5.4.1 Dam Failure

This section provides a profile and vulnerability assessment of the dam failure hazard.

5.4.1.1 Hazard Profile

Profile information is provided below (including description, extent, location, previous occurrences and losses, probability of future occurrences, and impacts of climate change).

Description

A dam is an artificial barrier that can store water, wastewater, or liquid-borne materials for many reasons (flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control). Many dams fulfill a combination of these stated functions (Association of State Dam Safety Officials 2013). They are an important resource in the United States.

Man-made dams can be classified according to type of construction material used, methods applied in construction, slope or cross-section of the dam, how the dam resists forces of the water pressure behind it, means used for controlling seepage, and, occasionally, according to the purpose of the dam. Materials used for construction of dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, miscellaneous materials (plastic or rubber), and any combination of these materials (Association of State Dam Safety Officials 2013).

Average age of our nation's dams is over 52 years. By 2020, 70 percent of the total dams in the United States will be over 50 years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs, and many older dams are not expected to safely withstand current predictions regarding large floods and earthquakes. About 2,000 unsafe dams are present throughout the United States, in almost every state.

Dam failures typically occur when spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-filled water that rushes downstream damaging and/or destroying anything in its path (Federal Emergency Management Agency [FEMA] 1996).

Dam failures can result from one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Deliberate acts of sabotage
- Structural failure of materials used in dam construction
- Movement and/or failure of the foundation supporting the dam
- Settlement and cracking of concrete or embankment dams
- Piping and internal erosion of soil in embankment dams
- Inadequate maintenance and upkeep (FEMA 2013a)

Regulatory Oversight of Dams

Potential for catastrophic flooding caused by dam failures led to passage of the National Dam Safety Act (Public Law 92-367). For 30 years, the National Dam Safety Program (NDSP) has protected Americans from dam failure. NDSP is a partnership among the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have

allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchase of needed equipment. FEMA has also expanded existing training programs and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most dams in the United States (FEMA 2013a).

New York State (NYS) has a comprehensive dam safety program through which three governmental authorities regulate dam safety throughout the State:

- NYS Department of Environmental Conservation (NYSDEC) – Environmental Conservation Law (ECL) Article 15, Part 673
- Federal Energy Regulatory Commission (FERC) – 18 *Code of Federal Regulations* (CFR) 12.22-24
- U.S. Army Corp of Engineers (USACE) – EP 1110-2-13, Dam Safety Preparedness.

Dam safety emergency action plans (EAP) are formal dam failure procedures written by the dam owner/operator. EAPs are site-specific plans and relate only to the facility's procedures to prevent/mitigate occurrence of a catastrophic dam failure. USACE is responsible to submit an EAP for dams it owns, operates, and maintains. EAPs for hydroelectric dams fall under the purview of FERC, and NYSDEC regulates dam safety and EAPs for all dams in NYS.

New York State Department of Environmental Conservation

The NYSDEC's Dam Safety Section is responsible for safety inspection of dams, technical review of proposed dam construction or modification, monitoring of remedial work for compliance with dam safety criteria, and emergency preparedness for all dams in NYS. NYSDEC is responsible for more than 100 flood control projects throughout the State, most of which were constructed by USACE and are operated and maintained by NYSDEC, in some cases with local municipal partners.

The State generally inspects high hazard (Class C) dams every two (2) years, and moderate hazard (Class B) dams every four (4) years. To support emergency planning efforts and raise awareness among local officials and emergency managers, a copy of each inspection report is sent to the chief executive of the community in which the dam is located. Municipal officials or emergency managers from any municipality in the dam's inundation area may receive a copy of the inspection report upon request.

U.S. Army Corps of Engineers Dam Safety Program

USACE is responsible for safety inspections of some federal and non-federal dams in the United States that meet size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams and has surveyed each state's and federal agency's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of dams. USACE has also developed guidelines for inspection and evaluation of dam safety (USACE 1997).

Federal Energy Regulatory Commission Dam Safety Program

FERC has the largest dam safety program in the United States. FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. A total of 3,036 dams are part of regulated hydroelectric projects and are included in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, rendering oversight and regular inspection especially important (FERC 2011).

