5.3 DAM & LEVEE FAILURE

2019 Michael Baker International. We Make a Difference.

SECTION 5.3 DAM AND LEVEE FAILURE

5.3.1 HAZARD DESCRIPTION

DAM FAILURE

A dam is an artificial barrier that has the ability to 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 the 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 the type of construction material used, the methods used in construction, the slope or cross-section of the dam, the way the dam resists the forces of the water pressure behind it, the means used for controlling seepage, and, occasionally, according to the purpose of the dam. The 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).

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 waters that rush downstream damaging and/or destroying anything in its path (FEMA 1996).

More than a third of the country's dams are 50 or more years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs. There are also about 2,000 unsafe dams in the United States, located in almost every state.

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)

LEVEE FAILURE

Levees are man-made structures, usually an earthen embankment designed and constructed with sound engineering practices to contain, control, or divert the flow of water in order to provide protection from temporary flooding. A levee is built parallel to a body of water, typically a river, to protect the lives and properties behind it. Currently, there are thousands of miles of levees across the United States. No levee provides full protection from flooding (FEMA 2013c).

Levees are typically barriers between floodwaters and a nearby municipality. They include a series of culverts, canals, ditches, storm sewers, or pump stations, called "interior drainage" systems. These systems channel water from the land side of a levee over to the water side. When floodwaters exceed the height of a levee, overtopping occurs. As the water passes over the top, it can erode the levee, worsening the flooding and potentially causing an opening or beach in the levee. A levee breach occurs when part of a levee gives way, creating an opening through which floodwaters may pass. A breach can occur gradually or suddenly. The most dangerous breaches happen quickly during periods of high water. The resulting torrent can quickly swamp a large area behind the failed levee with little to no warning (American Society of Civil Engineers 2010).

2019 Michael Baker International. We Make a Difference.

USACE operates, maintains, and evaluates levees to determine if they meet accreditation requirements. Most levees are owned by local communities and flood control districts that must ensure proper operation and maintenance of the levee system as well (FEMA 2013c).

As per the National Committee on Levee Safety, levees, when functioning properly, reduce the risk of flooding for communities. However, an unexpected levee breach or failure can be catastrophic, with the flooding causing loss of life, emergency evacuations, and insufficient time to reduce damages to property.

5.3.1.1 REGULATIONS

Dam Failure

The potential for catastrophic flooding caused by dam failures led to the passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program (NDSP) has been used for 30 years to protect Americans from dam failure. The NDSP is a partnership of 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 the purchase of needed equipment. New Jersey is one of those participating states. FEMA has also expanded existing training programs and initiated new training programs. Grant assistance from FEMA provides support for the improvement of dam safety programs that regulate most of the dams in the United States.

New Jersey Department of Environmental Protection – Dam Safety Section

The NJDEP Dam Safety Section under the Bureau of Dam Safety and Flood Control has responsibility for overseeing dam safety in the State. In 1912, the New Jersey legislature passed a series of safety regulations related to the construction, repair, and inspection of existing and proposed dams in the State. In 1981, the law was amended and became the Safe Dam Act, N.J.S.A. 58:4. In 1985, the Dam Safety Standards, N.J.A.C. 7:20 regulations were passed, leading to the Dam Safety Section.

The primary goal of the program is to ensure the safety and integrity of dams in New Jersey and, thereby, protect people and property from the consequences of dam failures. The Section also coordinates with the Division of State Police, local and county emergency management officials in the preparations and approval of Emergency Action Plans.

The Dam Safety Section reviews plans and specifications for the construction of new dams or for the alternation, repair, or removal of existing dams and must grant approval before the owner can proceed with construction. Engineers from the Section evaluate each project, investigate site conditions, and check recommended construction materials. During construction, engineers identify conditions that may require design changes, check for compliance with approved plans and specifications, and approve foundations before material is placed.

Existing dams are periodically inspected to assure that they are adequately maintained and owners are directed to correct any deficiencies found. The regulations require the owner to obtain a professional engineer to inspect their dams on a regular basis. These investigations include a comprehensive review of all pertinent material contained in the Department's files, a visual inspection, technical studies when necessary, and the preparation of a comprehensive report (NJDEP 2012a).

The owners or operators of all dams which raise the waters of any stream more than 70 feet above its usual mean low-water height or which impound more than 10,000 acre-feet of water shall have a regular inspection performed annually and formal inspections performed every three years by a New Jersey licensed professional engineer obtained by the owner. In addition, these inspections must be attended by a professional engineer assigned from the NJDEP.

2019 Michael Baker International. We Make a Difference.

United States Army Corps of Engineers Dam Safety Program

The United States 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 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 1997).

Federal Emergency Management Agency National Dam Safety Program

The National Dam Safety Program (NDSP) is used to protect people from dam failures. The NDSP is a partnership of state and federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety (FEMA 2013b). The Program was established to improve safety and security around dams by providing assistance grants to state dam safety agencies to assist them in improving their regulatory programs; funding research to enhance technical expertise as dams are built and rehabilitated; establishing training programs for dam safety inspectors; and creating a National Inventory of Dams (NID). The NDSP includes:

- *Information needs for dam safety* – under FEMA's leadership, state assistance funds have enabled all participating states to better their programs through increased inspections, emergency action planning, and the purchase of needed equipment.
- *Dam safety training* – grant assistance provides vital support for the improvement of state dam safety programs that regulate most of the dams in the United States.
- *Dam safety research* – a national research program in dam safety focuses on priorities and produces products for both the layperson and the expert and develops technological tools that drive data collection and analysis toward a better understanding of risk and remediation needs (FEMA 2013b).

The National Dam Safety Program Act was signed into law on October 12, 1996 as part of the Water Resources Development Act of 1996. It was amended by the Dam Safety and Security Act of 2002. It is administered through the Department of Homeland Security and FEMA. The Act calls for FEMA to provide educations to the public, to dam owners and others about the need for strong dam safety programs, nationally and locally, and to coordinate partnerships among all players within the dam safety community to enhance dam safety (Association of State Dam Safety Officials 2004).

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, on dams associated with hydropower. There are 3,036 dams that 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, so oversight and regular inspection are important (FERC 2011). FERC staff inspects 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 the terms and conditions of a license (FERC 2011).

Every five 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 a total storage capacity of more than 2,000 acre- feet (FERC 2011).

2019 Michael Baker International. We Make a Difference.

FERC monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and after floods, FERC staff visits dams and licensed projects, determines the extent of damage, and directs any studies or remedial measures the licensee must undertake. FERC's *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the 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 emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam failure. The plans include operational procedures that may be used, 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 everyone knows what to do in emergency situations (FERC 2011).

Levee Failure

USACE and FEMA

USACE and FEMA have differing roles and responsibilities related to levees. USACE addresses a range of operation and maintenance, risk communication, risk management, and risk reduction issues as part of its responsibilities under the Levee Safety Program. FEMA addresses mapping and floodplain management issues related to levees, and it accredits levees as meeting requirements set forth by the National Flood Insurance Program.

Depending on the levee system, USACE and FEMA may be involved with the levee sponsor and community independently or—when a levee system overlaps both agency programs—jointly. Under both scenarios, the long-term goals are similar: to reduce risk and lessen the devastating consequences of flooding. Some USACE and FEMA partnering activities related to levees include:

- Joint meetings with levee sponsors and other stakeholders
- Integration of levee information into the National Levee Database
- State Silver Jackets teams
- Sharing of levee information
- Targeted task forces to improve program alignment

Coordination between USACE and FEMA with regard to levees is now standard within many of each agency's policies and practices. Over the past several years, both agencies coordinated policies where appropriate; jointly participated in meetings with stakeholders; and participated in many multiagency efforts, such as the National Committee on Levee Safety, the Federal Interagency Floodplain Management Task Force, and the Silver Jackets Program.

