

5.4.4 EXTREME TEMPERATURE

This section provides a profile and vulnerability assessment for the extreme temperature hazard.

HAZARD PROFILE

This section provides profile information including description, extent, location, previous occurrences and losses and the probability of future occurrences.

Description

Extreme temperature includes both heat and cold events, which can have a significant impact to human health, commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). What constitutes “extreme cold” or “extreme heat” can vary across different areas of the country, based on what the population is accustomed to.

Extreme Cold: Extreme cold events are when temperatures drop well below normal in an area. What constitutes extreme cold and its effects can vary across different areas of the country. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered “extreme cold.” Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0 degrees Fahrenheit (°F) or below.

Exposure to cold temperatures, whether indoors or outside, can lead to serious or life-threatening health problems such as hypothermia, cold stress, frostbite or freezing of the exposed extremities such as fingers, toes, nose and ear lobes. Hypothermia occurs when the core body temperature is <95°F. If persons exposed to excessive cold are unable to generate enough heat (e.g., through shivering) to maintain a normal core body temperature of 98.6°F, their organs (e.g., brain, heart, or kidneys) can malfunction. When brain function deteriorates, persons with hypothermia are less likely to perceive the need to seek shelter. Signs and symptoms of hypothermia (e.g., lethargy, weakness, loss of coordination, confusion, or uncontrollable shivering) can increase in severity as the body's core temperature drops. Extreme cold also can cause emergencies in susceptible populations, such as those without shelter, those who are stranded, or those who live in a home that is poorly insulated or without heat (such as mobile homes). Infants and the elderly are particularly at risk, but anyone can be affected (Centers of Disease Control and Prevention [CDC], 2005).

Extremely cold temperatures often accompany a winter storm, so individuals may have to cope with 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.

During cold months, carbon monoxide may be high in some areas because the colder weather makes it difficult for car emission control systems to operate effectively. Carbon monoxide levels are typically higher during cold weather because the cold temperatures make combustion less complete and cause inversions that trap pollutants close to the ground (U.S. Environmental Protection Agency [USEPA], 2009).

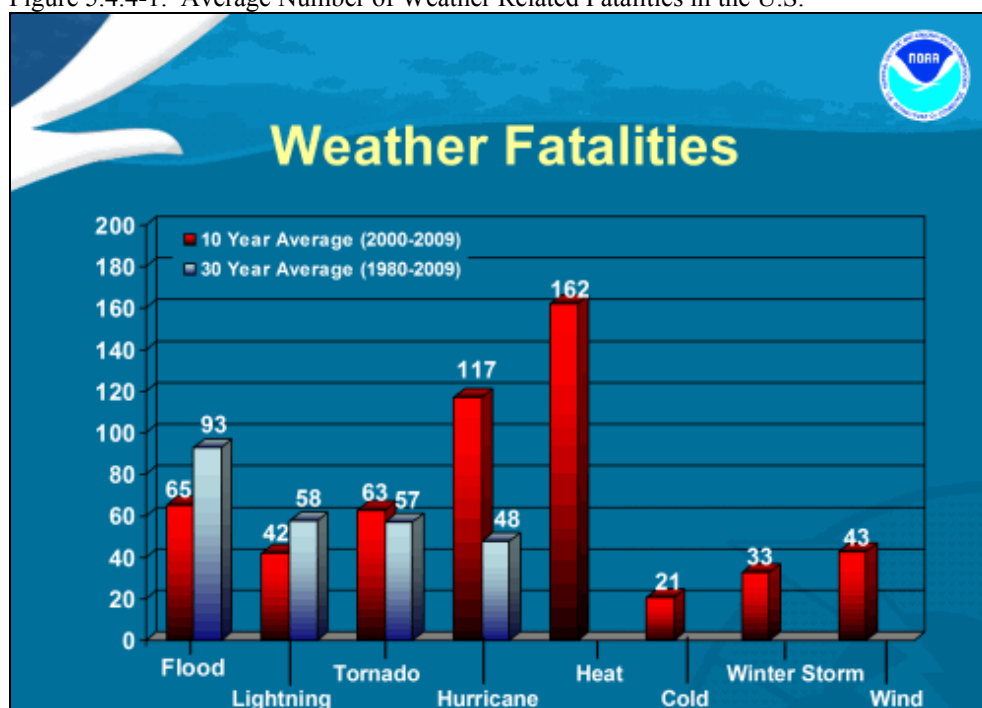
Extreme Heat: Temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks are defined as extreme heat (FEMA, 2006; CDC, 2006). An extended

period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (Ready America, Date Unknown; NWS, 2005). 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). A basic definition of a heat wave implies that it is an extended period of unusually high atmosphere-related heat stress, which causes temporary modifications in lifestyle and which may have adverse health consequences for the affected population (Robinson, 2000). The Weather Channel uses the following criteria for a heat wave in the U.S.: a minimum of 10 states with greater than or equal to 90°F temperatures and the temperatures must be at least five degrees above normal in parts of that area for at least two days or more (The Weather Channel, Date Unknown; NWS, 2005).

Depending on severity, duration and location; extreme heat events can create or provoke secondary hazards including, but not limited to, dust storms, droughts, wildfires, water shortages and power outages (FEMA, 2006; CDC, 2006). This could result in a broad and far-reaching set of impacts throughout a local area or entire region. Impacts could include significant loss of life and illness; economic costs in transportation, agriculture, production, energy and infrastructure; and losses of ecosystems, wildlife habitats and water resources (Adams, Date Unknown; Meehl and Tebaldi, 2004; CDC, 2006; NYSDPC, 2008).

