LEHIGH VALLEY HAZARD MITIGATION PLAN

The Lehigh Valley Multi-Jurisdictional Hazard Mitigation Plan update has been financed through the Pre-Disaster Mitigation (PDM) Program, under the Robert T. Stafford Disaster Assistance and Emergency Relief Act. This program funds governments and communities for hazard mitigation planning prior to a disaster event. Funding these plans and projects reduces overall risks to the population and structures, while also reducing reliance on funding from actual disaster declarations. Based upon the provisions of the grant agreement with the Pennsylvania Emergency Management Agency (PEMA) and Federal Emergency Management Agency (FEMA), Lehigh and Northampton County also provided funding for this project.

Federal Emergency Management Agency Approval Pending Adoption October 10, 2018

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

In the five years since the Lehigh Valley updated its Hazard Mitigation Plan, there hasn't been the kind of devastating floods that forced hundreds of people from their homes and businesses like the ones in 2004, 2005 and 2006. Or the kind of 80 mile per hour winds that left nearly 200,000 structures without power for days after Hurricane Sandy hit in 2012.

However, the lessons learned during those events and countless others in the history of this region now help us take steps to prepare before the next disaster hits.

The Lehigh Valley drafted hazard mitigation plans in 2006 and 2013, and federal regulation requires that plans be updated every five years, but perhaps more importantly, the effects of climate and cultural changes, and emerging hazards require that we evolve our methods of preparing for disaster.

The *Lehigh Valley Hazard Mitigation Plan* reflects that evolution.

Both counties and all 62 Lehigh Valley municipalities agreed to participate in the Plan.

Together, they've proposed 1,161 actions designed to lessen the impact of future hazards.

The Plan still addresses the 22 natural and non-natural hazards that were covered in the previous plan. Hurricanes, sinkholes, winter storms and drought remain serious risks, and flooding is still the number one threat to communities across the region. However, three new hazards have been added to combat changes in a region that is growing in population by more than 5,000 residents per year. Like much of the nation, the Lehigh Valley is dealing with a drug overdose crisis that claimed the lives of 193 Lehigh Valley residents in 2016. Therefore, the new Drug Overdose Crisis hazard includes actions designed to save lives and prevent addiction.

Invasive Species was added as a hazard to help people deal with the growing damage caused by the arrival of the Spotted Lanternfly, Emerald Ash Borer, Hemlock Woolly Adelgid, Gypsy Moth and Asian Tiger Mosquito.

Pandemic and Infectious Disease was also added as a hazard for the first time. Thousands of people who fled to the Lehigh Valley from hurricane-ravaged Puerto Rico last fall prompted us to consider population evacuation strategies in hazards where it applies.

The goals of this Plan reach to the core of the life and death struggles that accompany most disasters. They include minimizing the risk to life and property, enhancing the resiliency benefits of our natural resources, improving planning and emergency response to protect public health and safety, raising public awareness, and promoting hazard avoidance, particularly in floodplains.

MITIGATION GOALS

1. **To minimize the risk to human life associated with natural and non-natural hazards.**
2. **To promote hazard avoidance, especially in floodplains.**
3. **To reduce the damages and fuctional loss from natural and non-natural hazards to existing and future public and private assets, including structures, critical facilities and infrastructure.**
4. **To preserve and enhance the effectiveness of natural resources, including woodlands, streams, rivers, wetlands, floodplains and riparian buffers to provide resiliency benefits.**
5. **To develop, prioritize and implement cost-effective, long-term actions that will reduce the impacts of natural and non-natural hazards.**
6. **To improve local regulations to reduce the impacts of natural and non-natural hazards.**
7. **To enhance planning and emergency response efforts among federal, state, county and local emergency management personnel to protect public health and safety.**
8. **To promote public awareness on both the potential impacts of natural and non-natural hazards and actions to reduce those impacts.**

Hazard mitigation priorities for the region moving forward include:

- Integrating hazard mitigation into municipal and county plans, especially related to infrastructure and capital improvement programs.
- Identifying hazard mitigation project funding opportunities and giving communities the tools to compete for it.
- Improving outreach to the public and business community.
- Helping municipalities implement the Community Rating System designed to lower their flood insurance costs.
- Committing to annual monitoring and updating of the Plan to ensure its effectiveness.

Keeping that focus is important, not only for the obvious reasons of helping to insulate residents from the pain that comes from natural and non-natural hazards, but because, for local communities to have access to federal hazard mitigation funding, they have to both participate in and adopt the Plan.

The months since the Plan kick-off meeting have revealed the kind of teamwork needed to cover a 726-square-mile region with a diverse topography that includes mountains and waterways that wrap around a robust transportation network and a population of 659,312 people. All 62 municipalities agreed to participate, all 62 municipalities offered data used to build the plan, and together they've devised more than 1,000 actions designed to protect the community. Every city, borough and township has designed strategies to prepare for rising waters in a region that includes 71 miles of rivers and 1,000 miles of streams.

In the coming years, this Plan will allow municipalities to apply for federal aid to relocate or remove homes and businesses that have been repeatedly flooded. They'll be eligible to apply for grants to buy back-up generators to keep essential services running during emergencies, and virtually all communities are proposing actions to enhance education and community outreach.

In the coming months, every municipality in the region will be asked to adopt this Plan, and every year they'll be expected to make progress on the many actions they've proposed to help protect their residents. Fighting the impacts of hurricanes, floods and drug overdose isn't something we can do by thinking about it every five years. This Plan's purpose is to make hazard mitigation planning part of every community's everyday routine.

In the end, it is everyone's shared responsibility—from municipal leaders to emergency management professionals to private developers and citizens—to implement the Plan to saves lives, property and the environment.

1. INTRODUCTION

1.1 BACKGROUND

Preparing before a disaster strikes can save lives, lessen property damage and enable communities to recover more quickly from a disaster or emergency.

That focus is at the heart of the federal Disaster Mitigation Act of 2000 and is the basis for the *Lehigh Valley Hazard Mitigation Plan*, which covers Lehigh and Northampton counties and the 62 municipalities that make up the Lehigh Valley.

The Lehigh County Emergency Management Agency and the Northampton County Emergency Management Services, in partnership with the LVPC, have led the effort to develop a regionwide commitment to that focus.

Hazard mitigation is any sustained action taken to reduce or eliminate the long-term risk to life and property from 25 hazards such as floods, winter storms and drug overdose.

Across the United States, natural and non-natural disasters have led to increasing levels of deaths, injuries, property damage and interruption of business and government services. The time, money and effort needed to recover from these disasters exhausts resources, diverting attention from important public programs and private agendas. Since 1955, there have been 59 presidential disaster declarations and emergency declarations in Pennsylvania, 23 of which have affected the Lehigh Valley. The emergency management professionals, citizens, elected officials and other stakeholders in the region recognize the impact of disasters on their community and support proactive efforts needed to reduce the impact of natural and non-natural hazards.

$16

Amount FEMA estimates is saved for every community dollar spent on damage prevention through avoided post-disaster damage repair.

Beyond those benefits, hazard mitigation helps planning and municipal leaders better manage land use, environmental resources and population to help lessen the effects of disaster.

The Federal Emergency Management Agency (FEMA) and the Pennsylvania Emergency Management Agency (PEMA) have issued guidelines for how hazard mitigation plans should be developed, and those guides provided the foundation for how this Plan was built. Specifically, federal regulations require that local governments update the Plan every five years, while monitoring and evaluating the data, events and actions that make up the Plan.

For this multi-jurisdictional *Lehigh Valley Hazard Mitigation Plan,* the Lehigh County Emergency Management Agency and Northampton County Emergency Management Services worked in partnership with the Lehigh Valley Planning Commission to craft a plan that protects residents in every municipality in both counties. All 62 municipalities joined that partnership along with dozens of community stakeholders. The *Hazard Mitigation Plan* is the third for the region, updating plans adopted in 2006 and 2013.

1.2 PURPOSE

The purpose of the Lehigh Valley Hazard Mitigation Plan is to reduce the loss of life, property and resources caused by natural and non-natural hazards. This Plan is designed to achieve:

- An increased understanding of hazards faced in the Lehigh Valley by local governments, stakeholders and the general public.
- A more sustainable, disaster-resistant and resilient community.
- Financial savings through partnerships that support planning and mitigation efforts.
- Focused use of limited resources on hazards that have the biggest impact on the community.
- A blueprint for reducing property and infrastructure damage and saving lives from the effects of future disasters.
- Making county and local municipalities eligible for pre-disaster and post-disaster grant funding.
- Commitment for monitoring and updating the Plan.

1.3 SCOPE

The *Lehigh Valley Hazard Mitigation Plan* serves as a tool to help save lives and protect the economic vitality of every community in Lehigh and Northampton counties. Designed to be continuously monitored, evaluated and updated as circumstances change and communities work to become more resilient, the Plan is built on community outreach and input. Public outreach to governments and stakeholders during the planning process included the clear message that participation is required to be eligible for federal or state mitigation funding.

1.4 AUTHORITY AND REFERENCE

Authority for this document originates from the following federal sources:

- Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 U.S.C., Section 322, as amended.
- Disaster Mitigation Act of 2000, Public Law 106-390, as amended.
- Code of Federal Regulations (CFR), Title 44, Parts 201 and 206.
- National Flood Insurance Act of 1968, as amended, 42 U.S.C. 4001 et seq.

Authority for this document originates from the following Pennsylvania sources:

- Pennsylvania Emergency Management Services Code. Title 35, Pa. C.S. Section 101.
- Pennsylvania Municipalities Planning Code of 1968, Act 247, as reenacted and amended.
- Pennsylvania Stormwater Management Act of October 4, 1978. P.L. 864, No 167.

The following PEMA and FEMA guides and reference documents were used to prepare this Plan:

- PEMA All-Hazard Mitigation Planning Standard Operating Guide, October 2013.
- PEMA Do It Yourself Hazard Mitigation Plan Update, 2017.
- PEMA Hazard Mitigation Planning Made Easy, 2007.
- PEMA Mitigation Ideas: Potential Mitigation Measures by Hazard Type; a Mitigation Planning Tool for Communities, March 2009.
- FEMA Hazard Mitigation Assistance Guidance, February 2015.
- FEMA Mitigation Ideas: A Resource for Reducing Risk to Natural Hazards, January 2013.
- FEMA Local Mitigation Plan Review Guide, October 2011.
- FEMA Plan Integration: Linking Local Planning Efforts, July 2015.
- FEMA Local Mitigation Planning Handbook, March 2013.

2. COMMUNITY PROFILE

2.1 GEOGRAPHY AND ENVIRONMENT

Geographical Location

The Lehigh Valley region is comprised of two counties, Lehigh and Northampton, which together measure about 726 square miles. The region is located in the central eastern portion of the Commonwealth about 65 miles north of Philadelphia, 90 miles west of New York City and within 350 miles of 46 other metropolitan areas of the Northeastern and Mid-Atlantic United States.

The Lehigh Valley contains 62 incorporated municipalities. In addition to the cities of Allentown, Bethlehem and Easton, there are 27 boroughs and 32 townships. The two counties form the core of a metropolitan area defined by the Bureau of the Census as the Allentown–Bethlehem–Easton Metropolitan Statistical Area, which is the 3rd largest metropolitan area in Pennsylvania. The location of the Lehigh Valley is shown in Figure 2.1.1.

A Growing Region

Population is expected to grow by more than 5,000 per year

647,232
in 2010

690,374
in 2020

760,326
in 2030

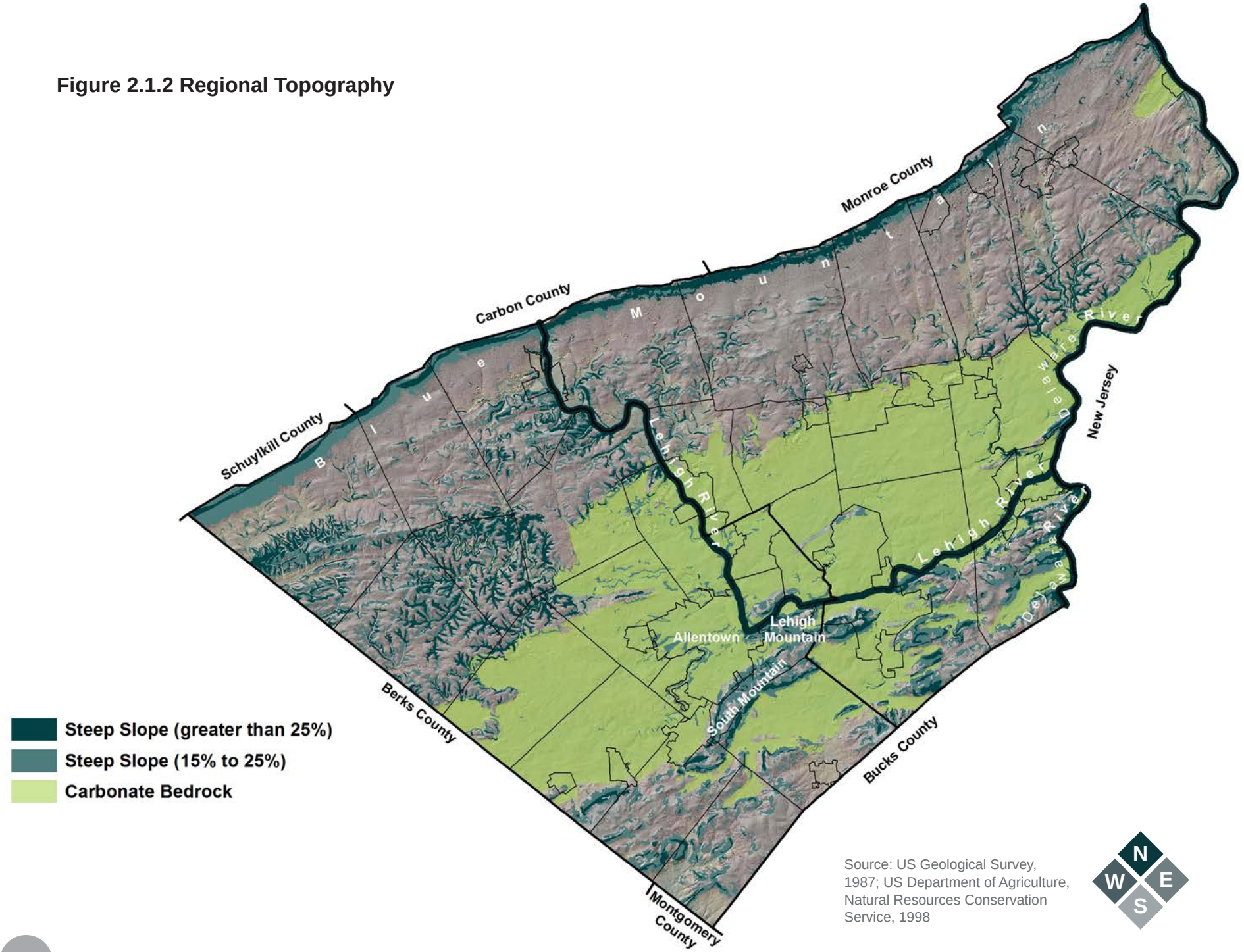
813,187
in 2040

Figure 2.1.1 Lehigh Valley Location

Topography

The Blue Mountain forms the northern boundary of the Lehigh Valley and extends southwest to the Maryland border. To the south, Lehigh Mountain and South Mountain are two landmark ridges located on the southern border of Allentown. The Delaware River serves as the Lehigh Valley's eastern boundary, while to the west, the valley plain breaks into low, rolling hills, which rise to form a divide between lands drained by the Lehigh and Schuylkill rivers. Between Blue Mountain and South Mountain is a seven-mile wide limestone valley where most people in the Lehigh Valley live and work. Elevations vary from 200 feet above mean sea level along some parts of the Lehigh and Delaware rivers to greater than 1,695 feet above mean sea level on Blue Mountain and 1,042 feet on South Mountain. There are large areas of steep slope in townships along the northern and southern borders of Lehigh and Northampton counties, with the steepest slopes and the greatest concentration of steep slopes found on Blue Mountain and South Mountain. The region's topography is shown in Figure 2.1.2.

Figure 2.1.2 Regional Topography



Source: US Geological Survey, 1987; US Department of Agriculture, Natural Resources Conservation Service, 1998

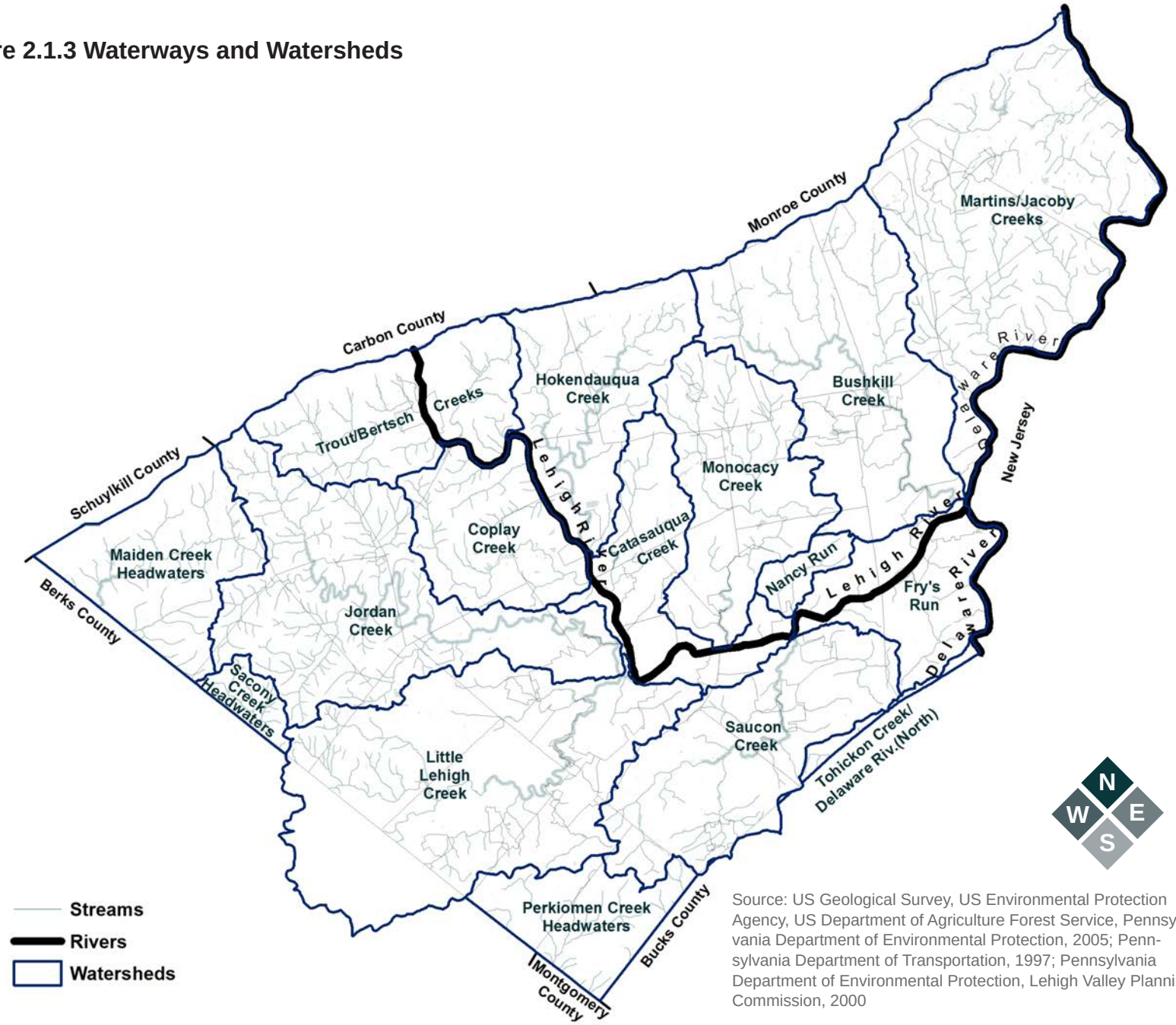
Hydrography and Hydrology

Two major rivers, the Lehigh and Delaware, and 1,000 miles of streams flow through the region. Major tributary streams flowing into the Lehigh River are Jordan Creek, Little Lehigh Creek, Hokendauqua Creek, Monocacy Creek and Saucon Creek. Bushkill Creek and Martins Creek flow directly into the Delaware River. The entire Lehigh Valley lies within the Delaware River Basin, which drains an area of 13,539 square miles in the states of Pennsylvania, New York, New Jersey and Delaware. Within the Lehigh Valley, there are 16 watersheds:

- Three tributaries to the Schuylkill River in the western parts of Lehigh County: Maiden Creek Headwaters, Perkiomen Creek Headwaters and Sacony Creek Headwaters
- Nine tributaries to the Lehigh River: Trout/Bertsch Creeks, Coplay Creek, Jordan Creek, Little Lehigh Creek, Saucon Creek, Hokendauqua Creek, Catasauqua Creek, Nancy Run and Monocacy Creek
- Four tributaries to the Delaware River: Martins/Jacoby Creeks, Bushkill Creek, Fry's Run and Tohickon Creek

In addition, there are areas that drain directly to the Lehigh and Delaware rivers that do not enter a named stream. The region's rivers, streams and watersheds are shown on Figure 2.1.3.

Figure 2.1.3 Waterways and Watersheds



Source: US Geological Survey, US Environmental Protection Agency, US Department of Agriculture Forest Service, Pennsylvania Department of Environmental Protection, 2005; Pennsylvania Department of Transportation, 1997; Pennsylvania Department of Environmental Protection, Lehigh Valley Planning Commission, 2000

Geology

From the perspective of hazard mitigation planning, the most significant geologic feature in the Lehigh Valley is the carbonate bedrock (limestone and dolomite) that underlies nearly all of the urban development areas. In Lehigh and Northampton counties, 47 of the 62 municipalities are underlain entirely or in part by carbonate rock. These carbonate formations provide the primary raw material for the local cement industry, and they lie under the most fertile soils. Carbonate rock has the potential for sinkhole formation, which is fairly common in the Lehigh Valley.

Climate

The area enjoys a moderate climate, with an annual average temperature of about 51 degrees Fahrenheit. Temperatures are rarely above 100 degrees or below 0 degrees Fahrenheit. Precipitation is generally ample and dependable. The growing season is 170 to 185 days.

2.2 COMMUNITY FACTS

Before the arrival of European settlers, the Lehigh Valley was inhabited by the Delaware/Lenape tribes who hunted the bear, fish and other wildlife thriving in the natural environment. In the 1730s, Scotch-Irish and German settlers began the agricultural development of the Lehigh Valley. Early industry in Lehigh County consisted primarily of agriculture and small-scale, water-powered grist mills, served by a network of roads and covered bridges.

Local entrepreneurs constructed the Lehigh Canal in 1818-1820 to capitalize on the Lehigh Valley's strategic location between the Pennsylvania Coal Region to the north and the major commercial ports of New York and Philadelphia. By 1855, the canal was supplemented and quickly supplanted by the Lehigh Valley Railroad.

In the late 19th century, the mining of iron ore fueled the rise of iron and steel production along the banks of the Lehigh River at Catasauqua, Allentown and, most notably, Bethlehem. The discovery of significant limestone deposits also launched the Lehigh Valley's cement industry, while the northern Lehigh Valley developed into a major center for slate production. The silk-weaving industry thrived into the early 20th century. As the weaving industry began to sunset locally, the region's heavy manufacturing grew, and in 1905, Mack Trucks relocated its truck-building operation from Brooklyn to the City of Allentown.

In the decades after World War II, the Lehigh Valley experienced growth trends that were similar to those in other metropolitan areas throughout the country. Construction of Routes 22 and 378, as well as a new terminal building for the Lehigh Valley International Airport, spurred the region's post-war suburban expansion, particularly in the townships surrounding the region's three cities.

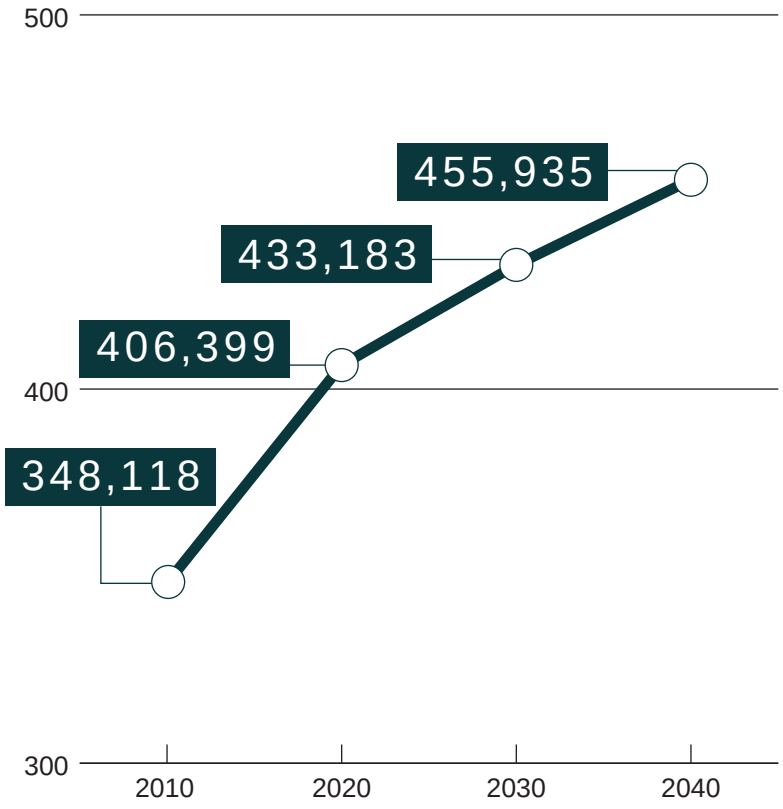
Economy

Total employment in the Lehigh Valley for 2016 was 386,669, and the LVPC forecasts a 31% increase in jobs in the Lehigh Valley between 2010 and 2040 as shown in Figure 2.2.1. In 2016, the average unemployment rate in the Lehigh Valley was 5.4%, compared to a statewide average of 5.4% and a national average of 4.9%. The region's median income of roughly $58,500 is higher than the state and national medians. The average median household income for 2012-2016 was $57,685 in Lehigh County and $62,753 in Northampton County.

As the labor market has become more service-oriented than goods-producing, sectors like finance, insurance, real estate and business management have become increasingly important to regional employment and economy. Nearly 60,000 people work in the region's healthcare industry, making it the Lehigh Valley's largest employment sector. Manufacturing, which is the largest contributor to the Lehigh Valley's $27 billion gross domestic product, employs more than 30,000 people. Products manufactured in the region include food and beverages, metal fittings and industrial components, medical supplies, apparel and trucks.

Sources: PA Department of Labor & Industry Center for Workforce Information & Analysis; US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates; Bureau of Economic Analysis; REMI, LVPC.

Figure 2.2.1 Employment Projections



In Thousands
Source: REMI 2014 and LVPC 2017

2.3 POPULATION AND DEMOGRAPHICS

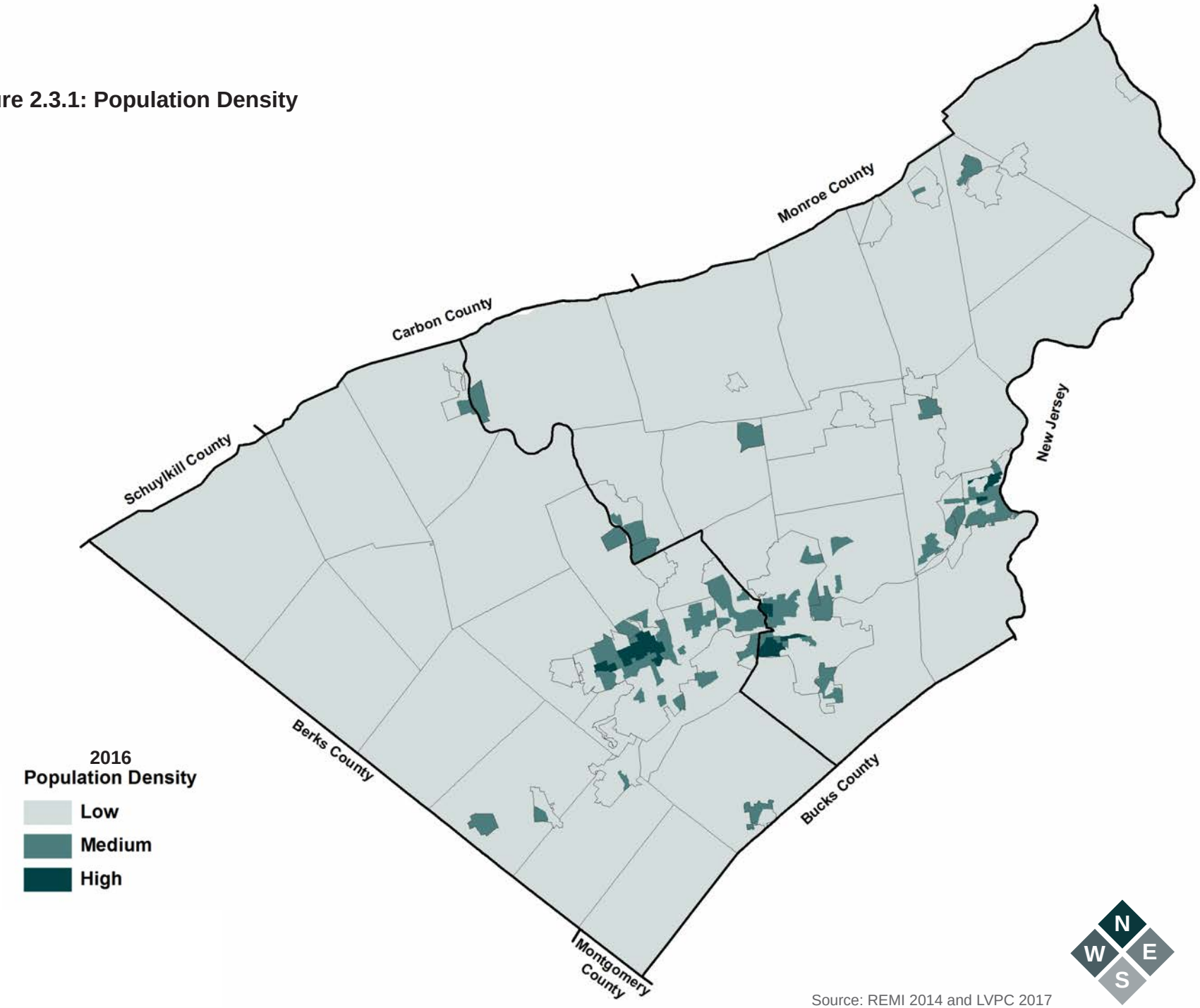
Population and Density

The total population of the Lehigh Valley in 2016 was 659,312. The City of Allentown's estimated 119,624 residents easily make it the Lehigh Valley's most populous municipality and the third largest city in Pennsylvania. Chapman Borough is the region's least populated municipality with 178 people.

The Lehigh Valley has 909 people per square mile, with the region's cities and boroughs generally having the highest population density. The City of Allentown is the densest municipality at 6,637 people per square mile. The region's rural townships have the lowest population densities, with Lynn Township being the least dense at 103 people per square mile. The region's population density is shown in Figure 2.3.1 and Table 2.3.1.

Source: US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates.

Figure 2.3.1: Population Density



Source: REMI 2014 and LVPC 2017

Table 2.3.1 Population and Density Statistics

Lehigh County	2010 Population	2016 Population	Population Change, 2010-2016	2016 Population Density (Pop/Sq. Mile)
Alburtis Borough	2,361	2,454	3.9%	3,444
Allentown, City of	118,032	119,624	1.3%	6,637
Bethlehem, City of	19,343	19,642	1.5%	3,874
Catasauqua Borough	6,436	6,509	1.1%	4,884
Coopersburg Borough	2,386	2,402	0.7%	2,566
Coplay Borough	3,192	3,232	1.3%	5,158
Emmaus Borough	11,211	11,363	1.4%	3,920
Fountain Hill Borough	4,597	4,634	0.8%	6,102
Hanover Township	1,571	1,716	9.2%	402
Heidelberg Township	3,416	3,480	1.9%	141
Lower Macungie Township	30,633	31,662	3.4%	1,410
Lower Milford Township	3,775	3,864	2.4%	196
Lowhill Township	2,173	2,112	-2.8%	150
Lynn Township	4,229	4,314	2.0%	103
Macungie Borough	3,074	3,115	1.3%	3,154
North Whitehall Township	15,703	16,088	2.5%	564
Salisbury Township	13,505	13,697	1.4%	1,217
Slatington Borough	4,232	4,278	1.1%	3,087
South Whitehall Township	19,180	19,624	2.3%	1,138
Upper Macungie Township	20,063	22,515	12.2%	858
Upper Milford Township	7,292	7,516	3.1%	417
Upper Saucon Township	14,808	15,904	7.4%	645
Washington Township	6,624	6,733	1.6%	284
Weisenberg Township	4,923	5,075	3.1%	189
Whitehall Township	26,738	27,239	1.9%	2,122
Lehigh County	**349,497**	**358,792**	**2.7%**	**1,030**

Source: US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

Table 2.3.1 Population and Density Statistics

Northampton County	2010 Population	2016 Population	Population Change, 2010-2016	2016 Population Density (Pop/Sq. Mile)
Allen Township	4,269	4,630	8.5%	411
Bangor Borough	5,273	5,198	-1.4%	3,433
Bath Borough	2,693	2,691	-0.1%	2,990
Bethlehem Township	23,730	23,880	0.6%	1,623
Bethlehem, City of	55,639	55,468	-0.3%	3,874
Bushkill Township	8,178	8,359	2.2%	325
Chapman Borough	199	178	-10.6%	497
East Allen Township	4,903	4,855	-1.0%	333
East Bangor Borough	1,172	1,099	-6.2%	1,288
Easton, City of	26,800	27,014	0.8%	6,199
Forks Township	14,721	15,229	3.5%	1,238
Freemansburg Borough	2,636	2,633	-0.1%	3,482
Glendon Borough	440	513	16.6%	651
Hanover Township	10,866	11,352	4.5%	1,708
Hellertown Borough	5,898	5,837	-1.0%	4,369
Lehigh Township	10,526	10,431	-0.9%	350
Lower Mt. Bethel Township	3,101	3,088	-0.4%	125
Lower Nazareth Township	5,674	5,905	4.1%	435
Lower Saucon Township	10,772	10,796	0.2%	441
Moore Township	9,198	9,239	0.4%	245
Nazareth Borough	5,746	5,703	-0.7%	3,367
North Catasauqua Borough	2,849	2,841	-0.3%	3,788
Northampton Borough	9,926	9,887	-0.4%	3,769
Palmer Township	20,691	21,114	2.0%	2,024
Pen Argyl Borough	3,595	3,567	-0.8%	2,554
Plainfield Township	6,138	6,138	0.0%	250
Portland Borough	519	482	-7.1%	831
Roseto Borough	1,567	1,619	3.3%	2,540
Stockertown Borough	927	1170	26.2%	1,176
Tatamy Borough	1,203	1,027	-14.6%	1,811
Upper Mt. Bethel Township	6,706	6,843	2.0%	155
Upper Nazareth Township	6,231	6,576	5.5%	880
Walnutport Borough	2,070	2,112	2.0%	2,693
Washington Township	5,122	5,186	1.2%	289
West Easton Borough	1,257	1,347	7.2%	4,066
Williams Township	5,884	5,985	1.7%	321
Wilson Borough	7,896	7,819	-1.0%	6,334
Wind Gap Borough	2,720	2,709	-0.4%	1,972
Northampton County	**297,735**	**300,520**	**0.9%**	**797**

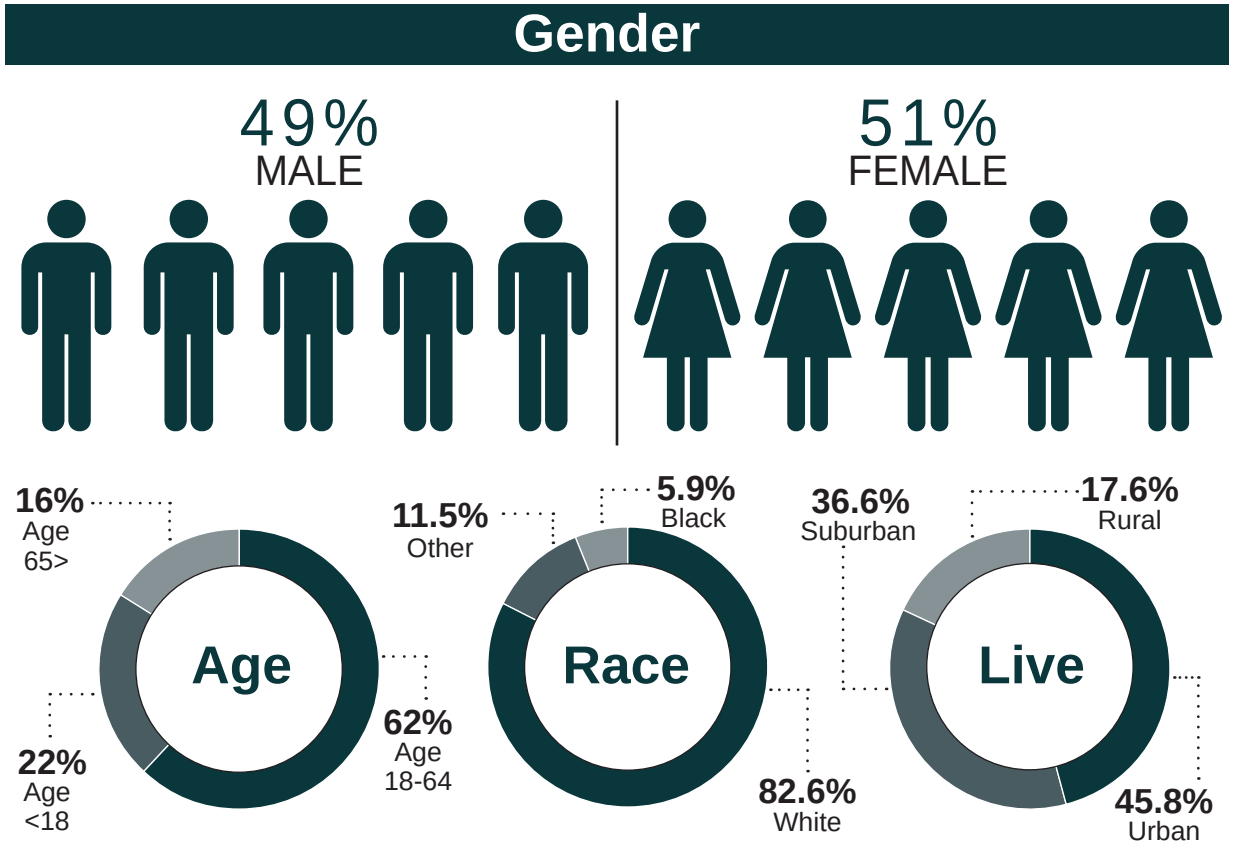
Source: US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates

Population Characteristics

The region's population is almost evenly split between women and men. Just more than 60% are between the ages of 18 and 64. The population is 82.6% White and 5.9% African-American, with 17.4% identifying as Hispanic or Latin-American.

Just less than half of Lehigh Valley residents live in urban areas and more than a third live in suburban areas, with the remaining 17.6% living in rural areas. Population characteristics are shown in Figure 2.3.2.

Figure 2.3.2 Population Characteristics



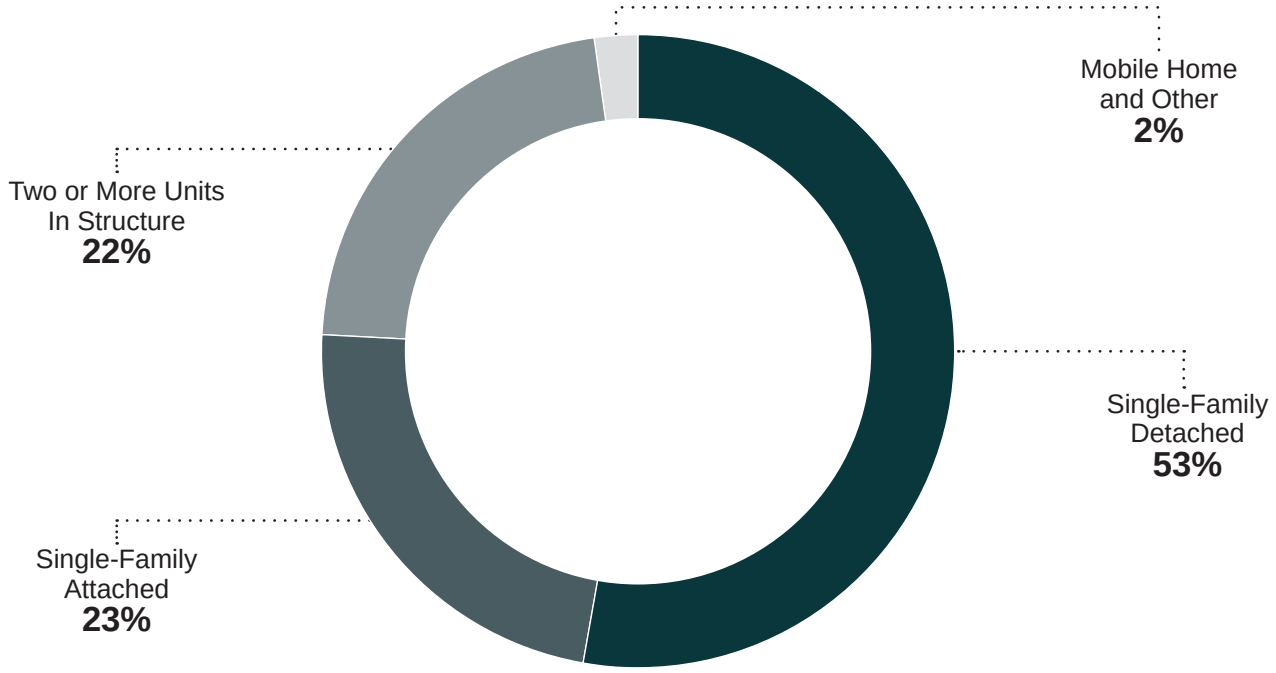
Source: US Census 2016 American Community Survey

Housing

The Lehigh Valley has an estimated 264,745 housing units, with 143,538 in Lehigh County and 121,207 in Northampton County. Further, the Lehigh Valley has 248,182 households, with 135,363 in Lehigh County and 112,819 in Northampton County. More than half of the region's housing units are single-family detached homes. About 46% of residences were built since 1970, and one in four residences was built before 1940.

The majority of Lehigh Valley houses are occupied by homeowners, while just under a third of residents are renters. Rural townships are dominated by owner-occupied households, while the region's cities and boroughs have higher shares of renter-occupied households. Vacancy rates are highest in the cities of Allentown and Easton and in northern Northampton County. However, the region's cities and exurban townships are experiencing an apartment boom. Approved apartments in 2016 more than doubled regionwide from 2015. Household data is shown in Figure 2.3.3.

Figure 2.3.3 Percentage of Lehigh Valley Households by Units in Structure



Source: US Census 2016 American Community Survey 5-Year Estimates

2.4 LAND USE AND DEVELOPMENT

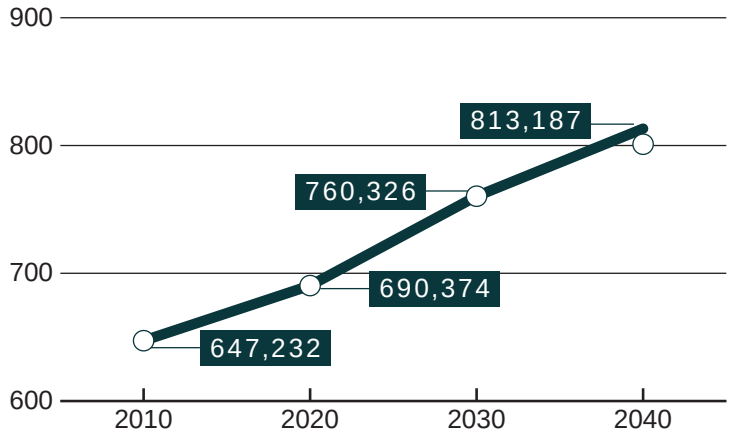
Population Growth

The Lehigh Valley population is projected to increase from 647,232 in 2010 to 813,187 in 2040, or by 25.6% over three decades as shown in Figure 2.4.1. This increase is slightly slower than the growth rate over the previous 30 years (1980-2010), when population increased by 30%.

In Lehigh County, where the population is projected to increase by 90,897 people, or an average of 8.7% per decade, the top five municipalities projected to experience the largest population growth are the City of Allentown and the townships of Upper Macungie, Upper Saucon, North Whitehall and Whitehall.

Northampton County's population is projected to increase by 75,058 people, or an average of 8.4% per decade. In Northampton County, the three municipalities projected to grow the most are the City of Bethlehem, Bethlehem Township and Forks Township.

Figure 2.4.1 Lehigh Valley Population Projections



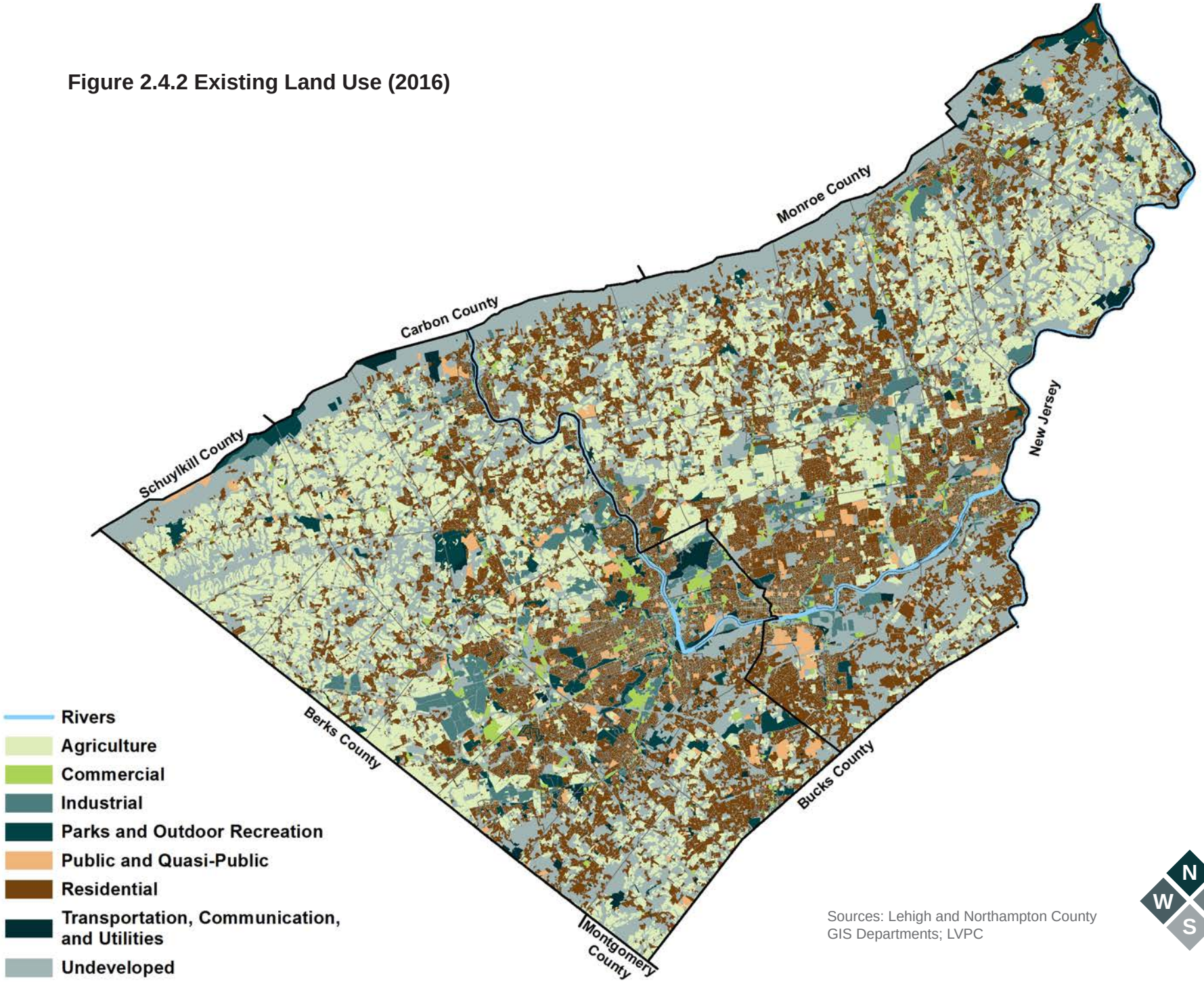
In thousands
Source: REMI 2014 and LVPC 2017

Extent of Developed Area

Most urban development in the region encompasses the area around Route 22 and I-78 from Route 100 east to the Delaware River. Interchange locations in this corridor have been popular sites for business and industrial locations since the late 1950s. The corridor is also bounded by rapidly developing suburbs such as Hanover and Bethlehem townships in Northampton County and Upper and Lower Macungie townships in western Lehigh County. Development in western Lehigh County grew quickly after the building of a long sewer interceptor from western Allentown to the industrial area around the I-78/Route 100 interchange in the late 1960s. Since its final completion in 2002, Route 33 has also spurred significant commercial and industrial growth in Northampton County.

Expanses of farmland and other open space still exist in northwestern Lehigh County, southwestern Lehigh County, northeastern Northampton County and southeastern Northampton County. There is also an area of prime farmland south of Bath and Nazareth boroughs. However, industrial and residential development has greatly reduced farmland. Rural single-family subdivisions on large lots served by on-lot sewer and water are scattered throughout the region. In the less developed areas, individual lots or small groups of lots are found along existing roads and at rural road intersections. The region's existing land use is shown in Figure 2.4.2.

Figure 2.4.2 Existing Land Use (2016)



Sources: Lehigh and Northampton County GIS Departments; LVPC

Development Trends

The Lehigh Valley's three cities and 27 boroughs have very different land use and development characteristics than the region's suburban and rural townships. About 89% of the total area of all cities and boroughs is developed, and some of the remaining 11% may not be suitable or available for development. Therefore, new development usually comes from the redevelopment of previously developed land. Allentown's Neighborhood Improvement Zone (NIZ) has spurred significant office and residential development in the city's central business district and along the Lehigh River Waterfront. In Bethlehem, the ongoing adaptive reuse of the former Bethlehem Steel complex is bringing new industrial, warehouse, office and commercial development to the city's South Side. Easton has experienced infill redevelopment downtown and the redevelopment of its former silk mill site in the west. However, while the cities of Allentown and Bethlehem were among the top four municipalities in approving residential units from 2007 to 2016, residential development in the region's boroughs has been limited during that same period.

The fastest growing municipalities in the Lehigh Valley are suburban townships adjacent to the cities of Allentown, Bethlehem and Easton and served by public sewer and water. The townships of Upper Macungie, Upper Saucon, Hanover (Northampton County), South Whitehall and Forks were among the top seven municipalities in approving residential units from 2007 to 2016. While residential development in suburban townships was previously characterized mainly by low density, single-family residential subdivisions, these municipalities have seen significant increases in higher density apartment and assisted-living development.

From 2007 to 2016, suburban townships have also had the highest total acreage in approved non-residential development. With the current expansion in warehouse and logistics development, rural townships like Weisenberg, Allen and Upper Mt. Bethel have also seen a significant amount of acreage go towards non-residential development. However, this increase in non-residential development in rural townships has been accompanied by a drop in residential subdivision development since 2007. Without continuing action to preserve farmland, coordinate municipal zoning and effectively manage growth, rural municipalities will become more suburban by 2040.

Sources: BuildLV, LVPC 2017, Comprehensive Plan The Lehigh Valley ... 2030

Highways, Roadways and Associated Systems

The roadway network is by far the dominant system of travel infrastructure in the Lehigh Valley. It serves passenger vehicles, trucks and public bus transportation needs in the region. In 2016, there were 14,164,373 daily vehicle miles of travel on the entire regional road network. By 2030, this figure is anticipated to grow to 19,600,000. The Lehigh Valley is served by six expressways, two of which are interstate highways. The interstate roads are I-78 and I-476. Other expressways are Route 22, a portion of Route 33, a portion of Route 309 and a portion of Route 378 through the City of Bethlehem.

The Lehigh Valley's 912 bridges are owned by several entities that include the Commonwealth of Pennsylvania, Lehigh County, Northampton County, municipalities, Pennsylvania Turnpike Commission, Delaware River Joint Toll Bridge Commission, railroad companies and private entities. Bridges with high traffic volumes in the area include the Route 22 Lehigh River Bridge, Route

33 Lehigh River Bridge, Route 329 Cementon Bridge, Route 145 Treichlers Bridge, Hamilton Street and Tilghman Street bridges in the City of Allentown, Hill-to-Hill, Fahy, and Minsi Trail bridges in the City of Bethlehem, 25th Street Bridge in Palmer Township, and the 3rd Street Bridge in the City of Easton. The average age of a bridge in the Lehigh Valley is 50 years old. The region's transportation infrastructure and average daily traffic are shown in Figure 2.4.3.

Road Type	Miles
Interstate Highways	60
Freeways/Expressways	38
Arterials	411
Collectors	525
Local Roads	3,107
TOTAL	**4,141**

Sources: PennDOT; LVPC

Railways

The dominant class 1 rail freight carrier in the Lehigh Valley is the Norfolk Southern Railroad. The railroad's Newark, New Jersey to Harrisburg main line passes through the two counties. This line is part of the Central Corridor, the largest of the six priority freight corridors in the state. A secondary line extends north from Allentown to the Scranton area.

Numerous branch lines provide Norfolk Southern service to area shippers. Among them are the Cement Secondary, which serves the Forks Industrial area, and the C&F Secondary, which serves the Fogelsville area. A second class 1 carrier, Canadian Pacific, also uses trackage rights to serve the Lehigh Valley. Canadian Pacific Rail has assumed the operations once provided by the Delaware and Hudson Railway.

The area is also served by six short line railroads: RJ Corman-Allentown, the East Penn Railroad, the Northampton Development Corp. Railroad, the Belvidere & Delaware River Railroad, the Delaware Lackawanna Railroad and the Lehigh Valley Rail Management Railroad.

These railroads operate several significant rail facilities within the Lehigh Valley. The Allentown Classification Yard is one of the major yards in the Norfolk Southern System. The Lehigh Valley Rail Management operates an intermodal terminal and container terminal, both in the City of Bethlehem.

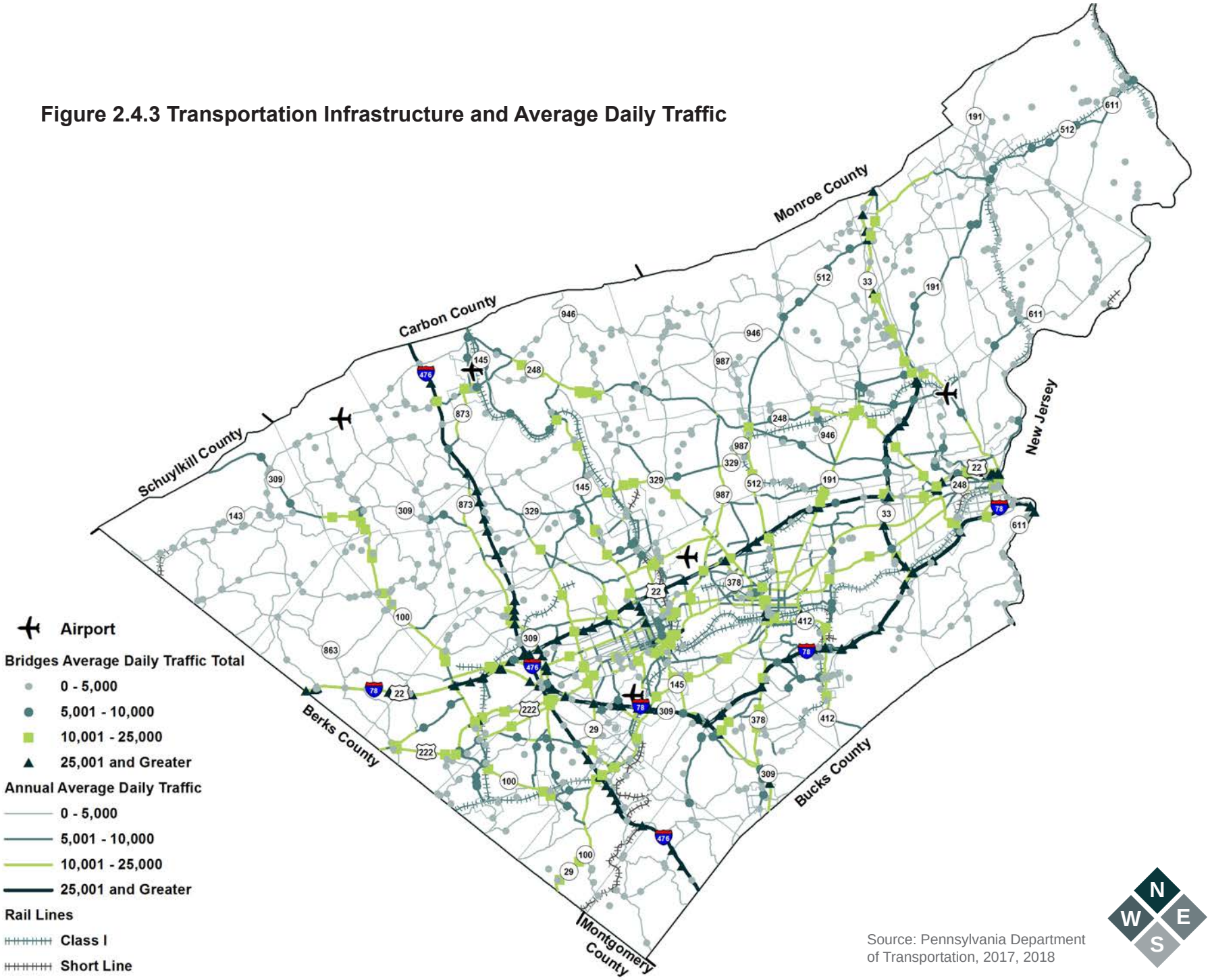
Airports and Heliports

Lehigh and Northampton counties are served by air passenger carrier, air cargo and general aviation services. The Lehigh Valley International Airport (LVIA), located on a 789-acre site in Hanover Township, Lehigh County, provides passenger, general aviation and air cargo services. LVIA is operated by the Lehigh-Northampton Airport Authority. In addition, the Queen City Airport in Allentown, Braden Airpark in Forks Township, the Slatington Airport, and the Flying "M" Aerodrome in Heidelberg Township also serve general aviation aircraft needs.

Public Transportation

The Lehigh and Northampton Transportation Authority (LANta) operates the LANtaBus and LANtaVan operations. The LANtaBus division provides fixed-route services along 28 routes and operates about 4.9 million trips annually. It serves the Lehigh Valley metropolitan area, including the cities of Allentown, Bethlehem and Easton and their surrounding municipalities. The LANtaVan division provides more than 400,000 door-to-door trips a year for the region's elderly and those with disabilities.

Figure 2.4.3 Transportation Infrastructure and Average Daily Traffic



Source: Pennsylvania Department of Transportation, 2017, 2018

In the 1980s, an intermodal center was developed in the City of Bethlehem to serve as a transportation hub. In the summer of 2007, a transportation hub was developed in Center City Allentown. A similar facility opened in 2015 on S. 3rd Street in Easton and is used by Trans-Bridge Lines Inc., Greyhound, New Jersey Transit, LANta and Fullington Trailways.

Inter-city bus service exists to popular destinations such as New York City and Philadelphia. This service is provided by private bus operators Carl R. Beiber, Trans-Bridge Lines, Inc., Greyhound, and Fullington Trailways.

Non-Motorized Travel

The Lehigh Valley has a robust sidewalk and trail network that is used for recreation, and increasingly for commuting. The D&L Trail, in particular, connects the three cities, passing through several population and employment zones along the way.

In the Lehigh Valley there are ...

289 MILES
of trails

2,077 MILES
of sidewalks

2.5 DATA SOURCES AND LIMITATIONS

An extensive list of data sources was used to develop the 2018 Plan as provided in Appendix A. Sources used for the Plan include national, state and county data as well as published material.

Primary sources of data for the Community Profile section include the US Census Bureau for population and demographic data. The Lehigh Valley Planning Commission (LVPC) provided data on population and employment projections, development trends and transportation infrastructure. Existing GIS layers from the LVPC were used to create the mapping. Data from the 2013 Plan was reviewed and updated as appropriate with the best available data.

For the risk assessment, loss estimates, exposure assessments and hazard-specific evaluations relied on the best available data and methodologies. Lehigh and Northampton counties provided existing spatial data, including tax parcels and building footprints for the hazard vulnerability assessments. RS Means 2018 building valuations were used to estimate replacement cost values for buildings.

To assess the vulnerability of different jurisdictions to hazards, historical disaster event data was obtained from a variety of sources, including the National Climatic Data Center, Lehigh and Northampton County Knowledge Center databases and Pennsylvania Emergency Management Agency, among many others. The most current countywide FEMA flood maps for Lehigh County, effective July 2004, and Northampton County, effective July 2014, were used in the flood hazard risk assessment to evaluate exposure and determine potential future losses. FEMA is in the process of developing new flood mapping for the Lehigh River Watershed, however, the mapping is not available for this 2018 Plan. Preliminary mapping is anticipated to be available by September 2019.

As additional data becomes available, estimates of vulnerabilities to natural and non-natural hazards can be refined for future plan updates.

3. PLANNING PROCESS

3.1 UPDATE PROCESS AND PARTICIPATION SUMMARY

The goal of this process was to prepare a plan that not only meets the requirements of the Disaster Mitigation Act of 2000, using the guidelines provided by the Federal Emergency Management Agency (FEMA) and Pennsylvania Emergency Management Agency (PEMA), but one built from community input that would best assist the region in minimizing the impacts of future disasters.

Creating the *Lehigh Valley Hazard Mitigation Plan* was a 12-month process that involved monthly meetings with municipalities and stakeholders, more than two dozen presentations before community groups and the Lehigh Valley Planning Commission, five scheduled public meetings, regular media stories, a dedicated webpage, television appearances, public service radio announcements and an advertising campaign that included ads—in English and Spanish—on every mass transit bus in the region.

The 2013 Plan included a discussion on Integration/Coordination with Existing Plans and Programs, which has been moved to the Capability Assessment section. A summary update chart was added. The public outreach section was expanded to reflect the extensive efforts taken to get community input, including outreach into the region's growing Hispanic community. A social media element was added to reflect evolving methods of communication.

The 2018 Hazard Mitigation Plan was formatted to strictly follow the guidelines set by Pennsylvania's All-Hazard Mitigation Planning Standard Operating Guide. Therefore, the format varies greatly from the 2013 Plan, which was drafted before the state guide was published. The format changes are shown in Table 3.1.1.

PUBLIC ENGAGEMENT

30
Community Meeting Presentations

5
Public Meetings

83
Transit Buses with Hazard Mitigation Ads

32
Public Service Annoucements on La Mega 99.5 Spanish Radio

3
RCN TV4 Hazard Mitigation Program Air Dates

Table 3.1.1 Summary of Changes to the Lehigh Valley Hazard Mitigation Plan

2013 PLAN SECTION	2018 PLAN SECTION
1. Introduction	**Executive Summary**
1.1 Background	**1. Introduction**
1.2 Purpose	1.1 Background
1.3 Scope	1.2 Purpose
1.4 Authority and References	1.3 Scope
1.5 Summary of Changes in Plan Update	1.4 Authority and Reference
1.6 Organization of Mitigation Plan	**2. Community Profile**
2. Regional Profile	2.1 Geograghy and Environment
2.1 Location	2.2 Community Facts
2.2 History	2.3 Population and Demographics
2.3 Government and Political Subdivisions	2.4 Land Use and Development
2.4 Physical Setting	2.5 Data Sources and Limitations
2.5 Population and Demographics	**3. Planning Process**
2.6 General Building Stock	3.1 Update Process and Participation Summary
2.7 Critical Facilities	3.2 The Planning Team
2.8 Other Facilities (User-Defined)	3.3 Meetings and Documentation
2.9 Economic Profile	3.4 Public & Stakeholder Participation
3. Planning Process	3.5 Multi-Jurisdictional Planning
3.1 Introduction	**4. Risk Assessment**
3.2 Organization of Planning Process	4.1 Update Process Summary
3.3 Plan Update Activity	4.2 Hazard Identification
3.4 Stakeholder Outreach and Involvement	4.3 Hazard Profiles
3.5 Public Outreach and Participation	4.4 Hazard Vulnerability Summary
3.6 Integration/Coordination with Existing Plans and Programs	**5. Capability Assessment**
4. Hazard Profiles	5.1 Update Process Summary
4.1 Methodology and Tools	5.2 Capability Assessment Findings
4.2 Hazard Identification	**6. Mitigation Strategy**
4.3 Hazard Profiles	6.1 Update Process Summary
4.4 Hazard Ranking	6.2 Mitigation Goals and Objectives
5. Capability Assessment	6.3 Identification and Analysis of Mitigation Techniques
5.1 Emergency Management	6.4 Mitigation Action Plan
5.2 Participation in the National Flood Insurance Program	**7. Plan Maintenance**
5.3 Community Rating System (CRS)	7.1 Update Process Summary
5.4 Planning and Regulatory Capability	7.2 Monitoring, Evaluating and Updating the Plan
5.5 Administrative and Technical Capability	7.3 Continued Public Involvement
5.6 Fiscal Capability	**8. Plan Adoption**
5.7 Political Capability	
5.8 Self-Assessment	
5.9 Capability Assessment Recommendations	
6. Mitigation Strategy	
6.1 Review and Update of Hazard Mitigation Goals	
6.2 Update of Municipal Mitigation Strategies	
6.3 Update of County-Level Mitigation Strategies	
6.4 Mitigation Strategy Prioritization and Implementation	
7. Plan Maintenance Procedures	
7.1 Monitoring, Evaluating and Updating the Plan	
7.2 Implementation of Mitigation Plan through Existing Programs	
7.3 Continued Public Involvement	
8. Plan Adoption	
8.1 Overview	

3.2 THE PLANNING TEAM

The 2018 Plan process began with the creation of the Administrative Planning Team that includes Lehigh and Northampton County Emergency Management officials and the LVPC, as well as representatives from PEMA and FEMA as listed in Table 3.2.1. After Lehigh County secured a FEMA planning grant on behalf of the region, the counties arranged for the LVPC, the official planning agency for the region, to prepare the *Lehigh Valley Hazard Mitigation Plan*. Tetra Tech Inc. was contracted as a consultant by the LVPC to assist in preparing Hazard Profiles and Vulnerability Assessments for the Plan.

