5.4.5 Flood

The following section provides the hazard profile and vulnerability assessment for the flood hazard in Putnam County.

5.4.5.1 Profile

This section provides information regarding the description, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences for the flood hazard.

Hazard Description

Floods are one of the most common natural hazards in the U.S. 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). As defined in the NYS HMP (NYS DHSES 2019), flooding is a general and temporary condition of partial or complete inundation on normally dry land as a result of the following:

- Riverine overbank flooding
- Flash floods
- Alluvial fan floods
- Mudflows or debris floods
- Dam-break floods
- Local draining or high groundwater levels
- Fluctuating lake levels
- Ice-jams
- Coastal flooding
- Urban flooding

For the purpose of this HMP and as deemed appropriate by the Putnam County Steering Committee, coastal, riverine, flash, stormwater/urban, ice jam, and dam failure flooding are the main flood types of concern for the County. These types of flood are further discussed below.

Coastal Flooding

Coastal flooding occurs along the coasts of oceans, bays, estuaries, coastal rivers and large lakes. Coastal floods are the submersion of land areas along the ocean coast and other inland waters caused by seawater over and above normal tide action. Hurricanes, tropical storms and other storm events cause most of the coastal flooding in New York State. Coastal flooding may cause beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures. Coastal structures can include sea walls, piers, bulkheads, bridges, or buildings (FEMA 2011).

Coastal flooding conditions are defined by sea level relative to land. In tidally influenced bodies of water such as the Hudson River, sea level rise due to thermal expansion, glaciostatic adjustments, and other geological and climatological factors has been recorded and is anticipated to increase in the future. According to the New York State Energy Research and Development Authority (NYSERDA) estimates, as of 2014 sea level is anticipated to rise by three to eight inches on the Hudson River by the 2020s, nine to twenty-one inches by 2050s, and by fourteen to thirty-nine inches by the 2080s (NYSERDA 2014).

There are several forces that occur with coastal flooding:

- *Hydrostatic forces* against a structure are created by standing or slowly moving water. Flooding can cause vertical hydrostatic forces, or flotation. These types of forces are one of the main causes of flood damage.
- *Hydrodynamic forces* on buildings are created when coastal floodwaters move at high velocities. These high-velocity flows are capable of destroying solid walls and dislodging buildings with inadequate foundations. High-velocity flows can also move large quantities of sediment and debris that can cause additional damage. In coastal areas, high-velocity flows are typically associated with one or more of the following:
    - Storm surge and wave run-up flowing landward through breaks in sand dunes or across low-lying areas
    - Tsunamis
    - Outflow of floodwaters driven into bay or upland areas
    - Strong currents parallel to the shoreline, driven by waves produced from a storm
    - High-velocity flows

  High-velocity flows can be created or exacerbated by the presence of manmade or natural obstructions along the shoreline and by weak points formed by roads and access paths that cross dunes, bridges or canals, channels, or drainage features.
- *Waves* can affect coastal buildings from breaking waves, wave run-up, wave reflection and deflection, and wave uplift. The most severe damage is caused by breaking waves. The force created by these types of waves breaking against a vertical surface is often at least 10 times higher than the force created by high winds during a coastal storm.
- *Flood-borne debris* produced by coastal flooding events and storms typically includes decks, steps, ramps, breakaway wall panels, portions of or entire houses, heating oil and propane tanks, cars, boats, decks and pilings from piers, fences, erosion control structures, and many other types of smaller objects. Debris from floods are capable of destroying unreinforced masonry walls, light wood-frame construction, and small-diameter posts and piles (FEMA 2011).

Riverine (Inland)

Riverine floods are the most common flood type. They occur along a channel and include overbank and flash flooding. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (The Illinois Association for Floodplain and Stormwater Management 2006).

Flash Flooding

Flash floods are defined by the National Weather Service as "A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam." (NWS 2009).

Stormwater and Urban Flooding

Stormwater flooding described below is due to local drainage issues and high groundwater levels. Locally, heavy precipitation may produce flooding in areas other than delineated floodplains or along recognizable channels. If local conditions cannot accommodate intense precipitation through a combination of infiltration and surface runoff, water may accumulate and cause flooding problems. During winter and spring, frozen ground and snow accumulations may contribute to inadequate drainage and localized ponding. Flooding issues of this nature generally occur in areas with flat gradients and generally increase with urbanization which speeds the accumulation of floodwaters because of impervious areas. Shallow street flooding can occur unless channels have been improved to account for increased flows (FEMA 1997).

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).

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).

