4.3.19 Winter Storm

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 Winter Storm hazard in Dauphin County.

This section provides a profile and vulnerability assessment of the winter storm hazard in Dauphin County. Winter storms occur, on average, approximately five times each year in Pennsylvania. From November through March, Pennsylvania is exposed to winter storms that move up the Atlantic coast or sweep in from the west. Every county in the Commonwealth is vulnerable to severe winter storms; however, the northern tier, western counties, and mountainous regions tend to experience winter weather more frequently and with greater severity. Dauphin County does not fall within these areas.

Complications caused by winter storms can lead to road closures (especially 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. More information on flooding from winter storms can be found in Section 4.3.6 Flood Hazard Profile.

Most severe winter storm hazards include heavy snow (snowstorms), blizzards, sleet or freezing rain, ice storms, and mid-Atlantic cyclones locally known as Northeasters or Nor'easters. Because most 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 depth of 4 inches or more within 12 hours or less or snowfall accumulating to depth 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 having a wind velocity of 45 mph, temperatures of 10°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 render walking and driving extremely dangerous and can create extreme hazards to motorists and pedestrians (NWS 2009).

- **Nor'easter:** Nor'easters are macro-scale, extra-tropical storms named for the strong northeasterly winds that blow in from the Atlantic Ocean ahead of the storm and over coastal areas of the northeastern United States and Atlantic Canada. They are also referred to as a type of extra-tropical cyclone (mid-latitude storms or Great Lake storms). Wind gusts associated with Nor'easters can exceed hurricane forces in intensity. Unlike tropical cyclones that form in the tropics and have warm cores (including tropical depressions, tropical storms, and hurricanes), Nor'easters contain a cold core of low barometric pressure that forms in the mid-latitudes. Their strongest winds are close to the earth's surface and often extend several hundred miles across. Nor'easters may occur at any time of the year but are more common during fall and winter months (September through April) (NWS 2019).

  Nor'easters can induce heavy snow, rain, and gale-force winds that can cause structural damage, power outages, and unsafe human conditions. If a Nor'easter cyclone travels up the coast on an inland track, it is more impactful than if it stays just offshore. Nor'easters can be stronger if they stay offshore, but impacts are usually focused closer to the coast. Nor'easters that stay inland usually cause strong winds and rain. Those that stay offshore can bring heavy snow, blizzards, ice, and strong winds. In these storms, the warmer air is aloft. Precipitation falling from this warm air moves into the colder air at the surface, causing crippling sleet or freezing rain (McNoldy Multi-Community Environmental Storm Observatory [MESO], n.d.). While some of the most devastating effects of Nor'easters occur in coastal areas (e.g., beach erosion, coastal flooding), effects on inland areas like Dauphin County may include heavy snow, strong winds, and blizzards.

4.3.19.1 Location and Extent

Winter storms are regional events, most of which impact a large area of the entire Commonwealth. In many cases, surrounding states and even the northeast region of the United States is affected by a single winter storm incident.

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 (NOAA)'s National Centers for Environmental Information (NCEI) is currently producing 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 the extent and snowfall totals with population (based on the 2018 U.S. Census). NCEI has analyzed and assigned RSI values to over 500 storms since 1900 (NCEI 2011). Table 4.3.19-1 lists the five RSI ranking categories.

Table 4.3.19-1. RSI Ranking Categories

Category	Description	Regional Snowfall Index (RSI)
1	Notable	1–3
2	Significant	3–6
3	Major	6–10
4	Crippling	10–18
5	Extreme	18.0+

