4.3.14 Severe Winter Weather

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

2022 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- A new table explaining prior severe winter weather events was added.
- Previous occurrences were updated with events that occurred between 2015 and 2021.
- A vulnerability assessment was conducted for the severe winter weather hazard using a more accurate and updated building inventory.

4.3.14.1 Profile

Hazard Description

A winter storm is a weather event in which the main types of precipitation are snow, sleet, or freezing rain. They can be a combination of heavy snow, blowing snow, and dangerous wind chills. According to the National Severe Storms Laboratory (NOAA 2021), the three basic components needed to make a winter storm include the following:

- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

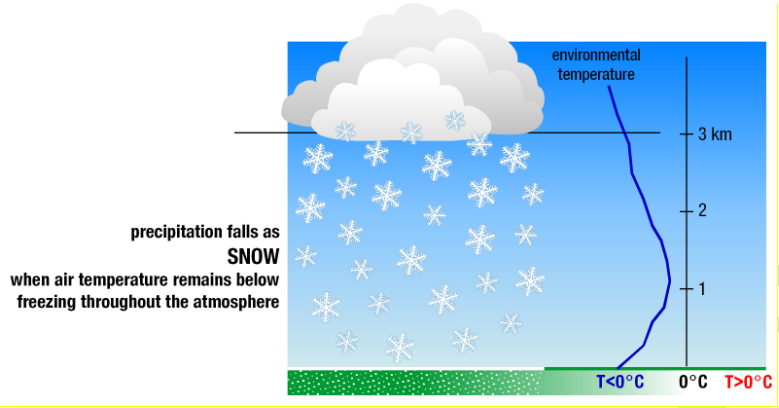
Some winter storms can immobilize an entire region, while others might only affect a single community. Winter storms typically are accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and blocked roadways, downed utility lines, and power outages. Gloucester County's winter storms include, but are not limited to blizzards, snowstorms, sleet, and ice storms. For details regarding Nor'Easters, refer to Section 4.3.12.

Heavy Snow

According to the National Snow and Ice Data Center (NSIDC), snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32 °F) and water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed,

it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or a snow pellet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Figure 5.4.9-1 depicts snow creation.

Figure 4.3.14-1. Snow Creation



Source: NOAA 2021

Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals.

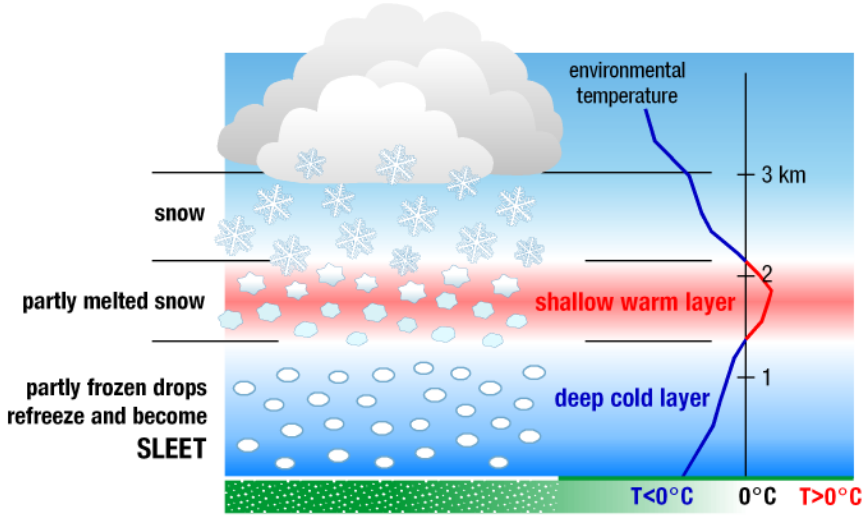
Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard conditions but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (Lam 2019).

Sleet

Sleet is made up of drops of rain that freeze into ice as they fall. They are usually smaller than 0.30 inch in diameter (NSIDC 2013). A sleet storm involves significant accumulations of solid pellets, which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists (NSIDC 2013).

