## 4.3 HAZARDS OF CONCERN

The Morris County hazards of concern are presented in Section 4.3 and outlined as follows:

- **Hazard Profile**
  - Location - geographic area most affected by the hazard
  - Extent – severity of each hazard
  - Previous Occurrences and Losses
  - Impacts of Climate Change
  - Probability of Future Hazard Events
- **Vulnerability Assessment**
  - Impact to Life, Health and Safety
  - Impact to the General Building Stock
  - Impact to Critical Facilities and Lifelines
  - Impact to the Economy
  - Impact to the Environment
  - Future Changes that may Impact Vulnerability
  - Change of Vulnerability Since 2015 HMP

## 4.3.1 Dam Failure

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the flood hazard in Morris County.

### 2020 HMP Changes

- All subsections have been updated using best available data.
- Previous events between 2014 and 2019 are listed with a comprehensive list of previous events in Appendix E (Risk Assessment Supplement).
- Updated dam classifications are included from the NJDEP Bureau of Dam Safety.

### 4.3.1.1 Profile

#### Hazard Description

A dam or a levee is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water (FEMA 2007). Dams are man-made structures built across a stream or river that impound water and reduce the flow downstream (FEMA 2003). They are built for the purpose of power production, agriculture, water supply, recreation, and flood protection. Dam failure is any malfunction or abnormality outside of the design that adversely affects a dam's primary function of impounding water (FEMA 2007). Levees typically are earthen embankments constructed from a variety of materials ranging from cohesive to cohesionless soils. Dams and levees can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam or levee (inadequate spillway capacity);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage (terrorism);
- 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 or negligent operation, maintenance and upkeep;
- Failure of upstream dams on the same waterway; or
- Earthquake (liquefaction / landslides) (FEMA 2018a).

### *Regulatory Oversight of Dams*

Potential for catastrophic flooding caused by dam failures led to enactment of the National Dam Safety Act (Public Law 92-367), which for 30 years has protected Americans from dam failures. The National Dam Safety Program (NDSP) is a partnership among 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 purchases of needed equipment. FEMA has also expanded existing 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 2016).

### *U.S. Army Corps of Engineers Dam Safety Program*

The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet the 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 the dams. USACE has also developed guidelines for inspection and evaluation of dam safety (USACE 2019).

### *Federal Energy Regulatory Commission Dam Safety Program*

The Federal Energy Regulatory Commission (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 dams are more than 50 years old. Concern about their safety and integrity grows as dams age, rendering oversight and regular inspection especially important (FERC 2017). 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 2017).

Every 5 years, an independent consulting engineer, approved by 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 2017).

## Location

Table 4.3.1-1 lists the dams located in the County according to the National Performance of Dams Program.

**Table 4.3.1-1. Dams Located in Morris County Listed by National Performance of Dams Program**

| Dam Name | Dam Type | Hazard Class | Main Purpose | Dam Height (m) |
|---|---|---|---|---|
| Denmark Lake Dam | Earth; Gravity | High | Recreation | 3.7 |
| Picatinny Lake Dam | Earth; Gravity | High | Water Supply | 3.9 |
| Oak Ridge Reservoir Dam | Earth; Gravity | High | Water Supply | 18.3 |

