SECTION 3A - HAZARD PROFILES

Overview

This section includes detailed profiles for each of the hazards identified in the previous section and described in **Appendix 2.1**. Each hazard profile includes a general description of the location of each hazard, its extent (magnitude or severity), notable historical occurrences and the probability of future occurrences. Profiles also include specific items noted by members of the Planning Committee as it relates to unique historical or anecdotal hazard information for Atlantic County or a particular municipal jurisdiction.

As part of this plan update, revisions to this section include things such as: summaries of disaster activity since the previous update; updates to hazard area mapping based on new data that has become available since the previous update; incorporation of new hazard information that has become available in recent years; updated assessments of hazard descriptions, frequencies of occurrence, hazard histories; as well as updated information on the FEMA National Flood Insurance Program (NFIP), including Repetitive Loss Property and Severe Repetitive Loss Property information, and the latest flood mapping products and policy and claims data.

Table 3a.1 lists each significant hazard for Atlantic County and identifies whether or not it has been determined to be a specific hazard of concern for each of the 24 participating jurisdictions (the County and each of its 23 municipalities) based on best available data and local information provided by the Planning Committee (■ = hazard of concern).

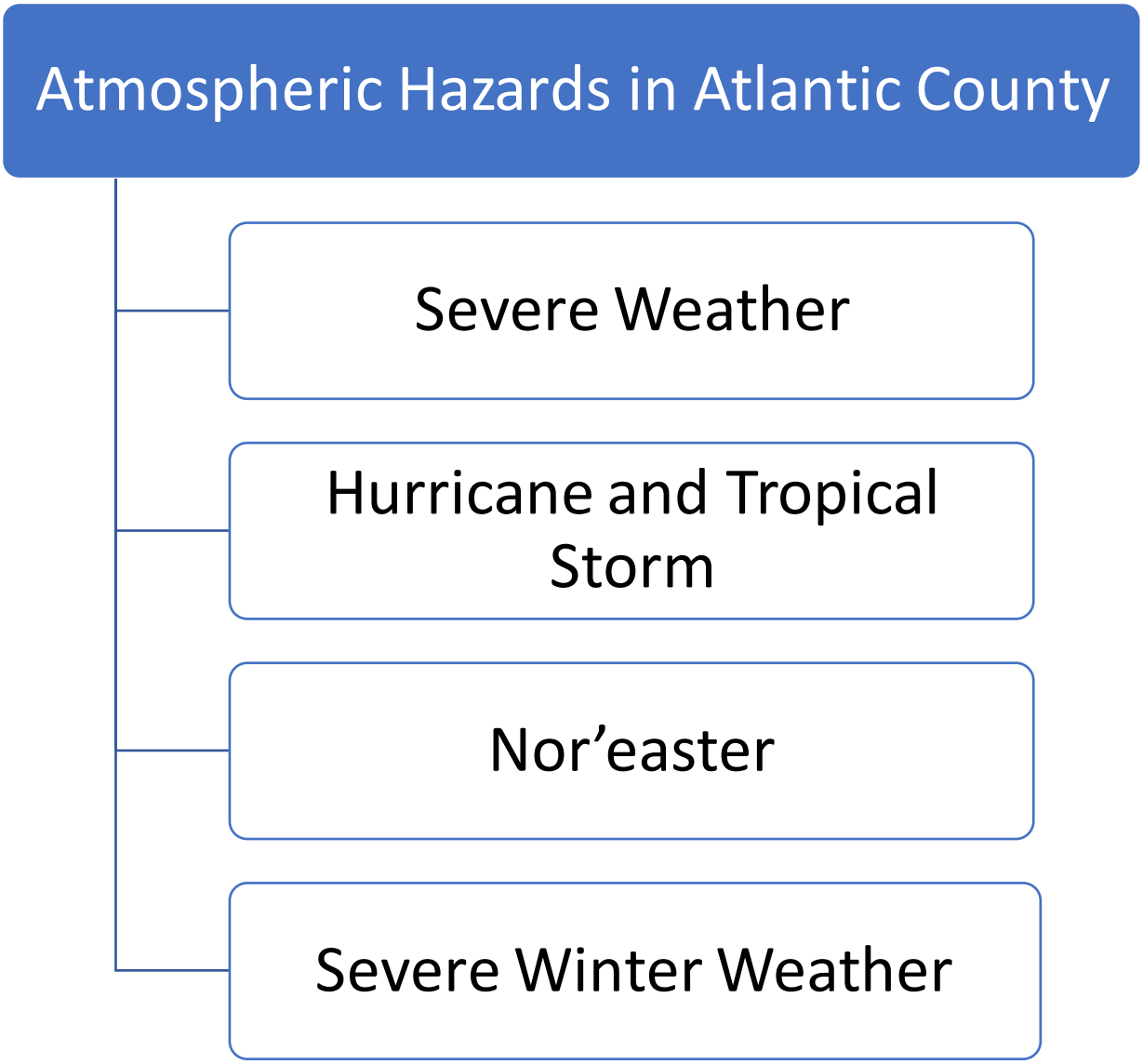
The remainder of this section will discuss, for each identified hazard, its:

- location (the geographic areas in the planning region that are affected by the hazard);
- extent (the strength or magnitude of the hazard);
- history of previous occurrences; and
- probability of future occurrences (the likelihood of the hazard occurring, in terms of general descriptors, historical frequencies, or statistical probabilities).

Table 3a.1
Summary of Identified Events in Atlantic County

Jurisdiction	Atmospheric				Hydrologic				Geologic	Other
	Severe Weather	Hurricane and Tropical Storm	Nor'easter	Severe Winter Weather	Coastal Erosion & Sea Level Rise	Dam and Levee Failure	Drought	Flood	Earthquake	Wildfire
Atlantic County	■	■	■	■	■	■	■	■	■	■
Absecon, City of	■	■	■	■	■	■	■	■	■	■
Atlantic City, City of	■	■	■	■	■		■	■	■	■
Brigantine, City of	■	■	■	■	■		■	■	■	■
Buena Vista, Township of	■	■	■	■		■	■	■	■	■
Buena, Borough of	■	■	■	■			■	■	■	■
Corbin City, City of	■	■	■	■	■		■	■	■	■
Egg Harbor City, City of	■	■	■	■		■	■	■	■	■
Egg Harbor, Township of	■	■	■	■	■	■	■	■	■	■
Estell Manor, City of	■	■	■	■	■	■	■	■	■	■
Folsom, Borough of	■	■	■	■		■	■	■	■	■
Galloway, Township of	■	■	■	■	■	■	■	■	■	■
Hamilton, Township of	■	■	■	■		■	■	■	■	■
Hammonton, Town of	■	■	■	■		■	■	■	■	■
Linwood, City of	■	■	■	■	■	■	■	■	■	■
Longport, Borough of	■	■	■	■	■		■	■	■	■
Margate City, City of	■	■	■	■	■		■	■	■	■
Mullica, Township of	■	■	■	■		■	■	■	■	■
Northfield, City of	■	■	■	■	■		■	■	■	■
Pleasantville, City of	■	■	■	■	■		■	■	■	■
Port Republic, City of	■	■	■	■	■	■	■	■	■	■
Somers Point, City of	■	■	■	■	■		■	■	■	■
Ventnor City, City of	■	■	■	■	■		■	■	■	■
Weymouth, Township of	■	■	■	■		■	■	■	■	■

ATMOSPHERIC HAZARDS



Severe Weather

Severe weather events are common in Atlantic County and can occur at any time. Severe weather events profiled in this section include extreme temperatures, extreme wind, hail storms, lightning, and tornadoes.

Extreme Temperatures

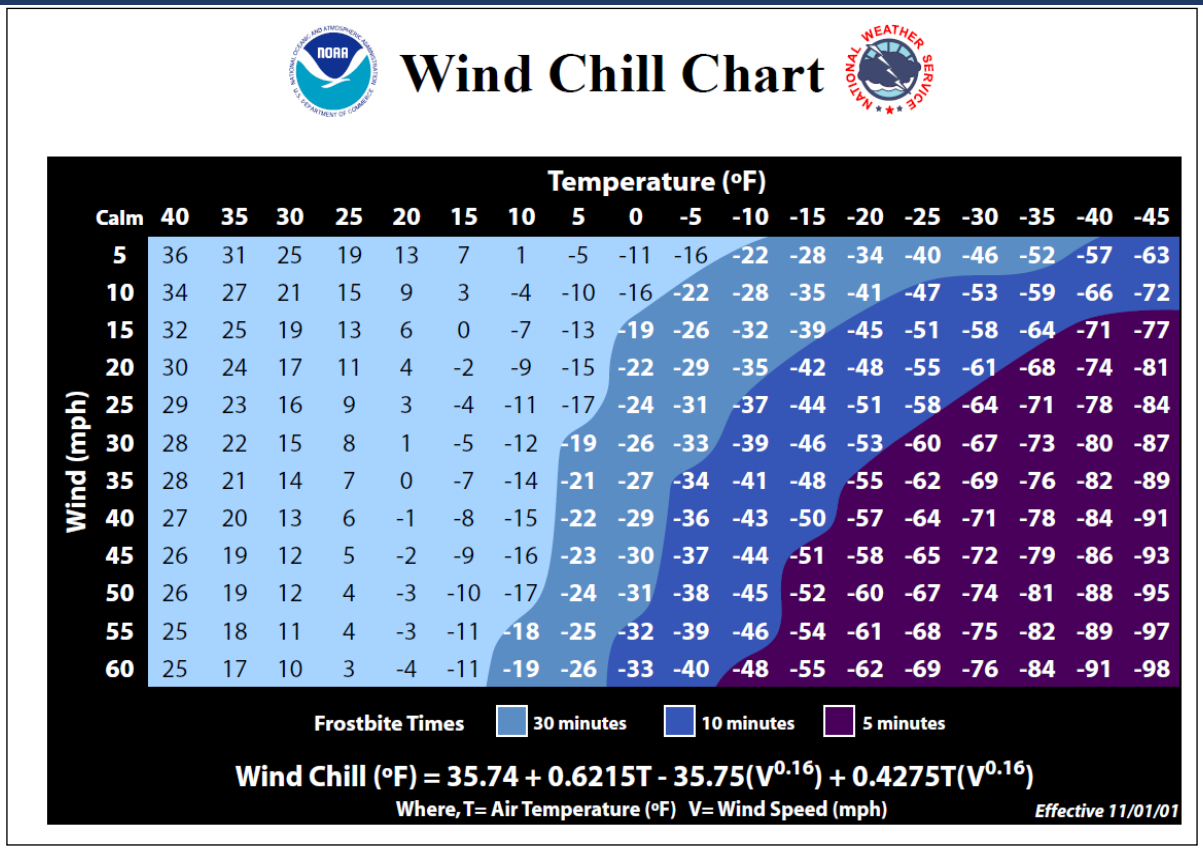
Location – Extreme Temperatures

Atlantic County is located in a region of the country that is susceptible to both extreme heat and extreme cold. During periods of extreme temperature conditions, the effects are felt over a widespread geographic area and it is generally assumed that the entire planning area is uniformly exposed to extreme heat and extreme cold. Areas along the immediate coast might experience minor differences in apparent temperatures due to the combined effects of air temperature, relative humidity, and wind speed.

Extent – Extreme Temperatures

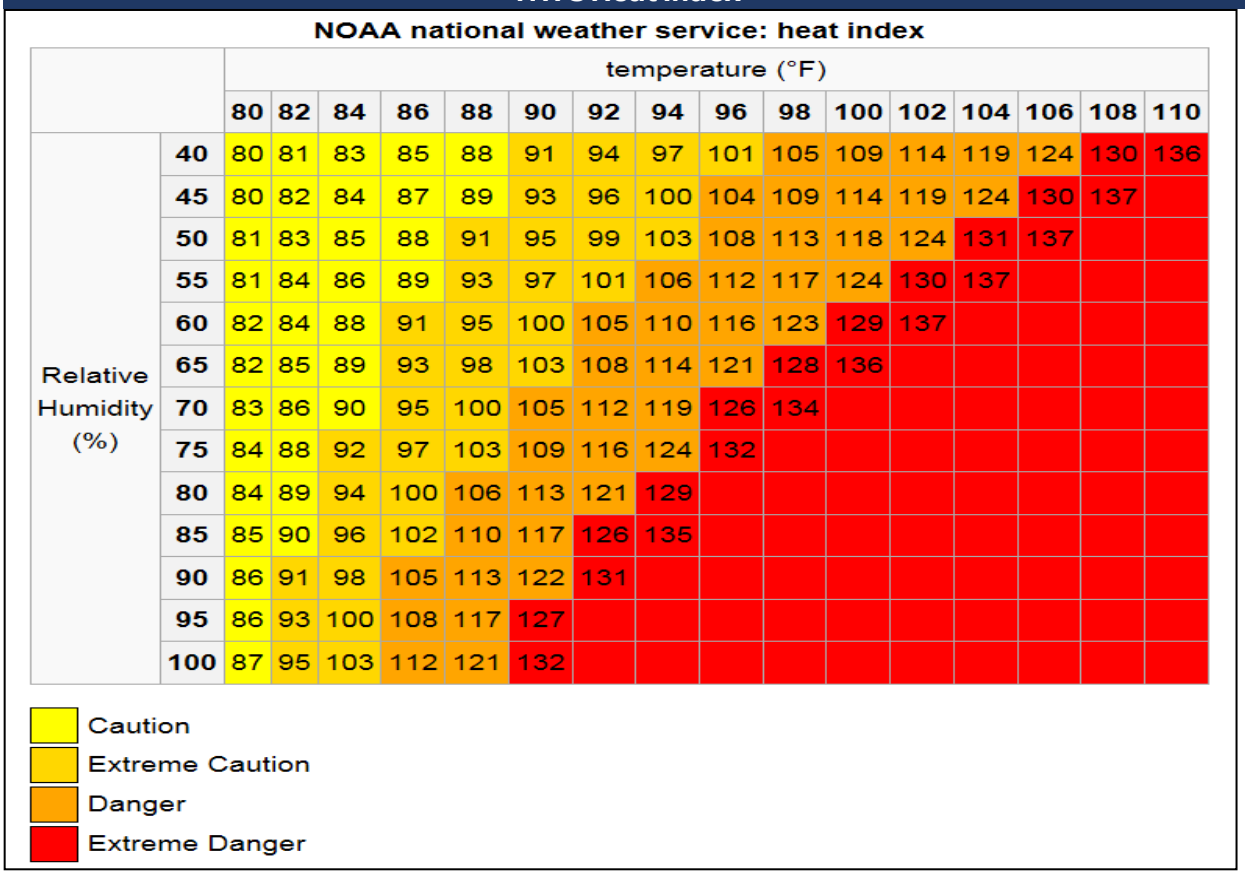
The speed of onset of extreme temperature events typically offers 24 hours of warning time. The duration of historic events in Atlantic County is typically less than one week. The extent of extremely cold temperatures is typically measured through the Wind Chill Temperature (WCT) Index. The WCT Index provides a formula for calculating the dangers from winter winds and freezing temperatures. It is, essentially, a calculation of the temperature that is felt when the effects of wind speed are added to the base air temperature. **Figure 3a.1** shows the NOAA NWS Wind Chill Chart.

Figure 3a.1
NWS Wind Chill Index



The extent of the extremely hot temperatures is typically measured through the Heat Index, which calculates the dangers from high relative humidity and extremely hot temperatures. It is, essentially, a calculation of the temperature that is felt when the effects of relative humidity are added to the base air temperature. **Figure 3a.2** shows the NOAA NWS Heat Index.

Figure 3a.2
NWS Heat Index



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

Historical Occurrences – Extreme Temperatures

According to the National Center for Environmental Information (NCEI) database (formerly the National Climatic Data Center)[1], 87 days of recorded **extreme heat** events have affected Atlantic County between February 1996 and May 2021. Of these events, two have occurred since the last version of the plan was approved in February 2016. Thirty-six injuries have been recorded in Atlantic County as a result of extreme heat, none of which have occurred since February 2016. Some *notable historic events* include the following:

July 14-15, 1995. An oppressive heat wave gripped most of New Jersey, with almost every location reporting record-breaking heat. Dew point temperatures reached into the 80s across southern New Jersey, an almost unheard of phenomenon. This, combined with sweltering temperatures, produced an apparent temperature (Heat Index) of 115 degrees in Pomona (Galloway Township). Statewide, nine people died and more than 100 people were treated for heat exhaustion; though no deaths were reported in Atlantic County.

June 25-26 1997. The first hot spell of 1997 brought the hottest weather in two years to New Jersey. The highest temperatures in the State reached near 100 degrees on the 25th. The highest temperatures recorded in Atlantic County included 98 degrees in Hammonton, 97 degrees in Estell Manor, and 96 degrees in Atlantic City.

[1] Current as of May 2021.

July 4-6, 1999. A very strong and oppressive high pressure system gave New Jersey a brutal heat wave over the Independence Day weekend. There were 17 heat related deaths and around 100 reported heat related injuries state-wide. No deaths were recorded in Atlantic County. The combination of the temperature and humidity produced heat indices of around 110 degrees, leading to record demand for electricity. Over 110,000 homes and businesses lost power state-wide by either intentional or unintentional blackouts. High temperatures included 102 degrees in Margate City.

August 1-3, 2006. Temperatures during this event soared well into the 90s with some areas more than 100 degrees. Atlantic City topped out at 98 degrees on both August 2nd and 3rd. Sporadic power outages affected pockets of people for up to two hours at a time. New Jersey American Water asked customers to immediately begin conserving water on August 2nd in seven Atlantic County towns as the excessive heat and dry weather led to a record high water usage. The conservation request affected 115,096 residents in Absecon, Galloway, Egg Harbor Township, Linwood, Northfield, Pleasantville, and Somers Point.

July 21 2011. This event represented one of the most oppressive heat waves in New Jersey since July 1995. The heat was responsible for two deaths and hundreds of heat related injuries across the state. Many locations recorded high temperatures into the 100s. Heat index values on July 22nd ranged from 110F to 120F. High temperatures in Atlantic County included 105 degrees at the Atlantic City International Airport. The highest hourly heat index at the Atlantic City International Airport was 122 degrees on the 22nd.

June 17-18, 2014. High temperatures were in the lower to mid-90s both days with the hottest weather on the 18th. Afternoon heat index values were in the mid-90s both days. Highest temperatures included 97 degrees in Margate, and 95 degrees at the Atlantic City International Airport.

June 23, 2015. Unseasonably hot and humid weather occurred across southern New Jersey on the 23rd with high temperatures reaching into the lower to mid-90s and afternoon heat indices of around 100F. About 30 people had to be treated for heat exhaustion at the Egg Harbor Township graduation. A high temperature of 94 degrees was recorded at the Atlantic City International Airport.

According to the NCEI database, 30 recorded **extreme cold** events have affected Atlantic County between February 1996 and May 2021, though no such events have occurred since the last version of the plan was approved in 2016. No deaths or property damage was reported but 7 people did suffer injuries. A *sampling of more notable events* includes the following[2]:

February 4-6, 1996. The coldest air mass of the winter season moved in after the snow storm of the 2nd and 3rd. Most locations had low temperatures below zero on the 5th and 6th. In central New Jersey alone, the Automobile Association of America (AAA) responded to over 900 calls of dead batteries the morning of the 5th. Low temperatures the morning of the 5th included 10 degrees below zero in Estell Manor and 8 degrees below zero at Atlantic City International Airport. Low temperatures the morning of the 6th included 3 degrees below zero at Atlantic City International Airport.

January 14-19, 2003. For many locales, these were the coldest days in three years. The coldest mornings were on the 18th and 28th as low temperatures dipped into the single digits or below

[2] All temperatures are reported in degrees Fahrenheit.

zero. There were several cases of either frostbite or hypothermia throughout the state. The extreme cold filled homeless shelters to capacity in many places. Many dead vehicle batteries and frozen brakes were reported. Calls to heating oil firms and utilities rose dramatically. Several water mains broke and pipes burst in both owner occupied homes and in vacant summer homes which were not properly winterized. Lowest temperatures included 2 degrees below zero in Estell Manor and 3 degrees at the Atlantic City International Airport.

January 28, 2005. Low temperatures across the state hovered around zero degrees. The unseasonably cold weather prompted code blue declarations to help the homeless, elderly, homebound and poor; and resulting in a high demand for heating oil, natural gas and electricity. A low temperature of 3 degrees was reported at the Atlantic City International Airport.

January 16-18, 2009. The majority of the state experienced wind chill values between 0 and 10 degrees below zero during early morning hours of the 16th and 17th. The coldest wind chill value was recorded at the Sussex Airport (Sussex County) of 14 degrees below zero. The low temperatures on the 17th were the coldest in some time across the region. As an example, 4 degrees was the morning low at the Atlantic City International Airport, which was the coldest since March 8, 2007, when it was 4 degrees.

January 4-7 and January 22, 2014. A high pressure system coupled with fresh snow cover from the winter storm on the 2nd and 3rd gave the area one of its coldest winter morning in years on January 4th. The low temperature reached a daily record breaking 3 degrees below zero at the Atlantic City International Airport, the coldest of the meteorological winter and the coldest since February 5, 1996 when the low reached 8 degrees below zero. Other low temperatures on the morning of the 4th included 13 degrees above zero in Margate 14 degrees above zero at the Atlantic City Marina. The excessive cold on January 7th caused many schools to either cancel classes or delay openings. AAA Mid-Atlantic reported an 81 percent increase in service calls, mainly for dead batteries. Amtrak reported extensive delays in its rail service. Electricity suppliers struggled to keep up with surging demand; some power plants were forced to shut down. An all-time winter record usage was recorded at 8 a.m. on the 7th. Lowest hourly wind chill factors included 18 degrees below zero at the Atlantic City International Airport. Another arctic air mass dropped low temperatures on the morning of the 22nd. An hourly wind chill of 10 degrees below zero was recorded at the Atlantic City International Airport (corresponding to an actual temperature of 5 degrees above zero at this same location).

February 16, 2015. The arrival of an arctic high pressure system to New Jersey brought some of the lowest wind chills and temperatures of the winter season to New Jersey. Wind chill factors as low as around 20 degrees below zero occurred in most of the state. Actual low temperatures were around zero. Outreach teams were dispatched to get homeless people to shelters. Code Blues remained in effect. The extreme cold weather caused pipes to freeze and AAA Mid-Atlantic responded to more than 1,600 dead battery calls. Plumbers said they had not been this busy with frozen pipes in over 20 years. Lowest hourly wind chill factors included 19 degrees below zero in Atlantic City. Actual low temperatures included 2 degrees above zero at the Atlantic City International Airport. The low temperature of 2 degrees above zero at the Atlantic City International Airport established a new daily record low for February 16th which stood since 1888.

Probability of Occurrence – Extreme Temperatures

Extreme temperature events will continue to have a high probability of occurrence in Atlantic County, and the probability of future occurrences in Atlantic County is certain (higher for extreme heat than extreme cold). While the impact of such occurrences on people and property is

typically minimal, it is anticipated that the threat to human lives and safety is increasing due to growing elderly populations in many of Atlantic County's municipal jurisdictions. The New Jersey State Hazard Mitigation Plan states: "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)."

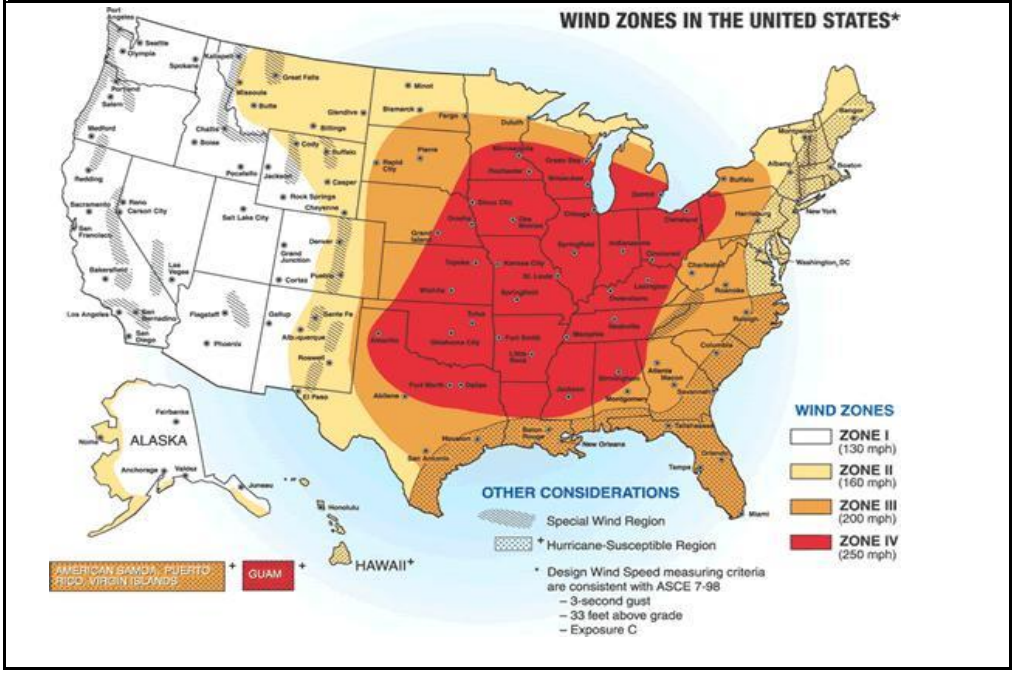
The 2019 New Jersey State Hazard Mitigation Plan states: "Extreme temperatures are predicted to occur more frequently as part of regular seasons. Specifically, extreme heat may continue to impact New Jersey and, based upon data presented, may increase in the next several decades." Many heat records have been set in the last 10 to 15 years while record-setting cold temperatures are decreasing; this trend is likely to continue.

Extreme Wind

Location – Extreme Wind

Extreme wind events are experienced in every region of the United States. The extreme wind hazard area covers the whole of Atlantic County and the entire planning area is uniformly susceptible to the extreme wind hazard. **Figure 3a.3** illustrates various wind zones throughout the country based on design wind speeds established by the American Society of Civil Engineers. It divides the country into four wind zones, geographically representing the frequency and magnitude of potential extreme wind events including severe thunderstorms, tornadoes and hurricanes. The figure shows that all areas of Atlantic County are located within Zone II and are susceptible to hurricanes, with a design wind speed for shelters of 160 mph (3-second gust).

Figure 3a.3
Wind Zones in the United States



Source: Federal Emergency Management Agency

Extent – Extreme Wind

Extreme wind can occur alone, such as during straight-line wind events and derechos, or it can accompany other natural hazards, including hurricanes and severe thunderstorms. Severe wind poses a threat to lives, property, and vital utilities primarily due to the effects of flying debris or downed trees and power lines. Severe wind will typically cause the greatest damage to structures of light construction, particularly manufactured homes. **Table 3a.2** illustrates the severity and typical effects of various sustained wind speeds. These would be reflective of high winds associated with thunderstorms, hurricanes, tropical storms and nor'easters. Typical effects of wind are very different for tornadoes. **Table 3a.3** illustrates the severity and typical effects of wind during tornadoes, as measured by various 3 second gusts. Note that tornadoes are addressed separately later in this plan section.

Table 3a.2
Severity and Typical Effects of Various Sustained Wind Speeds

Sustained Wind Speed* (mph)	Equivalent Saffir-Simpson Scale** (Hurricanes)	Severity of Damage	Typical Effects
0-73 *(V_{3S}=0 to 88)*	N/A	Isolated	Isolated damage for winds below 50 mph. Above 50 mph, expect some minor damage to buildings of light material. Small branches blown from trees.
74-95 *(V_{3S} =89 to 115)*	1	Minor	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, and 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.
96-110 *(V_{3S}=116 to 130)*	2	Extensive	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
111-129 *(V_{3S}=131 to 149)*	3	Devastating	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
130-156 *(V_{3S}=150 to 176*	4	Catastrophic	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
157 or higher *(V_{3S}>177)*	5	Catastrophic	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: National Oceanic and Atmospheric Administration

* *The 2003 International Building Code Table 1609.3.1 was used to convert Saffir-Simpson sustained wind speeds to 3- second gusts (V_{3S}) for the purposes of comparison between hurricane and tornado winds.*

TABLE 1609.3.1
EQUIVALENT BASIC WIND SPEEDS[a,b,c]

V_{3S}	85	90	100	105	110	120	125	130	140	145	150	160	170
V_{fm}	70	75	80	85	90	100	105	110	120	125	130	140	150

For SI: 1 mile per hour = 0.44 m/s.
a. Linear interpolation is permitted.
b. V_{3S} is the 3-second gust wind speed (mph).
c. V_{fm} is the fastest mile wind speed (mph).

** *The Saffir-Simpson Scale is described further in this section under Hurricanes.*

Table 3a.3 Severity and Typical Effects of Various Tornado Wind Speeds (3 second gust)			
Maximum Wind Speeds 3 Second Gust (mph)	**Equivalent Enhanced Fujita Scale* (Tornadoes)**	**Severity**	**Typical Effects**
65-85	EF0	Light	Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
86-110	EF1	Moderate	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
111-135	EF2	Significant	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; high-rise windows broken and blown in; light-object missiles generated.
136-165	EF3	Severe	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
166-200	EF4	Devastating	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
Over 200	EF5	Incredible	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; steel reinforced concrete structures badly damaged.

Source: National Oceanic and Atmospheric Administration
** The Enhanced Fujita Scale is described further in this section under Tornadoes.*

Historical Occurrences – Extreme Wind

Atlantic County has experienced numerous types of damaging extreme wind events in the past including severe thunderstorms, tornadoes, hurricanes, tropical storms and nor'easters. According to the NCEI database[3], 315 days with recorded high wind events have affected Atlantic County from September 1956 to June 2015 (data excludes tornado events which are addressed separately within this section). These incidents resulted in a reported total of eight injuries, and roughly $424 million in property damages ($400 million of which are related to Superstorm Sandy wind damages alone). Thirty days with high wind events have been recorded after the last version of this plan was approved in February 2016. Extreme wind events occur regularly in Atlantic County. Most events are associated with thunderstorms occurring during the summer months, with relatively low reported property damages per event (in the thousands of dollars). However, stronger weather systems have produced much more extreme and widespread wind-related impacts. A sampling of more *notable extreme, damage-causing events* includes the following:

> **February 17, 2003.** Strong winds during a powerful winter storm caused $300,000 in wind-related property damage in Atlantic County. U.S. Route 30 was closed for three miles between Atlantic City and Absecon on the 17th because 56 light poles were

[3] Data current as of May 2021.

knocked down. Homes and businesses lost power. The strong winds carried sand onto nearby roads, porches and boardwalks. Sand drifts blocked several roadways. Peak wind gusts of 53 mph were recorded at the Atlantic City International Airport.

September 18, 2003. Extreme winds during Tropical Storm Isabel caused $500,000 in damage to property in Atlantic County. Winds gusted up to 53 mph at the Atlantic City Marina and downed trees, tree limbs, and power lines causing one of the worst power outages on record for area utilities.

January 18, 2006. Extreme winds during a winter storm caused damage throughout the state. Strong west winds occurred from late in the morning through most of the afternoon before diminishing at night. Numerous trees and power lines were downed, causing travel delays during the morning rush due to closed roads. Several roofs were torn away. More roofs and homes were damaged by downed trees. Vehicles were also damaged by downed trees. Throughout the state about 150,000 homes and businesses lost power. About $635,000 in wind-related property damage was reported in Atlantic County alone. Downed trees and wires forced traffic to be routed onto the White Horse Pike (U.S. Route 30) and the Atlantic City Expressway. A piece of a large sign at the Trump Plaza Hotel and Casino fell down and caused a road closure. Peak wind gusts included 59 mph in Hammonton and 48 mph at the Atlantic City International Airport.

November 12, 2009. A powerful nor'easter caused more than $500,000 in wind-related property damage in Atlantic County. The highest winds occurred from the afternoon of the 12th into the afternoon of the 13th. Hundreds of people lost power. Peak wind gusts included 59 mph at the Atlantic City Marina and 47 mph at the Atlantic City International Airport.

March 13, 2010. Approximately $6.2 million in wind-related property damage was reported in Atlantic County as a strong winter storm hit the state. Trees, tree limbs, power lines, telephone poles were downed, causing record breaking power outages, damages to homes, and transportation impacts from closed roadways until debris could be removed. In Atlantic City, boom debris from a partially collapsed 780-foot crane at the Revel Entertainment site fell down on a four block area. A police officer was injured from the falling debris. Four stories of glass were also damaged. About 385 people who live near the crane site were evacuated for two days until the crane was lowered. Elsewhere in Atlantic City, the roof of one home was torn away, the front of a building collapsed, the roof above a cleaning establishment was partially torn away and a home under construction collapsed. Peak wind gusts included 73 mph at the Marina in Atlantic City and 67 mph at the Atlantic City International Airport.

June 29, 2012 - Derecho[4]. - The June 2012 North American Derecho took out electrical power to more than 3.7 million customers starting in the Midwestern United

[4] The National Weather Service defines a **derecho** as a widespread, long-lived, straight-line wind storm that is associated with a land-based, fast-moving group or band of severe thunderstorms that have winds of at least 58 miles per hour along the entire span of the storm front, maintained over a time span of at least six hours. They typically possess a high or rapidly increasing forward speed and can cause hurricane force winds, tornadoes, heavy rains, and flash floods. Winds take on a bow echo (backward "C") form of squall line on weather radar. Derechos are a warm-weather phenomenon, usually occurring during the summer months. Winds in a derecho can be enhanced by downburst clusters embedded inside the storm.

States, across the central Appalachians, into the Mid-Atlantic States during a heat wave. In New Jersey, the Derecho produced widespread, significant wind damage from southern New Jersey southward into the Delmarva during the late evening and overnight of the 29th. Salem, Cumberland and Atlantic Counties were the hardest hit counties in the state, with downed trees, power lines and poles, which sparked fires and destroyed some homes. In Atlantic County, one storm related death was reported - a man whose boat capsized in Absecon Bay. A state of emergency was declared in Atlantic County. The National Guard was mobilized to help provide fuel and water. Atlantic City Electric reported that 105,000 homes and businesses in Atlantic County lost power. Destructive wind gusts, measuring around 75 miles per hour, resulted in significant tree and power line damage county-wide. Based on the extensive damage, winds were estimated to be as high as 90 miles per hour in areas across the county. There were seven homes that were destroyed, forty-nine that suffered major damage, fifty-two that suffered minor damage and forty-two others that were affected. Extensive damage occurred across Atlantic County as a result of the strong wind gusts associated with the gust front and cluster of severe thunderstorms, and a State of Emergency was declared in the county. An idle 727 aircraft was moved and damaged by the Derecho at the Atlantic City International Airport. Numerous large trees and electric wires were knocked down in many communities, including Estell Manor, Northfield, Mays Landing, Egg Harbor City, Hamilton Township, Galloway Township, Linwood, Margate City, Egg Harbor Township, Ventnor City, Longport, and Atlantic City. As a result, much of the county was affected by long-term power outages, and numerous roads were impassable. In addition to the widespread tree and power line damage, structural damage was also significant across the county, with trees blown down onto houses in Buena and Absecon and shingles blown off of homes in Somers Point. Thousands of customers experienced power outages for about one week. Approximately 1,400 Atlantic City Electric customers that had lost power during the early morning of June 30th did not have their electricity restored until July 8th.