Figure 4.3.14-2. Sleet Creation

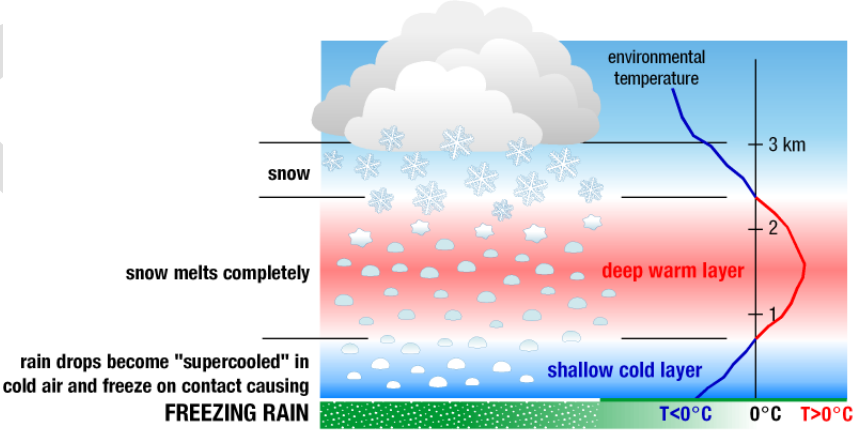


Source: NOAA 2021

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2020).

Figure 4.3.14-3. Freezing Rain Creation



Source: NOAA 2021

Location

Snow and Blizzards

Heaviest snowfall from winter storms is typically within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. The trajectory of the snowstorm will determine the location of heaviest snowfalls. In Gloucester County the average yearly snowfall is between 20" and 25". There is, however, significant variation from year to year. February is the month when maximum accumulations on the ground are usually reached. The southeastern third of Gloucester County receives slightly less snowfall most likely due to the coastal influences moderating temperatures slightly. Snow may fall from about October 15 to April 30 in the highlands and from about November 15 to April 15 in southern counties, including Gloucester (Rutgers University 2021).

Ice Storms

All regions across New Jersey are subject to ice storms. In addition to temperature, their occurrence depends on the regional distribution of the pressure systems, as well as local weather conditions. The occurrence and intensity of ice storms often coincides with general distribution of snow. In Gloucester County, a cold rain may be falling near the Atlantic County border in the southeastern part of the county, transforming into freezing rain in the central region, and snow over the northwestern portion as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm, especially given the confined geographical region the storms often reach and affect. Based on data from 1948–2000, Gloucester County can anticipate 2-4 days with freezing rain per year. Based on data from 1932–2001, the County can anticipate 9-15 total hours of freezing rain per year (MRCC 2021).

Extent

The magnitude or severity of a severe winter storm depends on several factors, including snowfall rates, regional climatological susceptibility to snowstorms, snowfall amounts, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day and week (e.g., 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 National Climatic Data Center (NCDC) 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 1 to 5. 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 2010 Census. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2021). Table 5.4.7-1 presents the five RSI ranking categories.

Table 4.3.14-1. RSI Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6

Category	Description	RSI Value
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA 2021
Note: RSI = Regional Snowfall Index

The NWS operates a widespread network of observing systems such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts.

The NWS uses winter weather watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location and timing are uncertain. A watch is issued to provide 12 to 48 hour notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS 2021).

Previous Occurrences and Losses

Winter storms occur frequently enough in Gloucester County to be a threat to people and property. Generally, the winter storm season in the Gloucester County runs from December to March. The NCDC reports there have been 180 snow and ice events in Gloucester County between 1950 and 2020. Although the query results begin in 1950 the first reported event is in 1995. This is likely the case because weather events were reported using different methods prior to this year and thus are not consistent with those after 1995, according to the National Weather Service (NWS 2021). The probability of winter storms occurring in the future is relatively high, based on previous data. On average, between 7 and 10 winter storms occur every year in Gloucester County (Gloucester County 2016).

