



4.3.21 Winter Storm

This section provides a profile and vulnerability assessment of the winter storm hazard in Pike County. Winter storms occur, on average, approximately five times each year in Pennsylvania. From November through March, the State is exposed to winter storms that move up the Atlantic coast or sweep in from the west. Every county in the Commonwealth is subject to severe winter storms; however, the northern tier, western counties, and mountainous regions tend to undergo winter weather more frequently and with greater severity.

Winter storms can produce more damage than any other severe weather event, including tornados. Complications caused by winter storms can lead to road closures, especially of secondary and farm roads; business losses to commercial centers built in outlying areas because of supply interruption and loss of customers; property losses and roof damages from snow and ice loading and fallen trees; utility interruptions; and loss of water supplies. Flooding can result from winter storm events as well.

Most severe winter storm hazards include heavy snow (snowstorms), blizzards, sleet or freezing rain, ice storms, and Nor'easters. Because most extra-tropical cyclones (mid-Atlantic cyclones locally known as Northeasters or Nor'Easters) generally occur during winter weather months, these hazards have also been grouped as a type of severe winter weather storm. Types of severe winter weather events or conditions are further defined as follows:

- **Heavy Snow:** According to the National Weather Service (NWS), heavy snow is generally considered snowfall accumulating to depths of 4 inches or more within 12 hours or less; or snowfall accumulating to depths of 6 inches or more within 24 hours or less. A snow squall is an intense but limited-duration period of moderate to heavy snowfall, also known as a snowstorm, accompanied by strong, gusty surface winds and possibly lightning (generally moderate to heavy snow showers) (NWS 2009). Snowstorms are complex phenomena involving heavy snow and winds, whose impact can be affected by a great many factors, including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and occurrence during the course of the day, weekday versus weekend, and time of season (Kocin and Uccellini 2013).
- **Blizzard:** Blizzards are characterized by low temperatures, wind gusts of 35 miles per hour (mph) or more, and falling and/or blowing snow that reduces visibility to 0.25 mile or less for an extended period of time (3 or more hours) (NWS 2009). A severe blizzard is defined as an event with wind velocity of 45 mph, temperatures of 10 degrees Fahrenheit (°F) or lower, and a high density of blowing snow with visibility frequently measured in feet over an extended period of time.
- **Sleet or Freezing Rain:** Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen, partially-melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Freezing rain is rain that falls as a liquid but freezes into glaze upon contact with the ground. Both types of precipitation, even in small accumulations, can cause significant hazards to a community (NWS 2009).
- **Ice storm:** An ice storm is described as an occasion when damaging volumes of ice are expected to accumulate during freezing rain situations. Significant accumulations of ice pull down trees and utility lines, resulting in loss of power and means of communication. These accumulations of ice make walking and driving extremely dangerous, and can create extreme hazards to motorists and pedestrians (NWS 2009).