FERC staff inspect hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with terms and conditions of a license (FERC 2011).

Every five (5) years, an independent consulting engineer approved by the FERC must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with total storage capacity of more than 2,000 acre-feet (FERC 2011).

FERC monitors and evaluates seismic research in geographic areas where concerns have been raised about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects within these areas. FERC staff also evaluate effects of potential and actual large floods on safety of dams. During and after floods, FERC staff visit dams and licensed projects, determine extent of damage, and direct any studies or remedial measures the licensee must undertake. FERC's *Engineering Guidelines for the Evaluation of Hydropower Projects* guides FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies (FERC 2011).

FERC requires licensees to prepare EAPs, and conducts training sessions on developing and testing these plans. The plans outline an early warning system in the event of an actual or potential sudden release of water from a dam failure. The plans include operational procedures that may be implemented during imposition of regulatory measures such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies responsible for emergency management. These plans are frequently updated and tested to ensure that all applicable parties are informed of proper procedures in emergency situations (FERC 2011).

Extent

Anticipated extent or magnitude of damage from a dam failure event can be estimated by reference to the classification of the dam. FEMA has three hazard classification levels of dams: low, significant, and high. The classification levels build on each other. The hazard potential classification system should be utilized with understanding that failure of any dam or water-retaining structure could pose a danger to downstream life and property (FEMA 2004).

- **Low hazard potential dams** are those where failure or misoperation would result in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- **Significant hazard potential dams** are those where failure or misoperation would result in no probable loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, or other impacts of concern. Many significant hazard potential dams are within predominantly rural or agricultural areas.
- **High hazard potential dams** are those where failure or misoperation would probably cause loss of human life.

USACE developed the classification system listed in Table 5.4.1-1 for hazard potentials of dam failures. This USACE hazard rating system is based only on potential consequences of a dam failure; it does not take into account probability of such failures.

Table 5.4.1-1. United States Army Corps of Engineers Hazard Potential Classification

Hazard Category[1]	Direct Loss of Life[2]	Lifeline Losses[3]	Property Losses[4]	Environmental Losses[5]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location; only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

Source: FEMA 2012

Note(s):

(1) Categories are assigned to overall projects, not individual structures at a project.

(2) Loss-of-life potential is based on inundation mapping of area downstream of the project. Analyses of loss-of-life potential should take into account the population at risk, time of flood wave travel, and warning time.

(3) Lifeline losses include indirect threats to life caused by interruption of lifeline services because of project failure or operational disruption—for example, loss of critical medical facilities or access to these.

(4) Property losses include damage to project facilities and downstream property, and indirect impacts from loss of project services, such as impact from loss of a dam and navigation pool, or impact from loss of water or power supply.

(5) Environmental losses include environmental impacts downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

According to the NYSDEC Division of Water Bureau of Flood Protection and Dam Safety, the hazard classification of a dam is assigned according to potential impacts of a dam failure pursuant to 6 *New York Codes Rules and Regulations* (NYCRR) Part 673.3 (NYSDEC No Date [n.d.]). Dams are classified in terms of potential for downstream damage if the dam fails. These hazard classifications are identified and defined as follows:

- *Low Hazard (Class A)* is a dam within an area where failure would damage nothing more than isolated buildings, undeveloped lands, or township or county roads, and/or would cause no significant economic loss or serious environmental damage. Failure or misoperation would result in no probable loss of human life. Losses would be principally limited to the owner's property
- *Intermediate Hazard (Class B)* is a dam within an area where failure may damage isolated homes, main highways, and/or minor railroads; interrupt use of relatively important public utilities; and/or cause significant economic loss or serious environmental damage. Failure or misoperation would result in no probable loss of human life, but could cause economic loss, environment damage, disruption of lifeline facilities, or other effects. Significant hazard potential classification dams are often within predominantly rural or agricultural areas, but could be within areas with population and significant infrastructure.
- *High Hazard (Class C)* is a dam within an area where failure may cause loss of human life; serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or railroads; and/or excessive, direct economic loss (urban area including extensive community, industry, agriculture, or outstanding natural resources).
- *Negligible or No Hazard (Class D)* is a dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or a dam that was planned but never constructed. Class "D" dams are considered defunct dams posing negligible or no hazard. NYSDEC may retain pertinent records regarding such dams.

