4.3.5 Extreme Temperatures

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 extreme temperature hazard in Morris County.

2020 HMP Update Changes

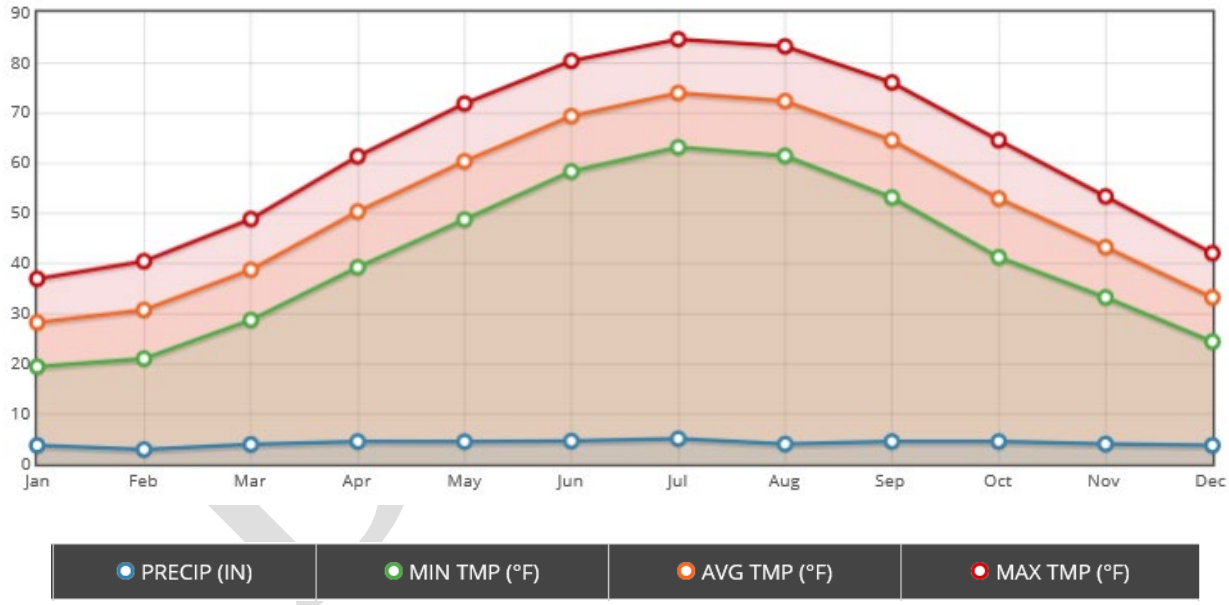
- All subsections have been updated using best available data.
- Previous occurrences are updated with events that occurred between 2014 and 2019.

4.3.5.1 Profile

Hazard Description

Extreme temperature includes both heat and cold events that can have significant direct impacts to human health and commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). Distinguishing characteristics of "extreme cold" or "extreme heat" vary by location, based on the conditions to which the population is accustomed. Figure 4.3.5-1 shows the average low and high temperatures each month at the Boonton station in Morris County.

Figure 4.3.5-1. Average Temperatures at Boonton



Source: NOAA NCEI 2019

Extreme Cold

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0ºF or below (Centers of Disease Control and Prevention [CDC] 2007). Extremely cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Although staying

indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2007).

Extreme Heat

Extreme heat is defined as temperatures which hover 10 degrees or more above the average high temperature for a region and that last for several weeks (Centers for Disease Control and Prevention [CDC] 2016). A heat wave is defined as a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts two or more days (National Weather Service [NWS] 2013). There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi 2004).