Extreme heat is the number one weather-related cause of death in the U.S. On average; more than 1,500 people die each year from excessive heat. This number is greater than the 30-year mean annual number of deaths due to tornadoes, flooding, hurricanes and lightning combined. In 2006, New York State reported 42 heat-related fatalities (NOAA, Date Unknown). Figure 5.4.4-1 shows the number of weather fatalities based on a 10 year average and 30 year average. Heat has the highest average of weather related fatalities between 2000 and 2009.

Figure 5.4.4-1. Average Number of Weather Related Fatalities in the U.S.



Source: NOAA, 2010

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 Bureau, 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 discontinuous areas with qualifying densities (U.S. Census Bureau, 2003).

Approximately 47-percent of the world's population lives in urban areas. This number is expected to increase by two-percent each year between 2000 and 2015. Urbanization is caused by natural growth of the urban population and migration of the rural population towards cities (United Nations Environment Program, 2002). 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 (USEPA, 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 and 5.4°F warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22°F. 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 50 to 90°F 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 (USEPA, 2009 and 2010). Detailed information regarding the affects of heat islands are described below.

- Elevated summer temperatures increase the energy demand for cooling. Research has shown that for every 1°F, electricity demand increases between 1.5 and 2-percent, starting when temperatures reach between 68 and 77°F. Urban heat islands increase overall electricity demand, as well as peak demand. This generally occurs during hot, summer afternoons when homes and offices are running cooling systems, electricity and appliances. During extreme heat events, the demand for cooling can overload systems and require utility companies to institute controlled brownouts or blackouts to prevent power outages (USEPA, 2009).
- Urban heat islands raise the demand for electricity during the summer. Companies that provide the electricity generally rely on fossil fuel power plants to meet the demand. This can lead to an increase in air pollution and greenhouse gas emissions. The primary pollutants include sulfur dioxide (SO₂), nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and mercury (CO₂). These can all contribute to global climate change. Elevated temperatures can also directly increase the rate of ground-level ozone formation. Ground-level ozone is formed when NO_x and volatile organic compounds (VOCs) react to the presence of sunlight and hot weather (USEPA, 2009).
- Increased temperatures and higher air pollution levels can affect human health by causing discomfort, respiratory difficulties, heat cramps and exhaustion, heat stroke, and mortality. Heat

islands can also intensify the impact of heat waves. High risk populations are at particular risk from extreme heat events (USEPA, 2009).

- Urban areas often have many buildings and paved areas. During the hot, summer months, high pavement and rooftop surface temperatures can heat stormwater runoff. Pavements that are 100°F can elevate initial rainwater temperature from approximately 70°F to over 95°F. The heated stormwater usually becomes runoff and drains into storm sewers and raises water temperatures of streams, river, ponds and lakes. Water temperature affects aquatic life. Rapid temperature changes in aquatic ecosystems from stormwater runoff can be stressful and sometimes fatal to aquatic habitats (USEPA, 2009).

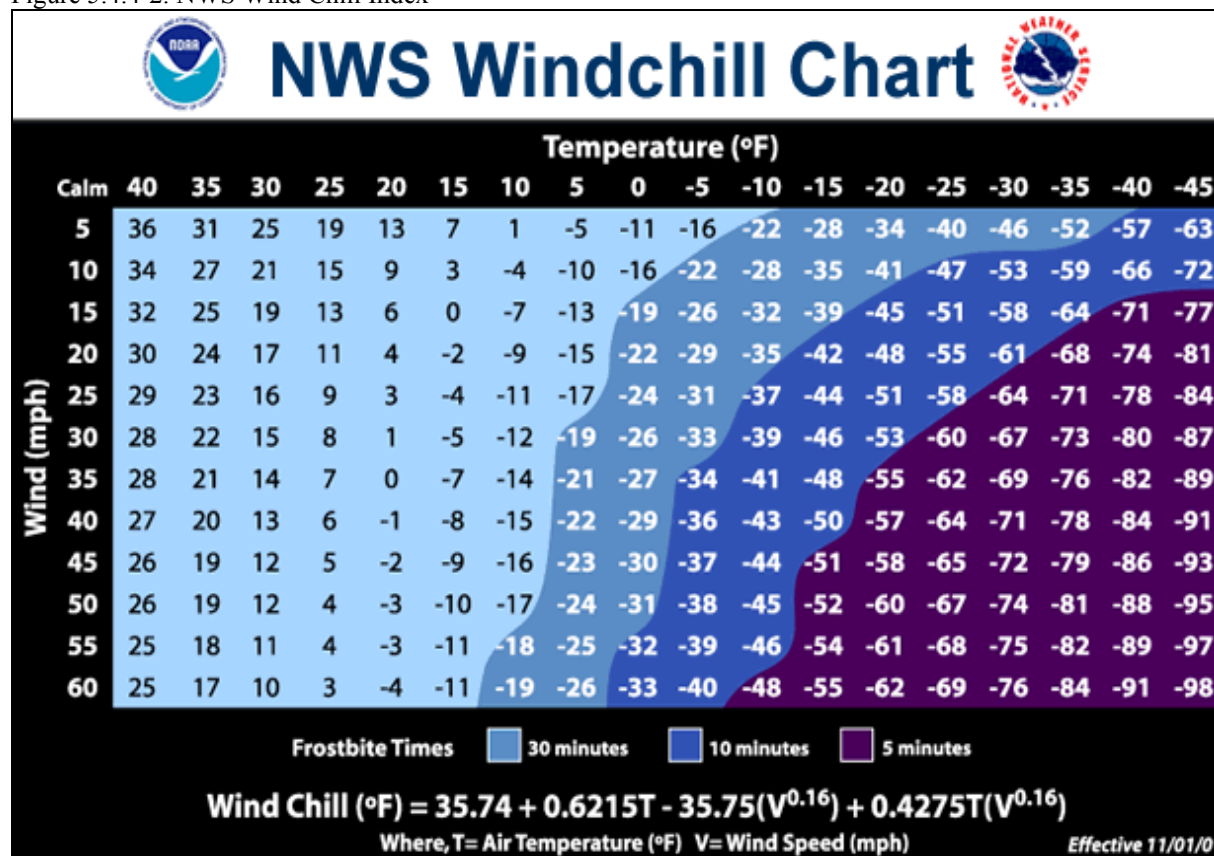
Extent

Extreme Cold Temperatures

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop (NWS, 2009).