The Silver Jackets is a program that provides an opportunity to consistently bring together multiple state, federal, tribal, and local agencies to learn from each other and apply their knowledge to reduce risk. The Program's primary goals include the following:

- Create or supplement a mechanism to collaboratively identify, prioritize, and address risk management issues and implement solutions
- Increase and improve risk communication through a unified interagency effort
- Leverage information and resources and provide access to such national programs (FEMA's Risk MAP and USACE's Levee Inventory and Assessment Initiative)
- Provide focused, coordinated hazard mitigation assistance in implementing high-priority actions such as those identified by state hazard mitigation plans

2019 Michael Baker International. We Make a Difference.

- Identify gaps among agency programs and/or barriers to implementation, such as conflicting agency policies or authorities, and provide recommendations for addressing these issues

New Jersey has an active Silver Jackets team for life-cycle flood risk management. The focus of the State's team is the Passaic River Flood Advisory Commission recommendations, flood inundation mapping, and outreach and coordination.

National Committee on Levee Safety
Congress created the National Committee on Levee Safety to "develop recommendations for a national levee safety program, including a strategic plan for implementation of the program." The Committee adopted the vision of "an involved public and reliable levee systems working as part of an integrated approach to protect people and property from floods," and has been working toward this goal since October 2008 (National Committee on Levee Safety 2010).

The Committee is made up of representatives from state, regional, and local agencies, the private sector, USACE, and FEMA.

New Jersey
Currently in New Jersey, no single agency oversees the operation and maintenance of levees or levee systems nor has specific regulatory authority or responsibility over the safety of existing or proposed levees or levee systems. Rather, the oversight is accomplished through coordination of federal, state and local authorities.

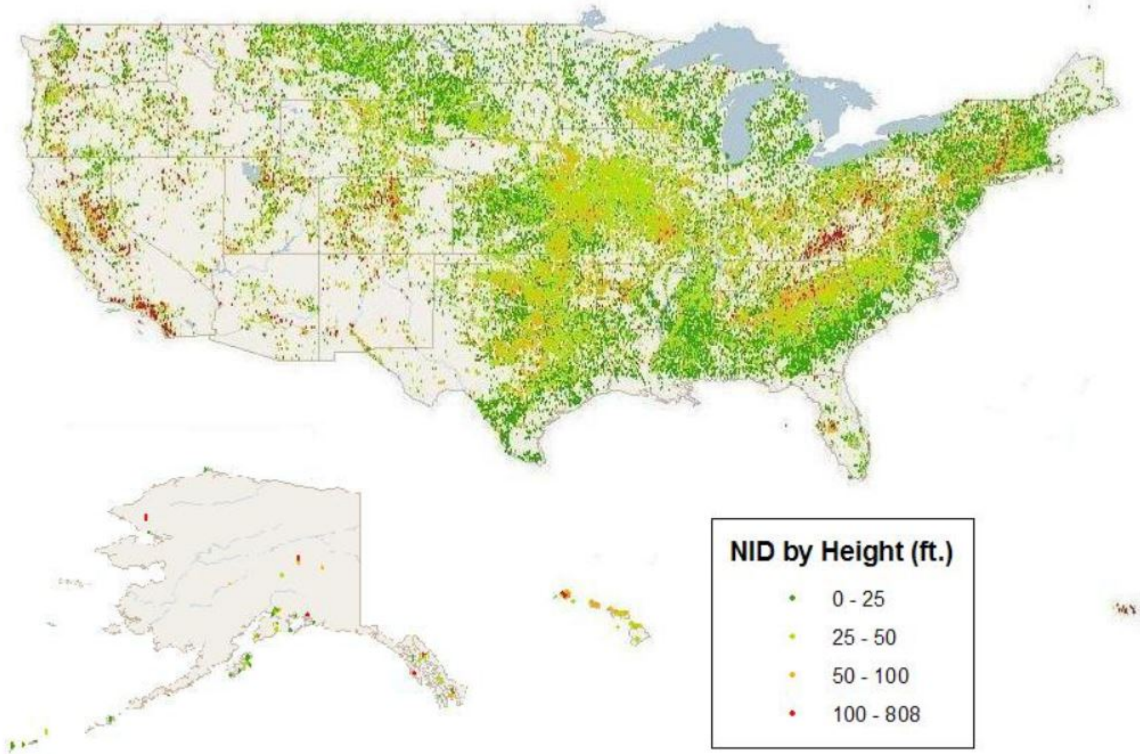
5.3.2 LOCATION

DAM FAILURE
According to the National Inventory of Dams (NID), there are 87,359 dams in the United States. Of these 87,359 dams, federal agencies own 3,808; state agencies own 6,435; local agencies own 15,938; public utilities companies own 1,686; and private entities or individuals own 56,541. Ownership to 2,951 dams is undetermined (USACE 2013a). Figure 5.3-1 displays the location of these dams throughout the United States. The NID categorizes the dams according to their primary function:

- Recreation - 31.8% (27,733 dams)
- Flood Control - 17.0% (14,883 dams)
- Fire Protection - 12.9% (11,253 dams)
- Irrigation - 9.3% (8,133 dams)
- Other - 8.1% (7,087 dams)
- Water Supply - 7.2% (6,307 dams)
- Undetermined - 5.0% (4,416 dams)
- Fish and Wildlife – 3.8% (3,300 dams)
- Hydroelectric – 2.5% (2,209 dams)
- Tailings – 1% (839 dams)
- Grade Stabilization – 0.7% (573 dams)
- Debris Control – 0.5% (422 dams)
- Navigation – 0.2% (204 dams) (USACE 2013b)

2019 Michael Baker International. We Make a Difference.

Figure 5.3-1 Locations of Dams in the United States (National Inventory of Dams)