With the Administrative Planning Team in place, the Planning Team was established through invitations to all municipalities and a wide variety of stakeholders, resulting in 100% participation by all 62 municipalities in addition to dozens of experts and the public. The Administrative Planning Team guided overall direction of the planning effort, made day-to-day decisions and developed a public outreach program. The Planning Team attended monthly meetings and provided information and input.

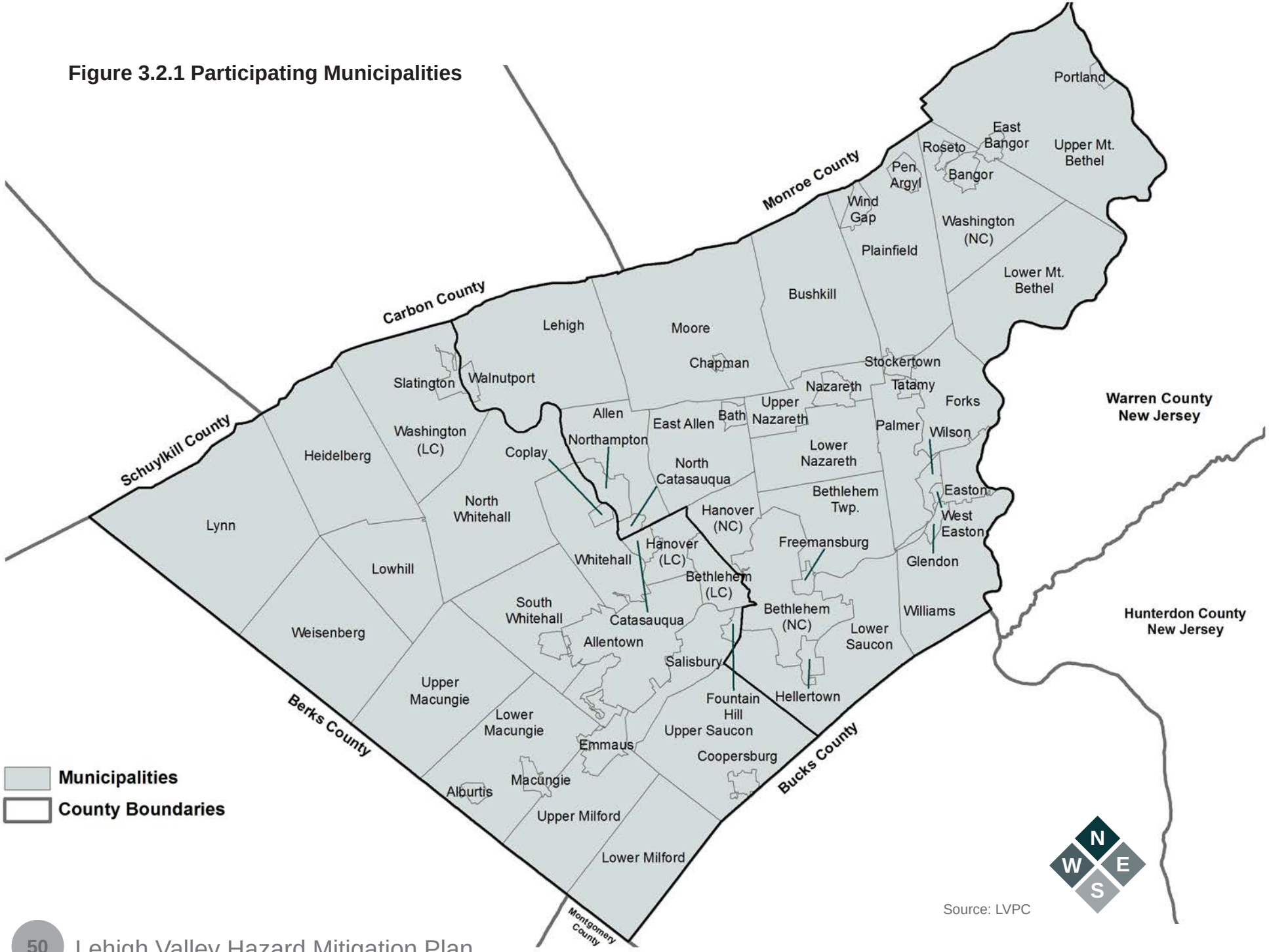
All 62 municipalities signed a letter of intent to participate, agreeing to provide a municipal point of contact, stakeholders in the community and relevant data en route to ultimately adopting the Plan. The participating municipalities are shown in Figure 3.2.1.

Diligent efforts were made to assure broad regional, county and local participation during the planning process. Regional stakeholders were invited to participate on the Planning Team, including officials from hospitals, churches, transportation organizations, public utilities, economic development organizations, businesses, non-profit organizations, universities, school districts, neighboring counties and environmental groups, as well as officials from local, county, state and federal agencies.

Table 3.2.1 Administrative Planning Team

Name	Title	Organization
Scott Lindenmuth	Director	Lehigh County Emergency Management Agency
Tanya Hook	Community Outreach Coordinator	Lehigh County Emergency Management Agency
Jon Al-Khal	Training and Operations	Lehigh County Emergency Management Agency
Todd Weaver, ENP	Director	Northampton County Emergency Management Services
Thomas Guth, Jr.	Manager, Hazard Mitigation Services and Disaster Recovery	Northampton County Emergency Management Services
Jeff Steiert	Deputy Director	Northampton County Emergency Management Services
Michael Rinker	Emergency Management Planning Manager	Northampton County Emergency Management Services
William Hillanbrand, MA	Manager, Emergency Management Planning (retired)	Northampton County Emergency Management Services
Nick Tylenda	Deputy Director (retired)	Northampton County Emergency Management Services
Wade Haubert, Jr.	Deputy Emergency Management Coordinator	City of Bethlehem
Becky Bradley, AICP	Executive Director	Lehigh Valley Planning Commission
Geoffrey Reese, PE	Director of Environmental Planning	Lehigh Valley Planning Commission
Matt Assad	Managing Editor	Lehigh Valley Planning Commission
Susan Rockwell	Senior Environmental Planner	Lehigh Valley Planning Commission
Mari Radford, CFM	Mitigation Planner	Federal Emergency Management Agency
Ernie Szabo	Hazard Mitigation Planner	Pennsylvania Emergency Management Agency

Figure 3.2.1 Participating Municipalities



Source: LVPC

3.3 MEETINGS AND DOCUMENTATION

The Planning and Administrative Teams met monthly from October 2017 through July 2018 to provide municipalities and stakeholders sufficient opportunities to participate and provide input. Meeting documentation is located in Appendix C.

September 14, 2017: LVPC newsletter article, delivered to more than 2,000 stakeholders and posted on LVPC website, announces *Lehigh Valley Hazard Mitigation Plan* update.

October 16, 2017: Article detailing the Plan appears in The Lehigh Valley Business Journal.

October 19, 2017, Planning Team Kick-Off Meeting: Attendees were provided an overview of hazard mitigation planning, the plan update process, municipal participation and responsibilities, stakeholder involvement, previous plan goals and hazards profiled, and the plan update timeline. The first nine of 11 worksheets to be completed by municipalities were reviewed and distributed at the meeting.

October 2017 Community Presentations

- **October 5:** Northampton County Association of Township Officials at Green Pond Country Club, Bethlehem Township.
- **October 8:** RCN TV-4 program *Community Spotlight* features Hazard Mitigation Plan. Thirty minute program re-airs October 10 and 12.
- **October 17:** Seventh Lehigh Valley Watershed Conference at Lehigh University, Bethlehem.
- **October 31:** Lehigh County Congress of Governments at the America On Wheels Museum, Allentown.

November 16, 2017: Planning Team coordinated a broad municipal participation effort. Potential new hazards to profile in the 2018 Plan were identified, including several from the 2013 Pennsylvania Hazard Mitigation Plan.

December 18, 2017: lvpc.org/Hazard-Mitigation.html goes live, including a place for public comment. Webpage gets 752 page views from 427 unique users in its first two weeks of operation.

December 21, 2017: Planning Team overview of the National Flood Insurance Program's Community Rating System. Twenty-two hazards from the 2013 Lehigh Valley Plan and three new hazards—invasive species, pandemic and infectious disease, and drug overdose crisis—are added to the 2018 effort.

December 2017 Community Presentations

- **December 7:** Lehigh Valley Regional Partnership at the PPL Training Center, South Whitehall Township. The partnership posts monthly meeting agendas and PowerPoint presentations on its website.

January, 2018: Hazard Mitigation Plan social media campaign begins on Facebook, Twitter and LinkedIn.

January 18, 2018: Planning Team begins discussing mitigation strategies.

January 2018 Community Presentations

- **January 30:** Lehigh Valley General Assembly at Penn State Lehigh Valley, Center Valley.

February 12, 2018: LVPC staff appears on La Mega 99.5 Spanish Radio for an 11-minute segment to discuss the Hazard Mitigation Plan and how people can participate. The campaign includes 32 public service announcements between February 12 and 19, reaching more than 27,000 listeners. More than 12% of the Lehigh Valley is Spanish-speaking.

February 14, 2018: Advertisements, in English and Spanish, urging public participation in the Hazard Mitigation Plan go up inside all 83 LANta mass transit buses. The ads remain on the buses through the Hazard Mitigation process. LANta served 350,000-400,000 riders per month during the six-month ad campaign.

February 15, 2018: Planning Team hears presentation by Jeffrey Jumper, State Meteorologist with PEMA, on Lehigh Valley-related weather hazards.

February 20, 2018: Public Meeting at Pinebrook Family Answers, located in an Allentown neighborhood with a high percentage of Spanish-speaking residents. Topics included an introduction to hazard mitigation planning, hazards impacting the Lehigh Valley, types of mitigation actions and plan update timeline. Attendees had the opportunity to discuss past experiences with hazard events and provide input. A Spanish language interpreter was provided at the meeting. In an effort to reach traditionally underserved populations, the five public meetings were held at a variety of locations and along mass transit routes.

February 2018 Community Presentations

- **February 15:** Lehigh County Emergency Management Coordinators Meeting at the Joint Operations Center, South Whitehall Township.
- **February 22:** Lehigh Valley Regional Partnership at the PPL Training Center, South Whitehall Township.

March 8, 2018: Public Meeting Planning + Pizza at the LVPC Office. Topics discussed were similar to the February 20 meeting to provide information on the importance of hazard mitigation planning. This meeting was held to reach out to additional community members.

March 15, 2018: Planning Team hears presentation by Jennifer Massaro, Client Relationship Manager, Penn State Extension, about invasive species—one of the three new hazards to be profiled in the 2018 Plan—and potential mitigation action ideas.

April 19, 2018: Planning Team hears presentation by Kristen Wenrich, Bethlehem Health Bureau Director and Chair of the Northampton County Opioid and Heroin Overdose Task Force, and Vicky Kistler, Allentown Health Bureau Director, about the drug overdose crisis, and pandemic and infectious diseases. Sample actions for the these new hazards, including invasive species, are considered.

April 23, 2018: The Lehigh Valley Business Journal column, "Planning for disaster now is vital for business," is published.

April 25, 2018: Public Meeting at Nurture Nature Center, Easton. Topics included the hazards of concern for the region, risk assessment, capability assessment, plan goals and mitigation actions.

April 2018 Community Presentations

- **April 3:** Lehigh County Congress of Governments at the America On Wheels Museum, Allentown.
- **April 11:** Northampton County Emergency Management Coordinators Meetings at 9 a.m. and 7 p.m., Upper Nazareth Township.
- **April 25:** Northampton County Council of Governments at Northampton County Human Services, Bethlehem.
- **April 28:** Municipal Leaders' Conference at Northampton Community College, Monroe Campus, Tannersville.

May 17, 2018: Planning Team discusses draft goals and objectives, and actions completed from the previous plan.

May 2018 Community Presentations

- **May 2:** Lehigh Valley Master Watershed Steward Program at Illick's Mill, Bethlehem.

June 21, 2018: Planning Team discusses draft Plan.

July 3, 2018: Public comment period begins on draft Plan.

July 10, 2018: Public meetings on the draft 2018 Plan: a mid-day Planning + Pizza at LVPC and an evening meeting at the Catasauqua Municipal Building.

July 11, 2018: Lehigh Valley Sustainability Network presentation and discussion of draft 2018 Plan at Allentown Brew Works.

July 19, 2018: Planning Team meeting to discuss revisions to the draft 2018 Plan.

August-October: Public comment period ends. Draft Plan is sent to PEMA and FEMA and municipal adoption campaign is initiated.

3.4 PUBLIC AND STAKEHOLDER PARTICIPATION

Municipalities and stakeholders met monthly to provide information and input on hazards and risks, and to develop goals, objectives and mitigation actions. Capabilities were assessed based on compliance with the National Flood Insurance Program, community assets, willingness to protect vulnerable populations, economic, built and environmental resources. Hazard event history, changes in hazard risk, including new and anticipated development and mitigation actions over the last five years, were considered. Revised goals and new mitigation actions resulted from the strategic, collaborative effort.

One of the key roles of the municipalities in this effort was to assist and provide public outreach in their community by engaging municipal and community stakeholders.

Public participation and comment was encouraged throughout the planning process. A wide-ranging public outreach plan was developed that included radio, television, online, print media and social media strategies.

Representatives from these stakeholder organizations participated in the planning process by attending Planning Team or public meetings and providing input:

- American Red Cross of the Greater Lehigh Valley
- Allentown Health Bureau
- Bethlehem Health Bureau
- Borton-Lawson Engineering
- Citizen's Climate Lobby
- Community Action Committee of the Lehigh Valley
- Jewish Federation of the Lehigh Valley
- J.G. Petrucci Co.
- Lehigh County Authority
- Lehigh University
- Hanover Engineering
- Northampton County Council
- Nurture Nature Center
- Office of Congressman Cartwright
- PA One Call System
- Parkland School District
- Partnership for Disability Friendly Community
- Pennsylvania Department of Environmental Protection
- Pennsylvania Emergency Management Agency
- Penn State Extension
- St. Luke's Hospital
- US Transportation Security Administration
- Wildlands Conservancy

The comment period for the draft Lehigh Valley Hazard Mitigation Plan began July 3, 2018 and continued through August 3, 2018. Social media and the LVPC homepage were used to promote comment on the Plan. During that period, 16 municipalities and the public issued comments. The plan was altered to reflect those comments.

3.5 MULTI-JURISDICTIONAL PLANNING

Municipalities were informed throughout the planning process that only municipalities that participate in the process and adopt the Plan would be eligible for hazard mitigation project funds.

All municipalites participated in the 2006 and 2013 plans, with all adopting the 2006 Plan, but only 37 adopting the 2013 Plan. The goal for the 2018 Plan is adoption by all 62 municipalities. Throughout the planning process, each municipality was emailed a reminder prior to every Planning Team meeting, with 57 municipalities attending at least one meeting.

In the months after the Plan receives FEMA and PEMA approval, an outreach campaign will be launched to prompt Plan adoption by all municipalities. The LVPC will provide each municipality with a summary of the Plan and a copy of their municipal annex. Municipal participation in the planning process is shown in Table 3.5.1.

Table 3.5.1 Municipal Participation and Worksheets

Lehigh County	#1 Statement of Intent to Participate	#2 Participation Survey	#3 NFIP Survey	#4 Community Assets Survey	#5 Capability Assessment Survey	#6 Future Development	#7 Mitigation Action Review	#8 Natural Hazard Event History	#9 Hazard ID and Risk Evaluation	#10 Goal Evaluation	#11 Mitigation Strategy Action Plan	Meeting Attendance
Alburtis Borough	X	X	X	X	X	X	X	X	X	X	X	X
City of Allentown	X	X	X	X	X	X	X	X	X	X	X	X
City of Bethlehem	X	X	X	X	X	X	X	X	X			X
Catasauqua Borough	X	X	X	X	X	X	X	X	X	X	X	X
Coopersburg Borough	X	X	X	X	X	X	X	X	X	X	X	X
Coplay Borough	X	X	X	X	X	X	X	X	X	X	X	
Emmaus Borough	X	X	X	X	X	X	X	X	X	X		X
Fountain Hill Borough	X	X	X	X	X	X	X	X	X	X	X	X
Hanover Township	X	X	X	X	X	X	X	X	X	X	X	X
Heidelberg Township	X	X	X	X	X	X	X	X	X	X	X	X
Lower Macungie Township	X	X	X	X	X	X	X	X	X	X	X	X
Lower Milford Township	X	X	X	X	X	X	X	X	X	X	X	X
Lowhill Township	X	X	X	X	X	X	X	X	X		X	X
Lynn Township	X	X	X	X	X	X	X	X	X	X	X	X
Macungie Borough	X	X	X	X	X	X	X	X	X			X
North Whitehall Township	X	X	X	X	X	X	X	X	X			X
Salisbury Township	X	X	X	X	X	X	X	X	X	X	X	X
Slatington Borough	X	X	X	X	X	X	X	X	X	X	X	X
South Whitehall Township	X	X	X	X	X	X	X	X	X	X	X	X
Upper Macungie Township	X	X	X	X	X	X	X	X	X	X	X	X
Upper Milford Township	X	X	X	X	X	X	X	X	X	X	X	X
Upper Saucon Township	X	X	X	X	X	X	X	X	X	X	X	X
Washington Township	X	X	X	X	X	X	X	X	X	X	X	X
Weisenberg Township	X	X	X	X	X	X	X	X	X		X	X
Whitehall Township	X	X		X	X	X	X	X	X			X

Table 3.5.1 Municipal Participation and Worksheets

Northampton County	#1 Statement of Intent to Participate	#2 Participation Survey	#3 NFIP Survey	#4 Community Assets Survey	#5 Capability Assessment Survey	#6 Future Development	#7 Mitigation Action Review	#8 Natural Hazard Event History	#9 Hazard ID and Risk Evaluation	#10 Goal Evaluation	#11 Mitigation Strategy Action Plan	Meeting Attendance
Allen Township	X	X		X	X	X	X	X	X			X
Bangor Borough	X	X	X	X	X	X	X	X	X	X	X	X
Bath Borough	X	X	X	X	X	X	X	X	X	X	X	X
Bethlehem Township	X	X	X	X	X	X	X	X	X	X	X	X
Bushkill Township	X	X	X	X	X	X	X	X	X			X
Chapman Borough	X	X	X	X	X	X	X	X	X	X	X	X
East Allen Township	X	X	X	X	X	X	X	X	X	X	X	X
East Bangor Borough	X	X	X	X	X	X	X	X	X	X	X	
City of Easton	X	X	X	X	X	X	X	X	X	X	X	X
Forks Township	X	X	X	X	X	X	X	X	X	X	X	X
Freemansburg Borough	X	X	X	X	X	X	X	X	X	X	X	X
Glendon Borough	X	X	X	X	X	X	X	X	X	X	X	X
Hanover Township	X	X	X	X	X	X	X	X	X	X	X	X
Hellertown Borough	X	X	X	X	X	X	X	X	X	X	X	X
Lehigh Township	X	X	X	X	X	X	X	X	X	X	X	X
Lower Mt. Bethel Township	X	X	X	X	X	X	X	X	X	X	X	X
Lower Nazareth Township	X	X	X	X	X	X	X	X	X	X	X	X
Lower Saucon Township	X	X	X	X	X	X	X	X	X	X	X	X
Moore Township	X	X		X	X	X	X	X				X
Nazareth Borough	X	X	X	X	X	X	X	X	X	X	X	X
Northampton Borough	X	X	X	X	X	X	X	X	X	X	X	X
North Catasauqua Borough	X	X	X	X	X	X	X	X	X	X	X	X
Palmer Township	X	X	X	X	X	X	X	X	X	X	X	X
Pen Argyl Borough	X	X	X	X	X	X	X	X	X	X	X	X
Plainfield Township	X	X	X	X	X	X	X	X	X	X	X	X
Portland Borough	X	X	X	X	X	X	X	X	X	X	X	X
Roseto Borough	X				X	X	X	X		X	X	
Stockertown Borough	X	X	X	X	X	X	X	X	X			
Tatamy Borough	X	X	X	X	X	X	X	X	X	X	X	X
Upper Mt. Bethel Township	X		X	X	X	X	X	X				X
Upper Nazareth Township	X	X	X	X	X	X	X	X	X	X	X	X
Walnutport Borough	X				X	X	X	X	X			
Washington Township	X	X	X	X	X	X	X	X	X	X	X	X
West Easton Borough	X	X	X	X	X	X	X	X	X	X	X	X
Williams Township	X	X	X	X	X	X	X	X	X			X
Wilson Borough	X	X	X	X	X	X	X	X	X	X	X	X
Wind Gap Borough	X	X	X	X	X	X	X	X	X	X	X	X

4. RISK ASSESSMENT

4.1 UPDATE PROCESS SUMMARY

A risk assessment determines the potential impacts of hazards to the people, economy and built and natural environments of a community. It includes identification and profiling hazards of concern to the community, an inventory of community assets, an analysis of hazard risks and a summary of the community's vulnerability to the identified hazards. A risk assessment provides the foundation for the rest of the mitigation planning process, which is focused on identifying and prioritizing actions to reduce the risk from hazards.

The Planning Team considered the 22 hazards profiled in the 2013 Plan and determined they remained relevant to the region. For the 2018 Plan, the information for each of these hazards was reviewed and updated as appropriate. In addition, the Planning Team identified three new hazards of concern to the region—invasive species, pandemic and infectious disease, and drug overdose crisis—to be profiled in the 2018 Plan. A risk assessment was completed that evaluates vulnerable assets, describes potential impacts and estimates losses (where possible) for each of the 25 hazards.

The hazard risk ranking methodology used for the 2018 Plan is based on the Lehigh and Northampton County Emergency Management Agencies' operational experience. The overall hazard risk for the region has changed since the 2013 Plan for the following hazards:

- Structural Collapse (from low to moderate)
- Drought (from moderate to high)
- Extreme Temperature (from moderate to high)
- Fire: Urban/Structural (from high to moderate)
- Hailstorm (from moderate to low)
- Levee Failure (from high to moderate)
- Subsidence/Sinkhole (from low to moderate)
- Terrorism (from low to moderate)
- Windstorm/Tornado (from moderate to high)

The risk assessment is the foundation for identifying and prioritizing actions supporting a safer and more resilient region.

4.2 HAZARD IDENTIFICATION

4.2.1 Table of Presidential Disaster Declarations

Presidential Disaster and Emergency Declarations are issued when it has been determined that state and local governments require assistance in responding to a disaster event. Table 4.2.1.1 identifies 17 Presidential Disaster Declarations and six Emergency Declarations issued between 1955 and 2017 that have affected Lehigh County or Northampton County. These declarations were primarily for flooding, winter storm and hurricane or tropical storm/depression events.

4.2.2 Summary of Hazards

As part of the 2018 planning process, the Lehigh Valley Hazard Mitigation Planning Team reviewed the hazards of concern profiled in the 2013 Lehigh Valley Plan as well as those identified in the Pennsylvania 2013 Standard State All-Hazard Mitigation Plan. The Planning Team also considered the history of hazard events that have occurred in the Lehigh Valley, including those that occurred since completion of the 2013 Plan.

The 2018 Plan profiles 25 hazards, as shown in Table 4.2.2.1.

Table 4.2.1.1 Presidential Disaster and Emergency Declarations (1955-2017)

Date	Event	Counties Affected
March 2016	Severe Winter Storm and Snowstorm	Lehigh and Northampton
January 2013	Hurricane Sandy	Northampton
October 2012*	Hurricane Sandy	Lehigh and Northampton
September 2011*	Remnants of Tropical Storm Lee	Lehigh and Northampton
September 2011	Remnants of Tropical Storm Lee	Northampton
September 2011	Hurricane Irene	Lehigh and Northampton
August 2011*	Hurricane Irene	Lehigh and Northampton
June 2006	Flooding	Lehigh and Northampton
September 2005*	Hurricane Katrina	Lehigh and Northampton
April 2005	Severe Storms, Flooding and Mudslides	Northampton
September 2004	Tropical Depression Ivan	Northampton
September 2003	Hurricane Isabel/Henri	Lehigh and Northampton
February 2003*	Severe Winter Storm	Lehigh and Northampton
September 1999	Hurricane Floyd	Lehigh and Northampton
January 1996	Severe Winter Storms	Lehigh and Northampton
January 1996	Flooding	Lehigh and Northampton
January 1994	Severe Winter Storms	Lehigh and Northampton
March 1993*	Blizzard	Lehigh and Northampton
September 1975	Flood (Eloise)	Northampton
July 1973	Flood	Northampton
June 1972	Flood (Agnes)	Northampton
August 1965	Drought	Lehigh and Northampton
August 1955	Flood (Diane)	Lehigh and Northampton

* Emergency Declaration
Source: PEMA (2013), FEMA (2017)

Table 4.2.2.1 Hazards Profiled

NATURAL HAZARDS	2006	2013	2016
Drought	✓	✓	✓
Earthquake	✓	✓	✓
Extreme Temperature	✗	✓	✓
Flood, Flash Flood, Ice Jam	✓	✓	✓
Hailstorm	✗	✓	✓
Invasive Species	✗	✗	✓
Landslide	✗	✓	✓
Lightning Strike	✗	✓	✓
Pandemic and Infectious Disease	✗	✗	✓
Radon Exposure	✗	✓	✓
Subsidence/Sinkhole	✓	✓	✓
Wildfire	✓	✓	✓
Windstorm/Tornado	✓	✓	✓
Winter Storm	✓	✓	✓

NON-NATURAL HAZARDS	2006	2013	2016
Civil Disturbance/Mass Gathering	✗	✓	✓
Dam Failure	✗	✓	✓
Drug Overdose Crisis	✗	✗	✓
Environmental Hazards/Explosion	✗	✓	✓
Fire (Urban/Structural)	✗	✓	✓
Levee Failure	✗	✓	✓
Nuclear Incident	✗	✓	✓
Structural Collapse	✗	✓	✓
Terrorism	✗	✓	✓
Transportation Crash	✗	✓	✓
Utility Interruption	✗	✓	✓

✓ Profiled ✗ Not Profiled

A description of each hazard profiled in the 2018 Plan is listed below:

NATURAL HAZARD DESCRIPTIONS

Drought - Drought is a natural climatic condition which occurs in virtually all climates, the consequence of a natural reduction in the amount of precipitation experienced over a long period of time, usually a season or more in length. High temperatures, prolonged winds and low relative humidity can exacerbate the severity of drought. This hazard is of particular concern in Pennsylvania due to the presence of farms as well as water-dependent industries and recreation areas across the Commonwealth. A prolonged drought could severely impact these sectors of the local economy, as well as residents who depend on wells for drinking water and other personal uses. (National Drought Mitigation Center, 2006).

Earthquake - An earthquake is the motion or trembling of the ground produced by sudden displacement of rock usually within the upper 10-20 miles of the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides or the collapse of underground caverns. Earthquakes can affect hundreds of thousands of square miles, cause damage to property measured in the tens of billions of dollars, result in loss of life and injury to hundreds of thousands of persons, and disrupt the social and economic functioning of the affected area. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking which is dependent upon amplitude and duration of the earthquake. (FEMA, 1997).

Extreme Temperature - Extreme cold temperatures drop well below what is considered normal for an area during the winter months and often accompany winter storm events. Combined with increases in wind speed, such temperatures in Pennsylvania can be life-threatening to those exposed for extended periods of time. Extreme heat can be described as temperatures that hover 10°F or more above the average high temperature for a region during the summer months. Extreme heat is responsible for more deaths in Pennsylvania than all other natural disasters combined (Lawrence County, PA HMP, 2004).

Flood, Flash Flood, Ice Jam - Flooding is the temporary condition of partial or complete inundation on normally dry land and it is the most frequent and costly of all hazards in Pennsylvania. Flooding events are generally the result of excessive precipitation. General flooding is typically experienced when precipitation occurs over a given river basin for an extended period of time. Flash flooding is usually a result of heavy localized precipitation falling in a short time period over a given location, often along mountain streams and in urban areas where much of the ground is covered by impervious surfaces. The severity of a flood event is dependent upon a combination of stream and river basin topography and physiography, hydrology, precipitation and weather patterns, present soil moisture conditions, the degree of vegetative clearing as well as the presence of impervious surfaces in and around flood-prone areas. (NOAA, 2009). Winter flooding can include ice jams which occur when warm temperatures and heavy rain cause snow to melt rapidly. Snow melt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of a river. The ice layer often

breaks into large chunks, which float downstream, piling up in narrow passages and near other obstructions such as bridges and dams. All forms of flooding can damage infrastructure (USACE, 2007).

Hailstorm - In addition to flooding and severe winds, hail is another potential damaging product of severe thunderstorms. 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 (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. Damage to crops and vehicles are typically the most significant impacts of hailstorms. Areas in eastern and central Pennsylvania typically experience less than two hailstorms per year, while areas in western Pennsylvania experience 2-3 annually. (FEMA, 1997).

Invasive Species - An invasive species is a species that is not indigenous to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health. These species can be any type of organism: plant, fish, invertebrate, mammal, bird, disease or pathogen. Infestations may not necessarily impact human health, but can create a nuisance or agricultural hardships by destroying crops, defoliating populations of native plant and tree species, or interfering with ecological systems (Governor's Invasive Species Council of Pennsylvania, 2009).

Landslide - A landslide is the downward and outward movement of slope-forming soil, rock and vegetation reacting to the force of gravity. Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes and changes in groundwater levels. Mudflows, mudslides, rockfalls, rockslides and rock topples are all forms of a landslide. Areas that are generally prone to landslide hazards include previous landslide areas, the bases of steep slopes, the bases of drainage channels, developed hillsides and areas recently burned by forest and brush fires. (Delano & Wilshusen, 2001).

Lightning Strike - Lightning is a discharge of electrical energy resulting from the build-up of positive and negative charges within a thunderstorm. The flash or "bolt" of light usually occurs within clouds or between clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000°F. On average, 89 people are killed each year by lightning strikes in the United States. Within Pennsylvania, the annual average number of thunder and lightning events a given area can expect ranges between 40-70 events per year (FEMA, 1997).

Pandemic and Infectious Disease - A pandemic occurs when infection from of a new strain of a certain disease,

to which most humans have no immunity, substantially exceeds the number of expected cases over a given period of time. Such a disease may or may not be transferable between humans and animals. (Martin & Martin-Granel, 2006).

Radon Exposure - Radon is a cancer-causing natural radioactive gas that you can't see, smell or taste. It is a large component of the natural radiation that humans are exposed to and can pose a serious threat to public health when it accumulates in poorly ventilated residential and occupation settings. According to the US Environmental Protection Agency, radon is estimated to cause about 21,000 lung cancer deaths per year, second only to smoking as the leading cause of lung cancer (EPA 402-R-03-003: EPA Assessment…, 2003). An estimated 40% of the homes in Pennsylvania are believed to have elevated radon levels (Pennsylvania Department of Environmental Protection, 2009).

Subsidence/Sinkhole - Subsidence is a natural geologic process that commonly occurs in areas with underlying limestone bedrock and other rock types that are soluble in water. Water passing through naturally occurring fractures dissolves these materials leaving underground voids. Eventually, overburden on top of the voids causes a collapse which can damage structures with low strain tolerances. This collapse can take place slowly over time or quickly in a single event. Karst topography describes a landscape that contains characteristic structures such as sinkholes, linear depressions and caves. In addition to natural processes, human activity such as water, natural gas and oil extraction can cause subsidence and sinkhole formations. (FEMA, 1997).

Wildfire - A wildfire is a raging, uncontrolled fire that spreads rapidly through vegetative fuels, exposing and possibly consuming structures. Wildfires often begin unnoticed and can spread quickly, creating dense smoke that can be seen for miles. Wildfires can occur at any time of the year, but mostly occur during long, dry hot spells. Any small fire in a wooded area, if not quickly detected and suppressed, can get out of control. Most wildfires are caused by human carelessness, negligence and ignorance. However, some are precipitated by lightning strikes and in rare instances, spontaneous combustion. Wildfires in Pennsylvania can occur in fields, grass, brush and forests. 98% of wildfires in Pennsylvania are a direct result of people, often caused by debris burns (PA DCNR, 1999).

Windstorm/Tornado - A wind storm can occur during severe thunderstorms, winter storms, coastal storms or tornadoes. Straight-line winds such as a downburst have the potential to cause wind gusts that exceed 100 miles per hour. Based on 40 years of tornado history and over 100 years of hurricane history, FEMA identifies western and central Pennsylvania as being more susceptible to higher winds than eastern Pennsylvania. (FEMA, 1997). A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity (but sometimes result from hurricanes or tropical storms) when cool, dry air intersects and overrides a layer of warm,

moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of high wind velocities and windblown debris. According to the National Weather Service, tornado wind speeds can range between 30 to more than 300 miles per hour. They are more likely to occur during months of March through June and are most likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touch down briefly, but even small, short-lived tornadoes can inflict tremendous damage. Destruction ranges from minor to catastrophic depending on the intensity, size and duration of the storm. Structures made of light materials such as mobile homes are most susceptible to damage. Waterspouts are weak tornadoes that form over warm water and are relatively uncommon in Pennsylvania. Each year, an average of over 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries (NOAA, 2002). Based on NOAA Storm Prediction Center Statistics, the number of recorded F3, F4, & F5 tornadoes between 1950-1998 ranges from <1 to 15 per 3,700 square mile area across Pennsylvania (FEMA, 2009).

Winter Storm - Winter storms may include snow, sleet, freezing rain or a mix of these wintry forms of precipitation. A winter storm can range from a moderate snowfall or ice event over a period of a few hours to blizzard conditions with wind-driven snow that lasts for several days. Many winter storms are accompanied by low temperatures and heavy or blowing snow, which can severely impair visibility and disrupt transportation. Pennsylvania has a long history of severe winter weather. (NOAA, 2009).

NON-NATURAL HAZARD DESCRIPTIONS

Civil Disturbance/Mass Gathering - Civil disturbance hazards encompass a set of hazards emanating from a wide range of possible events that cause civil disorder, confusion, strife and economic hardship. Civil disturbance hazards include:

- Famine - Involving a widespread scarcity of food leading to malnutrition and increased mortality (Robson, 1981).
- Economic Collapse, Recession - Very slow or negative growth, for example (Economist, 2009).
- Misinformation - Erroneous information spread unintentionally (Makkai, 1970).
- Civil Disturbance, Public Unrest, Mass Hysteria, Riot - Group acts of violence against property and individuals, for example (18 U.S.C. § 232, 2008).
- Strike, Labor Dispute - Controversies related to the terms and conditions of employment, for example (29 U.S.C. § 113, 2008).

Dam Failure - A dam is a barrier across flowing water that obstructs, directs or slows down water flow. Dams provide benefits such as flood protection, power generation, drinking water, irrigation and recreation. Failure of these structures results in an uncontrolled release of impounded water. Failures are relatively rare, but immense damage and loss of life is possible in downstream communities when such events occur. Aging infrastructure, hydrologic, hydraulic and geologic characteristics, population growth, and design and maintenance practices should be considered when assessing dam failure hazards. The failure of the South Fork Dam, located in Johnstown, PA,

was the deadliest dam failure ever experienced in the United States. It took place in 1889 and resulted in the Johnstown Flood which claimed 2,209 lives (FEMA, 1997). Today there are approximately 3,200 dams and reservoirs throughout Pennsylvania (Pennsylvania Department of Environmental Protection, 2009).

Drug Overdose Crisis - Based on the methodology of the US Drug Enforcement Administration (US DEA), this hazard encompasses only drug-related overdose deaths ruled accidental or undetermined (if provided and toxicology was present) and excludes drug-related suicides. Drawing upon information from Pennsylvania's coroners and medical examiners as well as law enforcement intelligence, the DEA has prepared a list of drugs of interest under the following six drug categories:

- Benzodiazepines (e.g., Alprazolam, Chlordiazepoxide, Clonazepam, etc.)
- Cocaine
- Fentanyl/Fentanyl-Related Substances (FRS)/Non-Prescription Synthetic Opioids (NPSOs)
- Heroin
- Other Illicit Drugs (e.g., LSD, MDMA, Methamphetamine, and PCP)
- Prescription Opioids (e.g. Hydrocodone, Hydromorphone, Meperidine, etc.)

(US Department of Justice and US DEA, Analysis of Overdose Deaths in Pennsylvania, 2016)

Environmental Hazards/Explosion - Environmental hazards are hazards that pose threats to the natural environment, the built environment, and public safety through the diffusion of harmful substances, materials or products. Environmental hazards include the following:

- Hazardous material releases at fixed facilities or in transit; including toxic chemicals, infectious substances, biohazardous waste, and any materials that are explosive, corrosive, flammable or radioactive (PL 1990-165, § 207(e)).
- Mining incidents; including the release of harmful chemical and waste materials into water bodies or the atmosphere, explosions, fires, and other hazards and threats to life safety stemming from mining (Environmental Protection Agency, Natural Disaster PSAs, (2009).
- Oil and gas well incidents; including the release of the release of harmful chemical and waste materials into water bodies or the atmosphere, explosions, fires, and other hazards and threats to life safety stemming from oil and gas extraction(Environmental Protection Agency, Natural Disaster PSAs, 2009).

Explosions are extremely rapid releases of energy that usually generate high temperatures and often lead to fires. The risk of severe explosions can be reduced through careful management of flammable and explosive hazardous materials. (FEMA, 1997).

Fire (Urban/Structural) - An urban fire involves a structure or property within an urban or developed area. For hazard mitigation purposes, major urban fires involving large buildings and/or multiple properties are of primary concern. The effects of a major urban fire include minor to significant property damage, loss of life, and residential or business displacement.

Levee Failure - A levee is a human-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding (Interagency Levee Policy Review Committee, 2006). Levee failures or breaches occur when a levee fails to contain the floodwaters for which it is designed to control or floodwaters exceed the height of the constructed levee. 51 of Pennsylvania's 67 counties have been identified as having at least one levee (FEMA Region III, 2013).

Nuclear Incident - Nuclear incidents generally refer to events involving the release of significant levels of radioactivity or exposure of workers or the general public to radiation (FEMA, 1997). Nuclear accidents/incidents can be placed into three categories: 1) Criticality accidents which involve loss of control of nuclear assemblies or power reactors, 2) Loss-of-coolant accidents which result whenever a reactor coolant system experiences a break or opening large enough so that the coolant inventory in the system cannot be maintained by the normally operating make-up system, and 3) Loss-of-containment accidents which involve the release of radioactivity. The primary concern following such an incident or accident is the extent of radiation, inhalation, and ingestion of radioactive isotopes which can cause acute health effects (e.g. death, burns, severe impairment), chronic health effects (e.g. cancer) and psychological effects. (FEMA, 1997).

Structural Collapse - Collapse of a building or structure refers to the loss of the load-carrying capacity of a component of the structure or the entire structure itself. The loss of a structure's load carrying capacity occurs when the loads applied to the structure exceed the structure's load-carrying capacity. This can be a result of improper design, lack of maintenance, events from a structure's load history that have gradually reduced its load-carrying capacity, or sudden and severe hazard events such as severe weather or terrorism. (Ratay, 2000).

Terrorism - Terrorism is use of force or violence against persons or property with the intent to intimidate or coerce. Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and bombings; cyber-attacks (computer-based); and the use of chemical, biological, nuclear and radiological weapons (FEMA, 2009).

Transportation Crash - Transportation crashes can result from any form of air, rail, water or road travel. It is unlikely that small accidents would significantly impact the larger community. However, certain accidents could have secondary regional impacts such as a hazardous materials release or disruption in critical supply/access routes, especially if vital transportation corridors or junctions are present. (Research and Innovative Technology Administration, 2009). Traffic congestion in certain

circumstances can also be hazardous. Traffic congestion is a condition that occurs when traffic demand approaches or exceeds the available capacity of the road network. This hazard should be carefully evaluated during emergency planning since it is a key factor in timely disaster or hazard response, especially in areas with high population density. (Federal Highway Administration, 2009).

Utility Interruption - Utility interruption hazards impair the functioning of important utilities in the energy, telecommunications, public works and information network sectors. Utility interruption hazards include:

- Geomagnetic Storms; including temporary disturbances of the Earth's magnetic field resulting in disruptions of communication, navigation and satellite systems (National Research Council et al., 1986).
- Fuel or Resource Shortage; resulting from supply chain breaks or secondary to other hazard events, for example (Mercer County, PA, 2005).
- Electromagnetic Pulse; originating from an explosion or fluctuating magnetic field and causing damaging current surges in electrical and electronic systems (Institute for Telecommunications Sciences, 1996).
- Information Technology Failure; due to software bugs, viruses or improper use (Rainer Jr., et al, 1991).
- Ancillary Support Equipment; electrical generating, transmission, system-control and distribution-system equipment for the energy industry (Hirst & Kirby, 1996).
- Public Works Failure; damage to or failure of highways, flood control systems, deep water ports and harbors, public buildings, bridges and dams, for example (United States Senate Committee on Environment and Public Works, 2009).
- Telecommunications System Failure; Damage to data transfer, communications and processing equipment, for example (FEMA, 1997)
- Transmission Facility or Linear Utility Accident; liquefied natural gas leakages, explosions and facility problems, for example (United States Department of Energy, 2005)

Based on Planning Team input, the 2018 Lehigh Valley Plan does not include the following hazards from the 2013 State Plan:

Coastal Erosion: According to the PEMA Standard Operating Guide, "With the exception of portions of Erie County, coastal erosion is not a hazard for communities in Pennsylvania."

Mass Food/Animal Feed Contamination: According to the 2013 State Plan, "[w]ith the aggressive testing and food safety outreach the Department of Agriculture conducts, the overall probability of a mass food or animal feed contamination event is unlikely, according to the Risk Factor Methodology. Pennsylvania has not been the origin or cause of a mass food or animal feed contamination."

As the 2018 Plan is monitored and evaluated over the five-year maintenance period, the Planning Team will review the list of hazards to ensure it remains appropriate and relevant to the region and update the Plan as appropriate.

4.3 HAZARD PROFILES
Natural Hazards
4.3.1 Drought
4.3.1.1 Location and Extent

A drought can be defined by rainfall amounts, vegetation conditions, agricultural productivity, soil moisture, reservoir levels and stream flow. Simply put, a drought is a significant deficit in water due to lower than normal rainfall. As rainfall is the primary basis for both ground and surface water resources in the Commonwealth, the earliest indicator of a potential drought is precipitation deficits. Drought is a normal, recurrent feature of climate that occurs in virtually all climate zones, from very wet to very dry. Drought is a temporary aberration from normal climatic conditions and can vary significantly from one region to another. Human factors, such as water demand and water management, can exacerbate the drought impact on a region.

Droughts are regional in scope and may affect the entirety of the Lehigh Valley rather than only individual municipalities. Droughts may also concurrently affect counties near the Lehigh Valley, or even the entire Commonwealth. Generally, areas along waterways will indicate drought conditions later than areas away from waterways.

4.3.1.2 Range of Magnitude

Droughts can have varying effects depending on their severity, timing, duration and location. Some droughts may have their greatest impact on agriculture, while others may impact water supply or recreation. Most droughts cause direct impacts to aquatic resources (PEMA 2013). When droughts occur, they can have significant adverse effects on:

- Public water supplies for human consumption
- Rural water supplies for livestock consumption and agricultural operations
- Water quality
- Natural soil water or irrigation water for agriculture
- Water for forests and for fighting forest fires
- Water for navigation and recreation

The Pennsylvania Department of Environmental Protection (PADEP) and Pennsylvania Emergency Management Agency (PEMA) manage water supply droughts in Pennsylvania according to four conditions of drought defined in the Pennsylvania 2013 Hazard Mitigation Plan:

- **Drought Watch:** A period to alert government agencies, public water suppliers, water users and the public regarding potential for future drought-related problems. The focus is on increased monitoring, awareness and preparation for response in the event that conditions worsen. A request for voluntary water conservation is issued. The objective of voluntary water conservation measures during a drought watch is a 5% reduction in water use. Because of varying conditions, individual water suppliers or municipalities may ask for more stringent conservation actions.
- **Drought Warning:** This drought stage involves a coordinated response to imminent drought conditions by seeking concerted voluntary

conservation measures aimed at reducing overall consumption by 10 to 15% and avoiding the need for mandatory water restrictions. Individual water suppliers or municipalities may ask for more stringent conservation actions.

- **Drought Emergency:** During this drought stage, water management entities marshal all available resources to respond to actual emergency conditions, avoid depletion of water sources, ensure at least minimum water supplies to protect public health and safety, support essential and high-priority water uses, and avoid unnecessary economic dislocations. If deemed necessary and if ordered by the Governor during this stage, imposition of mandatory restrictions on nonessential water usage could occur as provided for in the Pennsylvania Code Chapter 119. The objective of water use restrictions is to reduce consumption by 15%, and to reduce total use to the extent necessary to preserve public water system supplies, avoid or mitigate local or area shortages, and ensure equitable sharing of limited supplies.
- **Local Water Rationing:** This condition of drought is not defined as a drought stage. Local municipalities may, with the approval of the Pennsylvania Emergency Management Council, implement local water rationing to share a rapidly dwindling or severely depleted water supply within designated water supply service areas. These individual water rationing plans, authorized through provisions of the Pennsylvania Code Chapter 120, require specific limits on individual water consumption to achieve significant reductions in use. Under both mandatory restrictions imposed by the Commonwealth and local water rationing practices, procedures are specified for granting variances in consideration of individual hardships and economic dislocations (PEMA 2013).

Pennsylvania uses five parameters to assess drought conditions: precipitation deficits, stream flows, reservoir storage levels, groundwater levels and soil moisture.

- **Precipitation Deficits:** As rainfall is the primary basis for both groundwater and surface water resources, precipitation deficits are the earliest indicators of a potential drought. The National Weather Service records “normal” monthly precipitation data for each county in Pennsylvania. These figures are generated from long-term monthly and decennial averages of precipitation and are updated at the end of each decade based on the most recent 30 years.
- **Stream Flows:** Stream flows offer the second earliest indication of drought conditions. PADEP uses 73 US Geological Survey (USGS)-maintained stream gages throughout the State as its drought monitoring network, computing 30-day average stream flow values for each stream gage based on the entire period of record for each gage. The various stages of drought watch, warning and emergency conditions are indicated, respectively, by 75-, 90- and 95% exceedances of 30-day average flows (PEMA 2013).

- **Reservoir Storage Levels:** Water level storage in several large public water supply reservoirs is another indicator that PADEP uses for drought monitoring. Depending on total quantity of storage and length of the refill period for the various reservoirs, PADEP uses varying percentages of storage drawdown to indicate the three drought stages for each reservoir (PEMA 2013).
- **Groundwater Levels:** Groundwater levels can be an indicator of a developing drought. USGS also maintains groundwater monitoring wells in each county throughout the Commonwealth. Groundwater measurements taken from these wells at exceedances of 75, 90, and 95% are used to indicate drought watch, warning and emergency status, respectively (PEMA 2013).
- **Soil Moisture:** The Palmer Drought Severity Index (PDSI) provides soil moisture information for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry weather. The tool is frequently used to indicate availability of irrigation water supplies, reservoir levels, range conditions, amount of stock water and forest fire potential. Although notably ineffective for monitoring short-term drought, the PDSI is effective for determining long-term droughts, and is most frequently used to delineate disaster areas (CPC 2015). Palmer Drought Severity Index is shown in Table 4.3.1.1.

The PDSI uses 0 to reflect normal status, and negative numbers to indicate droughts. For example, 0 is no drought, -2 is moderate drought and -4 is extreme drought. Positive numbers signify excess precipitation (NDMC 2013).

Table 4.3.1.1 Palmer Drought Severity Index (PDSI) Classifications

Severity	PDSI Value	Drought Status
Extremely Wet	4.0 or more	None
Very Wet	3.0 to 3.99	None
Moderately Wet	2.0 to 2.99	None
Slightly Wet	1.0 to 1.99	None
Incipient Wet Spell	0.5 to 0.99	None
Near Normal	0.49 to -0.49	None
Incipient Dry Spell	-0.5 to -0.99	None
Mild Drought	-1.0 to -1.99	None
Moderate Drought	-2.0 to -2.99	Watch
Severe Drought	-3.0 to -3.99	Warning
Extreme Drought	-4.0 or less	Emergency

Source: Hayes 2006; PEMA 2013

Drought impacts on the economy and environment can be significant. Economic impacts include losses to the agriculture industry, recreation/tourism industry, fishery production, water suppliers and timber production, as well as increased food prices. According to the National Drought Mitigation Center at the University of Nebraska-Lincoln (2013), environmental impacts of drought include:

- Damage to animal species in the form of reduced water and feed availability, degradation of fish and wildlife habitat, migration and concentration issues (too many or too few animals in a given area), stress to endangered species and loss of biodiversity
- Lower water levels in reservoirs, lakes and ponds
- Reduced stream flow
- Loss of wetlands

- Increased groundwater depletion, land subsidence, and reduced groundwater recharge
- Water quality impacts like salinity, water temperature increases, pH changes, dissolved oxygen or turbidity
- Loss of biodiversity
- Loss of trees
- Increased number and severity of fires
- Reduced soil quality and erosion issues
- Increased dust or pollutants

Based on historical drought occurrence data for the region, the worst drought event in the Lehigh Valley occurred during 2002. The Lehigh Valley was under a drought emergency due to continuing unseasonably dry weather. Groundwater levels declined resulting in adverse impacts to water supply wells, and streamflow levels reached record lows in some places. Crop losses for the Lehigh Valley in 2002 were valued at $4.2 million.

4.3.1.3 Past Occurrence

Historical information has been drawn from many sources to recount previous occurrences and losses associated with drought events throughout Pennsylvania and the Lehigh Valley. According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 43 drought events between April 30, 1950 and December 31, 2017. Additionally, the Northeast Regional Climate Center (NRCC), Drought Impact Report (DIR), PEMA and FEMA provided details on droughts that occurred prior to 1950, as identified in the 2013 Plan. Between 1895 and 1942, 14 drought events occurred in the Lehigh Valley, with PDSI values ranging from -3.27 to -4.95.

Since 1950, Pennsylvania experienced 12 drought events that resulted in a governor's proclamation or a Federal Emergency Management Agency (FEMA) declared disaster or emergency. The Lehigh Valley was included in five of these events. One FEMA declared disaster occurred as a result of a 1964-1966 drought/water shortage event, and Northampton County was included in the declaration. In addition to these events, the PADEP indicated that Lehigh County has experienced 15 drought watch declarations, 20 drought warning declarations, and 12 drought emergency declarations and Northampton County has experienced 15 drought watch declarations, 20 drought warning declarations, and 14 drought emergency declarations between the years of 1980 and 2009. Past occurrences of drought in the Lehigh Valley are shown in Table 4.3.1.2.

Table 4.3.1.2 Past Occurences of Drought Events From 1950-2017

Dates of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
September-November 1957	Drought	N/A	N/A	Lowerst PDSI of -3.07	NRCC
August 1964-January 1966	Drought, Water Shortage	DR-206	Northampton	In August, the Delaware River Basin was included in a FEMA disaster declaration. Lowest PDSI of -4.95	NRCC, PEMA, FEMA
June-November 1966	Drought	N/A	N/A	Lowest PDSI of -4.21	NRCC
January-February 1967	Drought	N/A	N/A	Lowest PDSI of -3.40	NRCC
August 1980-January 1981	Drought	N/A	N/A	The Lehigh Valley was under a declared drought emergency in November. Lowest PDSI of -5.07	NRCC, PADEP, PEMA
March-July 1985	Drought	N/A	N/A	The Lehigh Valley was under a declared drought emergency between April and July. Lowest PDSI of -4.30	NRCC, PADEP, PEMA
August 1991-April 1992	Drought	N/A	N/A	Lowest PDSI of -3.58	PA HMP
September - November 1995	Drought	N/A	N/A	A drought emergency was declared for the Lehigh Valley in mid-September. Preliminary crop losses caused by the drought were $300 million statewide and $26,799 in the Lehigh Valley.	PADEP, PEMA
December 1998-July 1999	Drought	N/A	N/A	The Lehigh Valley was under a drought warning. The precipitation in December at the Lehigh Valley International Airport (LVIA) was the second driest on record. In March 1999, the drought warning was downgraded to a drought watch. By June, the state declared a drought warning again, including all of eastern Pennsylvania. The drought intensified in July and was the driest on record at the LVIA.	PADEP
July-August 1999	Drought	N/A	N/A	The Lehigh Valley was under a drought emergency in July. Alfalfa cutting was expected to be one quarter of normal, the soybean crop one third of normal and the corn crop one half of normal. Low water levels made it difficult or impossible to use waterways for fishing and boating. Fish were dying due to low stream flows. By August, many farms in the Lehigh Valley reported corn losses around 9%. Crop loss figures in the Lehigh Valley were $214,388 for 1998 and $2.2 million for 1999.. The continued lack of rain resulted in wells going dry. Lowest PDSI of -3.54.	NRCC
December 18, 2001-November 25, 2002	Drought	N/A	N/A	In November 2001, a drought warning was issued for eastern Pennsylvania due to unseasonably dry weather. Due to low groundwater levels, a well in East Allen Township ran dry, cutting off water service to 73 area homes. Water was trucked in to restore water service between August and November. From February to September 2002, the Lehigh Valley was under a drought emergency. Groundwater levels were continuing to decline with streamflow levels reaching record low levels in some cases. In August 2002, water once again had to be trucked in to serve customers in East Allen Township. Crop losses due to drought in the Lehigh Valley for 2002 were $4.2 million.	DIR, PADEP, PEMA, PA HMP

Table 4.3.1.2 Past Occurences of Drought Events From 1950-2017

Dates of Event	Event Type	FEMA Declaration Number	County Designated	Losses/Impacts	Source(s)
June-November 2005	Drought	N/A	N/A	A drought warning was put into effect in September. The Pennsylvania governor asked for $128 million in subsidence for farmers who lost a majority of their soybean, corn, hay, and alfalfa crops. Farmers were then eligible for low interest loans from the USDA. The counties eligible for assistance included Lehigh County.	DIR
June 2007-January 2008	Drought	N/A	N/A	As a result of a dry summer, the Lehigh Valley remained under a declared drought watch as of January 1, 2008. Surface and groundwater conditions had improved during the last quarter of 2007 and the trend continued during the first few weeks of 2008. In response to the improvement, PADEP lifted drought watch declarations in the Lehigh Valley on January 11, 2008.	DRBC
April-November 2010	Drought	N/A	N/A	The hot, dry summer and decreasing water supplies led Pennsylvania environmental authorities to issue a drought warning for 24 counties, including Lehigh and Northampton, and asked residents to reduce their water use by 10 to 15 percent. Sixteen counties in Pennsylvania were declared to be natural disaster areas by the USDA due to an ongoing drought that started in May, including Lehigh and Northampton. This declaration permitted impacted farmers, ranchers, and other agricultural producers to apply for low-interest emergency loans from the Farm Service Agency.	DIR, PADEP
June 17, 2015-July 10, 2015	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
August 2, 2016-November 3, 2016	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
November 3, 2016-February 14, 2017	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP
February 14, 2017-May 16, 2017	Drought	N/A	N/A	According to the PADEP Division of Planning and Conservation, the Lehigh Valley was under a drought watch.	PADEP

Sources: NRCC, 2012; DIR, 2012; DRBC, 2008; PEMA, 2010; PADEP, 2012; PADEP 2017
DIR National Drought Mitigation Center Drought Impact Reporter
DRBC Delaware River Basin Commission
NRCC Northeast Regional Climate Center
PA HMP Pennsylvania 2013 Standard All Hazard Mitigation Plan
PADEP Pennsylvania Department of Environmental Protection
PEMA Pennsylvania Emergency Management Agency

4.3.1.4 Future Occurrence

The frequency of droughts is difficult to forecast. It appears that the occurrences of drought are cyclical in nature and thus will occur in the future. Based on national annual data from 1895 to 1995, the Lehigh Valley was in severe or extreme drought conditions approximately 5 to 9.9% of the time. Based on national annual data from 1895 to 2011, the East Central Mountains climate division, in which the Lehigh Valley is located, had an average PDSI of -.25. This climate division has been in severe or extreme drought during approximately 11% of the 117 years on record. Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for drought events in the Lehigh Valley is considered 'possible' as defined in Section 4.4.1.

4.3.1.5 Vulnerability Assessment

For the drought hazard, the entire Lehigh Valley has been identified as the hazard area and the entire population in the Lehigh Valley is vulnerable to drought events. Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the drought hazard.

No structures are anticipated to be directly affected by a drought and all are expected to be operational during a drought event. However, droughts contribute to conditions conducive to wildfires. Assets at particular risk during drought or extreme heat would include any open land or structures located along areas in which wildlands and urban areas connect. Risk to life and property is greatest in these areas where forested areas adjoin urbanized areas. Therefore, all assets in and adjacent to these areas, including population, structures, critical facilities and businesses are considered vulnerable to wildfire as discussed in the Wildfire profile.

Drought conditions can cause a shortage of water for human consumption and reduce local firefighting capabilities. The drought hazard is a concern because private water supply sources in the Lehigh Valley come from local groundwater sources. Finally, vulnerable populations could be particularly susceptible to the drought hazard and cascading impacts due to age, health conditions, and limited ability to mobilize to shelter, cooling and medical resources.

If a drought is severe enough to deplete the water supply of an area, residents may be forced to leave the area for another location with ample water supply (Koba 2014). The opposite may also occur in the Lehigh Valley. Areas outside of the planning area that are forced to leave due to lack of water supply may choose to migrate to the Lehigh Valley. This can have negative impacts on Lehigh and Northampton counties such as increased demand for drinking water and impacts to emergency and social services.

A prolonged drought can have serious direct and indirect economic impacts on a community or across the Lehigh Valley, especially on the agriculture industry. Lehigh County is threatened with higher agricultural losses than Northampton County. If a drought were to eliminate the entire Lehigh Valley's agricultural yield, total losses may exceed $134 million, which would be devastating to the local economy.

County	Farmland Acreage Exposed	Market Value of all Agricultural Products
Lehigh	**76,331**	**$90,833,000**
Northampton	**65,744**	**$43,496,000**

Source: USDA Census of Agriculture, 2012

4.3.2 Earthquake

4.3.2.1 Location and Extent

According to the Pennsylvania Bureau of Topographic and Geologic Survey, the Commonwealth is relatively free of earthquake activity compared to other states, however, earthquakes do occur. Pennsylvania has experienced fewer and milder earthquake events than most other eastern states. When events occur in Pennsylvania, their impact area is less than about 60 miles in diameter. Areas of Pennsylvania, including the Lehigh Valley, may be subject to the effects of earthquakes with epicenters outside the state.

Pennsylvania has three earthquake hazard area zones (very slight, slight and moderate) (PEMA, 2013). The Lehigh Valley falls into the “moderate” zone, along with other municipalities and counties located within 17.5 miles from a historical epicenter. In this zone, minor earthquake damage is expected.

Earthquakes above a magnitude 5.0 can cause damage near their epicenters, and larger-magnitude earthquakes can cause damage over larger, wider areas. Earthquake epicenters in Pennsylvania have tended to be centered in the southeastern portion and northwestern corner of the Commonwealth.

4.3.2.2 Range of Magnitude

The Richter scale is the most widely known scale that measures magnitude of earthquakes as shown in Table 4.3.2.1. It has no upper limit and is not used to express damage. An earthquake in a densely populated area that results in many deaths and considerable damage may have the same magnitude and shock in a remote area that did not undergo any damage. Based on historical data of earthquakes with a recorded intensity, little damage is expected from earthquake events. However, since the worst earthquake recorded in Pennsylvania was a magnitude 5.2, a worst-case scenario for this hazard would be if an earthquake of similar magnitude occurred in the Lehigh Valley or near the border in an adjacent county, resulting in trees swaying, objects falling off walls, cracked walls and falling plaster.

Table 4.3.2.1 Richter Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but causes only minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can destroy communities near the epicenter

Source: PEMA 2013

The intensity of an earthquake is based on observed effects of ground shaking on people, buildings and natural features, and varies with location. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale, which expresses the intensity of an earthquake and is a subjective measure that describes the strength of a shock felt at a particular location on a scale from I to XII as shown in Table 4.3.2.2. Earthquakes that occur in Pennsylvania originate deep within the earth's crust, not on an active fault. Therefore, little or no damage is typically expected. No injury or severe damage from earthquake events has been reported in the Lehigh Valley.

Earthquakes can lead to numerous, widespread and devastating environmental impacts. These impacts may include, but are not limited to:

- Induced flooding or landslides
- Poor water quality

Table 4.3.2.2 Modified Mercalli Intensity Scale With Associated Impacts

Scale	Intensity	Description of Effects	Corresponding Richter Scale Magnitude
IV	Moderate	Felt by people walking	<4.2
V	Slightly Strong	Sleepers awake; church bells ring	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves	<5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures; poorly constructed buildings are damaged	<6.9
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<6.9
X	Disastrous	Ground cracks profusely; many buildings are destroyed; liquefaction and landslides are widespread	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes, and cables are destroyed; general triggering of other hazards occurs	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>8.1

Source: PEMA, 2013

- Damage to vegetation
- Breakage in sewage or toxic material containments

Secondary impacts can include train derailments and spillage of hazardous materials and utility interruption.

4.3.2.3 Past Occurrence

Data from the Pennsylvania Department of Conservation and Natural Resources and USGS shows six recorded earthquakes occurred in the Lehigh Valley between the dates of 1871 and 2017, five with epicenters in the City of Allentown area and one near the City of Easton. Earthquake events in the Lehigh Valley are shown in Table 4.3.2.3. The magnitude of these earthquakes ranged from 2.3 to 4.3 on the Richter Scale, suggesting relatively minor events (PA DCNR, 2007; USGS 2018). According to the USGS, Incorporated Research Institutions for Seismology, almost 300 earthquakes were recorded within 100 miles of the Lehigh Valley from 1990-2017, including three that were between 4.00 and 4.99 in magnitude. However, no damages or injuries were reported in the Lehigh Valley.

4.3.2.4 Future Occurrence

The Pennsylvania Bureau of Topographic and Geologic Survey indicates that an earthquake is a relatively low-level hazard in Pennsylvania based on a probabilistic

Table 4.3.2.3 Earthquake Events Occurring in the Lehigh Valley Region Between 1871-2017

Date	Magnitude (Richter Scale)	Losses/Impacts
May 31, 1884	2.9	Epicenter near the City of Allentown. Maximum intensity of V. In Allentown, dishes were thrown from tables.
May 31, 1908	3.1	Epicenter near the City of Allentown. Maximum intensity of VI. In Allentown, the shock shook down chimneys.
June 22, 1928	2.4	Epicenter near the City of Allentown. Maximum intensity of III. No reference and/or no damage reported.
November 23, 1951	3.3	Epicenter near the City of Allentown. Maximum intensity of IV. No reference and/or no damage reported.
September 14, 1961	4.3	Epicenter near the City of Allentown. Maximum intensity of V. The earthquake shook buildings over a broad area. There was only one report of damage of loose bricks that fell from a chimney in Allentown. Other areas that were effected included Bethlehem, Catasauqua, Coplay, Egypt, Fountain Hill, Freemansburg, and Hellertown.
December 20, 2009	2.3	Epicenter approximately 3.2 miles from Raubsville (Williams Township, Northampton County).

Source: PEMA, 2013; US Geological Survey 2016

analysis considering the threat from earthquakes both outside and inside Pennsylvania. An earthquake's severity can be expressed by considering the rate in change of motion of the earth's surface during a seismic event as a percent of the normal rate of acceleration due to gravity, which is called the Peak Horizontal Ground Acceleration (PHGA). In general, ground acceleration must exceed 15 percent of gravity for significant damage to occur, although soil conditions at local sites are extremely important in controlling how much damage will occur as a consequence of a given amount of ground acceleration. According to PEMA, the highest seismic hazard in the state exists in southeastern Pennsylvania, where PHGA values range from 10-14 percent, and there is a 90 percent probability that maximum horizontal acceleration in rock of 10 percent of gravity will not be exceeded in a 50-year period (PEMA 2013).

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for earthquake events in the Lehigh Valley is considered 'unlikely' as defined in Section 4.4.1.

4.3.2.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability to the earthquake hazard has not changed since the 2013 Plan. All jurisdictions will continue to be vulnerable. Therefore, all population, structures and critical facilities are exposed and potentially vulnerable to direct and indirect impacts of earthquakes. However, several differences between the 2013 Plan and 2018 Plan risk assessment are acknowledged, including an updated version of the FEMA HAZUS-MH model and inventory data used, which may indicate a change in vulnerability. For the 2013 Plan, HAZUS-MH v2.1 was used. For the 2018 Plan, an updated version of FEMA's HAZUS-MH earthquake module (version 4.0) was used to estimate potential losses. There have been changes and advances to the latest version of HAZUS-MH used for the 2018 Plan, including a longer historical record. Three probabilistic earthquake events were developed through a Level 2 analysis in HAZUS-MH v4.0 for the Lehigh Valley: the 100-year, 500- and 2,500-year mean return periods (MRPs), in addition to annualized losses for eight return periods to estimate the annualized general building stock dollar losses.

For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the LVPC and Lehigh and Northampton County GIS Departments. Both updated inventories were integrated into HAZUS-MH v4.0 to estimate potential losses.

