4.3.5 FLOOD

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

2021 HMP Changes

- All subsections have been updated using best available data.
- The urban flooding discussion and problem areas was expanded.
- Previous events between 2015 and 2020 are listed with a comprehensive list of previous events in Appendix E (Risk Assessment Supplement).
- The vulnerability assessment was updated utilizing updated and expanded building, critical facility and community lifeline inventories.

Profile

Hazard Description

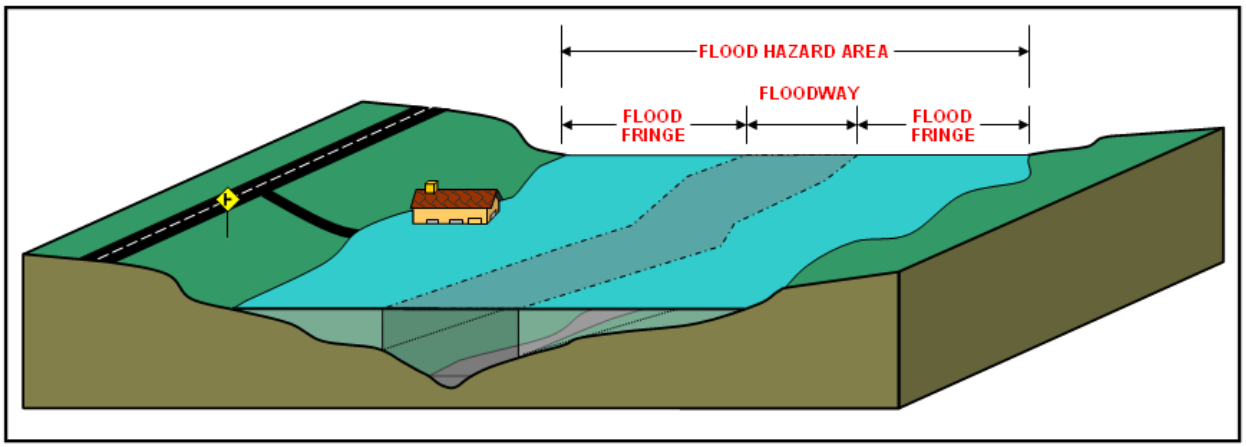
A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, 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 Sussex County are riverine (inland) flooding, ice jam flooding, and flooding as a result of a dam failure. Dam failure is discussed in Section 4.3.1 (Dam Failure). In addition, Sussex 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 Sussex County, floodplains line the rivers, streams, and lakes of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques. Figure 4.3.5-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 4.3.5-1. Floodplain



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

Ice Jam Flooding

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

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

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.

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

those streams can occur more quickly and reach greater depths than prior to development in that area (Harris 2008).

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

Location

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

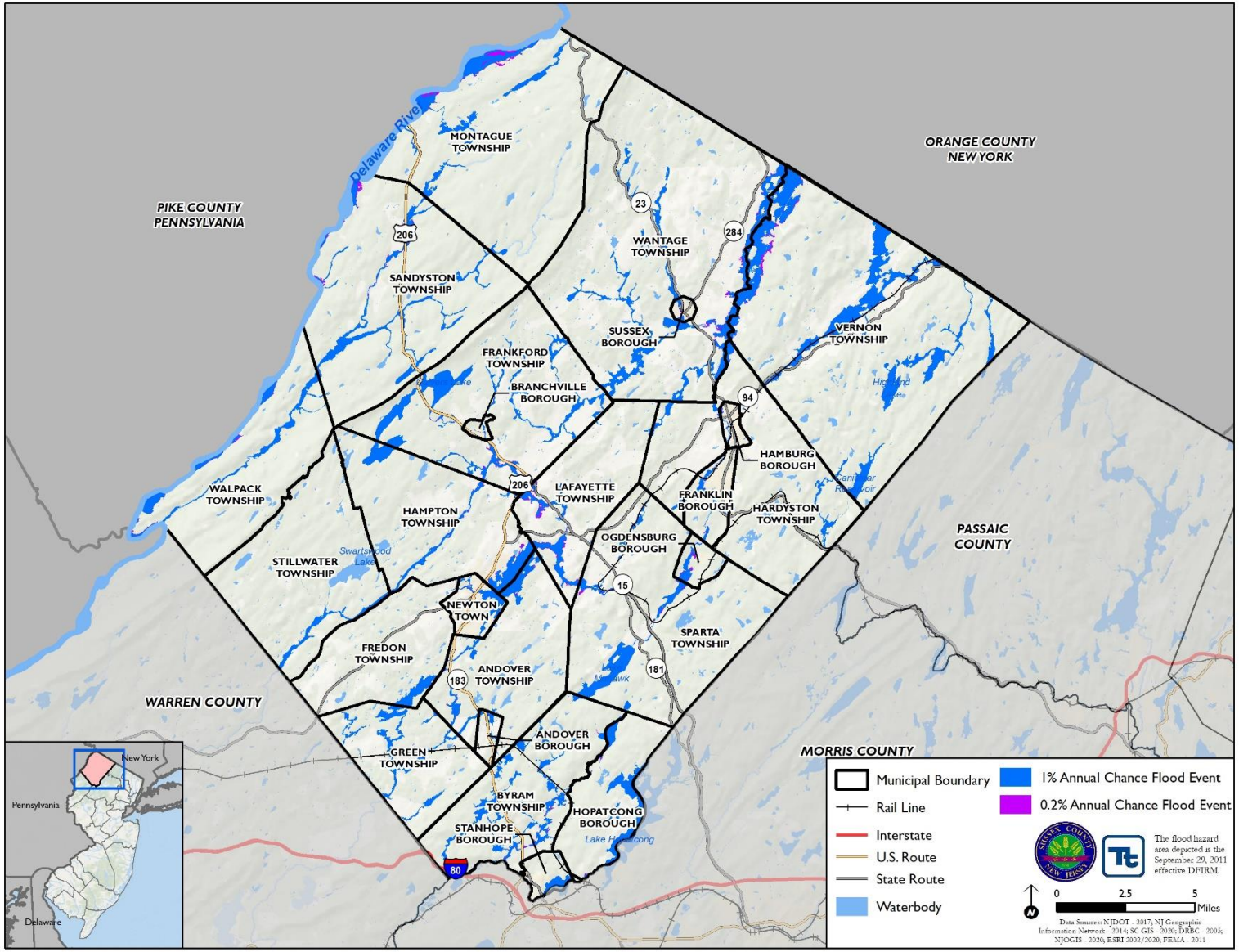
Flooding in Sussex County is often the direct result of frequent weather events such as thunderstorms, heavy rains, tropical storms, and hurricanes. Floods can happen almost anywhere in County, although they do tend to occur in and around areas near existing bodies of water, such as rivers and streams. The most damaging floods (particularly riverine floods) in New Jersey appear to occur in the northern half of the State, which includes Sussex County. This is a function of several physiographic and physical features of the landscape. Greater geographic relief in the northern half results in flowing water moving down steeper gradients and being naturally or artificially channelized through valleys and gullies.

Sussex County has primarily a mountainous terrain, with significant exposure to water and vulnerability to the flood hazard. Sussex County has several large waterways, including the Musconetcong River and Paulins Kill, as well as the Delaware River, which has a total drainage area of over 14,000 square miles. Larger lakes and reservoirs include Lake Hopatcong, Lake Musconetcong and Lake Mohawk (FEMA FIS 2011). Over the years, Sussex County has been impacted by flooding, especially in the municipalities situated adjacent to these bodies of water.

Development patterns have resulted in denser development in northern New Jersey. In addition, proximity to New York City boosts property values and therefore increases damage dollar totals. Extensive development also leaves fewer natural surfaces available to absorb rainwater, forcing water directly into streams and rivers, swelling them more than when more natural surface buffered the runoff rate. Since the Delaware, Raritan, and Passaic Rivers drain more than 90 percent of the northern New Jersey counties, these rivers and their tributaries are common locations for flooding.

The 1-percent annual chance flood hazard zones are widely dispersed in Sussex County, generally following riverine corridors as shown in Figure 4.3.5-2. A significant concentration of 1 percent annual chance flood hazard zones is located in the northeastern portion of the County, around the Wallkill River, and the Pochuck and Wawayanda Creeks, especially as they near the New York State border in Wantage and Vernon Townships, respectively. Additional 1-percent annual chance flood hazard zones exist along Lake Hopatcong as it forms the southeastern Sussex County boundary with Morris County, around Lake Mohawk in Sparta Township, and along Moore's Brook in Andover and Hampton Townships. In addition, 1-percent annual chance floodplains are scattered throughout the County tracing the footprints of numerous other creeks, rivers, and bodies of water, as shown in Figure 4.3.5-2 below.

