4.3.5 Hailstorm

This section provides a profile and vulnerability assessment for the hailstorm hazard. Hailstorms occur when ice crystals form within a low pressure front due to the rapid rise of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation in the form of balls or irregularly shaped masses of ice greater than 0.75 inches in diameter (i.e., hailstones) (FEMA, 1997). The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface.

4.3.5.1 Location and Extent

Hail precipitation is often produced at the front of a severe thunderstorm system. Hailstorms are not limited to any particular geographic area of the Lehigh Valley. Neither the duration of the storm nor the extent of area affected by such an occurrence can be predicted.

4.3.5.2 Range of Magnitude

Hail can vary in size from less than an inch to several inches in diameter, and can cause significant damage to crops and property. Damage is dependent on the size, duration, and intensity of hail precipitation. Those who do not seek shelter could face serious injury. Automobiles and aircraft are particularly susceptible to damage. Since hail precipitation usually occurs during thunderstorm events, the impacts of other hazards associated with thunderstorms (i.e. strong winds, intense precipitation, lightning, etc.) often occur simultaneously.

Based on reports from the National Climatic Data Center (NCDC), the Lehigh Valley's worst hailstorm incident occurred in 2007, when $250,000 in damages were claimed due to hailstorms. Hail as large as two-inches in diameter fell across the central and southern parts of Northampton County on August 17th, reaching as far as Williams Township. Half dollar size hail fell in the City of Bethlehem. Penny-size hail fell in Nazareth Borough, and other reports indicated the presence of hail in Lehigh County. The thunderstorms which precipitated the hail moved across Pennsylvania and New Jersey during the afternoon and the evening of August 17th.

4.3.5.3 Past Occurrence

The NCDC report contains references to hail as a reported storm incident in the Lehigh Valley from 1950 to 2011, as shown in Table 4.3.5-1 below. Seventy-six separate reports were issued throughout the Lehigh Valley in this time period. Some reports represented different times of day or different localities in regards to the same storm. According to these reports, the Lehigh Valley has experienced hail ranging in size from 0.75" to 2.5" in diameter, with property damage from two separate events totaling $350,000 and crop damage from one event amounting to $50,000. No deaths or injuries have been recorded due to hail in the Lehigh Valley.

Table 4.3.5-1. History of Hailstorms in the Lehigh Valley

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Lehigh County						
Lehigh County	5/24/1962	1.25	0	0	0	0
Lehigh County	4/30/1984	1.00	0	0	0	0
Lehigh County	6/16/1985	1.00	0	0	0	0
Lehigh County	6/16/1985	1.00	0	0	0	0
Lehigh County	6/24/1985	1.75	0	0	0	0
Lehigh County	6/24/1985	1.75	0	0	0	0
Lehigh County	8/2/1986	1.00	0	0	0	0
Lehigh County	8/2/1986	1.75	0	0	0	0
Lehigh County	7/17/1988	0.75	0	0	0	0
Lehigh County	7/5/1990	0.75	0	0	0	0
Lehigh County	7/5/1990	0.75	0	0	0	0
Slatedale	6/4/1996	0.75	0	0	0	0
Bethlehem	7/1/2001	0.75	0	0	0	0
Macungie	5/15/2004	0.75	0	0	0	0
Schnecksville	4/24/2006	0.75	0	0	0	0
Schnecksville	5/26/2006	0.75	0	0	0	0
Bethlehem	7/18/2006	1.25	0	0	0	0
New Smithville, Weisenberg (T)	5/31/2007	0.75	0	0	0	0
Bethlehem	8/17/2007	0.75	0	0	0	0
Bethlehem	8/17/2007	2.00	0	0	250,000	0
Breinigsville	6/10/2008	1.00	0	0	0	0
Catasauqua	6/10/2008	1.00	0	0	0	0
Allentown	7/17/2008	0.88	0	0	0	0
Allentown	8/10/2008	1.00	0	0	0	0
Lyon Vly, Lowhill (T)	8/10/2008	1.00	0	0	0	0
East Texas	3/29/2009	0.88	0	0	0	0
Catasauqua	3/29/2009	1.00	0	0	0	0
Coffeetown, North Whitehall (T)	3/29/2009	1.00	0	0	0	0
Macungie Knepper Arp	3/29/2009	1.75	0	0	0	0
Dillingersville, Lower Milford (T)	6/15/2009	0.88	0	0	0	50,000
Allentown	6/15/2009	1.00	0	0	0	0
Schnecksville	5/14/2010	1.75	0	0	0	0
Allentown	5/14/2010	1.75	0	0	0	0
New Tripoli	5/14/2010	2.50	0	0	0	0