The entire Lehigh Valley population of 659,312 people is potentially exposed to direct and indirect impacts from earthquakes (US Census Bureau, 2012-2016 American Community Survey 5-Year Estimates). The degree of exposure is dependent on many factors, including the age and construction type of buildings and the soil type on which buildings are constructed. The impact of earthquakes on life, health and safety is dependent upon the severity of the event. Risk to public safety and loss of life from an earthquake in the Lehigh Valley is minimal, with higher risks occurring in buildings as a result of damage to the structure, or people walking below building ornamentation and chimneys that may be shaken loose and fall as a result of the quake. Business interruption

may prevent people from working, road closures could isolate populations and loss of functions of utilities could impact populations that may not have suffered direct damage from the event itself.

Populations considered most vulnerable include people over the age of 65 and people living below the Census poverty threshold. These socially vulnerable populations are most susceptible based on factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Residents may be displaced or require temporary to long-term sheltering. The number of people requiring shelter is generally less than the number displaced, as some displaced persons use hotels or stay with family or friends following a disaster event. Estimates generated by HAZUS-MH are based on the 2010 US Census Bureau population total for the Lehigh Valley and are shown in Table 4.3.2.4. A complete listing of sheltering needs by municipality is located in Appendix F.

Table 4.3.2.4 Estimated Sheltering Needs for the Lehigh Valley

Scenario	Displaced Households	People Requiring Short-Term Shelter
100-Year Earthquake	0	0
500-Year Earthquake	62	39
2,500-Year Earthquake	740	471

Source: HAZUS-MH 4.0

If an event is severe enough, residents may not be able to return to their homes or communities for a long period of time (Huynh et al. 2013). Surrounding areas of the impacted areas may experience an increase in population for those fleeing their homes and communities to seek safety. Earthquakes that occur in the area of Lehigh and Northampton counties can lead to evacuations as well. Moderate-size earthquakes can lead to minor building damage, resulting in the need for inspections to make sure buildings and homes are safe. Residents would need to leave their homes to ensure their safety.

No injuries or casualties are estimated for the 100-year event. However, HAZUS-MH 4.0 estimates injuries and casualties for both the 500-year event and 2,500-year event as shown in Tables 4.3.2.5 and 4.3.2.6, respectively.

Table 4.3.2.5 Estimated Injuries and Casualties: 500-Year Earthquake Event

Level of Severity	Time Of Day		
	2 AM	2 PM	5 PM
Injuries	41	32	29
Hospitalization	5	4	4
Casualties	1	1	1

Table 4.3.2.6 Estimated Injuries and Casualties: 2,500-Year Earthquake Event

Level of Severity	Time Of Day		
	2 AM	2 PM	5 PM
Injuries	307	263	232
Hospitalization	57	46	42
Casualties	11	8	8

Source: Hazus-MH 4.0

The entire building stock (as provided in Appendix E), in the Lehigh Valley is exposed and vulnerable to the earthquake hazard. The analysis estimated annualized losses to the building stock, potential building damage by building type and occupancy class, and building stock losses (structure and contents).

Earthquakes also have impacts on the economy, including loss of business function, damage to inventory, relocation costs, wage loss and rental loss due to the repair/ replacement of buildings. The total economic loss was also estimated for the 100-, 500- and 2,500-year events. The Lehigh Valley is estimated to incur $38.3 million in income losses for the 500-year event and $291 million for the 2,500-year event.

In addition, impacts to critical facilities and utilities were evaluated, including the percent functionality for each facility days after the event. No impacts were identified for critical facilities and utilities for the 100-year event.

In terms of transportation, roadway segments and railroad tracks may experience damage due to ground failure. Damage estimates for roadways were not calculated by HAZUS. It is assumed that regional transportation and distribution of materials may be interrupted as a result of an earthquake event. In terms of bridges, HAZUS estimates $10,000 in highway bridge loss as a result of a 500-year event and $330,000 as a result of a 2,500-year event.

HAZUS-MH 4.0 also estimates the volume of debris that may be generated as a result of an earthquake event to enable the Lehigh Valley to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break it up before it can be transported, and (2) brick, wood and other debris that can be loaded directly onto trucks with bulldozers (HAZUS-MH Earthquake User's Manual). For the 100-year MRP event, HAZUS-MH estimates no debris will be generated. HAZUS-MH estimates greater than 90,000 tons of debris will be generated by the 500-year event and 575,000 tons for the 2,500-year event.

Analysis results, including potential loss estimates are reported in Appendix F.

4.3.3 Extreme Temperature

4.3.3.1 Location and Extent

The Lehigh Valley falls within the Piedmont Plateau geographic area, which can experience uncomfortably hot summers. Records from across the Piedmont Plateau are generally representative of conditions in the Lehigh Valley, and show daily temperatures reaching 90°F or above on the average of 25 days during the summer season, while temperatures of 100°F or above are rare. From about July 1 to the middle of September, this area occasionally experiences uncomfortably warm periods, four to five days in length, during which light wind movement and high relative humidity make conditions oppressive. In general, the winters are comparatively mild, with an average of less than 100 days with minimum temperatures below the freezing point (NCDC Date Unknown).

During July, the warmest month, high temperatures in the Lehigh Valley normally range from the low-80s in the northern areas to the upper-70s/mid-80s in the central and southern areas. Minimum temperatures in the Lehigh Valley range from the upper-60s in the southeast to the lower-50s in the north-central mountains. During the colder months, most of the Lehigh Valley experiences low temperature averages ranging from 16°F in the north to as high as 21°F in urban areas.

The Lehigh Valley can experience many different temperature extremes in the summer and winter seasons. Areas most susceptible to extreme heat are urban environments, which tend to retain the heat well into the night, leaving little opportunity for dwellings to cool. 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 ‘heat islands’ that are hotter than nearby rural areas (US Environmental Protection Agency [EPA] 2009).

Heat islands can increase peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA 2010 and 2011). The effects of heat islands include:

- Elevated energy demands. 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.
- Increased pollution. 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. Elevated temperatures can also directly increase the rate of ground-level ozone formation. Ground-level ozone is formed when NOx and volatile organic compounds (VOC) react to the presence of sunlight and hot weather.
- Health issues. Increased temperatures and higher air pollution can cause respiratory difficulties, heat cramps, exhaustion, heat stroke and mortality. Heat

islands can also intensify the impact of heat waves. High risk populations are most vulnerable to extreme heat events.

- Heated stormwater runoff. Pavements that are 100ºF can elevate initial rainwater temperature from approximately 70ºF to over 95ºF. The heated runoff drains into storm sewers and raises water temperatures of streams, rivers, 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 (EPA 2011).

Heat islands are typically most intense over dense urban areas. Vegetation and parks within a downtown area may help reduce heat islands (EPA 2008).

4.3.3.2 Range of Magnitude

Extreme temperatures can result in elevated utility costs to consumers and can also lead to human risks. The elderly and the very young are the most vulnerable to health-related impacts of extreme temperatures (PEMA 2013).

Meteorologists can accurately forecast extreme temperature event development and the severity of the associated conditions with several days lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations. For heat events, the National Weather Service (NWS) issues excessive heat outlooks when the potential exists for an excessive heat event in the next three to seven days. Watches are issued when excessive heat is expected in the next 24 to 72 hours. Excessive heat warning/ advisories are issued when an excessive heat event is expected in the next 36 hours (PEMA 2013; NWS 2018).

Without heat and shelter, cold temperatures can lead to hypothermia, frostbite and death. Wind chill temperatures are often used in place of raw temperature values due to the effect that wind can have on the body under cold temperatures. Similar to high temperatures, the effect of cold temperatures will vary by individual (PEMA 2013). In Pennsylvania (including in the Lehigh Valley), wind chill warnings are issued when wind chills drop to -25°F or lower. Wind chill advisories are issued when wind chill values drop to -15°F (NWS 2018).

Extreme Heat

Extremely high temperatures can cause heat stress, which is divided into four categories. Each category is defined by apparent temperature, which is associated with a heat index value that captures the combined effects of dry air temperature and relative humidity on humans and animals. Major human risks for these temperatures include heat cramps, heat syncope, heat exhaustion, heatstroke and death. The temperatures serve as a guide for various danger categories; the impacts of high temperatures will vary from person to person based on individual age, health and other factors.

NOAA's heat alert procedures are based mainly on heat index values. The heat index is given in degrees Fahrenheit (°F). It is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the heat index temperature, the temperature and relative humidity need to be known. It is important to know that the heat index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F (NWS 2013).

Extreme Cold

The extent of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind chill 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 Date Unknown). The WCT Index includes a frostbite indicator, showing points where temperature, wind speed and exposure time will produce frostbite to humans, including how long a person can be exposed before frostbite develops (NWS Date Unknown).

The Lehigh Valley's worst-case extreme heat scenario would be an excessive heat spell occurring during a summer holiday weekend, such as Independence Day weekend. Summer holiday weekends bring people out of their air-conditioned environments and into the outdoors, often despite dangerous heat and humidity. This took place in July 1999. High temperatures reached the 90s for the first time on July 3rd, but sweltering humidity and record breaking maximum temperatures of approximately 100°F occurred from Independence Day through July 6th. The combination of the temperature and humidity produced heat indices of around 110°F. Record high temperatures of 100°F were reported on July 5th at the Lehigh Valley International Airport and in the City of Easton. Two heat-related deaths were reported in the Lehigh Valley, with a total of 74 heat-related deaths and more than 100 reported heat-related injuries across the 10 Pennsylvania counties impacted.

The Lehigh Valley's worst-case extreme cold temperature scenario would involve below zero temperatures and chilling winds accompanied by snow or ice accumulation and power failure. The Lehigh Valley's worst extreme cold temperature event took place in January 2003 when temperatures were between 8 and -11°F. There were four deaths related to this event.

Temporary periods of extreme hot or cold temperatures typically do not have significant environmental impacts but have serious health impacts, especially in urban areas experiencing the heat island effect. However, prolonged periods of hot temperatures may be associated with drought conditions and can damage or destroy vegetation, dry up rivers and streams, and reduce water quality. Prolonged exposure to extremely cold temperatures can kill wildlife and vegetation (PEMA 2013).

4.3.3.3 Past Occurrence

Since 1994, the Lehigh Valley was subject to more than 70 extreme temperature events. These events have been responsible for one death, 14 injuries and over $4.4 million in property damage. Please note that extreme temperature data is regional and the temperatures, deaths and injuries were not necessarily in the Lehigh Valley. Table 4.3.3.1 shows extreme temperature events recorded since the 2013 Plan.

4.3.3.4 Future Occurrence

Due to its location and geography, the Lehigh Valley is more likely to encounter excessive heat than extreme cold weather. Topography and vegetation can impact temperature differentials across the Lehigh Valley. It is estimated that the entire Lehigh Valley will continue to experience temperature extremes annually that may induce secondary hazards such as potential snow, hail, ice or windstorms, thunderstorms, drought, human health impacts, utility interruptions and transportation crashes.

Table 4.3.3.1 Extreme Temperature Events in the Lehigh Valley, 2012-2017

Date	Type	Actual Temperature in °F*	Deaths	Injuries
6/20/2012	Heat	95	0	0
6/29/2012	Heat	96	0	0
7/4/2012	Heat	99	3	0
7/18/2012	Excessive Heat	98	0	0
7/26/2012	Heat	91	0	0
7/7/2013	Heat	92	0	0
7/18/2013	Excessive Heat	98	0	0
9/11/2013	Heat	92	0	0
1/4/2014	Cold/wind Chill	-4	0	0
1/7/2014	Cold/Wind Chill	-1	0	0
1/22/2014	Cold/Wind Chill	-1-1	0	0
7/2/2014	Heat	94	0	0
1/7/2015	Cold/Wind Chill	2	0	0
2/13/2015	Cold/Wind Chill	5	0	0
2/15/2015	Cold/Wind Chill	7	1	0
2/20/2015	Cold/Wind Chill	-3	1	0
2/24/2015	Cold/Wind Chill	-8	0	0
7/19/2015	Heat	93	0	0
2/14/2016	Cold/Wind Chill	2	0	0
Total			**5**	**0**

Source: NCEI 2018
* not including wind chill/heat index

The 2013 Pennsylvania All-Hazard Mitigation Plan provides information on the probability of extreme maximum and minimum temperatures using data from 30 recording stations throughout the State. According to this data, high temperatures of 90°F or above occur on the average of 10 to 20 days per year in the Lehigh Valley, with the fewest events occurring in the northeast areas of Northampton County, and the greatest frequency occurring in the south and southwest portions of both counties.

There are, on average, three days per year in which temperatures in the Lehigh Valley reach or exceed 95°F, while temperatures exceed 100°F once every five to six years. For extreme cold temperatures, the Lehigh Valley can expect temperatures of less than 0°F every year, while temperatures of less than -10°F are rare.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for extreme temperature events in the Lehigh Valley is considered 'likely' as defined in Section 4.4.1.

4.3.3.5 Vulnerability Assessment

Most extreme temperature events involve a large region, therefore, the entire Lehigh Valley has been identified as the hazard area. All people, structures and critical facilities are exposed and potentially vulnerable. Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan.

Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include: 1) the elderly, who are less able to withstand temperature extremes due to their age, health conditions and limited mobility to access shelters, especially urban-dwelling elderly without access to an air-conditioned environment for at least part of the day; 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 who cannot afford proper heating and cooling; and 5) people who overexert during work or exercise during extreme heat or cold events.

It is essential that critical facilities, including utilities, remain operational during natural hazard events. In times of extreme heat, the increased use of air conditioners can overload existing utility grids and spur localized or regionalized brown-outs. Extreme cold events, especially when coupled with severe winter weather, can cause utility pipes to burst and interrupt the distribution of utilities. Prolonged extreme temperature events can also spur fuel shortages. The impact of extreme temperatures on utilities will depend on the overall use and duration of the event (PEMA 2013). Backup power is recommended for critical facilities and infrastructure.

Highways and railroad tracks can become distorted in high heat. Disruptions to the transportation network and crashes due to extreme temperatures represent an additional risk.

Extreme temperature events also have impacts on the economy, including loss of business function and damage or loss of inventory. Those losses, the need for repairs or increased utility costs can increase the financial burden on business owners.

The agricultural industry is most at risk in terms of economic impact and damage. Temperature and duration of extreme cold can have devastating effects on trees and winter crops. Livestock is especially vulnerable to heat, and crop yields can be impacted by heat waves that occur during key development stages. Lehigh County is threatened with higher agricultural losses than Northampton County. If an extreme temperature event were to eliminate the entire Lehigh Valley's agricultural yield, total losses may exceed $134 million, which would be devastating to the local economy, as indicated in the Drought profile.

Similar to drought, changing temperatures are classified as a slow environmental change. In response to this change, most likely driven by climate change, people adopt various migration patterns, from temporary migration for a few weeks or months, to longer-term seasonal migration each year and even permanent migration away from their homes. Historically, urban to rural migration usually occurs to minimize the health effects of heat during times of hot temperatures, while rural to urban migration is usually observed when people move to cities to find help and access basic services during heat-related events (International Organization on Migration).

In the Lehigh Valley, prolonged extreme temperature events have the potential to impact the agricultural industry, water supply for human consumption, power and utility supplies, water quality and natural habitats of plants and animals. If extreme heat or cold events coincide with power outages, residents may be forced to temporarily leave their homes and seek shelter that has comfort measures such as air conditioning or heat. If the Lehigh Valley does not have ample shelters, residents may need to leave the region to find shelter. The Lehigh Valley may also experience an increase in population during extreme temperature events impacting areas outside of the region. Those in other counties and states may temporarily move into the Lehigh Valley to find relief from temperature extremes.

4.3.4 Flood, Flash Flood, Ice Jam

4.3.4.1 Location and Extent

Floods are one of the most common natural hazards in the United States and are the most prevalent type of natural disaster occurring in Pennsylvania. Over 94% of the municipalities in the Commonwealth have designated flood-prone areas. Both seasonal and flash floods have been the cause of millions of dollars in annual property damages, loss of lives and disruption of economic activities [Pennsylvania Emergency Management Agency (PEMA) 2013].

Flooding is the most significant natural hazard in the Lehigh Valley. Riverine, flash, stormwater and ice jam floods occur around rivers, streams and creeks found throughout the Lehigh Valley. Stormwater/urban flooding occurs in areas of ditches, storm sewers, retention ponds and other facilities constructed to store runoff. Within Lehigh and Northampton Counties, the State has designated 16 watersheds for the purposes of stormwater management. The Lehigh Valley has ordinances in place for all 16 watersheds.

Two major rivers, the Lehigh and Delaware, are located within the Lehigh Valley, along with the tributaries of these two rivers. The Lehigh River flows through Lehigh Gap at the northern boundary of Lehigh and Northampton counties southbound to Allentown where it turns eastward. The Lehigh River essentially splits the Lehigh Valley in half. From Allentown, the Lehigh River flows eastward to its confluence with the Delaware River at Easton. Major tributary streams flowing into the Lehigh River are Coplay Creek, Little Lehigh Creek, Hokendauqua Creek, Jordan Creek, Monocacy Creek and Saucon Creek.

The Delaware River flows along the eastern portion of Northampton County and eventually flows into the Atlantic Ocean. Bushkill Creek and Martins Creek flow directly into the Delaware. In Lehigh and Northampton counties, all municipalities have areas prone to flooding along streams and/or rivers.

Ice jams are common in the northeastern US, and the Lehigh Valley is not an exception. Ice jams act as a natural dam and restrict flow of a body of water and may build up to a thickness great enough to raise the water level and cause flooding. The Lehigh Valley has experienced ice jams in the past.

Flood hazard areas are identified on the FEMA Flood Insurance Rate Map (FIRM) and are identified as a Special Flood Hazard Area (SFHA). SFHAs are defined as the area that will be inundated by the flood event having a 1% chance of being equaled or exceeded in any given year. The 1% annual chance flood is also referred to as the base flood or 100-year flood. The FIRM also identifies areas of the 0.2% chance flood or 500-year floodplain. The SHFA is the area where the National Flood Insurance Program's (NFIP) floodplain management regulations must be enforced, and the area where the mandatory purchase

of flood insurance applies. A structure located within a 1% floodplain has a 26% chance of suffering flood damage during the term of a 30-year mortgage (FEMA 2018).

At the time of this 2018 Plan, the 2004 Lehigh County digital FIRMs (DFIRMS) and the 2014 Northampton County DFIRMs are considered the best available and used for the risk analysis. Floodplains within the Lehigh Valley are shown in Figure 4.3.4.1.

To determine the area within the 1% and 0.2% annual chance floodplains, DFIRMs were overlaid upon the Lehigh Valley to summarize the flood mapping and hazard areas in Lehigh and Northampton counties. Based on the analysis, more than 37 square miles or about 5% of the Lehigh Valley area lies within a 1% annual chance floodplain, and about 43 square miles or about 6% lies within a 0.2% chance floodplain. A complete listing of the area exposed by municipality is located in Appendix F.

While the DFIRMs provide a credible source to document extent and location of the flood hazard, there are limitations to the accuracy of the data reflected on these maps. As such, it is noted that FIRMs are based upon the existing hydrology conditions at the time of the maps' preparation. FIRMs are not set up to account for the possible changes in hydrology that can occur over time.

4.3.4.2 Range of Magnitude

Both localized and widespread floods are considered hazards when people and property are affected. Injuries and deaths can occur when people are swept away by flood currents or bacteria and disease are spread by moving or stagnant floodwaters. Most property damage results from inundation by sediment-filled water. A large amount of rainfall over a short time span can result in flash flood conditions. Small amounts of rain can result in floods in locations where the soil is frozen or saturated from a previous wet period or if the rain is concentrated in an area of impermeable surfaces such as large parking lots or paved roadways (PEMA 2013).

Several factors determine the severity of floods, including intensity and duration, topography, ground cover and rate of snowmelt. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover. Many areas in Pennsylvania have relatively steep slopes, which promote quick surface water runoff. (PEMA 2013).

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. One element is the size of rivers and streams in an area, but an equally important factor is the land's absorbency. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration into the ground slows and any more water that accumulates must flow as runoff (Harris 2001).

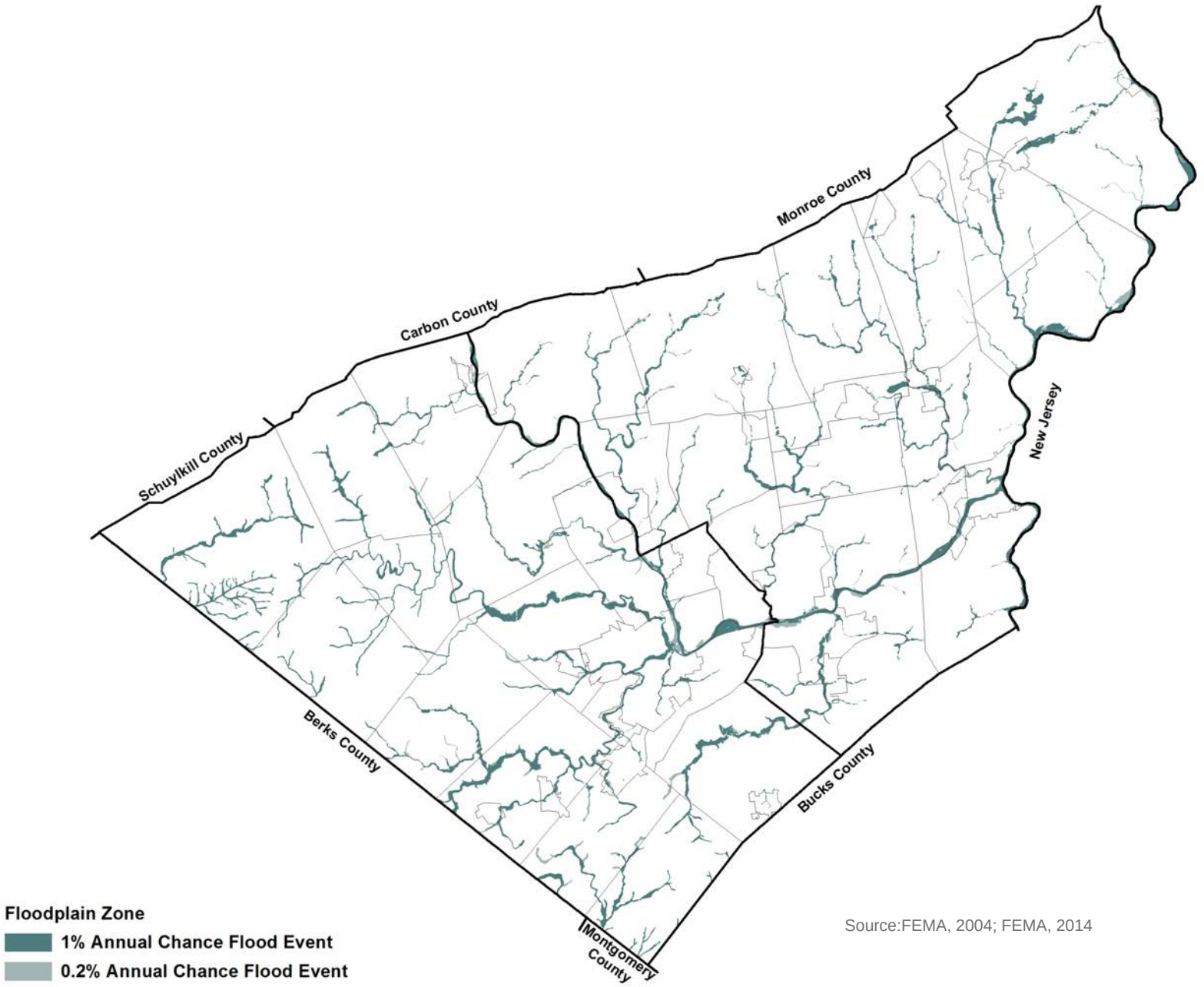
In the case of riverine or flash flooding, once a river reaches flood stage, the flood extent or severity categories used by the National Weather Service include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

Minor Flooding - minimal or no property damage, but public threat or inconvenience is possible.

Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and transfer of property to higher elevations are necessary.

Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

Figure 4.3.4.1 Floodplains in the Lehigh Valley



Source:FEMA, 2004; FEMA, 2014

One of the worst flooding events for the Lehigh Valley occurred in September 2004 with Tropical Storm Ivan. Storm totals averaged around five inches and caused widespread creek and river flooding throughout Lehigh Valley. In Lehigh County, the hardest hit municipalities in the County included the City of Allentown, Lower Macungie Township and Macungie Borough. It was estimated that 85 homes, 31 businesses and 5 public buildings and structures were damaged. Damage along the Nancy Run, Monocacy, Bushkill, Saucon and Schoeneck creeks was the result of flash flooding. Damage along Jacoby Creek resulted when an old earthen dam at Lake Poco failed and caused increased damage in the Borough of Portland, which was already flooded by the Delaware River. The Little Lehigh Creek within the Lehigh Parkway crested at 4.49 feet above flood stage. The Little Lehigh Creek at 10th Street in Allentown crested at 2.05 feet above flood stage.

In Northampton County, nearly every municipality reported flood damages. Approximately 865 homes, businesses and structures were damaged, including several roads and bridges. The Lehigh River at Walnutport Borough crested at 4.32 feet above flood stage. The Lehigh River in Bethlehem crested at 2.79 feet above flood stage. In Glendon Borough, the Lehigh River crested at 0.82 feet above flood stage. The Monocacy Creek at Bethlehem crested at 5.17 feet above flood stage. The Delaware River at Easton crested at 11.45 feet above flood stage. Both counties were included in a presidential disaster declaration. Total damages for the counties were approximately $6 million.

Floods are naturally occurring events that benefit riparian systems that have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediment, which improves soil fertility. However, the destruction of riparian buffers, changes to land use and land cover throughout a watershed, and introduction of chemical or biological contaminants, which often accompany human presence, cause environmental harm when floods occur. Hazardous material facilities are potential sources of contamination during flood events. Other environmental impacts of flooding include: waterborne diseases, heavy siltation, erosion of stream banks and riverbeds, destruction of aquatic habitat, damage to water and sewer infrastructure located in floodplains, damage or loss of crops and drowning of both humans and animals.

4.3.4.3 Past Occurrence

The Lehigh Valley has a long history of flooding events. According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 178 flood events between January 1, 1950 and October 31, 2017. Total property damages as a result of these flood events were estimated at $75.75 million. Total crop damages as a result of these flood events were estimated at $2 million. These totals may also include damages to other counties (NOAA NCEI 2018).

Table 4.3.4.1 describes five flood/flash flood events that occurred since the 2013 Plan.

The Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL) maintains an Ice Jam Database. Based on review of the CRREL database, the ice jam events that have occurred in the Lehigh Valley between 1948 and 2017 are identified in Table 4.3.4.2. Information regarding losses associated with these reported ice jams is unknown.

Table 4.3.4.1 Flooding Events in the Lehigh Valley, 2012-2017

Dates of Event	Event Type	Losses/Impacts	Source(s)
July 1, 2013	Flash Flood	Torrential rains caused flash flooding in northeastern Northampton County. The basement of several homes were flooded with 2 to 5 feet of water in Bangor, where one family had to be rescued. Streets were closed and some home were without power. Numerous streets were also flooded in Pen Argyl Borough. Flooding also damaged several homes in East Bangor Borough. $100, 000 in property damage was reported. No injuries or deaths were reported.	NOAA-NCEI
August 29, 2013	Flash Flood	Very heavy rain caused roadway and small creek flash flooding in Allentown and Whitehall Township. About 43 vehicles were badly damaged in West Allentown and several businesses were flooded. A child was nearly swept away in flood waters. Numerous roadways were flooded with some water rescues from trapped vehicles. Flood damage in the area also occurred to homes, garages and basements. $100,000 in property damage was reported. No injuries or deaths were reported.	NOAA-NCEI
June 15, 2015	Flood/Flash Flood	Slow-moving thunderstorms caused flash flooding in parts of Northampton County, with estimates exceeding four inches in south central Northampton County. Flash flooding in Bethlehem closed Easton Avenue at Willow Park Road. Flash flooding along Nancy Run washed out sections of Willow Park Road south through Walnut Street. $100,000 in property damage was reported. Flash flooding occurred along Monocacy Creek. Parts of Illick's Mill Road and locations behind Hotel Bethlehem were flooded. $50,000 in property damage was reported. Monocacy Creek at the Illick's Mill Road gage reached its 4.5 foot flood stage at 8:37 pm on the 15th and crested at 5.99 feet at 10:45 pm. No injuries or deaths were reported.	NOAA-NCEI
June 30, 2015	Flash Flood	Multiple thunderstorms with heavy rain caused flash flooding with two inches of rainfall estimated in the Lehigh Valley. Flash flooding occurred in Northampton Borough as the Dry Run flooded. About 12-14 homes were flooded. One home suffered structural damage. $100,000 in property damage was reported. Flash flooding also occurred in Coplay Borough. Several roadways were flooded with vehicles trapped in floodwaters. One water rescue was required. No injuries or deaths were reported.	NOAA-NCEI
February 24-25, 2016	Flash Flood	Strong to severe thunderstorms, heavy rain, flash flooding and stream flooding occurred in eastern Pennsylvania. Major flooding was reported on several roadways in and near downtown Bethlehem. Water rescues occurred at 33rd and Lehigh Streets. $200,000 in property damage was reported. Motorists were also stranded due to floodwaters in Lower Macungie Township and Allentown. No injuries or deaths were reported.	NOAA-NCEI

Source: NOAA NCEI

Note: Monetary figures within this table were US Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of increased US Inflation Rates. NCEI: National Centers for Environmental Information; NOAA: National Oceanic Atmospheric Administration.

For historical data, please refer to the 2013 or 2006 Lehigh Valley Hazard Mitigation Plans

Table 4.3.4.2 Ice Jam Events in the Lehigh Valley, 1948-2017

Municipality	River	Jam Date	Water Year	Gage Number
City of Allentown	Jordan Creek	2/20/1948	1948	1452000
Walnutport Borough	Lehigh River	2/3/1970	1970	1451000
Walnutport Borough	Lehigh River	2/14/1971	1971	1451000
North Whitehall Township	Jordan Creek	2/6/2004	2004	1451800
Walnutport Borough	Lehigh River	1/30/2004	2004	1451000
Easton City	Lehigh River	1/8/2014	2014	1454700

Source: CRREL 2017

4.3.4.4 Future Occurrence

Given the history of flood events that have impacted Lehigh and Northampton counties, it is apparent that future flooding of varying degrees will occur. The fact that the elements required for flooding exist and that major flooding has occurred throughout the counties in the past suggests that many people and properties are at risk from the flood hazard in the future.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for flood events in the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

4.3.4.5 Vulnerability Assessment

Flooding can cause widespread damage throughout rural and urban areas, including but not limited to: water-related damage to the interior and exterior of buildings; destruction of electrical and other expensive and difficult-to-replace equipment; injury and loss of life; proliferation of disease vectors; disruption of utilities, including water, sewer, electricity, communications networks and facilities; loss of agricultural crops and livestock; placement of stress on emergency response and healthcare facilities and personnel; loss of productivity; and displacement of persons from homes and places of employment (Foster, Date Unknown).

The flood hazard is a major concern for the Lehigh Valley, and the region continues to be vulnerable to the flood hazard. To assess risk, an exposure estimate was conducted for the 1% and 0.2% annual chance flood events and potential losses were calculated for the Lehigh Valley 1% annual chance flood event using an updated version of FEMA's HAZUS-MH riverine flood module (version 4.0).

There are several differences between the risk assessment completed for the 2013 and 2018 Plan in terms of spatial hazard data used and analyses conducted, which may result in changes in reported vulnerability. As of July 2014, the Northampton County FEMA DFIRMs became effective; the 2013 Plan utilized these maps while in a preliminary status. There is also a

new FEMA Risk MAP product for the Schuylkill Watershed (9/30/2017) that encompasses a portion of Lynn Township in Lehigh County. Both new data sets were used for the vulnerability assessment update.

For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and LVPC. The general building stock and critical facility inventory are located in Appendix E. Both updated inventories were integrated into HAZUS-MH v4.0 to estimate losses. This assessment provides more accurate exposure and potential losses for the Lehigh Valley.

A Level 2 HAZUS-MH riverine flood analysis was performed. The default building inventory in HAZUS-MH was updated and replaced at the Census-block level with a custom-building inventory developed for both counties. The updated building inventory was built using detailed structure-specific assessor data, as well as parcel and structure location information. An updated critical facility inventory was also developed and incorporated into HAZUS-MH, replacing the default essential facility such as police, fire and school facilities and utility inventories.

The Lehigh County FEMA DFIRMs dated July 2004 and the Northampton County effective DFIRMs dated July 2014 were used to evaluate exposure and determine potential future losses.

A 3.2-foot resolution depth grid was developed for the 1% annual chance flood event for the Lehigh Valley. Using Geographic Information System (GIS) tools and the best available data including the DFIRM database for both Counties and the 2008 3.2-foot Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) available from Pennsylvania Spatial Data Access – the Pennsylvania Geospatial Data Clearinghouse, a flood depth grid was generated and integrated into the HAZUS-MH riverine flood model.

To estimate exposure to the 1% and 0.2% flood events, the DFIRM flood boundaries, updated building and critical facility inventories and 2010 US Census population data were used. The HAZUS-MH 4.0 riverine flood model was run to estimate potential losses for the Lehigh Valley for the 1% annual chance flood event. HAZUS-MH 4.0 calculated the estimated potential losses to the population (default 2010 U.S. Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS-MH damage functions in the flood model. Due to an error in the HAZUS-MH v4.0 software, debris results were not calculated and the model was run in v4.2 to estimate the results.

The impact of flooding on life, health and safety is dependent upon several factors, including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by a hazard event, including emergency responders and people traveling into the area. The degree of that impact will vary and is not strictly measurable.

To estimate the population exposed to the 1% and 0.2% annual chance flood events, the FEMA DFIRM floodplain boundaries were used to estimate the number of structures within the floodplains, which were then factored by the average number of persons per household in the Lehigh Valley. Average household size is 2.54 for Lehigh County and 2.53 for Northampton County (US Census, 2010). While this assumes that all structures in the floodplain are residential and single-household, it provides a reasonable estimate of population directly exposed to the flood risk.

Within the Lehigh Valley, more than 12,000 people are exposed to the 1% annual chance flood. The City of Allentown has the greatest number of people exposed in Lehigh County with just over 1,000 people, followed by Lower Mt. Bethel Township in Northampton County with approximately 900 people. About 18,500 people are exposed to the 0.2% annual chance flood, with the City of Allentown and Lower Macungie Township having the greatest number of people exposed, and Lower and Upper Mt. Bethel townships have the highest number of people exposed in Northampton County. A complete listing of the population exposed to the 1% and 0.2% annual chance floods is included in Appendix F.

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available due to isolation during a flood event and they may have more difficulty evacuating.

Given the Lehigh Valley's geographic location along major waterways, as well as the contributing factors that population and development are located in the floodplain, a flood event may cause residents to be displaced and seek short or long-term sheltering within the region, causing a population evacuation. The impacted population may not be limited to only those who reside in a defined hazard zone, but others who may be impacted by the effects of a hazard event. To address this issue, the Lehigh Valley recognizes the need to identify shelters and potential sites for temporary housing and relocation to ensure displaced residents have a local option.

Potential consequences of population evacuation resulting from a flood event may include the following:

- Economic impact to local communities
- Increased demand for food and shelter
- Impacts to emergency and social services

Using 2010 US Census data, HAZUS-MH 4.0 estimates the potential sheltering needs as a result of a 1% annual chance flood event. The displacement estimate is provided in number of households. For the purposes of this analysis, the average household size for each County was used to estimate the number of estimated displaced persons. For the 1% annual chance flood event, HAZUS-MH 4.0 estimates 17,816 people will be displaced and 3,930 people will seek short-term sheltering, representing 5.1% and 1.1% of the Lehigh County population, respectively. For the 1% annual chance flood event in Northampton County, HAZUS-MH 4.0 estimates 14,305 people will be displaced and 2,869 people will seek short-term sheltering, representing 4.8% and 1.0% of the County population, respectively. A complete listing by municipality is located in Appendix F.

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

After considering the population exposed and vulnerable to the flood hazard, the built environment was evaluated. Exposure to the flood hazard includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

To provide a general estimate of the number of structures, parcels and replacement value exposure, the FEMA DFIRM flood boundaries (1% and 0.2% annual chance flood zones) were overlaid upon Lehigh and Northampton counties' parcel and the updated building stock inventory point shapefiles. The parcels that intersect the 1% and 0.2% annual chance flood zones were totaled for each municipality. The total number of buildings with their centroid located in the 1% and 0.2% annual chance flood boundaries was also determined, and their estimated building stock replacement value is identified for each municipality.

The depth grid developed for the 1% annual chance flood event for Lehigh and Northampton counties was integrated into the HAZUS-MH riverine flood model. The model was then run to estimate the potential general building stock losses for the 1% annual chance flood event.

Approximately 11,850 parcels are located in the 1% annual chance floodplain and 14,300 are located in the 0.2% annual chance floodplain. For the 1% annual chance flood, the potential damage to structures in Lehigh County is estimated to be $401 million and $440 million in Northampton County. The City of Allentown has by far the largest potential loss estimate for the 1% annual flood at $190 million, or nearly half of all Lehigh County losses. In Northampton County, the City of Easton has the largest potential loss estimate at $92 million, or one-fifth of the total county losses. A complete listing of parcels and potential losses by municipality is located in Appendix F.

In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties were analyzed and shown in Table 4.3.4.3. PEMA provided a list of residential properties with NFIP policies, past claims and multiple claims (including RL/SRL). According to the metadata provided: "The NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than $1,000 for each loss. The two losses must be within 10 years of each other and be as least 10 days apart. Only losses from (sic since) 1/1/1978 that are closed are considered."

Table 4.3.4.3 NFIP Policies, Claims and Repetitive Loss Statistics

Lehigh County	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)
Alburtis Borough	1	1	$0	0	0
Allentown, City of	129	390	$3,765,182	43	1
Bethlehem, City of*	103	179	$2,833,953	16	1
Catasauqua Borough	27	11	$222,652	2	0
Coopersburg Borough	3	5	$16,414	1	0
Coplay Borough	2	0	$0	0	0
Emmaus Borough	19	11	$65,317	2	0
Fountain Hill Borough	3	1	$3,161	0	0
Hanover Township	0	0	$0	0	0
Heidelberg Township	12	8	$20,540	1	0
Lower Macungie Township	124	123	$1,713,140	20	0
Lower Milford Township	9	2	$0	0	0
Lowhill Township	7	2	$17,108	0	0
Lynn Township	20	2	$6,862	0	0
Macungie Borough	4	42	$300,452	6	0
North Whitehall Township	25	11	$85,149	1	0
Salisbury Township	11	6	$15,872	0	0
Slatington Borough	2	3	$7,525	0	0
South Whitehall Township	51	55	$346,928	9	0
Upper Macungie Township	38	14	$35,069	2	0
Upper Milford Township	27	12	$192,595	2	0
Upper Saucon Township	29	17	$82,602	0	0
Washington Township	10	2	$23,080	0	0
Weisenberg Township	7	0	$0	0	0
Whitehall Township	56	51	$213,272	7	0
Lehigh County	**719**	**948**	**$9,966,874**	**112**	**2**

Source: PEMA, 2018
(1): Repetitive loss and severe repetitive loss statistics provided by PEMA in February 2018 using the “Comm_Name”. These statistics are current as of November 30, 2017. Please note the total number of repetitive loss properties includes the severe repetitive loss properties. Policy and claims totals were provided as totaled by ‘Community.’
(2): Total building and content losses from the claims file provided by PEMA (current as of November 30, 2017).
Notes: * Includes Lehigh and Northampton County portions

Table 4.3.4.3 NFIP Policies, Claims and Repetitive Loss Statistics

Northampton County	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)
Allen Township	8	3	$18,209	1	0
Bangor Borough	76	57	$1,617,699	13	0
Bath Borough	6	7	$48,539	0	0
Bethlehem Township	70	43	$2,036,642	4	0
Bushkill Township	17	13	$170,522	0	0
Chapman Borough	1	0	$0	0	0
East Allen Township	9	8	$54,947	1	0
East Bangor Borough	0	0	$0	0	0
Easton, City of	123	273	$11,419,001	49	2
Forks Township	69	166	$5,993,182	39	8
Freemansburg Borough	21	46	$285,453	4	0
Glendon Borough	3	0	$0	0	0
Hanover Township	15	3	$33,455	2	0
Hellertown Borough	26	16	$252,655	2	0
Lehigh Township	18	8	$55,045	1	0
Lower Mt. Bethel Township	84	219	$7,248,867	61	5
Lower Nazareth Township	21	8	$79,891	1	0
Lower Saucon Township	44	27	$375,280	4	0
Moore Township	19	14	$90,856	1	0
Nazareth Borough	6	4	$18,664	0	0
North Catasauqua Borough	1	0	$0	0	0
Northampton Borough	86	33	447.568.03	3	0
Palmer Township	77	27	$1,616,186	2	0
Pen Argyl Borough	0	0	$0	0	0
Plainfield Township	9	0	$0	0	0
Portland Borough	2	15	$2,454,858	2	0
Roseto Borough	0	1	$0	0	0
Stockertown Borough	2	3	$118,958	0	0
Tatamy Borough	3	0	$0	0	0
Upper Mt. Bethel Township	63	139	$4,087,048	35	3
Upper Nazareth Township	10	3	$53,507	1	0
Walnutport Borough	4	3	$829	0	0
Washington Township	19	3	$7,760	1	0
West Easton Borough	7	18	$206,233	4	0
Williams Township	43	129	$4,660,949	35	3
Wilson Borough	3	0	$0	0	0
Wind Gap Borough	0	0	$0	0	0
Northampton County	**965**	**1,289**	**$43,005,236**	**266**	**21**

Source: PEMA, 2018

(1): Repetitive loss and severe repetitive loss statistics provided by PEMA in February 2018 using the “Comm_Name”. These statistics are current as of November 30, 2017. Please note the total number of repetitive loss properties includes the severe repetitive loss properties. Policy and claims totals were provided as totaled by ‘Community.’

(2): Total building and content losses from the claims file provided by PEMA (current as of November 30, 2017).

SRL properties were then examined in the Lehigh Valley. According to section 1361A of the National Flood Insurance Act (NFIA), as amended, 42 U.S.C. 4102a, an SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- for both of the above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

According to PEMA, there are 112 RL and two SRL properties in Lehigh County, and 266 RL and 21 SRL properties in Northampton County. The two SRL properties in Lehigh County are classified as residential structures. Of the 21 SRL properties in Northampton County, 18 are classified as residential, two are classified as two-to-four family, and one is classified as other residential. This information is current as of November 30, 2017.

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

In addition to considering general building stock at risk, the risk of flood to critical facilities, utilities and user-defined facilities was evaluated. HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, HAZUS estimates the percent of damage to the building and contents of critical facilities.

Critical facilities and utilities located in the FEMA DFIRM flood zones and the percent damage HAZUS-MH 4.0 estimates to the facility as a result of the 1% annual chance flood event are listed in Appendix F. In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Flood vulnerability maps for each municipality in the Lehigh Valley are in Appendix D. These maps show locations of both the 1% annual chance floodplain and the 0.2% annual chance floodplain with critical facilities.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. The potential damage estimated to the general building stock inventory associated with the 1% annual chance flood event is approximately $842 million. This estimated building damage represents less than 1% of the Lehigh Valley's overall total general building stock inventory exposed to this hazard. These dollar value losses to the Lehigh Valley's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact the tax base and local economy in both counties.

When a flood occurs, the agricultural industry is at risk in terms of economic impact and crop damage. In 2012, according to the Census of Agriculture, the market value of all Lehigh County agricultural products sold was $90.8 million with 70% in crop sales. The market value of all agricultural products sold from Northampton County was greater than $43 million with 83% in crop sales (USDA, 2012).

HAZUS-MH estimates the amount of debris generated from the flood events as a result of the 1% annual chance flood event. The model breaks down debris into three categories: 1) finishes (dry wall, insulation, etc.); 2) structural (wood, brick, etc.) and 3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. HAZUS-MH 4.2 estimates approximately 40,000 tons of debris will be generated as a result of the 1% annual chance flood event. A complete listing of debris generated by the 1% annual chance flood by municipality is located in Appendix F.

4.3.5 Hailstorm

4.3.5.1 Location and Extent

Hailstorms can impact the entire 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 1 inch to several inches in diameter and can cause significant damage to crops and property. Damage depends on the size, duration and intensity of hail precipitation. Individuals who do not seek shelter could face serious injury. Automobiles and aircraft are particularly susceptible to damage. Effects of other hazards such as strong winds, intense rain and lightning often occur concurrently because hail precipitation usually occurs during thunderstorms (PEMA 2013). The Lehigh Valley has experienced hail ranging in size from 0.75 inches to 2.5 inches in diameter. No deaths or injuries due to hail have been recorded in the Lehigh Valley (Storm Prediction Center [SPC] 2018).

A potential worst-case scenario would be if a storm carrying hail of over 2 inches was to occur over a prolonged period in the agricultural areas of the Lehigh Valley. Since hail can cause significant crop damage, a storm of this magnitude could potentially destroy agricultural yields and result in significant lost revenue, as well as property damage or injuries.

Damage to trees, shrubbery and other vegetation may occur during hailstorm events through defoliation. Unless there are compounding stresses, natural vegetation can typically recover over time following the event. However, crops such as corn and soybeans can be damaged to the point of total loss, particularly if an event occurs later in the growing season (PEMA 2013).

4.3.5.3 Past Occurrence

Hailstorms can occur as a routine part of severe weather in the Lehigh Valley. The potential for hail exists throughout the Lehigh Valley, with a few minor incidents recorded each year. The Pennsylvania 2013 All-Hazard Mitigation Plan states that approximately 96% of hailstorm events throughout the Commonwealth have occurred from April through September. Moreover, approximately 87% of historical hailstorms happened from noon to 9 p.m. (PEMA 2013). Both of these results are consistent with the relationship between hail and thunderstorms, which most often occur during late spring, summer and early fall months.

According to NOAA's National Centers for Environmental Information (NCEI) Storm Events Database, the Lehigh Valley experienced 99 hailstorms between 1950 and 2017, but just four that caused a combined $425,000 in property and crop damage. No deaths or injuries were reported for any of these events. Table 4.3.5.1 shows hailstorm events recorded since the 2013 Plan.

Based on reports from the NOAA NCEI, the Lehigh Valley's worst hailstorm incident occurred in 2007, when $250,000 in damages was 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 that precipitated the hail moved across Pennsylvania and New Jersey during the afternoon and the evening of August 17.

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 usually occur every year throughout the months of April and August. 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.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for hailstorm events in the Lehigh Valley is considered 'possible' as defined in Section 4.4.1.

4.3.5.5 Vulnerability Assessment

For hailstorm events, the entire Lehigh Valley has been identified as the hazard area. Therefore, all people structures, critical facilities and lifelines are exposed and potentially vulnerable. Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan.

The entire Lehigh Valley, including all critical infrastructure, continues to be 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

Table 4.3.5.1 Hailstorm Events in the Lehigh Valley, August 2011-2017

Location	Date	Diameter (inches)	Deaths	Injuries	Property Damage ($)	Crop Damage ($)
Lehigh County						
Germansville	8/19/2011	0.75 in.	0	0	0	0
Emmaus	5/24/2012	0.75 in.	0	0	0	0
Schnecksville	6/3/2012	0.75 in.	0	0	0	0
Allentown	6/3/2012	0.88 in.	0	0	0	0
Allentown	7/4/2012	0.75 in.	0	0	0	0
Macungie	7/28/2012	1.00 in.	0	0	0	0
Allentown	4/10/2013	0.75 in.	0	0	0	0
East Penn Junction	5/8/2013	0.75 in.	0	0	0	0
Coplay, Allentown, Bethlehem	5/22/2014	1.00 in.	0	0	0	0
Orefield	6/25/2014	1.00 in.	0	0	0	0
Macungie	9/6/2014	0.75 in.	0	0	0	0
Orefield, Coplay	6/30/2015	1.75 in.	0	0	$25,000	0
Allentown	2/25/2017	0.75 in.	0	0	0	0
Lehigh County Total	**N/A**	**N/A**	**0**	**0**	**$25,000**	**0**
Northampton County						
Farmersville, Bethlehem (T)	6/1/2011	1.00	0	0	0	0
Mount Bethel	5/26/2012	0.75 in.	0	0	0	0
Tatamy	7/26/2012	0.75 in.	0	0	0	0
Bethlehem	4/10/2013	0.75 in.	0	0	0	0
Freemansburg	4/10/2013	1.00 in.	0	0	0	0
Bethlehem	5/23/2013	0.88 in.	0	0	0	0
Nazareth	6/24/2013	1.00 in.	0	0	0	0
Uhlers	6/24/2013	0.75 in.	0	0	0	0
Bath	7/9/2014	1.00 in.	0	0	0	0
Moorestown	7/9/2014	1.25 in.	0	0	0	0
North Catasaugua	6/30/2015	1.00 in.	0	0	0	0
Uhlers	7/17/2017	0.75 in.	0	0	0	0
Klecknersville	8/2/2017	0.75 in.	0	0	0	0
Northampton County Total	**N/A**	**N/A**	**0**	**0**	**$0**	**$0**

Source: NOAA-NCEI 2018
Note: T - Township; N/A - Not Applicable

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 (PEMA 2010).

People outdoors 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.

A hailstorm may cause damage to buildings, including exterior walls, windows, roof shingles and outdoor mechanicals such as air conditioning units. Agriculture buildings may be more vulnerable if they are constructed of glass such as greenhouses. According to the 2013 Pennsylvania State Hazard Mitigation Plan, the Lehigh Valley has three agriculture critical facilities (PEMA 2013).

As discussed in the Past Occurrence subsection, the Lehigh Valley has experienced historical hailstorm property and crop damage ($375,000 in property damage and $50,000 in crop damage) (NOAA NCEI 2018). However, the crop damage provided by NOAA-NCEI differs from the total in crop damage claims provided by the US Department of Agriculture (USDA). According to the USDA Risk Management Agency (RMA), hailstorm events between 2001 and 2017 resulted in $147,371.70 in crop insurance claims related to hail events (USDA 2018). Given the unpredictability of hailstorms, significant property and crop damage is possible during any hailstorm event in the Lehigh Valley.

Economic losses are based on lost agricultural revenues throughout the Lehigh Valley. The USDA 2012 Census of Agriculture enumerates farmland acreage by county, as well as the annual market value of all agricultural products sold by county. The 2012 Census is the most current information available for Lehigh and Northampton counties. If a hailstorm would eliminate the entire agricultural yield in the Lehigh Valley, total losses could reach over $134 million as indicated in the Drought profile.

4.3.6 Invasive Species

4.3.6.1 Location and Extent

An invasive species is one that is not indigenous to a given ecosystem and that, when introduced to a non-native environment, is likely to cause economic or environmental harm, or pose a health hazard to people. Pennsylvania plays host to a number of invasive pathogens, insects, plants, invertebrates, fish and higher mammals. These species have largely been introduced by the actions of humans. Common pathways for invasive species threats include unintentional release of species, the movement of goods and equipment that may unknowingly harbor species, smuggling, ship ballast, hull fouling, and escape from cultivation (Pennsylvania Invasive Species Council [PISC] 2010).

The Invasive Species hazard is new to the Lehigh Valley Hazard Mitigation Plan. The 2013 Pennsylvania Hazard Mitigation Plan discusses a number of identified invasive species impacting the Commonwealth. For the purpose of this 2018 Plan and as identified by the Lehigh Valley Planning Team, invasive species included are:

- Emerald Ash Borer
- Hemlock Woolly Adelgid
- Gypsy Moth
- Asian Tiger Mosquito
- Spotted Lanternfly

Additionally, the Planning Team identified ticks and mosquitos as a concern due to the diseases they can carry and spread. Refer to the Pandemic and Infectious Disease profile for details regarding diseases spread by ticks and mosquitos. The location and extent of invasive threats depends on the preferred habitat of the species as well as the species' ease of movement and establishment. The presence of invasive species has been reported throughout the Lehigh Valley.

Emerald Ash Borer (EAB) is a half-inch long metallic green beetle. Larvae of this beetle feed under the bark of green, white and black ash trees. Their feeding eventually girdles and kills branches and entire trees. It was detected for the first time in Pennsylvania in late June 2007. The Emerald Ash Borer is currently quarantined throughout Pennsylvania and has been confirmed in at least 22 counties. The quarantine was established by the Pennsylvania Department of Agriculture to slow the invasive's spread. It makes it illegal to move out of the Commonwealth all hardwood firewood, ash trees of any size, ash saw logs, limbs, branches, stumps or roots (DCNR 2011). Between 2007 and 2016, the Emerald Ash Borer has been confirmed in nearly all counties of Pennsylvania, including Lehigh and Northampton counties. (PA Department of Agriculture 2016).

Hemlock Woolly Adelgid (HWA) is a serious pest of Eastern hemlock in the northeastern states. This insect was first reported in southeastern Pennsylvania in the late 1960s and has spread to both ornamental and forest hemlocks. Adelgids are small, soft-bodied insects that are closely related to aphids. The Hemlock Woolly Adelgid sucks sap from the young branches, which results in premature needle drop and branch dieback. Some trees die within four years while others persist in a weakened

state for many years. As of October 2016, the Lehigh Valley is infested by Hemlock Woolly Adelgid (DCNR 2016).

Gypsy Moth is a non-native insect from France that was introduced to Massachusetts in 1869. It is now established in 19 states, including Pennsylvania. Its caterpillar (larva) stage eats the leaves of a large variety of trees. A sample of some of the many species it eats includes oak, maple, apple, crabapple, aspen, willow, birch, mountain ash, pine and spruce. The populations of Gypsy Moths rise and fall in cycles. When populations are high, thousands of acres of trees can be damaged. In Pennsylvania, it was first discovered in Luzerne and Lackawanna counties in 1932. A total of 4.3 million acres were defoliated in the Commonwealth during the historical peak year in 1990. Suppression programs have been carried out by the Pennsylvania Bureau of Forestry since 1968 to minimize the impacts of the Gypsy Moth. In 2017, Lehigh and Northampton counties were included in the Gypsy Moth suppression program (DCNR 2017). Lehigh and Northampton counties worked with the DCNR in a joint effort to spray for Gypsy Moth caterpillars in certain public high use areas within the counties (Parkland Press 2017; Merlin 2017).

The USDA has a Gypsy Moth program that regulates the movement of host material from infested areas to other areas of the country. This program is a federal-state partnership that prevents the establishment of Gypsy Moths in areas of the United States that are not contiguous to current regulated states and counties. Lehigh and Northampton counties are located within a Gypsy Moth quarantine area that includes all of Pennsylvania and most Northeast states.

Asian Tiger Mosquito entered the United States in shipments of used tires from northern Asia in the mid-1980s. It can survive a wide range of climates and has spread rapidly from the point of first detection in the south-central United States. It is now widespread throughout the southern and eastern United States. This species of mosquito transmits a variety of arboviruses, including dengue, chikungunya, yellow fever and Zika (CDC 2017). According to the CDC, the Lehigh Valley is a very likely area to find the mosquito. Both counties have active surveillance sites for Asian Tiger Mosquito (State of Pennsylvania 2016).

Spotted Lanternfly is an invasive plant hopper. It is native to China, India and Vietnam. This insect has the potential to greatly impact the grape, hops and logging industries of Pennsylvania. If infected, trees such as tree of heaven and willow, will develop weeping wounds that will leave a greyish or black trail along the trunk. The sap will attract other insects to feed. In the late fall, adults will lay egg masses on host trees. Both Lehigh and Northampton counties are quarantined for Spotted Lanternfly. The quarantine is in place to stop the movement of the Spotted Lanternfly into new areas and to slow its spread within the quarantined areas (Pennsylvania Department of Agriculture 2018).

4.3.6.2 Range of Magnitude

The magnitude of invasive species threats ranges from nuisance to widespread killer and is generally amplified when the ecosystem or host species is already stressed, such as in times of drought. The already weakened state of the native ecosystem causes it to more easily succumb to an infestation. Some invasive species are not considered an agricultural pest and do not harm humans. However, other species can cause significant changes in the composition of an ecosystem. For example, the Emerald Ash Borer has a 99% mortality rate for any ash tree it infects. Other species can clog waterways, smother native plants and impact animals (PEMA 2013).

DCNR's Bureau of Forestry has a variety of surveys and projects that monitor and manage forest insects and diseases. Each year, DCNR Bureau of Forestry conducts an aerial survey program to detect and map tree dieback, mortality, defoliation, and foliage discoloration. Ground surveys are done to confirm the suspected insect or disease for each mapped area. The information collected from the surveys helps determine the extent of damage for insects and diseases of concern; anticipate future outbreaks; and make management recommendations (DCNR 2018). If trees and other plants are left untreated, the impacts of invasive species could be devastating.

There is a wide range of environmental impacts caused by invasive species. The aggressive nature of many invasive species can cause significant reductions in biodiversity by crowding out native species. This can affect the health of individual host organisms as well as the overall well-being of the affected ecosystem. Beyond causing human, animal and plant harm, there are secondary impacts of invasive species that go beyond harm to host species and ecosystems, particularly in the case of invasive species that attack forests. Pennsylvania's forests prevent soil degradation and erosion, protect watersheds, stabilize slopes, and absorb carbon dioxide emissions. The key role of forests in the hydrologic system means that, if forest land is lost, the effects of erosion and flooding will be amplified. There is also an impact on agricultural harvests like honey, potatoes and stone fruits. As a state with strong agricultural population, invasive species remain a hazard for the economic livelihood of the state (PEMA 2013).

According to the Nature Conservancy, invasive species have contributed directly to the decline of 42% of the threatened and endangered species in the United States. The annual cost to the United States economy is estimated at $120 billion a year, with over 100 million acres (an area roughly the size of California) suffering from invasive plant infestations. Freshwater ecosystems and estuaries are especially vulnerable because these areas are more difficult to contain invasive species and reverse any impacts they may have had on the ecosystem. Forests have suffered from the impacts of invasive species because they weaken trees and cause extensive die-offs (for example, eastern hemlock trees infested by Hemlock Woolly Adelgid) (The Nature Conservancy 2018; PennState Extension 2018).

4.3.6.3 Past Occurrence

Invasive species have been entering the Lehigh Valley for quite some time, though not all occurrences have required government action. Specific occurrences and quantified losses were not identified for these invasive species in the Lehigh Valley. Past occurrences of invasive species are shown in 4.3.6.1.

Table 4.3.6.1 Invasive Species in the Lehigh Valley, 2007-2017

Date	Event Type	Losses/Impacts	Source(s)
2007	Emerald Ash Borer	Emerald Ash Borer was first identified in western Pennsylvania during 2007. Since then, Emerald Ash Borer has been detected in a majority of the State, including Lehigh and Northampton counties.	PADCNR
2013	Hemlock Woolly Adelgid	Hemlock Woolly Adelgid was detected in Lehigh and Northampton counties in 2013.	USDA
2014	Spotted Lanternfly	Spotted Lanternfly was confirmed in Pennsylvania in September 2014. By 2017, 13 counties were quarantined, including Lehigh and Northampton counties.	PA Department of Agriculture
2014	Gypsy Moth	Gypsy moths were detected in Lehigh and Northampton counties in 2014.	USDA
2016	Asian Tiger Mosquito	The Asian tiger mosquito was detected in the Lehigh Valley.	Kennedy

PADCNR: Pennsylvania Department of Conservation and Natural Resources; USDA: US Department of Agriculture

4.3.6.4 Future Occurrence

According to the Pennsylvania Invasive Species Council (PISC), the probability of future occurrence for invasive species threats is on the rise because of the growing volume of transported goods, increasing technology, efficiency and speed of transportation and expanding international trade agreements. Expanded global trade has created opportunities for many organisms to be transported to and establish themselves in new countries and regions (PEMA 2013). In 2017, Pennsylvania imported more than $83 billion in goods from abroad, including agricultural, forestry and fisheries goods that commonly carry unknown pests (US Census 2017).

Furthermore, climate change is contributing to the introduction of new invasive species. As maximum and minimum seasonal temperatures change, pests are able to establish themselves in previously inhospitable climates. This also gives introduced species an earlier start and increases the magnitude of their growth (PEMA 2013). This may shift the dominance of ecosystems in the favor of non-native species.

Based on historical documentation, increased incidences of infestation throughout Pennsylvania and the overall impact of changing climate trends, it is estimated that the Lehigh Valley and all its jurisdictions will continue to experience the impacts of invasive species and may see an increase in the number of invasive species. This has the potential to induce secondary hazards and health threats to the Lehigh Valley population if they are not prevented, controlled or eradicated effectively.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for invasive species impacting the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

4.3.6.5 Vulnerability Assessment

For invasive species, the entire Lehigh Valley has been identified as the hazard area. Therefore, all people, structures, critical facilities and lifelines are exposed and potentially vulnerable.

Invasive species are a significant concern to the Lehigh Valley, mainly due to their impacts on public health, natural resources and agriculture. Estimated losses are difficult to quantify, but invasive species can impact the Lehigh Valley's population and economy. The elderly population and individuals with suppressed immune systems may be more susceptible to effects of diseases carried by Asian Tiger Mosquitoes.

Direct impacts of invasive species have cascading indirect impacts. As vegetation dies or becomes stressed/weakened by pests such as Hemlock Woolly Adelgid, Emerald Ash Borer, Spotted Lanternfly or Gypsy Moth, there is an increase in available fuel and increase in high intensity wildfires. As species composition changes due to invasive species, whole fire regimes can shift. Physical stresses on trees may also affect how street trees respond to physical stresses caused by other natural hazards such as hurricanes, drought and winter weather.

No structures are anticipated to be affected directly by invasive species, but the Emerald Ash Borer, Hemlock Woolly Adelgid, Spotted Lanternfly and Gypsy Moth may cause catastrophic loss of numerous tree species throughout forests, parks, and communities. This may result in stream bank instability, erosion, and increased sedimentation. In addition, a large amount of dead tree limbs could increase the occurrences of downed trees

on structures, roadways, and power lines in storms with heavy winds. The dead trees may also provide fuel for wildfires.

The impacts invasive species have on the economy and estimated dollar losses are difficult to measure and quantify. In the Lehigh Valley, losses depend on the aggressiveness of the invasive species of concern. Losses due to invasive species stem from three sources: loss of revenue from diseased, damaged, or deceased crops, livestock, lumber, etc.; economic losses from the cost of eradication programs; and losses in the form of illness or death of humans (PEMA 2013). Costs associated with the activities and programs implemented to conduct surveillance and address invasive species are not available at this time. Not only do invasive species have a negative impact on the natural native environment but may impact the fishing, boating and tourism economies in the Lehigh Valley as well. The economic and health impacts of the invasive species impacting the Lehigh Valley include:

- Emerald Ash Borer - loss of trees for timber production and loss of green, white and black ash trees from city and suburban landscapes, which would lead to tree removal and replacement costs for impacted municipalities (USDA 2007).
- Hemlock Woolly Adelgid - loss of trees for timber production and loss of hemlock trees from residential and natural landscapes. Additionally, Hemlock Woolly Adelgid may lead to loss of property values (Li, et al. 2014; USDA 2005).
- Gypsy Moth - loss of trees for timber production and loss of oak, apple, poplar, beech, willow, birch and sweetgum trees from city and suburban landscapes, which would lead to tree removal and replacement costs for impacted municipalities (State of Iowa 2010).
- Asian Tiger Mosquito - has the potential to impact the health of those living and working in the Lehigh Valley. Communities may need to invest more in treatments to reduce this population of mosquitos (Riddix 2010).
- Spotted Lanternfly - the Pennsylvania Department of Agriculture stated that this species possesses a significant threat to the state's more than $20.5 million grape, nearly $134 million apple, and more than $24 million stone fruit industries (Forest Invasives 2018).

4.3.7 Landslide

4.3.7.1 Location and Extent

Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, and changes in groundwater levels. Areas that are prone to landslide hazards include previous landslide areas, the bases of steep slopes, the bases of drainage channels, developed hillsides and areas recently burned by forest and brush fires (Delano and Wilshusen, 2001). Human activities that contribute to slope failure include altering the natural slope gradient, increasing soil water content and removing vegetation cover. Expansion of urban and recreational developments into hillside areas exposes more people to the threat of landslides each year.

According to the 2013 PA Hazard Mitigation Plan, landslides have occurred in many parts of Pennsylvania, but happen more often in much of the western and north central portions of the state. Rockfalls and other slope failures can occur in areas of the Lehigh Valley with moderate to steep slopes. According to the USGS, Lehigh and Northampton counties have low landslide potential.

4.3.7.2 Range of Magnitude

Landslides have the potential to damage transportation routes, utilities and buildings. They can also create travel delays. Fortunately, deaths and injuries caused by landslides are rare in Pennsylvania, and most landslides in the Commonwealth are moderate to slow moving. Almost all of the known deaths caused by landslides have occurred when rockfalls or other slides along highways have involved vehicles. Storm-induced debris flows are the only other type of landslide likely to cause death and injuries. As residential and recreational development increases on and near steep mountain slopes, the hazards from these events will also increase (PEMA 2013).

The Lehigh Valley's worst-case scenario is for a landslide to hit an area such as the Lehigh Gap, or any busy roadway in this area, including the intersection of Routes 145, 248 and 873. This scenario is based on a rough overlay of steep slopes and major roadways or populated areas throughout the Valley. This specific area is based on the topographic and land use conditions for this area. A landslide into the Lehigh River from the adjacent slopes could divert or entirely block water flows, resulting in flood effects upstream. Also, depending on the time of day and the number of vehicles on the road at that time, a slide over one of the riverside roadways in either Lehigh Gap or Slatington Borough could trigger a severe traffic accident, resulting in multiple fatalities.

The impact of landslides on the environment depends on the size and specific location of the event. Impacts include:

- Changes to topography
- Damage or destruction of vegetation
- Potential diversion or blockage of water in the vicinity of streams, rivers, etc.
- Increased sediment runoff both during and after event (PEMA 2013).

4.3.7.3 Past Occurrence

Pennsylvania has a long history of significant landslide activity. This has resulted from a combination of humid temperature climate, locally steep and rugged topography, and great diversity in the erosion and weathering characteristics of relatively near surface sedimentary rocks. Human activities such as commercial, industrial and residential developments, transportation, and mining often compound landslide problems.