October 29, 2012 – Superstorm Sandy[5]. When Superstorm Sandy made landfall, sustained winds of as high as 60 to 70 miles per hour battered New Jersey, with gusts as high as 80 to 90 miles per hour. Most of the peak wind gusts occurred during the late afternoon and evening hours as Sandy was making landfall. Most of the high winds in the state were over by midnight, and as Sandy rapidly weakened, most of the strong wind gusts were also over by 6 a.m. on the 30th. The most widespread measured hurricane force wind gusts occurred in northern Ocean County and in Monmouth County. In Atlantic County, the northern end of the famed Atlantic City boardwalk was destroyed. The wind damaged boardwalks within the city. Nearly every Atlantic County municipality from Egg Harbor and Galloway Townships eastward suffered widespread wind and/or tide damage. Peak wind gusts included 77 miles per hour at the Atlantic City Marina, 66 miles per hour in Absecon, and 64 miles per hour at the Atlantic City International Airport. Maximum sustained winds of 51 miles per hour were recorded in Atlantic City. Downed trees and power lines damaged homes and vehicles, and blocked roadways throughout the county. Sandy caused $400 million in wind-related property damage in Atlantic County alone.

[5] This section focuses on impacts from the wind hazard of Superstorm Sandy. Other sections of the hazard profile focus on impacts from other hazards during this event, such as flooding, storm surge, wave damage, etc.

Probability of Occurrence – Extreme Wind

Extreme wind events will continue to have a high probability of occurrence in Atlantic County, and the probability of future occurrences in Atlantic County is certain. The entire planning area is susceptible to a wide variety of recurring events that cause extreme wind conditions including severe thunderstorms (most frequent), tornadoes, hurricanes, tropical storms and nor'easters. Based on historic occurrence data, Atlantic County can expect between four and nine extreme wind days per year[6].

Hail Storms

Hail is a form of frozen precipitation, consisting of solid ice that forms inside thunderstorm updrafts.[7]

Location and Extent – Hail Storms

It is generally assumed that the entire planning area is uniformly exposed to hail storm events.

While hail can result from many different types of storms, it typically occurs during thunderstorm events. The extent of a hail storm can be measured by comparing the size of hail to known objects. Various extents of hail are summarized in **Table 3a.4**.

Table 3a.4
Hail Size[8]

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

[6] More than four extreme wind days per year is based on the NCEI database period of record of 65.5 years and 285 event days. However, the database is not particularly robust for its initial years of coverage between 1956 and 1996 during which only 54 event days are recorded. When the same calculation of extreme wind days per year is done using only the 25.5 years of robust record keeping and 231 event days during that period, the estimate of extreme wind days per year goes up to 9.
[7] Source: https://www.nssl.noaa.gov/education/svrwx101/hail/
[8] https://www.weather.gov/boi/hailsize

Historical Occurrences – Hail Storms

The NCEI database reports 37 hail days (with 3/4 inch size hail or greater) for Atlantic County between July 1974 and January 2021. For these events there are no recorded deaths or injuries, but $10,000 in property damage and $5.01 million in crop damages. These damages were incurred during only two of the total number of reported events: (a) August 2008, Hammonton, with ping pong ball sized hail causing $5M in crop damages; and (b) $20,000 in damages to vehicles and crops in Buena Vista Township in June 2011..

Probability of Occurrence – Hail Storms

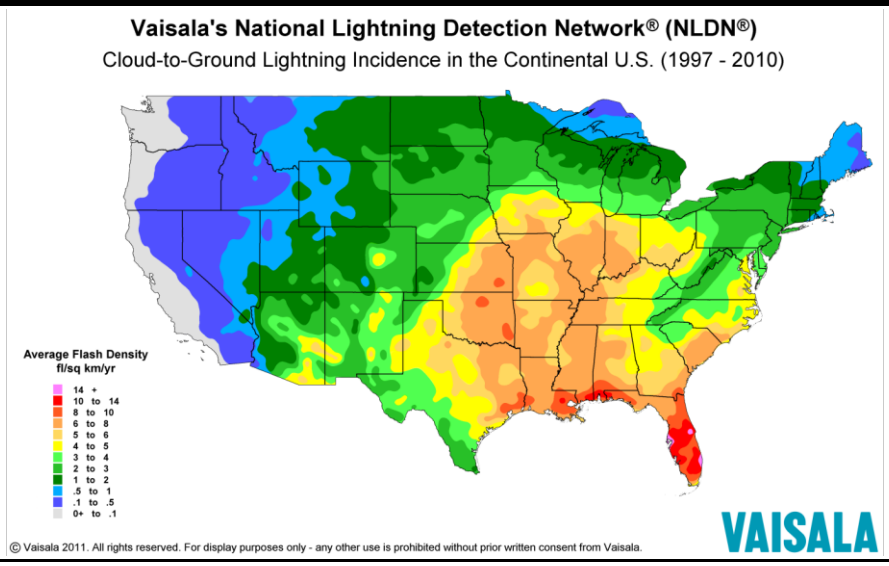
According to the New Jersey State Hazard Mitigation Plan, hail storms occur regularly in New Jersey but not at the frequency or intensity of thunderstorms. Damaging hail storms that occur regularly in other parts of the United States do not occur with significant frequency in New Jersey.

Lightning

Location and Extent – Lightning

Atlantic County is located in a region of the country that is susceptible to lightning strikes, though not as susceptible as southeastern states. **Figure 3a.4** shows a lightning flash density map for the years 1997-2010 based upon data provided by Vaisala's National Lightning Detection Network® (NLDN®)[9].

Figure 3a.4
Lightning Flash Density in the United States



All areas of Atlantic County are equally susceptible to lightning strike. While lightning occurs randomly anywhere and anytime, the most common location for lightning fatalities and injuries to people is in open areas such as parks, beaches, golf courses and other recreational areas.

[9] Source: http://www.vaisala.com/Vaisala%20Documents/Scientific%20papers/2014%20ILDC%20ILMC/ILMC-Thursday/Roeder%20et%20al-Mapping%20Lightning%20Fatality%20Risk-2014-ILDC-ILMC.pdf

Atlantic County remains susceptible to lightning deaths and injuries due to the large number of people who engage in outdoor activities, particularly more so along the shoreline of its coastal jurisdictions.

Historical Occurrences – Lightning

According to the NCEI database[10], 24 lightning days have been recorded in Atlantic County between April 2001 and May 2021. These incidents resulted in a reported total of two deaths and six injuries, and caused more than $1.3 million in property damages. A total of eight events were added to the database since the last version of this plan was approved in 2016. Some *more notable events* include the following:

April 18, 2002. Lightning strikes in Hamilton Township started a couple of small brush fires, struck a senior citizen center and damaged the municipal emergency center's telephone lines and radio communications. A dollar estimate of property damage for this event was not reported in the NCEI database.

June 6, 2002. Lightning struck the parking lot of a closed service station in Somers Point. The lightning traveled to the underground gasoline tank. The subsequent explosion created a crater about 50 feet in diameter and 8 to 10 feet deep. No serious injuries were reported. Lightning also struck the roof of a home in Pleasantville, causing a fire. A dollar estimate of property damage for this event was not reported in the NCEI database.

August 5, 2002. Lightning struck a house under construction in the City of Brigantine. It also struck a construction worker at the site and injured him. Another lightning strike hit a garage, causing a fire which spread to the home. Lightning also struck an antenna on a hotel roof. Guests were evacuated from the hotel. No fire occurred. Brigantine Beach Patrol's radio tower was also struck by lightning as were two radio stations' antennas. About 1,200 Conectiv customers lost power in Brigantine, Northfield and Egg Harbor Township. Property damage was reported as $30,000.

July 18, 2005. Atlantic City Electric reported about 4,500 homes and businesses lost power in Ocean and Atlantic Counties during a thunderstorm event. Outages in Atlantic County were concentrated in Galloway. A dollar estimate of property damage for this event was not reported in the NCEI database.

June 29, 2008. A lightning strike and ensuing fire destroyed the landmark Sweetwater Casino Restaurant in Mullica Township. Lightning struck the restaurant's electrical system. When firefighters arrived, the building was already engulfed in flames. One million dollars in property damage was reported for this event.

July 3, 2011. A lightning strike to Lucy the Elephant in Margate caused significant damage to the tourist attraction's electrical and climate control system. The computer printers, air conditioning controllers, lighting and fire alarm controllers all suffered electrical damage. Ten thousand dollars in property damage was reported. Lucy was hit by lightning in 2007 as well. That hit caused

[10] Data current as of May 2021.

$162,000 worth of damage to her riding carriage. Lightning rods were installed after that incident; they may have helped limit the damage from the 2011 strike.

June 30, 2012 – Derecho. The June 2012 North American Derecho took out electrical power to more than 3.7 million customers starting in the Midwestern United States, across the central Appalachians, into the Mid-Atlantic State. Salem, Cumberland and Atlantic Counties were the hardest hit NJ counties. During this event, a lightning strike and the ensuing fire gutted the 104-year-old Episcopal Church of the Redeemer in Longport. Firefighters had a difficult time battling the blaze as strong to damaging wind gusts were occurring with the Derecho at the time of the blaze. About $250,000 in property damage was reported.

Probability of Occurrence – Lightning

The probability of occurrence for future lightning events in Atlantic County is certain. Using the NLDN® data from Figure 3a.4, Atlantic County is located in an area of the country that experiences two to three lightning flashes per square kilometer per year (about 3,600 flashes countywide per year). Given this regular frequency of occurrence, it can be expected that future lightning events will continue to threaten life and cause minor property damages throughout Atlantic County.

A lightning strike and ensuing fire destroyed the landmark Sweetwater Casino Restaurant in Mullica Township on June 29, 2008. (photo courtesy of Elwood Fire Rescue)

Lucy the Margate Elephant, a National Historic Landmark built in 1881 by James V. Lafferty, has been struck twice by lightning in recent years, once in 2007 and again in 2011 (photo courtesy Wikipedia)

A lightning strike and ensuing fire during the June 2012 Derecho severely damaged the Episcopal Church of the Redeemer in Longport. (Sarah Watson/Press of Atlantic City)

Tornadoes

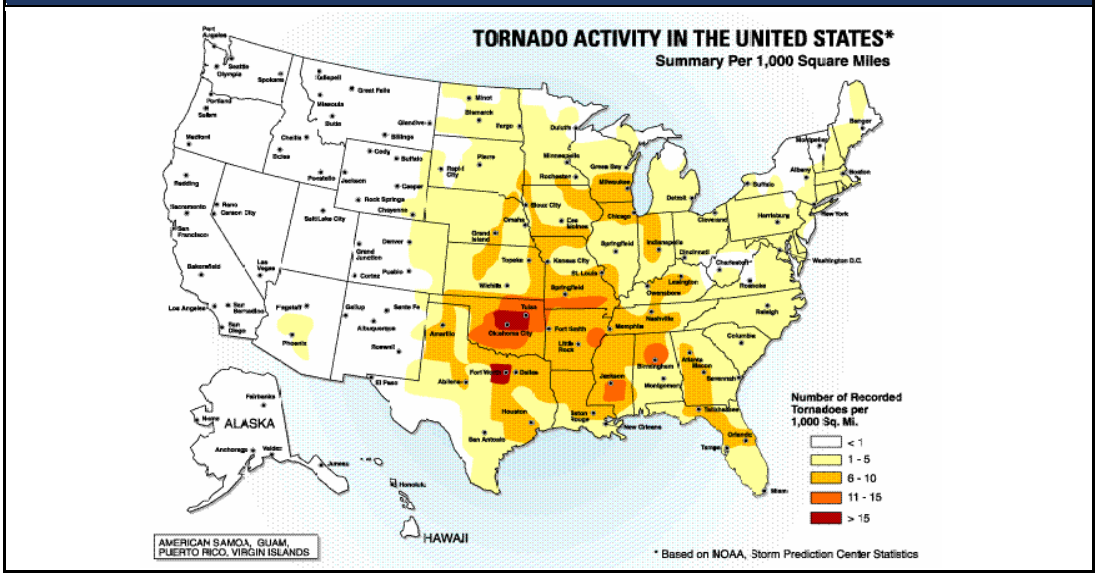
Location – Tornado

Atlantic County is located in an area that is susceptible to tornadoes, though their occurrence is not nearly as frequent or intense as it is in other regions of the country. Of the roughly five tornadoes that touch down in New Jersey each year, most tend to be of low magnitude (from EF0 to EF2) and typically impact only relatively small areas. **Figure 3a.5** shows tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles. Tornadoes are completely random and it is not possible to predict specific tornado hazard areas. Tornadoes can occur anywhere, and while the susceptibility to tornadoes can vary greatly with location across the United States, all of Atlantic County is uniformly exposed to the same degree.

Extent – Tornado

Table 3a.5 shows the Enhanced Fujita Scale for Tornadoes which was developed to measure tornado strength and associated damages. The tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

Figure 3a.5
Tornado Activity in the United States



Source: Federal Emergency Management Agency

Table 3a.5
Enhanced Fujita Scale for Tornadoes

Storm Category	Damage Level	3 Second Gust (mph)	Description of Damages	Photo Example
EF0	LIGHT	65–85	Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.	
EF1	MODERATE	86–110	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.	
EF2	SIGNIFICANT	111–135	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; highrise windows broken and blown in; light-object missiles generated.	
EF3	SEVERE	136–165	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.	
EF4	DEVASTATING	166–200	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.	
EF5	INCREDIBLE	200+	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 m (109 yd); trees debarked; steel reinforced concrete structures badly damaged.	

Source: National Oceanic and Atmospheric Administration; Federal Emergency Management Agency

Historical Occurrences – Tornado

According to the NCEI database[11], there have been seven recorded tornado days in Atlantic County between November 1970 and August 2021. Intensities ranged from F0 to F2 (note the Fujita Scale has since been superseded by the Enhanced Fujita Scale), as shown in **Table 3a.6**. These events resulted in three injuries and more than $1 million in property damages, approximately half of which are attributable to a tornado that touched down in Hammonton in August 1993. No new tornadoes have been recorded since the last version of the plan was approved in 2016. These are shown graphically in **Figure 3a.6.**

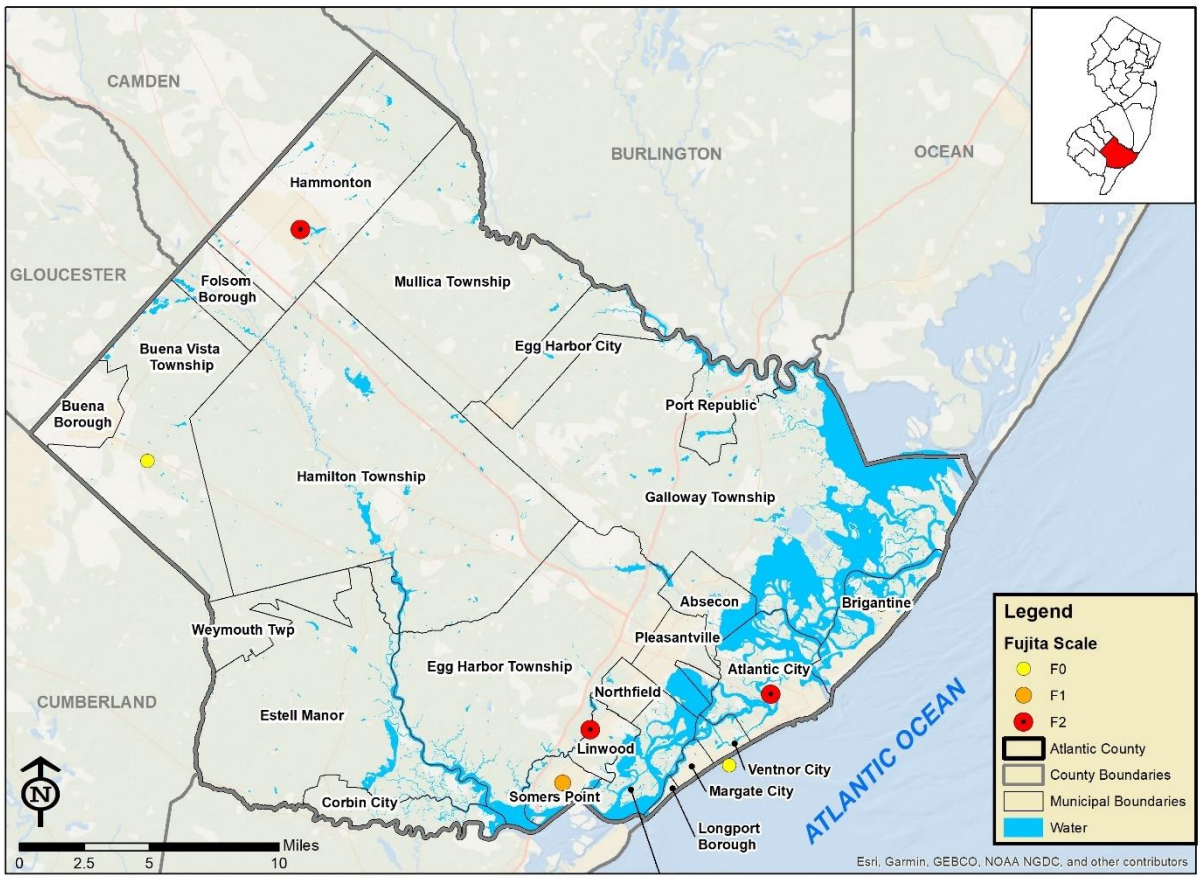
Table 3a.6
Historical Tornadoes in Atlantic County

Location	Date	NCEI Reported Magnitude	Deaths	Injuries	Property Damage
Atlantic City, City of	11/4/1970	F2	0	0	$250,000
Egg Harbor, Township of	7/21/1987	F2	0	3	$2,500
Buena Vista, Township of	8/5/1987	F0	0	0	$2,500
Ventnor City, City of	10/18/1990	F0	0	0	$250,000
Hammonton, Town of	8/21/1993	F2	0	0	$500,000
Brigantine, City of	9/8/1993	F0	0	0	$5,000
Cities of Somers Point and Linwood	7/5/2001	F1	0	0	$15,000
		Total	**0**	**3**	**$1,025,000**

Source: National Center for Environmental Information, 1970 to August 2021

[11] Data current as of August 2021.

Figure 3a.6
Historical Tornado Touchdown Locations, 1970-2021



SOURCE: NOAA National Centers for Environmental Information (NCEI) Storm Events Database, 2021; NJGIN: County Boundary, 2021; Municipal Boundary, 2021.
NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

Since the initial version of the plan was prepared in 2010, it is now customary to categorize tornado using an Enhanced Fujita Scale (EF-scale). The Enhanced F-scale is still a set of wind estimates (no measurements) based on damage. NCEI database records for historic occurrences, however – such as those shown for historic events in Atlantic County in **Table 3a.6** – are still provided in the old Fujita Scale (F-scale). **Table 3a.7** shows how the two scales compare to one another[12].

[12] As per www.spc.noaa.gov/faq/tornado/ef-scale.html

Table 3a.7 Comparison, Fujita Scale (F) versus Enhanced Fujita Scale (EF)			
Fujita Scale		Enhanced Fujita Scale	
F-Number	3 Second Gust (mph)	EF-Number	3 Second Gust (mph)
0	45-78	0	65-85
1	79-117	1	86-110
2	118-161	2	111-135
3	162-209	3	136-165
4	210-261	4	166-200
5	262-317	5	Over 200

Descriptions of the *most recent events* in Atlantic County include the following:

October 19, 1990. An F0 tornado struck Ventnor City on October 19, 1990, causing damage to trees, chimneys, and beachfront structures. Portions of roofs blew off, a shed was destroyed, and trees and utility poles were downed. A large wooden deck was blown off a high-rise building and went through the roof of a house next to the buildings.

August 21, 1993. A tornado touched down just northwest of Hammonton Lake which is oriented east-west in a heavily wooded area. The tornado moved east-southeast across the lake, becoming a waterspout. On the eastern edge of the lake, the tornado apparently lifted off the ground for about 500 feet and then touched down again farther east before dissipating. Tree damage was extensive, with several trees twisted, snapped off and uprooted. Numerous trees were 2 to 3 feet in diameter, with a few of the trees 4 to 5 feet in diameter. The damage suggested that the tornado hugged the northern edge of the lake more closely. One large portion of a tree was sent through the roof of a nearby house. Another house was damaged by a 3-foot diameter trunk falling over on its roof. A wooden boat dock, some 30 feet in length, was completely destroyed and tossed up on the land. A 10- foot by 10-foot wooden shed was demolished and its roof lifted and carried about 200 feet away. Some other observers reported automobiles being moved about by the wind, and large areas of sod being vacuumed off the ground leaving exposed root pits. Fortunately, there were no known injuries from the storm.

September 8, 1993. Four waterspouts were observed off the southern New Jersey coast in the midst of very moist and unstable atmospheric conditions. One waterspout was located 20 miles east of Barnegat, the other three were reported off the barrier island City of Brigantine. One of the three moved inland as a weak tornado at the northern end of the City of Brigantine. Police said the tornado moved southward tearing off roof shingles and tree limbs along its short path. One resident had a 55-pound barbecue grill tossed about 150 feet from its original position and an outdoor table destroyed. The funnel dissipated rapidly after moving inland and was accompanied by small hail and very heavy rain.

Somers Point/Linwood F1 Tornado, July 5, 2001, as seen from the Longport/Somers Point Bridge at mid-span. (Photo courtesy of Ronald Fallon, as posted on www.erh.noaa.gov).

July 5, 2001. An F1 tornado caused wind damage in Somers Point and Linwood. About six homes were damaged by the tornado. More than 30 trees were either uprooted or badly twisted.

Electrical, telephone and cable wires were knocked down. Siding was ripped off several houses and one porch was badly damaged. At least one vehicle was damaged by downed trees. About 400 Conectiv customers lost power. Strongest winds were estimated at about 90 mph in Somers Point. The tornado apparently touched down as a waterspout over Patcong Creek and then moved into Somers Point. It crossed the Garden State Parkway near mile marker 30.4. The first observed wind damage was to trees down on Bala Drive. Wind damage also occurred on Bucknell and Exton Roads. On Bucknell Road, a boat was tossed 90 feet into a neighbor's yard. The tornado traveled east-northeast down Southview Drive across Chapman Boulevard. It was at this location where it reached its maximum intensity, badly damaged a porch and uprooted several large trees. The tornado proceeded to move through Crestview Drive, across U.S. Route 9, Euclid Avenue and Abbey Road before entering Linwood near West Royal Drive. Trash cans were flying in circular motions. The last property damage occurred in Linwood near Candlewood Drive where a couple of bird house poles were bent and twisted. The tornado continued on the ground through the marshes before it dissipated as a waterspout over Scull Bay. The total path length was about 3.6 miles. The tornado was not on the ground for its entire length. Its maximum width was about 100 yards. No injuries were reported.

Probability of Occurrence – Tornado

It is likely that Atlantic County will continue to experience weak to moderate tornado events, though their frequency of occurrence will be fairly low. Probability data made available through NOAA's National Severe Storms Laboratory (NSSL) indicate that Atlantic County is in an area that experiences less than one tornado event per year. Historical storm data made available through the NCEI database confirms this data (seven confirmed events in 44 years, resulting in an estimated annual probability of a tornado event of about 16 percent). In New Jersey, tornadoes are more likely to occur during the months of March through August and tend to form in the late afternoon and early evening.

Hurricane and Tropical Storm

Location– Hurricane and Tropical Storm

Hurricanes and tropical storms threaten the entire Atlantic and Gulf seaboard of the United States, and while coastal areas are most directly exposed to the brunt of landfalling storms their impact is often felt hundreds of miles inland. Atlantic County is located in a region of the country that is susceptible to all of the hazards wrought by hurricanes and tropical storms. In the strictest sense, hurricanes and tropical storms are not hazards in their own right but, rather, events where the primary damaging hazards are high-level sustained winds, heavy precipitation that causes inland flooding and tornadoes (coastal areas are also susceptible to the additional forces of storm surge, wind-driven waves and tidal flooding, which can be more destructive than cyclonic wind). The entire planning area is located within a geographic area that is affected by hurricanes and tropical storms. The hazard areas for the accompanying extreme wind, storm surge, coastal erosion, riverine flooding, tornadoes, and wave action hazards do, however, vary across the county. While mentioned here, each of these individual forces are more thoroughly addressed as separate hazards within this section (i.e., extreme wind, coastal erosion, flood, tornado, storm surge, and wave action).

Extent – Hurricane and Tropical Storm

As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 mph, the system is designated a tropical storm, given a name and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach 74 mph the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale (**Table 3a.8**), which rates hurricane intensity in categories on a scale of 1 to 5, with Category 5 being the most intense. The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, which are combined to estimate potential damage. Categories 3, 4 and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States. Tropical storms and hurricanes that parallel the Atlantic County coastline many dozens of miles away without ever making direct landfall can still cause significant damage.

Table 3a.8
Saffir-Simpson Scale for Hurricanes

Category	Maximum Sustained Wind Speed (mph)	Minimum Surface Pressure (Millibars)	Storm Surge (Feet)
1	74–95	Greater than 980	3–5
2	96–110	979–965	6–8
3	111–129	964–945	9–12
4	130–156	944–920	13–18
5	157 +	Less than 920	19+

Source: National Oceanic and Atmospheric Administration

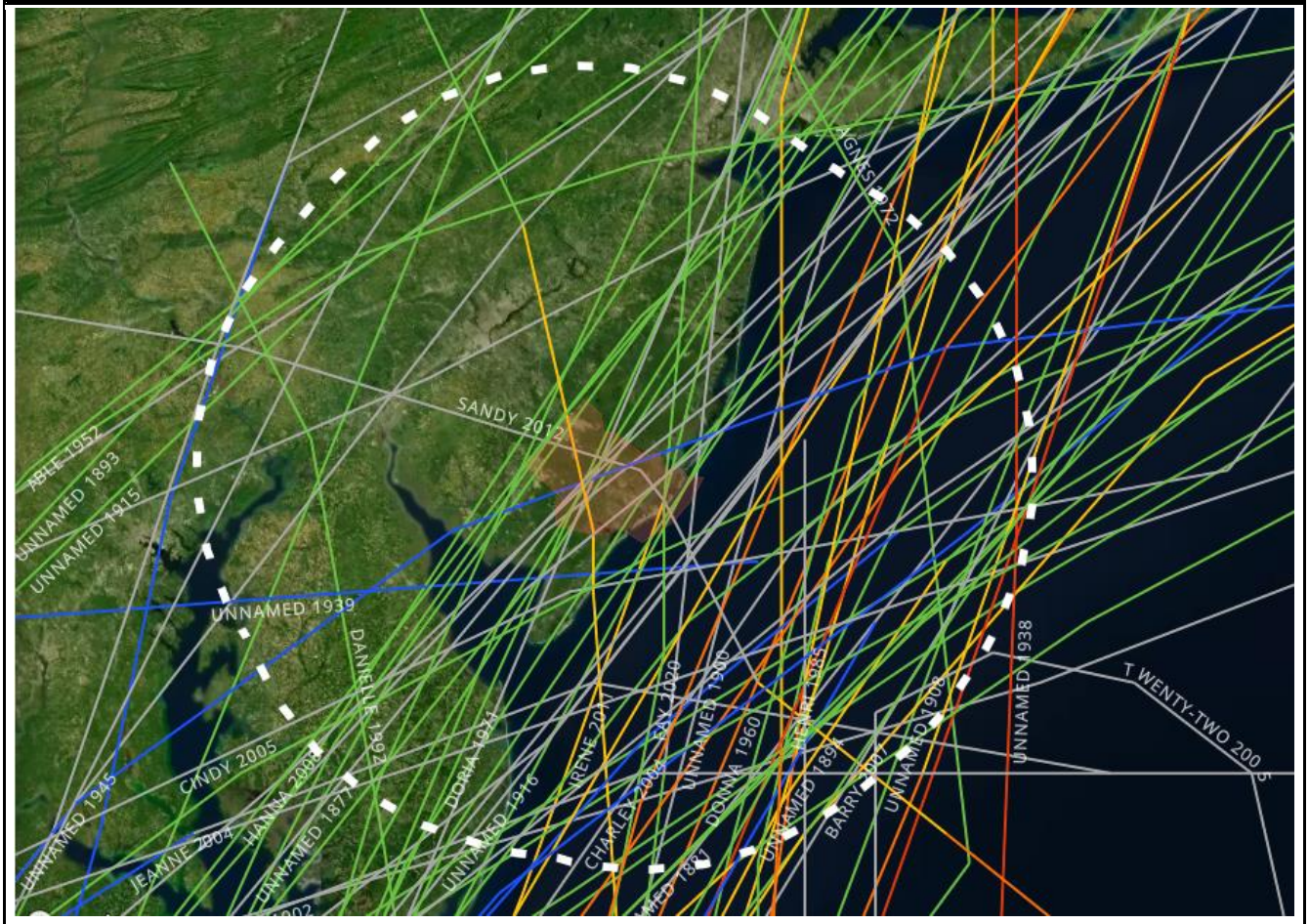
Historical Occurrences – Hurricane and Tropical Storm

Atlantic County has an active history of hurricanes and tropical storms. According to NOAA historical records[13], 43[14] hurricane and tropical storm tracks have passed within 75 nautical miles of Atlantic County since 1856. **Figure 3a.7** shows the track of each recorded historical storm in relation to the Atlantic County area. As can be seen in the figure, almost all hurricane and tropical storm tracks traverse northward through the area. For each event, **Table 3a.9** provides the date of occurrence, storm name (if applicable), maximum wind speed (as recorded within 75 miles of Atlantic County) and category of the storm based on the Saffir-Simpson Scale. This includes seven Category 2 hurricanes; six Category 1 hurricanes; and 30 tropical storms. Of the 43 recorded storm events, the center tracks of 12 storms traversed directly through Atlantic County (marked with * in Table 3a.9). Of these 12 storms, two were Category 1 hurricanes and 10 were tropical storms.

[13] NOAA Historical Hurricane Tracks, database filtered exclusively for hurricane Categories 1 through 5 and tropical storms within 75 nautical miles of Atlantic City (with tropical depressions and extratropical systems excluded from the search results), online at http://coast.noaa.gov/hurricanes/. This is a new version of the NOAA database, which has been improved upon including various data corrections since the 2016 Plan was prepared.

[14] Superstorm Sandy, which was extratropical at its landfall, is included.

Figure 3a.7
Historical Hurricane and Tropical Storm Tracks within 75 Nautical Miles of Atlantic County, 1856-2021*



* *NOAA 2021 (latest date available from data source, http://coast.noaa.gov/hurricanes/).*

Table 3a.9
Historical Hurricane and Tropical Storm Tracks within 75 Nautical Miles of Atlantic County (1856-2014*)

Date of Occurrence	Storm Name	Maximum Wind Speed (knots)	Storm Category
8/20/1856	Not Named	50	Tropical Storm
9/17/1859	Not Named	40	Tropical Storm
9/27/1861	Not Named*	60	Tropical Storm
11/3/1861	Not Named	70	Category 1 Hurricane
9/19/1863	Not Named	50	Tropical Storm
10/30/1866	Not Named	60	Tropical Storm
10/26/1872	Not Named*	40	Tropical Storm
9/29/1874	Not Named*	50	Tropical Storm
8/18/1879	Not Named	90	Category 2 Hurricane
9/10/1881	Not Named	50	Tropical Storm

Table 3a.9
Historical Hurricane and Tropical Storm Tracks within 75 Nautical Miles of Atlantic County (1856-2014*)

Date of Occurrence	Storm Name	Maximum Wind Speed (knots)	Storm Category
9/23/1882	Not Named*	40	Tropical Storm
9/25/1889	Not Named	40	Tropical Storm
8/24/1893	Not Named	85	Category 2 Hurricane
9/30/1894	Not Named	65	Category 1 Hurricane
10/10/1894	Not Named	65	Category 1 Hurricane
9/24/1897	Not Named	60	Tropical Storm
9/16/1903	Not Named*	70	Category 1 Hurricane
9/15/1904	Not Named*	55	Tropical Storm
9/8/1934	Not Named	70	Category 1 Hurricane
8/3/1944	Not Named	35	Tropical Storm
9/14/1944	Not Named	85	Category 2 Hurricane
8/31/1954	Carol	85	Category 2 Hurricane
7/11/1959	Cindy	40	Tropical Storm
7/30/1960	Brenda*	45	Tropical Storm
9/12/1960	Donna	95	Category 2 Hurricane
9/14/1961	Not Named*	35	Tropical Storm
8/28/1971	Doria*	55	Tropical Storm
6/22/1972	Agnes	60	Tropical Storm
8/9/1976	Belle	90	Category 2 Hurricane
9/27/1985	Gloria	90	Category 2 Hurricane
9/24/1985	Henri	35	Tropical Storm
7/13/1996	Bertha	60	Tropical Storm
9/16/1999	Floyd	60	Tropical Storm
9/18/2003	Isabel**	46	Tropical Storm
8/31/2004	Gaston	35	Tropical Storm
9/7/2008	Hanna	42	Tropical Storm
8/27/2011	Irene*	60	Tropical Storm
10/29/2012	Sandy*	80	Category 1 Hurricane[15]
5/12/2015	Ana	50	Tropical Storm
7/10/2020	Fay*	50	Tropical Storm
8/4/2020	Isaias	50	Tropical Storm

* *NOAA 2021 (latest date available from data source, http://coast.noaa.gov/hurricanes/)*
** *This event record was added as per NCEI query.*

Some more *notable tropical events* include the following:

September 14-15, 1944 – Great Atlantic Hurricane. This unnamed 1944 storm, dubbed the "Great Atlantic

[15] Sandy was a Category 1 Hurricane passing into the 75 nautical mile search area for this database query, but weakened as it passed over the continental shelf, ultimately making landfall as an extratropical system.

Hurricane", impacted the entire coast of New Jersey when it paralleled the coastline as a Category 2 Hurricane. Wind velocities ranged from 90 miles per hour at Atlantic City to over 100 miles per hour at New York City. The peak stage recorded by the Atlantic City tide gage was 8.21 feet NGVD, which held as a stage of record at this location into the late 1990's. The hurricane destroyed the Atlantic City boardwalk and damaged the famous Heinz and Steel Piers in Atlantic City. Only the Steel Pier was rebuilt. The Atlantic City-Brigantine Bridge was destroyed.

August 28, 1971 – Tropical Storm Doria. Doria's path crossed directly over Atlantic County on August 28th. Doria produced wind gusts of up to 54 mile per hour and storm tides of 5.3 feet above normal in Atlantic City. The storm dropped heavy rainfall, leading to record flooding on several small streams across the state. Rainfall totals in Atlantic County were recorded in the range of 5 to 7 inches.