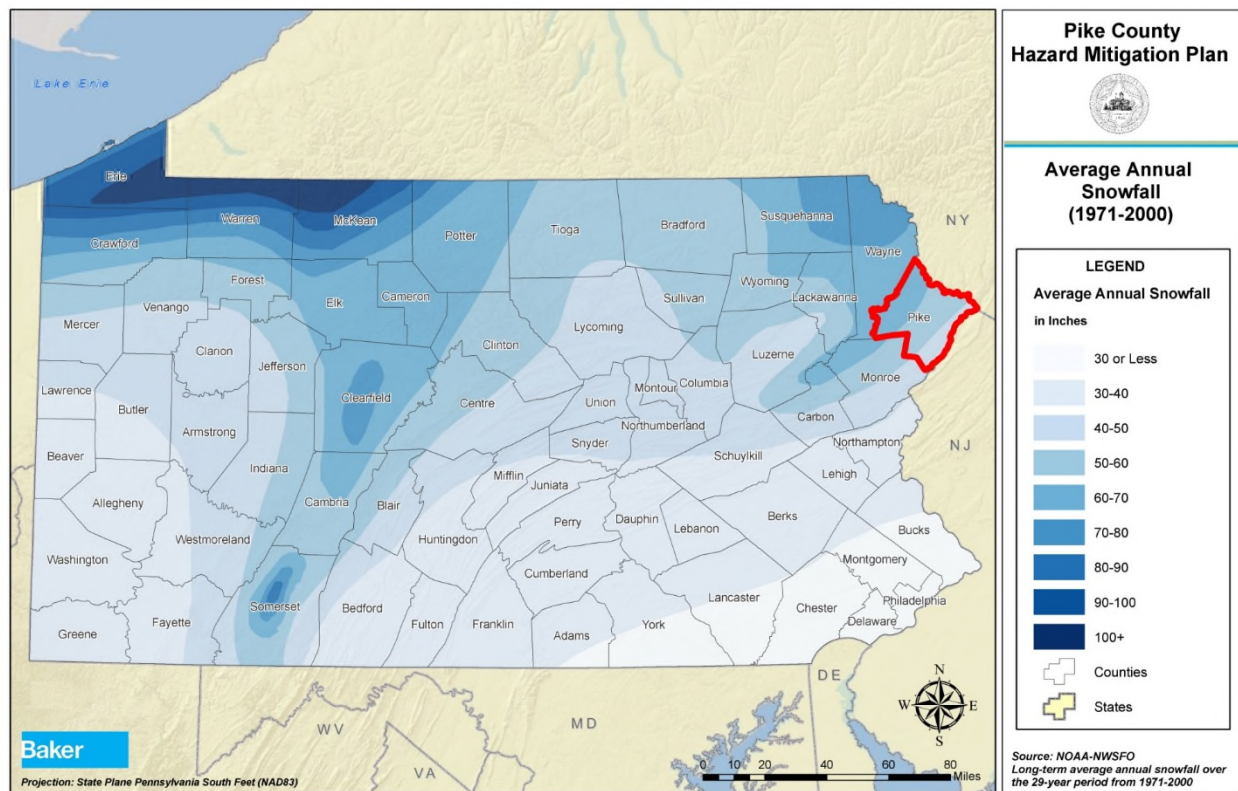


Location and Extent

Winter storms can consist of cold temperatures and heavy snow or ice. Major winter storms occur in Pennsylvania several times annually and are regional events. Every county in the Commonwealth, including Pike, is subject to severe winter storms.

Within Pike County there are variations in the average amount of snowfall that is received throughout different parts of the County because of terrain differences; higher elevations experience greater snowfalls than lower-lying areas. Generally, the average annual snowfall in the County increases from the southeast to northwest as shown in Figure 4.3.21-1.

Figure 4.3.21-1. Average Annual Snowfall (1971-2000) for Pennsylvania



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 (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. National Oceanic and Atmospheric Administration’s (NOAA) National Climatic Data Center (NCDC) currently produces the Regional Snowfall Index (RSI) for significant snowstorms that affect the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. The index is based on spatial extent of the storm, amount of snowfall, and interaction of extent and snowfall totals with population (based on the 2000 U.S. Census). NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 4.3.21-1 describes the five RSI ranking categories.





Table 4.3.21-1. RSI Ranking Categories

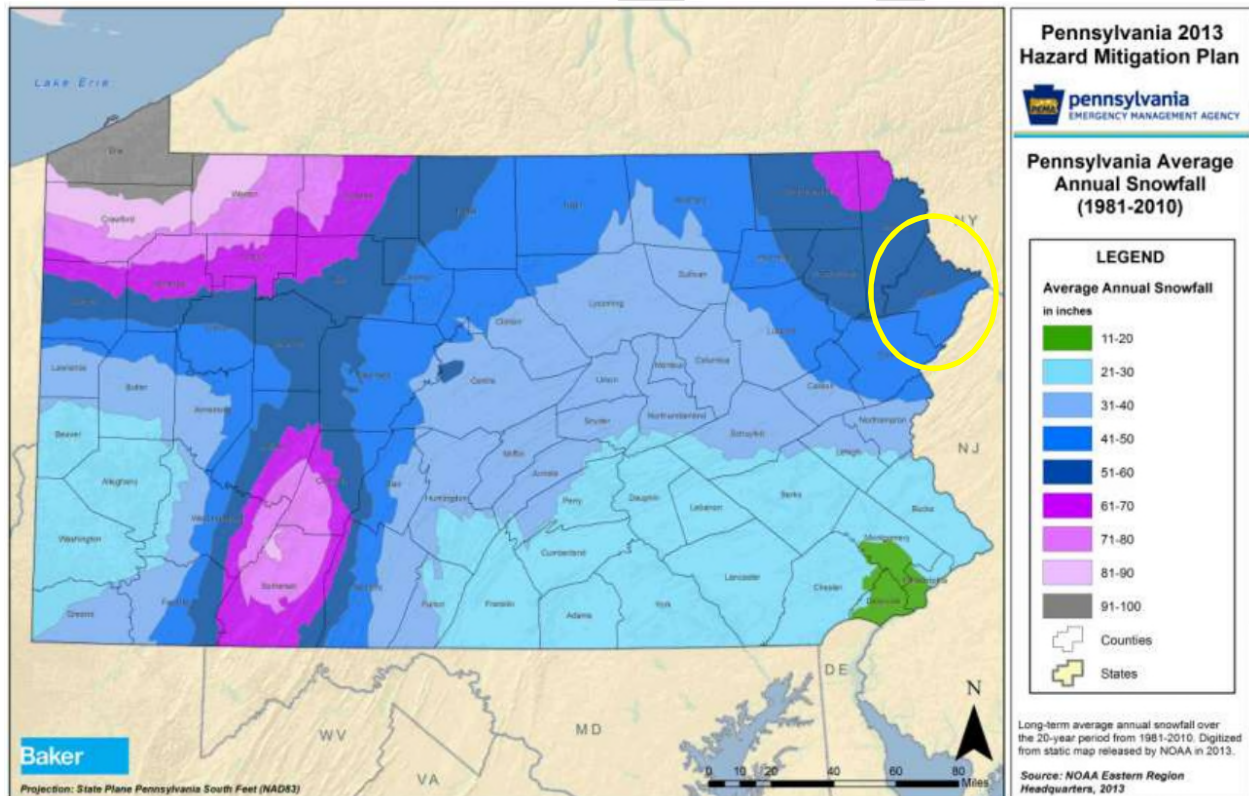
Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA-NCDC 2011

