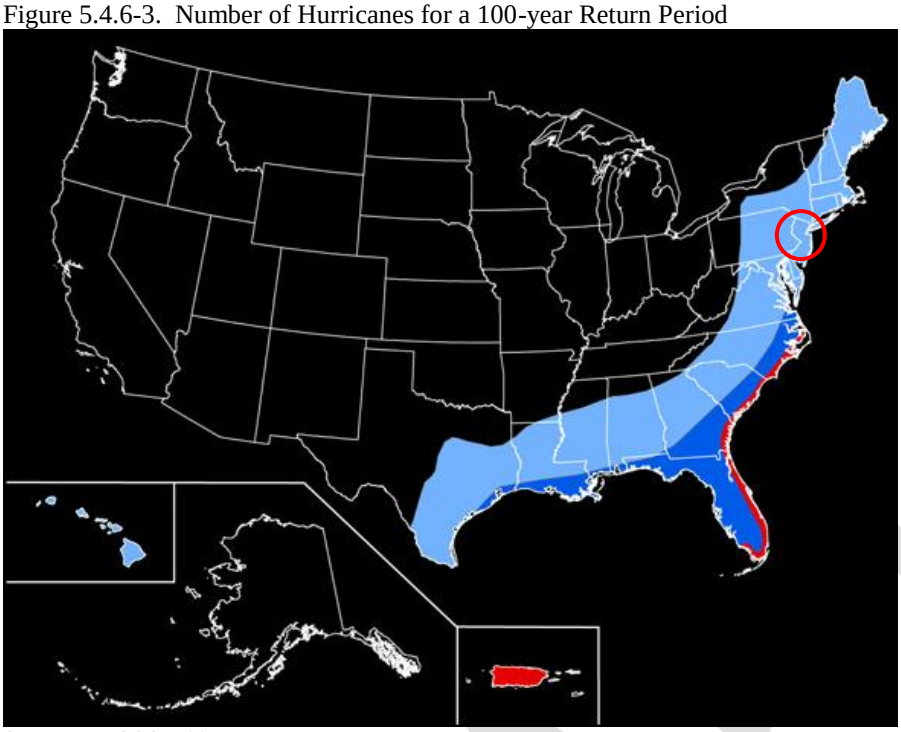
Tornadoes

For tornado events, this plan indicates the probability of future occurrences in terms of frequency based on historical events. According to the NOAA-NCDC Storm Database, Burlington County has experienced 28 tornadoes in the 63 year period between 1950 and 2013, or an average of 0.44 tornadoes per year.

Hurricanes

Figure 5.4.6-3 illustrates the number of hurricanes expected to occur during a 100-year period. According to this map, portions of New Jersey, including Burlington County, can expect between 20 and 40 hurricanes during a 100-year return period.

Figure 5.4.6-3. Number of Hurricanes for a 100-year Return Period



Source: USGS, 2005

Note: The number of hurricanes expected to occur during a 100-year MRP based on historical data—light blue area, 20 to 40; dark blue area, 40 to 60; red area, more than 60. Map not to scale.

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For severe storms, the entire County has been identified as the hazard area. Therefore, all County assets (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable. The following text evaluates and estimates the potential impact of severe storms on the County including:

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

Overview of Vulnerability

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

Due to the large geographic area the County covers with both coastal and inland locations, the loss associated with hurricanes can vary across the County (see flooding discussion in Section 5.4.4 Flood). Secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a primary concern in the County. The County has experienced flooding in association with several hurricanes and tropical storms in the past.

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

Table 5.4.6-8. Summary of Potential Surge Inundation Areas by Community

Municipality	Total Acres	% in CAT1 Surge Zone	% in CAT2 Surge Zone	% in CAT3 Surge Zone	% in CAT4 Surge Zone
Bass River (T)	50,140	12.6%	22.7%	25.6%	31.6%
Beverly (C)	486	0.4%	0.5%	0.5%	0.7%
Bordentown (C)	618	5.0%	5.0%	5.0%	5.0%
Bordentown (T)	5,926	2.9%	2.9%	2.9%	2.9%
Burlington (C)	2,426	5.3%	5.4%	5.4%	7.7%
Burlington (T)	8,992	0.3%	0.4%	0.6%	3.0%
Chesterfield (T)	13,736	0.0%	0.0%	0.0%	0.0%
Cinnaminson (T)	5,099	0.6%	0.7%	0.7%	8.6%
Delanco (T)	2,190	0.8%	0.9%	0.9%	1.4%
Delran (T)	4,654	2.1%	2.2%	2.2%	3.2%