It is worth noting that NCEI database indicates that between 1950 and 2020, there have been no ice storm events reported in Gloucester County. However, according to the 2009 Gloucester County Hazard Mitigation Plan , there have been two ice storms that have impacted Gloucester County between 1950 and 2007. One of the two events listed in the HMP occurred on February 15th and 16th, 1995 when a warm front associated with a storm system over the Great Lakes helped push warmer air aloft above a dome of cold, dry air near the ground. As warmer air moved in aloft, precipitation mainly fell as freezing rain the afternoon and evening of the 15th. Once the sun set, many roadways in Gloucester County became slippery and ice-covered. Transportation and commerce were disrupted as driving on icy roadways became extremely hazardous. This discrepancy in records can be attributed to the categorization of the event reporting, as the NCEI also reports

that there have been eight other reported events that were similar to but were not categorized as ice storms. These included sleet events in 2001, 2002, and 2003; and Frost Freeze incidents in 2007. While these events had disruptive impacts in Gloucester County, there were no reported property or crop damages, according to the National Centers for Environmental Information (NOAA 2021).

FEMA Disaster Declarations

Between 1954 and 2020, FEMA declared that the State of New Jersey experienced six winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storm, severe storm, snowstorm, blizzard, and ice conditions. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Gloucester was included in five of these declarations. Table 4.3.14-2 lists FEMA DR and EM declarations that included Gloucester County.

Table 4.3.14-2. FEMA Declarations for Severe Winter Weather Events in Gloucester County

FEMA Declaration Number	Date(s) of Event	FEMA Declaration Date(s)	Event Type
DR-528	February 8, 1977	February 8, 1977	Ice Conditions
EM-3106	March 13-17, 1993	March 17, 1993	Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Blizzard of '96 (severe snow storm)
EM-3181	February 16-17, 2003	March 20, 2003	Snow
DR-1873	December 19-20, 2009	February 5, 2010	Winter Storm
DR-1889	February 5-6, 2010	Mar 23, 2010	Severe Winter Storm and Snowstorm

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

Agriculture-related winter disasters are quite common. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. From 2015-2021, Gloucester County was not included in any USDA disaster declarations for winter storm events (USDA 2021).

Severe Winter Weather Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines severe winter storm events as follows:

- Blizzard is reported in the NOAA-NCEI database when a winter storm which produces the following conditions for 3 consecutive hours or longer: (1) sustained winds or frequent gusts 30 knots (35 mph) or greater, and (2) falling and/or blowing snow reducing visibility frequently to less than 1/4 mile.
- Heavy snow is reported in the NOAA-NCEI database whenever snow accumulation meets or exceed locally/regionally defined 12 and/or 24 hour warning criteria.
- Ice storm is reported in the NOAA-NCEI database when ice accretion meets or exceed locally/regionally defined warning criteria (typical value is 1/4 or 1/2 inch or more).

- Sleet is reported in the NOAA-NCEI database whenever sleet accumulations meet or exceed locally/regionally defined warning criteria (typical value is ½ inch or more).
- Winter storm is reported in the NOAA-NCEI database whenever a winter weather event has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12 and/or 24 hour warning criteria for at least one of the precipitation elements.

For this 2022 HMP update, winter weather events were summarized from 2015 to 2021. For information regarding severe winter weather events prior to 2015, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 4.3.14-3. Severe Winter Weather Events in Gloucester County, 2016-2021

