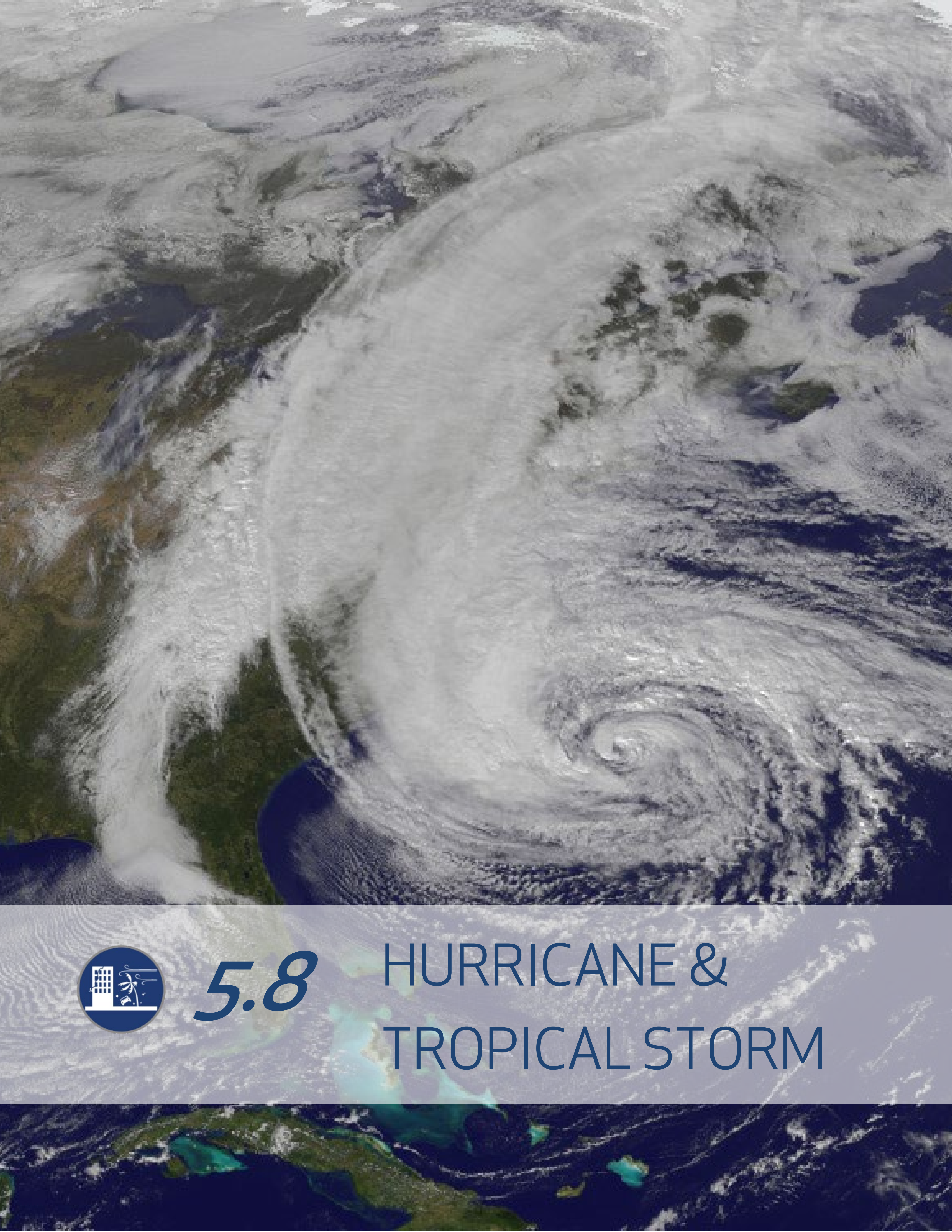


5.8 HURRICANE & TROPICAL STORM

SECTION 5.8 HURRICANE AND TROPICAL STORM

5.8.1 HAZARD DESCRIPTION

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or sub-tropical waters and has a closed low-level circulation. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds (NOAA, 2013). Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development. The average wind speeds for tropical storms and hurricanes are listed below:

- A tropical depression has a maximum sustained wind speeds of 38 miles per hour (mph) or less
- A tropical storm has maximum sustained wind speeds of 39 to 73 mph
- A hurricane has maximum sustained wind speeds of 74 mph or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- A major hurricane has maximum sustained wind speeds of 111 mph or higher (NOAA, 2013).

Over a two-year period, the United States coastline is struck by an average of three hurricanes, one of which is classified as a major hurricane. Hurricanes, tropical storms, and tropical depressions may pose a threat to life and property. These storms bring heavy rain, storm surge and flooding (NOAA, 2013). The cooler waters off the coast of New Jersey can serve to diminish the energy of storms that have traveled up the eastern seaboard. However, historical data show that a number of hurricanes/tropical storms have impacted New Jersey, often as the remnants of a larger storm hitting the Gulf or Atlantic coast hundreds of miles south of New Jersey but maintaining sufficient wind and precipitation to cause substantial damage to the State.

Tropical cyclones affect New Jersey the most during the month of September, though the State has experienced tropical cyclones throughout the hurricane season, excluding November. Because of peak warmth in water temperatures in September, storms usually affect New Jersey during this time (Bucholz and Savadove, 1993). Each element of the hurricane and tropical storm hazard is described below, as the impacts relate to New Jersey:

- Flooding can cause severe damage in New Jersey during tropical cyclones. Flooding and flash floods brought by the torrential rains of a hurricane may be dangerous threats. Rain delivered by a tropical storm can amount to almost nothing to as much as 15 inches in two to three days. Hurricane Diane (1955) caused little damage as it moved onto the continent, but long after its winds subsided, it brought floods to Pennsylvania, New York and New England that killed 200 persons and cost an estimated $700 million in damage. In 1972, Hurricane Agnes fused with another storm system, flooding streams and river basins in the Northeast with more than 1 foot of rain in less than 12 hours, killing 117 people and causing almost $3 billion in damage. In 1999, Hurricane Floyd brought an average of seven inches of rain to New Jersey, with a maximum rainfall total of 14.13 inches in Little Falls. A maximum storm surge of 7.36 feet was reported in Cape May. Overall, Floyd caused $250 million in damages and six deaths in New Jersey. In 2011, Hurricane Irene caused approximately $1 billion in damages and seven deaths in the State. Rainfall totals averages seven inches with a maximum of 9.85 inches in Cranford. In 2012, Superstorm Sandy brought an average of 2.78 inches of rain, with a maximum total of 10.29 inches in Cape May. A maximum wind gust of 78 mph was reported and a storm surge of 8.57 feet in Sandy Hook. Overall, Sandy caused $30 billion in damages and 12 deaths in New Jersey (New Jersey Office of Emergency Management [NJOEM] 2011).
- It is estimated that 90% of deaths and most property damage near the coast during hurricanes are caused by storm surge. Storm surge occurs when coastal waters are pushed toward shore and

held above mean sea level. Depending on storm size, characteristics and distance from the shoreline, the storm can raise the sea level of along 50 or more miles of coastline by 20 or more feet. The higher sea level, along with the wind-enhanced hammering of waves, act as a giant bulldozer sweeping everything in its path. Additionally, still-water damage to inundated structures and facilities is exacerbated by the harmful effects of saltwater. Structures, once salted, will remain more susceptible to moisture, leading to mildewing and corrosion of the structure and all contents that came in contact with the saltwater (NJOEM, 2011).

- High wind speeds occur in a narrow ring usually extending 20 to 30 miles from the wall of the eye of a hurricane. Minor damage begins at approximately 50 miles per hour (mph) and includes broken branches. Moderate damage, such as broken window and loosed shingles begins around 80 mph, and major structural damage and destruction begins at 100 mph. For some structures, wind force alone is sufficient to cause total destruction. Mobile homes with their lack of foundation, light weight, and minimal anchoring make them particularly vulnerable to hurricane winds. Some hurricanes spawn tornadoes that contribute to the damage delivered by hurricanes. Tornadoes are discussed in the thunderstorms and tornadoes section of this report. Winds to the east of the storm track typically cause more damage. New Jersey, typically to the west of the storm track, tends to suffer less damage than Long Island (NJOEM, 2011).

Hurricanes and tropical storms often occur at the same time. Because of this, officials assign short, distinctive names to the storms to avoid confusion among weather stations, coastal bases, and ships at sea. Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Center. Currently, they are maintained and updated by the World Meteorological Organization. The list of names in the table below are used in rotation and recycled every six years. For example, the 2014 list will be used again in 2020. The only time there is a change in the list is if the named storm was so costly or deadly that the future use of it would be inappropriate. If that occurs, the World Meteorological Organization committee will select a new name to replace the one removed from the list. If all the names in a season's list have been used, later storms are named for Greek letters, in alphabetical order. A storm is given a name once its winds reach a speed of 40 mph. In addition to the Atlantic list of names, there are ten other lists corresponding to other storm-prone regions of the world (NOAA 2013c). Table 5.8-1 lists the tropical cyclone names for 2017 through 2022.

Table 5.8-1 Tropical Cyclone Names for the Atlantic

2017	2018	2019	2020	2021	2022
Arlene	Alberto	Andrea	Arthur	Ana	Alex
Bret	Beryl	Barry	Bertha	Bill	Bonnie
Cindy	Chris	Chantal	Cristobal	Claudette	Colin
Don	Debby	Dorian	Dolly	Danny	Danielle
Emily	Ernesto	Erin	Edouard	Erika	Earl
Franklin	Florence	Fernand	Fay	Fred	Fiona
Gert	Gordon	Gabrielle	Gonzalo	Grace	Gaston
Harvey	Helene	Humberto	Hanna	Henri	Hermine
Irma	Isaac	Imelda	Isaias	Ida	Ian
Jose	Joyce	Jerry	Josephine	Joaquin	Julia
Katia	Kirk	Karen	Kyle	Kate	Karl
Lee	Leslie	Lorenzo	Laura	Larry	Lisa
Maria	Michael	Melissa	Marco	Mindy	Matthew
Nate	Nadine	Nestor	Nana	Nicholas	Nicole
Ophelia	Oscar	Olga	Omar	Odette	Otto

2017	2018	2019	2020	2021	2022
Philippe	Patty	Pablo	Paulette	Peter	Paula
Rina	Rafael	Rebekah	Rene	Rose	Richard
Sean	Sara	Sebastien	Sally	Sam	Shary
Tammy	Tony	Tanya	Teddy	Teresa	Tobias
Vince	Valerie	Van	Vicky	Victor	Virginie
Whitney	William	Wendy	Wilfred	Wanda	Walter

Source: NOAA, 2017

Tropical Storm

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as tropical storm versus hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings; a phenomenon called "warm core" storm systems (NOAA, 1999).

The term "tropical" refers both to the geographical origin of these systems, which usually form in tropical regions of the globe, and to their formation in maritime tropical air masses. The term "cyclone" refers to such storms' cyclonic nature, with counterclockwise wind flow in the Northern Hemisphere, and clockwise wind flow in the Southern Hemisphere. The opposite direction of the wind flow is a result of the Coriolis force (National Weather Service [NWS], 2010).

According to NOAA, tropical storms and tropical depressions, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions/storms are usually not the greatest threat; rather, the rains, flooding, and severe weather associated with the tropical storms are what customarily cause more significant problems. Serious power outages can also be associated with these types of events (NOAA, 1999).

According to an article in Science Daily, while tropical storms can produce extremely powerful winds and torrential rain, they are also able to produce high waves, damaging storm surges, and tornadoes. They develop over large bodies of warm water and lose their strength if they move over land because of increased surface friction and loss of the warm ocean as an energy source. This is why coastal regions can receive significant damage from a tropical cyclone, while inland regions are relatively safe from receiving strong winds. Heavy rains, however, can produce significant flooding inland, and storm surges can produce extensive coastal flooding up to 25 miles from the coastline.

As per the United States Naval Observatory, one measure of the size of a tropical cyclone is determined by measuring the distance from its center of circulation to its outermost closed isobar. If the radius is less than two degrees of latitude, or 138 miles, then the cyclone is "very small" or a "midget". A radius between three and six latitude degrees or 207 to 420 miles are considered "average-sized". "Very large" tropical cyclones have a radius of greater than eight degrees or 552 miles.

5.8.1.2 HURRICANE

A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 or more miles an hour. 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.

Because of its northern location on the Atlantic coastline, direct hits by storms of hurricane strength have a relatively low probability of impacting New Jersey, compared to the Southern coastal and Gulf States. It is possible, though rare, for the entire State to be impacted by hurricanes. Wind and surge effects tend to be concentrated in coastal areas of New Jersey, as well as specific riverine regions that may experience storm surge backwater effects.

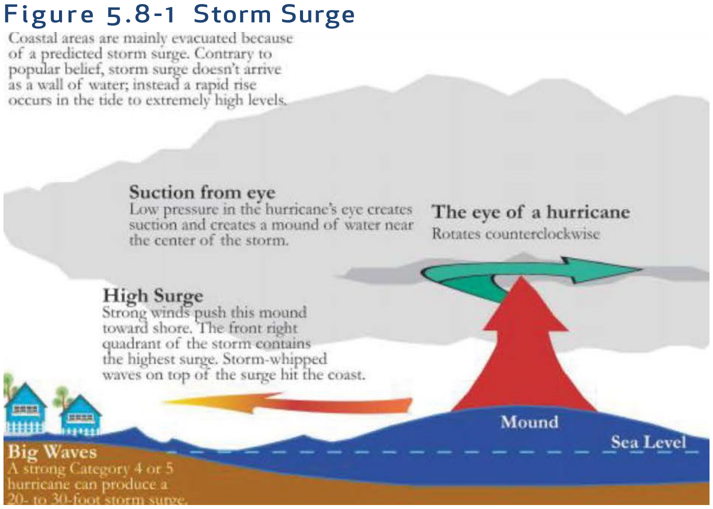
A hurricane is a storm system with sustained winds of greater than 74 mph. Storms of this intensity develop a central eye that is an area of relative calm and the lowest atmospheric pressure. Surrounding the eye is a circulating eye wall and the strongest thunderstorms and winds (NJOEM, 2011).