Ice Jam Flooding

An ice jam occurs when pieces of floating ice are carried with a stream's current and accumulate behind any obstruction to the stream flow. Obstructions may include river bends, mouths of tributaries, points where the river slope decreases, as well as dams and bridges. The water held back by this obstruction can cause flooding upstream, and if the obstruction suddenly breaks, flash flooding can occur as well (NOAA 2013). The formation of ice jams depends on the weather and physical condition of the river and stream channels. They are most likely to occur where the channel slope naturally decreases, in culverts, and along shallows where channels may freeze solid. Ice jams and resulting floods can occur during at different times of the year: fall freeze-up from the formation of frazil ice; mid-winter periods when stream channels freeze solid, forming anchor ice; and spring breakup when rising water levels from snowmelt or rainfall break existing ice cover into pieces that accumulate at bridges or other types of obstructions (NYS DHSES 2019).

Ice Jams At a Glance

- ✓ Freeze-up jams occur 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.

Dam Failure Flooding

A dam 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). Dams can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam (inadequate spillway capacity due to uncontrolled release or exceedance of design);
- 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 2010).

Extent

The severity of a flood event is typically determined by a combination of several factors including: stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and degree of vegetative clearing and impervious surface. Generally, floods are long-term events that may last for several days.

Riverine, Flash, Coastal, and Stormwater/Urban Flooding

Regarding the riverine flood hazard, once a river reaches flood stage, flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category is based on property damage and level of public threat (NWS 2011).

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

Ice Jam

Ice jam flooding events often occur suddenly and difficult to predict, allowing for little time to prepare for and warn of an event. The size of the snowpack and the rate of snowmelt controls the extent of an ice jam (Rokaya 2018).

Dam Failure

According to the NYSDEC Division of Water Bureau of Flood Protection and Dam Safety, the hazard classification of a dam is assigned according to the potential impacts of a dam failure pursuant to 6 New York Codes, Rules, and Regulations (NYCRR) Part 673.3 (NYSDEC 2009). Dams are classified in terms of potential for downstream damage if the dam were to fail. These hazard classifications are identified and defined below:

- *Low Hazard (Class A)* is a dam located in an area where failure will damage nothing more than isolated buildings, undeveloped lands, or township or county roads and/or will cause no significant economic loss or serious environmental damage. Failure or mis-operation would result in no probable loss of human life. Losses are principally limited to the owner's property
- *Intermediate Hazard (Class B)* is a dam located in an area where failure may damage isolated homes, main highways, minor railroads, interrupt the use of relatively important public utilities, and/or will cause significant economic loss or serious environmental damage. Failure or mis-operation would result in no probable loss of human life, but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- *High Hazard (Class C)* is a dam located in an area where failure may cause loss of human life, serious damage to homes, industrial or commercial buildings, important public utilities, main highways or railroads and/or will cause extensive economic loss. This is a downstream hazard classification for

dams in which excessive economic loss (urban area including extensive community, industry, agriculture, or outstanding natural resources) would occur as a direct result of dam failure.

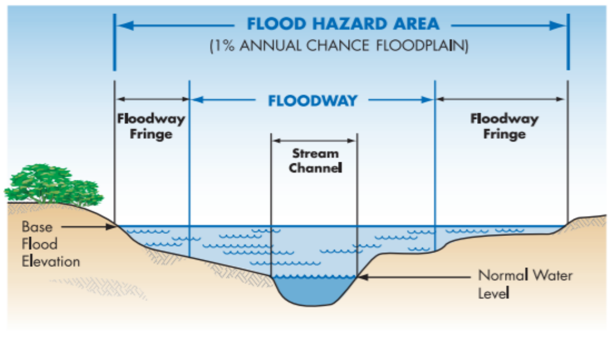
- *Negligible or No Hazard (Class D)* is (1) a dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or (2) a dam that was planned but never constructed. Class "D" dams are considered to be defunct dams posing negligible or no hazard. The department may retain pertinent records regarding such dams (NYSDEC 2009).

Location

Flooding potential is influenced by climatology, meteorology, and topography (elevations, latitude, and water bodies and waterways). Flooding potential for each type of flooding that affects Putnam County is described in the subsections below.

Floodplains

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 Putnam County, floodplains line the rivers and streams 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 (NJAFM 2015).



Source: NJAFM 2014

Flood Map Terms
• Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). • SFHA = the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. • 1-percent annual chance flood = the base flood or 100-year flood. • SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. • Zone B or Zone X (shaded) = Moderate flood hazard areas and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. • Zone C or Zone X (unshaded) = Areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled

Source: FEMA, 2018

Flood hazard areas are identified as Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1 percent chance of being equaled to or exceeded in any given year. The 1 percent annual chance flood is also referred to as the base flood or 100-year flood. 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. Similarly, the moderate flood hazard area (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 (FEMA 2020). The 1-percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements.