Figure 4.3.5-2. FEMA 2011 Flood Hazard Areas in Sussex County



Flood-Prone Areas in Sussex County

Watersheds in New Jersey are referred to as the name of the water body to which the land area drains and the corresponding Hydrologic Unit Code (HUC). The HUC can range from 2 to 16 digits long- the longer the numeric code, the smaller the watershed area. NJDEP also has divided the state into 21 Watershed Management Areas (WMAs) based on large scale drainage pattern. Each WMA encompasses a particular group of major rivers. Sussex County falls within parts of 4 regions: WMA 01: Upper Delaware - Northwest Region; WMA 02: Wallkill - Northwest Region; WMA 03: Pompton, Pequannock, Wanaque, Ramapo - Northeast Region; and WMA 06: Middle Passaic, Whippany – Northeast Region. These areas delineate the principal stream systems that drain the county's land area. WMA 1, the Upper Delaware River Watershed, is the largest watershed in the county by area, with waters draining west and southwest to the Delaware River. The second largest is WMA 2, the Wallkill River Watershed. The Wallkill, which flows north into Orange County, New York, drains the north-central and northeastern section of Sussex County. WMA 3 (Pequannock River Watershed) and WMA 6 (Rockaway River Watershed) both drain to the southeast, and comprise small parts of the county.

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

Watershed Management Area 01 – Upper Delaware River

Located in the western and southern sections of Sussex County, the Upper Delaware River Watershed comprises greater than half of the County's land area, and includes the following principal waterways: the Flat Brook; the Paulins Kill; the Pequest River and a short stretch of the Musconetcong River. Waterways in WMA 01 run southwesterly, roughly parallel to one another, towards the Delaware River. Montague and Sandyston townships contain a large amount of these waterways, most of which are streams part of the Big and Little Flat Brook systems. The upper half of the Big Flat Brook flows through High Point State Park and Stokes State Forest. Clove Brook and Mill Brook also run through Montague Township. Walpack Township contains tributaries of the Flat Brook draining the west slope of the Kittatinny Ridge. Other waterways in this area include several stretches and tributaries of the Paulins Kill, Pequest River and Musconetcong River in Stillwater, Fredon, Green and Byram Townships, as well as parts of Kymer Brook and Lubbers Run (Sussex County 2015).

Watershed Management Area 02 – Wallkill River

The Wallkill River watershed occupies the northern and northeastern parts of Sussex County, extending south through Sparta and northern Byram Townships. The Wallkill River flows northeast across the NJ state border and lets out on the Hudson River near Kingston, NY. Major tributaries of the Wallkill River that pass through Sussex County include Papakating Creek, which begins its run in Frankford Township, and Clove Brook, the upper reaches of which flow south from northern Wantage Township. Pochuck Creek drains parts of Vernon and Hardyston Townships east of Pochuck Mountain before merging with the Wallkill several miles over the NJ-NY border. Several branches of the Black Creek flow through Vernon Township (Sussex County 2015).

Watershed Management Area 03 – Pequannock River

A small area of eastern Sussex County is drained by the Pequannock River, which flows south out of Vernon Township continuing into Hardyston Township where it turns southeast, forming the border between Morris and Passaic Counties, before ultimately converging with the Passaic River in Essex County. Tributaries of the Pequannock in Sussex County include a stretch of the upper Pacack Brook and an unnamed tributary located in Hardyston Township (Sussex County 2015).

Watershed Management Area 6 – Rockaway River

The Rockaway River itself does not pass through Sussex County, but the system's upper reaches includes many tributaries in eastern Sparta Township, where several streams merge to form Russia Brook. Russia Brook flows into Jefferson Township (Morris County) where it meets the Rockaway River (Sussex County 2015).

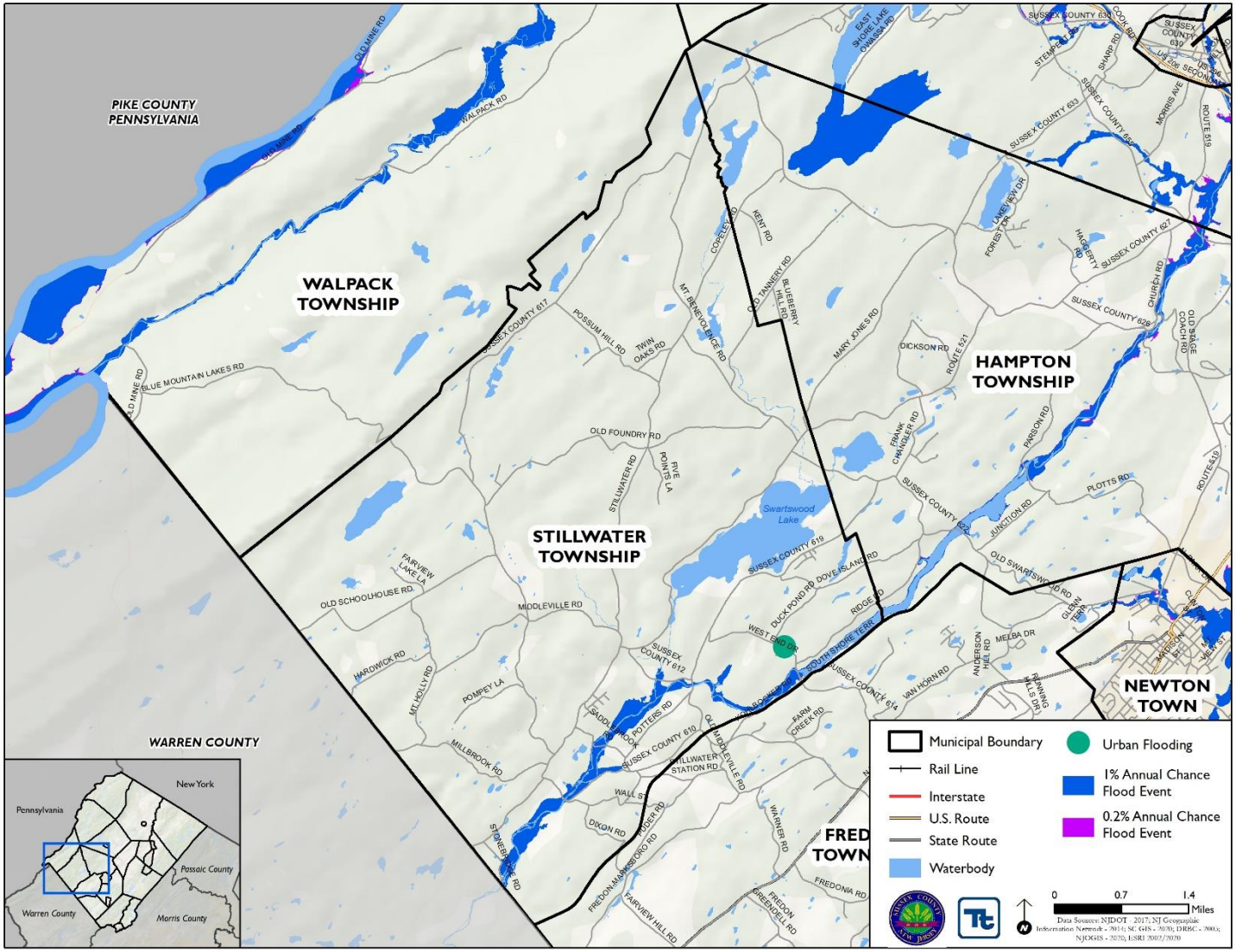
Ice Jams

Ice jams can occur along rivers and creeks. In Sussex County, ice jams have historically occurred along the Delaware River (USACE CRREL 2020).

Urban Flooding

Throughout Sussex County, low-lying surface flooding and interior shallow ponding occurs as a result of heavy rainfall and inadequate capacity of stormwater systems. While riverine flooding is mapped by FEMA, urban flooding is not. Stillwater Township identified one urban flooding location where a low-lying area floods. Figure 4.3.5-3 illustrates this urban flood location.

Figure 4.3.5-3. Urban Flood Areas Identified in Sussex County



Natural and Beneficial Floodplain Areas

Although typically associated as a hazard area, floodplains also serve beneficial and natural functions (on ecological/environmental, social, and economic levels). Disruption of these natural systems can have long-term consequences on entire regions; however, this potential impact has only recently been noted. Some of the more well-known water-related functions for floodplains include:

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

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

Table 4.3.5-1. Acreage of Wetlands by Jurisdiction

Jurisdiction	Total Area (Acres)	Wetlands	
		Area (Acres)	Percent of Total Area
Andover (B)	872	76	8.7%
Andover (Twp)	13,304	1,847	13.9%
Branchville (B)	383	5	1.3%
Byram (Twp)	14,536	1,218	8.4%
Frankford (Twp)	22,585	3,222	14.3%
Franklin (B)	2,833	370	13.1%
Fredon (Twp)	11,464	1,314	11.5%
Green (Twp)	10,429	1,175	11.3%
Hamburg (B)	747	80	10.8%
Hampton (Twp)	16,305	2,738	16.8%
Hardyston (Twp)	20,892	3,475	16.6%
Hopatcong (B)	7,949	569	7.2%
Lafayette (Twp)	11,499	2,172	18.9%
Montague (Twp)	29,840	3,730	12.5%
Newton (T)	2,164	337	15.6%