Storm Surge

Storm surges inundate coastal floodplains by dune over wash, tidal elevation rise in inland bays and harbors, and backwater flooding through coastal river mouths. Strong winds can increase in tide levels and water-surface elevations. Storm systems generate large waves that run up and flood coastal beaches. The combined effects create storm surges that affect the beach, dunes, and adjacent low-lying floodplains. Shallow, offshore depths can cause storm-driven waves and tides to pile up against the shoreline and inside bays.

Based on an area's topography, a storm surge may inundate only a small area (along sections of the northeast or southeast coasts) or storm surge may inundate coastal lands for a mile or more inland from the shoreline. Figure 5.8-1 depicts storm surge.

Figure 5.8-1 Storm Surge



Source: FEMA 2010

5.8.2 LOCATION

New Jersey and its coastal communities are vulnerable to the damaging impacts of major storms along its 127 miles of coastline. New Jersey's coastal zone includes portions of eight counties and 126 municipalities. The coastal boundary of New Jersey encompasses the Coastal Area Facility Review Act (CAFRA) area and the New Jersey Meadowlands District. The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area. Figure 5.8-2 shows New Jersey and the highlighted coastal zone area.

Figure 5.8-2 New Jersey Coastal Zone Area

Source: New Jersey Department of Environmental Protection, 2012

In addition to the coastal zone, the entire State may be vulnerable to hurricanes and tropical storms, depending on the storm's track. The coastal areas are more susceptible to damage caused by the combination of both high winds and tidal surge. Inland areas, especially those in floodplains, are also at risk for flooding because of heavy rain and winds. The majority of damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent 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 2011 (latest date available from data source). Figure 5.8-3 displays tropical cyclone tracks for New Jersey; however, the associated names for some of these events are unknown. Between 1856 and 2011, New Jersey has experienced in excess of 70 tropical cyclone events. These events tracked within 65 nautical miles of the State.

Figure 5.8-3 Historical Tropical Storm and Hurricane Tracks 1856 – 2013

Source: NOAA, 2013

As noted, inundation from storm surge has devastating impacts on the State's coastal communities. The United States Army Corps of Engineers (USACE), in cooperation with FEMA, initially prepared Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation maps. SLOSH maps represent potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. It does not include riverine flooding caused by hurricane surge or inland freshwater flooding. The mapping was developed for the coastal communities in New Jersey using the computer model to forecast surges that occur from wind and pressure forces of hurricanes coastline topography. In New Jersey, hurricane category is the predominant factor in worst-case hurricane surges. The resulting inundation areas are grouped into Category 1 and 2 (dangerous), Category 3 (devastating), and Category 4 (catastrophic) classifications. The hurricane category refers to the Saffir/Simpson Hurricane Intensity Scale, summarized below.

5.8.3 EXTENT

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). Table 5.8-2 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Table 5.8-2 The Saffir-Simpson Scale

Category	Wind Speed (mph)	Expected Damage
1	74-95 mph	Very dangerous winds will produce some damage: Homes with well-constructed frames could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Homes with well-constructed frames could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph	Devastating damage will occur: Homes with well-built frames may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	Catastrophic damage will occur: Homes with well-built frames can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	>157 mph	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA, 2013

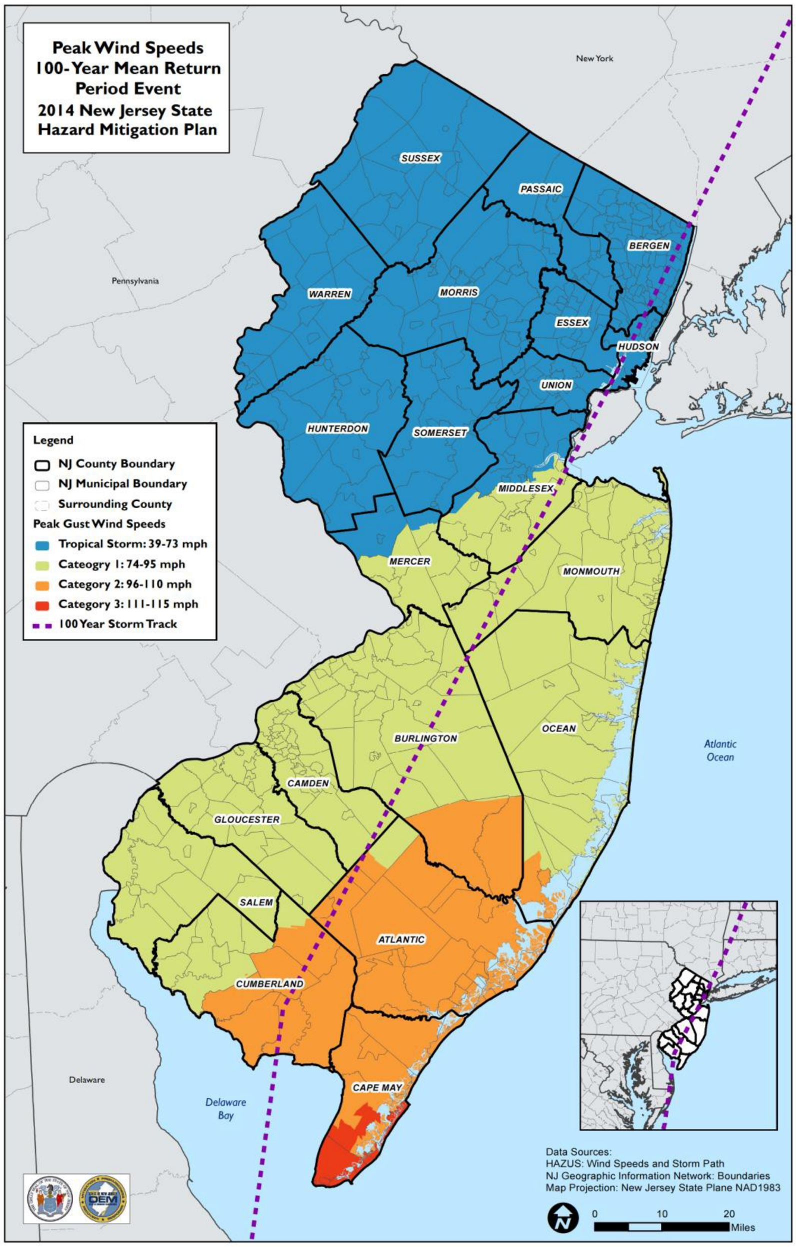
Storm Surge

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance (Dinicola 2009).

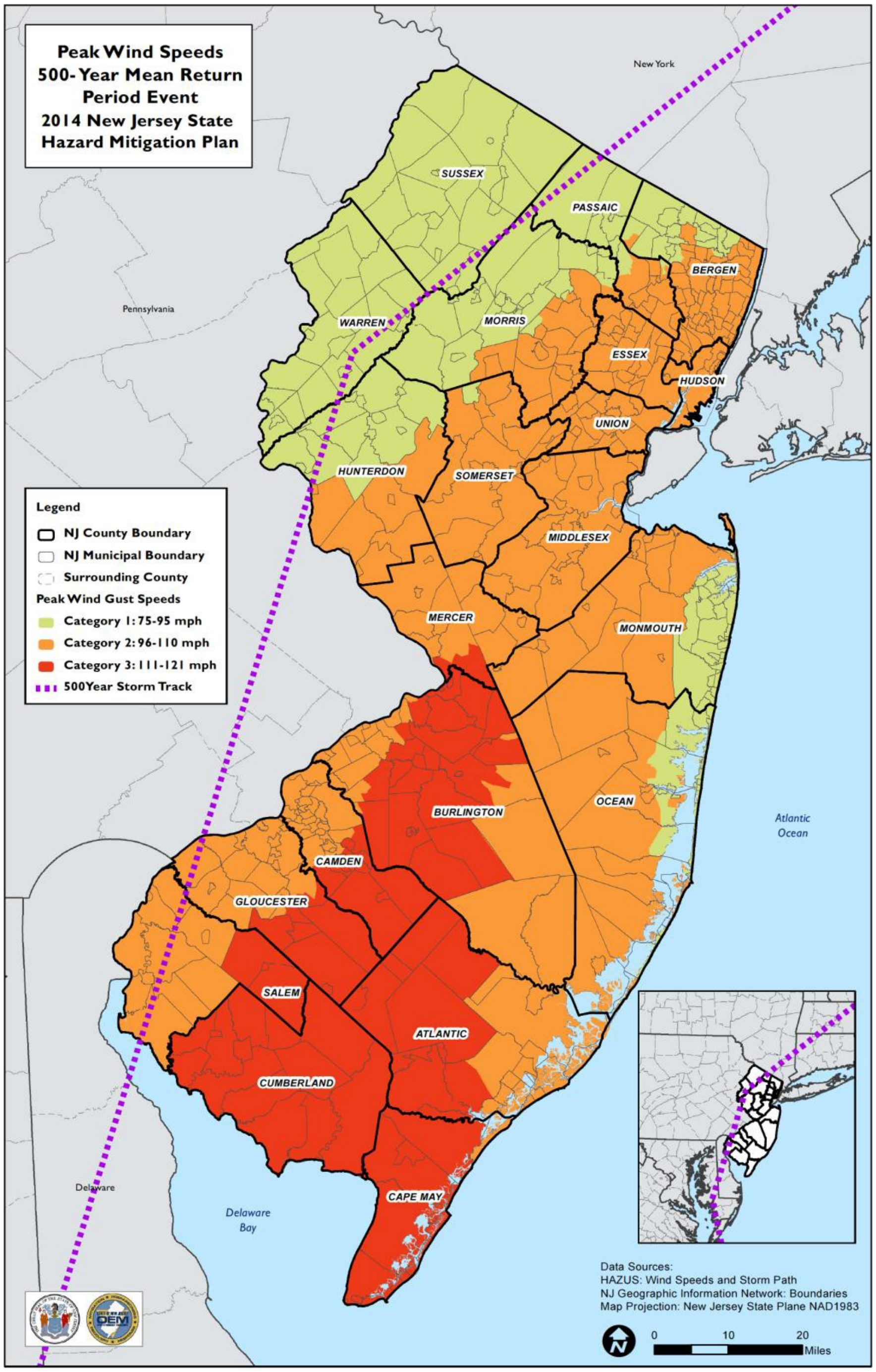
Figure 5.8-4 and Figure 5.8-5 show the estimated maximum three-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using Hazards U.S. Multi-Hazard (HAZUS-MH) model runs. The estimated hurricane track used for the 100- and 500-year event is also shown. The maximum three-second gust wind speeds for the State range from Tropical Storm to Category 3 hurricane speeds for the 100-year MRP event. The maximum three-second gust wind speeds for the State range from Category 1 to Category 3 hurricane speeds for the 500-year MRP event. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment presented in Section 5.8.2.

Figure 5.8-4 Wind Speeds for the 100-Year Mean Return Period Event



Note: Map from 2014 plan used as placeholder

Figure 5.8-5 Wind Speeds for the 500-Year Mean Return Period Event



Note: Map from 2014 plan used as placeholder

Storm Surge

Typically, storm surge is estimated by subtracting the regular/astrological tide level from the observed storm tide. Typical storm surge heights range from several feet to more than 25 feet. The exact height of the storm surge and which coastal areas will be flooded depends on many factors: strength, intensity, and speed of the hurricane or storm; the direction it is moving relative to the shoreline; how rapidly the sea floor is sloping along the shore; the shape of the shoreline; and the astronomical tide. Storm surge is the most damaging when it occurs along a shallow sloped shoreline, during high tide, in a highly populated, and developed area with little or no natural buffers (for example, barrier islands, coral reefs, and coastal vegetation).

The most common reference to a return period for storm surges has been the elevation of the coastal flood having a one-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood. Detailed hydraulic analyses include establishing the relationship of tide levels with wave heights and wave run-up. The storm surge inundation limits for the one-percent annual chance coastal flood event are a function of the combined influence of the water surface elevation rise and accompanying wave heights and wave run-up along the coastline.

The risk of storm surge elevations higher than seven feet exists along certain coastal segments of Oregon, Washington, and Alaska; and in every coastal state from Texas to New Jersey. A storm surge associated with storms of longer recurrence intervals may result in more storm surge flooding, higher water levels, larger waves, and an increased likelihood of dune overwash, wave damage, and possible breaching of barrier islands.

5.8.4 PREVIOUS OCCURRENCES AND LOSSES

Hurricane/tropical storm and coastal/storm surge events that occurred in New Jersey between 1950 and 2017 are detailed in Table 5.8.3. Table 5.8-3 includes events discussed in the 2014 Plan, events provided by the Office of the New Jersey State Climatologist (ONJSC), and new events that occurred between 2012 and 2017. With documentation for New Jersey being so extensive, not all sources have been identified or researched. Therefore, Table 5.8-3 may not include all events that have occurred throughout the State. Highlighted in detail below are losses associated with Superstorm Sandy – one of the worst storms to have ever hit New Jersey or the nation in recent history.

5.8.4.1 SUPERSTORM SANDY

The effects of Superstorm Sandy on New Jersey in 2012 were severe, with economic losses to businesses of up to $30 billion. Superstorm Sandy, the most intense storm of the 2012 Atlantic hurricane season, formed in the Caribbean Sea north of Panama on October 22, 2012. The strengthening hurricane moved northwards, severely impacting areas of and around the Greater Antilles. As it curved towards the New England region, the hurricane degenerated into an extra-tropical cyclone and shortly afterwards the massive storm made landfall in New Jersey on October 29.

Over two million households in the state lost power in the storm, 346,000 homes were damaged or destroyed, and 37 people were killed. Storm surge and flooding affected a large swath of the state. Governor Chris Christie said the losses caused by Sandy were, "going to be almost incalculable...The devastation on the Jersey Shore is probably going to be the worst we've ever seen." While moving ashore at Atlantic City, Sandy dropped heavy rainfall that reached 11.62 inches in Wildwood Crest. Its landfall was accompanied by high winds, and the highest recorded wind gust in the state was 90 mph at a station just across the border from Staten Island, New York.

Damages

As Governor Christie predicted, the Jersey Shore suffered the most severe winds and surf from Superstorm Sandy and the most damage from the storm. Mantoloking was especially hard hit, suffering severe "wash over" including the creation of two new, temporary inlets. Approximately two dozen oceanfront houses in Mantoloking were completely removed from their foundations and destroyed. The Belmar boardwalk was destroyed, along with Perth Amboy's marina and waterfront. Much of the Casino Pier in Seaside Heights and nearby Funtown Pier in Seaside Park collapsed into the ocean due to intense waves. Most of the rides in these amusement parks were destroyed, including roller coasters.