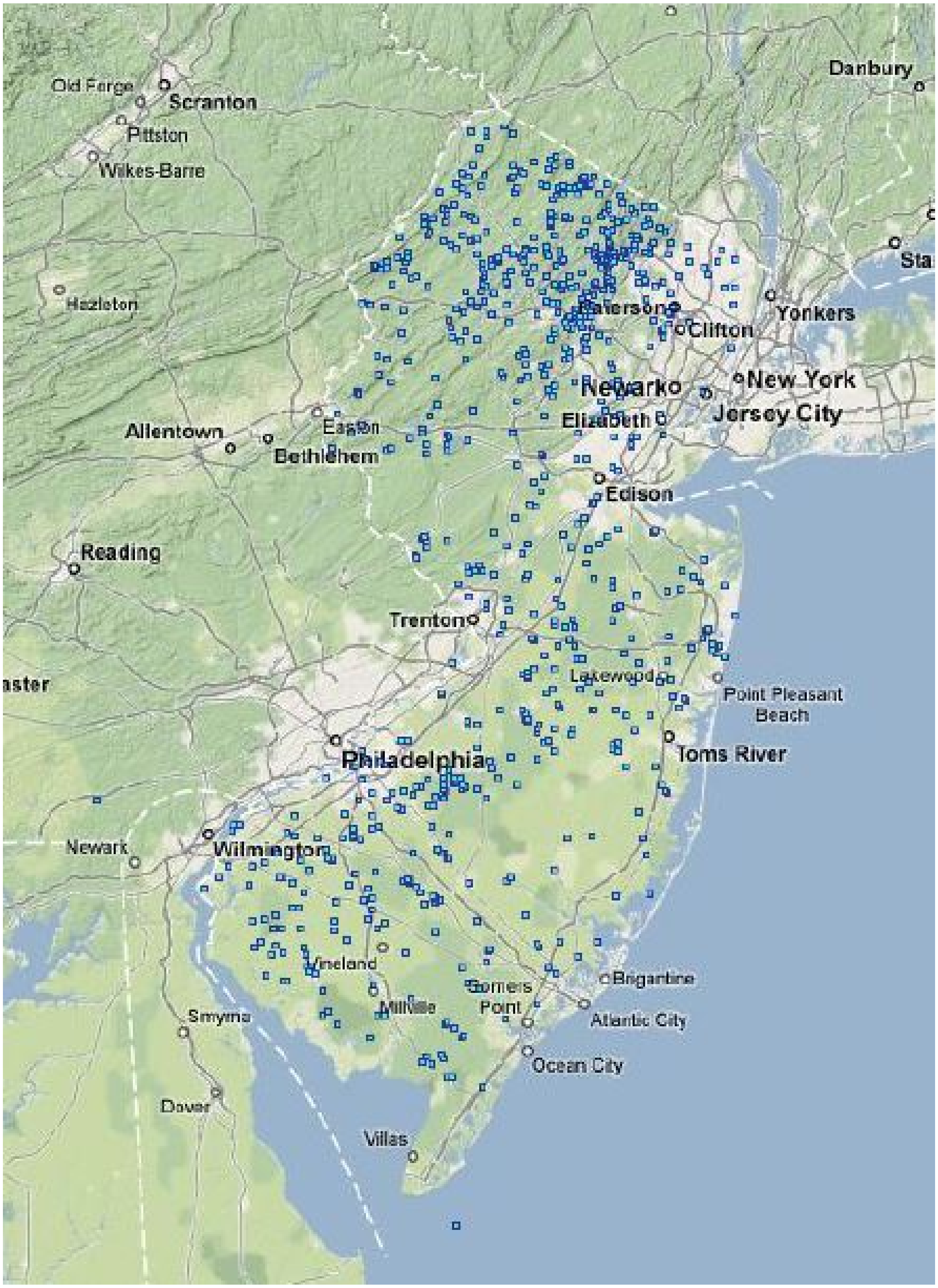
Source: USACE

According to the NID, there are 825 dams in New Jersey. Of these 825 dams, federal agencies own 23; State agencies own 125; local agencies own 282; public utilities companies own 1; and private entities or individuals own 394 (Figure 5.3-2) (USACE 2016). Nearly half (48%) of the dams in New Jersey are owned by private entities or individuals and the public utilities sector owns the least number of all dams in New Jersey.

However, the NJDEP maintains a listing of 1,998 dams across the State (NJDEP 2018). Figure 5.3-2 displays the location of these dams throughout New Jersey.

2019 Michael Baker International. We Make a Difference.

Figure 5.3-2 Locations of Dams in New Jersey (National Inventory of Dams)



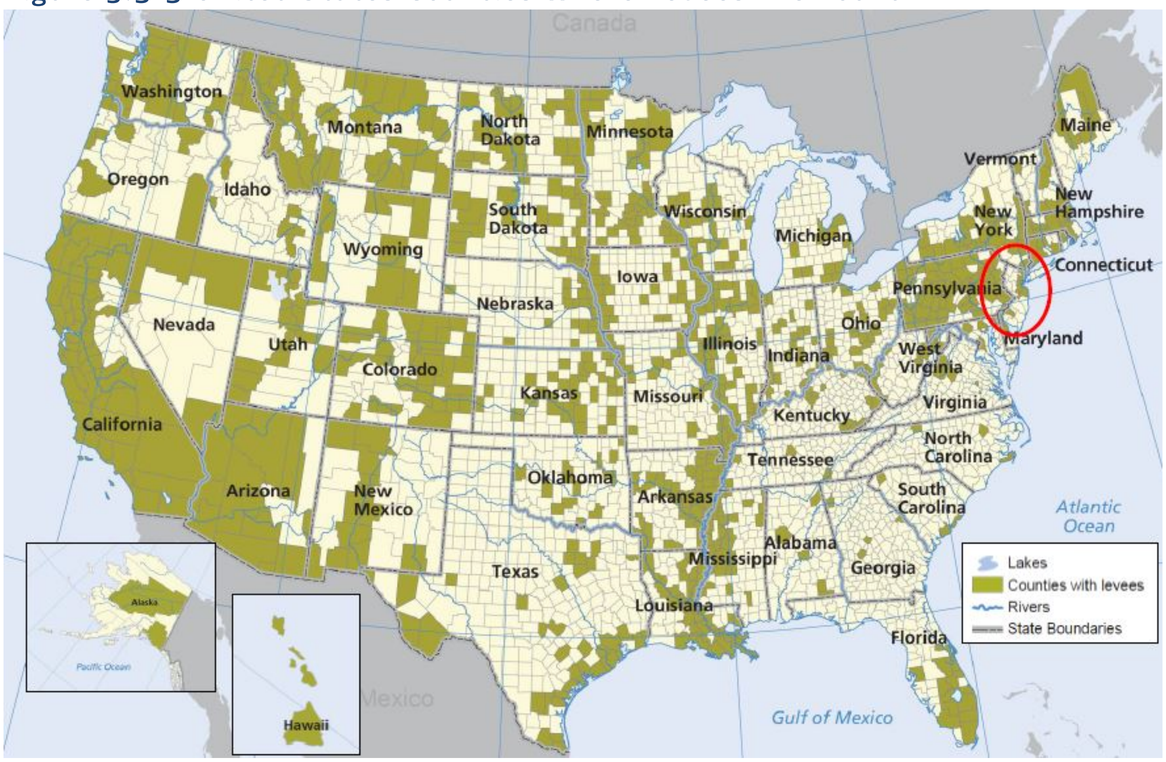
Source: USACE

2019 Michael Baker International. We Make a Difference.

Levee Failure

Levees are located across the country, but certain states rely on them more than others (such as Arkansas, Louisiana, Missouri, Mississippi, and California). There is no exact number of miles of levees in the United States; however, it is believed to be as many as 100,000 miles of levees. More than 85% are thought to be locally owned and the remaining 15% are overseen by the USACE or other federal or state agencies. FEMA has estimated that levees are located in approximately 22% of the counties in the United States, and 43% of the population lives in counties with levees. Figure 5.3-5 shows which counties in the United States contain levees, including Bergen, Essex, Gloucester, Hudson, Middlesex, Monmouth, and Union Counties in New Jersey, according to the American Society of Civil Engineering. Information shown on this figure is current as of August 2009. The red circle indicates the approximate location of New Jersey.

Figure 5.3-3 United States Counties Where Levees Are Found



Source: American Society of Civil Engineering 2010

A comprehensive listing regarding the types and locations of levees across the State is not available. This is due in part to the lack of oversight at the State level, but more notably because many of the levee systems were not built through formal processes. Table 5.3-1 lists the locations of levee systems throughout the State reported in the USACE National Levee Database. These systems represent the major structures across the State in which the USACE has provided some degree of assistance or oversight during development. The table includes levees that are owned federally, by the State, or locally. According to USACE, there are 10 levees in New Jersey in Essex, Gloucester, Monmouth, and Union Counties. The following table provides details about these levees.

