4.3.6 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 Essex County.

2020 HMP Update Changes

- All subsections have been updated using best available data.
- Storm surge is now discussed in Section 4.3.2 - Coastal Storm.
- The discussion of urban flooding has been expanded.
- Previous events between 2014 and 2019 are listed with a comprehensive list of previous events in Appendix X.
- The 2007 effective Essex County FEMA Digital Flood Insurance Rate Map (DFIRM) with a Letter of Map Revision (LOMR) dated December 2018 and the preliminary Essex County FEMA DFIRMs dated May 2014 and June 2017 were used to evaluate exposure and determine potential future losses. Additionally, FEMA released coastal Risk Map products in May 2017, and riverine Risk Map products for the Hackensack-Passaic Watershed in September 2018 which were incorporated into the flood depth grid and imported into the HAZUS-MH flood model.
- An updated version of the HAZUS-MH flood model was used to estimate potential losses version 4.2.
- A repetitive loss area analysis was conducted.

4.3.6.1 Profile

Hazard Description

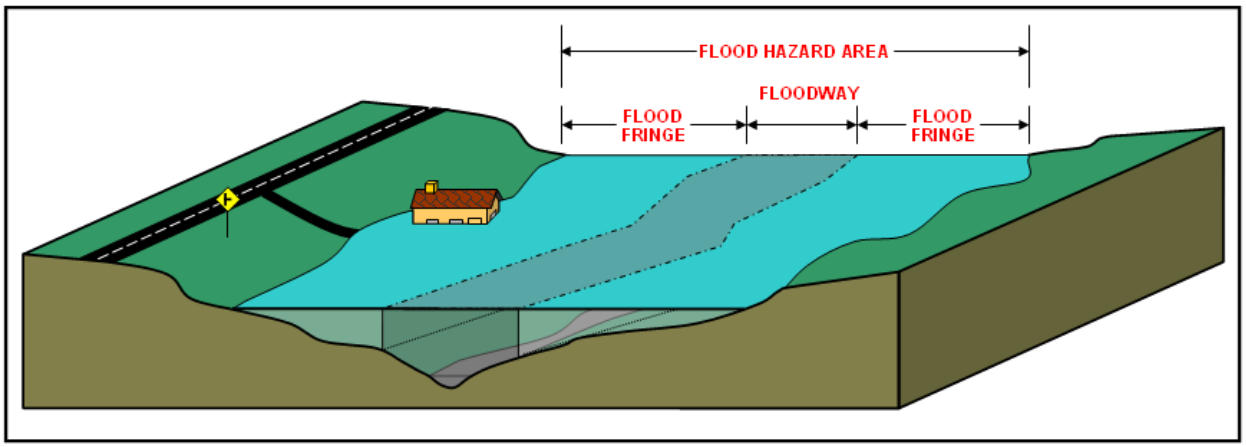
A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, 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 Essex County are riverine (inland) flooding, coastal flooding from tidally-influenced rivers and flooding as a result of a dam failure. In addition, Essex 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 Essex County, floodplains line the rivers and streams of the County and the coastal areas. 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 4.3.6-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 4.3.6-1. Floodplain



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

Dam Failure

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

- Overtopping caused by floods that exceed the capacity of the dam or levee (inadequate spillway capacity);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage (terrorism);
- Structural failure of materials used in dam construction;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams;
- Inadequate or negligent operation, maintenance and upkeep;
- Failure of upstream dams on the same waterway; or
- Earthquake (liquefaction / landslides) (FEMA 2018a).

Regulatory Oversight of Dams

Potential for catastrophic flooding caused by dam failures led to enactment of the National Dam Safety Act (Public Law 92-367), which for 30 years has protected Americans from dam failures. The National Dam Safety Program (NDSP) is a partnership among states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and purchases of needed equipment. FEMA has also expanded existing and initiated new training programs. Grant assistance from FEMA provides support for improvement of dam safety programs that regulate most dams in the United States (FEMA 2016).

U.S. Army Corps of Engineers Dam Safety Program

The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams and has surveyed each state's and federal agency's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of the dams. USACE has also developed guidelines for inspection and evaluation of dam safety (USACE 2019).

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. A total of 3,036 dams are part of regulated hydroelectric projects and are included in the FERC program. Two-thirds of these dams are more than 50 years old. Concern about their safety and integrity grows as dams age, rendering oversight and regular inspection especially important (FERC 2017). FERC staff inspect hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with terms and conditions of a license (FERC 2017).

Every 5 years, an independent consulting engineer, approved by FERC, must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with total storage capacity of more than 2,000 acre-feet (FERC 2017).

Urban Flooding

Heavy rainfall that overwhelms a developed area's stormwater infrastructure causing flooding is commonly referred to as urban flooding. Urban flooding can be worsened by 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.

Location

Flooding potential is influenced by climatology, meteorology and topography. Extensive development, such as that seen in Essex County, also 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.

According to the 2017 preliminary FEMA Flood Insurance Study and the 2007 effective FEMA Flood Insurance Study, flooding in Essex County is caused by coastal flooding, (discussed in Section 4.3.2 – Coastal Storm), riverine flooding, and heavy rainfall events.

Riverine flooding takes place in low-lying areas adjacent to Essex County's rivers and brooks. The 2007 FEMA Flood Insurance Study identifies the following waterways as sources of riverine flooding: Passaic River and its tributaries, Second River and its tributaries, Third River, Peckman River, Nishuane Brooke, Pompton River, Toneys Brook, Canoe Brook, Slough Brook, Rahway River, East Branch Rahway River, West Branch Rahway River, Elizabeth River, Crooked Brook, Lightning Brook, Taylor Brook, Great Hills Brook, Wigwam Brook, Foulerton's Brook, North Branch Foulerton's Brook, Pine Brook, Green Brook, and Kane Brook.

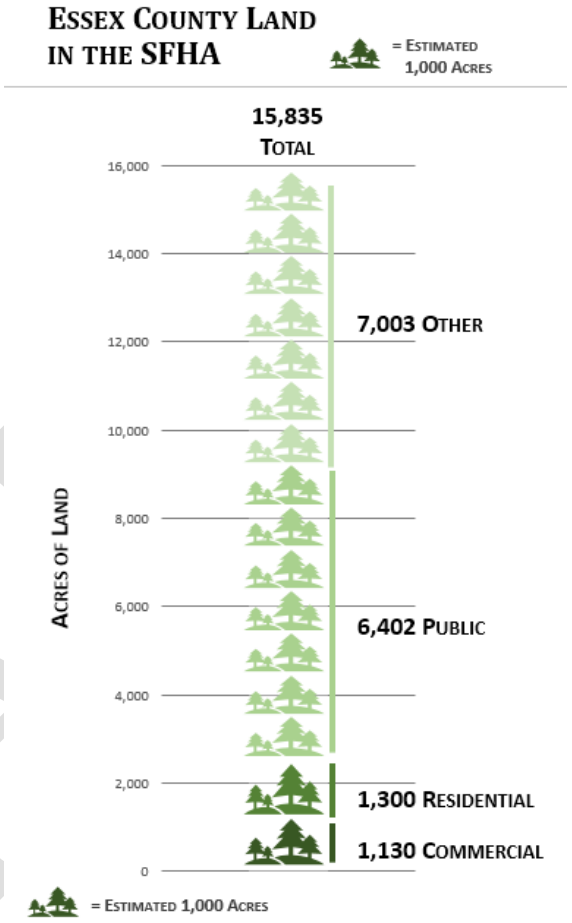
For additional information on flood prone areas in each municipality, refer to Section 9 (Jurisdictional Annexes).

There are numerous flood control measures in place to alter the flooding hazard within Essex County (FEMA 2017). In addition to cleaning and repair initiatives, these measures include:

- The Township of Belleville has been granted funds through the Hazard Mitigation Grant Program (HMGP) to fund the installation of a system of values within the existing 17 outfalls from Main Street to the Passaic River.
- Almost the entire length of Nishuane Brook in the City of East Orange was constructed to include concrete sidewalls and inverts. Culverts have also been installed at all the street crossings. These improvements, designed to contain the 2-percent-annual-chance flood, were not enough to prevent some local flooding during the August 1973 storm.
- The Township of Irvington has a flume which was constructed in 1933 along the Elizabeth River. The flume varies from 6 to 10 feet (ft). deep with widths from 20 to 30 ft. A double culvert was built to accommodate the Garden State Parkway.
- Improvements by the Township of Livingston along Canoe Brook, including a new concrete lined channel to improve flow conditions and prevent bank erosion upstream of Cedar Street, were constructed in 1972. In the section between Serbrooke Parkway and East Mount Pleasant Avenue (State Route 10), a concrete lining was created to prevent erosion of the bank slopes, and concrete grade beams were placed across the bottom of the channel to reduce erosion of the streambed. Upstream of Slough Brook, along West Northfield Road, a channel was protected from erosion by lining the bank slopes with riprap.
  During the early 1930s, the Works Progress Administration constructed mortar rubble masonry walls along the East Branch of the Rahway River, from the Jefferson Avenue Bridge to a point approximately 750 ft. downstream from the Baker Street Bridge in the Township of Maplewood. The purpose of this work was to protect the banks of the river and to prevent erosion.
- In the Township of Millburn some of the brooks have paved or piped sections that may aid in reducing channel obstructions and a section of the West Branch Rahway River is channelized although these improvements were not made specifically for flood control.
- The Memorial Park Retention Basin on the Second River in the Township of Montclair was modified around 1950 to provide storage for approximately 357,000 cubic ft. of floodwater.

- An overall Rahway River Flood Control Project was authorized by the Flood Control Act of October 27, 1965. The flood area for which protection is being provided consists of approximately 70 acres on the left and right banks of the East Branch Rahway River. The improvement is designed to protect the area against an overflow of the East Branch Rahway River with a frequency of occurrence of once in 100 years. The improvement is essentially a channel enlargement project, which provides for clearing and excavation for a length of about 7,000 ft. Generally, the project consists of concrete walls, levees, a flume, drainage structures, replacement of four bridges, and miscellaneous changes to existing utilities. The upstream limit of the project is the upstream corporate limits of the Township of South Orange Village and the downstream limit is approximately 800 ft. upstream of the Erie-Lackawanna Railroad spur, about 1,400 ft. below Third Street.

  The area around the Township of South Orange Village water-pumping plant and the service building has been previously flooded and will still be susceptible to future flooding when the upstream channel is completed. Installing flashboards at the doors and windows has temporarily protected the pumping station, and valuable equipment within the service building has been raised above flood levels.
- The East and West Forks of East Branch Rahway River have had channel improvements along substantial lengths.
- No levee type structures exist within Essex County.



Floodplains

The Digital Flood Insurance Rate Map (DFIRM) data provided by FEMA for Essex County show the following flood hazard areas:

- 1-Percent Annual Chance Flood Hazard: Areas subject to inundation by the 1-percent-annual-chance flood event. This includes Zone AE and Zone VE. This is also referred to as the Special Flood Hazard Area (SFHA). Mandatory flood insurance requirements and floodplain management standards apply.
- 0.2-Percent Annual Chance Flood Hazard: Area of minimal flood hazard, usually depicted on FIRMs as the 500-year flood level or Shaded X Zone.

Locations of flood zones in Essex County as depicted on the FEMA 2007 effective DFIRM (last LOMR in 2018), preliminary 2014 and 2017 DFIRMs are illustrated in Figure 4.3.6-2 and the total land area in the floodplain, inclusive of waterbodies, is summarized in Table 4.3.6-1.

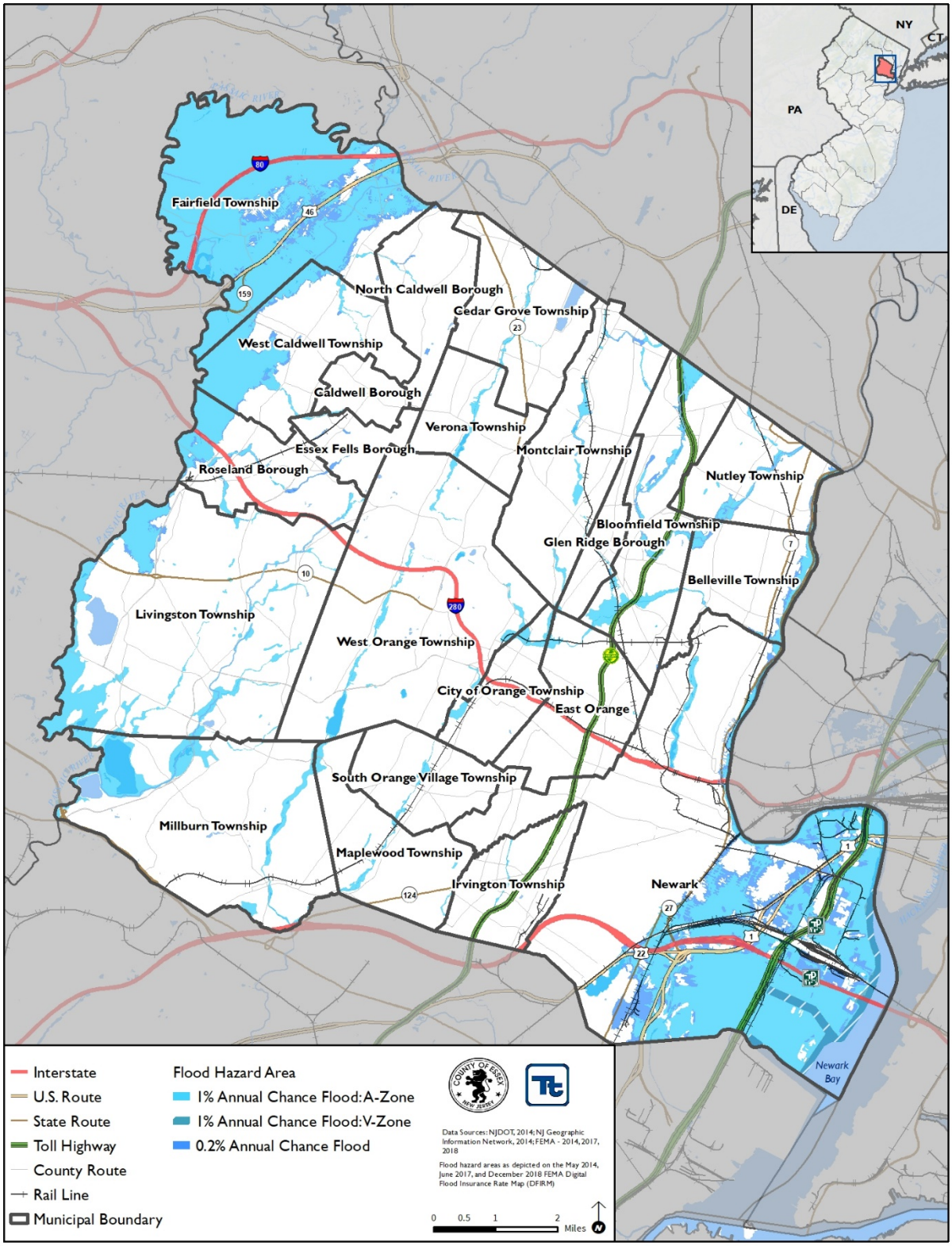
Table 4.3.6-1. Total Land Area in the 1-Percent and 0.2-Percent Annual Chance Flood Zones (Acres)

Municipality	Total Area (acres)	1% Flood Event Hazard Area				0.2% Flood Event Hazard Area	
		A-Zone Area (acres)	% of Total	V-Zone Area (acres)	% of Total	Area (acres)	% of Total
Township of Belleville	2,156	200	9.3%	0	0.0%	270	12.5%
Township of Bloomfield	3,434	390	11.3%	0	0.0%	440	12.8%
Borough of Caldwell	759	6	0.8%	0	0.0%	7	0.9%
Township of Cedar Grove	2,791	47	1.7%	0	0.0%	47	1.7%
City of East Orange	2,514	42	1.7%	0	0.0%	42	1.7%
Borough of Essex Fells	906	9	1.0%	0	0.0%	26	2.8%
Township of Fairfield	6,618	5,374	81.2%	0	0.0%	5,982	90.4%
Borough of Glen Ridge	818	15	1.8%	0	0.0%	16	1.9%
Township of Irvington	1,866	23	1.2%	0	0.0%	23	1.2%
Township of Livingston	9,040	1,257	13.9%	0	0.0%	1,312	14.5%
Township of Maplewood	2,480	116	4.7%	0	0.0%	116	4.7%
Township of Millburn	6,324	816	12.9%	0	0.0%	816	12.9%
Township of Montclair	3,995	150	3.8%	0	0.0%	179	4.5%
City of Newark	16,778	4,938	29.4%	398	2.4%	6,734	40.1%
Borough of North Caldwell	1,968	24	1.2%	0	0.0%	38	1.9%
Township of Nutley	2,186	163	7.4%	0	0.0%	209	9.6%
City of Orange Township	1,418	115	8.1%	0	0.0%	115	8.1%
Borough of Roseland	2,361	463	19.6%	0	0.0%	528	22.4%
Township of South Orange Village	1,822	43	2.4%	0	0.0%	43	2.4%
Township of Verona	1,796	65	3.6%	0	0.0%	65	3.6%
Township of West Caldwell	3,239	897	27.7%	0	0.0%	897	27.7%
Township of West Orange	7,756	285	3.7%	0	0.0%	395	5.1%
Essex County (Total)	**83,023**	**15,437**	**18.6%**	**398**	**0.5%**	**18,297**	**22.0%**

Source: FEMA 2014, 2017, 2018
Note: % = Percent
The area presented includes the total area of the municipality, which may include waterways.