Notes: RSI Regional Snowfall Index

All of Pike County is susceptible to winter storms. Based on annual snowfall averages according to the 2013 State Hazard Mitigation Plan (HMP) (Figure 4.3.21-2), Pike County expectedly would receive an average of 41-60 inches of snowfall accumulation during the winter season.

Figure 4.3.21-2. Pennsylvania Average Annual Snowfall, 1981-2010



Source: Pennsylvania State HMP 2013

Note: The yellow circle indicates the approximate location of Pike County.



Range of Magnitude

Winter storms consist of cold temperatures, heavy snow or ice and sometimes strong winds. They begin as low-pressure systems that move through Pennsylvania following the jet stream. Being located in the northeast portion of Pennsylvania, Pike County often experiences the effects of Nor'Easter storms – low pressure fronts that move northward along the Atlantic coastline, pulling large amounts of moisture off of the Atlantic Ocean.

Due to their regular occurrence, these storms are considered hazards only when they result in damage to communications networks, impacts vegetation, cause structural collapse, cause very serious transportation problems and utility interruptions. Winter storms have also been known to contribute to severe flooding. A winter storm can adversely affect roadways, utilities, business activities, and can cause frostbite or loss of life. These storms may include one or more of the following weather events:

- **Heavy Snowstorm:** Accumulations of four inches or more in a six-hour period, or six inches or more in a twelve-hour period.
- **Sleet Storm:** Significant accumulations of solid pellets which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces posing hazards to pedestrians and motorists.
- **Ice Storm:** Significant accumulations of rain or drizzle freezing on objects (trees, power lines, roadways, etc.) as it strikes them, causing slippery surfaces and damage from the sheer weight of ice accumulation.
- **Blizzard:** Wind velocity of 35 miles per hour or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period of time.
- **Severe Blizzard:** Wind velocity of 45 miles per hour, temperatures of 10 degrees Fahrenheit or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period time.

Any of the above events can result in the closing of major or secondary roads, particularly in rural locations, stranded motorists, transportation accidents, loss of utility services, and depletion of oil heating supplies. Environmental impacts often include damage to shrubbery and trees due to heavy snow loading, ice build-up and/or high winds which can break limbs or even bring down large trees. Gradual melting of snow and ice provides excellent groundwater recharge. However, high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flooding.

Figure 4.3.21-1 shows mean annual snowfall in Pike County to be 40 to 50 inches in the southern part of the County, 50 to 60 inches in the central section, and 60 to 70 inches in the northwest. Two of the twelve Presidential Disaster and Emergency Declarations affecting Pike County have been in response to hazard events related to winter storms (see Table 4.2-1). Other reported winter storm events since 1994, including those associated with Disaster Declarations, are listed in Table 4.3.21-1.

A worst case scenario for winter storms occurred in March 1997. An isolated snow storm which affected only the northeast portion of Pennsylvania dumped up to 30 inches of very wet snow in Pike County. This storm caught everyone by surprise, stranding thousands of travelers along Interstate 84. This storm also brought down hundreds of trees throughout the county, dropping power and telephone lines, leaving large portions of the county without electricity and/or telephone service for up to five days. Highway departments and emergency responders struggled to cope with the multiple problems this storm caused. Eventually, with the help of the National Guard, over 1,200 people were brought off the highways and placed in shelters.