Source: NCEI 2011

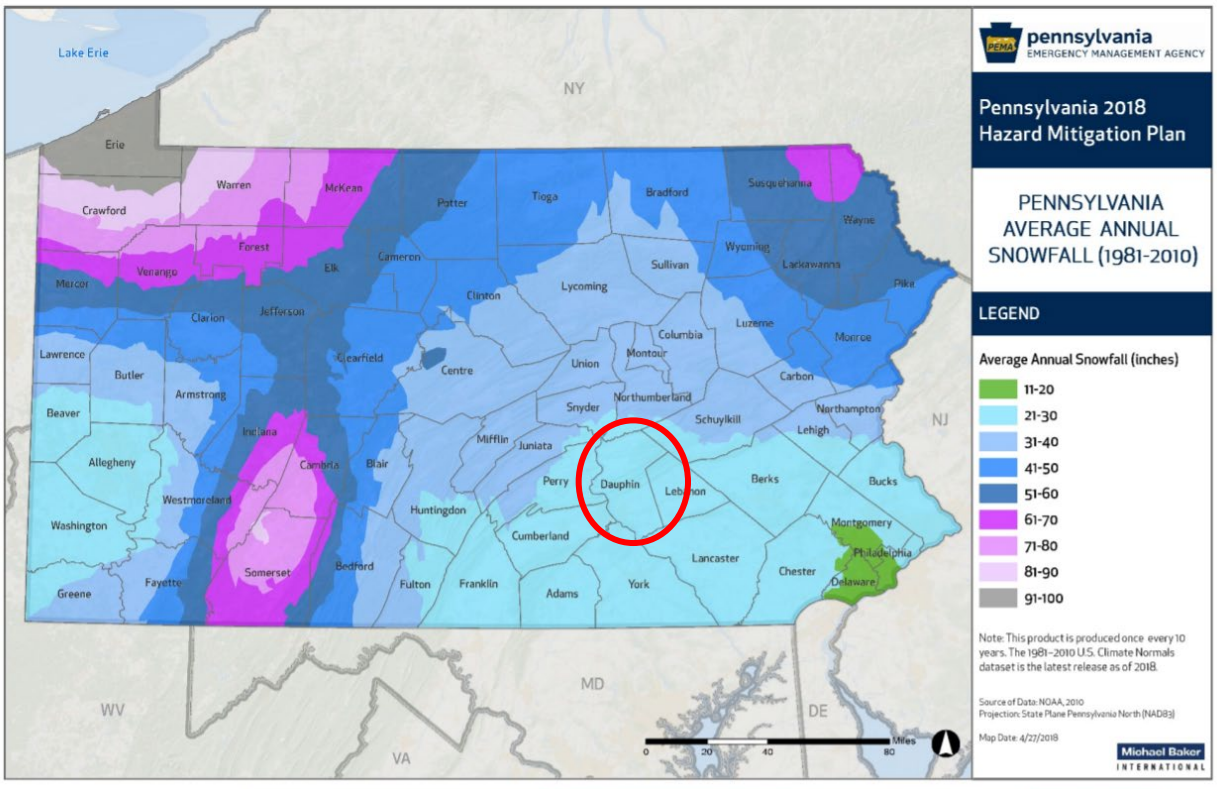
4.3.19.2 Range in Magnitude

A winter storm can adversely affect roadways, utilities, and businesses and can cause loss of life, frostbite, and freezing conditions. These storms typically fall into one of the following categories, defined in the previous section:

- Heavy snow
- Sleet or freezing rain
- Ice storm
- Blizzard
- Nor'easter

All of Dauphin County is susceptible to winter storms. Based on annual snowfall averages according to the 2018 State Hazard Mitigation Plan (HMP) (Figure 4.3.19-1), snowfall accumulation during the winter season in Dauphin County averages 21–30 inches.

Figure 4.3.19-1. Annual Snowfall



Source: Pennsylvania Emergency Management Agency (PEMA) 2018
Note: The red circle surrounds Dauphin County.

In the winter of 1993–1994, the state was hit by a series of protracted winter storms. The first of these winter storms occurred in early January, with a record snowfall depth in excess of 33 inches in the state, strong winds, and sleet/freezing rain. PPL stated it was the worst winter storm in the history of the company, and related damage repair cost exceeded $5,000,000. The March 1993 snowstorm has been referred to as the "storm of the century," where 20.4 inches of snow fell between March 13–15, 1993. The worst-case scenario of a winter storm in Dauphin County occurred on January 22–23, 2016, when 30.2 inches fell in the county, and nine deaths were reported in Pennsylvania.

4.3.19.3 Past Occurrence

Many sources provided historical information regarding previous occurrences and losses associated with winter storm events throughout the Commonwealth of Pennsylvania and Dauphin County. With so many sources reviewed for the purpose of this plan, loss and impact information for many events varied depending on the source. Therefore, accuracy of monetary figures discussed is based only on available information identified during research for this plan. Monetary figures may also have been calculated for the region as a whole, based on entire storm damage, and include damage from other counties.

Between 1954 and 2020, the Federal Emergency Management Agency (FEMA) declared that the Commonwealth of Pennsylvania experienced eight winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storms, snowstorms, blizzards, winter storms, severe storms, and snowfalls. Generally, these disasters covered a wide region of the Commonwealth, and therefore may have impacted many counties. However, not all counties were included in the disaster declarations. PEMA and other sources indicate that Dauphin County has been declared as a disaster area as a result of seven of the declarations for winter storm events (FEMA 2020).

