SECTION 4. RISK ASSESSMENT

This section provides a hazard profile and vulnerability assessment of the severe winter weather hazard in Camden County.

2022 HMP Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2015 and 2020.

4.3 Hazards of Concern

4.3.12 Severe Winter Weather

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/or dangerous wind chills. There are three basic components needed to make a winter storm. Below freezing temperatures (cold air) in the clouds and near the ground are necessary to make snow and ice. Lift, something to raise the moist air to form clouds and cause precipitation, is needed. Examples of this is warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside. The last thing needed to make a winter storm is moisture to form clouds and precipitation. Air blowing across a body of water, such as a large lake or the ocean (National Severe Storms Laboratory 2014).

Some winter storms are large enough to immobilize an entire region while others may only affect a single community. Winter storms are typically 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/or blocked roadways, downed utility lines, and power outages. In Camden County, winter storms include blizzards, snowstorms and ice storms. Nor'easters are also a common type of storm that may occur during winter months within the State of New Jersey; however, given the frequency of these types of storms in the State and their severe potential impact, Nor'easters are considered by the Planning Committee as a separate hazard and are further discussed in Section 4.3.9 (High Wind) within this plan. Extreme cold temperatures and wind chills are also associated with winter storms; however, based on input from the County and Planning Committee, these events are further discussed in this Plan in Section 4.3.6 (Extreme Temperatures).

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 degrees Fahrenheit [°F]), when 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 snow pellets, which then fall to the earth. Snow falls in different forms, such as snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud.

Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets that are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. A heavy snowstorm is defined as a snowstorm with accumulations of 4 inches or more of snow in a 6-hour period, or 6 inches of snow in a 12-hour period (NWS 2009).

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be the predominant over a 3-hour period. Extremely cold temperatures are often 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 (The Weather Channel 2012).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are typically accumulations of ¼" or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines and 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 2008).

4.3.12.1 Location and Extent

Snow and Blizzards

The trajectory of the storm center—whether it passes close to the New Jersey coast or at a distance—largely determines both the intensity and the duration of the snowfall over the State. Winter storms tend to have the heaviest snowfall within a 150-mile-wide swath to the northwest of what are generally southwest to northeast moving storms. Depending on whether all or a portion of New Jersey falls within this swath, the trajectory determines which portion of the State (or all of the State) receives the heaviest amount of snow. According to the ONJSC, Camden County's normal seasonal snowfall is approximately 13 inches.

Ice Storms

All regions of New Jersey are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the State. A cold rain may be falling over the southern portion of the State, freezing rain over the central region, and snow over the northern counties 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. Based on data from 1948–2000, Camden County can anticipate 3-4 days with freezing rain per year (Changnon & Karl 2003). Based on data from 1932–2001, the County can anticipate 6-9 total hours of freezing rain per year (Changnon 2004).

4.3.12.2 Range of Magnitude

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, time of occurrence during the day (for example, weekday versus weekend), and time of season. While sleet accumulation is measured and tracked in a method similar to snow events, the extent or severity of freezing rain or an ice storm requires a different and sometimes more challenging process. According to NWS, ice accumulation does not coat the surface of an object evenly, as gravity typically forces rainwater to the underside of an object before it freezes. Wind can also force rainwater downward prior to freezing, resulting in a thicker coating of ice on one side of the object than the other side. Ice mass is then determined by taking the average from the thickest and thinnest portions of ice on the sample used for measurement.

The National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) produces 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 Category 1 to 5, which is similar to the Enhanced Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. RSI is based on the spatial extent of the storm, the amount of snowfall, and the combination of the extent and snowfall totals with population (based on the 2000 Census). The NOAA NCEI has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCEI 2020). Table 4.3.12-1 explains the five RSI ranking categories.

Table 4.3.12-1. RSI 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+

Source: NOAA-NCEI 2020
Note: RSI = Regional Snowfall Index

NWS operates a widespread network of observation 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 future weather, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts (NWS 2013). While winter weather is normal during the winter season for Camden County, the NWS uses winter weather

watches, warnings, and advisories to help people anticipate what to expect in the days and hours prior to an approaching storm.