Location

Dams provide a life-sustaining resource to people in all regions of the United States. They can supply water for domestic, agricultural, industrial, and community use; provide flood control; and create and furnish energy. The exact number of dams in the United States is unknown. According to the USAC National Inventory of Dams (NID), the country has more than 87,000 dams; however, this inventory covers only dams that meet minimum height and impoundment requirements, and numerous small dams are not identified by USACE. The NID reported 1,968 dams in the State of New York, of which 16 are within Allegany County. However, this total differs from that provided by NYSDEC, which identifies 156 dams in the County. For the purpose of this HMP, the NYSDEC data will be used.

Of the 156 dams identified by NYSDEC in Allegany County, 107 are classified as low hazard (Class A), five (5) are classified as intermediate hazard (Class B), two (2) are classified as high hazard (Class C), and 37 are classified as negligible or no hazard (Class D). Another five (5) dams have no classification (NYSDEC 2016). The two (2) High Hazard dams (Class C) and the five (5) intermediate hazard dams (Class B) consist of the following (associated basin and river names in parentheses):

Class B

- Wiscoy Dam (Genesee, Wiscoy Creek)
- Cuba Lake Outlet Spillway Dam (Allegheny, Cuba Lake Outlet)
- Arling Saunders Pond Dam / Saunders Pond Dam (Genesee, Tr-N Branch Plumbottom Creek)
- Herr Pond Dam / Herald Ford Pond Dam (Genesee, Tr-Chenunda Creek)
- Amity Lake Dam (Genesee, Tr-N Branch Plumbottom Crk).

Class C

- Caneadea Dam, Rushford Lake (Genesee, Caneadea Creek)
- Cuba Lake Dam (Allegheny, Oil Creek).

Table 5.4.1-2 summarizes the dams and their hazard classifications in Allegany County. According to the 2016 NYSDEC dam inventory, high hazard dams are within the following municipalities: Town of Caneadea, Town of Rushford, and Town of Cuba.