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Fogelsville	5/14/2010	2.50	0	0	100,000	0
Fogelsville	5/27/2010	0.88	0	0	0	0
Germansville	5/27/2010	1.00	0	0	0	0
Slatington	7/21/2010	1.00	0	0	0	0
Allentown	9/22/2010	0.75	0	0	0	0
Fogelsville	5/15/2011	0.88	0	0	0	0
Breinigsville	5/19/2011	0.75	0	0	0	0
Edgemont	5/26/2011	1.00	0	0	0	0
Allentown	6/1/2011	0.75	0	0	0	0
Bethlehem	6/1/2011	0.75	0	0	0	0
Lehigh County Total	***N/A***	***N/A***	***0***	***0***	***$350,000***	***$50,000***
Northampton County						
Northampton County	7/3/1975	0.75	0	0	0	0
Northampton County	6/16/1985	1.00	0	0	0	0
Northampton County	6/16/1985	1.00	0	0	0	0
Northampton County	6/24/1985	1.75	0	0	0	0
Northampton County	7/29/1986	1.00	0	0	0	0
Northampton County	7/29/1986	1.75	0	0	0	0
Northampton County	8/2/1986	1.75	0	0	0	0
Northampton County	7/9/1990	1.75	0	0	0	0
Northampton County	6/7/1992	1.75	0	0	0	0
Wind Gap	7/18/1997	1.00	0	0	0	0
Chapman	9/2/1998	0.75	0	0	0	0
Walnutport	6/7/1999	0.88	0	0	0	0
Easton	5/24/2000	0.75	0	0	0	0
Tatamy	5/24/2000	1.00	0	0	0	0
Easton	5/24/2000	1.00	0	0	0	0
Glendon	5/24/2000	1.25	0	0	0	0
Glendon	5/29/2001	0.75	0	0	0	0
Zucksville, Forks (T)	8/2/2002	0.88	0	0	0	0
Palmer Hgts	7/9/2006	0.88	0	0	0	0
Cherryville, Lehigh (T)	8/17/2007	0.88	0	0	0	0
Nazareth	8/17/2007	1.00	0	0	0	0
Martins Creek, Lower Mt.	8/2/2008	0.75	0	0	0	0

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Bethel (T)						
Berlinsville, Lehigh (T)	8/13/2008	0.88	0	0	0	0
Farmersville, Bethlehem (T)	5/23/2009	1.00	0	0	0	0
Walnutport	6/15/2009	1.75	0	0	0	0
Bath	6/30/2009	0.88	0	0	0	0
Ulhers, Forks (T)	7/17/2009	1.00	0	0	0	0
Glendon	5/27/2010	1.75	0	0	0	0
Nazareth	9/13/2010	0.75	0	0	0	0
Ulhers, Forks (T)	5/19/2011	0.75	0	0	0	0
Farmersville, Bethlehem (T)	6/1/2011	1.00	0	0	0	0
Northampton County Total	***N/A***	***N/A***	***0***	***0***	***$0***	***$0***

Source: National Climatic Data Center, 2010
Note: T – Township; N/A – not applicable