Outside of impacts to important transportation routes, landslide history is not documented as completely (if at all) as other hazards, primarily because landslides are not always seen, and therefore historical landslide occurrences in the Lehigh Valley are not well known. Information provided by the 2013 Lehigh Valley Hazard Mitigation Plan and Lehigh and Northampton County Knowledge Center databases identified the following landslide events:

- **March 2007** – mudslide occurred after heavy rainfall, creating hazardous road conditions in Hanover Township (Lehigh County). Dauphin Drive was temporarily closed and no injuries were reported.
- **March 30, 2014** – rockslide in Lower Saucon Township (Northampton County)
- **April 30, 2014** – mudslide in Upper Mt. Bethel Township (Northampton County)
- **July 11, 2017** – rockslide along Route 611 in Lower Mt. Bethel Township (Northampton County)

Between 1954 and 2017, FEMA issued a disaster (DR) or emergency (EM) declaration for Pennsylvania for one geological hazard-related event, classified as severe storms, flooding and mudslide (DR-1649 declared on June 30, 2006). This declaration included Northampton County, with public and individual assistance provided to those impacted by this event (FEMA 2018).

4.3.7.4 Future Occurrence

Based upon risk factors and past occurrences, it is likely that landslides will continue to occur in the Lehigh Valley in the future. However, the severity of the landslides can vary depending on type and location of event. Mismanaged, intense development in steeply sloped areas could increase the frequency of landslides in the Lehigh Valley. Building and road construction are contributing development factors to landslides, as they can often undermine or steepen otherwise stable soil.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for landslide events in the Lehigh Valley is considered 'unlikely' as defined in Section 4.4.1.

4.3.7.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability to the landslide hazard has not changed since the 2013 Plan. There are minor differences between the National Atlas Landslide Incidence and Susceptibility layer used in 2013 and the USGS landslide hazard layer used for the 2018 Plan. The categorization and overall hazard extent remain the same, however, the USGS layer provides a more detailed hazard extent. Several differences exist between the landslide risk assessment in the 2013 and the 2018 Plans. For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical

facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and LVPC. The updated risk assessment provides a more accurate exposure estimate.

Vulnerability to ground failure hazards is a function of location, soil type, geology, type of human activity, use and frequency of events. The effects of landslides can be lessened by avoidance of hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on past hazard history of the site, and by making inquiries to planning and engineering departments of local governments (National Atlas, 2007). In general, the built environment located in the high susceptibility zones and the population, structures and infrastructure located downslope are vulnerable to this hazard. Approximately 6.1% of Lehigh County and 5.6% of Northampton County are located in the high susceptibility/moderate incidence landslide hazard area. In Lehigh County, Washington Township has the highest percentage of its area (38.4%) in this zone, while in Northampton County, Lehigh Township has the highest percentage (36.9%). A complete listing by municipality is located in Appendix F.

To estimate the population located within the landslide hazard areas, the approximate hazard area boundaries were overlaid on the 2010 Census population data (US Census, 2010). The Census blocks with their center within the boundary of the high susceptibility/moderate incidence landslide hazard area were used to calculate the estimated population considered exposed to this hazard. The population located in the low susceptibility area was also estimated and reported. Approximately 0.8% of the population in Lehigh County and 1.6% in Northampton County are located in high susceptibility/moderate incidence landslide hazard area. A complete listing by municipality is located in Appendix F.

The landslide hazard's impact on the economy and estimated dollar losses are difficult to measure. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs, include clean-up costs, business interruption, loss of tax revenues, reduced property values and loss of productivity. Additionally, ground failure threatens transportation corridors, fuel and energy conduits and communication lines (USGS, 2003).

In an attempt to estimate the general building stock vulnerable to this hazard, the associated building replacement values (buildings and contents) were determined for the identified buildings within the approximate hazard area. In summary, the estimated replacement value of general building stock located in high susceptibility/moderate incidence landslide hazard areas is nearly $3 billion. This estimate represents approximately 1% of the total building stock value inventory in the Lehigh Valley. These dollar value losses to the region's total building inventory replacement value would impact the local tax base and economy. The building replacement cost located in the low susceptibility area was also estimated and reported in Appendix F.

The approximate landslide hazard area was also used to identify the critical facilities located within the identified high susceptibility/moderate incidence zone and is also reported in Appendix F.

4.3.8 Lightning Strike

4.3.8.1 Location and Extent

Lightning is a rapid discharge of electrical energy in the atmosphere. The clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. It ranks as one of the deadliest weather events in the United States, killing approximately 50 people and injuring about 400 people each year. Lightning can occur anywhere there is a thunderstorm (NOAA 2014).

More than 100,000 thunderstorms occur in the United States each year, with lightning striking more than 25 million points on the ground, causing injuries and fatalities each year (NOAA, Date Unknown). Lightning can occur with all thunderstorms, making all of the Lehigh Valley susceptible. Different geographic areas experience varying event frequencies, but in all cases lightning strikes and associated fatalities occur primarily during the summer months.

According to the average annual lightning flash density for 2000-2009 from the Cooperative for Applied Meteorological Studies (2013), relatively more lightning flashes occur in southwestern Pennsylvania and in the Lehigh Valley. While the impact of lightning events is highly localized, strong storms can result in numerous widespread events over a broad area. In addition, the impacts of an event can be serious or widespread if lightning strikes a particularly significant location such as a power station or large public venue. According to the Pennsylvania 2013 Standard State All-Hazard Mitigation Plan, Northampton County has one of the highest lightning risks of all counties in Pennsylvania (PEMA 2013). Both Lehigh County and Northampton County have experienced more than 20 lightning events over NOAA-NCEI's reporting period and are considered vulnerable to lightning events.

4.3.8.2 Range of Magnitude

Lightning costs more than $1 billion in insured losses every year (National Weather Service [NWS] 2010). Many case histories show observed heart damage, inflated lungs and brain damage in lightning fatalities. Loss of consciousness, amnesia, paralysis and burns are reported by many who have survived. Deaths and injuries to livestock and other animals, thousands of forest and brush fires, as well as millions of dollars in damage to buildings, communications systems, power lines, and electrical systems are also the result of lightning (PEMA 2013).

Between 1959 and 2014, Pennsylvania ranked ninth among all states for the number of lightning deaths with 133 deaths. This represents approximately 3% of all fatalities that occurred throughout the United States over this time frame (NWS 2015).

The worst-case scenario for lightning strikes would be a strike in a large group of people, such as at an outdoor sporting event, in the Lehigh Valley (PEMA 2013). Numerous injuries or deaths could occur.

The environmental impacts most often associated with lightning strikes include damage or destruction of trees and ignition of wildfires (PEMA 2013).

4.3.8.3 Past Occurrence

A lightning “event” is defined as a lightning strike which results in fatality, injury and/or property or crop damage (PEMA 2013). Records from NOAA-NCEI show that there were 91 reported lightning events in the Lehigh Valley between 1993 and 2017. Northampton County recorded 64 of these lightning events, averaging 2.67 events every year. Lehigh County experienced 27 of these recorded events. The City of Easton recorded the most events with nine, followed by the City of Bethlehem with eight (NCEI 2018).

The Lehigh Valley’s worst lightning event in terms of property damage occurred on August 25, 2007, when lightning struck and caused a fire and $250,000 in damage at a church in Plainfield Township. Shortly after the church was struck, lightning struck and destroyed a saw mill in Upper Mount Bethel Township, which resulted in an additional $1 million dollars in loss. No injuries were reported.

With regards to loss of life and injuries, available data identifies a lightning fatality in Bethlehem Township in August of 2009. On July 19, 2011, a father and daughter were struck by lightning as they stood under a tree at the Moore Township Recreation Fields in Northampton County. The father had burns on his feet, stomach and leg and felt numbness and a burning sensation. The daughter suffered a flash burn to her right eye.

Since 1993, lightning strikes have been responsible for one death, 14 injuries and over $4.4 million in property damage in the Lehigh Valley. Table 4.3.8.1 shows lightning strikes recorded since the 2013 Plan.

Table 4.3.8.1 Lightning Events in the Lehigh Valley, September 2012-2017

County	Location	Date	Death	Injuries	Property Damage ($)
Lehigh County					
Lehigh	Whitehall Township	3/28/2012	0	0	$5,000
Lehigh	Alburtis Borough	7/26/2012	0	0	$5,000
Lehigh	Salisbury Township	8/9/2012	0	0	$100,000
Lehigh	New Tripoli (Lynn Township)	7/8/2014	0	1	-
Lehigh	Slatington Borough	8/22/2017	0	0	-
Northampton County					
Northampton	Hanover Township	8/9/2012	0	1	-
Northampton	Moore Township	9/4/2012	0	0	$5,000
Northampton	Forks Township	9/2/2013	0	0	$5,000
Northampton	Forks Township	9/12/2013	0	0	-
Northampton	Northampton Borough	9/12/2013	0	0	$5,000
Northampton	Forks Township	6/13/2014	0	0	$10,000
Northampton	Williams Township	7/8/2014	0	0	$5,000
Northampton	Williams Township	7/8/2014	0	0	$5,000
Northampton	City of Easton	7/8/2014	0	0	$5,000
Northampton	Lower Saucon Township	6/14/2015	0	0	$1,000
Northampton	Palmer Township	8/4/2015	0	0	$1,000
Northampton	Bushkill Township	6/28/2016	0	0	$1,000
Northampton	Bath Borough	6/28/2016	0	0	$1,000
Northampton	Moore Township	7/25/2016	0	0	-
Northampton	Nazareth Borough	8/2/2017	0	0	-
Northampton	Wind Gap Borough	8/3/2017	0	0	-
Lehigh Valley Total			**0**	**2**	**$204,000**

Source: NOAA NCEI 2018

For historical data, please refer to the 2013 or 2006 Lehigh Valley Hazard Mitigation Plans

4.3.8.4 Future Occurrence

Lightning strikes in the Lehigh Valley that resulted in multiple injuries or extensive property damage have occurred 47 times over 24 years of record (1993 to 2017). The future occurrence of lightning activity in the Lehigh Valley is anticipated, and the susceptibility to damage from these events will remain unchanged.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for lightning strike events is considered 'highly likely' as defined in Section 4.4.1.

4.3.8.5 Vulnerability Assessment

For lightning events, the entire Lehigh Valley has been identified as the hazard area. Therefore, all assets, including people, structures, critical facilities and lifelines are exposed and potentially vulnerable. Evaluation of NOAA-NCEI lightning data for the Lehigh Valley, along with data from the current and previous versions of the PA Hazard Mitigation Plan, show that while the number of lightning events has changed for individual municipalities, the basic pattern of vulnerability across the Lehigh Valley has remained relatively consistent. The direct and indirect losses associated with these events include injury and loss of life, damage to structures and infrastructure, agricultural losses, power outages and stress on community resources.

In general, population and building density have a correlation with hazard vulnerability and loss. The urban areas of the Lehigh Valley are at greater lightning risk than others due to higher population and building density. Taller buildings can act as lightning rods; therefore, they naturally have experienced greater vulnerability and loss during past lightning strike events (PEMA, 2013). The precise vulnerability of lightning strikes will depend on a facility's height relative to surrounding buildings, as well as the absence or presence of a lightning rod or other lightning channeling technology in the structure.

According to the 2013 PA Hazard Mitigation Plan, fire departments, schools and police departments are the most vulnerable to lightning strikes. Livestock operations may also be more vulnerable to lightning strikes because during storms animals often shelter under trees that are more likely to be hit by lightning. It is important to note that most of the food and agriculture-related critical facilities are privately owned farms that may own sizeable herds of livestock, but the Commonwealth critical facilities list does not indicate which of the farms own herds. The Lehigh Valley hosts 159 state critical facilities of the total 1,631 state critical facilities spread among 14 vulnerable counties (PEMA 2013). Also, if the entertainment and recreation facilities are outdoor recreation spaces with wide open spaces, there may be added lightning strike vulnerability (PEMA 2013).

Lightning can also cause electrical, forest and/or wildfires; and damage infrastructure such as power transmission lines and communication towers. Agricultural losses can be devastating due to lightning and resulting fires.

The PA Hazard Mitigation Plan estimated jurisdictional losses for the Lehigh Valley at more than $108 million, involving 394,328 buildings. Installing surge protection in critical electronic lighting or information technology system can lessen losses. Lightning protection devices and methods such as lightning rods and grounding can be installed on a community's communications infrastructure and other critical facilities to reduce losses (PEMA 2013).

4.3.9 Pandemic and Infectious Disease

4.3.9.1 Location and Extent

Pandemics are large-scale disease outbreaks, defined by how the disease spreads, not by how many fatalities are associated with it. Pandemics typically result from infectious diseases. An infectious disease, as defined by the World Health Organization (WHO), is caused by pathogenic organisms such as bacteria, viruses, fungus or parasites that spread from one person to another, whether through direct or indirect contact.

Pandemic and infectious disease events can cover a wide geographical area and can affect large populations, potentially the entire Lehigh Valley. The exact size and extent of an infected population is dependent upon how easily the illness is spread, the mode of transmission and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in more densely populated areas. The transmission rate of infectious disease will depend on the mode of transmission of a given illness. Pandemic events can also occur after other natural disasters, particularly floods, when there is the potential for bacteria to grow and contaminate water (PEMA 2013).

The Pandemic and Infectious Disease hazard is new to the Lehigh Valley Hazard Mitigation Plan. Of particular concern to the Lehigh Valley are arthropod-borne viruses (arboviruses), which are viruses that are spread from being transmitted between susceptible hosts, including people, and blood-feeding arthropods such as mosquitos and ticks. The Lehigh Valley has been impacted by high populations of mosquitoes and deer ticks. For the purpose of this 2018 Plan and as identified by the Lehigh Valley Planning Team, the specific pandemic and infectious diseases include:

- **Dengue Fever** is a mosquito-borne disease of concern for the Lehigh Valley. The Asian Tiger Mosquito, a species known to transmit Dengue fever, is found in the Lehigh Valley and can infect humans (PA Department of Health 2016). Most cases in the United States occur in people who contracted the infection while traveling abroad. However, the risk is increasing for people living along the Texas-Mexico border and in other parts of the southern United States. In 2009, an outbreak of Dengue fever was identified in Key West, Florida (WebMD 2018).
- **West Nile Virus** is a mosquito-borne disease that can cause an inflammation of the brain. West Nile is commonly found in Africa, West Asia, the Middle East and Europe. For the first time in North America, the West Nile virus was confirmed in New York City during the summer and fall of 1999. Since 2004, a continent-wide epidemic flares up in the summer and continues into the fall as infected mosquitos spread the virus from birds to horses, humans and other animals (Pennsylvania Department of Health 2018).
- **Zika Virus** is a mosquito-borne disease and a concern for the Commonwealth. A Zika outbreak began in May 2015 in Brazil, which led to reports of a neurological disease called Guillain-Barré

syndrome, and pregnant women giving birth to babies with birth defects such as microcephaly. The outbreak has spread to numerous countries and areas, prompting the Centers for Disease Control and Prevention (CDC) to issue travel notices to regions where the Zika virus transmission is ongoing. In response to the emerging disease, Pennsylvania has created a Zika Response Plan (Pennsylvania Department of Health 2018).

- **Tick-Borne diseases** are transmitted by ticks infected with bacteria, viruses or parasites and are a concern for the Lehigh Valley. One of the most common in the northeast is Lyme disease. Pennsylvania has led the nation in confirmed cases of Lyme disease for three straight years and for the first-time, infected deer ticks have been found in all 67 counties. In 2016, there were 11,443 cases of Lyme disease in the Commonwealth (Pennsylvania Department of Health 2018).
- **Influenza** can claim thousands of lives and adversely affect critical infrastructure and key resources. An influenza pandemic has the ability to reduce the health, safety and welfare of the essential services workforce; prevent core infrastructure from operating normally, such as hospitals (essential personnel becoming ill and unable to work); and induce fiscal instability. Influenza viruses with the potential to reach pandemic levels include the avian influenza A (H5N1) and avian influenza H7N9 (CDC 2015). Several years ago, the swine influenza (H1N1) was of particular concern. H1N1 was first detected in people in the United States in April 2009.
- **Measles** is caused by a virus and is normally passed through direct contact and through the air. The virus infects the mucous membranes and then spreads throughout the body. It is highly contagious and considered a very serious disease. In 1980, before widespread vaccination, measles caused an estimated 2.6 million deaths each year. It remains as one of the leading causes of death among young children. The US experienced a record number of measles during 2014, with 667 cases from 27 states reported, including three cases reported in Pennsylvania (New Jersey Department of Health 2015).
- **Ebola** is a rare and deadly disease caused by infection from one of the Ebola virus strains. According to the CDC, the 2014 Ebola epidemic was the largest in history, affecting multiple countries in West Africa. Two imported cases that included one death and two locally-acquired cases in healthcare workers have been reported in the US.

4.3.9.2 Range of Magnitude

The severity of a pandemic depends on a number of factors, including aggressiveness of the disease, ease of transmission and factors associated with the impacted community. Advancements in medical technologies have greatly reduced the number of deaths caused by influenza, the disease most likely to reach pandemic scale in Pennsylvania. Consequently, global effects of various influenza outbreaks have declined over the past century.

Since it was discovered in the western hemisphere, the West Nile virus has spread rapidly across North America, affecting thousands of birds, horses and humans. West

Nile swept from the New York City region in 1999 to almost all of the continental US by 2004 (USGS 2016).

On January 22, 2016, the CDC activated its Emergency Operations Center (EOC) to respond to outbreaks of Zika and increased reports of birth defects and Guillain-Barré syndrome in areas affected by Zika. On February 8, 2016, the CDC elevated its EOC activation to a Level 1, the highest level, but by September 29, 2017, the CDC deactivated its response to Zika (CDC 2018).

With more than one-third of the world's population living in areas at risk for infection, the Dengue virus is a leading cause of illness and death in the tropics and subtropics. As many as 400 million people are infected yearly. Dengue fever has emerged as a worldwide problem only since the 1950s. Although Dengue fever rarely occurs in the continental United States, it is endemic in Puerto Rico and in many popular tourist destinations in Latin America, Southeast Asia and the Pacific islands (CDC 2016).

Lyme disease is the most commonly reported vector-borne illness in the United States. In 2014, 96% of Lyme disease cases in the US were reported from 14 states, which included Pennsylvania (CDC 2015). Between 2001 and 2016, there were 4,813 confirmed cases of Lyme disease in the Lehigh Valley (Pennsylvania Department of Health 2018). The Lehigh Valley is at high risk for Lyme disease in humans (Yale School of Public Health 2014). If left untreated, infection can spread to joints, the heart and the nervous system. Patients with Lyme disease are frequently misdiagnosed with chronic fatigue syndrome, fibromyalgia, multiple sclerosis and various psychiatric illnesses, including depression. Misdiagnosis with these diseases may delay the correct diagnosis and treatment as the underlying infection progresses unchecked.

The Ebola virus is spread to others through direct contact; it is not spread through the air like influenza. Person-to-person transmission follows this initial infection and can lead to large numbers of affected people. When an infection occurs in humans, the virus can spread to others through direct contact through broken skin or mucous membranes (CDC 2017).

Measles is a highly contagious virus that lives in the nose and throat mucus of an infected person. It can spread to others through coughing and sneezing. The measles virus can live for up to two hours in an airspace where the infected person coughed or sneezed. If other people breathe the contaminated air or touch the infected surface, then touch their eyes, noses or mouths, they can become infected. Measles is so contagious that if one person has it, 90% of the people close to that person who are not immune will also become infected (CDC 2017; PADOH 2018).

There are no significant environmental impacts of pandemic and infectious disease threats, but there will be significant economic and social costs beyond the possibility of disease-related death. Widespread illness may increase the likelihood of shortages of personnel to perform essential community services. In addition, high rates of illness and worker absenteeism occur within the business community, and these contribute to social and economic disruption. Although these disruptions could be temporary, they may be amplified in today's closely interrelated and interdependent systems of trade and commerce. Social disruption may be greatest when rates of absenteeism impair essential services, such as power, transportation and communications (PEMA 2013).

4.3.9.3 Past Occurrence

In 2017, there were 80 confirmed Dengue fever cases reported in the United States, with 43 determined to be travel-associated and 37 locally transmitted. One of the cases was reported in Pennsylvania, but there were no reported cases in the Lehigh Valley (CDC ArboNET2018).

The West Nile virus was first detected in the Lehigh Valley in 2001 when mosquito pools, dead birds and/or horses tested positive for the virus. In the Lehigh Valley, there have been birds, mosquitoes and humans that have tested positive for the virus. West Nile virus occurrences in the Lehigh Valley are listed in Table 4.3.9.1.

Table 4.3.9.1 West Nile Virus Occurrences in the Lehigh Valley, 2001-2017

Year	Lehigh County		Northampton County	
	Number of Positive Cases	Positive Human Cases	Number of Positive Cases	Positive Human Cases
2001	4	0	0	0
2002	44	0	24	0
2003	52	2	16	3
2004	3	0	4	0
2005	60	0	2	0
2006	6	0	4	0
2007	10	0	6	0
2008	4	0	3	0
2009	1	0	0	0
2010	17	0	9	0
2011	75	0	18	0
2012	129	2	46	1
2013	42	0	25	0
2014	67	0	10	0
2015	62	0	31	0
2016	0	0	0	1
2017	74	1	17	1

Source: Pennsylvania's West NIle Virus Control Program 2018

Documented Zika cases in the Lehigh Valley since the Brazilian outbreak in 2015 were contracted outside of the United States and were not locally acquired cases. All Lehigh Valley cases occurred in 2016, with 18 in Lehigh County and 11 in Northampton County (CDC ArboNET 2018).

The number of reported cases of Lyme disease in the Lehigh Valley from 2001 to 2016 are identified in Table 4.3.9.2.

Table 4.3.9.2 Lyme Disease Occurrences in the Lehigh Valley, 2001-2016

Year	Reported Cases Lehigh County	Reported Cases Northampton County
2001	84	85
2002	62	172
2003	215	241
2004	201	197
2005	179	164
2006	105	99
2007	134	123
2008	147	109
2009	197	197
2010	102	132
2011	193	170
2012	153	129
2013	137	140
2014	140	84
2015	170	171
2016	242	139

Source: Pennsylvania Department of Health 2018

The United States Department of Health and Human Services estimates that influenza pandemics have occurred for at least 300 years at unpredictable intervals. There have been several pandemic influenza outbreaks over the past 100 years as indicated in Table 4.3.9.3.

Table 4.3.9.3 Significant Influenza Outbreaks Over the Past Century

Date	Pandemic Name/ Subtype	Worldwide Deaths (Approximate)
1918-1920	Spanish Flu/H1N1	50 Million
1957-1958	Asian Flu/H2N2	1.5 to 2 Million
1968-1969	Hong Kong Flu/H3N2	1 Million
2009-2010	Swine Flu/2009 H1N1	18,036

Deaths occurred in the United States as a result of the Spanish Flu, Asian Flu and Hong Kong Flu outbreaks. The Spanish Flu claimed 500,000 lives in the United States and there were 350,000 cases in Pennsylvania—150,000 in Philadelphia alone. Most deaths resulting from the Asian Flu occurred between September 1957 and March 1958, when there were about 70,000 deaths in the United States and approximately 15% of the population of Pennsylvania was affected. The first cases of the Hong Kong Flu in the US were detected in September 1968, with deaths peaking between December 1968 and January 1969 (PEMA 2013).

The Pennsylvania Department of Health maintains an influenza surveillance data archive that provides summaries for each influenza season, dating back to 2005, with data for the Lehigh Valley shown in Table 4.3.9.4.

Table 4.3.9.4 Reported Influenza Cases in the Lehigh Valley, 2005-2016

Year	Reported Cases Lehigh County	Reported Cases Northampton County
2005	285	349
2006	473	346
2007	917	643
2008	1,198	653
2009	1,696	2,136
2010	1,087	730
2011	188	170
2012	3,338	1,702
2013	2,071	968
2014	3,555	2,094
2015	1,603	2,164
2016	2,889	3,307

Source: Pennsylvania Department of Health 2018

According to the CDC, in 2014, the United States experienced a record number of measles cases, with 667 cases reported in 27 states. That was the greatest number of cases since measles elimination was documented in 2000. In 2015, 189 people from 24 states were reported to have measles. There were no reported cases of measles in Pennsylvania during this outbreak (CDC 2015).

There are no reported cases of Ebola in the Lehigh Valley.

4.3.9.4 Future Occurrence

Predicting the future occurrences of pandemics is difficult. Although any infectious disease can reach pandemic levels, influenza has the greatest likelihood of causing the next pandemic. It is likely that both Lehigh Valley counties will be impacted by certain diseases in the future. Additionally, an increase in population and population density in the Lehigh Valley may increase resident exposure and susceptibility to outbreaks. Infected mosquitos and ticks will continue to inhabit and impact the Lehigh Valley.

Future occurrences of pandemic West Nile virus are unclear. Instances of the virus have been generally decreasing due to aggressive planning and eradication efforts, but some scientists suggest that, as global temperatures rise and extreme weather conditions occur due to climate change, the range of the virus in the United States will grow (Epstein 2001).

Tick-borne diseases including Lyme disease will continue to impact the Lehigh Valley due to its natural environment. Each year, the number of cases increases. Research continues to address concerns of the disease (CDC 2014). Climate has been linked to one of the factors that influences the transmission, distribution and incidence of Lyme disease. Studies have provided evidence that climate change has also contributed to the expanded range of ticks, increasing the potential risk of Lyme disease (EPA 2016).

As with West Nile virus, the precise timing of pandemic influenza is uncertain. Based on historical events, the Lehigh Valley is expected to experience pandemic influenza outbreaks approximately every 11 to 41 years. The precise timing of pandemic influenza is uncertain,

but occurrences are most likely when the Influenza Type A virus makes a dramatic change, or antigenic shift, that results in a new or “novel” virus to which the population has no immunity. This emergence of a novel virus is the first step toward a pandemic (US Health and Human Services 2009).

Adults and children who contracted measles during the most recent outbreak were reported to have not been vaccinated against the disease or they did not know if they were ever vaccinated. For every 1,000 children who get measles, one to three of them will die from the disease (Connell 2015). If the number of vaccinations for measles decreases, there may be an increased number of reported cases.

Based on previous occurrences of the various diseases, pandemics and outbreaks of the different diseases will continue to occur. However, it is uncertain as to the future of these diseases and their impacts on the Lehigh Valley. Future pandemics may also emerge from other diseases, especially invasive pathogens that residents from both Lehigh and Northampton counties do not have natural immunity to.

Based on the Lehigh and Northampton County Emergency Management Agencies’ operational viewpoint, the probability of occurrence for pandemic and infectious disease events in the Lehigh Valley is considered ‘likely’ as defined in Section 4.4.1.

4.3.9.5 Vulnerability Assessment

For the pandemic hazard, the entire Lehigh Valley has been identified as the hazard area, therefore, the entire population of the Lehigh Valley is vulnerable to a pandemic event. Pandemic events are a significant concern, mainly due to their impact on public health. The elderly population and individuals with suppressed immune systems may be more susceptible to effects of diseases such as influenza. Additionally, there are some occupation-specific risks that may make some employees more vulnerable. Those working in direct contact with patients are more likely to be exposed to a pandemic disease, just as employees working outdoors during warmer months may be more vulnerable to West Nile virus, Zika, Dengue fever and Lyme disease (PEMA 2013).

Areas with a higher population density will have a higher exposure to diseases, especially those populations living in areas prone to mosquitoes and ticks. Additionally, vulnerable populations such as the young and elderly are considered at higher risk. In the event of a disease pandemic, such as influenza, people will not likely evacuate the impacted areas unless ordered by government officials. Most people would likely choose to shelter in place and avoid highly populated public places (Meit et al. 2007). Overall, the Lehigh Valley may experience an increase in population after a natural disaster that may impact the health of Lehigh and Northampton County residents. In the event of a pandemic, such as influenza, residents may choose to temporarily leave the area to avoid becoming ill. If a pandemic were to occur outside of the Lehigh Valley, the region may see an increase in population of people moving away from the impacted areas.

4.3.10 Radon Exposure

4.3.10.1 Location and Extent

Radon is a natural gas that cannot be seen, smelled or tasted. It is a noble gas that originates from natural radioactive decay of uranium and thorium. It is a large component of the natural radiation to which humans are exposed, and can pose a serious threat to public health when it accumulates in poorly ventilated residential and occupation settings.

Radioactivity caused by airborne radon has been recognized for many years as an important component in the natural background radioactivity exposure of humans. Not until the 1980s were the wide geographic distribution of elevated radon levels in houses and the possibility of extremely high radon concentrations in houses recognized. In 1984, routine monitoring of employees leaving the Limerick nuclear power plant near Reading, Pennsylvania, showed that readings from one employee frequently exceeded expected radiation levels, yet only natural, nonfission-product radioactivity was detected on him. Radon levels in his home were detected around 2,500 picoCuries per liter (pCi/L), much higher than the 4 pCi/L guideline set by EPA or even the 67 pCi/L limit for uranium miners. As a result of this event, the Reading Prong section of Pennsylvania, where this person lived, became the focus of the first large-scale radon scare in the world (PEMA 2013).

Like other noble gases, such as helium, neon and argon, radon forms essentially no chemical compounds and tends to exist as a gas or as a dissolved atomic constituent in groundwater. Two isotopes of radon are significant in nature, 222Rn and 220Rn, formed in the radioactive decay series of uranium and thorium, respectively. The isotope thoron has a half-life of 55 seconds, barely long enough for it to migrate from its source to the air inside a house and pose a health risk. However, radon, which has a half-life of 3.8 days, is a widespread hazard.

The distribution of radon is correlated with the distribution of radium, its immediate radioactive parent, and with uranium, its original ancestor. Due to the short half-life of radon, the distance that radon atoms can travel from their parent before decay is generally limited to distances of feet or tens of feet.

Three sources of radon in houses are now recognized:

- Radon in soil air that flows into the house
- Radon dissolved in water from private wells and exsolved during water usage. This is rarely a problem in Pennsylvania.
- Radon emanating from uranium-rich building materials such as concrete blocks or gypsum wallboard. This is not known to be a problem in Pennsylvania (PEMA 2013).

Each county in Pennsylvania is classified as having a low, moderate or high radon hazard potential. While this analysis has not been repeated since 1993, it represents the best available comprehensive radon hazard potential information available. A majority of counties across the Commonwealth, particularly counties in eastern Pennsylvania, have a high hazard potential. The average indoor radon screening level for these counties is greater than 4 pCi/L (PEMA, 2013). According to the EPA, Lehigh and Northampton counties are both located in a high radon potential zone.

High radon levels were initially thought to be exacerbated in tightly sealed houses, although it is now recognized that rates of air flow into and out of houses, plus the location of air inflow and the radon content of air in the surrounding soil, are key factors affecting radon concentrations. Air must be drawn into a house to compensate for outflows of air caused by a furnace, fan, thermal “chimney” effect, or wind effects. If the upper part of the house is tight enough to impede influx of outdoor air (radon concentration generally below 0.1 pCi/L), an appreciable fraction of the air may be drawn in from the soil or fractured bedrock through the foundation and slab beneath the house, or through cracks and openings for pipes, sumps, and similar features. Soil gas typically contains between a few hundred to a few thousand pCi/L of radon; therefore, even a small rate of soil gas inflow can lead to elevated radon concentrations in a house (PEMA 2013).

The radon concentration in soil gas depends on a number of soil properties, the importance of which are still being evaluated. In general, 10 to 50% of newly formed radon atoms escape the host mineral of their parent radium and gain access to the air-filled pore space. The radon content of soil gas clearly tends to be higher in soils containing higher levels of radium and uranium, especially if the radium occupies a site on or near the surface of a grain from which the radon can easily escape. The amount of pore space in the soil and its permeability for air flow, including cracks and channels, are important factors determining radon concentration in soil gas and its rate of flow into a house. Soil depth and moisture content, mineral host and form for radium, and other soil properties may also be important. Fractured zones may supply air having radon concentrations similar to those in deep soil for houses built on bedrock (PA Hazard Mitigation Plan 2013).

Areas where houses have high levels of radon can be divided into three groups in terms of uranium content in rock and soil:

- Areas of very elevated uranium content (>50 parts per million [ppm]) around uranium deposits and prospects: Although very high levels of radon can occur in such areas, the hazard normally is restricted to within a few hundred feet of the deposit. In Pennsylvania, such localities occupy an insignificant area.

- Areas of common rocks having higher than average uranium content (5 to 50 ppm): In Pennsylvania, such rock types include granitic and felsic alkali igneous rocks and black shales. In the Reading Prong, high uranium values in rock or soil and high radon levels in houses are associated with Precambrian granitic gneisses commonly containing 10 to 20 ppm uranium, but locally containing more than 500 ppm uranium. In Pennsylvania, elevated uranium occurs in black shales of the Devonian Marcellus Formation and possibly the Ordovician Martinsburg Formation. High radon values are locally present in areas underlain by these formations.
- Areas of soil or bedrock that have normal uranium content but properties that promote high radon levels in houses. This group is not fully understood. Relatively high soil permeability can lead to high radon, the clearest example being houses built on glacial eskers. Limestone-dolomite soils also appear to be predisposed for high radon levels in houses, perhaps because of the deep clay-rich residuum in which radium is concentrated by weathering on iron oxide or clay surfaces, coupled with moderate porosity and permeability (PEMA, 2013). Forty-seven of the 62 municipalities in Lehigh and Northampton counties are underlain entirely or in part by carbonate bedrock.

4.3.10.2 Range of Magnitude

Exposure to radon is the second leading cause of lung cancer after smoking. It is the number one cause of lung cancer among non-smokers. Radon is responsible for about 21,000 lung cancer deaths every year; approximately 2,900 of which occur among people who have never smoked. Lung cancer is the only known effect on human health from exposure to radon in air and thus far, there is no evidence that children are at greater risk of lung cancer than are adults (EPA, 2010). The main hazard is actually from the radon daughter products (218Po, 214Pb, 214Bi), which may become attached to lung tissue and induce lung cancer by their radioactive decay.

The worst-case scenario for radon exposure would be that a large area of tightly sealed homes provided residents high levels of exposure over a prolonged period of time without the residents being aware. This worst-case scenario exposure then could lead to a large number of people with cancer attributed to the radon exposure (PEMA 2013).

Radon exposure has minimal environmental impacts. Due to the relatively short half-life of radon, it tends to only affect living and breathing organisms such as humans or pets, which are routinely in contained areas, such as a basement or house where the gas is released (PEMA, 2013).

4.3.10.3 Past Occurrence

Current data on abundance and distribution of radon as it affects individual houses in Pennsylvania in general is considered incomplete and potentially biased (PEMA 2013). The EPA has estimated that the national average indoor radon concentration is 1.3 pCi/L and the level for action is 4.0 pCi/L; however they have estimated that the average indoor concentration in Pennsylvania basements is about 7.1 pCi/L and 3.6 pCi/L on the first floor (PADEP 2016).

The PADEP Bureau of Radiation Protection provides available radon test results by zip code for Pennsylvania.

The total number of tests reported to the Bureau since 1990 and their results are provided by zip code on the Bureau's website: (http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?/Radon/RadonZip). This information is only provided if over 30 tests were reported to best approximate the average for the area (PADEP 2018). Test results are available for first floor and basements. Radon testing is typically done under one of two different scenarios: one for real estate and one for non-real estate transactions. In the real estate situation, PADEP collects the basement or lowest livable level to be tested, at a minimum. In non-real estate situations, the protocol is to test the lowest living level. This usually implies the first floor.

Please note that zip codes with no data do not indicate the absence of results; instead, those zip codes had insufficient results or the existing results were missing some key information, causing the results to be suppressed. Average basement results ranged between 0.1 pCi/L and 20.0 pCi/L in the Lehigh Valley, and the average first floor results ranged between 0.1 pCi/L and 10.0 pCi/L.

4.3.10.4 Future Occurrence

Radon exposure is inevitable given present soil, geologic and geomorphic factors in the Lehigh Valley. Development in areas where previous radon levels have been significantly high will continue to be more susceptible to exposure. However, new incidents of concentrated exposure may occur with future development or deterioration of older structures. Exposure can be limited with proper testing for both past and future development, and appropriate mitigation measures (PEMA 2013).

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for radon exposure events in the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

4.3.10.5 Vulnerability Assessment

Radon exposure is of particular concern in the Lehigh Valley due to its location within an EPA High Potential Radon Zone. While factors such as building construction and engineered mitigation measures can influence the level of radon exposure, all residents and structures within the Lehigh Valley are vulnerable to radon exposure. Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan.

While the entire general building stock and critical facility inventory in the Lehigh Valley is exposed to radon, radon does not result in direct damage to structures and facilities. Rather, engineering methods installed to mitigate human exposure to radon in structures results in economic costs. The EPA determined that an average radon mitigation system costs $1,200, though costs can vary due to technique and the extent of the problem (EPA 2017).

The EPA also states that current state surveys show that one home in five has elevated radon levels. Using this methodology, radon loss estimation is factored by assuming that 20% of the buildings within the Lehigh Valley have elevated radon values and each would require a radon mitigation system installed at an average of $1,200. US Census data and the custom building inventory for the Lehigh Valley provided in Appendix E were used to support an evaluation of assets exposed to this hazard and the potential impacts associated with this hazard. According to this methodology, estimated radon mitigation costs for residential structures in the Lehigh Valley could exceed $60 million.

4.3.11 Subsidence/Sinkhole

4.3.11.1 Location and Extent

Land subsidence is the sudden sinking or gradual downward settling of the earth's surface with little or no horizontal motion, owing to the subsurface movement of earth materials (USGS, 2007). In Pennsylvania, the two common causes of subsidence are mining activity and the dissolution of carbonate rock such as limestone or dolomite that often are to blame for sinkholes. In dissolution, water passing through naturally occurring fractures and bedding planes dissolves bedrock leaving voids below the surface. Eventually, overburden on top of the voids collapses, leaving surface depressions resulting in karst topography. Characteristic structures associated with karst topography include sinkholes, linear depressions and caves. Often, subsurface solution of limestone will not result in the immediate formation of karst features. Collapse sometimes occurs only after a large amount of activity, or when a heavy burden is placed on the overlying material (PEMA 2013).

Karst features are a type of landscape characterized by surface depressions and sinkholes. The density of karst features ranges from 0 to 600 features per square mile, with wide variations in size. Fewer karst features have been mapped in existing urban areas. However, this is likely a result of development activities that disguise, cover or fill existing features rather than an absence of the features themselves (PEMA 2013).

Sinkholes are a natural and common geologic feature in areas with underlying carbonate rock that is soluble in water. Over periods of time measured in thousands of years, the carbonate bedrock can be dissolved through acidic rain water moving in fractures or cracks in the bedrock. This creates larger openings in the rock through which water and overlying soil materials will travel. Over time, the soil sloughing into the bedrock voids can leave the remaining soils insufficient to support their own weight, and a collapse or sinkhole occurs. In this example, the sinkhole occurs naturally, but in other cases the root causes of a sinkhole are anthropogenic, especially those that involve changes to the water balance of an area. These changes can be caused by leaking water pipes, mining activity, over-withdrawal of groundwater, diverting surface water from a large area and concentrating it in a single point, artificially creating ponds of surface water, or drilling new water wells. These actions can also serve to accelerate the natural processes of bedrock degradation, which can have a direct impact on sinkhole creation.

Both natural and man-made sinkholes can occur without warning. Slumping or falling fence posts, trees or foundations, sudden formation of small ponds, wilting vegetation, discolored well water and structural cracks in walls and floors are all specific signs that a sinkhole is forming. They can form into steep-walled holes to bowl or cone shaped depressions.

Forty-seven of the 62 municipalities in Lehigh and Northampton counties are underlain entirely or in part by carbonate bedrock as shown in the Community Profile section. The carbonate rock formations have developed karst landforms. These limestone and dolomite formations underlie the heart of the Lehigh Valley's urban core, and soils produced from the weathering of carbonate bedrock

also provide the area's most fertile farmland. The bedrock itself serves as a source of raw material for the cement industry.

The following municipalities have identified near-surface limestone and are vulnerable to sinkholes:

LEHIGH COUNTY

Alburtis Borough
City of Allentown
City of Bethlehem
Catasauqua Borough
Coplay Borough
Emmaus Borough
Fountain Hill Borough
Hanover Township
Lower Macungie Township
Lower Milford Township
Macungie Borough
North Whitehall Township
Salisbury Township
South Whitehall Township
Upper Macungie Township
Upper Milford Township
Upper Saucon Township
Weisenberg Township
Whitehall Township

NORTHAMPTON COUNTY

Allen Township
Bath Borough
City of Bethlehem
Bethlehem Township
Bushkill Township
East Allen Township
City of Easton
Forks Township
Freemansburg Borough
Glendon Borough
Hanover Township
Hellertown Borough
Lower Mt. Bethel Township
Lower Nazareth Township
Lower Saucon Township
Moore Township
Nazareth Borough
Northampton Borough
North Catasauqua Borough
Palmer Township
Plainfield Township
Portland Borough
Stockertown Borough
Tatamy Borough
Upper Mt. Bethel Township
Upper Nazareth Township
West Easton Borough
Williams Township
Wilson Borough

4.3.11.2 Range of Magnitude

No two subsidence areas or sinkholes are identical. Variations in size and shape, time period under which they occur and their proximity to development ultimately determines the magnitude of damage incurred. Events could result in minor elevation changes or deep, gaping holes in the ground surface. Subsidence and sinkhole events can cause severe damage in urban environments, although gradual events can be addressed before significant damage occurs. Primarily, problems related to subsidence include the disruption of utility services and damages to private and public property including buildings, roads and underground infrastructure. If long-term subsidence or sinkhole formation is not recognized and mitigation measures are not implemented, fractures or complete collapse of building foundations and roadways may result.

The worst-case scenario for subsidence and sinkholes in the Lehigh Valley would be for a sinkhole to form in the urban areas of Allentown, Bethlehem or Easton. A sinkhole in any one of these cities, either in a highly trafficked pedestrian area or under one of the many high traffic roadways or bridges, could potentially cause significant property damage and loss of life. Refer to the Vulnerability Assessment for further details on the population, general building stock and critical facilities and infrastructure vulnerable to this hazard.

Sinkholes can have negative effects on local groundwater. Groundwater in carbonate rock formations can be easily polluted, because water moves readily from the earth's surface down through solution cavities and fractures, thus undergoing very little filtration. Sinkholes have the potential to cause damage to chemical infrastructure such as pipelines and facilities that store or transport hazardous

materials. The result from a breach of one of these systems may result in a hazardous materials release and damage the environment. Contaminants such as sewage, fertilizers, herbicides, pesticides or industrial products are of concern. Vegetation is usually damaged during abrupt subsidence events. However, regrowth takes place over time (PEMA 2013).

4.3.11.3 Past Occurrence

According to the Pennsylvania Department of Conservation and Natural Resources' Sinkhole Inventory Online Database and the 2013 Pennsylvania State Hazard Mitigation Plan, there have been 470 recorded sinkholes in Lehigh County and 677 in Northampton County from 2010-2013 (PEMA 2013; DCNR 2013).

Locally documented information from the Lehigh and Northampton County Knowledge Center databases for 2012 and 2017 includes 101 sinkhole events in 23 municipalities. Of the 23 municipalities with sinkhole occurrences, Bethlehem Township had the most sinkholes reported (28), followed by Palmer Township (19), Easton (12), Hanover Township, Northampton County (6) and Lower Saucon Township (5). No information on damages or injuries are available. It should be noted that many sinkholes go unreported because they're happen on private property and do not endanger structures such as in farm fields and woodlots.

Several major sinkhole events occurred in the region. In February 1994, one of the worst known events in Pennsylvania occurred in the City of Allentown. The sinkhole measured 100-feet long, 50-feet wide and 20-feet deep and collapsed a portion of 7th Street and the adjoining new Corporate Plaza Building in downtown Allentown. The building was ultimately demolished and replaced with a parking lot. Damage amounts are not known.

Sinkholes along the Bushkill Creek led to the closure of the bridge on the main road between Tatamy Borough and Stockertown Borough in 2000. During the time when PennDOT was attempting to repair the sinkholes near the bridge, a large sinkhole opened up in the rear yard of a residence to the south and west of the bridge, and a portion of the creek bank adjacent to the property collapsed. The damage extended from the creek bank to the location of the original sinkhole repair.

In terms of monetary damages, the worst sinkhole event on record was reported in January 2004. A sinkhole caused structural damage to the northbound Route 33 Bridge over the Bushkill Creek. PennDOT closed the bridge and determined the bridge needed to be demolished and replaced. The southbound bridge was also replaced for a total project cost of about $6 million. This event resulted in a disaster declaration by the Governor.

4.3.11.4 Future Occurrence

Sinkhole occurrence is a continuing phenomenon and is fairly common in the carbonate areas of the Lehigh Valley. As these areas become increasingly developed, the risk for sinkholes will increase.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for subsidence/sinkhole events in the Lehigh Valley is considered 'likely' as defined in Section 4.4.1.

4.3.11.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability to the subsidence/

sinkhole hazard has not changed since the 2013 Plan. However, several differences exist between the 2013 and 2018 data used to conduct the subsidence/sinkhole risk assessment, which may indicate a change in vulnerability. For the 2018 Plan, the best available state spatial layer from the Pennsylvania Bureau of Topographic and Geologic Survey Geology (PBTGS) was used. Both limestone and dolomite geology were extracted from this layer. This carbonate layer closely aligns with the location of karst environments across the Lehigh Valley and accurately represents the estimated hazard area.

For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and LVPC. This updated assessment provides more accurate exposure for the Lehigh Valley. The general building stock and critical facility inventory are located in Appendix E.

Unlike the flood, wind and earthquake hazards, there are no standard loss estimation models or methodologies for the subsidence/sinkhole hazard. In an attempt to estimate the Lehigh Valley's vulnerability, the portion of the region underlain by carbonate bedrock is considered exposed to natural subsidence. To determine exposure to this hazard, the asset spatial data was overlaid on the carbonate bedrock from the PBTGS geology spatial layer. The limitations of this analysis are recognized and are only used to provide a general estimate of exposure.

Approximately 35% of the Lehigh Valley is underlain by carbonate bedrock. In Lehigh County, 19 of the 25 municipalities and approximately 77,965 acres are within the carbonate area. Only five of the 19 municipalities have less than 50% of their total acres in carbonate areas. These include Lower Milford Township, North Whitehall Township, Salisbury Township, Upper Milford Township and Weisenberg Township. Both Lower Milford Township and Weisenberg Township have less than 5% of their total acres in a carbonate area and, therefore, have a much lower hazard risk than the other municipalities.

In Northampton County, 29 of the 38 municipalities and approximately 85,146 acres are within the carbonate area for a total of 163,111 acres, or 254.9 square miles, in the Lehigh Valley. Only eight of the 29 Northampton County municipalities have less than 50% of their total acres underlain by carbonate bedrock. These include Allen, Bushkill, Lower Mt. Bethel, Lower Saucon, Moore, Plainfield, Upper Mt. Bethel and Williams townships. Of these, Bushkill, Moore, Plainfield and Upper Mt. Bethel townships have less than 5% of their total acres in a carbonate area. For purposes of this plan, it is assumed that the higher the percentage of carbonate bedrock in a municipality, the higher the risk for sinkhole formation.

A complete listing of the area exposed by municipality is located in Appendix F.

To estimate the population exposed, the approximate hazard area was overlaid upon the 2010 Census population data. The Census blocks with their center (centroid) within the hazard boundary were used to calculate the estimated population exposed to this hazard. Based on the analysis, the estimated population exposed in the Lehigh Valley is 478,958. A complete listing of the population exposed by municipality is located in Appendix F.

Evacuations associated with these geological events are typically forced evacuations, small-scale and occur in the immediate area of the sinkhole. The evacuations may impact residents and businesses. These evacuations can be short-term until the area of the incident is assessed and determined safe for residents to return to their homes. Some incidents are severe enough to destroy a home or homes. In the Lehigh Valley, if a sinkhole or subsidence incident occurred and evacuations were necessary, shelter may need to be provided for those impacted by the event.

In general, the built environment located in carbonate areas is exposed and potentially vulnerable to this hazard. In an attempt to estimate the general building stock vulnerable to this hazard, the structures and their associated building and contents replacement values located in the approximate hazard area were totaled. In the Lehigh Valley, the total replacement value for the building stock is more than $204 billion, or about 73% of the building stock replacement costs for the entire Lehigh Valley. A complete listing of the building stock replacement costs by municipality is located in Appendix F.

A number of critical facilities, transportation and utility assets are located in the hazard area and are also exposed to subsidence/sinkholes. A complete listing of critical facilities exposed is located in Appendix F

Subsidence and sinkholes can also severely impact roads and infrastructure. The limestone and dolomite formations underlie the heart of the Lehigh Valley's urban core, including many of the major roadways throughout the region. The Lehigh Valley is served by six expressways, including interstates 78 and 476, which as located in the identified subsidence hazard area. Other expressways exposed include Routes 22 and 33, a portion of Route 309, and a portion of Route 378 through the City of Bethlehem. Bridges with high traffic volumes in the area include the Route 22 Lehigh River Bridge, Route 33 Lehigh River Bridge, Route 329 Cementon Bridge, Route 145 Treichlers Bridge, Hamilton Street and Tilghman Street bridges in Allentown. Other hazard area bridges with high volume include the Hill-to-Hill, Fahy and Minsi Trail bridges in the City of Bethlehem, the 25th Street Bridge in Palmer Township and the 3rd Street Bridge in Easton. It is not possible to estimate potential future economic losses due to subsidence/sinkhole events at this time.

4.3.12 Wildfire

4.3.12.1 Location and Extent

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. Wildfires often begin unnoticed and can spread quickly, creating dense smoke that can be seen for miles. A wildland fire is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines and similar facilities. A wildland-urban interface (WUI) fire is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland.

Wildfires can occur at any time of the year, but are most likely in the Lehigh Valley during a drought, and can occur in forests, fields, grass and brush. Under dry conditions or drought, croplands may also be prone to wildfires. Any small fire in a wooded area, if not quickly detected and suppressed, has the potential to grow out of control. About 98% of wildfires in Pennsylvania are caused by human carelessness, negligence and ignorance. However, some are caused by lightning strikes, and in rare instances, spontaneous combustion (Pennsylvania Department of Conservation and Natural Resources [DCNR] 2018).

The greatest potential for wildfires is in March, April and May, and to a lesser extent October and November. In the spring, bare trees allow sunlight to reach the forest floor, drying fallen leaves and other ground debris. In the fall, dried leaves are also fuel for fires (PEMA 2013).

According to 2011 land use/land cover data, nearly 30% of the land in the Lehigh Valley is developed, nearly 40% is farmland and 30% is forested as shown in Table 4.3.12.1 (US Geological Survey [USGS] 2011). Urban areas are located adjacent to forests and farmlands. Both vegetation and structures serve as fuel for wildfire events.

Table 4.3.12.1 Land Use Summary for the Lehigh Valley

Land Use Category	Total Area (Square Miles)	Percent of Total
Barren (Quarry)	1.8	0.2
Developed	202.4	27.9
Farmland	288.2	39.7
Forested	217.6	30.0
Water	6.8	0.9
Wetlands	8.7	1.2
TOTAL	**725.5**	**100**

Source: USGS 2011

The WUI is considered the area where houses and wildland vegetation coincide. According to the Spatial Analysis for Conservation and Sustainability (SILVIS) Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison, the WUI is divided into two categories: intermix and interface. Intermix WUI areas are where housing and vegetation “intermingle.” Intermix areas have more than one house per 40 acres and have more than 50% vegetation. Interface WUI areas contain housing in the vicinity of contiguous wildland vegetation. Interface areas have more than one house per 40 acres, have less than 50% vegetation, and are within 1.5 miles of an area larger than 1,235 acres that is more than 75% vegetated (University of Wisconsin Date Unknown).

The California Fire Alliance determined that areas within 1.5 miles of wildland vegetation are the approximate

distance that firebrands can be carried from a wildland fire to the roof of a house. Therefore, even structures not located within the forest are at risk from wildfire. This buffer distance, along with housing density and vegetation type, were used to define the WUI in the Lehigh Valley (University of Wisconsin Date Unknown). Across the Lehigh Valley, approximately 31% is classified as WUI. A majority of the Lehigh Valley is located in the WUI intermix areas. There are bands of the WUI interface along the northern and southern borders of the counties.

Most high priority areas are found along the northern tier of the Lehigh Valley, along the Blue Mountain, bordering Schuylkill, Carbon and Monroe counties. In addition, large high priority areas are found in Alburtis Borough, Emmaus Borough, Fountain Hill Borough, Macungie Borough, Salisbury Township and Upper Milford Township. Please note that other high priority areas are also found scattered throughout the Lehigh Valley. These areas have favorable fuels, intermixed areas of vegetation and development, and are “hotspots” of past wildland fire occurrences.

Areas that have been categorized as ‘medium’ priority areas exhibit favorable fuels, but do not have a history of wildland fire occurrence or do not have intermixed areas of vegetation and development. In the Lehigh Valley, the medium priority areas tend to be concentrated along the northern and southern tier. The low priority areas, located in the central portion of the Lehigh Valley, have unfavorable fuels, a lack of wildland fire occurrence, and less agriculture or other non-forest land uses.

4.3.12.2 Range of Magnitude

Wildfire events in the Lehigh Valley can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating.

In addition to the risk wildfires pose to the general public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in Pennsylvania, it is always a risk. More common firefighting injuries include falls, sprains, abrasions or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle accidents and can place them in remote areas away from the communities that they are chartered to protect (PEMA 2013).

While some fires are not human-caused and are part of natural succession processes, a wildfire can kill people, livestock, fish and wildlife. They often destroy property, valuable timber, forage and recreational and scenic values. The most significant environmental impact is the potential for severe erosion, silting of stream beds and reservoirs, and flooding due to ground-cover loss following a fire event. Wildfire can also have a positive environmental impact in that they burn dead trees, leaves, and grasses to allow more open spaces for new vegetation to grow and receive sunlight. Another positive effect is that it stimulates the growth of new shoots on trees and shrubs and its heat can open pine cones and other seed pods.

Wildfires in the Lehigh Valley have generally been small and easily contained. Since 2000, single events have been as minor as a small brushfire, while others have involved up to 100 acres. The worst-case scenario for the Lehigh Valley is a multiple-acre fire occurring during a period of drought, which could cause the fire to spread rapidly. Because significant areas of the Valley are characterized

by a wildland-urban interface, severe property damage could occur.

Wildfires can increase the probability of other natural disasters, specifically floods and mudflows. Wildfires, particular large-scale fires, can dramatically alter the terrain and ground conditions, making land already devastated by fire susceptible to floods. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren and unable to absorb water, making the area more susceptible to flash flooding and mudflows. Flood risk in these impacted areas remains significantly higher until vegetation is restored, which can take up to five years after a wildfire (FEMA 2013).

4.3.12.3 Past Occurrence

The 2013 PA Hazard Mitigation Plan notes reported wildfires and acres burned in the Lehigh Valley between 2002 and 2013. A total of 64 wildfires in Lehigh County burned over 56 acres, while 62 wildfires in Northampton County burned more than 95 acres (PEMA 2013). Additionally, the 2013 Plan listed all wildfires that were recorded in the National Centers for Environmental Information (NCEI) Storm Events Database and the Pennsylvania Emergency Incident Reporting System (PEIRS). Wildfire events that were recorded in the NCEI database are shown in Table 4.3.12.2, with one death reported. In addition, Lehigh and Northampton County Knowledge Center databases identified 67 brushfires from 2012 to 2017. Information regarding damages, injuries or deaths was not available.

Table 4.3.12.2 Wildfires in the Lehigh Valley, 2012-2017

Date	County	Location	Acres Burned	Deaths	Injuries	Property Damage ($)
3/26/2012	Northampton	Lower Nazareth Township	Unknown	0	0	0
4/9/2012	Northampton	Upper Mount Bethel	7	0	0	0
11/24/2013	Lehigh	South Whitehall Township	Unknown	0	0	0
11/24/2013	Northampton	Forks Township	Unknown	0	0	0
4/6/2015	Lehigh	Washington Township	27	0	0	0
4/6/2015	Northampton	Lower Saucon Township	2	1	0	$1,000
4/18/2015	Lehigh	Blue Mountain	300	0	0	0
4/18/2015	Northampton	Unknown	5	0	0	0
6/15/2017	Northampton	Lehigh Township	10	0	0	0

Source: NOAA NCEI 2018

For historical data, please refer to the 2013 or 2006 Lehigh Valley Hazard Mitigation Plans

4.3.12.4 Future Occurrence

Estimating the approximate number of wildfires to occur in the Lehigh Valley is difficult to predict. This is because a number of variable factors impact the potential for a fire to occur and because some conditions, such as development patterns, location, fuel sources and construction sites exert increasing pressure on the WUI zone.

The likelihood of a fire attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response. Droughts cause drier conditions, which lead to an increase in wildfire risk. Additionally, invasive forest insects can increase the likelihood of wildfires occurring. Insects that attack and kill trees increase the wildfire fuel.

Based on the Lehigh and Northampton County Emergency Management Agencies operational viewpoint, the probability of occurrence for wildfire events in the Lehigh Valley is considered 'possible' as defined in Section 4.4.1.

4.3.12.5 Vulnerability Assessment

Overall, the Lehigh Valley continues to be vulnerable to the wildfire hazard. Several differences exist between the wildfire risk assessment in the 2013 Plan and the 2018 Plan. For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and LVPC. The general building stock and critical facility inventory are located in Appendix E.

For the purposes of this risk assessment, the 2012 wildfire urban interface and intermix (WUI) obtained through the SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison defines the wildfire hazard area. The asset data for population, general building stock and critical facilities was used to support an evaluation of assets exposed and the potential impacts and losses associated with this hazard. To determine exposure for this hazard, the WUI spatial layer was overlaid on the asset spatial data. The limitations of this analysis are recognized, and as such the analysis is only used to provide a general estimate.

Potential losses related to wildfires include the health and life of residents and responders. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment.

To estimate the Lehigh Valley population vulnerable to the wildfire hazard, the WUI was overlaid on the 2010 Census population data. The Census blocks with their center within the hazard area were used to calculate the estimated 97,183 people in Lehigh County and 60,038 people in Northampton County exposed to wildfire risks. A complete listing of estimated population exposed to the wildfire hazard is located in Appendix F.

If a wildfire evacuation was ordered in the Lehigh Valley, adequate sheltering and medical needs will need to be provided for residents. Most likely the evacuations will be temporary and residents will move back to the Lehigh Valley after it is deemed safe.

Wildfire events can have major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed businesses

and decreases in tourism. Wildfires can also severely impact roads and infrastructure. Interstates I-78 and I-476, major east to west and north to south corridors through the Lehigh Valley, have portions that run through WUI areas. This should be considered for evacuation route purposes.

The most vulnerable structures to wildfire events are those within the WUI. Buildings constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete. To estimate the Lehigh Valley buildings exposed to the wildfire hazard, the WUI was overlaid on the updated building inventory at the structure level. The replacement cost value of the structures with their center in the WUI were totaled.

Based on the analysis, municipalities in Lehigh County with over 90% of their general building stock exposed are Alburtis, Coopersburg, Macungie and Slatington boroughs. In Northampton County, Hellertown, Pen Argyl, Roseto, Walnutport and Wind Gap boroughs have over 90% of their building stock exposed to the hazard. A complete listing of building stock exposed by municipality is located in Appendix F.

It is recognized that a number of critical facilities are located in the wildfire hazard area and are also vulnerable to the threat of wildfire. Many of these facilities are the locations for vulnerable populations, such as schools and senior facilities, and responding agencies to wildfire events, such as fire and police facilities. A complete listing of critical facilities exposed by municipality is located in Appendix F.

4.3.13 Windstorm/Tornado

4.3.13.1 Location and Extent

Damaging winds are often called “straight-line” winds to differentiate the damage they cause from tornado damage. Straight-line winds and windstorms are experienced on a more region-wide scale. Straight-line winds are movements of air from areas of higher pressure to areas of lower pressure—the greater the difference in pressure, the stronger the winds. Windstorms are generally defined with sustained wind speeds of 40 mph or greater lasting for one hour or longer, or winds of 58 mph or greater for any duration.

Tornadoes are nature’s most violent storms, often causing fatalities and devastating neighborhoods in seconds. A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 mph. Damage paths can be greater than one mile wide and 50 miles long. Tornadoes typically develop from a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph, and can generate internal winds exceeding 300 mph. The lifespan of a tornado is rarely longer than 30 minutes (FEMA 1997).

Tornadoes can occur at any time, but are most frequent during late afternoon into early evening, the warmest hours of the day, and most likely to occur during the spring and early summer months of March through June. Tornado movement is characterized in two ways: direction and speed of spinning winds, and forward movement of the tornado, also known as the storm track. The forward motion of the tornado path can be a few hundred yards or several hundred miles in length. The width of tornadoes can vary greatly, but generally range from less than 100 feet to more than a mile in width. Some tornadoes never touch the ground and are short-lived, while others may touch the ground several times. High wind velocity and wind-blown debris, along with lightning or hail, cause the damage from tornadoes. Destruction from tornadoes depends on the size, intensity and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential and mobile homes, and tend to remain localized during impact (PEMA 2013: Northern Virginia Regional Commission [NVRC] 2006).

4.3.13.2 Range of Magnitude

The United States experiences more tornadoes than any other country, approximately 1,000 in a typical year (NWS 2011). While the extent of tornado damage is usually localized, extreme winds of this vortex can be among the most destructive on Earth when they move through populated, developed areas.

Windstorms and tornadoes can occur throughout the Lehigh Valley, though events are usually localized. The Lehigh Valley is also located within the Hurricane Susceptibility Region, which extends along the northeastern coastline of the United States (FEMA, 2010).

A tornado’s magnitude is classified using the Enhanced Fujita Scale (EF-Scale) as shown in Table 4.3.13.1. Since 2007, the EF-Scale has been used to measure the strength of a tornado. It is used to assign tornadoes a ‘rating’ based on estimated wind speeds and related

damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DI) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned similar to that of the F-Scale used prior to 2007, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF-Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys and considers how most structures are designed (NOAA 2018).

Table 4.3.13.1 Enhanced Fujita Damage Scale

EF-Scale Number	F-Scale Number	Wind Speed (mph)	Type of Damage Done
EF0	F0-F1	65-85	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	F1	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	F1-F2	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	F2-F3	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	F3	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	F3-F5	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 yards; high-rise buildings have significant structural deformation.

Source: National Weather Service 2018

Since tornado events are typically localized, environmental impacts are rarely widespread. The impacts of windstorms on the environment usually take place over a larger area. Severe damage to plant species is likely with both tornado and windstorm events. This includes uprooting or total destruction of trees, and increased threat of wildfire in areas of tree debris. Hazardous material facilities should meet design requirements for the wind zones to prevent release of hazardous materials into the environment (PEMA 2013).

4.3.13.3 Past Occurrence

Past occurrences and losses associated with historic tornado events prior to February 2007 are based on the former Fujita Scale. Events after February 2007 are based on the Enhanced Fujita Scale.

According to the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events Database, between 1950 and 2017, Lehigh County had 359 tornado and windstorm events and Northampton County experienced 384 events. These events include funnel clouds, high winds, strong winds, thunderstorm winds and tornadoes. Total property damages, as a result of these windstorm and tornado events, were estimated at $38.957 million in Lehigh County and $33.098 million in Northampton County. Of these recorded events, NOAA's NCEI reported 10 recorded tornadoes in Lehigh County and 11 recorded tornadoes in Northampton County. The intensity of these events ranged from F0 to F3.

The most severe tornado to hit Lehigh County since 2006 was an EF1 that touched down in east Allentown in 2008. This was the only confirmed tornado in the United States associated with Tropical Storm Hanna, producing widespread damages exceeding $1.5 million, but no deaths or injuries. Of the 11 tornadoes recorded in Northampton County, two were categorized as F0, six as F1, two as F2, and one was categorized as an F3. There have been no recorded tornadoes in Northampton County since 1996 (NCEI, 2017).

The most recent recorded tornado in the Lehigh Valley occurred on July 14, 2010, and was recorded as a magnitude EF0. The thunderstorm-induced tornado touched down in areas of Lehigh County between Lynnville and New Tripoli, uprooting trees, flattening fields, damaging homes. It caused about $500,000 in property damages and no injuries were reported (NCEI, 2017).

One high wind event in April 1975 resulted in a PEMA statewide disaster declaration. Impacts of the wind event on the Lehigh Valley are not known.

Since the 2013 Lehigh Valley Hazard Mitigation Plan, there have been two high wind events, 44 thunderstorm winds, two funnel clouds and 19 strong wind events reported within the Lehigh Valley. No tornado events were reported. Total property damage reported since the 2013 Plan was $5.6 million. No deaths were reported from any of these events, however, one injury was reported (NCEI 2017). Two major events are described in Table 4.3.13.2.

Table 4.3.13.2 Tornado and Windstorm Events in the Lehigh Valley, 2012-2017

Dates of Event	Event Type	Location	Magnitude	Losses/Impacts	Source(s)
October 29, 2012	High Winds	Lehigh and Northampton Counties	77-80 mph	Post Tropical Storm Sandy caused $3 million in property damage in Lehigh County and $1 million in Northampton County. Both counties were included in a Presidential Emergency Declaration. All 67 Pennsylvania counties received a Gubernatorial Emergency Declaration. Lehigh County was one of the hardest hit by wind damage. The highest measured wind gust in Mount Holly's forecast and warning area in Pennsylvania was 81 mph in Allentown. In the Lehigh Valley, 181,000 homes and businesses lost power. In Lehigh County, the winds caused major damage to 32 homes and affected an additional 86 homes.	NOAA
June 30, 2015	Thunderstorm Wind	Lehigh and Northampton Counties	60-80 mph	Strong to severe thunderstorms produced damaging winds that affected eastern Pennsylvania. The Lehigh Valley and Chester County were hit hardest, with the Lehigh Valley experiencing a strong microburst. PPL reported 11,000 Lehigh Valley customers lost power and First Energy reported 4,000 customers lost power in Northampton County. Hanover Township in Northampton County had the most tree damage reported of any municipality in the county. A total of $1.25 million in property damage was reported in the region.	NOAA

Note (1): Monetary figures within this table were US Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of increased US Inflation Rates.
MPH: Miles per Hour; NOAA: National Oceanic Atmospheric Administration; PPL: Pennsylvania Power and Light

4.3.13.4 Future Occurrence

The Lehigh Valley experiences strong winds on a frequent basis, and when those winds do strike, they can result in significant property damage, downed trees and utility outages. It can reasonably be assumed future tornadoes will be similar in nature to those that have affected the Lehigh Valley in the past. It is estimated that the Lehigh Valley will continue to experience direct and indirect impacts of windstorms and tornadoes annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, as well as transportation delays, accidents and inconveniences.

