5.4.6 SEVERE WEATHER

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

2019 HMP UPDATE CHANGES

- For the 2019 HMP update, the severe weather hazard groups together high winds, tornadoes, thunderstorms and lightning, hailstorms, hurricanes/tropical storms, and extreme temperature. The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the severe weather hazard is discussed.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2012 and 2018.
- A vulnerability assessment was conducted for the severe weather hazard; it directly follows the hazard profile.

5.4.6.1 PROFILE

Hazard Description

For the purpose of this HMP update and as deemed appropriated by the Burlington County Planning Committee, the severe weather hazard includes high wind, tornadoes, thunderstorms and lightning, hailstorms, hurricane/tropical storms, and extreme temperature, which are defined below.

High Winds

High winds, other than tornadoes, are experienced in all parts of the United States. Areas that experience the highest wind speeds are coastal regions from Texas to Maine, and the Alaskan coast; however, exposed mountain areas experience winds at least as high as those along the coast (FEMA 1997). Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth (Rosenstiel School of Marine & Atmospheric Science 2005). High winds have the potential to down trees, tree limbs and power lines which lead to widespread power outages and damaging residential and commercial structures throughout Burlington County. High winds are often associated by other severe weather events such as thunderstorms, tornadoes, hurricanes and tropical storms (all discussed further in this section).

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

Tornadoes

A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 miles per hour (mph). Damage paths can be greater than 1 mile wide and 50 miles long. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate combined wind speeds (forward motion and speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997). Tornadoes can occur at any time of the year, with peak seasons at different times for different states (National Severe Storms Laboratory [NSSL] 2013).

Thunderstorms and Lightning

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. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability in generating tornadoes, hailstorms, strong winds, flash flooding, and lightning. The NWS considers a thunderstorm severe only if it produces damaging wind gusts of 58 mph or higher or large hail one-inch (quarter size) in diameter or larger or tornadoes (NWS 2010).

Lighting is a bright flash of electrical energy produced by a thunderstorm. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. It ranks as one of the top weather killers in the United States and kills approximately 50 people and injures hundreds each year. Lightning can occur anywhere there is a thunderstorm.

Thunderstorms can lead to flooding, landslides, strong winds, and lightning. Roads may become impassable from flooding, downed trees or power lines, or a landslide. Downed power lines can lead to utility losses, such as water, phone and electricity. Lightning can damage homes and injure people. In the U.S., an average of 300 people are injured and 80 people are killed by lightning each year. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. An estimated 100,000 thunderstorms occur each year in the U.S., with approximately 10-percent of them classified as severe. During the warm season, thunderstorms are responsible for most of the rainfall.

Hailstorms

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32°F or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail. Most hail is small and typically less than two inches in diameter (NWS 2010).

Hurricanes/Tropical Storms

Tropical cyclones are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical storms from other cyclonic systems is that at any height in the atmosphere, the center of a tropical storm will be warmer than its surroundings, a phenomenon called "warm core" storm systems (National Oceanic and Atmospheric Administration [NOAA] 2013). Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. Tropical cyclones begin as disturbed areas of weather often referred to as tropical waves. As the storm organizes, it is designated as a tropical depression.

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds of 39 to 73 mph and heavy rain. A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 mph or higher. Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast, or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic coast of the United States and impact the eastern seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving offshore and heading east.

Extreme Temperatures

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

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0ºF or below (Centers of Disease Control and Prevention [CDC] 2007). Extremely cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2007).

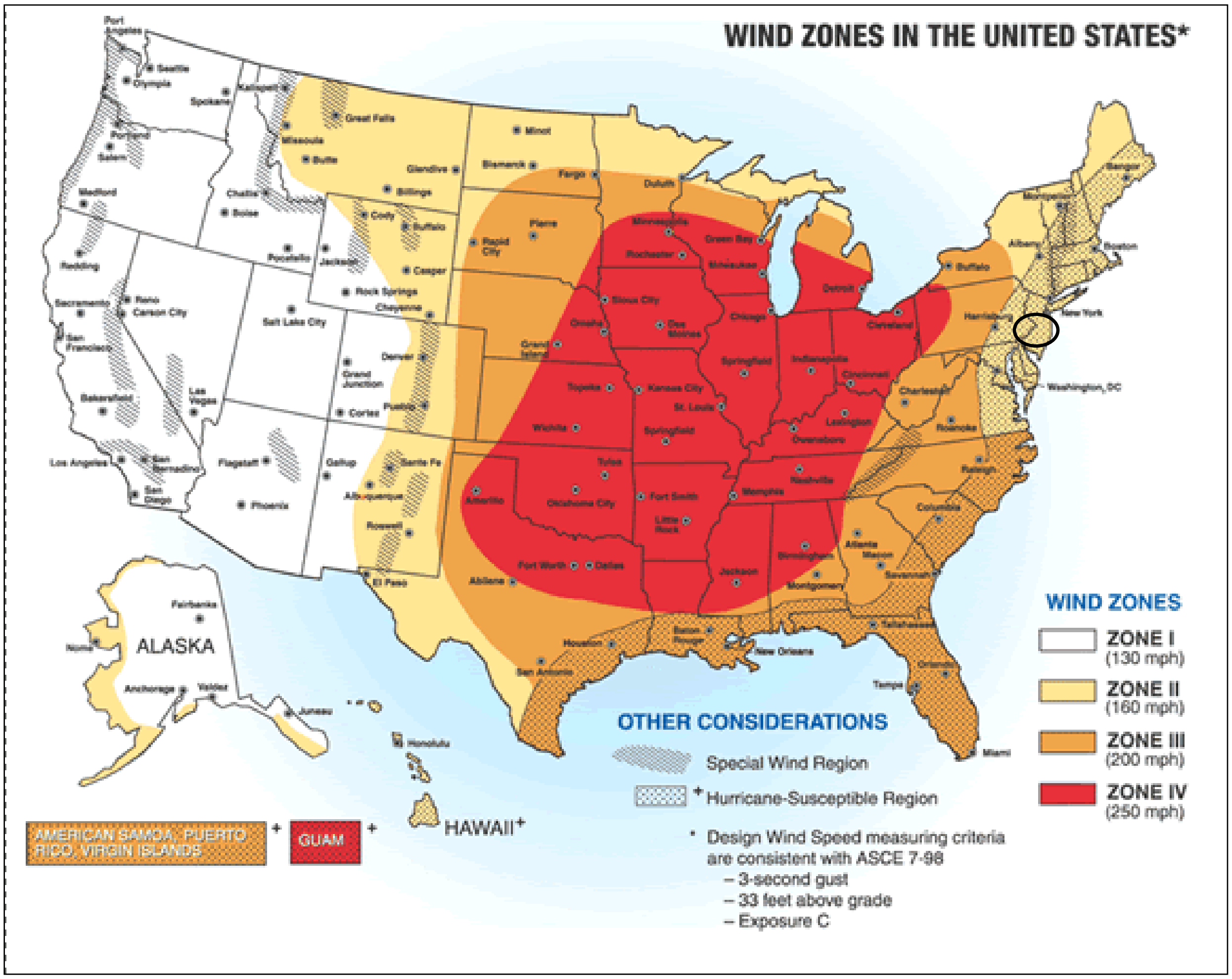
Conditions of extreme heat are defined as summertime temperatures that are substantially hotter and/or more humid than average for a location at that time of year (CDC 2009). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (NWS 2011). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi 2004). A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population. A heat wave is defined has three consecutive days of temperatures ≥90°F.

Extreme heat is the number one weather-related cause of death in the U.S. In a ten-year average of weather fatalities across the nation from 2005-2014, excessive heat claimed more lives each year than floods, lightning, tornadoes, and hurricanes. In 2017, heat claimed 107 lives, though none of them were in the State of New Jersey (NWS 2018).

Location

All of Burlington County is exposed to severe weather events (high winds, tornadoes, thunderstorms, lightning, hail, hurricanes/tropical storms, and extreme temperatures) and the entire County is subject to high winds from severe weather events. According to the FEMA Winds Zones of the United States map, Burlington County is located in Wind Zones II, where wind speeds can reach up to 160 mph. Figure 5.4.6-1 illustrates wind zones across the United States, which indicate the impacts of the strength and frequency of wind activity per region. The information on the figure is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Figure 5.4.6-1. Wind Zones in the United States



Source: FEMA 2018
Note: The black oval indicates the approximate location of Burlington County.

Hurricanes/Tropical Storms

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2013 (latest date available from data source). Between 1842 and 2018, 16 tropical cyclones tracked within 65 nautical miles of Burlington County. Between 2012 and 2018, no tropical cyclones tracked within 65 miles of Burlington County although post-Tropical Storm Sandy did cross directly over Burlington County in 2012. Table 5.4.6-1 displays the percent area for the Category 1 through Category 4 storm surge scenarios in each municipality. Bass River Township has the greatest percentage of area located in the Category 1 through Category 3 storm surge scenarios, while Palmyra Borough has the greatest percentage of area located in the Category 4 storm surge scenario.

Table 5.4.6-1. 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 Township	50,140	12.6%	22.7%	25.6%	31.6%
Beverly City	486	0.4%	0.5%	0.5%	0.7%

Municipality	Total Acres	% in CAT1 Surge Zone	% in CAT2 Surge Zone	% in CAT3 Surge Zone	% in CAT4 Surge Zone
Bordentown City	618	5.0%	5.0%	5.0%	5.0%
Bordentown Township	5,926	2.9%	2.9%	2.9%	2.9%
Burlington City	2,426	5.3%	5.4%	5.4%	7.7%
Burlington Township	8,992	0.3%	0.4%	0.6%	3.0%
Chesterfield Township	13,736	0.0%	0.0%	0.0%	0.0%
Cinnaminson Township	5,099	0.6%	0.7%	0.7%	8.6%
Delanco Township	2,190	0.8%	0.9%	0.9%	1.4%
Delran Township	4,654	2.1%	2.2%	2.2%	3.2%
Eastampton Township	3,723	0.0%	0.0%	0.0%	0.0%
Edgewater Park Township	1,976	0.1%	0.1%	0.2%	0.2%
Evesham Township	18,943	0.0%	0.0%	0.0%	0.0%
Fieldsboro Borough	224	1.0%	1.0%	1.0%	1.0%
Florence Township	6,559	0.3%	0.4%	0.4%	0.4%
Hainesport Township	4,344	0.1%	11.9%	13.8%	20.7%
Lumberton Township	8,327	0.0%	3.2%	4.1%	8.1%
Mansfield Township	14,010	0.4%	0.4%	0.4%	0.4%
Maple Shade Township	2,451	0.0%	0.0%	0.0%	3.7%
Medford Lakes Borough	812	0.0%	3.1%	4.0%	9.4%
Medford Township	25,474	0.0%	0.0%	0.0%	0.0%
Moorestown Township	9,585	0.2%	0.4%	0.4%	2.4%
Mount Holly Township	1,837	0.0%	0.4%	0.8%	3.2%
Mount Laurel Township	14,066	0.1%	0.7%	0.8%	1.5%
New Hanover Township	14,483	0.0%	0.0%	0.0%	0.0%
North Hanover Township	11,203	0.0%	0.0%	0.0%	0.0%
Palmyra Borough	1,673	1.7%	1.8%	4.4%	39.2%
Pemberton Borough	403	0.0%	0.0%	0.0%	0.0%
Pemberton Township	40,171	0.0%	0.0%	0.0%	0.0%
Riverside Township	1,048	0.5%	0.5%	0.6%	0.9%
Riverton Borough	614	1.3%	0.0%	1.6%	36.1%
Shamong Township	28,791	0.0%	0.0%	0.0%	0.0%
Southampton Township	28,446	0.0%	0.0%	0.0%	0.1%
Springfield Township	18,924	0.0%	0.0%	0.0%	0.0%
Tabernacle Township	31,688	0.0%	0.0%	0.0%	0.0%
Washington Township	66,539	8.3%	14.3%	18.2%	27.0%
Westampton Township	7,104	0.0%	1.6%	1.9%	3.2%
Willingboro Township	5,175	0.9%	1.0%	1.1%	1.7%
Woodland Township	61,001	0.0%	0.0%	0.0%	0.0%
Wrightstown Borough	1,146	0.0%	0.0%	0.0%	0.0%
Burlington County	**525,009**	**2.4%**	**4.3%**	**5.1%**	**7.4%**

Source: FEMA, 2012; Burlington County GIS

Extent

High Winds

The following table provides the descriptions of winds used by the NWS during wind-producing events.