Past Occurrence

The Commonwealth of Pennsylvania has a long history of severe winter weather. In the winter of 1993-4, the state was hit by a series of protracted winter storms. The severity and nature of these storms combined with accompanying record-breaking frigid temperatures posed a major threat to the lives, safety and well-being of Commonwealth residents and caused major disruptions to the activities of schools, businesses, hospitals, and nursing homes.

As mentioned above, the first of these devastating winter storms occurred in early January with record snowfall depths (in excess of 33 inches in the southwest and south-central portions of the Commonwealth), strong winds and sleet/freezing rains. Numerous storm-related power outages were reported, and as many as 600,000 residents were without electricity, in some cases for several days at a time. A ravaging ice storm followed, affecting the southeastern portion of the Commonwealth, which closed major arterial roads and downed trees and power lines. Utility crews from a five-state area were called to assist in power restoration repairs. Officials from PP&L stated that this was the worst winter storm in the history of the company, and related damage-repair costs exceeded \$5,000,000.

Serious power supply shortages continued through mid-January because of record cold temperatures at many places, causing sporadic power generation outages across the Commonwealth. The entire Pennsylvania-New Jersey-Maryland grid and its partners in the District of Columbia, New York and Virginia experienced 15-30 minute rolling blackouts, threatening the lives of people and the safety of the facilities in which they resided. Power and fuel shortages affecting Pennsylvania and the East Coast power grid system required the Governor to recommend power conservation measures be taken by all commercial, residential, and industrial power consumers.

The record cold conditions resulted in numerous water-main breaks and interruptions of service to thousands of municipal and city water customers throughout the Commonwealth. Additionally, the extreme cold in conjunction with accumulations of frozen precipitation resulted in acute shortages of road salt. As a result, trucks were dispatched to haul salt from New York to expedite deliveries to PA Department of Transportation (DOT) storage sites.

During January and February 1994, Pennsylvania experienced at least 17 regional or statewide winter storms. The consequences of these disasters resulted in the need for intervention by the President in an effort to alleviate the severity of the hardship and to aid the recovery of the hardest-hit counties.

In January 1996, another series of severe winter storms with 27- and 24-inch accumulated snow depths was followed by 50 to 60 degree temperatures resulting in rapid melting and flooding.

In addition to the events described above, other winter storm events that impacted Pike County are listed in Table 4.3.21-2. Details regarding some of these events are provided below.

Table 4.3.21-2. Previous Winter Storm Events Impacting Pike County Since 1994

Location	Date	Type
Lehigh, Monroe, Northampton, Pike	11/27/1994	Winter Storm
Multiple Counties	12/09/1994	Freezing Rain
Multiple Counties	12/14/1994	Freezing Drizzle
Multiple Counties	12/31/1994	Freezing Rain
Multiple Counties	01/06/1995	Winter Storm
Multiple Counties	01/31/1995	Freezing Rain
Multiple Counties	02/03/1995	Heavy Snow
Multiple Counties	02/15/1995	Freezing Rain



Location	Date	Type
Berks, Carbon, Lehigh, Monroe, Northampton, Northern Wayne, Pike	02/15/1995	Freezing Rain
Carbon, Monroe, Northern Wayne, Pike	02/27/1995	Freezing Rain
Multiple Counties	03/08/1995	Snow
Multiple Counties	06/01/1995	Snow Drought
Multiple Counties	11/14/1995	Heavy Snow
Multiple Counties	01/02/1996	Heavy Snow
Multiple Counties	01/07/1996	Heavy Snow
Multiple Counties	01/12/1996	Heavy Snow
Multiple Counties	03/06/1996	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	03/31/1997	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	04/01/1997	Heavy Snow
Multiple Counties	12/29/1997	Heavy Snow
Lackawanna, Northern Wayne, Pike	01/15/1998	Ice Storm
Multiple Counties	02/23/1998	Heavy Snow
Lackawanna, Northern Wayne, Pike, Susquehanna	03/20/1998	Heavy Snow
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	01/02/1999	Ice Storm
Multiple Counties	01/13/1999	Winter Storm
Lackawanna, Luzerne, Northern Wayne, Pike	03/14/1999	Heavy Snow
Multiple Counties	01/20/2000	Heavy Snow
Multiple Counties	01/25/2000	Heavy Snow
Multiple Counties	01/30/2000	Heavy Snow
Multiple Counties	02/13/2000	Ice Storm
Multiple Counties	02/18/2000	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	04/08/2000	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Wyoming	12/13/2000	Winter Storm
Lackawanna, Northern Wayne, Pike, Susquehanna	12/30/2000	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike	01/20/2001	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	02/05/2001	Heavy Snow
Pike	02/16/2001	Ice Storm
Pike	02/22/2001	Heavy Snow
Multiple Counties	02/24/2001	Ice Storm
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	03/04/2001	Heavy Snow
Northern Wayne, Pike, Susquehanna	03/12/2001	Ice Storm
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	01/06/2002	Heavy Snow
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	01/31/2002	Winter Storm
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	02/01/2002	Winter Storm
Lackawanna, Luzerne, Northern Wayne, Pike, Wyoming	12/05/2002	Heavy Snow
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	12/11/2002	Winter Weather/mix
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	12/24/2002	Heavy Snow
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike, Susquehanna, Wyoming	01/03/2003	Heavy Snow
Bradford, Lackawanna, Luzerne, Northern Wayne, Pike,	02/17/2003	Heavy Snow