According to the National Weather Service, Pennsylvania has an annual average of 10 tornadoes with two related deaths. While the chance of being hit by a tornado is small, the damage that results can be devastating. An F4 tornado can carry wind velocities of 200 mph, resulting in a force of more than 100 pounds per square foot of surface area. This is a “wind load” that exceeds the design limits of most buildings.

Based on the Lehigh and Northampton County Emergency Management Agencies’ operational viewpoint, the probability of occurrence for windstorm and tornado events in the Lehigh Valley is considered ‘possible’ as defined in Section 4.4.1.

4.3.13.5 Vulnerability Assessment

Overall, the Lehigh Valley’s vulnerability to the wind and tornado hazard has not changed since the 2013 Plan. All jurisdictions will continue to be vulnerable. However, several differences between the 2013 Plan and 2018 Plan risk assessment are acknowledged, including an updated version of the FEMA HAZUS-MH model and inventory data used, which may indicate a change in vulnerability. For the 2013 Plan, HAZUS-MH v2.1 was used. For the 2018 Plan, an updated version of FEMA’s HAZUS-MH hurricane module (version 4.0) was used to estimate potential losses. There have been changes and advances to the latest version of HAZUS-MH used for the 2018 Plan, including new surface roughness coefficients, updated tree coverage data and updated probabilistic hurricane wind speeds. In addition, the model now has a longer historical record to pull from when generating probabilistic events. Therefore, different probabilistic hurricane wind scenarios were developed by the model for the Lehigh Valley and the updated potential loss estimates are reported. For the 2018 Plan, HAZUS-MH hurricane module was run at the Census Tract Level, instead of the Census Block level as conducted in 2013, due to the latest HAZUS-MH version’s file size requirements.

For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Department and LVPC. The general building stock and critical facility inventory are provided in Appendix E.

The impact of strong winds and tornadoes ultimately depends on the amount of people and property that are present in the area. The extent of winds and tornadoes may lead to the evacuation of areas in the vicinity of the event. Residents may be ordered to shelter in place or evacuate their homes, but there may be little to no warning as strong winds and tornadoes can occur suddenly.

Tornadoes and strong wind events have been known to devastate entire cities and landscapes, often leaving people without food, water or shelter for days, weeks or even longer. If severe enough, wind and tornado events can permanently displace people who will have to relocate to a new home or find temporary housing. In the Lehigh Valley, if an evacuation were ordered, adequate sheltering and medical needs would need to be provided to residents.

Due to the Lehigh Valley's inland location, losses from wind are primarily associated with severe thunderstorm or tropical depression storm-related winds and rain (see Flood profile). Secondary flooding associated with the torrential downpours during severe storms is also a primary concern in the Lehigh Valley. Both counties have experienced flooding in association with numerous severe storms in the past.

All people, buildings and critical facilities in the Lehigh Valley are at risk of being damaged or lost due to impacts of severe windstorms and tornadoes. Certain areas, infrastructure and types of buildings are at greater risk than others due to proximity to falling hazards and manner of construction. Potential losses associated with high wind events were calculated for the Lehigh Valley for two probabilistic hurricane events, the 100-year and 500-year Mean Return Period (MRP) wind events.

Damage to buildings is dependent upon several factors including wind speed, storm duration, path of the storm track or tornado, distance from the tornado funnel and building construction. Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside. Due to their light-weight and often unanchored design, manufactured housing is extremely vulnerable to high winds and will generally sustain the most damage.

Total counts based on mobile/manufactured homes were included in the updated general building stock. The Lehigh Valley has 11,453 manufactured homes, with 7,354 located in Lehigh County and 4,099 in Northampton County. Upper Macungie, North Whitehall and Lower Macungie townships have the greatest number of manufactured homes in Lehigh County, and Lehigh, Moore and Upper Mt. Bethel townships have the greatest number in Northampton County. A complete listing of mobile homes by municipality is located in Appendix F.

According to HAZUS-MH wind model, direct wind-induced damage to buildings is dependent upon the performance of components and cladding, including the type of roof covering, roof sheathing, windows and doors and is modeled as such. Structural wall failures can occur for masonry and wood frame walls and uplift of whole roof systems due to failure where the roof meets the wall. Foundation failures can potentially take place for manufactured homes.

After considering the population exposed to the wind hazard, the general building stock replacement value exposed to and damaged by 100- and 500-year MRP events was examined. Wind-only impacts from a severe storm are reported based on the probabilistic hurricane runs in HAZUS-MH 4.0. Potential damage is the modeled

loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane.

For the 100-year MRP event, HAZUS-MH 4.0 estimates $3.7 million in building damages in Lehigh County and $21.0 million in building damages in Northampton County. Residential buildings comprise the majority of the building inventory and are estimated to experience the majority of the damage.

HAZUS-MH estimates $131 million in damages to the general building stock for Lehigh County and $70.7 million in building damages to Northampton County for the 500-year event. This is less than 1% of the value of the building inventory. The residential buildings are estimated to experience the majority of the damage.

Annualized losses for the Lehigh Valley were estimated to be more than $2 million. Please note that annualized loss does not predict what losses will occur in any particular year.

Potential loss estimates, including annualized losses, by municipality are located in Appendix F.

All critical facilities in the Lehigh Valley are exposed to the wind hazard. HAZUS-MH estimates the probability that critical facilities such as schools, medicals facilities, police, fire and municipal buildings may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH estimates the loss of use for each facility in number of days. No damages and zero loss of use for critical facilities are estimated as a result of the 100-year MRP event. Appendix F lists the estimated loss of use in days for each critical facility and the probability of each sustaining the specified damage categories for the 500-year wind event.

Transportation lifelines are not considered particularly vulnerable to the windstorm and tornado hazard. They are more vulnerable to cascading effects such as flooding and falling debris. Impacts to transportation lifelines affect both short-term transportation needs activities such as evacuation, and long-term needs such as daily commuting.

Utility structures could suffer damage associated with falling trees and debris. This can interrupt business operations and impact heating or cooling to homes, including those occupied by vulnerable populations such as children or the elderly. Post-event, there is a risk of fire, electrocution or an explosion.

Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

Recovery and clean-up costs can also be costly and impact the economy as well. HAZUS-MH estimates the debris generated as a result of the 100- and 500-year wind events for the Lehigh Valley. The 100-year wind event is estimated to generate 5,700 tons of brick, wood and tree debris, while the 500-year event is estimated to generate 41,000 tons of debris. Appendix F includes a listing of debris generated for both storm events by municipality.

4.3.14 Winter Storm

4.3.14.1 Location and Extent

Winter storms occur in Pennsylvania several times annually and are regional events. Every county in the Commonwealth is subject to severe winter storms, including both Lehigh Valley counties. Based on annual snowfall averages recorded in the 2013 Pennsylvania Hazard Mitigation Plan, the Lehigh Valley can expect an average of 21 to 50 inches of snowfall during the winter season.

4.3.14.2 Range of Magnitude

The magnitude or severity of a winter storm depends on factors that include a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day, day of occurrence and time of season.

Winter storms consist of cold temperatures, heavy snow or ice and sometimes strong winds. They begin as low-pressure systems that move through Pennsylvania usually following the jet stream. Due to their regularity, these storms are considered hazards when they result in damage to specific structures or cause disruption to traffic, utilities, business activities, and can cause loss of life, frostbite and freezing conditions. They can result in the closing of secondary roads, particularly in rural locations, loss of utility services and depletion of oil heating supplies. These storms typically fall into one of the following categories:

- **Heavy Snow**: According to the National Weather Service (NWS), heavy snow is generally snowfall accumulating to four inches or more within 12 hours, or snowfall accumulating to six inches or more in 24 hours or less.
- **Blizzard**: Blizzards have sustained wind or frequent gusts to 35 miles per hour (mph) or greater and falling or blowing snow that reduces visibility to a quarter-mile or less for three or more hours (NWS 2009). A severe blizzard is defined as having a wind velocity of 45 mph, temperatures of 10°F or lower, a high density of blowing snow with visibility frequently measured in feet over an extended period (PEMA 2013).
- **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. Heavy sleet is a relatively rare event, defined as ice pellets covering the ground to a depth of a one-half inch or more. Freezing rain falls as a liquid, but freezes into glaze upon contact with the ground (NWS 2009).
- **Ice storm**: An ice storm is used to describe damaging accumulations of ice during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous. Significant ice accumulations are usually a quarter-inch or greater (NWS 2009).

- **Nor'Easter**: A Nor'easter is a storm along the East Coast of North America, so called because the winds over the coastal area are typically from the northeast. These storms may occur at any time of year but are most frequent and most violent between September and April.

The worst-case scenario for the Lehigh Valley was the Blizzard of 1996. Record breaking snow fell January 7-8, with over two feet of snow recorded at the Lehigh Valley International Airport, prompting a state of emergency. Another 4-6 inches fell on January 12. Three people died over this period, and a number of building collapses occurred. The blizzard was immediately followed by rapid snowmelt, resulting in major flooding, with property damage exceeding $42 million in the Lehigh Valley.

Environmental impacts often include damaged shrubbery and trees due to heavy snow loading, ice build-up or high winds which can break limbs or bring down large trees. An indirect effect of winter storms is the treatment of roadway surfaces with salt, chemicals and other de-icing materials which can impair adjacent surface and ground waters (PEMA 2013). Winter storms have a positive environmental impact as gradual melting of snow and ice provides excellent groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flooding (PEMA 2013).

4.3.14.3 Past Occurrence

According to the National Oceanic and Atmospheric Administration (NOAA) and National Centers for Environmental Information (NCEI) Storm Events Database, Lehigh County experienced 247 winter storm events and Northampton County experienced 248 events between 1993 and 2017. Total property damages resulting from these winter storm events were estimated at $3.8 million in Lehigh County and $2.25 million in Northampton County. Table 4.3.14.1 shows winter storm events recorded since the 2013 Plan.

Between 1954 and 2017, FEMA documents that Pennsylvania experienced seven winter storm-related disaster (DR) or emergency (EM) declarations classified as one or a combination of severe winter storms, snowstorms, blizzards, winter storms, severe storms and snowfall. Generally, these disasters cover a wide region of the state, impacting many counties. Of those events, Lehigh and Northampton counties were included in five declarations (FEMA 2018).

Table 4.3.14.1 Winter Storm Events in the Lehigh Valley, 2012-2017

Date	Event Type	FEMA Declaration Number	Counties Designated?	Losses/Impacts	Source(s)
February 3, 2014	Heavy Snow	N/A	N/A	Snow fell across eastern Pennsylvania, with the greatest amounts falling in the Lehigh and Delaware Valleys. At LVIA, 9.3 inches of snow was recorded. LANTA suspended all commuter bus service. Tractor- trailers became stuck on hills. Airport Road closed due to a truck accident. No injuries or property damage were reported.	NOAA-NCEI
February 12-14, 2014	Winter Storm	N/A	N/A	A major winter storm affected all eastern Pennsylvania with heavy snow and sleet. A state of emergency was in effect in Pennsylvania. Commuter bus service from the Lehigh Valley to New York City was cancelled. 19.2 inches of snow was recorded at LVIA and all flights were cancelled. Five injuries were reported.	NOAA-NCEI
January 22-24, 2016	Winter Storm	DR-4267	Yes	A major Nor'easter produced record snowfall in eastern Pennsylvania, with a 2-day total snowfall of 31.9 inches at the Lehigh Valley International Airport. The normal seasonal snowfall of 32.9 inches at the airport was almost exceeded by this one event. Pennsylvania Governor Tom Wolf declared a State of Emergency. Both Lehigh and Northampton counties were declared federal disaster areas. An Allentown man collapsed from a heart attack while shoveling snow. A second Allentown man was found unconscious in his car after being overcome by exhaust fumes and died later from related complications.	NOAA-NCEI
March 14, 2017	Blizzard/Winter Storm	N/A	N/A	Heavy snow fell across the region in the morning with a mix of sleet and freezing rain later in the day. 13.7 inches of snow was recorded at LVIA. No injuries or damages were reported. Governor Wolf signed a Proclamation of Disaster Emergency for the State on March 13, 2017.	NOAA-NCEI

DR: Federal Disaster Declaration
LANTA: Lehigh and Northampton Transportation Authority
LVIA: Lehigh Valley International Airport
N/A: Not applicable/available
NCEI: National Climate Data Center
NOAA: National Oceanic Atmospheric Administration

For historical data, please refer to the 2013 or 2006 Lehigh Valley Hazard Mitigation Plans

4.3.14.4 Future Occurrence

The history of winter storm events indicate that future winter storm events of varying degrees will occur in the Lehigh Valley. The frequency of major events in the past throughout the Lehigh Valley suggest that many people and properties will remain at future risk.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for winter storm events in the Lehigh Valley is considered 'likely' as defined in Section 4.4.1.

4.3.14.5 Vulnerability Assessment

Winter storms are a concern to the Lehigh Valley because of the region's location and geographic propensity to experience winter weather more frequently and with greater severity than many other parts of the State. Additionally, winter storms are of significant concern due to delays caused by the storms and impacts on the people and facilities of the region.

Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the winter storm hazard.

However, there are several differences between the 2013 Plan risk assessment and the 2018 Plan in terms of spatial hazard data used, which may result in changes in reported vulnerability. For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. The 2010 US Census data and the custom building inventory for the Lehigh Valley provided in Appendix E were used to support an evaluation of assets exposed to this hazard and the potential estimated impacts.

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 for this hazard. Given professional knowledge and the currently available information, the potential losses for this hazard are considered to be overestimated and represent conservative estimates for losses associated with severe winter storm events. Potential loss estimates range from $1.6 to $16.9 billion for the Lehigh Valley. A complete listing of damage loss estimates by municipality is located in Appendix F.

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, from heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. The elderly are considered most susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion or hypothermia. In addition, winter storm events can reduce the 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.

Heavy snow can immobilize a region, shutting down air and rail transportation, stopping the flow of supplies and disrupting medical and emergency services. In rural areas, homes and farms may be isolated for days, and unprotected livestock may be lost (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. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL, 2006).

In the event of a power outage, residents of the Lehigh Valley may choose to voluntary evacuate their homes to an area with electricity until power is restored. However, choosing to leave during a snow storm can put motorists at risk for car crashes if roadways are not plowed. Additionally, the Lehigh Valley may experience an increase in population for a short period of time if areas surrounding Lehigh and Northampton counties experience power outages during a winter storm.

Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. The potential secondary impacts from winter storms also impact the local economy including loss of utilities, interruption of transportation corridors and loss of business function.

4.3.15 Civil Disturbance/Mass Gathering

4.3.15.1 Location and Extent

Within the Lehigh Valley, pre-planned events such as sports gatherings, college ceremonies and public festivals draw large numbers of individuals that are considered mass gathering events. Additionally, the location of government facilities, landmarks, prisons, colleges and universities within the region may draw the attention of protest organizations. These facilities are generally located within the larger, more urban environments within the cities of Allentown, Bethlehem and Easton.

4.3.15.2 Range of Magnitude

Civil disturbance or mass gatherings range from small groups of individuals joined together with a common message or purpose to large groups intent on disrupting operations. These gatherings generally range from annual planned events such as festivals, sporting events and college graduations to peaceful or violent assemblies of large groups.

4.3.15.3 Past Occurrence

The Lehigh Valley is home to annual events classified as mass gatherings by the Pennsylvania Department of Health. The list in Table 4.3.15.1 is a partial compilation of annual events that draw large groups together with peaceful intent. Due to the number of events being hosted by each municipality in the Lehigh Valley, a full listing of events is unable to be maintained. The information identified below was provided by the County Emergency Management Agencies, and was noted to be events that require assistance from county and municipal agencies due to location and number of attendees.

Most past occurrences of non-planned gatherings within the Lehigh Valley have been peaceful, with only one incident identified in the 2013 Plan being associated with any type of violence: a large group of juveniles (30-40) were reported fighting in North Whitehall Township. Non-planned mass gatherings that have occurred since the 2013 Plan have been provided by the County Emergency Management Agencies and are listed in Table 4.3.15.2.

An additional event occurred in 2011 when Lehigh University rented their facilities out to a company that hosted a Rave party for the college students. During the event, a student became ill, followed by numerous others. Local responders quickly arrived and determined the event to be a Mass Casualty Incident. In total, 44 students were transported from the event and taken to local hospitals for a variety of injuries and illnesses.

4.3.15.4 Future Occurrence

Based upon the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the likelihood of civil disturbance/mass gathering is considered 'highly likely' as defined in Section 4.4.1.

4.3.15.5 Vulnerability Assessment

Civil disturbance/mass gathering is of particular concern in the Lehigh Valley due to numerous regularly scheduled and unscheduled gatherings of large numbers of individuals. Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the civil disturbance/mass gathering hazard.

4.3.15.1 Mass Gathering Pre-Planned Events

County	Jurisdiction	Event	Date	Estimated Population
Lehigh	Allentown	Drum Corps International Eastern Classic	August	Unknown
Lehigh	Allentown	Great Allentown Fair	August	Unknown
Lehigh	Allentown	Mayfair Festival of Arts	Memorial Day Weekend	Unknown
Lehigh	Allentown	Coca-Cola (Iron Pigs)	Up to 88 Games	Seating up to 10,000
Lehigh	Allentown	Agricultural Hall Events	Year Round	Unknown
Lehigh	Trexlertown	Valley Preferred Cycling Center	Weekly	Up to 2,000
Lehigh	Cementon	Cementon Fair	June	Unknown
Lehigh	Macungie	Paws for Fun Pet Festival	October	Unknown
Lehigh	Macungie	Truck Show	June	Unknown
Lehigh	Macungie	Das Awkscht Fest	August	Unknown
Lehigh	Macungie	Wheels of Time Car Show	August	Unknown
Lehigh	Schnecksville	Schnecksville Community Fair	June	Unknown
Northampton	Bethlehem	Musikfest	August	1.2 million over 10 days
Northampton	Bethlehem	Celtic Classic	September	260,000 over 3 days
Northampton	Bethlehem	Runners World Half-Marathon	October	9,000 over 3 days
Northampton	Bethlehem	Christkindlmarkt	Nov-Dec	65,000 over 36 days
Northampton	Easton	PA Bacon Fest	November	85,000 over 2 days
Northampton	Easton	Easton Garlic Festival	October	50,000 over 2 days
Northampton	Easton	Heritage Day	July	Unknown

Source: Lehigh and Northampton County Knowledge Center Databases

Table 4.3.15.2 Non-Planned Mass Gatherings

County	Jurisdiction	Event	Date	Estimated Population
Lehigh	Salisbury Township	Protest against housing immigrant minors at KidsPeace	7/20/14	Unknown
Northampton	Lower Nazareth Township	Union protest	11/19/15	Unknown
Northampton	Easton City	Anti- and pro-Trump rallies	11/12/16	Unknown
Northampton	Bethlehem City	Pantsuit rally: silent rally to promote unity	11/12/16	Unknown
Northampton	Bethlehem Township	Northampton Community College students protest against anti-acceptance religious group	5/3/17	Unknown

Source: Lehigh and Northampton County Knowledge Center Databases

The vulnerability of a jurisdiction and its residents to a non-planned mass gathering is difficult to measure due to the unknown target or topic that is causing the group to gather. Mass gatherings may stretch health systems beyond their capacity. However, these events also present opportunities for long-lasting positive effects such as a stronger public health system after the event, or residents and visitors that are better informed about how they can protect themselves from certain disease (WHO, 2016). Additionally, the health consequences of mass gathering-related events may include injuries resulting from crowd density and inadequate infrastructure, such as a bridge collapse, exposure to extreme weather events, and escalation of violence as a result of crowd behavior (Aitsi-Selmi, Murray, et al. 2016).

Past civil disturbance/mass gathering occurrences in the Lehigh Valley have not had loss measured by financial or property damage. Pre-planned events are generally coordinated with local municipalities, response agencies and county agencies to ensure safety. Costs associated with loss due to damage or other adverse incidents during or related to the event are generally covered by the organization hosting the event. Pre-planned or non-planned events may result in road closures, which in turn may delay the provision of emergency services.

The impacts of civil disturbance/mass gathering events are contingent upon numerous factors, including issues, politics and method of response. Generally, the impact of mass gathering events is nominal and short-lived unless acts of sabotage are performed. There may be minor injuries to first responders or participants from physical confrontations, and vandalism may cause minimal damage to property, facilities, and infrastructure. Adequate law enforcement at planned mass gathering events and around likely target locations like the offices of state agencies minimizes the chances of a small assembly of individuals turning into a significant disturbance.

4.3.16 Dam Failure

Due to the sensitive nature of dam information, the Dam Failure Profile can be found in Appendix G.

4.3.17 Drug Overdose Crisis

4.3.17.1 Location and Extent

Pennsylvania is in the midst of an unprecedented epidemic of drug abuse and drug-related overdose deaths impacting every corner of the state and all of its residents. In 2016, Pennsylvania coroners and medical examiners reported 4,642 drug-related overdose deaths. The rate of drug-related overdose deaths in Pennsylvania increased from 26.7 per 100,000 people in 2015 to 36.5 per 100,000 in 2016, far exceeding the national average of 16.3 per 100,000.

In 2017, the United States Drug Enforcement Administration (US DEA) Philadelphia Division and the University of Pittsburgh prepared "Analysis of Overdose Deaths in Pennsylvania, 2016" to assist law enforcement's efforts to identify and combat drug suppliers, and ultimately drug abuse and related overdoses. The Drug Overdose Crisis hazard is new to the Lehigh Valley Hazard Mitigation Plan. The drugs included in the analysis were selected based on law enforcement intelligence regarding frequency of abuse, as well as those identified as the most common drugs present in drug-related overdose deaths by national public safety and public health sources. For the purpose of this 2018 Plan and as identified by the Planning Team, the drugs included in the hazard profile are listed in Table 4.3.17.1.

Table 4.3.17.1 Drugs Included in Hazard Profile

Drug Category	Substances Included		
Benzodiazepines	Alprazolam Chlordiazepoxide Clonazepam Delorazepam	Diazepam Estazolam Flurazepam Lorazepam	Midazolam® Oxazepam Temazepam
Cocaine			
Fentanyl/Fentanyl-Related Substances (FRS)/Non-Prescription Synthetic Opioids (NPSOs)	3-Methylfentanyl 4-Methoxy-Butyryl Fentanyl Acetyl Fentanyl Acryl Fentany	Carfentanil Fentanyl Fluorobutyrfentanyl Fluorofentanyl	Furanyl Fentanyl Para-Fluoro-Isobutyryl Fentanyl/FIBF Sufentanil U-47700
Heroin			
Other Illicit Drugs	Lysergic Acid Diethylamid (LSD) Methylenedioxy-amphetamine (MDA) 3,4-Methylenedioxymethamphetamine (MDMA)		Methamphetamine Phencyclidine (PCP)
Prescription Opioids	Hydrocodone Hydromorphone Meperidine	Morphine Oxycodone Oxymorphone	Tapentadol Tramadol

Source: DEA Philadelphia Field Division, Analysis of Overdose Deaths in Pennsylvania, 2016

In the Lehigh Valley, the annual drug overdose death rate per 100,000 people in 2016 was 31.5, with Lehigh County at 38.3 and Northampton County at 23.5.

The most commonly identified drug category in toxicology reports varied for counties across Pennsylvania in 2016. In the Lehigh Valley, the most frequently reported drug category was heroin.

Fentanyl/FRS/NPSOs emerged as the most frequently reported drug category in overdose deaths in 2016 across the Commonwealth. When analyzed separately, fentanyl was found in 61 of the 64 counties that reported an overdose death in 2016. Fentanyl was found in combination with heroin (64%), cocaine (34%), ethanol (22%), and alprazolam (21%) most frequently.

The top 10 drugs present in 2016 drug-related overdose deaths for Lehigh County and Northampton County are shown in Figure 4.3.17.1.

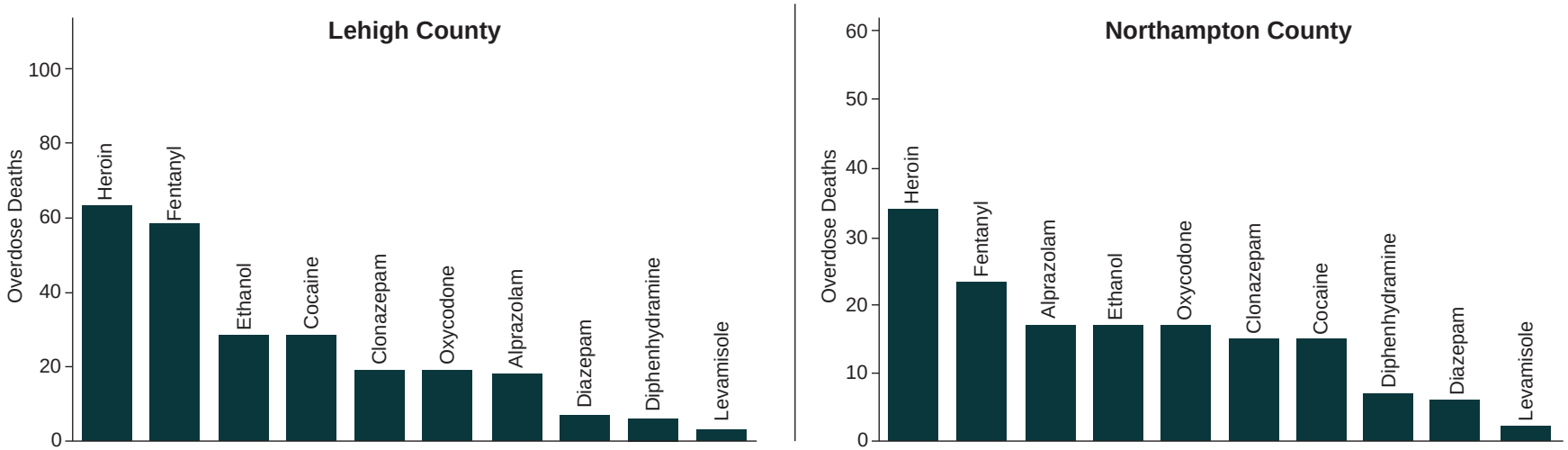
4.3.17.2 Range of Magnitude

Age

In 2016, the 25 to 34-year-old age group had the most drug-related deaths. Three ages groups combined—25 to 34, 35 to 44 and 45 to 54 year-olds—make up 40% of Pennsylvania's population but accounted for 75% of overdose deaths in 2016. Additionally, the 15 to 24-year-old age group accounted for 10% of all overdose deaths in 2016. The age distribution shows the bimodal distribution of the most common age groups that were affected by overdose deaths in Pennsylvania in 2016.

Fentanyl/FRS/NPSOs was within the top three most present drug categories of all age groups except 0 to 14-year-olds. Aside from fentanyl/FRS/NPSOs, heroin was more common in younger and middle age groups, benzodiazepines and ethanol were more common in

Figure 4.3.17.1 Drugs Present in 2016 Drug-Related Overdose Deaths



Source: Pennsylvania Coroner/Medical Examiner Data, Analysis of Overdose Deaths in Pennsylvania, 2016

middle age groups, and prescription opioids and cocaine were more common in middle age and older age groups. The presence of illicit drugs declined with age, with the peak occurring within the 15-24 age group.

Gender

In 2016, 3,237 males died of drug-related overdoses (70%), compared to 1,403 females (30%). Two deaths did not indicate gender. Since males comprise 49% of the Pennsylvania population, they account for a disproportionally high percent of the overdose deaths in 2016.

The three most prevalent drug categories in toxicology reports for males were fentanyl/FRS/NPSOs, heroin and benzodiazepines. The three most prevalent drug categories for females were fentanyl/FRS/NPSOs, benzodiazepines and heroin.

Race and Ethnicity

In 2016, 3,574 people who died of drug overdose were identified as White (77.0%), 534 were identified as Black (11.5%), 311 were identified as “Other Race” (6.7%), 195 were identified as Hispanic (4.2%) and 28 were identified as “Unknown” (0.6%). The racial breakdown for overdose deaths also coincides with the racial demographics in Pennsylvania, as Whites comprise approximately 77.9% and Blacks comprise approximately 11.6%. However, that is not the case for ethnicity, where the percentage of the Hispanic population is 50% higher than the percentage of Hispanic decedents.

4.3.17.3 Past Occurrence

Note that the data provided in this Past Occurrence section is from the Centers for Disease Control and Prevention (CDC) because it provides a more extensive list of past occurrences. The 2016 data from the CDC and the DEA report are not the same. Deaths from drug overdose are an increasing public health burden in the United States. In 2016, there were more than 63,600 drug overdose deaths (CDC, 2017). In the Lehigh Valley, there were 193 drug overdose deaths in 2016. From 1999 to 2016, the Lehigh Valley had a total of 1,519 drug-related deaths. From 1999 to 2016, the Lehigh Valley saw an increase of over 500% in drug-related deaths as shown in Table 4.3.17.2.

Figure 4.3.17.2 Drug-Related Deaths, Lehigh Valley 1999-2016

Year	Drug Deaths	Population	Drug Deaths per 100,000
1999	31	576,442	5.4
2000	47	579,156	8.1
2001	35	584,186	6.0
2002	34	590,034	5.8
2003	68	598,323	11.4
2004	67	607,512	11.0
2005	61	616,525	9.9
2006	62	626,422	9.9
2007	77	634,060	12.1
2008	87	639,839	13.6
2009	92	643,882	14.3
2010	78	647,232	12.1
2011	112	651,423	17.2
2012	104	654,512	15.9
2013	107	654,883	16.3
2014	106	658,477	16.1
2015	158	661,498	23.9
2016	193	665,441	29.0

Source: Centers for Disease Control and Prevention, National Center for Health Statistics. Underlying Cause of Death 1999-2016 on CDC WONDER Online Database, December 2017. Data from the Multiple Cause of Death Files, 1999-2016, from data provided by 57 jurisdictions through the Vital Statistics Cooperative Program. Accessed at http://wonder.cdc.gov/ucd-icd10.html on Feb 1, 2018 12:11:55 PM

In 2018, Pennsylvania Governor Wolf declared the Heroin and Opioid epidemic a statewide disaster emergency on January 10th. This first-ever public health disaster declaration is meant to enhance state response, increase access to treatment, and save lives. A command center at the Pennsylvania Emergency Management Agency (PEMA) will track progress and enhance coordination of health and public safety agencies.

4.3.17.4 Future Occurrence

One of the most important components in reducing drug-related overdose deaths is to prevent initial drug use. Therefore, the impact of education and prevention strategies in use today will be shown in future years. The DEA Philadelphia Field Division will continue efforts, in conjunction with law enforcement and public health partners, to define and address the factors impacting availability and abuse of illicit drugs and diverted pharmaceuticals in Pennsylvania, and ultimately overdose deaths.

As evidenced by the upward trajectory of drug-related overdose deaths over the past several years throughout the Lehigh Valley, Pennsylvania and United States, the drug overdose hazard is likely to continue if something is not done. A crisis exists among law enforcement, public health entities, and educators to address drug availability, drug treatment and drug education.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for drug overdose events in the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

4.3.17.5 Vulnerability Assessment

The entire population of the Lehigh Valley is vulnerable to the drug overdose crisis. The rates of drug overdose deaths are continuing to increase. According to the CDC, in 2016, Pennsylvania had one of the top four highest observed drug overdose death rates in the country. The data provided in this section supports the need to create awareness and provide education to Lehigh Valley residents regarding this hazard of concern.

4.3.18 Environmental Hazards/Explosion

4.3.18.1 Location and Extent

Hazardous materials are substances that are considered severely harmful to human health and the environment, as defined by the United States Environmental Protection Agency (EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. Many hazardous materials are commonly used substances which are harmless in their normal uses, but are dangerous if released. EPA designates more than 800 substances as hazardous and identifies many more as potentially hazardous due to their characteristics and the circumstances of their release (EPA 2013).

Hazardous material releases pose threats to the natural environment, the built environment and public safety. Hazardous materials can include toxic chemicals, infectious substances, biohazardous waste and any materials that are explosive, corrosive, flammable or radioactive. Hazardous material releases can occur along transportation routes or at fixed-site facilities wherever hazardous materials are manufactured, used, stored or transported. Hazardous material releases can result in human and wildlife injury, property damage, and contamination of air, water, and soils. According to County Emergency Management Agencies, there are 264 Superfund Amendments and Reauthorization Act (SARA) facilities in Lehigh County and 173 facilities in Northampton County.

For the purposes of this document, explosions are included under Environmental Hazards, as all reported and confirmed explosions have been the result of the loss of containment of a hazardous material, thus creating the explosion.

The federally required National Priorities Lists (NPL) is the list of sites of national priority among the known releases or threatened releases of hazardous substances, pollutants or contaminants throughout the United States and its territories. Revised annually, the NPL guides the EPA in determining which sites warrant further investigation. As of the date of this Plan, there are four NPL sites in Lehigh County and two sites in Northampton County (EPA 2018).

As part of the requirements for hazardous chemical storage reporting, facilities must submit annually an Emergency and Hazardous Chemical Inventory Form to the Local Emergency Planning Committees (LEPC), the State Emergency Response Commissions Contacts (SERC), or the Tribal Emergency Response Commissions (TERC), and the local fire department. In the Lehigh Valley, there are 120 facilities in Lehigh County and 40 facilities in Northampton County (PEMA 2013).

Transportation of hazardous materials on highways involves tanker trucks or trailers which are responsible for the greatest number of hazard material release incidents. Roads also cross rivers and streams at many points and have the potential to pollute watersheds that serve as domestic water supplies for parts of the state. The network of more than 4,100 miles of Lehigh Valley roadways linking more populated areas with rural communities facilitates the movement of hazardous materials throughout the region.

The exception is I-476, from Route 22 north to Route 209 in Carbon County, which is listed on the National Hazardous Materials Route Registry. The Registry restricts passage of hazardous materials, explosives, flammable liquids and solids, poisons, and radioactive and corrosive materials along this roadway.

Hazardous material releases are also possible along rail lines as collisions and derailments of train cars can result in large spills. No passenger rail service is available in the Lehigh Valley. However, Class 1 freight railroad companies Norfolk Southern Railway and Canadian Pacific, and six short line railroads, operate within the Lehigh Valley (LVPC 2015). Companies using these railroad lines to transport hazardous materials create a risk for a hazardous materials release. Refer to the Community Profile for freight rail lines in the Lehigh Valley.

Pipelines can also transport hazardous liquids and flammable substances such as natural gas. Incidents can occur when pipes corrode, when they are damaged during excavation, incorrectly operated or damaged by other forces. Pipelines exist in all but three counties in Pennsylvania. Pipelines transporting natural gas compose the largest percent of pipeline in the Commonwealth. Pipelines carrying highly volatile liquids make up the third-highest amount of total pipeline miles. In addition, hazardous materials can be transported by aircraft or by watercraft. Crashes, spills of materials, and fires on these vessels can pose a hazard (PA Hazard Mitigation Plan, 2013). According to the National Pipeline Mapping System (NPMS), the Lehigh Valley contains both gas transmission pipelines and hazardous liquid pipelines (NPMS 2018).

4.3.18.2 Range of Magnitude

Hazardous material releases can contaminate air, water and soils, possibly resulting in death or injuries. Dispersion can take place rapidly when transported by water and wind. While often accidental, releases can occur as a result of human carelessness, intentional acts or natural hazards. When caused by natural hazards, these incidents are known as secondary events. Such releases can affect nearby populations and contaminate critical or sensitive environmental areas.

Many products containing hazardous substances are used and stored in homes, and these products are shipped daily on highways, railroads, waterways and pipelines.

With a hazardous material release, there are several potentially exacerbating or mitigating circumstances that will affect its severity or impact. Mitigating conditions are precautionary measures taken in advance to reduce the impact of a release. Primary and secondary containment or shielding by sheltering-in-place protects people and property from the harmful effects of a hazardous material release. Exacerbating conditions, characteristics that can enhance or magnify the effects of a hazardous material release include:

- Weather conditions that affect how the hazard occurs and develops
- Micro-meteorological effects of buildings and terrain that alters dispersion of hazardous materials
- Non-compliance with building or fire codes and maintenance failures such as fire protection and containment features

The severity of the incident is dependent not only on the circumstances described above, but also with the type of

material released and the distance and related response time for emergency response teams. The areas within closest proximity to the releases are generally at greatest risk, yet depending on the agent, a release can travel great distances or remain present in the environment for centuries in the case of radioactive materials.(PEMA 2013).

Reported explosions within the Lehigh Valley are predominantly the result of a failure within local infrastructure leading to the expansion and ignition of natural gas. The age of the infrastructure within the Lehigh Valley leaves the region prone to this type of occurrence and is currently being investigated by many federal agencies in an attempt to develop more comprehensive federal guidance.

Environmental hazard incidents within the Lehigh Valley range from minor petroleum spills to large facility-based incidents that lead to the loss of life, property, environment and economy. Additionally, the range of explosion-related incidents within the region varies from a small incident that has an impact on a residential or smaller type commercial building to a catastrophic failure leading to the loss of life, large amounts of property and economy.

Environmental hazard and explosion incidents can contaminate soil and surface water, and groundwater supplies can result in many direct impacts on surrounding ecosystems. Local flora and fauna within hazard areas are also at risk. The application of salt to de-ice roads may impact groundwater and contaminate potable drinking water sources near major highway corridors and state highway routes in the Lehigh Valley.

The environmental impacts of hazardous material releases include:

- Hydrologic effects, such as surface and groundwater contamination
- Other effects on water quality such as changes in water temperature
- Damage to streams, lakes, ponds, estuaries and wetland ecosystems
- Air quality effects, such as pollutants, smoke, and dust
- Loss of quality in landscape
- Reduced soil quality
- Damage to plant communities, including loss of biodiversity and damage to vegetation
- Damage or death to animals, through the degradation of habitat, pollution of drinking water, loss of biodiversity or disease (PEMA 2013)

4.3.18.3 Past Occurrence

The Lehigh Valley's location between two major metropolitan areas provides for an increase in transportation of hazardous materials through rail, air and road. These routes of transportation combined with the large number of fixed facilities and end users of hazardous materials have provided for an incidence of frequent chemical and petroleum product releases with several being deemed as serious. The past decade brought about an increase in incidents based upon the population growth and business development.

The region has been home to significant hazardous materials releases over the previous decade, with the largest environmental hazard incident happening in Upper Macungie Township, Lehigh County, in August of 2011. The incident occurred on Interstate 78 near the Route 100 interchange. A tractor-trailer involved in a collision spilled more than 7,000 gallons of motor oil on the roadway and into the nearby soil and waterways. This incident lasted approximately 18 hours, prompting Pennsylvania Department of Transportation (PennDOT) to mill and resurface the roadway. In total, the initial response was able to collect just over 4,000 gallons of product, leaving almost 3,000 gallons for the state and environmental cleanup agencies to handle.

Additionally, in March of 2009, Wind Gap Borough in Northampton County was impacted by the spill of hydrogen fluoride following a motor vehicle accident. The incident took place on Route 33 just south of the borough. A truck carrying more than 33,000 pounds of chemical products rolled onto its side, closing the road for hours and forcing 5,000 people to evacuate.

The age of infrastructure in the region has led to an increase in reported explosions, primarily based on gas utility failures. These events range from simple building property incidents through large scale loss of life, property, economy and environment. In February 2011, the City of Allentown was impacted by a catastrophic failure of a large gas main under a row of homes in the 500 Block of North 13th Street. The explosion killed five people and destroyed six homes. The incident forced the evacuation of hundreds of residential and commercial properties, including a senior living complex on the adjoining block. Since that incident, the Lehigh Valley has been impacted by numerous failures of infrastructure causing smaller explosions with less impact.

The Lehigh Valley was also impacted in 1999 by a large commercial building explosion in Hanover Township, Lehigh County that led to the deaths of five employees and 14 injuries. The incident was caused by the failure of a containment vessel that was in the process of distilling a hazardous material. The explosion damaged numerous buildings within the industrial park and residential structures in the adjacent area. As a result of this incident, the expansion of Local Emergency Planning Committees (LEPC) was established throughout the country. In addition, Pennsylvania adopted Act 165, the Hazardous Materials Emergency Planning and Response Act. These changes in planning were implemented to enable planning, training and funding within local communities for facilities utilizing hazardous materials (US Chemical Safety and Hazard Investigation Board, 2002).

The number of environmental hazard incidents reported to PEMA are not a comprehensive listing, as the reporting requirements from the state changed in 2007, allowing state agencies to categorize the incident as something other than “Hazardous Materials.” For instance, a vehicle collision resulting in a spill of gas or motor oil may be reported as a vehicle accident instead of a hazardous materials release. Environmental hazard release incidents within the Lehigh Valley occur on a regular basis, with the majority being handled by the local responders with guidance from the PADEP. The region reported 7,086 hazardous material releases to the Pennsylvania Emergency Management Agency (PEMA) from 2001 to 2017. Table 4.3.18.1 shows the releases that occurred since the 2013 Plan.

Table 4.3.18.1 Reported Release of Hazardous Materials in the Lehigh Valley, 2012-2017

Year	Lehigh County	Northampton County
2012	497	424
2013	488	238
2014	521	245
2015	514	379
2016	545	391
2017	534	349
TOTAL	**3,099**	**2,026**

Source: Lehigh County 9-1-1 Computer Aided Dispatch; Northampton County Knowledge Center Database

The number of reportable explosion type incidents within the Lehigh Valley from 2012 to 2017 is not a comprehensive listing, as the explosive event may not be the primary incident. Rather, the incidents may be based on the events that led up to an explosion. According to the Pennsylvania Emergency Incident Reporting System and Lehigh and Northampton County Knowledge Center Databases, a total of 12 explosion incidents have been reported in Lehigh County and 10 in Northampton County. No information on injuries or damages are available.

4.3.18.4 Future Occurrence

Due to the wide scope definition of environmental hazards, ranging from a small spill to a large release of a highly volatile or toxic hazardous material, incidents can and will happen at any time. While many hazardous material release incidents have occurred in the Lehigh Valley in the past, they are generally considered difficult to predict. An occurrence is largely dependent upon the accidental or intentional actions of a person or group.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for environmental hazard/ explosion events in the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

4.3.18.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the region continues to be exposed and vulnerable to environmental hazards. However, only a qualitative analysis was conducted in 2013, whereas an exposure analysis was conducted as part of the 2018 Plan. For the 2018 Plan, buffers were applied in GIS to the location of roadways and facilities that store hazardous materials to estimate potential exposure to the general population using the 2010 US Census data.

Environmental hazards have the greatest impact on the residential population. The majority of incidents reported within the Lehigh Valley are the result of motor vehicle incidents or spills within a residential structure. To determine the potential impact on the Lehigh Valley, a quarter-mile buffer was placed around major roadways, as well as a half-mile radius around each SARA Title III facility to define the hazard area. Populations and features of the built environment within this area may be directly or indirectly affected by an environmental hazard. The hazard area was overlaid on the 2010 US Census population data. US Census blocks are not consistent with the hazard boundaries, so blocks with their centroids within the hazard area were assumed to be potentially exposed. Major roadways used for the analysis are I-476, I-78, PA-100, PA-143, PA-145, PA-191, PA-248, PA-29, PA-309, PA-329, PA-33, PA-378, PA-412, PA-512, PA-611, PA-863, PA-873, PA-946, and PA-987.

Based on the analysis, the estimated Lehigh Valley population within a quarter-mile of a major roadway is 193,462. The population within a half-mile of a SARA facility is 305,374. A complete listing of the population vulnerable to environmental hazards by municipality is located in Appendix F.

There are approximately 63 miles (roundtrip) of Interstate 78 east to west across the Lehigh Valley from the Delaware River at the Pennsylvania—New Jersey border in Williams Township to the Berks County border at Weisenberg Township. This road is a major route from New York City to Harrisburg, PA. It is a vulnerable corridor for hazardous waste accidents as many materials, including high-level radioactive waste are transported.

Other potential sources of hazardous materials include four natural gas transmission lines that cross the Lehigh Valley. Three pipelines cross through Northampton County from Bushkill Township to Lower Mt. Bethel Township, from Upper Mt. Bethel Township to the southern point of Lower Saucon Township, and from Williams Township into Lower Saucon Township. The other pipeline crosses the southern portion of Lower Milford Township in Lehigh County. Breaks in the pipelines could result in hazardous material releases as well as explosions and utility interruptions. Municipalities most vulnerable to pipeline accidents include the townships of Bethlehem, Bushkill, Forks, Lower Milford, Lower Mt. Bethel, Lower Saucon, Palmer, Plainfield, Upper Mt. Bethel, Upper Saucon, Washington, and Williams, and Tatamy Borough (US Energy Information Administration, 2012). Other pipeline facilities are being proposed for the Lehigh Valley.

While buildings and critical facilities may be present within the hazard area, estimating direct damage to these structures and facilities would be difficult. However, damages to the surrounding environment can result in indirect impacts, such as temporary loss of function due to hazard response or damage in the area.

Economic losses from environmental hazards and explosion incidents range from non-recordable to those exceeding millions of dollars. Impacts on the local economy from a single incident are almost impossible to measure because of complexities of predicting losses of work, revenue and future business.

4.3.19 Fire (Urban/Structural)

4.3.19.1 Location and Extent

Urban fires occur in denser, more populated areas statewide and most often occur in residential structures (US Fire Administration, 2009). They can more easily spread from building to building in these denser areas. Urban fires often begin as a result of other hazards, particularly storms, lightning strikes, drought, transportation accidents, hazardous materials releases, criminal activity (arson) and terrorism (PEMA 2013). Furthermore, they are a more significant threat in areas where a high number of buildings are more than 50 years old. Older residential structures that were built with lower standards for building construction and materials have created a threat of fire loss that is occurring on a regular basis. According to the US Census Bureau's 2012-2016 American Community Survey 5-Year Estimates, about 54% of residential buildings in the Lehigh Valley are over 50 years old, with one in four residences built before 1940.

4.3.19.2 Range of Magnitude

Urban/structural fire damage ranges from minor smoke or water damage to the destruction of residential, commercial or public properties. People can be displaced for months or years, depending on the magnitude of the event. Fires can also cause injuries and death (PEMA 2013).

The severity of structural fires varies due to the losses associated with the incident. The impact to the local economy is minimal with the loss of a residential structure, but the loss of a manufacturing facility that employs a large number of people can be extensive. Likewise, the impact to the local environment from a single residential fire is minimal, while the impact from an industrial or commercial fire can take years to measure. Finally, the loss of life can have a deep impact on a community. The loss of life during a residential fire is more likely than that of an industrial or commercial building fire. The building composition combined with the hour of the incident increase the risk for loss of life during a house fire.

The structural fires within the Lehigh Valley are usually small and generally affect residential structures. These fires are limited in duration and are generally contained within the local jurisdiction. While the average fire is small in nature, the threat from a large or even catastrophic fire is always present. Many operations within larger industrial and commercial sites within the Lehigh Valley are prone to small fires that if improperly contained can lead to catastrophic fire losses. Combined with the presence of materials that are volatile in nature, these threats are ever changing and increasing within the region.

There may be environmental impacts related to hazardous materials when a fire event releases dangerous materials (PEMA 2013).

4.3.19.3 Past Occurrence

Since 2001, more than 1,700 structural fires in the Lehigh Valley have been reported to PEMA as shown in Table 4.3.19.1. Please note that due to archiving processes and reporting requirements prior to 2007, databases are not complete and do not accurately represent the total number of fires reported. However, using these sources represents the most accurate probability estimates possible.

The Lehigh Valley has seen some notable fires from 2001-2017. In March of 2008, the City of Bethlehem, Northampton County reported a fire loss in a row of joined homes. The fire claimed the life of four children, injured one child and injured four emergency workers. It was the greatest single loss of life from a non-explosion related fire in the past decade.

In addition, Plainfield Township, Northampton County experienced a catastrophic fire within an industrial site. The site provided a scrap recycling service that provided the plastics industry with plastic, glass and metal separation and grinding services. In March of 2011, a fire was reported within the structure, which led to a five-county fire response that continued for more than 36 hours. Once extinguished, the building and all products on-site were deemed a loss, with a total cost in excess of $9 million.

4.3.19.4 Future Occurrence

Many factors contribute to the cause of urban and structural fires. According to the NFPA 2009 report *A Few Facts at the Household Level*, based on historical data collected, an average household is expected to experience a fire within a structure every 15 years, based on an average lifespan of the building to be 78 years. While most of these fires will be considered small and may not cause any significant damage, the possibility of a catastrophic loss due to fire is present. Due to the various factors, urban areas in Pennsylvania are considered at risk to one degree or another. Minor urban fires can be expected every day in Pennsylvania. Major fires will continue to occur several times a year, particularly in dense, urban areas with aging building stock.

Table 4.3.19.1 Reported Structural Fires in the Lehigh Valley, 2001 to 2017

Year	Lehigh County	Northampton County
2001	9	4
2002	5	2
2003	2	0
2004	2	0
2005	15	2
2006	16	7
2007	19	91
2008	10	73
2009	195	90
2010	194	135
2011	189	82
2012*	14	N/A
2013	16	82
2014	27	140
2015	21	96
2016	26	81
2017	21	62
TOTAL	**781**	**947**

Source: Lehigh and Northampton County Knowledge Center Databases 2017; *2012 data not available for Northampton County

The quantity of older residential structures within the Lehigh Valley, especially in the cities and boroughs, equates to a greater probability of loss in the future. In addition, the influx of commercial and industrial sites within the Lehigh Valley also increases the possibility of future commercial and/or industrial fires.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for urban/structural fire events in the Lehigh Valley is considered 'likely' as defined in Section 4.4.1.

4.3.19.5 Vulnerability Assessment

Structural fires most frequently affect the residential communities within the Lehigh Valley. While the impact of most structure fires is considered minimal due to the availability of support services following a fire, these fires need to be classified as a high threat due to the frequency and potential for injury and loss of life.

Within the Lehigh Valley, as the population density increases, there is a greater probability of structural fires. The increased population combined with the dense building saturation increases the threat from structural fires, increasing the likelihood of a larger loss. In the Lehigh Valley, denser jurisdictions include Alburtis, Allentown, Bangor, Bath, Bethlehem, Catasauqua, Coplay, Easton, Emmaus, Freemansburg, Fountain Hill, Hellertown, Macungie, Nazareth, Northampton, North Catasauqua, West Easton and Wilson. The continued growth within the Lehigh Valley, both commercial and residential, will continue to impact the threat of structural fires in the future.

The potential for structural fire is not limited to any one area of the Lehigh Valley, but structures most at risk include the aging building stock constructed prior to established building codes. Vulnerability may increase over time as the building stock continues to age and population growth continues. However, existing structures becoming compliant with code and increasing fire service capabilities will help to reduce losses and overall risk.

Economic consequences related to urban fires include lost wages due to temporarily or permanently closed businesses, destruction and damage involving business and personal assets, loss of tax base, recovery costs and lost investments in destroyed property (PEMA 2013).

The secondary effects of urban/structural fire events relate to the ability of public, private and non-profit entities to provide post-incident relief. Human services agencies can be affected by fire events as well. Effects may consist of physical damage to facilities and equipment, disruption of emergency communications, loss of health and medical facilities and supplies and an overwhelming load of victims who are suffering from the effects of the urban fire, including loss of their home or place of business (PEMA 2013).

4.3.20 Levee Failure

Due to the sensitive nature of levee information, the Levee Failure Profile can be found in Appendix G.

4.3.21 Nuclear Incident

4.3.21.1 Location and Extent

Nuclear hazards and incidents generally refer to incidents involving a release of significant levels of radioactive materials or the exposure of workers or the general public to radiation. Primary concerns following a nuclear incident or accident are the impact on public health from direct exposure to a radioactive plume, inhalation of radioactive materials, ingestion of contaminated food, water or milk. Long-term exposure to deposited radioactive materials in the environment can also lead to radiation sickness or death, or chronic health effects such as cancer.

The Nuclear Regulatory Commission (NRC) encourages the use of Probabilistic Risk Assessments (PRA) to estimate the potential risk to public health and safety considering the design, operations and maintenance practices at nuclear power plants. PRAs typically focus on accidents that can severely damage the radioactive core and that may challenge containment. Federal Emergency Management Agency (FEMA), Pennsylvania Emergency Management Agency (PEMA), and county governments have formulated Radiological Emergency Response Plans to prepare for radiological emergencies at the five nuclear power-generating facilities in Pennsylvania. These plans include a Plume Exposure Pathway Emergency Planning Zone (EPZ) that extends 10 miles from each nuclear power facility, and an Ingestion Exposure Pathway EPZ that extends 50 miles from each facility.

The Limerick Generation Station and the Susquehanna Steam Electric Station are both located outside the Lehigh Valley, but maintain a 50-mile ingestion exposure pathway zone that includes parts of the region. Limerick is south of the Lehigh Valley in central Montgomery County, and Susquehanna is northeast of the region in Luzerne County. Limerick maintains two Mark 2 reactors producing 2,345 megawatts of electricity while Susquehanna maintains two Boiling Water direct cycle reactors producing 2,600 megawatts of electricity.

Within the Lehigh Valley, Lehigh County maintains the classification of Support County for both facilities. This classification's responsibilities include planning, training and facility support. Lehigh County maintains a nuclear planning annex to their Emergency Operations Plan (EOP), train regularly, and complete exercise programs set forth by state and federal entities. Lehigh County, in support of Limerick, maintains two reception centers designed to provide residential population monitoring and decontamination. In addition, the state-designated regional trauma center—Lehigh Valley Health Network Cedar Crest Campus—provides medical decontamination for the general public and emergency workers. These medical services require additional annual training and exercise programs.

4.3.21.2 Range of Magnitude

The magnitude of a nuclear incident differs for those within the Plume Exposure Pathway and those within the Ingestion Exposure Pathway. The Plume Exposure Pathway refers to whole-body external exposure to gamma radiation from a radioactive plume and from deposited materials and inhalation exposure from the

passing radioactive plume. The duration of primary exposures could range in length from hours to days. The Ingestion Exposure Pathway refers to exposure primarily from ingestion of water or foods such as milk and fresh vegetables that have been contaminated with radiation.

Nuclear accidents themselves are classified into three categories:

- **Criticality Accidents** - Involves loss of control of nuclear assemblies or power reactors.
- **Loss-of-coolant Accidents** - Occurs whenever a reactor coolant system experiences a break or opening large enough so that the coolant inventory in the system cannot be maintained by the normally operating system.
- **Loss-of-containment Accidents** - Involves the release of radioactivity from materials such as tritium, fission products, plutonium, and natural, depleted or enriched uranium. Points of release have been containment vessels at fixed facilities or damaged packages during transportation accidents (PA Hazard Mitigation Plan 2013).

All facilities are required to notify jurisdictional agencies of an incident or occurrence within the facility. PEMA, in coordination with the facility owners, has established notification levels that are based upon an internal trigger:

- **Unusual Event** – An event has occurred that indicates potential degradation in the level of safety of the plant. No release of radioactive material requiring offsite response or monitoring is expected unless further degradation occurs.
- **Alert** - If an alert is declared, an event has occurred that involves an actual or potential substantial degradation in the level of safety of the plant. Any releases of radioactive material from the plant are expected to be limited to a small fraction of the Environmental Protection Agency (EPA) Protective Action Guides (PAGs).
- **Site Area Emergency** - A site area emergency involves an event that has occurred, resulting in actual or likely major failures of plant functions needed for protection of the public. Any releases of radioactive material are not expected to exceed the EPA PAGs except near the site boundary.
- **General Emergency** - A general emergency involves actual or imminent substantial radioactive core damage or melting of reactor fuel with the potential for loss of containment integrity. Radioactive releases during a general emergency can reasonably be expected to exceed the EPA PAGs for more than the immediate site area (USNRC 2012).

After a nuclear incident, the primary concern is the effect on the health of people near the incident. The duration of primary exposure could range in length from hours to months depending on the proximity to radioactive release. External radiation and inhalation and ingestion of radioactive isotopes can cause acute health effects, cancers and psychological effects.

The southern and northern regions of the Lehigh Valley are closest in proximity to Limerick and Susquehanna, respectively, but fall well outside the prescribed 10-mile evacuation zone for either facility. In the event of an incident within either of the locations, the Lehigh Valley could become a temporary staging location for the hundreds of thousands of residents needing to evacuate

the 10-mile emergency planning zone. Additionally, jurisdictions found within the 50-mile ingestion exposure pathway could receive radioactive particles on crops, water and ground surfaces, rendering local agricultural harvest unusable for consumption by people or livestock.

If the total agricultural yield for the region was contaminated, losses would exceed $134 million. Public water supplies and private water supply wells are vulnerable to the effects of a nuclear incident. Areas underlain by limestone and some types of glacial sediments are particularly susceptible to contamination.

4.3.21.3 Past Occurrence

While no fixed facility nuclear emergencies have occurred in the Lehigh Valley, Pennsylvania is home to the only recorded nuclear emergency in the US. In 1979, the Three Mile Island Nuclear Generating Station declared a General Emergency following an internal system failure. The repercussions from this event were swift, with sweeping changes of the NRC oversight to include FEMA for outside support. The growing nuclear power industry immediately reversed course with the number of facilities decreasing over the next decade. In addition, public confidence in the nuclear industry was greatly impacted. While reports show conflicting information on the medical impact on the residential population following the disaster, cleanup costs exceeded $1billion.

4.3.21.4 Future Occurrence

Nuclear power has become significantly safer and is one of the most heavily regulated industries in the nation since the Three Mile Island incident. Despite the knowledge gained since then, there is still the potential for a similar accident to occur at one of the five nuclear generating facilities in the Commonwealth. The Nuclear Energy Agency of the Organization for Economic Co-Operation and Development notes that studies estimate the chance of compromise or failure of protective barriers in a modern nuclear facility at less than one in 100,000 per year (PEMA 2013). Nuclear incident occurrences may also occur as a result of intentional actions. These acts are addressed in the Terrorism profile.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for a nuclear incident in the Lehigh Valley is considered 'unlikely' as defined in Section 4.4.1.

4.3.21.5 Vulnerability Assessment

In the event of a nuclear plant accident, there are procedures in place for the 10-mile Plume Exposure Pathway EPZ and the 50-mile Ingestion Exposure Pathway EPZ. For the Plume Exposure zone, actions include sheltering, evacuation and the use of potassium iodide where appropriate. For the Ingestion Exposure Pathway zone, actions include a ban of contaminated food and water (US Nuclear Regulatory Commission 2014).

The effects from a radiological incident at a fixed facility will vary based on the type of radiation being released, the quantity released, the current weather conditions and the time of day. The priority following an incident within Pennsylvania is safety of all individuals within the area impacted. The duration of primary exposure could range in length from hours to months, depending on the proximity to the radioactive release. External radiation and inhalation and ingestion of radioactive isotopes can cause death, acute health effects, cancers and psychological effects.

Secondary to health and safety will be the impact on critical infrastructure, environment, property and the economy.

Most Lehigh Valley jurisdictions are identified as vulnerable to the nuclear incident hazard due to their proximity to the Limerick Generating Station and the Susquehanna Steam Electric Station. These jurisdictions will continue to be vulnerable as long these facilities operate. Jurisdictions that fall within the 10-mile EPZ and 50-mile ingestion zones have the greatest vulnerability to an incident within the facility. All of Lehigh County and all but Portland Borough and Upper Mt. Bethel Township in Northampton County are located within the 50-mile ingestion zone of the Limerick Generating Station.

The following Lehigh County jurisdictions are located in the Susquehanna Steam Electric Station 50-mile ingestion zone:

- Alburtis Borough
- City of Allentown
- City of Bethlehem
- Catasauqua Borough
- Coplay Borough
- Hanover Township
- Heidelberg Township
- Lowhill Township
- Lower Macungie Township
- Lynn Township
- Macungie Borough
- North Whitehall Township
- Salisbury Township
- Slatington Township
- South Whitehall Township
- Upper Macungie Township
- Washington Township
- Weisenberg Township
- Whitehall Township

The following Northampton County jurisdictions are located in the Susquehanna Steam Electric Station 50-mile ingestion zone:

- Allen Township
- Bath Borough
- Bethlehem City
- Bushkill Township
- Chapman Borough
- East Allen Township
- Hanover Township
- Lehigh Township
- Lower Nazareth Township
- Moore Township
- Northampton Borough
- North Catasauqua Borough
- Nazareth Borough
- Pen Argyl Borough
- Plainfield Township
- Upper Nazareth Township
- Walnutport Borough
- Wind Gap Borough

In the Lehigh Valley, if an incident were to occur at the Limerick Station, Emmaus High School and Southern Lehigh High School are identified reception centers. Additionally, evacuation routes away from the Limerick Generating Station go through Lehigh County (Montgomery County 2009). The Lehigh Valley may experience an influx in population due to residents evacuating areas closer to the nuclear facilities.

Lehigh and Northampton counties maintain a radiological emergency response plan in accordance with the regulations set forth by the NRC and PEMA. The plan addresses actions that are to be taken to mitigate and respond to a possible radiological release. In support of the radiological response plan, Lehigh County participates in a variety of exercises designed to validate the planning found within the county documents. These exercises run once every five years for all counties within the 50-mile ingestion zone.

In addition to these exercise programs, Lehigh County participates annually in the Medical Service Agreement (MS-1) radiological decontamination training program. The MS-1 program provides classroom and practical training to emergency medical services in areas of decontamination and patient handling. Additionally, the MS-1 designated hospitals receive two training sessions focusing on proper patient management and levels of care. At the completion of these training programs each year, the staff at both the hospital and EMS agency is provided with the opportunity to validate plans, policies and training levels through a full-scale exercise program. The exercise is federally evaluated once every seven years, with the remaining six years being evaluated by PEMA.

Several differences exist between the nuclear incident risk assessment in the 2013 Plan and the 2018 Plan. For the 2018 Plan, building footprints for both counties were available and used, along with updated tax assessor and the RS Means 2018 building valuations data, to estimate the replacement cost value for the general building stock in the Lehigh Valley. Additionally, an updated critical facility inventory was generated using the 2013 inventory and updated spatial layers provided by the Lehigh and Northampton County GIS Departments and LVPC. Within the Lehigh Valley, the critical infrastructure inventory is located in Appendix E. The 2018 updated risk assessment provides a more accurate exposure estimate for the nuclear incident hazard. Within the Lehigh Valley, the total number of structures within the Limerick Generation Station 50-mile Ingestion Zone is 319,855. Critical facilities account for 7,768 of those structures. The total structures within the Susquehanna Steam Electric Station 50-mile Ingestion Zone is 175,433, with 3,518 being critical facilities. A complete listing of vulnerable structures by municipality is located in Appendix F.

4.3.22 Structural Collapse

4.3.22.1 Location and Extent

Collapse of a building or structure refers to the loss of the load-carrying capacity of a component of the structure or the entire structure itself. Structural collapse can range from the failure of a single load-bearing element, weakening the structure, to the failure of all load-bearing elements, bringing about a complete collapse.

Based upon building age, construction type, maintenance and modification, structural collapses could happen anywhere within the limits of the Lehigh Valley. In addition, incidents of structural collapse may be reported as a cascading event following the identification of another incident. For example, a water main break under a residence may cause the failure of any of its load bearing elements.

4.3.22.2 Range of Magnitude

Following any type of collapse, partial or complete, the development of additional cascading effects must be anticipated. Building construction utilizes load bearing and non-load bearing voids to house transmission lines for gases, liquids and other products based upon the use of the structure. The failure of any of these elements can create the release of an unwanted material into the environment either from utilities such natural gas, water or electricity or used in the building's construction, such as sheetrock dust or asbestos.

In winter storm events, critical facility buildings are vulnerable to widespread utility disruptions, including loss of heat and electricity, as well as building collapse or damage from downed trees. Structural vulnerability frequently depends on the age of the structure in question and its roof pitch. The older the structure, especially the roof, the less snow load it can handle. Similarly, roofs with a more gradual pitch are less able to have snow and ice slide off of them, increasing the weight of snow and ice sitting on top and thus the potential for damage (PEMA 2013).

4.3.22.3 Past Occurrence

Historical records for the Lehigh Valley, submitted annually to the state, note two incidents of structural collapse, not generated as a cascading impact from a separate incident, over the past two decades. In 2006, while constructing a new apartment building in Upper Macungie Township, Lehigh County construction crews reported a catastrophic failure of the structure. No injuries resulted from this incident. In 2007, a ceiling within a commercial building in Bangor Borough, Northampton County failed, temporarily trapping four individuals.

In addition to stand-alone incidents, some notable structural failures based upon other incidents have caused significant damage within the Lehigh Valley. Lehigh County has been home to notable structural collapses suspected of being generated from incidents such as water main breaks or sinkholes. The most notable of these incidents happened in 1994 in the City of Allentown. A commercial structure valued at more than $9 million was impacted by a large sinkhole, which caused the failure of systems

within the structure. Following unsuccessful mitigation attempts, the structure was imploded to minimize any additional damage to surrounding structures.

Similar to Lehigh County, Northampton County has also been impacted by structural collapses based upon cascading events. In 2008, a large sinkhole at an apartment complex in Hanover Township forced the evacuation of more than 40 residents. The incident caused the failure of load bearing walls within the structures, ultimately leading to the demolition of the two buildings. In addition, the City of Easton evacuated an apartment complex in 2004 following the development of a large sinkhole. The structure sustained partial failure of load bearing elements forcing the relocation of 25 residents. Additional information on land subsidence (sinkhole) frequency can be found in the Subsidence/Sinkhole profile.

Since the 2013 Plan, 22 incidences involving either partial or complete collapse have occurred in the Lehigh Valley as provided by the Lehigh and Northampton County Knowledge Center databases. No information is available on damages or injuries.