Table 5.4.6-2. NWS Wind Descriptions

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

Source: NWS 2011
mph miles per hour

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

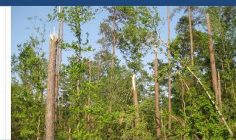
- High Wind Warnings are issued when sustained wind speeds of 40 mph or greater lasting for one hour or longer or for winds of 58 mph or greater for any duration or widespread damage are possible.
- Wind Advisories are issues when sustained winds of 30 to 39 mph are forecast for one hour or longer, or wind gusts of 46 to 57 mph for any duration (NWS 2018).

Tornadoes

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). This is the scale now used exclusively for determining tornado ratings by comparing wind speed and actual damage. Figure 5.4.6-2 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

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

Figure 5.4.6-2. Explanation of EF-Scale Ratings

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Thunderstorms and Lightning

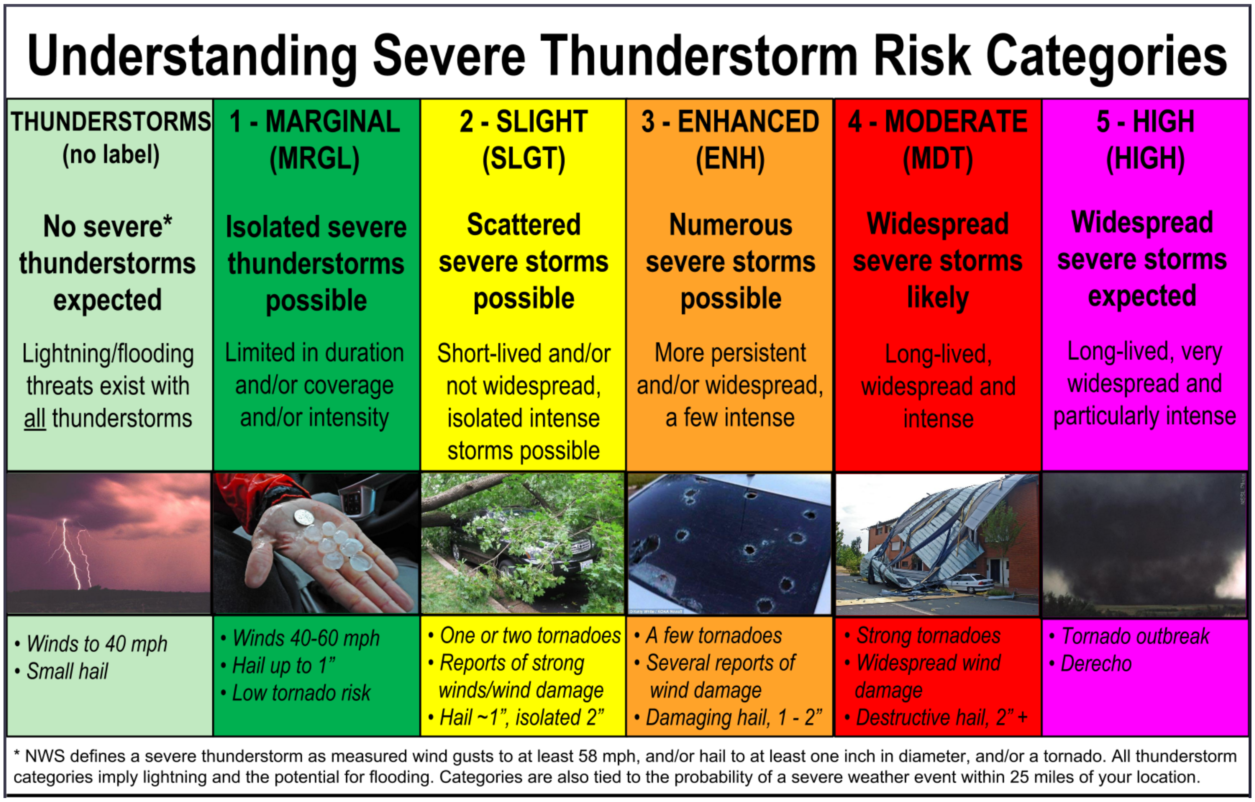
Severe thunderstorm watches and warnings are issued by the local NWS office and SPC. The NWS and SPC will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for tornadoes in New Jersey are as follows:

- Severe Thunderstorm Warnings are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing, or forecast to produce, wind gusts of 58 mph or greater, structural wind damage, and/or hail one-inch in diameter or greater. A warning will include where the storm was located, what municipalities will be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements which contain updated information on the severe thunderstorm and will let the public know when the warning is no longer in effect.
- Severe Thunderstorm Watches are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least three hours. Tornadoes are not expected in such situations, but isolated tornado development may also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, the NWS will keep the public informed on what is happening in the watch area and also let the public know when the watch has expired or been cancelled (NWS 2009; NWS 2010).

- Special Weather State for Near Severe Thunderstorms are issued for strong thunderstorms that are below severe levels, but still may have some adverse impacts. Usually, they are issued for the threat of wind gusts of 40 to 58 mph or small hail less than one-inch in diameter (NWS 2010).

Figure 5.4.6-2 below provides the various risk categories for thunderstorms, as presented by the Storm Prediction Center (SPC).

Figure 5.4.6-3. Severe Thunderstorm Risk Categories



Source: NOAA SPC 2017

Hailstorms

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

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail is estimated by comparing it to a known object. Most hailstorms are made up of a variety of sizes, and only the very largest hail stones pose serious risk to people, when exposed. Table 5.4.6-4 shows the different sizes of hail and the comparison to real-world objects.

Table 5.4.6-3. Hail Size

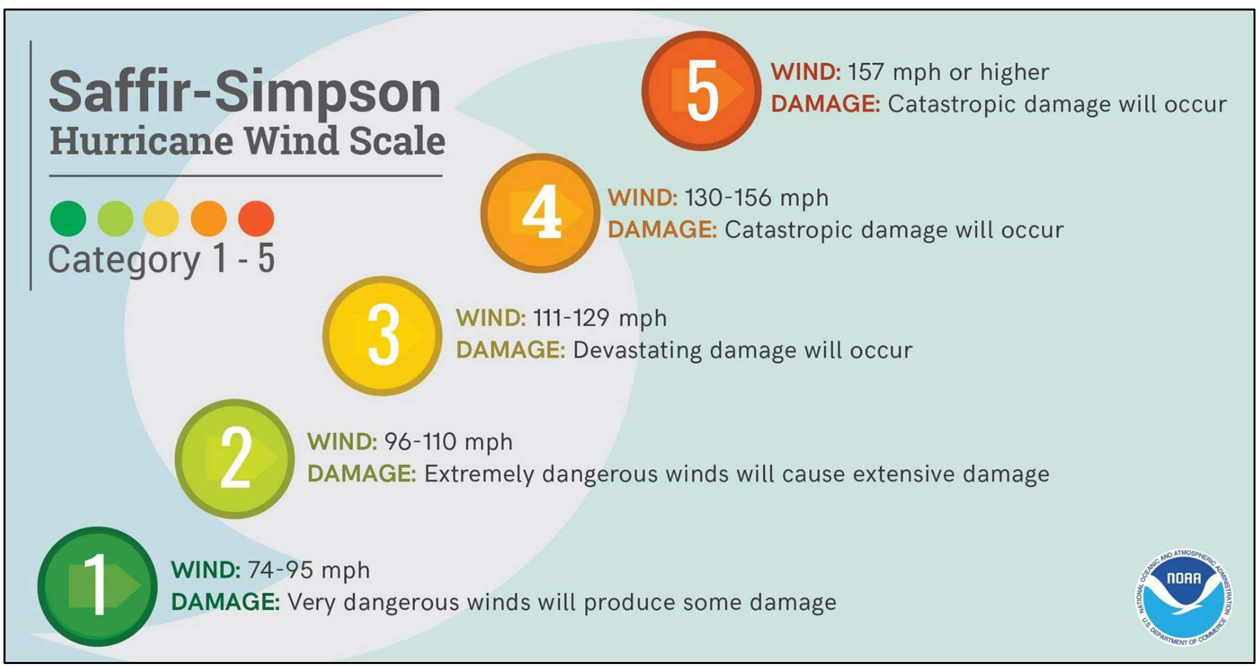
Size	Inches in Diameter
Pea	0.25 inch
Marble/mothball	0.50 inch
Dime/Penny	0.75 inch
Nickel	0.875 inch
Quarter	1.0 inch
Ping-Pong Ball	1.5 inches
Golf Ball	1.75 inches
Tennis Ball	2.5 inches
Baseball	2.75 inches
Tea Cup	3.0 inches
Grapefruit	4.0 inches
Softball	4.5 inches

Source: NWS 2010

Hurricanes/Tropical Storms

The extent of a hurricane is categorized in accordance with 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 2013). Figure 5.4.6-4 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Figure 5.4.6-4. The Saffir-Simpson Scale