The most extensive areas of the 1-percent annual chance floodplains extend along the Passaic River through much of the Passaic Meadows Complex in Fairfield, West Caldwell and Roseland. In southwestern Essex County, extensive 1/2- to 1-mile-wide floodplains exist in the vicinity of Slough and Canoe Brooks in Millburn Township and near Willow Brook in Livingston. In eastern Essex County, much of Lower Newark City is within the Floodplain of Newark Bay. Other larger floodplains are identified along the West Branch of the Rahway River, and along Second River, Wigwam Brook, and Third River in northeastern Essex County (Essex County Environmental Resource Inventory 2007).

Figure 4.3.6-2. FEMA Flood Hazard Areas in Essex County



Flood Insurance Study (FIS)

The following discussion presents flood information as directly provided in the FEMA FIS document(s) (FEMA 2007, FEMA 2017). The FIS also included dates of historic flood events, which will also be included in this section.

- *Township of Belleville* – The Township of Belleville is subject to flooding from the Passaic River, the Second River, and the Third River. All three flooding sources flow in well-defined channels with flooding occurring in adjacent low-lying areas. Flooding is generally the result of heavy rainfall produced by hurricanes moving up the Atlantic coastline, large frontal storms from the west and south, and local thunderstorms. Frequent flooding is also known to occur along the Third River between Fairway Avenue and Joralemon Street.

  Historic floods occurred in 1902, 1903, 1936, and 1945. The 1903 flood had an estimated peak discharge of 39,800 cubic feet per second (cfs) and estimated 1% annual chance frequency at the confluence of the Passaic River and Newark Bay. The floods inundated large areas, causing damage to buildings and disruption of transportation and utility lines.

- *Township of Bloomfield* – The Township of Bloomfield is subject to flooding from the Passaic River and the Second River. The flooding along the streams within the corporate limits to attributed mainly to backwater created by inadequate storm drains and culverts, clogged bridges, or shallow stream beds. Most of the lands adjacent to the rivers in the Township are affected by flooding, with the exception of the Third River section between John F. Kennedy Drive and Maple Street, where natural high riverbeds combined with natural high grounds confine floodwater to the channel. There are several other areas throughout the Township that experience flooding due to inadequate storm drainage systems. Historic floods in the Township occurred in May 1968, August and September 1971, and February 1973.

- *Township of Cedar Grove* - The Township of Cedar Grove is subject to flooding from the Peckman River and its tributaries. All flooding sources flow in well-defined channels with flooding occurring in adjacent low-lying areas. Flooding occurs along the Peckman River and its tributaries during times of excessive and prolonged rainfall, particularly in residential areas having steep slopes. This flooding is the result of high runoff combined with insufficient carrying capacity of bridge openings and culverts.

- *City of East Orange* - The flooding problem along the channel of the Second River Tributary in the City of East Orange has long been recognized and studied. The first comprehensive report on flooding problems of Second River Tributary in 1940 was stimulated by the 1938 flood. This report contained a master plan for the improvement of Second River Tributary, setting channel slopes and improvements capable of carrying design flows with an expected frequency of 30 years.

  Nishuane Brook has some reported flooding problems at the Dodd Street and Thomas Boulevard crossings. Flood damages during the August 1971 storm (Hurricane Doria) consisted of damage to approximately a dozen homes between Dodd Street and Lake Street along Second River Tributary. No specific damages were reported for East Orange for the flood of August 1973, even though the reported magnitude of this flood was on the same order as that of the 1971 flood in East Orange.

  In addition to the problems outlined above, there is local flooding in East Orange caused by poor pipe drainage facilities along Summit Street and Melmore Gardens west of North Clinton Street, and at the street crossing at the railroad and Fourth Avenue.

- *Borough of Essex Fells* – Flooding within the Borough of Essex Fells usually occurs as a result of heavy rainfall from localized thunderstorms and hurricanes during the summer and fall months. Because of the low

permeability of certain soils, the high degree of development, and the borough's inadequate storm sewers, some areas are subject to frequent flooding and ponding of surface water.

The basements of five houses along Devon Road and one house along Hawthorne Road in Essex Fells suffered considerable damage from flooding during Tropical Storm Doria in August 1971. The flood of August 2, 1973 had an 83-year recurrence interval measured at the nearest upstream gage (No. 01379500) to confluence with Passaic River, and had a less than 10-year recurrence interval measured at the nearest downstream gage (No. 01381900) at Pine Brook. The length of record of the upstream gage is from 1903 to 1911, and 1937 to the present, and the latter is from 1966 to the present. The flood of April 6-7, 1984, measured with the aforementioned gages, had a less than a 10-year recurrence interval upstream and a 44-year recurrence interval downstream. Floodwaters resulting from Hurricane Irene on August 29-30, 2011, measured at the same gages, had a recurrence interval of 16 years upstream and 22 years downstream.

- *Township of Fairfield* – The low-lying area of the wide floodplain of the Passaic River comprises much of the Township of Fairfield and forms a large natural storage area. Floodwaters from the Pompton River enter this storage area from the north near the Two Bridges area. During large floods, Beatties Dam, which is located above Little Falls, constricts the river section enough to cause floodwaters from the Pompton River to enter the Passaic River, flowing in both an upstream and downstream direction at the point where the two rivers join (Richard P. Browne Associates, 1975 and 1976). The storage area thus contains flows from the Passaic River and the Pompton River.

  The flood peaks from the Pompton River are reduced and retarded somewhat due to the lake and reservoir storage on the northern upland tributaries and the valley storage between Pompton Lakes and Two Bridges. According to a USACE analysis, the Pompton River peak reaches the Passaic River approximately 12 to 18 hours before the Passaic River peaks. The southern upland tributaries of the Passaic River are as precipitous as the northern tributaries, but they join the Passaic River at widely separated points which results in desynchronization of their peaks. They are greatly affected by the large valley storage in the lower reaches and are, therefore, low flood producers into the Passaic River floodplains.

- *Borough of Glen Ridge* - Toneys Brook is contained in a deep gorge formed by the railroad embankment and Bloomfield Avenue. The gorge runs from a point upstream of Hillside Avenue to a point behind the Parkway Apartments. Downstream of Hillside Avenue, a limited amount of homes and businesses have experienced minor flooding.

- *Township of Irvington* - The two major sources of flooding in the Township of Irvington are the Elizabeth River and inadequate internal drainage. During the August 2, 1973, (40-year recurrence interval, based upon frequency discharge curve for the Elizabeth River at Hillside) storm there was severe flooding throughout the township with many streets being impassable. During the August 17, 1974, (10-percent-annual-chance recurrence interval, based upon frequency discharge curve for the Elizabeth River at Hillside) storm and during Hurricane Doria (2-percent-annual-chance recurrence interval, based upon frequency discharge curve for the Elizabeth River at Hillside) in 1971, the township was declared a flood disaster area.

  Additional flooding due to inadequate internal drainage has occurred in several areas of Irvington located in the vicinity of Durand Place and Wagner Place, Isabella Avenue and Delmar Place, Augusta Street and Ball Street, and Chestnut Avenue.

- *Township of Livingston* - The Livingston area is subject to frequent rainfalls of great intensity and varying origin. The rainfall may be from local thunderstorms, hurricanes, storms originating over the Atlantic Ocean, or storms coming from the mainland. High intensity, short duration storms tend to cause flooding of the

smaller drainage basins of the Township. Lower intensity, longer duration storms are more troublesome to the waterways with larger tributary areas, such as Canoe Brook and the Passaic River.

The Township of Livingston is highly developed, with buildings and paved areas covering a significant portion of the land area and effectively reducing the amount of land available to absorb precipitation. Throughout most of the Township, the surface soil has a relatively low permeability, although there are a few local deposits of sand and gravel. In general, the slope of the terrain varies from 1 percent to 10 percent throughout most of the Township. The low permeability of the soil, the steep slope of the terrain, and the high degree of development in Livingston all contribute to relatively high amounts of runoff, especially from the high intensity storms experienced on the east coast of the United States. The runoff is carried in open waterways to the Passaic River. The present problems due to storm water runoff are principally related to high velocity flow, channel erosion (particularly in upstream areas), and subsequent depositions of rock and silt in the downstream portions of the brooks.

Local flooding in Livingston is generally due to inadequate storm sewers, high-water elevations in the streams to which the storm sewers discharge, or blockages, such as silting of the stream channel at the point of discharge from a storm sewer. In addition to causing silting and blockage of the stream channel, the erosion caused by the high velocities also undermines the embankments of the streams and affects the adjacent land area. This type of damage is caused not only by severe floods but also by the cumulative effects of lesser, but more frequent storms.

The downstream portions of Canoe Brook and Slough Brook, as well as the land area bordering the Passaic River, are greatly influenced by high-water levels in the Passaic River. A historic flood in Livingston in the Passaic River Basin occurred during October 1903; however, because of the low level of development at that time, damages were not too severe. The storm of October 1903 was centered over Paterson, where a total of 15.5 inches of rainfall was recorded.

A review of the great storms which have occurred in the northeastern states reveals that the Rahway River and its tributaries are located in the North Atlantic storm belt. Under extremely intensive and prolonged rains, the East Branch Rahway River; its tributary, Crooked Brook; and Lightning Brook, a tributary of the Elizabeth River, overflow their banks in the Township of Maplewood. Also, some bridges over East Branch Rahway River are topped by floodwaters, thus making roads impassable.

- *Township of Maplewood* - At the time the FIS for the Township of Maplewood was published, local flooding was due mainly to poor drainage. The storm sewer system was originally designed for 5- to 10-percent-annual-chance storms and the storm sewer could not accommodate rainfall resulting from the 1-percent-annual-chance storm.

  The Township of Maplewood has sustained damages from floods that have occurred in the past, with the historic floods occurring during July 1901, February 1902, October 1903, August 1927, July 1938, August 1955, September 1971, and August 2, 1973. The damaging storms occurred in Maplewood during the floods of August 2, 1973, and July 1938. The historic flooding occurred during the storm of October 1903; however, because of the absence of development in the community, damages were not as great as those caused by the August 2, 1973 flood.

- *Township of Montclair* - Flooding along the streams within the Township of Montclair is mainly caused by backwater that is created by inadequate pipes, box culverts, and bridges clogged by deposits of silt and debris. Shallow, rocky streambeds and heavy brush cover on overbanks also limit effective flow areas.

The adjacent land area for the streams studied in detail in Montclair is affected by heavy rainfall, with the exception of a few areas where the channel is relatively wide, and the banks are well stabilized. There are several other areas in the township, which, although not adjacent to a body of water, experience flooding due to an inadequate storm water drainage system.

Montclair has sustained damages from past floods. The significant floods occurred during May 1968, August and September 1971, and on February 2, 1973. Floodwaters caused disruption in traffic, inundation of streets, interruption of businesses, danger to life, and flooding of homes.

- *City of Newark* - The City of Newark is subject to tidal flooding from the Passaic River and Newark Bay with VE zones located along the waterfront (FEMA FIS 2017). Most of the flood problems occur in the south and eastwardly (Ironbound Section) adjacent to U.S. Route 22 and Frelinghuysen Avenue. Flooding always occurs when an annual peak rainfall coincides with a high tide in Newark Bay. This area is susceptible to flooding because of its flat topography and low elevations.

  A historic tide record was obtained in Newark during the October 1903 flood. The largest flood on record occurred August 28, 1971, with a peak discharge of approximately 6,500 cfs recorded at the USGS Second River at Belleville gage (no. 1392500). Due to drastic changes in urbanization over the gaging period a meaningful statistical return period could not be computed.

- *Borough of North Caldwell* – Due to the steep terrain through which it passes; the floodplain of Green Brook is confined and causes no major flood problems in the Borough.

- *Township of Nutley* - Flooding along the streams within the Township of Nutley is mainly attributable to backwater created by inadequate storm drains and culverts. Flooding that occurs from the culvert between Elm Street and Hillside Avenue on St. Pauls Branch is of particular concern to the township. The narrow, rocky channel and flat overbanks with heavy vegetation also contribute to the flooding problem. Even though some storms may last only a short period of time, heavy rainfall affects most of the adjacent land area along the streams within the community. Certain areas of River Road, which are parallel to the Passaic River, are subject to flooding during a rainstorm of high intensity.

  There are several other areas within the Township of Nutley that, although not adjacent to a body of water, experience flooding because the storm water drainage system is inadequate. Problems also occur due to flooding conditions in the Third River and St. Pauls Branch, causing backwater in the storm drainage system. Another source of flooding is sanitary sewer backup due to excessive infiltration of the storm waters into the sanitary sewer system.

- *City of Orange Township* – The floodplains of Wigwam Brook, the East Branch Rahway River, and the East Fork of East Branch Rahway River in the City of Orange Township have been encroached upon to the point where most of them are developed. This encroachment has caused flood problems and damage from storms with recurrence intervals of less than one year.

  The principal flood problems in the City of Orange Township are due to a combination of urbanization in the floodplain, manmade restrictions within the streams, and inadequate storm drainage. In a report prepared for the City of Orange Township and the Township of West Orange, it was determined that the approximate capacity of the East Fork of East Branch Rahway River between Forest Street and Central Avenue is only 90 cfs (Elson T. Killman Associates, Inc., 1977). The 1-percent-annual-chance flood at this location produces a flow of 560 cfs.

A significant flood along the East Fork of East Branch Rahway River occurred on August 28-29, 1971 (Tropical Storm Doria) and produced a discharge of 385 cfs at Mitchell Street (USACE, 1973). This discharge is equivalent to a flood with a recurrence interval of approximately 30 years. Flooding along Wigwam Brook is rather extensive throughout its length within the City of Orange Township corporate limits. Due to its highly developed floodplain, even minor flooding produces damage to residential and commercial structures.

- *Borough of Roseland* – Flooding within the Borough of Roseland occurs as a consequence of heavy rains usually resulting from localized thunderstorms and hurricanes during the summer and fall months. Due to the low permeability of certain soils, the high degree of development and less than adequate storm sewers in the borough, some areas are subject to frequent flooding and ponding of surface water. A damaging storm occurred on August 2, 1973, creating considerable overbank flooding along Passaic River, Foulerton's Brook, North Branch Foulerton's Brook, and Canoe Brook. This flood on Passaic River had an estimated return period of 83 years. Flooding associated with this storm caused traffic interruptions, property damage, siltation of streambeds, and erosion of embankments. Hurricane Irene on August 29-30, 2011, caused flooding on Passaic River and was estimated to have a 16-year return period.

  Problem flooding locations in Roseland identified at various times include area along Foulerton's Brook at Locust, Second, Third, and Fourth Avenues, all of which have experienced flooding during severe rainstorms. There are other areas along North Branch Foulerton's Brook at Gates, Mitchell, and Godfrey Avenues, Plymouth Place, Freeman Street, and Condit Court where overbank erosion occurred during the August 1973 storm.

- *Township of South Orange Village* – Due to the topography of the East Branch Rahway River, and the Township of South Orange Village's proximity to the headwaters of the river, flood peaks occur rapidly. The flood cycle usually lasts a matter of hours, and, in most cases, lasts less than a day. Local drainage area flooding in Township of South Orange Village follows the same pattern. The major flood damage has occurred in the business community, where the flood waters have entered first-floor levels of retail and service type establishments and businesses; in addition, flood damage has occurred to the basements of residences. Because the village is highly congested, even minor flooding causes damage to both public and private property and creates traffic hazards.

  The Rahway River and its tributaries are located in the North Atlantic Storm Belt and flooding of the East Branch Rahway River in South Orange occurs frequently. Overflow of the East Branch Rahway River causes a flood problem in the Township of South Orange Village, between the northern and southern boundaries of the village, for residential, commercial, industrial, and public facilities. The principal cause of the flooding is the inability of the existing channel to accommodate the precipitation runoff. This is partly due to bridge constrictions and low channel capacities caused by encroaching development.

  The Township of South Orange Village has sustained damages from floods; the historic floods occurred during July 1901, February 1902, October 1903, August 1927, July 1938, August 1955, May 1968, September 1971, and August 1973. The damaging storms on record occurred in South Orange during the floods of July 1938. The historic flooding occurred during the storm of October 1903; however, because of the absence of development in the community, damages were not as great as those that occurred during the August 1973 flood.