Municipality	Total Acres	% in CAT1 Surge Zone	% in CAT2 Surge Zone	% in CAT3 Surge Zone	% in CAT4 Surge Zone
Eastampton (T)	3,723	0.0%	0.0%	0.0%	0.0%
Edgewater Park (T)	1,976	0.1%	0.1%	0.2%	0.2%
Evesham (T)	18,943	0.0%	0.0%	0.0%	0.0%
Fieldsboro (B)	224	1.0%	1.0%	1.0%	1.0%
Florence (T)	6,559	0.3%	0.4%	0.4%	0.4%
Hainesport (T)	4,344	0.1%	11.9%	13.8%	20.7%
Lumberton (T)	8,327	0.0%	3.2%	4.1%	8.1%
Mansfield (T)	14,010	0.4%	0.4%	0.4%	0.4%
Maple Shade (T)	2,451	0.0%	0.0%	0.0%	3.7%
Medford (T)	812	0.0%	3.1%	4.0%	9.4%
Medford Lakes (B)	25,474	0.0%	0.0%	0.0%	0.0%
Moorestown (T)	9,585	0.2%	0.4%	0.4%	2.4%
Mt. Holly (T)	1,837	0.0%	0.4%	0.8%	3.2%
Mt. Laurel (T)	14,066	0.1%	0.7%	0.8%	1.5%
New Hanover (T)	14,483	0.0%	0.0%	0.0%	0.0%
North Hanover (T)	11,203	0.0%	0.0%	0.0%	0.0%
Palmyra (B)	1,673	1.7%	1.8%	4.4%	39.2%
Pemberton (B)	403	0.0%	0.0%	0.0%	0.0%
Pemberton (T)	40,171	0.0%	0.0%	0.0%	0.0%
Riverside (T)	1,048	0.5%	0.5%	0.6%	0.9%
Riverton (B)	614	1.3%	0.0%	1.6%	36.1%
Shamong (T)	28,791	0.0%	0.0%	0.0%	0.0%
Southampton (T)	28,446	0.0%	0.0%	0.0%	0.1%
Springfield (T)	18,924	0.0%	0.0%	0.0%	0.0%
Tabernacle (T)	31,688	0.0%	0.0%	0.0%	0.0%
Washington (T)	66,539	8.3%	14.3%	18.2%	27.0%
Westampton (T)	7,104	0.0%	1.6%	1.9%	3.2%
Willingboro (T)	5,175	0.9%	1.0%	1.1%	1.7%
Woodland (T)	61,001	0.0%	0.0%	0.0%	0.0%
Wrightstown (B)	1,146	0.0%	0.0%	0.0%	0.0%
Burlington County (Total)	**525,009**	**2.4%**	**4.3%**	**5.1%**	**7.4%**

Source: Burlington County GIS

Data and Methodology

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

A probabilistic scenario was run for Burlington County for annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. These results are shown in Figure 5.4.6-1 and

Figure 5.4.6-2, earlier in this section, which show the HAZUS-MH maximum peak gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP hurricane events. The estimated hurricane track for the 100- and 500-year events is also shown.

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

The "Sea – Lake Overland Surge from Hurricanes – SLOSH Model, which represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide were used to estimate exposure. Please note these inundation zones do not include riverine flooding caused by hurricane surge or inland freshwater flooding. The model, developed by the National Weather Service to forecast surges that occur from wind and pressure forces of hurricanes, considers only storm surge height and does not consider the effects of waves.

Impact on Life, Health and Safety

The impact of a severe storm on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire County's population (U.S. Census 2010 population of 448,734 people) is exposed to this storm hazard (wind).

To estimate potential exposure to storm surge, the SLOSH inundation zones were used. The estimated population in the Category 1 through 4 inundation zones is summarized in Table 5.4.6-9 by municipality.

Table 5.4.6-9. Estimated Population Exposed to Storm Surge in Burlington County

Municipality	Total Population (U.S. Census 2010)	Percent Population in Hazard Area			
		Cat 1	Cat 2	Cat 3	Cat 4
Bass River township	1,443	3.8%	66.7%	67.7%	92.7%
Beverly city	2,577	0.0%	0.0%	0.0%	0.0%
Bordentown city	3,924	0.0%	0.0%	0.0%	0.0%
Bordentown township	11,367	0.0%	0.0%	0.0%	0.0%
Burlington city	9,920	2.7%	2.7%	2.7%	2.7%
Burlington township	22,594	0.0%	0.0%	0.0%	2.0%
Chesterfield township	7,699	0.0%	0.0%	0.0%	0.0%
Cinnaminson township	15,569	0.0%	0.0%	0.0%	5.2%
Delanco township	4,283	0.0%	0.0%	0.0%	0.0%
Delran township	16,896	0.2%	0.2%	0.2%	1.3%
Eastampton township	6,069	0.0%	0.0%	0.0%	0.0%
Edgewater Park township	8,881	0.0%	0.0%	0.0%	0.0%
Evesham township	45,538	0.0%	0.0%	0.0%	0.0%
Fieldsboro borough	540	0.0%	0.0%	0.0%	0.0%
Florence township	12,109	0.0%	0.0%	0.0%	0.0%