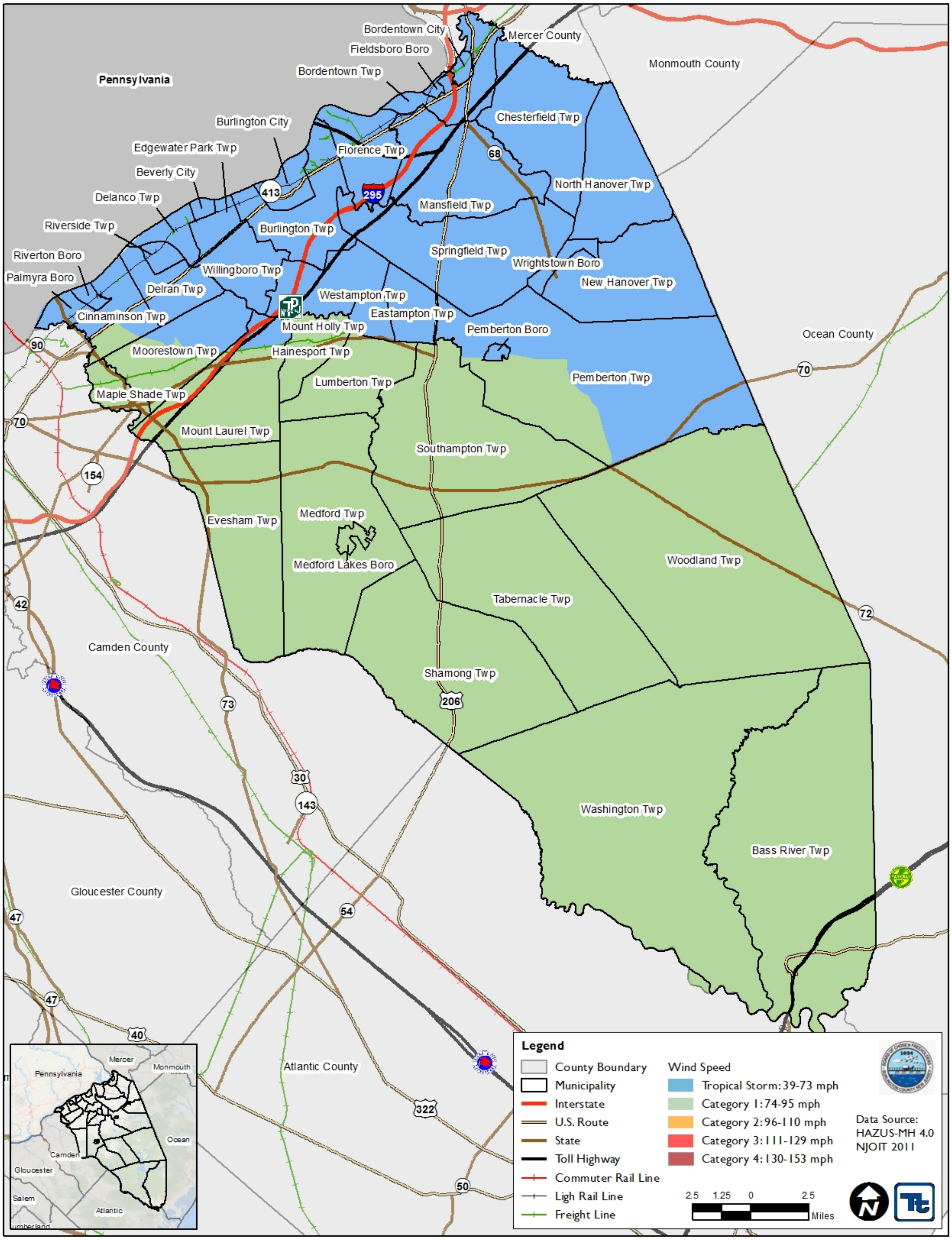
Source: Disaster Readiness Portal 2017

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a 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 (Dinicola 2009).

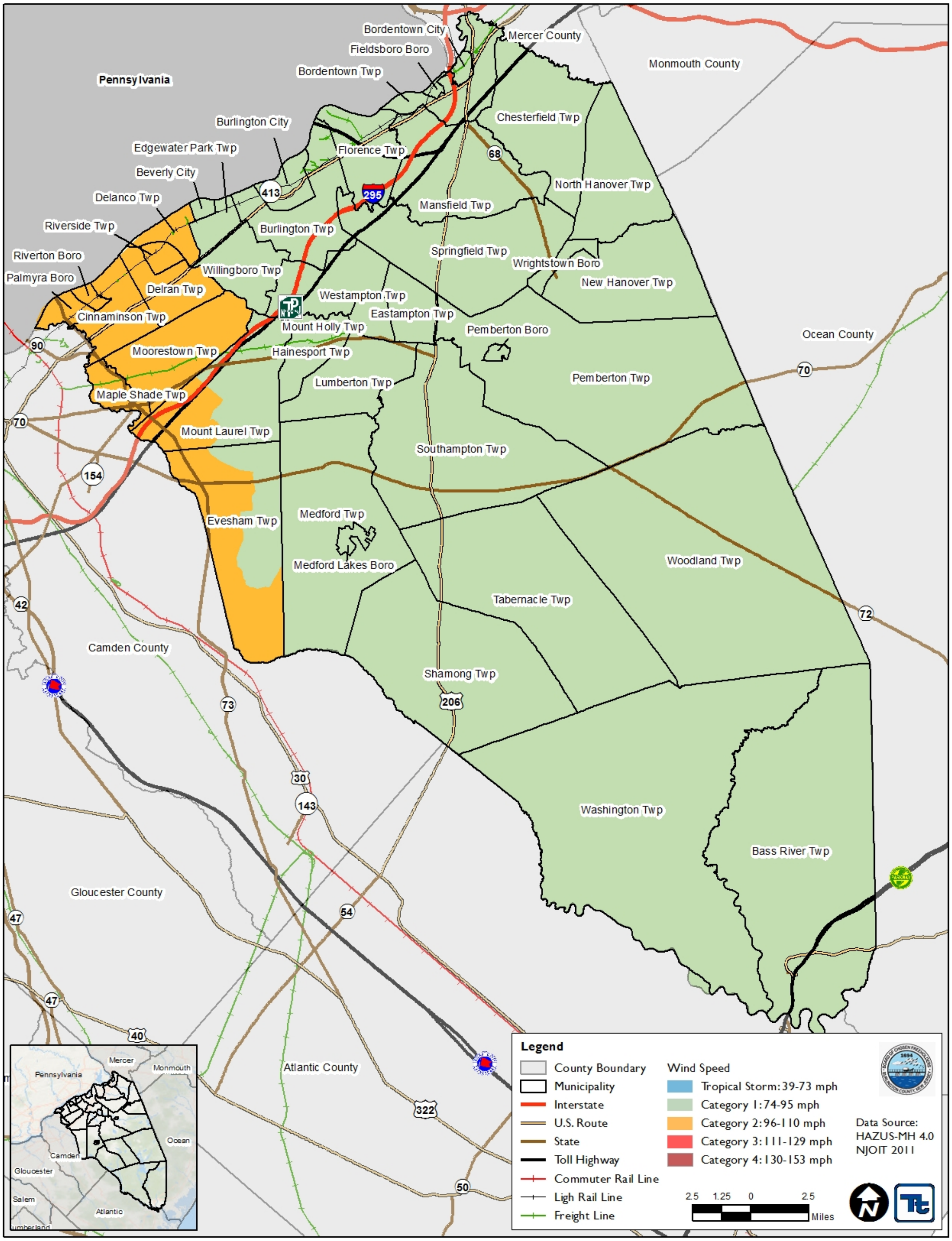
Figure 5.4.6-2 and Figure 5.4.6-3 display the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using HAZUS-MH model runs. The maximum 3-second gust wind speeds for Burlington County are 64 to 84 mph (Tropical Storm to Category 1 hurricane), for the 100-year MRP event. The maximum 3-second gust wind speeds for Burlington County are 82 to 98 mph (Category 1 hurricane), for the 500-year MRP event. The storm tracks for the 100- and 500-year event were not available in HAZUS-MH 4.0; a HAZUS-acknowledged error in this version that will be addressed in the future. The associated impacts and losses from these 100-year and 500-year MRP hurricane events are discussed later in the Vulnerability Assessment subsection.

Figure 5.4.6-5. Wind Speeds for the 100-Year Mean Return Period Event



Source: HAZUS-MH 4.0

Figure 5.4.6-6. Wind Speeds for the 500-Year Mean Return Period Event



Source: *HAZUS-MH 4.0*

Extreme Temperature

Extreme Heat

NOAA's heat alert procedures are based mainly on Heat Index values. The Heat Index is given in degrees Fahrenheit. The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the Heat Index temperature, the temperature and relative humidity need to be known. Once both values are known, the Heat Index will be the corresponding number with both values (Figure 5.4.6-4). The Heat Index indicated the temperature the body feels. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. Strong winds, particularly with very hot dry air, can also be extremely hazardous (NWS 2013).

Figure 5.4.6-7. NWS Heat Index Chart

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: NWS 2016
°F degrees Fahrenheit
% percent

Figure 5.4.6-8. Adverse Effects of Prolonged Exposures to Heat on Individuals

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

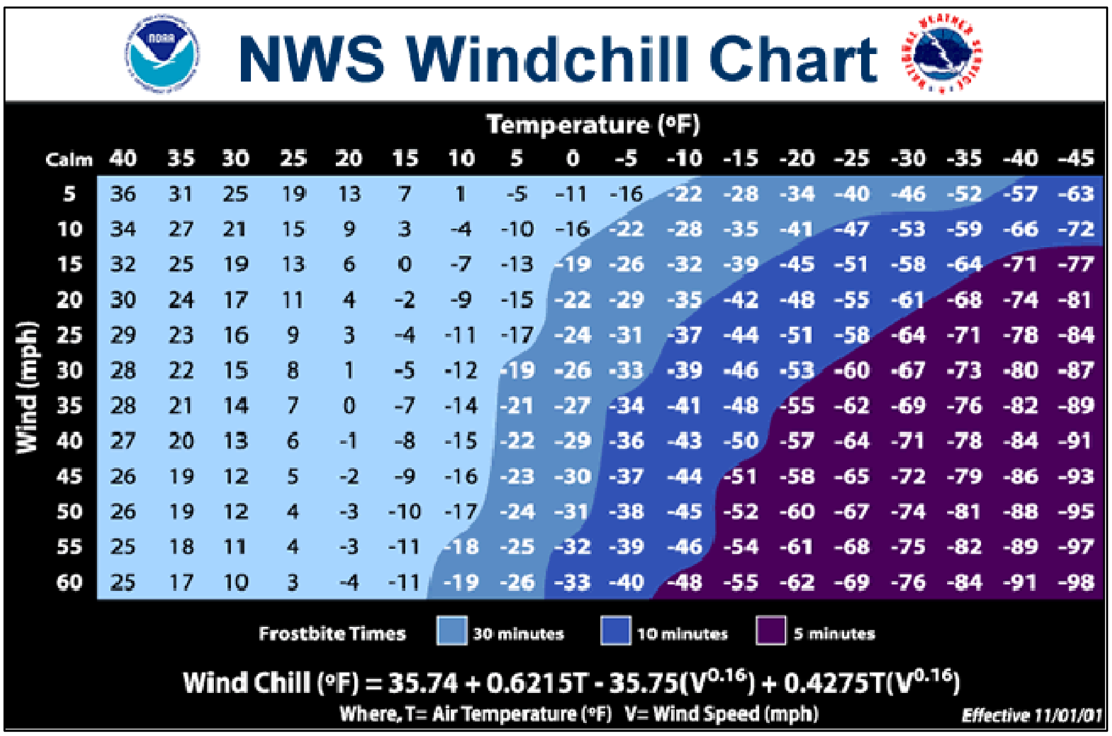
Source: NWS 2009
°F degrees Fahrenheit

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop (NWS 2001).

On November 1, 2001, the NWS implemented a new WCT Index. It was designed to more accurately calculate how cold air feels on human skin. The table below shows the new WCT Index. The WCT Index includes a frostbite indicator, showing points where temperature, wind speed, and exposure time will produce frostbite to humans. Figure 5.4.6-6 shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS 2001).

Figure 5.4.6-9. NWS Wind Chill Index



NWS Windchill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

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

Effective 11/01/01

Source: NWS 2001
°F degrees Fahrenheit
mph miles per hour

Warning Time

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

Previous Occurrences and Losses

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

Based on the Midwestern Regional Climate Center (MRCC) data for Burlington County, Table 5.4.6-6 presents the extreme cold (minimum) and hot (maximum) temperature records for the weather stations located in Burlington County between 1836 and 2018.