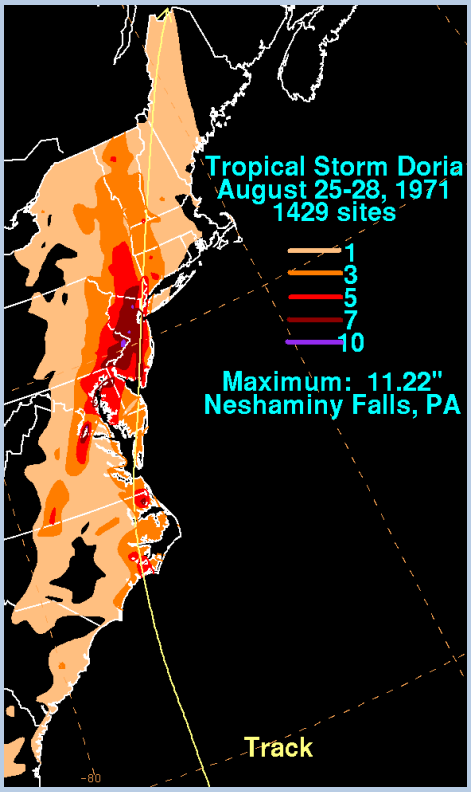
August 9, 1976 – Hurricane Belle. Belle was a tropical storm when it passed off the shore of New Jersey on August 9th. A storm surge of 8.85 feet was measured in Atlantic City. Gusty winds knocked down power lines across the state. Roughly 500 feet of the Atlantic City boardwalk was damaged or destroyed, with repairs estimated to have reached $5 million. On August 21, then-President Gerald Ford issued a major disaster declaration for Atlantic, Cape May, Monmouth, and Ocean counties.

September 16, 1999 – Tropical Storm Floyd. In New Jersey, Floyd was predominantly an inland rain and riverine flooding event. Minor beach erosion and back bay flooding was reported, however, in Atlantic, Cape May and Ocean Counties. The NOAA NCEI database recorded $500,000 in property damage in Atlantic County during this event. Rainfall totals were recorded at 4.41 inches in Estell Manor, 4.37 inches in Folsom, and 4.02 inches at the Atlantic City Marina.

September 18, 2003 – Tropical Storm Isabel. Isabel made landfall as a hurricane near Drum Inlet, North Carolina on the 18th and weakened as it tracked farther inland. 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 Conectiv Energy reported about 162,000 of its customers lost power. While tide heights along the ocean side only reached minor, wave action caused considerable beach erosion, especially in Cape May and Atlantic Counties.

Storms have caused significant damage to Atlantic City's iconic boardwalk throughout its existence. Shown here is South Inlet during the Great Atlantic Hurricane of 1944. *(Archive of the Beach Erosion Board stored at the Coastal and Hydraulics Laboratory, Engineer and Research Development Center, Vicksburg, Mississippi, USA)*

Hurricane 1944
Longport



The heaviest rain with tropical systems often falls west of its storm track, thus the Atlantic County area (being on the eastern side of the track) was spared from the heaviest rain. Most places had less than an inch and half of rain. Peak wind gusts included 53 mph at the Atlantic City Marina. The NCEI database reported that property damage was $600,000.

Vehicles go through a partially flooded Bethel Road near New Road in Somers Point about 6:30 a.m. Sunday August 28, 2011 in the wake of Hurricane Irene. (Vernon Ogrodnek).

August 27, 2011 – Tropical Storm Irene. Prior to Irene making landfall, approximately one million people were evacuated from coastal and low lying areas throughout the state of New Jersey (including all of Cape May County). National Guard troops were deployed state-wide to help with evacuations. All Atlantic County shore communities east of U.S. Route 9, including Atlantic City, were placed under a voluntary evacuation on the evening of August 25th; a mandatory evacuation followed at 6 a.m. on the 26th. All Atlantic City casinos were shut down as the city faced its first mandatory evacuation in history. Irene initially made landfall near Cape Lookout, North Carolina on the 27th as a Category 1 hurricane. She later made a second landfall as a tropical storm on Brigantine Island, just north of Atlantic City, on the 28th. Tropical storm force wind gusts overspread New Jersey. The highest wind gusts recorded in Atlantic County were 66 miles per hour at the Atlantic City Marina, and 58 miles per hour in Atlantic City. Event precipitation totals averaged between 5 and 10 inches and caused widespread, record breaking flooding. Irene helped make August 2011 the wettest August on record for the state of New Jersey dating back to 1895. Moderate to severe tidal flooding occurred. Peak storm tides included 6.96 feet above mean lower low water in Atlantic City (moderate tidal flooding starts at 6.0 feet above mean lower low water). The shore took a pounding from the coastal flooding and heavy surf. Waves were estimated to reach as high as 12 feet, as offshore seas reached 25 feet. There were numerous reports of dune fence damage and sand overwash[16] onto streets and boardwalks. In Atlantic County, erosion scarps[17] averaged 1 to 4 feet, but reached 6 feet in Brigantine. All counties in the state were declared disaster areas. Before Superstorm Sandy, Irene stood as one of the costliest natural disasters in the state's history. Preliminary state-wide damage estimates were near one billion dollars in damages to approximately 200,000 homes and

Erosion and damage near Bally's in Atlantic City. Sunday, August 28, 2011. Aftermath of Hurricane Irene. (The Press of Atlantic City/Ben Fogletto)

[16] Overwash is a term used to describe the landward transport of beach sediments across a dune area. Large coastal storms and their associated high winds, waves, and tides can result in overwash of the beach and dune system. During storm conditions, elevated storm tides and high waves may erode beaches and dunes, and the eroded sand can be carried landward by surging water. The sand and water may wash over or break through the dunes, and spill out onto the landward side of the barrier dune. This deposit is usually fan-shaped and therefore is known as an overwash (or washover) fan. Low-lying areas such as a break in the dune system are particularly vulnerable to overwash. Along developed shoreline areas, the breaks in dune systems are typically found at street ends or pedestrian dune cross-over pathways. When large storm waves and high tides breach the dunes, overwash occurs as sand is transported through the open dune area and onto the street.

[17] An erosion scarp is a steep, near-vertical cut in a dune produced by the erosive forces of wave action.

businesses. Around 1.5 million people lost power throughout the state. Power was not fully restored until September 5th. Riverine flooding in many basins reached record or near-record levels (with some locations at levels second only to Tropical Storm Floyd in 1999). The closure of the Atlantic City casinos for three days caused an estimated 45 million dollars in lost revenue. The combination of wind and flooding forced the closure of about 350 main roadways in the state including sections of Interstate 287, the Garden State Parkway and the New Jersey Turnpike. The flooding rains and winds severely damaged crops. New Jersey Transit rail, bus and light rail operations were suspended on the weekend of the 27th and 28th. Numerous homes suffered structural damages from the winds, and limbs impacting their roofs. Widespread wind damage to trees (and damage to homes and vehicles when trees fell on them) occurred in every county. In Atlantic County, a piece of an exterior wall of the Borgata Hotel was blown off. NOAA's NCEI database reports total property damage in Atlantic County as $5.5 million.

A large section of a tree fell on this home on 2nd Avenue in Northfield, causing severe damage during Hurricane Irene. (Anthony Smedile)

October 29, 2012 - Superstorm Sandy. Three days prior to Sandy's landfall, voluntary evacuations of barrier island communities were called for by the Governor on October 26th. On the 27th, a State of Emergency was declared and a mandatory evacuation was ordered for all barrier island communities. More than 2,000 National Guard troops were deployed. Tolls along sections of the Garden State Parkway and all of the Westbound Atlantic City Expressway were suspended. On October 28th, President Obama signed a federal emergency declaration for New Jersey. All State Parks and Historic Sites were closed. Late that afternoon, New Jersey Transit began a gradual, system-wide shut down.

Sandy made landfall at the City of Brigantine on October 29th as a post-tropical storm. Sandy was the costliest natural disaster by far in the State of New Jersey. Record breaking high tides and wave action combined with sustained winds as high as 60 to 70 miles per hour - with gusts as high as 80 to 90 miles per hour - battered 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 Mantoloking (Ocean County) where some homes were swept away. About 2.4 million households in the state lost power and it took weeks for power to be fully restored.

Hardest hit areas in the state were the coastal areas of Ocean and Monmouth counties. However, Atlantic County was not spared. The NCEI database records indicate $690 million in property damage due to high surf, flooding, and extreme wind. The northern end of the famed Atlantic City boardwalk was destroyed. The wind damaged boardwalks within the city. The city was cut off from the mainland by tidal flooding after the morning high tide. Elsewhere in the county, heavy tidal damage was reported in Longport, Margate and Ventnor. Nearly every municipality from Egg Harbor and Galloway Townships eastward suffered widespread wind and or tide damage. Deaths in Atlantic County included a 65-year-old woman who died of a heart attack while on an evacuation bus in Atlantic City, a 73-year-old man who died from hypothermia after failing to evacuate in Brigantine, and a 93-year-old man who fell and struck his head while moving a car in Ventnor. Sandy produced record breaking power outages. Statewide, 2.7 million utility customers lost power, by far surpassing the record from Tropical Storm Irene in 2011. Public Service Electric and Gas alone had power lost to 1.4 million of its customers and reported about 48,000 trees had to be removed or trimmed to restore power and over 2,400 poles had to be replaced. Jersey Central Power and Light estimated that nearly 1.0 million of its customers lost power, about ninety percent of its customer base. This included hardest hit areas of Ocean and Monmouth Counties. Monmouth County had the greatest number of sustained outages of any county in the state. The utility had to cut through approximately 45,000 fallen trees. It was unable to restore power to about 30,000 of its shore and barrier island customers because of massive infrastructure damage to those homes and businesses. Elsewhere in the state, power restoration was hampered by a nor'easter that occurred on November 7th. Public Service Electric and Gas restored all power on November 12th and Jersey Central Power and Light by November 14th.

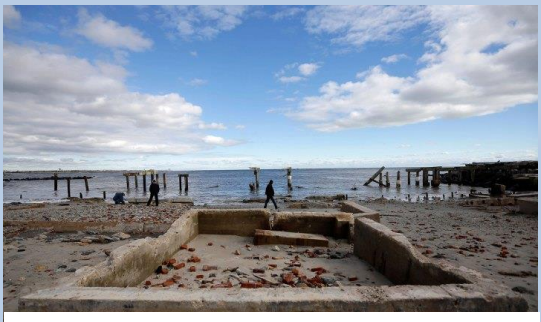
The unique aspect of Sandy, unlike most tropical systems, was the multi-tide cycle increase of onshore winds prior to landfall. This caused multiple high tide cycles with tidal flooding and also helped produce catastrophic wave action. Record breaking or near record breaking high tides were exacerbated by the high astronomical spring tides associated with the full moon. Sandy's landfall coincided closely with the high tide cycle on the evening of the 29th.

Hurricane Sandy Damage, North End of Brigantine, New Jersey

(Photo Susanne Fluhr)

A section of beach at 24th Street in Longport, where there are no dunes. The borough has already suffered $10 million in public property damage. (TOM GRALISH / Staff Photographer)

Homes are seen on a street covered in beach sand due to flooding from Superstorm Sandy in Longport, New Jersey. (October 29, 2012 – Source: Mario Tama/Getty Images North America)



A Man walks past the remains of a building near a damaged section of boardwalk in the wake of Superstorm Sandy, Wednesday, Oct. 31, 2012, in Atlantic City, N.J. (Matt Slocum / AP)

On the ocean side, Raritan Bay and the lower Delaware Bay, minor tidal flooding started during the high tide cycle on the morning of the 28th with some moderate tidal flooding during the high tide cycle on the evening of the 28th. Widespread major tidal flooding occurred during the morning and evening high tide cycles on the 29th. The highest tide (and surge) along the ocean front and Raritan Bay was with the landfalling high tide cycle on the evening of the 29th. The ocean front and Raritan Bay surge was 5 to 9 feet. A new all-time record tide was set in Sandy Hook. The tide reached 13.31 feet above mean lower low water before the pier collapsed about 45 minutes before high tide. An after the event survey performed by the USGS and Rutgers University determined that an estimated crest of 14.40 feet above mean lower low water will be used as the new record for Sandy Hook. The entrance to New York Harbor Buoy (a relatively new buoy) had record breaking seas of 32.5 feet. The Delaware Bay Buoy (about 19 miles east of Fenwick Island, Delaware) had seas that reached 24.5 feet. Most of the surveyed damage to barrier island homes that were either destroyed or moved indicated that it was the storm surge and wave action that caused most of the damage. Either minor or no tidal flooding occurred with the subsequent high tide cycles the rest of the month. The previous record was 10.1 feet above mean lower low water during Hurricane Donna on September 12, 1960 and the December 11, 1992 nor'easter. In Atlantic City, the highest tide reached 8.9 feet above mean lower low water during the evening high tide on the 29th. This was the second highest tide on record; the highest was 9.0 feet above mean lower low water on December 11, 1992.

Strong winds associated with Sandy began to spread across the state during the morning of the 29th; most of the peak wind gusts (between 70 miles per hour and 90 miles per hour) occurred during the late afternoon and evening hours as Sandy was making landfall. Most of the strong wind gusts were over by the following morning. Peak wind gusts were recorded at 77 miles per hour at the Atlantic City Marina, 66 miles per hour in Absecon, and 64 miles per hour at the Atlantic City International Airport. Maximum sustained winds of 51 miles per hour were reported in Atlantic City.

Heavy rain also occurred with Sandy. This made it easier for shallow rooted and leafed trees to be uprooted, it also complicated the tidal flooding. Event rainfall totals averaged 1 to 3 inches in the northern half of the state and 3 to 7 inches in the southern half of the state, except 6 to 12 inches along the southern tier counties of Salem, Cumberland, Cape May County as well as coastal Atlantic County. The steady rains associated with Sandy were from the 28th to the 30th throughout most of the state.

Approximately 130 miles of the Garden State Parkway was closed from Woodbridge in Middlesex County to its terminus in Cape May County. The New Jersey Turnpike was closed in central New Jersey. Most schools were closed. The nuclear power plants at Oyster Creek (Ocean County) and Salem (Salem County) suspended operations because of tidal flooding. The day after Sandy's landfall, all 580 school districts in the state were closed. All courts and state offices were also closed. Over 200 roadways were closed. Numerous boil water advisories were issued for the northern and coastal parts of the state, some that lasted into November. Governor Christie postponed Halloween in the state until November 5th. On October 31st, Amtrak started limited rail service. State offices were still closed, but some schools reopened. Most major roadways away from the immediate coast including the New Jersey Turnpike were reopened. On November 1st, Governor Christie rescinded evacuation orders for some of the Atlantic County barrier islands. The River Line Transit service between Camden and Trenton resumed. New Jersey Transit bus service resumed as did the Cape May-Lewes Ferry. On November 2nd, the governor lifted the evacuation order for Atlantic City and the casinos opened the next day. Evacuation orders were also lifted for Cape May County. Limited New Jersey Rail Service resumed. Because of power outages, lines for gas reached 100 cars long in the northern part of the state. The governor declared a limited state of emergency and imposed odd-even rationing for gasoline purchases in twelve northern New Jersey counties because of the shortages. They remained in effect through November 12th. The EPA temporarily suspended some Clean Air Act restrictions. The entire state was also under odd-even water restrictions. On November 3rd about 75 major roadways were still closed. On November 4th, rail service between Philadelphia and Atlantic City resumed. It was estimated that the average New Jersey beach became 30 to 40 feet narrower. It was difficult for people whose homes were uninhabitable to find rental properties.

July 10, 2020 – Tropical Storm Fay. Fay made landfall as a tropical storm northeast of Atlantic City with maximum wind speeds of 50 knots. Significant street flooding was reported in Margate City and Somers Point. One person was recorded as drowned and another injured by rough surf conditions while swimming in the ocean off Atlantic City during the storm.

Dann Cuellar/6abc Action News/WPVI-TV, via Associated Press

The Inlet section of Atlantic City, N.J., was flooded.

By THOMAS KAPLAN and N. R. KLEINFIELD
Published: October 29, 2012

Clean-up begins on New Hampshire Avenue in Atlantic City after Sandy. October 30, 2012. (Staff photo by Cindy Hepner/South Jersey Times)

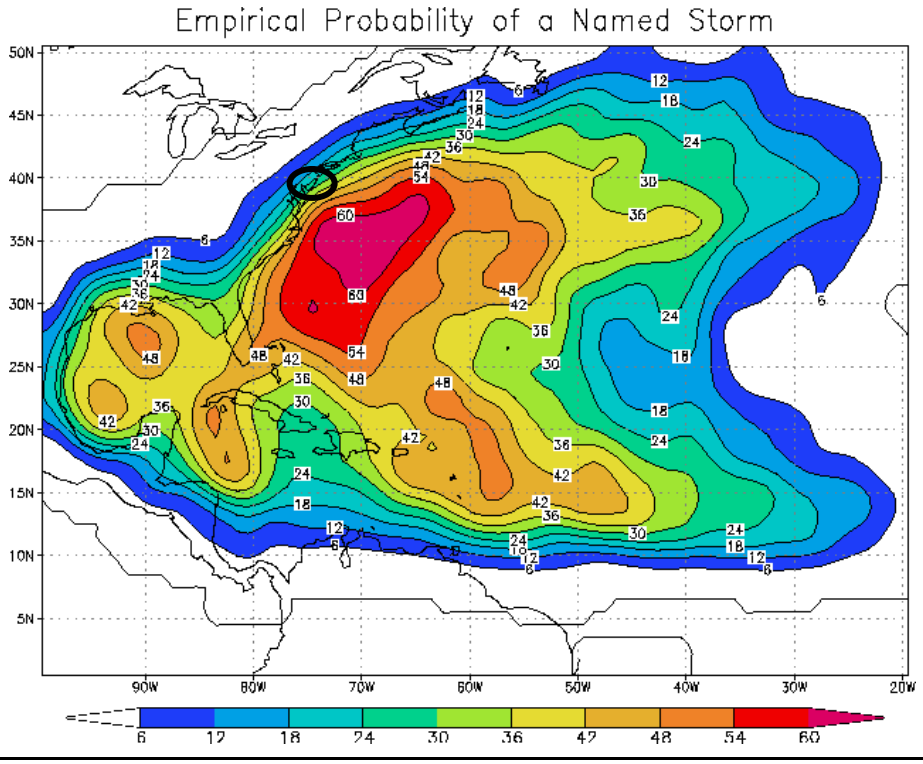
A boardwalk and waterfront property were heavily damaged following Hurricane Sandy in Atlantic City, N.J. One year later, some businesses are still unprepared for disaster, while others have been spurred to make changes. MICHAEL REYNOLDS

U.S. Route 30, the White Horse Pike, one of three major approaches to Atlantic City, New Jersey, is covered with water from Absecon Bay during the approach of Hurricane Sandy

Probability of Occurrence – Hurricane and Tropical Storm

The probability of future hurricane and tropical storm events for Atlantic County is high. According to NOAA statistical data, Atlantic County is located in an area with an annual probability of a named storm between 24 and 30 percent (**Figure 3a.8**). This empirical probability is fairly consistent with other scientific studies and observed historical data made available through various federal, state and local sources. NOAA data on historical storm tracks indicates the annual probability of a hurricane or tropical storm coming within 75 miles of Atlantic County is roughly 25 percent and the annual probability of a hurricane or tropical storm traversing directly through Atlantic County is about 7 percent. Occurrences are most likely during the official Atlantic hurricane season (the months of June through November). The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in this basin is six. The probability of storm occurrences will vary significantly based on the return interval for different categories of magnitude. The probability of less intense storms (lower return periods) is higher than more intense storms (higher return periods). **Table 3a.10** profiles the potential peak wind speeds that can be expected in Atlantic County for the 100-year and 500-year mean return period events.

Figure 3a.8
Empirical Probability of a Named Storm*



Source: NOAA

Table 3a.10
Peak Wind Speeds for 100-year and 500-Year Mean Return Period Events*

Jurisdiction	Peak Wind Speed for a 100-year Mean Return Period Event	Peak Wind Speed for a 500-year Mean Return Period Event
Absecon, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Atlantic City, City of	Category 2 (96-110 mph)	Category 3 (111-115 mph)
Brigantine, City of	Category 2 (96-110 mph)	Category 3 (111-115 mph)
Buena, Borough of	Tropical Storm (39-73 mph)	Category 1 (74-95 mph)
Buena Vista, Township of	Tropical Storm (39-73 mph)	Category 2 (96-110 mph)
Corbin City, City of	Category 1 (74-95 mph)	Category 2 (96-110 mph)
Egg Harbor City, City of	Category 1 (74-95 mph)	Category 2 (96-110 mph)
Egg Harbor, Township of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Estell Manor, City of	Category 1 (74-95 mph)	Category 2 (96-110 mph)
Folsom, Borough of	Tropical Storm (39-73 mph)	Category 2 (96-110 mph)
Galloway, Township of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Hamilton, Township of	Between Tropical Storm (39-73 mph) and Category 1 (74-95 mph)	Between Category 2 (96-110 mph) and Category 3 (111-115 mph)
Hammonton, Town of	Tropical Storm (39-73 mph)	Category 2 (96-110 mph)
Linwood, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Longport, Borough of	Category 2 (96-110 mph)	Category 3 (111-115 mph)
Margate City, City of	Category 2 (96-110 mph)	Category 3 (111-115 mph)
Mullica, Township of	Tropical Storm (39-73 mph)	Category 2 (96-110 mph)
Northfield, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Pleasantville, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Port Republic, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Somers Point, City of	Category 1 (74-95 mph)	Category 3 (111-115 mph)
Ventnor City, City of	Category 2 (96-110 mph)	Category 3 (111-115 mph)
Weymouth, Township of	Category 1 (74-95 mph)	Category 2 (96-110 mph)

**Source: Atlantic County 4 Hazard Mitigation Plan (2014)*

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Atlantic County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Atlantic County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks,

government buildings, libraries, parks, etc.); economic viability of a community – particularly for communities where tourism tends to drive local economies, as is the case in many of Atlantic County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Nor'easter

Location – Nor'easter

Nor'easters threaten the entire Atlantic Coast of the United States, and while coastal areas are most directly exposed to the damaging forces of such storm systems their impact is often felt far inland. Atlantic County is located in an area that is extremely susceptible to nor'easters. All areas throughout the County are susceptible to the hazards that can be associated with nor'easters: extreme wind, flooding and heavy snowfall. Atlantic County's coastal jurisdictions are also extremely susceptible to the added effects of storm surge, wave action, coastal erosion and tidal flooding.[18]

Extent – Nor'easter

While there are a variety of indicators for nor'easter intensity, **Table 3a.11** describes the Dolan-Davis Nor'easter Intensity Scale which is based on coastal storm erosion, degradation and property damage.

Table 3a.11
Dolan-Davis Nor'easter Intensity Scale

Storm Class	Beach Erosion	Dune Erosion	Overwash	Property Damage
1 WEAK	Minor changes	None	No	No
2 MODERATE	Modest; mostly to lower beach	Minor	No	Modest
3 SIGNIFICANT	Erosion extends across beach	Can be significant	No	Loss of many structures at local level
4 SEVERE	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community-scale
5 EXTREME	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

Historical Occurrences – Nor'easter

Atlantic County has a lengthy history of devastating impacts wrought by nor'easters. This includes damages caused by the effects of extreme wind, heavy rain, snow, wave action, storm surge, coastal flooding and beach erosion (also addressed separately within this section).

[18] Distinct hazard area locations for coastal flooding, wave action and coastal erosion are discussed elsewhere in this section.

According to the State Hazard Mitigation Plan (2014), 17 nor'easters have affected Atlantic County since 1962. Some *notable events* include the following[19]:

March 6-8, 1962 – Ash Wednesday Nor'easter. One of the state's worst nor'easters occurred in 1962 in what became known as the "Ash Wednesday Nor'easter" – a massive storm caused by an unusual combination of three pressure areas and exceptionally high tides associated with the spring equinox stalled in the mid-Atlantic for almost three days, pounding coastal areas with continuous rain, high winds, and tidal surges and dumping large quantities of snow inland for several hundred miles. Gale force winds (sustained at 45 miles per hour with gusts to 70 miles per hour) kept storm surges on shore for five successive high tides. In Atlantic County, the Steel Pier in Atlantic City was partially destroyed. Brigantine, Margate, Ventnor, and Longport also suffered significant damage from wind and flooding. Statewide, the total damage caused by this event was about $85 million (in 1962 dollars).

March 1962 Nor'easter. Men on the roof of the collapsed Boardwalk Pavilion in Margate. (Photo courtesy of the Margate Library)..

October 28, 1991 – Halloween Nor'easter. The 1991 Halloween Nor'easter, also referred to as "The Perfect Storm", caused strong waves of up to 30 feet in height. High tides along the shore were only surpassed, at the time, by the 1944 hurricane, while significant bay flooding occurred. Strong waves and persistent intense winds caused extreme beach erosion of millions of cubic feet of sand. In all, damage was estimated about $90 million (1991 dollars).

Boardwalk at Oriental Avenue, Atlantic City, days after the December 1992 Nor'easter (Photo courtesy of Flikr user PentaxTravels).

December 11-12, 1992. An intense, slow-moving nor'easter hit the eastern coast of New Jersey during December 11 and 12, 1992. It occurred while shore residents were still trying to rebuild beaches after the October 1991 and January 1992 storms. This storm produced strong winds and record or near-record flooding along the entire Atlantic Coast of New Jersey. Two deaths were attributed to the storm. Bergen, Essex, Hudson, Somerset, Union, Middlesex, Monmouth, Ocean, Salem, Atlantic, Cumberland, and Cape May Counties were declared disaster areas. The State was granted $46 million in disaster relief funds for public damages and $265 million for insured damage (National Weather Service, 1994) that occurred as a result of this storm.

A home in Brigantine after the March 1962 Nor'easter (from the photo archive of the Atlantic City Press).

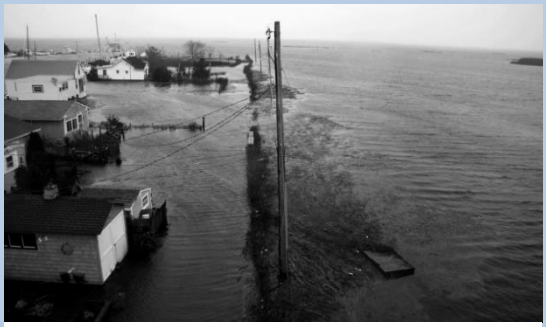
January 28-29, 1998. An intense nor'easter pounded the New Jersey Shore with tidal flooding, beach erosion, strong winds and rain. Conditions were progressively worse farther south. In Atlantic County, both the White

Horse (U.S. Route 30) and Black Horse (U.S. Route 40) Pikes in and out of Atlantic City were closed for more than four hours the morning of the 28th. The Eastbound lanes of the Black Horse Pike were closed again the evening of the 28th. Several other roads were closed due to bayside tidal flooding in Egg Harbor Township, Absecon, Atlantic City and Pleasantville. Sections of U.S. Route 9 in Linwood and County Road 152 in Somers Point and Longport were also closed. Along the ocean side, erosion took a heavy toll. In Margate, 50 to 90 percent of the dunes vanished or suffered damage. In Brigantine, about 1,000 feet of dune fencing was lost. In Ventnor, the ramp to the beach washed away and the ocean carved huge chunks out of the dunes. Atlantic City lost about 3 feet of its beach and vertical drops of 3 to 4 feet were created in Absecon and Brigantine.

February 4-9, 1998. Both Atlantic and Cape May Counties were declared federal disaster areas as a result of this strong nor'easter. Damage statewide was estimated at about 17 million dollars and it was the worst storm to affect the area since December 1992. Atlantic County suffered an estimated 3.9 million dollars in damage. Twenty-two persons from Brigantine and Atlantic City were sheltered. Throughout the county one home and one business suffered major damage, 93 other dwellings and businesses suffered minor damage while tidal flooding affected but caused little damage to 219 others. Brigantine suffered substantial flooding and beach erosion. About 75 percent of its sand was carried away. In Atlantic City, the 84 residents of the Oceanside Nursing Home were removed to 14 other nursing homes on the mainland. The boardwalk was ripped at New Hampshire Avenue. All access roads into the city were closed on the morning of the 5th, except for the Atlantic City Expressway. The worst tidal flooding occurred in the back-bay area with much of Venice Park, the Chelsea Bay Front, and Chelsea Heights inundated. Dozens of cars had water up to their doors. The beach was described as "destroyed" in Margate. In Longport, the ocean met the bay from 11th through 24th Streets. The erosion caused vertical cliffs of 4 to 5 feet and streets had to be cleared of debris. The mainland was not spared in the county as the heavy rain caused basement flooding in the Donald J. Adams School in Northfield and trees were uprooted in Linwood.

Damage in Longport from the March 1962 Nor'easter. Photo courtesy of the Stewart Farrell Collection.

The March 1962 Nor'easter destroyed a section of the Steel Pier in Atlantic City (Photo courtesy of the archives of the Daily Journal).



Flooding in Port Republic during a nor'easter on November 13, 2009 (photo courtesy of Flikr user Steve Maciejewski).

Waves crash along the shore in Atlantic city during the nor'easter of October 2, 2015 (Photo courtesy of Don Woods for NJ.com).

[19] Descriptions extracted from the NJSHMP 2014.

November 11-14, 2009. By several measures this was one of the worst nor'easters to affect New Jersey since 1990. The Dolan Davis Nor'easter power ranking at the Long Island Buoy #44025 ranked it 4th and the strongest since March of 1994. The Miller Storm Erosion Index and the Kraus and Wise Maximum Wave Run-up Index were both ranked second only to December 1992 nor'easter. In Atlantic County, flooding caused the closure of the Black Horse (U.S. Routes 40 and 322) and White Horse (U.S. Route 30) Pikes near Atlantic City on the 12th and 13th. This caused huge traffic delays on the Atlantic City Expressway. Motels were also evacuated along the Black and White Horse Pikes. Dozens of motorists were rescued from flood waters along the White Horse Pike and U.S. Route 9. The surf and tides caused about 10 million dollars in damage to the Atlantic City boardwalk and beach. In Atlantic City and also Ventnor, ramps to the beach and boardwalk were destroyed. Overall county damage was estimated at 16 million dollars.

October 2, 2015. A nor'easter on October 2, 2015 was one of multiple weather systems impacting New Jersey. The impacts of this particular nor'easter were magnified by the presence of Hurricane Joaquin off of the coast. Overall, minor tidal flooding occurred. Roadways, including the Black Horse Pike between Atlantic City and Pleasantville, were shut down due to rising floodwaters. Motorists had to be rescued after becoming trapped in the rising waters.

January 22-24, 2016. A nor'easter struck much of New Jersey from January 22-24, 2016. An impulse from the west coast traversed the midsection of the country, then developed into a low-pressure system as it tracked across the Gulf states before intensifying along the Carolina coast into a major Nor'easter, producing record snowfall in parts of New Jersey on January 23rd. It then moved out to sea after passing by the mid-Atlantic coast early on January 24th.

March 1-3, 2018. A nor'easter struck the entire state of New Jersey from March 1 to March 3, 2018. Sussex County in the northern part of the state reported 10 inches (25 cm) of snow. At the Jersey Shore, the storm caused minor flooding and road closures during the high tide on the morning of March 2. Two local roads in Absecon were closed from flooding and there was flooding on U.S. Route 40 leading into Atlantic City. Flooding also caused lane closures along portions of Route 35 in Brick and Belmar while floodwaters covered roads in Neptune and Highlands. Some flights were cancelled at Newark Liberty International Airport. Atlantic City Electric reported 29,111 customers without power and PSE&G reported tens of thousands of customers without power. New Jersey Transit cancelled some service.[20]

Probability of Occurrence – Nor'easters

Nor'easters will continue to have a high probability of occurrence for Atlantic County, and the probability of future occurrences affecting all of Atlantic County's jurisdictions is certain. The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Atlantic County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Atlantic County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to

[20]Description extracted from the 2019 New Jersey State Hazard Mitigation Plan.

people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community – particularly for communities where tourism tends to drive local economies, as is the case in many of Atlantic County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Severe Winter Weather

Location – Severe Winter Weather

Nearly the entire continental United States is susceptible to winter storms, but the degree of exposure typically depends on the normal expected severity of local winter weather. Atlantic County is accustomed to severe winter weather conditions and is prepared for the potential disruptions they might cause, though intense winter storms might still overwhelm local capabilities. Atlantic County is located south of the typical boundary between freezing and non-freezing precipitation during wintertime. The 2019 State Plan notes that Atlantic County averaged about 16.5 inches of normal seasonal snowfall from 1981 to 2010 (the northernmost corner of the county averaging closer to 18.1 inches per season). All areas throughout the County are susceptible to the hazard effects of winter storms including snow and ice, and Atlantic County's coastal jurisdictions are also extremely susceptible to the added effects of storm surge, wave action, coastal erosion and tidal flooding that might be wrought by nor'easters.[21]

Extent – Severe Winter Weather

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (i.e., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's NCEI is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from one to five. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCEI has analyzed and assigned RSI values to over 500 storms that have occurred since 1900 (NOAA NCEI 2021). **Table 3a.12** presents the five RSI ranking categories.

[21] Nor'easters and their hazard effects are discussed separately within this section.

Table 3a.12 Regional Snowfall Index Ranking Categories		
Category	**Description**	**RSI Value**
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Historical Occurrences – Severe Winter Weather

According to the NCEI database[22], 165 recorded winter storm days (classified as: blizzard, heavy snow, ice storm, sleet, winter storm, winter weather) have affected Atlantic County between January 1996 and May 2021. Of these, 17 days have occurred since data was last compiled for the completion of the last approved plan in 2016. These incidents have resulted in one death and approximately $5.3 million in property damages in Atlantic County[23]. A sampling of some of the more *notable recent events* includes the following:

January 7, 1996. Dubbed the "Blizzard of 1996", this storm system impacted a region from as far south as North Carolina to as far north as Maine from January 6th to January 9th with 10 inches to upwards of 30 inches of snow. Extreme southern New Jersey, including Atlantic County, received 10-20 inches. Nearly one million dollars in property damage was reported in Atlantic County alone.

January 25, 2000. The most intense winter storm since the Blizzard of 1996 buried New Jersey on the 25th with 6 to 15 inches of snow, sleet and freezing rain, wind gusts as strong as 60 miles per hour along the shore, moderate coastal flooding and drifts as high as four feet. For the first time since 1996, county and government offices were closed. Many businesses and all schools were closed. Many malls never opened and all the others closed early. Dozens of public events were postponed. Both the Millville Airport and the Atlantic City International Airport were shut down. In Atlantic County, there was a long list of bayside roads

[22] Data current as of May 2021.

[23] No property damages or crop damages are reported in the NCEI database in Atlantic County for events occurring since the last version of this plan was prepared.

flooded from Brigantine to Somers Point. In Atlantic City, both the Black (U.S. Route 40 and 322) and White (U.S. Route 30) Horse Pikes were closed. Individual accumulations included 10 inches in Pomona (Township of Galloway), 9 inches in the City of Estell Manor and 8.3 inches at the Atlantic City International Airport.

February 16-17, 2003. The most powerful storm to affect New Jersey since the Blizzard of 1996 struck during the President's Day Weekend. Strong winds caused about 11,000 homes and businesses to lose power along coastal New Jersey on the 17th. Power was restored by 6 p.m. EST that evening in Atlantic County. In Atlantic County, the roof parapet of the Egg Harbor Township Middle School collapsed. It caused cracks and strain in the supports of the school's gym and auditorium. Flights at the Atlantic City International Airport resumed on the 18th after being halted on the 16th. Bus transportation in and out of Atlantic City was suspended on the 16th and restored on the 18th. Schools did not reopen until the 20th. Many business awnings collapsed because of the weight of the snow and sleet. In Atlantic County, causeways into the Borough of Longport and Margate City were closed on the 17th. U.S. Route 40 (The Black Horse Pike) was closed due to flooding throughout the 17th. Severe erosion was reported in Ventnor. The beach dropped seven feet in Atlantic City. Peak wind gusts reached 53 miles per hour at the Atlantic City International Airport, Specific snow accumulations included 19.8 inches in Margate City. Approximately $1.5 million in property damage was reported in Atlantic County during this event.