Location	Date	Type
Susquehanna, Wyoming		
Pike	03/06/2003	Heavy Snow
Multiple Counties	12/06/2003	Heavy Snow
Lackawanna, Northern Wayne, Pike, Susquehanna	01/28/2004	Heavy Snow
Multiple Counties	01/06/2005	Winter Weather/mix
Multiple Counties	01/23/2005	Heavy Snow
Multiple Counties	03/01/2005	Heavy Snow
Multiple Counties	03/24/2005	Heavy Snow
Multiple Counties	10/25/2005	Winter Weather/mix
Lackawanna, Luzerne, Northern Wayne, Pike, Southern Wayne, Susquehanna, Wyoming	12/09/2005	Heavy Snow
Lackawanna, Luzerne, Northern Wayne, Pike, Southern Wayne, Wyoming	12/16/2005	Winter Storm
Multiple Counties	02/13/2007	Winter Storm
Pike, Southern Wayne, Wyoming	03/16/2007	Heavy Snow
Pike, Southern Wayne	02/22/2008	Winter Storm
Multiple Counties	12/19/2008	Heavy Snow
Multiple Counties	10/15/2009	Winter Weather
Multiple Counties	02/10/2010	Winter Storm
Pike, Southern Wayne	02/23/2010	Winter Storm
Multiple Counties	02/25/2010	Winter Storm
Bradford, Luzerne, Pike, Southern Wayne, Wyoming	02/20/2011	Winter Storm
Multiple Counties	02/23/2011	Winter Storm
Multiple Counties	10/29/2011	Winter Storm
Multiple Counties	12/14/2013	Winter Storm
Multiple Counties	01/02/2014	Winter Storm
Multiple Counties	02/05/2014	Winter Storm
Multiple Counties	02/13/2014	Winter Storm
Multiple Counties	11/26/2014	Winter Storm
Multiple Counties	02/01/2015	Heavy Snow
Multiple Counties	01/23/2016	Heavy Snow

Source: Pike County HMP 2012; NOAA NCEI 2016

Note: Events with the location "Multiple Counties" include Pike County

Between 1954 and 2016, FEMA issued a major disaster (DR) or emergency (EM) declaration for the Commonwealth of Pennsylvania for eight winter storm-related events, classified as one or a combination of the following disaster types: severe winter storm, snowstorm, blizzard, winter storm, severe storm, and snowfall. Generally, these disasters covered a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, Pike County has been included in two winter storm-related declarations during this time period (FEMA 2016).

Table 4.3.21-3. FEMA DR and EM Declarations for Winter Storm Events in Pike County

FEMA Declaration Number	Date(s) of Event	Event Type	Location
EM-3105	March 13-17, 1993	Severe Snowfall and Winter Storm	67 counties including Pike County
DR-1085	January 6-12, 1996	Blizzard of 96	51 counties including Pike County

Source: FEMA 2016

In addition to the events identified above, Pike County and other sources have record of winter storms. These include:



- January 1966 - very heavy snow causes problems across the entire state.
- November 1971 - heavy snow fell on Pike County on Thanksgiving, stranding hundreds of travelers along Rt. 84.
- January 1978 - very heavy snow brought the county to a standstill for two days.
- February 1978 - another storm similar to the one only about a week earlier with the same effects.
- March 1993 - a major Nor'easter hit the county, dumping in excess of 24 inches of snow over the majority of the county. This storm affected the entire east coast from Florida to Maine. Pike County was eligible for Public Assistance under the Presidential Declaration (EM-3105).
- February 20-21, 2011 - Snow fell across northeast Pennsylvania on the 20th and brought between six and eight inches of snow to Pike County.
- March 23, 2011 - Cold air combined with significant moisture brought widespread snow to northeast Pennsylvania. Snowfall totals ranged from five to 10 inches, with a foot of snow falling in higher terrain of western Bradford County. In Pike County, snowfall totals ranged from five to nine inches.
- October 28, 2011 (Nor'easter/Winter Storm) - An early season winter storm brought wet snow across northeast Pennsylvania. Snow amounts varied depending on elevation. More than a foot of snow fell in the Poconos. In Pike County, snowfall totals across the county averaged around 12 inches.
- December 14-15, 2013 - Moderate to heavy snowfall fell across portions of the Poconos and the northern tier of Pennsylvania. The highest snowfall of 10 inches was reported in Bradford County. In Pike County, snowfall totals ranged from eight to 10 inches.
- February 5, 2014 - An intense snow band developed and produced as much as one to three inches of snow per hour during the morning of February 5th. Widespread snow amounts ranged from seven to 16 inches, with the highest totals occurring across the northern tier of Pennsylvania. In Pike County, snowfall totals ranged from 11 to 14 inches across the county. The highest amount of 14 inches fell in Panther (Greene Township).
- November 26, 2014 - A low pressure system brought snow into northeast Pennsylvania during the morning and afternoon of November 26th. The highest snowfall total of 10.2 inches was reported in Wyoming County. In Pike County, snowfall totals ranged from six to 10 inches, with the highest amount of 10 inches falling in the Borough of Milford.
- January 23, 2016 - This blizzard brought record-breaking snow across southern Pennsylvania but just clipped Luzerne, Pike and Lackawanna Counties. Snowfall totals ranged from six to eight inches in southern Pike and Lackawanna Counties. Up to 15.5 inches of snow fell in the Hazelton area with much less snow falling in the north. In Pike County, snowfall totals ranged from a few inches in the far northern section of the county to between six and seven inches in the Borough of Milford and Greentown (Greene Township).

Future Occurrence

Winter storms are a regular, annual occurrence in Pike County. Table 4.3.21-4 shows the probability of receiving measureable snowfall by month in Pike County at the listed snow station locations. These probabilities are based on data collected over a minimum of 20 years. There is slight variation in the probabilities of snowfall in different locations in Pike County.



Table 4.3.21-4. Probability of Measurable Snowfall in Pike County by Snow Station Location

Month	Probability (%)			
	Hawley 1 E	Lake Minisink	Matamoras	Paupack 1 WSW
January	100.00%	100.00%	96.70%	98.40%
February	100.00%	100.00%	100.00%	95.40%
March	97.50%	90.00%	93.20%	96.90%
April	66.70%	47.80%	53.10%	73.40%
May	3.90%	0.00%	0.00%	0.00%
June	0.00%	0.00%	0.00%	0.00%
July	0.00%	0.00%	0.00%	0.00%
August	0.00%	0.00%	0.00%	0.00%
September	0.00%	0.00%	0.00%	0.00%
October	8.80%	7.10%	1.90%	4.50%
November	68.80%	40.00%	55.00%	72.10%
December	96.30%	96.00%	95.30%	90.50%

Source: Pike County HMP 2012

For the 2017 HMP update, the most up-to-date data was collected to calculate the probability of future occurrence of winter storm (heavy snow, blizzard, sleet/freezing rain, winter weather, and winter storm) events for Pike County. Information from the 2012 Pike County HMP, NOAA-NCEI storm events database, and the Pennsylvania State Climatologist were used to identify the number of winter storm events that occurred between 1950 and 2015. Using these sources ensures the most accurate probability estimates possible. The table below shows these statistics, as well as the annual average number of events and the estimate percent chance of an incident occurring in a given year. Based on these statistics, there is an estimated 100-percent chance of a winter storm event occurring in any given year in Pike County.

Table 4.3.21-5. Probability of Future Winter Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent chance of occurrence in any given year
Winter Weather	70	1.08	0.94	1.0	100%

Sources: Pike County HMP 2012; NOAA-NCEI 2016; Pennsylvania State Climatologist 2016

Based on available historical data, the future occurrence of winter storm events can be considered *highly likely* as defined by the Risk Factor Methodology probability criteria (refer to Section 4.4).

