4.3.20. Levee Failure

4.3.20.1. Location and Extent

FEMA completed an inventory of all known levees across Pennsylvania in 2009 with an update in 2012, known as the Mid-Term Levee Inventory (MLI). The MLI contains levee data gathered first and foremost for structures designed to protect from the 1%-annual-chance flood event. The area behind a maintained and certified levee that is designed to protect from a 1%-annual-chance flood is called a Levee Protected Area. The MLI also frequently includes levees that were not designed to protect against this base flood, but the MLI does not include every levee in every county – especially small levees and agricultural levees not engineered or able to be accredited to the 1%-annual-chance event (FEMA, 2011). FEMA's inventory was compiled using all effective Flood Insurance Rate Maps and Flood Insurance Study reports in Pennsylvania, the USACE levee inventory, the DEP's Flood Control Project summaries, information from local governments, aerial photography, and additional information such as news articles and websites.

A total of 317 levee segments and 63 floodwall segments levees have been identified throughout Pennsylvania via the MLI, with at least one levee in 51 of 67 counties (FEMA-Region III, 2012). Figure 4.3.20-1 shows the locations of the levee systems along with any levee protected areas identified in the MLI while Figure 4.3.20-2 shows all Pennsylvania flood protection projects sponsored by DEP and the USACE, most of which are levee systems. These state- and federally-constructed levees are included in the MLI but are shown separately to demonstrate DEP's work in designing and constructing structural flood protection throughout Pennsylvania. Note that generally levees protect small areas that may not be able to be seen on the map. The distribution of these systems is relatively scattered throughout the Commonwealth with most having been constructed in more populated areas to protect property and structures from flood events. Particularly extensive levee systems have been built in the Scranton Wilkes-Barre area in Luzerne and Lackawanna Counties.

In the event of a levee failure, flood waters will ultimately inundate the protected area landward of the levee. The extent of inundation is dependent on the flooding intensity. Failure of a levee during a 1% annual chance flood will inundate the approximate 100-year flood plain previously protected by the levee. Residential and commercial buildings located nearest the levee overtopping or breach location will suffer the most damage from the initial embankment failure flood wave. Landward buildings will be damaged by inundation.

Levees require maintenance to continue to provide the level of protection they were designed and built to protect. Maintenance responsibility belongs to a variety of entities including local, state and federal government and private land owners. Well maintained levees may obtain certification through independent inspections. Levee owners need to both maintain levees and pay for an independent inspection in order to have the levee certified as providing flood protection. The impacts of an un-certified levee include levee failure and insurance rate increases because FEMA identifies that the structures are not designed to protect to the 1%-annual-chance flood height on Flood Insurance Rate Maps.

Figure 4.3.20-1 Location of levees and floodwalls identified in the Mid-Term Levee Inventory throughout Pennsylvania.