| Dam Name | Dam Type | Hazard Class | Main Purpose | Dam Height (m) |
|---|---|---|---|---|
| Fayson Lakes (south) Dam | Earth; Gravity | Significant | Recreation | 2.4 |
| Kakeout Dam | Earth; Gravity | High | Water Supply | 9.1 |
| Kakeout Dike | Earth; Gravity | High | Water Supply | 4.0 |
| Hackettstown Res. Dam | Concrete | Low | Water Supply | 11.6 |
| Lake Juliet Dam | Earth; Gravity | Significant | Recreation | 3.7 |
| Deer Pond Dam | Earth; Gravity | Low | Recreation | 5.3 |
| Durham Pond Dam | Earth; Gravity | Low | Recreation | 3.4 |
| Indian Lake Dam | Earth; Gravity | Low | Recreation | 5.8 |
| Birchwood Lake Dam | Earth; Gravity | High | Recreation | 6.2 |
| Crystal Lake Dam | Earth; Gravity | High | Recreation | 5.0 |
| Lake Arrowhead Dam | Earth; Gravity | Significant | Recreation | 2.4 |
| Old Morris Canal Dam | Concrete | Significant | Recreation | 5.5 |
| Powerville Dam | Concrete | Significant | Recreation | 3.6 |
| Dixons Pond Dam | Earth; Gravity | Low | Recreation | 3.0 |
| Rock Ridge Lake Dam | Earth; Gravity | Significant | Recreation | 3.1 |
| Lake Estling Dam | Earth; Gravity | High | Recreation | 5.8 |
| Untermeyer Dam | Earth; Gravity | Significant | Recreation | 7.0 |
| Boonton Reservoir Dam | Earth; Gravity | Significant | Water Supply | 4.5 |
| Surprise Lake Dam | Earth; Gravity | Significant | Recreation | 6.7 |
| Split Rock Pond Dam | Concrete | High | Water Supply | 11.9 |
| Upper Waterloo Lake Dam | Earth; Gravity | Low | Recreation | 2.7 |
| Saxton Falls Dam | Earth; Gravity | High | Recreation | 4.9 |
| Moose Pac Lake Dam | Earth; Gravity | Significant | Recreation | 3.0 |
| Mountain Lake Dam | Earth; Gravity | High | Recreation | 4.6 |
| Stickle Pond Dam | Earth; Gravity | Low | Recreation | 5.2 |
| Wildcat Ridge WMA Dam | Earth; Gravity | Significant | Recreation | 3.0 |
| Cozy Lake Dam | Earth; Gravity | Low | Recreation | 2.4 |
| Swannanoa Lake #2 (North) Dam | Masonry | High | Recreation | 3.4 |
| Swannanoa Lake #1 (South) Dam | Masonry | High | Recreation | 4.6 |
| Camp Nyoda Dam | Earth; Gravity | Significant | Recreation | 2.7 |
| Cantys Lake Dam | Earth; Gravity | Significant | Recreation | 6.1 |
| Lake Hopatcong Dam | Concrete | High | Flood Control | 5.2 |
| Lake Musconetcong Dam | Earth; Gravity | High | Flood Control | 4.3 |
| Valhalla Lake Dam | Earth; Gravity | High | Recreation | 5.5 |
| Longwood Lake Dam | Concrete | Low | Recreation | 6.6 |
| Lake Shawnee Dam | Earth; Gravity | Significant | Recreation | 2.7 |
| Green Pond Reservoir Dam | Other | Low | Recreation | 4.6 |
| Lake Telemark Dam | Earth; Gravity | Significant | Recreation | 3.4 |
| Lake Ames Dam | Earth; Gravity | Significant | Recreation | 2.7 |
| Saffin Pond Dam | Earth; Gravity | Significant | Recreation | 7.3 |
| White Meadow Lake Dam | Earth; Gravity | High | Recreation | 4.6 |
| Washington Forge Pond Dam | Earth; Gravity | Significant | Recreation | 3.0 |
| Fox Lake Dam | Earth; Gravity | Significant | Recreation | 6.7 |
| Pleasant Valley Lake Dam | Earth | High | Recreation | 10.7 |
| Dalrymple Pond Dam | | Unknown | Irrigation | 4.9 |
| Shongum Lake Dam | Earth | High | Recreation | 3.7 |