- *Township of Verona* – The Township is subject to flooding from the Peckman River and its tributaries. All flooding sources flow in well-defined channels, within adjacent low-lying areas. Flooding occurs during times of excessive and prolonged rainfall, particularly in residential areas having steep slopes. The flooding is a result of high runoff combined with insufficient carrying capacity of bridge openings and culverts.

- *Township of West Caldwell* - Flooding in West Caldwell is a result of heavy rainfall produced by hurricanes moving up the coast, large frontal storms from the west and south, and local thunderstorms. Historic floods affecting the Township of West Caldwell occurred in 1902, 1903, 1936, and 1945. The 1903 flood, with an estimated peak discharge of 39,800 cfs at the confluence of the Passaic River and Newark Bay, inundated large areas, causing damage to buildings and disruption of transportation and utility lines (New Jersey, 1974). A storm similar to the one which caused the flood of 1903 would result today in a significantly larger area of inundation and greater discharges, due to the increased percentage of impervious areas (New Jersey, 1973). Flooding has occurred in 1968 and 1971, resulting in estimated damages in excess of 1 million dollars in this locality.

  The Passaic River flows along the western boundary of West Caldwell. The low areas in West Caldwell, adjacent to the Passaic River, are subject to flooding. Areas subject to inundation include residential, commercial, and park lands. The low flat areas adjacent to Pine, Green, and Kane Brooks in the lower reaches are also subject to flooding.

- *Township of West Orange* – The Township has been affected by flooding in most of the low-lying areas located along the numerous open stream courses within its boundaries. Several other areas are also affected by flooding due to poor drainage. In 2010, the Township of West Orange passed 2274-10 An Ordinance Amending and Supplementing Chapter 25 Section 28 of the General Ordinances of the Town of West Orange, entitled "Steep Slope and Natural Features Ordinance" which amended the steep slope ordinance by placing additional restrictions of State open waters, wetlands, wetland transition areas, flood hazard areas, floodways and riparian zones. This amendment was warranted to prevent flooding, protect water quality, and preserve wildlife and aquatic habitat.

  A major flood area exists along the East Fork of the East Branch Rahway River in West Orange, east of Valley Road between Freeman Street and Kingsley Street. The flooding problem there, which is due to inadequate channel capacity, has been studied by the USACE (USACE, 1973). The upper portions of this stream are steeply sloped but as of the publication of the [date] countywide FIS report, requests have been made to the USACE and NJDEP to assess whether there is flood storage potential at golf courses and other open spaces as a part of the larger study underway to study flood mitigation alternatives in the Rahway River Basin.

  North Branch Wigwam Brook has had serious flooding problems in the vicinity of Harrison and Mississippi Avenues, and along most downstream parts of the improved channel. This is due to excessive velocity and lack of channel capacity, notably at Ashwood Terrace, Whittelsey Avenue, Watson Avenue, and Washington Avenue. South Branch Wigwam Brook has had serious flooding reported in the vicinity of Watchung Avenue, Lakeside Avenue, Standish Avenue, and Ashland Avenue.

  West Branch Rahway River has had flooding problems along its entire length from Northfield Avenue to Lake Vincent, although parts of this river flow through undeveloped or country club areas.

  Along Peckman River, flooding has occurred between Nicholas Avenue and Kenz Terrace.

  An area on the western boundary of the Township of West Orange known as the Merklin District is subject to frequent flooding due to inadequate pipe sewers and insufficient capacity of the existing storm water pumping station. The area flooded is centered between Hunterdon and Morris Roads and Westover and Tappan Terraces. The Mayfair District centered on Mayfair Drive in the north central part of the township is one such location plagued by flooding related to drainage issues. In this location flooding is caused by an inadequate storm water ejector system (Elson T. Killman Associates, Inc., 1972). The Township of West Orange has been moving forward with plans to undertake storm sewer improvements and in 2011 awarded

construction contracts to begin the improvements to help alleviated flooding projects on several streets including Nestro Road, Midro Way, Mayfair Drive and Rosemont Terrace and Rosemont Drive. This project has been financed by a grant from the NJDEP and a loan from the New Jersey Environmental Infrastructure Trust.

Dam Failure

Table 4.3.6-2 lists the dams located in the County according to the National Performance of Dams Program (NPDP) database.

Table 4.3.6-2. Dams Located in Essex County

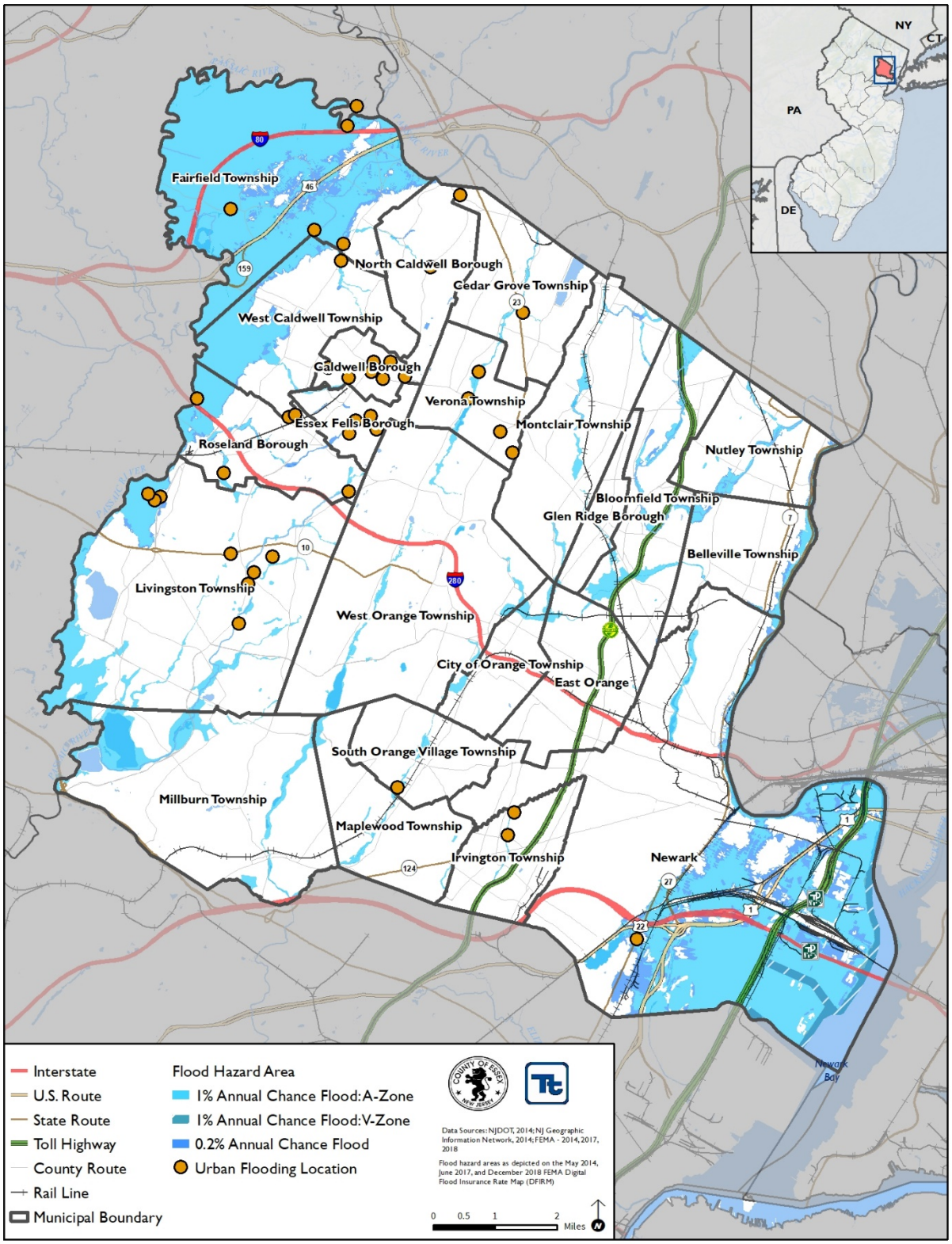
NPDP ID	Dam Name	Dam Type	Location	River	Dam Height (ft)	Dam Storage (acre-feet)
NJ00165	Canoe Brook Dam	Earth Gravity	East Orange	Passaic River	9	160
NJ00361	Orange Reservoir Dam	Earth Gravity	West Orange	West Branch of Rockaway River	34	245
NJ00386	Verona Lake Dam	Masonry	Verona	Peckman River	13	95
NJ00392	Cedar Grove West Res Dam	Earth Gravity	Cedar Grove	Offstream	55	2297
NJ00517	Campbells Pond Dam	Earth Gravity	Millburn	West Branch	18	21
NJ00525	Canoe Brook Reservoir #1 Dam	Earth Gravity	Millburn	Canoe Brook	25	3000
NJ00526	Canoe Brook Reservoir #2 Dam	Earth Gravity	Millburn	Canoe Brook - offstream	29	2200
NJ00527	Canoe Brook Reservoir #3 Dam	Earth Gravity	Livingston	Passaic River – offstream	57	6270
NJ00550	Canoe Brook Reservoir #3 Dike	Earth Gravity	Livingston	Canoe Brook – offstream	40	6000
NJS00031	Diamond Mill Pond Dam	N/A	N/A	N/A	N/A	N/A

Source: NPDP Multi-Attribute Dams Directory Query Summary, Date Unknown
N/A Not Available

Urban Flooding

Throughout Essex County, low-lying surface flooding and interior shallow ponding occurs as a result of heavy rainfall, and in some locations, this is accompanied by high tides. While riverine and coastal flooding is mapped by FEMA, urban flooding is not. Figure 4.3.6-3 illustrates the urban flood areas identified by the municipalities participating in the 2020 HMP update.

Figure 4.3.6-3. Urban Flood Areas Identified in Essex 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. 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. Essex County has 10 active USGS stream gages and one USGS tidal gage; 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).

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

Dam Failure

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

- Class I - High Hazard Potential: This classification includes those dams, the failure of which may cause the probable loss of life or extensive property damage.

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

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

A levee failure or breach causes flooding in landward areas adjacent to the structure. The failure of a levee or other flood protection structure could be devastating, depending on the level of flooding for which the structure is designed and the amount of landward development present. Large volumes of water may be moving at high velocities, potentially causing severe damage to buildings, infrastructure, trees, and other large objects. Levee failures are generally worse when they occur abruptly with little warning and result in deep, fast-moving water through highly developed areas.

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

Table 4.3.6-3 summarizes the number of dams and their hazard classifications in Essex County.

Table 4.3.6-3. Number of Dams by County in Essex County

High Hazard	Significant Hazard	Low Hazard	Other	Total
8	3	14	8	33

Source: NJDEP 2013

Previous Occurrences and Losses

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

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2019, FEMA declared that the State of New Jersey experienced 43 flood-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: hurricane, tropical storm, Nor'Easter, snowstorm, severe storms, flooding, inland and coastal flooding, coastal storm, high tides, heavy rain, and severe storms. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Essex County was included in 22 of these flood-related declarations; refer to Table 4.3.6-4.

Table 4.3.6-4. Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2019

Declaration	Event Date	Declaration Date	Event Description
DR-245	June 18, 1968	June 18, 1968	Flood: Heavy Rains & Flooding
DR-310	September 4, 1971	September 4, 1971	Flood: Heavy Rains & Flooding
DR-402	August 7, 1973	August 7, 1973	Flood: Severe Storms & Flooding
DR-477	July 23, 1975	July 23, 1975	Flood: Heavy Rains, High Winds, Hail & Tornadoes
DR-701	March 28-April 8, 1984	April 12, 1984	Flood: Coastal Storms & Flooding
DR-973	December 10-17, 1992	December 18, 1992	Flood: Coastal Storm, High Tides, Heavy Rain, & Flooding
EM-3106	March 13-17, 1993	March 17, 1993	Snow: Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Snow: Blizzard of 96 (Severe Snow Storm)
EM-3148	September 16-18, 1999	September 17, 1999	Hurricane: Hurricane Floyd Emergency Declarations
DR-1295	September 16-18, 1999	September 18, 1999	Hurricane: Hurricane Floyd Major Disaster Declarations
EM-3181	February 16-17, 2003	March 20, 2003	Snow: Snow
DR 1588	April 1-3, 2005	April 19, 2005	Severe Storm(s): Severe Storms and Flooding
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storm(s): Severe Storms and Inland and Coastal Flooding
DR-1897	March 12-April 15, 2010	April 2, 2010	Severe Storm(s): Severe Storms and Flooding
DR-1954	February 4, 2011	December 26-27, 2010	Snow: Severe Winter Storm and Snowstorm
EM-3332	August 26-September 5, 2011	August 27, 2011	Hurricane: Hurricane Irene
DR-4021	August 27-September 5, 2011	August 31, 2011	Hurricane: Hurricane Irene

Declaration	Event Date	Declaration Date	Event Description
DR-4048	October 29, 2011	November 30, 2011	Severe Storm(s): Severe Storm
EM-3354	October 26-November 8, 2012	October 28, 2012	Hurricane: Hurricane Sandy
DR-4086	October 26-November 8, 2012	October 31, 2012	Hurricane: Hurricane Sandy
DR-4264	January 22-24, 2016	March 14, 2016	Severe Storm(s): Severe Winter Storm and Snowstorm
DR-4368	March 6-7, 2018	June 8, 2018	Severe Storm(s): Severe Winter Storm and Snowstorm

Source: FEMA 2019

U.S. Department of Agriculture Disaster Declarations

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

The USDA crop loss data provide another indicator of the severity of previous events. Additionally, crop losses can have a significant impact on the economy by reducing produce sales and purchases. Such impacts may have long-term consequences, particularly if crop yields are low the following years as well. Between 2015 and 2019, Essex County did not report any crop losses due to flooding.

Flood Events

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

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

For the 2020 HMP update, known flood events that have impacted Essex County between May 2014 and March 2019 are identified in Table 4.3.6-5. For events prior to May 2014, refer to the 2015 HMP.