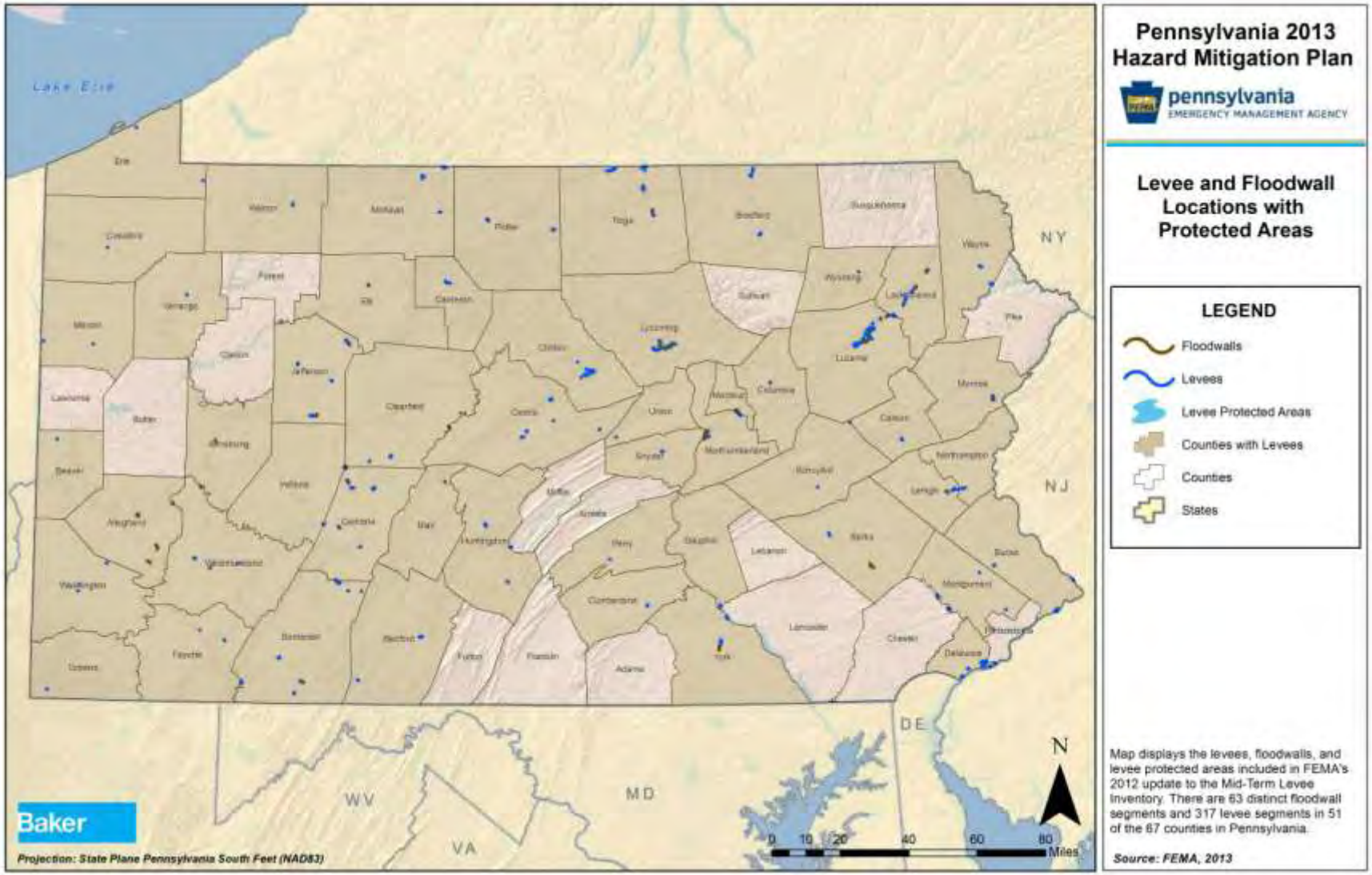
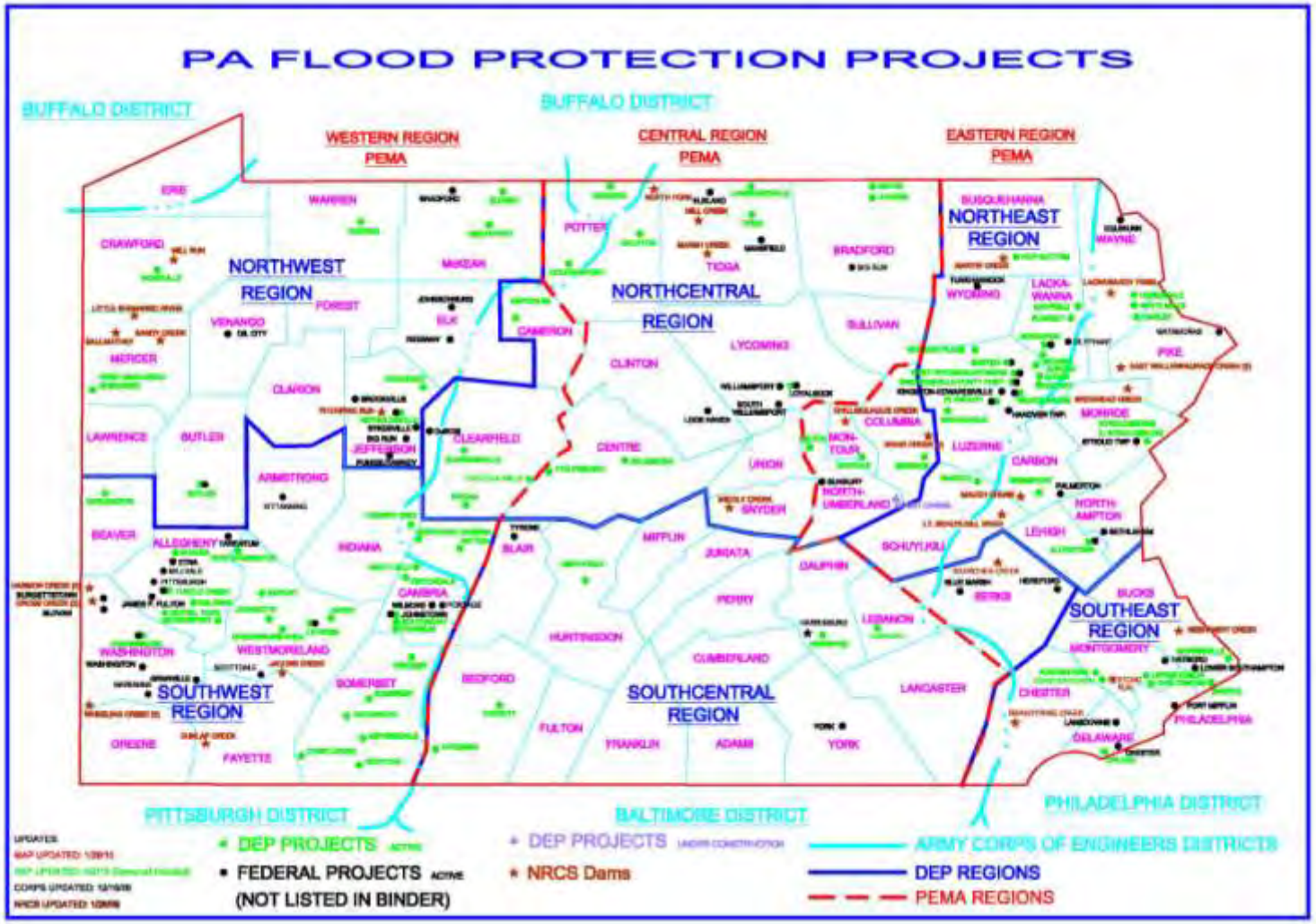