2019 Michael Baker International. We Make a Difference.

Table 5.3-1 USACE Levees in New Jersey

COUNTY	SPONSOR(S)	SYESTEM NAME	SEGMENTS	LENGTH (MILES)	RIP STATUS	INSPECTION RATING
Essex County	Town of South Orange	S. Orange, Rahway East Branch, RB South**	1	0.09	Active	Minimally Acceptable
Essex County	Town of South Orange	S. Orange, Rahway East Branch, LB North**	1	0.1	Active	Minimally Acceptable
Gloucester County	Dupont Repauno Works, Greenwich Township, Gloucester County, Hercules, Inc, Logan Township, Gloucester County	Gibbstown*	4	3.96	Inactive	N/A
Monmouth County	Hazlet township, NJ Keansburg borough, NJ Middletown township, NJ Union Beach borough, NJ	Raritan Bay & Sandy Hook Bay, Keansburg**	1	5.63	Active	Unacceptable
Union County	City of Rahway	Rahway, Rahway River South Branch RB**	1	0.96	Active	Minimally Acceptable
Union County	Town of Hillside	Hillside, Elizabeth, River Left Bank**	1	0.34	Active	Minimally Acceptable
Union County	City of Elizabeth	Elizabeth, Elizabeth, River Right Bank South**	1	1.28	Active	Unacceptable
Union County	City of Elizabeth	Elizabeth, Elizabeth River Right Bank North**	1	0.21	Active	Unacceptable
Union County	City of Elizabeth	Elizabeth, Elizabeth, River Left Bank South**	1	1.71	Active	Unacceptable
Union County	City of Elizabeth	Elizabeth, Elizabeth River Left Bank North**	1	0.16	Active	Minimally Acceptable

Source: USACE

The South Jersey Levee Inventory was created to identify and characterize the location, extent, and characteristics of existing levees/dikes in and along the Delaware Bay and the lower Delaware River in the southern New Jersey counties of Cape May, Cumberland, Gloucester, and Salem. The inventory provides an estimate of the amount, type, and extent of vulnerability of people and property, including agricultural acreages and businesses, protected by the levees. The goal of the information obtained

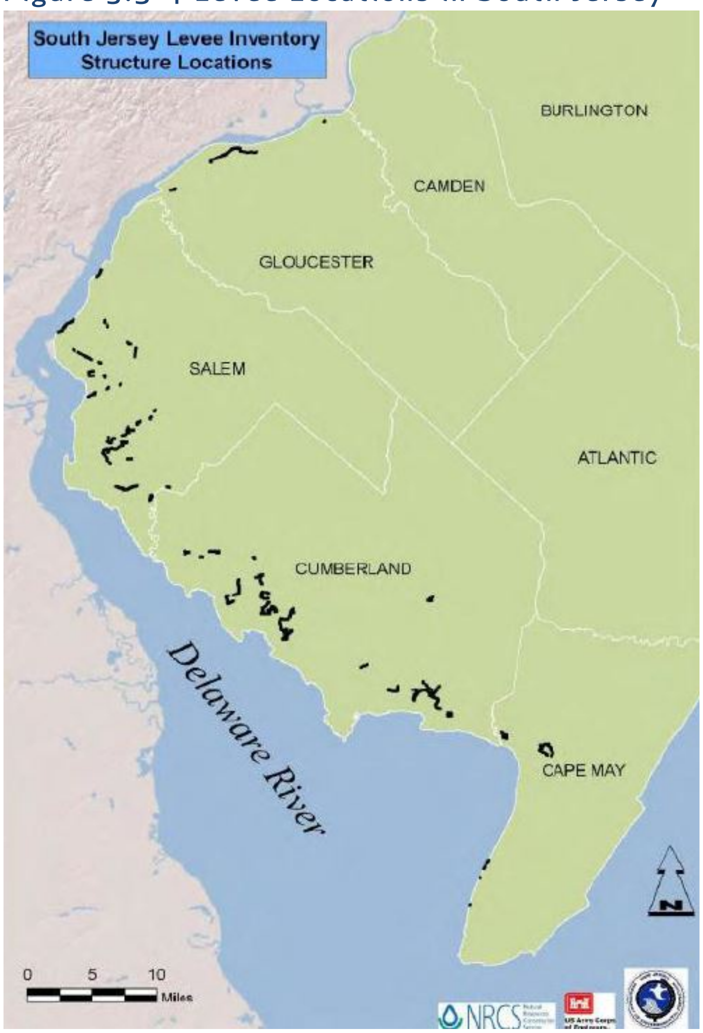
2019 Michael Baker International. We Make a Difference.

through the inventory would assist in providing for enhanced levee safety management and emergency response activities.

The South Jersey Levee Inventory was conducted by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) under an agreement signed in August 2006 with the USACE. Funding was provided by the Bureau of Dam Safety and Flood Control of the NJDEP. The inventory was divided into two parts: field inventory and the Light Detection and Ranging (LiDAR) analysis. The field inventory initially identified 107 levees using 2002 aerial photography. After the inventory was completed in May 2010, 70 structures were verified as actual levees. LiDAR analysis of these determined the location, extent, and areas protected from tidal inundation and flooding. Over 3,000 structures are identified as being protected by levees in six (of the 70 levees) selected levee locations. Approximately 86% of all levees identified in the four South Jersey counties surveyed were located in Cumberland and Salem Counties. Overall, the inventory revealed that 70% of the levees are owned by private individuals and each of the 22 municipalities in the four counties studied had at least one levee (http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_018319.pdf)

Figure 5.3-6 shows the locations of levees in the four counties study, as determined from a 2002 aerial photograph and field verification.

Figure 5.3-4 Levee Locations in South Jersey



Source: USDA 2010

2019 Michael Baker International. We Make a Difference.

5.3.3 EXTENT

Dam Failure

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

- Low hazard potential dams are those where failure or mis-operation results is 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 mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominately rural or agricultural areas.
- High hazard potential dams are those where failure or mis-operation will probably cause loss of human life.

USACE developed the classification system shown in Table 5.3-2 for the hazard potential of dam failures. USACE hazard rating systems is based only on the potential consequences of a dam failure; it does not take into account the probability of such failures.

Table 5.3-2 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: United States Army Corps of Engineers 1995

According to the NJDEP, there are four hazard classifications of dams in New Jersey. The classifications relate to the potential for property damage and/or loss of life in the event of a dam failure:

- Class I (High-Hazard Potential) - Failure of the dam may result in probable loss of life and/or extensive property damage.

2019 Michael Baker International. We Make a Difference.

- Class II (Significant-Hazard Potential) - Failure of the dam may result in significant property damage; however, loss of life is not envisioned.
- Class III (Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life and/or significant property damage.
- Class IV (Small-Dam Low-Hazard Potential) - Failure of the dam is not expected to result in loss of life or significant property damage.

Table 5.3-3 summarizes the number of dams and their hazard classifications, by County.

Table 5.3-3 Number of Dams by County in New Jersey

COUNTY	HIGH HAZARD	SIGNIFICANT HAZARD	LOW HAZARD	TOTAL	OTHER STRUCTURES*
Atlantic	1	7	31	39	12
Bergen	7	9	55	71	8
Burlington	11	39	95	145	28
Camden	1	19	56	76	7
Cape May	0	7	4	11	4
Cumberland	4	11	12	27	11
Essex	8	4	14	26	8
Gloucester	3	26	29	58	12
Hudson	1	0	0	1	2
Hunterdon	10	10	70	90	17
Mercer	8	8	72	88	9
Middlesex	4	11	24	39	12
Monmouth	11	16	85	112	16
Morris	37	46	137	220	31
Ocean	8	15	75	98	7
Passaic	49	23	61	133	22
Salem	1	20	21	42	9
Somerset	4	13	67	84	18
Sussex	40	40	156	236	32
Union	4	7	13	24	8
Warren	15	6	65	86	19
Totals	227	337	1,142	1,706	292

Source: NJDEP 2018

*NJDEP Dams database classifies structures that are not technically dams within their database. These include dams that are less than 5 feet, have been removed, never built, failed, etc.