Municipality	Total Population (U.S. Census 2010)	Percent Population in Hazard Area			
		Cat 1	Cat 2	Cat 3	Cat 4
Hainesport township	6,110	0.0%	0.2%	1.2%	1.5%
Lumberton township	12,559	0.0%	1.3%	2.5%	3.3%
Mansfield township	8,544	0.0%	0.0%	0.0%	0.0%
Maple Shade township	19,131	0.0%	0.0%	0.0%	0.6%
Medford Lakes borough	4,146	0.0%	0.0%	0.0%	0.0%
Medford township	23,033	0.0%	0.0%	0.0%	0.0%
Moorestown township	20,726	0.0%	0.0%	0.0%	0.0%
Mount Holly township	9,536	0.0%	0.0%	0.0%	1.2%
Mount Laurel township	41,864	0.0%	0.0%	0.0%	0.6%
New Hanover township	7,385	0.0%	0.0%	0.0%	0.0%
North Hanover township	7,678	0.0%	0.0%	0.0%	0.0%
Palmyra borough	7,398	0.0%	0.0%	6.1%	55.0%
Pemberton borough	1,409	0.0%	0.0%	0.0%	0.0%
Pemberton township	27,912	0.0%	0.0%	0.0%	0.0%
Riverside township	8,079	0.0%	0.0%	0.0%	0.0%
Riverton borough	2,779	0.0%	0.0%	0.0%	45.4%
Shamong township	6,490	0.0%	0.0%	0.0%	0.0%
Southampton township	10,464	0.0%	0.0%	0.0%	0.0%
Springfield township	3,414	0.0%	0.0%	0.0%	0.0%
Tabernacle township	6,949	0.0%	0.0%	0.0%	0.0%
Washington township	687	18.5%	57.6%	69.4%	73.5%
Westampton township	8,813	0.0%	0.0%	0.0%	0.2%
Willingboro township	31,629	0.0%	0.0%	0.0%	0.0%
Woodland township	1,788	0.0%	0.0%	0.0%	0.0%
Wrightstown borough	802	0.0%	0.0%	0.0%	0.0%
Burlington County	**448,734**	**0.1%**	**0.4%**	**0.6%**	**2.2%**

Source: Burlington County Department of Information Technology, 2013; U.S. Census 2010

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. HAZUS-MH estimates there will be 8 households displaced and 1 person that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, HAZUS-MH estimates 561 households will be displaced and 116 require short-term sheltering. Refer to Table 5.4.6-10 which summarizes the sheltering estimates for the 500-year MRP event by municipality.

Table 5.4.6-10. Sheltering Needs for the 500-year MRP Hurricane Events for Burlington County

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Bass River Township	3	1
Beverly	2	0

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Bordentown	6	1
Bordentown Township	6	1
Burlington	7	1
Burlington Township	17	5
Chesterfield Township	1	0
Cinnaminson Township	3	0
Delanco Township	1	0
Delran Township	18	4
Eastampton Township	13	3
Edgewater Park Township	14	4
Evesham Township	93	19
Fieldsboro Borough	0	0
Florence Township	10	2
Hainesport Township	2	0
Lumberton Township	23	5
Mansfield Township	2	0
Maple Shade Township	60	14
Medford Lakes Borough	5	1
Medford Township	38	7
Moorestown Township	16	3
Mount Holly Township	18	4
Mount Laurel Township	74	15
New Hanover Township	11	3
North Hanover Township	10	2
Palmyra Borough	6	1
Pemberton Borough	3	1
Pemberton Township	42	10
Riverside Township	7	1
Riverton Borough	2	0
Shamong Township	12	2
Southampton Township	15	3
Springfield Township	1	0
Tabernacle Township	13	2
Washington Township	0	0
Westampton Township	4	1
Willingboro Township	1	0
Woodland Township	1	0

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Wrightstown Borough	1	0
Burlington County (Total)	**561**	**116**

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

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

Impact on General Building Stock

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

It is assumed that the entire County's general building stock is exposed to the severe storm wind hazard (greater than $37.7 billion structure only). Expected building damage was evaluated by HAZUS across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.6-11 summarizes the definition of the damage categories.

Table 5.4.6-11. Description of Damage Categories

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

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	> 50%	> one and ≤ the larger of 20% & 3	> 3 and ≤ 25%	Typically 10 to 20 Impacts	No	No
Destruction Complete roof failure and/or failure of wall frame. Loss of more than 50% of roof sheathing.	Typically > 50%	> 50%	> 25%	Typically > 20 Impacts	Yes	Yes

Source: HAZUS-MH Hurricane Technical Manual

As noted earlier in the profile, HAZUS estimates the 100-year MRP peak gust wind speeds for Burlington County to be 75 to 82 miles per hour (mph). This equates to a Category 1 hurricane. For the 100-year MRP event, HAZUS-MH 2.1 estimates $87.3 Million in structure damages across the County. Residential buildings comprise the majority of the building inventory and are estimated to experience all of the damage.

HAZUS estimates the 500-year MRP peak gust wind speeds for Burlington County to range from 94 to 112 mph. This equates to a Category 2 hurricane and $491 Million in damages to the general building stock (structure only). This is between one- and two-percent of the County's building inventory. The residential buildings are estimated to experience the majority of the damage. Table 5.4.6-12 summarizes the building value (structure only) damage estimated for the annualized and 100- and 500-year MRP wind-only events by occupancy class.