Figure 4.3.20-2 Location of PA Flood Protection Projects with Federal and State Sponsorship (DEP, 2013)



4.3.20.2. Range of Magnitude

For levees designed and constructed by DEP, after construction the levee system is 'sponsored' by the municipality in which it resides. Sponsorship indicates the party that is responsible for the levee's operations and maintenance; the sponsor is usually a municipality or a municipal authority. PA DEP covers large repair and rehabilitation efforts, but the municipal sponsor is responsible for routine operations and maintenance as well as minor repairs. Major rehabilitation projects are identified in the capital budget for the Commonwealth but may take years to complete depending on the size of a project.

Flood-related hazards due to levees range in magnitude from overtopping, when the water level rises over the top of the levee, to back-ending, when water flows around the back of the levee outside of the edge of the levee system, to total failure as seen during Hurricane Katrina. Levees are typically designed with three feet of freeboard to prevent overtopping, but older levees were not built to that standard.

A levee failure causes flooding in landward areas adjacent to the levee system. The failure of a levee or other flood protection structure could be devastating depending on the level of flooding for which the structure is designed and the amount of landward development present. In some instances, the magnitude of flooding could be more severe under a levee failure event compared to a normal flooding event. If an abrupt failure occurs, the rushing waters of a flood wave could result in catastrophic losses.

Properties located in the area of reduced-risk landward of a levee system are not subject to the mandatory flood insurance purchase requirement of the National Flood Insurance Program. Thus, regardless of whether a levee is accredited, there is concern that properties in these areas lack flood insurance. In the event of a failure, it is likely that inundated properties will not be insured.

The worst-case levee failure is one which occurs abruptly with little warning and results in deep, fast-moving flood waters through a highly-developed or highly-populated area. While any levee may be overtopped and fail, it is these levees with large protected areas that have the potential to cause the most damage. During Tropical Storm Lee, the levee system in Wilkes-Barre effectively protected the city; if its levee and floodwall system had failed, the flood impact would have been much worse than it was.