Table 4.3.6-5. Flooding Events in Essex County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
April 29 – May 1, 2014	Heavy Rain	N/A	N/A		Rainfall totals in Essex County ranged from 2.36 inches in the Borough of Essex Fells to 5.36 inches at Newark Airport. Many roads in Newark were closed due to flooding. Lanes were closed along the New Jersey Turnpike in Newark as well.
May 23, 2014	Flash Flood	N/A	N/A	Newark, Silver Lake	A trough of low pressure slowly worked its way through the region, which caused isolated severe thunderstorms that produced large hail and flash flooding in portions of Northeast New Jersey. Route 21 southbound at 3rd Ave. in Newark was closed due to flooding. Numerous cars were trapped in flood waters and rescued on Route 21 near the viaduct in Newark.
June 9, 2014	Flash Flood	N/A	N/A	Newark	Showers and thunderstorms produced heavy rainfall which resulted in isolated flash flooding in Essex County. Multiple motorists were rescued from flood waters in Newark. A woman and her five children as well as two other adults were rescued at the Meeker Ave. underpass. Flood waters were even higher at the Freilinghuysen Ave. underpass and closed to traffic. Another woman was also rescued from flood waters at the intersection of Hawkins St. and Ferry Street.
June 13, 2014	Flash Flood	N/A	N/A	Livingston	An approaching cold front triggered a line of severe thunderstorms that produced heavy rain and resulted in flash flooding in portions of Northeast New Jersey. Route 10 was closed between Hillside Ave. and Livingston Ave. in Livingston due to flooding.
July 3, 2014	Flash Flood	N/A	N/A	Nutley	As a cold front slowly moved across the area, moisture from Tropical Cyclone Arthur passing to the south and east converged along the boundary resulting in severe thunderstorms, heavy rain and flash flooding in portions of Northeast New Jersey. Washington Ave. was closed due to flooding in Nutley.
August 31, 2014	Flash Flood	N/A	N/A	Newark, East Orange, Bloomfield	A very humid air mass combined with a passing surface trough to trigger numerous showers and thunderstorms, with embedded severe thunderstorms. Some of these storms produced very heavy rain which led to isolated flash flooding in Essex County. All exits in both directions on the Garden State Parkway in Newark, East Orange and Bloomfield were under water with a water rescue needed at the underpass at exit 147 southbound. A water rescue was also needed on Hoffman Ave. in East Orange after a car became trapped in flood waters.
December 9, 2014	Flood	N/A	N/A	East Newark	A coastal storm passed just south and east of the area causing strong winds and heavy rain with isolated flooding in portions of Northeast New Jersey. Passaic Ave. was closed between Central Ave. and Johnston Ave. in East Newark due to flooding.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
May 31, 2015	Flash Flood	N/A	N/A	Newark	A cold front approaching the area triggered scattered showers and thunderstorms that produced heavy rain leading to flash flooding across Northeast New Jersey. The intersection of Frelinghuysen Ave. and Meeker St. in Newark was closed due to severe flooding. Eleven people were rescued by the Newark EMS.
November 15, 2016	Flood	N/A	N/A	Bloomfield, Silver Lake	Low pressure moving north along the east coast of the United States resulted in a widespread 1-3 inch rainfall event across northeast New Jersey. Isolated flooding was observed across parts of Essex County, NJ as a result of this rainfall. Newark Airport received 2.79 inches of rain. John F. Kennedy Drive was closed in both directions due to flooding between Hoover Avenue and Belleville Avenue in Bloomfield. Watessing Avenue was closed due to flooding between Grove Street and Franklin Street in Bloomfield. NJ 21 was closed northbound at East 3rd Avenue due to flooding with all lanes detoured.
May 5, 2017	Flash Flood	N/A	N/A	Newark	A warm front approaching the area combined with a strong low level jet ushering in precipitable water values in excess of 1.5 inches, resulted in flash flooding across parts of northeast New Jersey. Newark Airport (3.05 inches) and Teterboro Airport (3.01 inches) received just over 3 inches of rain during the event, with the majority of that rain falling during a three hour period. Hourly rainfall rates of up to 1.5 inches were reported at Teterboro, with rates over one inch per hour at Newark. A vehicle was stuck in flood waters on Broadway in Newark with a water rescue in progress.
April 16, 2018	Flash Flood	N/A	N/A	Bloomfield, Newark	Heavy rainfall developed across the area on the morning of April 16th ahead of a slow moving warm front. This rain developed in an environment with precipitable water values greater than 1.25 inches, well above normal for mid April. Rainfall totals generally ranged from 2.5 to 4.5 inches across northeast New Jersey, with the majority of the rain falling in a 3-4 hour period. This resulted in flash flooding across the region. The Third River at Bloomfield rose above its flood stage of 6.0 feet at 10:05am EDT, crested at a height of 6.25 feet at 11:00am EDT, and fell back below flood stage at 11:50am EDT. The northbound lanes of US Route 1&9 were closed due to flooding at the Pulaski Skyway in Newark. Multiple cars were trapped in flood waters at the intersection of Adams Street and South Street in Newark with a water rescue conducted. At least six people were rescued from their cars due to flooding in the Ironbound District along the Passaic River. Cars were stranded due to flooding at the intersection of Frelinghuysen Avenue and Toler Place in Newark.
July 3, 2018	Flash Flood	N/A	N/A	Fairfield, Montclair	A surface trough developing out ahead of an approaching cold front initiated scattered afternoon showers and thunderstorms across northeast New Jersey. With very slow storm motions and precipitable water values rising from 1.5 to 2.0 inches, this resulted in isolated flash flooding across the region. The Caldwell, NJ ASOS reported 1.89 inches of precipitation, and a COOP observer in Harrison, NJ reported 1.00.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
					Gloria Lane was closed due to flooding in Fairfield. The Peckman River at Verona, NJ rose above its flood stage of 3.5 feet at 2:45pm EDT, crested at a height of 3.93 inches at 2:50pm EDT, and fell back below flood stage at 3:05pm EDT.
August 4, 2018	Flash Flood	N/A	N/A	Millburn	A developing area of low pressure along a surface trough helped produce heavy rainfall across parts of northeast New Jersey on the morning of August 4th that resulted in flash flooding. Rainfall amounts ranged from 1-3 inches in many places. Between the afternoon of August 3rd and the afternoon of August 4th, the Caldwell, NJ ASOS measured 2.75, and CoCoRaHS observers in Park Ridge and Hawthorne measured 2.90 and 2.95, respectively, with a CWOP station in Scotch Plains reporting 2.42. Old Short Hills Road was closed due to flooding in Millburn.
August 11, 2018	Flash Flood	N/A	N/A	Verona, Montclair, Caldwell, Bloomfield	A stalled stationary boundary within a very moist airmass provided a focusing mechanism for several rounds of heavy rain that resulted in widespread flash flooding across northeast New Jersey. The Caldwell, NJ ASOS recorded 4.92 inches of rain, and multiple other stations across northeast New Jersey received between 2.5 inches and 4 inches of precipitation. The Peckman River at Verona rose above its flood stage of 3.5 feet at 4:50pm EDT. The river continued to rise above its moderate flood stage of 4.0 feet (4:55pm EDT) and major flood stage of 5.0 feet (5:10pm EDT) before cresting at a height of 6.36 feet at 5:35pm EDT. The river fell back below flood stage at 6:50pm EDT. The crest of 6.36 feet was within about 0.2 feet of the record crest at this location of 6.6 feet. The Third River at Bloomfield rose above its flood stage of 6.0 feet at 6:40pm EDT, crested at a height of 7.15 feet at 7:40pm EDT, then fell back below flood stage at 9:30pm EDT. The intersection of Bloomfield Avenue and Ryerson Avenue in Caldwell was closed due to flooding. Flash flooding reported throughout the town of Verona. Flash flooding inundated portions of the Montclair Film Festival at 505 Bloomfield Avenue in Montclair. Both the cinema and education center were damaged when the current forced open doors to the building.
September 25, 2018	Flash Flood	N/A	N/A	Newark	Rain developed across the area ahead of an approaching warm front, consolidating into a slow-moving band of heavy rain across northeast New Jersey by late morning. Precipitable water values increased from 1.84 on the morning sounding from Upton, NY to 2.13 by evening. Both of these values are above the 90th percentile based on a sounding climatology, with the 2.13 precipitable water value on the evening of the 25th a record for the date. Rainfall amounts generally ranged from 3-5 inches, with one CoCoRaHS observer reporting 5.56 inches of rain in Palisades Park. All lanes closed on US Routes 1 & 9 in Newark approaching the Pulaski Skyway starting before Wilson Avenue due to flooding. This included the ramp from Routes 1

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
					& 9 north to the Turnpike toll plaza at interchange 15E. The local lanes of US Routes 1 & 9 were flooded northbound approaching Delancy Street in Newark.

Source: *FEMA 2019; NCDC 2019; NWS 2019; SPC 2019; NJ HMP 2019; NHC 2019; NOAA 2019*

Note: *Not all events that have occurred in Essex 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

Essex County is expected to continue experiencing direct and indirect impacts of flooding in the future. Table 4.3.6-6 summarizes data regarding the probability of occurrences of flood events in Essex County based on the historic record. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 4.3.6-6. Flood Events in Essex County 1950 to 2019

Hazard Type	Number of Occurrences Between 1950 and 2019	Rate of Occurrence	Recurrence Interval (in years)	Probability of Event Occurring in Any Given Year	Percent (%) Chance of Occurring in Any Given Year
Flash Flood	51	0.74	1.4	0.73	72.9
Flood	23	0.33	3.0	0.33	32.9
Total	**74**	**1.07**	**0.95**	**1**	**100**

Source: NOAA-NCEI 2019

Note: Not all events that have occurred in Essex County are included due to the extent of documentation and the fact that not all sources have been identified or researched.

K: Thousand

M: Million

There is minimal history of occurrence of dam and levee failure between 1950 and 2019. This suggests a low probability of future occurrence though the construction of new dam and levee structures could increase dam and levee failure risk. Likelihood of a dam failure in Essex County is difficult to predict. Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. However, the risk of such an event increases for each dam as the dam's age increases or frequency of maintenance decreases. Additionally, future climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration.

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

In Section 5.3, the identified hazards of concern for Essex County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Steering and Planning Committees, the probability of occurrence for flood in the County is considered 'frequent'; refer to Section 4.4 – Hazard Ranking.

Climate Change Impacts

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

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

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

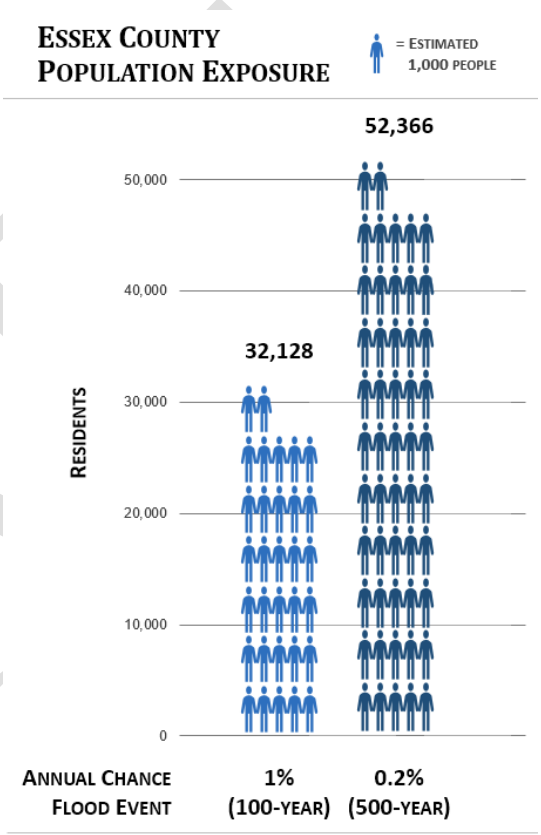
Climate change may also lead to sea level rise which will lead to more frequent and extensive flooding. According to NJDEP, New Jersey will continue to experience sea level rise with projections estimating another 1 to 1.8 feet by the year 2050 (NJDEP 2019). See Section 4.3.1 (Coastal Erosion and Sea Leve Rise) for detailed information regarding sea level rise.

4.3.6.2 Vulnerability Assessment

To assess Essex County's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. The 1- and 0.2-percent annual chance flood events were examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA HAZUS-MH v4.2 model. These results are summarized below. Refer to Section 4.2 (Methodology and Tools) 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 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. However, exposure is not be limited to only those who reside in a defined hazard zone, but all individuals 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.



Based on the spatial analysis, there are an estimated 32,128 people living in the Special Flood Hazard Area (SFHA, or 1-percent annual chance event floodplain) and an estimated 52,366 people located in the 0.2-percent annual chance flood event floodplain. These residents may be displaced due to their homes flooding, requiring them to seek temporary shelter with friends and family or in emergency shelters. The Township of Fairfield has the greatest percentage of its population located in the floodplain; approximately 56.7-percent and 82.7-percent for the 1-percent chance event and 0.2-percent chance event, respectively. The City of Newark has the greatest number of residents located in the floodplain; approximately 16,688 and 32,935 people located in the 1-percent chance event and 0.2-percent chance event floodplain boundaries, respectively. For this project, the potential population exposed is used as a guide for planning purposes.

Table 4.3.6-7. Estimated Population Exposed to the Flood Hazard

Municipality	Total Population	1-percent Annual Chance Flood Event		0.2-percent Annual Chance Flood Event	
		Number	% of Total	Number	% of Total
Township of Belleville	36,383	716	2.0%	1,606	4.4%
Township of Bloomfield	48,892	2,312	4.7%	2,534	5.2%
Borough of Caldwell	8,032	5	<1%	5	<1%
Township of Cedar Grove	12,638	29	<1%	29	<1%
City of East Orange	65,151	349	<1%	349	<1%
Borough of Essex Fells	2,095	0	0.0%	5	<1%

Municipality	Total Population	1-percent Annual Chance Flood Event		0.2-percent Annual Chance Flood Event	
		Number	% of Total	Number	% of Total
Township of Fairfield	7,671	4,346	56.7%	6,342	82.7%
Borough of Glen Ridge	7,668	102	1.3%	105	1.4%
Township of Irvington	54,715	263	<1%	263	<1%
Township of Livingston	29,955	617	2.1%	669	2.2%
Township of Maplewood	24,706	242	1.0%	242	1.0%
Township of Millburn	20,387	65	<1%	65	<1%
Township of Montclair	38,572	1,281	3.3%	1,500	3.9%
City of Newark	282,803	16,688	5.9%	32,935	11.6%
Borough of North Caldwell	6,637	19	<1%	51	<1%
Township of Nutley	28,829	810	2.8%	1,044	3.6%
City of Orange Township	30,731	2,648	8.6%	2,648	8.6%
Borough of Roseland	5,907	132	2.2%	277	4.7%
Township of South Orange Village	16,503	32	<1%	32	<1%
Township of Verona	13,585	110	<1%	110	<1%
Township of West Caldwell	10,932	132	1.2%	326	3.0%
Township of West Orange	47,609	1,230	2.6%	1,230	2.6%
Essex County (Total)	**800,401**	**32,128**	**4.0%**	**52,366**	**6.5%**

Sources: American Community Survey 5-year Estimate, 2017; FEMA, 2014/2017/2018

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a flood event, and they may have more difficulty evacuating. Within the 1-percent annual chance event, there are approximately 3,423 people over the age of 65 and 4,634 people below the poverty level. These populations are all located within the SFHA. As for the 0.2-percent chance event, there are approximately 5,352 people over the age 65 and 8,059 people below the poverty level.

Using 2010 U.S. Census data, HAZUS-MH v4.2 estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. For the 1-percent flood event, HAZUS-MH v4.2 estimates 33,068 people will be displaced, and 2,232 people will seek short-term sheltering. These statistics, by municipality, are presented in Table 4.3.6-8. The estimated displaced population and number of persons seeking short-term sheltering differs from the number of persons exposed to the 1-percent annual chance flood, because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event.

Table 4.3.6-8. Estimated Population Displaced or Seeking Short-Term Shelter from the 1-Percent Annual Chance Flood Event

Municipality	U.S. Census 2010 Population	1-Percent Annual Chance Event	
		Displaced Population	Persons Seeking Short-Term Sheltering
Township of Belleville	35,926	1,204	88
Township of Bloomfield	47,315	3,487	258
Borough of Caldwell	7,822	1	0
Township of Cedar Grove	12,411	105	3
City of East Orange	64,270	638	74
Borough of Essex Fells	2,113	1	0
Township of Fairfield	7,466	4,431	220
Borough of Glen Ridge	7,527	117	2
Township of Irvington	53,926	590	66
Township of Livingston	29,366	991	24
Township of Maplewood	23,867	454	9
Township of Millburn	20,149	222	6
Township of Montclair	37,669	1,499	65
City of Newark	277,140	12,619	988
Borough of North Caldwell	6,183	24	0
Township of Nutley	28,370	1,473	95
City of Orange Township	30,134	2,581	226
Borough of Roseland	5,819	166	3
Township of South Orange Village	16,198	184	8
Township of Verona	13,332	182	2
Township of West Caldwell	10,759	432	26
Township of West Orange	46,207	1,667	69
Essex County (Total)	**783,969**	**33,068**	**2,232**

Sources: HAZUS-MH v4.2

Total numbers of injuries and casualties resulting from typical riverine and tidal flooding are generally limited based on advance weather forecasting, blockades, and warnings. Injuries and deaths generally are not anticipated if proper warning and precautions occur. In contrast, warning time for flash flooding is limited. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard.

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. Molds 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, 2015).

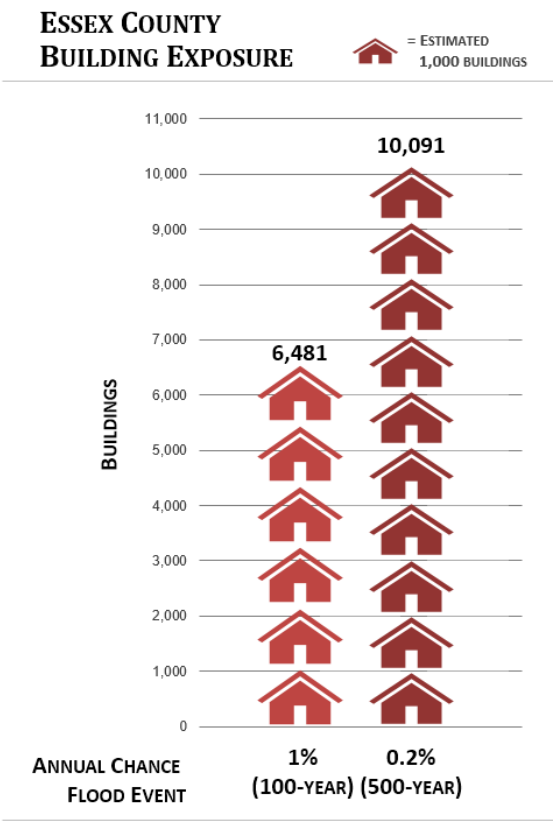
Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- 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-MH 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

Exposure to the flood hazard includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory measured by the structural and content value. There are an estimated 6,481 buildings located in the SFHA with a value of approximately $12.8 billion of building and contents (based on replacement cost value). This represents approximately 10.3-percent of the County's total general building stock inventory replacement cost value (approximately $125 billion).



There are 10,091 buildings located in the 0.2-percent annual chance flood boundary with approximately $20 billion of building/contents in replacement cost value (or 15.6-percent of the County's total replacement cost value). The Township of Fairfield has the greatest proportion of its buildings located in the floodplain; approximately 56.6-percent and 82.7-percent for the 1-percent chance event and 0.2-percent chance event, respectively. The City of Newark has the greatest number of its buildings located in the floodplain; approximately 2,411 and 4,691 located in the 1-percent chance event and 0.2-percent chance event boundaries, respectively. Refer to Table 4.3.6-9 and Table 4.3.6-10 for the building flood exposure analysis results by municipality.