| Dam Name | Dam Type | Hazard Class | Main Purpose | Dam Height (m) |
|---|---|---|---|---|
| Clyde Potts Reservoir Dam | Earth; Gravity | High | Water Supply | 24.4 |
| DeCozen s Dam | Earth; Rockfill | Significant | Recreation | 3.3 |
| Boonton Dam | Masonry | High | Water Supply | 36.6 |
| Lake Parsippany Dam | Earth; Gravity | High | Recreation | 4.0 |
| Lake Parsippany West Dike #1 | Earth; Gravity | High | Recreation | 2.4 |
| Jaqui Mill Dam | Earth; Gravity | Significant | Flood Control | 8.4 |
| Speedwell Dam | Masonry | High | Recreation | 4.1 |
| Pocahontas Dam | Concrete | High | Recreation | 3.4 |
| Mt. Kemble Lake Dam | Earth | Significant | Recreation | 11.0 |
| Mount Hope Lake Dam | Earth | High | Recreation | 5.5 |
| Terrace Lake Dam | Earth; Gravity | Significant | Recreation | 2.1 |
| Parsippany Dike | Masonry | High | Water Supply | 9.1 |
| Wildwood Lake Dam | Earth; Gravity | High | Recreation | 4.0 |
| Sunset Lake Dam | Earth; Gravity | Significant | Recreation | 2.5 |
| Rainbow Lakes Dam | Earth; Gravity | Low | Recreation | 3.4 |
| Washington Corner Dam | Earth; Gravity | Significant | Recreation | 3.7 |
| Kinnelon (Maple) Dam | Earth; Gravity | Significant | Recreation | 4.3 |
| Silver Lake Dam | Earth; Gravity | Low | Recreation | 4.6 |
| Lake Morski Oko Dam | Earth; Gravity | Low | Recreation | 3.7 |
| New Jersey No Name # 71 Dam | Earth; Rockfill | Low | Recreation | 3.7 |
| Lake Lenore Dam | Earth; Gravity | Low | Recreation | 3.7 |
| Emma Lake Dam | Earth; Gravity | Low | Flood Control | 3.0 |
| Morris County YMCA Dam | Earth; Gravity | Significant | Recreation | 5.5 |
| Fayson Lakes (west) Dam | Earth; Gravity | Significant | Recreation | 4.6 |
| Fayson Lakes (east) Dam | Earth; Gravity | Significant | Recreation | 5.2 |
| Mt. Hope Pond Dam | Earth; Gravity | Significant | Recreation | 4.6 |
| Griffith Dam | Earth | Low | Recreation | 2.7 |
| Lake Hudsonia Dam | Earth; Gravity | Significant | Recreation | 3.0 |
| Rickabear Dam | Earth; Gravity | Significant | Recreation | 6.6 |
| Intervale Lake Dam | Earth; Gravity | Low | Recreation | 1.9 |
| Mine Hill Reservoir Dam | Concrete; Masonry | Significant | Water Supply | 9.1 |
| Openaka Lake Dam | Earth; Gravity | Significant | Recreation | 6.1 |
| Cherokee Lake Dam | | Low | Recreation | 3.5 |
| Eden Mill Dam | Concrete | Significant | Water Supply | 3.5 |
| Powder Mill Pond Dam | Earth; Gravity | High | Recreation | 10.7 |
| New Jersey No Name # 56 Dam | | Low | Flood Control | 2.2 |
| Cedar Lake Dam | Earth; Gravity | Significant | Recreation | 4.0 |
| Sunrise Lake Dam | Earth; Gravity | Significant | Recreation | 5.4 |
| Cooks Pond Dam | Earth; Gravity | Significant | Recreation | 2.4 |
| Wildwood Dike | Earth; Gravity | Low | Water Supply | 2.4 |
| Mount Paul Dam | Earth; Gravity | High | Recreation | 7.9 |
| George Lake Dam | Earth; Gravity | Significant | Recreation | 9.0 |
| Cifrese Dam | Earth; Gravity | Low | Flood Control | 7.9 |
| PeapackGladstone Res Dam | Earth; Gravity | Significant | Water Supply | 7.9 |
| Lake Winona Dam | Earth; Gravity | High | Recreation | 4.6 |
| Burnham Park Lower Dam | Concrete | Significant | Recreation | 2.3 |