Locations of flood zones in Putnam County as depicted on the FEMA preliminary Digital Flood Insurance Rate Map (DFIRM) are illustrated in **Error! Reference source not found.** and the total land area in the floodplain, inclusive of waterbodies, is summarized in Table 5.4.5-1. Refer to Section 9 for a map of each jurisdiction depicting the floodplains. Flood hazard zones occur throughout the County.

Principal sources of flooding in Putnam include both the Hudson River and various tributaries. The East Branch Croton River produces flooding in the Village of Brewster, Patterson, and Southeast. The Hudson River produces tidal flooding in Cold Spring in low-lying shore areas. This was observed during Hurricane Sandy as shown in the below picture. Michael Brook, Tonetta Brook, Muddy Brook, Clove Creek, and Holly Stream are each smaller waterways that cause localized flooding in the County's various communities (FEMA 2013).

The Digital Flood Insurance Rate Map (DFIRM) data provided by FEMA for Putnam County show the following flood hazard areas: 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 A and Zone AE. Mandatory flood insurance requirements and floodplain management standards apply. Zone A and Zone AE do not have determined flood depths.
- 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.

Table 5.4.5-1.Total Land Area in the Floodplain (inclusive of waterbodies)

Jurisdiction	Total Area (acres)	1-Percent Annual Chance Flood Event		0.2-Percent Annual Chance Flood Event	
		Area (acres)	Percent of Total	Area (acres)	Percent of Total
Brewster (V)	286	27	9.4%	30	10.5%
Carmel (T)	26,134	3,553	13.6%	3,580	13.7%
Cold Spring (V)	544	208	38.2%	215	39.5%
Kent (T)	27,297	1,000	3.7%	1,035	3.8%
Nelsonville (V)	671	16	2.4%	18	2.7%
Patterson (T)	20,902	2,814	13.5%	2,948	14.1%
Philipstown (T)	31,986	2,267	7.1%	2,319	7.3%
Putnam Valley (T)	27,478	725	2.6%	794	2.9%
Southeast (T)	22,161	3,162	14.3%	3,243	14.6%
Putnam County (TOTAL)	**157,459**	**13,772**	**8.7%**	**14,182**	**9.0%**