4.3.20.3. Past Occurrence

There is no comprehensive list of levee failures in Pennsylvania, and historically few, if any, have been reported. However, Tropical Storm Lee in 2011 exceeded the design storm level for many levees in Pennsylvania. Lee placed extreme stress on Pennsylvania's levees since the event was relatively long in duration and the ground was already saturated from Irene the week prior. In Sayre, the levee system was overtopped and the levee was back-ended. The pump station at Sayre also flooded during this event, compounding the effects of the overtopping. While there is not a comprehensive list, there are news reports of a small agricultural levee failure in Columbia County and some levee-related flood damage from the Chemung Levee in Athens, Bradford County. In the case of Athens, the Susquehanna rose much faster than expected, and the extreme pressure exerted by the swollen river caused damage to a 125-foot

portion of the levee, damaging 300 homes. As of July 2013, the Chemung levee repairs are under construction with an 80/20 federal/state match. The Sayre levee repairs are being completed by the USACE, and Pennsylvania's H_2O program is covering the cost to repair the pump station.

4.3.20.4. Future Occurrence

Similarly to dam failures, given certain circumstances, a levee failure can occur at any time. However, the probability of future occurrence can be reduced through proper design, construction and maintenance measures. The age of the levee can increase the potential for failures if not maintained. Most levees are designed to operate safely at specified level of flooding. While FEMA focuses on mapping levees that will reduce the risk of a 1%-annual-chance flood, other levees may be designed to protect against smaller or larger floods. Design specifications provide information on the percent-annual-chance flood a structure is expected to withstand, provided that it has been adequately constructed and maintained.

4.3.20.5. Environmental Impacts

The environmental impacts of a levee failure result in significant water quality and debris disposal issues. Flood waters will back up sanitary sewer systems and inundate waste water treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooding waterway. The contents of unsecured containers of oil, fertilizers, pesticides and other chemicals get added to flood waters. Water supplies and waste water treatment could be off-line for weeks. After the flood waters subside, contaminated and flood damaged building materials and contents must be properly disposed. Contaminated sediment must be removed from buildings, yards and properties.

4.3.20.6. Jurisdictional Vulnerability Assessment

0lists the 16 counties that have profiled levee failure in their HMP along with any hazard ranking. Lawrence County profiled dams and levees together; while defining levees in the profile Lawrence did not identify any levees as a hazard in their county. As stated in Section 4.1, the decision by a county to profile a hazard is one indicator of the presence of risk from that hazard. This indicator should be viewed complementary to other analysis in this section. Together this analysis from reputable sources addresses different aspects of risk for a full risk profile.

Fourteen of the counties profiling levee failure have a calculated risk factor, the average of which is 1.9. The State Risk Factor for levee failure is 1.7. The Pennsylvania THIRA merged levee failure with dam failure and rated levee failure as a 5 of 10. For more details on the State Risk Factor and THIRA, please see Section 4.1.

Table 4.3.20-1 Counties profiling levee failure with hazard ranking and risk factor (if available).

COUNTY	PROFILED HAZARD	DID NOT PROFILE HAZARD	RANKING (IF AVAILABLE)	RISK FACTOR (IF AVAILABLE)
Adams		X		
Allegheny	X		Low	1.9
Armstrong		X		
Beaver	X		Low	1.7
Bedford	X		Medium	2.4
Berks		X		
Blair		X		
Bradford		X		
Bucks		X		
Butler		X		
Cambria	X		High	2.9
Cameron		X		
Carbon		X		
Centre		X		
Chester		X		
Clarion		X		
Clearfield	X		Low	1.7
Clinton	X		Low	1.9
Columbia	X		Low	1.8
Crawford		X		
Cumberland	X		Low	1.2
Dauphin		X		
Delaware	X		Low	1.7
Elk		X		
Erie		X		
Fayette		X		
Forest		X		
Franklin		X		
Fulton		X		
Greene		X		
Huntingdon		X		
Indiana		X		
Jefferson	X		Low	1.7

Table 4.3.20-1 Counties profiling levee failure with hazard ranking and risk factor (if available).