LEVEE FAILURE

In the event of a levee failure, floodwaters may 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 one-percent 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 (FEMA, 2004).

2019 Michael Baker International. We Make a Difference.

Levees require maintenance to continue to provide the level of protection they were designed and built to offer. Maintenance responsibility belongs to a variety of entities including local, state, and federal government and private landowners. Well-maintained levees may obtain certification through independent inspections. Levees may not be certified for maintaining flood protection when the levee owner does not maintain the levee or pay for an independent inspection. The impacts of an un-certified levee include higher risk of levee failure. In addition, insurance rates may increase because FEMA identifies on Flood Insurance Rate Maps that the structures are not certified to protect from a one-percent annual chance flood event (FEMA, 2004).

5.3.4 PREVIOUS OCCURRENCES AND LOSSES

Dam Failure

Dam failures can occur suddenly, without warning, and may occur during normal operating conditions. This is 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. Over the years, New Jersey has seen significant property damage including damage or loss of dams, bridges, roads, and buildings as a result of such storm events and dam failures. New Jersey has also been impacted by levee failures.

The following section provides details about several dam failure events that occurred in the State of New Jersey. Several sources provided historical information regarding previous occurrences and losses associated with dam failure events throughout the State. Loss and impact information for these events could vary depending on the source; therefore, the accuracy of monetary figures and event details is based only on the available information identified during research for this HMP.

Sarubbi Dam Failure 1927

In 1927, the Sarubbi Dam located in Morris County failed during non-storm conditions. Referred to as a "sunny-day failure," the sudden loss of concrete sections caused this dam to fail in November 1927. Based on anecdotal research, this is the only dam failure that was not a direct result of another hazard.

September 1940 Storm

On September 1, 1940, Southern New Jersey experienced an unusually large storm event associated with a tropical system. The system inundated portions of Camden, Gloucester, Salem, Cumberland, and Atlantic Counties.

Damage throughout South-Jersey was widespread, from Millville to Clementon. Dozens of roads, bridges, and dams were damaged or destroyed as a result of the ensuing floods. Portions of the area experienced over 24 inches of rain in less than 12 hours. This extraordinary rainfall intensity was experienced over a localized area near Parvin State Park, located northwest of the City of Vineland.

Hurricane Floyd 1999

On September 16, 1999, Hurricane Floyd, a tropical storm by the time it hit New Jersey, combined with a weather system from the west to drop significant rainfall in portions of the State.

Hardest hit was the Raritan River Basin. Although the State's dams were spared the worst and no loss of life or significant property damage was attributed to the failure of a dam, the storm left behind a trail of damage to the State's dams.

In the weeks following the storm, the NJDEP Dam Safety Section inspected over 50 dams to assess the impact of the storm. They documented complete failure of three dams and notable damage to 24 dams (NJDEP, 2012b). Table 5.3-4 lists dams affected by the incident.

2019 Michael Baker International. We Make a Difference.

Table 5.3-4 Dams Affected by Hurricane Floyd in 1999

DAM NAME	TOWNSHIP	COUNTY
COMPLETE FAILURE		
Kirbys Mill Dam	Medford Township	Burlington
Bostwick Lake Dam	Upper Deerfield Twp.	Cumberland
Spencer Detention Basin Dam	Morris Twp.	Morris
NOTABLE DAMAGE		
Whites Pond Dam	Borough of Waldwick	Bergen
Diamond Mill Dam	Millburn Twp.	Essex
Orange Reservoir Dam	West Orange Twp.	Essex
Singley Dam	Borough of Runnemede	Gloucester
Amwell Dam No. 2	West Amwell Twp.	Hunterdon
Lambertville Dam No. 1	West Amwell Twp.	Hunterdon
Lamberville Dam No. 2	West Amwell Twp.	Hunterdon
Amwell Dam No. 1	West Amwell Twp.	Hunterdon
Amwell Dam No. 3	West Amwell Twp.	Hunterdon
Lake Winona Dam	Jefferson Twp.	Morris
Shongum Lake Dam	Randolph Twp.	Morris
Hudsonia Dam	Rockaway Twp.	Morris
Laurel Lake Dam	West Milford Twp.	Passaic
West Milford Lake Dam	West Milford Twp.	Passaic
Stowaway Lake Dam	West Milford Twp.	Passaic
Pinecliff Lake Dam	West Milford Twp.	Passaic
Gordon Lake Dam	West Milford Twp.	Passaic
Watchung Lake Dam	Borough of Watchung	Somerset
Sunset Lake Dam	Bridgewater Twp.	Somerset
Skillman Dam	Montgomery Twp.	Somerset
Mountain Creek Pond Dam	Vernon Twp.	Sussex
Bloodgoods Dam	Clark Twp.	Union
Shackamaxon Dam	Scotch Plains Twp.	Union
Seeley's Pond Dam	Scotch Plains Twp.	Union

Source: NJDEP, 2012

Sparta Storm August 2000

Another dam failure incident occurred in August 2000 that affected northern counties in New Jersey. Unusually large amounts of rain produced by a series of thunderstorms deluged parts of northwestern New Jersey during the period August 11-14, 2000 (USGS 2001a). Rainfall was greatest in parts of southeastern Sussex County and northwestern Morris County where rainfall totals exceeded 14 inches. A total of four dams completely failed as a result of the ensuing floods. The dams were on Seneca Lake, Tomahawk Lake, Furnace Pond, and Edison Pond in Sussex County. An additional 26 dams in Sussex and Morris Counties were damaged (National Weather Service 2000). Total damage was an estimated $179 million (USGS 2001b).

Table 5.3-5 lists dams affected by the incident. Additionally, Figure 5.3-7 shows a photograph of the Tomahawk Lake Dam failure that occurred during this storm.

2019 Michael Baker International. We Make a Difference.

Table 5.3-5 Dams Affected by the 2000 Sparta Storm

DAM NAME	MUNICIPALITY	COUNTY
Complete Failure		
Seneca Lake Dam	Sparta	Sussex
Tomahawk Lake Dam	Byram	Sussex
Furnace Pond Dam	Stanhope	Sussex
Edison Pond Dam	Sparta	Sussex
Less Than Complete Failure		
Lake Tamarack Dam	Hardyston	Sussex
NJ No Name No. 51	Jefferson	Morris
Shawnee Lake Dam	Jefferson	Morris
Hawthorne Lake Dam	Sparta	Sussex
Glen Lake Dam	Sparta	Sussex
Washington Forge Pond	Wharton	Morris
Arapaho Lake Dam	Sparta	Sussex
NJ No Name No. 43	Sparta	Sussex
Rock Island Dam	Sparta	Sussex
Oak Ridge Lake Dam	Jefferson	Morris
Acquackanock Dam	Sparta	Sussex
Sparta Lake Dam	Sparta	Sussex
Cozy Lake Dam	Jefferson.	Morris
Saginaw Lake Dam	Sparta	Sussex
Summit Lake Dam	Hardyston	Sussex
Lower Waterloo Dam	Byram & Mt.	Sussex and Morris
Upper Waterloo Dam	Mt. Olive	Morris
Franklin Pond Dam	Franklin	Sussex
Heaters Pond Dam	Ogdensburg	Sussex
Morris Lake Dam	Sparta	Sussex
Camp Ryker Lake Dam	Sparta	Sussex
Swannanoa South Dam	Jefferson	Morris
Winona Lake Dam	Jefferson	Morris
Saffin Pond Dam	Jefferson	Morris
Lake Hartung Dam	Jefferson	Morris
Elwood Headley Pond	Jefferson	Morris

Source: USGS, 2011

2019 Michael Baker International. We Make a Difference.

Figure 5.3-5 Tomahawk Lake Dam Failure August 2000

Source: NJDEP, 2012

Burlington County Dam Failures 2004

A significant dam failure incident occurred in 2004 as a result of heavy rains. Unusually large amounts of rain deluged parts of Burlington, Camden, and Ocean Counties in southern New Jersey from the morning of July 12 through the early morning hours of July 13, 2004. Doppler radar estimates of total rainfall for the 24-hour period ending 7:00am on July 13 were from eight to 12 inches over central Burlington, western Ocean, and eastern Camden Counties. More than 11 inches of rain was recorded by rain gages in Pemberton and Tabernacle Townships in Burlington County (USGS, 2013).

