4.3.5 FLOOD

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 Mercer County.

2021 HMP UPDATE CHANGES

- New and updated figures from federal and state agencies are incorporated.
- Additional discussion of "urban flooding" has been included.
- Previous occurrences were updated with events that occurred between 2015 and 2021.

Profile

Hazard Description

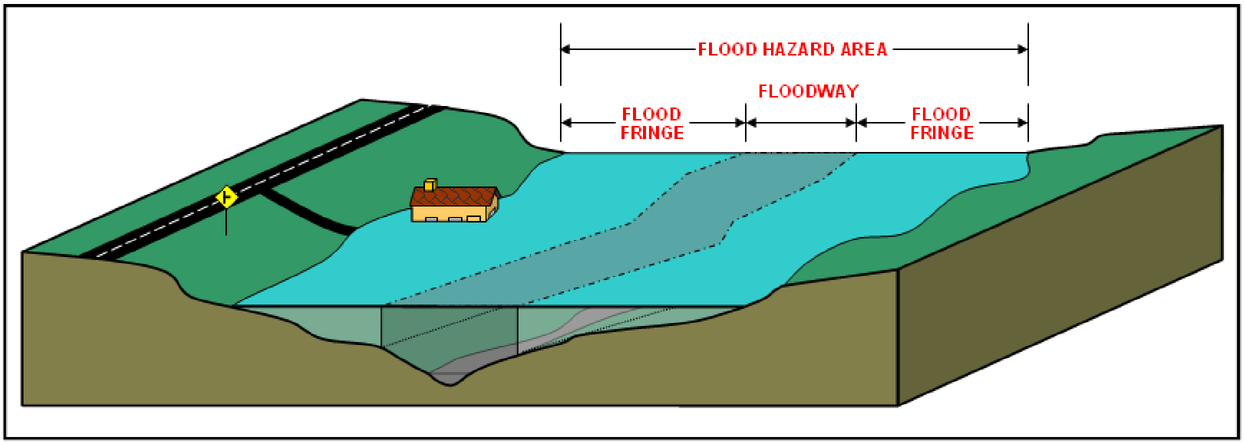
A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (FEMA 2007). Floods are frequent and costly natural hazards in New Jersey in terms of human hardship and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source.

The flood-related hazards most likely to impact Mercer County are riverine (inland) flooding, ice jam flooding, and flooding as a result of a dam failure. Dam failure is discussed in Section 4.3.1 (Dam Failure). In addition, Mercer County also experiences urban flooding which is the result of precipitation and insufficient drainage.

Riverine (Inland) Flooding

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. In Mercer County, floodplains line the rivers, streams, and lakes of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques. Figure 4.3.5-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 4.3.5-1. Floodplain



Source: New Jersey Department of Environmental Protection (NJDEP) Date Unknown

Ice Jam Flooding

As per the Northeast States Emergency Consortium and FEMA, an ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (FEMA 2015a). Ice jams may also be caused by frazil ice, which forms when mist freezes and then floats down a river, stream, or creek.

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt, or warmer temperatures (White 2013).

Coastal Flooding

Coastal floods are the submersion of land areas along the ocean coast and other inland waters caused by seawater over and above normal tide action. Hurricanes and tropical storms, severe storms, and Nor'Easters cause most of the coastal flooding in Mercer County. Coastal flooding can impact structures and infrastructure, similar to riverine flooding, and can cause beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures (i.e., sea walls, piers, bulkheads, bridges, buildings) (FEMA 2011).

There are several forces that occur with coastal flooding, including the following:

- Hydrostatic forces against a structure are created by standing or slowly moving water. Flooding can cause vertical hydrostatic forces, or flotation. These types of forces are one of the main causes of flood damage.
- Hydrodynamic forces on buildings are created when coastal floodwaters move at high velocities. These high-velocity flows are capable of destroying solid walls and dislodging buildings with inadequate foundations. High-velocity flows can also move large quantities of sediment and debris that can cause additional damage. In coastal areas, high-velocity flows are typically associated with one or more of the following:

- Storm surge and wave run-up flowing landward through breaks in sand dunes or across low-lying areas.
- Tsunamis.
- Outflow of floodwaters driven into bay or upland areas.
- Strong currents parallel to the shoreline, driven by waves produced from a storm.
- High-velocity flows.

High-velocity flows can be created or exacerbated by the presence of manmade or natural obstructions along the shoreline and by weak points formed by roads and access paths that cross dunes, bridges or canals, channels, or drainage features.

- Waves can affect coastal buildings from breaking waves, wave run-up, wave reflection and deflection, and wave uplift. The most severe damage is caused by breaking waves. The force created by these types of waves breaking against a vertical surface is often at least 10 times higher than the force created by high winds during a coastal storm.
- Flood-borne debris produced by coastal flooding events and storms typically includes decks, steps, ramps, breakaway wall panels, portions of or entire houses, heating oil and propane tanks, cars, boats, decks and pilings from piers, fences, erosion control structures, and many other types of smaller objects. Debris from floods are capable of destroying unreinforced masonry walls, light wood-frame construction, and small-diameter posts and piles (FEMA 2011).

Sea Level Rise

Sea level rise associated with climate change will have significant effects on coastal areas, including tidally influenced areas of Mercer County. Long-term sea level records show changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity. Sea levels provide a key to understanding the impact of climate change.

There are two types of sea level: global and relative. Global sea level rise refers to the increase currently observed in the average global sea level trend (primarily attributed to changes in ocean volume due to ice melt and thermal expansion). The melting of glaciers and continental ice masses can contribute significant amounts of freshwater input to the earth's oceans. In addition, a steady increase in global atmospheric temperature creates an expansion of saltwater molecules, increasing ocean volume.

Local sea level refers to the height of the water as measured along the coast relative to a specific point on land. Water level measurements at tide stations are referenced to stable vertical points on the land and a known relationship is established. Measurements at any given tide station include both global sea level rise and vertical land motion (subsidence, glacial rebound, or large-scale tectonic motion). The heights of both the land and water are changing; therefore, the land-water interface can vary spatially and temporally and must be defined over time. Relative sea level trends reflect changes in local sea level over time and are typically the most critical sea level trend for many coastal applications (coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, and sustainable habitat restoration) (U.S. Climate Resilience Toolkit 2019).

Short-term variations in sea level typically occur on a daily basis and include waves, tides, or specific flood events. Long-term variations in sea level occur over various time scales, from monthly to several years and may be repeatable cycles, gradual trends, or intermittent differences. Seasonal weather patterns (changes in the earth's declination), changes in coastal and ocean circulation, anthropogenic influences, vertical land motion, etc. may influence changes in sea level over time. When estimating sea level trends, a minimum of 30 years of data are used in order to account for long-term sea level variations and reduce errors in computing sea level trends based on monthly mean sea level (U.S. Climate Resilience Toolkit 2019).

In New Jersey, sea levels are rising faster than they are globally due to changes in the Gulf Stream, localized land subsidence, and continued geologic influences as land slowly adjusts to the loss of the North American ice sheet at the end of the last ice age. In Atlantic City, Cape May, and Sandy Hook, sea-level has risen at a rate of approximately 0.2 to 0.5 inches per year since the beginning of the 20th century, and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario) (Kopp et al. 2019). Understanding how precipitation and sea level rise will change in the future is vital to New Jersey's coastal zone because low-lying coastal areas are already experiencing tidal flooding, even on sunny days in the absence of precipitation events.

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the mid-Atlantic coast in response to sea level rise:

- Bluff and upland erosion – shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).
- Overwash, inlet processes, shoreline retreat, and barrier island narrowing – as sea level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).
- Threshold behavior – changes in sea level can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold; making the potential for rapid barrier-island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased overwashing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea level rise and climate change, it is very likely that these conditions will worsen (Gutierrez et al. 2007).
- Loss of critical habitat – natural ecosystems may be impacted by warmer temperatures and associated changes in the water cycle. The changes could lead to loss of critical habitat and further stresses on some threatened and endangered species (Rutgers 2013).

An increase in sea level will cause further issues as stormwater recharge is challenged as sea-levels submerge discharge points, resulting in increases in flooding (Kopp et al. 2019).

Urban Flooding

Heavy rainfall that overwhelms a developed area's stormwater infrastructure causing flooding is commonly referred to as urban flooding; factors that contribute to this are aging and inadequate infrastructure and over-development of land. The growing number of extreme rainfall events that produce intense precipitation are resulting in increased urban flooding (Center for Disaster Resilience 2016). While riverine and coastal flooding is mapped and studied by FEMA, urban flooding is not.

NOAA defines urban flooding as the flooding of streets, underpasses, low lying areas, or storm drains. (NOAA 2009). Urban drainage flooding is caused by increased water runoff due to urban development and inadequate drainage systems. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. The systems make use of a closed conveyance system that channels water away from an urban area to surrounding streams. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water. Because drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in that area (Harris 2008).

High groundwater levels can be a concern and cause problems even where there is no surface flooding. Basements are susceptible to high groundwater levels. Seasonally high groundwater is common in many areas, while elsewhere high groundwater occurs only after a long period of above-average precipitation (FEMA 1997).