According to the NOAA-NCEI storm events database, Dauphin County experienced 52 major winter storm events between March 1993 and March 2019. Based on all sources researched, known winter storm events that have affected Dauphin County are listed in Table 4.3.11-2. Because winter storm documentation for the Commonwealth of Pennsylvania is so extensive, not all sources have been identified or researched. Therefore, Table 4.3.19-2 may not include all events that have occurred throughout the county.

Table 4.3.19-2. Major Winter Storm Events in Dauphin County between 1993 and 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
March 13–17, 1993	Blizzard	EM-3105	Yes	A winter storm with heavy snowfall occurred in Dauphin County and other counties through Pennsylvania. Nearly 20.4 inches fell within the county.
January 4–February 25, 1994	Winter Storm, Severe Storm	DR-1015	Yes	A winter storm affected several counties in Pennsylvania including Dauphin with freezing temperatures and more than 15 inches of snow.
January 6–12, 1996	Blizzard	DR-1085	Yes	More than 2 feet of snow fell across the county. The storm was termed the Blizzard of '96. Transportation and commerce came to a halt as cities of south-central PA were buried under heavy snow. New snow of 38 inches was reported in southern York County at Glenville. 2 feet or more was reported near Harrisburg. The storm had a major impact on commerce across south-central PA and was to set the stage for the Great Flood on January 19.
January12–13, 1996	Heavy Snow	N/A	No	A foot of snow fell in Harrisburg, and snow in excess of 1 1/2 feet fell across areas from Sunbury northward to Muncy and Laporte.
November 28, 1996	Heavy Snow	N/A	No	One to two inches of snow fell across the county with hundreds of traffic accidents and injuries.
December 5–6, 1996	Heavy Snow	No	No	5.8 inches of snow fell on Harrisburg.
February 13, 1997	Winter Storm	N/A	N/A	3 to 7 inches of snow fell across the area with an ice coating on top.
January 2, 1999	Winer Storm	N/A	N/A	Maximum sustained wind speed was 17.26 MPH, no damages were reported
January 8, 1999	Winter Storm	N/A	N/A	A minimum temperature of 17.6 degrees Fahrenheit was reported.
January 14, 1999	Winter Storm	N/A	N/A	A minimum temperature of 12 degrees Fahrenheit was reported for Harrisburg.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
March 14, 1999	Heavy Snow	N/A	N/A	8.3 inches of snow were reported.
January 25, 2000	Heavy Snow	N/A	N/A	0-4 inches of snow was recorded for Dauphin County.
January 30–31, 2000	Heavy Snow	N/A	N/A	Temperatures ranged from 17-26 degrees Fahrenheit.
February 13, 2000	Ice Storm	N/A	N/A	Temperatures as low as 19 degrees Fahrenheit were reported for the county.
February 18–19, 2000	Winter Storm	N/A	N/A	A maximum sustained wind speed of 11.39 MPH were reported with a visibility of 3.2 miles.
December 13–14, 2000	Winter Storm	N/A	N/A	Temperatures as low as 15 degrees Fahrenheit were reported for Dauphin County.
March 4–7, 2001	Heavy Snow	N/A	N/A	Maximum wind speed of 23 MPH was reported, about one inch of snow fell across the county.
January 6–7, 2002	Heavy Snow	N/A	N/A	Less than an inch of snow fell throughout the county.
December 5, 2002	Heavy Snow	N/A	N/A	5-7 inches of snow fell throughout Dauphin County.
December 25, 2002	Heavy Snow	N/A	N/A	Less than an inch of snow fell throughout the county with a visibility of 2.1 miles.
February 6–7, 2003	Heavy Snow	N/A	N/A	5 to 8 inches of snow fell across the county.
February 14–19, 2003	Heavy Snow	EM-3180	Yes	Total snowfall accumulations ranged from 22 to 30 inches. Some power outages were reported.
December 5–6, 2003	Heavy Snow	N/A	N/A	15–30 inches were reported for Dauphin County.
March 19, 2004	Heavy Snow	N/A	N/A	About a half inch of snow fell in Harrisburg.
January 22–23, 2005	Winer Storm	N/A	N/A	Low temperatures were in the single numbers with below zero low temperatures in parts of the county.
February 24–25, 2005	Heavy Snow	N/A	N/A	3-7 inches of snow fell throughout the county.
March 1–2, 2005	Heavy Snow	N/A	N/A	6-12 inches of snow fell throughout the county.
December 9, 2005	Heavy Snow	N/A	N/A	Less than an inch of snow fell throughout the county.