Urbanized areas and urbanization creates an exacerbated type of risk during an extreme heat event, compared to rural and suburban areas. As defined by the U.S. Census, urban areas are classified as all territory, population, and housing units located within urbanized areas and urban clusters. The term urbanized area denotes an urban area of 50,000 or more people. Urban areas under 50,000 people are called urban clusters. The U.S. Census delineates urbanized area and urban cluster boundaries to encompass densely settled territory, which generally consists of:

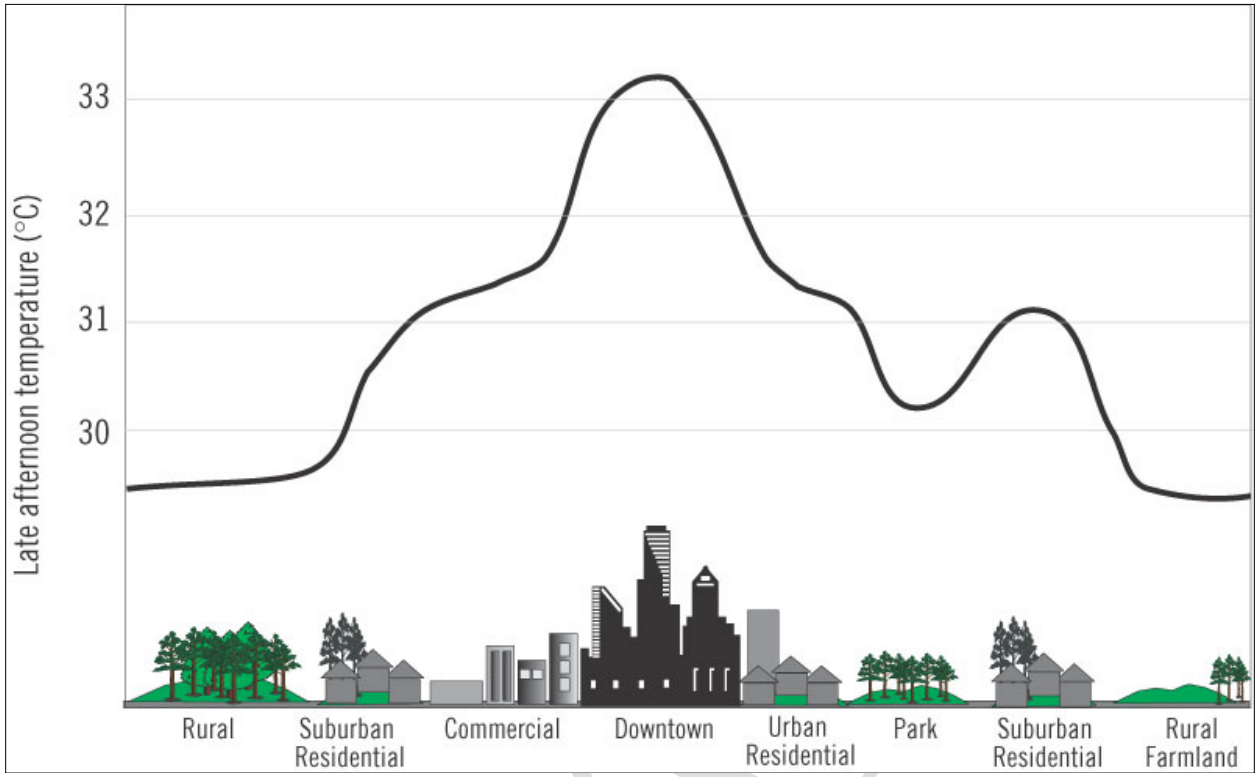
- A cluster of one or more block groups or census blocks each of which has a population density of at least 1,000 people per square mile at the time.
- Surrounding block groups and census blocks each of which has a population density of at least 500 people per square mile at the time.
- Less densely settled blocks that form enclaves or indentations, or are used to connect discontiguous areas with qualifying densities (U.S. Census 2010).

As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas. This forms an 'island' of higher temperatures (U.S. Environmental Protection Agency [EPA] 2009).

The term 'heat island' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with more than one million people can be between 1.8 ºF and 5.4ºF warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22ºF. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50ºF to 90ºF hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA 2010 and 2011).

Figure 4.3.5-2 below illustrates an urban heat island profile. The graphic demonstrates that heat islands are typically most intense over dense urban areas. Further, vegetation and parks within a downtown area may help reduce heat islands (U.S. EPA 2019).