Location

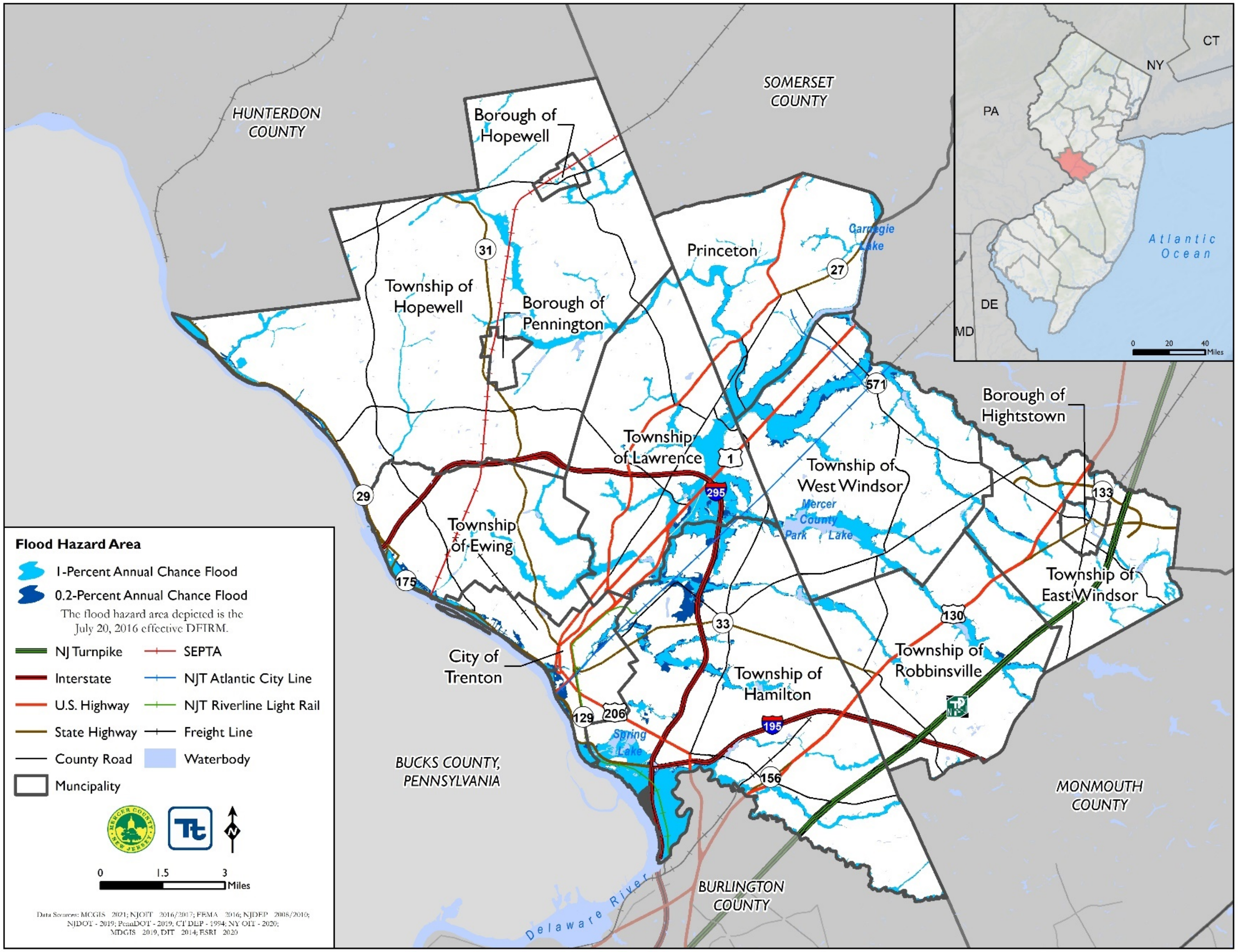
Flooding potential is influenced by climatology, meteorology and topography. Extensive development can impact flooding potential as it leaves fewer natural surfaces available to absorb rainwater, forcing water directly into streams, rivers, and existing drainage systems swelling them more than when more natural surface buffered the runoff rate.

Flooding in Mercer County is often the direct result of frequent weather events such as thunderstorms, heavy rains, tropical storms, and hurricanes. Floods can happen almost anywhere in County, although they do tend to occur in and around areas near existing bodies of water, such as rivers and streams.

Development patterns have resulted in denser development. In addition, proximity to New York City and Philadelphia boosts property values and therefore increases event impact totals. Extensive development also leaves fewer natural surfaces available to absorb rainwater, forcing water directly into streams and rivers, swelling them more than when more natural surface buffered the runoff rate. Since the Delaware and Raritan Riverare the major waterbodies in Mercer County, these rivers and their tributaries are common locations for flooding.

The Delaware River has been the source of many flood events in Mercer County. Flood exposure is greatest around the River and its smaller waterways, including Stoney Brook, the Delaware and Raritan Canal, Assunpink Creek, Shipetaukin Creek, and Crosswicks Creek among others. Over the years, Mercer County has been impacted by flooding, especially in the municipalities of Trenton, Lawrence Township, Ewing Township, The 1 percent annual chance of flood hazard zones are widely dispersed in Mercer County, generally following riverine corridors as shown in Figure 4.3.5-2. In addition to the areas along riverine corridors, a significant concentration of 1 percent annual chance flood hazard zones is located in and around the Hamilton Marshes and John A. Roebling Memorial Park in the City of Trenton; within Lawrence Township around the intersection of NJ State Route 1 and US I 295/95; in West Windsor Township within Mercer County Park and the Van Nest Wildlife Refuge; and within Princeton Township near the border with West Windsor Township and Duck Pond Run.

Figure 4.3.5-2. FEMA Flood Hazard Areas in Mercer County



Flood-prone Areas in Mercer County

Watersheds in New Jersey are referred to as the name of the water body to which the land area drains and the corresponding Hydrologic Unit Code (HUC). The HUC can range from 2 to 16 digits long- the longer the numeric code, the smaller the watershed area. NJDEP also has divided the state into 21 Watershed Management Areas (WMAs) based on large scale drainage pattern. Each WMA encompasses a particular group of major rivers. Mercer County falls within parts of two regions: Watershed Management Area 11 – Central Delaware Tributaries and Watershed Management Area 20 – Crosswicks Creek. These areas delineate the principal stream systems that drain the county's land area.

Please refer to Section 9 for information regarding specific areas of flooding within each municipality.

Watershed Management Area 11 – Central Delaware Tributaries

Watershed Management Area 11, known as the Central Delaware Tributaries, includes 24 municipalities within the counties of Hunterdon, Mercer and Monmouth. The predominant drainage funnels to either the Delaware River or the Delaware and Raritan (D&R) Canal. Within Area 11 there are four major drainage basins: Hakihokake/ Harihokake/Nishisakawick Creek, Lockatong Creek/Wickecheoke Creek, Alexauken Creek/ Moore Creek/Jacobs Creek and the Assunpink Creek – the Alexauken Creek/ Moore Creek/Jacobs Creek and the Assunpink Creek drain parts of Mercer County, including parts of Ewing, Hamilton, Hopewell, and Lawrence Townships; Pennington Borough; and the City of Trenton.

The *Alexauken Creek/Moore Creek/Jacob's Creek* watershed drains a total of 63 square miles of land across six municipalities in Hunterdon and Mercer counties, including Hopewell, Hamilton, and Ewing townships and the Borough of Pennington. Alexauken Creek and Moore Creek originate in the Sourland Mountain ridge, though only Moore Creek runs through Mercer County en route to its confluence with the Delaware in Hopewell Township. Jacob's Creek begins in Hopewell Township near Harbourton Road, then flows southeast through Hopewell Township, into Ewing Township, and empties into the Delaware River, near Jacob's Creek Road, in Ewing Township.

Assunpink Creek begins in rural Monmouth County, and flows into Mercer County under Old York Road. New Sharon Branch enters the creek from the south at Carsons Mills in Robbinsville Township. The creek now turns northwest, passing under the New Jersey Turnpike and then U.S. Route 130, just southwest of Windsor, also in Robbinsville Township. From there, the creek enters Central Mercer County Park, merges with Bridegroom Run enters before turning west and flowing into Mercer County Lake. From the lake, the creek passes under "Quaker Bridge" on Quaker Bridge Road and Interstate 295 before turning southwest and paralleling the Delaware and Raritan Canal. The Assunpink's watershed becomes highly urbanized as it flows through Trenton, and portions of the river are highly channelized in this area for flood control. Miry Run joins the channelized Assunpink near Hutchinson Mills, before it flows past the Trenton Rail Station and finally empties into the Delaware River in Trenton (DRBC 2008).

Watershed Management Area 20 – Crosswicks Creek

Watershed Management Area 20, Crosswicks Creek, covers 26 municipalities across four counties, including are Hamilton Township and the City of Trenton in Mercer County. Crosswicks Creek is 25 miles long and drains an area of 146 square miles to the Delaware River at Bordentown (Burlington County). Its headwaters flow from the Fort Dix and McGuire Air Force Base Military Reserves in a northwesterly direction and then turn sharply south where it meets the Delaware River at the City of Bordentown. Major tributaries include Jumping Brook, Lahaway Creek, North Run and Doctors Creek (DRBC 2008).

Flood Insurance Study (FIS)

According to the FEMA FIS for Mercer County (FEMA 2016) a history of flooding throughout Mercer County indicates that flooding may be experienced during any season of the year. Flooding during the winter months is less frequent. However, the Delaware River overflows most frequently during late winter and early spring because of snowmelt, with ice jams as an occasional factor increasing flooding conditions. Extensive flooding has occurred in the late summer and fall, usually being associated with thunderstorms, hurricanes and nor'easters along the Atlantic coast.

Over the past few decades, the flooding problem in Mercer County has been aggravated by urban and industrial development. Many inadequate road and railroad crossings constrict the floodplains and several of the industrial developments are situated where they hinder the free passage of flood flows. The resultant increases in flood stage compound the damage sustained during the occurrence of larger flood events (FEMA 2016).

Ice Jams

Ice jams can occur along rivers and creeks. According to the USACE, there have been over 107 incidents documented between 1780 and 2015, with the most recently documented event occurring in 2014. The Delaware River experienced more ice jams during this time period than any other river in the state (32 reported ice jams), and Mercer County had the most ice jams of all counties in New Jersey.

The Ice Jam Database, maintained by the Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL), currently consists of over 19,000 records from across the U.S. According to the USACE-CRREL, Mercer County experienced or may have been impacted by 28 historic ice jam incidents between 1780 and 2021 (CRREL 2021). Ice Jams have formed in Mercer County along the Delaware River, Stoney Brook, and Assunpink Creek (CRREL 2021).