The NJDEP reported that 17 dams failed and 28 dams were damaged in Burlington County. All 17 dam failures occurred in the Rancocas Creek Basin. Two of the dams were in the North Branch Rancocas Creek Basin, and the remaining 15 were in the upper reaches of the South Branch Rancocas Creek Basin. Of the 28 dams that were damaged, 27 were in the Rancocas Creek Basin, three in the North Branch Rancocas Creek Basin, and 24 were in the South Branch Rancocas Creek Basin. The remaining damaged dam was in the Batsto River Basin (Protz and Reed 2006). Table 5.3-6 lists the dams affected by the storm. Additionally, Figure 5.3-8 shows the locations of damaged and destroyed dams in Burlington County as a result of the incident.

Table 5.3-6 Dams Affected by the 2004 Burlington County Storm

DAM NAME	MUNICIPALITY	COUNTY
Complete Failure		
Kenilworth #2 Dam	Evesham	Burlington
Strokes-Lower Dam	Medford	Burlington
Lake Stockwell Dam	Medford	Burlington
Birchwood Lake Dam	Medford	Burlington
Papoose Lake Dam	Medford Lakes	Burlington
Upper Aetna Dam	Medford Lakes	Burlington
Lower Aetna Dam	Medford Lakes	Burlington
Camp Inawendiwin Lower Dam	Tabernacle	Burlington
Reeves Dam B	Woodland	Burlington
Lower Reeves Bog Dam	Woodland	Burlington
Crane Lake Dam	Evesham	Burlington
Lost Lake Dam	Evesham	Burlington

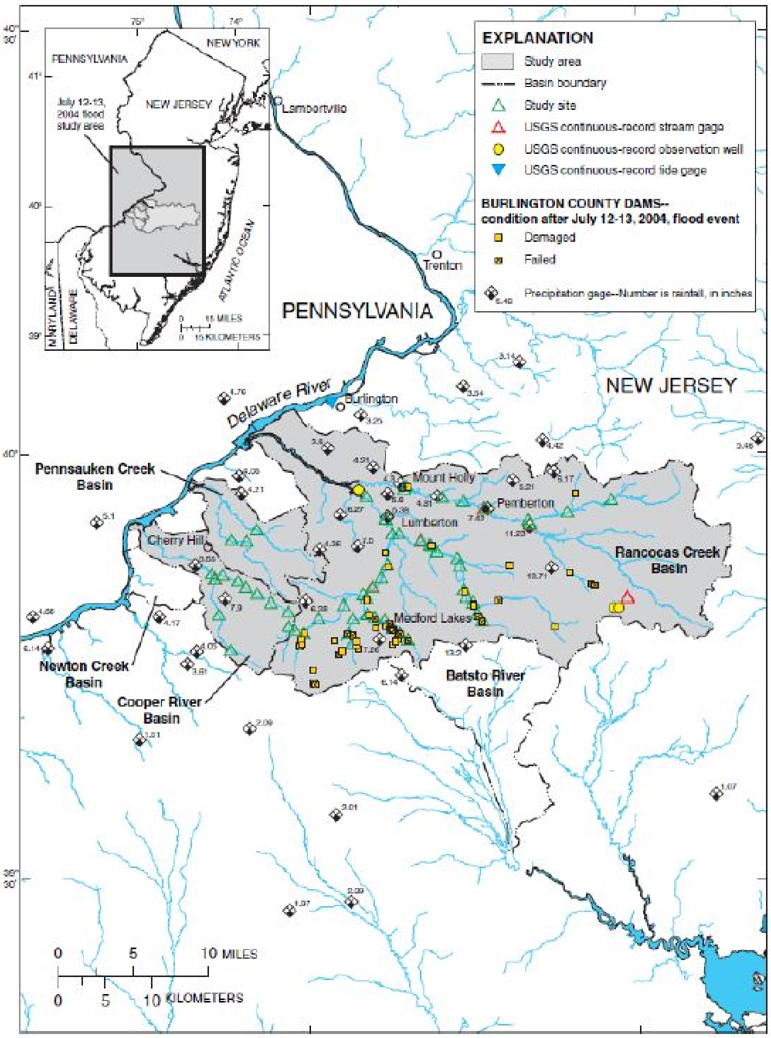
2019 Michael Baker International. We Make a Difference.

DAM NAME	MUNICIPALITY	COUNTY
Hinchman Dam	Medford	Burlington
Third Street Dam	Southampton	Burlington
Blue Lake Dam	Medford	Burlington
Squaw Lake Dam	Medford	Burlington
Less Than Complete Failure		
Saipe Lake Dam	Medford	Burlington
Fostertown Road Dam	Medford	Burlington
Upper Stokes Dam	Medford	Burlington
Golf Course Dam	Evesham	Burlington
Mill Dam	Mount Holly	Burlington
Cranberry Lakes Dam #6	Medford	Burlington
Kirby's Mill Road	Medford	Burlington
Burnt Bod Dam	Medford	Burlington
Oliphants Mill Lake Dam	Medford	Burlington
Old Forge Lake Dam	Southampton	Burlington
Bayberry Street Dam	Pemberton	Burlington
Upper Mimosa Dam	Medford	Burlington
Kenilworth #3 Dam	Evesham	Burlington
Mimosa Lake Dam	Medford	Burlington
Fisher Pond Dam	Southampton	Burlington
Quoque Dam	Medford Lakes	Burlington
JCC Dam	Medford	Burlington
Kenilworth Lake Dam	Evesham	Burlington
Kettle Run Road Dam	Evesham	Burlington
Lebanon Forrest #1 Dam	Pemberton	Burlington
Marlton Lakes Upper Dam	Evesham	Burlington
Batsto Lake Dam	Washington	Burlington
Union Mill Lake Dam	Evesham	Burlington
Van Dal Lake Dam	Evesham	Burlington
Sooy Dam	Woodland	Burlington
New Jersey No Name #8	Southampton	Burlington
Timer Lake Dam	Medford	Burlington
Vincentown Mill Dam	Southampton	Burlington

Source: NJDEP 2004

2019 Michael Baker International. We Make a Difference.

Figure 5.3-6 Locations of Damaged and Destroyed Dams 2004



Source: Protz and Reed, 2006

Gloucester County Levee Breach 2005

Heavy rain associated with the remnants of Tropical Storm Cindy fell across New Jersey on July 8, 2005. Storm totals ranged from 1.5 to five inches. The heavy rain caused poor drainage and roadway flooding. In Logan Township (Gloucester County), emergency repairs were made to a 30-foot breach in a levee off of Floodgate Road to keep the Delaware River at bay (NOAA NCDC, 2013).