On November 1, 2001, the NWS implemented a new WCT Index. It was designed to more accurately calculate how cold air feels on human skin. Figure 5.4.4-2 shows the new WCT Index. The Index includes a frostbite indicator, showing points where temperature, wind speed and exposure time will produce frostbite to humans. The chart shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS, 2009).

Figure 5.4.4-2. NWS Wind Chill Index



Source: NWS, 2008

According to the New York State Climate (NYSC) Office of Cornell University, cold winter temperatures prevail over New York State whenever Arctic air masses, under high barometric pressure, flow southward from central Canada or from Hudson Bay. High-pressure systems often move just off the Atlantic coast, become more or less stagnant for several days, and then a persistent airflow from the southwest or south affects the State. This circulation brings the very warm, often humid weather of the summer season and the mild, more pleasant temperatures during the fall, winter, and spring seasons. The highest temperature of record in New York State is 108° at Troy on July 22, 1926. Temperatures of 107° have been observed at Lewiston, Elmira, Poughkeepsie, and New York City. The record coldest temperature is -52° at Stillwater Reservoir (northern Herkimer County) on February 9, 1934 and also at Old Forge (also northern Herkimer County) on February 18, 1979. Some 30 communities have recorded temperatures of -40° or colder, most of them occurring in the northern one-half of the state and the remainder in the Western Plateau Climate Division and in localities just south of the Mohawk Valley (NYSC, Date Unknown).

Extreme Heat Temperatures

The extent of extreme heat temperatures are generally measured through the Heat Index, identified in Table 5.4.4-1. Created by the NWS, the Heat Index is a chart which accurately measures apparent temperature of the air as it increases with the relative humidity. The Heat Index can be used to determine what effects the temperature and humidity can have on the population (NYSDPC, 2008; NCDC, 2000).

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Table 5.4.4-1. Heat Index Chart

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

Source: NCDC, 2000; NYSDPC, 2008

Table 5.4.4-2 describes the adverse effects that prolonged exposure to heat and humidity can have on an individual.

Table 5.4.4-2. Adverse Effects of Prolonged Exposures to Heat on Individuals

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke / Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