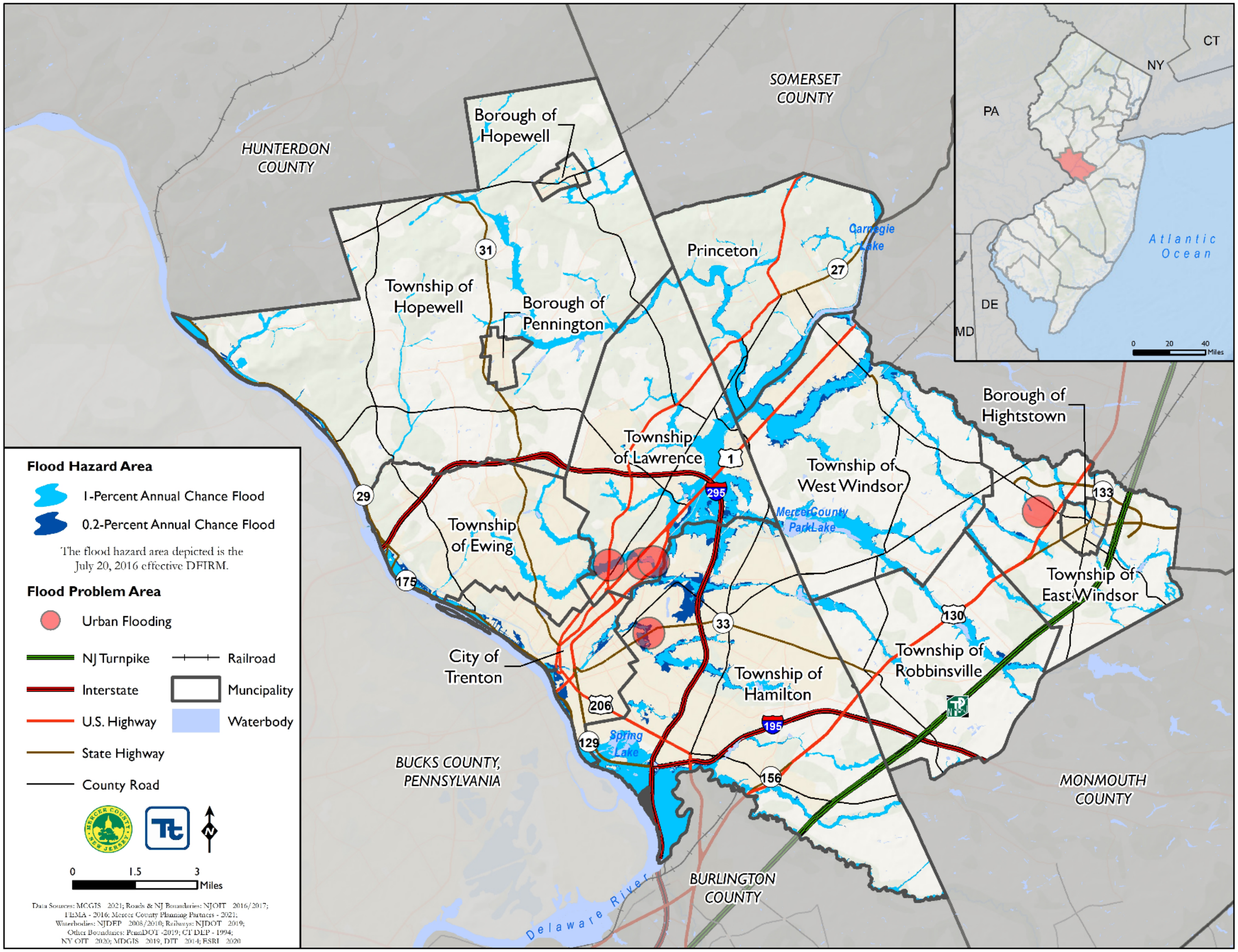
Coastal Flooding and Sea Level Rise

Coastal flood risk exists along the tidally influenced portions of the Delaware River in Mercer County in Hamilton Township and the southern limits of the City of Trenton. These areas will also be impacted by sea level rise in the future.

Urban Flooding

Throughout Mercer County, low-lying surface flooding and interior shallow ponding occurs as a result of heavy rainfall and inadequate capacity of stormwater systems. While riverine flooding is mapped by FEMA, urban flooding is not. Each municipality was asked to identify areas that flood outside the FEMA-mapped floodplain in an attempt to identify problem areas and assist with identifying mitigation solutions. Figure 4.3.4-3 illustrates the urban flood areas identified by the municipalities participating in the 2021 HMP update.

Figure 4.3.4-3. Urban Flood Areas Identified in Mercer County



Natural and Beneficial Floodplain Areas

Although typically associated as a hazard area, floodplains also serve beneficial and natural functions (on ecological/environmental, social, and economic levels). Some of the more well-known water-related functions for floodplains include:

- Natural flood and erosion control
  - Provide flood storage and conveyance
  - Reduce flood velocities
  - Reduce flood peaks
  - Reduce sedimentation
- Surface water quality maintenance
  - Filter nutrients and impurities from runoff
  - Process organic wastes
  - Moderate temperatures of water
- Groundwater recharge
  - Promote infiltration and aquifer recharge
  - Reduce frequency and duration of low surface flows (FEMA)

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species. According to NJ DEP 2015 Land-Use Land-Cover data the County has several floodplain areas that could serve natural and beneficial functions. This information is summarized in Tables 4.3.5-1 and 4.3.5-2, with wetlands illustrated on Figure 4.3.5-4.

Table 4.3.5-1. Acreage of Wetlands by Municipality

Municipality	Total Area (acres)	Wetland Area (acres)	% of Total
East Windsor (Twp)	10,019	2,074	20.7%
Ewing (Twp)	9,784	381	3.9%
Hamilton (Twp)	25,469	5,149	20.2%
Hightstown (B)	810	13	1.6%
Hopewell (B)	464	7	1.4%
Hopewell (Twp)	37,430	3,138	8.4%
Lawrence (Twp)	14,063	2,942	20.9%
Pennington (B)	624	0	0.0%
Princeton	11,784	1,297	11.0%
Robbinsville (Twp)	13,168	4,011	30.5%
Trenton (C)	4,893	64	1.3%
West Windsor (Twp)	16,801	3,513	20.9%
Mercer County (Total)	**145,308**	**22,589**	**15.5%**

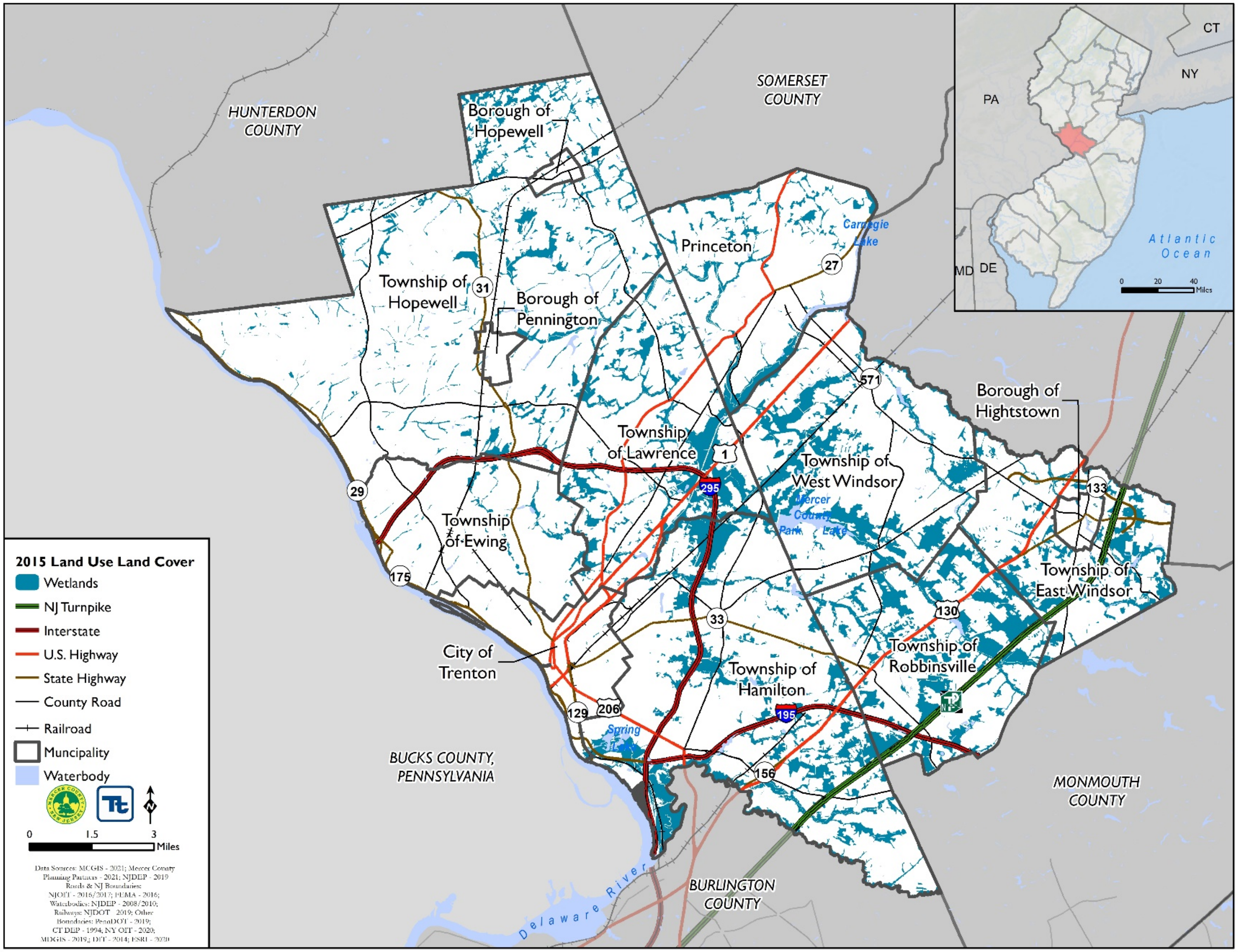
Source: NJDEP 2019 (the 2015 LULC Updated edition)

Table 4.3.5-2. Natural and Beneficial Land in Mercer County

Wetlands	Area (acres)	Forest	Area (acres)
Agricultural Wetlands (Modified)	2,269	Coniferous Brush/Shrubland	463
Atlantic White Cedar Wetlands	1	Coniferous Forest (>50% Crown Closure)	288
Coniferous Scrub/Shrub Wetlands	10	Coniferous Forest (10-50% Crown Closure)	139
Coniferous Wooded Wetlands	9	Deciduous Brush/Shrubland	801
Deciduous Scrub/Shrub Wetlands	771	Deciduous Forest (>50% Crown Closure)	16,049
Deciduous Wooded Wetlands	16,163	Deciduous Forest (10-50% Crown Closure)	3,250
Disturbed Tidal Wetlands	1	Mixed Deciduous/Coniferous Brush/Shrubland	2,757
Disturbed Wetlands (Modified)	111	Mixed Forest (>50% Coniferous With >50% Crown Closure)	414
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	193	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	156
Freshwater Tidal Marshes	464	Mixed Forest (>50% Deciduous With >50% Crown Closure)	651
Herbaceous Wetlands	1,012	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	308
Managed Wetland In Built-Up Maintained Rec Area	241	Old Field (< 25% Brush Covered)	1,412
Managed Wetland In Maintained Lawn Greenspace	251	Phragmites Dominate Old Field	2
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	71	Plantation	103
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	402		
Mixed Wooded Wetlands (Coniferous Dom.)	9		
Mixed Wooded Wetlands (Deciduous Dom.)	54		
Phragmites Dominate Coastal Wetlands	48		
Phragmites Dominate Interior Wetlands	78		
Phragmites Dominate Urban Area	8		
Wetland Rights-Of-Way	424		

Source: NJDEP 2019

Figure 4.3.4-4. Wetlands in Mercer County



Extent

The frequency and severity of riverine flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels.

Floodplains are often referred to as 100-year floodplains. A 100-year floodplain is not a flood that will occur once every 100 years; the designation indicates a flood that has a 1-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Due to this misleading term, FEMA has properly defined it as the 1-percent annual chance flood, or the SFHA. Similarly, the 500-year floodplain will not occur every 500 years but is an event with a 0.2-percent chance of being equaled or exceeded each year. The "1-percent annual chance flood" is now the standard term used by most federal and state agencies and by the National Flood Insurance Program (NFIP) (FEMA 2003). The 1-percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements and is also referenced as the regulatory floodplain.

The NJDEP is mandated to delineate and regulate flood hazard areas pursuant to N.J.S.A. 58:16A-50 et seq., the Flood Hazard Area Control Act. This Act authorizes the DEP to adopt land use regulations for development within the flood hazard areas, to control stream encroachments and to integrate the flood control activities of the municipal, county, state and federal governments. The State's Flood Hazard Area delineations are defined by the New Jersey Flood Hazard Area Design Flood which is equal to a design flood discharge 25% greater in flow than the 1-percent annual chance flood. In addition, the floodway shall be based on encroachments that produce no more than a 0.2-foot water surface rise above the 1-percent annual chance flood.