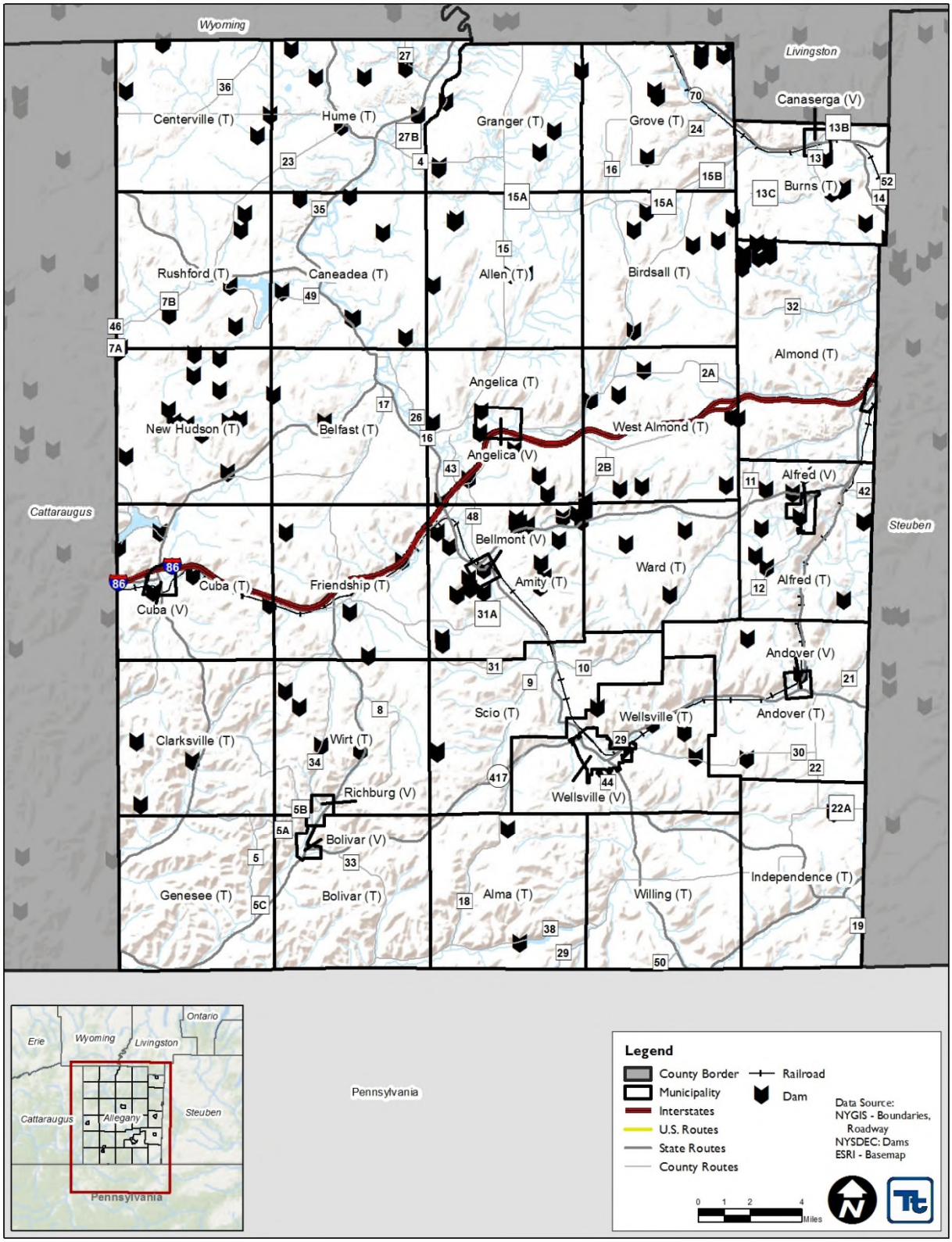
Table 5.4.1-2. Number of Dams in Allegany County

County	High Hazard	Significant Hazard	Low Hazard	Other	Total
Allegany	2	5	107	42	156

Source: NYSDEC 2016

Locations of dams in Allegany County are shown on Figure 5.4.1-1.

Figure 5.4.1-1. Dams in Allegany County



Source: NYSDEC

Previous Occurrences and Losses

Dam failures can occur suddenly, without warning, and under normal operating conditions—referred to as a "sunny-day" failure. Dam failures may also occur during a large storm event. Significant rainfall can quickly inundate an area and cause floodwaters to overwhelm a reservoir. If the spillway of the dam cannot safely pass the resulting flows, water will begin flowing in areas not designed for such flows, and a failure may occur. New York has undergone significant property damage including damage or loss of dams, bridges, roads, and buildings as a result of storm events and dam failures.

According to the Association of State Dam Safety Officials, no dam incidents in Allegany County have been recorded. Likewise, the County has no records of dam breaks occurring.

FEMA did not identify any dam break-related major disasters (DR) or emergencies (EM) between 1954 and 2016 that affected NYS. For this 2017 HMP, dam failure events impacting Allegany County between 1950 and 2016 were researched, and no known events were reported. Notably, not all previous events in Allegany County are included due to the extent of documentation and uncertainty whether all sources were identified or researched. Loss and impact information could vary depending on the source. Therefore, accuracy of monetary figures presented is based only on available information identified during research for this HMP.

United States Department of Agriculture (USDA) crop losses provide another indicator of severity of previous events. Additionally, crop losses can significantly affect the economy by reducing produce sales and purchases. These effects may have long-term consequences, particularly if crop yields are low the following years as well. Although Allegany County has undergone annual crop losses due to natural hazard events, USDA does not note in its records from 1989 to 2015 that any of these losses resulted from dam failure damages (USDA 2016).