Figure 4.3.5-2. Urban Heat Island Profile



Source: EPA n.d.
ºC degrees Celsius

Location

According to the ONJSC, New Jersey has five distinct climate regions. Elevations, latitude, distance from the Atlantic Ocean, and landscape (e.g. urban, sandy soil) produce distinct variations in the daily weather between each of the regions. The five regions include: Northern, Central, Pine Barrens, Southwest, and Coastal (ONJSC Rutgers University, Date Unknown). Figure 4.3.5-3 depicts these regions. A majority of Morris County is located within the Northern Climate Zone with the southeastern corner located in the Central Climate Zone.

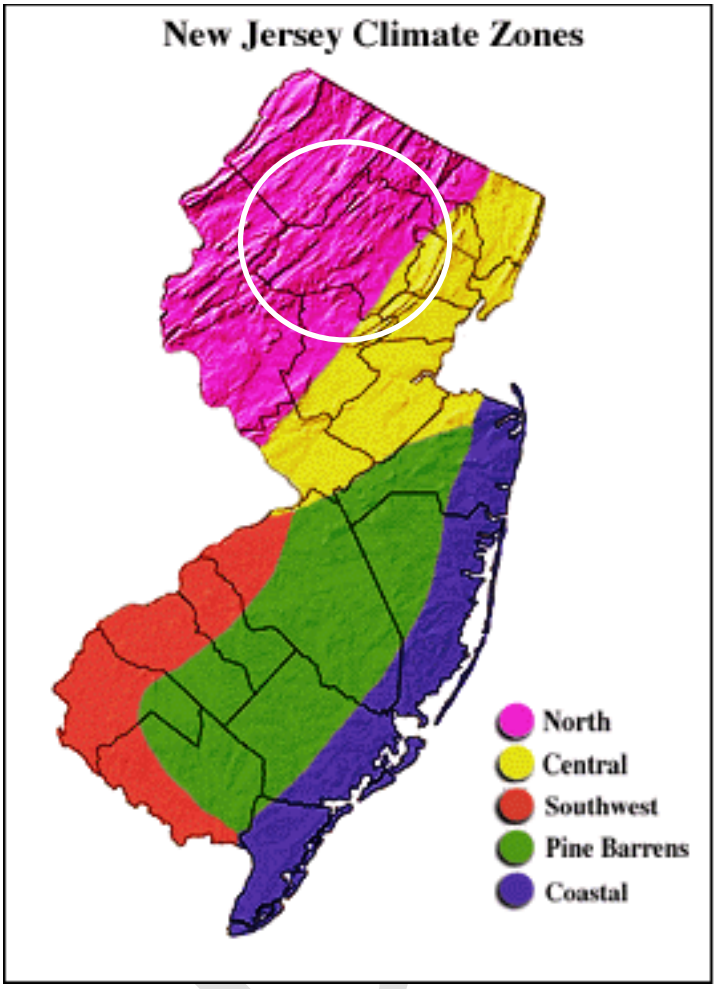
The Northern Climate Zone covers about one-quarter of New Jersey and consists mainly of elevated highlands and valleys which are part of the Appalachian Uplands. Surrounded by land, this region can be characterized as having a continental type of climate with minimal influence from the Atlantic Ocean, except when the winds contain an easterly component. Being in the northernmost portion of the state, and with small mountains up to 1800 feet in elevation, the Northern Zone normally exhibits a colder temperature regime than other climate regions of the State. This difference is most dramatic in winter when average temperatures in the Northern Zone can be more than ten degrees Fahrenheit cooler than in the Coastal Zone (ONJSC Rutgers University n.d.).

The Northern Climate Zone usually has the shortest growing season, about155 days. The average date for the last killing spring frost is May 4. The first frost in fall is around October 7. The exact dates vary significantly within the region as well as from year to year. Some valley locations have observed killing frost in mid-September and as late as mid-June (ONJSC Rutgers University n.d.).

The Central Zone has a northeast to southeast orientation, running from New York Harbor and the Lower Hudson River to the great bend of the Delaware River in the vicinity of Trenton. This region has many urban locations with large amounts of pollutants produced by the high volume of traffic and industrial establishments. The

concentration of buildings and impervious surfaces tend to retain more heat; thereby, affecting the local temperatures. The observed nighttime temperatures in heavily developed areas of this region are typically warmer than surrounding suburban and rural areas due to the amount of asphalt, brick, and concrete. The northern edge of the Central Region is often the boundary between freezing and non-freezing precipitation during the winter months. Areas in the southern part of this region tend to have nearly twice as many days with temperatures above 90°F than other locations in the central portion of the State (ONJSC Rutgers University n.d.).