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For winter storm events, all of Pike County has been identified as the hazard area. Therefore, all assets (population, structures, critical facilities and lifelines), as described in the County Profile (Section 2), are vulnerable. This section includes an evaluation and estimation of potential impacts of winter storm events on the County, including:

- Overview of vulnerability





- Data and methodology used for the evaluation
- Impacts on (1) life, health, and safety; (2) general building stock; (3) critical facilities; (4) economy; (5) environment; and (6) future growth and development
- Effect of climate change on vulnerability
- Further data collections that will assist understanding this hazard over time.

Overview of Vulnerability

Winter storms are a concern based on the frequency of winter storm effects on Pike County. Additionally, winter storms are of significant concern because of direct and indirect costs associated with these events, delays caused by the storms, and impacts on people and facilities of the region.

Data and Methodology

National weather databases, the 2013 Pennsylvania HMP, and local resources were referenced to collect and analyze information about severe winter storm impacts on Pike County. The 2010 U.S. Census data and the Hazards U.S. – Multi-Hazard (HAZUS-MH) building inventory for Pike County were referenced to support an evaluation of assets exposed to this hazard and potential impacts associated with this hazard.

Impact on Life, Health, and Safety

According to the NOAA National Severe Storms Laboratory (NSSL), winter weather indirectly kills hundreds of people in the United States every year, 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, extreme cold temperatures, and dangerous wind chill. Winter storms are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storms. People can die in traffic accidents on icy roads, of heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold.

Heavy snow can immobilize a region and paralyze a city, shutting down air and rail transportation, stopping flow of supplies, and disrupting medical and emergency services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost. In the mountains, heavy snow can lead to avalanches (NSSL 2006).

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2006).

For the purposes of this Plan, the entire population of Pike County is considered exposed to winter storm events (U.S. Census 2010). The elderly are considered most susceptible to this hazard because of their increased risk of injuries and death from falls and overexertion and/or hypothermia from exposure while attempting to clear snow and ice. In addition, winter storm events can reduce ability of these populations to access emergency services. Residents with low incomes may not have access to housing, or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). The County Profile (Section 2) of this Plan provides population statistics for each participating municipality and a summary of the more vulnerable populations (over the age of 65 and individuals living below the U.S. Census poverty threshold).



Impact on General Building Stock

The entire general building stock inventory in Pike County is exposed and vulnerable to the winter storm hazard. Snow accumulation in excess of building design conditions may be vulnerable to structure failure and possible collapse. In general, structural impacts include damage to roofs and building frames, rather than to building content. Structural failure due to roof snow loads can be linked to several different causes, including but not limited to:

- Actual snow load significantly exceeds design snow load
- Drifting and sliding snow conditions
- Deficient workmanship
- Insufficient operation and maintenance
- Improper design
- Inadequate drainage design
- Insufficient design; in older buildings, insufficient design is often related to inadequate snow load design criteria in the building code in effect when the building was designed (FEMA 2013)

Current modeling tools are not available to estimate specific losses from this hazard. As an alternate approach, this Plan considers percentage damages that could result from winter storm conditions. Table 4.3.21-6. General Building Stock Exposure (Structure Only) and Estimated Losses from Winter Storm Events in Pike County below summarizes percent damages to Pike County’s total general building stock (structure only) that could result from winter storm conditions. Considering professional knowledge and currently available information, potential losses from this hazard are considered overestimated; hence, values in Table 4.3.21-6. General Building Stock Exposure (Structure Only) and Estimated Losses from Winter Storm Events in Pike County are conservative estimates of losses associated with severe winter storm events.

Table 4.3.21-6. General Building Stock Exposure (Structure Only) and Estimated Losses from Winter Storm Events in Pike County

Municipality	Total GBS (Structure Only)	1% of Total	5% of Total	10% of Total
Blooming Grove Township	\$768,042,000	\$7,680,420	\$38,402,100	\$76,804,200
Delaware Township	\$973,607,000	\$9,736,070	\$48,680,350	\$97,360,700
Dingman Township	\$1,287,496,000	\$12,874,960	\$64,374,800	\$128,749,600
Greene Township	\$624,259,000	\$6,242,590	\$31,212,950	\$62,425,900
Lackawaxen Township	\$816,292,000	\$8,162,920	\$40,814,600	\$81,629,200
Lehman Township	\$1,303,700,000	\$13,037,000	\$65,185,000	\$130,370,000
Matamoras Borough	\$237,231,000	\$2,372,310	\$11,861,550	\$23,723,100
Milford Borough	\$224,907,000	\$2,249,070	\$11,245,350	\$22,490,700
Milford Township	\$414,595,000	\$4,145,950	\$20,729,750	\$41,459,500
Palmyra Township	\$824,628,000	\$8,246,280	\$41,231,400	\$82,462,800
Porter Township	\$255,805,000	\$2,558,050	\$12,790,250	\$25,580,500
Shohola Township	\$488,962,000	\$4,889,620	\$24,448,100	\$48,896,200
Westfall Township	\$238,350,000	\$2,383,500	\$11,917,500	\$23,835,000
Pike County (Total)	\$8,457,874,000	\$84,578,740	\$422,893,700	\$845,787,400