| Dam Name | Dam Type | Hazard Class | Main Purpose | Dam Height (m) |
|---|---|---|---|---|
| Lake Reality Dam | Earth; Gravity | Significant | Recreation | 4.3 |
| St. Mary s Abbey Lower Dam | Earth | Significant | Recreation | 4.0 |
| Yardley Road Lake Dam | Earth | Significant | Flood Control | 9.1 |
| Valley Estate at Chatham Township Dam | Earth; Gravity | Significant | Recreation | 2.1 |
| Lake Parsippany East Dike No. 2 | Earth; Gravity | High | Recreation | 1.5 |
| Saunders Fish Pond Dam | Earth; Gravity | Significant | Recreation | 3.7 |
| Ledgewood Pond Dam | Earth; Gravity | Significant | Recreation | 2.1 |
| Chester Pond Dam | Earth; Gravity | Low | Flood Control | 8.5 |
| Mountain Valley Park Dam | Earth; Gravity | Significant | Recreation | 3.0 |
| Rockaway Townsquare Mall Dam | | Unknown | Flood Control | 5.2 |
| Holstein Lake Dam | | Unknown | Recreation | 4.6 |
| Lake Denmark Dam | Earth | Significant | Water Supply | 3.7 |
| Picatinny Lake Dam | Earth | High | Water Supply | 4.6 |

*Source: National Performance of Dams Program, 2020*

## Extent

The NJ DEP classifies dams according to their hazard potential using the following criteria:

- Class I - High Hazard Potential: This classification includes those dams, the failure of which may cause the probable loss of life or extensive property damage.
    - i. The existence of normally occupied homes in the area that are susceptible to significant damage in the event of a dam failure will be assumed to mean "probable loss of life".
    - ii. Extensive property damage means the destructive loss of industrial or commercial facilities, essential public utilities, main highways, railroads or bridges. A dam may be classified as having a high hazard potential based solely on high projected economic loss.
    - iii. Recreational facilities below a dam, such as a campground or recreation area, may be sufficient reason to classify a dam as having a high hazard potential.
- Class II - Significant Hazard Potential: This classification includes those dams, the failure of which may cause significant damage to property and project operation, but loss of human life is not envisioned. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads or cause interruption of service of relatively important public utilities.
- Class III - Low Hazard Potential: This classification includes those dams, the failure of which would cause loss of the dam itself but little or no additional damage to other property. This classification applies to rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands or non-major roads.
- Class IV - Small Dams: This classification includes any project which impounds less than 15 acres/feet of water to the top of the dam, has less than 15 feet height-of-dam and which has a drainage area above the dam of 150 acres or less in extent. No dam may be included in Class IV if it meets the criteria for Class I or II. Any applicant may request consideration as a Class III dam upon submission of a positive report and demonstration proving low hazard.

Dam failures cause serious downstream flooding either because of partial or complete dam collapse. Failures are usually associated with intense rainfall and prolonged flood conditions; however, dam breaks may occur during dry periods as a result of progressive erosion of an embankment. The greatest threat from a dam break is to areas immediately downstream. Dam failures may or may not leave enough time for evacuation of people and property, depending on their abruptness. Seepages in earth dams usually develop gradually, and if the embankment damage is detected early, downhill residents have at least a few hours or days to evacuate. Failures of concrete or masonry dams tend to occur suddenly, sending a wall of water and debris down the valley at more than 100 mph. Survival would be a matter of having the good fortune not to be in the flood path at the time of the break. Dam failures due to the overtopping of a dam normally give sufficient lead time for evacuation.

A levee failure or breach causes flooding in landward areas adjacent to the structure. 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. Large volumes of water may be moving at high velocities, potentially causing severe damage to buildings, infrastructure, trees, and other large objects. Levee failures are generally worse when they occur abruptly with little warning and result in deep, fast-moving water through highly developed areas.