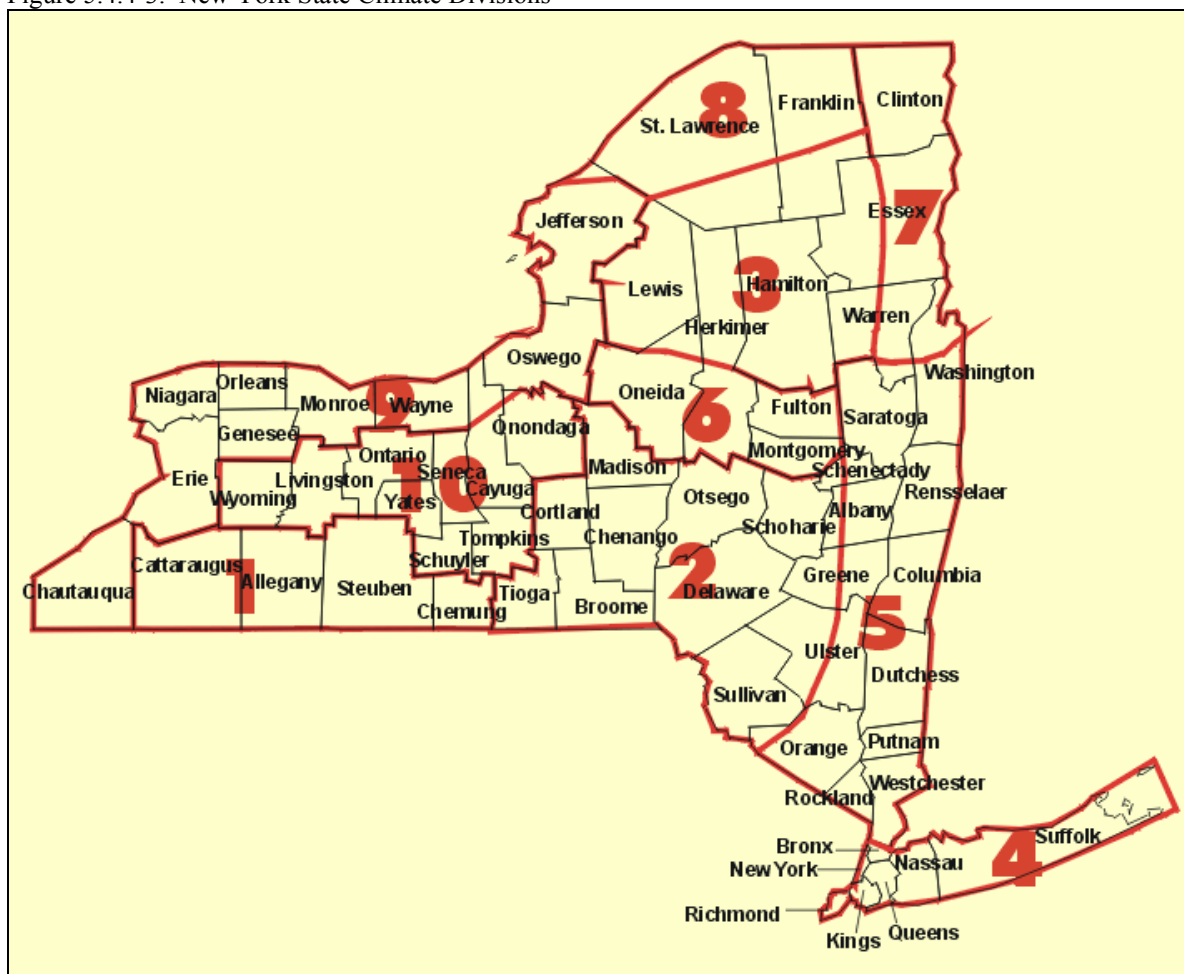
Source: NYSDEC, 2008

To determine the Heat Index, one needs to know the temperature and relative humidity. Once both values are known, the Heat Index will be the corresponding number with both values. That number provides a temperature that the body feels. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase the Heat Index by up to 15 degrees (NYSDEC, 2008).

Location

New York State is divided into 10 climate divisions: Western Plateau, Eastern Plateau, Northern Plateau, Coastal, Hudson Valley, Mohawk Valley, Champlain Valley, St. Lawrence Valley, Great Lakes, and central Lakes. According to NCDC, “Climatic divisions are regions within each state that have been determined to be reasonably climatically homogeneous.” (NWS, 2005; NCDC, 2010). The Greater Greenburgh Planning Area is located within the Hudson Valley Climate Division. Figure 5.4.4-X depicts the climate divisions in New York State.

Figure 5.4.4-3. New York State Climate Divisions



Source: NWS, 2005

Note: (1) Western Plateau; (2) Eastern Plateau (Catskill Mountains); (3) Northern Plateau (Adirondack Mountains); (4) Coastal; (5) Hudson Valley; (6) Champlain Valley; (7) St. Lawrence Valley; (8) Great Lakes; and (10) Central Lakes.

During the winter months in the southern portion of the Hudson Valley Climate Division, the coldest temperatures during most winters range between 0°F and -10°F. The New York City area experiences below zero minimums in two or three winters out of 10, with the low temperature typically near -5°F (NYSC, Date Unknown).

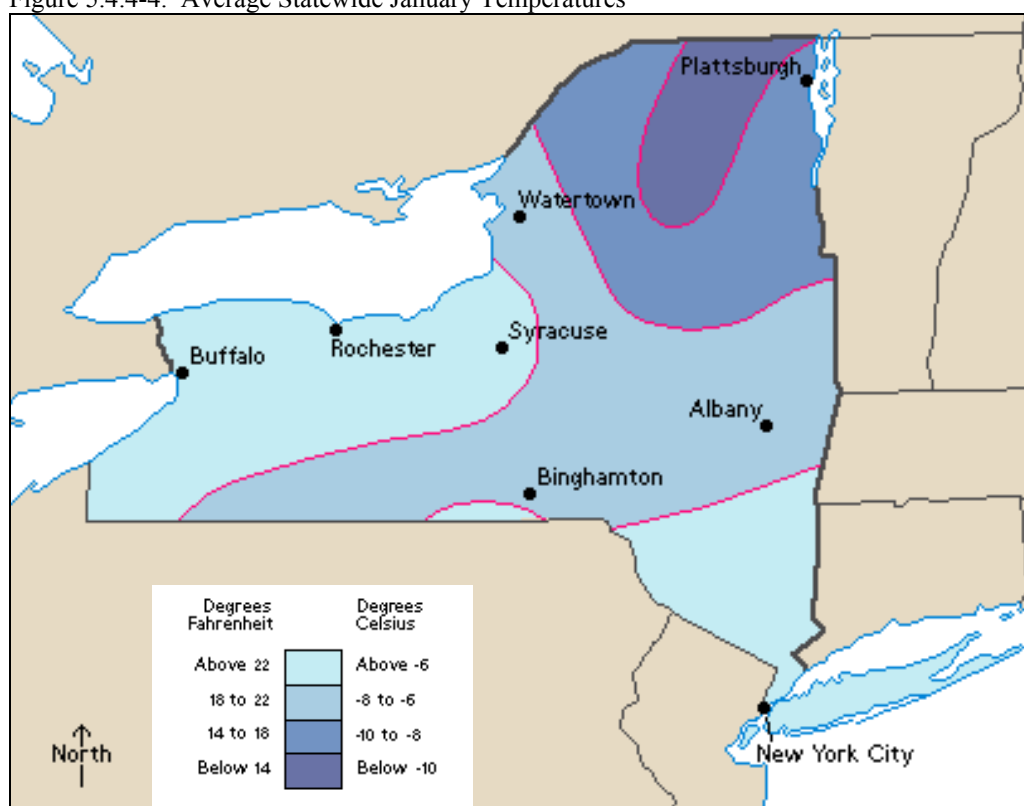
The southern portions of the Hudson Valley Climate Division and the New York City area have warm summers, with some periods of high humidity. Temperature averages range from 18 to 25 days with temperatures greater than 90°F. Temperatures of 100°F are rare, many long-term weather stations, especially those in the southern half of New York State, have recorded maximums in the 100°F to 105°F range (NYSC, Date Unknown).

Extreme Cold Temperatures

Extreme cold temperatures occur throughout most of the winter season and generally accompany most winter storm events throughout the State. The NYSC Office of Cornell University indicates that cold temperatures prevail over the State whenever arctic air masses, under high barometric pressure, flow southward from central Canada or from Hudson Bay (NYSC, Date Unknown). Figure 5.4.4-4, identifies

the average January temperatures of the State, with the northeast sections experiencing the coldest conditions and the west and southeast experiencing the mildest winters.