Table 5.4.5-2 FEMA DFIRM Flood Hazard Areas in Putnam County

Jurisdiction	Total Area (acres)	1-Percent Annual Chance Flood Event		0.2-Percent Annual Chance Flood Event	
		Area (acres)	Percent of Total	Area (acres)	Percent of Total
Brewster (V)	286	27	9.4%	30	10.5%
Carmel (T)	26,134	3,553	13.6%	3,580	13.7%
Cold Spring (V)	544	208	38.2%	215	39.5%
Kent (T)	27,297	1,000	3.7%	1,035	3.8%
Nelsonville (V)	671	16	2.4%	18	2.7%
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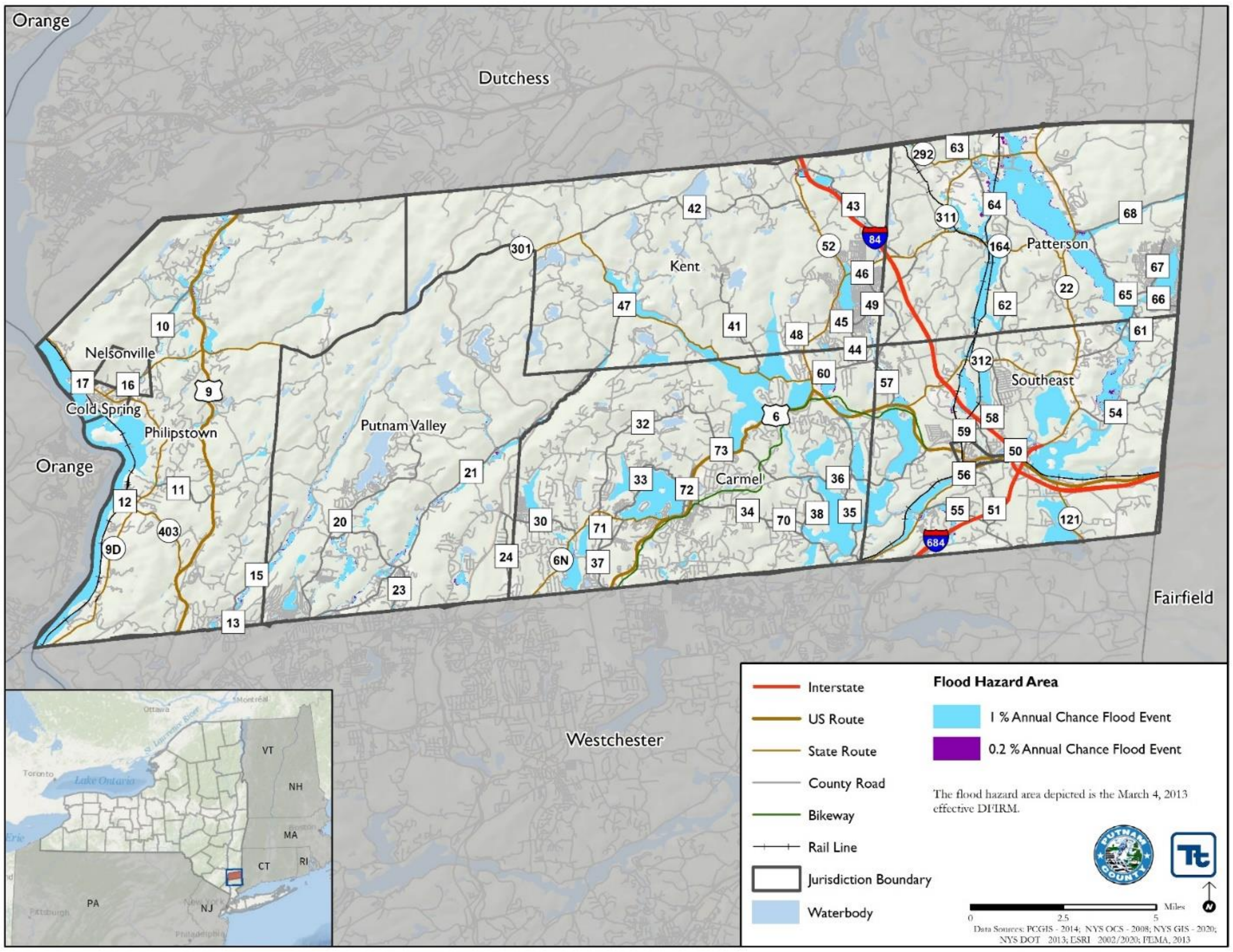
Jurisdiction	Total Area (acres)	1-Percent Annual Chance Flood Event		0.2-Percent Annual Chance Flood Event	
		Area (acres)	Percent of Total	Area (acres)	Percent of Total
Putnam County (TOTAL)	**157,459**	**13,772**	**8.7%**	**14,182**	**9.0%**

Source: Putnam County GIS 2014; FEMA 2013
Note: The area presented includes the area of waterways.
T = Town
V = Village

Figure 5.4.5-1 FEMA Flood Hazard Areas in Putnam County



Flood Gages

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.