Jurisdiction	Total Area (Acres)	Wetlands	
		Area (Acres)	Percent of Total Area
Ogdensburg (B)	1,438	258	17.9%
Sandyston (Twp)	26,926	2,170	8.1%
Sparta (Twp)	24,828	2,987	12.0%
Stanhope (B)	1,341	113	8.4%
Stillwater (Twp)	18,076	2,066	11.4%
Sussex (B)	399	34	8.5%
Vernon (Twp)	44,769	7,846	17.5%
Walpack (Twp)	15,945	744	4.7%
Wantage (Twp)	43,175	8,254	19.1%
Sussex County (Total)	**342,701**	**46,797**	**13.7%**

Source: NJDEP 2015
B – Borough; T – Town; Twp – Township; % - Percent

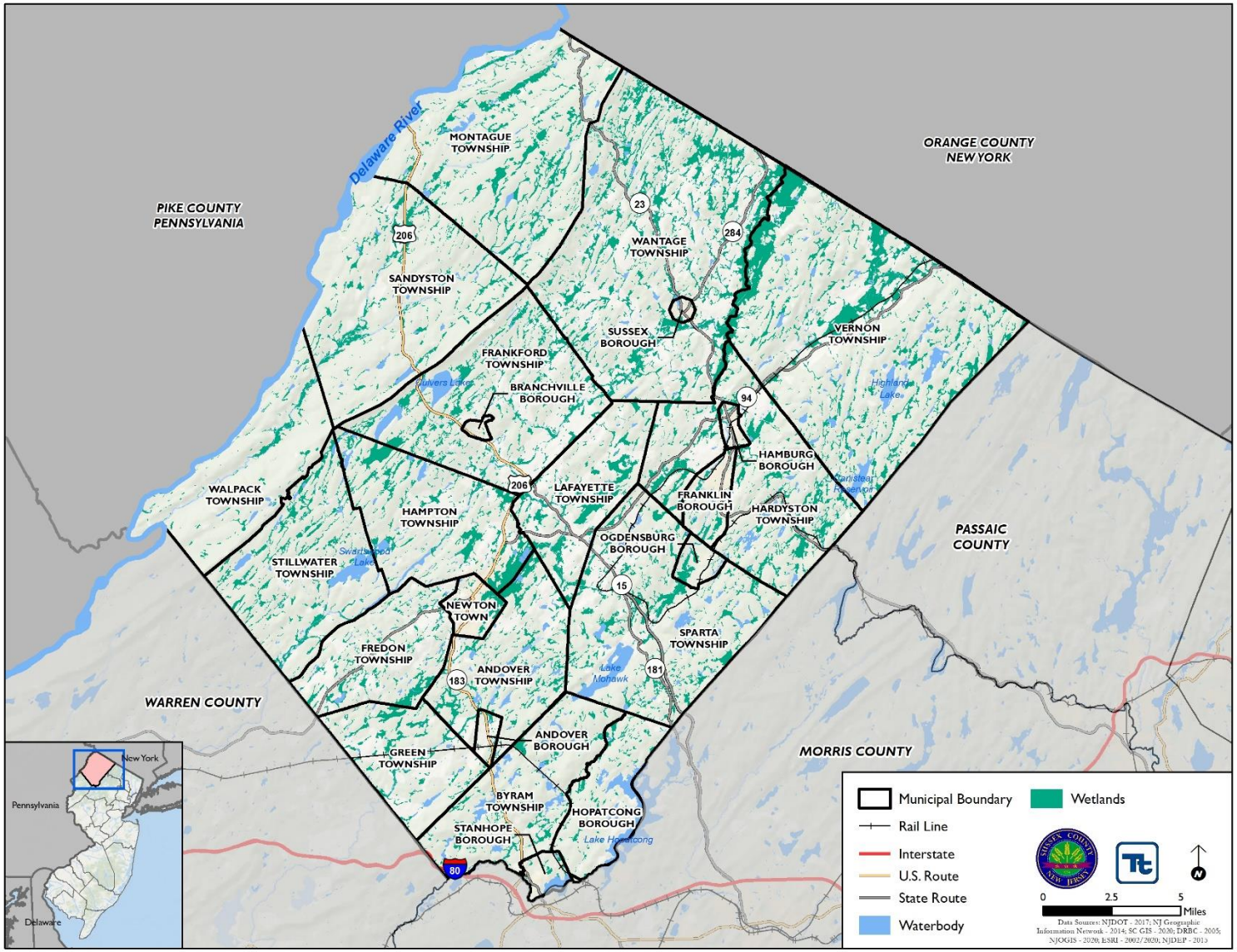
Table 4.3.5-2 Natural and Beneficial Land in Sussex County

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Agricultural Wetlands (Modified)	4,109	Coniferous Brush/Shrubland	1,402	State Threatened	7,735
Atlantic White Cedar Wetlands	31	Coniferous Forest (>50% Crown Closure)	5,814	State Endangered	100,568
Cemetery on Wetland	1	Coniferous Forest (10-50% Crown Closure)	935	Federally Listed	164,667
Coniferous Scrub/Shrub Wetlands	126	Deciduous Brush/Shrubland	4,772		
Coniferous Wooded Wetlands	858	Deciduous Forest (>50% Crown Closure)	133,379		
Deciduous Scrub/Shrub Wetlands	5,816	Deciduous Forest (10-50% Crown Closure)	7,817		
Deciduous Wooded Wetlands	24,741	Mixed Deciduous/Coniferous Brush/Shrubland	4,801		
Disturbed Wetlands (Modified)	100	Mixed Forest (>50% Coniferous With >50% Crown Closure)	8,545		
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	643	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	1,025		
Freshwater Tidal Marshes	1	Mixed Forest (>50% Deciduous With >50% Crown Closure)	14,151		
Herbaceous Wetlands	7,194	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	1,503		
Managed Wetland In Built-Up Maintained Rec Area	137	Old Field (< 25% Brush Covered)	6,038		

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Managed Wetland In Maintained Lawn Greenspace	125	Phragmites Dominate Old Field	13		
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	226	Plantation	948		
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	528				
Mixed Wooded Wetlands (Coniferous Dom.)	750				
Mixed Wooded Wetlands (Deciduous Dom.)	771				
Phragmites Dominate Interior Wetlands	400				
Unvegetated Flats	40				
Wetland Rights-Of-Way	203				

Source: NJDEP 2015/2019

Figure 4.3.4-4. Wetlands in Sussex County



Extent

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

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

The NJDEP is mandated to delineate and regulate flood hazard areas pursuant to N.J.S.A. 58:16A-50 et seq., the Flood Hazard Area Control Act. This Act authorizes the NJDEP 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. Sussex County has numerous active USGS stream gages; in addition, stream gauges are located upstream in neighboring counties.

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

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

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

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

Previous Occurrences and Losses

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.

Between 1954 and 2020, Sussex County was included in seven flood-related disaster declarations; refer to Table 4.3.5-3. Flood events that have impacted Sussex County between 2015 and 2020 are identified in Table 4.3.5-4 with associated impacts. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality. For events prior to 2015, refer to the Appendix E (Risk Assessment Supplement).

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 2020, Sussex County was included in two flood-related agricultural disaster declarations. In 2019, Sussex County was included in declaration S4479 for excessive precipitation and S4455 for the combined effects of excessive rainfall, moisture, and storm-force winds from Hurricane Florence. In 2019, indemnities for moisture/precipitation/rain for all other crops totaled $43,692.

Table 4.3.5-3 Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
DR-310	September 4, 1971	September 4, 1971	Flood: Heavy Rains & Flooding
DR-477	July 23, 1975	July 23, 1975	Flood: Heavy Rains, High Winds, Hail & Tornadoes
DR-1337	August 12-21, 2000	August 17, 2000	Severe Storms, Flooding and Mudslides
DR-1563	September 18-October 1, 2004	October 1, 2004	Severe Storms and Flooding
DR 1588	April 1-3, 2005	April 19, 2005	Severe Storm(s): Severe Storms and Flooding
DR-1653	June 23-July 10, 2006	July 7, 2006	Severe Storms and Flooding
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storm(s): Severe Storms and Inland and Coastal Flooding

Source: FEMA 2020

Table 4.3.5-4 Flooding Events in Sussex County, 2015 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
July 26, 2015	Flash Flood	N/A	N/A	Montague	A cold front over the Finger Lakes region of New York State helped trigger a cluster of showers and thunderstorms with very heavy rain that moved over northwest New Jersey mainly during the evening of the 26th. The heaviest rain fell over western parts of Warren County and especially in far northwest Sussex County. Doppler Radar storm total estimates exceeded 4 inches in the latter. A cluster of thunderstorms with torrential rain caused poor drainage and small creek flash flooding in the Shimers Brook

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					Basin in Montague Township. Event precipitation totals included 4.74 inches in Montague. A mesonet site within Montague measured 2.57 inches of rain in 70 minutes.
February 24, 2016	Flood	N/A	N/A	Flatbrookville through Wallpack Center	A strong low pressure system moving north through the Great Lakes region, combined with its associated warm front and cold front, copious amounts of moisture, and low level jet, produced strong to severe thunderstorms, heavy rain, flash flooding, and stream flooding in New Jersey late Wednesday afternoon and evening, February 24th, with stream flooding continuing into Thursday, February 25th. Thousands were without power for a period across the state, focused in South Jersey. Route 615 was closed due to flooding between Pompey Ridge Road and Flatbrook Bridge on the morning of 2/25.
October 2, 2018	Flash Flood	N/A	N/A	Newton, Hampton Township	Thunderstorms brought locally heavy rain to northern New Jersey on the evening of October 2. Sections of US Route 206 and NJ Route 94 were closed in Newton and in Hampton Township due to flooding.