The USGS National Water Information System (NWIS) collects surface water data from more than 850,000 stations across the country. The time-series data describes stream levels, streamflow (discharge), reservoir and lake levels, surface water quality, and rainfall. The data is collected by automatic recorders and manual field measurements at the gage locations. Mercer County has numerous active USGS stream gages; in addition, stream gauges are located upstream in neighboring counties.

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

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. The size of rivers and streams in an area and infiltration rates are significant factors. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2008).

In an article titled "A geological perspective on sea level rise and its impacts along the U.S. mid-Atlantic coast" written by Kenneth Miller, Robert Kopp, Benjamin Horton, James Browning, and Andrew Kemp, an analysis of geological and historical sea level records was done. This showed a significant rate of increase in sea level rise since the 19th century. It was stated that in New Jersey, it is extremely likely that sea level rise in the 20th century was faster than during any century in the last 4,300 years. Based on the findings of this article and the 2019 update of the initial study, it is anticipated that the arrival of one foot of sea level rise will be experienced before 2050. As sea level rise is expected to accelerate in this century, three feet of sea level rise is very likely before 2100. The table below (Table 4.3.5-3) shows the "low", "high", and "best" estimates for sea level rise projects in New Jersey for the years 2050 and 2100. "Best" refers to a 50 percent likelihood of that level of sea level rise occurring.

Table 4.3.5-3. Sea Level Rise Projections for New Jersey (ft. above year 2000 average sea level) for New Jersey From 2030 to 2150 Under Low, Moderate and High Emissions Scenarios.

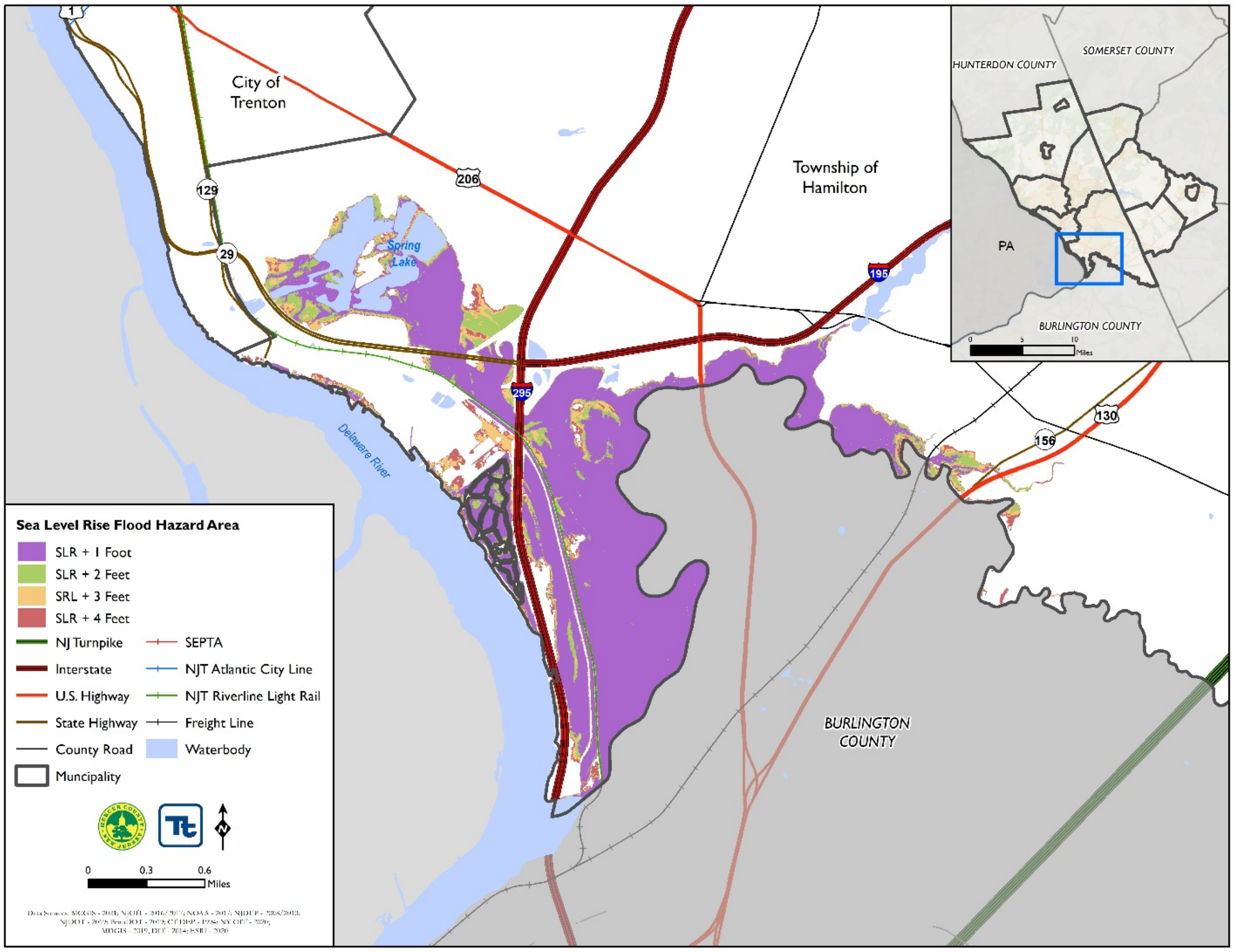
	Chance SLR Exceeds	2030	2050	2070 Emissions			2100 Emissions			2150 Emissions		
				Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End												
Likely Range	>83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50% chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	<5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

Source: *Kopp et al. 2019*

Note: *The likely range represents the range of levels between which there is 66% chance that SLR will occur*

Looking at Figure 4.3.4-5, sea level rise could result in permanent inundation of the Duck Island State Recreation Area and areas along Crosswicks Creek in the Township of Hamilton. Higher levels of sea level rise will result in minor expansion of the tidal area

Figure 4.3.4-5. Sea Level Rise Flood Hazard Area in Mercer County



Currently, there is no measurement used to further define the frequency and severity of urban flooding.

Previous Occurrences and Losses

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, Mercer County was included in two declarations for flood-related events. Table 4.3.5-4 lists these events.

Table 4.3.5-4. Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
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

Source: FEMA 2021

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the 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 2021, Mercer County was included in one flood related agricultural disaster declarations. In 2019, Mercer County was included in declaration S4519 for excessive rain, flash flooding, and flooding (USDA 2021a, USDA 2021b).

Flood Events

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.

Flood events that have impacted Mercer County between 2015 and 2021 are identified in Table 4.3.5-5. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.5-5. Flooding Events in Mercer County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
February 23-25, 2016	Flood	N/A	N/A	Princeton Township	A strong low pressure system moving north through the Great Lakes region, combined with its associated warm front and cold front, copious amounts of moisture, and low level jet, produced strong to severe thunderstorms, heavy rain, flash flooding, and stream flooding in New Jersey late Wednesday afternoon and evening, February 24th, with stream flooding continuing into Thursday, February 25th. Thousands were without power for a period across the state, focused in South Jersey. In Princeton Township, flooding reduced 206 to one lane near Quaker road. Numerous roads were closed due to flooding overnight and on the morning of 2/25 in Princeton as well. This had an adverse impact on the morning commute.
July 9, 2016	Flood	N/A	N/A	Princeton Township	A stationary frontal boundary remained in place with a sharp contrast in temperatures between the Jersey shore and areas further inland. This thermal difference along the front coupled with instability west of the front lead to the development of showers and thunderstorms across portions of the state. Heavy rain led to some roadway flooding in Princeton.
July 25, 2016	Flood	N/A	N/A	Hopewell Township	A trough of low pressure led to the development of afternoon and evening showers and thunderstorms which became severe in spots and produced locally heavy rains. 40,000 were left without power across the state. In Titusville, flooding closed route 29 between River and Valley roads for a duration.
July 30, 2016	Flash Flood	N/A	N/A	West Windsor Township	Several clusters of thunderstorms associated with several shortwaves and a cold front became nearly stationary over Mercer County on the 29th and Hunterdon County on the morning of the 30th. Heavy rainfall over 5 inches occurred in these areas. The persistent heavy rain resulted in severe flash flooding including a state of emergency being issued in West Windsor Twp. Thousands were left without power as a result of the storms. Multiple roads were flooded and impassable including US 1, Route 571, Washington and Alexander roads. Water rescues ongoing in Princeton. Canal Pointe Blvd also was closed due to flooding/ Several people were trapped in cars and needed to be rescued. The Princeton Junction train station inundated by flood waters with water up to the top of the tunnel. Four people were also rescued with a nearby home evacuated. West Windsor Township declared a state of emergency Due to widespread flash flooding, numerous water rescues occurred. $1M in damages were reported.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
June 24, 2017	Flood	N/A	N/A	Woodsville, Harbourtown	A band of gusty convective showers moved through during the morning hours in association with the remnants of Tropical Storm Cindy. Several reports of damage were reported from the winds. Thousands lost power. Roadway flooding occurred on state highway 31 near county road 654.
January 14-15, 2018	Ice Jam	N/A	N/A	Trenton	An Ice Jam on the Delaware River led to minor flooding in the Trenton area. Route 29 between Memorial drive and Market streets were closed for a time. The Trenton River gauge rose to around 20 feet for a time on Monday with some minor flooding reported on several roads near Route 29.
April 16, 2018	Coastal Flood	N/A	N/A	Delaware River	A strong backdoor cold front moved from northeast to southwest across the area late Saturday afternoon April 15th into Sunday morning April 16th. Along the coast, an extended period of onshore flow occurred, beginning with east-northeast winds Saturday Night, which then shifted to the southeast on Sunday Night into Monday Morning April 16th. Widespread winds gusts of 40 to 50 mph occurred in the east-northeast flow Saturday Night and Sunday, with a lull Sunday Night, then occasionally again in the south-southeast flow along and just in advance of a heavy line of showers and thunderstorms on Monday Morning. The onshore flow, and to a lesser extent the heavy rainfall, lead to multiple rounds of coastal flooding along the oceanfront and back bays with the high tide cycles on Sunday evening and again on Monday Morning. Moderate coastal flooding took place along the tidal Delaware River. Peak tide was 11.37 feet MLLW at Newbold Island (Bucks County, Pennsylvania).
May 27, 2018	Flash Flood	N/A	N/A	East Windsor Township, Princeton, Clarksville, East Trenton, Hopewell Township, East Trenton	Heavy rain fell on the morning of May 27 from Bucks County in southeastern Pennsylvania eastward into central New Jersey. Rainfall amounts of 2 to 4 inches were common with some locations receiving up to 5 or 6 inches of rain. Water rescues took place in East Windsor Township. The One Mile Road extension was flooded, and Route 130 was closed from around Dutch Neck Road to near Route 571. Road closures took place in Princeton, including Quaker Road and Mercer Road. Portions of the Princeton Pike were closed in Lawrence Township, including the areas around Shipetaukin Creek and Shabakunk Creek. Route 29 was closed due to flooding around Pleasant Valley Road in Hopewell Township. The Assunpink Creek exceeded its flood stage at Mercerville.
July 3, 2018	Flash Flood	N/A	N/A	West Windsor Township	Severe thunderstorms caused wind damage across portions of southwestern New Jersey on the evening of July 3. Rainfall amounts of 1 to 3 inches fell along the Interstate 95/New Jersey Turnpike Corridor in a short amount of time. A few locations received 3 to 4 inches of rain.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					There was flooding at and around the Princeton Junction train station in West Windsor Township. Sections of the parking lot were under water and a pedestrian tunnel was flooded. Also, there was flooding on Wallace Road.
July 6, 2018	Flash Flood	N/A	N/A	Robbinsville Township	A cold front approached the Mid-Atlantic following a prolonged heat wave over the 4th of July holiday week. High precipitable water values along with surface convergence allowed storms with high rainfall rates to form. Areas along the I-195 corridor saw the heaviest rainfall near and above 3 inches. Flooding occurred along Interstate 195 in Robbinsville Township. The westbound ramp at Exit 7 to County Road 526 was under water.
September 10, 2018	Coastal Flood	N/A	N/A	Delaware River	A persistent onshore flow and unusually high astronomical tides associated with the new moon resulted in widespread moderate coastal flooding along the bays and other tidal waterways in central and southern New Jersey. The flooding occurred across three consecutive high tide cycles, from the evening of September 9 through the early hours of September 11. Moderate flooding occurred along the Delaware River and its tidal tributaries in Mercer County. The tide gauge at Burlington reached 10.62 feet MLLW.
September 25, 2018	Flash Flood	N/A	N/A	Trenton, Hamilton Township	A quick 1 to 2 inches of rain fell in parts of southwestern and central New Jersey during the late afternoon and early evening of September 25. Widespread roadway flooding was reported in Trenton. Roadway flooding took place at the Interstate 195 and Interstate 295 interchange in Hamilton Township.
November 26, 2018	Coastal Flood	N/A	N/A	Delaware River	A coastal storm resulted in tidal flooding along the northern part of the New Jersey coast and along the tidal Delaware River. Moderate tidal flooding occurred along the tidal Delaware River in Mercer County. The tide gauge at Newbold Island reached 11.40 feet MLLW.
August 7, 2020	Flash Flood	N/A	N/A	Hopewell Township	An impulse riding along a west to east boundary stalled near the Mason-Dixon line produced severe thunderstorms and heavy rain across sections of South Jersey from late afternoon through the evening hours on August 7th. Strong winds knocked down trees, and torrential downpours on ground already saturated from the remnants of Hurricane Isaias produced flash flooding on many roadways and small streams in the area. NJ Route 29 was closed at Pleasant Valley Road in Hopewell Township due to flooding.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
August 13, 2020	Flash Flood	N/A	N/A	Princeton	Thunderstorms brought locally heavy rain to central and southern New Jersey on August 13. Rainfall totals were as high as 2 to 3.5 inches. Rosedale Road in Princeton was closed due to flooding. Quaker Road in Princeton was closed due to flooding.
July 29, 2021	Flash Flood	N/A	N/A	Princeton, Franklin Township, West Windsor Township	Severe thunderstorms resulted in heavy rain, leading to flooding and road closures. In Princeton, Quaker Road, Mercer Road, Rosedale Road between Em Road and Province Line Road, the Winfield Road and Mountain Avenue intersection, and Christopher Drive between Walker Drive and Rosedale Road were all closed. In Franklin Township, the Griggstown Causeway and Canal Road between Copper Mine Road and Old Georgetown Road were closed due to flooding. In West Windsor, too many roads were flooded for police to block them all. Instead, police issued a yellow road alert, meaning the majority of roads and bridges were unsafe to travel.