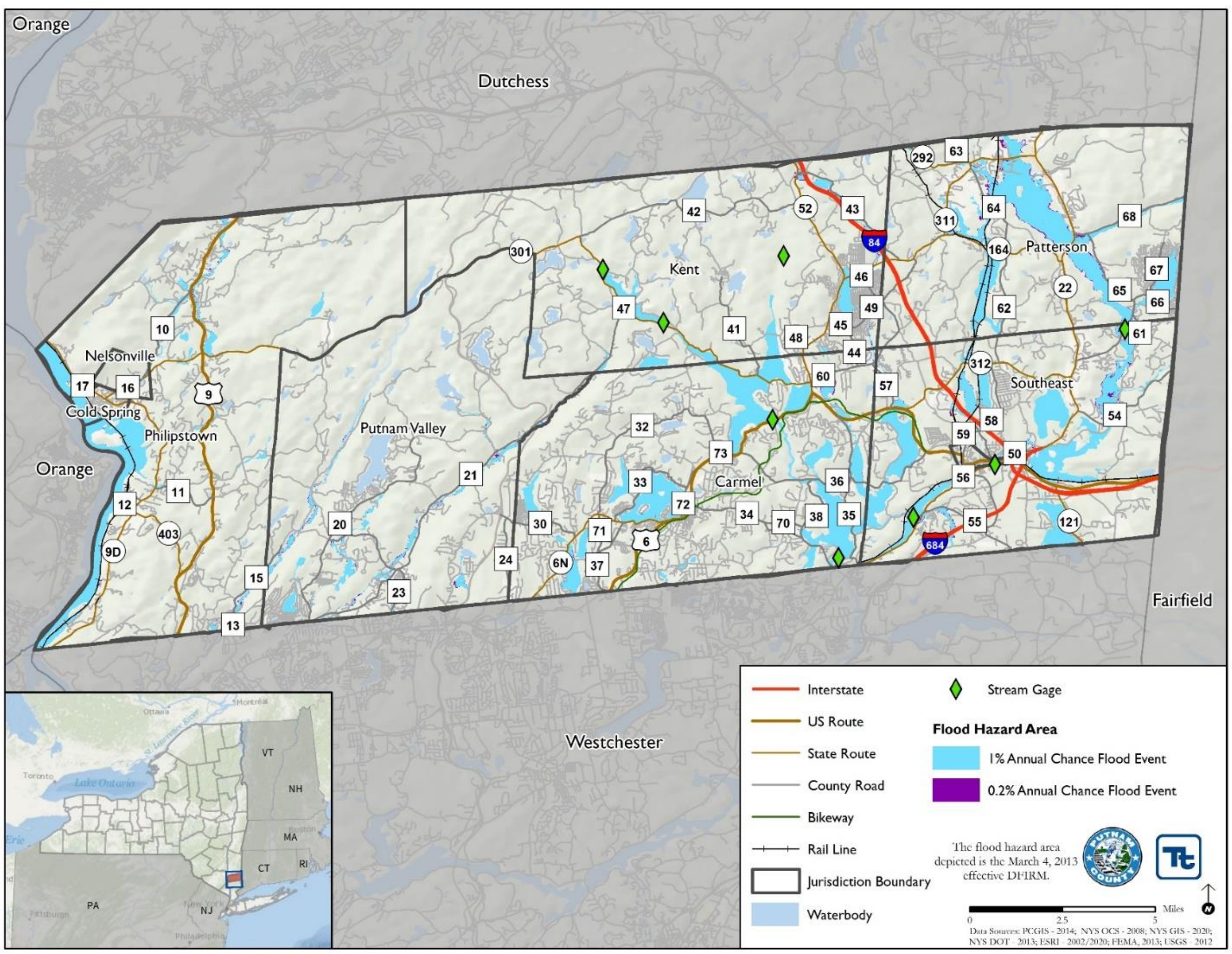
There are five stream gages in the County, none of which have defined flood and action stages. Table 5.4.5-3 and Figure show the gages in the County and details about each gage. The USGS website provides details about each of the gages (https://waterwatch.usgs.gov/index.php) and the gage heights of flooding events. The NWS provides the different flood stages for the gages (https://water.weather.gov/ahps/).

Table 5.4.5-3. Gages for Putnam County

Gage Site Number	Site Name	Flood Stage Data	Record Flood
01372043	Hudson River near Poughkeepsie*	No flood stage data available.	9.91 feet on Oct. 30, 2012
01374654**	Middle Branch Croton River near Carmel, NY	No flood stage data available.	1.19 feet on Aug 6, 7, 2010 and July 14, 15 2012
0137449480	East Branch Croton River near Putnam Valley, NY	No flood stage data available.	11.64 feet on Sept. 14, 2016
01374505	East Branch Croton River at Brewster, NY	No flood stage data available.	2.55 feet on Sept. 26, 2002
01374930	Muscoot River at Baldwin Place, NY	No flood stage data available.	3.53 feet on Aug. 15, 2010 and Sept. 7, 8, 28, 2015

Source: USGS 2020
** Tidal, outside of County*
Recent maximum stage (within the past 365 days)
***Gage is no longer active*

Figure 5.4.5-2. U.S. Stream Gages in Putnam County



Source: NOAA 2020

USGS uses stream gages to determine the severity of flood at different points along a body of water. There are several gages in Putnam County as shown in the table and figure above, in addition to others just outside of the County's boundary that provide critical flood data for waterways affecting the County. Though these gages actively record and display information about flooding, they do not have flood stage data calculated by the National Weather Service.

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

Riverine and Coastal Flooding

Putnam County is located within the Hudson River Basin. However, river basins are not the only areas of the State exposed to flood hazards. In some parts of New York State, annual spring floods result from snowmelt, and the extent of flooding depends on the depth of winter snowpack and spring weather patterns. In the northeast portions of the State, winter thaws, sometimes combined with rain, can also cause significant flooding. Riverine flooding is most severe in the Delaware, Susquehanna, Chemung, Erie-Niagara, Genesee, Allegany, Hudson, Mohawk, and Lake Champlain river basins (NYS DHSES 2014). New York State has over 3,000 miles of marine and lacustrine coastline that are often causes of flooding. This includes the areas adjacent to Lake Erie, Lake Ontario, the St. Lawrence and Niagara Rivers, Hudson River estuary, the Kill van Kull and Arthur Kill, Long Island Sound, and the Atlantic Ocean and their connecting bays, harbors, shallows and marshes. See Section 4 (County Profile) for information regarding the watersheds and drainage basins found within Putnam County.