Source: FEMA 2020; NOAA-NCEI 2020; NWS 2020; SPC 2020; NJOEM 2019
Note: Not all events that have occurred in Sussex 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

Ice Jam Events

Based on review of the CRREL database, 12 ice-jam events have occurred in or near Sussex County between 1780 and 2020. Events that occurred outside of the County were included because they were close enough to the borders to cause possible flooding impacts in Sussex County. Information regarding losses associated with these reported ice jams was limited. According to this database, there have been no ice jam events since 2015 in Sussex County along the Delaware River (CRREL 2020).

Probability of Future Occurrences

Sussex County is expected to continue experiencing direct and indirect impacts of flooding events in the future. These impacts may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

According to NOAA and the CRREL database, Sussex County experienced 52 flood events between 1950 and 2020, including 23 floods, 27 flash floods, and two ice jams as summarized in Table 4.3.5-5. The table summarizes data regarding the probability of occurrences of flood events in Sussex County based on the historic record. The information used to calculate the probability of occurrence is based solely on NOAA-NCEI storm events database results (NOAA NCEI 2020).

Table 4.3.5-5 Probability of Future Flood Events

Hazard Type	Number of Occurrences Between 1950 and 2020	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent chance of occurrence in any given year
Flood	23	0.33	3.1	0.32	32.4
Flash Flood	27	0.39	2.6	0.38	38.0
Ice Jams	2	0.03	35.5	0.03	2.8
Total	**52**	**0.74**	**1.4**	**0.73**	**73.2**

Source: NOAA-NCEI 2020; CRREL 2020

In Section 4.4, the identified hazards of concern for Sussex County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for flood events in the County is considered 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year, as presented in Table 4.4-1). The ranking of the flood hazard for individual municipalities is presented in the jurisdictional annexes (Section 9).

Climate Change Impacts

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

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

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme

storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71% (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

Vulnerability Assessment

To assess Sussex County's risk to the flood hazard, a spatial analysis was conducted using the FEMA Risk Map products dated September 2011. 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 riverine flood 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 or not adequate warning time is provided to residents. Hazard exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but all individuals who may be affected by the hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

To estimate population exposure to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were used. Based on the spatial analysis, there are an estimated 2,182 residents living in the Special Flood Hazard Area (SFHA, or 1-percent annual chance floodplain), or 1.5% of the County's total population. There are an estimated 2,433 residents living in the 0.2-percent annual chance floodplain, or 1.7% of the County's total population. The Borough of Hopatcong has the greatest number of residents living in the floodplain with approximately 333 residents living in the SFHA. The Township of Byram has the greatest number of residents living in the 0.2-percent annual chance flood area—approximately 374 people. Table 4.3.5-6 summarizes the population exposed to the flood hazard by jurisdiction.

Table 4.3.5-6. Estimated Sussex County Population Exposed to the 1-percent and 0.2-percent Flood Hazard Area

Jurisdiction	Total Population	Population Exposed to the 1-Percent Annual Chance Flood Event Hazard Area		Population Exposed to the 0.2-Percent Annual Chance Flood Event Hazard Area	
		Number of People	Percent Total	Number of People	Percent Total
Andover (B)	594	13	2.1%	13	2.1%
Andover (Twp)	5,996	6	0.1%	6	0.1%
Branchville (B)	896	26	2.9%	34	3.8%
Byram (Twp)	8,010	292	3.6%	374	4.7%
Frankford (Twp)	5,361	281	5.2%	287	5.4%
Franklin (B)	4,807	29	0.6%	29	0.6%
Fredon (Twp)	3,214	0	0.0%	0	0.0%
Green (Twp)	3,495	51	1.5%	51	1.5%

Jurisdiction	Total Population	Population Exposed to the 1-Percent Annual Chance Flood Event Hazard Area		Population Exposed to the 0.2-Percent Annual Chance Flood Event Hazard Area	
		Number of People	Percent Total	Number of People	Percent Total
Hamburg (B)	3,152	2	0.1%	2	0.1%
Hampton (Twp)	4,916	36	0.7%	41	0.8%
Hardyston (Twp)	7,886	2	0.0%	2	0.0%
Hopatcong (B)	14,362	333	2.3%	333	2.3%
Lafayette (Twp)	2,390	50	2.1%	70	2.9%
Montague (Twp)	3,716	123	3.3%	149	4.0%
Newton (T)	7,895	84	1.1%	106	1.3%
Ogdensburg (B)	2,314	8	0.3%	64	2.8%
Sandyston (Twp)	1,925	114	5.9%	127	6.6%
Sparta (Twp)	18,841	281	1.5%	281	1.5%
Stanhope (B)	3,377	14	0.4%	19	0.6%
Stillwater (Twp)	3,936	54	1.4%	56	1.4%
Sussex (B)	1,854	10	0.5%	17	0.9%
Vernon (Twp)	22,369	256	1.1%	256	1.1%
Walpack (Twp)	6	1	18.2%	1	18.2%
Wantage (Twp)	10,986	116	1.1%	119	1.1%
Sussex County (Total)	**142,298**	**2,182**	**1.5%**	**2,433**	**1.7%**

Sources: American Community Survey 2018 5-year estimates; FEMA 2011
Note: B – Borough; T - Town; Twp – Township

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. There are 7,191 persons below the poverty level and 22,889 persons that are over 65 years old in the County. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is more vulnerable because they are more likely to seek or need medical attention which may not be available due to isolation during a flood event and they may have more difficulty evacuating. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups.

The Hazus riverine model estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. The demographic data in Hazus has not been updated and the estimated sheltering needs are based on 2010 U.S. Census data. Hazus estimates 2,150 households may be displaced and 51 people may seek short-term sheltering. These statistics, by jurisdiction, are presented in Table 4.3.5-7. 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 4.3.5-7. Estimated Population Displaced or Seeking Short-Term Shelter from the 1-percent Annual Chance Flood Event

Jurisdiction	Population (ACS 5-Year 2014 - 2018)	1-Percent Annual Chance Flood Event Hazard Area	
		Displaced Population	Persons Seeking Short-Term Sheltering
Andover (B)	594	31	0
Andover (Twp)	5,996	15	0
Branchville (B)	896	33	0
Byram (Twp)	8,010	225	1
Frankford (Twp)	5,361	176	2
Franklin (B)	4,807	86	0
Fredon (Twp)	3,214	2	0
Green (Twp)	3,495	105	0
Hamburg (B)	3,152	0	0
Hampton (Twp)	4,916	14	0
Hardyston (Twp)	7,886	8	0
Hopatcong (B)	14,362	26	0
Lafayette (Twp)	2,390	82	0
Montague (Twp)	3,716	196	5
Newton (T)	7,895	335	39
Ogdensburg (B)	2,314	24	0
Sandyston (Twp)	1,925	57	0
Sparta (Twp)	18,841	85	0
Stanhope (B)	3,377	7	0
Stillwater (Twp)	3,936	61	0
Sussex (B)	1,854	30	0
Vernon (Twp)	22,369	328	4
Walpack (Twp)	6	5	0
Wantage (Twp)	10,986	219	0
Sussex County (Total)	**142,298**	**2,150**	**51**

Sources: Hazus; FEMA 2011
Note: B – Borough; T - Town; Twp – Township

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

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and

pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (CDC 2020).

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

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

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

Impact on General Building Stock

After considering the population exposed and potentially vulnerable to the flood hazard, the built environment was evaluated. Exposure includes those buildings located in the flood hazard zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content replacement cost values. Table 4.3.5-8 summarizes these results county-wide.

There are 1,267 buildings located in the 1-percent annual chance flood hazard area with an estimated $2.2 billion of replacement cost value (i.e., building and content replacement costs). In total, this represents approximately 1.8-percent of the County's total general building stock inventory. In addition, there are 1,400 buildings located in the 0.2-percent annual chance flood boundary with an estimated $2.3 billion of building stock and contents exposed. This represents approximately 1.9-percent of the County's total general building stock inventory.

The Hazus flood model estimated potential damages to the buildings in Sussex County at the structure level using the custom structure inventory developed for this HMP and the depth grid generated using the effective 2011 DFIRM data. The potential damage estimated by Hazus to the general building stock inventory associated with the 1-percent annual chance flood is approximately $137.7 million or 0.2-percent of the total building replacement cost value. The Township of Vernon has the greatest estimated building loss—approximately $21.5 million (i.e. 0.4-percent of the total replacement cost value). Refer to Table 4.3.5-9 for the estimated losses by jurisdiction, which also shows the estimated losses for residential, commercial, and other occupancy structures, respectively.