Source: HAZUS-MH 3.1 Note: GBS General building stock





An area especially vulnerable to the winter storm hazard is the floodplain. At-risk building stock and infrastructure in floodplains are addressed in the flood hazard profile (Section 4.3.5). Generally, losses from flooding associated with winter storms should be less than those associated with a 1-percent or 0.2-percent flood. In summary, snow and ice melt can cause both riverine and urban flooding. Estimated losses from riverine flooding in the County are discussed in Section 4.3.5.

Impact on Critical Facilities

Full functionality of critical facilities such as police, fire, and medical services is essential for response during and after a winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should undergo only minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure.

Impact on the Economy

Infrastructure at risk from the winter storm hazard includes roadways that could be damaged by application of salt, and intermittent freezing and warming conditions that can damage roads over time. Costs of snow and ice removal and repair of roads damaged by the freeze/thaw cycle can drain local financial resources. Potential secondary impacts from winter storms also affect the local economy, including loss of utilities, interruption of transportation corridors, and loss of business function.

Impact on the Environment

Environmental impacts often include damage to trees and shrubs caused by heavy snow loading, ice buildup, and/or high winds, which can break limbs and down large trees. An indirect effect of winter storms is impairment of surface and groundwater adjacent to roadway surfaces treated with salt, chemicals, and other de-icing materials (PEMA 2013).

Winter storms have a positive environmental impact: gradual melting of snow and ice provides groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause accelerated snowmelt, rapid surface water runoff, and severe flooding (PEMA 2013).

Future Growth and Development

Areas targeted for potential future growth and development within the next 5 years have been identified across the County at the municipal level, and are further discussed in Section 2.4 of this Plan. For the winter storm hazard, Pike County in its entirety has been identified as the hazard area. Therefore, any new development will be exposed to such risks.

Effect of Climate Change on Vulnerability

Climate is defined not just as average temperature and precipitation, but also by type, frequency, and intensity of weather events. Both globally and at the local level, climate change can alter prevalence and severity of weather extremes such as winter storms. While predicting changes in winter storm events under conditions of a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future impacts of climate change on human health, society, and the environment (U.S. Environmental Protection Agency [EPA] 2006).

The climate of Pennsylvania has changed in several ways. Over the past 100 years, annual average temperatures have been rising across the State. Warmer winters have led to decrease in snow cover and earlier arrival of spring. Recent analyses based on the Intergovernmental Panel on Climate Change models suggest a decrease in frequency and an increase in intensity of extra-tropical winter cyclones. However, based on the



methodology applied, some models show no significant change in the storm track whereas others indicate a northward displacement of the storm track in the North Atlantic. For the mid-Atlantic region, there is little indication of a change in storm activity or track over Pennsylvania. An overall increase in winter precipitation is anticipated, with a decrease in snow and increase in rain during winter months. Projections of future occurrences of extra-tropical cyclones in Pennsylvania are uncertain. Based on available information and projections, winter storms are anticipated to continue to affect Pennsylvania in the future. Future improvements in modeling smaller-scale climatic processes can be expected, and will lead to improved understanding of the ways the changing climate will alter temperature, precipitation, and storm events in Pennsylvania (Shortle and others 2009).

Additional Data and Next Steps

The assessment above identifies vulnerable populations and economic losses associated with the winter storm hazard. Historical data on structural losses to general building stock are not adequate to predict specific losses to this inventory; therefore, the percent of damage assumption methodology was applied. This methodology is based on FEMA How-to Series (FEMA 386-2), Understanding Your Risks, Identifying and Estimating Losses (FEMA 2001), and FEMA's Using HAZUS-MH for Risk Assessment (FEMA 433) (FEMA 2004). Acquisition of additional/actual data regarding (1) valuations of general building stock and (2) critical infrastructure losses would further support future estimates of potential exposure of and damage to the general building stock inventory.

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