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
January 6, 2015	Winter Weather	N/A	No	Gloucester County	A quick moving Alberta Clipper, dropping southeast from Canada and through the Northern Plains, tracked across the Ohio Valley and into the Mid Atlantic by the morning of the 6th. Snow began falling across New Jersey during the morning commute before tapering off from west to east across the state through the afternoon to early evening. With temperatures mainly in the 20s and snow to liquid ratios in the 15 to 1 range for most of the area, the snow quickly accumulated and adversely affected the morning commute.
January 18, 2015	Winter Weather	N/A	No	Gloucester County	Freezing rain at the onset of a protracted precipitation event helped cause hundreds of accidents across central and northern New Jersey on the morning into the mid-afternoon of the 18th. New Jersey State Police alone responded to 428 accidents and 186 calls for assistance. A couple of accidents resulted in fatalities. There were also numerous pedestrian slip and fall accidents.
January 21, 2015	Winter Weather	N/A	No	Gloucester County	A clipper low pressure system dropped 1 to 3 inches of snow across the southern half and less than an inch across the northern half of New Jersey during the afternoon and evening on the 21st. The snow helped cause slippery traveling conditions and accidents. There were about three dozen accidents or incidents on major roadways in the southern half of the state.
January 23-24, 2015	Winter Weather	N/A	No	Gloucester County	A winter storm dropped heavy snow in Northwest New Jersey and a mixture of snow, sleet and freezing rain in the central and southwest part of New Jersey on the evening of the 23rd into the morning of the 24th. Overall less wintry precipitation (a faster switch to rain) occurred progressively farther to the south and southeast in the state.
January 26-27, 2015	Winter Weather	N/A	No	Gloucester County	A complex winter storm that buried Long Island and southern New England under heavy snow and blizzard conditions spared most of New Jersey. The state was too far west to remain under heavier wrap-around snow for a prolonged period of time and the state was not affected much by a clipper low pressure system that preceded it from the west.
February 1 - 2, 2015	Winter Weather	N/A	No	Gloucester County	A winter storm brought a heavy mixture of snow, some sleet and freezing rain to the Raritan Valley and northwest New Jersey with less of a wintry impact to the rest of central and southwest New Jersey on the first into the second. Precipitation fell as rain in the southeast part of the state throughout the event. In southwest New Jersey, the snow transitioned briefly to sleet and then rain early on the 2nd.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
February 9-10, 2015	Winter Weather	N/A	No	Gloucester County	A protracted event of light snow, sleet and especially freezing rain caused traveling difficulties and accidents in northern and southwest New Jersey on the 8th and 9th. While precipitation occurred intermittently and amounts were overall light, untreated roadways were treacherous.
February 14-15, 2015	Winter Weather	N/A	No	Gloucester County	A vigorous cold front and a rapidly intensifying low pressure system east of the Delmarva Peninsula combined to drop 2 to 5 inches of snow across most of New Jersey (with some locally higher amounts in Ocean and Monmouth Counties) from the late morning on the 14th into the morning on the 15th.
February 16-17, 2015	Heavy Snow	N/A	No	Gloucester County	Snowfall totals primarily between 4 to 7 inches occurred across central to southern New Jersey, with mainly less than 4 inches occurring across northern New Jersey. The snow caused accidents and impacted the morning commute on the 17th.
February 21, 2015	Winter Storm	N/A	No	Gloucester County	A winter storm produced a protracted mixture of snow, sleet and freezing rain across most of New Jersey during the afternoon into the overnight of the 21st and lasted through the entire overnight in far northwest New Jersey where precipitation fell mainly as snow. Snowfall averaged 3 to 6 inches, with slightly lower amounts in the southeast part of the state.
February 26, 2015	Winter Weather	N/A	No	Gloucester County	A low pressure system that moved off the South Carolina coast brought snow into mainly southeast New Jersey on the 26th. Speed restrictions were in place on the New Jersey Turnpike and Garden State Parkway in the southern third of New Jersey.
March 1, 2015	Winter Storm	N/A	No	Gloucester County	Double barrel low pressure systems brought a winter storm to New Jersey on the 1st. A combination of snow, sleet and especially freezing rain in southern New Jersey affected the state.
March 3, 2015	Winter Weather	N/A	No	Gloucester County	An approaching warm front generated a mixture of snow, sleet and freezing rain in New Jersey during the afternoon and evening of the 3rd. The wintry mix led to hazardous conditions on non treated surfaces and many traffic accidents.
March 5, 2015	Heavy Snow	N/A	No	Gloucester County	Waves of low pressure that formed along a sinking cold front brought New Jersey heavy snow and the southern half of the state its heaviest snow of the season. Snowfall averaged 4 to 9 inches with the highest amounts in central New Jersey. Nearly all schools and universities in the state were closed on the 5th.
March 20, 2015	Winter Weather	N/A	No	Gloucester County	A winter storm on the first day of astronomical spring dropped snow across most of New Jersey on the 20th. Before precipitation ended, it transitioned to rain in the southern half of New Jersey. Snowfall averaged 3 to 7 inches from Gloucester and inland Atlantic Counties northward and two inches or less elsewhere in southern New Jersey. The snow also caused traveling difficulties and accidents during the afternoon