- A ***winter storm watch*** is issued when 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 24 to 72 hours of notice of the possibility of severe winter weather.
- A ***winter storm warning*** is issued when hazardous winter weather, in the form of heavy snow, heavy freezing rain, or heavy sleet, is imminent or occurring. A warning is usually issued 12 to 24 hours before the event is expected to begin.
- A ***winter weather advisory*** is issued when a hazardous winter weather event is occurring, is imminent, or has a greater than 80 percent chance of occurrence. Advisories are used to inform people that winter weather conditions are expected to cause significant inconveniences and that conditions may be hazardous. These conditions may refer to sleet, freezing rain, or ice storms, in addition to snow events.
- NWS may also issue a ***blizzard warning*** when snow and strong winds combine to produce the potential for blinding snow, deep drifts, and wind chill (NWS n.d.).

4.3.12.3 Past Occurrences

Many sources have provided historical information regarding previous occurrences and losses associated with severe winter storm events in Camden County. According to the NOAA-NCEI Storm Events Database, Camden County experienced 182 winter weather events between 1950 and 2020, including 32 heavy snow events, two ice storms, 27 winter storms, and 114 winter weather events. The table below shows these statistics (NOAA NCEI 2020).

Table 4.3.12-2. Severe Winter Weather Events in Camden County, 1950 to 2020

Hazard Type	Number of Occurrences Between 1950 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Blizzard	1	0	0	$1.2 Million	$0
Heavy Snow	32	0	0	$0	$0
Ice Storm	2	0	0	$0	$0
Sleet	6	0	0	$0	$0
Winter Storm	27	0	0	$3.5 Million	$0
Winter Weather	114	1	150	$0	$0
Total	**182**	**1**	**150**	**$4.7 Million**	**$0**

Source: NOAA-NCEI 2020
Note: Not all events that have occurred in Camden County are included due to the extent of documentation and the fact that not all sources have been identified or researched.

Between 1954 and 2020, FEMA included Camden County in 6 winter storm-related DR or EM declarations classified as one or a combination of the following disaster types: severe winter storm, snowstorm, snow, ice storm, winter storm, and blizzard.

Table 4.3.12-3. Severe Winter Weather-Related Disaster (DR) and Emergency (EM) Declarations, 1950 to 2020

Declaration	Event Date	Declaration Date	Event Description
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 Snowstorm)
EM-3181	February 16 – 17, 2003	March 20, 2003	Snowstorm
DR-1873	December 19 – 20, 2009	February 5, 2010	Snowstorm
DR-1889	February 5 – 6, 2010	March 23, 2010	Severe Winter Storm and Snowstorm
DR-4264	January 22-24, 2016	March 14, 2016	Severe Winter Storm and Snowstorm

Source: FEMA 2020

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2020, Camden County was included in one USDA declarations related to severe winter weather.

Table 4.3.12-4. Severe Winter Weather-Related USDA Disaster Declarations, 2015 to 2020

Declaration	Event Date	Declaration Date	Event Description
S4071	April 1 – September 19, 2016	October 5, 2016	Combined effects of freeze, excessive heat, and drought

Source: USDA 2020

The NOAA 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.

- Winter weather is reported in the NOAA-NCEI database when a winter precipitation event causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria.

Table 4.3.12-5 includes winter storm events that occurred in Camden County between 2015 and 2020.

Table 4.3.12-5. Severe Winter Weather Events in Camden County, 2015 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
January 6, 2015	Winter Weather	N/A	N/A	Camden County	A fast-moving Alberta Clipper moved into the Mid-Atlantic region, accumulating heavy snow across southern New Jersey. A fatal car accident occurred in Cherry Hill Township, resulting in road closures and minor injuries for the other driver and passengers involved. Snowfall totals reached 1.2 inches in Camden County.
January 12, 2015	Winter Weather	N/A	N/A	Camden County	A wintery mix affected nearly all of New Jersey with snow and sleet, and ice accumulations over one tenth of an inch.
January 18, 2015	Winter Weather	N/A	N/A	Camden County	Freezing rain caused New Jersey State Police to respond to 428 accidents and 186 calls for assistance, including numerous slip and fall events. New Jersey Transit bus service was suspended. In Camden County, three people, including one fire fighter were injured and required hospitalization as a result of car accidents. All major bridges into Philadelphia were closed for several hours.
January 21, 2015	Winter Weather	N/A	N/A	Camden County	A low-pressure system dropped 1 to 3 inches of snow across southern New Jersey, resulting in icy conditions and numerous accidents.
January 23, 2015	Winter Weather	N/A	N/A	Camden County	A winter storm brought snow, sleet and freezing rain to central and southwestern New Jersey. Over 2,000 homes and businesses lost power across the state.
January 26, 2015	Winter Weather	N/A	Yes	Camden County	A complex winter storm brought average snowfall up to 5 inches in southern New Jersey. A state of emergency was declared, and a driving ban was enacted. Over 3 inches of snow was recorded in Camden County.
February 14, 2015	Winter Weather	N/A	N/A	Camden County	A cold front brought heavy snowfall and rapidly falling temperatures and high winds, resulting in hazardous driving conditions and roadways across