COUNTY	PROFILED HAZARD	DID NOT PROFILE HAZARD	RANKING (IF AVAILABLE)	RISK FACTOR (IF AVAILABLE)
Juniata		X		
Lackawanna		X		
Lancaster		X		
Lawrence	X		Low	1.9
Lebanon*		X		
Lehigh	X		High	2.5
Luzerne		X		
Lycoming		X		
McKean		X		
Mercer		X		
Mifflin		X		
Monroe	X		Low	1.7
Montgomery	X		Low	1.3
Montour*		X		
Northampton	X		High	2.5
Northumberland	X		Medium	2.1
Perry*		X		
Philadelphia**		X		
Pike		X		
Potter		X		
Schuylkill		X		
Snyder		X		
Somerset		X		
Sullivan		X		
Susquehanna		X		
Tioga		X		
Union		X		
Venango		X		
Warren		X		
Washington		X		
Wayne		X		
Westmoreland		X		
Wyoming		X		
York		X		

Table 4.3.20-1 Counties profiling levee failure with hazard ranking and risk factor (if available).				
COUNTY	**PROFILED HAZARD**	**DID NOT PROFILE HAZARD**	**RANKING (IF AVAILABLE)**	**RISK FACTOR (IF AVAILABLE)**
* Lebanon, Montour, and Perry use an alternate weighted ranking where Risk Factor = Frequency x [(0.25 x Critical facilities) + (0.40 x Social) + (0.25 x Economic) + (0.10 x Environmental)]. While this risk factor was used to comparatively rank hazards, the number does not correspond to a high-medium-low rating. **Philadelphia uses an A, B, C rating system where A is high, B is medium, and C is low.				

As stated in Section 4.2.2, jurisdictional and state critical facility vulnerability assessments were completed by spatially overlaying hazards with census tracts and state critical facility layers in GIS. When spatial analysis determined that the hazard would impact a census tracts within a county or the location of state critical facilities these locations where deemed vulnerable to the hazard. Loss estimates were prepared based on the value of the facilities impacted by census tract and by state critical facility. Each hazard uses a methodology that is specific to the type of risk it may cause; Table 4.2.2-2 includes a complete methodology description for vulnerability assessments and loss estimates for each hazard.

As of 2012, 317 levee segments and 63 floodwall segments exist within 51 of the 67 Pennsylvania counties. 82 state critical facilities have been identified that fall within the known 105 Levee Protected Areas. The Levee Protected Areas were obtained from FEMA Region III's Midterm Levee Inventory database (as of 2012). However, not all levees have Levee Protected Areas identified, leaving a gap in the analysis. Actions 1-5a and 1-5b address improving the levee data and outreach regarding levee regulations in the Commonwealth. To accommodate for the non-existent protected areas, a secondary vulnerability analysis was be performed on all levees in the Commonwealth, seeking out critical facilities that fall within 2,000 feet from the levee system. While this will provide an overestimation of the risk to a levee failure, the 2,000 feet measurement was selected based on a review of the Levee Protected Areas. This review found the 2,000 feet was approximately the typical size of the identified Levee Protected Areas. Both the Levee Protected Areas and the 2,000 feet based analysis is approximate analysis based on the best available data. Table 4.3.20-2 accounts for the number of critical facilities falling within Levee Protected Areas and within the 2,000 foot GIS buffer of the levee systems. Counties with the most levees are Lackawanna, Cambria, Snyder and Jefferson having over 10 each. Luzerne is most vulnerable having the highest number of critical facilities falling within vulnerable zones (49).

Table 4.3.20-2 Number of State Critical Facilities falling within levee Protected Areas and 2,000-foot GIS buffer of levees in each county	
COUNTY	**CRITICAL FACILITIES LEVEE PROTECTED AREA OR IN 2,000 FOOT LEVEE GIS BUFFER**
Allegheny	2
Armstrong	7
Bedford	3

Table 4.3.20-2 Number of State Critical Facilities falling within levee Protected Areas and 2,000-foot GIS buffer of levees in each county	
COUNTY	**CRITICAL FACILITIES LEVEE PROTECTED AREA OR IN 2,000 FOOT LEVEE GIS BUFFER**
Berks	1
Blair	2
Bradford	7
Bucks	6
Cambria	13
Cameron	4
Carbon	2
Centre	4
Chester	1
Clearfield	3
Clinton	12
Crawford	1
Delaware	7
Erie	3
Greene	1
Huntingdon	7
Indiana	1
Jefferson	14
Lackawanna	23
Lehigh	5
Luzerne	49
Lycoming	12
McKean	3
Mercer	1
Monroe	4
Montour	7
Northampton	2
Northumberland	17
Philadelphia	1
Pike	2
Potter	5
Schuylkill	4
Snyder	4
Somerset	15
Tioga	12
Warren	1
Wayne	3
Westmoreland	14