Monmouth County Dam Failure 2005

Heavy rain associated with a low-pressure system southeast of New Jersey moved into Monmouth County between October 13 and 14, 2005. The three-day storm totals in the County averaged between four and 11 inches, with the highest amounts near the coast. Dams failed on both Spring Lake and Mill Pond, and Deal Lake overflowed. Nearly 1,200 people were evacuated and a state of emergency was declared. Approximately 100 people were evacuated near the Shark River when a

2019 Michael Baker International. We Make a Difference.

levee along the River broke. In Wall Township, a dam breach on Mill Pond in Allaire State Park caused significant water damage and a roadway collapse in the village within the Park (NOAA NCDC, 2013).

Hunterdon County 2006

Several days of heavy rain throughout the Delaware River Basin culminated with major flooding along the Delaware River between June 28 and 30, 2006. It was the fourth highest crest on record for the Delaware River along Hunterdon County. Rainfall totals in the County averaged from four to eight inches, with storm totals exceeding 10 inches in parts of the Upper Delaware River Basin in New York State. The County was declared a state of emergency. Approximately 1,250 homes and businesses were damaged and four were destroyed. In the Borough of Stockton, a levee breach compounded the flooding. Evacuations occurred from the Delaware River east to New Jersey State Route 29. Most of the flooding was confined to basements. Overall damages from the storm were estimated at $7.5 million.

Rainbow Lake Dam 2007

A Nor'Easter struck New Jersey between April 15 and 16, 2007, bringing up to 10 inches of rain in parts of the State. Salem County was particularly hit hard, with high flood flows that overflowed and failed the Rainbow Lake Dam on State Route 56 in Pittsgrove Township. The 20-foot high earth embankment dam impounded an 80-acre lake. The road washed out and a gas main broke (Dam Safety, 2010).

Southwestern New Jersey Dam Breaks 2011

A series of thunderstorms brought three to seven inches of rain across New Jersey on August 14, 2011. In southern Gloucester, eastern Salem, and western Cumberland Counties, rainfall totals ranged from seven to 11 inches. This event, combined with scattered thunderstorms on August 15, 2011, caused severe flash flooding with dam breaks in southwestern New Jersey (NOAA NCDC, 2013). The NJDEP Bureau of Dam Safety reported the failure of five dams as a result of this storm. The Seeley's Mill Pond Dam, located upstream from the Cohansey River at Seeley gaging station completely failed (USGS, 2013). Other sources indicated that four dams failed and as a result, approximately 24 dams had to lower reservoirs in order for inspections and analyses to be completed. Damage totals were estimated at $25 million, most of which occurred in Salem and Cumberland Counties (NOAA NCDC, 2013).

Hurricane Irene August 2011

The NJDEP Bureau of Dam Safety reported the failure of six dams as a result of Hurricane Irene. Three of these dams are located upstream from USGS gaging stations. Saffrin Pond Dam, failed completely. It is located on Weldon Brook, a tributary to Lake Hopatcong, upstream from the USGS stage-only gage on Lake Hopatcong and the continuous-record streamflow-gaging station on Musconetcong River at the outlet of Lake Hopatcong. The New Jersey No Name # 89 Dam, located on a tributary to Crosswicks Creek in North Hanover Township in Burlington County upstream from the gage on Crosswicks Creek at Extonville, failed completely. The Bureau of Dam Safety also reported damage to the spillway at Cassville Dam, located on a small tributary to the Toms River, upstream from the gage on Toms River near Toms River. Water stored in these impoundments contributed to the flow past these gages during the flood. The portion of the hydrograph contributed by the dam breaches is not distinguishable from the runoff contributed by the rainfall (USGS, 2013).

FEMA Disaster Declarations

Based on all sources researched, the State of New Jersey was not included in any FEMA disaster declarations directly related to dam or levee failure events.

2019 Michael Baker International. We Make a Difference.

5.3.5 PROBABILITY OF FUTURE OCCURRENCES

Dam Failure

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. As noted in the Previous Occurrences and Losses section, dam failures typically occur in New Jersey as a result of heavy rains or other precipitation. There is a "residual risk", or risk that remains after safeguards have been implemented, associated with dams. The residual risk for dams is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam failure is low in today's dam safety regulatory and oversight environment.

Levee Failure

A complete levee failure, like dam failures, is rather infrequent and typically coincides with events that cause them such as heavy rainfall, storm surge, or hurricanes. As previously stated, there have been no major documented levee failures in New Jersey to date; however, the potential does exist given the varied construction and maintenance procedures in place for systems in New Jersey. Aside from unregulated levee systems, some levees that the USACE inspects regularly have not scored well in terms of structural standing. Table 5.3-7 shows the current inspection ratings for levees in New Jersey under the USACE program.

Table 5.3-7 Inspection Status of New Jersey Levees Monitored by the United States Army Corps of Engineers

SYSTEM NAME	LAST INSPECTION	INSPECTION RATING*
S. Orange, Rahway East Branch, LB North	40,374	Minimally Acceptable
S. Orange, Rahway East Branch, RB South	40,367	Minimally Acceptable
Gibbstown	-	-
Raritan Bay and Sandy Hook Bay, Keansburg	40,318	UNACCEPTABLE
Rahway, Rahway River South Branch RB	40,332	Minimally Acceptable
Hillside, Elizabeth River Left Bank	40,065	Minimally Acceptable
Elizabeth, Elizabeth River Right Bank South	40,317	UNACCEPTABLE
Elizabeth, Elizabeth River Right Bank North	40,317	UNACCEPTABLE
Elizabeth, Elizabeth River Left Bank South	40,315	UNACCEPTABLE
Elizabeth, Elizabeth River Left Bank North	40,317	Minimally Acceptable

*Three National Levee Database Inspection Ratings can be given: Acceptable, Minimally Acceptable, and Unacceptable.
Source: USACE 2013

Additionally, many levees assessed as part of the South Jersey Levee Inventory did not fare well either. The study found that 24% had erosion issues, 35% had significant settlement, 29% had significant depressions, 25% showed signs of cracking, and nearly 30% showed signs of burrowing animals (shown on Figure 5.3-9 through Figure 5.3-11).

Figure 5.3-7 Erosion Cracking Burrowing

2019 Michael Baker International. We Make a Difference.

Source: USDA 2010

5.3.5.2 POTENTIAL EFFECTS OF CLIMATE CHANGE

Dam Failure

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or its entire designed margin of safety, also known as freeboard. Loss of designed margin of safety may cause floodwaters more readily to overtop the dam or create unintended loads. Such situations could lead to a dam failure.

The New Jersey Climate Adaptation Alliance is a network of policymakers, public and private-sector practitioners, academics, non-governmental organizations (NGO), and business leaders aligned to build climate change preparedness in the state of New Jersey. The Alliance is facilitated by Rutgers University, which provides science and technical support, facilitates the Alliance's operations and advances its recommendations. A document titled Change in New Jersey: Trends and Projections was developed to identify recommendations for State and local public policy that will be designed to enhance climate change preparedness and resilience in New Jersey (Rutgers 2013).

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over 5" (12%) greater than the average from 1895-1970. Southern New Jersey became 2" (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Changes in climate may lead to higher intensity rainfall events. As a result, the failure probability of low, significant, and under-designed high hazard dams may increase.

Levee Failure

Levees in New Jersey may be affected by the impacts of climate change. Of particular concern may be the stress that a rising sea level could have on levee systems. As the seas rise there may be additional hydrostatic pressure placed on coastal and tidal river levee systems, thus increasing the potential for failure. Additionally, climatologists predict an increase in the intensity and frequency of coastal storms such as hurricanes and tropical storms. The increase of coastal storms could also place additional burdens on levee systems, thus testing their structural integrity. As mentioned, many of the State's levees are structurally deficient, and may be affected by increased intensity of storms. A shift in the amount of precipitation is also predicted as climates shift; therefore, levee systems may have to retain more water from storms themselves.