Source: FEMA 2021; NOAA-NCEI 2021; NWS 2021; SPC 2021; NJOEM 2019; Planet Princeton 2021
Note: Not all events that have occurred in Mercer County are included due to the extent of documentation and the fact that not all sources have been identified or researched.
K: Thousand
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

Probability of Future Occurrences

Based on the historic and more recent flood events in Mercer County, it is clear that the County has a high probability of flooding for the future. The fact that the elements required for flooding exist and that major flooding has occurred throughout the County in the past suggests that many people and properties are at risk from the flood hazard in the future. It is estimated that Mercer County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

According to the NOAA National Climate Data Center (NCDC) and the CRREL database, Mercer County experienced 52 flood events between 1950 and 2021, including 51 floods, 50 flash floods, and 28 ice jams. The table below shows these statistics, as well as the annual average number of events and the percent chance of these individual flood hazards occurring in Mercer County in future years (NOAA NCEI 2021).

Table 4.3.5-6. Probability of Future Flood Events

Hazard Type	Number of Occurrences Between 1950 and 2021	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent chance of occurrence in any given year
Coastal Flood	4	0.06	18.00	0.06	5.6
Flood	51	0.72	1.41	0.71	70.8
Flash Flood	50	0.70	1.44	0.69	69.4
Ice Jams	28	0.39	2.57	0.39	38.9
Total	133	1.87	0.54	1.85	100

Source: NOAA-NCEI 2021; CRREL 2021

In Section 4.4, the identified hazards of concern for Mercer 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 Planning Committee, the probability of occurrence for flood in the county is considered 'frequent'. The ranking of the flood hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation. Changes in winter temperatures could result in a change in the frequency of ice jam events.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

Sea level rise associated with climate change will have significant effects on tidally impacted areas of Mercer County along the tidal portion of the Delaware River. Long-term sea level records show changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity. Sea levels provide a key to understanding the impact of climate change.

In New Jersey, sea levels are rising faster than they are globally due to changes in the Gulf Stream, localized land subsidence, and continued geologic influences as land slowly adjusts to the loss of the North American ice sheet at the end of the last ice age. In Atlantic City, Cape May, and Sandy Hook, sea-level has risen at a rate of approximately 0.2 to 0.5 inches per year since the beginning of the 20th century, and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario) (Kopp et al. 2019). Understanding how precipitation and sea level rise will change in the future is vital to New Jersey's coastal zone because low-lying coastal areas are already experiencing tidal flooding, even on sunny days in the absence of precipitation events.

4.3.6 VULNERABILITY ASSESSMENT

To assess Mercer County's risk to the flood hazard, a spatial analysis was conducted using the FEMA Effective DFIRM published on July 20, 2016 and NOAA's 2017 sea level rise 1-foot increment hazard areas. The 1- and 0.2-percent annual chance flood events were examined to determine the assets located in the FEMA flood hazard areas and to estimate potential loss using the FEMA Hazus riverine flood model. These results are summarized below. Refer to Section 4.2 (Methodology) for additional details on the methodology used to assess flood risk.

Impact on Life, Health and Safety

The impact of flooding on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the effects of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

To estimate population exposure to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were used. Based on the spatial analysis, there are an estimated 7,445 residents living in the SFHA (or 1-percent annual chance floodplain), or 2-percent of the County's total population. There are an estimated 12,881 residents living in the 0.2-percent annual chance floodplain, or 3.5-percent of the County's total population. The City of Trenton has the greatest number of residents living in the floodplain with approximately 1,968 residents living in the SFHA. The City of Trenton also has the greatest number of residents living in the 0.2-percent annual chance flood area—approximately 4,006 people. Table 4.3.4-7 summarizes the population exposed to the flood hazard by jurisdiction.

Table 4.3.5-7. Estimated Mercer County Population Exposed to the 1-percent and 0.2-percent Flood Hazard Area

Jurisdiction	American Community Survey (2015-2019) Population	Number of Persons Located in the 1-Percent Annual Chance Flood Hazard Area	Percent of Total	Number of Persons Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total
East Windsor (Twp)	27,245	438	1.6%	848	3.1%
Ewing (Twp)	36,037	1,348	3.7%	1,584	4.4%
Hamilton (Twp)	87,424	1,942	2.2%	3,989	4.6%
Hightstown (B)	5,375	24	0.4%	63	1.2%
Hopewell (B)	1,915	33	1.7%	33	1.7%
Hopewell (Twp)	18,067	102	0.6%	222	1.2%
Lawrence (Twp)	32,614	1,000	3.1%	1,105	3.4%
Pennington (B)	2,531	0	0.0%	0	0.0%
Princeton	31,000	259	0.8%	363	1.2%
Robbinsville (Twp)	14,365	12	0.1%	45	0.3%
Trenton (C)	83,412	1,968	2.4%	4,006	4.8%
West Windsor (Twp)	27,937	320	1.1%	623	2.2%
Mercer County (Total)	**367,922**	**7,445**	**2.0%**	**12,881**	**3.5%**

Sources: American Community Survey 2019 5-year estimates; FEMA 2016
Note: B – Borough; C – City; Twp – Township; % - Percent

People living and working in the sea level rise hazard area may also be displaced as homes and businesses become flooded and permanently lost. To estimate population exposed and vulnerable to the sea level rise hazards, a spatial analysis was conducted using the NOAA sea level rise inundation areas. The exposure analysis estimates that three persons in the Township of Hamilton are exposed to the 1-foot through 4-feet sea level rise scenarios.

Research has shown that some populations may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. There are 40,980 persons below the poverty level and 46,347 persons that are over 65 years old in the County. 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 more vulnerable because they are more likely to seek or need medical attention which may not be available due to isolation during a flood event and they may have more difficulty evacuating. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups.

In addition, displaced populations were estimated for the 1-percent annual chance flood event. Using 2010 U.S. Census data, Hazus estimates that 439 people may seek short-term sheltering. These figures, by jurisdiction, are presented in Table 4.3.5-8.

Table 4.3.5-8. Estimated Population Seeking Short-Term Shelter from the 1-percent Annual Chance Flood Event

Jurisdiction	American Community Survey (2015-2019) Population	1-Percent Annual Chance Flood Event
		Persons Seeking Short-Term Sheltering
East Windsor (Twp)	27,245	18
Ewing (Twp)	36,037	115
Hamilton (Twp)	87,424	74
Hightstown (B)	5,375	2
Hopewell (B)	1,915	0
Hopewell (Twp)	18,067	2
Lawrence (Twp)	32,614	117
Pennington (B)	2,531	0
Princeton	31,000	10
Robbinsville (Twp)	14,365	13
Trenton (C)	83,412	67
West Windsor (Twp)	27,937	21
Mercer County (Total)	**367,922**	**439**

Sources: Hazus; FEMA 2016
Note: B – Borough; C – City; Twp – Township

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

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (CDC 2020).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals

- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

Impact on General Building Stock

After considering the population exposed and potentially vulnerable to the flood hazard, the built environment was evaluated. Exposure includes those buildings located in the flood zone and sea level rise hazard areas. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content replacement cost values. Table 4.3.5-9 and Table 4.3.5-10 summarize these results county-wide. Refer to Appendix E (Risk Assessment Supplement) for a breakdown of the estimated building stock exposed to the FEMA flood events and NOAA sea level rise hazard areas by general occupancy class.