The seaside communities on Long Beach Island were among the hardest-hit as well. Scores of homes and businesses were destroyed, and the storm surge deposited up to four feet of sand on island streets, making them impassable. Governor Christie issued a mandatory evacuation on October 28th, and residents and business owners were prohibited from returning until November 10th. While no fatalities recorded on Long Beach Island, preliminary damage estimates suggest between $750 million and $1 billion in damages occurred on the island alone.

By November 12th, homeowners of Ortley Beach still had not been allowed onto the Barrier Island to check on their properties. Ortley Beach was declared "Ground Zero" because of the unbelievable amount of devastation.

Superstorm Sandy created an insurmountable amount of riverine flooding. New Jersey's communities along the west side of the Hudson River (an area dubbed the Gold Coast by real estate marketers), were flooded by the storm surge through New York Bay and into the Hudson River. There were massive power outages in

Bayonne, Jersey City, Hoboken, Weehawken, North Bergen, and Edgewater, forcing the evacuation of patients from Palisades Medical Center.

Half of Jersey City lost power, while large sections of the city's downtown, including City Hall and the Jersey City Medical Center, flooded and had to be evacuated. As high tide approached the Hudson River and overflowed the wall at Exchange Place. Around the same time, Liberty Harbor spilled into the southern part of Marin Boulevard. Both breaches caused water to rush down Columbus Drive and Marin Boulevard where they met near the Historic Downtown. From there, the flood spread throughout the low-lying areas of Jersey City.

Half the city of Hoboken was flooded, and the city government evacuated two of its fire stations. Hoboken's mayor asked for National Guard help. By late night October 30th, an estimated 20,000 people were stranded in Hoboken, surrounded by water. The New Jersey National Guard was deployed and began assisting in rescues on October 31st. Additionally, Weehawken fared no better. The downtown neighborhood known as the Shades incurred terrible damage, with nearly every resident forced to temporarily relocate.

In the early morning of October 30th, authorities in Bergen County, New Jersey, were evacuating residents after a berm overflowed and flooded several communities. Chief of Staff for the Bergen County Executive, said there were up to five feet of water in the streets of Moonachie and Little Ferry. Also, Sayreville, a community along the Raritan River, faced rising flood waters from the storm surge entering Raritan Bay, which forced the evacuation and rescue of dozens of residents by the Sayreville water rescue team. The Oyster Creek Nuclear Generating Station in Lacey Township was placed on alert when storm waters around the plant rose six feet above normal.

Fires that had destroyed about 14 homes on October 29th in Mantoloking restarted in the early morning of October 31st, possibly fueled by natural gas. In Morristown, sustained winds peaked at 40 mph with gusts to 68 mph. Other peaks gusts included 88 mph in Montclair, 80 mph in Clifton, 78 mph in Newark, 74 mph in Point Pleasant, and 61 mph in Basking Ridge. Gusts along Long Beach Island peaked between 75-90 mph. Many buildings and homes were damaged especially to siding and roof surfaces and hundreds of trees were downed across the state.

Energy
Governor Christie said on the morning of October 30th, that some 2.4 million households in the state were without power. No timetable was given on the restoration of power to these customers, although some estimates mentioned a week would be needed before a full damage assessment could be made.

On November 2th, 1.6 million customers were still without power, down from 2.7 million. Unfortunately, by November 3rd, 31% of homes and businesses in the state did not have electricity.

On the morning of November 5th, reported customers in the state without electricity were:

- Jersey Central Power & Light: 382,000

- Public Service Electric & Gas: 375,000
- Atlantic City Electric: 606
- Rockland Electric Company: 19,224

On the morning of November 6th, more than 582,000 homes and businesses in the state still did not have power:

- Public Service Electric & Gas: 310,000 remain without service
- Jersey Central Power & Light: 257,884 outages, mainly in Monmouth and Morris counties
- Orange & Rockland: 13,913 remain without service
- Atlantic City Electric: 227, mostly in Atlantic County

On the morning of November 7th, winds from a nor'easter delayed restoration of electricity. Federal safety rules prevent line crews working in bucket trucks when winds are greater than 40 mph. About 396,000 homes and businesses remained without service.

- Public Service Electric & Gas: 190,400 remain without service.
- Jersey Central Power & Light: 190,278 remain without service mainly in Monmouth and Morris counties
- Orange & Rockland: 10,744 remain without service.
- Atlantic City Electric: 4,488 remain without service.

At approximately, 6 a.m. EST on November 9th, about 265,000 homes and businesses were without power in the state because of Sandy and the subsequent nor'easter.

In the aftermath of the storm, many gas stations were closed, and people lined up for hours to get gasoline. According to the American Automobile Association, on November 2th, about 60% of the gas stations in New Jersey were closed. On the night of November 2th, Governor Christie took action to prevent a fuel shortage and ease the problem of extended wait times and lines at gas stations by signing Executive Order 108, declaring a limited state of energy emergency with regard to the supply of motor fuel and implementing odd-even rationing for gasoline purchases in 12 New Jersey counties. Odd-even fuel sales took effect in the following counties at noon on November 3rd: Bergen, Essex, Hudson, Hunterdon, Middlesex, Morris, Monmouth, Passaic, Somerset, Sussex, Union, and Warren counties. This ended at 6 a.m. EST on November 13th.

Table 5.8-3 Past Occurrences of Tropical Storms and Hurricanes in New Jersey 1950 - 2017

Date(s) of Event	Event Type	Counties Affected	Description
September 11-12, 1950	Hurricane Dog	Statewide	Average rainfall amounts were 1.07 inches. Maximum rainfall total was 4.34 inches at the Canton station.
August 20-21, 1950	Hurricane Able	Statewide	Average rainfall amounts were 1.29 inches. Maximum rainfall total was 3.5 inches at the Freehold Marlboro (Monmouth County) station.
August 31-September 1, 1952	Hurricane Able	Statewide	Average rainfall amounts were 2.42 inches. Maximum rainfall total was 5.64 inches at the Oak Ridge Reservoir (Morris County) station.
2/4/1952	Tropical Storm	Statewide	Average rainfall amounts were 1.13 inches. Maximum rainfall total was 1.99 inches at the Vineland station.
August 14-15, 1953	Hurricane Barbara	Statewide	Average rainfall amounts were 1.23 inches. Maximum rainfall total was 5.98 inches at the Tuckerton (Ocean County) station.

Date(s) of Event	Event Type	Counties Affected	Description
October 15-16, 1954	Hurricane Hazel	Statewide	Average rainfall amounts were 0.35 inch. Maximum rainfall total was 1.24 inches at the Pleasantville station.
September 10-11, 1954	Hurricane Edna	Statewide	Average rainfall amounts were 3.55 inches. Maximum rainfall total was 6.38 inches at the Lakehurst station.
August 30-31, 1954	Hurricane Carol	Statewide	Average rainfall amounts were 2.61 inches. Maximum rainfall total was 5.25 inches at the Midland Park (Bergen County) station.
September 19-20, 1955	Hurricane Ione	Statewide	Average rainfall amounts were 0.65 inch. Maximum rainfall total was 4.17 inches at the Berlin station.
August 17-19, 1955	Hurricane Diane	Statewide	Average rainfall amounts were 2.91 inches. Maximum rainfall total was 8.1 inches at the Sussex (Sussex County) station.
August 12-13, 1955	Hurricane Connie	Statewide	Average rainfall amounts were 6.28 inches. Maximum rainfall total was 10.89 inches at the Canistear Reservoir (Sussex County) station.
September 27-28, 1956	Hurricane Flossy	Statewide	Average rainfall amounts were 0.47 inch. Maximum rainfall total was 3.41 inches at the Shiloh station.
August 28-29, 1958	Hurricane Daisy	Statewide	Average rainfall amounts were 0.06 inch. Maximum rainfall total was 0.4 inch at the Belmar/Bass River State Forest station.
September 27-28, 1958	Hurricane Helene	Statewide	Average rainfall amounts were 1.68 inches. Maximum rainfall total was 3.41 inches at the Shiloh station.
September 30-October 1, 1959	Hurricane Gracie	Statewide	Average rainfall amounts were 0.99 inch. Maximum rainfall total was 2.87 inches at the Oak Ridge Reservoir (Morris County) station.
July 10-11, 1959	Hurricane Cindy	Statewide	Average rainfall amounts were 0.9 inch. Maximum rainfall total was 8.43 inches at the Belleplain SF (Cape May County) station.
9/12/1960	Hurricane Donna	Statewide	Average rainfall amounts were 4.91 inches. Maximum rainfall total was 8.99 inches at the Hammonton (Atlantic County) station. Maximum wind gust of 100 mph was observed in Wildwood (Cape May County). Maximum storm surge of seven feet was reported in Long Branch (Monmouth County). Tides were 5.7 feet above normal. Considerable damage to piers and beach front homes. Hurricane Donna caused three fatalities and $6.9 million in damages in New Jersey.
July 29-30, 1960	Hurricane Brenda	Statewide	Average rainfall amounts were 3.65 inches. Maximum rainfall total was 6.27 inches at the Cedar Grove station.
September 20-21 and 25, 1961	Hurricane Esther	Statewide	Average rainfall amounts were 1.62 inches. Maximum rainfall total was 5.6 inches at the Tuckerton (Ocean County) station. Maximum wind gust of 68 mph was observed in Atlantic City (Atlantic County). High surf and rip tides were also reported.
August 28-29, 1962	Hurricane Alma	Statewide	Average rainfall amounts were 2.14 inches. Maximum rainfall total was 4.85 inches at the Pemberton (Burlington County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were reported.
October 16-18, 1964	Hurricane Isabell	Statewide	Average rainfall amounts were 0.72 inch. Maximum rainfall total was 2.01 inches at the Belleplain SF (Cape May County) station. Maximum wind gusts were below 20 mph.

Date(s) of Event	Event Type	Counties Affected	Description
September 13-14, 1964	Hurricane Dora	Statewide	Average rainfall amounts were 0.44 inch. Maximum rainfall total was 2.9 inches at Hightstown station. Maximum wind gusts were below 20 mph. High surf and rip tides were reported.
June 12-13, 1966	Hurricane Alma	Statewide	Average rainfall amounts were 0.18 inch. Maximum rainfall total was 0.91 inch at the Bass River State Forest station. Maximum wind gusts of 26 mph in Atlantic City (Atlantic County). Maximum storm surge of 4.5 feet was reported in Atlantic City (Atlantic County).
September 15-17, 1967	Hurricane Doria	Statewide	The average rainfall for this event was 0.26 inch, with a maximum of 0.94 inch at the Lakehurst station. A maximum wind gust of 39 mph in Atlantic City (Atlantic County). High surf and rip tides were associated with this storm. Three boaters drown on their way to Boston as a result of this event.
August 19-21, 1969	Hurricane Camille	Statewide	The average rainfall for this event was 0.19 inch, with a maximum of 1.25 inches at the Fortescue (Cumberland County) station. Maximum wind gusts were below 20 mph.
September 8-9, 1969	Hurricane Gerda	Statewide	The average rainfall for this event was 0.58 inch, with a maximum total of 1.78 inches at the Fortescue (Cumberland County) station. Maximum wind gusts were below 20 mph.
August 27-29, 1971	Hurricane Doria	Statewide	The average rainfall for this event was 7.09 inches, with a maximum total of 10.29 inches at the Little Falls (Passaic County) station. A maximum wind gust of 54 mph was reported at Atlantic City (Atlantic County). A maximum storm surge of 5.3 feet was also reported at Atlantic City (Atlantic County). Total damages in New Jersey were estimated at $772 M. Three deaths were attributed to this event.
October 2-4, 1971	Hurricane Ginger	Statewide	The average rainfall for this event was 0.23 inch, with a maximum total of 1.64 inches at the Sea Brooks Farms (Cumberland County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this storm.
June 21-25, 1972	Hurricane Agnes	Statewide	The average rainfall for this event was 3.4 inches, with a maximum total of 6.44 inches at the Canton station. Maximum wind gusts were below 20 mph. Total damages in New Jersey were estimated at $15 M. One death was attributed to this storm.
September 3-4, 1972	Hurricane Carrie	Statewide	The average rainfall for this event was 0.28 inch, with a maximum total of 1.73 inches at the Cape May (Cape May County) station. Maximum wind gusts were below 20 mph.
September 24-28, 1975	Hurricane Eloise	Statewide	The average rainfall for this event was 5.45 inches, with a maximum total of 8.94 inches at the Hightstown (Mercer County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event.
June 30-31, 1975	Hurricane Amy	Statewide	The average rainfall for this event was 0.08 inch, with a maximum total of 0.63 inch at the Morris Plains (Morris County) station. Maximum wind gusts were below 20 mph.
October 27-28, 1975	Hurricane Hallie	Statewide	The average rainfall for this event was 0.02 inch, with a maximum of 0.3 inch at the Fortescue station. Maximum wind gusts were below 20 mph.