February 9, 2010. For the second time within a week a major winter storm affected New Jersey. Blizzard conditions occurred at times across the extreme southern part of the state during the afternoon and early evening of the 10th. Snowfall averaged 7 to 15 inches across northwest New Jersey, 12 to 20 inches across central New Jersey and 6 to 12 inches across the southern third of New Jersey. Ice accretions were less than one tenth of an inch. Two storm related deaths occurred in Burlington and Middlesex Counties. Winds plus the weight of the snow brought down tree limbs and trees. States of emergencies continued (from the previous winter storm) in Cape May and Atlantic Counties. Many city, federal, social and county offices as well as courthouses were closed on the 10th. Except for court houses, most were reopened on the 11th. Municipal meetings were canceled as were sports games and racing cards. Flights were canceled going in and out of Atlantic City International Airport. State police reported nearly 500 accidents throughout the state. Schools were closed on the 10th and 11th, some even on the 12th. A limited number of businesses were opened on the 10th. New Jersey Transit canceled and or combined bus service on the 10th. Because the heavy snow clung to the trees first and then the winds increased, New Jersey utilities reported about 100,000 new outages, 80,000 in the southern half of the state and 14,000 in Cape May County alone. There was considerable pine tree damage. Several shelters were opened. Many school districts ran out of snow days and had to make up class-time later. Many municipal snow removal budgets were exceeded. Trash collections were postponed. The combination of the two heavy snow events within a week started causing roof collapses in the southern half of the state. Representative snowfall included 10.3 inches in Hammonton, 8.6 inches in Estell Manor, and 7.3 inches at the Atlantic City International Airport. Only 10 days into February and the seasonal total of 50.1 inches of snow to date at the Atlantic City International Airport already made it the snowiest season on record surpassing the previous record of 46.9 inches set in 1966-1967. Peak wind gusts included 41 miles per hour in Atlantic City. The onshore flow preceding the low pressure system helped cause minor tidal flooding with the morning high tide on the 10th along coastal New Jersey. Minor tidal flooding starts at 6.0 feet above mean lower low water[24]. Minor to locally moderate beach erosion also occurred with the winter storm. Vertical cuts averaged 1 to 3 feet along the ocean front with the highest cuts reported in Ocean County. Property damage in Atlantic County was estimated at $1 million dollars.

December 26, 2010. This major blizzard (and, for parts of eastern New Jersey, record-breaking winter storm and blizzard) affected the state on Sunday the 26th and Monday the 27th. Snowfall averaged around two feet for the shore counties as well as Middlesex and Morris Counties in New Jersey with drifts often at

[24] https://www.weather.gov/media/phi/atlant.pdf

least twice that high. Snowfall across southwest New Jersey averaged around one foot and in northwest New Jersey around six inches. A state of emergency was declared in New Jersey. President Barack Obama approved federal disaster reimbursement related to the winter storm and blizzard in Atlantic, Burlington, Cape May, Cumberland, Mercer, Middlesex, Monmouth, Morris, Ocean and Somerset Counties. Senate President Steven Sweeney declared a State of Emergency for New Jersey on the evening of the 26th. Several county and local municipalities also declared states of emergencies or snow emergencies. A total travel ban was in effect in Atlantic County. In Atlantic County, all departures from Atlantic City International Airport were cancelled on the 26th. The Route 52 Bridge between Somers Point and Ocean City in Cape May County was closed for about 24 hours until 11 a.m. EST on the 27th. The Garden State Parkway was closed in Egg Harbor Township because of a jack-knifed tractor-trailer. The snowfall at Atlantic City International Airport was a record breaking 20.1 inches. This was a new single snowstorm record surpassing the previous record of 20.0 inches during the President's Day II snowstorm of February 16 to 17 in 2003. Other representative snowfall included 20.0 inches in Absecon, 16.5 inches in Estell Manor and 16.3 inches in Folsom; The onshore flow preceding the passage of the low pressure system caused minor tidal flooding around the time of overnight high tide. At Atlantic City, the high tide reached 6.55 feet above mean lower low water. Minor tidal flooding starts at 6.0 feet above mean lower low water.

Events, 2011-2015. While several events have occurred per year in 2011-2015, most could be characterized as fairly typical of winter weather events in this part of the country, with relatively minor impacts and insignificant snow accumulations. A notable event occurring prior to the completion of the 2016 Update was on **March 20, 2015**. This winter storm on the first day of astronomical spring dropped snow across most of New Jersey on the 20th. Snowfall averaged 3 to 7 inches from Gloucester and inland Atlantic Counties northward and two inches or less elsewhere in southern New Jersey. It was a heavy, wet snow that did knock down some weak trees and tree limbs and caused isolated power outages in central New Jersey, primarily in Burlington County. The snow also caused travel difficulties and accidents during the afternoon and evening. Speed restrictions were in place on major road ways. Some schools dismissed children early. The snow caused more than 1,150 flights to be cancelled on the 20th in the northeastern United States. One of the worst reported vehicle accidents occurred in Hamilton Township when a driver traveling westbound on the Atlantic City Expressway lost control of his vehicle and subsequently crashed into another vehicle that was stopped on the right shoulder, where the driver was out of the vehicle checking a flat tire. He was struck and thrown by the other vehicle, but survived. Representative snowfall included 3.8 inches in Hammonton, 1.6 inches in Estelle Manor, and 0.3 inches at the Atlantic City International Airport. Minor tidal flooding occurred with the high tide cycle on the evening of the 20th.

November 20, 2016. An area of low pressure near James Bay Canada led to a strong cold frontal passage across the middle Atlantic Saturday evening November 19. Northwesterly winds increased substantially immediately following the cold frontal passage, with several reports of gusts generally in the 45 to 55 mph range over New Jersey.[25]

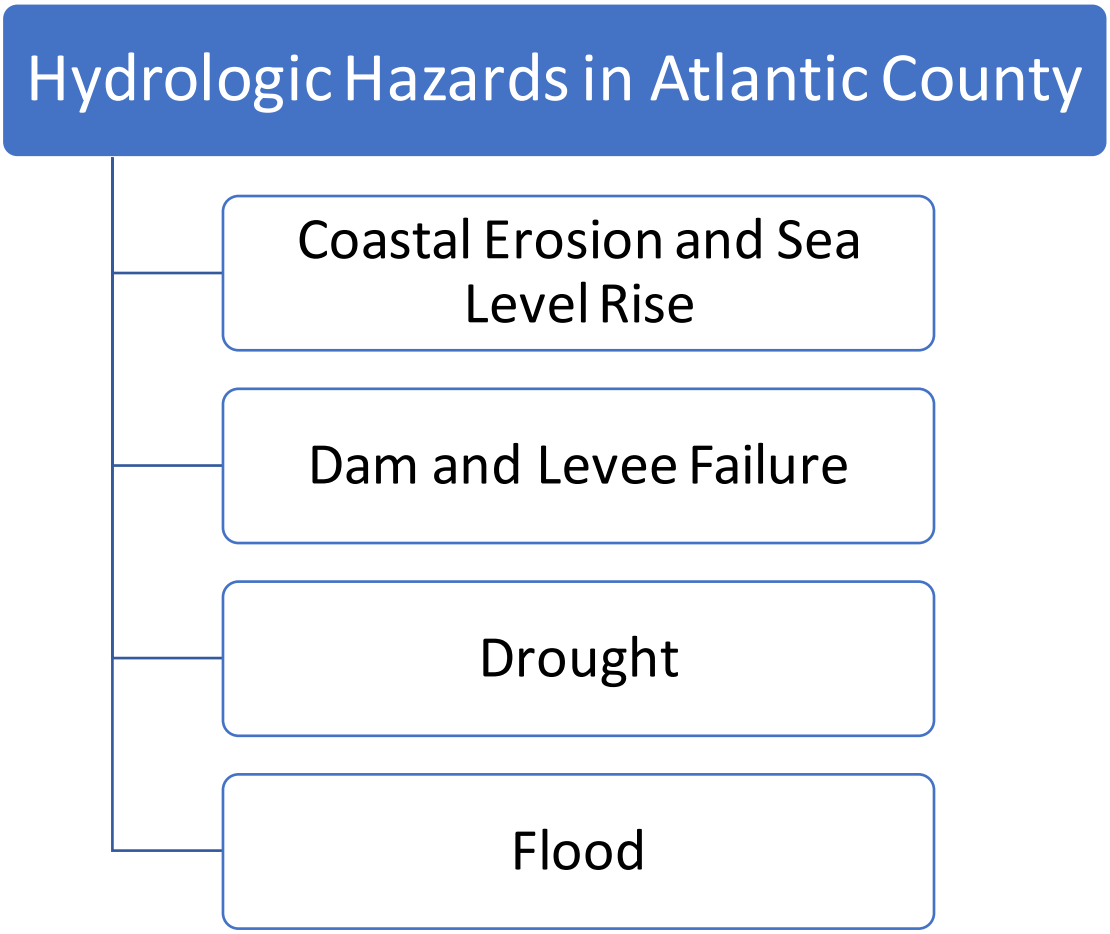
[25] Descriptions extracted from the 2019 New Jersey State Hazard Mitigation Plan.

Probability of Occurrence – Severe Winter Weather

Winter storm events will continue to have a high probability of occurrence in Atlantic County, and the probability of future occurrences in Atlantic County is certain. While the impact of snow and ice storms will cause major disruptions to transportation, commerce and electrical power as well as significant overtime work for government employees, large scale property damages and/or threats to human life and safety are not expected. Nor'easters occur less frequently but represent a much greater hazard of concern as it relates to the impacts of winter storm events (addressed separately within this section). Winter storms typically occur in New Jersey from late November through mid-April, with peak months being December through March. Nor'easters are one type of severe winter storm that typically bring high winds, coastal surge and tidal flooding along with heavy precipitation, which are addressed separately within this section.

The 2019 State Plan indicates that there is a lack of quantitative data to predict how future climate change will affect this hazard, saying, "It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013)."

HYDROLOGIC HAZARDS



Coastal Erosion and Sea Level Rise

Location – Coastal Erosion and Sea Level Rise

All of Atlantic County's coastal jurisdictions are susceptible to the hazards of coastal erosion hazard and sea level rise. Following a review of historic shoreline data dating back to 1836 provided by the New Jersey Department of Environmental Protection (NJDEP), it is clear that Atlantic County has experienced significantly changing shorelines (moving landward and seaward) due to the effects of erosion, accretion, beach nourishment and structural shoreline protection measures.

Figure 3a.9 illustrates the type of shorelines in Atlantic County as classified by NJDEP. These include the following types: (1) beach, which includes waterfront areas comprised of 100 percent sand; (2) bulkhead, which includes manmade structures at the water's edge, after the rip-rap, which were designed to hold back water and protect the adjacent areas from erosion; (3) marsh, which is classified areas of natural marsh edge; (4) earthen dike, classified as structures which

serve as natural barriers between the land and the water; and (5) erodible, which includes any soft shoreline other than beach, rock, marsh or earthen dike, which are vulnerable at the water's edge. As can be seen in the figure, most of Atlantic County's shoreline is classified as susceptible to coastal erosion (including "beach" and "erodible" classifications). Coastal erosion in these areas, where coupled with densely developed or significant recreational shorelines, are routinely addressed through beach nourishment programs.

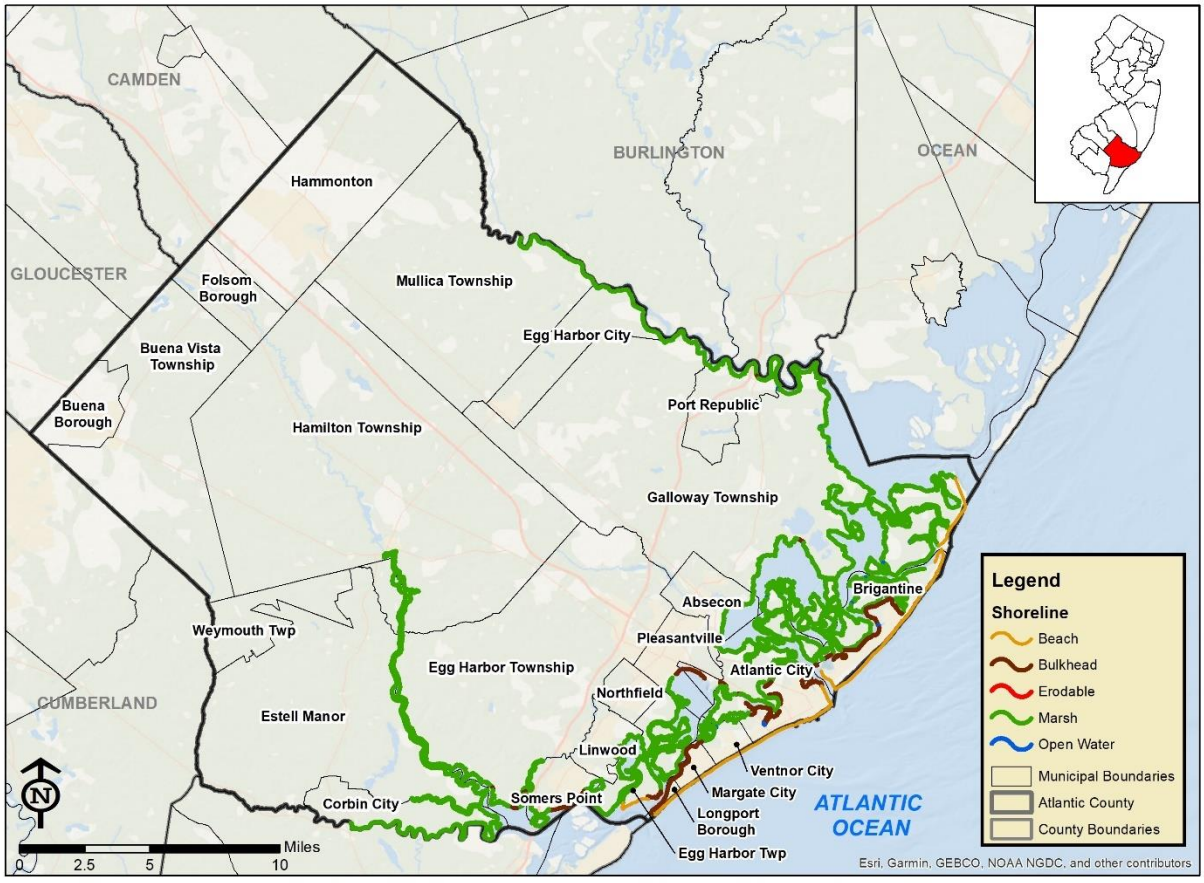
Although not shown on the countywide map figure, there are also many shoreline protection features located along the Atlantic County shore that are designed to reduce coastal storm and erosion hazards. These include hard structures such as jetties, groins, revetments, sea walls and breakwaters. Jetties and groins are protective structures (usually built from rock, wood or concrete) which extend outward from the shoreline. They look alike and provide similar function, but the difference between the two is that jetties are located at inlets, while groins are located along beaches. Sea walls are similar to bulkheads in function, but unlike bulkheads, they are located along the high beach line adjacent to the ocean, protecting property from ocean forces. Revetments are sea walls, which are surrounded on either side by rock or earth fill. A breakwater structure is a protective barrier placed in the water, out in front of a harbor. The 2019 New Jersey State Hazard Mitigation Plan summarizes the number and type of NJDEP shoreline structures off the coastline of New Jersey along the Atlantic Ocean and Inland Bays (current as of 1993). Atlantic County is reported to have 0 breakwaters, 30 groins, 3 jetties, 0 revetments, and 0 seawalls.

In addition to hard structures, some areas also feature coastal protection systems incorporating engineered dunes and beaches, which are maintained through regular scheduled maintenance and renourishment. Failure to continue these activities would result in an increased risk of damage in many areas during coastal storm events, as the levels of protection are degraded. However, local government entities within Atlantic County and the State of New Jersey have been very active in cooperating with Federal government agencies to ensure that these activities continue to be implemented and adequately maintained. These practices are encouraged and expected to continue. The State of New Jersey has completed several moderately sized shoreline restoration projects and is concentrating on cooperative projects with the ACOE to maximize utilization of its shore protection funding. The City of Brigantine received fill during April of 1997. Brigantine completed a 638,000 cubic yard maintenance of its 1997 project during the spring of 2001, assisted by FEMA disaster assistance funds from 1998, and NJ State co-sponsorship. The Absecon Island joint ACOE and NJ State project was completed during the fall of 2003, but limited thus far to the beaches of Atlantic City and Ventnor City. Margate City and Longport declined to participate in the initial project which the ACOE has named Phase I. The City of Brigantine is the location of a federally matched project originally formulated at the "Brigantine Inlet to Great Egg Harbor Inlet Shore Protection Project" to reduce the risk of damages from coastal storms. Initially constructed by ACOE in 2006, the project has received periodic renourishment in 2013 and 2018, with further renourishment scheduled for 2023, depending on the availability of funding.[26] The Brigantine portion was separated from the effort on Absecon Island to create two projects. The Brigantine project plan focuses on adding sand to the northern third of the municipal shoreline.[27]

[26] https://www.nap.usace.army.mil/Missions/Factsheets/Fact-Sheet-Article-View/Article/490777/new-jersey-shore-protection-brigantine-inlet-to-great-egg-harbor-inlet-briganti/

[27] Stockton University, http://intraweb.stockton.edu/eyos/page.cfm?siteID=149&pageID=3

Figure 3a.9
NJDEP Shoreline Classifications for Atlantic County



SOURCE: NJDEP: Shoreline Type, 1993 (with modifications by AECOM to reflect current oceanfront shoreline conditions, 2021) NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

The extent of sea level rise is measured by change in mean sea levels at fixed tide stations of the National Water Level Observation Network.

Extent – Coastal Erosion and Sea Level Rise

Coastal erosion is measured as the rate of change in the position or displacement of a riverbank or shoreline over a period of time. Short-term erosion typically results from periodic natural events, such as flooding, hurricanes, storm surge, and windstorms, but may be intensified by human activities. Long-term erosion is a result of multi-year impacts such as repetitive flooding, wave action, sea level rise, sediment loss, subsidence, and climate change. The severity of coastal erosion is typically measured through a quantitative assessment of annual shoreline change for a given beach cross-section of profile (feet or meters per year) over a long period of

time.[28] Erosion rates vary as a function of shoreline type and are influenced primarily by episodic events, but can be used in land use and hazard management to define areas of critical concern. Unfortunately, there is no uniform erosion rate database or GIS data layer that defines erosion rates or such areas of critical concern for Atlantic County's shoreline. However, NJOEM indicates that the New Jersey coast is characterized by episodic change resulting from severe but episodic storm events with a recurrence interval of 25 years or greater. Areas of natural erosion and accretion show erratic and almost cyclical patterns in response to storm events. The recovery process, although long, results in a stable beach with a slight recession of approximately one foot per year, half of which can be attributed to relative sea level rise. Erosion rates experienced along the New Jersey shore may vary significantly from location to location. According to a study prepared by the Heinz Center[29], much of the coastline of New Jersey, including Atlantic County, experiences an average of three feet of erosion per year. In addition, the 2019 State Plan states that Atlantic County experiences a maximum long-term erosion rate of -14.1 feet per year, and a maximum short-term rate of -63.3 feet per year (based on USGS data, 2011).

Recent scientific studies have shown that the tidal inlets have much greater impact on beach erosion or accretion on individual barrier islands than the steady flow of littoral currents to the south. If the sand moved south from Monmouth County toward Cape May Point in a never-ceasing stream, then Cape May Point and Cape May City would, theoretically, be buried in beach sand. The fact is, however, that both of New Jersey's southern-most communities were sand starved as major man-made structures and indirect, development-caused changes contributed to shoreline instability. In Atlantic County: Absecon Inlet is presently confined between rock jetties and cannot shift position as it once did; and Great Egg Inlet has one jetty or one shoreline armored with rocks to prevent inlet channel migration from taking more of the municipal lands adjacent to the inlet. Brigantine Inlet, however, is still in its natural state with no structures to modify the natural equilibrium.[30]

Historical Occurrences – Coastal Erosion and Sea Level Rise

The State of New Jersey has experienced eight FEMA coastal erosion related disaster declarations between 1954 and 2012[31]. Atlantic County was declared during six of these events: the December 1992, March 1998, and April 2007 coastal storms; severe storms and flooding associated with Tropical Depression Ida and a nor'easter in December 2009; Hurricane Irene in August 2011; and Superstorm Sandy in October 2012. No other county in the state has received more federal disaster declarations for coastal erosion events (though Cape May County also has been declared six times). The NJ State Plan reports 20 instances of coastal erosion affecting Atlantic County from 1936 to 2017 (see **Table 3a.14**). Six of these historic events are new as of this update.

[28] Seasonal fluctuations in beach width is common along the New Jersey shore, but is not considered erosion as the sand removed is typically re-deposited at other times of the year.
[29] "*Evaluation of Erosion Hazards*" prepared by The H. John Heinz III Center for Science, Economics and the Environment, April 2000
[30] Stockton University, http://intraweb.stockton.edu/eyos/page.cfm?siteID=149&pageID=3
[31] Source: NJSHMP (2019), Table 5.2-5

Table 3a.14
Historical Incidents of Coastal Erosion in Atlantic County[32]

Date	Associated Hazard Event Type	Federal Disaster Declaration Number[33]
March 6-8, 1962	Nor'easter	Not Available
October 28-November 4, 1991	Nor'easter	Not Declared
September 22-26, 1992	Tropical Storm Danielle	Not Declared
December 10-17, 1992	Coastal Storm	DR-973
August 8-25, 1994	Hurricane Felix	Not Declared
December 22-26, 1994	Storm	Not Declared
January 7-8, 1996	Blizzard	Not Declared
July 13, 1996	Tropical Storm Bertha	Not Declared
February 4-9, 1998	Nor'easter	DR-1206
April 16, 2007	Nor'easter	DR-1694
November 11-15, 2009	Remnants of Tropical Storm Ida (Nor'easter)	DR-1867
August 27-September 5, 2011	Hurricane Irene	DR-4021
October 29, 2011	Nor'easter	Not Declared
October 26-November 8, 2012	Superstorm Sandy	DR-4086
January 23-30, 2015	Winter Storm Juno	Not Declared
October 2, 2015	Nor'Easter	Not Declared
January 22-24, 2016	Blizzard	Not Declared
August 28-September 8, 2016	Remnants of Tropical Storm Hermine	Not Declared
March 14, 2017	Nor'Easter	Not Declared
September 5-26, 2017	Hurricane Jose	Not Declared

Descriptions of some of the *more notable events* from Table 3a.14 identified in the NJSHMP – in addition to some less extreme, more local events - include:

August 20, 1997. Very strong onshore winds coupled with torrential rain, that nearly coincided with high tide along the back bays caused moderate tidal flooding along the barrier islands of Atlantic County. Some significant erosion was observed in Atlantic City.

January 28, 1998. An intense nor'easter pounded the New Jersey Shore with tidal flooding, beach erosion, strong winds and rain. Along the ocean side, erosion took a heavy toll. In Margate 50 to 90 percent of the dunes vanished or suffered damage. In the City of Brigantine about 1,000 feet of dune fencing was lost. In the City of Ventnor City, the ramp to the beach washed away and the ocean carved huge chunks out of the dunes. Atlantic City lost about 3 feet of its beach and vertical drops of 3 to 4 feet were created in the Cities of Absecon and Brigantine.

February 4-9, 1998. The strongest nor'easter of the winter battered Coastal New Jersey, especially from Ocean County southward, with damaging winds, moderate to severe coastal flooding, extensive beach erosion, several dune breaches and heavy rain. A state of emergency was declared for all the coastal counties and both Atlantic and Cape May Counties were declared federal disaster areas. Damage statewide was estimated at about 17 million dollars and it was determined to be the worst storm to affect the area since December 1992.

[32] Source: NJSHMP (2014), Table 5.2-5 and NJSHMP (2019), Table 5.2-4
[33] Source: NJSHMP (2014) Table 5.2-6

Atlantic County suffered an estimated 3.9 million dollars in damage. Twenty-two persons from the Cities of Brigantine and Atlantic City were sheltered. Throughout the county one home and one business suffered major damage, 93 other dwellings and businesses suffered minor damage while tidal flooding affected but caused little damage to 219 others. The City of Brigantine suffered substantial flooding and beach erosion, especially at the north end of the island. About 75 percent of its sand was carried away. The boardwalk was ripped up at New Hampshire Avenue. All access roads into the city were closed on the morning of the 5th, except for the Atlantic City Expressway. The beach was described as "destroyed" in Margate City. In the Borough of Longport, the ocean met the bay from 11th through 24th Streets. The erosion caused vertical cliffs of 4 to 5 feet and streets had to be cleared of debris.

September 29, 2001. The onshore flow around a nor'easter brought minor to locally moderate tidal flooding along the New Jersey coast from the 29th through October 1st. Some beach erosion occurred. In the City of Brigantine, heavy beach erosion along the north end of the island produced cliffs that were four feet high.

September 18-19, 2003. Tropical Storm Isabel passed some way to the southeast of Atlantic County, but caused winds gusting up to 62 miles per hour in New Jersey and considerable beach erosion in Atlantic County.

October 21-25, 2004. The combination of a nearly stationary high pressure system over nearby Canada and low pressure systems over the western Atlantic produced six consecutive days of rough surf along the New Jersey shore from the 20th through the 25th Waves as large as six to eight feet were reported breaking on the shore. This produced moderate beach erosion along the coast with areas of severe erosion on Long Beach Island in Ocean County. In Atlantic County, erosion averaged between 3 and 5 feet vertically and sloped up to 100 feet wide. The worst reported damage was in the Cities of Brigantine and Atlantic City. In the City of Brigantine, an 8 foot vertical cut to the dune system occurred between Promenade and Vernon Place. In Atlantic City, damage occurred to the dune system north of Rhode Island Avenue with loss of sand fencing. Groins were exposed in the City of Margate City.

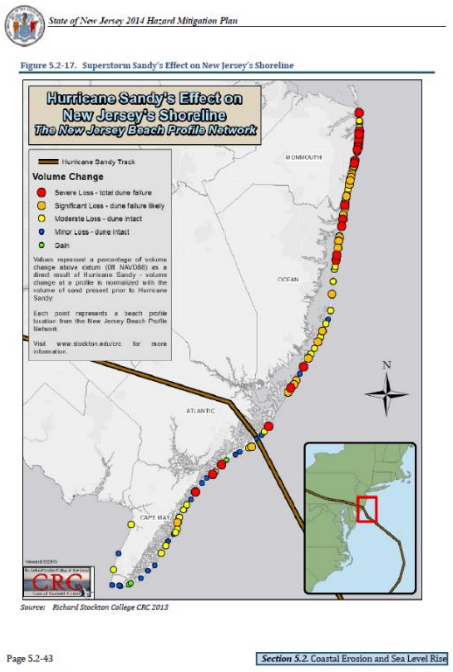
November 11-15, 2009. From November 11th through November 15th, 2009 coastal areas of New Jersey were impacted by severe storms and flooding associated with the remnants of **Tropical Storm Ida** and a Nor'easter. On December 22, 2009 a Presidentially-declared Disaster was declared for the three coastal Counties in New Jersey (FEMA DR-1867). The hardest hit counties included Atlantic, Cape May, and Ocean Counties. Only Public Assistance was made available.

August 27-September 5, 2011. Hurricane Irene produced torrential downpour rains that resulted in major flooding and a number of record breaking crests on area rivers, tropical storm force wind gusts with record breaking outages for New Jersey utilities, one confirmed tornado and a three to five foot storm surge that caused moderate to severe tidal flooding with extensive beach erosion. The average sand loss was about four to five feet high and one hundred fifty feet wide. Waves were estimated to reach as high as 12 feet as offshore seas reached 25 feet. There were numerous reports of dune fence damage and sand overwashes onto streets and boardwalks. In Atlantic County, vertical cuts averaged 1 to 4 feet, but reached 6 feet in Brigantine.

October 29, 2011. A nor'easter on October 29, 2011, caused strong winds and moderate tidal flooding. Atlantic County received less than one inch of snow during this event. However, wind gusts of 56 miles per hour were observed at the Atlantic City Marina with highest tides at 7.29 feet above mean lower low water at Atlantic City. Moderate tidal flooding starts at 7.0 feet

above mean lower low water at Atlantic City. In addition to impacts from wind and tidal flooding, this nor'easter was also a coastal erosion event in Atlantic County.

October 29, 2012. Like much of coastal New Jersey, Atlantic County's coastal communities were severely impacted by coastal erosion during Superstorm Sandy. The Richard Stockton College Coastal Research Center (CRC) researchers monitor shoreline change at 105 beach sites in Atlantic, Cape May, Monmouth, and Ocean Counties. A 25-year shoreline change analysis of each of the 105 monitoring sites was conducted to present the overall trend for each county. Richard Stockton College CRC also conducts post-storm survey and assessment of the New Jersey shoreline in response to severe beach erosion resulting from the impact of storm events. Nearly all of the 105 NJBPN sites were surveyed immediately after Superstorm Sandy to provide accurate assessments of sand volume losses to New Jersey's beaches. Figure 5.2-17 of the NYSHMP (reproduced here) illustrates the percent volume change above datum (0 feet NAVD88) as a direct result of Superstorm Sandy at each beach profile site. The volume change at each site is normalized with the volume of sand present prior to Superstorm Sandy. As this figure depicts, nearly all of these sites in Atlantic, Cape May, Monmouth, and Ocean Counties showed evidence of sand volume losses as a result of Superstorm Sandy in 2012 (Richard Stockton College CRC 2013). Dune breaches, loss and scarping of dunes, and decreased beach width and elevation occurred from southern Absecon Island's oceanfront north into Brigantine. The CRC reports[34] a total sand loss volume for Atlantic County of 845,132 cubic yards. Impacts of Sandy cited in the CRC report[35] include:



- **Green Acres Area, Brigantine**. The northern-most profile site on the Island of Brigantine is located on the undeveloped northern end of the island now in the possession of the State of New Jersey. This location was overwashed by waves from the ocean to the bay marshes by Sandy.

- **Brigantine**: Where development begins, the beach has been erosional due to the orientation difference between the physical infrastructure and the long-term changes in the shoreline. The Federal project includes a part of the natural shoreline where sand is placed to act as a feeder beach to the worst of the erosional segment. Prior to Sandy, the beach was wet to the toe of the rock revetment, so it provided little protection. During Sandy, waves crashed over the promenade and flooded Brigantine Boulevard. Dunes and a dry beach begin near the southern end of the promenade where steep scarps were in evidence going south to approximately 25th Street South. The dune-defended section did much better in stopping the storm waves except at 15th Street South where a large, multi-story building occupies the footprint of the dune. Both the 15th and 14th Street ends and the building's parking lot were overrun by waves and sand was transported into Brigantine Blvd. However, south of 15th Street South, the ever-widening beach absorbed the storm surge and the wave energy with no ill effects on any public or private property. Further south, extending to the Absecon Inlet jetty the

[34] http://intraweb.stockton.edu/eyos/coastal/content/docs/sandy/Atlantic.pdf
[35] New Jersey Beach Profile Network Report, Atlantic County, 2014. Richard Stockton College.

berm was eroded and sand pushed landward into the seaward-most part of the dune area.

- **Atlantic City**: Atlantic City has participated with a Federal beach nourishment project since 2003. The dunes were constructed to an elevation of 14.5 feet NAVD88 and were just high enough to withstand the wave run-up during Sandy. The oceanfront beach lost width and elevation, but the dunes prevented damage to the City's famous boardwalk.

- **Ventnor**: Ventnor City chose to participate in the 2002-2003 Federal beach restoration project. The Dorset Avenue site saw no serious impact from Sandy other than beach elevation loss and a narrower berm width. Further south toward Margate, the end-effect losses to the Federal project allowed waves to reach the timber bulkhead protecting the upland development and water came over the bulkhead at a variety of locations. The end effect sand losses were significant and a significant reason to complete the project as designed.

  Margate: Margate City had significant amounts of water wash over the timber in sufficient force and water volume to move sand into homes, businesses and the general infrastructure all along Atlantic Avenue. At the Benson Avenue site, a lack of consistent dunes, but a very wide beach permitted wave energy to deposit sand to the very top of the bulkhead, over it and into the street. Some spots did have "island" dunes that acted to protect from the overwash process, but in many cases the water came into the City. Sand recovered from inland was hauled back to the beach, but since the federal project has yet to start there has been no organized dune building in Margate City. The Margate City council has so far not sought inclusion in the Federal beach nourishment project because multiple oceanfront owners are strongly opposed to any dune as part of the project.

NJBPN 127 – Benson Avenue, Margate City

The photographs above were taken on April 13, 2012 (left) and November 6, 2012 (right). The relatively robust berm was cut down and pushed landward as a substantial deposit that included Benson Avenue and environs. The work was underway to excavate the sand at the sea-side of the bulkhead to keep water from simply running over it.

Photo courtesy of Richard Stockton College Coastal Research Center, Beach-Dune Performance Assessment of New Jersey Beach Profile Network (NJBPN) Sites at Atlantic County, New Jersey, After Hurricane Sandy Related to FEMA Disaster DR-NJ-4086.

- **Longport**: The damage incurred in Longport during Superstorm Sandy has convinced the community to seek inclusion in the Federal beach nourishment project to continue the work south from Ventnor. The southern community has an old concrete seawall protecting some of the development with a narrow, low elevation beach seaward. Waves crashed into the wall and poured over it down most of the Borough streets into Atlantic Avenue. Since the homes are very close to the wall, house damage was evident as well.

Sea level rise is a continuous event that does not have discrete occurrences. According to the 2019 New Jersey State Hazard Mitigation Plan, the sea level rose on average 4.1 millimeters annually between 1911 and 2016 in Atlantic City, a trend of 1.3 feet per century.[36]

Probability of Occurrence – Coastal Erosion and Sea Level Rise

Coastal erosion remains a natural, dynamic and continuous process for Atlantic County's coastal jurisdictions and its probability of occurrence is certain. The damaging impacts of coastal erosion are lessened through continuous (and costly) beach nourishment and structural shoreline protection measures; however, it is likely that the impacts of coastal erosion will increase in severity due to future episodic storm events as well as the anticipated slow onset, long-term effects of climate change and sea level rise. The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Atlantic County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Atlantic County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community – particularly for communities where tourism tends to drive local economies, as is the case in many of Atlantic County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Sea level rise is a continuous event that does not have discrete occurrences. The 2019 New Jersey State Hazard Mitigation Plan references the Rutgers University report titled 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 (STAP), 2016, to project and local and regional sea level rise in New Jersey. Local and regional sea level rise projections in New Jersey,

[36] Table 5.2-3 Mean Sea Level Rise Trends, 2019 SHMCAP

as identified in the 2019 SHMCAP are provided in **Table 3a.13**. It should be noted that many future sea level rise projections are not linear; that is they do not follow a trajectory with a constant gradient, but instead show the rate of sea level rise increasing over time.