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
					New Jersey. Speed limits on the bridges to Philadelphia were reduced and numerous car accidents were reported. Over 4 inches of snow was reported in Camden County.
February 16, 2015	Heavy Snow	N/A	N/A	Camden County	A low-pressure system brought heavy snow throughout New Jersey, with accumulation totals reaching over 6 inches in Camden County.
February 21, 2015	Winter Storm	N/A	N/A	Camden County	A winter storm produced a mix of snow, sleet and freezing rain across most of New Jersey. In Camden County, a major back-up occurred near the junction of State Routes 42 and 55 because of numerous spin-outs. Ice accumulations in Camden County reached 0.2 inches, and snowfall totals were over 6 inches.
March 1, 2015	Winter Storm	N/A	N/A	Camden County	Double barrel low pressure systems brought a winter storm to New Jersey, with snow, sleet, and freezing rain affecting southern New Jersey. Ice accumulations in Camden County reached 0.4 inches.
March 5, 2015	Heavy Snow	N/A	Yes	Camden County	Heavy snow resulted in a declaration of a state of emergency, with nearly all schools and universities closing. Snowfall totals reached 7.7 inches in Camden County.
March 20, 2015	Winter Weather	N/A	N/A	Camden County	A winter storm brought heavy snow and numerous traffic accidents. Snowfall totals reached 4.5 inches in Camden County.
January 22, 2016	Winter Storm	Yes DR-4264	Yes	Camden County	A nor'easter produced record snowfall in parts of New Jersey, with wind gusts up to 60 mph. Over 270,000 customers were without power throughout New Jersey. The storm cost the state of New Jersey $82.6 million in damages and expenses. Over 22 inches of snow was recorded in Camden County.
January 7, 2017	Winter Storm	N/A	N/A	Camden County	A low-pressure system brought over 6.5 inches of snow to Camden County.
March 14, 2017	Ice Storm	N/A	N/A	Camden County	Ice accumulations were estimated at 0.4 inches in Chesilhurst, which brought down trees and wires.
January 4, 2018	Winter Storm	N/A	N/A	Camden County	A low-pressure system brought between 4 and 6 inches of snow to Camden County.
March 6, 2018	Winter Storm	N/A	N/A	Camden County	A broad area of low pressure brought a precipitation mix of rain and snow across New Jersey. A state of emergency was declared, and flights were canceled at all major airports. Snowfall totals reached 8.5 inches in Camden County.
March 21, 2018	Winter Storm	N/A	N/A	Camden County	A heavy mix of rain and snow resulted in at least 10 inches of snow accumulation in Camden County.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
November 15, 2018	Winter Weather	N/A	N/A	Camden County	An early season winter storm brought 4.5 inches of snow to Camden County.
February 11, 2019	Winter Weather	N/A	N/A	Camden County	A multi-day storm impacted the region with a wintery mix of snow and rain. Estimated snowfall totals reached 4 inches in Camden County.
March 1, 2019	Winter Weather	N/A	N/A	Camden County	A fast-moving weather system brought an intense burst of snow, accumulating 2 to 4 inches within a 3-hour window.

Source: *NOAA-NCEI 2020; NJOEM 2020; NWS 2020; FEMA 2020*
DR *Disaster Declaration*
FEMA *Federal Emergency Management Agency*
N/A *Not Applicable*
NOAA *National Oceanic and Atmospheric Administration*
NWS *National Weather Service*

4.3.12.4 Future Occurrences

Camden County is estimated to continue experiencing direct and indirect impacts of severe winter storms annually. Table 4.3.12-6 provides the probability of occurrences of severe winter storm events. However, the information used to calculate the probability of occurrences is only based on NOAA-NCEI storm events database results.