HAZUS-MH estimates $2.1 billion in building and content damage as a result of the 1-percent annual chance flood event (or 1.7-percent of the total building stock replacement cost value). Of the $2.1 billion in potential loss, $229 million is estimated to residential structures. Refer to Table 4.3.6-11 for the potential losses estimated by HAZUS-MH v4.2 by municipality.

Table 4.3.6-9. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed			
			Number of Buildings - 1-percent Annual Chance Flood	% of Total	RCV - 1-percent Annual Chance Flood	% of Total
Township of Belleville	7,910	$4,483,250,138	152	1.9%	$269,142,437	6.0%
Township of Bloomfield	11,720	$6,021,089,887	490	4.2%	$322,196,753	5.4%
Borough of Caldwell	1,738	$1,183,204,981	1	0.1%	$460,358	0.0%
Township of Cedar Grove	3,944	$3,008,045,785	9	0.2%	$5,826,693	0.2%
City of East Orange	7,908	$6,090,766,912	50	0.6%	$66,066,174	1.1%
Borough of Essex Fells	766	$527,629,662	0	0.0%	$0	0.0%
Township of Fairfield	3,121	$6,082,819,367	1,768	56.6%	$3,770,560,301	62.0%
Borough of Glen Ridge	2,256	$1,095,474,263	30	1.3%	$11,206,209	1.0%
Township of Irvington	7,934	$5,384,838,816	39	0.5%	$33,487,235	0.6%
Township of Livingston	9,795	$7,691,376,811	206	2.1%	$195,419,853	2.5%
Township of Maplewood	6,738	$3,575,395,600	65	1.0%	$30,653,851	0.9%
Township of Millburn	6,437	$5,241,567,136	19	0.3%	$18,711,975	0.4%
Township of Montclair	9,436	$5,845,976,130	289	3.1%	$147,691,514	2.5%
City of Newark	43,085	$40,970,549,425	2,411	5.6%	$6,993,978,807	17.1%
Borough of North Caldwell	2,095	$1,727,767,442	6	0.3%	$7,579,865	0.4%
Township of Nutley	7,945	$3,841,553,722	231	2.9%	$152,170,149	4.0%
City of Orange Township	3,890	$3,520,865,708	378	9.7%	$349,703,802	9.9%
Borough of Roseland	1,794	$1,955,487,279	40	2.2%	$31,474,456	1.6%
Township of South Orange Village	4,188	$2,877,374,186	6	0.1%	$9,692,920	0.3%
Township of Verona	4,113	$2,213,338,613	33	0.8%	$16,950,844	0.8%
Township of West Caldwell	3,730	$3,533,044,820	46	1.2%	$181,233,465	5.1%
Township of West Orange	11,845	$8,358,783,858	212	1.8%	$230,208,600	2.8%
Essex County (Total)	**162,388**	**$125,230,200,542**	**6,481**	**4.0%**	**$12,844,416,261**	**10.3%**

Sources: Microsoft, 2018, Open Street Map, 2019; NJOIT, 2018; FEMA 2014/2017/2018

Table 4.3.6-10. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed			
			Number of Buildings - 0.2-percent Annual Chance Flood	% of Total	RCV - 0.2-percent Annual Chance Flood	% of Total
Township of Belleville	7,910	$4,483,250,138	340	4.3%	$422,664,450	9.4%
Township of Bloomfield	11,720	$6,021,089,887	545	4.7%	$376,258,468	6.2%
Borough of Caldwell	1,738	$1,183,204,981	1	0.1%	$460,358	0.0%
Township of Cedar Grove	3,944	$3,008,045,785	9	0.2%	$5,826,693	0.2%
City of East Orange	7,908	$6,090,766,912	50	0.6%	$66,066,174	1.1%

Municipality	Total # Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed			
			Number of Buildings - 0.2-percent Annual Chance Flood	% of Total	RCV - 0.2-percent Annual Chance Flood	% of Total
Borough of Essex Fells	766	$527,629,662	2	0.3%	$883,278	0.2%
Township of Fairfield	3,121	$6,082,819,367	2,580	82.7%	$5,077,660,338	83.5%
Borough of Glen Ridge	2,256	$1,095,474,263	31	1.4%	$11,428,139	1.0%
Township of Irvington	7,934	$5,384,838,816	39	0.5%	$33,487,235	0.6%
Township of Livingston	9,795	$7,691,376,811	223	2.3%	$253,113,825	3.3%
Township of Maplewood	6,738	$3,575,395,600	65	1.0%	$30,653,851	0.9%
Township of Millburn	6,437	$5,241,567,136	19	0.3%	$18,711,975	0.4%
Township of Montclair	9,436	$5,845,976,130	358	3.8%	$174,401,040	3.0%
City of Newark	43,085	$40,970,549,425	4,691	10.9%	$11,898,186,446	29.0%
Borough of North Caldwell	2,095	$1,727,767,442	16	0.8%	$22,307,127	1.3%
Township of Nutley	7,945	$3,841,553,722	295	3.7%	$188,211,964	4.9%
City of Orange Township	3,890	$3,520,865,708	378	9.7%	$349,703,802	9.9%
Borough of Roseland	1,794	$1,955,487,279	84	4.7%	$61,317,271	3.1%
Township of South Orange Village	4,188	$2,877,374,186	6	0.1%	$9,692,920	0.3%
Township of Verona	4,113	$2,213,338,613	33	0.8%	$16,950,844	0.8%
Township of West Caldwell	3,730	$3,533,044,820	114	3.1%	$288,143,027	8.2%
Township of West Orange	11,845	$8,358,783,858	212	1.8%	$230,208,600	2.8%
Essex County (Total)	**162,388**	**$125,230,200,542**	**10,091**	**6.2%**	**$19,536,337,825**	**15.6%**

Sources: Microsoft, 2018, Open Street Map, 2019; NJOIT, 2018; FEMA 2014/2017/2018

Table 4.3.6-11. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Municipality	Total Replacement Cost Value	1-Percent Annual Chance Event							
		All Occupancies		Residential		Commercial		Agricultural, Industrial, Religious, Education and Government	
		Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total
Township of Belleville	$4,483,250,138	$28,159,334	0.6%	$4,799,573	0.1%	$3,497,298	0.1%	$19,862,463	0.4%
Township of Bloomfield	$6,021,089,887	$65,998,384	1.1%	$35,222,224	0.6%	$10,901,194	0.2%	$19,874,966	0.3%
Borough of Caldwell	$1,183,204,981	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Cedar Grove	$3,008,045,785	$265,734	0.0%	$265,734	0.0%	$0	0.0%	$0	0.0%
City of East Orange	$6,090,766,912	$9,633,804	0.2%	$855,090	0.0%	$2,442,355	0.0%	$6,336,359	0.1%
Borough of Essex Fells	$527,629,662	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Fairfield	$6,082,819,367	$542,543,680	8.9%	$112,439,152	1.8%	$83,939,702	1.4%	$346,164,826	5.7%
Borough of Glen Ridge	$1,095,474,263	$1,203,509	0.1%	$753,495	0.1%	$397,904	0.0%	$52,110	0.0%
Township of Irvington	$5,384,838,816	$3,547,860	0.1%	$2,837,436	0.1%	$710,424	0.0%	$0	0.0%
Township of Livingston	$7,691,376,811	$23,847,476	0.3%	$6,400,208	0.1%	$13,921,626	0.2%	$3,525,643	0.0%
Township of Maplewood	$3,575,395,600	$4,154,899	0.1%	$772,797	0.0%	$3,382,103	0.1%	$0	0.0%
Township of Millburn	$5,241,567,136	$429,737	0.0%	$353,062	0.0%	$0	0.0%	$76,676	0.0%
Township of Montclair	$5,845,976,130	$6,252,388	0.1%	$4,614,422	0.1%	$1,607,084	0.0%	$30,882	0.0%
City of Newark	$40,970,549,425	$1,337,220,168	3.3%	$29,243,029	0.1%	$78,860,702	0.2%	$1,229,116,436	3.0%
Borough of North Caldwell	$1,727,767,442	$18,789	0.0%	$18,789	0.0%	$0	0.0%	$0	0.0%
Township of Nutley	$3,841,553,722	$19,096,478	0.5%	$8,450,732	0.2%	$7,786,476	0.2%	$2,859,271	0.1%
City of Orange Township	$3,520,865,708	$32,313,694	0.9%	$13,883,450	0.4%	$6,360,974	0.2%	$12,069,270	0.3%
Borough of Roseland	$1,955,487,279	$1,173,160	0.1%	$109,247	0.0%	$967,026	0.0%	$96,887	0.0%
Township of South Orange Village	$2,877,374,186	$7,869,838	0.3%	$0	0.0%	$162,066	0.0%	$7,707,772	0.3%
Township of Verona	$2,213,338,613	$2,226,580	0.1%	$1,320,995	0.1%	$905,586	0.0%	$0	0.0%
Township of West Caldwell	$3,533,044,820	$22,672,000	0.6%	$828,289	0.0%	$8,303,965	0.2%	$13,539,747	0.4%
Township of West Orange	$8,358,783,858	$22,605,480	0.3%	$6,267,696	0.1%	$2,777,674	0.0%	$13,560,111	0.2%
Essex County (Total)	**$125,230,200,542**	**$2,131,232,996**	**1.7%**	**$229,435,419**	**0.2%**	**$226,924,158**	**0.2%**	**$1,674,873,419**	**1.3%**

Source: HAZUS-MH v4.2

Impact on Land Uses

An exposure analysis was completed to assess the vulnerability of the residential and non-residential land uses within the County to flooding. To estimate the land use exposure to the 1- and 0.2-percent flood events, the floodplain boundaries were overlaid upon the 2018 parcel data in GIS (2018 New Jersey Geographic Information Network) and used to calculate the estimated the number and area of residential and non-residential properties exposed to this hazard.

The analysis shows while most of the residential properties in the County are not vulnerable to flooding, the majority of the residential properties in Fairfield Township are vulnerable. Across Essex County, approximately 5-percent of all structures and approximately 4-percent of the total residential land use area are within the 1-percent annual chance of flooding flood hazard area. Approximately 8-percent of all properties and 6-percent of residential land use area in the County are within the 0.2-percent annual chance of flooding flood hazard area. Fairfield Township has the highest amount of residential structures and land use area exposed. Approximately 66-percent of the total residential land use acreage and 77-percent of the residential properties are located in the 1-percent annual chance of flooding flood hazard area. Approximately 86-percent of the total residential land use area and 89-percent the residential properties are located in the 0.2-percent annual chance of flooding flood hazard area.

The analysis shows approximately 15-percent of the total acreage of non-residential properties and 37-percent of the non-residential land use area in the County are vulnerable to flooding. In Fairfield Township, approximately 87% of the total non- residential land use acreage and 86-percent of the non-residential properties are located in the 1-percent annual chance of flooding flood hazard area. Approximately 92-percent of the total non-residential land use area and 92-percent of the non-residential properties are located in the 0.2-percent annual chance of flooding flood hazard area.

Figure 4.3.6-4. Essex County Residential Land Uses Flooding Exposure

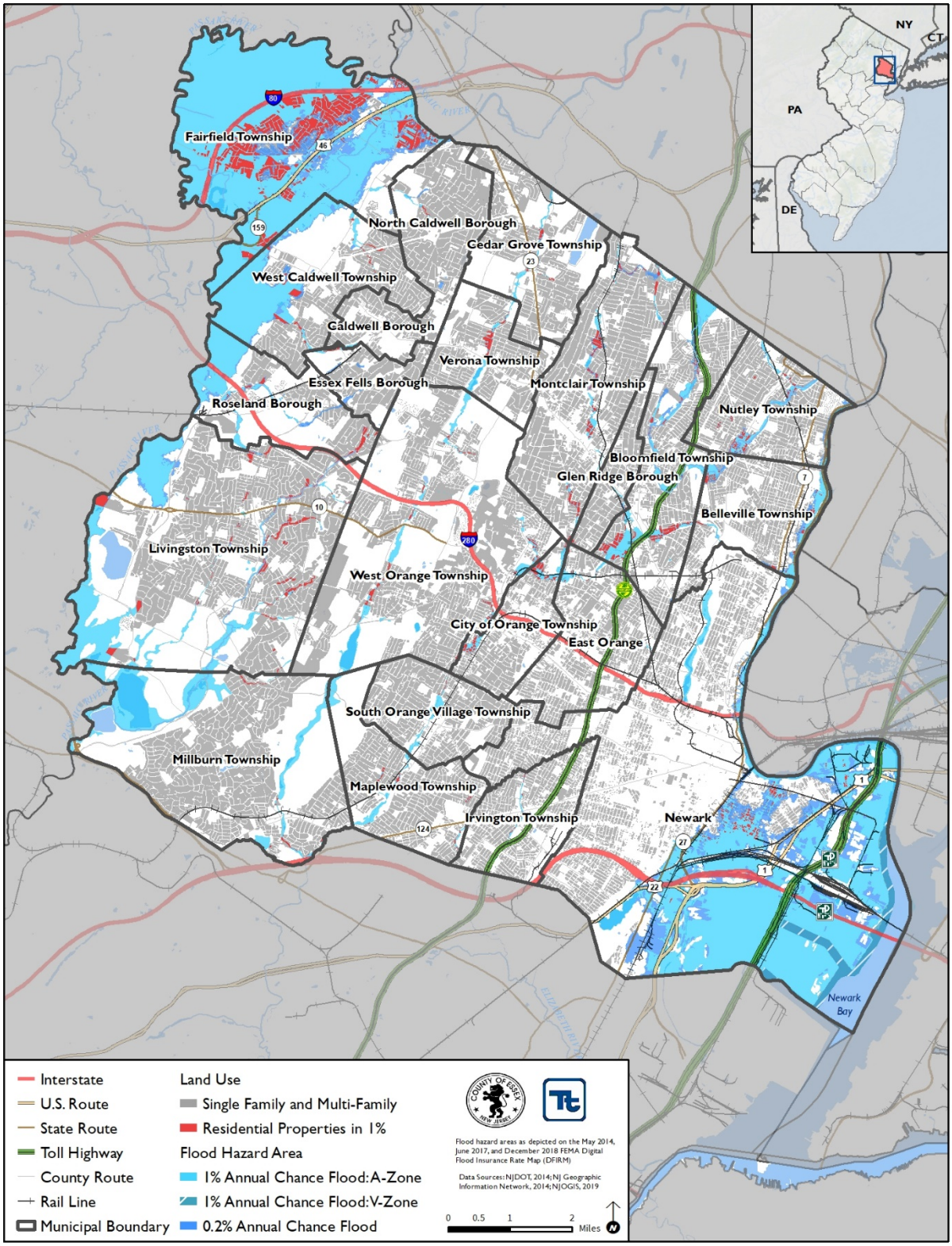


Table 4.3.6-12. Residential Land Use Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events

Municipality	Total Residential Land Use Area (acres)	Total Number of Residential Properties	1% Flood Event Hazard Area				0.2% Flood Event Hazard Area			
			Number of Residential Properties in A and V-Zone	% of Total	Residential Land Use Area in A and V-Zone (acres)	% of Total	Number of Residential Properties in 0.2%	% of Total	Residential Land Use Area in 0.2% (acres)	% of Total
Township of Belleville	908	8,288	550	6.6%	31	3.4%	826	10.0%	52	5.7%
Township of Bloomfield	1,516	10,597	713	6.7%	73	4.8%	776	8.0%	86	5.7%
Borough of Caldwell	401	1,851	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Cedar Grove	1,180	3,617	52	1.4%	10	0.9%	52	2.4%	10	0.9%
City of East Orange	1,164	8,365	137	1.6%	9	0.8%	137	1.7%	9	0.8%
Borough of Essex Fells	531	737	10	1.4%	1	0.3%	27	10.0%	6	1.1%
Township of Fairfield	1,092	2,468	1,896	76.8%	715	65.5%	2,198	89.4%	935	85.6%
Borough of Glen Ridge	529	2,165	64	3.0%	5	0.9%	65	3.0%	5	0.9%
Township of Irvington	826	8,209	124	1.5%	7	0.9%	124	3.6%	7	0.9%
Township of Livingston	3,711	9,808	668	6.8%	131	3.5%	680	7.7%	134	3.6%
Township of Maplewood	1,142	6,897	143	2.1%	12	1.0%	143	2.7%	12	1.0%
Township of Millburn	2,499	6,147	97	1.6%	12	0.5%	97	8.1%	12	0.5%
Township of Montclair	2,423	9,719	537	5.5%	61	2.5%	616	6.7%	79	3.3%
City of Newark	2,523	29,709	1,291	4.3%	57	2.2%	2,661	9.1%	141	5.6%
Borough of North Caldwell	1,245	2,097	18	0.9%	5	0.4%	39	3.8%	8	0.6%
Township of Nutley	1,152	8,305	402	4.8%	31	2.7%	505	6.2%	41	3.5%
City of Orange Township	638	3,980	471	11.8%	41	6.4%	471	13.6%	41	6.4%
Borough of Roseland	634	2,026	103	5.1%	24	3.8%	175	11.4%	36	5.6%
Township of South Orange Village	1,140	4,270	36	0.8%	1	0.1%	36	0.9%	1	0.1%
Township of Verona	915	4,843	130	2.7%	19	2.1%	130	5.2%	19	2.1%

Township of West Caldwell	1,149	3,419	153	4.5%	38	3.3%	215	6.6%	62	5.4%
Township of West Orange	2,729	12,215	431	3.5%	38	1.4%	431	5.3%	38	1.4%
Essex County (Total)	**30,045**	**149,732**	**8,026**	**5.4%**	**1,326**	**4.4%**	**10,404**	**7.9%**	**1,732**	**5.8%**

Source:FEMA 2014, 2017, 2018
Note: % = Percent
The area presented includes the area of inland waterways and excludes bays or oceans.