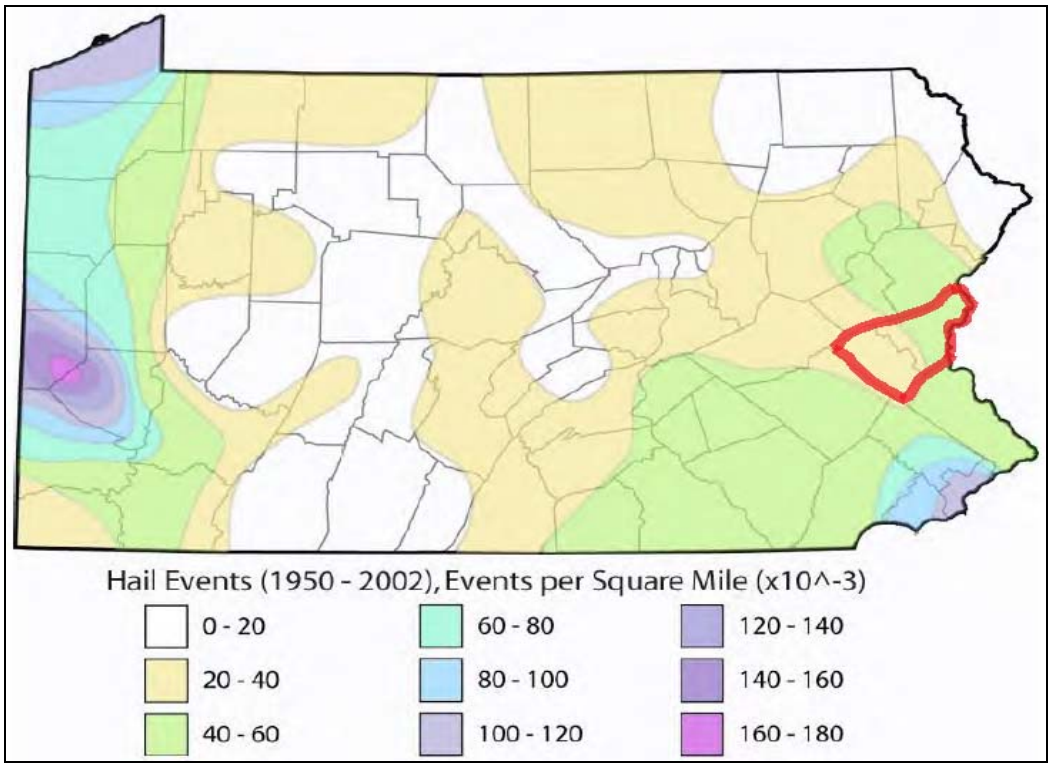
According to the U.S. Department of Agriculture Risk Management Agency, hailstorm events between 1950 and 2011 have resulted in $13,772 in crop insurance claims (NCDC, 2012). There have been no reported crop insurance claims due to hail in the Valley during 16 of the last 23 years.

The Commonwealth of Pennsylvania 2010 All-Hazard Mitigation Plan (PA HMP) states that approximately 96% of hailstorm events throughout the Commonwealth occurred during the months of April, May, June, July, August, and September. In addition, approximately 87% of historic hailstorm events have occurred during the afternoon (noon to 5 pm) or evening (5 pm to 9 pm) hours. Both of these results are consistent with historical hailstorm reports from the Lehigh Valley, and the relationship between hail and thunderstorms.

4.3.5.4 Future Occurrence

It is not possible to predict the formation of a hailstorm with more than a few days' lead time. The past occurrences described above, however, indicate that hailstorm events in the Lehigh Valley will occur every year throughout the months of April and August. Using events collected state-wide between 1950 and 2002, Figure 4.3.5-1 below shows the number of hail events per square mile across Pennsylvania. Based on this historical data, the east and northeast sections of Northampton County can expect to experience a higher number of hailstorm events compared to other areas in the Lehigh Valley. The Lehigh Valley as a whole has experienced significantly fewer hailstorm events per square mile than areas in the western and southeastern parts of Pennsylvania.

Figure 4.3.5-1. Hail Events Per Square Mile in Pennsylvania



Source: PEMA, 2010
Note: The red highlight indicates the location of the Lehigh Valley

The future occurrence of hailstorms can be considered *likely* as defined by the Risk Factor Methodology probability criteria (refer to Section 4.4).