Table 4.3.12-6. Probability of Future Occurrence of Severe Winter Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2020	Rate of Occurrence	Recurrence Interval	% Chance of Event Occurring in Any Given Year
Blizzard	1	0.01	71	1.4%
Heavy Snow	32	0.45	2.22	45%
Ice Storm	2	0.03	35.5	2.8%
Sleet	6	0.09	11.84	8.4%
Winter Storm	27	0.39	2.63	38%
Winter Weather	114	1.63	0.62	100%
Total	**182**	**2.6**	**0.39**	**100%**

Source: *NOAA-NCEI 2020*
Note: *Probability was calculated using the available data provided in the NOAA-NCEI storm events database. Due to limitations in data, not all extreme temperature events occurring between 1950 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated. A 100 percent chance of occurring means that at least one severe winter storm event is likely to occur annually.*

In Section 4.4 (Hazard Ranking), the identified hazards of concern for Camden County are ranked using a variety of parameters. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for severe winter storms in the County is considered "frequent".

4.3.12.5 Climate Change Impacts

In terms of snowfall and ice storms, 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).

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). Due to the increase in temperature, snow cover and sea ice extent are predicted to likely decrease over the next century and the snow season length is very likely to decrease over North America. However, warming of the lower atmosphere could potentially lead to more ice storms by allowing snow to more frequently melt as it falls and then refreeze near or at surface (NYCPCC 2010).

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 (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 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 et al. 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 et al. 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 (Runkle et al. 2017). 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.

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 (Office of the New Jersey State Climatologist 2020). 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 et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity

(Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

4.3.12.6 Vulnerability Assessment

All of Camden County is vulnerable to severe winter storm events. The following subsections discuss Camden County's vulnerability, in a qualitative nature, to the severe winter weather hazard.

Impact on Life, Health and Safety

The entire population of Camden County (506,738 people) is exposed to severe winter storm events (American Community Survey 2019). 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 ACS 5-Year estimate, there are 77,791 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.

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 Camden County, area with the highest concentration of population below the poverty level are located in the City of Camden (35.3-percent of its total population). Refer to Section 3 (County Profile) that displays the densities of low-income populations in Camden County.

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. 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).

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. 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.

This allows planners and emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Table 4.3.12-7 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 many times 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 4.3.12-7. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Municipality	Total Replacement Cost Value	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Audubon (B)	$3,982,105,081	$39,821,051	$199,105,254	$398,210,508
Audubon Park (B)	$113,958,539	$11,395,854	$5,697,927	$11,395,854
Barrington (B)	$3,993,943,132	$39,939,431	$199,697,157	$399,394,313
Bellmawr (B)	$4,528,930,831	$452,893,083	$226,446,542	$452,893,083
Berlin (B)	$3,513,614,243	$35,136,142	$175,680,712	$351,361,424
Berlin (Twp)	$8,790,953,567	$879,095,357	$439,547,678	$879,095,357
Brooklawn (B)	$1,349,439,712	$13,494,397	$67,471,986	$134,943,971
Camden (C)	$56,584,405,974	$5,658,440,597	$2,829,220,299	$5,658,440,597
Cherry Hill (Twp)	$33,592,477,509	$335,924,775	$1,679,623,875	$3,359,247,751
Chesilhurst (B)	$753,192,869	$75,319,287	$37,659,643	$75,319,287
Clementon (B)	$2,920,934,056	$29,209,341	$146,046,703	$292,093,406
Collingswood (B)	$9,994,688,881	$999,468,888	$499,734,444	$999,468,888
Gibbsboro (B)	$2,794,254,297	$27,942,543	$139,712,715	$279,425,430
Gloucester City (C)	$8,699,066,833	$869,906,683	$434,953,342	$869,906,683
Gloucester (Twp)	$24,827,109,084	$248,271,091	$1,241,355,454	$2,482,710,908
Haddon (Twp)	$8,495,714,525	$849,571,453	$424,785,726	$849,571,453
Haddon Heights (B)	$4,935,884,626	$49,358,846	$246,794,231	$493,588,463
Haddonfield (B)	$8,852,674,248	$885,267,425	$442,633,712	$885,267,425
Hi-Nella (B)	$364,325,072	$3,643,251	$18,216,254	$36,432,507
Laurel Springs (B)	$1,450,376,747	$145,037,675	$72,518,837	$145,037,675
Lawnside (B)	$1,722,718,258	$17,227,183	$86,135,913	$172,271,826
Lindenwold (B)	$7,681,293,689	$768,129,369	$384,064,684	$768,129,369
Magnolia (B)	$2,481,735,074	$24,817,351	$124,086,754	$248,173,507
Merchantville (B)	$2,982,747,312	$298,274,731	$149,137,366	$298,274,731
Mount Ephraim (B)	$3,176,898,888	$31,768,989	$158,844,944	$317,689,889
Oaklyn (B)	$2,536,130,354	$253,613,035	$126,806,518	$253,613,035
Pennsauken (Twp)	$18,990,295,898	$189,902,959	$949,514,795	$1,899,029,590
Pine Hill (B)	$2,320,272,349	$232,027,235	$116,013,617	$232,027,235
Pine Valley (B)	$82,965,246	$829,652	$4,148,262	$8,296,525
Runnemede (B)	$4,203,633,200	$420,363,320	$210,181,660	$420,363,320