Table 4.3.5-8 Estimated General Building Stock Located in the FEMA Flood Zones - All Occupancies

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposure - Total (All Occupancies)							
			1-Percent Annual Chance Flood Event Hazard Area				0.2-Percent Annual Chance Flood Event Hazard Area			
			Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total	Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total
Andover (B)	328	$628,463,029.95	14	4.3%	$174,979,627	27.8%	14	4.3%	$174,979,627	27.8%
Andover (Twp)	2,584	$3,609,679,724.39	5	0.2%	$36,001,962	1.0%	5	0.2%	$36,001,962	1.0%
Branchville (B)	426	$532,377,368.38	14	3.3%	$14,360,449	2.7%	18	4.2%	$20,126,263	3.8%
Byram (Twp)	3,676	$2,746,550,445.88	136	3.7%	$59,432,969	2.2%	171	4.7%	$70,866,182	2.6%
Frankford (Twp)	3,537	$3,129,888,304.60	179	5.1%	$266,202,978	8.5%	186	5.3%	$284,523,862	9.1%
Franklin (B)	2,061	$1,921,211,856.14	20	1.0%	$35,297,163	1.8%	22	1.1%	$42,004,974	2.2%
Fredon (Twp)	1,615	$1,372,050,934.47	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Green (Twp)	1,698	$1,598,635,803.93	29	1.7%	$18,997,556	1.2%	29	1.7%	$18,997,556	1.2%
Hamburg (B)	1,594	$1,588,049,291.35	3	0.2%	$68,017,193	4.3%	4	0.3%	$71,157,825	4.5%
Hampton (Twp)	2,763	$2,196,131,598.39	21	0.8%	$13,488,730	0.6%	23	0.8%	$15,725,292	0.7%
Hardyston (Twp)	4,403	$3,183,033,541.83	1	<0.1%	$302,627	<0.1%	1	<0.1%	$302,627	<0.1%
Hopatcong (B)	8,040	$2,888,571,675.73	188	2.3%	$153,787,091	5.3%	188	2.3%	$153,787,091	5.3%
Lafayette (Twp)	1,462	$1,958,174,065.00	30	2.1%	$37,074,106	1.9%	44	3.0%	$56,651,230	2.9%
Montague (Twp)	2,175	$1,459,611,020.48	68	3.1%	$62,615,830	4.3%	82	3.8%	$69,659,154	4.8%
Newton (T)	2,679	$5,093,275,807.16	53	2.0%	$321,219,681	6.3%	60	2.2%	$330,994,913	6.5%
Ogdensburg (B)	992	$819,879,628.63	4	0.4%	$64,763,950	7.9%	26	2.6%	$68,977,030	8.4%
Sandyston (Twp)	1,528	$1,212,626,664.22	78	5.1%	$95,822,091	7.9%	91	6.0%	$101,399,933	8.4%
Sparta (Twp)	8,132	$9,070,094,285.30	128	1.6%	$149,119,235	1.6%	129	1.6%	$150,249,278	1.7%
Stanhope (B)	1,557	$1,051,183,581.21	9	0.6%	$141,434,869	13.5%	12	0.8%	$144,564,976	13.8%
Stillwater (Twp)	2,493	$1,417,579,397.87	31	1.2%	$8,960,900	0.6%	32	1.3%	$9,108,181	0.6%
Sussex (B)	678	$1,945,578,915.70	20	2.9%	$194,803,769	10.0%	24	3.5%	$200,856,377	10.3%
Vernon (Twp)	12,039	$5,658,971,163.02	153	1.3%	$127,448,710	2.3%	154	1.3%	$136,976,734	2.4%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposure - Total (All Occupancies)							
			1-Percent Annual Chance Flood Event Hazard Area				0.2-Percent Annual Chance Flood Event Hazard Area			
			Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total	Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total
Walpack (Twp)	51	$63,691,550.30	9	17.6%	$25,116,984	39.4%	9	17.6%	$25,116,984	39.4%
Wantage (Twp)	5,510	$4,877,543,884.74	74	1.3%	$81,399,036	1.7%	76	1.4%	$82,105,518	1.7%
Sussex County (Total)	**72,021**	**$60,022,853,538.68**	**1,267**	**1.8%**	**$2,150,647,504**	**3.6%**	**1,400**	**1.9%**	**$2,265,133,569**	**3.8%**

Source: FEMA 2011; Sussex County GIS 2020; RS Means 2020
Note: B – Borough; T – Town; Twp – Township

Table 4.3.5-9 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Jurisdiction	Total Replacement Cost Value	All Occupancies 1-Percent Annual Chance Flood Event		Residential Losses Only 1-Percent Annual Chance Flood Event		Commercial Losses Only 1-Percent Annual Chance Flood Event		All Other Occupancies Total Losses 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total	Estimated Loss (Replacement Cost Value)	Percent of Total Residential Value	Estimated Loss (Replacement Cost Value)	Percent of Total Commercial Value	Estimated Loss (Replacement Cost Value)	Percent of Total Other Occupancies Value
Andover (B)	$628,463,030	$18,269,210	2.9%	$256,824	0.2%	$18,012,386	3.9%	$0	0.0%
Andover (Twp)	$3,609,679,724	$4,158,644	0.1%	$10,153	<0.1%	$4,148,492	0.2%	$0	0.0%
Branchville (B)	$532,377,368	$13,442	<0.1%	$13,442	<0.1%	$0	0.0%	$0	0.0%
Byram (Twp)	$2,746,550,446	$5,020,306	0.2%	$641,380	0.1%	$1,067,569	0.1%	$3,311,356	1.1%
Frankford (Twp)	$3,129,888,305	$7,604,867	0.2%	$2,345,629	0.2%	$1,132,760	0.1%	$4,126,478	0.4%
Franklin (B)	$1,921,211,856	$525,746	<0.1%	$449,981	0.1%	$75,765	<0.1%	$0	0.0%
Fredon (Twp)	$1,372,050,934	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Green (Twp)	$1,598,635,804	$3,953,072	0.2%	$424,189	0.1%	$0	0.0%	$3,528,884	0.5%
Hamburg (B)	$1,588,049,291	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%

Jurisdiction	Total Replacement Cost Value	All Occupancies 1-Percent Annual Chance Flood Event		Residential Losses Only 1-Percent Annual Chance Flood Event		Commercial Losses Only 1-Percent Annual Chance Flood Event		All Other Occupancies Total Losses 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total	Estimated Loss (Replacement Cost Value)	Percent of Total Residential Value	Estimated Loss (Replacement Cost Value)	Percent of Total Commercial Value	Estimated Loss (Replacement Cost Value)	Percent of Total Other Occupancies Value
Hampton (Twp)	$2,196,131,598	$202,871	<0.1%	$76,105	<0.1%	$0	0.0%	$126,766	<0.1%
Hardyston (Twp)	$3,183,033,542	$182,343	<0.1%	$182,343	<0.1%	$0	0.0%	$0	0.0%
Hopatcong (B)	$2,888,571,676	$1,074,057	<0.1%	$73,491	<0.1%	$0	0.0%	$1,000,566	0.3%
Lafayette (Twp)	$1,958,174,065	$8,157,067	0.4%	$365,595	0.1%	$768,384	0.2%	$7,023,088	0.7%
Montague (Twp)	$1,459,611,020	$2,007,280	0.1%	$1,822,040	0.3%	$0	0.0%	$185,239	<0.1%
Newton (T)	$5,093,275,807	$3,528,378	0.1%	$211,423	<0.1%	$727,209	<0.1%	$2,589,746	0.3%
Ogdensburg (B)	$819,879,629	$10,265,826	1.3%	$61,283	<0.1%	$10,204,543	3.1%	$0	0.0%
Sandyston (Twp)	$1,212,626,664	$3,885,891	0.3%	$493,390	0.1%	$2,487	<0.1%	$3,390,014	0.6%
Sparta (Twp)	$9,070,094,285	$13,918,398	0.2%	$1,298,468	<0.1%	$12,204,611	0.3%	$415,320	<0.1%
Stanhope (B)	$1,051,183,581	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Stillwater (Twp)	$1,417,579,398	$56,587	<0.1%	$4,088	<0.1%	$0	0.0%	$52,499	<0.1%
Sussex (B)	$1,945,578,916	$72,932	<0.1%	$0	0.0%	$0	0.0%	$72,932	<0.1%
Vernon (Twp)	$5,658,971,163	$21,538,532	0.4%	$1,944,482	0.1%	$17,592,777	1.8%	$2,001,273	0.2%
Walpack (Twp)	$63,691,550	$15,594,172	24.5%	$59,321	2.1%	$0	0.0%	$15,534,851	34.0%
Wantage (Twp)	$4,877,543,885	$17,621,344	0.4%	$2,555,710	0.1%	$8,860,280	1.0%	$6,205,354	0.3%
Sussex County (Total)	**$60,022,853,539**	**$137,650,964**	**0.2%**	**$13,289,334**	**0.1%**	**$74,797,262**	**0.3%**	**$49,564,367**	**0.4%**

Source: Hazus; FEMA 2011; Sussex County GIS 2020; RS Means 2020
Note: B – Borough; T – Town; Twp – Township

NFIP Statistics

FEMA provided a list of properties with NFIP policies, past claims, and multiple claims. According to FEMA, a repetitive loss (RL) property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978. A severe repetitive loss (SRL) property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss (FEMA 2018).