Table 5.4.6-12. Estimated Building Replacement Value (Structure Only) Damaged by the 100-Year and 500-Year Mean Return Period Hurricane-Related Winds for All Occupancy Classes

Municipality	Total Building Replacement Value ($) (Structure Only)	Total Building Damage (All Occupancies)						Residential Buildings		Commercial Buildings	
		Annualized		100 Year		500 Year					
		Loss ($)	% of GBS RCV Total	Loss ($)	% of GBS RCV Total	Loss ($)	% of GBS RCV Total	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)
Bass River Township	101,257,000	37,847	0.04%	154,318	0.15%	2,962,003	2.93%	152,979	2,819,295	572	55,172
Beverly City	203,182,000	25,830	0.01%	479,929	0.24%	1,708,818	0.84%	456,408	1,543,769	10,313	65,023
Bordentown City	364,327,000	47,510	0.01%	627,501	0.17%	3,398,007	0.93%	599,189	3,130,801	17,680	154,143
Bordentown Township	756,748,000	120,728	0.02%	1,548,645	0.20%	7,654,391	1.01%	1,491,283	7,117,586	43,969	380,731
Burlington City	847,191,000	109,674	0.01%	1,807,851	0.21%	7,593,207	0.90%	1,702,752	6,754,403	67,030	507,680
Burlington Township	1,950,990,000	245,224	0.01%	3,934,147	0.20%	17,322,137	0.89%	3,725,784	15,467,146	145,944	1,175,144
Chesterfield Township	299,950,000	57,304	0.02%	549,141	0.18%	3,424,906	1.14%	533,952	3,141,644	6,902	109,021
Cinnaminson Township	1,416,712,000	179,386	0.01%	3,406,602	0.24%	12,127,904	0.86%	3,229,064	10,834,136	106,086	708,604
Delanco Township	282,362,000	37,068	0.01%	669,730	0.24%	2,346,132	0.83%	626,038	1,998,296	26,338	181,574
Delran Township	1,295,952,000	175,012	0.01%	3,304,645	0.25%	12,834,451	0.99%	3,145,164	11,673,098	122,138	812,286
Eastampton Township	451,284,000	92,452	0.02%	1,183,308	0.26%	6,878,200	1.52%	1,155,334	6,508,778	23,540	297,154
Edgewater Park Township	589,879,000	83,300	0.01%	1,587,967	0.27%	6,312,256	1.07%	1,520,976	5,822,149	55,416	389,750
Evesham Township	3,885,335,000	648,986	0.02%	10,709,394	0.28%	66,500,797	1.71%	10,180,513	59,215,598	450,422	5,884,305
Fieldsboro Borough	42,846,000	5,936	0.01%	86,223	0.20%	379,174	0.88%	82,801	351,607	1,716	14,771
Florence Township	922,519,000	135,347	0.01%	2,107,560	0.23%	9,186,065	1.00%	2,022,422	8,377,118	62,038	541,414
Hainesport Township	485,136,000	70,104	0.01%	982,703	0.20%	5,634,614	1.16%	904,096	4,480,864	55,923	713,995
Lumberton Township	926,654,000	180,814	0.02%	2,296,362	0.25%	15,479,326	1.67%	2,214,990	14,011,533	63,585	1,043,378
Mansfield Township	1,053,948,000	212,326	0.02%	1,388,861	0.13%	15,443,283	1.47%	1,026,823	5,489,978	28,053	388,078
Maple Shade Township	1,455,690,000	212,265	0.01%	4,423,676	0.30%	20,254,781	1.39%	4,284,511	19,169,724	103,257	756,506
Medford Lakes Borough	361,430,000	68,996	0.02%	1,025,309	0.28%	7,136,110	1.97%	1,012,316	6,869,915	10,069	194,203
Medford Township	2,279,232,000	380,377	0.02%	5,566,083	0.24%	38,802,642	1.70%	5,333,910	34,525,123	172,298	2,929,451
Moorestown Township	2,427,401,000	317,996	0.01%	5,625,366	0.23%	24,229,181	1.00%	5,162,163	20,363,556	349,917	2,780,730
Mount Holly Township	942,557,000	147,778	0.02%	1,876,325	0.20%	11,210,691	1.19%	1,747,323	9,588,717	97,116	1,151,357
Mount Laurel Township	4,195,041,000	615,445	0.01%	10,560,323	0.25%	52,585,049	1.25%	9,948,584	46,569,948	507,797	4,686,832
New Hanover Township	825,998,000	128,011	0.02%	670,640	0.08%	8,166,556	0.99%	556,403	6,198,060	107,910	1,816,213
North Hanover Township	419,942,000	93,182	0.02%	714,968	0.17%	5,512,851	1.31%	692,275	5,105,014	15,873	262,672