In Putnam County, riverine flooding can be experienced along the County's many brooks and streams. The FEMA Flood Insurance Study specifically notes riverine flooding impacts along the East Branch Croton River and Tonetta Brook in Brewster, along Michael Brook in Carmel, along Muddy Brook Tributary 1 and East Branch Croton River in Patterson, Clove Creek in Philipstown, and East Branch Croton River, Tonetta Brook, and Holly Stream in the Town of Southeast. In all cases, localized flooding can be experienced due to periods of high-water following precipitation events.

Figure 5.4.5-3: Flooding in Cold Spring following Hurricane Sandy

Image credit: Highlands Current 2013

Putnam County's Hudson River shoreline is vulnerable to coastal flooding. The Hudson River is tidally influenced, and low-lying areas along the shoreline can be impacted during high-water events such as nor'easters and coastal storms. The Village of Cold Spring and the Town of Philipstown are particularly vulnerable to coastal flooding owing to waterfront development in Special Flood Hazard Areas.

Flash Flooding

Flash flooding can occur throughout any region of New York State; however, the distinctive flash flood event that is characterized by fast moving water and damaging impacts requires a steep topography. Areas of steep topography are found in the Allegany-Catskill plateau, which runs the entire width of New York State's Southern Tier, and the Adirondack Mountains to the north (NYS DHSES 2014, Armstrong 2016).

Stormwater and Urban Flooding

Urban and stormwater flooding has been reported at various locations in the County. Impacts are generally limited to roadways with underlying culverts. In various communities, such as the area surrounding Lake Mahopac in the Town of Carmel, the vicinity of Wiccopee Road in the Town of Putnam Valley, and Holmes in the Town of Patterson, poor drainage and rainstorms lead to localized flooding on various streets and in residential developments.