Figure 4.3.5-3. Climate Regions of New Jersey



Source: ONJSC Rutgers University, Date Unknown

Note: The white circle indicates the location of Morris County. The County is mainly located in the Northern Climate Zone of New Jersey.

Previous Occurrences and Losses

New Jersey has been experiencing an increase in extreme temperatures across the State. The number of very hot days has been above average since the early 2000's. However, declines in the number of extreme cold days have occurred since the early 1990's (NOAA NCEI 2019).

FEMA Major Disasters and Emergency Declarations

Between 1954 and March 15, 2019, neither Morris County nor the State of New Jersey were not included in any major disaster (DR) or emergency (EM) declarations due to extreme temperatures. However, during the same

time period, the Federal Emergency Management Agency (FEMA) included Morris County in four winter storm-related DR or EM declarations classified as one or a combination of the following disaster types that may have had associated extreme cold temperatures: severe winter storm, snowstorm, snow, ice storm, winter storm, and blizzard (Table 4.3.5-1).

Table 4.3.5-1. Winter Weather Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
EM-3106	March 13-17, 1993	March 17, 1993	Snow: Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Snow: Blizzard of 96 (Severe Snow Storm)
EM-3181	February 16-17, 2003	March 20, 2003	Snow: Snow
EM-1954	December 26-27-2010	February 4, 2011	Snow: Severe Winter Storm and Snowstorm

Source: FEMA 2019

Extreme Temperature Events

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

- Cold/Wind Chill is reported in the NOAA-NCEI database when a period of low temperatures or wind chill temperatures reach or exceed locally or regionally defined advisory conditions (typical value is -18 °F or colder).
- Excessive Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established excessive heat warning thresholds.
- Extreme Cold/Wind Chill is reported in the NOAA-NCEI database when a period of extremely low temperatures or wind chill temperatures reaches or exceeds locally or regionally defined warning criteria (typical value around -35 °F or colder).
- Heat is reported in the NOAA-NCEI database whenever heat index values meet or exceed locally or regionally established advisory thresholds.

Extreme temperature events that have impacted Morris County between 2014 and 2019 are identified in Table 4.3.5-2. Please see Section 9 (Jurisdictional Annexes) for available information regarding impacts and losses to each municipality, where available.

Table 4.3.5-2. Extreme Temperature Events in Morris County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Description
January 7, 2015	Cold/wind Chill	N/A	N/A	The arrival of an arctic air mass brought one of the coldest mornings of the month of January to most of New Jersey. Morning low temperatures were mainly in the single numbers above zero. In addition, gusty northwest winds continued into the morning and lowest hourly wind chill factors reached around degrees below zero throughout the state. Temperatures dipped to 4 degrees above zero in Morristown.
February 13, 2015	Cold/wind Chill	N/A	N/A	Northwest winds that persisted into the morning of the 13th combined with an arctic air mass to produce wind chill factors of around 10 degrees below zero and low temperatures in the positive single numbers throughout most of New Jersey.
February 15-16, 2015	Cold/wind Chill	N/A	N/A	The combination of strong to high winds and an approaching arctic air mass produced wind chill factors of 10 to 15 degrees below zero during the first half of the day on the 15th in New Jersey. One person in Ocean County died from hypothermia. Actual morning low temperatures were around 10 degrees above zero. In Lakewood (Ocean County), a 66-year-old woman died from hypothermia while walking home early on the 15th. Many municipalities declared code blues. Plumbers were swamped with frozen pipe calls. Some say it was the busiest they have been in over 20 years. Shelters were full. Even oil lines were freezing. Some homes ran out of heating oil. Temperatures dipped to one degree above zero in Morristown.
February 20, 2015	Cold/wind Chill	N/A	N/A	The arrival of another arctic air mass brought some of the lowest wind chills as well as the lowest temperatures of the winter season to New Jersey on the 20th and 21st. As far as wind chill factors went, the first half of the day on the 20th was colder with wind chill factors as low as around 20 degrees below zero during the morning. Actual low temperatures were around zero. On the morning of the 21st, little, if any, wind was present as the arctic high pressure system was nearby. Low temperatures in more rural inland areas were lower, many were below zero, some well below zero. But, because of the lack of wind, wind chill factors nearly matched the air temperatures and it felt relatively warmer on the morning of the 21st. A low temperature of five degrees below zero was recorded in Denville.
February 24, 2015	Cold/wind Chill	N/A	N/A	The high pressure system responsible for third and last arctic blast of the month of February arrived in New Jersey on the morning of the 24th. Unlike the two previous arctic outbreaks earlier this month, this one was not accompanied by strong winds during the first half of the day. Air and wind chill temperatures were nearly the same. The calm conditions and snow cover combined to give many locations in northwest New Jersey the coldest morning of the winter