February 13–14, 2007	Winter Storm	N/A	N/A	In Dauphin County, a mix of sleet and freezing rain fell in addition to 6 to 9 inches of snow.
March 16–17, 2007	Heavy Snow	N/A	N/A	7-10 inches of heavy snow fell throughout the county.
December 15–16, 2007	Winer Storm	N/A	N/A	A quarter to one-half inch of ice build-up brought down numerous trees and wires across the southern half of Dauphin County. Over 25,000 customers were without power in the county.
February 1, 2008	Winter Storm	N/A	N/A	Over a quarter-inch of freezing rain and sleet fell across the county.
February 12, 2008	Ice Storm	N/A	N/A	A wintry mix of sleet and freezing rain affected Central Pennsylvania with significant ice accumulations ranging from a quarter to one-half inch.
January 6, 2009	Ice Storm	N/A	N/A	A prolonged period of freezing rain resulted in a significant ice accumulation across much of Central Pennsylvania. Many locations received one quarter to one half inch of ice accumulation. The icing caused sporadic power outages and brought down several tree limbs.
January 27–28, 2009	Winter Storm	N/A	N/A	1-3 inches of snow and sleet along with a significant ice accretion was reported.
December 19, 2009	Winter Storm	N/A	N/A	Total snow accumulations ranged from 6 to 9 inches.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
February 5–11, 2010	Winter Storm	DR-1898	Yes	Storm total snow accumulation ranged from 15 to 20 inches
January 26, 2011	Heavy Snow	N/A	N/A	Snowfall totals up to 6 inches were observed in the southern half of the county
February 1-2, 2001	Winter Storm	N/A	N/A	Snow and sleet accumulation were around 1 to 2 inches
October 29, 2011	Heavy Snow	N/A	N/A	Snow accumulations ranged from 4 to 8 inches. There were more than a half-million (520,000) power outages state-wide at the height of the storm.
December 14–15, 2013	Winter Storm	N/A	N/A	Snow, sleet, and freezing rain/drizzle with over a quarter-inch of ice topping storm total snow accumulations between 3 and 6 inches. The mixed wintry precipitation adversely impacted travel, especially along the PA Turnpike and I-81 corridors.
February 3, 2014	Heavy Snow	N/A	N/A	Heavy snow accumulations ranged from 4 to 8 inches.
February 4–5, 2014	Winter Storm	N/A	N/A	Snow accumulations ranged from 1 to 2 inches. Ice accumulations from sleet and heavy freezing rain averaged between 0.25 and 0.50 inches.
February 13–14, 2014	Heavy Snow	N/A	N/A	Storm total snow accumulations ranged from 8 to 12 inches.
November 25–26, 2014	Heavy Snow	N/A	N/A	A high-impact snowfall of 3 to 6 inches fell across the county.
January 22-23, 2016	Winter Storm	DR-4267	Yes	Heavy snowfall amounts of 30.2 inches were observed across the county. A Halifax man suffered cardiac arrest and died while shoveling snow.
February 15–16, 2016	Winter Storm	N/A	N/A	A quarter of an inch or more of ice accumulation was observed across the county.
January 29 2017	Winter Storm	N/A	N/A	Select school closures throughout the county.
February 8–9, 2017	Winter Storm	N/A	N/A	A winter storm produced 4 to 8 inches of snow from south to north across Dauphin County. All schools in the county were closed.
March 13–14, 2017	Winter Storm	N/A	N/A	A winter storm produced 15-20 inches of snow across Dauphin County.
January 16, 2018	Winter Storm	N/A	N/A	Northern Dauphin County snowstorm and school closures.
February 17, 2018	Winter Storm	N/A	N/A	A winter storm produced 6 to 7 inches of snow in a 12-hour period across Dauphin County.
March 20–21, 2018	Winter Storm	N/A	N/A	A winter storm produced 10 to 15 inches of snow in a 24-hour period across Dauphin County
November 15–16, 2018	Winter Storm	N/A	N/A	A winter storm produced 6 to 10 inches of snow and sleet across Dauphin County.
February 11–12, 2019	Winter Storm	N/A	N/A	A winter storm produced 3 to 5 inches of snow and sleet, and greater than 0.25 of freezing rain across Dauphin County.
February 20–21, 2019	Winter Storm	N/A	N/A	A winter storm produced 4 to 6 inches of snow and sleet followed by greater than 0.25 of freezing rain across Dauphin County.
March 3–4, 2019	Winter Storm	N/A	N/A	A winter storm produced up to 6 inches of snow across Dauphin County.