5.3.6 IMPACT ANAYSIS

2019 Michael Baker International. We Make a Difference.

5.3.6.1 SEVERITY AND WARNING TIME

Dam Failure

USACE developed the classification system shown in Table 5.3-2 for the hazard potential of dam failures. USACE's hazard rating system is based only on the potential consequences of a dam failure; it does not take into account the probability of such failures. The worst-case scenario would be a failure of one of New Jersey's 218 high-hazard dams noted in Table 5.3-3. The result could be severe damage to downstream communities and the potential for loss of life.

Dams can fail with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods can occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams, the accumulation of melting snow, buildup of water pressure on a dam with deficiencies after days of heavy rain, etc. Flooding can occur when a dam operator releases excess water downstream to relieve pressure from the dam (FEMA, 2013d).

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure because of earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (USACE, 1997).

High and significant hazard dam owners are required to prepare and maintain Emergency Action Plans (EAP). The EAP is to be used in the event of a potential dam failure or uncontrolled release of stored water. Owners are also required to have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan. These protocols are tied to the emergency action plans also created by the dam owners. These documents are customarily maintained as confidential information, although copies are required to be provided to the NJDEP for response purposes. State and local Offices of Emergency Management also have copies of the approved EAPs.

Levee Failure

A failure of one of the major levee systems could be devastating to the communities that are protected by the system. As noted in Table 5.3-7, several of these systems are in disrepair, thus increasing the probability of a failure. The worst-case scenario would involve a failure of a levee in a highly populated area such as the levees that protect Elizabeth City or the levees in Monmouth County located along the Raritan Bay. A flood in a populated area, such as was witnessed during Hurricane Katrina in 2005, could strand hundreds and flood the highly populated areas in northern New Jersey.

Like dam failures, warning time depends on the cause of the failure. A levee failure caused by structural failure can be sudden and perhaps with little to no warning. This is despite warnings regarding the structural integrity of the system. If heavy rains are impacting a levee system, communities located in the immediate danger zone can be evacuated before a failure occurs. If the levee failure is caused by overtopping, the community may or may not be able to recognize the impending failure and evacuate. If a levee failure occurs suddenly, evacuation may not be possible.

5.3.6.2 SECONDARY HAZARDS

Dam Failure

Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion

2019 Michael Baker International. We Make a Difference.

on the rivers, and destruction of downstream habitat. Dam failures can occur as a result of structural failures, such as progressive erosion of an embankment or overtopping and breaching by a severe flood. Earthquakes may weaken dams. Floods caused by dam failures have caused loss of life and property damage (FEMA, 1996).

Levee Failure

Levee failures can cause severe downstream flooding similar to that of dam failure. Also similar to dam failure, levee failure can cause landslides, bank erosion, and destruction of habitat. Levee failures can also cause environmental incidents due to hazardous materials releases when floodwaters infiltrate facilities that store these types of materials.

5.3.6.3 ENVIRONMENTAL IMPACTS

Dam and levee failure can cause severe downstream flooding and may transport large volumes of sediment and debris, depending on the magnitude of the event. Potential secondary hazards include landslides, bank erosion on the rivers, and destruction of downstream habitat. Dam and levee failures may also cause the release of hazardous materials into the environment when floodwaters infiltrate development and infrastructure. This may lead to widespread contamination resulting in costly remediation (FEMA, 1996).

5.3.7 VULNERABILITY ASSESSMENT

Dam and levee failure inundation maps and downstream hazard areas are considered sensitive information and are not made available to within this plan. The following discusses New Jersey's vulnerability to the hazard in a qualitative nature. A consequence analysis for this hazard was also conducted and presented in Section 9 (Consequence Analysis). Impacts on the public, responders, continuity of operations, and delivery of services; property, facilities, and infrastructure; the environment and economic condition of the State; and the public confidence in the State's governance are discussed in Section 9 in accordance with Emergency Management Accreditation Program (EMAP) standards. This section addresses assessing vulnerability and estimating potential losses by jurisdiction and to State facilities.

5.3.7.1 ASSESSING VULNERABILITY BY JURISDICTION

Of the 21 New Jersey counties with hazard mitigation plans, 15 counties included dam/levee failure as a hazard of concern in their hazard mitigation plans (whether as a stand-alone hazard, or combined with the flood hazard). The decision to include and profile this hazard in their mitigation plans indicates county awareness of the presence of risk from dam/levee failure in their county. Of these 17, the three counties that categorized hazards into high/medium/low rankings indicated the following: Essex (medium/high); Monmouth (low); and Somerset (high). If dam and levee failure were not ranked by a local HMP, the jurisdictions identified their most significant hazards using other methods.

All assets located in a dam failure inundation zone could be exposed to the risk of a dam failure. The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation. Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the needed timeframe. This population includes the elderly and young who may be unable to get themselves out of the inundation area. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also highly vulnerable because they are more likely to seek or need medical attention, which may not be available because of isolation during a flood event and difficulties in evacuating.

2019 Michael Baker International. We Make a Difference.

There is often limited warning time for a dam failure event. While dam failure is rare, when events do occur, they 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 from a television or radio emergency warning system are highly vulnerable to this hazard.

As noted earlier in this section, every county, with the exception of Cape May, has at least one high-hazard dam located within its boundaries. Sussex and Morris Counties have the highest number of high-hazard dams in the State (greater than 200 each). Table 5.3-3 lists the number of dams per hazard class in each county.

Similarly, all assets protected by levees are exposed to the effects of a levee failure. A levee breech could endanger populations and assets located in the immediate inundation area. Because there are potentially hundreds of levees in the State, it is impossible to estimate the exact exposure to the hazard. The following counties contain USACE levees: Essex, Gloucester, Monmouth and Union. Other sources indicate that levees are also present in Bergen, Cape May, Cumberland, Hudson, Middlesex, and Salem Counties.

5.3.7.2 ESTIMATING POTENTIAL LOSSES BY JURISDICTION

All populations, buildings, infrastructure, and natural resources located in a dam/levee failure inundation zone may be considered exposed and vulnerable. The environment could be exposed to a number of risks in the event of a dam/levee failure. The inundation could introduce many foreign elements into local waterways, which could result in destruction of downstream habitat and could have detrimental effects on many species of animals. In addition, damage to buildings can impact a community's economy and tax base. As previously stated, buildings and property located closest to the inundation zone have the greatest potential to experience the largest, most destructive surge of water. Because of the sensitive nature of the dam/levee failure inundation zones, these inundation zones were not available to use to estimate potential losses.

5.3.7.3 ASSESSING VULNERABILITY TO STATE FACILITIES

All State facilities in a dam/levee failure inundation zone may be vulnerable to damage. Buildings and properties located closest to the dam inundation zone have the greatest potential to experience the largest, most destructive surge of water in the event of a failure. All critical facilities and transportation infrastructures in the dam failure inundation zone may be vulnerable to damage. Flood waters may potentially cut off evacuation routes, limit emergency access, and create isolation issues. Utilities such as overhead power, cable, and phone lines in the inundation zone may also be vulnerable. Loss of these utilities could create additional isolation issues for State facilities and populations residing in the inundation zones.

5.3.7.4 ESTIMATING POTENTIAL LOSSES TO STATE FACILITIES

Similarly, all State assets located in a dam/levee failure inundation zone may be considered exposed and vulnerable. Because of the sensitive nature of the dam/levee failure inundation zones, they were not available to use to estimate potential losses to state facilities.

2019 Michael Baker International. We Make a Difference.

[This page intentionally left blank.]