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					and evening. Speed restrictions were in place on major roadways. Some schools dismissed children early. The snow caused more than 1,150 flights to be cancelled on the 20th in the northeastern United States.
January 22-24, 2016	Winter Storm	DR-4264	Yes	Gloucester County	A storm impulse from the west coast developed into a nor'easter over the Carolinas, resulting in blizzard conditions to the County. A 62-year-old male from East Greenwich (Gloucester County) died from a heart attack on Saturday evening, January 23rd, while he and his wife were walking home after his car got stuck in a snowdrift just up the street from his house. The storm, known as Jonas, caused widespread power failures and flooding throughout the County. Philadelphia International Airport canceled all Saturday flights, and 155 departures and 133 arrivals scheduled for Sunday.
February 5, 2016	Winter Weather	N/A	No	Gloucester County	Precipitation associated with a low pressure system moving north along a nearby offshore front began as light rain during the evening hours on the 4th, then turned to snow during the overnight hours. Reported snowfall totals included: 3.0 inches in Williamstown, 2.8 inches in Pitman, and 1.5 inches in Washington Township.
February 15-16, 2016	Winter Weather	N/A	No	Gloucester County	Precipitation from a low pressure system moving north from the Tennessee River Valley began as snow early Monday afternoon as it ran into colder air established over the area the previous few days. A strong southerly flow associated with this low brought with it very warm air, which turned the snow over to freezing rain, then plain rain, from south to north Monday night and early Tuesday. 1.6 inches of snow was reported in Williamstown, 1.2 inches in Pittman, and 1.0 inches in Sewell. Between 0.01 and 0.05 inches of ice accumulation was reported from freezing rain.
March 3-4, 2016	Winter Storm	N/A	No	Gloucester County	A light snow began late Thursday evening and continued into the beginning of the Friday morning commute, with accumulations mainly on grassy surfaces and some slush on untreated roads. Snowfall totals include 3.0 inches in Williamstown, 2.0 inches in Deptford Township, and 1.8 inches near Pitman. By Friday afternoon, most of the snow had melted.
April 9, 2016	Winter Weather	N/A	No	Gloucester County	A vigorous upper level low pressure system, combined with unseasonably cold air, produced rain and snow showers during the daytime hours on the 9th. Most of the accumulating snow was confined to grassy surfaces, so human impact was minimal. By late in the day, precipitation had moved out of the area. 3.5 inches of snow was reported in Franklin Township, 3.0 inches in Mullica Hill, 3.0 inches in Swedesboro, and 2.0 inches in Newfield. All other reports from the county were less than 2.0 inches.
December 17, 2016	Winter Weather	N/A	No	Gloucester County	Low pressure developed to the lee of the Rockies over the Central Plains on December 16 and moved eastward to the Appalachians on December 17. A warm front moved