Probability of Future Events

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. As noted earlier, dam failures typically occur in NYS as a result of heavy rains or other precipitation. However, the risk of such an event increases for each dam as the dam's age increases and/or frequency of maintenance decreases. As the Rushford and Cuba dams continue to age, possibility of a dam break or dam-related incident increases.

A "residual risk" is associated with dams—risk that remains after implementation of safeguards. This residual risk is associated with events beyond those that the facility was designed to withstand. For instance, both the Rushford and Cuba dams are within the southern portion of the Clarendon-Linden fault zone. Information from a study of Allegany County indicates this zone is currently seismically active. Excerpts from the study suggest a magnitude and rate of possible seismic activity that could affect Allegany's dams. Even so, the probability of any type of dam failure is low in today's dam safety regulatory and oversight environment. No dam failures have occurred in Allegany County.

For the 2017 HMP update, the Stanford University National Performance of Dams Plan (NPDP) database and the National Oceanic and Atmospheric Administration (NOAA)-National Climatic Data Center (NCDC) storm events database were both examined to identify the number of dam failures/incidents between 1950 and 2015. Neither database had record of any events in Allegany County (NOAA-NCDC 2016, NPDP 2016). Because no dam failures have been recorded within the past 65 years, the future probability is unlikely.

In Section 5.3, the identified hazards of concern for Allegany County were ranked. Probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, probability of occurrence of dam failure in the County is considered "Rare" (not likely

to occur within 100 years, as presented in Table 5.3-3). Rankings of the dam failure hazard for individual municipalities appears in Section 5.3 and in the jurisdictional annexes.

Impacts of Climate Change

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can significantly affect the hydrograph used for design of a dam. If the hygrograph changes, the dam conceivably could lose some or all of its designed margin of safety, also known as freeboard. Loss of designed margin of safety increases possibility that floodwaters would overtop the dam or create unintended loads. These situations could lead to a dam failure.

Climate change is beginning to affect both people and resources in NYS, and these impacts are projected to continue growing. Effects related to increasing temperatures and sea level rise are already evident within the State. The Integrated Assessment for Effective Climate Change in NYS (ClimAID) was undertaken to provide decision-makers with information on the State's vulnerability to climate change, and to facilitate development of adaptation strategies informed by both local experience and scientific knowledge (NYS Energy Research and Development Authority [NYSERDA] 2011).

Each region within NYS, as defined by ClimAID, has attributes that will be affected by climate change. Allegany County is part of Region 3, Southern Tier. Attributes to be affected by climate change include possible loss of agricultural revenue, as dairy dominates the agricultural economy and milk production losses are projected; increased incidence of Susquehanna River flooding; and increases in invasive insects, weeds, and other pests (NYSERDA 2011).

Annual average precipitation is projected to increase by up to one (1) to seven (7) percent by the 2020s, four (4) to 10 percent by the 2050s, and six (6) to 14 percent by the 2080s. During the winter months, additional precipitation will most likely occur, in the form of rain, and with possibility of slightly reduced precipitation projected for the late summer and early fall (NYSERDA 2014).

The projected increase in precipitation is expected to occur via heavy downpours and less in the form of light rains. Over the past 50 years, heavy downpours have increased, and this trend is projected to continue, contributing to localized flash flooding in urban areas and hilly regions. Total precipitation amounts have slightly increased in the northeastern states by approximately 3.3 inches over the last 100 years. The number of 2-inch rainfall events over a 48-hour period has increased since the 1950s (67-percent increase). The number and intensity of extreme precipitation events are increasing in NYS as well (Cornell University College of Agriculture and Life Sciences 2011). As a result of these higher intensity rainfall events, failure probabilities of low, significant, and under-designed high hazard dams may increase.

5.4.1.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. For the dam failure hazard, all areas and assets within a dam failure inundation zone are at risk. The following section includes a qualitative evaluation of the dam failure hazard in Allegany County, including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impacts on (1) life, safety, and health of residents; (2) general building stock; (3) critical facilities; (4) economy; and (5) future growth and development
- Change of vulnerability as compared to that presented in the 2011 Allegany County HMP
- Further data collection that will increase understanding of this hazard over time.