Table 5.4.6-4. MRCC Temperature Extremes

Station Name	Highest Max (°F)	Date	Lowest Minimum (°F)	Date
Burlington	106	July 10, 1936	-14	February 9, 1934
Chatsworth	104	July 19, 1977	-15	January 18, 1965
Indian Mills 2 W	107	July 2, 1901	-25	February 9, 1934
McGuire AFB	101	July 3, 1966	-4	February 2, 1961
Moorestown	106	July 10, 1936	-13	February 9, 1934
Mount Holly South Jersey Regional AP	104	July 6, 2010	-3	January 4, 2014
Pemberton	107	July 10, 1936	-17	February 9, 1934
Philadelphia/Mt. Holly WFO	103	July 7, 2010	-6	January 19, 1994

Source: MRCC 2018

Note: There may be some potential problems with the data collected at the stations. The values of the all-time records for stations with brief histories are limited in accuracy and could vary from nearby stations with longer records. Although the data sets have been through quality control, there is still a need for more resources to quality control extremes. The record sets are for single stations in the cooperative observer network and are limited to the time of operation of each station under one coop number. The records for a place may need to be constructed from several individual station histories. Some of the data may vary from NWS records due to NWS using multiple stations and additional sources like record books (MRCC, Date Unknown).

Between 1954 and 2018, the State of New Jersey was included in 32 FEMA declared severe weather-related disasters (DR) or emergencies (EM) classified as one or a combination of the following hazards: coastal storm, high tides, heavy rain, flooding, hurricane, tropical storm, Nor'Easter, straight-line winds, and mudslide. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those declarations, Burlington County has been included in 11 declarations (FEMA 2018). Since the original 2014 HMP, Burlington County has been included in the FEMA disaster declarations for two additional declarations. Table 5.4.6-7 lists FEMA DR and EM declarations from January 1, 2012 to May 2019 for this HMP update.

Table 5.4.6-5. FEMA DR and EM Declarations Since 2012 for Severe Storm Events in Burlington County

FEMA Declaration Number	Date(s) of Event	Event Type	Location
DR-4086, EM 3354	October 26 – November 8, 2012	Hurricane Sandy	Atlantic, Bergen, Burlington, Camden, Cape May, Cumberland, Essex, Gloucester, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Salem, Somerset, Sussex, Union, and Warren
DR-4231	June 23, 2015	Severe Storm	Atlantic, Burlington, Camden, and Gloucester

Source: FEMA 2018

Agriculture-related severe weather disasters are quite common. One-half to two-thirds of the counties in the U.S. have been designated as disaster areas in each of the past several years. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2018, New Jersey has been included in 10 USDA severe weather-related declarations. Burlington County was included in six of these declarations, to date.

- S3487 – June-November 2012 – disaster declared as a result of the combined effects of drought, high winds (derecho), hail, excessive heat, excessive rain, flash flooding, Hurricane Sandy, a snowstorm, and a Nor'Easter; over $62,000 in claims filed in Burlington County
- S3603 – May-September 2013 – disaster declared as a result of the combined effects of excessive rain, related flooding, high winds, and hail
- S3930 – April-September 2015 – disaster declared as a result of excessive heat and drought; over $328,000 in claims filed in Burlington County
- S3931 – May-July 2015 – disaster declared as a result of excessive rain, flash flooding, high winds, and lightning; over $328,000 in claims filed in Burlington County
- S3932 – July-September 2015 – disaster declared as a result of excessive heat and drought; over $328,000 in claims filed in Burlington County
- S4071 – April-September 2016 – disaster declared as a result of the combined effects of freeze, excessive heat, and drought; over $203,000 in claims filed in Burlington County

For this 2019 HMP update, severe weather events were summarized from January 1, 2012 to May 2019. Known severe weather events, including FEMA disaster declarations, which have impacted Burlington County between 2012 and 2018 are identified in Table 5.4.6-8. For events prior to 2012, please refer to Appendix G (Supplementary Data). Please note that not all events that have occurred in Burlington County are included due to the extent of documentation and the fact that not all sources may have been identified or researched. Loss and impact information 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. Please see Section 9 for detailed information regarding impacts and losses to each municipality.

Table 5.4.6-6. Severe Weather Events in Burlington County, 2012 to 2018

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
June 1, 2012	Thunderstorm Wind	N/A	N/A	A strong thunderstorm 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 were reported. Willingboro reported $10,000 in property damages.
October 29-30, 2012	Hurricane Sandy	DR-4086, EM 3354	Yes	Post Tropical Storm Sandy was the costliest natural disaster by far in the state of New Jersey. Record breaking high tides and wave action combined with sustained winds as high as 60 to 70 mph with wind gusts as high as around 90 mph to batter the state. Statewide, Sandy caused an estimated $29.4 billion in damage, destroyed or significantly damaged 30,000 homes and businesses, affected 42,000 additional structures and was responsible directly or indirectly for 38 deaths. A new temporary inlet formed in Mantaloking (Ocean County) where some homes were swept away. About 2.4 million households in the state lost power. It would take two weeks for power to be fully restored to homes and businesses that were inhabitable. In the Mount Holly warning and forecast area of New Jersey, Sandy was responsible for 24 deaths, 8 that are considered directly caused by the system: two drownings, five people killed by fallen trees and one person was blown over by the wind. Hardest hit were the coastal areas of Ocean and Monmouth Counties. Approximately 230,000 residents of the state have applied for assistance from FEMA. In Burlington County, heavy rain caused urban and poor drainage flooding and exacerbated the tidal flooding along the Delaware River and near the Atlantic Coast. Along the Delaware River, tidal flooding occurred in the Columbus Park development along Assiscunk Creek in the City of Burlington. In Mount Laurel Township, Union Mill Road was closed because Parkers Creek flooded. Rainfall totals in Burlington County included 4.10 inches in Medford Township, 3.51 inches in Chatsworth, 3.15 inches in Medford Lakes, 2.92 inches in Mount Laurel Township, 2.82 inches in Morrestown Township and 2.42 inches in Westampton Township. Peak wind gusts in the County ranged from 56 mph in Woodland Township to 70 mph in Florence Township. The most widespread damage in Burlington County was reported in Bass River Township, mainly due to tidal and flood-related damages. In Mount Holly Township, a resident was trapped inside their home after a tree landed on the house. Seven roadways in Medford Township were closed due to downed trees. Overall, the County reported approximately $5 million in property damage from Hurricane Sandy.
December 26, 2012	Strong Wind	N/A	N/A	A 54 mph gust was reported in Florence Township; $10,000 in property damages were reported.
March 6, 2013	Strong Wind	N/A	N/A	A 49 mph gust was recorded at Coyle Field (Woodland Township); $5,000 in property damages were reported.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
June 24, 2013	Lightning	N/A	N/A	Strong to severe thunderstorms moved across central and southern New Jersey, bringing damaging winds, hail and lightning strikes. In Burlington County, a lightning strike caused minor damage to a home in Shamong Township. The Township reported $5,000 in property damage from this event.
July 21, 2013	Lightning	N/A	N/A	Strong thunderstorms in Burlington County brought strong winds and lightning. A lightning strike took down a couple of wires in Bordentown Township. Bordentown Township reported $1,000 in property damages.
August 13, 2013	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down numerous trees and wires in Shamong Township with the wind damage centered around Indian Mills Road. A few homes were damaged by downed trees and a roof was blown off a barn. One downed tree crashed through the bedroom roof of one home. Indian Mills Road remained closed for most of the day. No serious injuries were reported. Indian Mills reported $50,000 in property damages.
March 12, 2014	Strong Wind	N/A	N/A	Strong northwest winds moved across New Jersey, bringing peak wind gusts of around 50 mph to 60 mph in central and southern New Jersey. In Burlington County, gusts of 49 mph were recorded at McGuire Air Force Base and 45 mph was recorded in Lumberton Township. The winds caused $10,000 in property damage.
May 10, 2014	Hail	N/A	N/A	A thunderstorm dropped penny size hail in Burlington Township and Florence Township. A 56 mph wind gust was also measured with this thunderstorm in Burlington Township. Burlington Township reported $500 in property damages; Florence Township reported $500 in property damages.
May 23, 2014	Lightning	N/A	N/A	A lightning strike and ensuing fire left several people displaced from their homes in a condominium complex on Friday night on Tarnbrook Drive in Mount Laurel Township. Eight units were declared uninhabitable after the blaze, which was controlled in less than an hour. Four nearby townships assisted in battling the blaze. Lightning struck the upper part of the building and started a roof fire. Other condominium units suffered fire, smoke and water damage. Springville reported $250,000 in property damages.
July 2, 2014	Thunderstorm Wind	N/A	N/A	A severe thunderstorm damaged sail boats in the Delaware River off of Cinnaminson Township. No injuries were reported. Palmyra Borough reported $10,000 in property damages.
July 3, 2014	Lightning	N/A	N/A	A lightning strike and ensuing fire damaged a home in Beverly City. No injuries were reported. Beverly City reported $25,000 in property damages.
July 14, 2014	Thunderstorm Wind	N/A	N/A	A severe thunderstorm caused wind damage in Southampton Township. Trees and power lines were knocked down and an irrigation pipe was blown across Buddtown Road. Nearly 4,300 homes and businesses lost power in Burlington County. Vincentown reported $10,000 in property damages.
July 15, 2014	Lightning, Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down large tree limbs and wires around New Jersey State Route 70 in from Friendship Road east to Big Hill Road in Southampton Township. North Friendship reported $5,000 in property damages. The storm

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
				knocked down large tree limbs and wires in Tabernacle Township resulting in $5,000 in property damages. Lightning struck the Shawnee Baptist Church on Oakshade Road in Shamong Township. Tabernacle Township reported $5,000 in property damages.
July 28, 2014	Lightning, Thunderstorm Wind	N/A	N/A	A severe thunderstorm tore down several trees and caused wind damage in the Hoot Owl subdivision of Medford Township. Two homes suffered major damage and were uninhabitable. A tree fell onto a home on Christopher Mills Road. About four or five other homes suffered shingle or siding damage. Three vehicles were also damaged by fallen trees. Lake Pine reported $1,000,000 in property damages. A lightning strike and ensuing fire destroyed a shed and its contents on Ridge Road in Southampton Township. Buddtown (Southampton Township) reported $3,000 in property damages.
April 22, 2015	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down a tree that damaged the roof of a home in Wrightstown Borough resulting in $20,000 in property damages. Trees were knocked down trees along New Jersey State Route 70 in Pemberton Township resulting in $20,000 in property damages at Country Lake Estates.
May 28, 2015	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down a couple of trees in Washington Township, one of which fell onto and damaged a home. Jenkins reported $10,000 in property damages.
June 23, 2015	Thunderstorm Wind	DR-4231	Yes	A severe thunderstorm knocked down several trees in Palmyra Borough. Riverton Borough reported $50,000 in property damages. A severe thunderstorm knocked down several trees in Maple Shade Township. One downed tree damaged a home resulting in $50,000 in property damages. Dozens of trees were knocked down in Evesboro resulting in $50,000 in property damages. $1,000,000 in property damages were reported in Mount Laurel Township as trees were snapped, siding was ripped from some homes, and sheds and fences destroyed. In Medford Township, hundreds upon hundreds of trees were either uprooted or snapped. Three people were injured after a tree fell onto their vehicle. Another person was injured after a tree fell on their home on Mississippi Trail. Several other people were trapped in their homes. Some gas lines were ruptured. A firefighter suffered cardiac arrest the next day after assisting people through the night. There were approximately 350 calls for assistance because of wind damage from the thunderstorms within the township. Medford Township reported $8,000,000 in property damages. Medford Lakes Borough had multiple downed trees resulting in $1,000,000 in property damages. In Tabernacle Township the storm knocked down several trees. One downed tree fell onto and damaged a truck. The thunderstorm winds also damaged the roof of Seneca High School. Tabernacle Township reported $100,000 in property damages.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
				Vincentown and Jenkins each reported $50,000 in property damages from downed trees.
March 28, 2016	Strong Wind	N/A	N/A	A utility pole and downed wires due to wind on route 73 in Maple Shade Township due to wind. $10,000 in property damages were reported.
July 3, 2018	Hail	N/A	N/A	Severe thunderstorms caused wind damage across portions of southwestern New jersey. Rainfall amounts of one to three inches fell along the I-95/New Jersey Turnpike corridor. In Burlington County, nickel to quarter size hail was reported in Riverside Township.