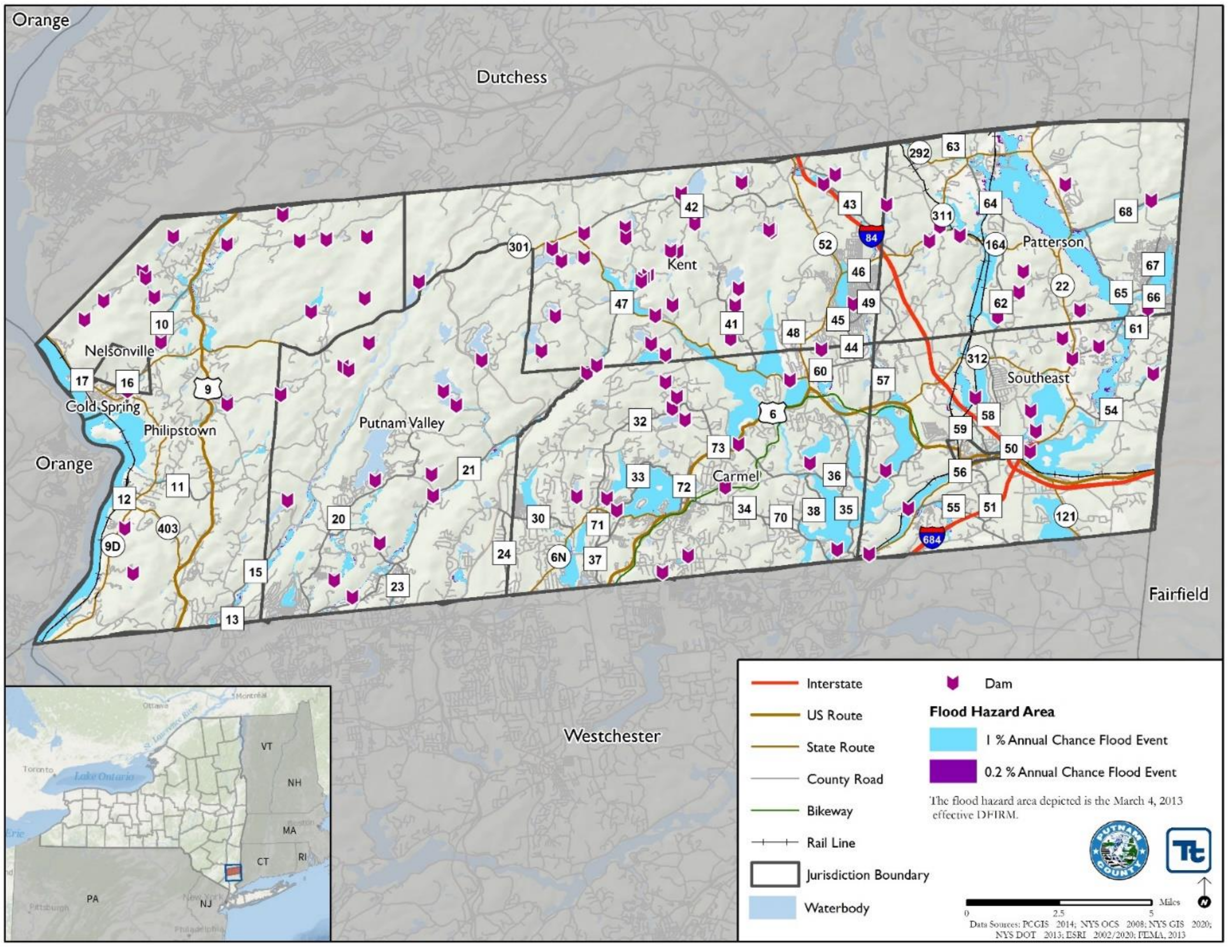
Ice Jams

There have been three instances of reported ice jams in Putnam County. According to the US Army Corps of Engineers CRREL database, ice jams in both 2000 and 2003 were reported along Horse Pond Brook near Lake Carmel in the Town of Kent. In 2002, a freeze-up event was reported along the Croton River near the intersection of John Simpson Road and Fair Street.

Dams and Flood Control Measures

NYSDEC maintains an inventory of dam failure data. Hazard classification, location, volume, elevation, and condition information for each dam in Putnam County that has a federal identification number is included in the inventory. Currently, there are 130 dams in Putnam County, as shown in Section 4 (County Profile). Of these 130 dams, 66 are low hazard, 28 are intermediate hazard, 21 are high hazard, 10 are negligible or no hazard classification, and five have an unknown classification (NYSDEC 2020).

Figure 5.4.5-4 Inventory of Dams in Putnam County



Previous Occurrences and Losses

Table 5.4.5-4 documents historical flood events from 1950 to December 2019 in Putnam County based on data collected from the NCEI, National Performance of Dams Program (NPDP), and Cold Regions Research and Engineering Laboratory (CRREL) databases.

Table 5.4.5-4. Flood Events 1950-2019

Hazard Type	Number of Occurrences Between 1996 and 2019	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Flash Flood	11	0	0	0	$0
Flood	15	0	0	$1,957,000	$0
Dam Failure	1	0	0	0	0
Ice Jam	3	0	0	0	0
TOTAL	**30**	**0**	**0**	**$1,957,000**	**$0**

Source: NOAA-NCEI 2020; CRELL 2020; NPDP 2020
Notes: CRELL data does not include information on total fatalities, injuries, property damages, or crop damages

FEMA Disaster Declarations

Between 1954 and April 2020, FEMA included New York State in 45 flood-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storms, flooding, storms, rain, landslides, severe storms, hurricane, and inland/coastal flooding. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Putnam County was included in 12 of these flood-related declarations; refer to Table 5.4.5-5.

Table 5.4.5-5. Flood-Related FEMA Declarations for Putnam County, 1954 to 2020

Disaster Number	Declaration Date	Event Date	Incident Type	Title
DR-4085	October 30, 2012	October 27, 2012 -- November 8, 2012	Hurricane	Hurricane Sandy
EM-3351	October 28, 2012	October 27, 2012 -- November 8, 2012	Hurricane	Hurricane Sandy
DR-4020	August 31, 2011	August 26, 2011 -- September 5, 2011	Hurricane	Hurricane Irene
EM-3328	August 26, 2011	August 25, 2011 -- September 5, 2011	Hurricane	Hurricane Irene
DR-1692	April 24, 2007	April 14, 2007 -- April 18, 2007	Severe Storm(s)	Severe Storms and Inland Coastal Flooding
DR-1589	April 19, 2005	April 2, 2005 -- April 4, 2005	Severe Storm(s)	Severe Storms and Flooding
DR-1534	August 3, 2004	May 13, 2004 -- June 17, 2004	Severe Storm(s)	Severe Storms and Flooding
DR-1296	September 19, 1999	September 16, 1999 -- September 18, 1999	Hurricane	Hurricane Floyd Major Disaster Declaration
EM-3149	September 18, 1999	September 16, 1999 -- September 18, 1999	Hurricane	Hurricane Floyd Disaster Declaration
DR-1095	January 24, 1996	January 19, 1996 -- January 30, 1996	Flood	Severe Storms and Flooding
DR-487	October 2, 1975	October 2, 1975	Flood	Storms, Rains, Landslides, and Flooding
DR-311	September 13, 1971	September 13, 1971	Flood	Severe Storms & Flooding

Source: FEMA 2020

Previous Events

For this update, flood events were summarized from 2015 to 2020. Known flood events, including FEMA disaster declarations, which have impacted Putnam County between 2015 and 2020 are identified in Table 5.4.5-6. Appendix E (Supplemental Data) contains details on flood events that occurred prior to 2015.