Municipality	Total Building Replacement Value ($) (Structure Only)	Total Building Damage (All Occupancies)						Residential Buildings		Commercial Buildings	
		Annualized		100 Year		500 Year					
		Loss ($)	% of GBS RCV Total	Loss ($)	% of GBS RCV Total	Loss ($)	% of GBS RCV Total	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)
Palmyra Borough	582,624,000	78,752	0.01%	1,577,661	0.27%	5,548,368	0.95%	1,522,767	5,189,404	36,056	215,605
Pemberton Borough	110,647,000	20,583	0.02%	202,708	0.18%	1,660,510	1.50%	190,266	1,451,101	3,706	59,729
Pemberton Township	1,970,889,000	469,439	0.02%	3,503,278	0.18%	32,300,687	1.64%	3,416,502	29,903,888	56,865	1,384,464
Riverside Township	533,916,000	64,698	0.01%	1,256,716	0.24%	4,616,209	0.86%	1,202,734	4,267,098	28,109	171,187
Riverton Borough	221,269,000	29,162	0.01%	612,407	0.28%	2,094,136	0.95%	594,462	1,989,291	11,633	63,900
Shamong Township	500,704,000	123,629	0.02%	1,248,162	0.25%	12,474,610	2.49%	1,225,593	11,580,476	15,362	506,708
Southampton Township	823,737,000	184,197	0.02%	1,959,866	0.24%	15,666,963	1.90%	1,913,818	14,567,944	32,953	691,924
Springfield Township	282,453,000	56,897	0.02%	650,398	0.23%	3,548,219	1.26%	627,210	3,161,953	14,129	193,796
Tabernacle Township	576,928,000	132,231	0.02%	1,119,419	0.19%	13,217,824	2.29%	1,086,920	11,936,026	16,985	517,065
Washington Township	63,380,000	12,122	0.02%	55,433	0.09%	1,224,191	1.93%	49,762	964,411	2,760	122,264
Westampton Township	769,854,000	117,578	0.02%	1,584,986	0.21%	8,054,625	1.05%	1,473,645	6,632,248	72,507	803,589
Willingboro Township	2,284,353,000	342,492	0.01%	6,044,451	0.26%	22,896,527	1.00%	5,903,119	21,809,426	95,811	690,224
Woodland Township	75,012,000	19,936	0.03%	124,862	0.17%	1,508,673	2.01%	123,969	1,472,935	495	18,781
Wrightstown Borough	80,320,000	14,582	0.02%	101,450	0.13%	1,001,049	1.25%	90,853	827,698	6,868	114,375
Burlington County (Total)	**37,659,649,000**	**6,095,196**	**0.02%**	**87,329,374**	**0.23%**	**490,896,123**	**1.30%**	**82,929,673**	**432,881,755**	**3,046,141**	**33,553,798**

Municipality	Industrial Buildings		Agriculture Buildings		Religious Buildings		Government Buildings		Education Buildings	
	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)
Bass River Township	419	49,621	49	11,444	78	4,939	96	8,718	124	12,813
Beverly City	1,839	17,618	70	784	5,870	33,262	435	3,915	4,995	44,446
Bordentown City	4,471	50,729	93	2,269	4,020	41,543	978	7,824	1,070	10,698
Bordentown Township	8,052	97,347	770	16,201	3,294	29,641	880	9,192	396	3,693
Burlington City	12,862	127,290	209	3,766	16,542	124,008	1,434	15,225	7,022	60,836
Burlington Township	46,565	528,538	1,311	20,780	10,483	91,998	1,677	18,116	2,383	20,415
Chesterfield Township	3,477	83,380	1,064	36,159	3,291	45,254	55	1,010	402	8,438
Cinnaminson Township	52,108	445,345	2,308	28,868	8,056	53,389	2,074	12,798	6,905	44,764
Delanco Township	11,396	122,053	463	5,649	3,320	19,919	621	6,214	1,553	12,427
Delran Township	27,048	269,297	1,047	15,760	4,637	32,960	814	5,814	3,798	25,236
Eastampton Township	1,278	24,115	607	16,080	1,879	21,415	251	4,651	419	6,007
Edgewater Park Township	4,448	50,015	155	2,144	5,071	32,388	308	3,133	1,593	12,678
Evesham Township	34,913	684,502	4,487	135,399	19,912	248,668	10,843	201,066	8,305	131,260
Fieldsboro Borough	1,579	11,737	-	-	121	997	7	63	-	-
Florence Township	11,819	158,187	405	8,061	5,164	44,671	2,266	25,812	3,447	30,803
Hainesport Township	15,647	339,642	845	21,965	3,779	42,325	451	8,347	1,963	27,476
Lumberton Township	9,818	263,819	1,578	54,455	3,904	55,924	202	5,242	2,287	44,976
Mansfield Township	11,737	293,549	317,042	9,193,009	2,393	29,328	401	8,283	2,413	41,058
Maple Shade Township	20,200	200,882	1,111	16,849	8,216	60,813	2,037	16,944	4,344	33,062
Medford Lakes Borough	1,259	34,058	146	7,125	554	10,934	98	2,548	866	17,328
Medford Township	31,772	800,444	3,370	121,259	13,306	214,719	2,458	52,982	8,970	158,665
Moorestown Township	85,320	823,724	3,691	57,869	14,972	123,446	2,537	23,993	6,766	55,863
Mount Holly Township	6,997	117,635	312	8,825	9,437	117,023	9,748	155,968	5,393	71,167
Mount Laurel Township	64,905	894,855	3,095	65,175	20,303	193,058	8,973	108,161	6,666	67,021
New Hanover Township	1,245	48,468	146	7,900	1,306	24,382	2,862	55,051	768	16,483
North Hanover Township	1,938	42,968	578	26,588	1,941	32,876	1,265	18,972	1,099	23,762