Overview of Vulnerability

As discussed above, dam failure events may occur suddenly, without warning, or during normal operating conditions. Additionally, events can occur as a result of a natural hazard event, including severe weather, earthquakes, landslides, and flooding. Direct and indirect losses associated with dam failures include injury and loss of life, damage to structures and infrastructure, agricultural losses, utility failure, and stress on community resources. Warning time for a dam failure event is often limited, which contributes to direct and indirect losses.

The dam failure hazard is of significance to Allegany County because 156 dams are present across the county, two of which are classified as high hazard by NYSDEC.

The impacts of potential failure of high hazard dams in the County are summarized as follows:

- Cuba Lake Dam: A dam failure would be catastrophic to downstream towns and villages. Cuba School would be destroyed.
- Caneadea Dam/Rushford Lake: At Rushford Lake, it has been determined that a dam failure would cause a 90-foot wall of water to rush downstream. At least two bridges would be damaged or destroyed, with losses for the County totaling $898,628. In the Town of Caneadea, losses would include critical facilities such as the sewer plant, multiple water plants, two fire halls, the highway department, a medical center, and various electric utilities— total damages exceeding $14 million. In Houghton College, townhouses, college flats, Waldorf hall, and the maintenance center would be damaged or destroyed at a cost of over $5.1 million.

Risk of dam failure increases during wet seasons. The Rushford Lake site is on the Clarendon/Linden fault. Theoretical expectation is that the dam would survive a seismic event.

The Cuba Lake District and the Rushford Lake District have EAPs in place in case of dam failure, whether resulting from earthquake or another natural/man-made disaster.

Data and Methodology

Dam failure inundation maps and downstream hazard areas are considered sensitive information and were not available to conduct a quantitative risk assessment. The following discusses the County's vulnerability to the hazard qualitatively.

Impact on Life, Health and Safety

Population located within a dam failure inundation zone is considered exposed and vulnerable. Potential for loss of life is affected by capacities and number of evacuation routes available to populations living within these areas. Of the population exposed to dam failure and flash flooding, the most vulnerable include the economically disadvantaged and the population over age 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impact on their families. The population over age 65 is also highly vulnerable because these people are more likely to seek or need medical attention that may not be available because of isolation during a flood event, and they may have more difficulty evacuating.

Often, warning time for dam failure is limited. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard. Ongoing mitigation efforts including dissemination and early warning systems noted in Section 6 (Mitigation Strategies)

of this HMP should help avoid the most likely cause of injury—persons trying to cross flooded roadways or channels during a dam failure-induced flood.

Impact on General Building Stock, Critical Facilities, and Economy

All buildings and infrastructure within a dam failure inundation zone are considered exposed and potentially vulnerable. Property closest to the dam inundation area is most likely to undergo the largest, most destructive surge of water. All transportation infrastructure within the dam failure inundation zone is vulnerable to damage, resulting in potential cutoff of evacuation routes, limitations on emergency access, and possible isolation issues. Utilities such as overhead power lines, cable lines, and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues within the inundation areas.

Dam failure can cause severe downstream flooding and may transport large volumes of sediment and debris, depending on the magnitude of the event. Widespread damage to buildings and infrastructure affected by an event would result in large costs to repair these locations. In addition to physical damage costs, businesses can be closed while flood waters retreat and utilities are returned to a functioning state.

Change of Vulnerability

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and potentially vulnerable to dam failure events, especially people, structures, and economically valuable resources within or near flood hazard areas (i.e., downstream dam-failure inundation areas such as those delineated in EAPs).

Future Growth and Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across the County. Any areas of growth could be impacted by dam failure if within an inundation area. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this HMP.

Additional Data and Next Steps

Because of sensitivity of dam failure inundation zones, potential losses have not been quantified and presented in this HMP. To estimate potential losses of population, buildings, critical facilities, and infrastructure, dam inundation areas and depths of flooding can be used to generate depth grids. Hazards United States (HAZUS) – MultiHazards (MH) may be applied to estimate potential losses within the County and participating municipalities.