Table 4.3.20-2 Number of State Critical Facilities falling within levee Protected Areas and 2,000-foot GIS buffer of levees in each county	
COUNTY	**CRITICAL FACILITIES LEVEE PROTECTED AREA OR IN 2,000 FOOT LEVEE GIS BUFFER**
York	3
Grand Total	***288***

4.3.20.7. State Facility Vulnerability Assessment

The majority of facilities falling in these GIS buffered levee areas are fire departments, police departments and schools (Table 4.3.20-3).

Table 4.3.20-3 State Critical Facilities vulnerable to levee failure by Critical Facility Type	
STATE CRITICAL FACILITY TYPE	**CRITICAL FACILITIES LEVEE PROTECTED AREA OR IN 2,000 FOOT LEVEE GIS BUFFER**
Agriculture	4
Education	4
Emergency Services	5
Energy	1
Fire Departments (Non-HSIP)	134
Healthcare & Public Health	1
Hospital (Non-HSIP)	6
Police (Non-HSIP)	78
Postal & Shipping	1
School (Non-HSIP)	54
Grand Total	***288***

4.3.20.8. Jurisdictional Loss Estimation

Jurisdictional loss estimates were identified at the tract level and aggregated at the county level to show the possible losses per county. Due to the fragmentation of the levees, GIS was used to buffer 2,000 feet from the levees for a better representation of losses. It was identified that the Commonwealth has a total of 138,872 potentially impacted buildings with over $32 billion in exposure in 26 counties. Luzerne County is the most threatened jurisdiction with over 33,000 vulnerable buildings and over $7 billion in possible losses stemming from levee failure. Table 4.3.20-4 illustrates the number of impacted buildings and their associated dollar value of exposure by county. It should be noted that only the GIS buffer exposure value was presented in jurisdictional loss estimates, since the Levee Protected Areas do not exist for all levees. The GIS buffer method considers all existing levees. Jurisdictional loss estimates were identified at the tract level and aggregated at the county level to show the possible losses per county.

Table 4.3.20-4 Estimated jurisdictional losses in 2,000 foot Levee GIS buffer areas.		
COUNTY	**NUMBER OF IMPACTED BUILDINGS**	**DOLLAR VALUE OF EXPOSURE, BUILDING AND CONTENTS (THOUSANDS $)**
Allegheny	2,102	$411,689.00
Armstrong	1,237	$272,827.00
Blair	3,486	$694,269.00
Bradford	1,352	$258,539.00
Bucks	1,636	$734,678.00
Cambria	2,775	$525,910.00
Cameron	1,273	$298,105.00
Chester	2,293	$550,676.00
Clearfield	3,282	$598,452.00
Clinton	3,867	$1,030,151.00
Delaware	3,506	$981,258.00
Elk	1,527	$275,797.00
Erie	3,174	$715,794.00
Jefferson	5,229	$1,108,980.00
Lackawanna	10,549	$2,015,249.00
Lehigh	5,686	$1,436,192.00
Luzerne	33,110	$7,277,187.00
Lycoming	16,115	$3,736,522.00
Mercer	633	$101,276.00
Montgomery	8,298	$3,065,329.00
Northampton	4,088	$935,153.00
Northumberland	7,435	$1,903,122.00
Philadelphia	1,397	$483,484.00
Somerset	5,385	$1,022,485.00
Westmoreland	3,943	$789,195.00
York	5,494	$1,122,326.00
Grand Total	***138,872***	***$32,344,645.00***

4.3.20.9. State Facility Loss Estimation

The estimated replacement cost of all State Critical Facilities located in levee vulnerability areas is $1,559,284,911.

4.3.21. Mass Food and Animal Feed Contamination

4.3.21.1. Location and Extent

Mass food or animal feed contamination hazards occur when food or food sources are contaminated with pathogenic bacteria, viruses, or parasites, as well as chemical or natural toxins. They may lead to foodborne illnesses and/or interruptions in the food supply.