Municipality	Industrial Buildings		Agriculture Buildings		Religious Buildings		Government Buildings		Education Buildings	
	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)	100 Year Loss ($)	500 Year Loss ($)
Palmyra Borough	9,063	82,329	296	3,517	7,204	42,679	751	5,422	1,524	9,411
Pemberton Borough	2,067	40,722	22	850	5,308	84,928	279	5,863	1,060	17,317
Pemberton Township	6,069	291,347	1,426	80,790	9,099	243,457	2,092	65,302	11,224	331,439
Riverside Township	17,217	126,416	148	1,858	6,042	36,257	1,061	6,010	1,406	7,384
Riverton Borough	1,253	10,740	378	4,234	3,899	21,443	465	2,790	316	1,738
Shamong Township	3,906	210,910	994	98,923	1,435	50,222	311	11,655	561	15,716
Southampton Township	6,179	203,539	2,207	103,646	3,453	67,126	563	16,383	693	16,401
Springfield Township	3,490	86,721	1,284	44,930	3,378	47,292	295	5,159	612	8,368
Tabernacle Township	6,050	244,599	3,732	350,827	2,228	74,280	611	20,767	2,893	74,259
Washington Township	687	48,972	60	6,049	982	36,014	497	18,036	685	28,444
Westampton Township	21,344	397,655	975	22,917	6,092	63,352	1,719	27,504	8,705	107,359
Willingboro Township	8,076	87,720	2,124	34,799	24,670	183,971	2,529	20,577	8,122	69,811
Woodland Township	46	1,882	8	1,120	181	6,787	163	7,168	-	-
Wrightstown Borough	50	818	-	-	2,595	35,684	782	16,296	301	6,179
Burlington County (Total)	**558,609**	**8,414,189**	**358,606**	**10,638,843**	**248,415**	**2,723,372**	**65,889**	**1,008,974**	**122,049**	**1,675,201**

Source: HAZUS-MH 2.1
Notes: B = Borough; GBS = General Building Stock; RCV = Replacement Cost Value; T = Town

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

Of the exceeding $27.7 billion in total residential replacement value (structure) for the entire County, an estimated $82.9 million in residential building damage can be anticipated for the 100-year event and $433 million in residential building damage can be anticipated for the 500-year event. Residential building damage accounts for 95-percent and 88-percent of total damages for the 100- and 500-year wind-only events, respectively. This illustrates residential structures are the most vulnerable to the wind hazard.

Annualized losses were also examined for Burlington County. A total of $6.1 Million is estimated as the annualized loss for the entire County; see Table 5.4.6-12 above. Please note that annualized loss does not predict what losses will occur in any particular year.

To estimate potential building exposure to storm surge, the SLOSH inundation zones were used. The estimated total assessed improved value in the Category 1 through 4 inundation zones is summarized in Table 5.4.6-13 by municipality.

Table 5.4.6-13. Estimated Assessed Value of Improved Property in the SLOSH Inundation Zones

Municipality	Total Assessed Value of Improvements	Percent Improved Value in Hazard Area			
		Cat 1	Cat 2	Cat 3	Cat 4
Bass River Township	$112,293,600	30.78%	74.14%	80.14%	93.93%
Beverly*	$72,091,800	0.00%	0.00%	0.00%	0.00%
Bordentown	$298,534,950	0.00%	0.00%	0.00%	0.00%
Bordentown Township	$997,461,800	0.03%	0.00%	0.00%	0.00%
Burlington	$571,882,875	0.04%	0.09%	0.09%	3.62%
Burlington Township	$2,097,110,708	0.00%	0.00%	0.01%	2.38%
Chesterfield Township	$666,455,492	0.00%	0.00%	0.00%	0.00%
Cinnaminson Township	$1,304,483,700	0.03%	0.02%	0.02%	4.99%
Delanco Township	$290,621,560	0.00%	0.00%	0.00%	0.03%
Delran Township	$1,474,866,100	0.22%	0.06%	0.06%	0.08%
Eastampton Township	$421,225,400	0.00%	0.00%	0.00%	0.00%
Edgewater Park Township	$528,294,400	0.00%	0.00%	0.00%	0.00%
Evesham Township	$4,389,240,875	0.00%	0.00%	0.00%	0.00%
Fieldsboro Borough	$48,903,400	0.00%	0.00%	0.00%	0.00%
Florence Township	$1,040,584,300	0.00%	0.00%	0.00%	0.00%
Hainesport Township	$367,702,666	0.00%	0.46%	0.50%	2.07%
Lumberton Township	$1,164,991,807	0.00%	0.27%	0.31%	2.18%
Mansfield Township	$899,612,400	0.01%	0.00%	0.00%	0.00%
Maple Shade Township	$1,405,067,900	0.00%	0.00%	0.00%	5.81%
Medford Lakes Borough	$1,297,069,100	0.00%	0.00%	0.00%	0.02%
Medford Township	$980,612,600	0.00%	0.00%	0.00%	0.00%
Moorestown Township	$3,410,132,200	0.01%	0.01%	0.01%	0.40%