Table 4.3.5-10, Table 4.3.5-11, and Table 4.3.5-12 summarize the NFIP policies, claims, and repetitive loss statistics for Sussex County. A majority of the repetitive loss properties are single family residential homes (87.5-percent). There are no SRL properties reported for the County. This information is current as of September 2019.

The locations of repetitive flooding were geocoded and mapped. Figure 4.3.5-3 illustrates these properties with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address.

Table 4.3.5-10. Occupancy Class of Repetitive Loss Structures in Sussex County

Occupancy Class	Total Number of NFIP Repetitive Loss (RL) Properties
Single Family	14
2-4 Family	1
Non-Residential	1
Sussex County (Total)	**16**

Source: FEMA Region 2 2019; JUDEX 2020
Note: Repetitive loss statistics provided by FEMA Region 2 and are current as of September 2019.

Table 4.3.5-11. Occupancy Class of Repetitive Loss Structures in Sussex County, by Jurisdiction

Jurisdiction	NFIP Repetitive Loss Properties		
	Single Family	2-4 Family	Non-Residential
Andover (B)	0	0	0
Andover (Twp)	0	0	0
Branchville (B)	1	1	0
Byram (Twp)	3	0	0
Frankford (Twp)	1	0	0
Franklin (B)	0	0	0
Fredon (Twp)	0	0	0
Green (Twp)	0	0	0
Hamburg (B)	0	0	0
Hampton (Twp)	0	0	0
Hardyston (Twp)	0	0	0
Hopatcong (B)	1	0	0
Lafayette (Twp)	1	0	0
Montague (Twp)	2	0	0
Newton (T)	0	0	0

Jurisdiction	NFIP Repetitive Loss Properties		
	Single Family	2-4 Family	Non-Residential
Ogdensburg (B)	2	0	0
Sandyston (Twp)	1	0	0
Sparta (Twp)	0	0	0
Stanhope (B)	0	0	0
Stillwater (Twp)	0	0	0
Sussex (B)	0	0	1
Vernon (Twp)	2	0	0
Walpack (Twp)	0	0	0
Wantage (Twp)	0	0	0
Sussex County (Total)	14	1	1

Source: FEMA Region 2 2019; JUDEX 2020
B – Borough; T – Town; Twp – Township NFIP = National Flood Insurance Program
Notes: Repetitive loss statistics provided by FEMA Region 2 and are current as of September 2019. The statistics were summarized using the Community Name provided by FEMA Region 2.

Table 4.3.5-12. Repetitive Loss Properties and NFIP Data for Sussex County

Jurisdiction	Number of NFIP Policies	Number of Write Your Own Policies	Total Number of Policies	Number of NFIP Claims	Number of Write Your Own Claims	Total Claims	Total NFIP Payments	Total Write Your Own Payments	Total Payments	Number of NFIP Repetitive Loss (RL) Properties	Number of NFIP Severe Repetitive Loss (SRL)
Andover (B)	1	2	3	0	1	1	$0	$4,314	$4,314	0	0
Andover (Twp)	2	2	4	0	2	2	$0	$304	$304	0	0
Branchville (B)	1	3	4	3	6	9	$24,016	$33,573	$57,589	2	0
Byram (Twp)	5	17	22	2	12	14	$6,831	$123,046	$129,878	3	0
Frankford (Twp)	0	20	20	1	10	11	$0	$61,459	$61,459	0	0
Franklin (B)	2	9	11	3	8	11	$14,871	$61,017	$75,888	1	0
Fredon (Twp)	1	2	3	0	2	2	$0	$6,937	$6,937	0	0
Green (Twp)	1	8	9	0	2	2	$0	$11,652	$11,652	0	0
Hamburg (B)	0	4	4	0	0	0	$0	$0	$0	0	0
Hampton (Twp)	0	7	7	0	1	1	$0	$0	$0	0	0
Hardyston (Twp)	0	8	8	0	2	2	$0	$60,787	$60,787	0	0
Hopatcong (B)	1	10	11	4	8	12	$1,151	$53,042	$54,193	1	0
Lafayette (Twp)	0	3	3	0	7	7	$0	$24,566	$24,566	1	0
Montague (Twp)	6	13	19	7	10	17	$7,470	$170,778	$178,248	2	0
Newton (T)	2	22	24	0	8	8	$0	$295,505	$295,505	0	0
Ogdensburg (B)	1	10	11	4	5	9	$4,185	$44,937	$49,122	2	0
Sandyston (Twp)	1	7	8	0	5	5	$0	$209,806	$209,806	1	0
Sparta (Twp)	2	44	46	3	11	14	$628	$32,371	$32,999	0	0
Stanhope (B)	0	3	3	1	1	2	$6,052	$10,205	$16,257	0	0
Stillwater (Twp)	0	7	7	1	4	5	$0	$87,323	$87,323	0	0
Sussex (B)	0	4	4	0	4	4	$0	$65,202	$65,202	1	0
Vernon (Twp)	2	24	26	8	10	18	$36,310	$82,702	$119,012	2	0
Walpack (Twp)	0	0	0	0	1	1	$0	$7,076	$7,076	0	0
Wantage (Twp)	0	14	14	3	7	10	$21,511	$159,452	$180,963	0	0
Sussex County (Total)	**28**	**243**	**271**	**40**	**127**	**167**	**$123,025**	**$1,606,054**	**$1,729,080**	**16**	**0**

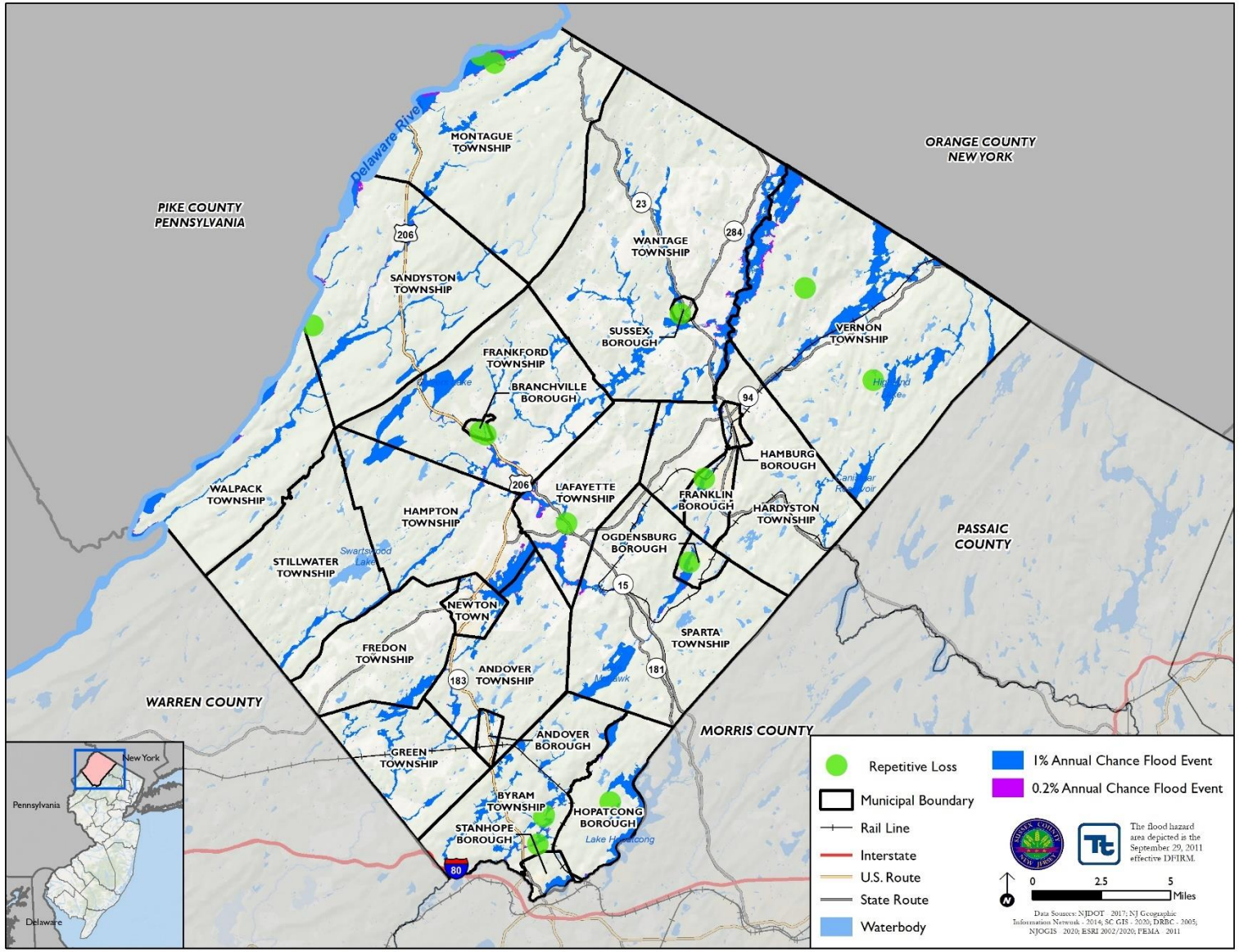
Source: FEMA Region 2 2019; JUDEX 2020

B – Borough; T – Town; Twp – Township NFIP = National Flood Insurance Program

1 - Policies, claims, repetitive loss, and severe repetitive loss statistics provided by FEMA Region 2 and HUDEX and are current as September 2019 and 2020, respectively. The total number of repetitive loss properties includes the severe repetitive loss properties.