In summary, there are 2,529 buildings located in the 1-percent annual chance flood boundary with an estimated $5.4 billion of replacement cost value (i.e., building and content replacement costs). In total, this represents approximately 2.4-percent of the County's total general building stock inventory. In addition, there are 4,118 buildings located in the 0.2-percent annual chance flood boundary with an estimated $8.8 billion of building stock and contents exposed. This represents approximately 4.0-percent of the County's total general building stock inventory. Further, there are three structures located in the 1-foot through 4-feet sea level rise hazard areas with an estimated $63.9 million of building stock and contents exposed. This represents approximately 0.2-percent of the County's total general building stock inventory.

The Hazus riverine flood model estimated potential damages to the buildings in Mercer County at the structure level using the custom structure inventory developed for this HMP and the depth grid generated using the effective DFIRM data. The potential damage estimated by Hazus to the general building stock inventory associated with the 1-percent annual chance flood is approximately $587.7 million or less than 1-percent of the total building stock improvement value. The City of Trenton has the greatest amount of estimated building loss (i.e., $154.9 million). The Borough of Hopewell has the greatest proportion of structures with estimated losses (i.e., 1.8-percent of total replacement cost value). Refer to Table 4.3.5-9 for the estimated losses by jurisdiction, which also shows the estimated losses for residential and commercial structures, respectively.

Table 4.3.5-9. Estimated General Building Stock Located in the 1-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the 1-Percent Annual Chance Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the 1-Percent Annual Chance Flood Hazard Area	Percent of Total
East Windsor (Twp)	5,439	$7,712,408,240	105	1.9%	$91,286,448	1.2%
Ewing (Twp)	12,054	$18,161,858,212	589	4.9%	$1,296,059,455	7.1%
Hamilton (Twp)	29,515	$30,878,928,699	747	2.5%	$1,176,399,726	3.8%
Hightstown (B)	1,624	$1,867,544,787	21	1.3%	$116,635,213	6.2%
Hopewell (B)	844	$850,167,003	26	3.1%	$80,195,397	9.4%
Hopewell (Twp)	7,719	$11,709,101,176	60	0.8%	$170,266,027	1.5%
Lawrence (Twp)	9,027	$14,232,035,476	360	4.0%	$923,532,791	6.5%
Pennington (B)	953	$1,009,760,468	0	0.0%	$0	0.0%
Princeton	7,527	$12,608,393,758	77	1.0%	$136,409,834	1.1%
Robbinsville (Twp)	4,162	$7,167,631,183	11	0.3%	$22,289,220	0.3%
Trenton (C)	17,152	$36,604,311,832	410	2.4%	$923,143,577	2.5%
West Windsor (Twp)	7,563	$13,179,360,332	123	1.6%	$444,525,503	3.4%
Mercer County (Total)	**103,579**	**$155,981,501,165**	**2,529**	**2.4%**	**$5,380,743,191**	**3.4%**

Source: FEMA 2016; Mercer County GIS 2020; MODIV 2019; RS Means 2021
Notes: B – Borough; C – City; Twp – Township; % - Percent

Table 4.3.5-10. Estimated General Building Stock Located in the 0.2-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total
East Windsor (Twp)	5,439	$7,712,408,240	180	3.3%	$148,630,557	1.9%
Ewing (Twp)	12,054	$18,161,858,212	667	5.5%	$1,421,900,411	7.8%
Hamilton (Twp)	29,515	$30,878,928,699	1,491	5.1%	$2,349,702,468	7.6%
Hightstown (B)	1,624	$1,867,544,787	42	2.6%	$143,516,522	7.7%

Jurisdiction	Number of Buildings	Total Replacement Cost Value	Number of Buildings Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total	Total Replacement Cost Value of Structures Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total
Hopewell (B)	844	$850,167,003	26	3.1%	$80,195,397	9.4%
Hopewell (Twp)	7,719	$11,709,101,176	109	1.4%	$209,938,735	1.8%
Lawrence (Twp)	9,027	$14,232,035,476	422	4.7%	$1,336,937,157	9.4%
Pennington (B)	953	$1,009,760,468	0	0.0%	$0	0.0%
Princeton	7,527	$12,608,393,758	104	1.4%	$169,759,545	1.3%
Robbinsville (Twp)	4,162	$7,167,631,183	24	0.6%	$62,260,022	0.9%
Trenton (C)	17,152	$36,604,311,832	835	4.9%	$2,197,027,116	6.0%
West Windsor (Twp)	7,563	$13,179,360,332	218	2.9%	$652,492,855	5.0%
Mercer County (Total)	**103,579**	**$155,981,501,165**	**4,118**	**4.0%**	**$8,772,360,784**	**5.6%**

Source: FEMA 2016; Mercer County GIS 2020; MODIV 2019; RS Means 2021
Notes: B – Borough; C – City; Twp – Township; % - Percent

Table 4.3.5-11. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Jurisdiction	Total Replacement Cost Value	All Occupancies		Residential		Commercial	
		Estimated Loss	Percent of Total Replacement Cost Value	Estimated Loss	Percent of Total Replacement Cost Value	Estimated Loss	Percent of Total Replacement Cost Value
East Windsor (Twp)	$7,712,408,240	$5,235,749	0.1%	$713,077	0.0%	$1,091,729	0.0%
Ewing (Twp)	$18,161,858,212	$122,535,406	0.7%	$40,799,260	0.2%	$65,535,137	0.4%
Hamilton (Twp)	$30,878,928,699	$151,930,244	0.5%	$19,452,458	0.1%	$91,556,994	0.3%
Hightstown (B)	$1,867,544,787	$17,518,234	0.9%	$140,673	0.0%	$509,982	0.0%
Hopewell (B)	$850,167,003	$14,892,997	1.8%	$1,087,675	0.1%	$13,805,323	1.6%
Hopewell (Twp)	$11,709,101,176	$43,622,838	0.4%	$5,276,676	0.0%	$1,877,179	0.0%
Lawrence (Twp)	$14,232,035,476	$43,691,251	0.3%	$3,782,392	0.0%	$31,514,876	0.2%
Pennington (B)	$1,009,760,468	$0	0.0%	$0	0.0%	$0	0.0%
Princeton	$12,608,393,758	$14,592,127	0.1%	$1,847,931	0.0%	$6,790,401	0.1%
Robbinsville (Twp)	$7,167,631,183	$154,856	0.0%	$11,003	0.0%	$143,853	0.0%
Trenton (C)	$36,604,311,832	$154,915,370	0.4%	$37,035,251	0.1%	$70,459,418	0.2%
West Windsor (Twp)	$13,179,360,332	$18,634,453	0.1%	$2,953,183	0.0%	$11,973,592	0.1%
Mercer County (Total)	**$155,981,501,165**	**$587,723,523**	**0.4%**	**$113,099,578**	**0.1%**	**$295,258,482**	**0.2%**

Source: FEMA 2016; Mercer County GIS 2020; MODIV 2019; RS Means 2021; Hazus v4.2
Notes: B – Borough; C – City; Twp – Township; % - Percent

NFIP Statistics

NJOEM and FEMA provided a list of properties with NFIP policies, past claims, and multiple claims. According to FEMA, a repetitive loss (RL) property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978. A severe repetitive loss (SRL) property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss (FEMA 2020).

Table 4.3.5-12 through Table 4.3.5-14 summarize the NFIP policies, claims, and repetitive loss statistics for Mercer County. The majority of the RL and SRL properties are single-family residences (83-percent of all repetitive loss properties). This information is current as of September 16, 2019. The location of the repetitive and severe repetitive flooding was geocoded by FEMA with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

Table 4.3.5-1. Occupancy Class of Repetitive Loss Structures in Mercer County

Occupancy Class	Total Number of NFIP Repetitive Loss (RL) Properties (excludes SRL)	Total Number of NFIP Severe Repetitive Loss (SRL) Properties (excludes RL)	Total NFIP RL and SRL Properties
Assumed Condo	3	0	3
2-4 Family	16	2	18
Business Non-Residential	5	2	7
Other Residential	2	0	2
Non-Residential	20	9	29
Single Family	229	20	249
Mercer County (Total)	**275**	**33**	**308**

Source: FEMA Region 2 2019
Note: Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of September 16, 2019.

Table 4.3.5-2. Occupancy Class of Repetitive Loss Structures in Mercer County, by Municipality

Jurisdiction	NFIP Repetitive Loss (RL) Properties (excludes SRL)						NFIP Severe Repetitive Loss (SRL) Properties					
	Assumed Condo	2-4 Family	Business Non-Residential	Other Residential	Non-Residential	Single Family	Assumed Condo	2-4 Family	Business Non-Residential	Other Residential	Non-Residential	Single Family
East Windsor (Twp)	0	0	0	0	0	0	0	0	0	0	0	0
Ewing (Twp)	1	0	1	0	7	43	0	0	0	0	1	7
Hamilton (Twp)	0	2	0	0	2	12	0	0	0	0	0	0
Hightstown (B)	0	0	0	0	0	0	0	0	0	0	0	0
Hopewell (B)	0	1	0	0	0	0	0	0	0	0	0	0
Hopewell (Twp)	1	0	0	0	1	3	0	0	0	0	0	3
Lawrence (Twp)	1	1	0	0	2	8	0	0	0	0	1	1
Pennington (B)	0	0	0	0	0	1	0	0	0	0	0	0
Princeton	0	0	0	0	0	3	0	0	0	0	0	1
Robbinsville (Twp)	0	0	0	0	0	0	0	0	0	0	0	0
Trenton (C)	0	9	2	2	7	154	0	2	1	0	7	8
West Windsor (Twp)	0	3	2	0	1	5	0	0	1	0	0	0
Mercer County (Total)	**3**	**16**	**5**	**2**	**20**	**229**	**0**	**2**	**2**	**0**	**9**	**20**