Municipality	Total Assessed Value of Improvements	Percent Improved Value in Hazard Area			
		Cat 1	Cat 2	Cat 3	Cat 4
Mount Holly Township	$1,079,081,000	0.00%	0.00%	0.00%	1.15%
Mount Laurel Township	$2,396,695,600	0.00%	0.01%	0.11%	0.18%
New Hanover Township	$852,205,300	0.00%	0.00%	0.00%	0.00%
North Hanover Township	$498,418,446	0.00%	0.00%	0.00%	0.00%
Palmyra Borough	$254,304,240	0.26%	1.79%	2.73%	48.89%
Pemberton Borough	$63,520,200	0.00%	0.00%	0.00%	0.00%
Pemberton Township	$2,014,515,095	0.00%	0.00%	0.00%	0.00%
Riverside Township	$349,218,580	0.16%	0.00%	0.00%	0.00%
Riverton Borough	$207,879,600	0.02%	0.20%	0.20%	57.25%
Shamong Township	$294,159,200	0.00%	0.00%	0.00%	0.00%
Southampton Township	$549,437,950	0.00%	0.00%	0.00%	0.00%
Springfield Township	$282,324,750	0.00%	0.00%	0.00%	0.00%
Tabernacle Township	$580,603,200	0.00%	0.00%	0.00%	0.00%
Washington Township	$13,020,400	25.42%	17.34%	17.34%	39.59%
Westampton Township	$919,859,000	0.00%	0.02%	0.02%	0.16%
Willingboro Township	$1,705,779,550	0.01%	0.04%	0.04%	0.13%
Woodland Township	$305,887,600	0.00%	0.00%	0.00%	0.00%
Wrightstown Borough	$47,025,100	0.00%	0.00%	0.00%	0.00%
Burlington County	**$36,253,174,444**	**0.12%**	**0.27%**	**0.31%**	**1.77%**

Source: Burlington County Department of Information Technology, 2013
*Beverly data source: 2011 NJGIN MODIV

Impact on Critical Facilities

HAZUS-MH estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH estimates the loss of use for each facility in number of days. HAZUS-MH estimates a 1 to 3-percent chance that critical facilities in Burlington County will experience minor damage; and continuity of operations at these facilities will not be interrupted (loss of use is estimated to be zero days) as a result of a 100-year MRP event.

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

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

To estimate potential building exposure to storm surge, the SLOSH inundation zones were used. The critical facilities and utilities located in the Category 1 through 4 inundation zones are summarized in Table 5.4.6-14 by municipality.

Table 5.4.6-14. Critical Facilities and Utilities Located in the SLOSH Inundation Zones

Name	Municipality	Type	Located in the SLOSH Zone			
			Cat 1	Cat 2	Cat 3	Cat 4
Station 421	Bass River	Fire		x	x	x
Bass River Elementary School	Bass River	School		x	x	x
Bass River Elementary School	Bass River	Shelter		x	x	x
Bass River Township Municipal Building	Bass River	Municipal Hall		x	x	x
Bass River Township Schl Dist	Bass River	Admin		x	x	x
New Gretna Volunteer Fire Co #1	Bass River	Fire		x	x	x
Cinnaminson	Cinnaminson	Riverline				x
Lumberton Fire Co #1	Lumberton Twp	Fire				x
Mount Holly Heliport	Mount Holly Twp	Airport		x	x	x
Delaware Avenue School	Palmyra Boro	School				x
Palmyra Board Of Education	Palmyra Boro	Board Of Ed				x
Palmyra Child Study Team	Palmyra Boro	Child Study Tm				x
Tacony Palmyra Bridge Police Dept	Palmyra Boro	Police				x
Municipal	Riverton	Municipal Hall				x
Riverview Estates (Baptist Home Of South Jersey)	Riverton	Long-Term Care				x
Riverton Boro Police Dept	Riverton Boro	Police				x
Riverton Borough Municipal Building	Riverton Boro	Municipal Hall				x
Riverton Borough Public School	Riverton Boro	School				x
Riverton Borough School Dist	Riverton Boro	Admin				x
Riverton Fire Co	Riverton Boro	Fire				x
Riverton School	Riverton Boro	Shelter				x
Green Bank Elementary School	Washington Twp	Shelter				x
Green Bank School	Washington Twp	School				x
Green Bank Vol Ambulance Co	Washington Twp	Ems			x	x
Green Bank Vol Ambulance Co 451	Washington Twp	Shelter			x	x
Green Bank Vol Ambulance Co 452	Washington Twp	Shelter			x	x
Green Bank Vol Ambulance Co 459	Washington Twp	Shelter			x	x
Green Bank Volunteer Fire Co	Washington Twp	Fire			x	x
Lower Bank Volunteer Fire Co	Washington Twp	Fire			x	x
Nj State Park Service - Southern Region	Washington Twp	Police		x	x	x
Pacemaker Heliport	Washington Twp	Airport		x	x	x
Senior Citizens' Center	Washington Twp	Shelter	x	x	x	x
Washington Township Municipal Building	Washington Twp	Municipal Hall	x	x	x	x

Source: Burlington County Department of Information Technology, 2013

Impact on Economy

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

For the 100-year MRP wind event, HAZUS-MH estimates $2.9 Million in relocation costs. For the 500-year MRP wind only event, HAZUS-MH estimates $61.7 Million in business interruption losses for Burlington County which includes loss of income, relocation costs, rental costs and lost wages. Further HAZUS-MH estimates $1.7 Million in loss of inventory.