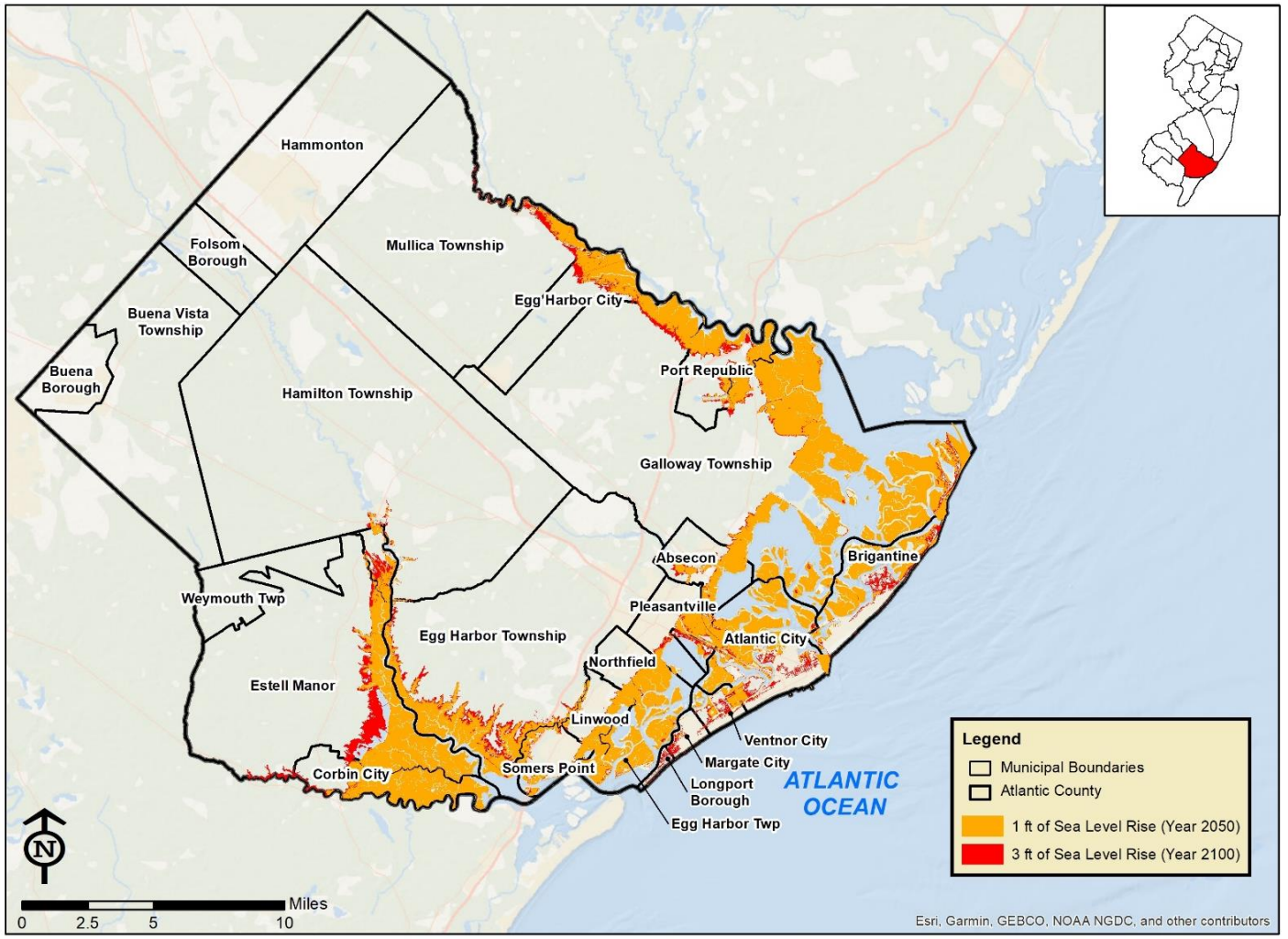
Table 3a.13
Projected Sea Level Rise for New Jersey

Year	Central Estimate	Likely Range	1-in-20 Change	1-in-200 Chance	1-in-1,000 Change
	50% probability SLR meets or exceeds	67% probability SLR is between	5% probability SLR meets or exceeds	0.5% probability SLR meets or exceeds	0.1% probability SLR meets or exceeds
2030	0.8 ft	0.6-1.0 ft	1.1 ft	1.3 ft	1.5 ft
2050	1.4 ft	1.0-1.8 ft	2.0 ft	2.4 ft	2.8 ft
2100 Low Emissions	2.3 ft	1.7-3.1 ft	3.8 ft	5.9 ft	8.3 ft
2100 High Emissions	3.4 ft	2.4-4.5 ft	5.3 ft	7.2 ft	10.0 ft

While the obvious impact of sea level rise is the permanent loss of land for human habitation, economic activity, and ecosystem conservation, even small amounts of sea level rise may significantly increase the annual probability that periodic coastal flooding events reach damaging or critical elevations.

Figure 3a.10 shows the areas potentially inundated by two future seal level rise scenarios taken from the Rutgers STAP Report and recommended by the 2019 State Plan for the assessment of future vulnerability to sea level rise: These two scenarios project one foot of sea level rise occurring by 2050 and three feet of sea level rise by 2100.

Figure 3a.10
Inundation from Projected Sea Level Rise



SOURCE: 1 ft (2050) and 3 ft (2100) Sea Level Rise Mapping provided by NOAA Sea Level Rise Viewer, https://coast.noaa.gov/digitalcoast/tools/slr.html and Kopp, R.E, et al, 2016.
NJGIN: County Boundary, 2021; Municipal Boundary, 2021.
Basemap: ESRI Ocean/World Ocean Basemap

Dam and Levee Failure

Location – Dam and Levee Failure

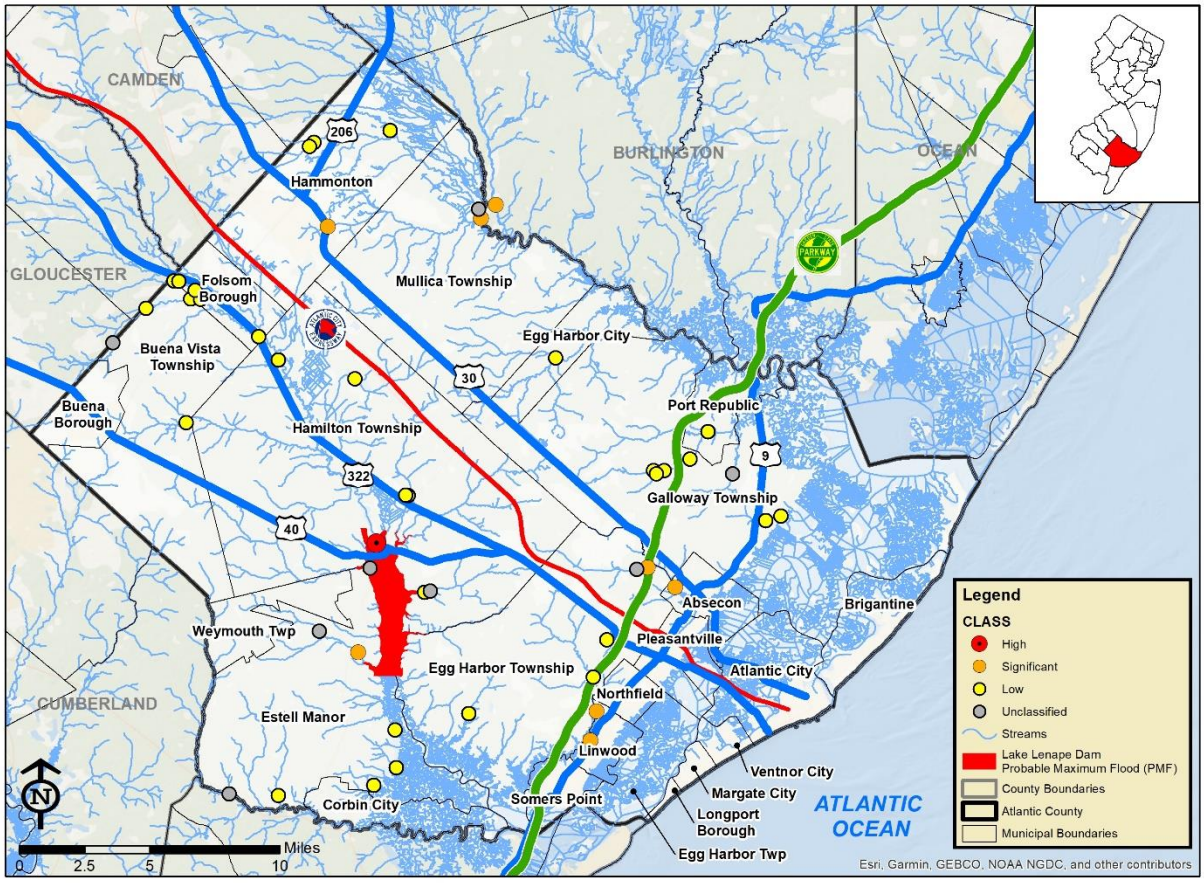
A dam is an artificial barrier that has the ability to store water or wastewater for many reasons, including flood control, water supply, irrigation, and energy generation. The New Jersey Department of Environmental Protection has identified and classified 48 dams[37] in Atlantic County. Of these, one dam has been classified as having "high hazard potential," meaning that its failure may cause the probable loss of life or extensive property damage. Another seven dams have been classified as having "significant hazard potential," meaning their failure may cause significant damage to property and project operation, but loss of human life is not envisioned. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads or cause interruption of service of relatively important public utilities. Thirty dams are classified as "low hazard potential" meaning their failure would cause loss of the dam itself but little or no additional damage to other property. The remaining ten dams are unclassified. It is important to note that dam hazard classifications are based on the consequences of dam failure—not the condition, probability or risk of failure itself. Specific locations for all state-regulated dams that have been geo-referenced for mapping purposes are illustrated in **Figure 3a.11**. This figure also shows the Probable Maximum Flood delineation for the Lake Lenape Dam. Of the eight "high" or "significant" hazard dams in Atlantic County, only one has been classified by USGS as a "major" dam and represents the most significant hazard risk based on the potential consequences of a dam failure. Major dams are described as 50 feet or more in height, or with a normal storage capacity of 5,000 acre-feet or more, or with a maximum storage capacity of 25,000 acre-feet or more. In Atlantic County, this includes the Lake Lenape Dam along the Great Egg Harbor River (located in, and owned by, Hamilton Township).

Levees are human-made structures designed to contain, control, or divert the flow of water in order to provide protection from temporary flooding.[38] There are no significant levees recorded in Atlantic County.

[37] As defined in NJAC 7:20 (Dam Safety Standards), "Dam" means any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of dam.

[38] State of New Jersey Office of Emergency Management, New Jersey State Hazard Mitigation Plan, 2019.

Figure 3a.11
State-Regulated Dams in Atlantic County



SOURCE: US Army Corps of Engineers National Inventory of Dams (NID), 2021; Stanford University National Performance of Dams Database (NPDP), 2021; NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

Extent – Dam and Levee Failure

The extent or magnitude of a dam failure event can be measured in terms of the classification of the dam.

The NJDEP assigns one of four hazard classifications to state-regulated dams in New Jersey. The classifications relate to the potential for property damage and/or loss of life in the event of a dam failure:

- Class I (High-Hazard Potential) - Failure of the dam may result in probable loss of life and/or extensive property damage.
- Class II (Significant-Hazard Potential) - Failure of the dam may result in significant property damage; however, loss of life is not envisioned.
- Class III (Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life and/or significant property damage.
- Class IV (Small-Dam Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life or significant property damage.

Table 3a.15 lists information for all state-regulated dams in Atlantic County reported as having high (H) hazard potential or significant (S) hazard potential (a total of 8 dams, 1 being classified as high hazard potential and 7 being classified as significant hazard potential). The County's high hazard dam – Lake Lenape Dam – is also listed as a "major" dam in the USGS National Inventory of Dams (NID).

Table 3a.15
State-Regulated Dams with High or Significant Hazard Potential

Dam Name	Hazard Potential	Jurisdiction	River/Stream	Dam Storage (acre-feet)	Owner(s)
Lake Lenape Dam*	H	Hamilton Township	Great Egg Harbor River	6610	Hamilton Township
Doughty Pond Dam	S	Absecon City	Absecon Creek	2400	Atlantic City M.U.A.
Bargaintown Mill Pond Dam	S	Egg Harbor Township	Patcong Creek	123	Atlantic County
Kuehnle Pond Dam	S	Egg Harbor Township	South Branch Absecon Creek	2100	Atlantic City M.U.A.
Stephen Lake Dam	S	Estell Manor City	Stephen Creek	130	Lenape Game Preserve & Breeding Assoc.
Hammonton Lake Dam	S	Hammonton Town	Hammonton Creek	426	NJDOT
Off's Pond Dam	S	Linwood City	Patcong Creek tributary	N/A	Brighton Farms Corp.
Pleasant Mills Dam	S	Mullica Township	Hammonton Creek	160	Nescochague Lake Assoc. Inc.

Source: New Jersey Department of Environmental Protection, Bureau of Dam Safety and Flood Control
* Dam also listed as a "major" dam in the USGS National Inventory of Dams (NID). Major dams are described as 50 feet or more in height, or with a normal storage capacity of 5,000 acre-feet or more, or with a maximum storage capacity of 25,000 acre-feet or more.

Historical Occurrences – Dam and Levee Failure

According to NJDEP's Bureau of Dam Safety and Flood Control, New Jersey has not experienced any historic major dam failures but there have been an increasing number of small dam failures. This is largely attributed to the lack of maintenance and inspection of the small dams, as well as the fact that many of the dams in the state are nearing the end of their design life. At the time the initial plan was prepared, local sources on the CPG reported concerns regarding a series of lakes and dams on the campus of the Richard Stockton College of New Jersey, in the Township of Galloway. The lower dam (Lake Fred Dam) forms the main impoundment of the lakes. Constructed in the 1930's, the Lake Fred Dam is an earth fill embankment approximately 850 feet long, 12-feet wide and 10 feet high. On August 20, 1997, the entire length of the earth fill dam was overtopped from a 100-year storm due to the apparent failure of the main spillway to control the volume of water. At that time a hole was scoured under the bottom of the main spillway, water overtopped the majority of the dam's crest causing erosion along the dam's downstream slope of the embankment, and sections of the earth fill dam along the spillway were undermined causing subsidence (sinkholes) in the dam's crest. Downstream areas of concern for the flooding were the Evergreen Woods Lakefront Resort Campground and the Garden State Parkway. After the incident, the rehabilitation of the Lake Fred Dam was managed by the State of New Jersey, Division of Property Management and Construction in coordination with the requirements of the

New Jersey Department of Environmental Protection, Bureau of Dam Safety & Flood Control. Rehabilitation included: a new spillway, with sluice gate, designed to manage the additional volume of water generated by a 100-year storm and prevent overtopping of the dam, and articulated concrete block on the downstream slope of the embankment designed to prevent erosion if overtopping should occur. These design elements of the rehabilitation effort have minimized concerns associated with the Lake Fred Dam, which is currently classified by the Bureau of Dam Safety & Flood Control as a Class III structure (Low Hazard Potential – those dams the failure of which will cause loss of the dam itself but little or no additional damage to other property. Failure may result in the damage of farm buildings, agricultural lands and non-major roads). There have not been any dam failures in Atlantic County since the 2016 Update.

There are no levees recorded in Atlantic County, and subsequently there are no recorded instances of historic levee failures.

Probability of Occurrence – Dam and Levee Failure

The probability of a dam failure occurrence in Atlantic County is relatively low due to routine inspection, repair and maintenance programs, though the possibility of a future failure event is likely increasing due to aging dam structures that may be in need of repair or reconstruction. The NJDEP's Dam Safety program serves to ensure the safety and integrity of dams in New Jersey and, thereby, protect people and property from the consequences of dam failures.

Drought

Location – Drought

Droughts occur in all parts of the country and at any time of year, depending on temperature and precipitation over time. Similarly, droughts can occur in all parts of Atlantic County at any time of year, depending on temperature and precipitation over time. While arid regions of the United States are more susceptible to long-term or extreme drought conditions, other areas such as Atlantic County tend to be more susceptible to short-term, less severe droughts. It is impossible to delineate a drought hazard area for the County, per se, but it is generally assumed that drought is a county-wide hazard, with drought conditions being possible in all geographic areas.

Extent – Drought

The extent (i.e., magnitude or severity) of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. The intensity of the impact from drought could be minor to extreme damage in a localized area or regional damage affecting human health and the economy. Generally, impacts of drought evolve gradually, and regions of maximum intensity change with time. The severity of a drought is determined by areal extent as well as intensity and duration. The frequency of a drought is determined by analyzing the intensity for a given duration, which allows determination of the probability or percent chance of a more severe event occurring in a given mean return period.

The Palmer Drought Severity Index (PDSI) is one of many available drought indices used to assess the extent of a drought event. It was developed by Wayne Palmer in 1965 and indicates prolonged and abnormal moisture deficiency or excess. The PDSI tends to be used more commonly than other available indices, and is an important tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. PDSI drought classifications are based on observed drought conditions and will range from -0.5 (incipient dry spell) to -4.0 (extreme drought). The PDSI also reflects excess precipitation using positive numbers. The PDSI is the most effective in determining long-term droughts; but has limitations in terms of use for short-term forecasts. To improve monitoring and measurement of drought severity from region to region within the State of New Jersey, NJDEP implemented a unique set of indices in January 2001 specifically designed for the particular characteristics and needs of the State. This new set of statewide indicators supplements the Palmer Drought Severity Index (PDSI) with the measurement of regional precipitation, streamflow, reservoir levels, and groundwater levels. New Jersey currently measures the status of each indicator as near or above normal, moderately dry, severely dry, or extremely dry. The status is based on a statistical analysis of historical values with generally the driest 10 percent being classified as extremely dry, from 10 percent to 30 percent as severely dry, and 30 percent to 50 percent as moderately dry.

Historical Occurrences – Drought

Drought is continuous event that does not always have a discrete start and end time. According to NCEI database[39], drought conditions have affected Atlantic County for 38 months between June 1997 and May 2021, occurring in eight years. No deaths, injuries, property, or crop damages are recorded in the NCEI database. No events have been recorded since the last version of the plan was prepared in 2016. A sampling of *more notable* historical events includes:

> **July 1998 – December 1998**. July 1998 started a run of drier than normal weather across New Jersey. The unseasonably dry weather forced the NJDEP to issue a severe forest fire warning for southern New Jersey, and on December 14th the NJDEP declared a drought warning for the entire state. Agriculture was significantly affected, with grain farmers in particular suffering serious losses of corn and late season crops. For most of the state the precipitation was around 2.5 inches below normal. July through December 1998 was the second driest six-month period ever in the state of New Jersey: the average statewide precipitation total of 12.04 inches was only 52 percent of normal. The only drier six-month period previously recorded was November 1984 through April 1985 when a statewide average of 11.92 inches of precipitation fell. Statewide precipitation records have been kept in New Jersey since 1895.
>
> **June 1999 – September 1999**. Unseasonably dry weather that had begun in May 1999 intensified, and on July 19th the Governor declared a water shortage alert and called for residents to voluntarily conserve water by not watering lawns or washing cars. On August 5th this was raised to a drought emergency, with mandatory water restrictions. Farmers in New Jersey felt a double pinch: irrigation, if possible, was driving up the costs of farming. Meanwhile, ideal growing conditions elsewhere in the country kept crop prices low. If possible, irrigation was occurring everywhere. Irrigation ponds were drying out and well permits were being issued. Irrigated corn fields were in fair condition, most corn was in poor condition. Low yields and nutrient content were expected with many fields already lost. Livestock feed crops were at a near-total loss and many farmers had to borrow money to buy food for their cattle into 2000. Soybean crops (normally not irrigated) were in fair to poor condition. The second hay

[39] Data current as of May 2021.

cutting was poor at best. No third cutting of alfalfa was possible. Pasture conditions were in poor condition. Supplemental feeding, some that is normally saved for the winter, was occurring. The hot weather also cut back milk production by about 20 percent. Sun damage was reported to pepper and tomato crops. Overall crop losses in the State of New Jersey were estimated at exceeding $80 million dollars. On August 10th, the Secretary of Agriculture declared 19 counties in New Jersey a drought disaster. This made farmers in those counties and adjacent ones eligible for low interest loans of up to $500,000. Farmers eligible for help must have lost at least 30 percent of their crops, have adequate security, been turned down by two banks, and be able to repay the loan. The Agriculture Department also provided $20 million in grants to provide emergency services to low income migrant and seasonal farm workers in declared areas.

October 2001 – September 2002. October 2001 was an unseasonably dry month across the state of New Jersey. The ongoing dry weather prompted the state Environmental Protection Commissioner to issue a drought watch for the entire state on October 30th. The declaration called on residents to voluntarily conserve water. The NJDEP upgraded the drought watch to a drought warning for counties in southern New Jersey on November 21st. It was also the driest meteorological winter on record at the Atlantic City International Airport as only 4.66 inches of precipitation fell. By the time near-normal precipitation returned in September 2002, it was estimated that the drought will cost farmers about $125 million in revenue. The corn harvest was expected to be down 25 percent and the soybean harvest down 30 percent. Revenue drops in some areas were over 50 percent. Field crops such as hay, wheat, sorghum, soybeans and corn for animal feed were hardest hit because they are not irrigated. *USA Today* reported that in New Jersey "crop damage is widespread, varying from a total loss to expected drops in yield of 20 to 50 percent depending on the crop, when it was planted and farm location."

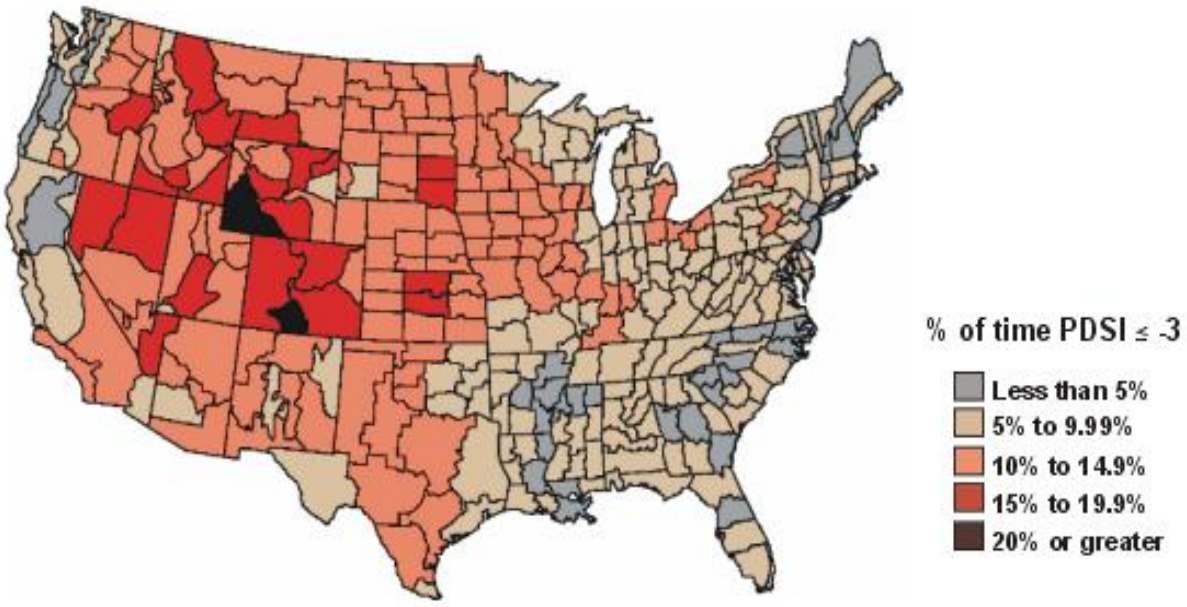
September 2010 – October 2010. The hot and dry summer taxed reservoir stream and groundwater levels. Shallow groundwater (private) wells were also starting to show stress. The NJDEP issued a state-wide drought watch on September 8th. All residents were asked to voluntarily conserve water. September was another unseasonably warm month in New Jersey. Statewide it was the 4th warmest September on record since 1895 with an average temperature of 69.2 degrees. Because of the heavy rain on the last day of the month, September averaged closer to normal rainfall. It was the 7th warmest (71.0 degrees) September on record at the Atlantic City International Airport and the warm season as a whole established a new record for the number of days that the maximum temperature reached or exceeded 90 degrees (46 days). The wet weather on September 30th and October 1st started to recharge water supplies in the State of New Jersey. On October 26th, the New Jersey Department of Environmental Protection cancelled the drought watch for most of the state, except for Monmouth and Ocean Counties. Despite improvements elsewhere, conditions in those counties showed that the combination of reservoir storage remained below the long-term average and severely dry and shallow ground water levels were still occurring. The summer drought took its toll on New Jersey farmers and the United States Secretary of Agriculture declared all counties in southern, central and northwest New Jersey natural disaster areas in November. The declaration made farm operators eligible for assistance from the Farm Service Agency. The assistance included low interest loans which could cover up to 100 percent of the dollar value of the crop losses. The statewide October monthly precipitation average for New Jersey was 4.88 inches, about one hundred forty percent of normal and 1.37 inches wetter than average.

New Jersey has not experienced significant drought events since the February 2016 Update.

Probability of Occurrence – Drought

Atlantic County faces a low to moderate probability of severe drought conditions, though short-term instances of drought will be a more frequent occurrence. **Figure 3a.12** shows the PDSI Summary Map for the United States from 1895 to 1995. According to the PDSI map, Atlantic County is in a zone that experienced severe drought conditions less than 5 percent of the time between 1895 and 1995, but short-term, less severe drought conditions are more common and may occur several times in a decade.

Figure 3a.12
Palmer Drought Severity Index Summary Map for the United States



Source: National Drought Mitigation Center, 1895-1995

Flood

Flood hazards profiled in this section include the following:

- Riverine Flooding
- Coastal Flooding and Storm Surge
- Tsunami
- Wave Action

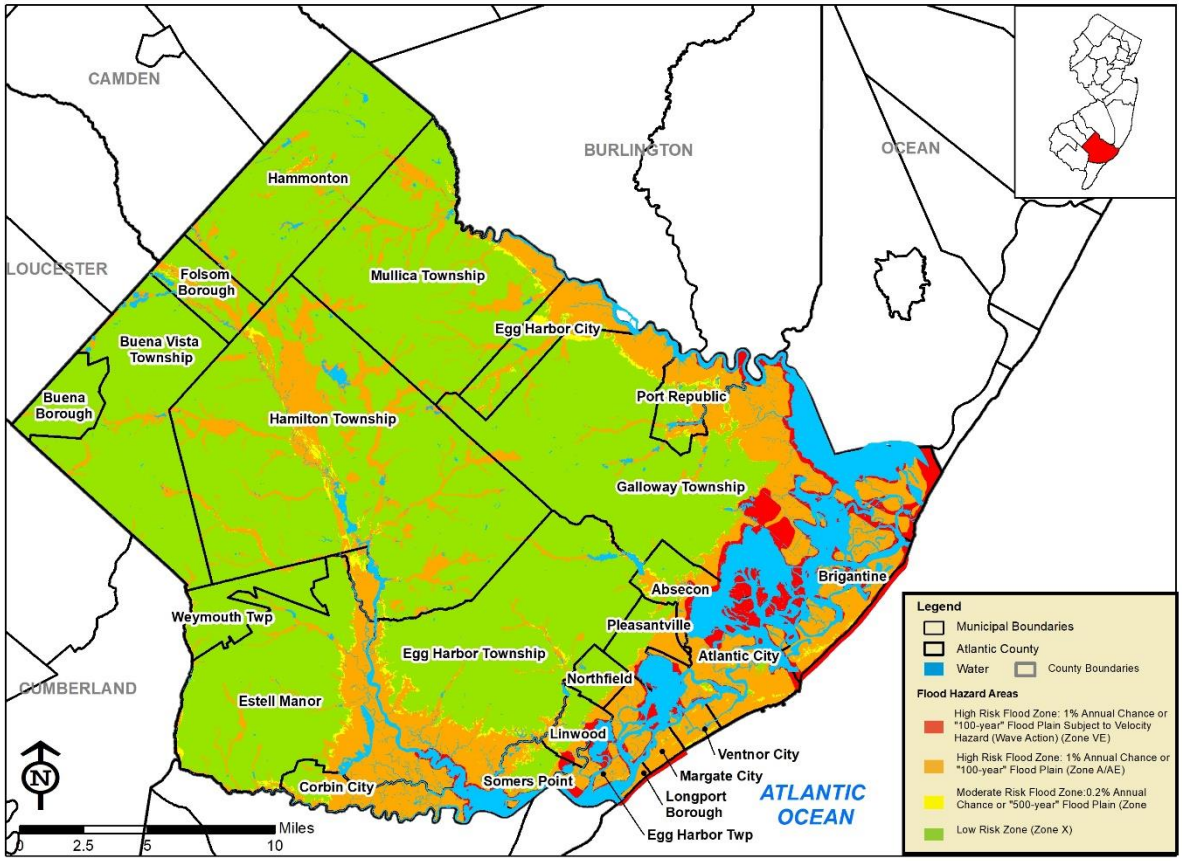
Location – Riverine Flooding

Riverine flooding occurs along inland channels such as rivers, creeks, streams. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas. Many areas of Atlantic County are susceptible to riverine and urban (stormwater) flooding, and its coastal jurisdictions are also very susceptible to tidal and coastal flooding due to coastal storm events including storm surge.[40] It is estimated that nearly 27 percent of lands within Atlantic County are located in the 100-year floodplain. **Figure 3a.13** illustrates the location and extent of currently mapped special flood hazard areas for Atlantic County based on FEMA's 2021 Digital Flood Insurance Rate Maps (DFIRMs) where available, and Preliminary FIRM data in the remaining areas. This includes Zones A/AE (100-year floodplain), Zone VE (100-year coastal flood zones, associated with wave action) and Zone X500 (500-year floodplain). It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood-related losses often do occur outside of delineated special flood hazard areas – particularly in areas that were not included in detailed study areas.

The FEMA Flood Insurance Study (FIS)[41] notes that along the Atlantic Ocean, most of the shoreline is sandy with a variable height sand dune and characterized by high-density residential areas. The bay sides of the barrier islands are a mix of low-lying marsh, armored shoreline and residential areas. For example, bulkheads have been constructed along mainland shorelines in Egg Harbor Township, Somers Point, Pleasantville, Galloway, and Port Republic; and along barrier island back-bay areas in Longport, Margate, Ventnor, Atlantic City, and Brigantine.[42] The inland shoreline is primarily low-lying with a mix of residential areas and marsh.

[40] Storm surge is addressed as a separate hazard within this section.
[41] FEMA FIS for Atlantic County, NJ. August 2018.
[42] Source: NJDEP Shoreline Type, 1993. See Figure 3a.9.

Figure 3a.13
Special Flood Hazard Areas in Atlantic County



SOURCE: FEMA Digital Flood Insurance Rate Map (DFIRM) data, 2021, where available; Preliminary FIRM Data 2014 for areas not currently included in 2021 DFIRM: Atlantic City, Corbin City, Egg Harbor City, Estell Manor, Galloway Township, Northfield, Pleasantville, Port Republic, Somers Point, Ventnor City. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

The flooding portion of this hazard mitigation plan was revised during the first update to reflect changes between the Q3 mapping and 2014 Preliminary DFIRMs.[43] As part of the 2014 update, the FIS notes that updated coastal storm surge and wave height analyses were performed for the entirety of the shoreline within Atlantic County. In addition, floodplains for all riverine flooding sources studied by detailed methods in the county were redelineated using updated topographic data provided to FEMA by USGS and NJDEP. Flood hazard areas previously assessed by approximate methods were reanalyzed throughout the county, with results mapped using the updated topographic data mentioned above. Base map information for the 2014 Preliminary FIRMs was developed from high-resolution orthophotography provided by the State of New Jersey.[44] As noted in the footnote to Figure 3a.13, this plan update made use of the latest Digital Flood Insurance Rate Map (DFIRM) data where available, and the 2014 Preliminary FIRM data in remaining parts of the County.

[43] The projection used for the production of this FIRM is New Jersey State Plane (FIPS 2900) zone. The horizontal datum was NAD 83, GRS80 spheroid. Differences in the datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent counties may result in slight positional differences in map features at the county boundaries. These differences do not affect the accuracy of information shown on the FIRM.

[44] This information was derived from digital orthophotos produced at a scale of 1:2,400 with a 1-foot pixel resolution from photography dated 2012.

Extent – Flooding

In the case of riverine flood hazard, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations. (NWS 2011)

The extent of flooding associated with a 1 percent annual probability of occurrence (the base flood or 100-year flood, **Figure 3a.13** for Atlantic County) is used as the regulatory boundary by many agencies. Also referred to as the SFHA, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the water elevation resulting from a given discharge level, which is one of the most important factors used in estimating flood damage.

Historical Occurrences – Flood

Flooding is the most common major natural hazard in New Jersey. The FIS notes that most serious tidal flooding problems are attributed to hurricanes, which occur during the late summer and early autumn. In addition to heavy precipitation, hurricanes produce high tides and strong waves, which can result in severe damage to coastal areas. Although extratropical cyclones, referred to as northeasters, can develop at almost any time of the year, they are more likely to occur during the winter and spring. Thunderstorms are a common occurrence during the summer months.