Figure 5.4.4-4. Average Statewide January Temperatures



Source: World Book Inc., 2007

Many atmospheric and physiographic controls on the climate result in a considerable variation of temperature conditions over New York State. The average annual mean temperature ranges from about 40°F in the Adirondacks to near 55°F in the New York City area. In January, the average mean temperature is approximately 16°F in the Adirondacks and St. Lawrence Valley, but increases to about 26°F along Lake Erie and in the lower Hudson Valley (Westchester County) and to 31°F on Long Island. The record coldest temperature in New York State is -52°F at Stillwater Reservoir (northern Herkimer County) on February 9, 1934. Approximately 30 communities have recorded temperatures of -40°F or colder, most of them occurring in the northern half of New York State and the remainder in the Western Plateau Climate Division and in localities just south of the Mohawk Valley (Earth System Research Laboratory [ESRL], Date Unknown; NYSC, Date Unknown).

Westchester County falls within the Hudson Valley Division (Division 5) (NCDC, Date Unknown; CPC, 2005; ESSL, Date Unknown). Winter temperatures in this division are moderated by the Atlantic Ocean. The coldest temperatures in most winters range between 0° and -10°F. Long Island and New York City experience below zero minimums in two or three winters out of 10, with the low temperature generally near -5°F (NYSC, Date Unknown).

As provided by The Weather Channel, average high and low temperatures during the winter months around the Greater Greenburgh Planning Area are identified in Table 5.4.4-X. Temperature averages for the Planning Area were collected from Unincorporated Greenburgh and the Villages of Ardsley, Dobbs Ferry, Elmsford, Hastings-on-Hudson, Irvington, and Tarrytown.

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Table 5.4.4-3. Average High and Low Temperature Range for Winter Months in the Greater Greenburgh Planning Area

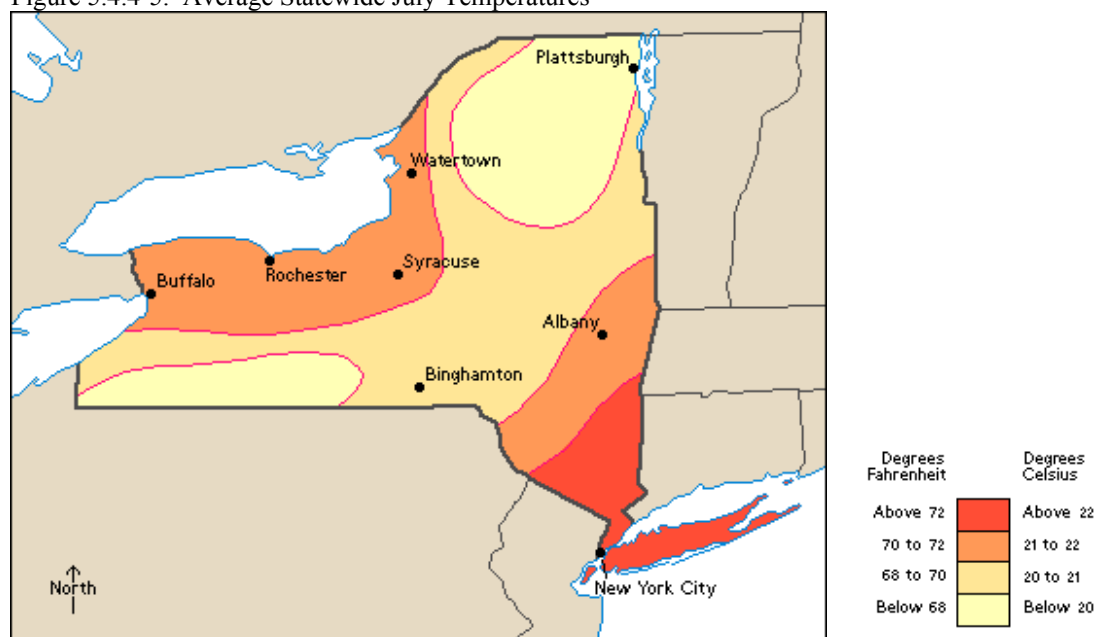
Month	Average High	Average Low	Record Low Event(s)
January	36 °F - 39 °F	23 °F - 20°F	-8 °F (1985)
February	41 °F - 43°F	22°F - 27 °F	-14 °F (1979)
March	50 °F - 51°F	29°F – 34 °F	-3°F (1967)
November	54 °F - 55°F	35°F - 45 °F	12°F (1989)
December	43 °F - 44°F	26°F -30 °F	-4 °F (1980)

Source: The Weather Channel, 2010

Extreme Heat Temperatures

Extreme heat temperatures of varying degrees are existent throughout the State for most of the summer season, except for areas with high altitudes. Figure 5.4.4-5 identifies the average July temperatures of the State, with the southeast and northwest sections experiencing the hottest conditions.

Figure 5.4.4-5. Average Statewide July Temperatures



Source: World Book Inc., 2008

As provided by The Weather Channel, average high and low temperatures during the summer months around the Greater Greenburgh Planning Area are identified in Table 5.4.4-4. Temperature averages for the Planning Area were collected from Unincorporated Greenburgh and the Villages of Ardsley, Dobbs Ferry, Elmsford, Hastings-on-Hudson, Irvington, and Tarrytown.