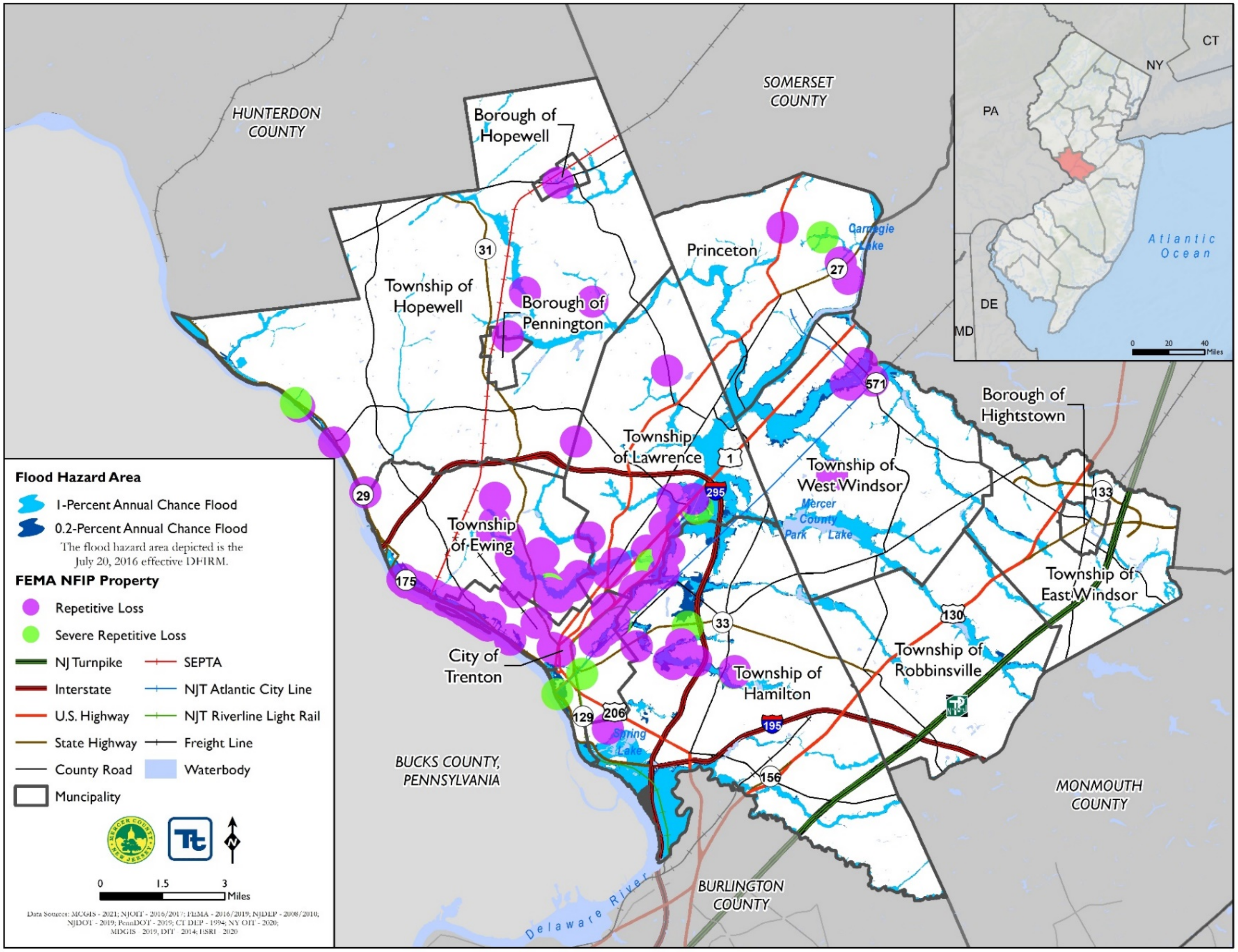
Source: FEMA Region 2, 2019
Notes: B – Borough; C – City; Twp - Township
Repetitive loss and severe repetitive loss statistics provided by FEMA Region 2 and are current as of September 16, 2019. The statistics were summarized using the Community Name provided by FEMA Region 2.

Table 4.3.5-3. NFIP Policies, Claims, and Repetitive Loss Statistics

Jurisdiction	Total Number of Policies	Total Claims	Total Payments	Number of NFIP Repetitive Loss (RL) Properties (Excludes SRL)	Number of NFIP Severe Repetitive Loss (SRL) Properties (Excludes RL)	Number of Mitigated RL/SRL Properties
East Windsor (Twp)	92	16	$53,963	0	0	0
Ewing (Twp)	324	338	$3,175,942	52	8	1
Hamilton (Twp)	433	193	$3,255,359	16	0	1
Hightstown (B)	23	9	$304,319	0	0	0
Hopewell (B)	7	2	$42,807	1	0	0
Hopewell (Twp)	86	37	$1,268,298	5	3	0
Lawrence (Twp)	233	143	$6,824,706	12	2	0
Pennington (B)	4	0	$0	1	0	0
Princeton	189	80	$2,077,652	3	1	0
Robbinsville (Twp)	28	2	$2,432	0	0	0
Trenton (C)	204	817	$15,747,505	174	18	3
West Windsor (Twp)	138	65	$3,728,366	11	1	1
Mercer County (Total)	**1,761**	**1,702**	**$36,481,349**	**275**	**33**	**6**

Source: FEMA Region 2 2019
Notes: B – Borough; C – City; Twp – Township; NFIP - National Flood Insurance Program
1 - Policies, claims, repetitive loss, and severe repetitive loss statistics provided by FEMA Region 2, and are current as of September 16, 2019. The number of claims represents claims closed by September 16, 2019.

Figure 4.3.5-3. FEMA NFIP Repetitive Loss Properties in Mercer County



Impact on Critical Facilities and Lifelines

It is important to determine the critical facilities, lifelines, and infrastructure that may be at risk to flooding, and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the planning area to many service providers needing to reach vulnerable populations or to make repairs.

Sea level rise may potentially impact critical facilities identified within the County. Critical services may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are permanently inundated by sea level rise. Residual impacts from sea level rise include increased frequency of coastal flooding events and coastal erosion. Flooding could disrupt utilities that are not protected with berms or other flood-proof measures. Coastal erosion may destabilize the roadways leading to facilities or destroy the foundation that supports the critical facilities along the shoreline.

Overall, most of the critical facilities within the flood and sea level rise hazard areas are bridges. The Township of Hamilton is estimated to be the only municipality with critical facilities and lifelines exposed to the sea level rise hazard areas. The Township of Lawrence has the greatest number of critical facilities and lifelines exposed to the 1-percent annual chance flood event. The City of Trenton and the Township of Hamilton has the greatest number of critical facilities and lifelines exposed to the 0.2-percent annual chance flood event, respectively. Up to 16.1-percent of the County's critical facilities and up to 17.6-percent of the County's lifelines are exposed to the 0.2-percent flood hazard area. Refer Table 4.3.5-13 and Table 4.3.5-14 for a summary of critical facilities and lifelines exposed to the flood hazard areas for each municipality.

Furthermore, out of the 453 critical facilities exposed to the 1-percent annual chance flood event, 428 of these critical facilities are considered lifelines for the County. Additionally, there are 545 critical facilities located in the 0.2-percent annual chance flood event boundary. Out of these critical facilities, 495 are considered lifelines for the County. All facilities exposed to the sea level rise hazard areas are also considered a transportation or safety and security lifeline to the County. Refer to Table 4.3.5-15 and Table 4.3.5-16 for a summary of lifelines by FEMA lifeline categories exposed to the flood hazard areas. Refer to Appendix E to view the distribution of critical facilities by type located in the 1- and 0.2-percent annual chance flood event boundaries, in addition to the 1-foot through 4-feet sea level rise hazard areas.

Table 4.3.5-4. Distribution of Critical Facilities and Lifelines Located in the 1-Percent Annual Chance Flood Event

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
East Windsor (Twp)	171	154	28	16.4%	25	16.2%
Ewing (Twp)	266	215	39	14.7%	37	17.2%
Hamilton (Twp)	639	537	69	10.8%	65	12.1%
Hightstown (B)	70	63	7	10.0%	6	9.5%
Hopewell (B)	47	39	5	10.6%	5	12.8%
Hopewell (Twp)	438	406	66	15.1%	65	16.0%
Lawrence (Twp)	334	304	73	21.9%	66	21.7%
Pennington (B)	44	40	0	0.0%	0	0.0%

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Princeton	252	209	60	23.8%	58	27.8%
Robbinsville (Twp)	136	127	17	12.5%	17	13.4%
Trenton (C)	701	478	41	5.8%	38	7.9%
West Windsor (Twp)	288	234	48	16.7%	46	19.7%
Mercer County (Total)	**3,386**	**2,806**	**453**	**13.4%**	**428**	**15.3%**

Source: FEMA 2016; Mercer County GIS 2020
Notes: B – Borough; C – City; Twp – Township; % - Percent

Table 4.3.5-5. Distribution of Critical Facilities and Lifelines Located in the 0.2-Percent Annual Chance Flood Event

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located in the 0.2-Percent Annual Chance Flood Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
East Windsor (Twp)	171	154	30	17.5%	27	17.5%
Ewing (Twp)	266	215	40	15.0%	38	17.7%
Hamilton (Twp)	639	537	87	13.6%	81	15.1%
Hightstown (B)	70	63	9	12.9%	7	11.1%
Hopewell (B)	47	39	5	10.6%	5	12.8%
Hopewell (Twp)	438	406	67	15.3%	65	16.0%
Lawrence (Twp)	334	304	75	22.5%	68	22.4%
Pennington (B)	44	40	0	0.0%	0	0.0%
Princeton	252	209	65	25.8%	60	28.7%
Robbinsville (Twp)	136	127	17	12.5%	17	13.4%
Trenton (C)	701	478	93	13.3%	74	15.5%
West Windsor (Twp)	288	234	57	19.8%	53	22.6%
Mercer County (Total)	**3,386**	**2,806**	**545**	**16.1%**	**495**	**17.6%**

Source: FEMA 2016; Mercer County GIS 2020
Notes: B – Borough; C – City; Twp – Township; % - Percent

Table 4.3.5-6. Number of Lifelines Categorized by FEMA Lifeline Categories Located in the 1-Percent Annual Chance Flood Event

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the 1-Percent Annual Chance Flood Hazard Area
Communications	160	9
Energy	132	7
Food, Water, and Shelter	620	65
Hazardous Materials	95	9
Health and Medical	422	20
Safety and Security	587	48

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the 1-Percent Annual Chance Flood Hazard Area
Transportation	790	270
Mercer County (Total)	**2,806**	**428**

Source: FEMA 2016/2020; Mercer County GIS 2020

Table 4.3.5-7. Number of Lifelines Categorized by FEMA Lifeline Categories Located in the 0.2-Percent Annual Chance Flood Event

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the 0.2-Percent Annual Chance Flood Hazard Area
Communications	160	9
Energy	132	7
Food, Water, and Shelter	620	86
Hazardous Materials	95	13
Health and Medical	422	22
Safety and Security	587	59
Transportation	790	299
Mercer County (Total)	**2,806**	**495**

Source: FEMA 2016/2020; Mercer County GIS 2020

In cases where short-term functionality is impacted by flooding, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce flood impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs. Actions addressing shared services agreements are included in Section 9 (Mitigation Strategies) of this HMP update.

Impact on Economy

Flood events can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, impacts on tourism, and impacts on the tax base to Mercer County. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Mercer County. Other economic components such as loss of facility use, functional downtime and socio-economic factors are less measurable with a high degree of certainty.

Flooding can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur and drinking water and wastewater treatment facilities may be temporarily out of operation.

Debris management may also be a large expense after a flood event. Hazus estimates the amount of debris generated from the 1-percent annual chance event. The model breaks down debris into three categories: (1) finishes (dry wall, insulation, etc.); (2) structural (wood, brick, etc.) and (3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. Table 4.3.5-19 summarizes the debris Hazus estimates for these events. As a result of the 1-percent annual chance event, Hazus estimates approximately 13,965 tons of debris will be generated in total.