Source: NOAA-NCEI 2018, FEMA 2018
DR Major Disaster Declaration (FEMA)
EM Emergency Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
NOAA National Oceanic and Atmospheric Administration
NCEI National Center for Environmental Information

Table 5.4.6-9 documents the number of severe weather events that have occurred in Burlington County from 1950 to 2018, including the number of fatalities, injuries, property damages, and crop damages that have been associated with severe weather according to the NOAA National Climatic Data Center (NCEI) Storm Events Database. Between 1950 and 2018, Burlington County has experienced 1,210 severe weather events resulting in three fatalities, 59 injuries, over $135 million in property damage, and over $1 million in crop damages. Please note that the information provided in the NOAA-NCEI database includes information as reported by the NWS. The NWS receives their information from a variety of sources, including but not limited to: county, state and federal emergency management officials, local law enforcement officials, skywarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry and the general public, among others. It may not include all losses associated with the events.

Table 5.4.6-7. Severe Weather Events 1950-2018

Hazard Type	Number of Occurrences Between 1950 and 2018	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Excessive Heat	39	1	1	0	0
Extreme Cold/Wind Chill	4	0	0	0	0
Funnel Cloud	14	0	0	0	0
Hail	100	0	0	$1,000	0
Heat	84	3	3	0	0
Heavy Rain	287	0	0	$1,000,000	0
High Wind	47	0	3	$101,426,000	0
Hurricane	0	0	0	0	0
Lightning	45	1	21	$3,071,000	0
Strong Wind	207	0	0	$657,890	$20
Thunderstorm Wind	364	1	16	$25,715,000	$1,000,000
Tornado	15	1	8	$2,430,000	0
Tropical Storm	4	0	1	$1,000,000	0
TOTAL	**1,210**	**7**	**53**	**$135,300,890**	**$1,000,020**

Source: NOAA-NCEI 2018

Probability of Future Occurrences

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

It is estimated that Burlington County will continue to experience direct and indirect impacts of severe weather events 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.

Extreme temperatures are expected to occur more frequently as part of regular seasons. Specifically, extreme heat will continue to impact New Jersey and its counties and, based upon data presented, will increase in the next several decades. As previously stated, several extreme temperature events occur each year in Burlington County. It is estimated that the county will continue to experience these events annually.

In order to determine the recurrence interval and the average annual number of events, data from 1950 to 2018 was examined using the NOAA National Climatic Data Center (NCEI) Storm Events Database to calculate these statistics for Burlington County. According to the database, Burlington County experienced 1,210 severe weather events. The table below shows these statistics, as well as the annual average number of events and the percent chance of these individual severe weather events occurring in Burlington County in future years.

Table 5.4.6-8. Probability of Future Occurrences of Severe Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2018	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent chance of occurrence in any given year
Excessive Heat	39	0.57	1.77	0.57	56.52%
Extreme Cold/Wind Chill	4	0.06	17.25	0.06	5.80%
Funnel Cloud	14	0.21	4.93	0.20	20.29%
Hail	100	1.47	0.69	1.45	100%
Heat	84	1.24	0.82	1.22	100%
Heavy Rain	287	4.22	0.24	4.16	100%
High Wind	47	0.69	1.47	0.68	68.12%
Hurricane	0	0	0	0	0%
Lightning	45	0.66	1.53	0.65	65.22%
Strong Wind	207	3.04	0.33	3.00	100%
Thunderstorm Wind	364	5.35	0.19	5.28	100%
Tornado	15	0.22	4.60	0.22	21.74%
Tropical Storm	4	0.06	17.25	0.06	5.80%

``Source: NOAA-NCEI 2018; SPC 2018

In Section 5.3, the identified hazards of concern for Burlington County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe weather events in the county is considered ‘frequent’ (likely to occur within 25 years, as presented in Table 5.3-3).

Climate Change Impacts

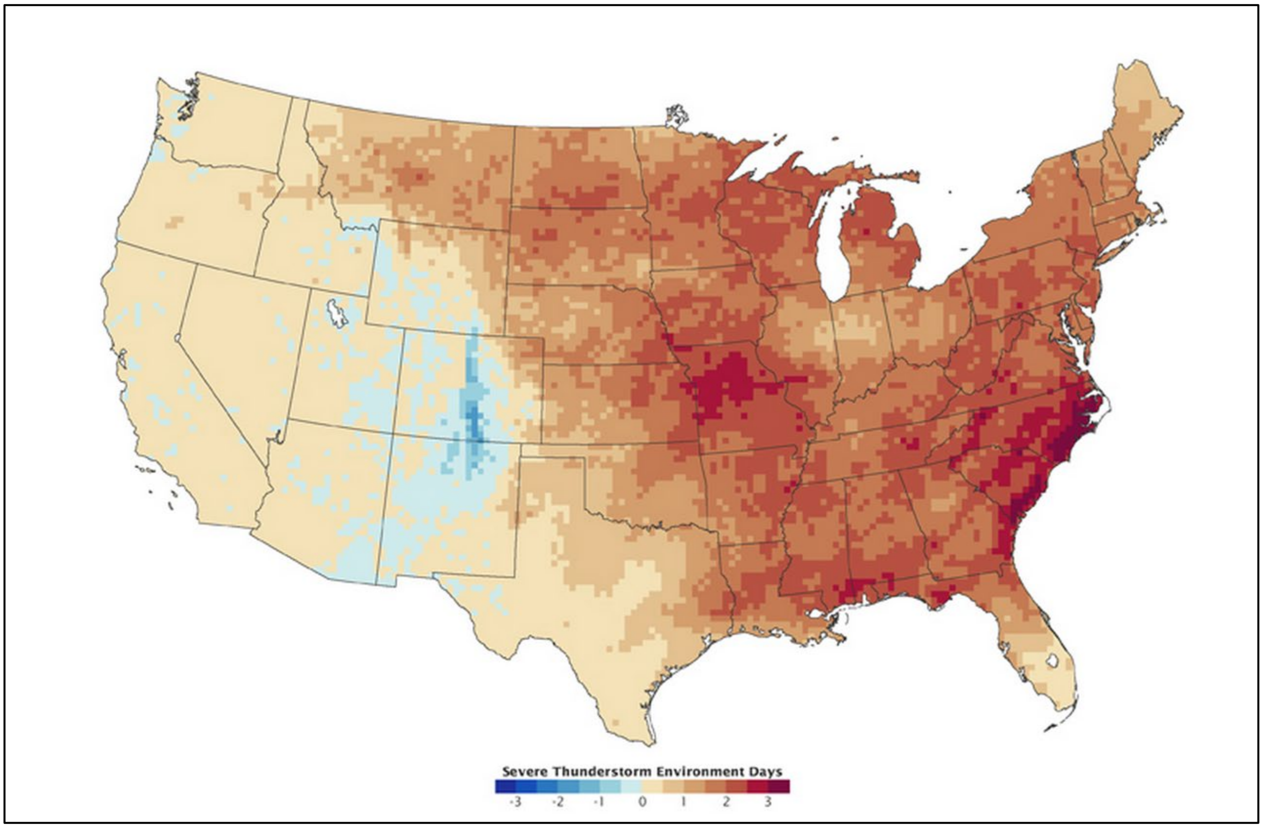
Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey’s 1971-2000 precipitation average was over five inches (12-percent) greater than the average from 1895-1970 (Sustainable Jersey Climate Change Adaptation Task Force [CATF] 2011). Average annual precipitation is projected to increase in the region by four to 11-percent by the 2050s and five to 13-percent by the 2080s. (New York City Panel on Climate Change [NPCC] 2015).

As the climate changes, temperatures and the amount of moisture in the air will both increase, thus leading to an increase in the severity of thunderstorms which can lead to derechos and tornadoes. Studies have shown that an increase in greenhouse gases in the atmosphere would significantly increase the number of days that severe thunderstorms occur in the southern and eastern United States (National Aeronautics and Space Administration [NASA] 2005).

As prepared by the NASA, Figure 5.4.6-7 identifies those areas, particularly within the eastern United States, that are predicted to be more prone to thunderstorms, including New Jersey and Burlington County. NASA scientists suggest that the United States will face more severe thunderstorms in the future, with deadly lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change.

Figure 5.4.6-10. Predicted Change in Severe Thunderstorm Environment Days from the 1962-1989 Period to the 2072-2099 Period



Source: NASA 2013

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

5.4.6.2 VULNERABILITY ASSESSMENT

Wind-related vulnerability data was generated using a HAZUS analysis for the severe storm hazard. A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in HAZUS-MH 4.0 to analyze the severe storm hazard and provide a range of loss estimates. Storm surge impacts were assessed using SLOSH data from FEMA's Coastal Flood Loss Atlas. The other severe weather hazards profiled above were assess qualitatively. Refer to Section 5.1 for additional details on the methodology used to assess severe weather risk.

Impact on Life, Health and Safety

For the purposes of this HMP, the entire population of Burlington County (448,734 people) is exposed to severe weather events (U.S. Census, 2010). Residents may be displaced or require temporary to long-term sheltering due to severe weather events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms and tornadoes. This is because there is little to no warning and shelter may not be available. Moving to a lower risk location will decrease a person's vulnerability.

Extreme temperatures generally occur for a short period of time but can cause a range of impacts, particularly to vulnerable populations that may not have access to adequate cooling or heating. Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand temperatures extremes due to their age, health conditions and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals who are physically ill (e.g., heart disease or high blood pressure), 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC, 2007; CDC 2009).

Meteorologists can accurately forecast extreme heat event development and the severity of the associated conditions with several days of lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions and focus on surveillance and relief efforts on those at greatest risk. Adhering to extreme temperature warnings can significantly reduce the risk of temperature-related deaths.

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; secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a primary concern in the County (see flooding discussion in Section 5.4.4 Flood). The estimated population in the Category 1 through 4 inundation zones is summarized in Table 5.4.6-11 by municipality. For the Category 1 inundation zone, Burlington City has the greatest total exposure with 272 people located in the inundation zone. For the Category 2 and Category 3 inundation zones, Bass River Township has the greatest total exposure with 962 and 977 people located in the Category 2 and Category 3 inundation zones, respectively. For the Category 4 inundation zone, Palmyra Borough has the greatest total exposure with 4,067 people located in the hazard area.