Table 5.4.4-4. Average High and Low Temperature Range for Summer Months in the Greater Greenburgh Planning Area

Month	Average High	Average Low	Record High Event(s)
May	72°F - 74 °F	47°F - 50°F	97°F in 1996

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Month	Average High	Average Low	Record High Event(s)
June	80°F - 82°F	57°F - 59°F	100°F in 1953
July	85°F - 86°F	62°F - 65°F	104°F in 1980
August	83°F - 84°F	61°F - 64°F	102°F in 1948
September	76°F	53°F	102°F in 1953

Source: The Weather Channel, Date Unknown

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with extreme temperatures throughout New York State and the Greater Greenburgh Planning Area. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

The Midwest Regional Climate Center (MRCC) operates an online annual temperature extremes database of the Continental U.S., otherwise known as “MRCC Cooperative Observer Station Annual Temperature Record Data Set”. The data set contains the annual maximum and minimum temperature records for stations in the U.S. Each station has a cooperative observer system i.d. number (coop number) and a running length of more than five years was examined. In New York State, there are 269 stations that were observed; however, only one station in the Greater Greenburgh Planning Area (Village of Dobbs Ferry). Not every city, town and/or village in New York State contains a station (MRCC, 2010).

There may be some potential problems with the data collected at the stations. The records were created by MRCC at the request of a user. The values of the all-time records for stations with brief histories are limited in accuracy and could vary from nearby stations with longer records. Although the data sets have been through quality control, there is still a need for more resources to quality control extremes. The record sets are for single stations in the cooperative observer network and are limited to the time of operation of each station under one coop number. The records for a place may need to be constructed from several individual station histories. Some of the data may vary from NWS records due to NWS using multiple stations and additional sources like record books (MRCC, Date Unknown).

Based on the data provided by MRCC, Table 5.4.4-5 presents the extreme cold (minimum) and hot (maximum) temperature records for the Village of Dobbs Ferry from 1945 to 2003.

Table 5.4.4-5. MRCC Temperature Extremes – Greater Greenburgh Planning Area

Station ID	Name	Begin	End	Max (°F)	Max Date	Min (°F)	Min Date	Avg Max	Avg Min
302129	DOBBS_FERRY	1945	2003	104	7/21/1980	-10	1/27/1994	53.8	35.6

Source: MRCC, 2010

Notes: Begin Year is when the data collection began; End Year is when the data collection stopped.

Between 1954 and 2010, New York State was not included in any major disaster declarations or emergency declarations due to extreme temperatures. Information regarding specific details of temperature extremes in the Greater Greenburgh Planning Area is scarce; therefore, previous occurrences and losses associated with extreme temperature events are limited. Table 5.4.4-X summarizes the extreme temperature events in the Greater Greenburgh Planning Area.

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Table 5.4.4-6. Extreme Temperature Events between 1999 and 2010

Event Date / Name	Location	Losses / Impacts	Source(s)
Extreme Heat July 4 – 6, 1999	Multi-County	A hot and humid air mass covered the New York City area between July 4 th and July 6 th . On July 4 th , temperatures were in the mid and upper 90s. With the high temperature and moderate humidity, heat indices ranged between 100 and 105°F. On July 5 th , new maximum temperature records were set. Temperatures ranged between 96°F to 102°F. Heat indices ranged from 110 to 115°F. 'Rolling' electrical blackouts occurred across the New York City area. On July 6 th , additional record high temperatures were set. Heat indices were around 110°F. Widespread blackouts occurred, including Westchester County. The heat was responsible for two deaths in Westchester County.	NOAA-NCDC, Hazards and Vulnerability Research Institute (SHELDUS)
Wind Chill January 27-28, 2000	Multi-County	Strong and gusty winds, combined with below normal temperatures, produced extremely low wind chill values. Across the Lower Hudson Valley, wind chill values ranged between -25°F to -35°F. At the Westchester County Airport, the lowest wind chill occurred around 4am on January 28 th and was -26°F.	NOAA-NCDC
Excessive Heat July 2-4, 2002	Multi-County	Temperatures rose to the mid to upper 90s across the New York City area. Overnight temperatures stayed in the lower 80s. Temperatures averaged 10 to 15 degrees above normal. High temperatures and humidity produced heat indices from 100 to 105°F throughout the region. Many cooling centers were opened in New York City. Brownouts occurred all over, including Westchester County.	NOAA-NCDC
Heat Wave July 29 – 31, 2002	Multi-County	An eight day heat wave hit across the region. Temperatures rose into the mid to upper 90s. The high temperatures combined with humidity produced heat indices between 95 and 105°F.	NOAA-NCDC
Excessive Heat August 1-3, 2006	Multi-County	A large air mass brought hot dry air causing temperatures to reach at least 90°F for five consecutive days. Excessive heat occurred mainly between noon and midnight for three days. High temperatures ranged from the upper 90s to around 100°F.	NOAA-NCDC
Excessive Heat July 4-7, 2010	Multi-State	A hot air mass developed over the central portion of the U.S. and settled over the New York City area. Several records were broken for high temperatures. Temperatures were in the mid to upper 90s and low 100s. The New York State DEC issued an ozone advisory for the New York metropolitan area, which includes Westchester County. Ozone levels were in the 'unhealthy for sensitive groups' category during this heat wave. In Westchester County, the Health Department issued a heat advisory on July 6 th due to the 101°F temperatures. More than 1,300 addresses were without power during the heat wave. Unincorporated Greenburgh Consolidated Water District urged customers to conserve water during this	NWS, Unincorporated Greenburgh, The Journal News, Sayegh, Ryser

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Event Date / Name	Location	Losses / Impacts	Source(s)
		heat wave. Two cooling centers were open in the Town to help residents from the heat. Cooling centers were also opened in the Village of Elmsford.	

Note (1): This table does not represent all events that may have occurred throughout Westchester County and the Greater Greenburgh Planning Area due to a lack of detail and/or their minor impact upon the County and Planning Area. NOAA NCDC storm query indicated that Westchester County has experienced 12 temperature extremes between January 1, 1950 and April 30, 2010, most of which affected a large region of New York State.