According to the NCEI database, 127 recorded flood days (coastal flood, flash flood, and flood) have occurred in Atlantic County between January 1996 and May 2021. These events have resulted in more than $357 million in property damages ($250 million of this is recorded from Superstorm Sandy alone). A sampling of *more recent, notable events* includes the following:

> **August 20, 1997.** A series of thunderstorms moved across eastern parts of Atlantic County causing torrential rain over several hours. Atlantic County bore the brunt of the storm and the flooding with storm totals in excess of 8 inches from Estell Manor through Galloway Township. The storm total at the Atlantic City International Airport of 13.52 inches represented by far a greater than 100-year storm for the area. A 100-year-storm for this area is 7.25 inches. Several major roadways and bridges collapsed or were completely washed out. The governor declared a state of emergency for the county on the 21st and the county was eventually declared a federal disaster area. In Galloway Township, the hardest hit area, about 1,100 homes suffered damage. This represented about 10 percent of all the township housing. The most damage occurred in the Pomona Oaks Development as 75 homes were badly flooded when a drainage pond filled and backed up. The Osprey Court Development was also badly flooded. The Atlantic City Medical Center was closed to emergencies when its first floor and basement were

flooded. Emergency personnel pumped out 1.8 million gallons of water from the center. The adjacent Bacharach Rehabilitation Center was also flooded. Flooding also damaged the Absegami High School and several facilities at the Richard Stockton College. The Atlantic City International Airport was closed at 1230 a.m. on the 21st when power was knocked out to the runways and street flooding closed access to the airport. The airport reopened at 1130 a.m. on the 21st, but had to shut down again at sunset as the runway lights were still not working. The FAA Technical Center was also closed. In Hamilton Township, three major bridges were closed: the Sugar Hill Bridge on County Road 559, the Gravelly Run Bridge (County Road 559 also) on Ocean Heights Avenue and the bridge between the Lake Lenape Dam and the Great Harbor River. Persons in homes near these bridges were evacuated to a senior citizen center. Working around the clock, the Sugar Hill Bridge was repaired in time for the Labor Day Weekend. The two other bridges were repaired by late September. Two New Jersey Transit buses and 40 passengers became stuck in the flood waters near the Hamilton Mall and had to be rescued. Five thousand books in the Atlantic Community College were damaged by the flooding. Parts of the Black Horse Pike (U.S. Route 40) were closed because the road washed out. Sections of U.S. Route 40 were also closed in Egg Harbor Township. In Absecon, a 180 foot section of the New Jersey Transit train track was closed after the gravel bed was washed away. In Pleasantville, the motels around U.S. Routes 30 and 40 were evacuated because of the heavy rain and back-bay flooding. Several people had to be rescued from their vehicles. At the water treatment plant pumping station, the sediment rate was above acceptable standards. Even though Atlantic City proper escaped the heavy rain, residents had to boil their tap water for several days to make it potable because the city's reservoir in Egg Harbor Township flooded. The United States Geological Survey Gage on the Tuckahoe River at Head of River reached a new record crest of 9.1 feet. This represented a greater than 100 year recurrence interval. To put the storm total of 13.52 inches at the Atlantic City International Airport in perspective, the all-time certified 24 hour rainfall record for the state of New Jersey is 14.81 inches in Tuckerton (Ocean County) on August 19, 1939. The 11.12 inches of rain that fell through midnight EST on the 20th, was a new all-time daily record. The previous 24 hour record was 6.46 inches set on July 10, 1949. The 13.52 inches also broke the previous all-time monthly record of 13.09 inches set in July of 1959. August 1997 would have a new rainfall record of 16.12 inches at the airport. Other storm totals from Atlantic County included 12.7 inches in Mays Landing, 12.6 inches in Estell Manor, and 10.21 inches in Pleasantville. Flood damages in Atlantic County alone were estimated to be $54 million.

February 4-9, 1998. This strong nor'easter battered the state with damaging winds, moderate to severe coastal flooding, extensive beach erosion, several dune breaches, and heavy rain. At the time, it was one of the worst storms to impact the study area since the December 1992 nor'easter. The heaviest rain occurred along the immediate shore and exceeded two inches. Tidal departures averaged around 4 feet above normal. Fortunately this storm did not coincide with the spring tide cycle. Nevertheless, for most other locations, this was the highest tide since the December 1992 nor'easter. Atlantic County suffered an estimated $3.9 million in flood related property damage. Twenty-two people from Brigantine and Atlantic City were sheltered. Throughout the county one home and one business suffered major damage, 93 other dwellings and businesses suffered minor damage while tidal flooding affected but caused little damage to 219 others. Brigantine suffered substantial flooding and beach erosion, especially at the north end of the island. About 75 percent of its sand was carried away. Within Atlantic City, the 84 residents of the Oceanside Nursing Home were removed to 14 other nursing homes on the mainland. The boardwalk was ripped at New Hampshire Avenue. All access roads into the city were closed on the morning of the 5th, except for the Atlantic City Expressway. The worst tidal flooding occurred in the back-bay with much of Venice Park, the Chelsea Bay Front and Chelsea Heights inundated. Dozens of parked cars had water up to their doors. The beach was described as "destroyed" in Margate. In Longport, the ocean met

the bay from 11th through 24th Streets. The erosion caused vertical cliffs of 4 to 5 feet and streets had to be cleared of debris. The mainland was not spared in the county as the heavy rain caused basement flooding in the Donald J. Adams School in Northfield and trees were uprooted in Linwood. The high tide on the 5th contained the highest tides including (all above mean lower low water): 9.0 feet in Absecon, 8.5 feet in Longport, 8.0 feet in Ventnor, and 7.8 feet in Atlantic City (3.9 feet above normal).

August 27-28, 2011. Tropical Storm Irene produced torrential downpour rains that helped make August 2011 the wettest August on record for the State of New Jersey dating back to 1895, and resulted in major flooding and a number of record breaking crests on area rivers and a three to five foot storm surge that caused moderate to severe tidal flooding with extensive beach erosion. Event precipitation totals from Irene averaged 5 to 10 inches and caused widespread, record breaking flooding. Irene made her initial landfall near Cape Lookout, North Carolina on the 27th as a Category 1 hurricane; and then proceeded to make her second landfall as a tropical storm on Brigantine Island, just north of Atlantic City, New Jersey at 5:35 a.m. on the 28th. All Atlantic County shore communities east of U.S. Route 9 including Atlantic City were placed under a voluntary evacuation at 8 p.m. on August 25th and a mandatory evacuation effective starting 6 a.m. on the 26th. To relieve evacuation traffic, toll operations were temporarily suspended on the Garden State Parkway south of the Raritan River and on the Atlantic City Expressway. The southbound lanes on the Garden State Parkway south of exit 98 were closed at 8 p.m. on August 26th. Peak storm tides were 6.96 feet above mean lower low water in Atlantic City; moderate tidal flooding starts at 7.0 feet above mean lower low water. Flooding along the Mullica and Great Egg Rivers threatened about 100,000 county residents. Flooding forced the evacuation of 102 residents of a senior mobile home development in Buena Vista Township. The English Creek flooded in Egg Harbor Township. Two bridges (one was the Somers Point-Mays Landing Bridge) were damaged by flooding in the county. Eight roadways were closed due to flooding. For the second time within the same month, the Great Egg Harbor River at Folsom had record breaking major flooding. It was above its 6 foot flood stage from 10:05 a.m. on the 28th through 4:15 a.m. on September 1st. It crested at 8.27 feet at 11:15 p.m. on the 29th. Event rainfall totals included 8.76 inches in Estell Manor, 7.75 inches in Egg Harbor Township, 7.53 inches in Buena Vista Township, 7.49 inches in Hammonton, 7.40 inches in Linwood and 7.06 inches in Hamilton Township and 5.88 inches at the Atlantic City International Airport. Roughly $30 million in flood-related property damage was reported in Atlantic County alone and the closure of the Atlantic City casinos (only the third time in history) for three days caused an estimated 45 million dollars in lost revenue.

August 11, 2012. Thunderstorms with torrential downpours caused flash flooding on Absecon Island in both Atlantic City and Margate City. Numerous streets were flooded in Atlantic City and vehicles were getting stuck in the high water. In Margate, flooding spread into some buildings. Doppler Radar storm total estimates reached 2.0 to 2.5 inches on the island. The Marina within Atlantic City measured 1.60 inches of rain.

August 14, 2012. Thunderstorms which back built over Galloway Township caused flash flooding during the late afternoon of the 14th. Doppler Radar storm total estimates reached 3 to 5 inches in the township. The Garden State Parkway was flooded in the township as were numerous other smaller roadways including Kensington Drive. Vehicles were partially submerged and flood waters reached up to the entrances of homes.

October 29, 2012. Superstorm Sandy made landfall in Atlantic County as a post tropical storm in Brigantine City just north of Atlantic City at 730 p.m. EDT on the 29th. Sandy was the costliest natural disaster by far in the state of New Jersey. The unique aspect of Sandy was its multi-tide cycle increase of onshore winds prior to landfall. This caused multiple high tide cycles with

tidal flooding and also helped produce catastrophic wave action and tidal flooding. Record breaking high tides and wave action combined with extreme winds and heavy rainfall to batter the state. Statewide, Sandy caused an estimated 29.4 billion dollars in damage, with an estimated $250 million in Atlantic County flood damages alone. Heavy rain caused urban and poor drainage flooding and exacerbated the tidal flooding along the ocean in Atlantic County. Flooding was reported along the Atlantic City Expressway near U.S. Route 9 in Pleasantville. Event precipitation totals included 7.06 inches in Estell Manor, 6.83 inches in Egg Harbor Township, 5.80 inches at the Atlantic City International Airport, 5.74 inches in Folsom and 5.46 inches in Hammonton. The northern end of the famed Atlantic City boardwalk was destroyed and the city was cut off from the mainland by tidal flooding after the morning high tide. Elsewhere in the county, heavy tidal damage was reported in Longport, Margate and Ventnor. Nearly every municipality from Egg Harbor and Galloway Townships eastward suffered widespread wind and or tide damage. In Atlantic City (Atlantic County), the highest tide reached 8.9 feet above mean lower low water during the evening high tide on the 29th. This was the second highest tide on record; the highest was 9.0 feet above mean lower low water on December 11, 1992.

March 7, 2013. An intense nor'easter brought minor to moderate tidal flooding along the ocean side. The coastal flooding was exacerbated by wave action. At least minor tidal flooding persisted into the morning high tide cycle on the 10th. The highest tide at Atlantic City (Atlantic County) reached 6.95 feet above mean lower low water. Moderate tidal flooding starts at 7.0 feet above mean lower low water. In Atlantic County, tidal flooding damaged 500 homes along the bay side in Atlantic City. The Black Horse Pike (U.S. Routes 40 and 322) were reduced to just one lane in both directions between Atlantic City and Pleasantville. Exit 2 off of the Atlantic City Expressway was closed because of this flooding. In Absecon, flooding affected the White Horse Pike (U.S. Route 30) and the southbound lanes of U.S. Route 9. Tidal flooding closed Ohio Avenue and Shore Road. Roughly $510,000 in property damages were reported in the NCEI database as a result of this event.

August 2014. Thunderstorms with torrential downpours caused flash flooding in Egg Harbor Township. Franklin Avenue near the headwaters of the Cedar Branch was flooded and closed. Event precipitation totals in Atlantic County included 6.79 inches in Buena Vista Township, 6.17 inches in Estell Manor, 5.58 inches at the Atlantic City International Airport, 5.55 inches in Egg Harbor City, 4.78 inches in Mays Landing, 4.14 inches in Mullica Township, 3.89 inches in Egg Harbor Township, 3.47 inches in Hammonton and 2.54 inches in Margate City.

June 1, 2015. Thunderstorms with very heavy rain caused flash flooding in Buena Vista Township and Folsom Borough in Atlantic County. While flash flooding started with the first wave of thunderstorms during the late afternoon, a second wave of thunderstorms continued flooding into the evening. In the Collings Lake area of Buena Vista Township as well as in Folsom, several roadways were flooded and closed. The fire department rescued some stranded motorists in Collings Lake. Event precipitation totals included 6.37 inches in Folsom, 4.60 inches in Hammonton, 4.40 inches in Mullica Township, 4.24 inches in Buena Vista Township, 3.20 inches in Estell Manor and 2.99 inches in Mays Landing.

Vernon Ogrodnek

The Brigantine brance of the Atlantic County Library is closed as a result of flooding, Wednesday Aug. 13, 2014.

June 27, 2015. Thunderstorms with very heavy rain caused flash flooding of smaller streams as well as poor drainage flooding in northern Atlantic County, mainly in and around Hammonton and Folsom. In Hammonton Township, Packard Street and Bellevue Avenue were closed due to flash flooding. In Buena Borough, U.S. Route 40 was closed near the Deep Run due to flash flooding. Flooding was also reported along New Jersey State Route 54. Event precipitation totals included 3.49 inches in Hammonton, 3.27 inches in Buena Vista Township, 3.22 inches in Folsom, and 2.69 inches at the Atlantic City International Airport.

July 28, 2016. A cold frontal boundary moved southward into the region, leading to the development of afternoon showers and thunderstorms. Some thunderstorms became severe with locally heavy rainfall, many locations saw between 2 and 3 inches of heavy rainfall.[45]

August 7, 2017. Thunderstorms developed along and ahead of a warm front. With a humid airmass in place, the storms produced heavy rain that led to flooding.[46]

Historical Summary of Insured Flood Losses

According to the latest FEMA flood insurance records[47], there are a total of 26,347 active flood insurance policies in Atlantic County and there have been 21,018 flood losses reported in Atlantic County through the National Flood Insurance Program (NFIP) since 1972[48], totaling $490.6 million in claims payments. Every municipal jurisdiction in Atlantic County is listed by FEMA as being an active participant in the NFIP[49]. The name of the Floodplain Administrator (the person responsible for ensuring that development activities comply with floodplain management ordinances and NFIP regulations) for each jurisdiction is included on Worksheet 2 in jurisdictional annexes of Appendix 1.2.

In addition to NFIP participation, the 11communities of Absecon, Atlantic City, Brigantine, Egg Harbor Township, Linwood, Longport, Margate, Mullica, Pleasantville, and, Somers Point Ventnor are listed by FEMA as Community Rating System (CRS) eligible communities[50]. Under the CRS, communities which implement floodplain management actions that go beyond the minimum requirements of the NFIP are eligible for discounts on flood insurance premiums for properties within that community.

ACOEP will continue to work with all jurisdictions in the County, encouraging them all to maintain full participation in the NFIP, and to take full advantage of additional FEMA programs such as the Community Rating System (CRS). Jurisdictions already eligible for the CRS will be encouraged to upgrade their CRS status, while non-eligible jurisdictions will be encouraged to work towards eligibility. The County may also support local jurisdiction participation in the Cooperating Technical Partners Program (CTP), of which the main objective is to increase local involvement in the floodplain mapping process.

[45] Data extracted from the 2019 New Jersey State Hazard Mitigation Plan.
[46] Data extracted from the 2019 New Jersey State Hazard Mitigation Plan.
[47] Policy data current as of June 3, 2021.
[48] Loss data current as of June 3, 2021.
[49] As per FEMA's Community Status Book of participating communities (June 3, 2021).
[50] As per the FEMA's list of Community Rating System Eligible Communities effective June 3, 2021, which was still the most recent available status book posted online by FEMA.

Table 3a.16 lists the total number of losses and total claims payments under the NFIP, by municipal jurisdiction. It should be emphasized that this listing includes only those losses to structures that were insured through the NFIP policies. Total number of losses includes some losses in which claims were sought but not received. It is likely that many additional instances of flood losses in Atlantic County were either uninsured or not reported.

The total value of all claims paid under the NFIP had increased from more than $58 million in 2008, to $490.6 million by 2021. This represents seven-fold increase over 2008 values that were presented in the initial version of this hazard mitigation plan. Much of this tremendous increase is attributed to Superstorm Sandy.

Table 3a.16
National Flood Insurance Program Loss Statistics[51]

Jurisdiction	Date Entered NFIP	Current Effective Map Date	CRS Class	Total Number of Policies 2015	Total Number of Losses 2015	Total Claims Payments to 2015 (in millions)	Municipal Claims as % of Countywide Total to 2015	Total Number of Policies 2021	Total Number of Losses to 2021	Total Claims Payments to 2021 (in millions)	Municipal Claims as % of Countywide Total to 2021
Absecon, City of	03/05/76	08/28/18	7	157	153	$4.1	1%	146	166	$4.7	1%
Atlantic City, City of	06/03/70	02/01/85	6	8,978	5,902	$111.3	25%	6,690	6,094	$121.5	25%
Brigantine, City of	05/15/70	08/28/18	5	7,385	4,180	$92.3	20%	6,638	4,216	$99.7	20%
Buena Vista, Township of	06/22/79	08/28/18	N/A	33	11	$0.1	0%	16	14	$0.1	0%
Buena, Borough of	03/04/83	08/28/18(M)	N/A	4	6	$0.1	0%	1	6	$0.1	0%
Corbin City, City of	09/30/81	09/30/81	N/A	29	8	$0.2	0%	24	8	$0.2	0%
Egg Harbor City, City of	08/02/82	08/02/82	N/A	21	17	$0.4	0%	13	17	$0.3	0%
Egg Harbor, Township of	02/16/83	08/28/18	5	861	771	$27.2	6%	699	891	$33.0	7%
Estell Manor, City of	11/03/78	07/02/03	N/A	7	3	$0.0	0%	3	3	$0.0	0%
Folsom, Borough of	01/06/82	08/28/18	N/A	17	4	$0.0	0%	23	4	$0.0	0%
Galloway, Township of	05/02/83	06/30/99	N/A	161	98	$1.3	0%	132	101	$1.4	0%
Hamilton, Township of	03/15/77	08/28/18	N/A	205	118	$2.4	1%	187	123	$2.5	1%
Hammonton, Town of	01/06/82	08/28/18	N/A	67	15	$0.0	0%	32	15	$0.0	0%
Linwood, City of	01/19/83	08/28/18	5	294	81	$1.5	0%	259	83	$1.5	0%
Longport, Borough of	06/18/71	08/28/18	5	1,466	1,263	$36.5	8%	1,326	1,276	$38.0	8%
Margate City, City of	06/19/71	08/28/18	5	5,791	3,109	$72.5	16%	5,023	3,163	$76.3	16%
Mullica, Township of	03/01/82	08/28/18	10	137	162	$5.3	1%	14	169	$5.6	1%
Northfield, City of	11/02/79	01/19/83(M)	N/A	100	34	$0.4	0%	86	36	$0.4	0%
Pleasantville, City of	01/19/83	01/19/83	5	174	251	$5.6	1%	85	255	$5.6	1%
Port Republic, City of	07/15/83	07/15/92	N/A	40	73	$1.7	0%	33	74	$1.8	0%
Somers Point, City of	11/17/82	11/17/82	5	1,042	338	$6.3	1%	859	344	$6.5	1%
Ventnor City, City of	06/18/71	09/15/83	5	5,056	3,848	$82.5	18%	4,232	3,938	$90.6	18%
Weymouth, Township of	08/10/79	08/28/18	N/A	20	22	$0.5	0%	26	22	$0.6	0%
			Total	**32,045**	**20,467**	**$452.1**	**100%**	**26,347**	**21,018**	**$490.6**	**100%**

[51] Policy data and loss data is current as of June 3, 2021. CRS Class as per the FEMA's list of Community Rating System Eligible Communities effective April 1, 2021, which was still the most recent available status book posted online by FEMA as of July 2021 when this section was written. *N/A= was Not Participating in the CRS Program in 2021

Repetitive Loss Properties

FEMA defines a Repetitive Loss (RL) property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. A repetitive loss property may or may not be currently insured by the NFIP. According to FEMA RL property records[52] there are 1,099 RL properties located in Atlantic County of which 877 are recorded as not yet having been mitigated. These non-mitigated RL properties are associated with a total of 3,249 losses and more than $79 million in claims payments under the NFIP since February 1979 (the earliest recorded date of loss), as shown in **Table 3a.17**.

Table 3a.17
NFIP RL Property Statistics for Non-mitigated RL Properties[53]

Jurisdiction	Totals for Non-mitigated RL Properties				
	Non-Mitigated RLP Properties	Total Losses	Total Payments	Average Payments per Non-mitigated RL Property Loss	Average Payments per Non-mitigated RL Property
Absecon, City of	6	48	$2,364,000	$394,000	$49,000
Atlantic City, City of	312	1,121	$17,789,000	$57,000	$16,000
Brigantine, City of	114	371	$8,235,000	$72,000	$22,000
Buena Vista, Township of	1	2	$11,000	$11,000	$6,000
Buena, Borough of	0	0	$0	$0	$0
Corbin City, City of	0	0	$0	$0	$0
Egg Harbor City, City of	0	0	$0	$0	$0
Egg Harbor, Township of	56	306	$15,207,000	$272,000	$50,000
Estell Manor, City of	0	0	$0	$0	$0
Folsom, Borough of	0	0	$0	$0	$0
Galloway, Township of	8	26	$374,000	$47,000	$14,000
Hamilton, Township of	15	40	$993,000	$66,000	$25,000
Hammonton, Town of	1	2	$11,000	$11,000	$5,000
Linwood, City of	1	2	$58,000	$58,000	$29,000
Longport, Borough of	48	165	$5,655,000	$118,000	$34,000
Margate City, City of	71	219	$5,406,000	$76,000	$25,000
Mullica, Township of	14	40	$1,776,000	$127,000	$44,000
Northfield, City of	3	17	$353,000	$118,000	$21,000
Pleasantville, City of	16	66	$1,556,000	$97,000	$24,000
Port Republic, City of*	6	25	$1,239,000	$207,000	$50,000
Somers Point, City of	18	46	$818,000	$45,000	$18,000
Ventnor City, City of	187	753	$17,292,000	$92,000	$23,000
Weymouth, Township of	0	0	$0	$0	$0
Total	**877**	**3,249**	**$79,137,000**	**$90,000**	**$24,000**

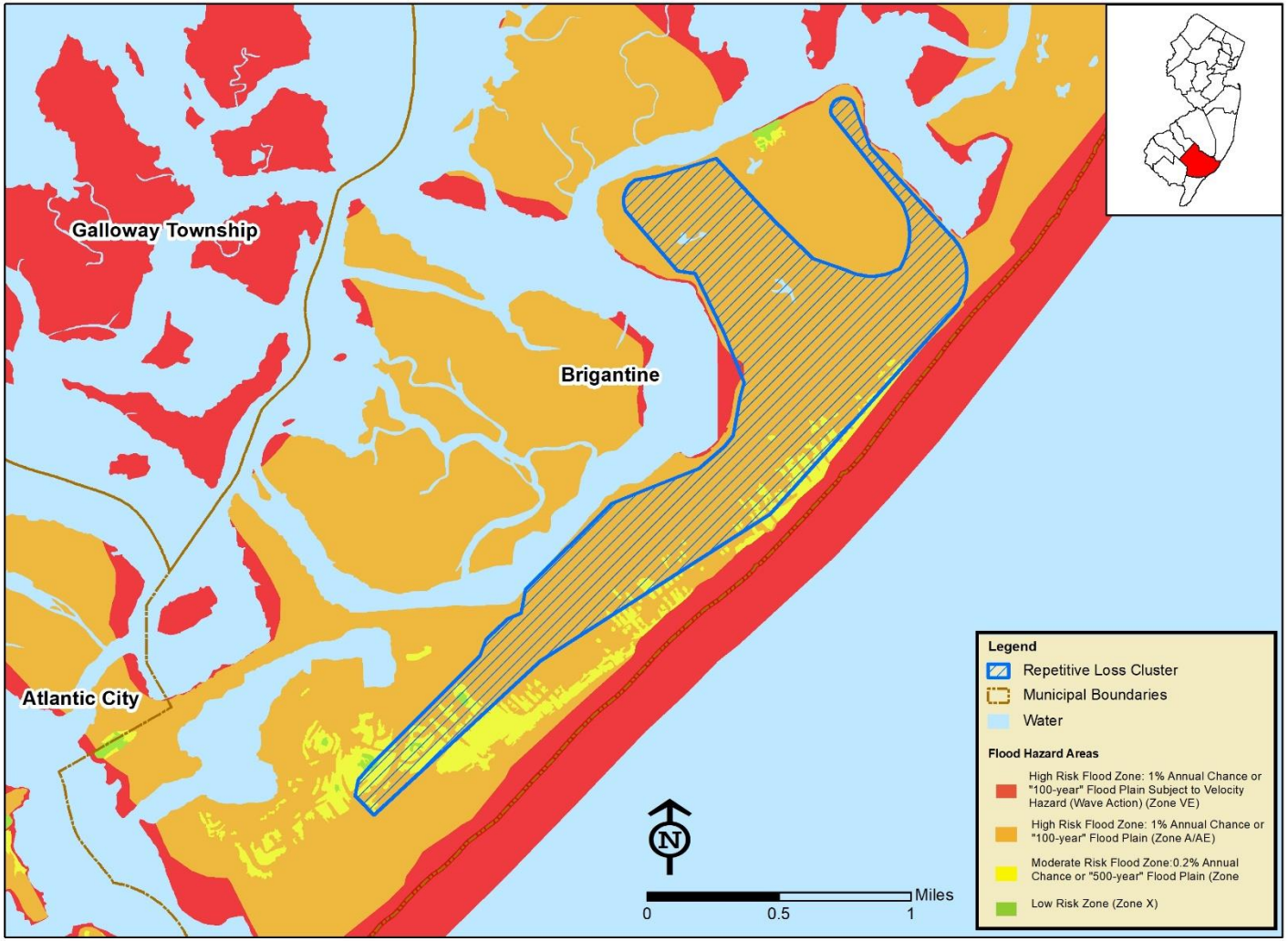
*While current records indicated six RL properties in Port Republic, municipal officials reported that all had recently been mitigated.

[52] Repetitive loss data as provided to AECOM on July 15, 2021 and dated July 13, 2021.
[53] Repetitive loss data as provided to AECOM on July 15, 2021 and dated July 13, 2021.

Seventeen of Atlantic County's municipal jurisdictions (roughly three fourths) are identified as having one or more RL properties. Atlantic City, Brigantine, and Ventnor have the most RL properties (312, 114, and 187, respectively; 70 percent of all the RL properties in the County). Atlantic City, Brigantine, and Ventnor also have the top three most recorded losses (1,121, 371, and 753, respectively) – accounting for 69 percent of all RL losses in the County. Total payments are the highest, however, in four communities: Atlantic City ($17.8 million from 312 Atlantic City properties, as compared to $7.2 million from 272 properties in 2008); Brigantine ($8.2 million from 114 properties, as compared to $3.2 million from 146 properties in 2008); Egg Harbor Township ($15.2 million from 56 properties, as compared to $5 million from 37 properties in 2008); and Ventnor ($17.3 million from 187 properties; as compared to $5 million from 159 properties in 2008). Average payments per non-mitigated RL property are highest in Absecon where only six properties have been paid more than $2.3 million, with an average of $390,000 per loss. Mitigating RL properties is one of the goals of the State Hazard Mitigation Plan and jurisdictions with RL properties in their communities should aim toward this same goal wherever possible.

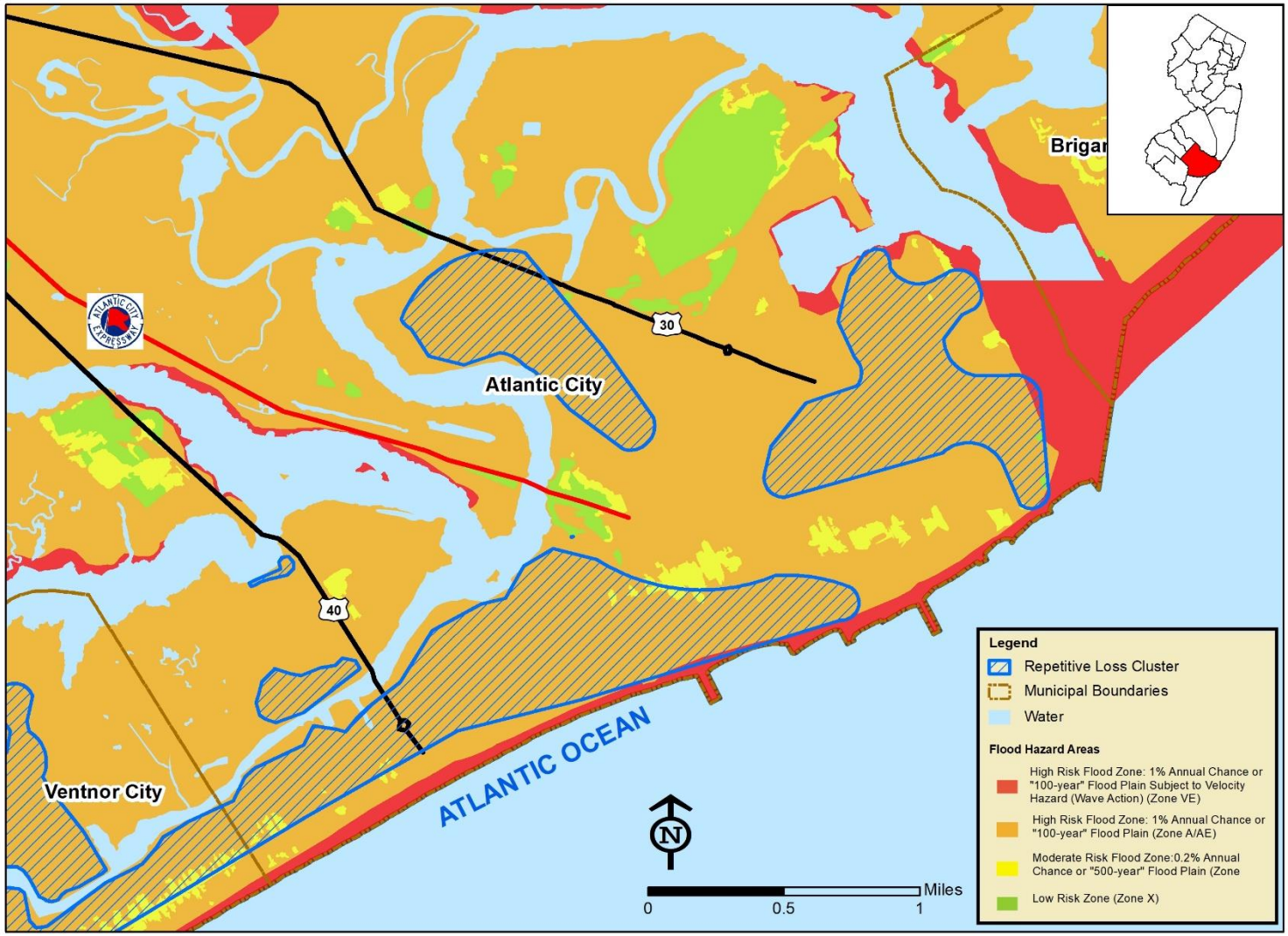
The approximate areas where RL properties are clustered are plotted in **Figure 3a.14 through Figure 3a.17** in comparison with the extent of the mapped FEMA Preliminary DFIRMs (the base/100-year floodplain). This figure does not show areas of the County where occasional isolated RL properties are located; rather, it depicts only the approximate areas covering clusters of RL properties, since the component data is subject to the 1974 Privacy Act which prohibits the public release of any information regarding individual NFIP claims or information which may lead to the identification of associated individual addresses and property owners. While detailed address information is not provided in this public document, local officials in the NFIP participating communities do have access to comprehensive RL property data from FEMA for the purposes of targeted mitigation of RL areas or individual RL structures.

Figure 3a.14
Repetitive Loss Property Cluster Area 1



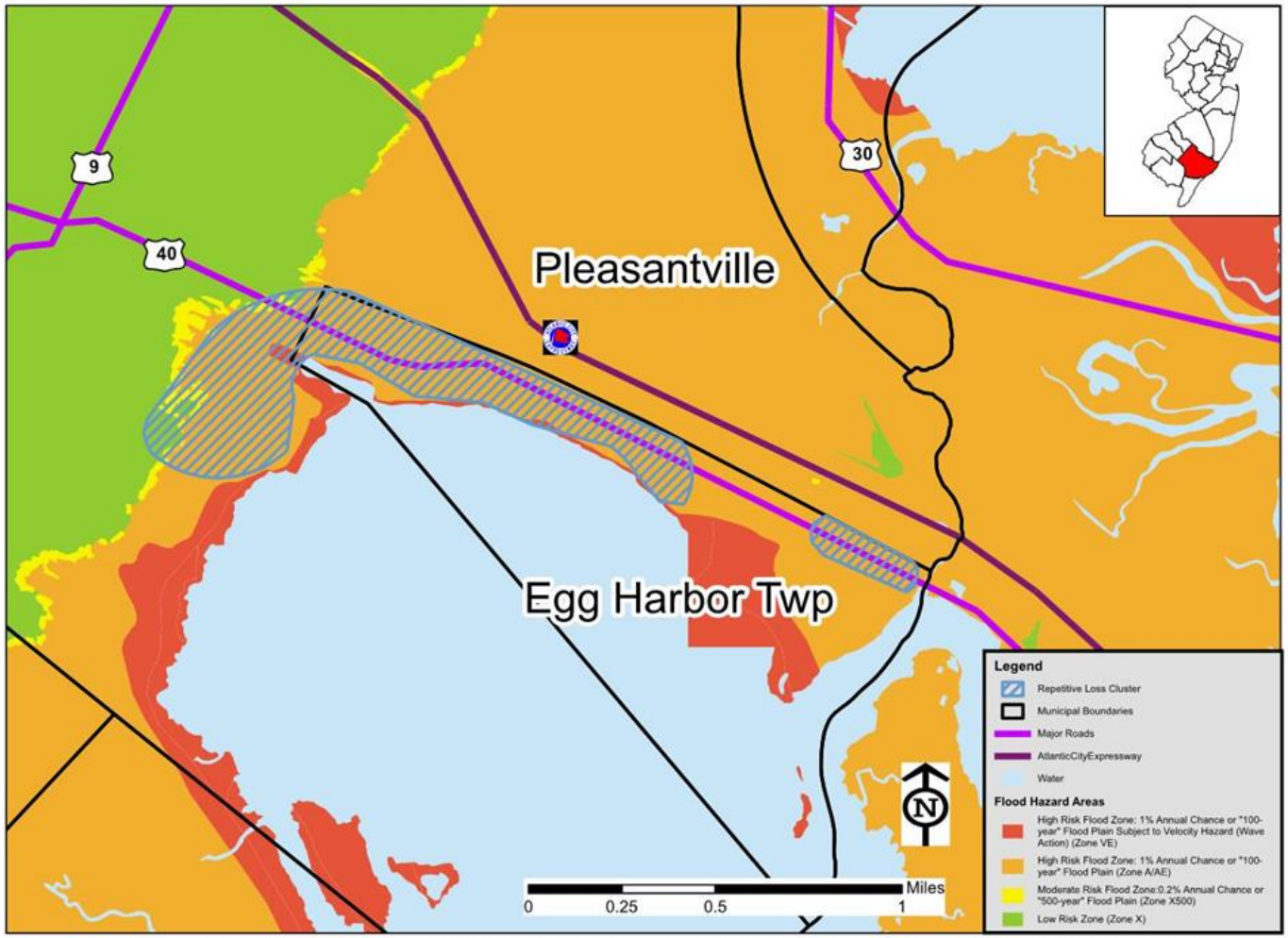
SOURCE: FEMA Repetitive Loss Data, 2021; FEMA Digital Flood Insurance Rate Map (DFIRM) data, 2021, where available; Preliminary FIRM Data 2014 for areas not currently included in 2021 DFIRM: Atlantic City, Corbin City, Egg Harbor City, Estell Manor, Galloway Township, Northfield, Pleasantville, Port Republic, Somers Point, Ventnor City. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002.

Figure 3a.15
Repetitive Loss Property Cluster Area 2



SOURCE: FEMA Repetitive Loss Data, 2021; FEMA Digital Flood Insurance Rate Map (DFIRM) data, 2021, where available; Preliminary FIRM Data 2014 for areas not currently included in 2021 DFIRM: Atlantic City, Corbin City, Egg Harbor City, Estell Manor, Galloway Township, Northfield, Pleasantville, Port Republic, Somers Point, Ventnor City. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002.

Figure 3a.16
Repetitive Loss Property Cluster Area 3



SOURCE: FEMA: Preliminary FIRM Data, 2014; Repetitive Loss Data, 2014. NJGIN: County Boundary, 2012; Municipal Boundary, 2014. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Atlantic County Office of GIS: US Highway, Atlantic City Expressway, and Garden State Pkwy, 2003.

Figure 3a.17
Repetitive Loss Property Cluster Area 4

SOURCE: FEMA Repetitive Loss Data, 2021; FEMA Digital Flood Insurance Rate Map (DFIRM) data, 2021, where available; Preliminary FIRM Data 2014 for areas not currently included in 2021 DFIRM: Atlantic City, Corbin City, Egg Harbor City, Estell Manor, Galloway Township, Northfield, Pleasantville, Port Republic, Somers Point, Ventnor City. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002.