The environmental impacts of a dam or levee failure can include significant water-quality and debris-disposal issues. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks. After the flood waters subside, contaminated and flood-damaged building

materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties. In addition, severe erosion is likely; such erosion can negatively impact local ecosystems.

The Townships of Jefferson and Parsippany have the greatest number of high rated dams according to the NJDEP Bureau of Dam Safety. Table 4.3.1-2 summarizes the number of dams and their hazard classifications in Morris County according to a recent dataset shared by the NJDEP Bureau of Dam Safety.

**Table 4.3.1-2. Dams in Morris County**

| Municipality | High Hazard | Significant Hazard | Low Hazard | Total |
|---|---|---|---|---|
| Boonton Town | 1 | 1 | 1 | 3 |
| Boonton Township | - | - | 6 | 6 |
| Butler Borough | - | 1 | 5 | 6 |
| Chatham Township | - | 1 | - | 1 |
| Chester Township | - | - | 13 | 13 |
| Denville Township | 1 | 5 | 7 | 13 |
| East Hanover Township | - | - | 1 | 1 |
| Florham Park | - | - | 1 | 1 |
| Hanover Township | - | 1 | 2 | 3 |
| Harding Township | - | 1 | 5 | 6 |
| Jefferson Township | 6 | 4 | 8 | 18 |
| Kinnelon Borough | 3 | 9 | 5 | 17 |
| Mendham Borough | | 2 | 3 | 5 |
| Mendham Township | 3 | 2 | 8 | 13 |
| Mine Hill Township | - | - | 1 | 1 |
| Montville Township | 2 | 1 | 6 | 9 |
| Morris Plains Borough | 1 | - | 2 | 3 |
| Morris Township | - | 1 | 9 | 10 |
| Morristown Town | 2 | 1 | 1 | 4 |
| Mount Arlington Borough | - | - | 1 | 1 |
| Mount Olive Township | 2 | 2 | 3 | 7 |
| Mountain Lakes Borough | 5 | - | 2 | 7 |
| Netcong Borough | 1 | - | - | 1 |
| Parsippany-Troy Hills Twp | 6 | 3 | 9 | 18 |
| Randolph Township | 1 | - | 9 | 10 |
| Riverdale Borough | - | - | 3 | 3 |
| Rockaway Borough | 1 | - | 1 | 2 |
| Rockaway Township | 5 | 5 | 13 | 23 |
| Roxbury Township | - | 1 | 4 | 5 |
| Washington Township | - | 1 | 11 | 12 |
| Wharton Borough | - | 1 | | 1 |
| **Total** | **40** | **43** | **141** | **224** |

*Source: NJDEP Bureau of Dam Safety 2020*

## Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with dam failure throughout the State of New Jersey and Morris County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

### FEMA Major Disasters and Emergency Declarations

Between 1954 and 2019, FEMA declared that the State of New Jersey experienced four flood-related disasters (DR) or emergencies (EM). Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Morris County was included in four of these flood-related declarations which may not have included a dam failure; refer to Table 4.3.1-3.

**Table 4.3.1-3. Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2019**

| Declaration | Event Date | Declaration Date | Event Description |
|---|---|---|---|
| DR-245 | June 18, 1968 | June 18, 1968 | Flood: Heavy Rains & Flooding |
| DR-310 | September 4, 1971 | September 4, 1971 | Flood: Heavy Rains & Flooding |
| DR-477 | July 23, 1975 | July 23, 1975 | Flood: Heavy Rains, High Winds, Hail & Tornadoes |
| DR-701 | March 28-April 8, 1984 | April 12, 1984 | Flood: Coastal Storms & Flooding |

*Source: FEMA 2019*

### Dam Failure Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines flood events as follows:

- Flash Flood is reported in the NOAA-NCEI database for a life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam).
- Flood is reported in the NOAA-NCEI database for any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property.