Date(s) of Event	Event Type	Counties Affected	Description
August 9-10, 1976	Hurricane Belle	Statewide	The average rainfall for this event was 2.66 inches, with a maximum of 5 inches at the Mays Landing (Atlantic County) station. A maximum wind gust of 90 mph was reported at Ship Bottom. A maximum storm surge of 8.85 feet was reported in Atlantic City (Atlantic County). New Jersey had approximately $50 million in damages from this event.
September 16-18, 1976	Tropical Depression #8	Statewide	The average rainfall for this event was 1.32 inches, with a maximum of 3.44 inches at the Oak Ridge Reservoir (Morris County) station. Maximum wind gusts were below 20 mph.
September 7-8, 1977	Hurricane Clara	Statewide	The average rainfall for this event was 0.11 inch, with a maximum total of 1.03 inches at the Jersey City (Hudson County) station. Maximum wind gusts were below 20 mph.
September 10-11, 1977	Hurricane Babe	Statewide	The average rainfall for this event was 0.04 inch, with a maximum total of 1.22 inches at the Hammonton (Atlantic County) station. Maximum wind gusts were below 20 mph.
July 15-16, 1979	Hurricane Bob	Statewide	The average rainfall for this event was 0.26 inch, with a maximum total of 1.92 inches at the Hightstown (Atlantic County) station. Maximum wind gusts were below 20 mph.
July 29-30, 1979	Hurricane Claudette	Statewide	The average rainfall for this event was 0.37 inch, with a maximum of 2.05 inches at the Princeton Water Work station. Maximum wind gusts were below 20 mph.
September 14-16, 1979	Hurricane Frederic	Statewide	The average rainfall for this event was 0.47 inch, with a maximum of 1.25 inches at the High Point Park (Sussex County) station. Maximum wind gusts were below 20 mph.
September 6-8, 1979	Hurricane David	Statewide	The average rainfall for this event was 2.94 inches, with a maximum of 5.83 inches at the Ringwood (Passaic County) station. A maximum wind gust of 54 mph was reported in Trenton (Mercer County). High surf and rip tides were associated with this storm. This event caused a tornado outbreak in New Jersey.
November 15-17, 1981	Tropical Depression #12	Statewide	The average rainfall for this event was 0.48 inch, with a maximum of 1.35 inches at the Cape May (Cape May County) station. Maximum wind gusts were below 20 mph.
June 19-20, 1982	Tropical Storm #2	Statewide	The average rainfall for this event was 0.02 inch, with a maximum of 0.27 inch at the Atlantic City (Atlantic County) station. Maximum wind gusts were below 20 mph.
September 30-October 2, 1983	Hurricane Dean	Statewide	The average rainfall for this event was 1.25 inches, with a maximum of 2.35 inches at the Newark (Essex County) station. Maximum wind gusts were below 20 mph.
July 26-27, 1985	Hurricane Bob	Statewide	The average rainfall for this event was 1.92 inches, with a maximum of 3.52 inches at the Canistear
			Reservoir (Sussex County) station. Maximum wind gusts were below 20 mph.
August 19-20, 1985	Hurricane Danny	Statewide	The average rainfall for this event was 0.2 inch, with a maximum of 2.32 inches at the Cape May (Cape May County) station. Maximum wind gusts were below 20 mph.
September 23-25, 1985	Hurricane Henri	Statewide	The average rainfall for this event was 0.51 inch, with a maximum of 2.27 inches at the Belvidere (Warren County) station. Maximum wind gusts were below 20 mph.

Date(s) of Event	Event Type	Counties Affected	Description
September 27-28, 1985	Hurricane Gloria	Statewide	The average rainfall for this event was 3.69 inches, with a maximum of six inches at the Charlotteburg Reservoir (Passaic County) station. A maximum wind gust of 45 mph was reported at Ocean City (Cape May County). A maximum storm surge of 1.4 feet was reported at Ventor City Pier. Gloria paralleled the coast of New Jersey, downing trees and leaving 230,000 people without power. Approximately 100,000 coastal residents were evacuated. New Jersey had approximately $14.7 million in damages from this event.
June 8-9, 1986	Hurricane Andrew	Statewide	The average rainfall for this event was 0.14 inch, with a maximum of 0.6 inch at the Pottersville (Morris County) station. Maximum wind gusts were below 20 mph.
August 18-19, 1986	Hurricane Charley	Statewide	The average rainfall for this event was 0.89 inch, with a maximum of 3.32 inches at the Split Rock Pond station. A maximum wind gust of 54 mph was reported in Atlantic City (Atlantic County). A maximum storm surge of 1.65 feet was reported at Atlantic City (Atlantic County). Two deaths were attributed to this event.
August 7-8, 1988	Hurricane Alberto	Statewide	The average rainfall for this event was 0 inch, with a maximum total of 0.7 inch at the High Point Park (Sussex County) station. Maximum wind gusts were below 20 mph.
August 29-30, 1988	Hurricane Chris	Statewide	The average rainfall for this event was 0.88 inch, with a maximum total of 2.19 inches at the High Point Park (Sussex County) station. Maximum wind gusts were below 20 mph.
September 22-24, 1989	Hurricane Hugo	Statewide	The average rainfall for this event was 0.43 inch, with a maximum total of 2.83 inches at the Belleplain SF (Cape May County) station. Maximum wind gusts were below 20 mph.
October 14-15, 1990	Hurricane Lili	Statewide	The average rainfall for this event was 0.55 inch, with a maximum total of 2.28 inches at the Canoe Brook (Essex County) station. Maximum wind gusts were below 20 mph.
August 18-19, 1991	Hurricane Bob	Statewide	The average rainfall for this event was 1.25 inches, with a maximum total of 3.16 inches at the Millville (Cumberland County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event.
September 26-27, 1992	Hurricane Danielle	Statewide	The average rainfall for this event was 0.91 inch, with a maximum total of 2.83 inches at the Belleplain SF (Cape May County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event. Two boaters drown from this storm.
September 1-2, 1993	Hurricane Emily	Statewide	The average rainfall for this event was 0.03 inch, with a maximum total of 0.26 inch at the Atlantic City International Airport (Atlantic County) station. Maximum wind gusts were below 20 mph.
August 17-19, 1994	Hurricane Beryl	Statewide	The average rainfall for this event was 1.09 inches, with a maximum total of 3.82 inches at the Sussex (Sussex County) station. Maximum wind gusts were below 20 mph.
November 17-19, 1994	Hurricane Gordon	Statewide	The average rainfall for this event was 0.2 inch, with a maximum total of 1.07 inches at the Cape May (Cape May County) station. Maximum wind gusts were below 20 mph.

Date(s) of Event	Event Type	Counties Affected	Description
June 7-8, 1995	Hurricane Allison	Statewide	The average rainfall for this event was 0.21 inch, with a maximum total of 2.04 inches at the Millville (Cumberland County) station. Maximum wind gusts were below 20 mph.
August 6-8, 1995	Hurricane Erin	Statewide	The average rainfall for this event was 0.79 inch, with a maximum total of one inch at the Belleplain SF (Cape May County) station. Maximum wind gusts were below 20 mph.
October 5-7, 1995	Hurricane Opal	Statewide	The average rainfall for this event was 2.36 inches, with a maximum total of 4.92 inches at the Sussex (Sussex County) station. Maximum wind gusts were below 20 mph.
June 20-22, 1996	Hurricane Arthur	Statewide	The average rainfall for this event was 0.54 inch, with a maximum total of 2.3 inches at the Mays Landing (Atlantic County) station. Maximum wind gusts were below 20 mph.
July 13-15, 1996	Hurricane Bertha	Statewide	Bertha was an unusually long-lasting and strong supercell. The average rainfall for this event was 2.94 inches, with a maximum total of 6.59 inches at the Estell Manor (Atlantic County) station. A maximum wind gust of 55 mph was reported at Harvey Cedars. A maximum storm surge of 2.27 feet was reported at Atlantic City (Atlantic County). One death was reported in New Jersey because of Bertha.
August 31-September 2, 1996	Hurricane Edouard	Statewide	The average rainfall for this event was zero inches, with a maximum total of 0.07 inch at the Sussex (Sussex County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event. There were two deaths in New Jersey because of Edouard.
September 7-9, 1996	Hurricane Fran	Statewide	The average rainfall for this event was 1.1 inches, with a maximum total of 2.72 inches at the Lambertville (Hunterdon County) station. Maximum wind gusts were below 20 mph.
October 9-10, 1996	Hurricane Josephine	Statewide	The average rainfall for this event was 1.69 inches, with a maximum total of three inches at the Canistear Reservoir (Sussex County) station. A maximum wind gust of 70 mph was reported at Atlantic City (Atlantic County).
July 24-26, 1997	Hurricane Danny	Statewide	The average rainfall for this event was 3.32 inches, with a maximum total of 7.76 inches at the Cranford (Union County) station. Maximum wind gusts were below 20 mph.
August 28-29, 1998	Hurricane Earl	Statewide	The average rainfall for this event was zero inches with a maximum total of 0.02 inch at the Moorestown (Burlington County) station. Maximum wind gusts were below 20 mph.
9/5/1998	Hurricane Bonnie	Statewide	The average rainfall for this event was 0.08 inch, with a maximum total of 0.92 inch at the Estell Manor (Atlantic County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event.
September 5-9, 1999	Hurricane Dennis	Statewide	The average rainfall was 1.22 inches for this event. Maximum rainfall totaled 5.59 inches at the Greenwood Lake (Passaic County) station. Maximum wind gusts were less than 20 mph. High surf and rip tides were also reported from this storm.

Date(s) of Event	Event Type	Counties Affected	Description
September 16-17, 1999	Hurricane Floyd	Somerset	The Raritan River basin experienced record flooding as a result of Floyd's heavy rains, 4.5 feet higher than the previous record flood crest. Bound Brook, New Jersey, was especially hard hit by a record flooding event: a 42-foot flood crest, 14 feet above flood stage, sent 12 feet of water on Main Street, and drowned three people. Manville, New Jersey was hit nearly as hard, with record-breaking floods coming from the Raritan River and the nearby Millstone River, which join in Manville. Princeton University in Princeton, New Jersey, for several days declared municipal tap water unsafe to drink, advised students in dorms not to shower, and provided bottled drinking water. Overall, average rainfall totals for Hurricane Floyd was 7.05 inches with maximum rainfall total of 14.13 inches reported in Little Falls. Maximum storm surge was 7.36 feet in Cape May. New Jersey had $250 million in damages and six deaths from this event.
October 18-19, 1999	Hurricane Irene	Statewide	The average rainfall total was 0.39 inch for this event, with a maximum total of 2.5 inches at the Brant Beach Haven station. Maximum wind gusts were below 20 mph.
September 19-20, 2000	Hurricane Gordon	Mercer	Hurricane Gordon caused heavy precipitation in west central and southwest New Jersey, causing poor drainage flooding in low-lying areas. The heaviest rain fell in Mercer County and caused some minor flooding along the Assunpink Creek. Roadway flooding along U.S. Route 130 was reported in Collingswood.
June 15-19, 2001	Hurricane Allison	Statewide	The average rainfall total was 2.38 inches for this event, with a maximum total of 4.62 inches at the Canoe Brook station. Another source indicated 4.86 inches of rain fell in Howell. A maximum wind gust of 36 mph was reported in Atlantic City (Atlantic County).
September 10-12, 2002	Hurricane Gustav	Statewide	The maximum rainfall total of 0.08 inch was recorded at the New Milford station. A maximum wind gust of 60 mph was reported in Keansburg.
10/12/2002	Hurricane Kyle	Statewide	The average rainfall total for this event was 1.72 inches, with a maximum total of 4.71 inches at the Rahway station. Maximum wind gusts were below 20 mph.
9/13/2003	Tropical Storm Henri	Statewide	Caused up to three inches of rain across the State.
September 18-19, 2003	Tropical Storm Isabel	Atlantic, Cape May, Warren	Tropical Storm Isabel produced strong power outage producing winds, moderate tidal flooding along the Delaware Bay and the Delaware River and erosion and rough surf along the shore. Two deaths were directly attributed to the storm. In Warren County, a 34-year-old woman died in Independence Township when a tree landed and crushed the vehicle in which she was riding. In Cape May County, a 51-year-old man drowned in the rough surf off of Wildwood Crest. Winds gusted up to 62 mph in New Jersey and downed countless numbers of trees, tree limbs and power lines. It was one of the worst power outages on record for area utilities. Jersey Central Power and Light reported that 220,000 of its customers lost power while

Date(s) of Event	Event Type	Counties Affected	Description
			Conectiv Energy reported about 162,000 of its customers lost power. While tide heights along the ocean side only reached minor levels, wave action caused considerable beach erosion, especially in Cape May and Atlantic Counties. Overall, average rainfall totals for Hurricane Isabel was 0.93 inch and the maximum rainfall of 2.46 was reported at the Ringwood (Passaic County) station. A maximum wind gust of 62 mph was reported at Ship John Shoal. Maximum storm surge of 10.6 feet was recorded in Burlington. Strong waves eroded beaches along the coast. New Jersey had $25 million in damages and one fatality as a result from this Event
August 3-4, 2004	Hurricane Alex	Statewide	Average rainfall totals were 0.09 inch and the maximum rainfall total of 1.89 inches at the West Deptford station. Maximum wind gusts were below 20 mph.
August 14-16, 2004	Hurricane Charley	Statewide	Average rainfall totals were 0.1.26 inches and the maximum rainfall of 3.49 inches was reported at the Ringwood station. Maximum wind gusts were below 20 mph.
August 30-31, 2004	Hurricanes Gaston and Hermin	Statewide	Average rainfall totals were 0.48 inch and the maximum rainfall of 4.06 inches was reported at the Indian Mills station. Maximum wind gusts were below 20 mph.
9/8/2004	Hurricane Francis	Northern New Jersey	Extra-tropical storm dropped around three inches of rain in northern New Jersey.
9/17/2004	Hurricane Ivan	Essex	Dropped 5.5 inches of rain in Maplewood.
9/28/2004	Hurricane Jeanine	Statewide	Passed to the south of the State as an extra-tropical storm, causing up to five inches of rainfall across New Jersey.
August 11-16, 2005	Hurricane Irene	Southeast New Jersey	Passed to the southeast of the State, causing rip currents and strong waves. In Point Pleasant Beach, New Jersey, lifeguards made 150 rescues in a three-day period. Many beaches banned swimming because of the threat.
September 7-8, 2005	Hurricanes Maria and Nate	Statewide	Rip currents from storms killed one and seriously injured another.
October 24-25, 2005	Hurricane Wilma	Statewide	Wilma brought an average rainfall of 1.2 inches, with a maximum rainfall total of 2.66 inches in Atlantic City (Atlantic County). Wind gusts were below 20 mph.
9/3/2006	Tropical Storm Ernesto	Atlantic, Cape May	The interaction between the remnants of the storm and a strong high-pressure system produced intense wind gusts of up to 81 mph in Strathmere (Cape May County). The storm also dropped heavy rainfall, totaling to a maximum of 4.92 inches in Margate. The winds and rain down trees and power lines, resulting in power outages. Overall, Ernesto brought an average of 1.13 inches of rain, with a maximum total of 4.03 inches at the Belleplain SF (Cape May County) station. Another source indicated a maximum rainfall amount of 4.92 inches in Margate. A maximum wind gust of 81 mph was reported in Strathmere (Cape May County). High surf and rip tides were reported as well.