Municipality	Total Replacement Cost Value	1-Percent Exposure/Loss	5-Percent Exposure/Loss	10-Percent Exposure/Loss
Somerdale (B)	$3,999,602,407	$39,996,024	$199,980,120	$399,960,241
Stratford (B)	$2,645,521,871	$264,552,187	$132,276,094	$264,552,187
Tavistock (B)	$17,692,986	$176,930	$884,649	$1,769,299
Voorhees (Twp)	$18,757,102,175	$1,875,710,217	$937,855,109	$1,875,710,217
Waterford (Twp)	$4,400,620,966	$44,006,210	$220,031,048	$440,062,097
Winslow (Twp)	$17,669,828,003	$1,766,982,800	$883,491,400	$1,766,982,800
Woodlynne (B)	$1,039,137,958	$10,391,380	$51,956,898	$103,913,796
Camden County (Total)	**$285,246,246,457**	**$28,524,624,646**	**$14,262,312,323**	**$28,524,624,646**

Source: Camden County GIS 2021; NJDEP 2019; MODIV 2020; RS Means 2020
Notes: B = Borough, C = City, Twp = Township

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 the 1-percent annual chance flood. Please refer to the High Wind (Section 4.3.9) profile for losses resulting from wind.

Impact on Critical Facilities

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.

Heavy snow can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. 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 (NOAA 2008).

4.3.12.6.1 Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Impacts on the economy also include commuter difficulties into or out of the area for work or school. The loss of power and closure of roads prevent commuters from traveling within the County. Between 2018 and 2021, the State of New Jersey has a recorded loss of $250 to $500 million

worth of expenses caused by winter storm events (NOAA 2021). During the 2019-2020 winter season, the State of New Jersey Department of Transportation has budgeted winter maintenance expenditures at $36.9 million, which includes costs for salt (124,911 tons), liquid calcium chloride (247,424 gallons), and brine (270,820 gallons) (NJDOT 2020).

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 (EPA 2021). For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources. 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.

Furthermore, chemically based winter maintenance practices have its own effect on the natural environment (Kaushal et al 2018). Melting snow and ice that carry deicing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth.

4.3.12.6.2 Future Changes That May Impact Vulnerability

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

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

Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across Camden County. Overall, the Camden County Planning Partners have identified that there are 89 recent or anticipated new development sites in the County. Out of the total new development sites, 32 are for residential properties for several hundred apartment/condo units or single-family homes.

Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area 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

According to the 2019 5-year population estimates from the American Community Survey, the population of Camden County (i.e., 506,738 persons) has decreased by approximately 1.3-percent since 2010. Even though the population has decreased, any changes in the distribution of the population can impact the how severe winter weather impacts persons throughout the County. Isolation caused by winter snow and ice may become exacerbated in rural areas where resources may be redistributed to care for higher density communities.

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 extreme events such as 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], 2006).

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). 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).

An increase in the frequency and severity of severe winter storms could result in an increase of snow loads on the County's building stock and infrastructure, putting each building at risk to structural damage. More frequent and severe events also will result in increased resources spent to prepare for and clean-up after an event. However, as winter temperatures continue to rise, climate projections indicate the increase in precipitation is likely to occur during the winter months as rain. Increased rain on snowpack or frozen or saturated soils can lead to increased flooding and related impacts on the County's assets.

Vulnerability Change Since the 2017 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.