Table 4.3.5-8. Estimated Debris Generated from the 1-Percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
East Windsor (Twp)	574	548	10	16
Ewing (Twp)	2,396	2,345	30	21
Hamilton (Twp)	3,151	1,976	682	492
Hightstown (B)	104	102	1	1
Hopewell (B)	64	64	0	0
Hopewell (Twp)	1,576	710	491	375
Lawrence (Twp)	909	825	51	33
Pennington (B)	4	2	1	1
Princeton	865	721	85	59
Robbinsville (Twp)	40	38	1	1
Trenton (C)	3,676	3,330	197	148
West Windsor (Twp)	607	588	12	7
Mercer County (Total)	**13,965**	**11,249**	**1,562**	**1,153**

Source: Hazus v4.2
Notes: B – Borough; C – City; Twp – Township

In addition, an exposure analysis was conducted to determine how many miles of transportation routes may be impacted by flood events and sea level rise (refer to Table 4.3.5-20 and Table 4.3.5-21, respectively). Overall, local roads have the greatest number of miles exposed to the flood hazard areas and interstate routes have the greatest number of miles exposed to the sea level rise hazard areas.

Table 4.3.5-20. Estimated Miles of Transportation Routes Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Events

Roadway Type	Total Miles for County	Total Roadway Miles Located in the 1-Percent Annual Chance Flood Hazard Area	Percent of Total	Total Roadway Miles Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total
State Routes	87	16	19.0%	24	27.9%
Interstate	101	5	4.7%	9	8.6%
US Route	98	7	7.0%	8	8.0%
County Routes	206	12	5.8%	15	7.4%
Local Roads	1,548	48	3.1%	74	4.8%
NJ Turnpike	66	1	1.5%	1	1.6%
Mercer County (Total)	**2,106**	**89**	**4.2%**	**131**	**6.2%**

Source: Mercer County GIS 2020; NJOIT 2017; FEMA 2016
Notes: % - Percent

Table 4.3.5-22. Estimated Miles of Transportation Routes Exposed to the 1-Foot through 4-Feet Sea Level Rise Hazard Areas

Roadway Type	Total Miles for County	Total Roadway Miles Located in the Sea Level Rise 1-Foot Flood Hazard Area	Percent of Total	Total Roadway Miles Located in the Sea Level Rise 2-Feet Flood Hazard Area	Percent of Total	Total Roadway Miles Located in the Sea Level Rise 3-Feet Flood Hazard Area	Percent of Total	Total Roadway Miles Located in the Sea Level Rise 4-Feet Flood Hazard Area	Percent of Total
State Routes	87	1	0.8%	1	0.8%	1	0.9%	1	0.9%
Interstate	101	2	1.8%	2	1.9%	2	2.1%	2	2.1%
US Route	98	0	0.1%	0	0.1%	0	0.1%	0	0.1%
County Routes	206	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Local Roads	1,548	0	0.0%	0	0.0%	0	0.0%	0	0.0%
NJ Turnpike	66	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Mercer County (Total)	**2,106**	**3**	**0.1%**	**3**	**0.1%**	**3**	**0.1%**	**3**	**0.1%**

Source: Mercer County GIS 2020; NJOIT 2017; NOAA 2017
Notes: % - Percent

Impact on the Environment

Flood extents for the 1- and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as sea level rise, climate change, and/or severity of storms. These flood events will inevitably impact Mercer County's natural and local environment. Severe flooding not only influences the habitat of these natural land areas, but it can also be disruptive to species that reside in these natural habitats. Table 4.3.5-23 lists the number of acres exposed to the 1- and 0.2-percent annual chance flood extents by land use type. Additionally, an exposure analysis estimates that up to 1,241 acres of land is located in the 4-feet sea level rise hazard area, where majority of the land is forested or wetlands (1,207 acres). Non-residential land use types include forested, wetlands, open space areas, and agricultural lands. Further, Table 4.3.5-24 lists the number of acres natural land use types within Mercer County that are at risk to flooding.

Table 4.3.5-9. Land Use Types in Mercer County Located in the 1-Percent and 0.2-Percent Annual Chance Flood Events

Land Use Type	Total Acres for County	Total Acres of Land Use Type Located in the 1-Percent Annual Chance Flood Hazard Area	Percent of Total	Total Acres of Land Use Type Located in the 0.2-Percent Annual Chance Flood Hazard Area	Percent of Total
Residential Land	72,215	2,592	3.6%	3,667	5.1%
Non-Residential Land	70,758	10,486	14.8%	11,424	16.1%
Natural Land	49,382	9,965	20.2%	10,800	21.9%
Mercer County (Total)	**142,973**	**13,078**	**9.1%**	**15,091**	**10.6%**

Source: NJDEP 2019; FEMA 2016
Notes: % - Percent
Residential = Urban
Non-Residential = Agriculture, Barren Land, Forest, Wetlands
Natural = Wetlands & Forest
**Acres reported does not include water*

Table 4.3.5-10. Natural Environmental Areas Within the 1-Percent and 0.2-Percent Annual Chance Flood Events

Natural Land Use Type	Area in the 1-Percent Annual Chance Floodplain (acres)	Area in the 0.2-Percent Annual Chance Floodplain (acres)
Forest	1,926	2,216
Wetlands	8,039	8,584

Source: NJDEP 2019; FEMA 2016

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 and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Sewer Service Areas) that may provide insight as to where potential new development may occur in Mercer County. In addition, each community was requested to provide potential major new development and infrastructure over the next five years; summarized in Section 9 (Jurisdictional Annexes).

An exposure analysis was conducted using the input from the communities as displayed in Figure 4.3.5-4 to determine if new development may be located in the floodplain. Based on the analysis, there are four recent new developments located in the 1-percent annual chance floodplain and eight new development locations within the 0.2-percent annual chance floodplain. Additionally, an exposure analysis found that there are no new development sites located within the sea level rise hazard areas (refer to Figure 4.3.5-5). The results of this analysis were shared with all jurisdictions. Being aware of these flood extents and requirements of protection will be critical for all future projects.

Projected Changes in Population

Mercer County has experienced a small overall increase in population since 2010, with Hopewell Township, Princeton and Robbinsville Township seeing the greatest growth. An increase in population density can create issues for local residents during an evacuation. Refer to Section 3 (County Profile) for more information about population trends in the County.

Climate Change

As discussed above, 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 to flash flooding and riverine flooding, and flood critical transportation corridors and infrastructure. Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure of populations, buildings, critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by future flooding events due to loss of service or access.

Change of Vulnerability Since 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2015-2019 American Community Survey. The general building stock was also updated using MOD-IV 2019 assessor data, 2020 building footprints provided by the County, and RS Means 2021 building valuations that estimated replacement cost value for each building in the inventory. This provides an up-to-date look at the entire building stock for Mercer County and gives more accurate results for the exposure and loss estimation analysis. In addition, FEMA's Hazus flood module (version 4.2) and the 1-percent annual chance flood event depth grid were used to estimate potential losses for the 1-percent annual chance flood event.

Since the 2016 HMP, several mitigation projects have been implemented in the County as summarized in Table 14 in each of the jurisdictional annexes. Overall, six RL and SRL properties have been mitigated with more in progress and identified in the updated mitigation strategy of this plan. Mercer County and all municipalities are making progress on reducing their flood risk; however still remain vulnerable to the hazard.

Figure 4.3.5-4. New Development, Areas of Potential Growth, and the 1-Percent and 0.2-Percent Annual Chance Flood Events

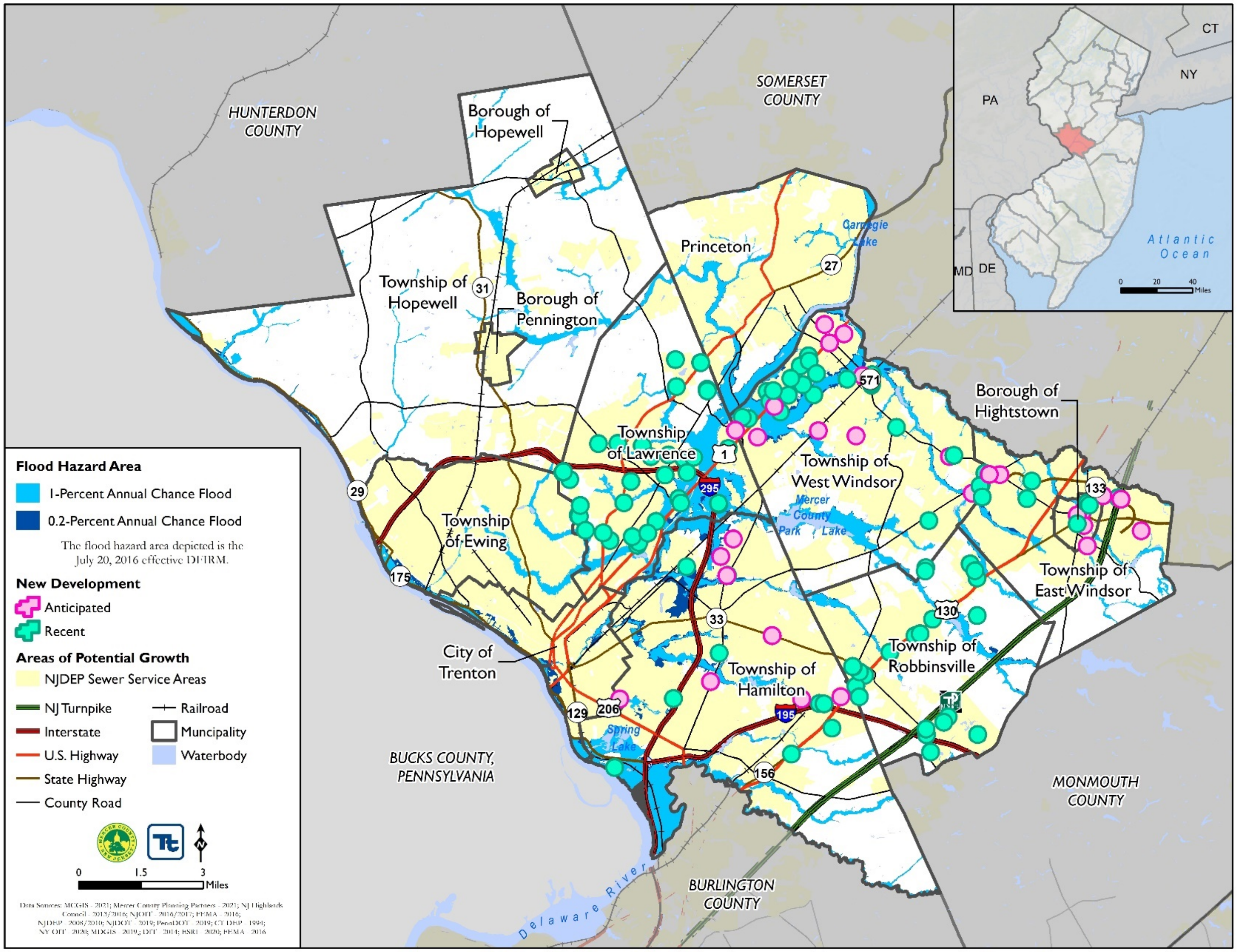


Figure 4.3.5-5. New Development, Areas of Potential Growth, and the 1-Foot through 4-Feet Sea Level Rise Hazard Areas