2 - Total building and content losses from the claims file provided by HUDEX.

Figure 4.3.5-5. NFIP Repetitive Loss Areas – Sussex County



Impact on Critical Facilities and Lifelines

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

Critical facility and community lifeline exposure to the flood hazard was examined. Table 4.3.5-13 and Table 4.3.5-14 list critical facilities in the 1- and 0.2-percent annual chance flood event boundaries. Of the 66 critical facilities located in the 1-percent annual chance flood event boundary, the greatest number are dams because they are located in the waterway. Additionally, there are 69 critical facilities located in the 0.2-percent annual chance flood event boundary, 57 of which are dams. A majority of the critical facilities located in the 1-percent and 0.2-percent annual chance flood event boundaries are built in the Township of Byram. Critical facility types that are not listed in the tables were not exposed to the flood hazard.

Table 4.3.5-15 summarizes the critical facilities categorized by the FEMA lifelines that are exposed to the 1-percent and 0.2-percent flood inundation areas. In cases where short-term functionality is impacted by flooding, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce flood impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Approximately 1.5-percent of all roadways are in the 1-percent annual chance flood event. Table 4.3.5-16 summarizes the total number of miles of exposed roadways. Figure 4.3.5-6 displays the major roadways that may be impacted by the 1-percent annual chance flood event. The major highways exposed to the 1-percent annual chance flood extent include portions of: I-80, NJ 181, NJ 23, NJ 15, NJ 94, NJ 183, and US 206.

There are several issues associated with transportation routes flooding, including: isolation caused by bridges being washed out or blocked by floods or debris, health problems caused by water and sewer systems that are flooded or backed up, drinking water contamination caused by floodwaters carrying pollutants in water supplies, and localized urban flooding caused by culverts blocked with debris.

Table 4.3.5-13. Distribution of Critical Facilities within the 1-percent Annual Chance Flood Boundary

Jurisdiction	Facility Types					
	Dam	DPW	Hazardous Material Facility	Potable Water Treatment	Shelter	Wastewater Pump
Andover (B)	0	0	0	1	0	0
Andover (Twp)	0	0	0	0	0	0
Branchville (B)	0	0	0	0	0	0
Byram (Twp)	9	0	0	0	2	2
Frankford (Twp)	4	0	0	0	1	0
Franklin (B)	1	0	0	0	0	0
Fredon (Twp)	0	0	0	0	0	0
Green (Twp)	3	0	0	0	0	0
Hamburg (B)	2	0	0	0	0	0

Jurisdiction		Facility Types				
	Dam	DPW	Hazardous Material Facility	Potable Water Treatment	Shelter	Wastewater Pump
Hampton (Twp)	2	0	0	0	0	0
Hardyston (Twp)	1	0	0	0	0	0
Hopatcong (B)	2	0	0	0	0	0
Lafayette (Twp)	1	0	0	0	0	0
Montague (Twp)	4	0	0	0	0	0
Newton (T)	2	0	0	0	0	0
Ogdensburg (B)	0	0	0	0	0	0
Sandyston (Twp)	8	0	0	0	0	0
Sparta (Twp)	7	0	1	0	0	0
Stanhope (B)	0	0	0	0	0	0
Stillwater (Twp)	3	0	0	0	0	0
Sussex (B)	1	1	0	0	0	0
Vernon (Twp)	4	0	0	0	1	0
Walpack (Twp)	2	0	0	0	0	0
Wantage (Twp)	1	0	0	0	0	0
Sussex County (Total)	**57**	**1**	**1**	**1**	**4**	**2**

Source: FEMA 2011; Sussex County GIS 2020
Note: B – Borough; T – Town; Twp – Township
Only Critical Facility types that are exposed to the flood hazard appear in the table.

Table 4.3.5-14. Distribution of Critical Facilities within the 0.2-percent Annual Chance Flood Boundary

Jurisdiction		Facility Types						
	Dam	DPW	Electrical Substation	Hazardous Material Facility	Post Office	Potable Water Treatment	Shelter	Wastewater Pump
Andover (B)	0	0	0	0	0	1	0	0
Andover (Twp)	0	0	0	0	0	0	0	0
Branchville (B)	0	0	0	0	0	0	0	0
Byram (Twp)	9	0	0	0	0	0	2	2
Frankford (Twp)	4	0	0	0	0	0	1	0
Franklin (B)	1	0	0	0	0	0	0	0
Fredon (Twp)	0	0	0	0	0	0	0	0
Green (Twp)	3	0	0	0	0	0	0	0
Hamburg (B)	2	0	0	0	0	0	0	0

Jurisdiction		Facility Types						
	Dam	DPW	Electrical Substation	Hazardous Material Facility	Post Office	Potable Water Treatment	Shelter	Wastewater Pump
Hampton (Twp)	2	0	0	0	0	0	0	0
Hardyston (Twp)	1	0	0	0	0	0	0	0
Hopatcong (B)	2	0	0	0	0	0	0	0
Lafayette (Twp)	1	1	0	0	0	0	0	0
Montague (Twp)	4	0	0	0	0	0	0	0
Newton (T)	2	0	0	0	0	0	0	0
Ogdensburg (B)	0	0	0	0	0	0	0	0
Sandyston (Twp)	8	0	0	0	1	0	0	0
Sparta (Twp)	7	0	0	1	0	0	0	0
Stanhope (B)	0	0	0	0	0	0	0	0
Stillwater (Twp)	3	0	0	0	0	0	0	0
Sussex (B)	1	1	1	0	0	0	0	0
Vernon (Twp)	4	0	0	0	0	0	1	0
Walpack (Twp)	2	0	0	0	0	0	0	0
Wantage (Twp)	1	0	0	0	0	0	0	0
Sussex County (Total)	**57**	**2**	**1**	**1**	**1**	**1**	**4**	**2**

Source: FEMA 2011; Sussex County GIS 2020
Note: B – Borough; T – Town; Twp – Township
DPW – Department of Public Works
Only Critical Facility types that are exposed to the flood hazard appear in the table.

Table 4.3.5-15. Estimated Number of Community Lifelines Categorized by FEMA Lifeline Categories Exposed to the Flood Hazard Areas

FEMA Lifeline Category	Total Number of Lifelines Identified in Sussex County	Number of Lifelines Exposed to 1-Percent Annual Chance Flood Event Hazard	Number of Lifelines Exposed to 0.2-Percent Annual Chance Flood Event Hazard
Communications	9	0	0
Energy	12	0	1
Food, Water, Shelter	75	6	6
Hazardous Materials	20	0	0
Health and Medical	15	0	0
Safety and Security	463	60	62
Transportation	2	0	0
Sussex County (Total)	**596**	**66**	**69**

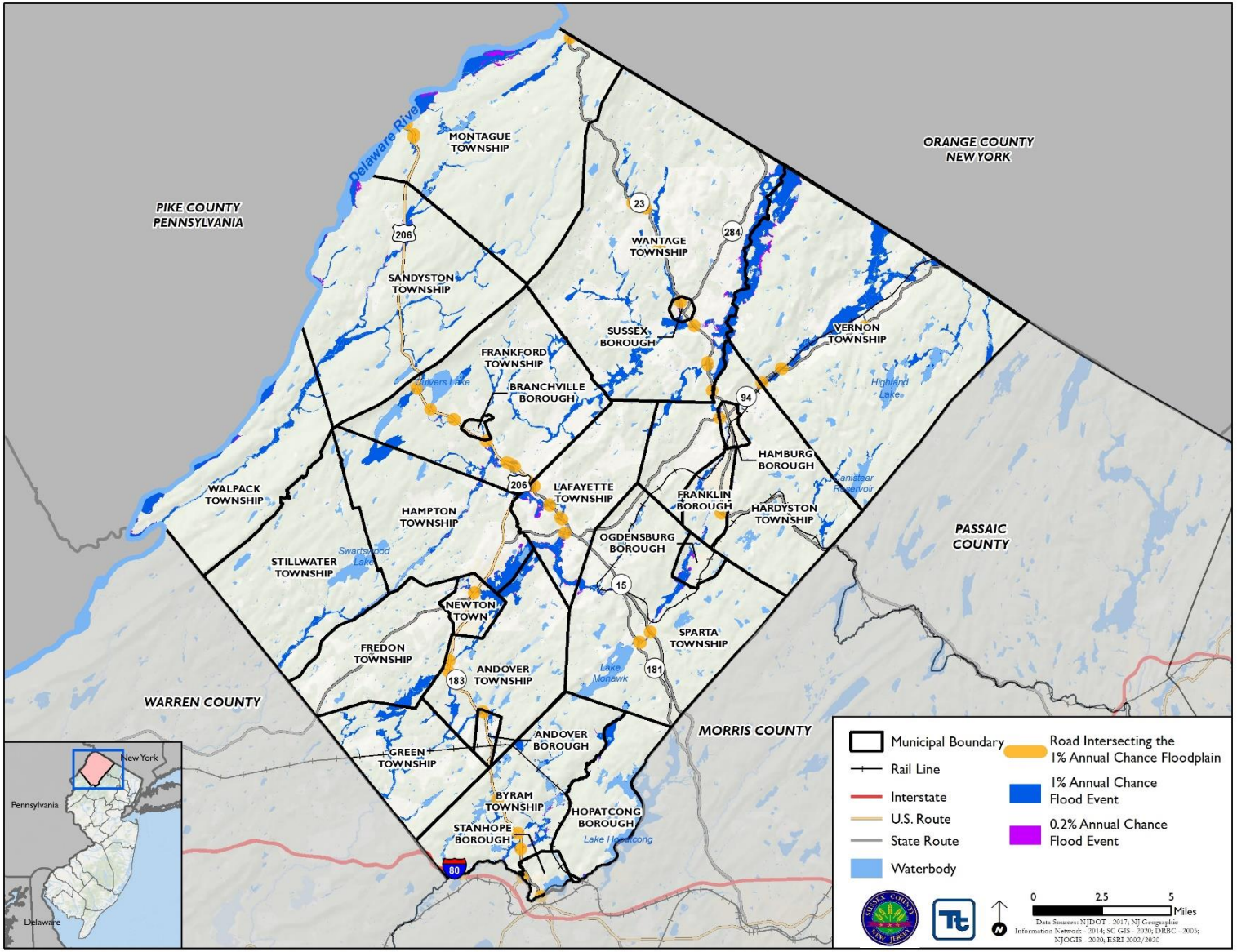
Sources: FEMA 2011/2020; Sussex County GIS 2020