NOAA-NCDC National Oceanic Atmospheric Administration – National Climate Data Center

NWS National Weather Service

NYS New York State

SHELDUS Spatial Hazard Events and Losses Database for the United States

Probability of Future Events

Several extreme temperature events occur each year throughout the Greater Greenburgh Planning Area. It is estimated that the Planning Area, will continue to experience extreme temperatures annually that may induce secondary hazards such potential snow, hail, ice or wind storms, thunderstorms, drought, human health impacts, utility failure and transportation accidents as well as many other anticipated impacts.

Based on historical records and input from the Planning Committee, the probability of occurrence for extreme temperatures in the Greater Greenburgh Planning Area is considered ‘frequent’ (hazard event is likely to occur within 25 years). The overall ranking assigned to this hazard is “medium” (see Section 5.3, Tables 5.3-3 and 5.3-6).

The Role of Global Climate Change on Future Probability

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Agriculture, forestry, fisheries and water resources, all important economic resources, may also be affected by global climate change. Warmer temperatures, droughts, storms, floods, and sea level rise could have a range of impacts on the ecosystem. All this combined with other influences such as population growth, land use changes, and pollution can create a much larger issue (NextGenerationEarth, Date Unknown).

Climate is defined not only as average temperature and precipitation but by the type, frequency and intensity of weather events. Human-induced climate change has the potential to change the prevalence and severity of extreme weather events (heat waves, cold waves, severe storms, floods, and droughts). Predicting these changes under a changing climate is difficult; understanding vulnerabilities to these changes is critical and is a part of estimating future climate change impacts to human health, society and the environment (USEPA, 2009).

It is important to understand that directly linking any one specific extreme event (for example, a severe hurricane) to climate change is not possible. However, climate change and global warming may increase the probability of some ordinary weather events reaching extreme levels or of some extreme events becoming more extreme (USEPA, 2006). It remains very difficult to assess the impact of global warming on extreme weather events, in large part because this analysis depends greatly on regional forecasts for global warming. Global warming will almost certainly have different effects on different regions of the Earth, so areas will not be equally susceptible to increased or more intense extreme weather events. Although regional climate forecasts are improving, they are still uncertain (Climate Institute, Date Unknown). These many uncertainties may exist regarding magnitude or severity; however, many sources indicate that future weather patterns and increased intensities are anticipated as a result of climate change, along with atmospheric, precipitation, storm and sea level changes (USEPA, 2007).

The USEPA’s current level of understanding of climate change, as summarized in the 2001 Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report, is as follows:

“... some extreme events are projected to increase in frequency and/or severity during the 21st century due to changes in the mean and/or variability of climate, so it can be expected that the severity of their impacts will also increase in concert with global warming. Conversely, the frequency and magnitude of extreme low temperature events, such as cold spells, is projected to decrease in the future, with both positive and negative impacts. The impacts of future changes in climate extremes are expected to fall disproportionately on the poor (IPCC, 2001).”

According to the 1997 USEPA publication Climate Change and New York, over the last 100 years, temperatures in Albany, New York have warmed by more than 1°F and precipitation throughout New York State increased by up to 20-percent. Over the next 100 years, it is predicted that the State's climate could change even more. Based on projections given by the IPCC and results from the United Kingdom Hadley Centre's climate model, by 2100, temperatures in the State could increase about 4°F in the winter and spring, and slightly more in the summer and fall. Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses. New York State, with its irregular, intense heat waves, could be especially susceptible (USEPA, 1997).

As presented by NextGenerationEarth of the Columbia University Earth Institute and as provided by the USEPA report on climate change, which uses data from the 2001 Third Assessment Report of the IPCC, potential impacts of climate change to temperatures in New York include, but are not limited to, the following:

- By 2100 temperatures in New York could increase about 4°F in winter and spring, and slightly more in summer and fall (with a range of 2-8°F).
- Higher temperatures and increased frequency of heat waves may increase the number of heat-related deaths and the incidence of heat-related illnesses. New York, with its irregular, intense heat waves, could be especially susceptible.
- There is concern that climate change could increase concentrations of ground-level ozone. For example, high temperatures, strong sunlight, and stable air masses tend to increase urban ozone levels. If a warmed climate causes increased use of air conditioners, air pollutant emissions from power plants also will increase. Ground-level ozone has been shown to aggravate existing respiratory illnesses such as asthma, reduce lung function, and induce respiratory inflammation. In addition, ambient ozone reduces agricultural crop yields and impairs ecosystem health.
- Along much of New York's coast, sea level already is rising 10 inches per century, and it is likely to rise another 22 inches by 2100.
- New York has one of the most urbanized coastlines in the United States. Over 20 million people use New York's beaches and coastal regions for recreation each year. New York has been successful at preventing major permanent losses of its beaches and urban coastline, but sites such as Long Island continue to suffer from chronic beach erosion. Long Island's south shore, which is made up of barrier islands, barrier spits, ponds, and sand beaches, could suffer extensive damage from sea level rise and coastal storms.
- Protecting New York's coast would require significant resources and planning. For example, Manhattan's 29-mile coast probably could be protected by raising existing bulkheads and sea walls at a cumulative cost of \$30-\$140 million for a 1-3 foot rise in sea level. The costs of raising existing bulkheads already have begun to accrue, and they could continue throughout the next century (NextGenerationEarth, Date Unknown).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the extreme temperature events, Unincorporated Greenburgh and the Villages of Ardsley, Dobbs Ferry, Elmsford, Hastings-On-Hudson, Irvington and Tarrytown (Greater Greenburgh Planning Area) have been identified as the hazard area. Therefore, all assets in the Planning Area (population, structures, critical facilities and lifelines), as described in the Regional Profile (Section 4), are vulnerable. The following text evaluates and estimates the potential impact of extreme temperatures on the Planning Area including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety and health of residents, (2) general building stock, (3) critical facilities (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time
- Overall vulnerability conclusion

Overview of Vulnerability

Based on available data, it appears that extreme heat events are more common than extreme cold events in the Greater Greenburgh Planning Area. Extreme temperatures generally occur for a short period of time but can cause a range of impacts, particularly to vulnerable populations that may not have access to adequate cooling or heating. This natural hazard can also cause impacts to the population, infrastructure (e.g., through pipe bursts associated with freezing, power failure) and the local economy.