Source: FEMA 2020, NOAA-NCEI 2020.

Notes:

Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, many monetary losses earlier than 2017 would be considerably higher in USDs as a result of increased U.S. Inflation Rates.

DR Federal Disaster Declaration NCEI National Centers for Environmental Information

FEMA Federal Emergency Management Agency
NOAA National Oceanic Atmospheric Administration
N/A Not applicable/available

4.3.19.4 Future Occurrence

Apparently, given the history of winter storm events that have impacted Dauphin County, future winter storm events of varying degrees will occur every year, and thus many people and properties are at risk from the winter storm hazard in the future.

Based on available historical data, future occurrences of winter storm events are considered likely, according to Risk Factor Methodology probability criteria (further discussed in Section 4.4).

4.3.19.5 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable within the identified hazard area. Regarding winter storm events, all of Dauphin 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 potentially vulnerable. The following section includes an evaluation and estimation of potential winter storm impacts on the county, including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impacts on life, health, and safety; general building stock; critical facilities; economy; environment; and future growth and development
- Effect of climate change on vulnerability
- Further data collections that will increase understanding of this hazard over time.

Overview of Vulnerability

In Dauphin County, winter storms are a concern because of frequency, associated direct and indirect costs, delays caused by the storms, and impacts on people and facilities of the region.

Data and Methodology

National weather databases, the 2018 Pennsylvania HMP, and local resources were referenced to acquire information about and analyze severe winter storm impacts on Dauphin County. Information from the 2018 U.S. Census data and the building inventory for Dauphin County supported an evaluation of exposed assets 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 and deceptively 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 storm. 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 2015c).

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 2015c).

For the purposes of this HMP, the entire population of Dauphin County is considered exposed to winter storm events (U.S. Census 2018). 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 HMP provides population statistics regarding 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 Dauphin County is exposed and vulnerable to the winter storm hazard. In general, structural impacts include damage to roofs and building frames rather than building content. Current modeling tools are not available to estimate specific losses from this hazard. As an alternate approach, this plan considers percentage damages that could result from winter storm conditions. Table 4.3.19-3 below summarizes percent damages from winter storm conditions on Dauphin County's total general building stock (structure only). Given professional knowledge and currently available information, potential losses from this hazard are considered overestimated; hence, the listed values in Table 4.3.19-3 represent conservative estimates of losses associated with severe winter storm events.

Table 4.3.19-3. General Building Stock Exposure and Estimated Losses from Winter Storm Events in Dauphin County

Jurisdiction	Number of Buildings	Total Replacement Cost Value	1-Percent of Total Replacement Cost Value	5-Percent of Total Replacement Cost Value	10-Percent of Total Replacement Cost Value
Berrysburg (B)	366	$131,114,498	$1,311,145	$6,555,725	$13,111,450
Conewago (T)	2,495	$1,131,218,434	$11,312,184	$56,560,922	$113,121,843
Dauphin (B)	456	$160,174,274	$1,601,743	$8,008,714	$16,017,427
Derry (T)	11,617	$13,980,976,171	$139,809,762	$699,048,809	$1,398,097,617
East Hanover (T)	5,054	$2,617,412,647	$26,174,126	$130,870,632	$261,741,265
Elizabethville (B)	949	$396,035,763	$3,960,358	$19,801,788	$39,603,576
Gratz (B)	715	$432,294,298	$4,322,943	$21,614,715	$43,229,430
Halifax (B)	469	$181,049,719	$1,810,497	$9,052,486	$18,104,972
Halifax (T)	3,457	$1,457,192,513	$14,571,925	$72,859,626	$145,719,251
Harrisburg (C)	18,718	$15,182,832,338	$151,828,323	$759,141,617	$1,518,283,234
Highspire (B)	1,374	$550,466,766	$5,504,668	$27,523,338	$55,046,677
Hummelstown (B)	2,337	$1,082,835,134	$10,828,351	$54,141,757	$108,283,513
Jackson (T)	2,371	$776,111,853	$7,761,119	$38,805,593	$77,611,185
Jefferson (T)	666	$230,110,295	$2,301,103	$11,505,515	$23,011,029
Londonderry (T)	5,080	$2,360,384,847	$23,603,848	$118,019,242	$236,038,485
Lower Paxton (T)	20,948	$14,635,453,846	$146,354,538	$731,772,692	$1,463,545,385
Lower Swatara (T)	4,771	$5,522,875,069	$55,228,751	$276,143,753	$552,287,507
Lykens (B)	1,322	$517,534,065	$5,175,341	$25,876,703	$51,753,406
Lykens (T)	2,155	$941,126,374	$9,411,264	$47,056,319	$94,112,637
Middle Paxton (T)	4,093	$1,462,655,724	$14,626,557	$73,132,786	$146,265,572
Middletown (B)	3,582	$1,981,507,138	$19,815,071	$99,075,357	$198,150,714
Mifflin (T)	1,125	$603,453,937	$6,034,539	$30,172,697	$60,345,394
Millersburg (B)	1,439	$770,504,424	$7,705,044	$38,525,221	$77,050,442
Paxtang (B)	869	$403,915,987	$4,039,160	$20,195,799	$40,391,599
Penbrook (B)	1525	$602,189,726	$6,021,897	$30,109,486	$60,218,973
Pillow (B)	301	$101,661,910	$1,016,619	$5,083,096	$10,166,191
Reed (T)	299	$117,139,877	$1,171,399	$5,856,994	$11,713,988
Royalton (B)	630	$196,935,626	$1,969,356	$9,846,781	$19,693,563