Since this plan was initially prepared in 2010, the number of listed RL properties has increased dramatically, with 775 RL properties in 2008 as compared to 877 in 2021. FEMA has indicated that their systems depend heavily on programmed address matching to identify repetitive losses and, while the software makes some allowances for misspellings and incomplete addresses, it is not perfect and sometimes legitimate address matches are missed. Sometimes repetitive loss properties go undetected for years because of address anomalies. FEMA actively works on updating the repetitive loss data system which allows them to link addresses that they have found should be linked. As these improvements and corrections are made on an ongoing basis, new RL properties can be created even though the loss dates may have been older. Sometimes RL properties can be combined as well and may create severe loss properties. For communities that participate in CRS, correction of this data is a required activity.

The average non-mitigated RL property in Atlantic County has experienced between three and four losses. At the extreme end, two properties in Egg Harbor Township and Absecon are recorded as having experienced 40 and 36 losses respectively, with a combined $4.4 million in paid claims. All told, there are 26 non-mitigated RL properties in the County that have had 10 or more losses. They are located one in Absecon, five in Atlantic City, 10 in Egg Harbor Township, one in Pleasantville, and nine in Ventnor. These 26 properties have had a total of 368 losses and $13.5 million in paid claims. The following six communities have no RL properties within their borders: Buena Borough, Corbin City, Egg Harbor City, Estell Manor, Folsom, and Weymouth. The majority of all RL properties are located in the 100-year floodplain, and leaving aside scattered individual RL properties, the RL clusters are almost entirely within the 100-year floodplain.

Severe Repetitive Loss Properties

FEMA defines a severe repetitive loss (SRL) property as a residential property that is covered under an NFIP flood insurance policy and: (a) that has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or (b) for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building; and (c) for both (a) and (b), at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart. According to FEMA repetitive loss property records[54] there are a total of 140 SRL properties located in 12 Atlantic County communities; all of which are identified as "non-mitigated". These 140 SRL properties are associated with a total of 1,010 losses more than $29.9 million in payments under the NFIP since January 1987 (the earliest recorded date of loss for this subset of properties), as shown in **Table 3a.18**. Mitigation of SRL properties should be pursued. There are an average of seven losses per property and an average payment of $29,600 per paid loss. Seventy percent of the County's SRL properties are located in Atlantic City, Brigantine, Egg Harbor Township, and Ventnor. Average payments per non-mitigated SRL property are highest in Absecon, where historically only two SRL properties have been paid more than $1.9 million (at present, there is one remaining non-mitigated SRL property in Absecon). Total payments to non-mitigated SRL properties are highest in Egg Harbor Township.

[54] Repetitive loss data as provided to AECOM on July 15, 2021 and dated July 13, 2021.

It should be noted that failure to mitigate SRL properties could eventually lead to significant increases in flood insurance premiums.

Table 3a.18
NFIP SRL Property Statistics for Non-mitigated SRL Properties[55]

Jurisdiction	Totals for Non-mitigated SRL Properties				
	Non-Mitigated SRL Properties	Total Losses	Total Payments	Average Payments per Non-mitigated SRL Property Loss	Average Payments per Non-mitigated SRL Property
Absecon, City of	1	36	$2,141,000	$2,141,000	$59,000
Atlantic City, City of	46	292	$5,269,000	$115,000	$18,000
Brigantine, City of	9	46	$1,099,000	$122,000	$24,000
Buena Vista, Township of	0	0	$0	$0	$0
Buena, Borough of	0	0	$0	$0	$0
Corbin City, City of	0	0	$0	$0	$0
Egg Harbor City, City of	0	0	$0	$0	$0
Egg Harbor, Township of	19	204	$12,113,000	$638,000	$59,000
Estell Manor, City of	0	0	$0	$0	$0
Folsom, Borough of	0	0	$0	$0	$0
Galloway, Township of	1	4	$120,000	$120,000	$30,000
Hamilton, Township of	1	4	$209,000	$209,000	$52,000
Hammonton, Town of	0	0	$0	$0	$0
Linwood, City of	0	0	$0	$0	$0
Longport, Borough of	7	33	$1,236,000	$177,000	$37,000
Margate City, City of	6	31	$733,000	$122,000	$24,000
Mullica, Township of	1	4	$121,000	$121,000	$30,000
Northfield, City of	1	9	$81,000	$81,000	$9,000
Pleasantville, City of	6	39	$923,000	$154,000	$24,000
Port Republic, City of*	2	8	$687,000	$343,000	$86,000
Somers Point, City of	1	5	$134,000	$134,000	$27,000
Ventnor City, City of	39	295	$5,052,000	$130,000	$17,000
Weymouth, Township of	0	0	$0	$0	$0
Total:	**140**	**1,010**	**$29,919,000**	**$214,000**	**$30,000**

*While current records indicated one SRL properties in Port Republic, municipal officials reported that it had recently been mitigated.

Probability of Occurrence – Flood

Flooding will continue to have a high probability of occurrence in Atlantic County, and the probability of future occurrences in Atlantic County is certain. The probability of future flood events based on magnitude and according to best available data is illustrated in **Figure 3a.12**, which indicates those areas susceptible to the 1 percent annual chance flood (100-year floodplain); the 1 percent annual chance flood with wave action (100-year coastal floodplain);

[55] Repetitive loss data as provided to AECOM on July 15, 2021 and dated July 13, 2021.

and the 0.2 percent annual chance flood (500-year floodplain). The frequency of intense precipitation events in Atlantic County is expected to increase in the future with climate change; this is likely to result in more riverine and flash flooding events.

Flooding in Atlantic County is attributed mainly to tropical storms, nor'easters, and - to a lesser extent - severe thunderstorms. Usually occurring during late summer and early autumn, these storms can result in severe damage to coastal areas. Although extratropical cyclones can develop at almost any time of the year, they are more likely to occur during winter and spring. Thunderstorms are a common occurrence during the warm summer months.

It should also be noted that anticipated sea level rise will increase the risk of damages/losses due to future coastal flooding events. Rising sea level over time will shorten the return period (increasing the frequency) of significant flood events. For example; sea level rise of 1 foot over a typical project analysis period (50 years) may cause a flood event currently of annual probability 2 percent (50-year flood) to become an event of 10 percent annual probability (10-year flood). This increased probability obviously has an effect on the estimation of annualized loss/damage, but one that is typically only analyzed during detailed feasibility studies for projects proposed by the US Army Corps of Engineers.

Storm Surge

Location – Storm Surge and Coastal Flooding

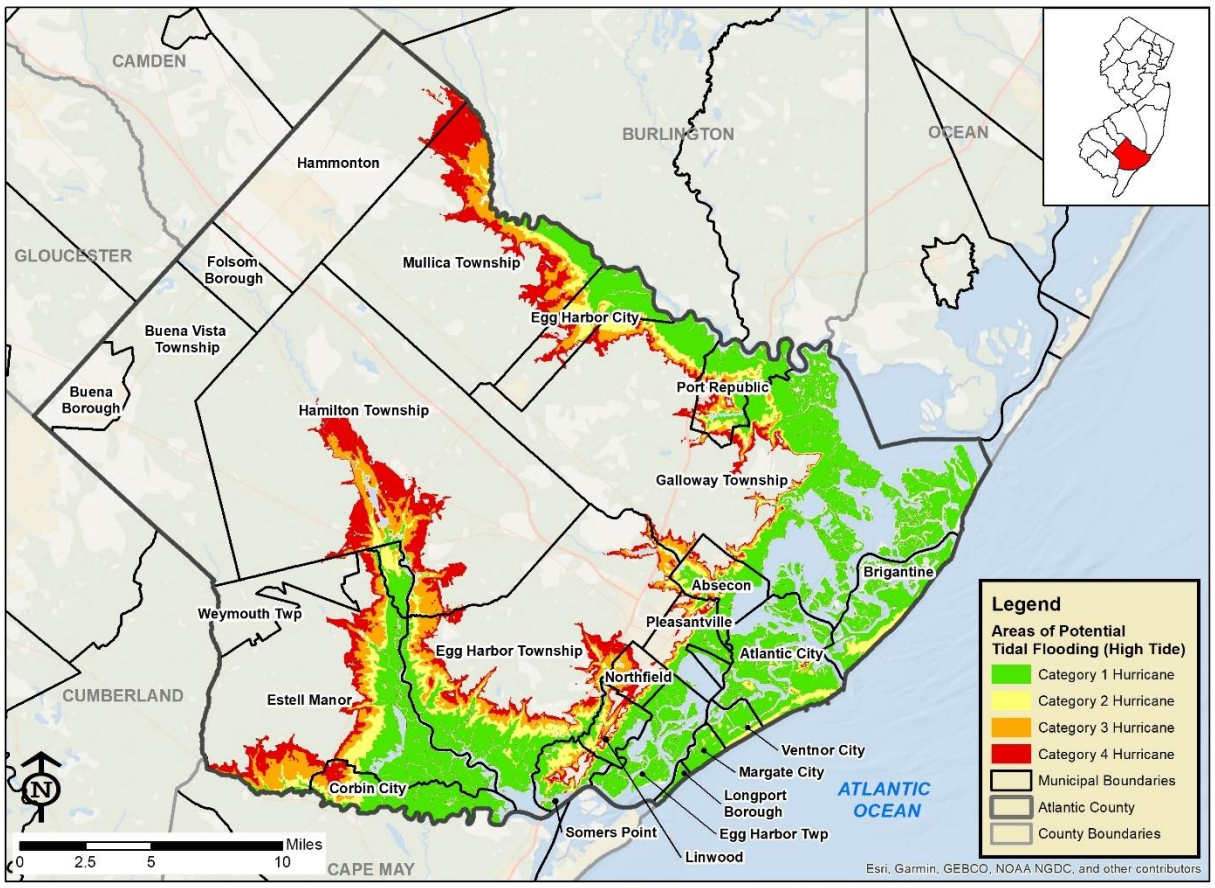
Storm Surge and Coastal flooding occurs when local sea levels temporarily rise during meteorological events to inundate areas along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes. Hurricanes and tropical storms, severe storms, and nor'easters cause most of the coastal flooding in New Jersey.

There are many areas in Atlantic County subject to potential storm surge inundation as modeled and mapped by the U.S. Army Corps of Engineers (USACE). **Figure 3a.18** illustrates inundation zones from storm surges associated with hurricanes of Category 1 to 4 for Atlantic County derived from georeferenced SLOSH (Sea, Lake and Overland Surge from Hurricanes) data produced by the USACE in coordination with NOAA[56]. SLOSH is a modeling tool used to estimate storm surge for coastal areas resulting from historical, hypothetical or predicted hurricanes taking into account maximum expected levels for pressure, size, forward speed, track and winds. Therefore, the SLOSH data is best used for defining the potential maximum surge associated with various storm intensities for any particular location. Storm surge arrives prior to a hurricane's landfall, and the greater the hurricane's intensity, the sooner the surge arrives. As shown in the figure, all of Atlantic County's coastal jurisdictions are at high risk to storm surge inundation. While non-coastal areas may not be directly impacted by storm surge inundation, they might experience flooding caused by storm surge and extremely high tides that can affect the drainage of areas further inland. Twenty of the County's 23 municipal jurisdictions (87

[56] This data represents a polygon feature set in Atlantic County showing the limits of potential flooding from Category 1-4 hurricanes. The data was compiled by the U.S. Army Corps of Engineers as part of its calculations in using the National Weather Service- National Hurricane Center's SLOSH model (Sea, Lake and Overland Surges from Hurricanes).

percent) have been identified as being at risk to the storm surge hazard[57]. Only Buena Borough, Buena Vista Township, and the Borough of Folsom have no land in mapped surge areas.

Figure 3a.18
Hurricane Storm Surge Inundation Zones in Atlantic County



SOURCE: NOAA: Sea, Lake, and Overland Surges from Hurricane (SLOSH), High Tide Conditions, 2018. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

Extent – Storm Surge

The magnitude or severity of the storm surge hazard is generally related to the category of storm making landfall, where Category 1 potential storm surge inundation areas are smaller than Category 4 potential inundation areas. The Saffir-Simpson is one scale used to classify storms according to their magnitude or severity. **Table 3a.19** shows the relationship between storm category and surge, as well as typical types of damages.

[57] By virtue of having some portion of their land area in a Category 1, 2, 3, or 4 mapped surge zone.

Table 3a.19
Saffir-Simpson Scale for Hurricanes

Storm Category	Maximum Sustained Wind Speed (mph)	Minimum Surface Pressure (Millibars)	Storm Surge (feet)	Damage Level	Description of Damages
1	74–95	Greater than 980	3–5	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery and trees. Also, some coastal flooding and minor pier damage.
2	96–110	979–965	6–8	MODERATE	Some roofing material, door and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings might break their moorings.
3	111–129	964–945	9–12	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain might be flooded well inland.
4	130–156	944–920	13–18	EXTREME	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain might be flooded well inland.
5	157 +	Less than 920	19+	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas might be required.

Source: National Oceanic and Atmospheric Administration

Historical Occurrences – Storm Surge

Before Superstorm Sandy, there was fairly limited data available for historical weather events that have caused storm surge inundation in Atlantic County. According to the NCEI database[58], Atlantic County experienced storm surge during 34 events between December 2002 and June 2015 that accounted for an estimated $281.2 million in property damages, as described below. Storm surge has been a major factor associated with various weather events affecting Atlantic County, particularly hurricanes, tropical storms, and nor'easters (as described separately within this section).

Some more *notable storm surge events* include the following:

> **September 14-15, 1944 – Great Atlantic Hurricane.** This unnamed hurricane impacted the entire coast of New Jersey when it paralleled the coastline as a Category 2 hurricane. The peak stage recorded by the Atlantic City tide gage was 8.21 feet NGVD, which held as a stage of record at this location into the late 1990's. The Atlantic City boardwalk was destroyed and the famous Heinz and Steel Piers were damaged. The Atlantic City-Brigantine Bridge was also destroyed.

[58] Current as of May 2021.

March 6-8, 1962 – Ash Wednesday Nor'easter. This massive nor'easter stalled in the mid-Atlantic for almost three days, pounding coastal areas with continuous rain, high winds, and tidal surges and dumping large quantities of snow inland for several hundred miles. Gale force winds kept storm surges on shore for five successive high tides. In Atlantic County, the Steel Pier in Atlantic City was partially destroyed. Brigantine, Margate, Ventnor, and Longport also suffered significant damage.

August 9, 1976 – Hurricane Belle. Belle was a tropical storm when it passed off the shore of New Jersey on August 9th. A storm surge of 8.85 feet was measured in Atlantic City. Roughly 500 feet of the Atlantic City boardwalk was damaged or destroyed, with repairs estimated to reach $5 million.

October 28, 1991 – Halloween Nor'easter. The 1991 Halloween nor'easter, also referred to as "The Perfect Storm", caused strong waves of up to 30 feet in height. High tides along the shore were only surpassed, at the time, by the 1944 hurricane.

December 11-12, 1992. An intense, slow-moving nor'easter hit the eastern coast of New Jersey during December 11 and 12, 1992. It occurred while shore residents were still trying to rebuild beaches after the October 1991 and January 1992 storms. This storm produced record or near-record flooding along the entire Atlantic Coast of New Jersey.

January 28-29, 1998. An intense nor'easter caused significant tidal flooding along the New Jersey Shore. In Atlantic County, both the White Horse (U.S. Route 30) and Black Horse (U.S. Route 40) Pikes in and out of Atlantic City were closed for more than four hours the morning of the 28th. The Eastbound lanes of the Black Horse Pike were closed again the evening of the 28th. Several other roads were closed due to bayside tidal flooding in Egg Harbor Township, Absecon, Atlantic City and Pleasantville. Sections of U.S. Route 9 in Linwood and County Road 152 in Somers Point and Longport were also closed.

February 4-9, 1998. This strong nor'easter was the worst storm to affect the area since December 1992. Atlantic County suffered an estimated 3.9 million dollars in damage. Tidal flooding was extensive. Brigantine suffered substantial flooding and beach erosion. In Atlantic City, the 84 residents of the Oceanside Nursing Home were removed to 14 other nursing homes on the mainland. The boardwalk was ripped at New Hampshire Avenue. All access roads into the city were closed on the morning of the 5th, except for the Atlantic City Expressway. The worst tidal flooding occurred in the back-bay area with much of Venice Park, the Chelsea Bay Front, and Chelsea Heights inundated. Dozens of cars had water up to their doors. The beach was described as "destroyed" in Margate. In Longport, the ocean met the bay from 11th through 24th Streets.

August 28, 2011 – Tropical Storm Irene. Irene initially made landfall near Cape Lookout, North Carolina on the 27th as a Category 1 Hurricane and then proceeded to the north northeast where she slowly weakened before making a second landfall as a tropical storm on Brigantine Island, just north of Atlantic City on the 28th. Moderate to severe tidal flooding occurred along the coast. Peak storm tides included 6.96 feet above mean lower low water in Atlantic City (moderate tidal flooding starts at 7.0 feet above mean lower low water). There were numerous reports of dune fence damage and sand overwashes onto streets and boardwalks.

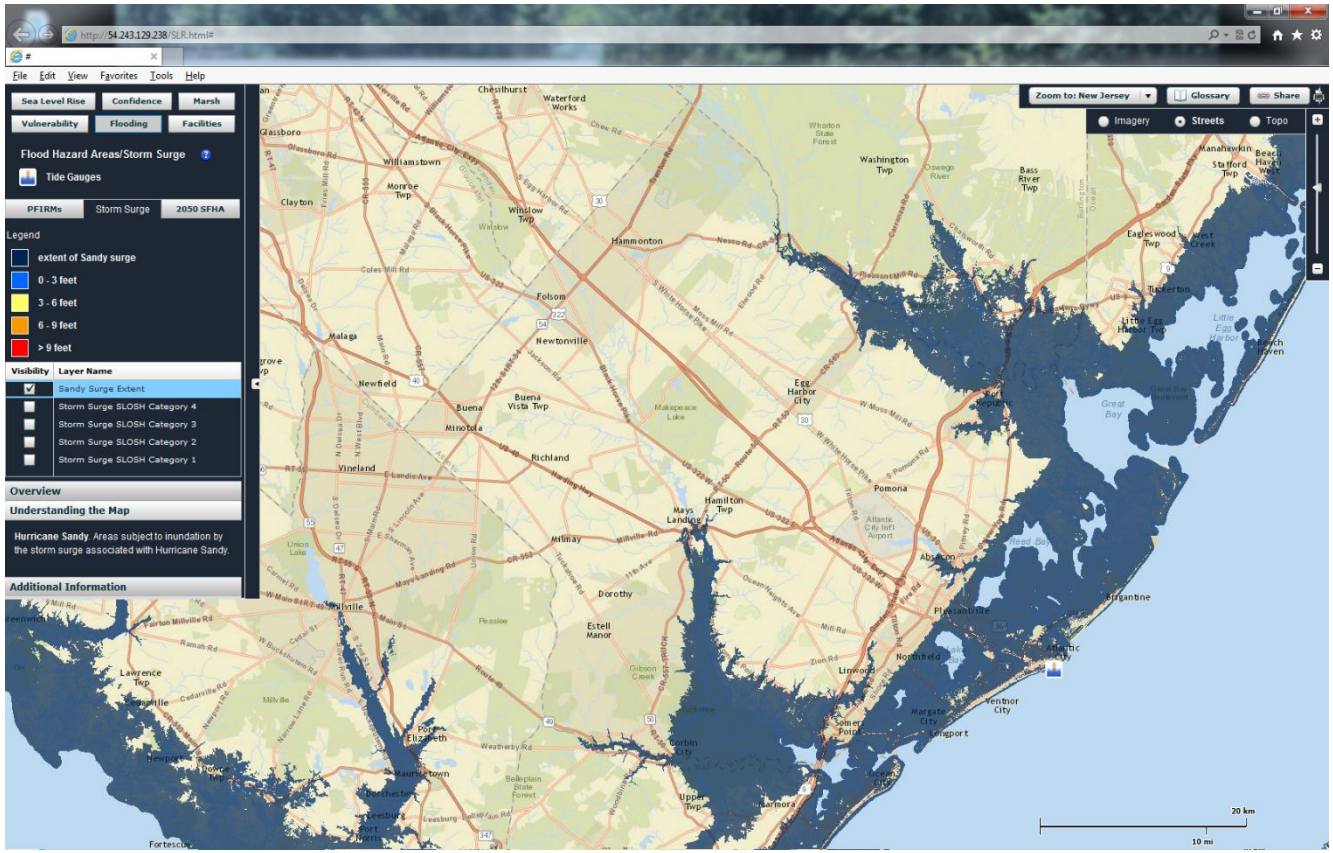
October 29, 2012 (Superstorm Sandy). Sandy made landfall at the City of Brigantine on October 29th as a post-tropical storm. Sandy was the costliest natural disaster by far in the

State of New Jersey. Record breaking high tides and wave action combined with sustained winds as high as 60 to 70 miles per hour - with gusts as high as 80 to 90 miles per hour - battered the state. The northern end of the famed Atlantic City boardwalk was destroyed. The city was cut off from the mainland by tidal flooding after the morning high tide. Elsewhere in the county, heavy tidal damage was reported in Longport, Margate and Ventnor. Nearly every municipality from Egg Harbor and Galloway Townships eastward suffered widespread wind and or tide damage. The unique aspect of Sandy and unlike most tropical systems was the multi-tide cycle increase of onshore winds prior to landfall. This caused multiple high tide cycles with tidal flooding and also helped produce catastrophic wave action. Record breaking or near record breaking high tides were exacerbated by the high astronomical spring tides associated with the full moon. Widespread major tidal flooding occurred during the morning and evening high tide cycles on the 29th. Most of the surveyed damage to barrier island homes that were either destroyed or moved indicated that it was the storm surge and wave action that caused most of the damage. In Atlantic City, the highest tide reached 8.9 feet above mean lower low water during the evening high tide on the 29th. This was the second highest tide on record; the highest was 9.0 feet above mean lower low water on December 11, 1992. Moderate tidal flooding starts at 7.0 feet above mean lower low water. **Figure 3a.19** shows the areas subject to inundation by the storm surge associated with Sandy in Atlantic County and immediately surrounding areas.

October 2, 2015. A nor'easter on October 2, 2015 was one of multiple weather systems impacting New Jersey. The impacts of this particular nor'easter were magnified by the presence of Hurricane Joaquin off of the coast. Overall, minor tidal flooding occurred. Roadways, including the Black Horse Pike between Atlantic City and Pleasantville, were shut down due to rising floodwaters. Motorists had to be rescued after becoming trapped in the rising waters.

According to the NCEI database, there have not been significant storm surge events affecting Atlantic County since the 2016 Update.

Figure 3a.19
Sandy Surge Extent[59]



Courtesy of *NJ Flood Mapper*.

[59] Courtesy of *NJ Flood* Mapper, produced in collaboration with the NOAA Coastal Services Center (CSC) through a partnership with the Jacques Cousteau National Estuarine Research Reserve (JCNERR) and the Grant F. Walton Center for Remote Sensing and Spatial Analysis (CRSSA), Rutgers University. This interactive mapping website was designed and created to provide a user-friendly visualization tool that will help get information into the hands of local communities who need to make decisions concerning flooding hazards and sea level rise. This website should be used to promote enhanced preparedness and land use planning decisions with considerations for possible future conditions. The *NJFloodMapper* uses high resolution mapping of the land surface elevation to model areas vulnerable to sea level rise. FEMA Preliminary Flood Insurance Rate Maps (FIRMs), coastal evacuation routes, state/municipal level infrastructure and socio-demographic information are included to provide a fuller picture of vulnerability to flooding hazards.

Probability of Occurrence – Storm Surge and Coastal Flooding

Atlantic County faces a relatively low probability of major storm surge inundation as derived from current SLOSH data for major hurricanes (Category 3-4). As described elsewhere in this section, the probability of a named storm making landfall in the vicinity of Atlantic County is 24 to 30 percent but is less for events that cause significant storm surge (dependent on storm speed, direction, tides, etc.). However, less severe to moderate storm surge events typically associated with nor'easters and less intense coastal storms are more likely to occur, and in the case of nor'easters will last longer and possibly cause more damage than fast-moving hurricanes. Additionally, the long-term rise in sea level can be expected to impact the occurrence of significant storm surges and hence future damages from coastal flooding in Atlantic County. Rising sea levels over time will shorten the return period (or exceedance interval) and hence increase the frequency of significant storm surge events. To take a hypothetical example, a one foot rise in sea level over 50 years could result in a storm surge event with a current annual occurrence probability of 2 percent (a "50-year" event) becoming an event of 10 percent annual probability (a "10-year" event).

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Atlantic County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Atlantic County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community – particularly for communities where tourism tends to drive local economies, as is the case in many of Atlantic County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Location and Extent – Tsunami

According to the New Jersey State Hazard Mitigation Plan, few tsunami events have occurred in the Gulf and East Coast states in the last 200 years, indicating no portions of Atlantic County are likely to experience a tsunami. As stated in the Maine State Hazard Mitigation Plan, all areas with an elevation of less than 100 feet and within a mile of the coast could be impacted by a tsunami, the chances of a catastrophic event are minimal.[60] There is no tsunami monitoring program on the East Coast of the United States.[61] The extent of a tsunami could be measured by land inundated and depth of inundation.

Probability of Occurrence and Previous Occurrences – Tsunami

The lack of significant tsunami events affecting the East Coast of the United States, combined with the lack of a tsunami monitoring program, suggest a low probability of a tsunami impacting New Jersey.

The New Jersey State Hazard Mitigation Plan identified potential tsunami events in New Jersey between 1821 and 2017. While the New Jersey State Hazard Mitigation Plan acknowledges that very few tsunami events have impacted the Gulf and East Coast states, potential tsunami events identified have damaged the Longport Thoroughfare (June 9, 1913) and the parts of Atlantic City (August 19, 1931). However, there were no reports of storms or earthquakes on June 9, 1913 and the weather bureau attributed the August 19, 1931 event affecting Atlantic City to a tropical storm north of Puerto Rico.

Wave Action

Location – Wave Action

The areas most susceptible to wave action in Atlantic County are predominantly located along the immediate coastal and shoreline areas of the Atlantic Ocean and along the back bays and inlet areas. Additional areas may occasionally experience wave action during extremely large storm events that cause storm surge (addressed separately within this section). **Figure 3a.20** illustrates the wave action hazard zones for Atlantic County based on FEMA 2014 Preliminary FIRMs. This includes areas mapped as Zone VE according to the most recent Flood Insurance Study (FIS) completed by FEMA. Zone VE refers to coastal areas with a 1 percent or greater chance of flooding and an additional hazard associated with storm-driven velocity waves of three feet or more.

Extent – Wave Action

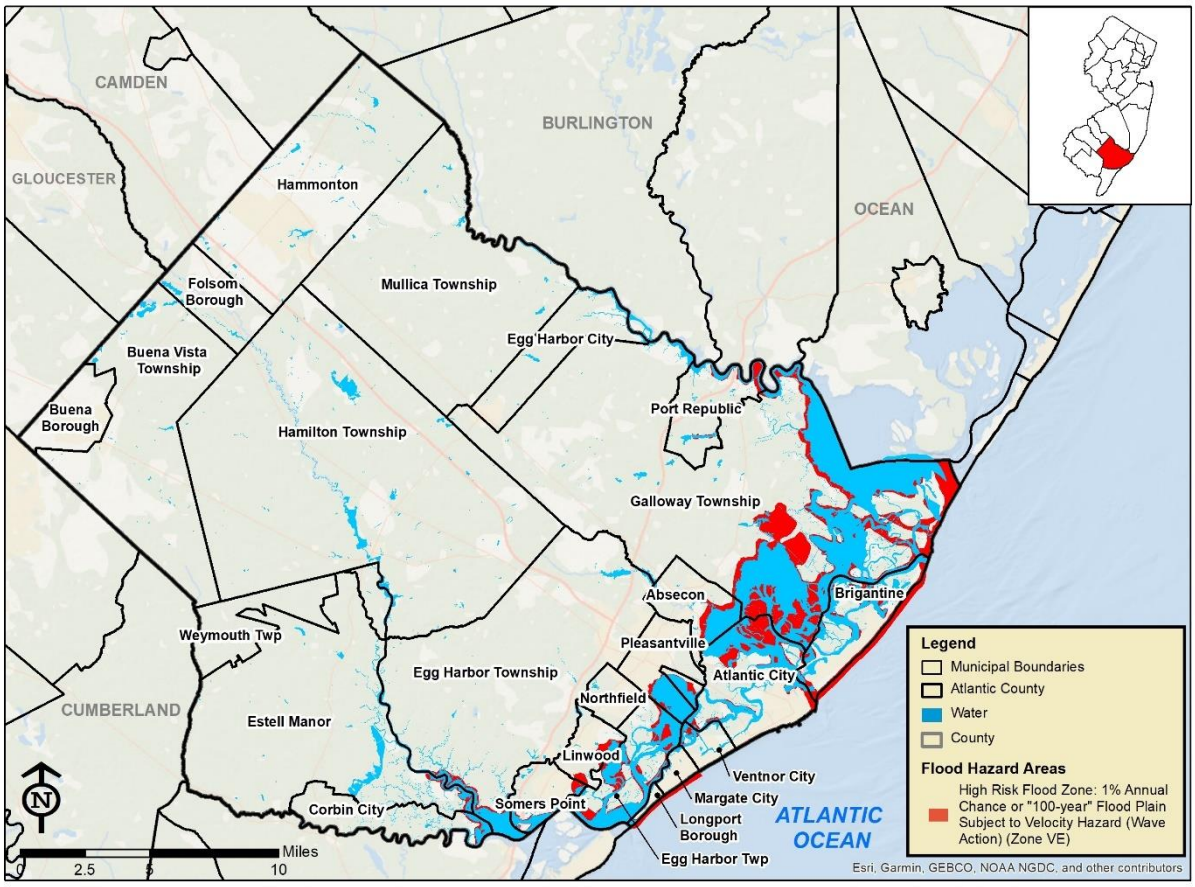
There is no particular scale that classified the magnitude or severity of different wave events for different category storms. The extent of flooding associated with a one percent annual

[60] Maine Emergency Management Agency, Maine State Hazard Mitigation Plan, 2019. Retrieved https://www.maine.gov/mema/sites/maine.gov.mema/files/inline-files/State%20Hazard%20Mitigation%20Plan%202019%20Update_10.8.2019.pdf

[61] State of New Jersey Office of Emergency Management, New Jersey State Hazard Mitigation Plan, 2019.

probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies and this mapping does include mapping of the VE-zone, or the lands that can support breaking waves of three feet or more. This boundary is therefore a convenient tool for assessing the extent of the wave action hazard and risk in flood-prone communities. Higher category storms on the Saffir-Simpson scale would, however, typically have more destructive waves breaking into the built environment at the coastline causing more extensive damages to those susceptible structures with increasing storm category.

Figure 3a.20
Wave Action Hazard Zones in Atlantic County



SOURCE: FEMA Digital Flood Insurance Rate Map (DFIRM) data, 2021, where available; Preliminary FIRM Data 2014 for areas not currently included in 2021 DFIRM: Atlantic City, Corbin City, Egg Harbor City, Estell Manor, Galloway Township, Northfield, Pleasantville, Port Republic, Somers Point, Ventnor City. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

Historical Occurrences – Wave Action

According to the NCEI database,[62] 27 recorded wave action events ("high surf") have affected Atlantic County from August 1996 to May 2021. These incidents resulted in a reported total of two deaths and two injuries in Atlantic County, and caused an estimated $48 million[63] in property

[62] Current as of May 2021.
[63] $40 million of which are attributed to Superstorm Sandy.

damages. This includes one death, one injury, and $6 million in property damages since data was collected for the February 2016 Plan Update. A sampling of *notable events* includes the following:

August 29 – September 1, 1996. Rough surf associated with Hurricane Edouard affected the New Jersey Coast around the Labor Day Weekend and caused one drowning in Atlantic County when a boat capsized in the Great Egg Harbor Inlet off of Longport. The hurricane passed about 250 miles east of Atlantic City the evening of Sunday September 1st. But, the roughest surf generally occurred on the 30th with slow improvement over the rest of the Labor Day Weekend. Most beaches were either closed or had bathing restrictions throughout the weekend. Beach patrols reported that the busiest day for rescues was Friday the 30th.

September 18-20, 2003. Tropical Storm Isabel produced strong winds, moderate tidal flooding, erosion and rough surf along the New Jersey shore. While tide heights along the oceanside only reached minor, wave action caused considerable beach erosion, especially in Cape May and Atlantic Counties. NOAA reports $2 million in wave damage in Atlantic County as a result of Isabel.

December 5-6, 2003. A northeaster caused wave action, minor tidal flooding and dune damage along coastal New Jersey on the 5th and 6th. Waves caused considerable erosion along the coast. About a foot of beach was eroded from most of the Atlantic County beaches.

October 21-25, 2004. Waves battered the coast in Atlantic County; erosion averaged between 3 and 5 feet vertically and sloped up to 100 feet wide. The worst reported damage was in Brigantine and Atlantic City. In Brigantine, an 8-foot vertical cut to the dune system occurred between Promenade and Vernon Place. In Atlantic City, damage occurred to the dune system north of Rhode Island Avenue with loss of sand fencing. Groins were exposed in Margate.

February 28, 2005. Waves battered the Atlantic County coastline during an intense nor'easter. In Atlantic County, two to four-foot vertical cuts occurred, except in Ventnor where the vertical cut reached five feet at the south end of the city. Walkways and fences were also damaged. Some walkways now ended at the water's edge. The Ventnor Beach had just been rebuilt in 2004.

September 10-11, 2009. A low pressure system moving on shore brought with it strong northeast winds, high tides and rough surf. The largest effect along the shore was the wave action and the ensuing erosion from the pounding surf. In Atlantic County, vertical cuts averaged 1 to 2 feet, but reached up to 6 feet in Ventnor from Richards to Newport Avenue.

November 11-14, 2009. Strong winds, high tides, heavy surf and severe beach erosion occurred along the New Jersey coast during this powerful nor'easter. The surf and tides caused about 10 million dollars in damage to the Atlantic City boardwalk and beach. In Atlantic City and also Ventnor, ramps to the beach and boardwalk were destroyed. Overall county damage was estimated at 16 million dollars.

October 28-30, 2012. Superstorm Sandy was the costliest natural disaster by far in the state of New Jersey. Record-breaking high tides, catastrophic wave action, and damaging winds battered that State. In Atlantic City, the highest tide reached 8.9 feet above mean lower low water during the evening high tide on the 29th. This was the second highest tide on record (the highest was 9.0 feet above mean lower low water on December 11, 1992). Wave action was so severe that the Ocean City-Longport Bridge was closed because boulders were pushed onto it. The northern end of the Atlantic City boardwalk was destroyed. The impact of wave action alone to property in Atlantic County communities was estimated at $40 million.