4.3.22.4 Future Occurrence

Structural collapse within the Lehigh Valley is generally considered as a cascading event following another incident. The regional geography, geology and age of infrastructure leave it prone to incidents such as land subsidence, which based upon location can lead to a partial to total structural collapse.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for structural collapse events in the Lehigh Valley is considered 'possible' as defined in Section 4.4.1.

4.3.22.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the structural collapse hazard. All infrastructure, commercial and industrial businesses, and residential structures within the Lehigh Valley are vulnerable to loss due to structural collapse whether due to a cascading event or a catastrophic structural failure. This vulnerability is compounded due to the ground composition, which is prone to subsidence throughout much of the region.

Following the initial events of a structural collapse, residents and businesses may be displaced. Depending on the type of structural collapse, it could cause disruption to the local economy, housing and healthcare access.

With any type of collapse, additional impacts should be anticipated. Structures can house transmission lines for gases, liquids and other products such as sheetrock dust and asbestos, which could be released into the environment during a failure.

4.3.23 Terrorism

4.3.23.1 Location and Extent

Terrorism may include armed attacks, the use of weapons of mass destruction such as chemical, biological, radiological, nuclear and high-yield explosive weapons, and industrial sabotage such as cyber-terrorism, and other means. There may be significant variation even within these general categories, especially in the areas of chemical and biological weapons.

In recent years, cyber-terrorism has become a larger threat. These acts can range from taking control of a host website to using networked resources to directly cause destruction and harm. Protection of databases and infrastructure appear to be the main goals at this point in time. Cyber-terrorists can be difficult to identify because the internet provides a meeting place for individuals from various parts of the world. Individuals or groups planning a cyber-attack are not organized in a traditional manner, as they are able to effectively communicate over long distances without delay. Any vulnerability that could allow access to sensitive data or processes should be addressed and any possible measures taken to harden those resources to attack (PEMA 2013).

Terrorism could occur at any location at any time of day in the Lehigh Valley, depending on the terrorist's or terrorist group's agenda. Any facility is vulnerable, as terrorists have historically sent chemical or biological agents through the mail. High-risk targets include local, county, state or federal government facilities, major venues and gathering places, sites with historic, cultural or other significance, and key infrastructure. Damage to or disruption of operations at government facilities could have a profound impact on the Lehigh Valley's population, even if the terrorism event is relatively small-scale.

4.3.23.2 Range of Magnitude

Terrorism events can cause public fear regarding the use of mass transportation or leaving their homes in the event of a biological or nuclear attack. Communication systems, both public and private, can fail because of an overwhelming amount of usage or damage to its infrastructure. Healthcare facilities can become quickly inundated and must be prepared to triage injured patients, handle mass casualties and conduct decontamination operations. The secondary hazards resulting from a terrorist attack depend on the size and scope of the incident. Some possible secondary hazards include widespread utility failure, health effects such as epidemics or pandemics, flooding if a dam is destroyed, and environmental contamination.

In the Lehigh Valley, terrorist attacks could vary from a mere threat to an individual facility to the use of a high-yield explosive or other device in a major urban area. The former is far more common in the Lehigh Valley, with bomb threats being the most prevalent form of terrorism (see Past Occurrence section).

The impacts of terrorism can vary in severity from nominal to catastrophic and are contingent upon the method of the attack, the amount of force applied and the population density of the attack site. There may be significant loss of life for people and animals, as well as economic losses. Significant damage to ecosystems can

occur with contamination associated with certain terror attacks. Additionally, the impact of the attack itself may be exacerbated by the fact that human services agencies like community support programs, health and medical services, public assistance programs, and social services can experience physical damage to facilities, supplies, and equipment and disruption of emergency communications. There may also be ancillary effects of terrorism such as urban fires (PEMA 2013).

4.3.23.3 Past Occurrence

The Lehigh Valley has experienced frequent domestic terror threats. Bomb threats, especially school bomb threats, are the most common terrorist event to occur in the Lehigh Valley, with 383 bomb threats reported since 2001 as shown in Table 4.3.23.1. Suspicious devices, packages and substances are a close second, with 284 instances since 2001.

Table 4.3.23.1 Terrorist Events in the Lehigh Valley, 2001-2017

Year	Bomb/ Explosives	Bomb/ Terroristic Threat	Suspicious Activity	Suspicious Device/ Package/ Substance	Threatening/ Barricaded Subject; Hostage Situation	Cyber-Attack
2001	NR	29	NR	73	2	NR
2002	1	14	2	6	2	NR
2003	NR	8	1	9	1	NR
2004	1	8	NR	4	1	NR
2005	NR	16	NR	2	NR	NR
2006	1	23	2	11	1	NR
2007	NR	27	3	5	3	NR
2008	NR	26	2	9	NR	NR
2009	NR	11	2	4	3	NR
2010	9	11	2	8	NR	NR
2011	9	6	2	44	5	NR
2012*	4	7	1	3	NR	NR
2013	10	30	NR	43	6	NR
2014	3	30	6	25	9	NR
2015	4	52	6	14	2	NR
2016	1	46	11	14	8	NR
2017	5	39	2	10	6	1
Total	**48**	**383**	**42**	**284**	**49**	**1**

Source: Lehigh and Northampton County Knowledge Center Databases (*2012 data not available for Northampton County)
NR = None reported

4.3.23.4 Future Occurrence

The Lehigh Valley does not contain any sites with national symbolism, such as the Statue of Liberty, therefore the likelihood of a national-level terrorist attack is unlikely. The Lehigh Valley can expect more than 20 bomb threats alone each year. Terrorist events in the Lehigh Valley will continue to occur frequently at local schools and government facilities.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for terrorism events in the Lehigh Valley is considered 'unlikely' as defined in Section 4.4.1.

4.3.23.5 Vulnerability Assessment

In the Lehigh Valley, there are numerous facilities that could be considered potential targets for local terrorist activity. These facilities, as well as any of the critical infrastructure, are potentially vulnerable to terrorist attacks. The degree to which they are vulnerable is assessed at the facility level by facility owners and local law enforcement. Overall, the Lehigh Valley's vulnerability to terrorism has not changed since the 2013 Plan.

Since the probability of terrorism occurring cannot be quantified in the same way as that of many natural hazards, it is not possible to assess vulnerability in terms of likelihood of occurrence. Instead, vulnerability is assessed in terms of specific assets. By identifying potentially at-risk terrorist targets in a community, planning efforts can be put in place to reduce the risk of attack. All communities in the Lehigh Valley are vulnerable on some level, directly or indirectly, to a terrorist attack. Site-specific assessments should be based on the relative importance of a particular site to the surrounding community or population.

Acts of terrorism can lead to forced or spontaneous evacuations of residents, depending on the severity of the incident. If there were a threat of an attack, people living near potential targets could be advised to evacuate or they could choose on their own to evacuate to an area not considered a likely target (FEMA 2011). Certain areas may experience an increase in population as people move out of the impacted area and into an area of refuge. This could lead to a strain on resources such as shelters reaching capacity, higher volume of patients at hospitals and clinics, and an increase in demand for water, food and lodging.

Measuring the economic impact of a terrorist attack on the Lehigh Valley is difficult. The initial impact can be measured in immediate costs, such as costs related to response to the event and those associated with immediate loss of productivity that results from closed

businesses. The full economic impact includes long-term costs such as terrorism mitigation activities. Additionally, a terrorist attack in a neighboring county or elsewhere in the state could lead to indirect economic impacts in the Lehigh Valley.

To reduce their vulnerability to terrorist activities, Lehigh and Northampton counties belong to the Northeast PA Emergency Response Group, a group of eight counties that collaborate to prevent, prepare for and respond to terrorism and other hazards on a regional level. This group, like the other regional task forces in Pennsylvania, is funded by PEMA using the US Department of Homeland Security's State Homeland Security Program. The counties use this funding to conduct emergency planning, training and exercise activities, and to purchase equipment to reduce the region's vulnerability to terrorism.

Additionally, the counties may use funding received by the respective counties' Local Emergency Planning Committees (LEPCs) to decrease their vulnerability to chemical hazards, which may be used by terrorists to conduct attacks. The Lehigh Valley is serviced by the Lehigh County Special Operations Team, with the exception of the City of Allentown, which provides hazardous materials response through the City Fire Department. The City of Bethlehem Fire Department also provides hazardous materials response in Bethlehem (PEIRS, 2012; PEMA 2013).

4.3.24 Transportation Crash

4.3.24.1 Location and Extent

A transportation hazard may be defined as a condition created by movement of anything by common carrier. Transportation hazards can be divided into two categories: hazards created by the material being transported, and hazards created by the transportation medium. Additionally, weather events such as winter weather and heavy rainfall can create hazardous driving conditions. Extreme temperatures can also pose a risk to vehicles and transportation systems. Cold weather can impact automotive engines, possibly stranding motorists and stressing metal bridge structures. Highways and railroad tracks can become distorted in high heat. Disruptions to the transportation network and crashes due to extreme temperatures represent an additional risk to the Lehigh Valley.

Transportation systems available in the Lehigh Valley include roadways, rail lines, airports, sidewalks, and bike and pedestrian pathways. However, non-motorized crashes are not discussed in this Plan. All county systems and supporting transportation resources provide services locally, regionally and nationally. Vehicular, aviation and railway crashes are defined below:

- **Vehicular Crashes:** A vehicular crash is a road traffic incident that usually involves one vehicle colliding with another vehicle or other road user, such as an animal, stationary roadside object or cyclist/ pedestrian. A vehicular crash may result in injury, property damage or death. Contributing factors include equipment failure, poor road conditions, weather, traffic volume and driver behavior.
- **Railway Crashes:** Railway crashes can involve a train derailment or one train impacting another train, vehicle, pedestrian or cyclist.
- **Aviation Crashes:** According to the International Civil Aviation Organization, an aviation crash occurs during operation of an aircraft from when a person boards the aircraft for a flight until they disembark the aircraft. Three different situations qualify as an aviation crash: (1) a person is fatally or seriously injured; (2) the aircraft sustains damage or structural failure; or (3) the aircraft is missing or inaccessible. An aviation incident is an occurrence, other than a crash, associated with operation of an aircraft that affects or could affect the safety of operation. Airport crashes and incidents have the potential to occur while the plane is over Lehigh Valley airspace or on airport property.

Transportation crashes described herein include incidents involving road, air and rail travel. Effects of the release of hazardous materials due to any of these crashes are described in the Environmental Hazards/Explosion profile.

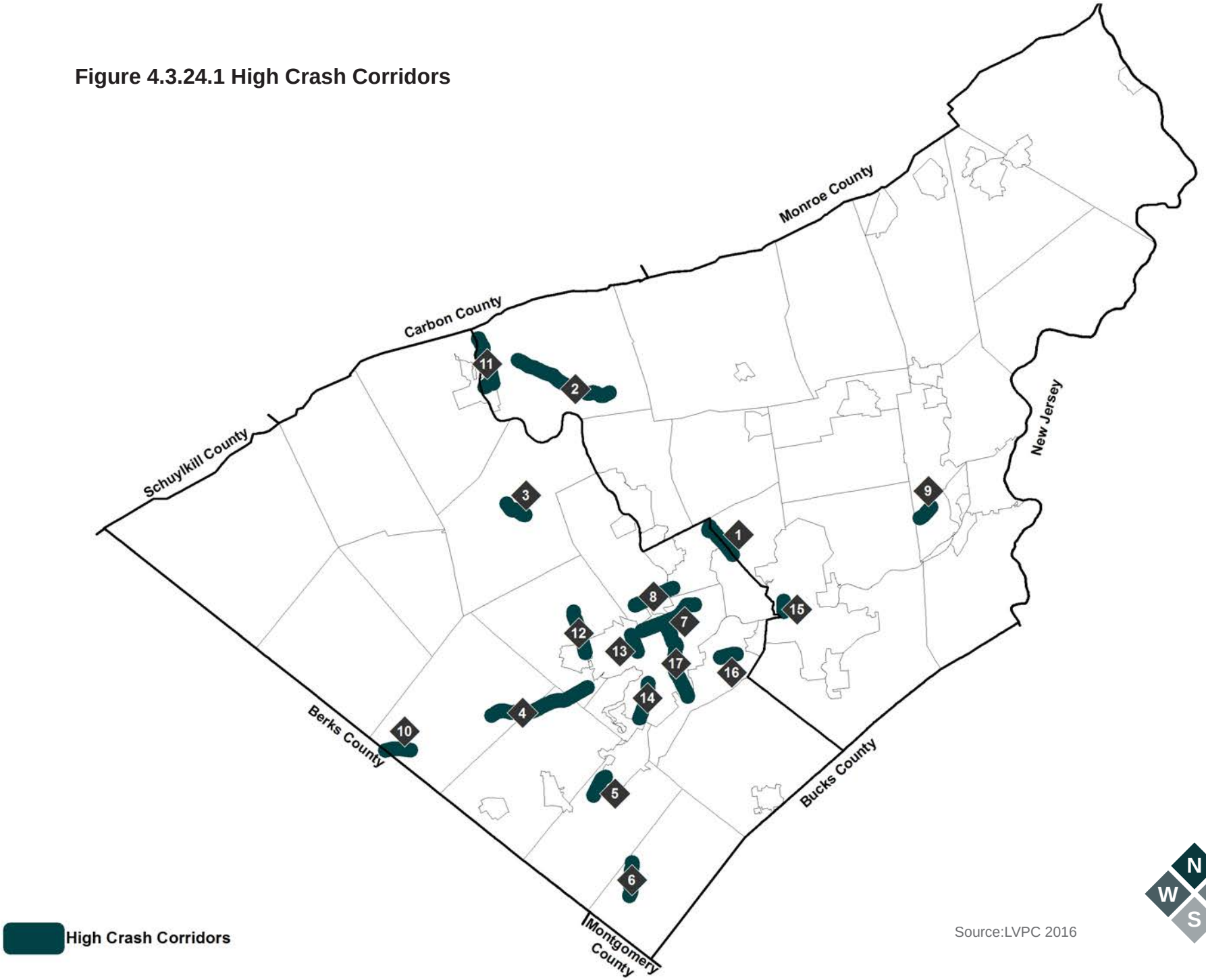
The Lehigh Valley has 4,141 miles of roadways. Transportation crashes can occur at any point along these roadways, with many occurring at the intersection of two or more roadways. The LVPC released the most recent Traffic Safety Plan in 2016, which identifies high crash corridors and intersections in the region. High crash corridors are listed in Table 4.3.24.1 and shown in Figure 4.3.24.1. High crash intersections are identified in Table 4.3.24.2.

Table 4.3.24.1 High Crash Corridors

Map ID	Road Name	From	To	Municipality	On TIP*
1	Schoenersville Rd.	Weaversville Rd.	Hanover Ave.	Hanover (LC) and (NC)	No
2	Route 248	W. Mountain View Dr.	Walnut Dr.	Lehigh	Yes
3	Route 329	Mauch Chunk Rd.	Bellview Rd.	North Whitehall	No
4	Route 222	Dorney Park	Prior to Rt. 100 Interchange	South Whitehall, Lower Macungie, Upper Macungie	No
5	Route 29, Chestnut St.	PA Turnpike	Mill Rd.	Upper Milford Township	No
6	Kings Highway	Zionsville Rd.	Palm Rd.	Lower Milford Township	No
7	Tilghman St.	Poplar St.	Airport Rd.	Allentown	No
8	Route 22	MacArthur Rd.	Lehigh River Bridge	Whitehall Township, Hanover Township (LC)	Yes
9	William Penn Highway	Stones Crossing Rd.	S. Greenwood Ave.	Palmer Township	No
10	Rt. 222 & Schantz Rd.	Schantz Rd.	Independent Rd.	Upper Macungie Township	Yes
11	Route 145	Riverview Dr.	Main St.	Lehigh Township, Walnutoprt	No
12	Cedar Crest Blvd.	Alright Ave.	Tilghman St.	South Whitehall Township, Allentown	No
13	15th St.	Tilghman St.	Hamilton Blvd.	Allentown	No
14	Lehigh St.	Jefferson St.	Oxford Dr.	Allentown	No
15	Center St.	W. Broad St.	Church St.	Bethlehem (NC)	No
16	East Susquehanna St.	Seidersville Rd.	Fretz Ave.	Salisbury Township	No
17	4th St. Corridor	Normand St.	Gordon St.	Allentown	No

Source: LVPC Traffic Safety Plan 2016
* The Transportation Improvement Program (TIP) 2017-2020 is the four-year high priority list of highway, bridge, public transit and multi-modal projects to be implemented with federal funds.

Figure 4.3.24.1 High Crash Corridors



Source:LVPC 2016

Table 4.3.24.2 High Crash Intersections

Location	Municipality
Freemansburg Ave. - Coolidge St. - Willow Park Rd.	Bethlehem Township
I-78 at Morgan Hill Road Interchange	Williams Township
Main Street and W. Union Blvd.	Bethlehem
Nazareth Park - Hanoverville Rd. - Hecktown Rd. - Schlegel Ave.	Lower Nazareth Township
Park Ave. and Oakwood Lane	Washington Township (LC), North Whitehall Township
Riverview Dr. and Birch Rd.	Lehigh Township, North Whitehall Township
Rose Inn Ave. and Robin Drive	Bushkill Township
Route 22 and Nazareth Pike Interchange	Bethlehem Township
Route 873 - Mountain Road	Lehigh Township
South 4th St. and West Federal St.	Allentown

Source: LVPC Traffic Safety Plan 2016

In addition, in response to the collapse of the I-35W Bridge in Minneapolis in August 2007, PennDOT assessed the structural integrity of all bridges in the Commonwealth. The total number of bridges in the Lehigh Valley, as well as the number of those that are structurally-deficient (in parentheses) are identified in Table 4.3.24.3. Each structurally-deficient bridge poses a risk for transportation crashes.

No passenger rail service is available in the Lehigh Valley. However, two Class 1 freight railroads Canadian Pacific and Norfolk Southern Railway, and six short line railroads operate within the Lehigh Valley. The location of railways is shown in the Community Profile section.

Table 4.3.24.3 Bridges in the Lehigh Valley

County	On State Roads	On Local Roads
Lehigh	347 (44)	119 (37)
Northampton	309 (52)	137 (36)
Total	**656 (96)**	**256 (73)**

Source: LVPC 2015

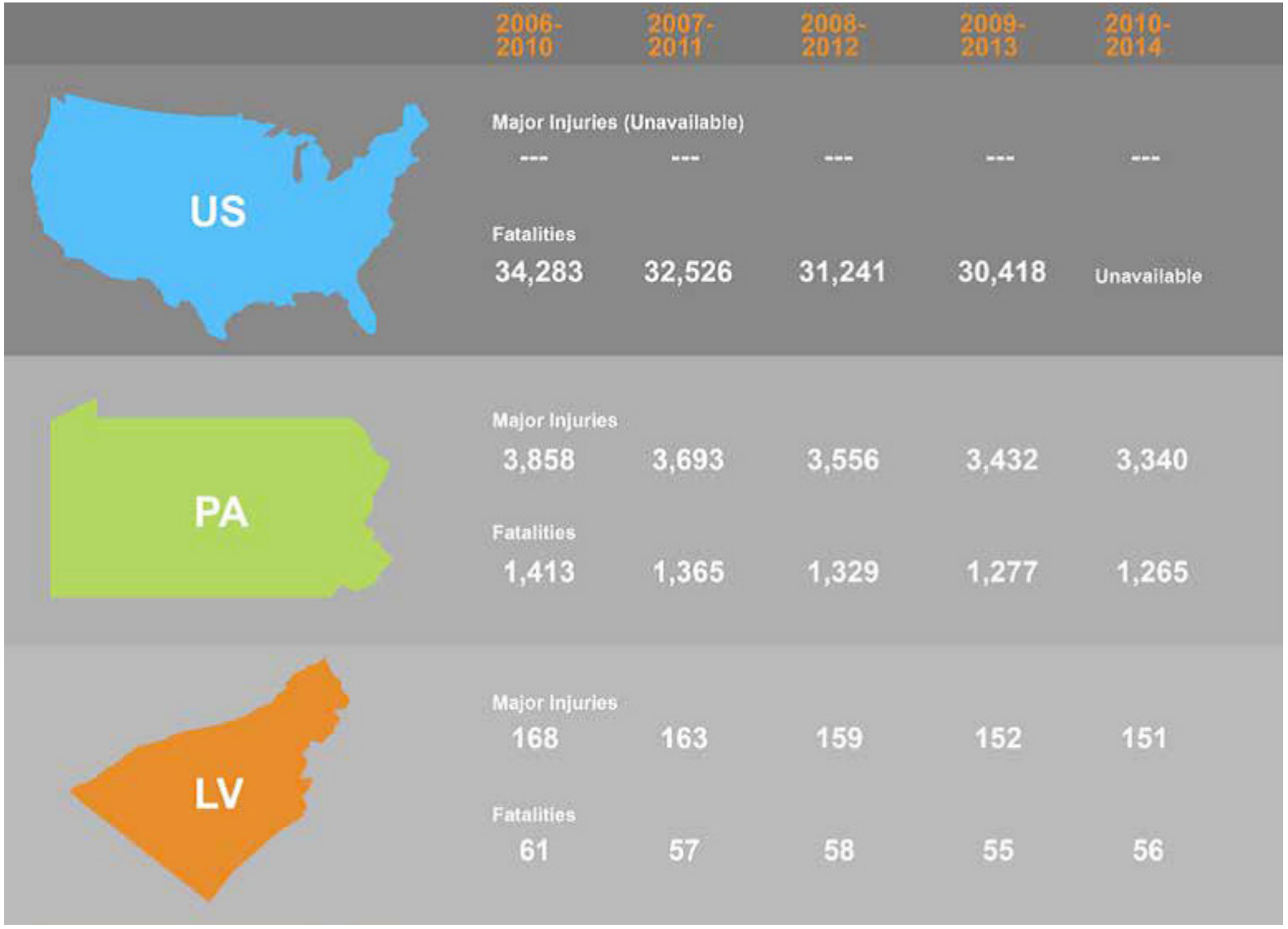
There are five airports in the Lehigh Valley. The location of airports is shown in the Community Profile section. In addition, there are large international airports in Newark, NJ, New York City and Philadelphia, PA, with associated air traffic patterns in the skies above the Lehigh Valley. Air traffic from these airports may experience problems in flight and crash in the Lehigh Valley.

4.3.24.2 Range of Magnitude

Significant passenger vehicle, air and rail transportation crashes can result in a wide range of outcomes from damage solely to property to serious injury or death. Most air incidents are non-fatal and cause minor injuries or property damage. The majority of motor vehicle crashes are non-fatal in Pennsylvania, but PennDOT estimates that every hour, ten people are injured in car crashes, and every seven hours someone dies in a car crash. Most fatal crashes occur in the months of July, August and September (PEMA 2013).

For this 2018 Plan, the 2016 Lehigh Valley Traffic Safety Plan released by the LVPC was used to determine injuries and fatalities from crashes, which are shown in Figure 4.3.24.2.

Figure 4.3.24.2 Total Vehicle Injuries and Fatalities in the Lehigh Valley



Source: LVPC Traffic Safety Plan 2016

Rail crashes can vary widely in terms of injuries, fatalities, property damage and interruption of service, depending on the nature and severity of the crash. Local residents may also be involved in rail crashes while traveling outside of the Lehigh Valley. Rail crashes fall into three categories (PEMA 2013):

- **Derailment:** A crash in which a train leaves the rails.
- **Collision:** A crash in which a train strikes an object such as another train or a vehicle.
- **Other:** A crash caused by another reason, such as a fire, explosion or rail obstruction.

Aircraft crashes can vary from a single-engine aircraft having a "hard landing" and causing damage to the aircraft, to a crash of a small turboprop or jet aircraft, to a crash of a large jet aircraft. Other aircraft crashes could include helicopter or experimental aircraft crashes. Aviation crashes also can involve radio-controlled or drone aircraft devices, many of which are experimental and not subject to defined regulatory oversight, potentially complicating issues for the public that could arise if one of these devices crashes.

The worst-case transportation crash within the Lehigh Valley would be a tractor trailer or rail car carrying an extremely hazardous substance overturning and experiencing a release of its cargo on a major roadway. Such an incident would block traffic on major transportation routes, and could threaten health and safety or people in the vicinity. In addition, a release could cause the closure of critical facilities.

Similar to the range of magnitude, the environmental impacts associated with transportation crashes can vary greatly. In the case of a simple motor vehicle crash, train derailment or aviation crash, the environmental impact is minimal. However, if the crash involves any type of vehicle moving chemicals or other hazardous materials, the impact will be considerably larger and may include an explosion or the release of potentially hazardous material (PEMA 2013). For a complete discussion of the environmental impacts of hazardous materials releases, refer to the Environmental Hazards/Explosion profile.

4.3.24.3 Past Occurrence

Vehicular transportation crashes are a daily occurrence across Pennsylvania and in the Lehigh Valley. According to the Lehigh and Northampton County Knowledge Center databases, from 2012 to 2017, the Lehigh Valley had 2,137 vehicular crashes. Total crashes of all types reported was 2,398 as shown in Table 4.3.24.4. No information on injuries or casualties was reported. While this reflects the crashes that are reported to the counties and Commonwealth, there are significantly more minor crashes that are not reported.

Table 4.3.24.4 Summary of Major Incidents by Type, 2012-2017

Year	Vehicle Crashes	Bus Crashes	Railroad Incidents	Aircraft Incidents
2012*	33	9	0	0
2013	298	63	9	6
2014	365	69	3	5
2015	489	22	4	5
2016	507	26	4	3
2017	445	19	4	10
Totals	**2,137**	**208**	**24**	**29**

Source: Lehigh and Northampton County Knowledge Center Databases 2012-2017
* 2012 data not available for Northampton County

4.3.24.4 Future Occurrence

Assuming that transportation crashes are as likely to occur in the future as they have occurred in the past and based on the available data, the Lehigh Valley can expect the following each year:

- Approximately 178 vehicle crashes (the actual number of vehicle crashes in the Lehigh Valley may be much higher, however, this figure is based on vehicle crashes captured in Lehigh and Northampton County Knowledge Center databases)
- Approximately 25 bus crashes
- 3 aircraft incidents
- 3 railroad incidents

Though historical data show two to three railroad incidents each year, the Pennsylvania Department of Transportation's (PennDOT) Pennsylvania Intercity Passenger and Freight Rail Plan (February 2010) identifies strategic improvements to Pennsylvania's rail system, and includes major rail initiatives in the Lehigh Valley. In terms of passenger rail, the PennDOT plan identifies a possible rail corridor from Harrisburg to New York City through Reading, Allentown, Bethlehem and Easton. However, the corridor in the Lehigh Valley does not currently contain the population densities necessary to support passenger rail. For rail freight, the Lehigh Valley is part of Norfolk Southern's Central Corridor, with an intermodal terminal in Bethlehem. Increased rail traffic volume may result in an increase in the number of rail crashes.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for a transportation crash in the Lehigh Valley is considered 'highly likely' as defined in Section 4.4.1.

Section 4.3.24.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the transportation crash hazard. However, increased development may lead to increased road traffic and increased exposure to this hazard in the Lehigh Valley.

Loss of roadway use and public transportation services would affect thousands of commuters, employment, day-to-day operations within the Lehigh Valley, and delivery of critical municipal and emergency services. Disruption of one or more of the modes of transportation can lead to congestion of another and affect the region as a whole.

Transportation hazards could lead to potential losses in human health and life, property and natural resources. Vehicular crashes, flooded roadways and other roadway impairments may result in injury or death. The number of people exposed depends on population density, time of day and proportions of the population located indoors and outdoors.

Vehicular crashes are not the only transportation incidents that can impact human health and life, property and natural resources. Rail and aviation crashes can also impact those living in the vicinity of the crash.

All critical infrastructure in the Lehigh Valley is vulnerable to transportation crashes. This vulnerability can come from a vehicle striking the facility, or through operators being injured or delayed in performing their duties due to congested or closed roadways. Critical transportation infrastructure such as bridges and highways may be the only property damaged by a crash. In addition, transportation crashes that result in the release of hazardous materials (as discussed in the Environmental Hazards/Explosion profile) may cause health effects or death, depending on the material released.

4.3.25 Utility Interruption

4.3.25.1 Location and Extent

Utility interruption includes any impairment of the functioning of telecommunication, gas, electric, water or waste networks. These interruptions or outages occur because of geomagnetic storms, fuel or resources shortage, electromagnetic pulses, information technology failures, transmission facility or linear utility accident, and major energy, power or utility failure. The focus of utility interruptions as a hazard lies in fuel, energy or utility failure. This hazard is often secondary to other hazard events, particularly transportation crashes, lightning strikes, extreme heat or cold events and winter storms (PEMA 2013).

Interruptions in basic utilities can have a detrimental impact on the Lehigh Valley. Utilities that employ above-ground wiring, such as power or phone lines, are vulnerable to the effects of other hazards such as high wind, heavy rain, heavy snow, ice and vehicular crashes. Utility interruptions occur throughout the Lehigh Valley, but are usually of small scale and short duration. Interruptions are possible anywhere there is utility service. Some utility facilities are especially vulnerable such as potable water facilities, wastewater treatment plants and substations located within the 1% annual chance floodplain.

4.3.25.2 Range of Magnitude

The most severe utility interruptions are regional power outages that can affect lighting, heating, air conditioning, communications, ventilation systems, fire and security systems, household appliances, office equipment and medical equipment. However, this is most often a short-term nuisance rather than a catastrophic hazard. In addition, the severity of a utility interruption can be compounded with extreme weather events, especially winter weather (PEMA 2013).

Interruptions can also be more severe for special needs populations that are dependent on electronic medical equipment. Utility interruptions can significantly hamper first responders in their efforts to provide aid in a disaster situation, especially with the loss of telecommunications and wireless capabilities (PEMA 2013).

In a possible worst-case scenario, a winter storm event causes widespread power outages, leaving citizens without heat in the midst of subzero temperatures. The power outage also means that elderly populations or others at risk of health problems due to the lack of heat are unable to call for assistance or leave their homes. Power lines are unable to be repaired because of the magnitude of the storm, and the power outage lasts for several days (PEMA 2013).

The most significant impact associated with utility interruptions is when the interruption involves a release of hazardous materials. Releases could occur from a pipeline accident or when material is in transit. Utility pipelines carrying flammable materials also have the possibility of exploding or starting a fire (PEMA 2013). For a discussion on the impacts of a hazardous materials release, see the Environmental Hazards/Explosion profile.

4.3.25.3 Past Occurrence

The Lehigh Valley experiences minor power outages multiple times a year. No injuries or deaths related to utility interruptions have been reported in the Lehigh Valley, and the total number of people historically affected by these outages is unknown.

The Lehigh Valley suffered its worst utility interruption in October 2011, when an early snowstorm dropped between six and ten inches of wet snow on trees that still had leaves on them, causing historic numbers of tree limbs and wires down, resulting in massive power outages. PPL and FirstEnergy, the two largest electric utility companies in the Lehigh Valley, reported over 109,000 customers without power for up to a week. Regional shelters and warming stations were opened throughout the Lehigh Valley to care for people without power.

Utility interruptions that have occurred from 2001 to 2017 are shown in table 4.3.25.1.

4.3.25.4 Future Occurrence

Utility interruptions will continue to occur annually with minimal impact. Widespread utility interruption events usually occur approximately once every five years, usually

Table 4.3.25.1 Utility Interruptions From 2001-2017

Year	911 Issue	Gas	Phone	Power	Sewer	Water	Wires Down	Total
2001	0	22	2	0	NR	0	NR	24
2002	2	24	0	2	NR	0	NR	28
2003	0	22	0	2	NR	0	NR	24
2004	0	24	0	1	2	0	NR	27
2005	1	23	1	0	NR	1	NR	26
2006	2	22	1	7	NR	1	NR	33
2007	3	32	2	28	1	14	NR	80
2008	1	26	3	18	3	14	NR	65
2009	3	11	4	26	NR	12	16	72
2010	1	5	4	58	2	30	20	120
2011	31	7	1	50	NR	23	6	118
2012*	NR	3	2	4	NR	NR	1	10
2013	1	4	9	24	NR	29	3	70
2014	NR	11	9	28	NR	27	7	82
2015	NR	4	12	67	NR	14	18	115
2016	NR	4	20	108	NR	17	21	170
2017	1	3	14	110	1	14	42	185
Total	**46**	**247**	**84**	**533**	**9**	**196**	**134**	**1,249**

Source: Lehigh and Northampton County Knowledge Center Databases
*2012 data not available for Northampton County
NR: None reported

as a secondary effect of an extreme weather event. These interruptions should be anticipated and first responders should be prepared during severe weather events (PEMA 2013).

Based on historic utility outages in the Lehigh Valley, short power failures of a few hours may occur several times a year for any given area, while major outages for longer periods happen once every few years. Power failures are often occurrences after minor vehicle accidents or severe weather and should be expected during those events.

Based on the Lehigh and Northampton County Emergency Management Agencies' operational viewpoint, the probability of occurrence for utility interruptions in the Lehigh Valley is considered 'likely' as defined in Section 4.4.1.

4.3.25.5 Vulnerability Assessment

Overall, the Lehigh Valley's vulnerability has not changed since the 2013 Plan, and the entire region continues to be exposed and vulnerable to the utility interruption hazard. Loss of power can have serious impacts on the health and welfare of residents. Utility interruptions most severely affect individuals with access and functional needs, such as children, the elderly and people with special medical needs. Certain medical equipment will not function without power. Likewise, a loss of air conditioning during periods of extreme heat or the loss of heat during extreme cold can be especially detrimental to those with medical needs, children and the elderly. A lack of clean, potable water has health implications for everyone, and a lack of water supply may also impact the sewer system and the availability of sewer service.

Long-term power outages may force residents to leave their homes if they do not have comfort measures or clean drinking water. For incidents outside of the Lehigh Valley, the planning area may experience an influx in people coming in to the Lehigh Valley for food and shelter. If long-term power outages occur within the Lehigh Valley, heating or cooling shelters will need to be provided for residents as well as drinking water and ice.

All buildings and facilities considered to be critical infrastructure are vulnerable to utility interruptions, especially the loss of power. Some key indicators of increased vulnerability to utility interruption include the presence of ground- or basement-level utilities, reliance on electronic banking or facilities located in isolated or wooded areas where a downed tree might cause a utility interruption. The establishment of reliable backup power at critical facilities is extremely important to continue to provide for the health, safety and well-being of the Lehigh Valley's population.

Utility interruptions could affect the ability of the government to function, especially if backup power is inadequate or unavailable, which could have cascading economic impacts. Increased costs such as those related to providing shelters, and cooling and heating centers may be incurred as a result of a utility outage. Extended power outages will require officials to shelter victims who require heat and power for activities of daily living. Power interruptions can cause economic impacts stemming from lost income and spoiled food and other goods, costs to the owners or operators of the utility facilities, and costs to government and community service groups. FEMA's benefit-cost analysis methodology measures loss of electrical service on a person-per-day-of-lost-service basis for the service area affected. For the electrical utility, the standard value is $131 per person per day (FEMA 2014).

4.4 HAZARD VULNERABILITY SUMMARY

4.4.1 Methodology

A comprehensive range of natural and non-natural hazards that pose significant risk to the Lehigh Valley were selected and considered in this 2018 Plan. However, it is recognized that the communities in the Lehigh Valley have differing levels of exposure and vulnerability to each of these hazards. It is important for each community participating in this Plan to recognize those hazards that pose the greatest risk to their community and direct their attention and resources accordingly to most effectively and efficiently manage risk.

To this end, a relative hazard risk ranking process was conducted for the Lehigh Valley using the Risk Factor (RF) methodology identified in the Pennsylvania All-Hazard Mitigation Planning Standard Operating Guide (October 2013). The guidance states:

> The Risk Factor approach produces numerical values that allow identified hazards to be ranked against one another. The higher the Risk Factor value, the greater the hazard risk. Risk Factor values are obtained by assigning varying degrees of risk to five categories for each hazard: probability, impact, spatial extent, warning time and duration.
>
> To calculate the Risk Factor value for a given hazard, the assigned risk value for each category is multiplied by the weighting factor. The sum of all five categories equals the final Risk Factor value:
>
> **Risk Factor Value = [(Probability x .30) + (Impact x .30) + (Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]**
>
> Hazards identified as high risk have Risk Factors greater than or equal to 2.5, with moderate risk hazards ranging from 2.0 to 2.4 and low risk hazards below 2.0.

The State Guide identifies five risk assessment categories, the criteria and associated risk level indices used to quantify their risk, and the weighting factor applied to each risk assessment category as shown in Table 4.4.1.1.

In determining the hazard Risk Factors for Lehigh and Northampton counties, the objectives were to assess the main risk areas and their likely impact on the counties, including its people, natural areas, buildings and infrastructure. Each of the hazard risks was analyzed using the established criteria for the likelihood and consequences for the overall Risk Factor rating. In analyzing the relationships of the hazards and the elements of risk anticipated, the Lehigh Valley Risk Factors, as developed by the counties, best reflect the activity incurred since 2013 and the last Hazard Mitigation Plan update. By looking at this from an operational viewpoint, the plan is adaptable to both the anticipated and unexpected hazards in the region's communities, in essence, personalizing the Plan for the Lehigh Valley.

Table 4.4.1.1 Summary of Risk Factor (RF) Criteria

Risk Assessment Category	Degree of Risk			Weight Value
	Level	Criteria	Index	
Probability: What is the likelihood of a hazard event occuring in a given year?	Unlikely	Less than 1% annual probability	**1**	**30%**
	Possible	Between 1% and 49.9% annual probability	**2**	
	Likely	Between 50% and 90% annual probability	**3**	
	Highly Likely	Greater than 90% annual probability	**4**	
Impact: In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?	Minor	Very few injuries, if any. Only minor property damage and minimal disruption on quality of life. Temporary shutdown of critical facilities	**1**	**30%**
	Limited	Minor injuries. More than 10% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than one day.	**2**	
	Critical	Multiple deaths/injuries possible. More than 25% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for more than a week.	**3**	
	Catastrophic	High number of deaths/injuries possible. More than 50% of property in affected area damaged or destroyed. Complete shutdown of critical facilities for 30 days or more.	**4**	
Spatial Extent: How large of an area could be impacted by a hazard event? Are impacts localized or regional?	Negligible	Less than 1% of area affected	**1**	**20%**
	Small	Between 1% and 10.9% of area affected	**2**	
	Moderate	Between 11% and 25% of area affected	**3**	
	Large	Greater than 25% of area affected	**4**	
Warning Time: Is there usually some lead time associated with the hazard event? Have warning measures been implemented?	More than 24 hours	Self-Defined	**1**	**10%**
	12 to 24 hours	Self-Defined	**2**	
	6 to 12 hours	Self-Defined	**3**	
	Less than 6 hours	Self-Defined	**4**	
Duration: How long does the hazard event usually last?	Less than 6 hours	Self-Defined	**1**	**10%**
	Less than 24 hours	Self-Defined	**2**	
	Less than 1 week	Self-Defined	**3**	
	More than 1 week	Self-Defined	**4**	

Note: Levels of warning time and criteria that define them may be adjusted based on hazard addressed.

Note: Levels of warning time and criteria that define them may be adjusted based on hazard addressed.

4.4.2 Ranking Results

Table 4.4.2.1 identifies the regionwide Risk Factor for each of the 25 hazards profiled in the 2018 Plan. Based on the analysis, there are nine high risk hazards, 12 moderate risk hazards and four low risk hazards.

A hazard risk assessment result for the entire Lehigh Valley does not mean that each municipality is at the same amount of risk for each hazard. Based on municipal input, an evaluation of the regionwide Risk Factors was completed for each municipality to determine whether their risk is greater than (>), less than (<) or equal to (=) the Risk Factor assigned to the Lehigh Valley as a whole for each hazard. Municipalities that indicated no changes in hazard risk since the 2013 Plan were assigned the same risk factor as provided in the 2013 Plan, which was then compared to the updated risk factors developed for the Lehigh Valley. For the three new hazards profiled in the 2018 Plan, municipalities were assumed to have the same risk as the Lehigh Valley since no risk rankings were available in the 2013 Plan. A comparative risk ranking for the new hazards profiled in the 2018 Plan can be completed for the municipalities with future plan updates. The municipal risk rankings are shown in Table 4.4.2.2.

Table 4.4.2.1 Lehigh Valley Hazard Risk Rankings

		RISK ASSESSMENT CATEGORY					
Hazard Risk	**Natural Hazards**	**Probability**	**Impact**	**Spatial Extent**	**Warning Time**	**Duration**	**Risk Factor (RF)**
HIGH	Extreme Temperature	3	3	3	1	3	2.8
	Flood	4	2	2	3	3	2.8
	Winter Storm	3	2	4	2	2	2.7
	Windstorm/Tornado	2	3	3	3	2	2.6
	Invasive Species	4	1	3	1	4	2.6
	Drought	2	2	4	1	4	2.5
MODERATE	Pandemic and Infectious Disease	3	2	2	1	4	2.4
	Radon Exposure	4	1	2	1	4	2.4
	Subsidence/Sinkhole	3	2	1	4	1	2.2
	Wildfire	2	2	2	3	2	2.1
	Lightning Strike	4	1	1	3	1	2.1
LOW	Earthquake	1	1	4	4	1	1.9
	Hailstorm	2	1	2	3	1	1.7
	Landslide	1	1	1	4	1	1.3

		RISK ASSESSMENT CATEGORY					
Hazard Risk	**Non-Natural Hazards**	**Probability**	**Impact**	**Spatial Extent**	**Warning Time**	**Duration**	**Risk Factor (RF)**
HIGH	Environmental Hazards/ Explosion	4	2	2	4	2	2.8
	Utility Interruption	3	1	3	4	3	2.5
	Drug Overdose Crisis	4	2	1	1	4	2.5
MODERATE	Fire (Urban/Structural)	3	2	1	4	2	2.3
	Transportation Crash	4	1	1	4	1	2.2
	Structural Collapse	2	3	1	4	1	2.2
	Civil Disturbance/ Mass Gathering	4	1	1	2	2	2.1
	Dam Failure	1	3	2	4	1	2.1
	Levee Failure	1	3	2	4	1	2.1
	Terrorism	1	3	1	4	2	2.0
LOW	Nuclear Incident	1	1	2	4	1	1.5

Table 4.4.2.2 Municipal Risk Compared to Regionwide Risk Factors

Lehigh County Risk Factors	Natural Hazards														Non-Natural Hazards											
	Extreme Temperature	Flood	Winter Storm	Wind	Invasive Species	Drought	Pandemic	Radon Exposure	Subsidence/Sinkhole	Wildfire	Lightning Strike	Earthquake	Hailstorm	Landslide	Environmental Hazards	Utility Interruption	Drug Overdose Crisis	Fire (Urban/Structural)	Transportation Crash	Structural Collapse	Civil Disturbance/ Mass Gathering	Dam Failure	Levee Failure	Terrorism	Nuclear Incident
	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.2	2.1	2.1	1.9	1.7	1.3	2.8	2.5	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.0	1.5
Alburtis Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
City of Allentown	<	=	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	>	<	<
Catasauqua Borough	<	<	>	<	=	=	=	=	>	>	<	=	>	=	<	>	=	>	=	=	<	<	<	<	<
Coopersburg Borough	=	=	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Coplay Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Emmaus Borough	=	<	=	<	=	<	=	=	>	>	<	>	>	=	<	=	=	>	>	<	<	<	<	<	<
Fountain Hill Borough	<	<	>	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Hanover Township (LC)	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Heidelberg Township	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
Lower Macungie Township	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	<	=	>	>	<	<	<	<	=	<
Lower Milford Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Lowhill Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Lynn Township	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	>	<	<	<
Macungie Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	>	<	<	=	>	=	<	<	<	<	<	<
North Whitehall Township	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
Salisbury Township	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Slatington Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
South Whitehall Township	<	=	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Upper Macungie Township	<	<	=	<	=	<	=	=	>	>	<	=	>	>	<	=	=	>	>	<	<	<	<	<	<
Upper Milford Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Upper Saucon Township	<	<	>	<	=	<	=	>	>	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Washington Township (LC)	<	=	=	>	=	>	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
Weisenberg Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Whitehall Township	<	=	>	=	=	<	=	=	>	>	=	=	>	=	<	=	=	>	=	<	<	<	<	<	<

Table 4.4.2.2 Municipal Risk Compared to Regionwide Risk Factors

Northampton County Risk Factors	Natural Hazards														Non-Natural Hazards											
	Extreme Temperature	Flood	Winter Storm	Wind	Invasive Species	Drought	Pandemic	Radon Exposure	Subsidence/Sinkhole	Wildfire	Lightning Strike	Earthquake	Hailstorm	Landslide	Environmental Hazards	Utility Interruption	Drug Overdose Crisis	Fire (Urban/Structural)	Transportation Crash	Structural Collapse	Civil Disturbance/ Mass Gathering	Dam Failure	Levee Failure	Terrorism	Nuclear Incident
	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.2	2.1	2.1	1.9	1.7	1.3	2.8	2.5	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.0	1.5
Allen Township	=	=	=	<	=	<	=	=	=	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Bangor Borough	<	=	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Bath Borough	<	=	=	<	=	<	=	=	<	>	<	=	>	=	<	>	=	>	=	<	=	<	<	<	<
City of Bethlehem	<	=	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	>	<	<
Bethlehem Township	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Bushkill Township	<	=	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
Chapman Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
East Allen Township	<	<	=	<	=	<	=	<	>	<	<	>	>	=	<	<	=	<	>	<	<	<	<	>	>
East Bangor Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
City of Easton	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Forks Township	<	=	=	<	=	<	=	=	>	>	<	=	>	=	<	>	=	<	=	<	<	<	<	<	<
Freemansburg Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	<	=	>	=	<	<	<	<	<	<
Glendon Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Hanover Township (NC)	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Hellertown Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Lehigh Township	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	<	=	>	=	<	<	<	<	<	<
Lower Mt Bethel Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Lower Nazareth Township	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Lower Saucon Township	<	=	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Moore Township	<	<	=	<	=	<	=	=	<	>	<	=	>	>	<	=	=	>	=	<	<	<	<	<	<
Nazareth Borough	<	<	<	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
North Catasauqua Borough	<	<	>	=	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	=	<	<	<	<	<
Northampton Borough	<	>	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Palmer Township	<	=	=	<	=	<	=	=	>	>	>	=	>	=	<	=	=	>	>	<	<	<	<	<	<

Table 4.4.2.2 Municipal Risk Compared to Regionwide Risk Factors

Northampton County Risk Factors	Natural Hazards														Non-Natural Hazards										
	Extreme Temperature	Flood	Winter Storm	Wind	Invasive Species	Drought	Pandemic	Radon Exposure	Subsidence/Sinkhole	Wildfire	Lightning Strike	Earthquake	Hailstorm	Landslide	Environmental Hazards	Utility Interruption	Drug Overdose Crisis	Fire (Urban/Structural)	Transportation Crash	Structural Collapse	Civil Disturbance/ Mass Gathering	Dam Failure	Levee Failure	Terrorism	Nuclear Incident
	2.8	2.8	2.7	2.6	2.6	2.5	2.4	2.4	2.2	2.1	2.1	1.9	1.7	1.3	2.8	2.5	2.5	2.3	2.2	2.2	2.1	2.1	2.1	2.0	1.5
Pen Argyl Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	<	=	>	>	<	<	<	<	=	<
Plainfield Township	<	=	>	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	>	<	<	<	<	<	<
Portland Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	=	=	=	>	=	<	<	=	<	<	<
Roseto Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	>	<	<	<
Stockertown Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Tatamy Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	>	<	<	<	<	<	<
Upper Mt Bethel Township	<	<	>	<	=	<	=	=	<	>	<	=	>	=	<	>	=	>	=	<	<	>	<	<	<
Upper Nazareth Township	<	<	=	<	=	<	=	=	>	>	<	=	>	=	=	=	=	>	<	<	=	<	<	<	<
Walnutport Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Washington Township (NC)	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
West Easton Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Williams Township	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Wilson Borough	<	<	=	<	=	<	=	=	>	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<
Wind Gap Borough	<	<	=	<	=	<	=	=	<	>	<	=	>	=	<	=	=	>	=	<	<	<	<	<	<

4.4.3 Potential Loss Estimates

The risk assessment process used for the 2018 Plan is consistent with the process and steps presented in FEMA 386-2, State and Local Mitigation Planning How-to-Guide, Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA, 2001). This process identifies and profiles the hazards of concern and assesses the vulnerability of assets, such as population, structures, critical facilities and the economy at risk in the community.

To address the requirements of DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, the Lehigh Valley used standardized tools, combined with local, state and federal data and expertise to conduct the risk assessment. A summary of potential loss estimates is included in the hazard profiles for earthquake, flood, landslide, subsidence/sinkhole, windstorm/tornado, winter storm and wildfire, with more detailed information in Appendix F.

Hazards US – Multi-Hazard (HAZUS-MH) Overview

HAZUS-MH is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations that have been developed by hazard and information technology experts to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

HAZUS-MH produces detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. HAZUS-MH uses default HAZUS-MH provided data for inventory, vulnerability and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements and economic impact) depending on the hazard and available local data. The guidance "Using HAZUS-MH for Risk Assessment: How-to Guide" (FEMA 433) was relied upon to support the application of HAZUS-MH for this risk assessment and plan (FEMA 2015). More information on HAZUS-MH is available at https://www.fema.gov/hazus.

In general, probabilistic analyses were performed to develop estimates of long-term average losses for the earthquake and wind hazards, as well as an expected/estimated distribution of losses for the earthquake, flood and wind hazards. The probabilistic hazard analysis generates estimates of damage and loss for specified return periods. For annualized losses, HAZUS-MH 4.0 calculates the maximum potential annual dollar loss resulting from various return periods averaged on a "per year" basis. It is the summation of all HAZUS-supplied return periods (e.g., 10, 50, 100, 200, 500) multiplied by the return period probability, as a weighted calculation. In summary, the estimated cost of a hazard is calculated each year.

Risk Assessment Changes from the 2013 Plan

General Building Stock and Critical Facilities

- Updated general building stock used:
  - Building footprints were not available for Northampton County for the 2013 Plan, but were used for this update.

- RS Means 2018 building valuations were used to estimate replacement cost value for each building in the inventory.

- Updated critical facility inventory used:
  - LVPC and Lehigh County and Northampton County GIS Departments provided updated spatial layers for facility types used in the 2013 Plan.
  - Locally-defined facility inventory for Lehigh County was expanded to encompass more critical facilities than were used in the 2013 Plan.

Hazard-Specific Changes

- Earthquake
  - An updated version of FEMA's HAZUS-MH earthquake module (version 4.0) was used to estimate potential losses. The latest version of HAZUS-MH has a longer historical record to pull from when generating probabilistic events; thus different probabilistic earthquake scenarios were developed by the model for the Lehigh Valley for this Plan and the updated potential loss estimates are reported.
- Flood
  - The FEMA effective DFIRM spatial data is now available for Northampton County (2014); whereas, the preliminary DFIRM was used in the 2013 Plan. There is also a new FEMA Risk MAP product for the Schuylkill Watershed (9/30/2017) that encompasses a portion of Lynn Township in Lehigh County. Both new data sets were used for the vulnerability assessment update.
  - An updated version of FEMA's HAZUS-MH flood module (version 4.0) and updated 1% annual chance flood event depth grid were used to estimate potential losses for the 1% annual chance food event. Only an exposure analysis was conducted for the 0.2% annual chance flood event.
- Landslide
  - The 2011 US Geologic Survey Landslide Incidence-Susceptibility layer was used for this update to assess the landslide hazard because it provides the most detailed hazard extent.
- Subsidence/Sinkhole
  - The 2001 Pennsylvania Bureau of Topographic and Geologic Survey Geology layer was used to define the hazard area for the update; this State source is the best available data that identifies carbonate bedrock (both limestone and dolomite).
- Wildfire
  - The 2012 Wildland-Urban Interface Spatial layer from the SILVIS Lab was used as the identified hazard areas.

- Windstorms & Tornado
  - An updated version of FEMA's HAZUS-MH hurricane module (version 4.0) was used to estimate potential losses. Several changes to the HAZUS-MH model have been implemented since the 2013 Plan, including a longer historical record to pull from when generating probabilistic events. Therefore, different probabilistic hurricane wind scenarios were developed by the model for the Lehigh Valley for this Plan and the updated potential loss estimates are reported.
  - FEMA's HAZUS-MH hurricane module was run at the Census Tract Level, instead of the Census Block level as conducted in 2013, due to the latest HAZUS-MH version's file size requirements.
- Environmental Hazard
  - An exposure analysis was conducted using major roadways and SARA Title III facilities.
- Nuclear Incident
  - The hazard area defined as the 50-mile ingestion buffer zones for Limerick Generating Station and Susquehanna Steam Electric Station were utilized to assess exposure.

HAZUS-MH Analyses

Custom methodologies in HAZUS-MH 4.0 were used to assess potential exposure and losses associated with hazards of concern for the Lehigh Valley:

- Inventory: The default demographic data in HAZUS-MH 4.0, based on the 2010 US Census, was used for the HAZUS-MH analysis and hazard exposure analysis at the municipal level.

The default building inventory in HAZUS-MH 4.0 was updated and replaced at the Census-block and Census-tract level with a custom-building inventory developed for the Lehigh Valley. The custom-building inventory was developed using building footprint data and detailed structure-specific assessor data provided by the Lehigh Valley Planning Commission and Lehigh and Northampton County GIS Departments. Structural and content replacement cost values were calculated for each building utilizing available assessor data and RSMeans 2018 values; a regional location factor for Lehigh Valley was applied (1.06) for all occupancy classes.

The occupancy classes available in HAZUS-MH 4.0 were condensed into the following categories (residential, commercial, industrial, agricultural, religious, governmental and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings.

An updated critical facility inventory was developed for the Lehigh Valley using the original critical facility inventory from the 2013 Plan and updated and expanded upon using spatial data provided by the Lehigh Valley Planning Commission. This updated inventory was incorporated into HAZUS-MH replacing the default critical facility (police, fire, schools, etc.) and utility inventories.

The 'locally-defined facilities' category includes all assets that the Lehigh Valley plan participants

deemed critical to include in the inventory and that do not fit within a pre-defined HAZUS-MH facility category. These facilities include shelters, senior care facilities and municipal-owned buildings. The 'locally-defined facility' types are listed below:

Agriculture and Food	Municipal Building
Boat Ramp	Museum
Cemetary	Post Office
Commercial Parcels	Print Media
Community Organization	Prison
County Building	Public Health
Day Care	Religious
EMS	Rescue
Federal Building	Senior
Funeral Home	Shelter
Golf Course	State Building
Industrial	Storage and Preservation (Archive)
Judicial Building	Stream Gauge
Library	Veterinary
Lodging	

- Earthquake: HAZUS-MH 4.0 was used to evaluate the Lehigh Valley's risk to the seismic hazard. A probabilistic assessment was performed to analyze the earthquake hazard losses (annualized losses and 100-, 500- and 2,500-year mean return period [MRP] losses). The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract.

  As noted in the HAZUS-MH Earthquake User Manual, "Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. These factors can result in a range of uncertainty in loss estimates produced by the HAZUS Earthquake Model, possibly at best by a factor of two or more" (FEMA 2015f). However, HAZUS' potential loss estimates are acceptable for the purposes of this 2018 Plan.

  The National Earthquake Hazard Reduction Program (NEHRP) developed five soil classifications that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage

and losses. NEHRP soil classifications were not available for the Lehigh Valley at the time of this analysis. Soils were classified as NEHRP soil type D across the Lehigh Valley as a conservative approach to this risk assessment. Groundwater was set as at a depth of five-feet (default setting). Damages and loss due to liquefaction, landslide or surface fault rupture were not included in this analysis.

Default demographic and the updated general building stock and critical facility inventory data in HAZUS-MH 4.0 were used for the earthquake analysis.

- Flood: The 1% and 0.2% chance flood events were examined to evaluate the Lehigh Valley's risk and vulnerability to the riverine flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

  A Level 2 HAZUS-MH riverine flood analysis was performed for only the 1% chance flood event; the 0.2% annual chance flood event was not evaluated in HAZUS-MH for the 2018 Plan due to budgetary constraints. The Lehigh County FEMA Digital Flood Insurance Rate Maps (DFIRMs) dated July 2004 and the Northampton County effective DFIRMs dated 2014 were used to evaluate exposure and determine potential future losses. A new FEMA Risk MAP product for the Schuylkill Watershed (9/30/2017) that encompasses a portion of Lynn Township in Lehigh County was also used.

  A 3.2-foot resolution depth grid was developed for the 1% annual chance flood event for the Lehigh Valley. Using Geographic Information System (GIS) tools and the best available data including the DFIRM database for both counties and the 2008 3.2-foot Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) available from Pennsylvania Spatial Data Access – the Pennsylvania Geospatial Data Clearinghouse, a flood depth grid was generated and integrated into the HAZUS-MH riverine flood model.

  To estimate exposure to the 1% and 0.2% annual chance flood events, the DFIRM flood boundaries, updated building and critical facility inventories and 2010 US Census population data were used. The HAZUS-MH 4.0 riverine flood model was run to estimate potential losses for the Lehigh Valley for the 1% annual chance flood event. HAZUS-MH 4.0 calculated the estimated potential losses to the population (default 2010 US Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS damage functions in the flood model.

  To estimate the exposure to population, the DFIRM flood boundaries were also overlaid upon the updated building inventory. This is because Census blocks are not consistent with boundaries of the floodplain, and gross overestimate or underestimate of exposed population can occur via use of the centroid or intersect of the Census block with these zones. In an attempt to estimate population exposure more accurately, the number of structures located in the hazard areas was totaled and multiplied by the average household size for each County: Lehigh County 2.54;

Northampton County 2.53 (US Census 2010). While this assumes that all structures in the floodplain are residential and single-household, it provides a reasonable estimate of population directly exposed to the flood risk. Limitations of these analyses are recognized, and thus results are used only to provide a general estimate for planning purposes.

To estimate debris generated by the 1% annual chance flood event, HAZUS-MH v4.2, which was released on January 29, 2018, was used instead of HAZUS-MH v4.0. This is because a FEMA-known error in v4.0 was detected, and the issue appears to have been resolved with the latest software release.

- Hurricane/Wind: A HAZUS-MH 4.0 probabilistic analysis was performed to analyze the wind hazard losses for the Lehigh Valley. The probabilistic hurricane hazard activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with the Lehigh Valley. HAZUS-MH contains data on historic hurricane events and wind speeds. It also includes surface roughness and tree coverage maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. Default demographic and updated building and critical facility inventories in HAZUS-MH 4.0 were used for the analysis.

  There is currently a FEMA-acknowledged issue with importing locally-defined facilities in HAZUS-MH v4.0 and v4.2. To estimate potential losses to locally-defined facilities identified by the Lehigh Valley, they were appended to the Emergency Operation Centers input in HAZUS-MH Comprehensive Data Management System (CDMS) and uploaded to the program. Due to the size of the two-county region in HAZUS-MH 4.0, the hurricane model was run at the Census Tract level to estimate potential losses using the same scenarios.

ESRI ArcGIS Analyses

For the following hazards, ArcGIS was used to assess potential exposure for hazards of concern with delineated hazard areas in Lehigh Valley. The defined hazard areas were overlaid upon the asset data (population, building stock, critical facilities) to estimate the exposure to each hazard. The limitations of these analyses are recognized, and as such the analyses are only used to provide a general estimate:

- Environmental Hazards: The Federal Title III Superfund Amendments and Reauthorization Act (SARA), the Emergency Planning and Community Right to Know Act, and the Commonwealth of Pennsylvania set up requirements for producing, storing, and transporting hazardous materials. These hazardous materials may be released either at their storage facility location (fixed site) or in-transit. The Pennsylvania Department of Transportation State Roads layer (2011) was used to define the hazard area around major roadways. The hazard area was defined as a ¼ mile buffer

around the major roadways where hazardous materials may be in transit to estimate areas that may be directly or indirectly impacted by a release. Additionally, a 0.5 mile buffer around the SARA Title III facilities for the Lehigh Valley and EPA Superfund sites was used to estimate potential exposure.

- Landslide: The 2011 Landslide Incidence and Susceptibility geographic information system (GIS) layer from the US Geological Survey was used to coarsely define the general landslide susceptible area. According to Radbruch-Hall and others, the Landslide Incidence and Susceptibility GIS layer from National Atlas; and applies to the US Geological Survey layer as well:

  "….was prepared by evaluating formations or groups of formations shown on the geologic map of the United States (King and Beikman 1974) and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to landsliding. Thus, those map units or parts of units with more than 15 percent of their area involved in landsliding were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landsliding, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence." (Radbruch-Hall 1982).

- Nuclear Incident: Population, building stock and critical facilities within the Ingestion Exposure Pathway Zone EPZ, which is a 50-mile radius around a nuclear facility, are susceptible to a nuclear incident. The Lehigh Valley is located within the Ingestion Exposure Pathway EPZs of the Susquehanna Steam Electric Station located in Luzerne County, PA and the Limerick Generating Station in Montgomery County, PA. The 50-mile EPZs were used to define the hazard area for a nuclear incident. The defined hazard area was overlaid upon the asset data (population, building and critical facilities) to estimate exposure to the nuclear incident hazard.

- Subsidence and Sinkholes: To estimate the Lehigh Valley's vulnerability to the subsidence and sinkhole hazard, the portion of the region underlain by carbonate bedrock (limestone and dolomite) is considered exposed to natural subsidence. To determine exposure to this hazard, the asset spatial data was overlaid on the carbonate bedrock from the Pennsylvania Bureau of Topographic and Geologic Survey Geology (PBTGS) geology spatial layer. The limitations of this analysis are recognized and are only used to provide a general estimate of exposure.

- Wildfire: The wildfire urban interface, known as WUI, obtained through the SILVIS Lab, Department of Forest Ecology and Management, University of Wisconsin-Madison was used to define the wildfire hazard areas. The University of Wisconsin Madison wildland fire hazard areas are based on the 2010 Census and 2006 National Land Cover Dataset and the Protected Areas Database. For the purposes of this risk assessment, the high-, medium- and low-density interface areas were combined and used as the 'interface' hazard area and the high-, medium- and low-density intermix areas were combined and used as the 'intermix'

hazard areas. The defined hazard area was overlaid upon the asset data (population, building stock, critical facilities) to estimate the exposure to each hazard.

- Winter Storm: The entire general building stock inventory in the Lehigh Valley 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 for this hazard. A percentage of the custom building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions. Given professional knowledge and the currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

Qualitative Analyses

For many of the hazards evaluated in this risk assessment, historic data are not adequate to model future losses at this time. Where GIS data are not available, a qualitative analysis was conducted for the following hazards using the best available data and professional judgment:

- Drought
- Extreme Temperature
- Hailstorm
- Lightning Strike
- Radon Exposure
- Structural Collapse
- Dam Failure
- Drug Overdose Crisis
- Fire (Urban/Structural)
- Invasive Species
- Levee Failure
- Civil Disturbance/Mass Gathering
- Pandemic and Infectious Disease
- Terrorism
- Transportation Crash
- Utility Interruption

Limitations

For this risk assessment, the loss estimates, exposure assessments and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1. Approximations and simplifications necessary to conduct such a study
2. Incomplete or dated inventory, demographic or economic parameter data
3. The unique nature, geographic extent, and severity of each hazard
4. Mitigation measures already employed by the participating municipalities
5. The amount of advance notice residents have to prepare for a specific hazard event

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, the Lehigh Valley will collect additional data to assist in developing refined estimates of vulnerabilities to natural and non-natural hazards.

4.4.4 Future Development and Vulnerability

Changes in population, growth and development may affect the future hazard vulnerability of a community. The Lehigh Valley's population is projected to increase 25.6% from 2010-2040, which is almost on par with the growth rate for the area from 1980-2010 (30%). With the exception of Chapman Borough, all municipalities are projected to see an increase in population through 2040. With the increase in population, these municipalities face increased vulnerability to hazards.

People are a community's most important asset and certain populations are more vulnerable than others. Vulnerable populations can be more susceptible to hazard events based on a number of factors, including their physical and financial ability to react or respond during a hazard event. These populations include the elderly, disabled, those living below the poverty line, and those with limited English proficiency. Information on these populations by municipality is located in Appendix H.

Since the Lehigh Valley's rebound from the 2008 recession, the region has seen a resurgence in development, including housing dominated by new apartment buildings and warehousing due to the rapid expansion of e-commerce. The three cities have been experiencing growth through redevelopment as revitalization efforts occur. Suburban townships adjacent to the cities have also experienced a significant amount of development as have rural townships. These trends are expected to continue, resulting in increased vulnerability to people and property. Known or anticipated future development, including known hazard risks and risk zones, was identified at the municipal level and documented in the municipal annexes.

The LVPC maintains a regional comprehensive plan, which at the time of this Plan is in the process of being updated, that recommends the preservation of farmland, natural resources, parks and open space in the Lehigh Valley. It also includes recommendations related to land use, transportation, community utilities, stormwater management and housing, in an effort to improve community resiliency and sustainability. With farmland and prime land areas disappearing due to growth, more development may occur in less suitable areas that may result in increased vulnerability to hazards. The LVPC will be working with a number of municipalities in the region to develop multi-municipal comprehensive plans that can incorporate specific recommendations related to hazard mitigation planning to reduce future vulnerability.

Other conditions, such as climate change, may affect the future vulnerability of the region. Climate change in and of itself may not be a hazard, but it may change the characteristics of hazards of concern in the region. In May 2015, the Commonwealth prepared the Pennsylvania Climate Impacts Assessment Update, which reports on the potential impacts of climate change in the state. The report provides:

- Scientific predictions regarding changes in temperature and precipitation in Pennsylvania.

- Potential impact of climate change on human health, the economy and other sectors.
- Economic opportunities created by potential need for alternative sources of energy and climate related technologies.

The May 2015 report's main findings indicate it is very likely that Pennsylvania will experience increased temperatures and precipitation in the 21st century. An increase in the variability of temperature and precipitation may lead to increased frequency and severity of many of the hazards profiled in the 2018 Plan, including flooding, high winds, lightning, hailstorms and extreme temperatures. For example, an increase in extreme heat may lead to various human health impacts such as an increased formation of ground level ozone, which has been shown to be related to higher incidences of respiratory disease and death, higher concentrations of particulates, which have been shown to be related to higher incidence of respiratory and heart disease, and higher concentrations of airborne allergens, such as mold spores and pollen. Increased temperatures may correspond to an increase in water-based recreation, resulting in increased exposure to water-based disease (Climate and Energy Element, LVPC 2014).