HAZUS-MH 2.1 also estimates the amount of debris that may be produced a result of the 100- and 500-year MRP wind events. Table 5.4.6-15 estimates the debris produced. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the HAZUS-MH Hurricane User Manual: '*The Eligible Tree Debris columns provide estimates of the weight and volume of downed trees that would likely be collected and disposed at public expense. As discussed in Chapter 12 of the HAZUS-MH Hurricane Model Technical Manual, the eligible tree debris estimates produced by the Hurricane Model tend to underestimate reported volumes of debris brought to landfills for a number of events that have occurred over the past several years. This indicates that that there may be other sources of vegetative and non-vegetative debris that are not currently being modeled in HAZUS. For landfill estimation purposes, it is recommended that the HAZUS debris volume estimate be treated as an approximate lower bound. Based on actual reported debris volumes, it is recommended that the HAZUS results be multiplied by three to obtain an approximate upper bound estimate. It is also important to note that the Hurricane Model assumes a bulking factor of 10 cubic yards per ton of tree debris. If the debris is chipped prior to transport or disposal, a bulking factor of 4 is recommended. Thus, for chipped debris, the eligible tree debris volume should be multiplied by 0.4'.*

Table 5.4.6-15. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Bass River Township	6	400	-	3	4,958	76,849	2,479	38,425
Beverly City	65	297	-	-	123	321	1,148	2,985
Bordentown City	86	594	-	-	124	466	994	3,727
Bordentown Township	139	1,037	-	2	1,186	4,362	3,788	13,866
Burlington City	238	1,303	-	2	493	1,482	2,897	8,373
Burlington Township	437	2,543	-	6	1,589	5,838	6,970	24,136
Chesterfield Township	36	432	-	2	2,062	11,619	1,640	9,248
Cinnaminson Township	287	1,501	-	6	1,324	3,746	7,976	22,737
Delanco Township	75	367	-	1	541	1,407	1,731	4,501
Delran Township	377	1,910	-	5	1,159	3,518	6,342	19,249
Eastampton Township	119	975	-	3	745	3,354	2,385	10,734

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Edgewater Park Township	232	1,085	-	2	449	1,579	2,822	10,024
Evesham Township	999	9,118	-	59	5,285	20,555	22,489	87,120
Fieldsboro Borough	7	47	-	-	26	122	190	887
Florence Township	219	1,355	-	4	1,369	5,013	4,075	13,553
Hainesport Township	84	741	-	4	859	3,864	2,748	12,364
Lumberton Township	224	2,220	-	10	2,082	8,330	4,853	19,411
Mansfield Township	250	2,434	-	56	2,858	11,178	4,221	16,356
Maple Shade Township	708	3,688	-	5	654	2,010	5,457	16,927
Medford Lakes Borough	47	770	-	4	209	1,002	1,754	8,418
Medford Township	392	4,646	-	22	6,853	29,571	17,594	75,624
Moorestown Township	527	3,179	-	9	2,385	7,631	12,341	39,490
Mount Holly Township	243	1,900	-	5	380	1,696	2,991	13,211
Mount Laurel Township	1,047	7,396	-	22	3,504	12,973	20,366	75,202
New Hanover Township	95	1,269	-	2	2,008	11,267	1,657	9,344
North Hanover Township	74	910	-	2	1,666	9,441	2,295	13,003
Palmyra Borough	201	910	-	2	343	1,048	2,121	6,000
Pemberton Borough	26	283	-	2	58	390	357	2,378
Pemberton Township	256	4,516	-	20	6,296	39,424	9,888	66,852
Riverside Township	192	878	-	-	228	616	1,654	4,401
Riverton Borough	75	324	-	-	150	391	1,399	3,637
Shamong Township	60	1,452	-	10	5,759	43,196	5,184	38,877
Southampton Township	144	2,174	-	23	4,843	30,310	5,984	36,219
Springfield Township	42	462	-	2	3,799	17,119	2,652	11,943
Tabernacle Township	62	1,607	-	11	6,329	45,886	5,696	41,298
Washington Township	7	203	-	1	13,147	111,752	5,259	44,701
Westampton Township	131	1,059	-	5	1,426	6,062	3,280	13,942
Willingboro Township	449	2,902	-	12	1,215	3,945	9,907	32,302
Woodland Township	7	191	-	1	9,240	83,156	3,696	33,263
Wrightstown Borough	18	180	-	-	162	916	341	1,969
Burlington County (Total)	**8,683**	**69,258**	**-**	**325**	**97,886**	**623,405**	**201,619**	**906,694**

Source: HAZUS-MH 2.1

Future Growth and Development

As discussed and illustrated in Section 4, areas targeted for future growth and development have been identified across Burlington County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire County is exposed and vulnerable to the wind hazard associated with severe storms.

Additional Data and Next Steps

Over time, Burlington County will obtain additional data to support the analysis of this hazard. Data that will support the analysis would include additional detail on past hazard events and impacts, specific

building information such as type of construction and details on protective features (for example, hurricane straps). In addition, information on particular buildings or infrastructure age or year built would be helpful in future analysis of this hazard.