Date(s) of Event	Event Type	Counties Affected	Description
9/6/2008	Tropical Storm Hanna	Cape May	Tropical Storm Hanna brought heavy rain and strong winds in New Jersey as well as some minor tidal flooding in Cape May County, up Delaware Bay, and into the Delaware River on September 6. Rain moved into the region around noon EDT, fell heavy at times during the late afternoon and early evening and ended during the late evening. Storm totals ranged from around two to around five inches with the highest amounts in northern New Jersey. The strongest winds occurred during the afternoon in the southern part of the State and the evening in the northern part of the State. The highest reported wind gust was 58 mph.
August 22-23, 2009	Hurricane Bill	Statewide	Average rainfall total of 1.77 inches for this event with a maximum rainfall total of 6.49 inches at the Estell Manor (Atlantic County) station. Maximum wind gusts were below 20 mph. High surf and rip tides were associated with this event.
September 3-4, 2010	Hurricane Earl	Statewide	A maximum rainfall total of 0.04 inches was reported at the Cape May station. A maximum wind gust of 65 mph was reported in Cape May (Cape May County). High surf and rip tides were also reported. The storm caused two fatalities in New Jersey, both because of the rough surf from Earl.
August 27-28, 2011	Hurricane Irene	Statewide	Hurricane Irene moved made its second landfall as a tropical storm near Little Egg Inlet along the southeast New Jersey coast at around 5:35 a.m. on August 28, 2011 Irene brought tropical-storm force winds, destructive storm surge, and record-breaking freshwater inland flooding across northeast New Jersey that resulted in three deaths, thousands of mandatory, and voluntary evacuations along the coast and rivers from surge and freshwater flooding, and widespread power outages that lasted for up to two weeks. The storm surge of three to five feet caused moderate-to-severe tidal flooding along the ocean side and moderate tidal flooding in Delaware Bay and tidal sections of the Delaware River. Major flooding occurred on the Raritan, Millstone, Rockaway, and Passaic Rivers. Overall, Irene brought an average rainfall total of 7.03 inches with a maximum rainfall total of 9.85 inches in Cranford (Union County). Another source indicated a maximum rainfall total of 11.27 inches in Freehold. A maximum wind gust of 65 mph was reported in Cape May (Cape May County). A maximum storm surge of 4.63 feet was reported in Sandy Hook. Irene caused approximately $1 billion in damages in New Jersey and seven deaths in the State.
September 7-10, 2011	Remnants of Tropical Storm Lee	Burlington, Camden, Cape May, Atlantic, Ocean	Remnants of Tropical Storm Lee brought three to eight inches of rain to many parts of New Jersey. The heavy rain caused flooding, mainly in west and northwest New Jersey. Most of the damage was reported along the Delaware River, where two homes were destroyed, 24 suffered major damage, 249 suffered minor damage, and 28 others were affected. Many roads were closed throughout the State because of flooding. Freshwater surge caused moderate

Date(s) of Event	Event Type	Counties Affected	Description
			tidal flooding along sections of the Delaware River. The State had approximately $11.5 million in damage.
October 26 - November 8, 2012	Hurricane Sandy	Statewide	Hurricane 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 80 to 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. Also devastated by the storm was New Jersey's shellfish hatcheries including approximately $1 million of losses to buildings and equipment, and product losses in excess of $10,000 at one location alone. Overall, average rainfall totals were 2.78 inches with a maximum rainfall of 10.29 inches at the Cape May (Cape May County) station. Another source indicated a maximum rainfall total of 12.71 inches in Stone Harbor (Cape May County). A maximum wind gust of 78 mph was reported in Robbins Reef. A maximum storm surge of 8.57 feet was reported in Sandy Hook. Hurricane Sandy caused approximately $30 billion in damages in New Jersey and caused 12 deaths in the State.
6/1/2013	Tropical Storm Andrea	Statewide	The storm caused heavy rains that knocked out power and flooded streets. Maximum sustained winds were 45mph.
October 56, 2013	Tropical Storm Karen	Statewide	Locally heavy rains across New Jersey caused minor street flooding.
7/4/2014	Hurricane Arthur	To the east of New Jersey	The storm produced moderate rainfall along the coast of New Jersey. Wind forces remained generally low.
8/28/2014	Hurricane Cristobal	Off the coast	While the storm passed well offshore of the state, it generated strong waves and rip currents that killed 2 people in Sandy Hook.
6/21/2015	Tropical Storm Bill	Statewide	The remains of the storm passed through New Jersey dropping heavy rain but causing no damage.
10/28/2015	Hurricane Patricia	Northeast New Jersey	Inches of heavy rain and winds caused downed tree limbs, power outages and flooding throughout the state
9/5/2016	Hurricane Hermine	Off the coast	Strong waves and minor coastal flooding occurred along the coastline
10/8/2016	Hurricane Matthew	Statewide	Brought light rain to the state.
6/24/2017	Tropical Storm Cindy	Statewide	Strong winds were brought to portions of the state. Many powerlines and trees were downed in parts of southern and central New Jersey. Two tornados related to the storm touched down in Howell Township, New Jersey damaging various buildings locally.

Date(s) of Event	Event Type	Counties Affected	Description
9/3/2017	Hurricane Harvey	Statewide	The remnants of the storm hit the state causing minimal damage
9/19/2017	Hurricane Jose	Statewide	Large waves caused beach erosion along the shore. Moderate rainfall and winds also occurred across the state.
9/27/2017	Hurricane Maria	The shore	Showers and gusty winds impacted the shore.

Source: NCDC 2017, NJ State HMP 2011; ONJSC 2013

5.8.4.2 FEMA DISASTER DECLARATIONS

Between 1954 and 2017, FEMA declared that the State of New Jersey experienced eight tropical cyclone disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: hurricane, tropical storm, severe storms, flooding, tropical depression, severe winter storm, snowstorm, and Nor'easter. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA, 2013).

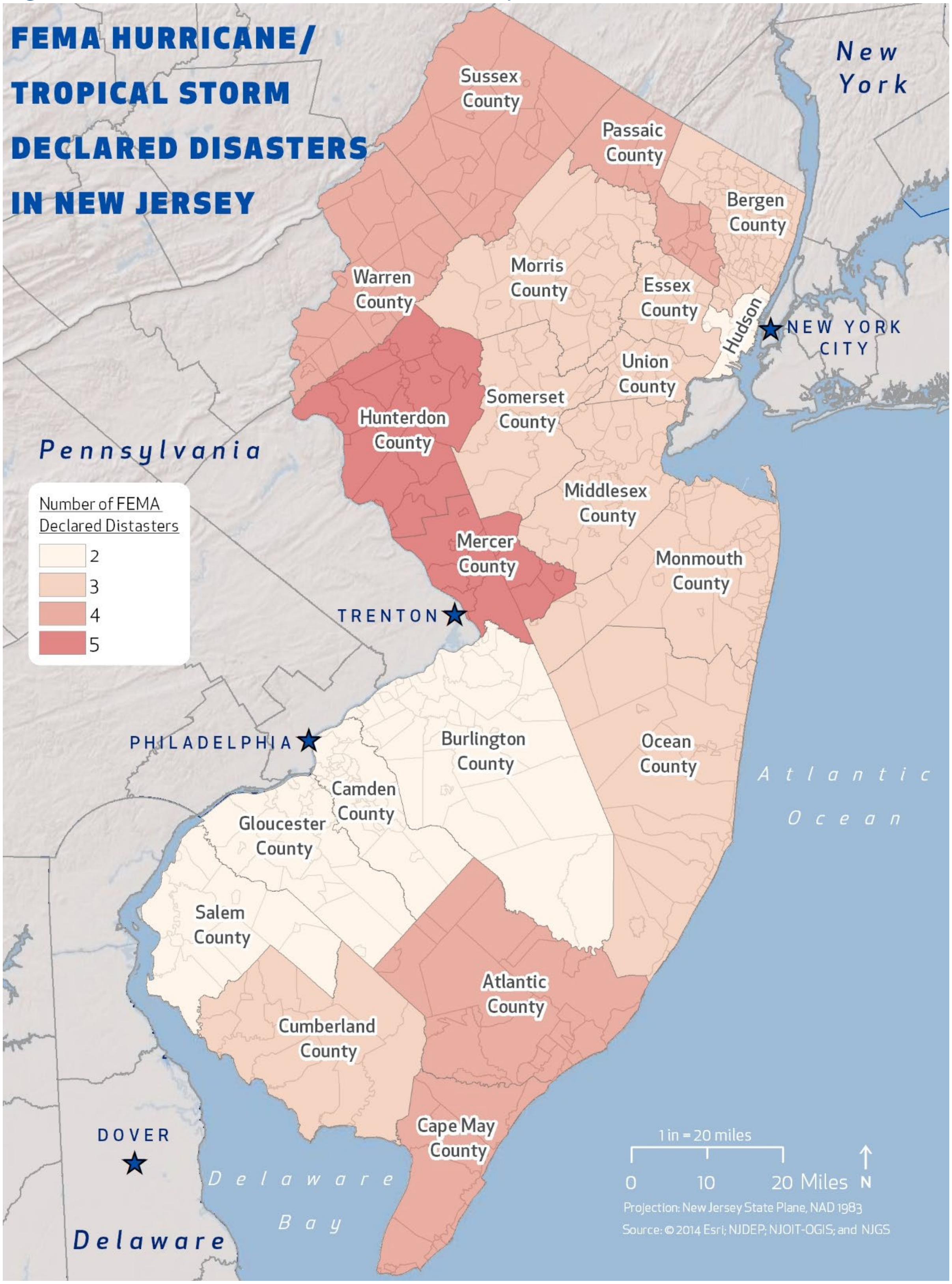
Based on all sources researched, known tropical cyclone events that have affected New Jersey and were declared a FEMA disaster are identified in Table 5.8-4. This table lists information concerning the FEMA disaster declarations for these disasters. Figure 5.8-6 illustrates the number of FEMA-declared disasters by county.

Table 5.8-4 FEMA Hurricane/Tropical Storm-Related Disaster Declarations

Disaster Number	Disaster Type	Incident Period	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	Impacted Number of Counties
DR-41	Hurricane, Floods	8/20/1955	Not Available																					
DR-749	Hurricane Gloria	9/27/1985	X				X	X							X									4
DR-1295	Hurricane Floyd	9/16/1999 - 9/18/1999		X					X			X	X	X		X		X		X		X		9
DR-1563	Tropical Depression Ivan	10/1/2004										X	X								X		X	4
DR-1867	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'easter	11/11/2009 - 11/15/2009	X				X										X							3
DR-4021	Hurricane Irene	8/27/2011 – 9/5/2011	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
DR-4039	Remnants of Tropical Storm Lee	9/28/2011 - 10/6/2011										X	X					X			X		X	5
DR-4086	Superstorm Sandy	10/26/2012 – 11/8/2012	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21

Source: FEMA, 2013

Figure 5.8-6 Number of FEMA Hurricane/Tropical Storm Declared Disasters

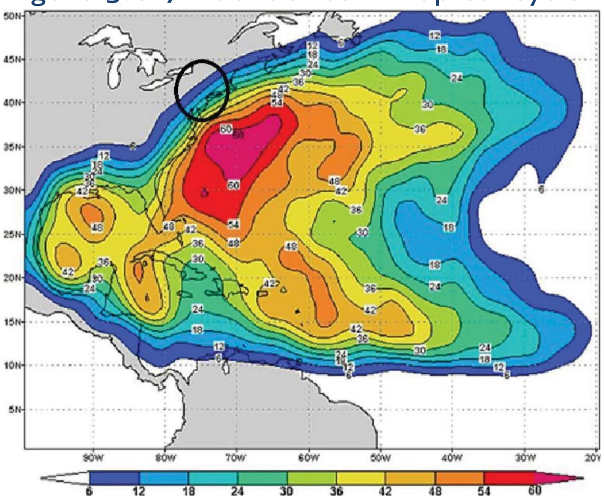


Source: FEMA 2017

5.8.5 PROBABILITY OF FUTURE OCCURRENCES

The NOAA Hurricane Research Division published a map (included as Figure 5.8-7) showing the chance that a tropical storm or hurricane (of any intensity) will affect a given area during the hurricane season (June to November). This analysis was based on historical data from 1944 to 1999. Based on this analysis, the State has a 6% to 30% chance of a tropical storm or hurricane affecting the area each year. The probability increases as you move from the northwest portion of the State to the southeast, with the highest probability along the coast in Cape May and Atlantic counties.

Figure 5.8-7 Atlantic Basin Tropical Cyclone Probabilities

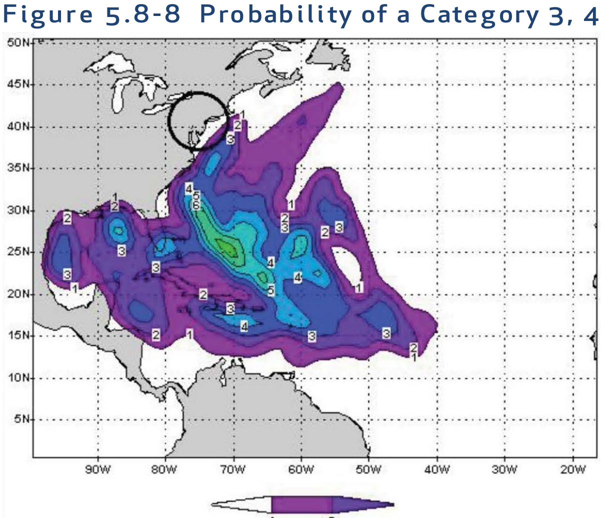


Source: NOAA, 2010

Note: The black circle was added to indicate the approximate location of the State of New Jersey

A similar analysis was conducted to determine the probability that a major hurricane (Category 3, 4, or 5) will directly affect the area during hurricane season (June through November). The analysis was based on historic data from 1944 to 1999 for hurricanes within approximately 30 miles of the identified area. This analysis indicates that the State has a less than 1% chance per year of a Category 3, 4, or 5 hurricane approaching the southern portion of the State (NOAA, 2010). Major hurricanes are rare along the mid-Atlantic coast; therefore, determining and obtaining a realistic probability is extremely difficult.