Figure 4.3.6-5. Essex County Non-Residential Land Uses Flooding Exposure

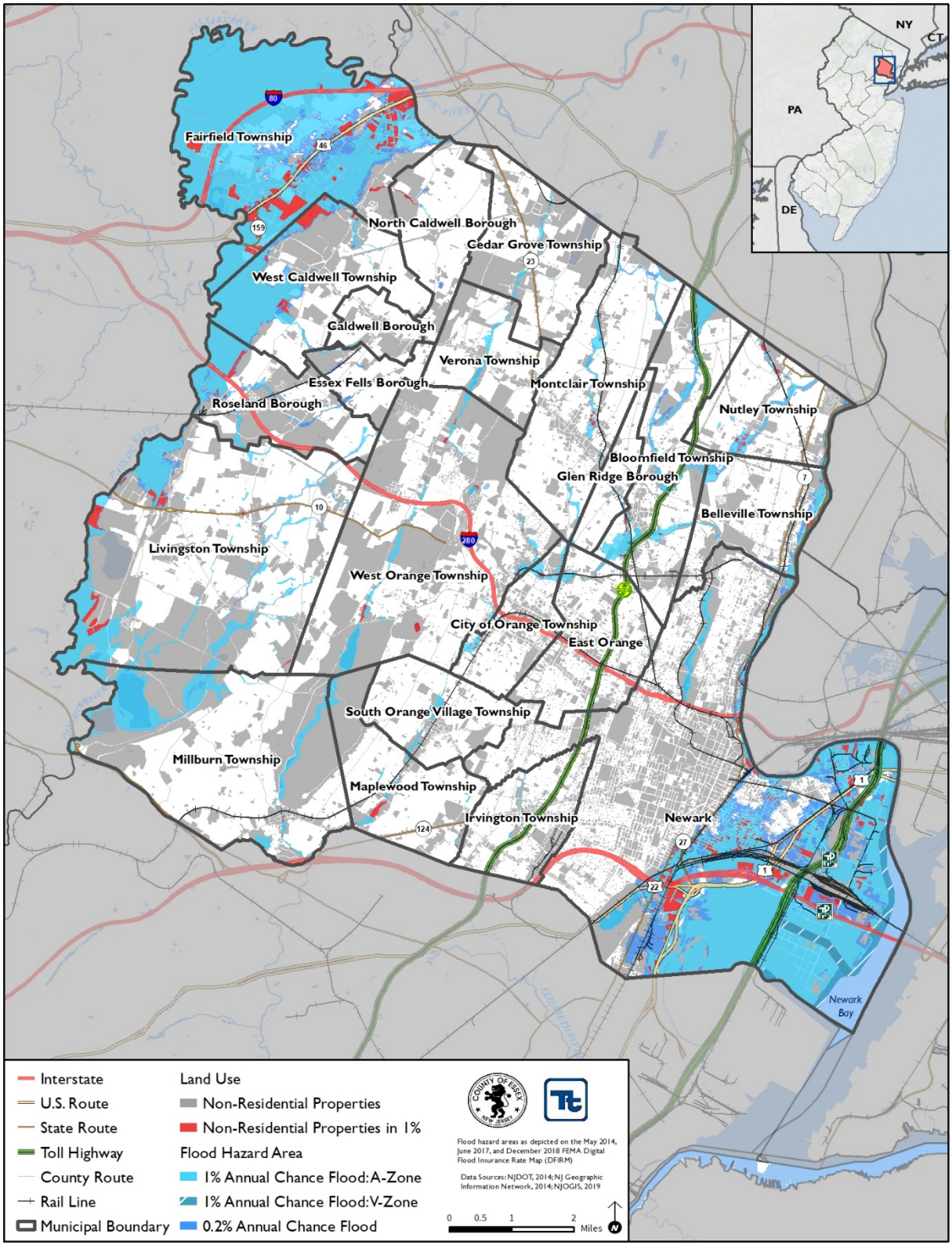


Table 4.3.6-13. Non-Residential Land Use Exposure to the 1-Percent and 0.2 Percent Annual Chance Flood Events

Municipality	Total Non-Res Land Use Area (acres)	Total Number of Non-Res Properties	1% Flood Event Hazard Area				0.2% Flood Event Hazard Area			
			Number of Non-Res Properties in A and V-Zone	% of Total	Non-Res Land Use Area in A and V-Zone (acres)	% of Total	Number of Non-Res Properties in 0.2%	% of Total	Non-Res Land Use Area in 0.2% (acres)	% of Total
Township of Belleville	766	1,536	132	8.6%	83	10.8%	188	12.24%	105	13.7%
Township of Bloomfield	1,134	1,560	249	16.0%	253	22.3%	267	17.12%	276	24.3%
Borough of Caldwell	233	375	1	0.3%	6	2.7%	1	0.27%	7	2.8%
Township of Cedar Grove	1,315	495	61	12.3%	34	2.6%	61	12.32%	34	2.6%
City of East Orange	707	1,968	76	3.9%	26	3.7%	76	3.86%	26	3.7%
Borough of Essex Fells	268	92	7	7.6%	8	2.9%	17	18.48%	18	6.6%
Township of Fairfield	4,744	1,265	1,092	86.3%	4,128	87.0%	1,173	92.73%	4,376	92.3%
Borough of Glen Ridge	129	182	21	11.5%	9	6.7%	22	12.09%	9	7.3%
Township of Irvington	530	1,824	62	3.4%	12	2.3%	62	3.40%	12	2.3%
Township of Livingston	4,320	1,053	234	22.2%	1,091	25.3%	249	23.65%	1,138	26.3%
Township of Maplewood	946	588	68	11.6%	95	10.0%	68	11.56%	95	10.0%
Township of Millburn	3,094	530	85	16.0%	782	25.3%	85	16.04%	782	25.3%
Township of Montclair	909	1,288	148	11.5%	66	7.2%	152	11.80%	71	7.8%
City of Newark	9,594	16,813	2,191	13.0%	4,168	43.4%	3,081	18.33%	5,160	53.8%
Borough of North Caldwell	510	134	11	8.2%	18	3.5%	15	11.19%	28	5.4%
Township of Nutley	559	842	139	16.5%	79	14.2%	155	18.41%	94	16.8%
City of Orange Township	476	1,356	181	13.3%	44	9.2%	181	13.35%	44	9.2%
Borough of Roseland	1,404	241	68	28.2%	398	28.4%	79	32.78%	444	31.6%
Township of South Orange Village	369	736	28	3.8%	39	10.6%	28	3.80%	39	10.6%
Township of Verona	645	351	19	5.4%	43	6.6%	19	5.41%	43	6.6%

Township of West Caldwell	1,809	306	102	33.3%	882	48.7%	118	38.56%	961	53.1%
Township of West Orange	3,797	2,712	385	14.2%	227	6.0%	385	14.20%	227	6.0%
Essex County (Total)	**38,258**	**36,247**	**5,360**	**14.8%**	**12,490**	**32.6%**	**6,482**	**17.88%**	**13,987**	**36.6%**

Source: FEMA 2014, 2017, 2018
Note: % = Percent
Non-Res = Non-residential
The area presented includes the area of inland waterways and excludes bays or oceans.

NFIP Statistics

FEMA Region 2 provided a list of NFIP policies, past claims, repetitive loss properties (RL), and severe repetitive loss properties (SRL) in Essex County. According to FEMA, a 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 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 2018).

Table 4.3.6-14 through Table 4.3.6-16 and Figure 4.3.6-6 summarize the NFIP policies, claims and repetitive loss statistics for Essex County. Table 4.3.6-14 and Table 4.3.6-15summarize the occupancy classes of the repetitive loss and severe repetitive loss properties in the County. Single family residences account for 69% of the RL properties and 90% of the SRL properties. This information is current as of March 31, 2019.

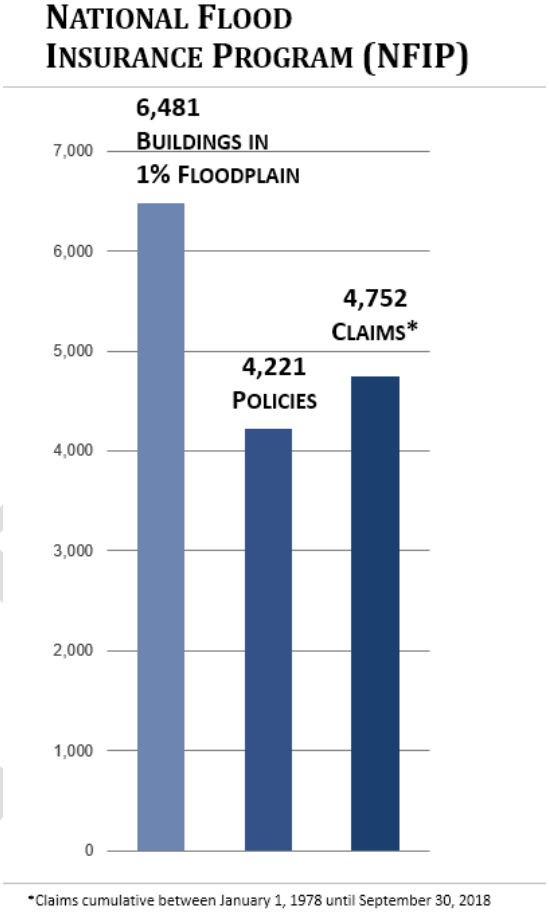


Table 4.3.6-14. Occupancy Class of Repetitive Loss Structures in Essex County

Occupancy Class	Total Number of Repetitive Loss Properties	Total Number of Severe Repetitive Loss Properties	Total (RL + SRL)
Single Family	312	56	368
Condo	4	1	5
2-4 Family	49	4	53
Other Residential	6	1	7
Non-Residential	79	0	79
Essex County	**450**	**62**	**512**

Source: FEMA Region 2 2019
Note: Repetitive loss and severe repetitive loss statistics provided by FEMA Region 2 and are current as of 03/31/19
The total number of repetitive loss properties does not include the severe repetitive loss properties; The severe repetitive loss properties totals only include validated properties.

Table 4.3.6-15. Occupancy Class of Repetitive Loss Structures in Essex County, by Municipality

Municipality	Repetitive Loss Properties					Severe Repetitive Loss Properties				
	2-4 Family	Assumed Condo	Non-Residential	Other Residential	Single Family	2-4 Family	Assumed Condo	Non-Residential	Other Residential	Single Family
Township of Belleville	6	0	11	1	14	2	0	0	0	1
Township of Bloomfield	8	2	2	0	15	0	0	0	0	0
Borough of Caldwell	0	0	0	0	0	0	0	0	0	0
Township of Cedar Grove	0	0	0	0	2	0	0	0	0	0
City of East Orange	2	0	0	0	1	0	0	0	0	0
Borough of Essex Fells	0	0	0	0	0	0	0	0	0	0
Township of Fairfield	3	1	27	0	186	2	1	0	0	52
Borough of Glen Ridge	0	0	0	0	1	0	0	0	0	0
Township of Irvington	7	0	1	0	4	0	0	0	0	0
Township of Livingston	0	0	0	0	11	0	0	0	0	0
Township of Maplewood	3	0	5	1	2	0	0	0	0	0
Township of Millburn	0	0	9	0	24	0	0	0	0	0
Township of Montclair	6	0	1	2	12	0	0	0	0	0
City of Newark	3	0	13	1	4	0	0	0	0	0
Borough of North Caldwell	0	0	0	0	3	0	0	0	0	0
Township of Nutley	3	1	2	0	15	0	0	0	1	0
City of Orange Township	7	0	1	1	4	0	0	0	0	1
Borough of Roseland	0	0	0	0	2	0	0	0	0	0
Township of South Orange Village	0	0	2	0	2	0	0	0	0	0
Township of Verona	0	0	0	0	2	0	0	0	0	1
Township of West Caldwell	0	0	3	0	0	0	0	0	0	1
Township of West Orange	1	0	2	0	8	0	0	0	0	0
Essex County	**49**	**4**	**79**	**6**	**312**	**4**	**1**	**0**	**1**	**56**

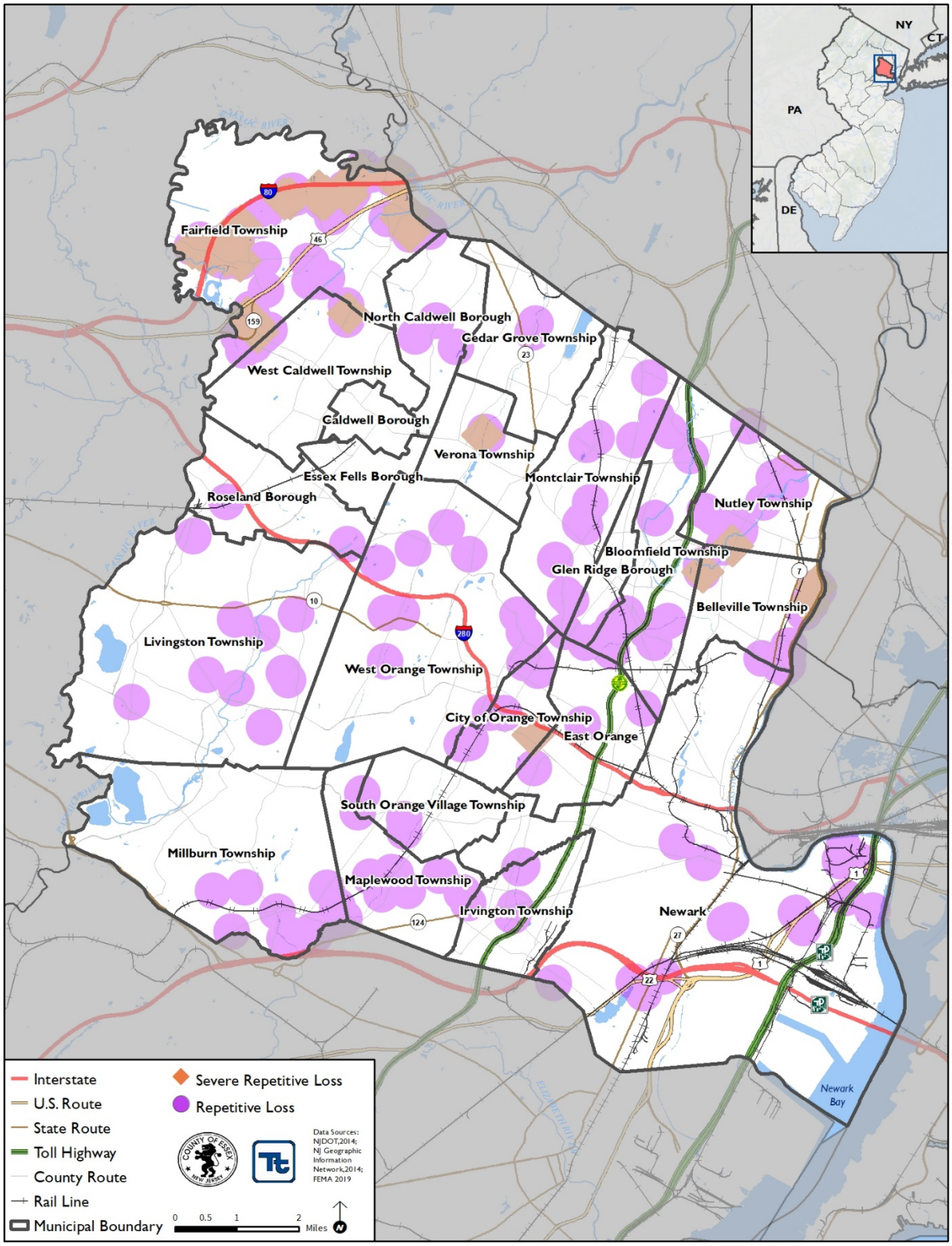
Source: *FEMA Region 2 2019*
Note: *Repetitive loss and severe repetitive loss statistics provided by FEMA Region 2 and are current as of 03/31/19*
The total number of repetitive loss properties does not include the severe repetitive loss properties; The severe repetitive loss properties totals only include validated properties.