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

Municipality	Total Population (U.S. Census 2010)	Population in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Bass River Township	1,443	55	3.8%	962	66.7%	977	67.7%	1,337	92.7%
Beverly City	2,577	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Bordentown City	3,924	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Bordentown Township	11,367	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Burlington City	9,920	272	2.7%	272	2.7%	272	2.7%	272	2.7%
Burlington Township	22,594	0	0.0%	0	0.0%	8	0.0%	446	2.0%
Chesterfield Township	7,699	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cinnaminson Township	15,569	0	0.0%	0	0.0%	0	0.0%	814	5.2%
Delanco Township	4,283	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Delran Township	16,896	36	0.2%	36	0.2%	36	0.2%	218	1.3%
Eastampton Township	6,069	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Edgewater Park Township	8,881	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Evesham Township	45,538	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fieldsboro Borough	540	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Florence Township	12,109	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hainesport Township	6,110	0	0.0%	11	0.2%	70	1.1%	90	1.5%
Lumberton Township	12,559	0	0.0%	161	1.3%	313	2.5%	410	3.3%
Mansfield Township	8,544	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Maple Shade Township	19,131	0	0.0%	0	0.0%	0	0.0%	112	0.6%
Medford Lakes Borough	4,146	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Medford Township	23,033	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Moorestown Township	20,726	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Mount Holly Township	9,536	0	0.0%	0	0.0%	0	0.0%	114	1.2%
Mount Laurel Township	41,864	0	0.0%	0	0.0%	3	0.0%	264	0.6%
New Hanover Township	7,385	0	0.0%	0	0.0%	0	0.0%	0	0.0%
North Hanover Township	7,678	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Palmyra Borough	7,398	0	0.0%	0	0.0%	453	6.1%	4,067	55.0%
Pemberton Borough	1,409	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Pemberton Township	27,912	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Riverside Township	8,079	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Riverton Borough	2,779	0	0.0%	0	0.0%	0	0.0%	1,261	45.4%
Shamong Township	6,490	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Southampton Township	10,464	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Springfield Township	3,414	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tabernacle Township	6,949	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Township	687	127	18.5%	396	57.6%	477	69.4%	505	73.5%
Westampton Township	8,813	0	0.0%	0	0.0%	0	0.0%	19	0.2%

Municipality	Total Population (U.S. Census 2010)	Population in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Willingboro Township	31,629	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Woodland Township	1,788	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wrightstown Borough	802	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Burlington County	**448,734**	**490**	**0.1%**	**1,838**	**0.4%**	**2,609**	**0.6%**	**9,929**	**2.2%**

Source: Burlington County GIS; U.S. Census 2010
The SLOSH boundaries were overlaid on the U.S. Census block; the blocks with their centroids within the hazard areas were totaled for each municipality.

Socially vulnerable and economically disadvantaged populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. The 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. Within the Category 1 inundation area, there are approximately 106 people over the age of 65 and 60 people considered low income populations (as present in Table 4-3 of the County Profile). Within the Category 2 inundation area, there are approximately 917 people over the age of 65 and 841 people considered low income populations. Within the Category 3 inundation area, there are approximately 1,340 people over the age of 65 and 2,775 people considered low income populations. Within the Category 4 inundation area, there are approximately 5,050 people over the age of 65 and 4,268 people considered low income populations.

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. HAZUS-MH 4.0 estimates there will be no households displaced and no one that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, HAZUS-MH 4.0 Hurricane wind model estimates 27 households will be displaced, and 4 people require short-term sheltering. Refer to Table 5.4.6-12 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

Mean Return Period	Displaced Households	Households Requiring Short-Term Shelter
100-year MRP	0	0
500-year MRP	27	4

Source: HAZUS-MH 4.0 (U.S. Census 2010)

Impact on General Building Stock

Damage to buildings is dependent upon several factors, including wind speed, storm duration, path of the storm track or tornado, and distance from the tornado funnel. Depending on the size of the hail and severity of the storm, the County could see damage from hail impacting structures. Lightning can spark wildfires or building fires, especially if structures are not protected by surge protectors on critical electronic, lighting, or information technology systems. While damage to the building stock are possible as a result of lightning and hail, they are difficult to estimate and would not have as wide of an impact as a high wind or tornado event.

Building construction plays a major role in the extent of damage resulting from a severe storm event. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings, in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

Extreme heat generally does not impact buildings. Losses may be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities may have inadequate capabilities to withstand extreme temperatures.

The U.S. Census Bureau defines manufactured homes as "movable dwellings, 8 feet or wider and 40 feet or more long, designed to be towed on its own chassis, with transportation gear integral to the unit when it leaves the factory, and without need of a permanent foundation (U.S. Census, 2010)." They can include multi-wides and expandable manufactured homes but exclude travel trailers, motor homes, and modular housing. Due to their light-weight and often unanchored design, manufactured housing is extremely vulnerable to high winds and will generally sustain the most damage.

Table 5.4.6-13 displays the number of manufactured housing units per municipality in Burlington County. Total counts were obtained from the custom general building stock; manufactured housing occupancy class determined using the property class descriptions from the NJ Department of the Treasury tax assessor data. As noted below, North Hanover Township contains the greatest number of manufactured homes.

Table 5.4.6-11. Manufactured Housing Units per Municipality in Burlington County

Municipality	Number of Manufactured Homes		Municipality	Number of Manufactured Homes
Bass River Township	2		North Hanover Township	594
Hainesport Township	19		Pemberton Township	56
Maple Shade Township	1		Shamong Township	335
			Burlington County:	**1,007**

Source: Burlington County, NJ Department of the Treasury, 2017

The entire County's general building stock is assumed to be exposed to the severe storm wind hazard (greater than $101 billion in structure cost only). Expected building damage was estimated by HAZUS-MH 4.0 and includes buildings damaged at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.6-14 summarizes the definition of the damage categories.

Table 5.4.6-12. 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 or 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

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
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%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>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 64 to 84 miles per hour (mph). This equates to a tropical storm. For the 100-year MRP event, HAZUS-MH 4.0 estimates $124.4 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 82 to 98 mph. This equates to a Category 1 hurricane and $588.9 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 5.4.6-15 summarizes the building value (structure only) damage estimated for the annualized and 100- and 500-year MRP wind-only events by occupancy class. The total cost of all damage estimates for both mean return periods and annualized loss is less than 1% of total replacement cost value for each municipality.

Table 5.4.6-13. Estimated Building Value (Structure Only) Damaged by the 100-Year and 500-Year MRP Hurricane-Related Winds

Municipality	Total Replacement Cost Value (Structure Only)	Estimated Total Damages*		
		Annualized Loss	100-Year	500-Year
Bass River Township	$592,479,667	$63,734	$1,086,271	$1,198,399
Beverly City	$307,500,140	$17,881	$303,079	$2,673,508
Bordentown City	$744,949,381	$35,102	$218,329	$2,897,951
Bordentown Township	$1,674,099,210	$74,182	$506,809	$5,817,204
Burlington City	$1,962,644,603	$88,160	$1,233,308	$10,871,676
Burlington Township	$5,000,155,300	$246,204	$3,366,026	$29,584,190
Chesterfield Township	$1,400,485,206	$83,460	$433,408	$4,529,647
Cinnaminson Township	$3,443,136,617	$135,322	$3,490,709	$25,509,624
Delanco Township	$918,559,858	$53,304	$980,085	$8,442,694
Delran Township	$3,217,120,782	$156,070	$3,375,285	$26,921,484
Eastampton Township	$1,060,270,313	$66,988	$988,097	$5,331,464
Edgewater Park Township	$1,457,974,255	$74,005	$1,072,498	$11,983,371
Evesham Township	$9,168,653,192	$538,952	$19,599,968	$66,107,914
Fieldsboro Borough	$84,982,564	$4,029	$29,766	$321,067
Florence Township	$1,673,982,403	$79,656	$824,115	$7,802,946

Municipality	Total Replacement Cost Value (Structure Only)	Estimated Total Damages*		
		Annualized Loss	100-Year	500-Year
Hainesport Township	$2,080,207,178	$102,159	$2,095,234	$10,689,794
Lumberton Township	$3,424,896,916	$237,536	$4,488,461	$20,719,417
Mansfield Township	$2,285,414,884	$111,611	$923,477	$7,898,645
Maple Shade Township	$2,679,790,126	$122,981	$3,376,477	$25,403,710
Medford Lakes Borough	$837,422,542	$62,146	$2,155,908	$5,295,461
Medford Township	$7,999,936,346	$516,992	$17,479,571	$46,668,322
Moorestown Township	$6,109,599,449	$278,625	$7,018,194	$43,702,347
Mount Holly Township	$2,150,068,863	$120,881	$2,113,887	$10,559,089
Mount Laurel Township	$9,343,991,534	$513,276	$14,358,752	$67,873,218
New Hanover Township	$1,546,232,618	$41,619	$274,549	$1,101,525
North Hanover Township	$1,729,559,019	$102,338	$476,842	$3,790,566
Palmyra Borough	$1,106,819,144	$49,933	$1,324,046	$10,846,848
Pemberton Borough	$207,432,867	$12,225	$178,587	$715,940
Pemberton Township	$5,772,021,833	$452,382	$5,347,002	$18,058,353
Riverside Township	$1,276,520,301	$54,671	$1,115,625	$9,549,798
Riverton Borough	$585,858,006	$32,130	$781,439	$6,782,962
Shamong Township	$1,696,218,832	$142,126	$4,465,749	$7,373,057
Southampton Township	$3,975,061,802	$295,912	$5,161,880	$17,209,412
Springfield Township	$2,223,461,090	$143,137	$1,337,822	$8,912,525
Tabernacle Township	$2,175,794,267	$162,814	$3,544,784	$6,655,568
Washington Township	$357,333,022	$40,123	$743,863	$823,158
Westampton Township	$2,487,347,035	$107,267	$1,655,690	$10,595,342
Willingboro Township	$5,281,247,833	$285,919	$5,544,354	$36,200,597
Woodland Township	$888,068,601	$63,541	$905,985	$1,030,013
Wrightstown Borough	$223,368,035	$10,150	$54,172	$413,181
Burlington County	**$101,150,665,635**	**$5,779,543**	**$124,430,102**	**$588,861,987**

Source: HAZUS-MH 4.0
**The Total Damages column represents the sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious and government) based on replacement cost value.*

The total damage to buildings (structure only) for all occupancy types across Burlington County is estimated to be $124.4 million for the 100-year MRP wind-only event, and approximately $588.9 million for the 500-year MRP wind-only event. The majority of these losses are to the residential building category. Refer to Figure 5.4.6-8 and Figure 5.4.6-9 that illustrate the density estimated building loss across Burlington County for these two events.

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.

Annualized losses were also examined for Burlington County. A total of $5.8 million is estimated as the annualized loss for the entire County; see Table 5.4.6-15 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 general building stock exposure to the Category 1 through 4 inundation zones is summarized in Table 5.4.6-16 and Table 5.4.6-17 by municipality.