Figure 5.8-8 Probability of a Category 3, 4, or 5 Hurricane



Source: NOAA 2010

Note: The black circle was added to indicate the approximate location of the State of New Jersey

5.8.5.2 POTENTIAL EFFECTS OF CLIMATE CHANGE

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

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

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

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over 5" (12%) greater than the average from 1895-1970. Southern New Jersey became 2" (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5% by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NYCPCC] 2009).

A 2016 Rutgers University Science and Technical Advisory Panel (STAP) Report entitled, Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel indicates that sea level has been steadily rising with sea levels along the New Jersey coastline rising faster than the global average. Continued Seal Level Rise could increase the baseline for flooding from coastal storms which could indicate more frequent and more severe coastal flooding events. Flooding events associated with storm surge caused by hurricanes and tropical storms could therefore also increase. Section 5.2 (Coastal Erosion) contains a discussion of the State's efforts to address sea level rise.

5.8.6 IMPACT ANALYSIS

5.8.6.1 SEVERITY AND WARNING TIME

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

- Hurricane/Typhoon Warning is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm force winds (24 hours in the western north Pacific). The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.

- Hurricane Watch is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm force winds.
- Tropical Storm Warning is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours (24 hours for the western north Pacific) in association with a tropical, subtropical, or post-tropical storm.
- Tropical Storm Watch is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm (NWS 2013).

5.8.6.2 SECONDARY HAZARDS

Precursor events or hazards related to tropical storms or hurricanes are heavy rains, winds, tornadoes, storm surge, insufficient flood preparedness, failure of sub-sea level infrastructure in coastal locations, and levee or dam breach or failure. Cascading events following a tropical storm or hurricane could include:

- health issues (mold, mildew),
- increased risk of fire hazards,
- hazardous materials including waste byproducts,
- coastal erosion,
- compromise of levees or dams,
- isolated population,
- increased risk of landslides or other types of land movement,
- disruption to transportation,
- disruption of power transmission and infrastructure,
- structural and property damage,
- debris distribution, and
- other environmental impacts.

5.8.6.3 ENVIRONMENTAL IMPACTS

The environmental impacts of a tropical storm or hurricane will depend upon the magnitude of the event. Tropical storm and hurricane-force winds can down foliage and trees, generating tons of debris. The damage to vegetation can alter or destroy specific wildlife habitat. Further, storm surge can drastically reshape the coastal landscape. Storm surge that reaches and impacts development or infrastructure may cause the release of hazardous substances such as heating fuel and sewage into the environment. Further, vegetative and construction material debris may accumulate on beaches and shorelines.

5.8.7 VULNERABILITY ASSESSMENT

To understand risk, the assets exposed to the hazard areas are identified. For the hurricane and tropical storm hazard, the entire State of New Jersey is exposed. The State is most exposed to the wind and rains associated with these events. However, certain areas and types of building and infrastructure are at greater risk than others because of their proximity to the coast and/or their manner of construction. Storm surge from a hurricane/tropical storm poses one of the greatest risks to residents and property along the coast.

Methodologies described in the local hazard mitigation plans (HMP) varied in relation to the wind and storm surge hazards associated with hurricanes and tropical storms. Some counties have used HAZUS-MH to quantify estimated potential losses (e.g., Burlington, Hudson, Monmouth and Somerset Counties) whereas other counties either discussed exposure or addressed this hazard in a more qualitative nature in their local HMPs. The previous plan used FEMA Region IV Risk Analysis Team's storm surge inundation grids. To assess the vulnerability and estimate potential losses across the State, a uniform methodology was applied and is discussed below.

The HAZUS-MH wind model was used to run probabilistic scenarios for the State to examine the estimated wind speeds, annualized losses, and losses associated with the wind-only 100- and 500-year mean return period (MRP) events. Figure 5.8-4 and Figure 5.8-5 presented earlier in this section illustrate the wind speeds associated with the 100- and 500-year MRP events.

5.8.7.1 ASSESSING VULNERABILITY BY JURISDICTION

Historically, hurricanes and tropical storms have impacted all 21 New Jersey counties. All local hazard mitigation plans identified hurricanes and tropical storms as a hazard of concern, as listed in Table 5.1-2 in Section 5.1 State Risk Assessment Overview. Of the five-local mitigation plans that ranked risk into high/medium/low categories for this hazard, the following New Jersey counties considered the hurricane and tropical storm hazard as high: Cape May, Essex, Hudson, Monmouth, and Somerset Counties. If hurricane/tropical storms were not ranked by a local HMP, the jurisdictions identified their most significant hazards using other methods.

The impact of a hurricane or tropical storm on life, health, and safety depends on several factors, including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire State's population is exposed to the wind hazard associated with a hurricane or tropical storm event.

Storm surge inundation is a significant threat to the population along the coast. To estimate the population exposed to the surge inundation areas, the SLOSH Category 1 through 4 zones were overlaid on the 2010 Census block population data in GIS (United States Census 2010). Census blocks do not follow the boundaries of the SLOSH model. The Census blocks with their centroid in the SLOSH boundaries were used to calculate the estimated population exposed to the hurricane surge hazard. Table 5.8-5 summarizes the 2010 Census population in the Category 1 through 4 SLOSH zones by county. Please note these population statistics do not account for the seasonal population along the coast during hurricane season.

Statewide, approximately 4.3% (Category 1) to 16.5% (Category 4) of the population is exposed to hurricane storm surge. It is clear that Cape May County is the most threatened County with greater than 90% of their total population exposed to a Category 4 event, followed by Salem (58%) and Atlantic (44%) Counties. However, all Counties with the exception of Hunterdon, Morris, Somerset, Sussex and Warren have population exposed and potentially vulnerable to Category 4 storm surge.

Of the total State population, economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable, and they may physically have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations. Also, they are more likely to seek or need medical attention, which may not be available because of isolation during a storm event.

Table 5.8-5 Estimated Population in Category 1 through 4 SLOSH Zones

County	Total Population (2015 ACS)	Category 1		Category 2		Category 3		Category 4	
		Population	% Total	Population	% Total	Population	% Total	Population	% Total
Atlantic	275,376	64,163	23.3%	90,048	32.7%	106,020	38.5%	121,716	44.2%
Bergen	926,330	27,790	3.0%	51,874	5.6%	87,075	9.4%	129,686	14.0%
Burlington	450,556	451	0.1%	6,308	1.4%	9,462	2.1%	37,396	8.3%
Camden	511,998	2,560	0.5%	3,584	0.7%	14,848	2.9%	95,744	18.7%
Cape May	95,805	38,801	40.5%	60,549	63.2%	79,039	82.5%	88,524	92.4%
Cumberland	157,035	2,198	1.4%	8,480	5.4%	15,075	9.6%	19,472	12.4%
Essex	791,609	5,541	0.7%	43,538	5.5%	64,120	8.1%	69,662	8.8%
Gloucester	290,298	2,032	0.7%	14,225	4.9%	23,224	8.0%	32,513	11.2%
Hudson	662,619	109,332	16.5%	145,776	22.0%	177,582	26.8%	218,664	33.0%
Hunterdon	126,250	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Mercer	370,212	370	0.1%	370	0.1%	370	0.1%	740	0.2%
Middlesex	830,300	21,588	2.6%	51,479	6.2%	80,539	9.7%	122,054	14.7%
Monmouth	629,185	33,976	5.4%	61,660	9.8%	138,421	22.0%	176,801	28.1%
Morris	498,192	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Ocean	583,450	50,760	8.7%	103,271	17.7%	146,446	25.1%	179,703	30.8%
Passaic	507,574	-	0.0%	508	0.1%	5,583	1.1%	7,614	1.5%
Salem	65,120	11,722	18.0%	28,653	44.0%	35,165	54.0%	37,770	58.0%
Somerset	330,604	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Sussex	145,930	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Union	548,744	14,816	2.7%	41,705	7.6%	83,958	15.3%	132,247	24.1%
Warren	107,226	-	0.0%	-	0.0%	-	0.0%	-	0.0%
Total	8,904,413	382,890	4.3%	712,353	8.0%	1,068,530	12.0%	1,469,228	16.5%

Source: FEMA CFLA 2012; ACS 2015

Table 5.8-6 Area Located in the SLOSH Zones (square miles)

County	Total Area (land and water)	Category 1		Category 2		Category 3		Category 4	
		Area	% Total	Area	% Total	Area	% Total	Area	% Total
Atlantic	610.65	102.6	16.8%	132.5	21.7%	160.6	26.3%	191.1	31.3%
Bergen	239.83	20.1	8.4%	26.4	11.0%	32.1	13.4%	40.1	16.7%
Burlington	820.32	28.7	3.5%	50.0	6.1%	62.3	7.6%	87.0	10.6%
Camden	227.57	5.2	2.3%	6.6	2.9%	9.3	4.1%	25.3	11.1%
Cape May	286.13	115.3	40.3%	161.1	56.3%	197.1	68.9%	218.9	76.5%
Cumberland	501.80	92.8	18.5%	155.6	31.0%	173.1	34.5%	189.2	37.7%
Essex	129.72	6.0	4.6%	10.4	8.0%	13.0	10.0%	13.6	10.5%
Gloucester	336.20	21.9	6.5%	42.4	12.6%	53.1	15.8%	62.5	18.6%
Hudson	51.53	22.7	44.1%	27.8	54.0%	31.6	61.3%	33.7	65.4%
Hunterdon	437.32	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%

County	Total Area (land and water)	Category 1		Category 2		Category 3		Category 4	
		Area	% Total	Area	% Total	Area	% Total	Area	% Total
Mercer	228.8	1.8	0.8%	1.8	0.8%	2.5	1.1%	4.1	1.8%
Middlesex	316.97	22.5	7.1%	32.3	10.2%	40.6	12.8%	54.2	17.1%
Monmouth	485.68	17.0	3.5%	27.2	5.6%	48.1	9.9%	58.3	12.0%
Morris	481.44	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Ocean	757.93	52.3	6.9%	106.9	14.1%	127.3	16.8%	145.5	19.2%
Passaic	198.32	0.2	0.1%	0.4	0.2%	0.8	0.4%	1.0	0.5%
Salem	347.12	79.8	23.0%	111.8	32.2%	128.1	36.9%	148.6	42.8%
Somerset	304.88	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Sussex	535.47	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Union	105.38	10.0	9.5%	14.4	13.7%	19.2	18.2%	22.9	21.7%
Warren	362.59	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Total	7,765.65	598.0	7.7%	908.6	11.7%	1102.7	14.2%	1296.9	16.7%

Source: FEMA, CFLA 2012; United States Census 2010

As New Jersey continues to develop, the State will remain vulnerable to the impacts of wind and storm surge from tropical storms and hurricanes. Improved mapping and higher regulatory standards will mitigate future impacts to new and redeveloped areas in defined hazard zones. FEMA's Advisory Base Flood Elevations (ABFE) maps were made available post Superstorm Sandy to certain impacted communities as best-available data for rebuilding and recovery efforts. Preliminary and updated work maps continue to be released showing coastal flood hazard data to replace the ABFE maps. These maps reflect the results of an ongoing coastal flood hazard study and are considered best available information. They are intended to help communities and property owners understand current flood risk and future flood insurance requirements based upon updated data. In addition, changes to New Jersey's Flood Hazard Area Control Act rules, adopted April 16, 2018, set minimum elevation standards for the reconstruction of houses and buildings in areas that are in danger of flooding. These standards will help mitigate the impacts of these events.

Measures taken by the New Jersey Department of Environmental Protection (NJDEP) further increase New Jersey citizens' awareness of the impacts of tropical cyclone wind and storm surge hazards. People are increasingly aware that measures, like elevating their homes or installing hurricane straps on their roofs will help protect and mitigate against these hazards. Municipalities are increasingly aware that requiring measures such as flood proofing of the lower levels of buildings will help mitigate the impacts of these hazards. However, it is clear that much of the existing infrastructure and development along the immediate coast and adjacent bays will continue to be vulnerable to both wind and storm surge hazards.

5.8.7.2 ESTIMATING POTENTIAL LOSSES BY JURISDICTION

Residents may be displaced or require temporary to long-term sheltering as a result of a hurricane or tropical storm. 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 during a hazard and the location and construction quality of their housing.

An analysis was conducted to determine the wind-only impacts from hurricane/tropical storm events for the 100- and 500-year probabilistic events for hurricanes and tropical storms in New Jersey. HAZUS-MH estimates the sheltering needs as a result of the 100- and 500-year wind-only probabilistic events (United States Census 2000). It should be noted that HAZUS-MH utilizes 2000 Census data, and therefore, the totals will vary slightly. The estimated shelter needs are summarized in Table 5.8-7. All counties, with the exception of Cape May and Essex Counties, have experienced an increase in population growth since the 2000 Census. Therefore, the numbers in Table 5.8-7 below are conservative.

Table 5.8-7 Estimated Shelter Needs – Wind Analysis Only (United States Census, 2010)

County	100 - Year Event		500 - Year Event	
	Displaced Households	Short-Term Shelter Needs	Displaced Households	Short-Term Shelter Needs
Atlantic	426	113	2,332	615
Bergen	0	0	640	133
Burlington	4	0	53	9
Camden	13	2	21	3
Cape May	143	29	472	107
Cumberland	31	8	16	5
Essex	0	0	1,200	350
Gloucester	3	0	3	-
Hudson	13	2	2,848	722
Hunterdon	0	0	-	-
Mercer	0	0	22	3
Middlesex	2	0	1,198	280
Monmouth	64	8	1,289	294
Morris	0	0	27	3
Ocean	88	15	1,142	260
Passaic	0	0	485	140
Salem	0	0	-	-
Somerset	0	0	23	2
Sussex	0	0	-	-
Union	0	0	603	163
Warren	0	0	-	-
Total	787	177	12374	3,089

Source: HAZUS-MH v. 4.2 (United States Census 2000)

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. HAZUS determines the general building stock wind-only impacts from hurricane/tropical storm events for the 100- and 500-year probabilistic events. Table 5.8-8 below summarizes the estimated damages (structure only) from wind from these events. Total dollar damage reflects the overall impact to buildings of all occupancy classes.

As a result of a 100-year probabilistic wind event, HAZUS-MH estimates the State will experience greater than $2.5 billion in building damage. For the 500-year probabilistic wind event, HAZUS-MH estimates the State may experience $12.8 billion in building damage. Please note these damage estimates account for damage as a result of the wind only and impacts will be much greater when factoring in storm surge inundation, debris, sheltering, and other losses; some of which are discussed further below.