Table 4.3.6-16. NFIP Policies, Claims and Repetitive Loss Statistics

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	Severe Rep. Loss Prop. (1)
Township of Belleville	376	182	$6,932,839	32	3
Township of Bloomfield	475	434	$2,896,258	27	0
Borough of Caldwell	3	1	$4,617	0	0
Township of Cedar Grove	37	21	$211,068	2	0
City of East Orange	76	57	$295,880	3	0
Borough of Essex Fells	9	12	$100,750	0	0
Township of Fairfield	1,016	1,948	$64,662,589	217	55
Borough of Glen Ridge	43	19	$40,864	1	0
Township of Irvington	47	105	$488,116	12	0
Township of Livingston	243	243	$1,217,213	11	0
Township of Maplewood	128	105	$1,178,060	11	0
Township of Millburn	266	308	$6,633,853	33	0
Township of Montclair	297	215	$1,258,078	21	0
City of Newark	198	287	$18,131,115	21	0
Borough of North Caldwell	32	23	$121,188	3	0
Township of Nutley	241	242	$1,735,278	21	1
City of Orange Township	294	163	$963,709	13	1
Borough of Roseland	24	23	$180,672	2	0
Township of South Orange Village	61	38	$150,472	4	0
Township of Verona	65	60	$284,742	2	1
Township of West Caldwell	86	47	$2,000,067	3	1
Township of West Orange	204	219	$901,606	11	0
Essex County	**4,221**	**4,752**	**$110,389,033**	**450**	**62**

Source: FEMA Region 2 2018
Rep. = Repetitive
(1) Repetitive loss and severe repetitive loss statistics provided by FEMA Region 2 and are current as of 03/31/19; Policies and claims are current as of 9/30/2019.
The total number of repetitive loss properties does not include the severe repetitive loss properties; The severe repetitive loss properties totals only include validated properties.
(2) Total building and content losses from the claims file provided by FEMA Region 2 https://bsa.nfipstat.fema.gov/reports/1040.htm

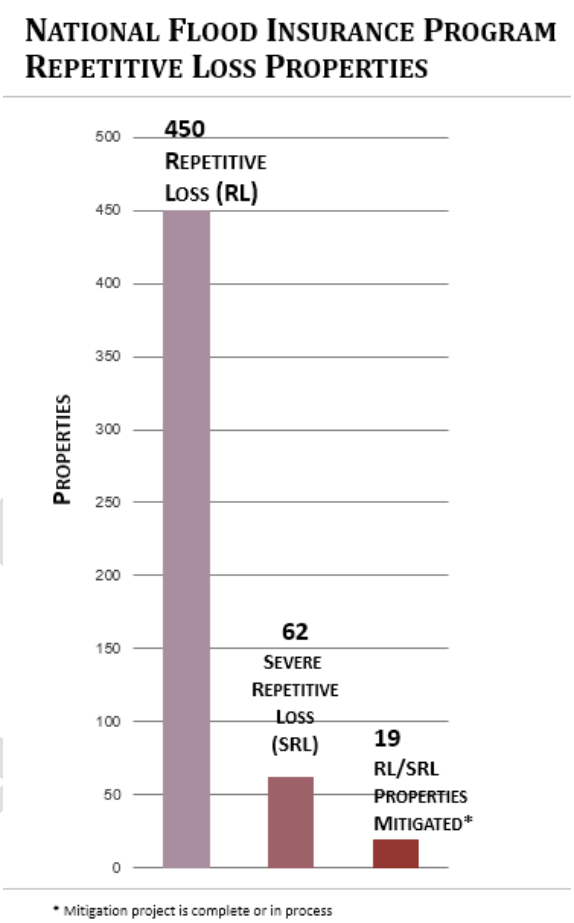
Figure 4.3.6-6. NFIP Repetitive Loss Properties in Essex County



Repetitive Loss Area Analysis (RLAA)

A repetitive loss area analysis was performed to enhance the flood analysis and support future targeted outreach and more effective floodplain management. The repetitive loss area includes repetitive loss properties, as determined by FEMA, and properties that may undergo repetitive flood damage but are either not participating in the NFIP or not technically classified as repetitive loss properties by the NFIP. Properties that may undergo repetitive flood damage but are not classified as NFIP RLs or SRLs can occur for a variety of reasons, including the following:

- Property owners may not have flood insurance. Only properties within the floodplain and with a federally-backed mortgage are required to carry flood insurance.
- Owners of a flooded property may choose not to file a claim, even if the owner has flood insurance.
- The flood damage may not meet the minimum $1,000 threshold necessary for repetitive loss, but the property may still undergo recurring flood damage.



Description of Selected Approach - RLAA Delineation Process

In ArcMap v10.5.1, repetitive loss areas were delineated using RL and SRL properties and the 1-percent annual chance flood event depth grid, 2-foot contours delineated from the USGS DEM, and FEMA flood hazard areas. For each repetitive loss area, the RL and SRL properties were displayed in ArcMap v10.5.1 along with the depth grid, contours, and flood hazard areas to identify clusters of RL and SRL properties that having similar flooding conditions. Initially, the 1-percent annual chance event floodplain was used to group together RL and SRL properties where applicable, and the depth grid and contours were used to delineate a more precise boundary within the floodplain.

A total of 85 of the 450 repetitive loss properties located outside of the floodplain; of these, two could not be geocoded within the County because the address is not the property location. For the 85 properties located outside the floodplain, contours were referenced to attempt to delineate a boundary around a low elevation area where stormwater may pond and cause repetitive damages. If contours did not provide a clear delineation, the area was identified as a single property repetitive loss area. Four of the areas delineated were categorized as riverine/stormwater flooding. Three of these areas are near the floodplain but located outside of the FEMA-delineated SFHA and 0.2-percent annual chance flood boundary; therefore, the cause of flooding could not be determined between riverine and stormwater flooding as both could be a contributing factor. The other is in an approximate A-zone that appeared to be delineating an area of ponding water from the Canoe Brook 1-percent annual chance event floodplain in Livingston.

RLAA Results

Table 4.3.6-17 displays the number of repetitive loss areas and number of structures located within these areas for each municipality. Figure 4.3.6-7 displays the repetitive loss areas to illustrate the relationship of the areas

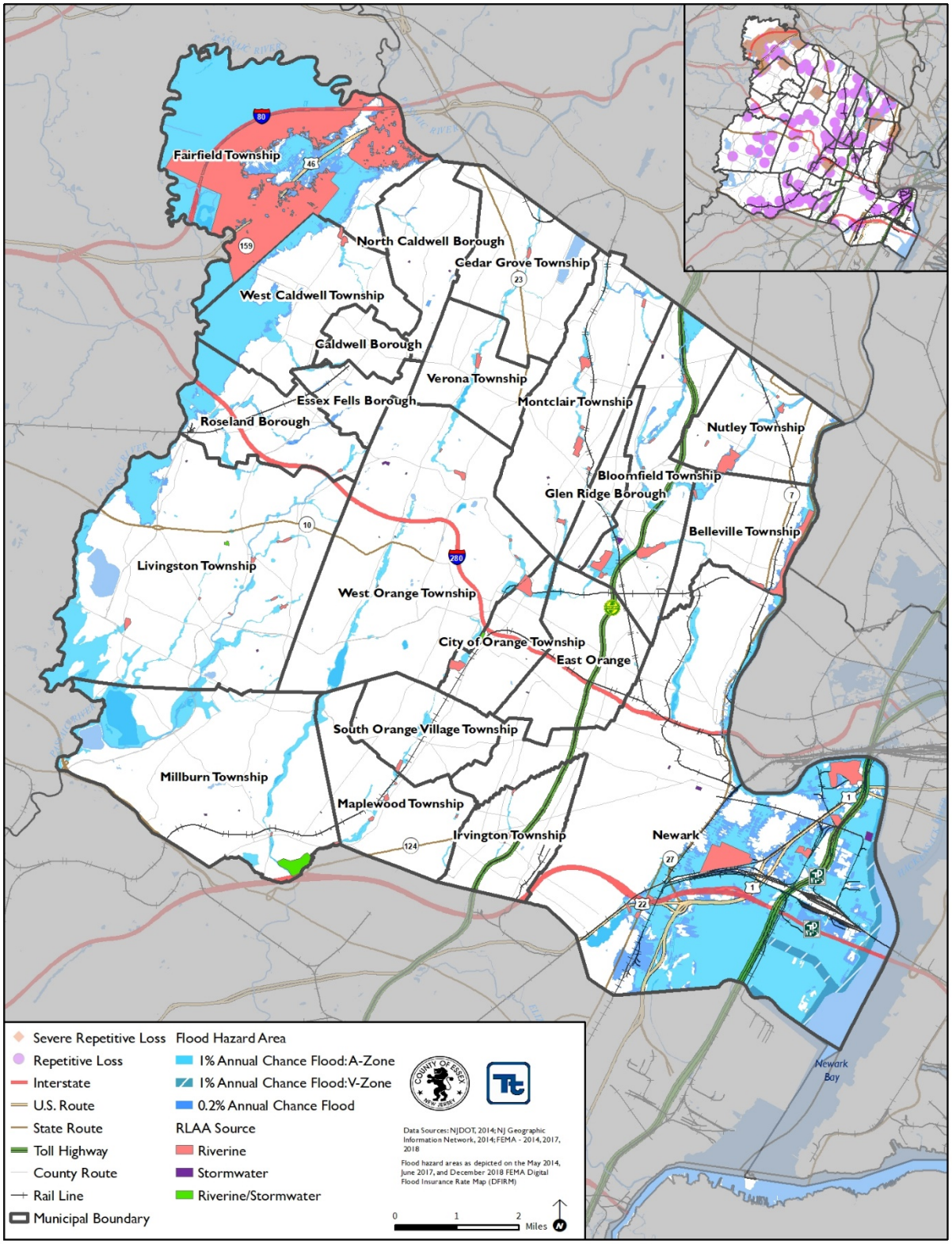
with documented NFIP RL properties and the probable causes of flooding. In Essex County, most repetitive loss properties are located in the floodplain. The cause of repetitive flooding at these properties is commensurate with the flood risk reflected on the current preliminary FIRM. There were 85 of the 450 repetitive loss properties located outside of the floodplain; of these, two could not be geocoded within the County because the address is not the property location. For these properties, it is assumed that stormwater flooding is the main cause of flooding. In total, 96 repetitive loss areas were identified including 3,830 structures based on the methodology detailed below.

Table 4.3.6-17. Number of Repetitive Loss Areas and Number of Structures Located in Each Area by Municipality

Municipality	Number of Repetitive Loss Areas	Number of Structures Located in a Repetitive Loss Area	# Rep. Loss Prop. (1)	Severe Rep. Loss Prop. (1)
Township of Belleville	2	116	32	3
Township of Bloomfield	10	419	27	0
Borough of Caldwell	0	0	0	0
Township of Cedar Grove	1	12	2	0
City of East Orange	3	14	3	0
Borough of Essex Fells	0	0	0	0
Township of Fairfield	1	1,630	217	55
Borough of Glen Ridge	1	5	1	0
Township of Irvington	2	28	12	0
Township of Livingston	10	53	11	0
Township of Maplewood	6	28	11	0
Township of Millburn	8	232	33	0
Township of Montclair	10	195	21	0
City of Newark	11	384	21	0
Borough of North Caldwell	3	4	3	0
Township of Nutley	8	192	21	1
City of Orange Township	4	264	13	1
Borough of Roseland	2	5	2	0
Township of South Orange Village	3	6	4	0
Township of Verona	1	29	2	1
Township of West Caldwell	1	4	3	1
Township of West Orange	10	74	11	0
Essex County (Total)	**96**	**3,694**	**450**	**62**

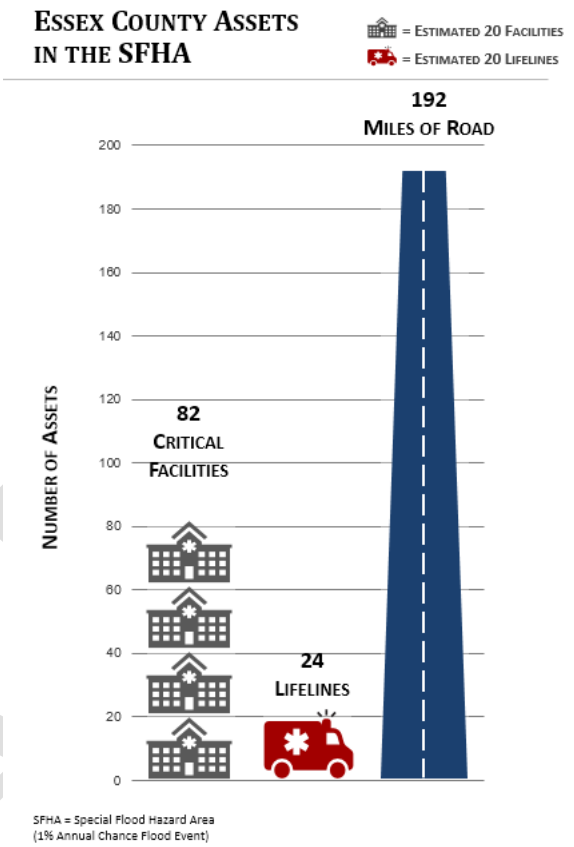
Rep. = Repetitive

Figure 4.3.6-7. Repetitive Loss Areas in Essex County



Impact on Critical Facilities

It is important to determine the critical facilities 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 get to vulnerable populations or to make repairs.



Critical facility exposure to the flood hazard was examined. In addition, HAZUS-MH v4.2 was used to estimate the flood loss potential to critical facilities located in the FEMA mapped floodplains. Table 4.3.6-18 summarizes these results. Figure 4.3.6-9 and Figure 4.3.6-10 display the distribution of critical facilities in the 1- and 0.2-percent annual chance flood event boundaries. Of the 82 critical facilities located in the 1-percent annual chance flood event boundary, 24 were identified as lifeline facilities.

Figure 4.3.6-8 displays the major roadways that may be impacted by the 1-percent annual chance flood event. These include NJ-7, NJ-10, NJ-21, NJ-23, NJ-24, NJ-27, NJ-124, NJ-159, I-78, I-80 I-95, I-280, US-1, US-22, and US-46 and the Garden State Parkway. Bridges washed out or blocked by floods or debris also can cause isolation. Floodwaters can get into drinking water supplies, causing contamination. Culverts can be blocked by debris from flood events, also causing localized urban flooding. Sewer systems can be backed up, causing wastewater to spill into homes, neighborhoods, rivers, and streams.

Additional critical facilities that have flooding issues were identified during a series of stakeholder workshops. The Clay Street combined sewer overflow in the City of Newark is prone to flooding and is worsened by high tide flooding. The Essex County Correctional Facility in Newark is also prone to inundation during flooding events. The Township of Millburn has flooding issues on the JFK Parkway (County road) which is a major thoroughfare and Brookside Drive, a cut through to the hospital. The Garden State Parkway floods during heavy rain events near the Route 280 interchange in East Orange. Flooding from the Passaic River can shut down Route 10 in Livingston.