Table 4.3.5-16. Major Transportation Routes Exposed to the Flood Hazard Areas

Road Type	Total Miles in the County	1-Percent Annual Chance Flood Event	
		Miles Located in the Hazard Area	Percent of Total
Local and Private Roads	1,337	19	1.4%
County Roads	313	5	1.6%
State Routes	86	1	1.2%
US Highways	34	1	2.9%
Interstate	1	<0.1	<0.1%
Sussex County (Total)	**1,771**	**26**	**1.5%**

Sources: Sussex County GIS 2020; NJDOT 2019; FEMA 2011

Figure 4.3.5-6. Major Roadways Located in the 1-percent Annual Chance Floodplain



Critical facilities and community lifelines that are near an area where frequent urban flooding occurs are even more vulnerable to flood damages. Urban flooding is defined by FEMA as flooding caused by rain that falls on densely populated areas that have increased amounts of impervious surfaces, which overwhelms the capacity of drainage systems (Natural Resources Defense Council 2019). This type of flooding can be exacerbated by riverine flooding within the County.

Debris from flood events may also affect culverts and sewer systems by creating bottlenecks in the wastewater system, which could not only cause or exacerbate localized urban flooding, but also cause wastewater to spill into homes and neighborhoods or contaminate local rivers and streams. As a result, contamination of drinking water supplies can be a significant secondary event created by major flood events.

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, impacts on tourism, and impacts on the tax base to Sussex County. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Sussex County. Other economic components such as loss of facility use, functional downtime and socio-economic factors are less measurable with a high degree of certainty.

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

Debris management may also be a large expense after a flood event. Hazus estimates the amount of debris generated from the 1-percent annual chance event. The model breaks down debris into three categories: (1) finishes (dry wall, insulation, etc.); (2) structural (wood, brick, etc.) and (3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. Table 4.3.5-17 summarizes the debris Hazus estimates for these events. As a result of the 1-percent annual chance event, Hazus estimates approximately 10,855 tons of debris will be generated in total. 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 4.3.5-17. Estimated Debris Generated from the 1-percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event Hazard Area			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Andover (B)	145	145	0	0
Andover (Twp)	38	38	0	0
Branchville (B)	65	65	0	0
Byram (Twp)	405	385	11	9
Frankford (Twp)	477	361	67	49
Franklin (B)	264	188	46	30
Fredon (Twp)	2	1	1	1
Green (Twp)	159	115	26	18
Hamburg (B)	0	0	0	0

Jurisdiction	1-Percent Annual Chance Flood Event Hazard Area			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Hampton (Twp)	27	27	0	0
Hardyston (Twp)	33	16	10	7
Hopatcong (B)	50	49	1	0
Lafayette (Twp)	138	130	4	3
Montague (Twp)	850	386	265	199
Newton (T)	371	336	22	14
Ogdensburg (B)	36	36	0	0
Sandyston (Twp)	259	174	50	35
Sparta (Twp)	3,564	698	1,765	1,101
Stanhope (B)	59	27	18	13
Stillwater (Twp)	152	127	15	10
Sussex (B)	284	209	43	32
Vernon (Twp)	1,411	955	276	180
Walpack (Twp)	1,227	52	675	500
Wantage (Twp)	837	532	179	127
Sussex County (Total)	**10,855**	**5,052**	**3,474**	**2,329**

Source: Hazus; FEMA 2011
Note: B – Borough; T – Town; Twp – Township

Impact on the Environment

As Sussex County communities grow, flood events may increase in frequency and/or severity as land use changes, more structures are built, and impervious surfaces expand. Furthermore, flood extents for the 1-percent and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as climate change and/or severity of storms. These flood events will impact Sussex County's natural and local environment.

Table 4.3.5-18 lists the number of acres exposed to the 1- and 0.2-percent annual chance flood extents by land use type. Non-residential land use types include forested and open space areas.

Table 4.3.5-18. Land Use Types in Sussex County Exposed to 1% and 0.2% Flood Extents

Land Use Type	Total Acres for County	1-Percent Annual Chance Flood Event		0.2-Percent Annual Chance Flood Event	
		Acres	Percent of Total	Acres	Percent of Total
Residential Land	54,839	811	1.5%	910	1.7%
Non-Residential Land	274,695	19,847	7.2%	20,701	7.5%
Natural Land	237,942	18,441	7.8%	19,138	8.0%
Total County Land	**342,701**	**27,961**	**8.2%**	**28,920**	**8.4%**

Source: NJDEP 2015, FEMA 2011
Notes: Area listed does not include water

Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of other hazards such as disease outbreak and landslides. After a flooding event, runoff can pick up and transport pollutants from wildlife and soils. Such organisms can then appear in water drinking facilities and transmit illnesses water-borne and vector diseases to the population (WHO, 2020). Flooding can also put additional strain on dams, which may lead to dam failure. More information about these hazards of concern can be found in Section 4.3.1 (Dam Failure) and Section 4.3.2 (Disease Outbreak).

Future Changes That May Impact Vulnerability

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

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

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Highlands Council has identified areas of potential growth (Existing Community Zones [where both in-fill of new development and/or re-development may occur], Designated Centers, as well as Sewer Service Areas) that may provide insight as to where potential new development may occur in Sussex County. In addition, each community was requested to provide potential major new development and infrastructure over the next five years; summarized in Section 9 (Jurisdictional Annexes).

An exposure analysis was conducted using the input from the communities as displayed in Figure 4.3.5-7 to determine if new development may be located in the floodplain. Based on the analysis, there is one potential new development located in the 1-percent and 0.2-percent annual chance floodplains, which is located in the Borough of Hamburg. The results of this analysis were shared with all jurisdictions. Being aware of these flood extents and requirements of protection will be critical for all future projects. The Sussex County Planning Board (SCPB) is responsible for review or approval of site plan and subdivision applications, and implementing the Sussex County Land Development Standards. Further, a site plan review process is done at the municipal level to ensure compliance with local ordinances.

Projected Changes in Population

Sussex County has experienced population decline since 2010. According to the U.S. Census Bureau, the County's population has decreased 4.7-percent between 2010 and 2018 (U.S. Census Bureau 2020). The Township of Walpack and the Borough of Sussex have experienced the greatest decline with a decrease of 62.5-percent and 13.0-percent, respectively. The population is expected to continue to decrease as residents move away from the suburbs and towards urban centers (Stirling 2018). Even though the population has decreased over the past decade, any changes in the density of population can impact the number of persons exposed to hurricanes and tropical storms. As the population changes, so will the number of people impacted by this hazard.

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.

Vulnerability Change Since 2016 HMP

The entire County continues to be vulnerable to the flood hazard. Since the 2016 analysis, population statistics have been updated using the 2014-2018 American Community Survey. The general building stock was also updated using RS Means 2020 building valuations that estimated replacement cost value for each building in the inventory. This provides an up-to-date look at the entire building stock for Sussex County and gives more accurate results for the exposure and loss estimation analysis. Additionally, the 2016 critical facility dataset was updated by the County and now includes FEMA community lifelines. A Hazus v4.2 riverine flood analysis of Sussex County was based on the most current and best available data, including building and critical facility inventories, and the FEMA 2011 effective DFIRM that was used in the last HMP to develop the 1-percent annual chance flood event depth grid and boundary as well as the 0.2-percent annual chance flood event boundary.

Figure 4.3.5-7. New Development in the Floodplain