Table 5.8-8 Estimated Building Damage – Wind Analysis Only

County	Annualized Loss	100 - Year Event	500 - Year Event
	RCV	RCV	RCV
Atlantic	$ 13,610,682	$ 448,482,680	$ 1,587,877,176
Bergen	$ 7,805,356	$ 59,014,412	$ 1,177,128,510
Burlington	$ 4,226,480	$ 142,939,094	$ 265,860,025
Camden	$ 4,215,473	$ 142,024,203	$ 156,236,797
Cape May	$ 11,257,429	$ 341,710,031	$ 865,231,391
Cumberland	$ 1,776,144	$ 69,427,677	$ 54,082,228
Essex	$ 4,588,778	$ 41,926,754	$ 1,055,559,555
Gloucester	$ 2,607,545	$ 88,846,733	$ 69,465,222
Hudson	$ 7,009,418	$ 59,621,971	$ 1,076,201,633
Hunterdon	$ 600,142	$ 8,495,926	$ 33,447,052
Mercer	$ 2,735,909	$ 71,372,422	$ 229,714,881
Middlesex	$ 8,900,021	$ 178,894,781	$ 1,307,330,971
Monmouth	$ 17,552,990	$ 276,557,106	$ 1,456,692,098
Morris	$ 2,593,013	$ 27,079,228	$ 362,647,445
Ocean	$ 22,776,391	$ 427,695,595	$ 1,567,383,178
Passaic	$ 2,156,631	$ 15,597,267	$ 498,759,533
Salem	$ 602,422	$ 18,661,330	$ 6,641,598
Somerset	$ 2,136,397	$ 40,058,067	$ 235,147,680
Sussex	$ 499,802	$ 1,818,236	$ 55,142,038
Union	$ 3,586,925	$ 47,145,823	$ 692,847,453
Warren	$ 308,594	$ 1,540,240	$ 10,010,209
Total	$ 121,546,539	$ 2,508,909,575	$ 12,763,406,674

Source: HAZUS-MH v. 4.2
Note: This takes into consideration the cost of the structural damage due to an event

In addition to building damages, hurricane/tropical storm events can greatly impact the economy, including loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss, and rental loss caused by the repair/replacement of buildings. HAZUS-MH estimates the (wind only) total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is discussed earlier in this section. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event. The economic losses generated by HAZUS-MH for each of the probabilistic wind scenarios are summarized in Tables 5.8-9 and 5.8-10.

Table 5.8-9 Estimated Economic Loss for the 100-Year Event – Wind Analysis Only

County	Inventory	Relocation	Income	Rental	Wages
Atlantic	$ 167,737	$ 17,581,328	$ 2,568,684	$18,237,828	$ 4,514,133

County	Inventory	Relocation	Income	Rental	Wages
Bergen	$ -	$ 79,751	$ -	$ 51,837	$ -
Burlington	$ 17,118	$ 2,722,404	$ 6,462	$ 1,400,323	$ 6,143
Camden	$ 11,068	$ 3,133,089	$ 4,984	$ 2,030,857	$ 1,768
Cape May	$ 134,624	$ 16,427,502	$ 1,858,635	$ 11,660,523	$ 3,131,177
Cumberland	$ 67,954	$ 2,395,639	$ 249,993	$ 1,481,440	$ 180,237
Essex	$ -	$ 180,217	$ -	$ 197,191	$ -
Gloucester	$ 13,574	$ 2,140,350	$ 18,910	$ 1,067,502	$ 6,709
Hudson	$ -	$ 1,281,194	$ -	$ 1,797,543	$ -
Hunterdon	$ -	$ 3,896	$ -	$ 4,335	$ -
Mercer	$ -	$ 236,236	$ -	$ 243,805	$ -
Middlesex	$ -	$ 754,219	$ -	$ 993,649	$ -
Monmouth	$ 32,191	$ 7,705,439	$ 335,463	$4,674,000	$ 124,849
Morris	$ -	$ 4,222	$ -	$ -	$ -
Ocean	$ 93,563	$ 15,022,315	$ 1,084,864	$ 7,442,071	$ 1,374,810
Passaic	$ -	$ 19,268	$ -	$ -	$ -
Salem	$ 1,536	$ 360,902	$ -	$ 143,125	$ -
Somerset	$ -	$ 37,450	$ -	$ 39,946	$ -
Sussex	$ -	$ 356	$ -	$ -	$ -
Union	$ -	$ 106,511	$ -	$ 99,587	$ -
Warren	$ -	$ 420	$ -	$ -	$ -
Total	$ 539,367	$ 70,192,710	$ 6,127,995	$51,565,563	$ 9,339,826

Source: HAZUS-MH v. 4.2

Table 5.8-10 Estimated Economic Loss for the 500-Year Event – Wind Analysis Only

County	Inventory	Relocation	Income	Rental	Wages
Atlantic	$ 1,635,867	$ 126,819,837	$ 9,880,510	$ 84,732,291	$ 18,389,206
Bergen	$ 1,438,520	$ 33,769,066	$ 5,472,079	$ 21,478,435	$ 6,468,346
Burlington	$ 157,745	$ 7,636,482	$ 707,158	$ 3,757,114	$ 1,116,769
Camden	$ 18,580	$ 3,611,245	$ 69,387	$ 2,302,607	$ 40,927
Cape May	$ 622,911	$ 72,131,121	$ 3,713,789	$ 36,122,575	$ 6,575,746
Cumberland	$ 45,931	$ 1,700,333	$ 150,452	$ 1,048,792	$ 111,815
Essex	$ 1,629,117	$ 45,522,584	$ 7,483,916	$ 35,821,740	$ 13,053,118
Gloucester	$ 5,784	$ 1,274,032	$ 23,441	$ 686,243	$ 8,317
Hudson	$ 1,232,460	$ 55,986,171	$ 9,886,521	$ 56,736,065	$ 11,597,702
Hunterdon	$ 322	$ 262,479	$ -	$ 128,413	$ -
Mercer	$ 61,604	$ 5,795,645	$ 238,871	$ 3,103,646	$ 125,608
Middlesex	$ 1,439,654	$ 42,955,722	$ 9,172,132	$ 28,111,431	$ 11,580,700
Monmouth	$ 1,625,056	$ 71,381,701	$ 12,070,151	$ 35,585,075	$ 18,186,677
Morris	$ 78,764	$ 5,613,839	$ 40,506	$ 2,684,581	$ 19,591
Ocean	$ 1,352,249	$ 106,266,950	$ 8,574,377	$ 42,094,524	$ 15,016,746
Passaic	$ 1,263,949	$ 19,734,507	$ 2,997,477	$ 14,909,275	$ 4,567,416
Salem	$ 288	$ 118,323	$ -	$ 38,196	$ -
Somerset	$ 47,777	$ 4,700,526	$ 67,904	$ 2,365,219	$ 24,875
Sussex	$ 325	$ 198,674	$ -	$ 111,671	$ -

County	Inventory	Relocation	Income	Rental	Wages
Union	$ 1,597,671	$ 26,244,415	$ 3,629,605	$ 17,544,385	$ 4,609,206
Warren	$ -	$ 8,855	$ -	$ 9,538	$ -
Total	$14,254,574	$ 631,732,507	$ 74,178,275	$ 389,371,816	$ 111,492,765

Source: HAZUS-MH v. 4.2

5.8.7.3 ASSESSING VULNERABILITY TO STATE FACILITIES

All State buildings are exposed to the wind and/or rain from the hurricane and tropical storm hazard. Tables 5.1-8 and 5.1-9 in Section 5.1 Risk Assessment Overview summarize the number of State-owned and leased buildings in the State by Agency and County.

To assess the exposure of the State buildings to the storm surge inundation from a hurricane event, the SLOSH boundaries provided by the FEMA Region IV Coastal Flood Loss Atlas team were used. The digital SLOSH zones were overlaid upon the State building data available from the LBAM database and the appropriate SLOSH zone was determined. Tables 5.8-11 and 5.8-12 summarize the number of State-owned and leased buildings located within the zones that may be affected by Category 1 through Category 4 storm surges, by County and State agency, respectively. The total number of buildings listed for Categories 2 through 4 in the tables below is cumulative. For example, the total number of State buildings exposed to Category 3 storm surge includes the number of buildings in zones that would be affected by Category 1 and Category 2 storm surge as well.

Overall, a total of 1,233 structures, or approximately 22% of State-owned and leased buildings, are located within the Category 1 through 4 SLOSH inundation zones. State-owned and leased structures that are not presented in Tables 5.8-11 and 5.8-12 below are not located within a defined SLOSH zone.

Table 5.8-11 Number of State Buildings Exposed to Storm Surge by County

County	Total Number of Buildings	Category 1		Category 2		Category 3		Category 4		Total in Entire SLOSH Area
		Owned	Leased	Owned	Leased	Owned	Leased	Owned	Leased	
Atlantic	165	46	10	49	10	56	11	57	13	70
Bergen	79	2	0	6	3	6	3	6	3	9
Burlington	683	140	1	152	2	167	2	208	2	210
Camden	154	0	2	0	2	1	5	10	10	20
Cape May	191	35	1	47	5	65	6	65	6	71
Cumberland	464	21	0	175	0	282	0	289	1	290
Essex	102	0	1	44	3	45	3	45	5	50
Gloucester	55	9	1	9	2	15	2	15	2	17

County	Total Number of Buildings	Category 1		Category 2		Category 3		Category 4		Total in Entire SLOSH Area
		Owned	Leased	Owned	Leased	Owned	Leased	Owned	Leased	
Hudson	53	31	1	31	1	35	2	35	5	40
Hunterdon	501	4	0	4	0	4		4	-	4
Mercer	673	63	7	63	7	63	7	63	7	70
Middlesex	334	1	0	7	0	95	2	107	2	109
Monmouth	450	2	4	35	4	82	4	86	5	91
Morris	227	-	0	0	0	-	-	-	-	-
Ocean	244	61	1	80	1	97	4	98	5	103
Passaic	250	-	0	0	0	-	-	-	-	-
Salem	121	29	0	41	3	51	3	51	3	54
Somerset	138	-	0	0	0	-	-	-	-	-
Sussex	446	-	0	0	0	-	-	-	-	-
Union	53	-	0	11	5	12	6	14	11	25
Warren	225	-	0	0	0	-	-	-	-	-
Total	5,608	444	29	754	48	1,076	60	1,153	80	1,233

Source: NOAA; NJOMB 2018

Table 5.8-12 Number of State Buildings Exposed to Storm Surge by Agency

Agency	Total Number of Buildings	Category 1		Category 2		Category 3		Category 4	
		Owned	Leased	Owned	Leased	Owned	Leased	Owned	Leased
Agriculture	10	-	-	-	-	-	-	-	-
Banking and Insurance	1	-	-	-	-	-	-	-	-
Chief Executive	2	1	-	1	-	1	-	1	0
Children and Families	157	7	1	7	4	7	7	8	8
Community Affairs	10	-	-	-	-	-	-	-	-
Corrections	801	-	2	190	2	380	2	380	2

Agency	Total Number of Buildings	Category 1		Category 2		Category 3		Category 4	
		Owned	Leased	Owned	Leased	Owned	Leased	Owned	Leased
Education	66	1	1	1	1	1	1	1	1
Environmental Protection	2,004	339	-	396	1	447	1	500	2
Health	9	1	1	1	1	1	1	1	1
Human Services	729	-	-	-	1	2	1	2	1
Judiciary	92	2	1	11	4	11	6	16	9
Juvenile Justice Commission	199	20	-	20	-	28	-	36	-
Labor and Work Force Development	50	-	2	-	5	-	5	-	13
Law and Public Safety	27	12	3	12	3	14	3	14	4
Legislature	6	2	-	2	-	2	-	2	-
Military and Veterans Affairs	273	21	-	46	1	79	1	80	1
Miscellaneous Commissions	2	-	-	-	-	-	1	-	1
Motor Vehicles Commission	141	-	1	6	5	15	7	19	9
Personnel	2	-	-	-	-	-	-	-	-
State	19	7	-	7	-	7	-	7	-
State Police	141	5	8	9	10	11	12	15	13
Transportation	617	15	-	33	-	56	-	57	-
Treasury	250	11	9	12	10	14	12	14	15
Total	5,608	444	29	754	48	1,076	60	1,153	80

Source: NOAA; New Jersey Office of Management and Budget 2018

5.8.7.4 ESTIMATING POTENTIAL LOSSES TO STATE FACILITIES

An exposure analysis was also completed using the critical facilities identified for the purposes of this plan. Tables 5.8-13 through 5.8-16 summarize the number of critical facilities exposed to Category 1 through 4 storm surge inundation (cumulative). This analysis was completed using a centroid selection analysis with the critical facility location data and the SLOSH data described above.