Table 5.4.6-14. Estimated Replacement Cost Value Located in the SLOSH Inundation Zones

Municipality	Total Replacement Cost Value	Replacement Cost Value in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Bass River Township	$1,027,917,130	$158,298,365	15.4%	$660,059,671	64.2%	$720,105,461	70.1%	$851,567,867	82.8%
Beverly City	$471,487,138	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Bordentown City	$1,244,995,904	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Bordentown Township	$2,820,041,247	$3,557,712	0.1%	$3,557,712	0.1%	$3,557,712	0.1%	$3,557,712	0.1%
Burlington City	$3,215,233,092	$2,924,761	0.1%	$2,924,761	0.1%	$2,924,761	0.1%	$55,924,247	1.7%
Burlington Township	$8,013,259,672	$4,721,750	0.1%	$4,721,750	0.1%	$25,476,505	0.3%	$193,652,531	2.4%
Chesterfield Township	$2,443,294,418	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Cinnaminson Township	$5,703,895,752	$316,061	0.0%	$316,061	0.0%	$1,216,651	0.0%	$184,269,672	3.2%
Delanco Township	$1,422,201,479	$0	0.0%	$0	0.0%	$0	0.0%	$2,029,502	0.1%
Delran Township	$5,145,622,596	$19,748,928	0.4%	$19,784,149	0.4%	$19,784,149	0.4%	$23,731,659	0.5%
Eastampton Township	$1,687,017,512	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Edgewater Park Township	$2,307,285,215	$409,975	0.0%	$409,975	0.0%	$409,975	0.0%	$409,975	0.0%
Evesham Township	$14,666,082,424	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Fieldsboro Borough	$139,371,126	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Florence Township	$2,787,263,607	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Hainesport Township	$3,447,208,735	$0	0.0%	$49,175,941	1.4%	$66,166,291	1.9%	$168,080,161	4.9%
Lumberton Township	$5,459,557,257	$0	0.0%	$25,769,841	0.5%	$29,675,257	0.5%	$156,132,285	2.9%
Mansfield Township	$4,056,501,589	$0	0.0%	$147,168	0.0%	$147,168	0.0%	$147,168	0.0%
Maple Shade Township	$4,385,500,913	$0	0.0%	$0	0.0%	$0	0.0%	$18,354,028	0.4%
Medford Lakes Borough	$1,280,050,871	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Medford Township	$12,845,907,494	$0	0.0%	$0	0.0%	$0	0.0%	$1,385,744	0.0%
Moorestown Township	$10,108,801,626	$0	0.0%	$0	0.0%	$0	0.0%	$45,372,669	0.4%
Mount Holly Township	$3,498,352,996	$0	0.0%	$669,667	0.0%	$669,667	0.0%	$15,933,343	0.5%
Mount Laurel Township	$14,653,800,804	$0	0.0%	$9,110,792	0.1%	$9,178,026	0.1%	$15,271,999	0.1%
New Hanover Township	$3,022,835,486	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%

Municipality	Total Replacement Cost Value	Replacement Cost Value in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
North Hanover Township	$3,079,878,987	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Palmyra Borough	$1,788,398,557	$316,731	0.0%	$496,314	0.0%	$19,205,603	1.1%	$778,171,913	43.5%
Pemberton Borough	$345,869,906	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Pemberton Township	$9,374,914,679	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Riverside Township	$2,039,139,951	$489,249	0.0%	$489,249	0.0%	$489,249	0.0%	$489,249	0.0%
Riverton Borough	$916,434,789	$41,731	0.0%	$41,731	0.0%	$2,971,394	0.3%	$489,758,472	53.4%
Shamong Township	$2,738,384,433	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Southampton Township	$6,722,347,774	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Springfield Township	$3,853,514,909	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Tabernacle Township	$3,619,040,765	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Washington Township	$597,426,933	$60,357,747	10.1%	$173,621,591	29.1%	$212,219,319	35.5%	$270,623,322	45.3%
Westampton Township	$4,269,433,407	$0	0.0%	$5,727,866	0.1%	$6,557,877	0.2%	$27,345,533	0.6%
Willingboro Township	$8,259,747,413	$3,430,398	0.0%	$3,430,398	0.0%	$3,430,398	0.0%	$11,859,768	0.1%
Woodland Township	$1,656,748,246	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Wrightstown Borough	$411,963,035	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Burlington County	**$165,526,729,867**	**$254,613,407**	**0.2%**	**$960,454,636**	**0.6%**	**$1,124,185,463**	**0.7%**	**$3,314,068,818**	**2.0%**

Source: FEMA 2012, Burlington County
Note: The SLOSH boundaries were overlaid on the custom general building stock inventory; the structures with their centroids within the hazard are were totaled for each municipality.

Table 5.4.6-15. Estimated Number of Buildings Located in the SLOSH Inundation Zones

Municipality	Total # Buildings	Number of Buildings in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Bass River Township	1,863	217	11.6%	1,032	55.4%	1,203	64.6%	1,576	84.6%
Beverly City	964	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Bordentown City	1,219	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Bordentown Township	3,113	4	0.1%	4	0.1%	4	0.1%	4	0.1%
Burlington City	3,644	7	0.2%	7	0.2%	7	0.2%	43	1.2%
Burlington Township	7,757	2	0.0%	2	0.0%	14	0.2%	283	3.6%
Chesterfield Township	2,093	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cinnaminson Township	6,358	1	0.0%	1	0.0%	2	0.0%	219	3.4%
Delanco Township	1,562	0	0.0%	0	0.0%	0	0.0%	9	0.6%
Delran Township	5,191	7	0.1%	8	0.2%	8	0.2%	15	0.3%
Eastampton Township	2,499	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Edgewater Park Township	2,567	2	0.1%	2	0.1%	2	0.1%	2	0.1%
Evesham Township	14,319	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Fieldsboro Borough	242	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Florence Township	2,522	0	0.0%	0	0.0%	0	0.0%	0	0.0%

Municipality	Total # Buildings	Number of Buildings in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Hainesport Township	2,747	0	0.0%	27	1.0%	29	1.1%	101	3.7%
Lumberton Township	4,009	0	0.0%	29	0.7%	38	0.9%	194	4.8%
Mansfield Township	2,798	0	0.0%	1	0.0%	1	0.0%	1	0.0%
Maple Shade Township	6,006	0	0.0%	0	0.0%	0	0.0%	27	0.4%
Medford Lakes Borough	1,909	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Medford Township	10,627	0	0.0%	0	0.0%	0	0.0%	3	0.0%
Moorestown Township	8,736	0	0.0%	0	0.0%	0	0.0%	77	0.9%
Mount Holly Township	4,573	0	0.0%	1	0.0%	1	0.0%	12	0.3%
Mount Laurel Township	12,900	0	0.0%	2	0.0%	3	0.0%	20	0.2%
New Hanover Township	1,964	0	0.0%	0	0.0%	0	0.0%	0	0.0%
North Hanover Township	2,901	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Palmyra Borough	2,713	2	0.1%	3	0.1%	8	0.3%	1,074	39.6%
Pemberton Borough	514	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Pemberton Township	13,511	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Riverside Township	2,868	3	0.1%	3	0.1%	3	0.1%	3	0.1%
Riverton Borough	1,274	1	0.1%	1	0.1%	2	0.2%	544	42.7%
Shamong Township	3,623	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Southampton Township	7,982	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Springfield Township	2,876	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Tabernacle Township	4,452	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Washington Township	939	111	11.8%	305	32.5%	372	39.6%	496	52.8%
Westampton Township	3,006	0	0.0%	4	0.1%	8	0.3%	34	1.1%
Willingboro Township	12,395	4	0.0%	4	0.0%	4	0.0%	13	0.1%
Woodland Township	1,323	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wrightstown Borough	485	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Burlington County	**173,044**	**361**	**0.2%**	**1,436**	**0.8%**	**1,709**	**1.0%**	**4,750**	**2.7%**

Source: FEMA 2012, Burlington County
Note: The SLOSH boundaries were overlaid on the custom general building stock inventory; the structures with their centroids within the hazard are were totaled for each municipality.

Figure 5.4.6-11. Density of Losses for Structures (All Occupancies) for the 100-Year MRP Wind Event

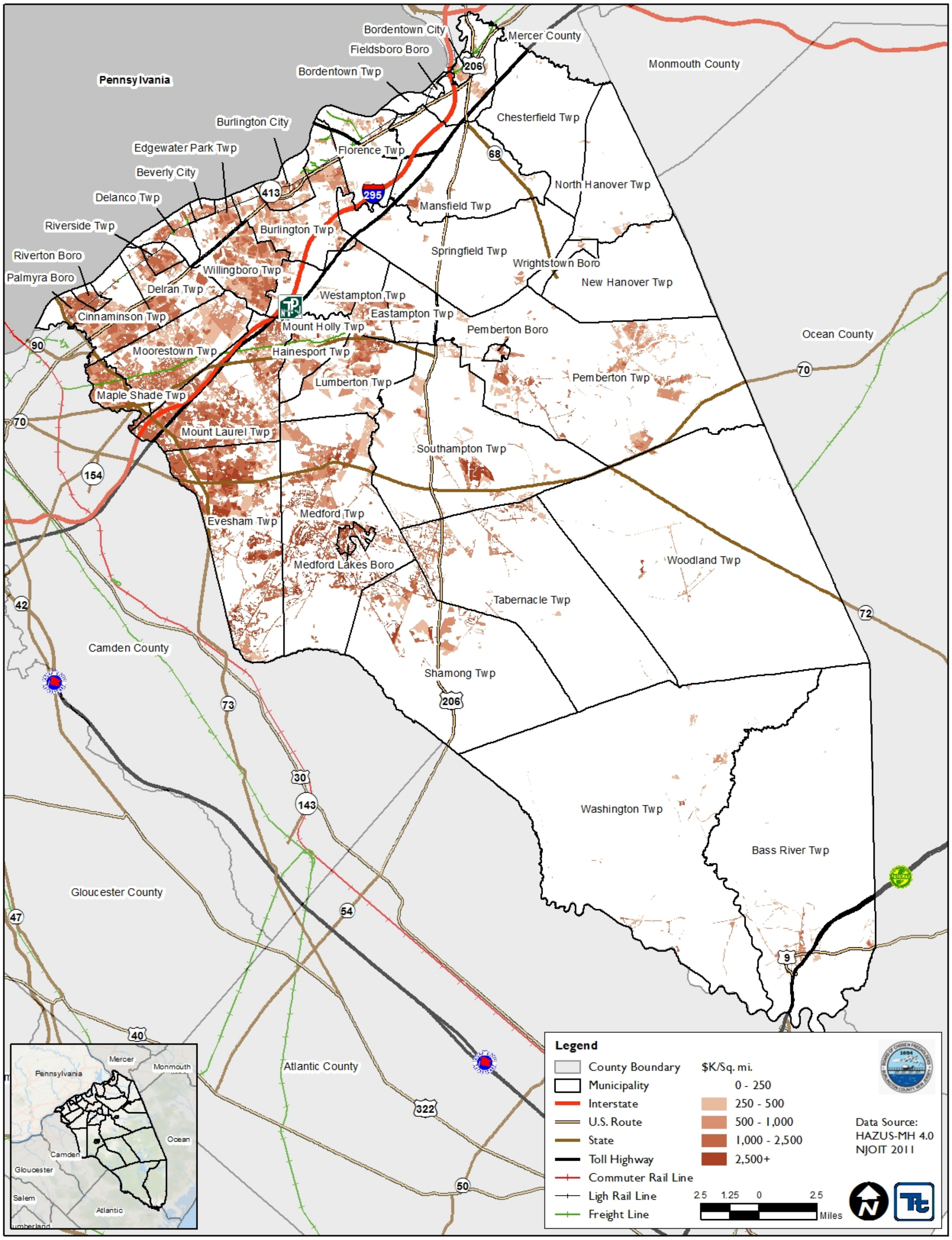
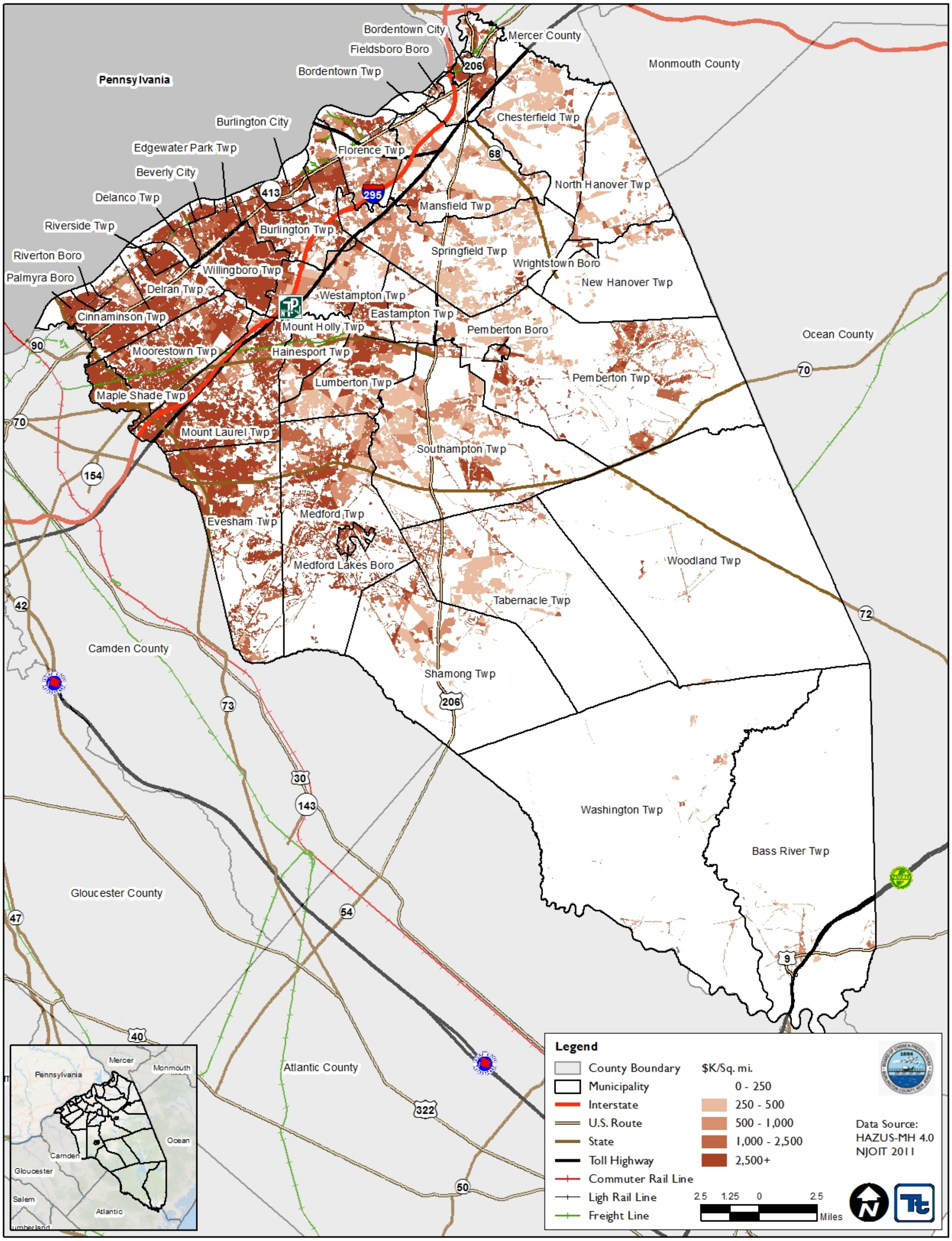