Figure 4.3.6-8. Major Roadways Located in the 1-percent Annual Chance Floodplain

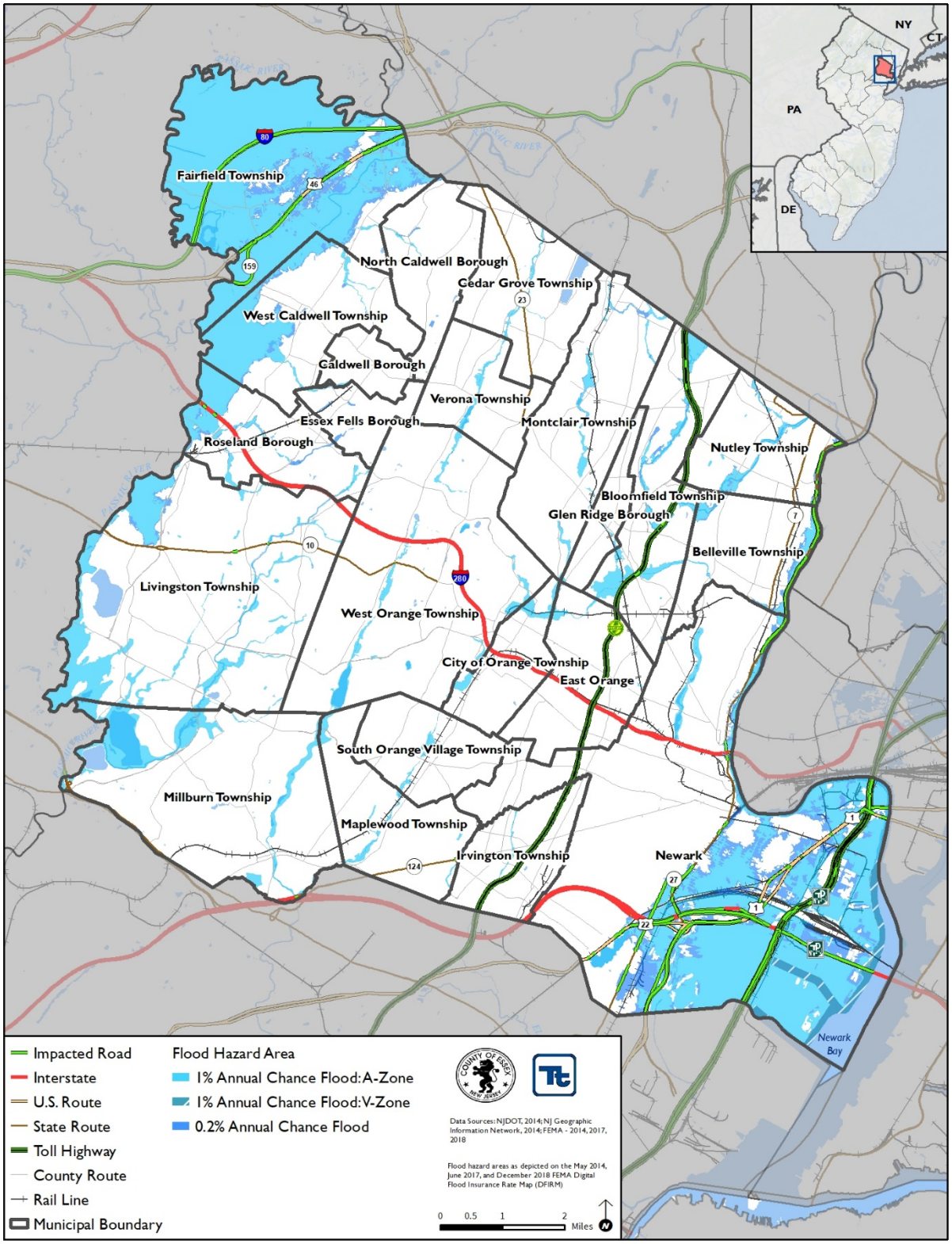
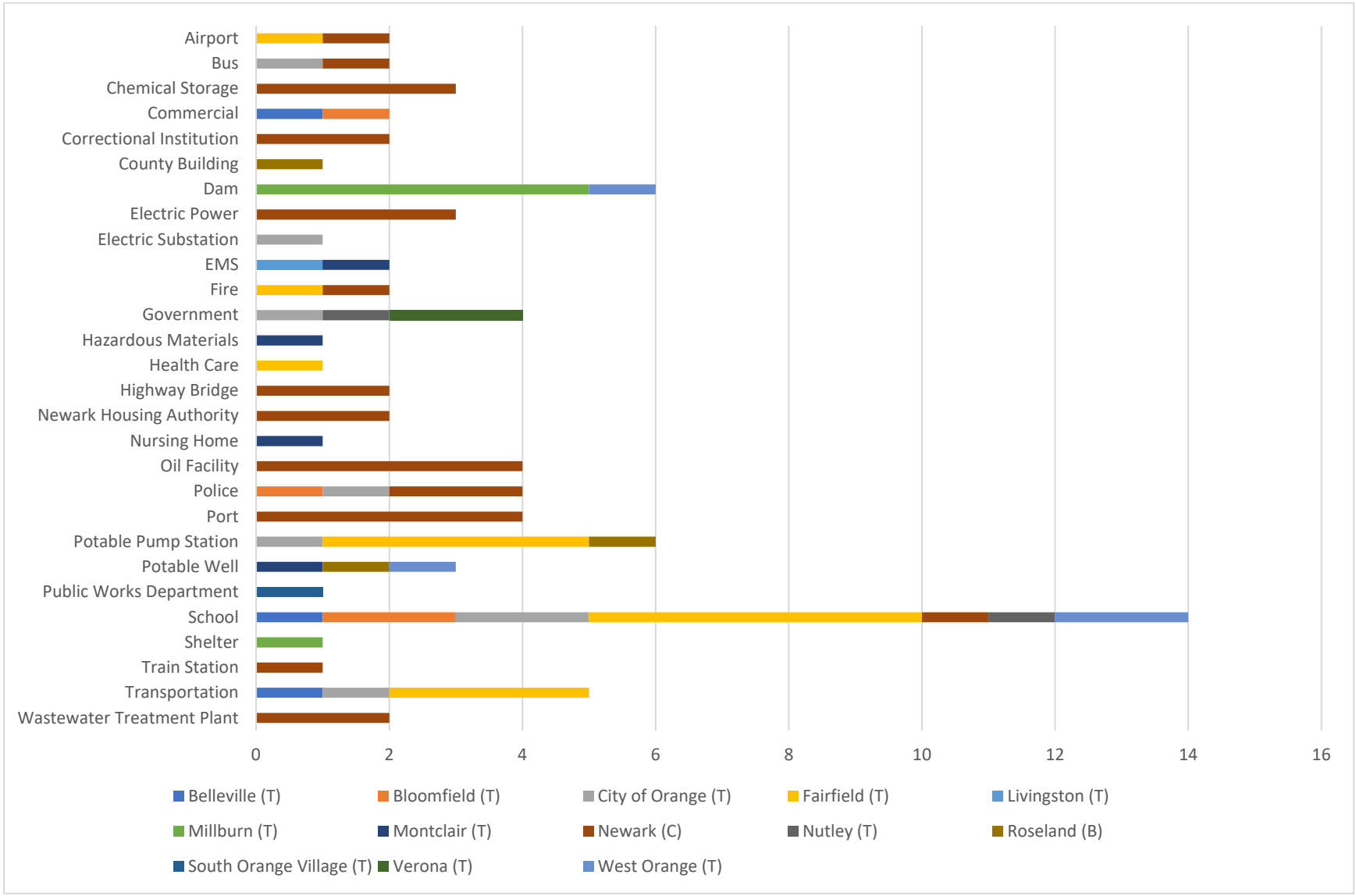


Table 4.3.6-18. Critical Facilities Located in the 1- and 0.2-Percent Annual Chance Event Floodplains

Facility Type	Number of Critical Facilities Located in the 1-Percent Annual Chance Event Floodplain	Number of Critical Facilities Located in the 0.2-Percent Annual Chance Event Floodplain
Airport	2	2
Bus	2	3
Chemical Storage	3	3
Commercial	2	2
Correctional Institution	2	2
County Building	1	1
Dam	6	7
Electric Power	3	3
Electric Substation	1	1
EMS	2	2
EOC	0	1
Fire	2	4
Government	4	7
Hazardous Materials	1	1
Health Care	1	1
Highway Bridge	2	2
Light Rail	0	1
Newark Housing Authority	2	3
Nursing Home	1	1
Oil Facility	4	4
Police	4	6
Port	4	4
Potable Pump Station	6	6
Potable Well	3	4
Public Works Department	1	1
Safety	0	1
School	14	21
Shelter	1	3
Train Station	1	1
Transportation*	5	8
Wastewater Treatment Plant	2	3
Total/Average	**82**	**109**

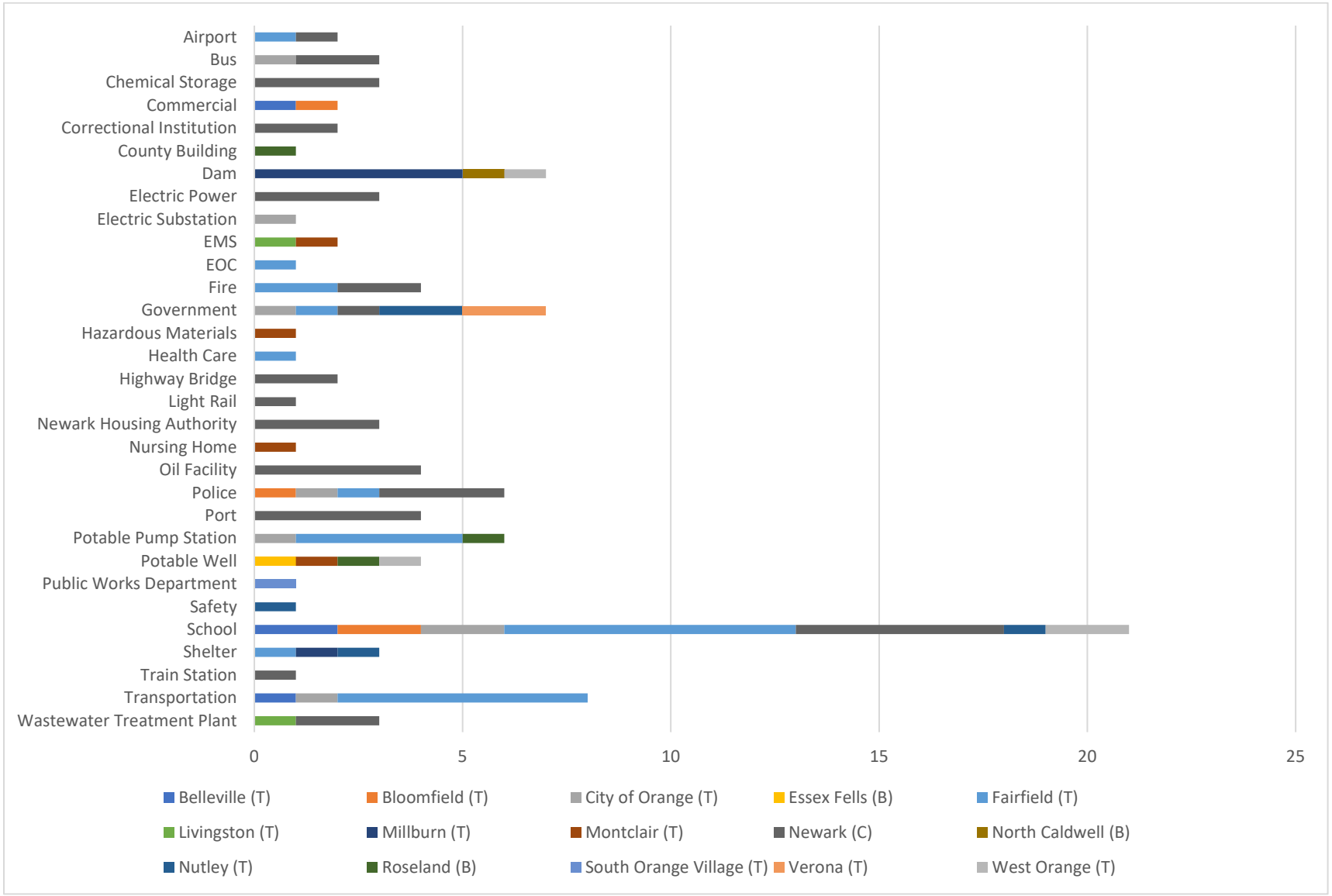
Source: Essex County, 2019; FEMA 2014/2017/2018; HAZUS-MH v4.2
** Only one facility was estimated to have structure and contents losses*
EMS = Emergency Medical Services
EOC = Emergency Operations Center

Figure 4.3.6-9. Distribution of Critical Facilities in the 1-Percent Annual Chance Flood Event Floodplain by Type and Municipality



Sources: FEMA 2014/2017/2018; Essex County, 2019

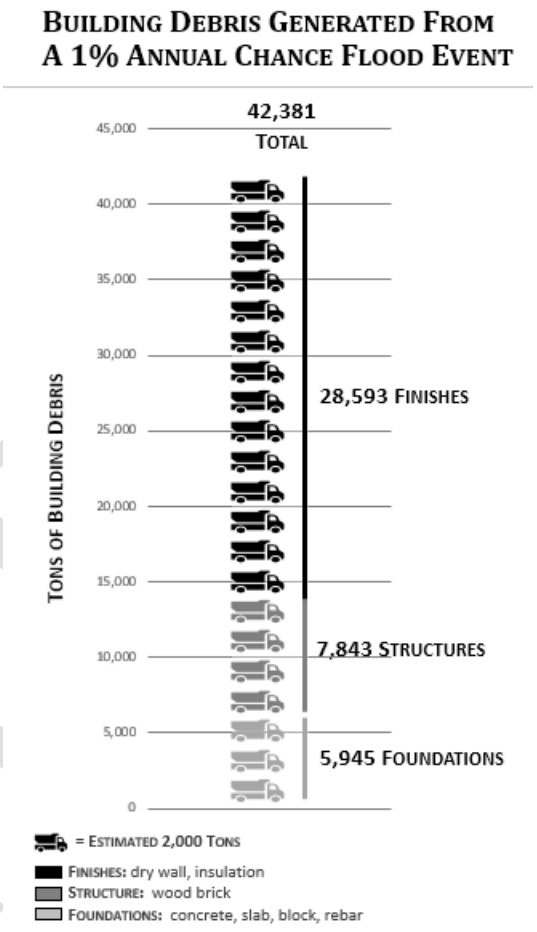
Figure 4.3.6-10. Distribution of Critical Facilities in the 0.2-Percent Annual Chance Flood Event Floodplain by Type and Municipality



Sources: FEMA 2014/2017/2018; Essex County, 2019

Impact on the 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, agricultural losses, business interruption, and effects on tourism. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the section earlier which discusses direct impacts to buildings in Essex County.



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. As presented in Figure 4.3.6-8, 82 critical facilities are exposed and potentially vulnerable to the 1-percent annual chance flood event.

Debris management may also be a large expense after a flood event. HAZUS-MH v4.2 estimates the amount of structural debris generated during a flood 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.). These distinctions are necessary because of the different types of equipment needed to handle debris. Table 4.3.6-19 summarizes the HAZUS-MH v4.2 countywide debris estimates for the 1-percent annual chance flood event. This table only estimates structural debris generated by flooding and does not include non-structural debris or additional potential damage and debris possibly generated by wind that may be associated with a flood event or storm that causes flooding.

Table 4.3.6-19. Estimated Debris Generated from the 1-Percent Flood Event

Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
42,381	28,593	7,843	5,945

Source: HAZUS-MH v4.2

Future Changes that May Impact Vulnerability

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

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

Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the flood hazard if located within the floodplain and mitigation measures are not considered. It is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards at the local level.

Each municipality identified areas of recent development and proposed development in their community. Development that could be located using an address or Parcel ID were geocoded and overlain with the FEMA DFIRM boundaries to determine exposure to the flood hazard. There are 7 recent, proposed, and future developments vulnerable to the flood hazard; this represents approximately 25.0 percent of the 28 identified developments. There is 1 development site located in the 1-percent annual chance flood event boundary, 1 of which is a recent development. There are 3 proposed developments located in the 0.2-percent annual chance flood event boundary. Refer to Section 3 (County Profile), and Volume II Section 9 (Jurisdictional Annexes) for more detailed information on potential new development areas in Essex County. Refer to Figure 4.3.6-11 for a map of proposed new development and the FEMA DFIRM boundaries for Essex County.

Projected Changes in Population

According to population projections from the State of New Jersey Department of Labor and Workforce Development, Essex County will experience an increase in population through 2034 (approximately 40,000 people between 2017 and 2034). Population change is not expected to have a measurable effect on the overall vulnerability of the County's population over time. Those moving from areas of lower vulnerability to higher will increase their vulnerability to flood. This includes areas that are directly impacted by flood events and those that are indirectly impacted (i.e., isolated neighborhoods, flood-prone roadways, etc.). Refer to Section 4.3.1, Population Trends in the County Profile, which includes a discussion on population trends for 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, and 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.

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

Change of Vulnerability Since 2015 HMP

The entire County continues to be vulnerable to the flood hazard. Several differences exist between the 2015 HMP flood vulnerability assessment and the assessment performed for this update. An updated general building stock based upon replacement cost value from MODIV tax assessment data and 2019 RS Means, and an updated critical facility inventory were used to assess the County's risk to the hazard areas. The 2017 American Community Survey population estimates were used and estimated at a structural level in place of the 2010 U.S.

Census blocks. In addition, updated DFIRMs for Essex County were released since the 2015 HMP and used to inform this analysis. Due to changes in the data used, a direct comparison of the change in vulnerability is challenging. The updated vulnerability assessment provides a more current exposure analysis for the County.

There have been changes to the County's NFIP statistics since the 2015 HMP. The 2015 HMP summarized 2014 NFIP statistics provided by FEMA, while the 2019 HMP summarizes 2018 and 2019 NFIP statistics. Since 2015, the County has seen an increase in the number of claims and repetitive and severe repetitive loss properties. There were 1,110 new claims totally an estimated $3 million, and an increase of 104 repetitive and severe repetitive loss properties since 2014. Most of these additional repetitive loss properties are located in the Township of Fairfield (27). There was an overall decrease of 198 NFIP policies with some municipalities experiencing an increase while others a decrease. The greatest increase in policies occurred in the Township of Belleville (238 policies), while the greatest decrease in policies occurred in the Township of Fairfield (-132 policies).

Overall, the vulnerability assessment presented uses a more accurate and updated building inventory, which provides more accurate exposure and potential loss estimates for Essex County. Essex County and its municipalities continue to be vulnerable to the flood hazard; however, progress has been made to decrease vulnerability through the implementation of mitigation projects (i.e., acquisition and elevation of flood-prone properties). Mitigation measures undertaken by each jurisdiction are described in the jurisdictional annexes in Section 9 of this HMP.

Figure 4.3.6-11. Potential New Development and Flood Boundaries