Data and Methodology

At the time of this draft HMP, insufficient data are available to model the long-term potential impacts of extreme temperature on the Planning Area. Data used to assess the extreme temperature natural hazard include HAZUS-MH, historic event data from various sources cited earlier in this profile, and Planning Committee sources. Over time additional data will be collected to allow better analysis for this hazard. Available information and a preliminary assessment are provided below.

Impact on Life, Health and Safety

For the purposes of this HMP, the entire population in the Planning Area is vulnerable to extreme temperature events. Extreme temperature events have potential health impacts including injury and death as seen as a result of the July 1999 event with the heat responsible for two deaths in Westchester County.

According to the 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 who are physically ill (e.g., heart disease or 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, 2006).

Meteorologists can accurately forecast extreme heat 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 (EPA, 2006).

Based on 2000 U.S. Census Bureau estimates, high risk populations exist throughout the Greater Greenburgh Planning Area. Approximately 6.1-percent of the Planning Area’s population is 65 years of age or older and approximately 3.3-percent of the population lives in households with an annual income of less than \$20,000. According to the NYS HMP, 20.3-percent of Westchester County’s population (under 5 years old and 65 and older) is most susceptible to extreme heat events (NYS HMP, 2008). Table 5.4.4-7 summarizes these population statistics in the Greater Greenburgh Planning Area.

Table 5.4.4-7. Greater Greenburgh Planning Area Population Statistics (2000 U.S. Census)

Municipality	Census/ HAZUS-MH 2000 Pop.	HAZUS-MH Pop. Over 65	HAZUS-MH Low- Income Pop. *
Unincorporated Greenburgh	41,828	2,562	1,294
Village of Ardsley	4,269	295	40
Village of Dobbs Ferry	10,622	586	416
Village of Elmsford	4,676	259	187
Village of Hastings-on-Hudson	7,648	499	284
Village of Irvington	6,631	402	187
Village of Tarrytown	11,090	650	459
Planning Area Total	86,764	5,253	2,867

Source: Census 2000 (U.S. Census Bureau); HAZUS-MH MR4, 2009

Note: Pop. = Population

* Individuals in households with an income of less than \$20,000

Due to a lack of data regarding past impacts on life and safety specific to the Greater Greenburgh Planning Area, it is not possible to estimate potential future losses to extreme temperature events.

Impact on General Building Stock

All of the building stock in the Greater Greenburgh Planning Area is exposed to the extreme temperature hazard (refer to Table 4-2 in Section 4), although no structures are anticipated to be directly impacted by an extreme heat event. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles. Additionally, antiquated or poorly constructed buildings may have inadequate capabilities to withstand extreme temperatures. Extreme heat events can contribute to conditions conducive to wildfires and reduce fire-fighting capabilities. Risk to life and property is greatest in those areas where forested areas adjoin urbanized areas (high density residential, commercial and industrial) or wildland/urban interface (WUI).

Due to a lack of data regarding past losses specific to the Planning Area, it is not possible at this time to estimate potential future losses to extreme temperature events.

Impact on Critical Facilities

All critical facilities in the Greater Greenburgh Planning Area are exposed to the extreme temperature hazard. Impacts to critical facilities are the same as described for general building stock (above). Additionally, it is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failure commonly referred to as “brown-outs”, due to increased usage from air conditioners, appliances, etc. and the sagging of utility lines from the heat itself. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption as well. As mentioned in the Severe Winter Storm section, backup

power is recommended for critical facilities. Only the Irvington Police Department has indicated they have backup power at their facility.

Impact on Economy

Extreme temperature events impact the economy including loss of business function and damage/loss of inventory. Business-owners and municipalities may be faced with increased financial burdens due to unexpected repairs (e.g., pipes bursting, broken water main) or higher than normal utility bills or business interruption due to power failure (i.e., loss of electricity, telecommunications).

During extreme heat events, even though most businesses will still be operational, they may be impacted by loss of inventory (spoilage of refrigerated goods) or even aesthetically (landscaping, etc). Massive power outages can interrupt transportation corridors and commuters getting into and out of Manhattan. Specific economic monetary losses associated with extreme temperature events were not identified for the Greater Greenburgh Planning Area.

Due to a lack of data regarding past losses specific to the Greater Greenburgh Planning Area it is not possible at this time to estimate potential future losses to extreme temperature events.

Additional Data and Next Steps

Extreme temperature loss data appears to be somewhat limited for the Greater Greenburgh Planning Area. Over time, the Planning Area will track data on future extreme temperature events, obtain additional municipal-specific information on past and future events, particularly in terms of any injuries, deaths, shelter needs, pipe freeze, water main breaks and other impacts. This will help to identify any concerns or trends for which mitigation measures should be developed or refined. In time, quantitative modeling of estimated extreme heat/cold events may be feasible as data is gathered and improved.

Overall Vulnerability Assessment

Historic data available indicate that extreme temperature events can impact the Greater Greenburgh Planning Area. The overall hazard ranking determined for this Plan for the extreme temperature hazard is “medium” (Tables 5.3-6 and 5.3-7).