Table 5.8-13 Critical Facilities Exposed to Category 1 Storm Surge by County

County	Total Number	Airport	Special Needs	Communication	Correctional Institutions	Dams	Electric Power	EMS	EOC	Ferry	Fire	Highway Bridges	Highway Tunnels	Light Rail Facilities	Medical	Military	Natural Gas	Oil	Police	Ports	Potable Water	Rail Facilities	Rail Tunnels	School	Shelters	Storage of Critical Records	Wastewater
Atlantic	388	-	1	-	-	11	1	11	-	-	12	2	-	-	-	-	-	-	5	-	1	-	-	17	6	-	1
Bergen	1,148	1	1	-	1	5	2	7	-	-	4	-	-	-	-	-	-	-	3	-	-	3	-	7	5	-	3
Burlington	747	-	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Camden	701	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Cape May	229	1	2	-	-	6	-	16	-	1	19	-	-	-	-	1	-	-	7	1	-	-	-	13	13	-	3
Cumberland	251	-	-	-	-	3	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Essex	784	1	-	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	1	1	-	1	-	-	-	-	1
Gloucester	346	-	-	-	-	3	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Hudson	493	-	2	-	1	-	2	6	-	3	12	1	1	12	4	-	-	-	2	4	1	6	-	29	11	-	4
Hunterdon	328	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercer	538	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middlesex	816	-	-	-	-	8	-	2	-	-	2	1	-	-	-	-	-	-	1	-	2	-	-	3	1	-	1
Monmouth	905	-	2	-	-	4	-	13	-	1	12	-	-	-	-	1	-	-	3	-	-	1	-	8	-	-	3
Morris	913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocean	621	-	-	-	-	5	-	11	-	-	7	-	-	-	-	-	-	-	5	-	-	1	-	4	-	-	-
Passaic	648	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salem	201	-	2	-	-	5	-	3	-	-	3	1	-	-	-	-	-	-	1	-	-	-	-	5	4	-	2
Somerset	539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sussex	542	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union	607	-	-	-	-	4	1	3	-	-	3	1	-	-	-	-	-	-	2	5	-	-	-	4	4	-	3
Warren	351	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	12,096	3	10	-	3	57	6	74	-	5	77	13	1	12	4	2	-	-	30	11	4	12	-	92	49	-	21

Table 5.8-14 Critical Facilities Exposed to Category 2 Storm Surge by County

County	Total Number	Airport	Special Needs	Communication	Correctional Institutions	Dams	Electric Power	EMS	EOC	Ferry	Fire	Highway Bridges	Highway Tunnels	Light Rail Facilities	Medical	Military	Natural Gas	Oil	Police	Ports	Potable Water	Rail Facilities	Rail Tunnels	School	Shelters	Storage of Critical Records	Wastewater
Atlantic	388	-	1	-	-	20	2	15	-	-	16	2	-	-	3	-	-	-	7	-	1	1	-	25	8	-	2
Bergen	1,148	1	1	-	1	6	2	11	-	-	8	-	-	-	-	-	-	-	7	-	1	5	-	13	9	-	4
Burlington	747	-	1	-	-	4	-	1	-	-	1	3	-	-	-	-	-	-	2	-	-	-	-	2	3	-	2
Camden	701	-	-	-	1	6	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	2	-	2
Cape May	229	1	5	-	-	14	-	22	1	1	24	-	-	-	1	1	-	-	12	1	1	-	-	26	27	-	5
Cumberland	251	-	-	-	-	11	-	8	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	5	5	-	2
Essex	784	1	-	-	2	-	1	1	-	-	3	2	-	1	-	-	-	-	2	3	-	1	-	8	2	-	2
Gloucester	346	-	-	-	-	5	-	2	-	-	2	1	-	-	-	-	-	-	4	-	-	-	-	5	-	-	3
Hudson	493	-	2	1	1	-	2	7	-	3	16	1	1	15	4	-	-	-	4	4	2	7	-	45	13	-	4
Hunterdon	328	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercer	538	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middlesex	816	-	1	-	-	11	-	9	-	-	5	1	-	-	-	-	-	-	3	-	3	1	-	10	5	-	2
Monmouth	905	-	2	-	-	9	-	20	-	2	19	-	-	-	-	1	-	-	7	-	-	1	-	16	1	-	3
Morris	913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocean	621	-	1	-	-	10	-	29	-	-	23	-	-	-	-	-	-	-	14	-	-	2	-	13	2	-	-
Passaic	648	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salem	201	-	4	-	-	12	-	9	-	-	10	1	-	-	-	-	-	-	5	-	-	-	-	16	17	-	3
Somerset	539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sussex	542	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union	607	-	-	-	-	5	1	4	-	-	5	1	-	-	-	-	-	-	3	5	-	-	-	16	15	-	3
Warren	351	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	12,096	3	18	1	5	114	8	138	1	6	140	13	1	16	8	2	-	-	71	13	8	18	-	201	109	-	37

Table 5.8-15 Critical Facilities Exposed to Category 3 Storm Surge by County

County	Total Number	Airport	Special Needs	Communication	Correctional Institutions	Dams	Electric Power	EMS	EOC	Ferry	Fire	Highway Bridges	Highway Tunnels	Light Rail Facilities	Medical	Military	Natural Gas	Oil	Police	Ports	Potable Water	Rail Facilities	Rail Tunnels	School	Shelters	Storage of Critical Records	Wastewater
Atlantic	388	-	3	-	-	24	2	20	-	-	21	2	-	-	3	-	-	-	9	-	1	1	-	33	12	-	2
Bergen	1,148	1	4	-	1	7	2	15	-	-	17	-	-	-	-	-	-	-	10	-	1	7	-	31	24	-	4
Burlington	747	-	1	-	-	7	-	2	-	-	4	3	-	1	-	-	-	-	3	-	-	-	-	5	6	-	4
Camden	701	-	-	-	1	9	-	-	-	-	-	2	-	3	-	-	-	-	2	1	-	-	-	5	4	-	2
Cape May	229	2	9	-	-	14	-	25	1	1	27	-	-	-	1	1	-	-	12	1	1	-	-	32	37	-	6
Cumberland	251	-	-	-	1	14	-	9	-	-	10	-	-	-	-	-	-	-	1	-	-	-	-	5	6	-	2
Essex	784	1	-	-	2	-	1	1	-	-	4	2	-	2	1	-	-	-	6	3	-	3	-	11	2	-	2
Gloucester	346	-	-	-	-	13	-	3	-	-	3	1	-	-	1	-	-	-	5	-	-	-	-	9	-	-	3
Hudson	493	-	2	1	1	-	2	8	-	3	17	1	2	19	4	-	1	-	5	4	2	7	-	52	13	-	4
Hunterdon	328	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercer	538	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middlesex	816	-	2	-	2	11	-	13	-	-	9	1	-	-	1	-	-	-	5	-	3	2	-	24	6	-	2
Monmouth	905	-	6	-	-	22	-	44	-	2	42	-	-	-	2	1	-	-	16	1	-	6	-	52	3	-	6
Morris	913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocean	621	-	2	-	-	13	-	43	-	-	35	-	-	-	-	-	-	-	15	-	-	2	-	22	6	-	1
Passaic	648	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Salem	201	-	4	-	-	14	-	12	-	-	13	1	-	-	-	-	-	-	6	-	-	-	-	23	22	-	3
Somerset	539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sussex	542	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union	607	-	1	-	1	6	1	8	-	-	10	1	-	-	-	-	-	-	5	5	-	3	-	30	27	-	4
Warren	351	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	12,096	4	34	1	9	156	8	203	1	6	212	14	2	25	13	2	1	-	100	15	8	31	-	335	168	-	45

Table 5.8-16 Critical Facilities Exposed to Category 4 Storm Surge by County

County	Total Number	Airport	Special Needs	Communication	Correctional Institutions	Dams	Electric Power	EMS	EOC	Ferry	Fire	Highway Bridges	Highway Tunnels	Light Rail Facilities	Medical	Military	Natural Gas	Oil	Police	Ports	Potable Water	Rail Facilities	Rail Tunnels	School	Shelters	Storage of Critical Records	Wastewater
Atlantic	388	-	3	-	-	25	2	23	-	-	24	2	-	-	4	-	-	-	10	-	1	2	-	40	18	-	2
Bergen	1,148	1	7	-	1	11	2	16	-	-	22	-	-	-	-	-	-	-	12	-	3	9	-	51	31	-	4
Burlington	747	-	1	-	-	19	-	12	-	-	14	3	-	5	-	-	-	-	7	-	-	-	-	15	13	-	10
Camden	701	-	5	-	2	14	-	11	-	-	14	3	-	5	3	-	-	-	10	1	1	1	-	46	15	-	2
Cape May	229	2	10	-	-	14	-	29	1	1	33	-	-	-	1	1	-	-	13	1	1	-	-	36	51	-	6
Cumberland	251	-	-	-	2	18	-	11	-	-	12	-	-	-	-	-	-	-	1	-	-	-	-	7	7	-	2
Essex	784	1	-	-	2	-	1	1	-	-	5	2	-	2	1	-	-	-	7	3	-	3	-	17	2	-	2
Gloucester	346	-	-	-	-	16	-	5	-	-	9	1	-	-	1	-	-	-	7	-	-	-	-	14	-	-	3
Hudson	493	-	2	1	1	-	2	10	-	3	22	1	2	21	4	-	1	-	6	4	2	7	-	72	22	-	5
Hunterdon	328	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercer	538	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middlesex	816	-	3	-	2	13	-	18	-	-	15	1	-	-	1	-	-	-	8	-	3	2	-	41	16	-	3
Monmouth	905	-	10	-	-	24	-	57	-	2	53	-	-	-	3	1	-	-	27	1	-	10	-	76	7	-	8
Morris	913	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocean	621	-	6	-	-	22	-	53	-	-	39	-	-	-	1	-	-	-	20	-	-	2	-	32	10	1	2
Passaic	648	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-
Salem	201	-	5	-	-	19	-	14	-	-	15	1	-	-	1	-	-	-	6	-	-	-	-	23	24	-	3
Somerset	539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sussex	542	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Union	607	-	3	-	1	6	1	8	-	-	10	1	-	-	2	-	-	-	6	5	1	3	-	44	42	-	4
Warren	351	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	12,096	4	55	1	11	203	8	268	1	6	287	15	2	33	22	2	1	-	140	15	12	39	-	518	258	1	56

Roads and bridges are also considered critical infrastructure, particularly those providing ingress and egress for evacuees and those allowing emergency vehicles access to those in need.

As discussed in the New Jersey Hurricane Evacuation Study Transportation Analysis, Cape May, Atlantic, Ocean, and Monmouth Counties are principal origination points for evacuation movements in the State during a hurricane evacuation event. These counties include significant westbound and northbound evacuation routes. The study contains maps illustrating the traffic evacuation zones and the storm surge limits by county. During major evacuation scenarios, lane reversal or contraflow may be utilized on major limited or controlled access highways to reduce the duration of an evacuation by opening up additional lanes in one direction.

As the State of New Jersey continues to grow from a development standpoint, State facilities need to be located where they will serve the population base. Populations continue to grow in existing urban areas within hurricane and tropical storm hazard areas. These areas will continue to be prone to the impacts of these hazards and as the population grows; however, as discussed above, improved mapping, elevation data, and regulatory changes will mitigate future damages to new development and areas being rebuilt after a hazard event.

5.8.7.5 ESTIMATING POTENTIAL LOSSES TO STATE FACILITIES

The previous plan calculated losses using FEMA's Region IV's SLOSH model developed for the Coastal Flood Loss Atlas. The Federal Emergency Management Agency (FEMA) Region IV Risk Analysis Team developed the Coastal Flood Loss Atlas (CFLA) as part of a comprehensive risk management strategy of the Mitigation Division to better assess and properly mitigate the risks and vulnerabilities associated with storm surge.

Through this method storm surge inundation grids from the National Hurricane Center's SLOSH model, SLOSH maximum of maximum (MOM) outputs were developed. These are the worst-case storm surge scenarios for each Saffir-Simpson hurricane category under perfect storm conditions for the State. Using ArcMap, the SLOSH zones were overlaid with the population, general building stock, State building data (owned and leased) and critical facilities. The appropriate SLOSH zone determination (categories one through four) was then assigned. Further, the depth grids were incorporated into HAZUS-MH to estimate potential losses to State buildings. Please note, the SLOSH maps do not account for future sea- level rise scenarios.

The following is what was reported in the 2014 Plan Update. As mentioned earlier, all buildings, critical facilities, and infrastructure are exposed to hurricane and tropical storm winds and rain; however, those located within the surge inundation zones are at greater risk. To estimate potential losses to State buildings from storm surge, the FEMA Coastal Flood Loss Atlas depth grids were used in HAZUS-MH's coastal flood model to calculate the potential damage to the State building inventory.

In summary, as a result of a Category 1 event, HAZUS-MH estimates the following Counties will experience the greatest potential state building loss (greater than or equal to 10% of their total inventory) as a result of storm surge: Salem, Hudson, Bergen, Union and Atlantic (in descending order). Statewide, an estimated loss of nearly $41 million is estimated to the State building inventory. HAZUS-MH estimates potential building and content damage to the following State agencies: Department of Children and Families, Department of Corrections, Department of Education, Department of Environmental Protection, Department of Labor and Work Force Development, Department of Military and Veteran Affairs, Motor Vehicles Commission, State Police, Department of Transportation and Department of Treasury.

As a result of a Category 2 event, HAZUS-MH estimates the following Counties will experience the greatest potential State building loss (greater than or equal to 10% of their total inventory) as a result of storm surge: Hudson, Salem and Essex. Statewide, an estimated loss of nearly $200 million is estimated to the State building inventory. HAZUS-MH estimates potential building and content damage to the following State agencies: Department of Children and Families, Department of Corrections, Department of Education, Department of Environmental Protection, Department of Labor and Work Force Development, Law and Public Safety, Department of Military and Veteran Affairs, Motor Vehicles Commission, State Police, Department of Treasury and other agencies.

As a result of a Category 3 event, HAZUS-MH estimates the following Counties will experience the greatest potential state building loss (greater than or equal to 10% of their total inventory) as a result of storm surge: Salem, Hudson, Monmouth, Essex, Middlesex, Atlantic and Cape May. Statewide, an estimated loss of nearly $488 million is estimated to the State building inventory. HAZUS-MH estimates potential building and content damage to the following State agencies: Department of Children and Families, Department of Corrections, Department of Education, Department of Environmental Protection, Juvenile Justice Commission, Department of Labor and Work Force Development, Law and Public Safety, Department of Military and Veteran Affairs, Motor Vehicles Commission, State Police, Department of Transportation, Department of Treasury and other agencies.

As a result of a Category 4 event, HAZUS-MH estimates that 14 of the 21 Counties will experience potential building damage to state facilities. The following Counties will experience the greatest potential state building loss as a result of storm surge (greater than 20% of their total inventory): Salem, Hudson, Monmouth, Middlesex, and Union. Statewide, an estimated loss of nearly $716 million is estimated to the State building inventory.

HAZUS-MH estimates potential building and content damage to the following State agencies: Department of Children and Families, Department of Community Affairs, Department of Corrections, Department of Education, Department of Environmental Protection, Department of Human Services, Juvenile Justice Commission, Department of Labor and Work Force Development, Law and Public Safety, Department of State of New Jersey Military and Veteran Affairs, Motor Vehicles Commission, Department of State, State Police, Department of Transportation, Department of Treasury and other agencies.

Currently, that data is being updated and revised. It is recommended to use the revised data to calculate losses for the next plan update.