4.3.5.5 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For hail events, the entire Lehigh Valley has been identified as the hazard area. Therefore, all assets in the Lehigh Valley (population, structures, critical facilities and lifelines), as described in the Regional Profile section, are vulnerable. The following text evaluates and estimates the potential impact of hailstorms on the Lehigh Valley including:

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

4.3.5.5.1 Overview of Vulnerability

The entire Lehigh Valley, including all critical infrastructure, is vulnerable to the effects of hail, as the storm cells that produce this hazard can develop over any part of the region. The area of damage due to

these storms is relatively small, since a single storm does not cause widespread devastation, but it may cause damage in a focused area.

As a hazard, hail can cause serious damage to automobiles, aircraft, skylights, livestock, and crops. Areas of the Lehigh Valley with large amounts of farmland and high agricultural yields are more likely to be affected by hailstorm hazards. Most notably, corn and soybean crops can be damaged to the point of total loss, especially if an event occurs later in the growing season (PEMA, 2010).

4.3.5.5.2 Data and Methodology

National weather databases, the PA HMP, and local resources were used to collect and analyze hazard impacts on the Lehigh Valley.

4.3.5.5.3 Impact on Life, Health and Safety

The entire population of the Lehigh Valley is considered exposed to the hail hazard. People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to the hazard. This is because there is little to no warning and shelter may not be available. Moving to a lower risk location will decrease a person's vulnerability.

4.3.5.5.4 Impact on General Building Stock, Critical Facilities and the Economy

Hailstorms primarily affect agricultural products. The facilities that are most vulnerable to hailstorm threats are those that are food and agriculture-related. These food and agricultural critical facilities are both food producers and food manufacturers. These facilities are located in both urban and rural areas and would be directly or indirectly impacted by a hailstorm event. According to the State HMP, Lehigh and Northampton Counties each have one food/agricultural state facility within their borders, as compared to Lancaster County, with 17 state food/agricultural facilities (the most of any Pennsylvania county).

As discussed earlier in the Past Occurrence subsection, historical hailstorm property damage has totaled $350,000 and crop damage to $50,000 in the Lehigh Valley. Jurisdictional loss estimation stems from lost agricultural revenues throughout the Lehigh Valley. The USDA Census of Agriculture enumerates farmland acreage by county as well as the annual market value of all agricultural products sold by county, from 2007. As shown in Table 4.3.5-2 below, if a hailstorm were to eliminate the entire agricultural yield from both counties in Lehigh Valley, total losses could top $100 million.

Table 4.3.5-2. Estimated Jurisdictional Losses Relating to Agricultural Production (USDA Census of Agriculture 2007)

Location	Potential Impacted Farmland Acreage	Market Value of all Agricultural Products
Lehigh County	84,643	$72,059,000
Northampton County	68,252	$31,762,000

Source: PEMA, 2010

4.3.5.5.5 Future Growth and Development

Areas targeted for potential future growth and development in the next five (5) to ten (10) years have been identified across the Lehigh Valley at the municipal level. Refer to the jurisdictional annexes in Volume II of this Plan. Table B.1 in each jurisdictional annex lists the location of the potential new development and its exposure (if any) to known hazard zones. Any areas of growth could be potentially impacted by the hailstorm hazard because the entire region is exposed and vulnerable.

4.3.5.5.6 Effect of Climate Change on Vulnerability

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

Pennsylvania's Department of Environmental Protection was directed by the Climate Change Act (Act 70 of 2008) to initiate a study of the potential impacts of global climate change on the Commonwealth. The June 2009 Pennsylvania Climate Impact Assessment's main findings indicate it is very likely that Pennsylvania will experience increased temperatures in the 21st century. An increase in the variability of temperature and precipitation may very well lead to increased frequency and/or severity of hailstorm events. Future improvements in modeling smaller scale climatic processes such as thunderstorms and associated hailstorms can be expected and will lead to improved understanding of how the changing climate will alter storms, such as hailstorm events, in Pennsylvania (Shortle et. al, 2009).

4.3.5.5.7 Additional Data and Next Steps

The assessment above identifies vulnerable populations and potential structural and economic losses associated with this hazard of concern. The collection of additional/actual loss data specific to the Plan participants will further enhance the Lehigh Valley's vulnerability assessment.