For the 2020 HMP update, known dam failure events that have impacted Morris County between May 2014 and 2019 were researched. No events were found to have occurred (NOAA NCEI 2019, FEMA 2019, NPDP 2019). For events prior to May 2014, refer to Appendix E (Risk Assessment Supplement).

### U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2019, Morris County was not included in any USDA declaration involving dam failure.

## Probability of Future Occurrences

There is minimal history of occurrence of dam failure between 1950 and 2019. This suggests a low probability of future occurrence though the construction of new dam and levee structures could increase dam and levee failure risk. Likelihood of a dam failure in Morris County is difficult to predict. Dam failure events are

infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. However, the risk of such an event increases for each dam as the dam's age increases or frequency of maintenance decreases. Additionally, future climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration.

"Residual risk" to dams is risk that remains after implementation of safeguards. Residual risk to dams is associated with events beyond those that the facility was designed to withstand. However, probability of any type of dam failure is low in today's dam safety regulatory and oversight environment.

In Section 4.4, the identified hazards of concern for Morris County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering and Planning Committees, the probability of occurrence for flood in the County is considered 'occasional'; refer to Section 4.4 – Hazard Ranking.

## Climate Change Impacts

According to the NJDEP, New Jersey is experiencing increased intensity, frequency and duration of storm events (NJDEP 2019). Northern New Jersey's 1971-2000 precipitation average was over five inches (12-percent) greater than the average from 1895-1970 (Sustainable Jersey Climate Change Adaptation Task Force [CATF] 2011). The heaviest 1% of daily rainfalls have increased by approximately 70% between 1958 and 2011 in the Northeast (Horton et al. 2015). Average annual precipitation is projected to increase in the region by four to 11-percent by the 2050s and five to 13-percent by the 2080s (New York City Panel on Climate Change [NPCC] 2015). Increased rainfall and heavy rainfalls increase the risk of flooding events.

Annual precipitation for New Jersey has been about 8 percent above average over the last 10 years. The number of extreme precipitation events has also been above average over the last 10 years. During 2010–2014, the state experienced the largest number of extreme precipitation events (days with more than 2 inches) compared to any other 5-year period, about 50 percent above the long-term average. Winter and spring precipitation are projected to increase for the 21st century; extreme precipitation is also projected to increase. The projections of increasing precipitation are characteristic of a large area of the Northern Hemisphere in the northern middle latitudes, as well as increases in heavy precipitation events. This may result in increased flooding risks throughout the state (NCEI 2019).

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 the 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 the possibility that floodwaters would overtop the dam or create unintended loads, which could lead to a dam failure.

### 4.3.1.2 Vulnerability Assessment

To assess Morris County's risk to dam and levee failure, a qualitative review was implemented and supplemented with information from Section 4.3.6 (Flood) from this HMP.

#### Impact on Life, Health and Safety

The impact of dam failure on life, health, and safety is dependent on several factors such as the area that the dam is protecting, the location, capacity, structural integrity, and the proximity of structures, infrastructure, and critical facilities downstream of the failure inundation area. According to the 2019 State of New Jersey HMP, the level of impact that a failure would have can be predicted based upon the hazard potential classification as rated by the United States Army Corps of Engineers (State of NJ 2019). Table 4.3.1-4 outlines the recommended hazard classifications.

**Table 4.3.1-4. United States Army Corps of Engineers Hazard Potential Classification**

| Hazard Category(a) | Direct Loss of Life (b) | Lifeline Losses (c) | Property Losses (d) | Environmental Losses |
|---|---|---|---|---|
| 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 |

a. Categories are assigned to overall projects, not individual structures at a project.
b. 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.
c. Lifeline losses include indirect threats to life caused by the interruption of lifeline services from project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Property losses include damage to project facilities and downstream property and indirect impact 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.
e. Environmental impact 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.