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Description
				season and comparably cold to the 20th and 21st weather in the rest of the state. Morning low temperatures averaged 25 to 35 degrees colder than normal.
July 19, 2015	Heat	N/A	N/A	Unseasonably hot and humid weather affected most of New Jersey on the 19th and 20th. High temperatures in most areas reached into the lower to mid 90s both days. The 19th was slightly hotter and more humid overall. The combination of heat and humidity brought afternoon heat index values as high as 100F to 105F on the 19th. These were some of the highest heat index values of the entire summer. A high temperature of 95 degrees was recorded in Madison.
February 14, 2016	Cold/wind Chill	N/A	N/A	Bitter cold temperatures and strong northwest winds associated with an Arctic outbreak combined to create dangerous wind chill temperatures across the entire northeast quadrant of the county beginning Saturday morning, February 13th into Sunday afternoon, February 14th. Many local governments set up Code Blue shelters for the vulnerable population. The lowest wind chill values were reported at the following locations during the early morning hours of February 14th: 26 degrees below zero in Stanhope, 22 degrees below zero in Basking Ridge, and 20 degrees below zero in Riverdale.
July 1, 2018	Excessive Heat	N/A	N/A	Temperatures in the middle to upper 90s and dew points in the upper 60s to lower 70s led to excessive heat across northern and western New Jersey. Heat indices reached 107 degrees at the Morristown Airport AWOS on July 3rd.

Source: NOAA-NCDC 2019; NWS 2019

°F degrees Fahrenheit

N/A Not applicable

Note: With documentation for New Jersey and Morris County being so extensive, not all sources have been identified or researched; therefore, Table 4.3.5-2 may not include all events that have occurred or impacted the County.

Probability of Future Occurrences

It is anticipated that Morris County will continue to experience extreme temperatures annually that may coincide with or induce secondary hazards such as snow, hail, ice or wind storms, thunderstorms, drought, human health impacts, and utility failures. Table 4.3.5-3 shows the annual number of events, recurrence interval, annual probability, and annual percent chance of occurrence for the hazards associated with extreme temperatures and reported in the NOAA-NCEI Storm Events Database.

Based on these historical records and input from the Steering Committee and Planning Committee, the probability of occurrence for extreme temperatures in Morris County is considered "frequent". Refer to Section 4.4. (Hazard Ranking) for more information.

Table 4.3.5-3. Probability of Occurrences of Extreme Temperature Events

Hazard Type	Number of Occurrences Between 1950 and September 2019	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years)	Probability of event Occurring in Any Given Year	% Chance of Occurring in Any Given Year
Cold/Wind Chill	29	0.42	2.4	0.41	41.4
Excessive Heat	11	0.16	6.4	0.16	15.7
Extreme Cold/Wind Chill	2	0.03	35.0	0.03	2.9
Heat	54	0.78	1.3	0.77	77.1
Total	**96**	**1.39**	**0.73**	**1.37**	**100**

Source: NOAA-NCEI 2019
Note: Probability was calculated using the available data provided in the NOAA-NCDC storm events database.

Climate Change Impacts

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

Average annual temperatures have increased by 3°F in New Jersey over the past century (NOAA NCEI 2019). Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (CATF 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013). According to a recent state-level analysis, by the middle of the 21st century an estimated 70 percent of summers in this region are anticipated to be hotter than what we now recognize as the warmest summer on record (NOAA NCEI 2019).