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					slowly north across New Jersey, leading to a wintry mix of precipitation during the morning hours of December 17. In Gloucester County, storm total snowfall was generally below 1.0 inches, and ice glaze amounts were generally below 0.1 inches.
January 5-6, 2017	Winter Weather	N/A	No	Gloucester County	Generally between one and two inches of snow fell from this event, with 2.0 inches in Mantua, 1.5 inches in Franklin Township, and 1.2 inches in Elk Township.
January 7, 2017	Winter Storm	N/A	No	Gloucester County	Snow began falling around dawn on January 7th, then continued heavy at times through the day before moving off the coast around sunset. Total snowfall reports ranged between 6 and 8 inches, including 7.0 inches in Pitman, 6.1 inches in Williamstown, and 6.0 inches in West Deptford. Strong winds the following day produced blowing and drifting snow.
March 10, 2017	Winter Storm	NA	No	Gloucester County	A cold frontal boundary moved through New Jersey early in the morning of the 10th. As a result, rain changed to snow. Spotters measured 2-3 inches of snow on grass in several locations throughout the days.
March 14, 2017	Winter Storm	NA	No	Gloucester County	A few inches of snow fell across the county with a sharp gradient in totals. ice accumulations were up to 1/4 inch.
December 9, 2017	Winter Weather	N/A	No	Gloucester County	Approximately three inches of snow were recorded in the coastal and southwestern sections of New Jersey following a low pressure system moving up the coast. Some mixed precipitation was recorded.
January 4, 2018	Winter Storm	N/A	No	Gloucester County	Snowfall ranged from 4 to 6 inches across the county. In other parts of the state, an emergency declaration was declared due to severe blizzard conditions.
March 2, 2018	Winter Storm	N/A	No	Gloucester County	A heavy, wet snow accumulated to a depth of up to 4 inches in the county. Some snowfall totals include 3.5 inches in South Harrison Township, 3.2 inches near Turnersville, 3.0 inches in Mantua, 2.5 inches in West Deptford, and 2.0 inches in East Greenwich Township. A wind gust of 65 MPH was reported in Washington Township at 1455EST on March 2nd.
March 6-7, 2018	Winter Storm	N/A	No	Gloucester County	Banding and thundersnow produced pockets of heavy snow in the western sections of the county, closer to the Delaware River. Further east, snow mixed with rain during parts of the event which tempered snowfall amounts. Some reported snowfall totals include: 6.5 inches in West Deptford, 6.5 inches in Sewell, 6.5 inches in Mantua, 5.5 inches in Williamstown, and 5.0 inches in Pitman.
March 21, 2018	Winter Storm	N/A	No	Gloucester County	Precipitation in Gloucester County began as rain during the evening hours on March 20th. After a lull during the overnight hours, rain mixed with snow during the morning and early afternoon hours of the 21st before changing over to all snow around noon,

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Event Details*
					falling heavy at times through the evening hours and accumulating up to 12 inches in parts of the county.
November 15, 2018	Winter Weather	N/A	No	Gloucester County	Early season Winter Storm. Total snow accumulation ranged from 4.0 in West Deptford to 0.7 in East Greenwich Township.
December 5, 2018	Winter Weather	N/A	No	Gloucester County	Localized snowfall was recorded which resulted in total snow accumulation ranging from 4.2 in Newfield to 1.2 4 WSW of Turnersville.
January 12-13, 2019	Winter Weather	N/A	No	Gloucester County	Gloucester County was struck by a weekend winter storm, yielding total snow accumulation from 4.5 in Malaga to 3.0 in Pitman.
February 10, 2019	Winter Weather	N/A	No	Gloucester County	Light snow was recorded in the southern mid-Atlantic region, which was followed by the second part of the storm that brought wintry mix and rain.
February 11, 2019	Winter Weather	N/A	No	Gloucester County	This event was the second part of a multi-day storm that impacted the region with light snow changing to a wintry mix and then to rain. Snow and ice totals were less across Delmarva than other locations farther north and west.
February 20, 2019	Winter Weather	N/A	No	Gloucester County	Mixed precipitation amounting to several inches of snow and freezing rain was recorded in the region following a complex area of low pressure. A trained spotter in West Deptford Twp reported 3.0 inches of snow. Trace amounts of ice were also reported in Washington.
March 1, 2019	Winter Weather	N/A	No	Gloucester County	Two to four inches fell over a three-hour period during a brief but intense winter weather event. A trained spotter in Washington Twp reported 2.0 inches of snow.
January 18, 2020	Winter Weather	NA	No	Gloucester County	A light mix of snow and freezing rain occurred across Gloucester County. Snowfall amounts were less than one inch, with trace amounts of icing.