*Source: State of NJ 2019*

As mentioned in the earlier sections, dam failure can cause in the most extreme case, loss of life and extensive property damage, or in the least extreme case, no loss of life or significant property damage. **Error! Reference source not found.** summarizes the number of dams in each municipality and their associated rating as provided by the NJDEP Bureau of Dam Safety (NJDEP 2020).

Dam failure can cause persons to become displaced if flooding of structures occurs. Dam failure may mimic flood events, depending on the size of the dam reservoir and breach. Understanding potential outcomes of flooding for each dam in Morris County would require intensive hydraulic modeling. However, Section 4.3.6 (Flood) reviews the outcome of flood events for the County to provide more insight about impacts to the population within each municipality should a certain flood event occur.

Generally, total numbers of injuries and casualties resulting from flooding of dam are not anticipated if proper warning and precautions occur. Cascading impacts may also include exposure to pathogens such as mold.

## Impact on General Building Stock

The existing dams throughout Morris County can have a varying impact on the general building stock. Communities that contain High hazard dams are most at risk for building stock destruction from flooding. The amount of flooding that these structures can experience depends on many factors including the reservoir size, and the time of day and season the breach occurs. Structures that are at a lower elevation from the reservoir will be most vulnerable to flooding from dam failure. The value of expected damage from flooding can be reviewed in Section 4.3.6 (Flood).

## Impact on Critical Facilities and Lifelines

Similar to the impacts on the general building stock, damage to critical facilities will vary for communities depending on the distribution of their dams and proximity of critical facilities to these dams and their downstream inundation area. Major roadways within Morris County may also be impacted by dam failure because of standing floodwaters or debris carried by the flooding. Roadblocks in transportation corridors can create disruption in the services provided to or by critical facilities. This puts communities in the County at greater risk if proper warning time is not provided to the community if a dam failure were to occur.

## Impact on the Economy

Dam failures have historically occurred in Morris County and can impact the local and regional economy. One of the first failures identified occurred in 1927 (NJDEP Bureau of Dam Safety 2017). This was the failure of the Sarubbi Dam when a sudden loss of concrete sections caused the breach. Further, when Hurricane Floyd passed through Morris County in 1999, four dams were damaged, and one of these four dams was a total loss (NJDEP Bureau of Dam Safety 2017). Shortly after Hurricane Floyd, a storm event in August 2000 caused 12 dams to fail in Morris County. Nine out the 12 dams that failed were located in the Township of Jefferson. In total, $179 million of damages were caused by all the dams throughout four NJ counties that breached after the storm in 2000 that included loss from 2,700 homes and businesses and 2,600 people that were evacuated (NJDEP Bureau of Dam Safety 2017).

## Impact on the Environment

The environmental impacts of a dam failure can include significant water-quality and debris-disposal issues. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks. After the flood waters subside, contaminated and flood-damaged building materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties. In addition, severe erosion is likely; such erosion can negatively impact local ecosystems.

## Future Changes that May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

### Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by a dam failure event if the structures are located within the flood protection area. It is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level.

### Projected Changes in Population

Overall the population in Morris County has been increasing and is projected to increase in the coming decades. As population increases, demographics change (e.g., an aging population) and infrastructure ages, it is important for the dam owners to continue to inspect and maintain their structures and update Emergency Action Plans to ensure residents are aware of this hazard.

### Climate Change

As discussed previously in this plan, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk of dam failures.

Further, existing dams may not be able to retain and manage increases in water flow from more frequent, heavy rainfall events. Heavy rainfalls may result in more frequent overtopping of these dams and flooding of the county's assets in adjacent inundation areas. However, the probable maximum flood used to design each dam may be able to accommodate changes in climate.

## Change of Vulnerability Since 2015 HMP

Dam failure inundation information is considered sensitive; therefore, this analysis only reviews the general areas that dams exist and does not identify the exact locations of vulnerable assets. A review of historical events provided more context about potential losses. Updates to data used in Section 4.3.6 (Flood) also enhance understanding of current value of building stock that is vulnerable to flood events.