4.3.5.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable. For the extreme temperature hazard, the entire County is exposed. The following section discusses Morris County's vulnerability, in a qualitative nature, to the extreme temperature hazard.

Impact on Life, Health and Safety

The entire population of Morris County is exposed to extreme temperature events (population of 498,847 people, according to the 2013-2017 American Community Survey population estimates). Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention (CDC), populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand temperatures extremes due to their age, health conditions, and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals with chronic medical conditions (e.g., heart disease, high blood pressure), 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2016).

According to the 2017 ACS 5-Year Population Estimate, persons that are most vulnerable to extreme temperature events (i.e., persons under 5, persons over 65, and persons in poverty) make up approximately 25.5% of the total population in Morris County. For example, 79,042 persons within Morris County are over 65 years in age. The highest concentration of persons over 65 years in age are found in the Township of Harding and the Township of Pequannock Township (25.2% and 25% of total municipal population, respectively).

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 Morris County, the area with the highest concentration of population below the poverty level are located in the Borough of Victory Gardens (24.6% of total municipal population). Refer to Section 3 (County Profile) which discusses vulnerable populations further.

Risk of structural fire in the winter months is elevated, although winter home fires only account for 8 percent of fires within the U.S., approximately 30 percent of all fire deaths occur in the winter months. Cooking, and heat sources too close to combustible materials are leading factors in winter home fires (U.S. Fire Administration 2018). Often times, power outages occur during extreme cold events. Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed. Improperly connected portable generators are capable of 'back feeding' power lines which may cause injury or death to utility works attempting to restore power and may damage house wiring and/or generators (NJOEM 2019).

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

Impact on General Building Stock

All buildings are exposed to the extreme temperature hazard. Refer to Section 3 (County Profile), which summarizes the building inventory in Morris County. Extreme heat generally does not impact buildings; however, elevated summer temperatures increase the energy demand for cooling. Losses can be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles, as well as increasing vulnerability

to home fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

Impact on Critical Facilities

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

In 2019, the North Jersey Transportation Planning Authority (NJTPA) released a report for the Passaic River Basin that discusses climate change including extreme heat and impacts to transportation infrastructure. Impacts associated with extreme heat events on bridges, culverts, facilities, rail, roads and mass transit include stress, sagging, thermal expansion and system failure. The NJTPA study assessed the level of vulnerability (as measured by criticality, sensitivity and adaptive capacity) of transportation assets in the Passaic River Basin which includes portions of Morris County (NJTPA 2019).

Impact on Economy

Extreme temperature events also have impacts on the economy, including loss of business function and damage to and loss of inventory. Business-owners can be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity, telecommunications). Disruptions in public transportation service will also impact the economy for both commuters and customers alike.

Extreme temperature events can impact agriculture yields. Based on information from the 2017 Census of Agriculture, 418 farms were present in Morris County, encompassing 14,514 acres of total farmland (USDA 2017). Refer to Section 4.3.3 (Drought) for more information about impacts that drought can have on agriculture.

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.

Projected Development

The ability of new development to withstand extreme temperature impacts lies in sound land use practices, building design considerations (e.g. Leadership in Energy and Environmental Design [LEED]), and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas forming (heat islands as described above). Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Projected Changes in Population

Municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during extreme temperature events to prevent increased stresses on these systems. NJTPA includes high population growth forecasts as one criterion to prioritize transportation adaptation strategies. Refer to Section 3 (County Profile) for a detailed discussion on population change in Morris County.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures. As the climate warms, extreme cold events might decrease in frequency, while extreme heat events might increase in frequency; the shift in temperatures could also result in hotter extreme heat events. With increased temperatures, vulnerable populations could face increased vulnerability to extreme heat and its associated illnesses, such as heatstroke and cardiovascular and kidney disease. Additionally, as temperatures rise, more buildings, facilities, and infrastructure systems may exceed their ability to cope with the heat.

Change of Vulnerability Since the 2015 HMP

Overall, the entire County remains vulnerable to extreme temperatures. As existing development and infrastructure continue to age, they can be at increased risk to failed utility and transportation systems if they are not properly maintained and do not adapt to the changing environment.