Sources: FEMA 2021; NOAA-NCEI 2021; SPC 2021; NJOSC 2021; NJOEM 2019

* *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table. No property damage or crop loss was reported by NOAA and USDA.*

DR Major Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph Miles per Hour
NCEI National Centers for Environmental Information
NJOSC New Jersey State Climatologist
NOAA National Oceanic and Atmospheric Administration
N/A Not Applicable

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter season in New Jersey. The majority of the State will receive at least one measurable snow event during the winter months. The months of January, February, March, April, October, November and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region. It is estimated that Gloucester County will continue to experience the direct and indirect impacts of severe winter weather events annually that many induce secondary hazards such as: structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

Table 5.4.9-4 summarizes data regarding the probability of occurrences of severe winter weather events in Gloucester County based on the historic record. To calculate the probability, the NOAA-NCEI database was queried for all winter weather-related events in Gloucester County. Table 5.4.9-4 shows the number of occurrences and the percent chance of the event occurring in any given year. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 4.3.14-4. Probability of Future Occurrence of Severe Winter Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2021	Annual Number of Events (average)	Recurrence Interval* (in years)	Probability of Event Occurring in Any Given Year	% Chance of Occurring in Any Given Year
Blizzard	1	0.01	70	0.01	1.4%
Ice Storm	0	0	NA	0	0%
Heavy Snow	32	0.45	2.19	0.45	45.7%
Sleet	0	0	NA	0	0%
Winter Storm	25	0.357	2.8	0.357	35.7%
Winter Weather	114	1.6	0.61	1.5	100%
Total	**128**	**1.8**	**0.56**	**1.8**	**100%**

Source: NOAA-NCEI 2021
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1950. Due to limitations in data, not all severe winter weather events occurring between 1950 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

In Section 4.4, the identified hazards of concern for Gloucester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for severe winter weather in the County is considered 'frequent' (100 percent chance occurring each year, occurring multiple times a year).

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (ONJSC 2021) which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo 2014) and the world (1.5° F [0.8° C]) (Meyer 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle 2017). New Jersey can also expect that by the middle of the 21st century, 70 percent of summers will be hotter than the warmest summer experienced to date. The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation (Broccoli 2020).

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (ONJSC 2021). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh 2014) and with more intensity (Huang 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan 2014).

4.3.14.2 Vulnerability Assessment

For the severe winter weather hazard, all of Gloucester County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 3), are vulnerable to a winter storm event. The following subsections discuss the County's vulnerability, in qualitative nature, to the severe winter weather hazard.

Impact on Life, Health and Safety

The entire population of Gloucester County (291,165 people) is exposed to severe winter weather events (ACS, 2019). According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold (NSSL 2020).

The homeless and elderly are considered most susceptible to this hazard. The elderly are considered susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. According to the 2019 American Community Survey 5-Year population estimate, there are 35,699 persons over 65 years old that reside in the County that are considered vulnerable to severe winter weather. In addition, severe winter storm events can reduce the ability of these populations to access emergency services.

Additionally, the homeless and residents below the poverty level may not have access to housing or their housing could be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Gloucester County, the Township of Deptford has the highest population below the poverty level (2,021 persons). Refer to Section 3 (County Profile) that displays the distribution of low-income populations in Gloucester County.

Impact on General Building Stock

The entire general building stock inventory is exposed and vulnerable to the severe winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Table 4.3.14-5 presents the total exposure value for general building stock for each participating municipality. Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percentage damages that could result from severe winter storm conditions. Table 4.3.14-5 below summarizes the estimated loss based on 1-, 5-, and 10-percent losses. Given professional knowledge and the currently available information, the potential loss for this hazard is considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

Table 4.3.14-5. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Clayton (B)	$1,933,299,905	$19,332,999	$96,664,995	$193,329,990
Deptford (Twp)	$10,081,159,584	$100,811,596	$504,057,979	$1,008,115,958
East Greenwich (Twp)	$2,927,045,409	$29,270,454	$146,352,270	$292,704,541
Elk (Twp)	$1,784,179,937	$17,841,799	$89,208,997	$178,417,994
Franklin (Twp)	$5,637,186,975	$56,371,870	$281,859,349	$563,718,697
Glassboro (B)	$5,816,332,907	$58,163,329	$290,816,645	$581,633,291
Greenwich (Twp)	$2,734,741,222	$27,347,412	$136,737,061	$273,474,122
Harrison (Twp)	$4,828,239,008	$48,282,390	$241,411,950	$482,823,901
Logan (Twp)	$6,591,573,691	$65,915,737	$329,578,685	$659,157,369
Mantua (Twp)	$4,738,271,524	$47,382,715	$236,913,576	$473,827,152