Figure 5.4.6-12. Density of Losses for Structures (All Occupancies) for the 500-Year MRP Wind Event



Impact on Critical Facilities

Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power. Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water and wastewater treatment and communications. In addition to public water services, property owners with private wells may not have access to potable water either until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effective respond to an event and maintain the safety of its citizens.

It is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as "brown-outs", due to increased usage from air conditioners, appliances, etc. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption as well. Backup power is recommended for critical facilities and infrastructure.

HAZUS-MH 4.0 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 4.0 estimates the loss of use for each facility in number of days. HAZUS-MH 4.0 estimates 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. Table 5.4.6-19 summarizes the estimated impacts to critical facilities as a result of the 500-year MRP event.

At this time, HAZUS-MH 4.0 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.

The critical facilities and utilities located in the Category 1 through 4 inundation zones are summarized in Table 5.4.6-18 by municipality. Overall, County buildings and dams are the most exposed facility types for each of the SLOSH categories.

Table 5.4.6-16. Number of Critical Facilities Located in the SLOSH Inundation Zones

Municipality	Facility Types																				
	Airport	Business/Industry	Chemical	County	Dam	Daycare	EMS	EOC	Fire	Hazmat	Intermodal Transit	Library	Light Rail	Municipal Hall	Police	Potable Pump Station	School	Senior	Shelter	Substation	Tier II Facility	Wastewater Treatment Plant
Category 1																						
Bass River Township	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cinnaminson Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington Township	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Burlington County	**0**	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
Category 2																						
Bass River Township	0	0	1	10	0	0	0	1	1	0	0	1	0	1	0	0	1	0	1	0	0	0
Cinnaminson Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hainesport Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lumberton Township	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington Township	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0
Burlington County	**2**	**1**	**1**	**10**	**3**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0**	**2**	**1**	**0**	**1**	**0**	**2**	**0**	**0**	**0**
Category 3																						
Bass River Township	0	0	1	10	1	0	0	1	1	0	0	1	0	1	0	0	2	0	1	0	0	0
Burlington Township	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cinnaminson Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hainesport Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lumberton Township	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Washington Township	1	1	0	0	2	0	1	0	2	0	0	0	0	1	1	0	0	0	4	0	0	0
Burlington County	**2**	**1**	**1**	**10**	**6**	**0**	**1**	**1**	**3**	**0**	**0**	**1**	**0**	**2**	**1**	**0**	**2**	**0**	**5**	**0**	**0**	**1**
Category 4																						
Bass River Township	0	0	1	10	1	0	0	1	1	0	0	1	0	1	0	0	2	0	1	0	0	0

Table 5.4.6-16. Number of Critical Facilities Located in the SLOSH Inundation Zones

Municipality	Facility Types																					
	Airport	Business/Industry	Chemical	County	Dam	Daycare	EMS	EOC	Fire	Hazmat	Intermodal Transit	Library	Light Rail	Municipal Hall	Police	Potable Pump Station	School	Senior	Shelter	Substation	Tier II Facility	Wastewater Treatment Plant
Burlington City	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Burlington Township	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Cinnaminson Township	0	0	3	0	3	0	0	0	0	0	2	0	1	0	0	0	0	0	0	1	0	1
Hainesport Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lumberton Township	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Medford Township	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moorsetown Township	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mount Holly Township	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Mount Laurel Township	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Palmyra Borough	0	4	0	1	0	1	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	1
Riverton Borough	0	0	1	2	0	0	0	1	1	0	0	1	0	1	1	0	2	1	1	0	1	1
Washington Township	1	1	0	0	2	0	1	0	2	0	0	0	0	1	1	0	1	0	5	0	0	0
Burlington County	**2**	**5**	**6**	**14**	**9**	**1**	**1**	**2**	**5**	**1**	**2**	**2**	**1**	**3**	**3**	**1**	**7**	**1**	**7**	**1**	**2**	**5**

Source: FEMA 2012, Burlington County

Table 5.4.6-17. Estimated Impacts to Critical Facilities for the 500-Year Mean Return Period Hurricane-Related Winds

Facility Type	Loss of Days	500-Year Event			
		Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	1-10	0-2	0	0
Medical	0	0-5	0-1	0	0
Police	0	2-10	0-2	0	0
Fire	0	0-5	0-1	0	0
Schools	0	0-9	1-6	0	0

Source: HAZUS-MH 4.0

Impact on Economy

Severe weather events can have impacts on the economy, including loss of business function and damage/loss of inventory. Business-owners may be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills or business interruption due to power failure (i.e., loss of electricity, telecommunications). The agricultural industry is most at risk in terms of economic impact and damage due to extreme temperature events. Extreme heat events can result in drought and dry conditions and directly impact livestock and crop production. See the Impact on the Economy section of the drought hazard profile (Section 5.4.2) for information regarding the impact on the agriculture as result of a drought in the county.

For the 100-year MRP wind event, HAZUS-MH 4.0 estimates approximately $1.3 million in business interruption costs (income loss, relocation costs, rental costs and lost wages) and less than $1,000 inventory losses. For the 500-year MRP wind only event, HAZUS-MH 4.0 estimates approximately $25.6 million in business interruption losses for the County, which includes loss of income, relocation costs, rental costs and lost wages, in addition to approximately $395 thousand in inventory losses.

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

Debris management can be costly and may also impact the local economy. HAZUS-MH 4.0 also estimates the amount of debris that may be produced a result of the 100- and 500-year MRP wind events. HAZUS-MH 4.0 estimates that no debris will be generated as a result of the 100-year MRP wind events. 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, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Table 5.4.6-20 summarizes debris production estimates for 500-year MRP wind events.

Table 5.4.6-18. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Mean Return Period	Brick and Wood (tons)	Concrete and Steel (tons)	Tree (tons)	Eligible Tree Volume (cubic yards)
100-year MRP	3,340	0	94,923	117,837
500-year MRP	32,274	3	210,661	414,670

Source: HAZUS-MH 4.0

Future Growth and Development

As discussed and illustrated in Sections 4 and 9, areas targeted for future growth and development have been identified across the county. Any areas of growth could be potentially impacted by the severe weather hazard because the entire Planning Area is exposed and vulnerable to the impacts associated with these events. The development of new buildings in these areas must meet or exceed the standards in Section R301.2.1.1 of the International Building Code (IBC) which will assist with mitigating future potential damages and losses. Any areas of growth could be potentially impacted by the extreme temperature hazard because the entire county is exposed and vulnerable. Areas targeted for potential future growth and development in the next five (5) years have been identified across the county at the jurisdiction level. Refer to the jurisdictional annexes in Volume II of this HMP.

As for new development located in the SLOSH boundaries, there are 21 developments located in the Category 1 through Category 4 SLOSH boundaries; 7 properties in Category 1, 3 properties in Category 2, 2 properties in Category 3, and 9 properties in Category 4. Of the 21 developments, the Township of Mount Laurel has the most located in the Category 1 through Category 4 SLOSH boundaries with 4 developments exposed. Refer to Figure 5.4.6-13 for a map of proposed new development and the landslide susceptibility areas of Burlington County.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events like hurricanes. While predicting changes to the prevalence or intensity of hurricanes and the events affects under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Climate Change in New Jersey: Trends and Projections describes changes in temperature, precipitation, and sea level rise. Each section of the report summarizes observed recent changes in climate in New Jersey. Observations are based on recorded climate data collected by the ONJSC and other institutions, and on other reports summarizing climate change in the northeastern United States. Each section also presents a synthesis of the most current projections for future climate changes based on climate science modeling and techniques. The projections reflect potential average climate over a span of future years (2020, 2050, and 2080). The projections in the report illustrate the potential climate changes that could impact the northeastern United States based on future emissions scenarios (A2, A1B, and B1 – high, medium, and low scenarios). Each emissions scenario would result in a range of potential climate outcomes in the State (Rutgers 2013).

In the coming years, most studies project that the State of New Jersey can expect an increase in average annual temperature, and steady or increasing amounts of precipitation with more rain in the winter. More frequent extreme events are likely, including heat waves, short-term droughts, and extreme precipitation events with subsequent flooding. Sea level rise in New Jersey is already occurring faster than the global average rate because of land subsidence and ground water withdrawal, and a continued rate of rise is expected to lead to more frequent and more severe coastal flooding events, including those associated with hurricane and tropical storms (Rutgers 2013).

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

Change of Vulnerability Since 2014 HMP

Burlington County and its municipalities continue to be vulnerable to the hurricane and tropical storm hazard. However, there are several differences between the exposure and potential loss estimates between the 2019 HMP update and the results in the original 2014 HMP. Their differences are due to changes in the HAZUS-MH model and updated building stock and critical facility inventories. For this plan update, the HAZUS-MH 4.0 hurricane model was run for the entire county at the block level and results reported at the municipal level. HAZUS-MH version 4.0 was utilized for this plan update; the hurricane model has been enhanced since the 2014 HMP. Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Burlington County.

Figure 5.4.6-13. Potential New Development and SLOSH Hazard Boundaries