Jurisdiction	Number of Buildings	Total Replacement Cost Value	1-Percent of Total Replacement Cost Value	5-Percent of Total Replacement Cost Value	10-Percent of Total Replacement Cost Value
Rush (T)	343	$71,032,585	$710,326	$3,551,629	$7,103,259
South Hanover (T)	3,972	$1,935,844,099	$19,358,441	$96,792,205	$193,584,410
Steelton (B)	2,721	$2,111,932,612	$21,119,326	$105,596,631	$211,193,261
Susquehanna (T)	11,785	$8,633,889,539	$86,338,895	$431,694,477	$863,388,954
Swatara (T)	11,354	$8,581,237,561	$85,812,376	$429,061,878	$858,123,756
Upper Paxton (T)	3,560	$1,473,328,502	$14,733,285	$73,666,425	$147,332,850
Washington (T)	2,270	$1,106,223,564	$11,062,236	$55,311,178	$110,622,356
Wayne (T)	1,324	$398,741,088	$3,987,411	$19,937,054	$39,874,109
West Hanover (T)	6505	$3,228,343,376	$32,283,434	$161,417,169	$322,834,338
Wiconisco (T)	995	$297,597,257	$2,975,973	$14,879,863	$29,759,726
Williams (T)	957	$390,058,854	$3,900,589	$19,502,943	$39,005,885
Williamstown (B)	908	$345,185,743	$3,451,857	$17,259,287	$34,518,574
Dauphin County (Total)	**145,877**	**$97,100,578,032**	**$971,005,780**	**$4,855,028,902**	**$9,710,057,803**

Source: Dauphin County GIS 2020; RS Means 2020
Notes: B – Borough; C – City; T – Township; % - Percent

An area especially vulnerable to the winter storm hazard is the floodplain. At-risk building stock and infrastructure in floodplains are presented in the flood hazard profile (Section 4.3.6). Generally, losses from flooding associated with winter storms should be less than those associated with a 1 percent or 0.2 percent flood. Snow and ice melt can cause both riverine and urban flooding. Estimated losses caused by riverine flooding in the county are discussed in Section 4.3.6.

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, these 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 removals, as well as repairs of roads undergoing freeze/thaw cycles, can drain local financial resources. Potential secondary impacts from winter storms also impact 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 build-up, and/or high winds, which can break limbs and down large trees. Indirect effects of winter storms include possible damage to surfaces and contamination of 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 recharges groundwater. However, abrupt high temperatures following a heavy snowfall can accelerate snowmelt, leading to 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 to 10 years have been identified across the county at the municipal level and are further discussed in Section 2.4 of this HMP. Because Dauphin County in its entirety has been identified as the hazard area vulnerable to the winter storm hazard, any new development will be exposed to associated 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 potentially can alter prevalence and severity of weather extremes such as winter storms. While predicting changes in winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment.

The climate of Pennsylvania has changed in several ways. Over the past 100 years, annual average temperatures have been rising across the Commonwealth. 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 decrease in snow and increase in rain during the winter months. Projections regarding future occurrences of extra-tropical cyclones in Pennsylvania are substantially 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 ways in which 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 of concern. 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 2015a). Acquisition of additional/actual valuation data regarding general building stock and critical infrastructure losses would further support future estimates of potential exposure of and damage to the general building stock inventory.