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Monroe (Twp)	$8,458,118,166	$84,581,182	$422,905,908	$845,811,817
National Park (B)	$781,021,288	$7,810,213	$39,051,064	$78,102,129
Newfield (B)	$622,948,021	$6,229,480	$31,147,401	$62,294,802
Paulsboro (B)	$2,076,864,026	$20,768,640	$103,843,201	$207,686,403
Pitman (B)	$2,916,470,733	$29,164,707	$145,823,537	$291,647,073
South Harrison (Twp)	$1,494,748,661	$14,947,487	$74,737,433	$149,474,866
Swedesboro (B)	$936,236,069	$9,362,361	$46,811,803	$93,623,607
Washington (Twp)	$13,732,374,547	$137,323,745	$686,618,727	$1,373,237,455
Wenonah (B)	$778,702,966	$7,787,030	$38,935,148	$77,870,297
West Deptford (Twp)	$9,201,121,261	$92,011,213	$460,056,063	$920,112,126
Westville (B)	$1,529,846,612	$15,298,466	$76,492,331	$152,984,661
Woodbury (C)	$4,139,381,075	$41,393,811	$206,969,054	$413,938,107
Woodbury Heights (B)	$1,265,332,236	$12,653,322	$63,266,612	$126,533,224
Woolwich (Twp)	$4,551,585,778	$45,515,858	$227,579,289	$455,158,578
Gloucester County (Total)	$99,556,781,602	$995,567,816	$4,977,839,080	$9,955,678,160

Source: Gloucester County 2021; RS Means 2021

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At-risk residential infrastructures are presented in the flood hazard profile (Section 4.3.7). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the Hurricanes and Tropical Storms (Section 4.3.10) profile and Nor'Easter (Section 4.3.12) profile for losses resulting from high winds which may also accompany severe winter weather.

Impact on Critical Facilities

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2020).

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required (NSSL 2020).

Impact on Economy

Heavy accumulations of ice can bring down trees and power lines, disabling electric power and communications for days or weeks. Heavy snow can immobilize a region and paralyze a city, shutting down all air and rail transportation and disrupting medical and emergency services. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The economic impact of winter weather each year is huge, with costs for snow removal, damage and loss of business in the millions (NOAA 2021).

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the County.

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020). Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals. Road-salt runoff can cause groundwater salinization, modify the soil structure, and result in loss or reduction in lake turnover. Additionally, road salt can cause changes in the composition of aquatic invertebrate assemblages and pose threats to birds, roadside vegetation, and mammals (Tiwari and Rachlin).

> Chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry de-icing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth.

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Project Development

As discussed in Sections 3 and 9, areas targeted for future growth and development have been identified across Gloucester County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. Any areas of growth could be potentially impacted by the severe winter weather hazard because the entire County is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the severe winter weather hazard compared with the aging building stock in the County.

Projected Changes in Population

Between 2010 and 2019, the County's population increased by about 1 percent., a trend that is expected to continue. Overall, aging infrastructure may result in increased stress on existing infrastructure and related services. Municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during winter weather events to prevent increased stresses on these systems. Refer to Section 3 (County Profile) for a detailed discussion on population change in Gloucester County.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA] 2016).

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

In terms of snowfall and ice storms in New Jersey, there is a lack of quantitative data to predict how future climate change will affect this hazard. 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). Future enhancements in climate modeling will provide an improved understanding of how the climate will change and impact the Northeast.

Change of Vulnerability Since 2016 HMP

Overall, the County's exposure and vulnerability have not changed, and the entire County will continue to be exposed and vulnerable to severe winter storm events.