Waves crashing through Atlantic City during Superstorm Sandy. (Photo courtesy of The Business Insider, Dina Spector, via @AccuWeather)

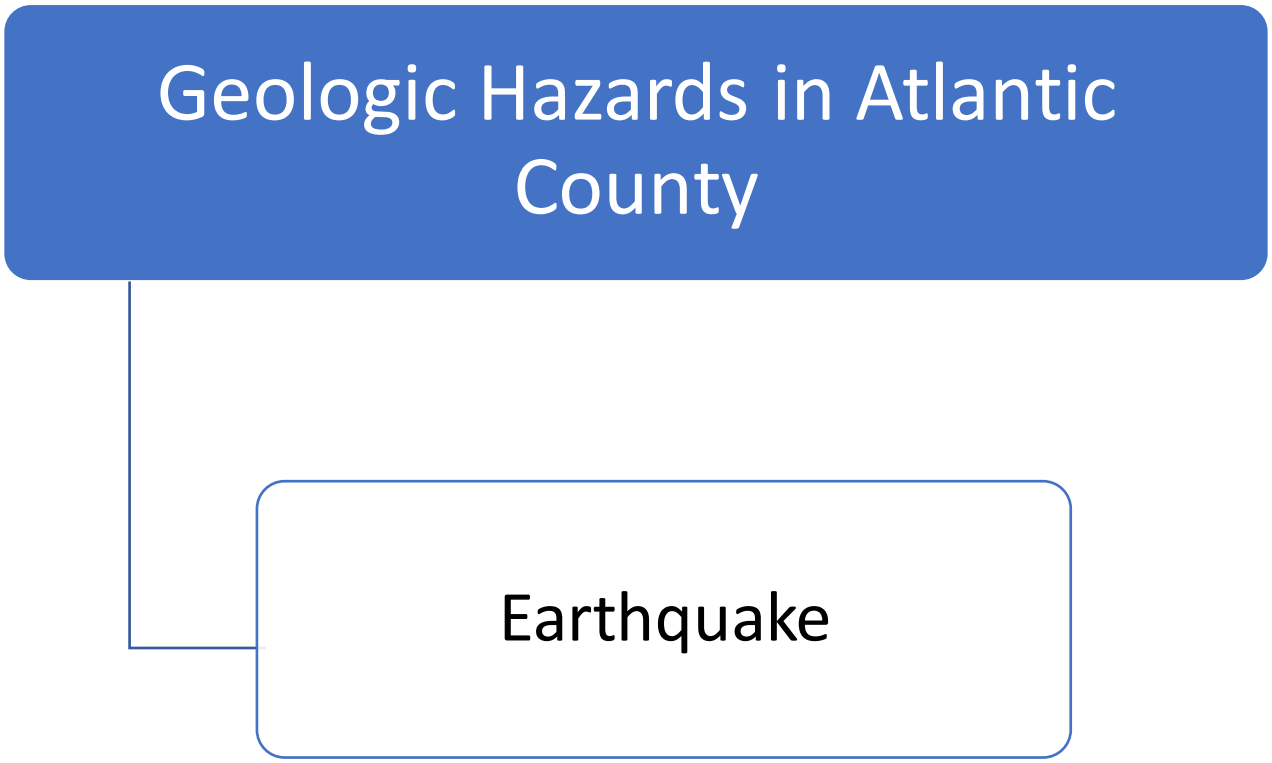
Probability of Occurrence – Wave Action

Wave action will continue to have a high probability of occurrence for the coastal flood hazard zones of Atlantic County, and the probability of future occurrences is certain. The most probably but least severe types of wave action events will be more frequent but are likely have fairly low impacts (i.e., minor damages, coastal erosion, etc.), while more severe waves associated with less frequent and lower probability coastal storm events such as hurricanes and nor'easters will cause much higher impacts (including property damages) along Atlantic County's shoreline.

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Atlantic County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Atlantic County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads,

bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community – particularly for communities where tourism tends to drive local economies, as is the case in many of Atlantic County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

GEOLOGIC HAZARDS

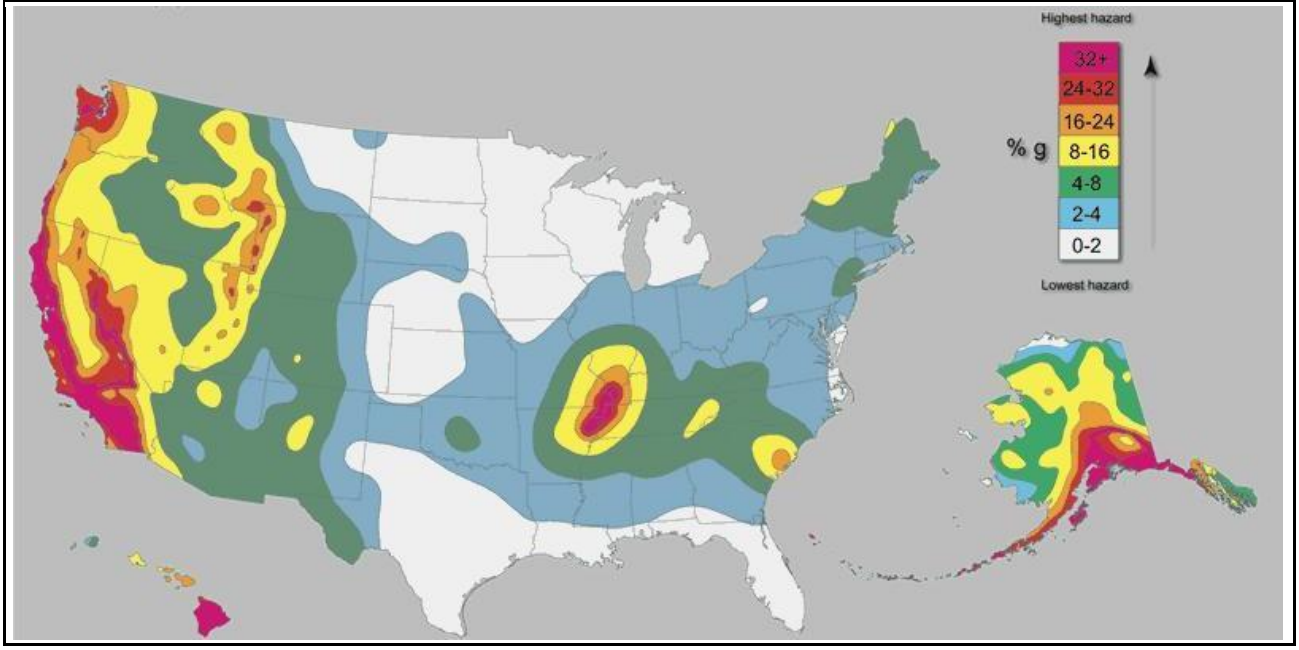


Earthquake

Location – Earthquake

The greatest earthquake threat in the United States is along tectonic plate boundaries and seismic fault lines located in the central and western states; however, the East Coast does face moderate risk to less frequent, less intense earthquake events. **Figure 3a.21** shows relative seismic risk for the United States.

Figure 3a.21
United States Earthquake Hazard Map



Source: United States Geological Survey

Figure 3a.17 shows the probability that ground motion will reach a certain level during an earthquake in Atlantic County and the surrounding region. The data shows peak horizontal ground acceleration (the fastest measured change in speed for a particle at ground level that is moving horizontally due to an earthquake) with a 10 percent probability of exceedance in 50 years. Atlantic County is located in an area with peak ground acceleration (PGA) values between 2%g and 3%g, which is a relatively low seismic risk but still enough to suggest that Atlantic County is susceptible to moderate, damaging earthquakes over time.

Extent – Earthquake

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. Each unit increase in magnitude on the Richter Scale corresponds to a 10-fold increase in wave amplitude, or a 32-fold increase in energy.

Table 3a.20 Magnitude/Intensity Comparison for Earthquakes		
Magnitude	**Typical Maximum Modified Mercalli Intensity**	**Abbreviated Modified Mercalli Intensity Scale**
1.0 - 3.0	**I**	**I**. Not felt except by a very few under especially favorable conditions.
3.0 - 3.9	**II - III**	**II**. Felt only by a few persons at rest, especially on upper floors of buildings.
		III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 - 4.9	**IV - V**	**IV**. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
		V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 - 5.9	**VI - VII**	**VI**. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
		VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6.0 - 6.9	**VII - IX**	**VII**. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
		VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
		IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	**VIII** or higher	**VIII**. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
		IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
		X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
		XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
		XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: US Geological Survey (http://earthquake.usgs.gov/learn/topics/mag_vs_int.php, page last modified September 29, 2014)

Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals, with a I corresponding to imperceptible (instrumental) events, IV

corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). A detailed description of the Modified Mercalli Intensity Scale of earthquake intensity and its correspondence to the Richter Scale is given in **Table 3a.20**.

Historical Occurrences – Earthquake

Earthquakes do occur on a fairly regular basis in New Jersey, though most are of very low magnitude (MMI intensity of less than II) and often not felt by people or capable of causing property damage. According to the New Jersey Geological Survey, there have been 150 recorded earthquakes in New Jersey since 1783, including one with an epicenter located in Atlantic County. This event occurred on November 6, 1912. Its epicenter was located in the City of Pleasantville. The depth and magnitude for this event are both listed as zero in both the NJGS data and the National Earthquake Information Center. Additional information on this event is not available.

New Jersey's susceptibility to earthquakes extends to events located beyond state borders, and some of the most damaging earthquakes were associated with larger, more significant events occurring elsewhere along the East Coast. Most past earthquake damage in New Jersey has been to building contents and architectural damage, such as fallen chimneys, cracked plaster and masonry, and items falling off shelves. Some of the more notable earthquake events for the New Jersey region are identified in **Table 3a.21**.

Table 3a.21
Damaging Earthquakes Felt in the New Jersey Region[64]

Date	Location	Richter Magnitude	Description
12/19/1737	Greater NYC Area	5.2	Chimneys down in New York City. Felt from Boston, MA to Philadelphia, PA.
11/30/1783	North-Central New Jersey	5.3	Felt from New Hampshire to Pennsylvania. Two foreshocks (11/24 and 11/30) and one aftershock (11/30); threw down chimneys.
08/10/1884	Greater NYC Area	5.2	Threw down chimneys; felt from Virginia to Maine
09/01/1895	Near High Bridge, NJ	7.7	Felt over a considerable area to the northeast and southwest. The total felt area covered points from Maine to Virginia in a long, narrow elliptical zone of about 92,000 square kilometers. Articles fell from shelves and buildings rocked (intensity VI) in several Hunterdon County towns. The shock was fairly sharp at Camden and Burlington. At Philadelphia, Pennsylvania, broken windows and overturned crockery were reported.
06/01/1927	Near Asbury Park, NJ	3.9	Occurred in the Asbury Park area. Three shocks were felt along the coast from Sandy Hook to Toms River. Maximum intensities of VII were observed at Asbury Park and Long Branch. Several chimneys fell, plaster cracked, and articles were thrown from shelves. The felt area extended over approximately 7,800 square kilometers.

[64] *Source: NJ State Hazard Mitigation Plan 2014, excerpts from Table 5.5-6.*

01/25/1933	Near Trenton, NJ	0.0	A sharp jolt was felt over central New Jersey from Lakehurst to Trenton. Although there is some doubt whether the shock was of seismic origin, the event was felt most strongly at Lakehurst, where people reported they were rolled out of bed (intensity V). Other people reported pictures shaken from walls. The shock was also felt at Bordentown, Burlington, Columbus, Englishtown, Freehold, Hightstown, New Egypt, Robbinsville, and White Horse.
08/23/1938	Northeast of New Egypt, NJ	3.8	Caused minor damage at Gloucester City and Hightstown (intensity V). The total felt area was about 13,000 square kilometers, including bordering portions of Delaware and Pennsylvania. Glassware was broken at Gloucester City and Hightstown and some furniture was displaced at Pitman. A few windows and some glassware were reported broken at Ardmore, Pennsylvania. Four smaller shocks occurred on 8/23 and one on 8/26.
11/15/1939	Salem County, NJ	3.4	The disturbance was reportedly felt from Trenton to Baltimore, Maryland, and from Cape May to Philadelphia and its adjoining counties. About 16,000 square kilometers were affected. Small objects were reported to have overturned at Deepwater, but little or no damage was noted.
3/23/1957	Schooley's Mountain, NJ	2.9	A shock affected west-central New Jersey, near the site of the 1895 earthquake. Chimneys cracked (intensity VI), windows and dishes broke, and pictures fell at Lebanon. A cracked chimney was also reported from Hamden. At Long Valley, some walls were cracked and plaster fell. The felt area was small in comparison with the other shocks previously described.
3/10/1979 "Cheesequake Earthquake"	Bernardsville, NJ (epicenter in Morris County)	3.1	Felt by some people in Manhattan
10/19/1985	Ardsley, NY	4	Many people in the NYC area felt this earthquake.
10/23/1990	Hancock's Bridge, NJ	2.9	Felt in New Jersey, Delaware, and Pennsylvania
02/03/2009	3.5km South-Southwest of Rockaway, NJ	3.0	There were reports of people having felt this earthquake throughout New Jersey.
02/14/2009	5 km North-Northeast of Boonton, NJ	2.4	There were reports of people having felt this earthquake throughout New Jersey.
07/01/2009	2.25km East-Southeast of Pennsville, NJ	2.8	There were reports of people having felt this earthquake throughout New Jersey.
02/21/2010	Gladstone, NJ	2.6	This earthquake hit just before 9 a.m. and prompted numerous phone calls to police. No damages were reported. Many people in New Jersey reported having felt this earthquake. A 2.3 occurrence later in the day was also reported as having been felt by numerous people in New Jersey, and was most likely an aftershock.
06/06/2010	6 km Southeast of Sayreville, NJ	2.3	People reported having felt this earthquake throughout New Jersey.

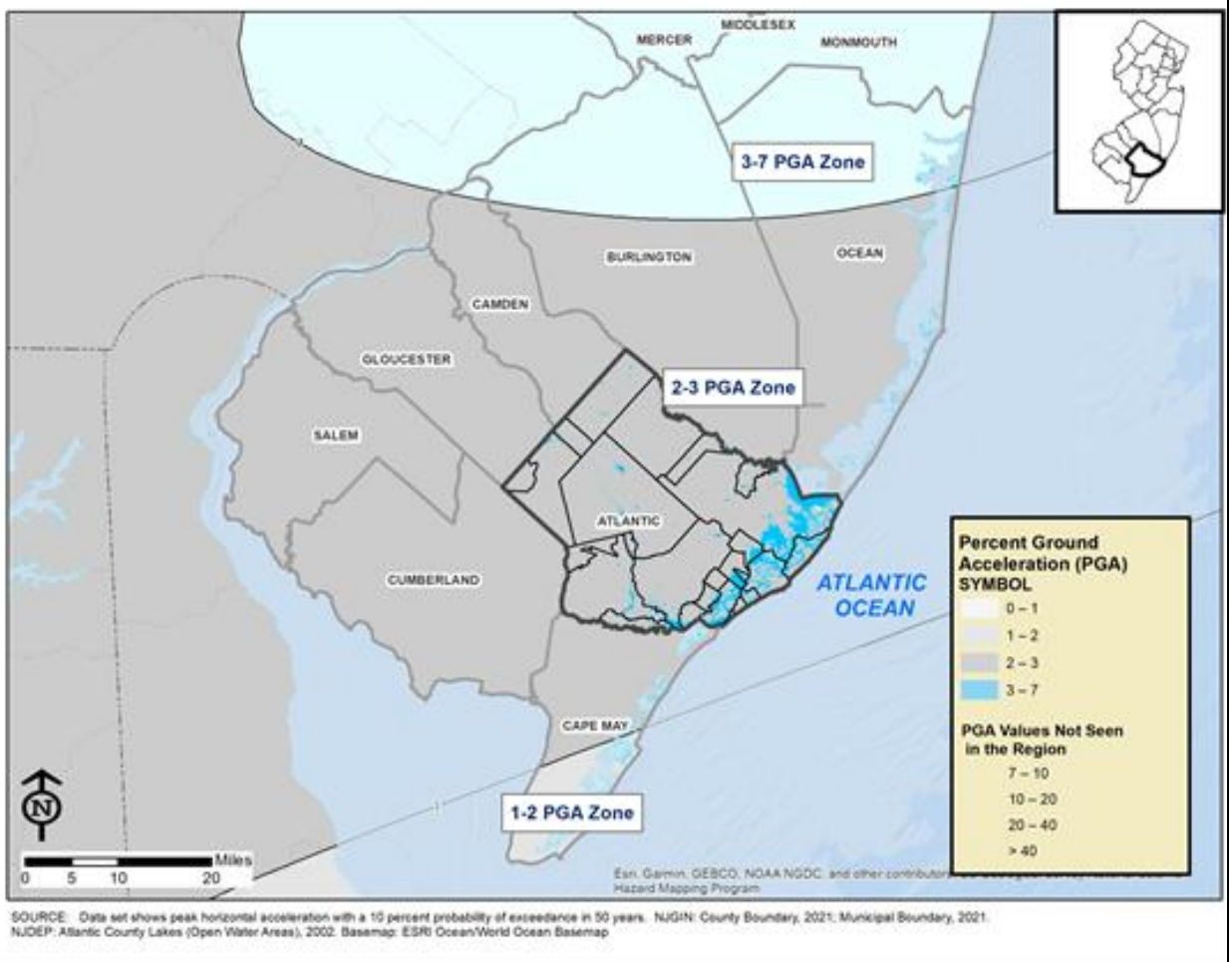
08/23/2011	Central Virginia	5.8	A moderate earthquake occurred in central Virginia and was felt throughout most of the east, from Georgia to southern Canada and from Indiana to coastal Maine. It was followed by four aftershocks. In New Jersey, the intensity ranged from one to four (weak to light). Areas underlain by thick silt and clay felt a stronger ground motion than did those where rock was very close to the surface. The quake was felt in South Brunswick and residents were calling 911 wanting to know what happened; some thought it was an explosion. It was also felt in the offices of Alcatel-Lucent in Murray Hill (Union County). Ceiling tiles fell out at a Sears store in Middletown. In Plainfield (Union County), employees in the Park Madison building were evacuated after the tremor. Union County's administration building in Elizabeth reported continuous shaking. In New Brunswick (Middlesex County), employees were evacuated from the County administration building. Atlantic City (Atlantic County) went into emergency mode with evacuations of high rises, hospitals, schools, casinos, and hotels. The County OEM received reports of a crack in a wall in a house and broken water pipe in a building. There were minor scattered power outages reported throughout the state.
11/05/20112	3 km Southwest of Mahwah, NJ	2.0	People reported having felt this earthquake in various parts of New Jersey.
11/23/2012	Greater Philadelphia Area/New Jersey	2.2	Numerous reports of people having felt the earthquake in southwestern New Jersey.

Atlantic County has not experienced earthquakes resulting in significant damages since the 2016 Plan Update.

Probability of Occurrence – Earthquake

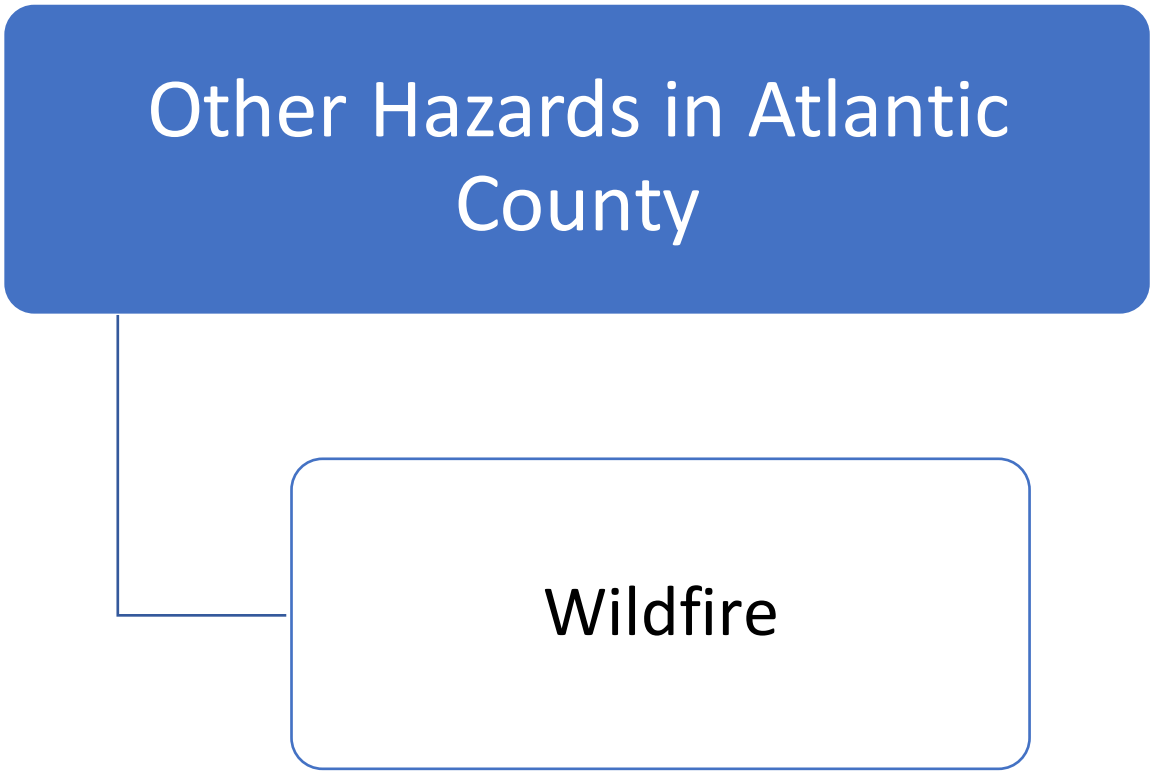
The probability of significant, damaging earthquake events affecting Atlantic County is low. According to the United States Geological Survey (USGS), an earthquake with a 10 percent probability of exceedance over 50 years would have PGA values between 2%g and 3%g, which would result in light to moderate perceived shaking and damages ranging from none to very light. More destructive earthquakes are very rare, low probability events for Atlantic County with highly infrequent recurrence periods. **Figure 3a.22** visualizes earthquake risk in southern New Jersey.

Figure 3a.22
Peak Ground Acceleration with a 10% Probability of Exceedance over 50 years



SOURCE: Data set shows peak horizontal acceleration with a 10 percent probability of exceedance in 50 years. NJGIN: County Boundary, 2021; Municipal Boundary, 2021. NJDEP: Atlantic County Lakes (Open Water Areas), 2002. Basemap: ESRI Ocean/World Ocean Basemap

OTHER HAZARDS

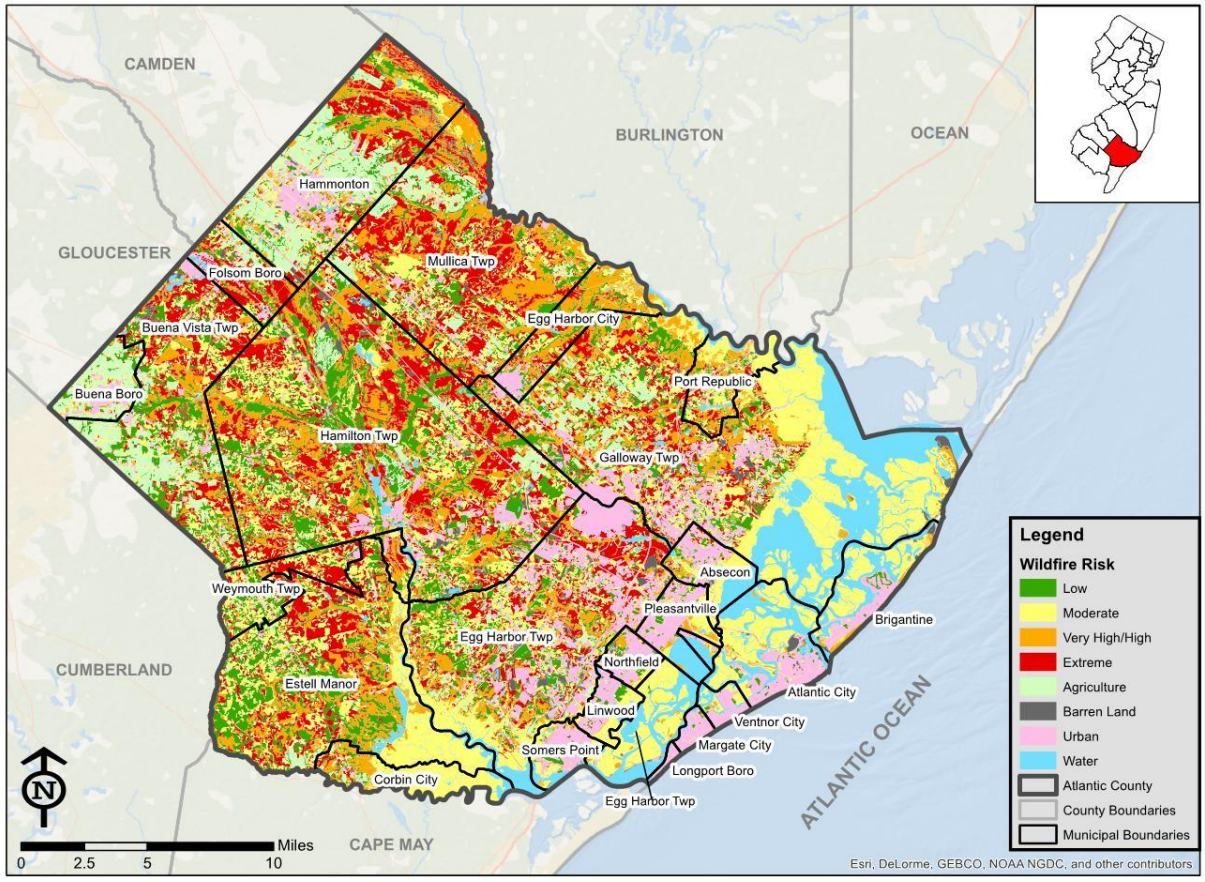


Wildfire

Location – Wildfire

Areas typically prone to wildfire occurrence include large tracts of undeveloped wildlands containing heavier fuels with high continuity, steep slopes and far away from firefighting apparatus that would suppress the spread of wildfires once reported. The New Jersey Forest Fire Service (NJFFS) recently conducted a wildfire hazard assessment[65] for much of the state and has published a map of wildfire hazard areas in Atlantic County. **Figure 3a.23** illustrates this information and shows that the most significant wildfire hazard areas are located predominantly in the western portions of the county.

Figure 3a.23
Wildfire Hazard Areas for Atlantic County



SOURCE: NJDEP and NJFFS: Atlantic County Wildfire Fuel Hazard, 2009. NJGIN: County Boundary, 2012; Municipal Boundary, 2014.

[65] The methodological basis for the NJFFS wildfire risk assessment in Atlantic County was based on a correlation of fire risk to vegetation type as recorded in 1996 data for Land Use / Land Cover data.

Extent – Wildfire

The extent (that is, magnitude or severity) of wildfires depends on weather and human activity. NJFFS uses two indices to measure and monitor dryness of forest fuels and the possibility of fire ignitions becoming wildfires. The State Plan notes that these indices include the National Fire Danger Rating System's Buildup Index, and the Keetch-Byram Drought Index. Both are used for fire preparedness planning, which includes the following: campfire and burning restrictions, fire patrol assignments, staffing of fire lookout towers, and readiness status for both observation and firefighting aircraft.

- The **Buildup Index (BUI)** is a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant. The BUI can represent three to four inches of compacted litter or can represent up to six inches or more of loose litter (North Carolina Forest Service 2009).
- The **Keetch-Byram Drought Index (KBDI)** is a drought index designed for fire potential assessment as defined by the United States Department of Agriculture Forest Service. It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. The index increases each day without rain and decreases when it rains. The scale ranges from zero (no moisture deficit) to 800 (maximum drought possible). The Florida Forest Service states that the range of the index is determined by assuming that 8 inches of moisture in a saturated soil is readily available to the vegetation. For different soil types, the depth of soil required to hold eight inches of moisture varies. A prolonged drought influences fire intensity, largely because more fuel is available for combustion. The drying of organic material in the soil can lead to increased difficulty in fire suppression.

There are also many other scales and fire weather indices that evaluate wildfire *potential* on any given day taking into account factors such as daily weather and vegetation condition information, fuel moisture, fuel hazard, moisture content in the lower atmosphere, etc.

Historical Occurrences – Wildfire

According to the New Jersey State Hazard Mitigation Plan (2014)[66], Atlantic County experienced 218 wildfire events from 1924 to 2007, more than any other county in the State with the exception of neighboring Ocean County (with 692 recorded events) and Burlington County (with 924 recorded events). A total of 228,667 acres was burned during these events. The State Plan records 11 wildfires that were considered to be major events (burning more than 100 acres) or otherwise significant[67]. Specific historical occurrences of wildfires in Atlantic County are also recorded in the NCEI database, which records details for nine wildfire events in Atlantic County between July 1997 and June 2015. The most recent occurrence included in the NCEI database was in April 2009. No events occurred during the last plan maintenance phase (2016-2021).

Further details on a sampling of prior events are provided here:

[66] Table 5.12-5 Number of Wildfire Events by County from 1924 to 2007
[67] Table 5.12-2 Wildland Fire Incidents (1905-2015)

March 31, 1977. A total of 15,000 acres of land was burned in Atlantic, Burlington, and Ocean Counties. A 15,000-acre fire on March 31 burned six homes and caused extensive damage in Burlington, Ocean, and Atlantic Counties.

July 29, 1997. In all 381 wildfires blackened 3,095 acres of forest throughout New Jersey during the month of July. The largest forest fire of the month blackened about 1,920 acres of the Wharton State Forest in the Township of Mullica and Town of Hammonton. One fire fighter suffered heat exhaustion. The fire started about 2.5 miles from the Totem Village in the Township of Mullica. About 100 persons (75 homes) were evacuated for about a day from that development and placed in the Mullica Township firehouse. The fire was declared contained at 6 p.m. EDT on the 30th. The unseasonably hot and dry weather contributed to a larger than normal number of wild and forest fires in the State of New Jersey.

April 30, 1999. A five acre marsh fire caused by a welder's torch was exacerbated by the unseasonably dry weather during the second half of April and very strong and gusty northeast winds. The fire started around 1120 a.m. EDT behind Harrah's within Atlantic City. Workers were building a walkway from a parking lot into the casino. The strong winds coupled with flames stretching into the marsh beyond the hoses' reach made it a difficult fire to control. Nevertheless, it was contained by 1 p.m. EDT. No injuries, property damage or evacuations occurred. The peak wind gust at the Marina within Atlantic City was 29 mph.

March 5, 2000. A fast moving brush fire, exacerbated by strong gusty northwest winds, forced the evacuation of an apartment complex in the City of Somers Point and the closure of the Garden State Parkway for 80 minutes. The fire started as a grass fire on Hoter Avenue in Somers Point shortly before 1 p.m. EST. It spread into the meadow grass and the strong gusty northwest winds extended it beyond the Garden State Parkway. The fire came dangerously close to three buildings in the Somers Point Village Apartments before it was extinguished at 247 p.m. EST. About 15 acres were burned. It was extinguished in 15 minutes. The peak wind gust at the Atlantic City International Airport was 33 mph.

April 18, 2002. An active thunderstorm caused a couple of lightning strike damage in Hamilton Township during the late afternoon of the 18th. Lightning strikes started a couple of small brush fires, struck a senior citizen center and damaged the township's emergency center telephone lines and radio communications.

March 5, 2007. A grass fire in the Township of Egg Harbor closed the northbound and southbound lanes of the Garden State Parkway near the intersection with the Atlantic City Expressway. Heavy smoke sharply reduced visibility. Later that afternoon, one lane in each direction on the Garden State Parkway was reopened. Traffic was also diverted on the Atlantic City Expressway. The spread of the brush fire was assisted by the gusty northwest winds. The peak wind gust at the Atlantic City International Airport on the 5th was 46 mph.

June 1, 2007. A wildfire in the Wharton State Forest near Atsion in Hammonton Township burned for several days and forced the closing of State Route 206. A total of 3,500 acres was burned.

October 21-27, 2008. The Sauder Ditch Wildfire consumed about 1950 acres of forest before it was contained. The fire began in a secluded section of Wharton State Forest in Waterford Township (Camden County) close to 3 p.m. EDT on the 21st. This location is west of U.S. Route 206 and south of the Atsion Recreational Area. It spread into parts of the Town of Hammonton (Atlantic County). Gusty northwest winds along with recent dry weather helped spread the fire

quickly and hampered firefighting efforts on the 21st and 22nd. About four homes and two businesses on U.S. Route 206 in the Town of Hammonton were evacuated because of fear of smoke and the fire itself on the 21st. They were allowed to return at noon EDT on the 22nd. The fire reached up to 100 feet in the air and was visible from Atlantic City. The heavily traveled U.S. Route 206 was closed between the White Horse Pike (U.S. Route 30) in the Town of Hammonton and Atsion Lake (Shamong Township, Burlington County) after the fire jumped the roadway on the evening of the 21st. The roadway had sporadic closures, especially at night when the smoke became thicker, through the 25th. About 200 fire fighters battled the blaze and used brush trucks, helicopters, bull dozers and air tankers in their efforts. Water was retrieved from nearby Atsion Lake. The fire was considered twenty percent contained on the 21st, forty percent contained on the 22nd, fifty percent contained on the 23rd, seventy percent contained on the 24th, ninety percent contained on the 26th and fully contained on the morning of the 27th. A firefighter suffered an irregular heartbeat from battling the blaze and one traffic cop was struck by a vehicle. On the morning of the 24th an atmospheric inversion caused by a nearby high pressure system trapped the smoke near the ground. This caused thick smoke with near zero visibilities to affect the Town of Hammonton and surrounding area. All Hammonton schools were closed and the White Horse Pike (U.S. Route 30) in Hammonton and Winslow was closed. Heavy rain on the 25th helped firefighting efforts. The peak wind gusts at Atlantic City International Airport were 37 miles per hour on the 21st and 35 miles per hour on the 22nd.

February 12, 2009. A wind whipped forest fire burned about 40 acres in Galloway Township during the afternoon and evening on the 12th before it was contained. The fire was believed to be caused by arcing downed wires. The fire occurred in the area bounded by Leipzig Avenue and Liebig and Herschel Streets. No homes were damaged or threatened and no injuries were reported.

April 18, 2009. The fire started near the former Jersey Devil cabin off of Bremen Avenue in Egg Harbor City within the Pinelands National Reserve. The fire briefly caused some evacuations including one woman with respiratory problems. The fire consumed about 315 acres of white cedar swamp within the Pinelands.

In addition, information from local sources on the CPG reported that a large wildfire in the 1960s threatened Weymouth Township, causing large scale evacuations and the loss of several homes. No further information was readily available. Based on a review of NCEI data and the 2019 New Jersey State Hazard Mitigation Plan, no significant wildfire events have occurred in Atlantic County since the 2016 Update.

Probability of Occurrence – Wildfire

Wildfire probability depends on local weather conditions; outdoor activities such as camping, debris burning, and construction; and the degree of public cooperation with fire prevention measures. Wildfire events will continue to have a high probability of occurrence in Atlantic County, and the probability of future occurrences in Atlantic County is certain. However, these events are typically contained and extinguished rather quickly and those events causing major property damage or life/safety threats are much less likely to occur.