Increases in temperature will likely lead to increased evapotranspiration and thus an increase in soil-moisture-related droughts throughout late spring and early fall. Pennsylvania's precipitation climate is projected to become more extreme in the future, with longer dry periods and greater intensity of precipitation. Most models indicate the maximum number of consecutive dry days in a year, a drought indicator, is projected to increase (Shortle et al. 2015).

Warmer climates create a more favorable habitat for Emerald Ash Borer, Hemlock Woolly Adelgid, Gypsy Moths, Asian Tiger Mosquito and the Spotted Lanternfly, expanding the area that is warm enough for these insects. Warmer temperatures will also allow the insects to remain active longer. This could have devastating impacts to certain tree species (oak, ash, and hemlock) and garden and landscape plants. The Asian Tiger Mosquito, which is known for carrying and transmitting diseases, will also see an increase in its range, thus increasing the public health risk from these mosquitos (EPA 2016; Natural Resources Defense Council 2013; Earlham College 2018; NYIS 2018; Munson et al. 2013; Extension 2011).

5. CAPABILITY ASSESSMENT

5.1 UPDATE PROCESS SUMMARY

A capability assessment evaluates the capabilities and resources that are already in place at the municipal, county, state and federal levels to reduce hazard risk and identifies where improvements can be made to increase disaster resistance in a community.

For the 2018 Plan, the 2013 Plan Capability Assessment section was reviewed and information updated as appropriate. Capabilities were categorized under four headings: Planning and Regulatory; Administrative and Technical; Financial; and Education and Outreach. The 2013 Plan did not include the Education and Outreach Capability category. For the 2018 Plan, Lehigh and Northampton counties and all 62 municipalities were surveyed to provide an updated assessment of their mitigation planning capabilities, including a self-assessment of capability for each category. Each municipality and both counties were provided a Capability Assessment Survey, with some revisions as described under each category. Descriptions of the plans and programs in place in the Lehigh Valley, and their relation to hazard mitigation, are included in the 2018 Plan. The 2018 Plan also includes a new survey not included in the 2013 Plan: Compliance with the National Flood Insurance Program. A discussion on the integration of hazard mitigation planning into local plans and programs, including the county comprehensive plan, and incorporation of existing studies, reports and technical information into the hazard mitigation plan have been added to this section.

Primary types of capabilities for reducing long-term vunerability through mitigation planning:

- **Planning and Regulatory**
- **Administrative and Technical**
- **Financial**
- **Education and Outreach**

5.2 CAPABILITY ASSESSMENT FINDINGS

5.2.1 Planning and Regulatory

While municipalities in Pennsylvania must comply with the minimum regulatory requirements established under the Pennsylvania Municipalities Planning Code (MPC)—Act 247 of 1968, as reauthorized and amended—they otherwise have considerable latitude in adopting ordinances, policies and programs that can support their ability to manage natural and non-natural hazard risk. Specifically, municipalities can manage these risks through comprehensive land use planning, zoning ordinances, subdivision and land development ordinances, hazard-specific ordinances (e.g., floodplain management, sinkholes, steep slopes), and building codes. For the 2018 Plan, the sample planning and regulatory capability survey, as provided in the Pennsylvania Standard Operating Guide, was revised to request whether the jurisdiction's response for each capability category represented a change since the 2013 Plan, if the 2013 Plan findings have been incorporated into the regulatory tool or program, and how the tool or program can be expanded or improved to reduce risk. Several municipalities identified adoption of new plans and ordinances since the 2013 Plan.

Municipal and county responses to the survey can be found in their municipal annexes. It is noted that both counties, and many of the municipalities, have identified specific mitigation initiatives in the 2018 Plan to help build and enhance mitigation-related planning and regulatory capabilities in the Lehigh Valley. The planning and regulatory capabilities of each municipality is shown in Table 5.2.1.1.

Table 5.2.1.1 Planning and Regulatory Capabilities

Lehigh County	Comprehensive Plan	Capital Improvement Plan	Economic Development Plan	Continuity of Operations Plan	Open Space Management Plan (or Parks/Rec or Greenways)	Natural Resources Protection Plan	Transportation Plan	Historic Preservation Plan	Farmland Preservation	Evacuation Plan	Disaster Recovery Plan	Emergency Operations Plan	Subdivision and Land Development Ordinance	Zoning Regulations	Building Code	Fire Code
Alburtis Borough	Yes	No	Yes	No	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No
Allentown City	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes	U/D	Yes	Yes	Yes	Yes	Yes
Bethlehem City	Yes	Yes	Yes	U/D	Yes	U/D	U/D	Yes	No	U/D	U/D	Yes	Yes	Yes	Yes	Yes
Catasauqua Borough	Yes	No	No	U/D	No	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Coopersburg Borough	Yes	U/D	No	No	No	No	No	U/D	No	U/D	No	Yes	Yes	Yes	Yes	Yes
Coplay Borough	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Emmaus Borough	Yes	No	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Fountain Hill Borough	Yes	No	No	No	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes
Hanover Township	Yes	Yes	No	No	No	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Heidelberg Township	Yes	No	No	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Lower Macungie Township	Yes	Yes	No	No	Yes	Yes	Yes	U/D	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Lower Milford Township	Yes	U/D	No	U/D	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Lowhill Township	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Lynn Township	Yes	No	No	No	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Macungie Borough	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
North Whitehall Township	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Salisbury Township	Yes	No	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Slatington Borough	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes-County	Yes	Yes	Yes
South Whitehall Township	Yes	Yes	No	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Macungie Township	Yes	No	No	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Upper Milford Township	Yes	No	No	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Upper Saucon Township	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Washington Township	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	U/D	U/D	Yes	Yes	Yes	Yes	No
Weisenberg Township	Yes	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Whitehall Township	Yes	Yes	No	U/D	Yes	U/D	No	No	U/D	Yes	U/D	Yes	Yes	Yes	Yes	Yes

U/D: Under Development

Table 5.2.1.1 Planning and Regulatory Capabilities

Northampton County	Comprehensive Plan	Capital Improvement Plan	Economic Development Plan	Continuity of Operations Plan	Open Space Management Plan (or Parks/Rec or Greenways)	Natural Resources Protection Plan	Transportation Plan	Historic Preservation Plan	Farmland Preservation	Evacuation Plan	Disaster Recovery Plan	Emergency Operations Plan	Subdivision and Land Development Ordinance	Zoning Regulations	Building Code	Fire Code
Allen Township	Yes	U/D	No	No	U/D	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Bangor Borough	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Bath Borough	Yes	Yes	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Bethlehem Township	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Bushkill Township	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Chapman Borough	Yes	No	No	Yes	No	No	No	No	No	Yes	No	Yes	Yes-County	No	Yes	No
East Allen Township	Yes	Yes	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
East Bangor Borough	Yes	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Easton City	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Forks Township	Yes	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Freemansburg Borough	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Glendon Borough	No	U/D	U/D	U/D	Yes	Yes	No	No	No	U/D	U/D	Yes	Yes-County	Yes	Yes	Yes
Hanover Township	Yes	Yes	No	U/D	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Hellertown Borough	Yes	No	No	No	Yes	No	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Lehigh Township	Yes	Yes	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Lower Mt. Bethel Township	Yes	U/D	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Lower Nazareth Township	Yes	No	No	No	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Lower Saucon Township	Yes	No	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	No
Moore Township	Yes	Yes	No	No	Yes	No	No	U/D	Yes	No	No	Yes	Yes	Yes	Yes	No
Nazareth Borough	Yes	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
North Catasauqua Borough	No	No	No	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Northampton Borough	Yes	No	No	No	U/D	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Palmer Township	Yes	No	No	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	No
Pen Argyl Borough	Yes	No	No	No	No	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes
Plainfield Township	Yes	U/D	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes

U/D: Under Development

Table 5.2.1.1 Planning and Regulatory Capabilities

Northampton County	Comprehensive Plan	Capital Improvement Plan	Economic Development Plan	Continuity of Operations Plan	Open Space Management Plan (or Parks/Rec or Greenways)	Natural Resources Protection Plan	Transportation Plan	Historic Preservation Plan	Farmland Preservation	Evacuation Plan	Disaster Recovery Plan	Emergency Operations Plan	Subdivision and Land Development Ordinance	Zoning Regulations	Building Code	Fire Code
Portland Borough	Yes	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Roseto Borough	Yes											Yes	Yes	Yes		
Stockertown Borough	Yes	No	No	No	U/D	U/D	No	No	No	U/D	U/D	Yes	Yes	Yes	Yes	Yes
Tatamy Borough	Yes	No	No	No	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	No
Upper Mt. Bethel Township	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upper Nazareth Township	Yes	No	No	No	U/D	No	U/D	No	No	Yes	No	Yes	Yes	Yes	Yes	No
Walnutport Borough	Yes	No	No	No	Yes	No		No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Washington Township	Yes	No	No	No	Yes	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	No
West Easton Borough	U/D	U/D	U/D	U/D	Yes	U/D	U/D	U/D	U/D	U/D	U/D	Yes	Yes-County	Yes	Yes	Yes
Williams Township	Yes	Yes	No	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Wilson Borough	Yes	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
Wind Gap Borough	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	No

U/D: Under Development

Comprehensive Plan

Comprehensive plans promote sound land use and regional cooperation among local governments to address planning issues. A comprehensive plan is a policy document that states objectives and guides the future growth and physical development of a municipality. With regard to hazard mitigation planning, the MPC requires comprehensive plans to include a plan for land use, which, among other provisions, suggests that the plan give consideration to floodplains and other areas of special hazards. The MPC also requires comprehensive plans to include a plan for community facilities and services, and recommends giving consideration to storm drainage and floodplain management.

Comprehensive plans promote sound land use and regional cooperation among local governments to address planning issues. A comprehensive plan is a policy document that states objectives and guides the future growth and physical development of a municipality.

Pennsylvania's MPC requires counties to prepare and maintain a county comprehensive plan and to update it every ten years. While county governments are required by law to adopt a comprehensive plan, local municipalities (or groups of municipalities) may do so at their option. In the Lehigh Valley, only the boroughs of Glendon, North Catasauqua and West Easton have not adopted their own plans. However, West Easton indicated a comprehensive plan is under development. As is the case in the Lehigh Valley, counties may opt to have the comprehensive planning done on a multi-county, regional basis. Planning on the regional level allows for the coordination and cooperation of 62 municipalities, which translates to shared objectives and actions among all entities.

Lehigh and Northampton counties adopted a regional comprehensive plan in June 2005 titled *Comprehensive Plan The Lehigh Valley…2030*, which was prepared by the LVPC. The regional comprehensive plan is the official and legal strategy guiding the growth, development, redevelopment and preservation of the assets of the Lehigh Valley, including streams and floodplains, riparian buffers, wetlands, important natural areas, steep slopes and woodlands. The county plan recommends that new growth not be located in areas recommended for natural resource or farmland preservation. Higher density residential growth and industrial and business expansion should occur in the recommended urban areas. Areas recommended for rural development should be planned for low density and low intensity uses. The regional comprehensive plan is inextricably tied to the *Long-Range Transportation Plan* and the *Transportation Improvement Program*, guiding public funding for infrastructure projects that are supportive of land use goals and recommendations. Many of these improvements are in line with the hazard mitigation actions in this plan. The goals in all of these plans reinforce the stated goals in this Hazard Mitigation Plan. Consistent reinforcement of good planning policy demonstrates a region that is unified in its broader goal of protecting the public health, safety and welfare. The Lehigh Valley has a variety of plans that address many mitigation strategies for a number of hazards, however, there is an opportunity to continue to expand actionable items.

FutureLV, an update to the regional comprehensive plan is underway at the time of this 2018 Plan. A major aspect of the Comprehensive Plan update is the integration with the *MoveLV Long-Range Transportation Plan*. A variety of additional studies and plans have been prepared by the Lehigh Valley Planning Commission that will influence the Comprehensive Plan update:

- ***One Lehigh Valley* (2014)** – Planning for the region's continued success, stability and resiliency, a 14-member regional alliance, the Lehigh Valley Sustainability Consortium, embarked on a nearly three-year effort to plan for a sustainable Lehigh Valley. The Consortium partners, including the LVPC, organized ten plans and projects around four themes: Economy, Environment, Transportation and Livable Communities. The LVPC assessed each of the Consortium partner's plans and projects and assembled a series of 31 goals intended to serve as an update to the regional comprehensive plan.

- ***Climate and Energy Element* (2014)** – The *Climate and Energy Element* was created as part of the *One Lehigh Valley* planning effort. The report identifies goals, policies and strategies to incorporate into the regional comprehensive plan update, including those to lessen the impacts of hazards. Public participation was an important component of preparing the report, with climate change and energy issues being the subject of public meetings June 19, 2014 in Easton, and June 26 and July 17, 2014 at the LVPC offices.

- ***One Water* (County Planning Directors Association of Pennsylvania 2016)** – The Pennsylvania MPC stipulates that comprehensive plans shall include a plan for the reliable supply of water, considering current and future water resources availability, uses and limitations, including provisions necessary to protect water supply sources. The County Planning Directors Association of Pennsylvania formed a task force to expand the understanding and implementation of Integrated Water Resources Management as a method for Pennsylvania counties and local governments to better address complex water resources and land planning issues. The Task Force reviewed an extensive body of information available from across the Commonwealth and the nation and prepared recommended actions to expand the implementation of Integrated Water Resources Management in Pennsylvania.

- **County Open Space Plans** – The LVPC, on behalf of Lehigh and Northampton counties, created open space plans for the two counties—*Livable Landscapes An Open Space Plan for Northampton County* (2016) and *Livable Landscapes A Park, Recreation, Open Space, Agricultural and Historic Lands Plan for Lehigh County* (2018). The LVPC will comment on open space issues identified in these plans during project reviews.

- ***Lehigh Valley Return on Environment* (2014)** – Prepared by the LVPC and the Wildlands Conservancy, this study identified a key trend—people's attachment to where they live and their quality of life positively impacts economic development. This study quantified the economic value of the benefits provided by open space and measured its impacts across four areas: Natural System Services ($355.5 million annual benefit), Air Quality ($54 million annual benefit),

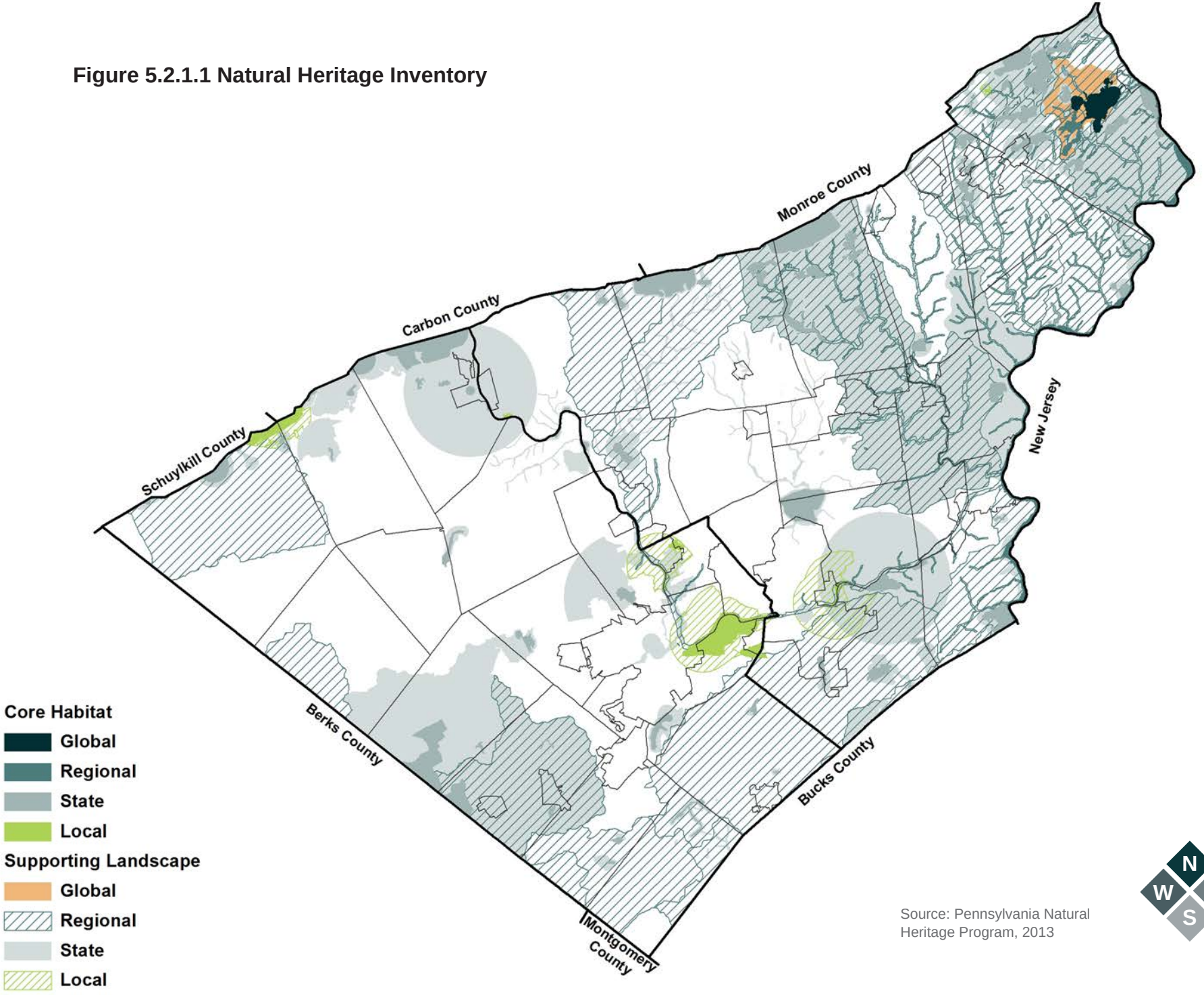
Outdoor Recreation ($795.7 million annual benefit) and Property Value ($1.8 billion total real estate premium attributed to living within ¼ mile of protected open space). Each of these areas generate the "natural capital" or economic value from the flow of goods and services supported by natural resources.

■ ***Lehigh Valley Greenways Plan* (2007)** – A greenway is defined as a corridor of open space that may vary greatly in scale from narrow strips of green that run through urban, suburban and rural areas to wider corridors that incorporate diverse natural, cultural and scenic features. Greenways are a critical component of any landscape—protecting the environment, providing alternate routes of transportation, supplying recreational opportunities, and connecting natural and cultural areas to one another, thus providing a linear resource for a variety of users. Connectivity is the defining characteristic that distinguishes greenways from isolated paths and pockets of open space. While individual parks, preserved lands, undisturbed natural areas and waterways are valuable resources, their conservation and recreational value is magnified when they are linked together.

■ **Natural Resources Plan** – This plan is a component of the regional comprehensive plan and identifies conservation priority areas based on steep slopes, stream quality, floodplains, wetlands, hydric soils, woodlands and important natural areas (identified in the Natural Heritage Inventory). The map shows areas considered very high, high and medium conservation priority. Very high priority areas are based on areas with the greatest combination of important natural resources. These areas should be given first consideration for public and private conservation acquisition or easement programs.

■ **Natural Heritage Inventory** – The LVPC contracted with the Western Pennsylvania Conservancy (Pennsylvania Natural Heritage Program) to complete a study titled *Natural Heritage Inventory of Lehigh and Northampton Counties Update 2013*. This document updated the 2005 report (the original study was completed in 1999) and identifies the plant and animal species of concern and outstanding natural communities in the Lehigh Valley. The region's National Heritage Inventory is showin in Figure 5.2.1.1.

Figure 5.2.1.1 Natural Heritage Inventory



Source: Pennsylvania Natural Heritage Program, 2013

Guides/Model Regulations

■ ***Floodplain Guide|Model Regulation*** **(2014)** – The LVPC released an updated floodplain model regulation in March 2014. The guide and model regulation was funded in part by a grant from the Pennsylvania Department of Conservation and Natural Resources through the Delaware and Lehigh National Heritage Corridor. The new model regulation was in advance of Northampton County communities receiving new Flood Insurance Rate Maps (FIRMs) in July 2014, requiring each community to update their floodplain management ordinances. The current model regulation was written using the policies of the 2005 Regional Comprehensive Plan, the 2013 Regional Hazard Mitigation Plan, the updated 2012 DCED floodplain provisions and the 2013 NFIP Community Rating System Coordinator's Manual as guides.

■ ***Riparian and Wetland Buffers Guide/Model Regulation*** **(2011)** - The US Environmental Protection Agency estimates that more than half of all stream pollution comes from land runoff, which can contain pollutants such as sediment, oil, fertilizers and pesticides. Increasing the amount of pavement in a watershed, or changing land use from forests to fields, can increase discharge to streams since both of these greatly reduce land permeability and soil storage. Streams in the Lehigh Valley are under pressure from the combined effects of farming uses and continued urbanization. Riparian buffers are a natural, effective means of protecting watercourses. The Commonwealth's Constitution, and more specifically the MPC, clearly authorizes local municipalities to adopt riparian buffer regulations.

■ ***Woodlands Guide/Model Regulation*** **(2009)** - Two regulatory approaches to protect woodlands are to adopt tree protection requirements for new development and regulate the timber harvest on private property. Tree protection can include replacement of trees removed from a development site if the tree removed meets the size threshold and that it be replaced by a native tree with the same estimated maximum height and growth rate of the tree to be removed. Another technique is to protect tree roots in the area of land disturbance and establish a "tree protection zone" during construction around these trees. A timber harvest or forestry regulation does not prevent harvesting, but rather defines best management practices to apply during harvesting.

■ ***Steep Slopes Guide/Model Regulation*** **(2008)** – This model regulation is designed as a section in a zoning ordinance. Applicants proposing development on steep slopes are required to obtain a conditional use permit. This process was chosen because it allows the governing body—not the zoning hearing board—the opportunity to thoroughly examine the proposal and impose any reasonable safeguards to protect the public's general welfare. The model regulation is constructed as an overlay district, to apply a common set of standards to a designated area that may cut across several underlying zoning districts.

■ ***Conservation Subdivisions Model Ordinance*** **(2015)** – Conservation subdivisions are residential developments in which a significant portion of the overall acreage of a property is set aside as undivided, permanently protected open space, while houses are clustered on the remainder of the property. The guide provides benefits and drawbacks of the approach,

and an annotated model regulation and example worksheets for municipalities to use in writing their own regulations.

In addition to these efforts, the LVPC held a number of strategy labs during 2017 to obtain public input on a variety of topics that will influence the development of the comprehensive plan update, including agriculture, community facilities, community utilities, economy, education and training, energy conservation and climate change, environment, hazard mitigation and resiliency, land use, parks and recreation, public health, transportation, water, and urban design and historic preservation.

Capital Improvement Plan

A capital improvement plan is a multiyear policy guide that identifies needed capital projects and is used to coordinate the financing and timing of public improvements. Capital improvements relate to streets, stormwater systems, water distribution, sewage treatment and other major public facilities. A capital improvement plan should be prepared by the respective county or municipal governments and should include a budget with identified priorities.

Both counties and about 26% of the municipalities that responded to the planning and regulatory capability survey, have capital improvement plans. An additional 11% indicated that a plan was under development.

Economic Development Plan

An economic development plan serves as a road map for economic development decision making, based on the collection of statistical data, historical perspective and human potential. The plan: 1) defines realistic goals and objectives, 2) establishes a defined time frame to implement goals and objectives, 3) communicates those goals and objectives to the organization's constituents, 4) ensures effective use of the organization's resources; 5) provides a baseline from which progress can be measured and 6) builds consensus around future goals and objectives. About 10% of responding municipalities indicated they have an economic development plan.

Continuity of Operations Plan

Continuity of operations planning is the process of developing advanced arrangements and procedures that enable an organization to continue its essential functions, despite events that threaten to disrupt them. The continuity discipline aims to identify emergency or unconventional means to replace or work around those deficiencies in the short term until the organization can be reconstituted on a normal basis. About 26% of responding municipalities indicated they have a continuity of operations plan.

Open Space Management Plan (Parks and Recreation or Greenways Plans)

An open space management plan is designed to preserve, protect and restore largely undeveloped lands in their natural state, and to expand or connect areas in the public domain such as parks, greenways and other outdoor recreation areas. In many instances open space management practices are consistent with the goals of reducing hazard losses, such as the preservation of wetlands or other flood-prone areas in their natural state in perpetuity. About 67% of responding municipalities indicated they have open space plans.

Natural Resource Protection Plan

Natural resource protection plans are designed to protect woodlands, steep slopes, waterways, floodplains and wetlands by prohibiting or severely limiting development in these areas. Emergency managers and community planners have been made more aware of the benefits of protecting these areas as mitigation measures over the last few decades. About 31% of municipalities in the Lehigh Valley indicated that they have a natural resource protection plan, however, many preserve natural resources through development restrictions in zoning or subdivision and land development regulations.

Transportation Plan

A transportation plan plays a fundamental role in a state, region, or community's vision for its future. It includes: 1) a comprehensive consideration of possible strategies; 2) an evaluation process that encompasses diverse viewpoints; 3) the collaborative participation of relevant transportation-related agencies and organizations; and 4) open, timely, and meaningful public involvement. Creating such a plan is a cooperative process designed to foster involvement by all users of the system, such as businesses, community groups, environmental organizations, the traveling public, freight operators, and the general public, through a proactive public participation process. This collaborative effort helps to better allocate resources for infrastructure improvements and provide efficient routes for both people and materials in the event of a disaster. About 23% of the municipalities that responded to the survey indicated that they have a transportation plan.

MoveLV Long Range Transportation Plan (2015-2040), prepared by the LVPC, covers both Lehigh and Northampton counties and is the $2.5 billion transportation investment strategy for the Lehigh Valley. The ***Long Range Transportation Plan*** considers the improvement of the region's roads, highways, bridges, transit system, sidewalks and trail networks. The ***Long Range Plan*** is updated every four years, is federally mandated and helps guide the transportation decision-making process through policy and investment decisions. The ***Long Range Plan*** includes a goal of constructing transportation improvements that are compatible with the built and natural environment, as well as providing a safe, well-maintained road network that facilitates the movement of traffic. These goals are compatible with the goals in the 2018 Hazard Mitigation Plan. The foundational policy of maintaining existing infrastructure before creating new infrastructure helps to ensure that the transportation network will be able to perform in the event of an emergency. This also allows for redundancy in the road network, providing first responders a multitude of routes when responding.

Historic Preservation Plan

This type of plan describes how the community will preserve the historic structures and areas within it. Since these structures pre-date building codes and modern community planning requirements, many of them are especially vulnerable to a variety of hazards. A historic preservation plan may include measures to retrofit or relocate historic treasures out of hazard impact areas. About 21% of the municipalities that responded to the survey indicated that they have a historic preservation plan. Four municipalities have indicated a plan is under development.

Farmland Preservation

Farmland preservation measures are important to hazard mitigation. Farms and forest land are important for recharging the community's aquifer and providing habitat for local wildlife. In addition, farmland reduces or eliminates future hazard vulnerability by maintaining the land as open space. As of July 2018, Lehigh County and Northampton County have 23,471 and 15,734 acres of preserved farmland, respectively.

Evacuation Plan

Evacuation is one of the most widely used methods of protecting the public from hazard impacts. The easiest way to minimize death and injury due to a hazard event is to remove as many people as possible from its path. Evacuation plans include descriptions of the area(s) being evacuated, the demographics and characteristics of people within those area(s), transportation routes to safe areas, and how the community will support those individuals who do not have access to their own transportation. Such plans address various evacuation situations, such as evacuation plans for dam safety, hazardous material spills and radiation releases. About 38% of the municipalities that responded to the survey have an evacuation plan. Six municipalities have a plan under development.

Disaster Recovery Plan

A Disaster Recovery Plan is a comprehensive set of measures and procedures that ensure essential resources and infrastructure are maintained or backed up by alternatives during various stages of a disaster. It is another step to ensure the preparedness and ability to respond quickly and effectively to restore the community's essential services. The plan addresses the public sector's responsibilities, including temporary shelter, refuse disposal, overall damage assessment, restoration of utility services, reconstruction priorities, financial assistance, as well as dealing with emergency demands. About 31% of the municipalities that responded to the survey indicated that they have a disaster recovery plan. Seven have a plan under development.

Subdivision and Land Development Ordinance

Subdivision and land development ordinances (SALDOs) are intended to regulate the development of housing, commercial, industrial, or other uses, including associated public infrastructure. Within these ordinances, the criteria on how land will be divided, the placement and size of roads and the location of infrastructure can reduce exposure of development to hazard events.

All municipalities in the Lehigh Valley, with the exception of Slatington Borough in Lehigh County and the boroughs of West Easton, Glendon and Chapman in Northampton County, have subdivision and land development regulations. Both Lehigh and Northampton counties have a subdivision and land development ordinance, which covers these four municipalities. The LVPC, on behalf of the counties, has the authority to enforce the county regulations in these communities per the Pennsylvania MPC.

Zoning Ordinance

Zoning ordinances allow for local communities to regulate the use of land to protect the interests and safety of the general public. Zoning ordinances can be designed to address unique conditions or concerns within a given

community. They may be used to create buffers between structures and high-risk areas, limit the type or density of development, and/or require land development to consider specific hazard vulnerabilities. All municipalities in the Lehigh Valley, except the Borough of Chapman, have zoning regulations. Neither county has a zoning ordinance.

Building Code

Building codes regulate construction standards for new construction and substantially renovated buildings. Standards can be adopted that require resistant or resilient building design practices to address hazard impacts common to a given community. In 2003, the Commonwealth of Pennsylvania implemented Act 45 of 1999, the Uniform Construction Code (UCC), a comprehensive building code that establishes minimum regulations for most new construction, including additions and renovations to existing structures. Effective December 2009, the Commonwealth adopted regulations of the 2009 International Code Council's codes. Since all municipalities in the Lehigh Valley are required to abide by the UCC, they are required to enforce the 2009 building code regulations.

Fire Code

Fire codes relate to both the construction and use of structures in terms of preventing fires from starting and minimizing their spread, and minimizing the injuries and deaths caused by a fire within a building. They govern such things as the following: 1) building materials that may be used; 2) the presence and number/type of fire extinguishers; 3) means of egress; and 4) hazardous materials storage and use. About 70% of municipalities responding to the survey indicated that their community had a fire code in place.

Stormwater Management Plan/Ordinance

The proper management of stormwater runoff can improve conditions and decrease the chance of flooding. The Pennsylvania legislature enacted the Stormwater Management Act (Act 167 of 1978), commonly called Act 167, requiring counties to develop stormwater management plans for all watersheds. This planning effort results in sound engineering standards and criteria being incorporated into local codes and ordinances to manage stormwater runoff from new development and redevelopment in a coordinated, watershed-wide approach.

Act 167 Stormwater Management Plans are intended to improve stormwater management practices and mitigate potential negative impacts from future development or redevelopment. It is not the intent of the plans to solve existing flooding or runoff problems, but to identify them for future correction and assure that problems do not get worse. The plan does allow municipalities to establish a capital improvement program to correct storm drainage issues. Since flooding is the most significant natural hazard affecting the Lehigh Valley, the hazard mitigation plan provides a thorough understanding of the current capabilities to manage stormwater and a clear action plan to mitigate future impacts.

The LVPC provides an advisory engineering review of the stormwater aspects of subdivision and land development proposals to assist in creating consistent implementation throughout each watershed. The municipalities have the authority to enforce the ordinance provisions. Within Lehigh and Northampton counties, the LVPC prepares plans on behalf of both counties. The state designated 16 Act 167 study areas within the region, and the plans

were approved by the Pennsylvania Department of Environmental Protection (PADEP) between 1988 and 2010, with updates to the Little Lehigh Creek Plan in 1999 and 2005. A Monocacy Creek Act 167 Plan update has been prepared and adopted by both counties and approved by the PADEP in May 2018. The model ordinance must be adopted by all watershed municipalities by November 21, 2018. All 62 municipalities have adopted Act 167 ordinances for their watersheds. Act 167 planning for the Tohickon Creek Watershed, including portions in the Lehigh Valley, was completed by Bucks County.

Until 2004, stormwater planning dealt solely with runoff quantity and not quality. To comply with requirements of the National Pollutant Discharge Elimination System (NPDES) regulations from the Environmental Protection Agency, 59 of the 62 municipalities in the Lehigh Valley must adopt and implement an ordinance to reduce or prevent the discharge of pollutants into receiving waters. All Act 167 plans have been prepared or updated to include water quality provisions. The region's stormwater watershed designations are shown in Figure 5.2.1.2.

In addition to the Act 167 stormwater management plans in place, other related planning efforts include:

Green Infrastructure Guidelines **(LVPC 2017)** – The *Green Infrastructure Guidelines* document was prepared in conjunction with the ***Monocacy Creek Watershed Act 167 Stormwater Management Plan Update***, 2018. The Guidelines are important for reinforcing the message of the natural resources in the Lehigh Valley and their variety of essential services and benefits to residents and visitors, describing the best practices available for community and site design to preserve or enhance those resources, and defining improved stormwater management design practices to better mimic natural systems.

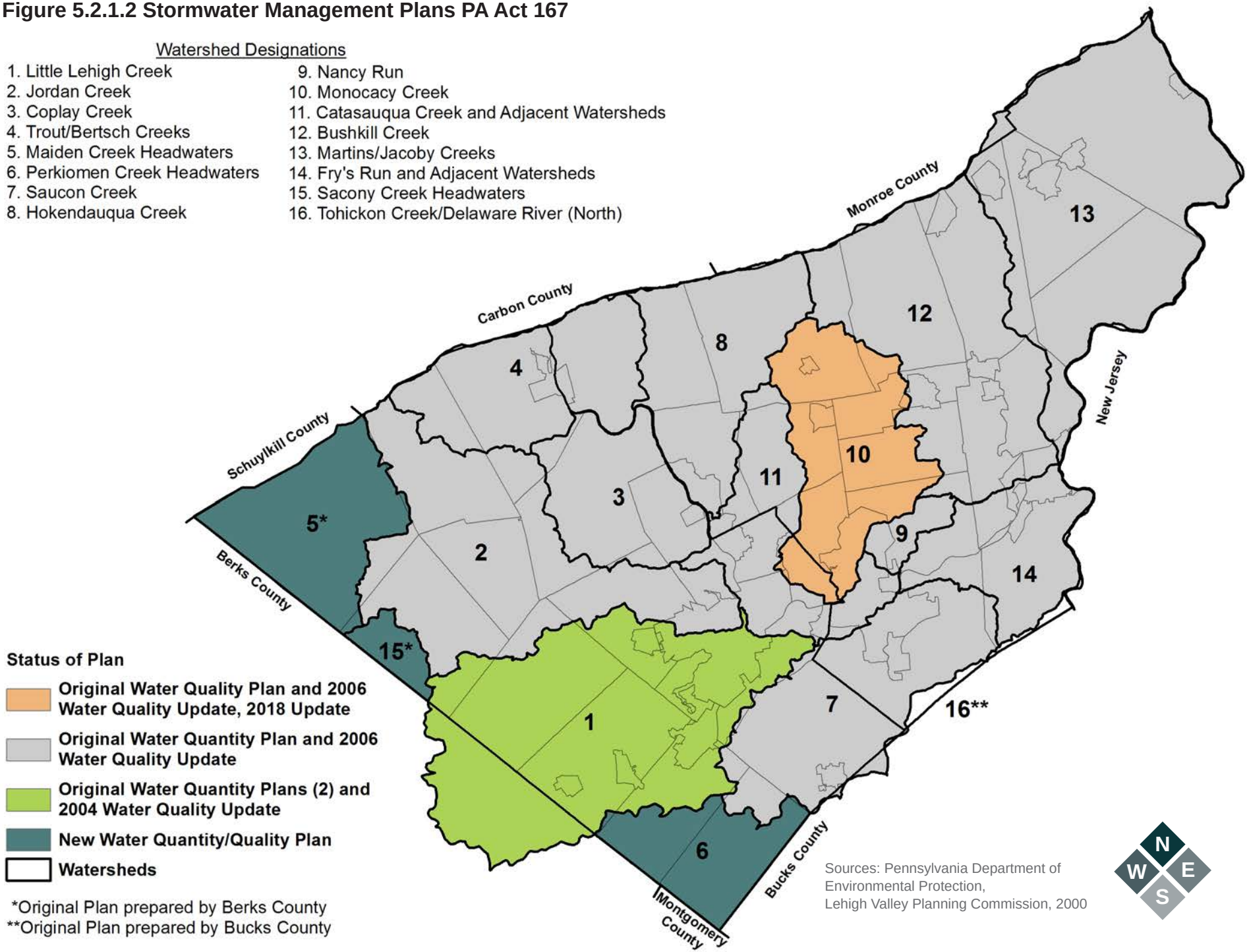
Recommended Procedures for Act 167 Drainage Plan Design **(LVPC 2006)** – This document provides a step-by-step process for creating a drainage design to meet Act 167 Ordinance requirements.

Technical Best Management Practice Manual & Infiltration Feasibility Report: Infiltration of Stormwater in Areas Underlain by Carbonate Bedrock within the Little Lehigh Creek Watershed **(LVPC 2002)** – The intent of this Best Management Practice design manual is to provide guidance for stormwater management systems to be developed in the rapidly developing Little Lehigh Creek Watershed. The manual was developed under the Act 167 Stormwater Management Program as administered by the Department of Environmental Protection and implemented by the LVPC.

National Flood Insurance Program Participation (Floodplain Management Plan/Floodplain Regulations)

When the US Congress passed the National Flood Insurance Act of 1968, it created the National Flood Insurance Program (NFIP). The program enables property owners in participating communities to purchase insurance as a protection against flood losses, in exchange for state and community floodplain management regulations that reduce future flood damages. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction and substantial improvements in floodplains, the federal government will make flood insurance available within the community as financial protection against flood losses.

Figure 5.2.1.2 Stormwater Management Plans PA Act 167



In addition, the Pennsylvania Floodplain Management Act (Act 166 of 1978) mandates municipal participation in and compliance with the NFIP. It also establishes higher regulatory standards for new or substantially improved structures that are used for the production or storage of dangerous materials by prohibiting them in the floodway. Additionally, Act 166 establishes the requirement that a Special Permit be obtained prior to any construction or expansion of any manufactured home park, hospital, nursing home, jail and prison if the structure is located within a special flood hazard area. The Pennsylvania Department of Community and Economic Development (DCED) provides communities with a suggested ordinance document to assist municipalities in meeting the minimum requirements of the NFIP along with Act 166. The model ordinance contains provisions for municipal consideration that are more restrictive than state and federal requirements.

Through administration of floodplain ordinances, municipalities can ensure that all new construction or substantial improvements to existing structures in the 1% annual chance floodplain are engineered to minimize the impact of flooding and are better able to withstand the forces of a flood event.

All municipalities in the Lehigh Valley participate in the NFIP. All municipalities have adopted a Floodplain Ordinance and are required to update the ordinance whenever the regulatory NFIP flood mapping is officially updated. Since the 2013 Plan, all Northampton County municipalities adopted a floodplain ordinance to reflect the FEMA floodplain mapping for the county that went into effect on July 16, 2014. FEMA is in the process of developing new flood mapping for the Lehigh River Watershed, with preliminary mapping anticipated to be available in September 2019. Once the map update process has been formally completed, each community in the watershed will have to update their ordinance. NFIP-participating communities are required to make current regulatory NFIP mapping available to their residents for review and provide mapping assistance. Typically, this mapping is available at the municipal offices in each community. About 44% of municipalities that responded to the survey indicated that, in addition to paper maps, they also have digital mapping available. Six municipalities indicated that their floodplain ordinance exceeds the minimum requirements, including regulating properties in the 500-year floodplain and requiring a 1.5 foot freeboard above the 100-year base flood elevation. 26% of municipalities that responded have a certified floodplain administrator. Based on review of the 62 municipal responses to the NFIP survey, only a few documented a high level of NFIP capability, and about half documented a moderate level of capability. Therefore, almost all municipalities would appear to benefit from NFIP training and education. To that end, the county annex includes several actions related to supporting and facilitating NFIP training and education programs for county and municipal personnel and the public.

The National Flood Insurance Program's Community Rating System (CRS) was established in 1990 to encourage local governments to increase their standards for floodplain development. The goal of this program is to encourage communities, through flood insurance rate adjustments, to implement standards above and beyond the minimum requirements.

The CRS is a voluntary program designed to reward participating communities for their efforts to create more disaster-resistant communities using the principles of sustainable development and management. By enrolling in the program, municipalities can leverage greater flood

protection while receiving flood insurance discounts, ranging from 5% up to 45%.

Currently within the Lehigh Valley, no municipalities participate in the CRS program. Increased participation in the Lehigh Valley will be supported by both counties as identified in their updated mitigation actions. Further, certain communities in the Lehigh Valley have identified in their updated mitigation actions that they plan to apply to the CRS program.

Flood hazard risk management in the Lehigh Valley is supported by the LVPC through the Act 167 Stormwater Management Planning program, as detailed and referenced within this Plan. The region's National Flood Insurance Program Compliance is shown in Table 5.2.1.2.

Emergency Operations Plan/Emergency Management Services

The Pennsylvania Emergency Management Services Code, Title 35, requires all political jurisdictions in the Commonwealth to have an Emergency Operations Plan (EOP), an Emergency Management Coordinator (EMC), and an Emergency Operations Center (EOC). All 62 municipalities and both counties comply with the code.

The Lehigh Valley is supported by strong regional and county-level emergency management capabilities provided by the Lehigh County Emergency Management Agency and Northampton County Emergency Management Services. Both Lehigh and Northampton counties continue to operate emergency 9-1-1 call centers and Emergency Operations Centers (EOCs) during emergencies in their counties. In addition, both counties continue to provide or support emergency service programs and measures, including emergency response, public alert and warning systems, emergency communications systems, hazard event monitoring systems, and public information and outreach programs.

9-1-1 Centers

9-1-1 is the telephone number used to report emergencies, wherein there is the presence or potential for an immediate threat to life or property, and response is needed by police, fire, or emergency medical service agencies. Examples include a crime which has just occurred or in-progress, odor or presence of fire, a sick or injured person requiring pre-hospital treatment and transportation to a hospital emergency department. The 9-1-1 System maintains the capability to accept calls from hearing or speech impaired callers utilizing a Telecommunications Device for the Deaf (TDD). Currently, each county operates a 9-1-1 Public Safety Answering Point (PSAP), as do the cities of Allentown and Bethlehem. These four PSAPs need to coordinate efforts during a regional hazard event until 2019. The consolidation of the Allentown and Lehigh County PSAPs and Bethlehem and Northampton County PSAPs must be completed in accordance to Act 12 by June 30, 2019. Opportunities are being taken to share 9-1-1 infrastructure between the two counties.

Emergency Operations Centers (EOC)

In the event of an emergency or disaster, both Lehigh and Northampton counties could activate their EOCs. The purpose of the EOC is to coordinate the response and distribution of resources to a disaster incident. Highly experienced and trained personnel staff the EOC when in operation. The EOC utilizes the expertise in the following disciplines to staff the following 15 Emergency Support Functions: Transportation, Firefighting, Public

Table 5.2.1.2 National Flood Insurance Program Compliance

Lehigh County	Participating Community	Initial Entrance into NFIP	Certified Floodplain Administrator/ NFIP Coordinator	Effective Date of Flood Insurance Rate Maps	Digital or Paper Maps	Floodplain Ordinance Meets or Exceeds Minimum Requirements	Participation in Community Rating System Program
Alburtis Borough	Yes	1/16/1974	No	7/16/2004	Paper	Meets	No
Allentown City	Yes	7/26/1974		7/16/2004	Both		No
Bethlehem City*	Yes	6/15/1973	No	7/16/2004	Both	Exceeds	No
Catasauqua Borough	Yes	11/30/1973	No	7/16/2004	Paper	Meets	No
Coopersburg Borough	Yes	11/19/1976		7/16/2004			No
Coplay Borough	Yes	11/22/1974	No	7/16/2004	Paper	Meets	No
Emmaus Borough	Yes	12/28/1973	No	7/16/2004	Paper	Meets	No
Fountain Hill Borough	Yes	11/22/1974	Unknown	7/16/2004	Paper	Meets	No
Hanover Township	Yes	12/20/1974	No	7/16/2004	Paper	Meets	No
Heidelberg Township	Yes	12/27/1974		7/16/2004			No
Lower Macungie Township	Yes	6/28/1974	Yes	7/16/2004	Paper	Exceeds	No
Lower Milford Township	Yes	10/18/1974	No	7/16/2004	Paper	Unknown	No
Lowhill Township	Yes	12/20/1974	No	7/16/2004	Both	Meets	No
Lynn Township	Yes	11/29/1974	Unknown	7/16/2004		Unknown	No
Macungie Borough	Yes	1/9/1974		7/16/2004			No
North Whitehall Township	Yes	10/18/1974		7/16/2004			No
Salisbury Township	Yes	12/28/1973	No	7/16/2004	Digital	Unknown	No
Slatington Borough	Yes	4/12/1974	Yes	7/16/2004			No
South Whitehall Township	Yes	1/16/1974	No	7/16/2004	Both	Exceeds	No
Upper Macungie Township	Yes	11/26/1976	Yes	7/16/2004	Digital	Meets	No
Upper Milford Township	Yes	11/1/1974	No	7/16/2004	Digital	Meets	No
Upper Saucon Township	Yes	7/26/1974	No	7/16/2004	Both	Exceeds	No
Washington Township	Yes	11/15/1974		7/16/2004			No
Weisenberg Township	Yes	1/10/1975	No	7/16/2004	Both	Meets	No
Whitehall Township	Yes	1/9/1974		7/16/2004			No

*Includes Lehigh and Northampton County portions

Table 5.2.1.2 National Flood Insurance Program Compliance

Northampton County	Participating Community	Initial Entrance into NFIP	Certified Floodplain Administrator/ NFIP Coordinator	Effective Date of Flood Insurance Rate Maps	Digital or Paper Maps	Floodplain Ordinance Meets or Exceeds Minimum Requirements	Participation in Community Rating System Program
Allen Township	Yes	9/6/1974		7/16/2014			No
Bangor Borough	Yes	1/25/1974	No	7/16/2014	Both	Meets	No
Bath Borough	Yes	7/30/1976	No	7/16/2014	Both	Unknown	No
Bethlehem Township	Yes	6/14/1974		7/16/2014			No
Bushkill Township	Yes	11/8/1974	No	7/16/2014	Paper	Unknown	No
Chapman Borough	Yes	11/15/1974	No	7/16/2014	Paper	Meets	No
East Allen Township	Yes	2/11/1983	No	7/16/2014	Both	Unknown	No
East Bangor Borough	Yes	11/15/1974		7/16/2014			No
Easton City	Yes	2/9/1973	No	7/16/2014	Digital	Meets	No
Forks Township	Yes	11/8/1974	Yes	7/16/2014	Paper	Unknown	No
Freemansburg Borough	Yes	12/28/1973		7/16/2014			No
Glendon Borough	Yes	11/15/1974	No	7/16/2014	Paper		No
Hanover Township	Yes	11/23/1973		7/16/2014	Both	Unknown	No
Hellertown Borough	Yes	2/8/1973	No	7/16/2014	Paper		No
Lehigh Township	Yes	11/15/1974	No	7/16/2014	Paper	Meets	No
Lower Mt. Bethel Township	Yes	1/4/1974	No	7/16/2014	Digital	Meets	No
Lower Nazareth Township	Yes	11/15/1974	No	7/16/2014	Both	Meets	No
Lower Saucon Township	Yes	6/28/1974	No	7/16/2014	Both	Meets	No
Moore Township	Yes	8/2/1974		7/16/2014			No
Nazareth Borough	Yes	1/9/1974		7/16/2014			No
North Catasauqua Borough	Yes	5/3/1974	No	7/16/2014	Paper	Meets	No
Northampton Borough	Yes	4/5/1974	Yes	7/16/2014	Both	Meets	No
Palmer Township	Yes	4/20/1973	No	7/16/2014	Both	Meets	No
Pen Argyl Borough	Yes	11/1/1974	No	7/16/2014	Paper	Meets	No
Plainfield Township	Yes	9/13/1974	No	7/16/2014	Both	Unknown	No
Portland Borough	Yes	4/12/1974	Yes	7/16/2014	Paper	Unknown	No
Roseto Borough	Yes	11/15/1974		7/16/2014			No
Stockertown Borough	Yes	8/2/1974		7/16/2014			No
Tatamy Borough	Yes	4/12/1974	Yes	7/16/2014	Both	Meets	No
Upper Mt. Bethel Township	Yes	11/8/1974		7/16/2014	Both	Exceeds	No
Upper Nazareth Township	Yes	12/27/1971	Yes	7/16/2014	Digital	Exceeds	No
Walnutport Borough	Yes	1/9/1974		7/16/2014			No
Washington Township	Yes	11/1/1974	No	7/16/2014	Both	Meets	No
West Easton Borough	Yes	12/28/1973	Unknown	7/16/2014	Paper	Meets	No
Williams Township	Yes	5/17/1974	Yes	7/16/2014	Both	Unknown	No
Wilson Borough	Yes	9/13/1974	No	7/16/2014	Digital	Meets	No
Wind Gap Borough	Yes	6/28/1974	Yes	7/16/2014	Paper	Meets	No

Safety, Communications/Radio Amateur Civil Emergency Services, Public Works, Emergency Management, Mass Care, Resource Support, Public Health and Medical Services, Urban Search and Rescue, HazMat, Energy, Public Information, Long-Term Recovery and Agriculture. Northampton County EOC has an additional function: Volunteer and Donations Management. When activated, the EOCs will maintain constant communications with the 9-1-1 centers and PEMA to ensure coordination of activities. Local EOCs could also be activated to coordinate the response and distribution of resources at the local level.

The Lehigh and Northampton County Emergency Management Agency (EMA) capabilities fall under two categories: Emergency Service Measures and Public Information Programs, which are provided in the Education and Outreach Capability section.

Emergency Service Measures

Emergency service measures protect people during and immediately following a disaster.

- **Alert Warning System** – Emergency Alert System (EAS) – Lehigh County operates as an EAS initiating station, covering Lehigh and Northampton counties. The EAS is an alert system for disseminating emergency information and warnings to the general public within the counties, utilizing the resources of the Broadcast and Cable Industries. The EAS allows state and local officials to quickly send out important area specific state and local information. The EAS has the capability of providing alerts in the language normally used by the station or cable system, such as the Spanish language.
- **Monitoring Systems** – The counties and municipalities have several systems they can monitor that will disseminate emergency information and warnings. These systems include: SEVAN, Knowledge Center, Radio Amateur Civil Emergency Services, CodeRED, NOAA Weather Radios and 800 MHz Statewide Radio.
- **SEVAN (Satellite Emergency Voice Alerting Network)** – The voice side of the satellite warning system allows PEMA, counties, regional offices and cities to communicate directly in real time regardless of the status of the telephone system. Warning messages are routinely broadcast by PEMA using the system.
- **Knowledge Center** – Knowledge Center is a web-based, interactive incident management tool used by the Northeast Pennsylvania Regional Counterterrorism Task Force (NEPARCTTF), which includes, Lehigh and Northampton counties. Knowledge Center provides emergency managers with the ability to gather large quantities of information related to incidents and coordinate that information for both small-scale and large-scale events. Small-scale events involve one or two responder agencies, and large-scale events involve complex, multi-jurisdictional responses comprised of hundreds of agencies from the local, state, and federal government, non-governmental organizations, and the private sector. The system allows for seamless communication with neighboring jurisdictions, counties and the state about the types of incidents and emergencies that may occur in the region.
- **RACES (Radio Amateur Civil Emergency Services)** – A group of amateur radio operators

who donate their services in time of natural disaster or emergency. They provide communication to fire, police and other agencies that need assistance.

- **Onsolve/CodeRED** – The system is used to send out emergency information, ranging from evacuation notices, AMBER Alerts, inclement weather, active shooter and other disaster response efforts to the residents of Lehigh and Northampton counties. The Emergency Alert System is a service brought to the area through the Northeast Pennsylvania Regional Counterterrorism Task Force.
- **NOAA Weather Radio All Hazards (NWR)** – A nationwide network of radio stations broadcasting continuous weather information directly from a nearby National Weather Service office. NWR broadcasts National Weather Service warnings, watches, forecasts and other hazard information 24 hours a day. NWR also broadcasts warning and post-event information for all types of hazards, including natural and non-natural (such as chemical releases or oil spills), and public safety (such as AMBER Alerts or 9-1-1 Telephone outages).
- **800 MHz Statewide Radio System** – This system provides two-way voice and data communications for all county and state agencies. The primary function of this system is to provide redundant communications between the county and the partner agency facilities in the event that the primary means of communication becomes interrupted. This system is integrated with the Northampton County Communication/9-1-1 center.

The municipalities may also be equipped with RACES, NWR and Knowledge Center systems to monitor emergency information and warnings.

Emergency Response Planning

- **Emergency Operations Plan (EOP)** - Lehigh and Northampton counties have prepared EOPs to document the counties' specific emergency response procedures during various emergency events. Emergency Operations Centers and other activities are guided by this plan.
- **Mutual Aid Agreements** – Lehigh and Northampton counties have formal agreements in place with each other and with the Pennsylvania counties contiguous to each as a result of the PA Intrastate Mutual Assistance Program (Act 93). All municipalities in Lehigh and Northampton counties are participants in this program.

The counties also assist in planning for:

- Lehigh Valley International Airport
- Lehigh and Northampton County Prisons
- County and Local (Municipal) Emergency Operations Plans
- Medical Facilities: Hospitals; Ambulatory Surgical Centers; Hospices; Psychiatric Residential Treatment Facilities; All-Inclusive Care for the Elderly; Transplant Centers; Long-Term Care Facilities; Intermediate Care Facilities for Individuals with Intellectual Disabilities; Home Health Agencies; Comprehensive Outpatient Facilities; Critical Access Hospitals; Clinics, Rehabilitation Agencies, and Public Health Agencies as Providers of Outpatient Physical Therapy and Speech-Language Pathology

Services; Community Mental Health Centers, Rural Health Clinics and Federally Qualified Health Centers; End-Stage Renal Disease Facilities

- Dams
- Mass Casualty/Fatality Management Plans
- Counterterrorism Preparedness
- Limerick Nuclear Power Station Evacuation and Sheltering/Radiological Ingestion and Response Plan
- Special Events Plans
- School District Plans
- Day Care, Group Homes, Personal Care and Special Needs Facility Plans
- SARA (Superfund Amendments and Reauthorization Act of 1986) facilities
- Commodity Flow Studies
- Preparedness, Prevention and Contingency (PPC) Plans
- Above-Ground Storage Tank Plans
- Rail Transportation Plans
- Pipeline Emergency Response Plans
- E-Cycling Plans
- High Hazard Dam Plans
- Water Treatment Emergency Response Plans
- Wastewater Treatment Emergency Response Plans
- Electric Generation Emergency Response Plans
- Influenza Pandemic and Points-of-Dispensing Plans – Department of Health
- Cedarbrook (Lehigh) and Gracedale (Northampton) Emergency Action Plans
- Continuity of Operations (COOP)/Continuity of Government (COG) Plans
- Historic Preservation Plans
- County Building Emergency Action Plans
- Volunteer/Donations Management Plans
- Incident Action Plans
- Mine Emergency Response Plan (Northampton County)

Each municipality is responsible to provide emergency response within their municipality in Emergency Medical Services (EMS), Fire and Police. If a municipality does not have one of these providers in their community, they have a contract with an adjacent political subdivision to provide services. If resources are exhausted, the services are provided through the mutual aid agreements.

In Lehigh County there are: 8 EMS Agencies, 44 Fire Companies, 13 Municipal Police Departments, 2 State Police Barracks, City of Allentown 9-1-1, City of Bethlehem 9-1-1. **In Northampton County there are:** 12 EMS Agencies, 38 Fire Agencies, 2 Rescue Agencies, 26 Municipal Police Agencies, 4 School District Police Agencies, 3 College Campus Police Agencies, 2 State Police Barracks, City of Bethlehem 9-1-1.

Evacuation Planning

Lehigh County has developed an evacuation plan for the county that addresses the following basic scenarios:

- Evacuation of a large population or geographic area within the regional task force.
- Mass exodus of population from another area entering the county.
- How would the county or could the county act as host for a large influx of evacuees?

Northampton County will follow the actions set forth in the county's emergency operations plan. For interstate evacuations, Northampton County will follow the state (PEMA) and federal (FEMA) guidelines set forth. Northampton County follows federal and state guidance in developing a comprehensive evacuation plan at the county level to include the principles and methods of evacuation and re-entry planning and operations.

Shelter Planning

The counties, in cooperation with the American Red Cross of the Greater Lehigh Valley, have designated shelters set up throughout the counties. These shelters may be used during times of emergency and disasters.

While the risk of certain hazards can be addressed partially through mitigation, the risks of other hazards (particularly certain non-natural hazards) are primarily managed through the preparedness and response elements of emergency management, or via other regulatory programs at the federal and state levels.

Carbonate Bedrock Standards

The LVPC *Minimizing Sinkhole Occurrences* (1988) provides a general understanding of sinkholes and how they can form. The document provides recommended ordinance provisions for municipal consideration to minimize the potential for sinkhole occurrence as it relates to new development. Within the Lehigh Valley, 47 of the 62 municipalities are underlain entirely or in part by carbonate bedrock, which is prone to sinkholes. There are 22 municipalities within the two counties that have adopted carbonate bedrock standards since 1986, as shown below.

Further, it is noted that the boroughs of Glendon and West Easton are covered under the Northampton County Subdivision and Land Development Ordinance carbonate bedrock provisions.

Lehigh County	Northampton County
Upper Saucon Township	Forks Township
Emmaus Borough	Lower Mt. Bethel Township
Lower Macungie Township	Bethlehem Township
North Whitehall Township	East Allen Township
Whitehall Township	Stockertown Borough
Weisenberg Township	Lower Nazareth Township
Upper Macungie Township	Palmer Township
Macungie Borough	Upper Nazareth Township
Lower MIlford Township	Upper Mt. Bethel Township
	Tatamy Borough
	Willliams Township
	Freemansburg Borough
	Wilson Borough

Official Map

An official map shows the locations of planned future public lands and facilities such as streets, trails, parks and open space. The official map expresses a municipality's interest in acquiring these lands for public purposes and notifies developers and property owners of this interest. The MPC defines an official map as a "land use ordinance." If a landowner seeks to build on or subdivide land noted on the official map, the municipality has up to a year to acquire the land from the owner before the owner may freely build or subdivide. Ultimately, an official map can serve as a tool to promote growth and infrastructure in appropriate areas, mitigating costs and risks to life associated with hazards. In addition to Lehigh County, 12 Lehigh Valley municipalities have adopted an Official Map, as shown below.

Lehigh County	Northampton County
Catasauqua Borough	Allen Township
Lower Macungie Township	Bushkill Township
South Whitehall Township	East Allen Township
Whitehall Township	Hanover Township
Upper Milford Township	Moore Township
Upper Saucon Township	Tatamy Borough

2009 International Property Maintenance Code

The International Property Maintenance Code (IPMC) is intended to establish minimum maintenance standards for basic equipment, light, ventilation, heating, sanitation and fire safety. Responsibility is fixed among owners, operators and occupants for code compliance. South Whitehall Township identified the IPMC as an additional regulatory tool in place in the community.

5.2.2 Administrative and Technical

Administrative and technical capability refers to the community's staff and their skills and tools that can be used for mitigation planning and to implement specific mitigation actions. It includes planners, engineers, emergency managers, floodplain administrators/managers, land surveyors, staff familiar with community hazards, personnel skilled in GIS, and grant writers. It also refers to the ability to access and coordinate these resources effectively. The degree of intergovernmental coordination among departments also affects administrative capability. Municipal responses to an administrative and technical capability survey can be found in their municipal annexes.

Overall, Lehigh Valley municipalities have a moderate to high level of administrative and technical capability, with smaller communities such as the boroughs having more limited capability. About 77% of municipalities indicated they have planners with land use/land development knowledge. About 69% have planners or engineers with knowledge of natural or non-natural hazards, however, 79% indicated that they did have staff familiar with community hazards. In addition, about 84% of municipalities indicated that they have engineers or other professional staff trained in building and/or infrastructure construction practices. Municipalities are more limited in personnel related to GIS skills, as well as grant writers.

More than three-fourths of the municipalities did not identify any changes in their administrative and technical capabilities since the 2013 Plan. Education and training for staff was the primary response for improving capabilities.

Municipalities are further supported by county and regional administrative and technical capabilities, including Lehigh and Northampton counties, Lehigh Valley Planning Commission, Lehigh Valley Transportation Study, Lehigh Valley Regional Partnership, local environmental groups and watershed associations. Additional technical assistance is available for mitigation activities from a number of state and federal agencies, including

- Pennsylvania Emergency Management Agency
- US Department of Agriculture
- Pennsylvania Department of Environmental Protection
- US Department of Housing and Urban Development
- Pennsylvania Department of Conservation and Natural Resources
- Economic Development Administration
- Pennsylvania Department of Transportation
- Emergency Management Institute
- Federal Emergency Management Agency
- US Environmental Protection Agency
- US Army Corps of Engineers
- Small Business Administration

It is noted that both counties, and many of the municipalities, have identified specific mitigation initiatives in the 2018 Plan to help build and enhance mitigation-related administrative and technical capabilities in the Lehigh Valley.

5.2.3 Financial

Financial capabilities are the resources that a municipality has access to or is eligible for to fund mitigation actions and include capital improvement programming; Community Development Block Grants; special purpose taxes; gas/electric utility fees; water/sewer fees; stormwater utility fees; development impact fees; general obligation, revenue, and/or special tax bonds; and partnering arrangements or intergovernmental agreements. The costs associated with implementing mitigation activities vary. Some mitigation actions such as outreach and education efforts require little to no costs other than staff time and existing operating budgets. Other actions such as acquisition of flood-prone properties could be largely or entirely dependent on available funding. As such, it is critical to identify all available sources of funding at the local, county, regional, state and federal level to support implementation of the mitigation actions identified in the 2018 Plan. Municipalities fund mitigation projects through existing local budgets, local appropriations (including referendums and bonding), and through a variety of federal and state loan and grant programs.

Municipal responses to the financial capabilities survey can be found in their municipal annexes. While most of the identified financial capabilities are available to all of the municipalities in the Lehigh Valley, the extent to which communities have leveraged these funding sources varies widely. It is logical to expect that communities that are familiar with accessing specific grant programs will continue to consider and pursue those sources.

The findings of the survey indicate that, overall, municipalities are limited in their financial capabilities. About half the municipalities responding indicated that they have capital improvement programming. About 61% of responding municipalities identified CDBG funding as a financial resource. Most municipalities do not have special purpose taxes and eight indicated they collect stormwater utility fees to fund stormwater system improvements. In addition, about 44% of municipalities collect development impact fees and 40% utilize general obligation, revenue, and/or special tax bonds. Six municipalities indicated that they collect gas/electric utility fees. One municipality noted that a fire service tax was under development.

About 84% of municipalities did not identify any changes in financial capability since the 2013 Plan. Several of those that did comment noted a reduction in some capabilities, including CDBG eligibility and capital improvement programming. Some municipalities provided suggested improvements to the financial capabilities, including providing additional funding to capital improvement programming, streamlining the CDBG application process and promoting intergovernmental cooperation by the counties.

Federal Hazard Mitigation Assistance Funding Opportunities

Hazard Mitigation Grant Program (HMGP)

The HMGP is a post-disaster mitigation program. It is made available to states by FEMA after each federal disaster declaration. The HMGP can provide up to 75% funding for hazard mitigation measures. The HMGP can be used to fund cost-effective projects that will protect public or private property in an area covered by a federal disaster declaration or that will reduce the likely damage from future disasters. Examples of projects include acquisition and demolition of structures in hazard prone areas, flood proofing or elevation to reduce future damage, minor structural improvements and development of state or local standards. Projects must fit into an overall mitigation strategy for the area identified as part of a local planning effort. All applicants must have a FEMA-approved Hazard Mitigation Plan. Applicants who are eligible for the HMGP are state and local governments, certain nonprofit organizations or institutions that perform essential government services, and Indian tribes and authorized tribal organizations. Individuals or homeowners cannot apply directly for the HMGP; a local government must apply on their behalf. Applications are submitted to PEMA and placed in rank order for available funding and submitted to FEMA for final approval.

Flood Mitigation Assistance (FMA) Program

FMA provides funding to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP. The FMA is funded annually; no federal disaster declaration is required. Only NFIP-insured homes and businesses are eligible for mitigation in this program. Funding for FMA is very limited and, as with the HMGP, individuals cannot apply directly for the program. Applications must come from local governments or other eligible organizations. The federal cost share for an FMA project is 75%. At least 25% of the total eligible costs must be provided by a non-federal source. Of this 25%, no more than half can be provided as in-kind contributions from third parties. At minimum, a FEMA-approved local flood mitigation plan is required before a project can be approved. FMA funds are distributed from FEMA to the state. PEMA serves as the grantee and program administrator for FMA.

Pre-Disaster Mitigation (PDM) Program

The PDM program is an annually funded, nationwide, competitive grant program. No disaster declaration is required. Federal funding is available for up to 75% of eligible activity costs and up to 90% for small, impoverished communities. As with the HMGP and FMA, a FEMA-approved local Hazard Mitigation Plan is required to be approved for funding under the PDM program.

Federal Funding Assistance Opportunities

Other federal programs that may provide financial support for mitigation actions include, but are not limited to:

- Department of Energy Weatherization Assistance Program
- FEMA Community Disaster Loan Program
- FEMA Emergency Management Performance Grants
- FEMA Environmental Planning and Historic Preservation Program
- FEMA Public Assistance Program
- FEMA Individuals and Households Program
- HUD Community Development Block Grants
- HUD Disaster Housing Assistance Program
- Department of Agriculture Watershed Protection and Flood Prevention Program
- Department of Agriculture Energy Conservation Program
- Department of Agriculture Non-Insured Crop Disaster Assistance Program
- Army Corp of Engineers Floodplain Management Services Program
- Department of Homeland Security

State Funding Assistance Opportunities

State programs that may provide financial support for mitigation actions include, but are not limited to:

- DCED Flood Mitigation Program
- DCED H2O PA Flood Control, Water Supply, Sanitary Sewer and Stormwater Projects
- DCED PA Small Water and Sewer Program
- DCED Municipal Assistance Program
- DCNR Community Conservation Partnerships Program
- DCNR Pennsylvania Recreational Trails Program
- DEP Growing Greener Program
- Pennsylania Emergency Management Agency
- Pennsylvania Infrastructure Investment Authority
- PennDOT Pennsylvania Infrastructure Bank Loan

Local Funding Assistance Opportunities

Local programs that may provide financial support for mitigation actions include, but are not limited to:

- Lehigh County Local Emergency Planning Committee
- Northampton County Local Emergency Planning Committee
- County and Municipal Budgets
- County and Municipal DCED

5.2.4 Education and Outreach

This type of capability refers to education and outreach programs and methods already in place in a community that could be used to implement mitigation activities and communicate hazard-related information to the public, including Firewise Communities certification, StormReady certification, natural disaster or safety-related school programs, ongoing public education/ information program, public-private partnership initiatives, and local citizen groups of nonprofit organizations. The Firewise Communities program is a national program that emphasizes community involvement and provides information for residents to reduce the risk of wildland fire igniting homes. The National Weather Service StormReady program encourages communities to take a proactive approach to improving local hazardous weather operations and public awareness. Municipal responses to the education and outreach survey can be found in their municipal annexes.

Overall, Lehigh Valley municipalities have low to moderate education and outreach capabilities based on survey results. About 82% of municipalities that responded have an ongoing public education or information program in place. About 24% have natural disaster or safety-related school programs. Three municipalities have Firewise Communities certification. Both counties are StormReady certified and four municipalities indicated they have certification. Twelve municipalities cited public-private partnership initiatives. About half the municipalities responding identified local citizens groups or nonprofit organizations that provide education to the public. One municipality identified the presence of internal safety and public safety committees as an additional capability.

About 82% of municipalities did not identify any changes in education and outreach capabilities since the 2013 Plan. Of those indicating a change, enhanced websites, education provided to daycare staff and healthcare facilities, an active Environmental Advisory Council and increased outreach through newsletters were identified as some of the changes. When asked how capabilities can be improved, responses included funding, greater community/ business involvement, greater focus on hazard-related information, additional public presentations, obtain StormReady certification, emergency awareness meetings and a fire prevention initiative.

Lehigh County Emergency Management Agency and Northampton County Emergency Services have the following education and outreach capabilities:

Public Information Programs

- Flood Maps/Data – The counties have access to this type of information through their GIS departments, as well as other information that is available through the county assessment offices. Information available through the county assessment offices includes County/Municipality Maps, District/Ward Maps, Millage Rate schedules, Property Assessment Records and Deeds.
- Library Resources – The counties have educational materials available upon request that are used at public speaking events, when appropriate.

  - Pennsylvania Emergency Preparedness Guides

  - Various types of training videos

  - American Red Cross packets for flash flooding, hurricane, thunder and lightning, tornado, winter storms

  - Family disaster planning guides

  - Homeland Security information for businesses, families, individuals, neighborhoods and schools

  - Pandemic brochures

- Outreach Projects

  - **Are You Ready?** – An in-depth program for citizen Preparedness (individual, family and community preparedness). Provides a step-by-step approach to disaster preparedness by walking the student through how to get informed about local emergency plans, how to identify hazards that affect their area, and how to develop and maintain an emergency communications plan and disaster supply kit. Other topics covered include evacuation, emergency public shelters, animals in disaster and information specific to people with disabilities. The course also provides in-depth information on specific hazards such as floods, tornadoes, hurricanes, thunderstorms and lightning, winter storms and extreme cold, extreme heat, earthquakes, volcanoes, landslide and debris flows (mudslide), tsunamis, fires, wildfires, hazardous materials incidents, household chemical emergencies, nuclear power plant, and terrorism (explosion, biological, chemical, nuclear, and radiological hazards) and includes what to do before, during and after each hazard type.

  - **Ready…Pack…Go** – This Lehigh County program is to encourage community members and their families to be self-sufficient for at least 72 hours. The theme of “Ready…Pack…Go” is to be “ready” to have a plan for you and your family; “pack” to have pre-packed food, water and supplies; and “go” to a safe location based on the type of disaster. What if there was an emergency today? Are you ready? Learn how to protect yourself, your family and your pets!

  - **Red E. Fox Children’s 9-1-1 Program** – Northampton County participates in the Red E. Fox program. The mission and purpose of this

program is to teach children how to save lives and property through the proper use of 9-1-1, the nation's universal emergency telephone number. Red E. Fox delivers this message and teaches children when to use 9-1-1 and when not to, how to place a 9-1-1 call, and what to say to the dispatcher during a police, fire, or medical emergency. Red E. Fox was created as a 9-1-1 Public Safety icon in the tradition of Smokey Bear and McGruff the Crime Dog.

- **SERVPA** - SERVPA is a secure, confidential volunteer registry site. Volunteers that register through SERVPA are open to the idea of volunteering in case of an emergency. The registration provides a little about their background, preferences and constraints. It does not guarantee that they will be called upon, nor does it mean that they must participate if called. If a volunteer is called to assist in an event or emergency, they will have the opportunity to learn more about the specific event and the commitment required. Lehigh County has utilized this system for the past 10 years to call out volunteers during emergencies, announce training opportunities, provide call down drill notifications and announce outreach events. Northampton County is in the initial stages of building up its community volunteering program.

- **Community Emergency Response Teams (CERT)** – Training to educate citizens about disaster preparedness and training in basic disaster response skills, such as fire suppression, disaster medical operations, light search and rescue, team organization, disaster psychology, and terrorism awareness. The goal of this program is for emergency personnel to train members of neighborhoods, community organizations, or workplaces in basic response skills. If a disastrous event overwhelms or delays the community's professional response, CERT members can assist others by applying the basic response and organizational skills that they learned during training. These skills can help save and sustain lives following a disaster until help arrives.

- **Citizen Corps Council** – The mission of Citizen Corps is to harness the power of every individual through education, training, and volunteer service to make communities safer, stronger, and better prepared to respond to the threats of terrorism, crime, public health issues and disasters of all kinds.

- **Emergency Management courses** are provided through the county EMA offices to the local coordinators and elected officials. The following courses are provided: Duties and Responsibilities of the Local Emergency Management Coordinator (LEMC), Elected Officials Seminar, Initial Damage Assessment, Safe Schools Training, National Incident Management System, Work Environment of the LEMC and numerous FEMA Independent Study Courses.

- **Local Emergency Planning Committee (LEPC)** – The LEPC works closely with the business community to form a safety net around the chemical industry to protect the

general population from the possible outcome of hazardous material incidents. The LEPC has a minimum of seven members and includes at least one representative from each of the following groups:

- Elected Official representing local governments within the county
- Law enforcement, first aid, health, local environmental, hospital and transportation personnel
- Firefighting personnel
- Civil Defense and emergency management personnel
- Broadcast and print media
- Community groups not affiliated with emergency service groups
- Owners and Operators of facilities subject to the requirements of SARA Title III

- **Technical Assistance** – The county EMA offices can support local, public and private entities as needed through coordination and provision of information and equipment resources. These include both existing county capabilities, such as County Hazardous Materials Response Team and Technical Rescue Teams, and predetermined private and public resources.

■ The Lehigh County Special Operations Team is/has:

- Greater than 30 active members trained to Operations and Technician level in compliance with OSHA 1910.120.
- Personal Protective Equipment (PPE) for all levels of HazMat entry. Level A, B, C.
- Self-contained breathing apparatus for 22 team members with in-suit communications. Dedicated radio frequencies.
- Monitoring equipment for Radiation, Chemical & Biological Warfare, Mercury and Industrial Toxics available at any time.
- Spill Containment and Mitigation supplies for spills, large and small.
- Specialized equipment for tanker and rail car emergencies.
- Certifications in the following: Confined Space Rescue Technician, Trench Rescue Technician, Low and High Angle Rope Rescue, Structural Collapse, and Incident Command.
- Medically trained members in CPR, AED, EMT and Paramedic, Nurse and Doctors.
- Paramedics and Doctors trained in Rescue Medicine to aid in the care of Technical Rescue Patients.
- Drone program used for:
  - Damage Assessment
  - Active Incidents

■ Northampton County Emergency Management Services provides IMT: Incident Management Teams and support, and supplements the contractual Hazardous Materials Response Team of Lehigh County Special Operations during HazMat incidents through trained staff, support equipment and assets. Northampton County personnel staff two HazMat

technicians, while all others are trained to HazMat Operations Level.

Lehigh County provides contractual Hazardous Materials Response Team coverage to Northampton County.

Northampton County has specialized equipment and apparatus to support incidents, such as:

- Command Post
- Mobile Communication
- Chemical, Biological, Radiological, Nuclear and Explosives (CBRNE) support truck –
  - Carries specialized equipment for decontamination and air monitoring
  - Equipment to support HazMat operations
  - Radiological and air monitoring equipment
- HazMat support trailers
  - Equipment for mass decontamination
- Firefighting Foam trailers
  - Vapor suppression and/or firefighting for use with Hazardous materials incidents.

To protect the assets of both counties, the capabilities listed are a brief description of equipment and services provided within the two counties and any contiguous counties.

Lehigh and Northampton counties have already taken several steps to take control of the drug overdose epidemic. Northampton County created the Heroin and Opioid Overdose Task Force that secured a $103,000 state grant in 2017 to provide communities with Naloxone and to fund the Angel program, which enables addicts to turn in their drugs at any police station, without fear of arrest, in exchange for help in finding treatment. Lehigh County has instituted the Blue Guardian program, in which police and a recovery specialist, within a few days, visit the home of anyone who has been saved by Naloxone to help them seek treatment. Both counties have joined court actions seeking monetary damages from Opioid manufacturing companies to help fund more programs to control the crisis.

The LVPC also has a variety of informational resources available to the public. Many of the publications discussed previously are available for review by the public at the LVPC office or on the LVPC website. The LVPC also provides or hosts a variety of educational workshops for the public. The Lehigh Valley Government Academy has sponsored seminars related to stormwater management, floodplain issues, model environmental ordinances, Growing Greener-Conservation by Design, and basic courses in subdivision and land development review, zoning and community planning. The LVPC, in partnership with PennDOT, hosts the Local Technical Assistance Program, providing free technical information and proven

technologies dealing with roadway maintenance and safety methods. The LVPC's popular Planning and Pizza series included recent sessions on the regional Hazard Mitigation Plan, regional Comprehensive Plan, Monocacy Creek Act 167 Plan, Lehigh County Parks and Agriculture Planning and the Transportation Improvement Program. Copies of the floodplain mapping and flood studies prepared by FEMA for Lehigh County are available for public review at the LVPC office. The floodplain mapping currently in effect in Lehigh County is dated July 16, 2004. Paper copies of the Northampton County flood maps and studies, effective July 16, 2014, are not available at the LVPC, however, the LVPC responds to floodplain information requests from the public related to the mapping and studies.

Self-Assessment of Capability

In addition to the inventory and analysis of specific local capabilities, the Capability Assessment Survey required each municipality to complete its own self-assessment of its capability for each of the four categories to effectively implement hazard mitigation actions. Respondents were required to identify their degree of capability as "Limited", "Moderate" or "High". More than 80% of the municipalities responding to the survey did not identify any change in degree of capability for any of the four categories since the 2013 Plan. For those that did provide comments, several noted a higher degree of education and outreach capability due to improvements in community outreach through enhanced websites and use of social media. Several others noted an increase in the administrative and technical capability due to hiring new staff. One municipality indicated a lesser degree of capability for all four categories due to less staff and unfunded mandates using municipal funds. Responses to the survey can be found in the municipal annexes.

SUMMARY OF MUNICIPAL CAPABILITY SELF-ASSESSMENT RESPONSES*

	Limited	Moderate	High
Planning & Regulatory	18%	55%	27%
Administrative & Technical	16%	57%	27%
Financial	44%	34%	22%
Education & Outreach	33%	48%	19%

* Expressed as percentage of responses received.

5.2.5 Plan Integration

Plan integration is the process by which communities look critically at their existing planning framework and align efforts with the goal of building a safer, smarter community. Plan integration involves a two-way exchange of information and incorporation of ideas and concepts between hazard mitigation plans (state and local) and other community plans. Specifically, plan integration involves the incorporation of hazard mitigation principles and actions into community plans and community planning mechanisms into hazard mitigation plans. In the Lehigh Valley, there are many existing plans and programs that support hazard risk management, and so it is critical that the 2018 Plan continue to integrate and coordinate with, and complement, those mechanisms.

Numerous existing plans, studies, reports and technical information were reviewed and incorporated into the 2018 Plan. The use of this information is cited in the various sections where it is used. An all-inclusive list of resources used to prepare the Plan is located in Appendix A.

The Community Profile section was prepared using existing LVPC plans and data, including the ***Comprehensive Plan The Lehigh Valley…2030*** (2005), ***BuildLV: Lehigh Valley Annual Development Report*** (2017), ***MoveLV: Long Range Transportation Plan*** (2017) and ***The People*** (2017). Data incorporated into this section included environmental information, Lehigh Valley population and employment projections through 2040, development trends and transportation infrastructure. The LVPC also provided GIS mapping using existing layers. The US Census Bureau American Community Survey provided demographic and housing data.

An extensive list of data sources, vital to the identification of historical disaster events and their impacts on the region, was reviewed and incorporated into the Risk Assessment section, including the ***Comprehensive Plan The Lehigh Valley…2030*** (2005), National Climatic Data Center, Lehigh and Northampton County Knowledge Center databases, ***Pennsylvania 2013 Standard State All-Hazard Mitigation Plan***, among others. Federal Emergency Management Agency data related to Presidential Disaster Declarations, repetitive property losses and National Flood Insurance Program policies and claims were also incorporated into the 2018 Plan. Existing GIS layers were used in conjunction with existing Lehigh and Northampton County tax parcel data for the hazard vulnerability assessments. FEMA floodplain mapping for Northampton County, which became effective in July 2014, was incorporated into the Flood profile.

In addition, existing municipal plans and programs incorporated in the 2018 Plan are documented in the Capability Assessment Survey located in the municipal annexes.

It is the intention of this 2018 Plan that the municipalities continue to incorporate the findings and recommendations into future local planning efforts and into the overall execution of their land use planning process. Some of the most important planning and regulatory capabilities for hazard mitigation integration include comprehensive plans, zoning and subdivision/land development ordinances, emergency operations plans and building codes. Further, the sample adoption resolutions in Appendix I includes a resolution item stating the intent of the local governing body to incorporate mitigation planning as an integral component of government and partner operations. The Administrative Planning Team will work with local government officials to integrate hazard mitigation goals and actions into the general operations of government and partner organizations.

The two counties and municipalities in the Lehigh Valley recognize that the findings and recommendations of the 2018 Plan need to be incorporated into their emergency planning, preparedness, response and recovery programs and operations. Specifics about response and recovery programs and efforts in the Lehigh Valley have led to county and local mitigation actions to improve regional emergency management coordination and build related risk management capabilities. Public education and outreach to improve personal preparedness and promote an awareness of mitigation opportunities and personal protection through risk insurance have also been incorporated in county and local mitigation actions.

FutureLV: Lehigh Valley Comprehensive Plan

The LVPC, at the time of this 2018 Plan, was in the process of updating the ***Comprehensive Plan The Lehigh Valley…2030***, which was adopted by both counties in 2005. While the 2005 Comprehensive Plan does not specifically discuss hazard mitigation planning, the plan's goals, policies and strategies are aligned with the goals of the hazard mitigation plan. For example, the 2005 Comprehensive Plan includes a number of goals related to hazard mitigation planning, including, but not limited to the following:

- To minimize flood damage and protect floodplains
- To protect the remaining wetlands in the Lehigh Valley
- To minimize the adverse environmental impacts of steep slope development
- To minimize the hazards to development in areas where carbonate bedrock exists
- To protect and manage the region's woodland resources
- To preserve open space and important natural areas
- To provide a safe, well-maintained road network that facilitates the movement of traffic
- To construct highway and bridge improvements that are compatible with the conservation, development and redevelopment goals of the plan
- To support expansion of the public transit system and to advocate transit use as an alternative to single-occupant driving
- To manage the rate, volume and quality of storm runoff for protection of public safety and welfare, property and the environment

However, the LVPC recognizes the need to more fully integrate hazard mitigation principles in the comprehensive plan update, which will also incorporate ***MoveLV***, the

region's Long-Range Transportation Plan, in an effort to create a more disaster-resilient Lehigh Valley. In addition, new federal requirements state that future Long-Range Transportation Plan updates must work on "improving the resiliency and reliability of the transportation system and reducing or mitigating the stormwater impacts of surface transportation."

The intent of hazard mitigation planning is to be proactive by taking steps to mitigate potential impacts to persons and property prior to hazard events. Three of the four themes in ***One Lehigh Valley***—environment, transportation and livable communities—are common elements shared by the comprehensive plan and hazard mitigation plan. The ***Climate and Energy Element*** provides a number of preventive goals, policies and implementation strategies to be included in the regional comprehensive plan that can be used to lessen the impact of hazards. The goal of protecting public infrastructure from potentially harmful impacts associated with climate change is inextricably linked to the goals in the ***MoveLV: Long-Range Transportation Plan***, which will be integrated with all subsequent comprehensive plan updates. Many of the plans for the Lehigh Valley highlight the need to protect, conserve and enhance natural ecosystems to provide long-term resilience to climate change as a goal. In addition to protecting natural resources, the ***Climate and Energy Element*** addresses the impacts of future development. One goal advocates providing building and site design practices that help to mitigate climate change impacts. These goals were created to protect residents, property and critical facilities from natural hazards that evolve over time due to climate change.

The ***Lehigh Valley Return on Environment*** (2014), which quantifies the economic benefits provided by open space for natural systems services, air quality, outdoor recreation and property value, has many ties to hazard mitigation planning that can be integrated into ***FutureLV***. Natural system services includes flood mitigation, water supply and soil retention benefits of open space that clearly link to hazard mitigation. Further, the air quality monetary benefits are partially based on the carbon sequestration benefits of trees to mitigate the impacts of climate change and reduce impacts such as drought, extreme temperature and severe weather. Importantly, the ***Return on Environment*** study assigns dollar values to these resources that aid in securing funding for projects that protect them.

The ***Floodplain Guide|Model Regulation*** (2014) deals directly with municipalities maintaining compliance with the National Flood Insurance Program and actions to provide higher regulation of flood prone areas, especially related to repetitive loss and severe repetitive loss properties.

The ***Green Infrastructure Guidelines*** (LVPC 2017) and the ***Monocacy Creek Act 167 Plan*** (2018) bring two important hazard mitigation elements regarding water balance and use of green stormwater practices to ***FutureLV***. Water balance refers to how rainfall is distributed to groundwater recharge, runoff and evapotranspiration to the atmosphere by the natural environment versus the built environment. Replacement of meadows, agriculture and other pervious surfaces that allow infiltration to groundwater with impervious surfaces that prevent infiltration can significantly increase runoff and reduce groundwater recharge and evapotranspiration. Stormwater management practices also have a significant

impact on water balance, whether designers choose detention basins, rain gardens or underground infiltration facilities, for example. Standards in the Monocacy Plan seek to create a built environment with stormwater management controls that mimic the natural water balance, thereby providing drought and flood mitigation benefits. The green infrastructure guidelines work hand in hand with the water balance standards by requiring green infrastructure practices “first “ in a land development plan. This translates to preserving a site’s natural resources as much as possible and using vegetative stormwater management practices. Both practices provide climate change mitigation along with flood, drought and extreme temperature mitigation, among others. Further, these efforts are part of the larger ***One Water*** effort to consider all aspects of water management planning and integrate with land use planning and comprehensive planning.

The ***Livable Landscapes*** plans created for Lehigh and Northampton counties bring together the elements of the various LVPC open space and natural resources plans and policies including all the guides and model ordinances, the Lehigh Valley Planning Commission Natural Resources Plan, Natural Heritage Inventory, ***Return on Environment*** study and the ***Greenways Plan***, among others. These efforts reinforce the hazard mitigation benefits of natural resources, build on the existing goals, policies and implementation strategies of the Comprehensive Plan and align with the natural resource goal of the hazard mitigation plan.

CAPABILITY ASSESSMENT SUMMARY

The described capabilities at the county and local levels when compared to the hazard risks for the Lehigh Valley identify gaps in capability that should be reconciled with recommended actions. The intention is to improve future capabilities thereby further reducing the Lehigh Valley’s vulnerability to hazard risks and improving the overall resiliency of the region. The capability assessment resulted in mitigation actions identified by the counties, LVPC and municipalities to enhance the capabilities of the Lehigh Valley.

6. MITIGATION STRATEGY

6.1 UPDATE PROCESS SUMMARY

The 2018 Plan focuses on improving the county and local mitigation strategies from the 2013 Plan. Throughout the planning process, both counties and all municipalities were encouraged to thoroughly consider their natural and non-natural hazard risks and vulnerabilities, and to identify appropriate actions to mitigate those risks.

The 2006 and 2013 Lehigh Valley Hazard Mitigation Plans included goals and actions. Objectives are a new component of the 2018 Plan. Goals are general guidelines that describe what the region would like to achieve. Objectives define strategies that must be implemented to achieve the identified goals and are specific and measureable. Actions provide more detailed descriptions of specific work tasks to help the counties and municipalities achieve prescribed goals and objectives.

Objectives were developed and included in the 2018 Plan. A mitigation technique matrix was completed to identify and evaluate possible mitigation actions for each hazard. Municipal actions were categorized and prioritized on a regional basis. National Flood Insurance Program-related actions are identified.

2
Counties and
62
municipalities
have devised
1,161
actions designed
to prepare the
Lehigh Valley
for disaster

For the 2018 Plan, the eight existing goals from the 2013 Lehigh Valley Plan were reviewed with the Planning Team, stakeholders and the public. The public was provided opportunities to comment on the existing goals through public meetings. Four comments were received on the goals. Four of the goals were confirmed and carried over to the 2018 Plan and four were revised slightly. The goals were revised in some cases to be more specific or inclusive, such as including woodlands under natural resources and including functional loss in addition to damages. In other cases, they were revised to be less specific to integrate with the newly created objectives, such as removing repetitive loss structures from the hazard avoidance goal, and to better reflect actions appropriate at both the county and local government levels.

The Planning Team concurred with the proposed revisions to the goals. The *Pennsylvania 2013 Standard State All-Hazard Mitigation Plan* was also reviewed to ensure that the 2018 Plan goals complement and support the five state goals identified below:

- Protect lives, property, environmental quality, and resources of the Commonwealth, including Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties.
- Enhance consistent coordination, collaboration, and communications among stakeholders.
- Provide a framework for active hazard mitigation planning and implementation.
- Build legislative support and secure funding for mitigation efforts.
- Increase awareness, understanding, and preparedness across all sectors.

The 2013 Lehigh Valley Plan identified 937 municipal actions to mitigate the impact of hazards and 45 county-level actions/initiatives, which included actions for the LVPC.

The status of these actions, whether completed, discountinued or no progress, was documented as part of this 2018 plan to identify those actions to be carried forward.

6.2 MITIGATION GOALS AND OBJECTIVES

To ensure the goals reflect updated conditions, the goal evaluation process included a review of the updated capability assessment and risk assessment, which included three new hazard profiles. Based on this review, the Planning Team determined that the revised goals reflect the region's vision for a disaster-resilient Lehigh Valley.

For the 2018 Plan, objectives were created for each of the eight goals for a total of 23 objectives. The Planning Team reviewed and concurred with the objectives. Goals and objectives that relate to a community's continued compliance with the National Flood Insurance Program are noted with (NFIP).

Goal 1: To minimize the risk to human life associated with natural and non-natural hazards (NFIP).

OBJECTIVES:

A. Create a better understanding among the public and local governments of the benefits and opportunities associated with hazard mitigation planning and actions. (NFIP)

B. Continuously promote and maintain better early warning and emergency communications.

C. Provide added protection for vulnerable populations. (NFIP)

Goal 2: To promote hazard avoidance, especially in floodplains (NFIP).

OBJECTIVES:

A. Minimize future risks of losses associated with structures, including repetitive loss structures. (NFIP)

B. Reduce flooding potential through planning, training and outreach. (NFIP)

C. Encourage and facilitate the development or revision of comprehensive plans and zoning/land use ordinances to limit development in high-hazard areas.

Goal 3: To reduce the damages and functional loss from natural and non-natural hazards to existing and future public and private assests, including structures, critical facilities and infrastructure (NFIP).

OBJECTIVES:

A. Identify the current risks of critical facilities and infrastructure from hazards, and determine actions to lessen those risks in the future. (NFIP)

B. Encourage and/or perform regular maintenance and upgrades of existing drainage systems potentially impacting critical facilities.

C. Encourage and/or provide backup power resources (generators) for critical facilities.

Goal 4: To preserve and enhance the effectiveness of natural resources, including woodlands, streams, rivers, wetlands, floodplains and riparian buffers to provide resiliency benefits (NFIP).

OBJECTIVES:

A. Encourage and/or provide maintenance and restoration of streams and rivers and associated floodplains to naturally provide flood mitigation.

B. Encourage regulation of and/or regulate development in priority conservation areas, including floodplains, to minimize flood damage. (NFIP)

Goal 5: To develop, prioritize and implement cost-effective, long-term actions that will reduce the impacts of natural and non-natural hazards (NFIP).

OBJECTIVES:

A. Thoroughly assess the community and established capabilities and identify specific cost-effective actions for improvement, relative to existing and future hazard risks. (NFIP)

B. Establish mitigation action priorities and encourage and track progress. (NFIP)

Goal 6: To improve local regulations to reduce the impacts of natural and non-natural hazards (NFIP).

OBJECTIVES:

A. Better integrate hazard mitigation planning with comprehensive planning and land use regulations. (NFIP)

B. Identify and promote “best practices” for municipal regulation of land use in zoning and subdivision ordinances and official maps.

C. Encourage proactive planning for potential hazard events and potential related property damage. (NFIP)

D. Incorporate hazard mitigation planning into existing municipal policy.

Goal 7: To enhance planning and emergency response efforts among federal, state, county and local emergency management personnel to protect public health and safety.

OBJECTIVES:

A. Continually improve communication capabilities, training and coordination for hazard events.

B. Continually improve the planning for shelters, evacuation routes and disaster recovery.

C. Continue the promotion of disaster resiliency in the business community.

D. Maintain and/or upgrade emergency response equipment and resources.

Goal 8: To promote public awareness on both the potential impacts of natural and non-natural hazards and actions to reduce those impacts (NFIP).

OBJECTIVES:

A. Encourage and/or provide education and outreach to increase awareness of hazards and opportunities for mitigation. (NFIP)

B. Encourage and/or provide public education programs for businesses, households and individuals on mitigation, safety measures and preparedness.

6.3 IDENTIFICATION AND ANALYSIS OF MITIGATION TECHNIQUES

The 2018 Plan mitigation strategy included an analysis of a comprehensive range of mitigation actions with an emphasis on existing and new buildings. The *Commonwealth of Pennsylvania All-Hazard Mitigation Planning Standard Operating Guide*, October 2013, and FEMA *Local Mitigation Planning Handbook*, March 2013, identify four types of actions or techniques for consideration in developing the mitigation action plan:

- **Local Plans and Regulations**
- **Structure and Infrastructure**
- **Natural Systems Protection**
- **Education and Awareness**

Mitigation techniques for each hazard are shown in Table 6.3.1.

Table 6.3.1 Mitigation Techniques

	MITIGATION TECHNIQUE CATEGORIES			
Hazard	**Local Plans and Regulations**	**Structure and Infrastructure**	**Natural Systems Protection**	**Education and Awareness**
Natural Hazards				
Drought	X	X	X	X
Earthquake	X	X		X
Extreme Temperature	X	X	X	X
Flood, Flash Flood, Ice Jam	X	X	X	X
Hailstorm		X		X
Invasive Species	X		X	X
Landslide	X	X	X	X
Lightning Strike	X	X		X
Pandemic and Infectious Disease				X
Radon Exposure		X		X
Subsidence/Sinkhole	X	X	X	X
Wildfire	X	X	X	X
Windstorm/Tornado	X	X		X
Winter Storm		X		X
Non-Natural Hazards				
Civil Disturbance/Mass Gathering		X		X
Dam Failure	X	X		X
Drug Overdose Crisis				X
Environmental Hazards/Explosion	X	X		X
Fire (Urban/Structural)	X	X		X
Levee Failure	X	X		X
Nuclear Incident	X	X		X
Structural Collapse	X	X		X
Terrorism	X	X		X
Transportation Crash	X	X		X
Utility Interruption		X		X

6.4 MITIGATION ACTION PLAN

On January 18, 2018, mitigation strategy ideas were reviewed with and provided to Planning Team members for their consideration. Municipalities were informed that they need at least one mitigation action in the 2018 Plan. Further, all 62 municipalities must have at least one action that relates to continued compliance with the NFIP. During the planning process, municipalities were encouraged to identify mitigation actions, focusing on identifying well-defined, implementable projects with a careful consideration of capabilities, risk reduction, losses avoided, costs and possible funding sources, including mitigation grant programs. Each municipality has identified more than one mitigation action, with at least one that relates to continued NFIP compliance. For the 2018 Plan, 1,102 actions covering all 62 participating municipalities are included in the municipal annexes. An additional 59 county-level actions are identified for the 2018 Plan in the county annex.

More than one related action is provided for each hazard in the 2018 Plan. For the three new hazards—Pandemic and Infectious Disease, Invasive Species and Drug Overdose Crisis—"common" actions related to the three hazards were developed by the Administrative Planning Team for municipal consideration. All municipalities were asked to review the actions and accept, amend or decline any of the actions, or develop their own actions. Fifteen municipalities included all the "common" actions, while ten other municipalities accepted some of the actions or amended them as appropriate for their community.

With the completion of the evaluation of 2013 Plan mitigation actions, those actions identified as "Complete" were removed from the 2018 mitigation actions unless they were part of a larger, ongoing action. Two examples of this are 1) multi-part projects where one or more parts were completed but other parts remain, and 2) continuous actions such as maintaining compliance with the NFIP, where a completed action since 2013 was adopting an updated floodplain ordinance. 2013 actions identified as "Discontinued" have been removed from this Plan. The 2013 actions identified as "No Progress/Unknown", "In Progress/Not Yet Complete" or "Continuous" have been carried forward in the 2018 Plan. The status of the 2013 Plan actions is provided in the municipal annexes.

Throughout the planning process, the public, through the public meetings, was given the opportunity to identify potential mitigation actions to be included in the Plan.

With all municipal 2018 actions identified, a region-wide mitigation action plan summary was created by categorizing all municipal actions under 28 regional action headings. Specific 2018 actions for each community are identified in the municipal annexes. For each regional action listed, the number of municipalities that include that action in their municipal annex is provided. Actions related to continued NFIP compliance are also identified in the action plan summary. The municipal action plan summary is shown in Table 6.4.1.

In addition, mitigation action numbers that apply to each municipality are documented in the Municipal Action Matrix shown in Table 6.4.2.

Table 6.4.1 Municipal 2018 Action Plan Summary

Regional Action Number	Action Description	# of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New/Existing Structures	Goal-Objective #	Priority
1	Retrofit structures in flood-prone areas, with repetitive and severe repetitive loss properties as a priority	48	Flood	Structure and Infrastructure	Existing	2-A	High
2	Purchase or relocate structures in hazard prone areas	47	Flood, Landslide, Subsidence/Sinkhole, Dam and Leves Failure	Structure and Infrastructure	Existing	2-A	High
3	Maintain compliance with the National Flood Insurance Program, including enforcement of floodplain management requirements, floodplain identification and mapping, and flood insurance outreach (NFIP)	57*	Flood	Local Plans and Regulations	Existing	2-A	High
4	Conduct and facilitate community and public outreach for residents and businesses to promote and effect hazard risk reduction (NFIP)	59*	All	Education and Awareness	Both	8-A	High
5	Begin and/or continue the process to adopt higher regulation of floodplains and carbonate bedrock areas (NFIP)	47*	Flood, Subsidence/Sinkhole	Local Plans and Regulations	N/A	2-C	High
6	Determine if CAV or CAC visit is needed and schedule (NFIP)	46	Flood	Local Plans and Regulations	Both	2-B	Low
7	Have designated Floodplain Administrator certified and/or pursue continuing education training (NFIP)	46	Flood	Local Plans and Regulations	N/A	2-B	Medium
8	Participate in the Community Rating System (NFIP)	45*	Flood	Local Plans and Regulations	N/A	2-A	High
9	Obtain/archive elevation certificates (NFIP)	47	Flood	Local Plans and Regulations	N/A	2-A	Low
10	Continue to support implementation, monitoring, maintenance and updating of the plan	61*	All	All	Both	5-C	High
11	Develop/enhance Comprehensive Emergency Management Plans	62*	All	Local Plans and Regulations	Both	6-C	Medium
12	Create/enhance/maintain mutual aid agreements with neighboring communi-ties for continuity of operations	56*	All	All	Both	7-A	Medium
13	Improve post-disaster capabilities, including processing FEMA/PEMA paperwork and qualified damage assessment personnel	55	All	Education and Awareness	N/A	7-A	Low

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

Table 6.4.1 Municipal 2018 Action Plan Summary

Regional Action Number	Action Description	# of Municipalities	Hazards Addressed	Mitigation Technique Category	Applies to New/Existing Structures	Goal-Objective #	Priority
14	Work with regional agencies to develop damage assessment capabilities through training programs, certification of qualified individuals such as floodplain managers (NFIP)	61*	All	Education and Awareness	N/A	5-A	Medium
15	General storm drainage/flooding projects	8	Flood	Structure and Infrastructure	Existing	5-A	Medium
16	Specific storm drainage/flooding projects (non-critical facilities)	22	Flood	Structure and Infrastructure	Existing	5-A	Medium
17	Critical facilities - storm drainage/flooding projects or relocation	3	Flood	Structure and Infrastructure	Existing	3-B	High
18	Critical facilities - back-up power projects	11	All	Structures and Infrastructure	Existing	3-C	High
19	Critical facilities - other projects	16*	All	Structures and Infrastructure	Existing	3-A	High
20	Emergency notifications/ communication/traffic control	4*	All	Education and Awareness	Existing	1-C	High
21	Stream or floodplain restoration/ stabilization projects	8	Flood	Natural Systems Protection	Existing	4-A	Medium
22	Work to minimize tree/electric line conflicts	9*	Windstorm/Tornado, Winter Storm	Structure and Infrastructure	Existing	3-A	High
23	Geotechnical/sinkhole evaluation (adopt construction standards, remediation)	3	Subsidence/Sinkhole	Local Plans and Regulations	Both	6-C	High
24	Hazardous materials inventory/emergency planning, education, certification	4	Environmental/Hazards/ Explosion	Education and Awareness	Both	5-A	High
25	Dam/levee projects	3	Flood, Earthquake	Structure and Infrastructure	Existing	3-A	Medium
26	Specific bridge replacement or retrofits	8*	Flood	Structure and Infrastructure	Existing	3-A	Medium
27	Wildfire mitigation	1	Wildfire	All	Existing	5-A	Medium
28	Integrate hazard mitigation into local plans and ordinances	4*	All	Local Plans and Regulations	Both	6-A	High

*County-level mitigation actions are also associated with these categories, noting that for actions that are specifically a municipal responsibility, such as maintaining National Flood Insurance Program compliance, the county actions include encouraging and supporting municipal efforts.

Table 6.4.2 Municipal Action Matrix

Lehigh County	Regional Action Numbers
Alburtis Borough	10-11,14,19,22
Allentown City	1-14, 16-17, 26
Bethlehem City*	1-14, 25
Catasauqua Borough	1-16, 19-21, 23
Coopersburg Borough	4, 10-11, 14-15, 19
Coplay Borough	3-5, 10-14,19, 22
Emmaus Borough	1-4, 9-11, 14-15, 19, 22
Fountain Hill Borough	3-4, 10-14, 19, 24
Hanover Township	1, 3-14
Heidelberg Township	10-12, 14, 16, 18-19, 22
Lower Macungie Township	1-14, 21, 26
Lower Milford Township	3-14, 16, 19
Lowhill Township	1-14
Lynn Township	3-4, 10-15, 18
Macungie Borough	1-4, 10-14, 16, 21
North Whitehall Township	3-4, 10-14, 19
Salisbury Township	3-4, 10-14, 23
Slatington Borough	10-11, 14,19, 22
South Whitehall Township	1-4, 10-14, 16, 18
Upper Macungie Township	1-14, 25
Upper Milford Township	1-14, 19, 22
Upper Saucon Township	1-14, 16, 26
Washington Township	10-11, 14, 19, 22
Weisenberg Township	3-4, 10-14, 19
Whitehall Township	1-14, 16, 18-20, 26

* Includes Lehigh and Northampton County portions

Northampton County	Regional Action Numbers
Allen Township	1-14
Bangor Borough	1-14, 16
Bath Borough	1-14, 16, 18
Bethlehem Township	3-4, 10-15, 24
Bushkill Township	1-14
Chapman Borough	1-14, 16
East Allen Township	3-4, 11, 15-16, 24, 26
East Bangor Borough	1-14, 18,26
Easton City	1-14, 16, 25-26
Forks Township	1-14
Freemansburg Borough	1-14, 16
Glendon Borough	1-14
Hanover Township	1-14
Hellertown Borough	1-17, 21, 24, 28
Lehigh Township	1-14, 18-20
Lower Mt. Bethel Township	1-14
Lower Nazareth Township	1-14
Lower Saucon Township	1-14, 16, 21
Moore Township	1-15
Nazareth Borough	1-14, 18
North Catasauqua Borough	1-14
Northampton Borough	1-14, 18-19, 21
Palmer Township	1-14, 28
Pen Argyl Borough	1-14
Plainfield Township	1-14, 16, 18, 27-28
Portland Borough	1-14, 16
Roseto Borough	1-14
Stockertown Borough	1-14, 20
Tatamy Borough	1-7, 9-14, 17, 21, 23, 28
Upper Mt. Bethel Township	1-14, 16, 22, 26
Upper Nazareth Township	1-14
Walnutport Borough	1-14
Washington Township	1-14, 16, 21
West Easton Borough	1-14
Williams Township	1-14, 16
Wilson Borough	1-14
Wind Gap Borough	1-14, 16, 18

The regional actions were prioritized against one another on a Lehigh Valley-wide basis by applying the PEMA Multi-Objective Mitigation Action Prioritization criteria. The weighted criteria include:

- Effectiveness (20% of score) – The extent to which an action reduces the vulnerability of people and property.
- Efficiency (30% of score) – The extent to which time, effort and cost is used as a means of reducing vulnerability.
- Multi-Hazard Mitigation (20% of score) – How much the action reduces vulnerability for more than one hazard.
- Addresses High Risk Hazard (15% of score) – How the action reduces vulnerability for people and property from a hazard(s) identified as high risk.
- Addresses Critical Communications/Critical Infrastructure (15% of score) – How the action pertains to the maintenance of critical functions and structures such as transportation, supply chain management, data circuits, etc.

Scores of 1-3 were assigned for each of the criteria, where 1 is low and 3 is high. Actions were then prioritized using the cumulative score assigned to each. Each mitigation action was given a priority ranking (Low, Medium or High) based on the following:

- Low Priority: 0-1.8
- Medium Priority: 1.9-2.4
- High Priority: 2.5-3

Through this method, the benefits that would result from a mitigation action were considered versus the cost based on a planning-level assessment. The benefits of an action on a general basis are examined under the Effectiveness, Multi-Hazard Mitigation, Addresses High Risk Hazard and Addresses Critical Communications/Critical Infrastructure categories. Cost is examined in the Efficiency category. A full benefit-cost analysis is typically the next step in the process of implementing mitigation actions.

The mitigation action prioritization results are located in Table 6.4.3.

Within the municipal annexes, the mitigation actions that were carried over from the 2013 Plan had been evaluated and prioritized in the 2013 Plan primarily using the PA STEEL (Political, Administrative, Social, Technical, Economic, Environmental, and Legal) methodology defined by state and federal guidelines. Municipalities were requested to update information associated with their 2013 Plan actions from their annex, which includes action priority. Based on this evaluation, there were no changes in priority for these actions at the municipal level, which may differ from the priority at the regional level. Any new actions added by a community were prioritized according to community assessment of vulnerabilities, considering benefits and cost-effectiveness.

The municipal annexes present the updated mitigation strategies identified by both counties and all participating municipalities, including:

- Mitigation actions for individual and multiple hazards
- Identification of the mitigation technique category
- Department or agency primarily responsible for project initiation and/or implementation
- Estimated cost (if known) for the mitigation action, and identification of known or potential sources of funding

Table 6.4.3 Mitigation Action Prioritization

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria Low = 0-1.8 Medium = 1.9-2.4 High = 2.5-3					
Regional Action Number	Action Description	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score/Priority
1	Retrofit structures in flood-prone areas, with repetitive and severe repetitive loss properties as a priority	3	3	1	3	2	2.5
2	Purchase or relocate structures in hazard prone areas	3	3	3	3	2	2.9
3	Maintain compliance with the National Flood Insurance Program, including enforcement of floodplain management requirements, floodplain identification and mapping, and flood insurance outreach	3	3	1	3	3	2.6
4	Conduct and facilitate community and public outreach for residents and businesses to promote and effect hazard risk reduction	3	2	3	3	2	2.6
5	Begin and/or continue the process to adopt higher regulation of floodplains and carbonate bedrock areas	3	3	2	3	2	2.7
6	Determine if CAV or CAC visit is needed and schedule	2	2	1	3	1	1.8
7	Have designated Floodplain Administrator certified and/or pursue continuing education training	2	3	1	3	1	2.1
8	Participate in the Community Rating System	3	3	1	3	2	2.5
9	Obtain/archive elevation certificates for National Flood Insurance Program compliance	1	2	1	3	1	1.6
10	Continue to support implementation, monitoring, maintenance and updating of the plan	3	2	3	3	2	2.6
11	Develop/enhance Comprehensive Emergency Management Plans	2	2	3	3	2	2.4
12	Create/enhance/maintain mutual aid agreements with neighboring communities for continuity of operations	1	2	3	3	2	2.2

Table 6.4.3 Mitigation Action Prioritization

Mitigation Actions		Multi-Objective Mitigation Action Prioritization Criteria Low = 0-1.8 Medium = 1.9-2.4 High = 2.5-3					
Regional Action Number	Action Description	Effectiveness	Efficiency	Multi-Hazard Mitigation	Addresses High Risk Hazard	Addresses Critical Communications/ Critical Infrastructure	Total Score/Priority
13	Improve post-disaster capabilities, including processing FEMA/PEMA paperwork and qualified damage assessment personnel	1	1	3	1	1	1.4
14	Work with regional agencies to develop damage assessment capabilities through training programs, certification of qualified individuals such as floodplain managers	1	2	3	3	1	2.0
15	General storm drainage/flooding projects	3	2	1	3	1	2.0
16	Specific storm drainage/flooding projects (non-critical facilities)	3	2	1	3	3	2.0
17	Critical facilities - storm drainage/flooding projects or relocation	3	3	1	3	3	2.6
18	Critical facilities - back up power projects	3	3	3	3	3	3.0
19	Critical facilities - other projects	3	3	3	3	3	3.0
20	Emergency notifications/communication/ traffic control	3	2	3	3	3	2.7
21	Stream or floodplain restoration/ stabilization projects	3	2	1	2	1	1.9
22	Work to minimize tree/electric line conflicts	3	3	2	3	3	2.8
23	Geotechnical/sinkhole evaluation (adopt construction standards, remediation)	3	3	3	2	2	2.7
24	Hazardous materials inventory/emergency planning, education, certification	3	3	1	3	2	2.5
25	Dam/levee projects	3	2	2	2	3	2.4
26	Specific bridge replacement or retrofits	2	2	1	3	3	2.1
27	Wildfire mitigation	3	2	1	2	1	1.9
28	Integrate hazard mitigation into local plans and ordinances	3	3	3	3	1	2.7

- Implementation schedule
- Implementation priority
- Effect of mitigation action on new or existing structures

The implementation of the specific mitigation actions identified in the municipal annexes is dependent on the approval of the local elected governing body and the ability of the municipality to obtain funding from local or outside sources. In general, mitigation actions ranked as high priority will be addressed first. However, medium or even low priority mitigation actions will be considered for concurrent implementation. Therefore, the ranking levels should be considered as a first-cut, preliminary ranking and will evolve based on prevailing priorities and decisions of local governments, the public, PEMA and FEMA as the 2018 Plan is implemented.

The county-level mitigation actions impact all the municipal mitigation actions in the form of encouragement, technical support and training as needed to accomplish the municipal objectives. In addition, Lehigh County, Northampton County and the Lehigh Valley Planning Commission have identified a variety of mitigation actions regarding the monitoring and maintenance of the hazard mitigation plan, integration of hazard mitigation into county-level plans and specific projects to be implemented at the county level to enhance hazard mitigation and resiliency. The 59 projects at the county level (including one project that has eight sub-parts) are fully described in the county annex. These projects impact 13 of the regional mitigation actions as noted by the asterisks in the Municipal 2018 Action Plan Summary, most notably Action Number 4 regarding community outreach.

With the exception of the three new hazards and associated impacts on the region as identified in the Risk Assessment section of this Plan, overall plan priorities remain relatively unchanged from the previous plan. However, the Administrative Planning Team recognizes that a concerted effort is necessary to keep the momentum of the Plan going during the five-year plan update period. The county-level mitigation actions for the 2018 Plan include a greater emphasis on hazard mitigation priorities moving forward.

Without a strong commitment from county and local leaders, effective implementation of the Plan will not be successful. This 2018 Plan aims to ensure that participation, as well as monitoring and evaluation, continues throughout the five-year plan update period.

HAZARD MITIGATION PRIORITIES

1. Improve the integration of hazard mitigation planning into existing plans, policies and programs, especially related to infrastructure and capital improvements programming.
2. Identify more funding opportunities and improve the ability to compete for hazard mitigation project funding, in part by encouraging development of projects that are consistent with the funding guidelines of the Pennsylvania and Federal Emergency Management Agencies, especially with regard to cost-effectiveness.
3. Improve the thoroughness and consistency of hazard mitigation outreach to the public and business community through coordinated county and municipal efforts across varied media and social media platforms.
4. Begin implementation of the Community Rating System at the municipal level to strengthen a community's floodplain management program, resulting in the reduction of flood insurance rates for those properties located within flood prone areas.
5. Commit to annual monitoring and updating of the hazard mitigation plan, as necessary, to ensure plan effectiveness and currency.

Mitigation Action Successes

The key to successful hazard mitigation planning is implementation of mitigation actions, demonstrating progress in risk reduction. Since the 2013 Plan, a total of 124 actions have been completed by the municipalities.

The list of completed municipal actions is included in Table 6.4.4.

Flood-related actions were the primary types of actions completed in the region, which is not surprising since flooding is one of the highest ranked hazards in the Lehigh Valley. FEMA floodplain mapping for Northampton County went into effect in July 2014. To maintain compliance and remain in good standing with the National Flood Insurance Program, all 38 Northampton County communities adopted an updated floodplain ordinance to reflect the new mapping. A number of storm drainage/flooding projects (21) were completed, involving both critical and non-critical facilities. Six projects were completed that involved retrofitting structures or purchasing/relocating structures in flood-prone areas located in five municipalities. Six municipalities indicated that their Floodplain Administrator was certified.

In addition to flood-related projects, eight back-up power projects were completed for critical facilities in eight municipalities.

Lehigh and Northampton counties completed the countywide generator projects, providing grant administration and technical support as needed to municipalities awarded funding for generator projects. Lehigh County provided grant administration and technical support for the Lower Milford Township Creek Stabilization Project, which stabilized a section of the Hosensack Creek that was threatening Schultz Bridge Road near its intersection with Buchman Road. Northampton County completed its effort to join the National Oceanic and Atmospheric Administration (NOAA) StormReady program, which is designed to enhance a community's resilience to severe storms.

Table 6.4.4 Municipal Action Completions Summary

Regional Action Number	Action Description	Actions Completed
1	Retrofit structures in flood-prone areas	3
2	Purchase or relocate structures in hazard prone areas	3
3	Maintain compliance with and good standing in NFIP	38
4	Conduct and facilitate community and public outreach	2
5	Begin the process to adopt higher regulation of floodplains and carbonate bedrock areas	10
6	Determine if CAV or CAC visit is needed and schedule	5
7	Have designated Floodplain Administrator certified	6
8	Participate in the Community Rating System	0
9	Archive elevation certificates	1
10	Continue to support implementation and monitoring of plan	0
11	Develop/enhance Comprehensive Emergency Management Plans	4
12	Create/enhance/maintain mutual aid agreements	4
13	Improve post-disaster capabilities	3
14	Work with regional agencies to develop damage assessment data	2
15	General storm drainage/flooding projects	0
16	Specific storm drainage/flooding projects (non-critical facilities)	12
17	Critical facilities - storm drainage/flooding projects or relocation	9
18	Critical facilities - back up power projects	8
19	Critical facilities - other projects	2
20	Emergency notifications/communication/traffic control	2
21	Stream or floodplain restoration/stabilization projects	2
22	Work to minimize tree/electric line conflicts	1
23	Geotechnical/sinkhole evaluation (adopt construction stds, remediation)	1
24	Hazardous materials inventory/emergency planning, education, certification	0
25	Dam/levee projects	3
26	Specific bridge replacement or retrofits	3
27	Wildfire mitigation	0
28	Integrate hazard mitigation into local plans and ordinances	0
	TOTAL	124

7. PLAN MAINTENANCE

7.1 UPDATE PROCESS SUMMARY

Monitoring, evaluating and updating the *Lehigh Valley Hazard Mitigation Plan* is critical for it to be usable and valuable. Following through on the actions laid out in the Plan is important to maintaining the momentum created by the municipal, county, state, federal and community partners who worked together to build it.

For the 2018 Plan, the Administrative Planning Team is committed to meeting annually, preparing progress reports for incorporation in the next plan update and meeting after significant hazard events that may require changes to the Plan.

The 2018 Plan identifies the positions responsible to lead the maintenance effort. Plan maintenance is now the joint responsibility of both counties. The discussion on Implementation of the Mitigation Plan through Existing Programs has been moved to the Capability Assessment section.

The *Lehigh Valley Hazard Mitigation Plan* will be subject to annual progress reports and a digital version will be available at:

lvpc.org/hazard-mitigation.html

7.2 MONITORING, EVALUATING AND UPDATING THE PLAN

The Lehigh Valley Hazard Mitigation Administrative Planning Team will remain intact as the group responsible for monitoring, evaluating and updating the 2018 Plan. The Administrative Planning Team will be co-chaired by the Lehigh County Director of Emergency Management Agency or their designee and the Northampton County Director of Emergency Management Services or their designee.

Each participating municipality in the Lehigh Valley is expected to maintain a Planning Team point of contact, and the Administrative Planning Team co-chairs are responsible for maintaining an updated list of municipal points of contact who will assist in keeping the plan current. Municipal points of contact for the 2018 Plan are identified in the municipal annexes. It shall be the responsibility of each municipality to inform the Administrative Planning Team co-chairs of any changes in their municipal representation.

If any member of the Administrative Planning Team can no longer fulfill their duties to the team, it is the responsibility of the co-chairs to choose their replacement.

The co-chairs will call the annual meetings of the Administrative Planning Team and Planning Team to evaluate the Plan's progress and effectiveness. The meetings should be in October, to allow municipal participants sufficient time to review their action plans and prepare grant applications in advance of the annual FEMA Hazard Mitigation Assistance Program announcements, typically in May.

The responsibilities of the Administrative Planning Team co-chairs shall include:

- Encouraging each municipality to adopt the 2018 Plan within one year of its passage.
- Contacting each municipal point of contact to request information regarding the status of mitigation actions and whether any new actions should be added due to changing conditions.
- Compiling the updated information and public outreach completed in an annual progress report, to be posted on the Hazard Mitigation webpage at lvpc.org/Hazard-Mitigation.
- Convening the Administrative Planning Team and the Planning Team for annual meetings and within 60 days of any significant disaster that may require changes to the plan.
- Providing FEMA and PEMA with all annual progress reports.
- Ensuring annual progress reports are incorporated into the five-year update.
- Providing opportunities for public input.

Each participating municipality, the counties or any other ancillary organization are responsible for implementing their mitigation actions and informing the Administrative Planning Team annually of any progress made. This includes incorporating those actions into other planning documents, such as comprehensive plans, zoning ordinances, capital improvement plans and budgets, as necessary. It will remain the responsibility of the Lehigh and Northampton County Emergency Management

Agencies to monitor grant opportunities to help the counties and municipalities fund their mitigation actions and inform the municipal points of contact of those opportunities. To give the region enough time to perform the next five-year update, the counties will apply for Hazard Mitigation Planning grant funding in 2020.

7.3 CONTINUED PUBLIC INVOLVEMENT

Public involvement that extends beyond the Plan's adoption is a priority for both counties and the LVPC. To promote continued involvement, the 2018 Plan, including municipal annexes, will remain online at LVPC.org/hazard-mitigation, giving people 24-hour access. The website will include a place for people to comment, and social media will be used as part of a continued outreach effort. Any media reports and public meeting notices will be posted online, as well as any progress reports and updates of the Plan.

Annual progress reports or any proposed updates to the Plan will be open for public review online and during at least one public meeting each year. The co-chairs will assist in scheduling public meetings and the LVPC will be responsible for maintaining the Hazard Mitigation webpage.

Responses to the public outreach worksheet are included in the municipal annexes. Over the next five years, municipal participation will continue to include assisting and promoting outreach to their community.

In addition, copies of the 2018 Plan will be made available for public access at each participating municipal building and at:

Lehigh County Emergency Management Agency
640 W. Hamilton Street
Allentown, PA 18101

Northampton County Emergency Management Services
100 Gracedale Avenue
Nazareth, PA 18064

The next update will be adopted by October of 2023.

8. PLAN ADOPTION

Adoption of the *Lehigh Valley Hazard Mitigation Plan* by Lehigh and Northampton counties and each participating municipality is a critical step for ensuring implementation of its goals, objectives and actions.

Adoption by the local governing bodies demonstrates the commitment of Lehigh and Northampton counties and each participating municipality to fulfill the mitigation goals and objectives outlined in the Plan. Adoption formalizes the Plan and authorizes responsible agencies to execute their responsibilities. For this multi-jurisdictional plan to be approved, each jurisdiction included in the Plan must have its governing body adopt the Plan upon notification of approval pending adoption by the Federal Emergency Management Agency (FEMA). County and municipal adoption resolution templates are provided in Appendix I.

Following adoption or formal action on the Plan, each participating jurisdiction must submit a copy of the resolution or other legal instrument showing formal adoption (acceptance) of the Plan to their respective county emergency management agency for this Plan. These will then be submitted to PEMA and forwarded to FEMA. Upon final FEMA approval, each municipality must submit a copy of the FEMA approval letter to their respective county emergency management agency.

In addition to being required by the Disaster Mitigation Act of 2000, adoption of the plan is necessary because:

- It lends authority to the plan to serve as a guiding document for all local and state government officials;
- It gives legal status to the plan in the event it is challenged in court;
- It certifies to program and grant administrators that the plan's recommendations have been properly considered and approved by the governing authority and jurisdictions' citizens; and
- It helps ensure the continuity of mitigation programs and policies over time because elected officials, staff and other community decision-makers can refer to the official document when making decisions about the community's future.

Source: FEMA 2003. "How to Series" - Bringing the Plan to Life (FEMA 386-4).

THANK YOU

To the many citizens, community leaders, stakeholders and municipal partners who helped develop this Plan. The *Lehigh Valley Hazard Mitigation Plan* would not have been possible without their time, incredible commitment and input.

County and Municipal Partners

Rick Adams, Zoning Officer, Williams Township

Zachary Albert, Fire Chief, Tatamy Borough

Kim Albert, Tatamy Fire Co. President, Tatamy Borough

Jon Al-khal, Emergency Management Agency, Lehigh County

Franklin Bartholomew, Emergency Management Coordinator, Lowhill and Weisenberg Townships

Jeff Bartlett, Township Manager, North Whitehall Township

John Bast, Fire Chief, Easton City

Anthony Branco, Executive Administrator, Fountain Hill Borough

Drake Brintzenhoff, Public Works Director, Lower Milford Township

LeRoy Brobst, Borough Manager, Northampton Borough

Beth Bucko, Treasurer, Hanover Township, Northampton County

Dane Carroll, Emergency Management Coordinator, Upper Saucon Township

Edward Carter, Assistant Manager, Upper Milford Township

Chuck Castetter, Fire Chief, Upper Saucon Township

Christopher Christman, Township Manager, Palmer Township

John Christman, former Deputy Emergency Management Coordinator, South Whitehall Township

William Concolino, Emergency Management Coordinator, West Easton Borough

Zack Cooperman, Assistant Manager, Lower Milford Township

Judith Danko, former Borough Manager, Slatington Borough

Duane Dellecker, Building Code Administrator, Upper Macungie Township

Daniel DePaul, Mayor, West Easton Borough

Susan Disidore, Township Supervisor, Lower Mount Bethel Township

Nathaniel Dysard, Borough Manager, Bangor Borough

Louise Firestone, Borough Administrator, Wind Gap Borough

Brad Flynn, Borough Manager, Bath Borough

John Frantz, Fire Marshal, South Whitehall Township

Chris Garges, Township Manager, Hanover Township, Lehigh County

Gerald Gasda, Borough Manager, Freemansburg Borough

Gene Goldfeder, former Borough Manager, Catasauqua Borough

Sherry Graver, Emergency Management Coordinator, Washington Township, Lehigh County

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Brian Harris, Township Manager, Bushkill Township

Wade Haubert, Deputy Emergency Management Coordinator, Bethlehem City

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Kevin Horvath, Engineer, Moore Township

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Jonathon Itterly, Police Chief, Freemansburg Borough

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Howard Klein, former Supervisor, Lower Mount Bethel Township

Gary Krill, Emergency Management Coordinator, Allen Township

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Lee Laubach, Fire Chief, Allentown City

Juli Lemak, Borough Administrative Assistant, Pen Argyl Borough

Scott Lindenmuth, Director of Emergency Services, Lehigh County

Tracy Malinowski, Treasurer, Alburtis Borough

Peter Mammana, Councilman, West Easton Borough

Lindsey Manzi, Emergency Management Coordinator, Upper Mount Bethel Township

E.J. Mentry, Township Manager, Upper Nazareth Township

Janice Meyers, Township Administrator, Heidelberg Township

Vince Milite, Public Works Director, Hanover Township,

Jim Milot, Engineering Representative, East Allen Township

Mark Morella, Emergency Management Coordinator, Nazareth Borough

Michael Natysyn, Volunteer Fire Chief, Macungie Borough

Sandra Newman, Supervisor, Lower Mount Bethel Township

Dorothy Niklos, Councilwoman, Chapman Borough

Timothy Paashaus, Borough Manager, Coopersburg Borough

Tom Petrucci, Township Manager, Plainfield Township

Lance Prator, Mayor, Portland Borough

Jason Quarry, Public Works Supervisor, Fountain Hill Borough

Lee Rackus, Planning, Zoning and Development Bureau Chief, Whitehall Township

Alice Rehrig, Township Manager, Lehigh Township

Mike Rinker, Emergency Management Coordinator, Upper Nazareth Township

Beth Ritter, Secretary, Hanover Township, Northampton County

Tina Roseberry, Planning Bureau Chief, Easton City

Vicky Roth, Township Clerk, Hanover Township, Lehigh County

Greg Scheier, Emergency Management Coordinator, North Catasauqua Borough

Lori Seese, Planning and Zoning Administrator, Lower Nazareth Township

Melissa Shafer, former Township Manager, Bethlehem Township

Terry Sidor, Secretary, Glendon Borough

Bryan Smith, Engineering Representative, Hellertown Borough

Cynthia Sopka, Director of Planning and Zoning, Salisbury Township

Jeff Steiert, Deputy Emergency Management Director, Northampton County

Jessica Teel, Councilwoman, Nazareth Borough

Vince Tranguch, Code Enforcement Officer, Lower Macungie Township

Mike Twining, former Emergency Management Planner, Northampton County

Nick Tylenda, former Deputy Director of Emergency Management, Northampton County

Monica Wall, Borough Engineer, Wilson Borough

Todd Weaver, Emergency Management Director, Northampton County

Anthony Werley, Township Supervisor, Weisenberg Township.

Tammy White, Sec/Treasurer, Lynn Township

Tim Weis, Zoning Officer, Forks Township

Robin Yoder, Emergency Management Director, Hanover Township, Lehigh County

Special thanks to those Citizens and Community Stakeholders who attended public or Planning Team meetings

Chuck Ballard, School Board member, East Penn School District

Paolo Bocchini, Assistant Professor, Lehigh University

Steve Boone, Engineer, Borton-Lawson

Tim Boyer, Representative, Disability Friendly Community

Renate Brosky, Citizen's Climate Lobby

Peter Brown, Executive Director, American Red Cross of the Greater Lehigh Valley

Jim Butt, Lehigh Valley Sustainability Network event attendee

Milagros Canales, Community Action Committee of the Lehigh Valley

Joseph M. Carr, Catasauqua Emergency Management Agency

Rachel Hogan Carr, Executive Director, Nurture Nature Center, Easton City

Martha Christine, Citizen Climate's Lobby

Wayne Conrad, Palmer Township

Matthew H. Dietz, Councilman, Northampton County Council

Dean Donaher, State Representative Candidate

James Finnen, Palmer Township

Lynn Fraser, Environmental Advisory Council, Easton City

Mike Gibson, Emmaus Planning Commission

Aaron Gorozinsky, Outreach Director, Jewish Federation Lehigh Valley

Mary Lou Green, Lehigh Valley Sustainability Network event attendee

Jim Green, Lehigh Valley Sustainability Network event attendee

Dustin Grow, Salisbury Township

John Halligan, Palmer Township

Joe Hebelka, Hydrogeologist, Pennsylvania Department of Environmental Protection

Brian Hillard, Technical Specialist, Energy Auditor, Sustainable Energy Fund

Phil Jones, Mid-Atlantic Renewable Energy Association

David Keppel, Director of School Services, Parkland School District

Arundhati (Tinku) Khanwalkar, Senior Counsel and Corporate Compliance Director, PPL Corporation

Mike Kichline, Assistant Federal Security Director, Transportation Security Administration

Debra Mellish, Catasauqua Borough Council

Jessica Morris, Lehigh Valley Sustainability Network event attendee

Betsy Nepon, Allentown resident

April Niver, Economic Development Coordinator for the Office of Congressman Matt Cartwright

Phil North, Principal, Engineer and Manager, Railroad Track Engineering

Marie North, Certified Sustainable Building Advisor

Norman Parrish, Liaison Representative, PA1Call

Abigail Pattishall, Vice President of Conservation, Wildlands Conservancy

Jason Peters, Chairman, Lehigh Valley Regional Partnership

Rosalyn Petrucci, J.G. Petrucci Co.

D. Terlaak Poot, Coopersburg Borough

Mari Radford, Hazard Mitigation Community Plan Lead, FEMA

Kirk Rohn, Easton City

Lynn Rothman, Bethlehem Environmental Advisory Council

Andrew Rubinstein, Director of Group Sales, Lehigh Valley Phantoms

Jarred Schlottman, Assistant Customer Service Manager, LANta

Heidi Stahl, RestoreCore, Inc.

Mary Wilford-Hunt, Senior Associate Director of Corporate, Foundation and Government Relations, Lafayette College

Bob Wittman, Convener, Disability Friendly Community

David Wieller, Senior Water/Wastewater Engineer at Borton-Lawson

Andrea Wittchen, Principal and Co-founder, iSpring Associates

C.M. Young, Palmer Township

This report was prepared by the Lehigh Valley Planning Commission. The LVPC complies with the Federal Highway Administration and Federal Transit Administration, US Department of Transportation, under the State Planning and Research Program, Section 505 [or Metropolitan Planning Program, Section 104(f)] of Title 23, US Code. The contents of this report do not necessarily reflect the official views or policy of the US Department of Transportation.


DROUGHT ■ EARTHQUAKE ■ EXTREME
FLOOD ■ FLASH FLOOD ■ ICE JAM ■
INVASIVE SPECIES ■ LANDSLIDE ■
PANDEMIC AND INFECTIOUS DI
SUBSIDENCE/SINKHOLE ■
WINTER STORM ■
FLASH FLOOD ■ ICE JAM ■ HAILSTORM
DROUGHT ■ EARTHQUAKE ■ EXTREME
TERRORISM ■ TRANSPORTATION CRA
LEVEE FAILURE ■ NUCLEAR INCIDENT
ENVIRONMENTAL HAZARDS ■ FIRE AND
DAM FAILURE ■ DRUG OVERDOSE CRIS
WINTER STORM ■ CIVIL DISTURBANCE
WILDFIRE ■ WINDSTORM/TORNADO
RADON EXPOSURE ■ SUBSIDEN
PANDEMIC AND INFECTIOU
LANDSLIDE ■ LIGHT
ENVIRONMENTAL
FIRE AND EXPLOSION
LEVEE FAILURE ■ NUCLEAR
STRUCTURAL COLLAPSE ■ TERRO
TRANSPORTATION CRASH ■ UTILITY INT
DROUGHT ■ EARTHQUAKE ■ EXTREME
FLOOD ■ FLASH FLOOD ■ ICE JAM ■
INVASIVE SPECIES ■ LANDSLIDE ■
PANDEMIC AND INFECTIOUS DISEASE
RADON EXPOSURE ■ SUBSIDENCE/SIN
WILDFIRE ■ WINDSTORM/TORNADO ■
DROUGHT ■ EARTHQUAKE ■ EXTREME
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WINTER STORM ■