Table 5.4.5-6. Flooding Events in Putnam County Between 2015 and 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
July 7, 2015	Flash Flood	N/A	N/A	Showers and thunderstorms struct the area, producing heavy rain and localized flash flooding. A vehicle at the intersection of Routes 6, 202, and 22 in Brewster became stranded in high water.
July 28, 2018	Flash Flood	N/A	N/A	Scattered showers and thunderstorms across the Lower Hudson Valley caused isolated flash flooding in northeastern Putnam County. Approximately 1.4 inches of rain fell. Route 311 in Patterson and Ludingtonville Road along I-84 in Lake Carmel were closed due to flooding.

Source(s): NOAA-NCDC 2020;
Note: Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table.

Climate Change Projections

Climate change is affecting both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt in the State. *ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID)* was undertaken to provide decision-makers with information on the State's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA], 2011). Observed trends between 1901 and 2012 indicate that the greater Putnam County region has seen temperature increase of 0.22 degrees per decade and increases in precipitation of 0.9 inches per decade (NYSERDA, 2014).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Putnam County is part of Region 5, East Hudson and Mohawk River Valleys. Some of the issues in this region, affected by climate change, include more frequent heat waves and above 90°F days, more heat-related deaths, increased frequency of heavy precipitation and flooding, decline in air quality, etc. (NYSERDA, 2011).

Temperatures and precipitation amounts are expected to increase throughout the State as well as in Region 5.

NYSERDA's middle range estimates for precipitation change increases in the region call for between two and seven percent increases above the 1971-2000 baseline by 2020, and between four and twelve percent increases by 2050. By 2100, middle range estimates call for increases by between five and twenty-one percent above the 1971-2000 baseline (NYSERDA, 2014). Table 5.4.5-7 displays the projected seasonal precipitation change for the East Hudson and Mohawk River Valleys ClimAID Region (NYSERDA, 2011).

Table 5.4.5-7. Projected Seasonal Precipitation Change in Region 5, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	-5 to +10	-5 to +5	-5 to +10

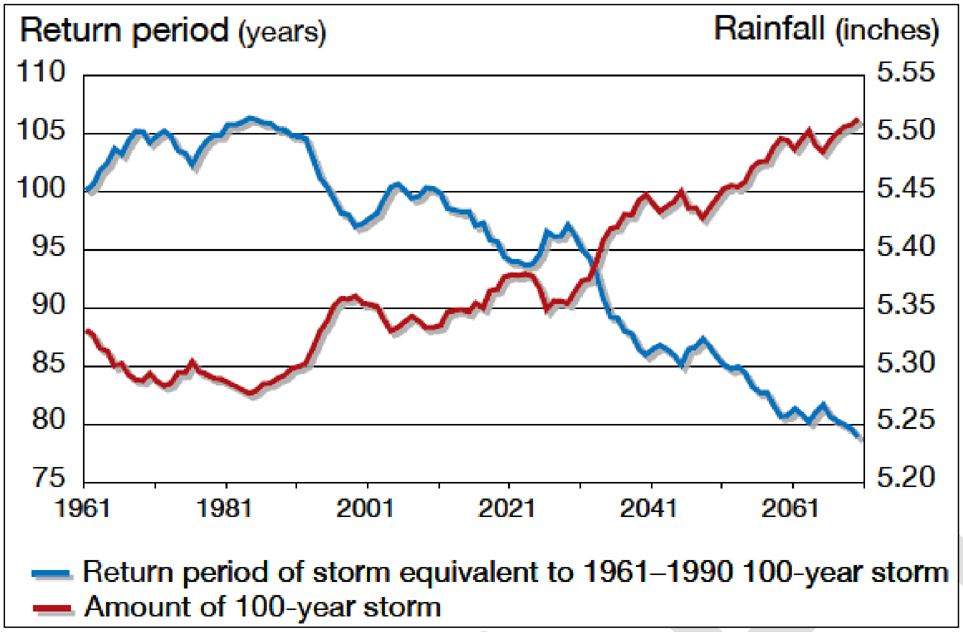
Source: NYSERDA 2011

The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways and transportation hugs; and increase delays and hazards related to extreme weather events (NYSERDA 2011).

Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA 2011). Table 5.4.5-8 displays the project rainfall and frequency of extreme storms in New York State. The amount of rain fall in a 100-year event is projected to increase, while the number of years between such storms (return period) is projected to decrease. Rainstorms will become more severe and more frequent (NYSERDA 2011).

Medium-range sea level rise estimates for the Lower Hudson region relative to the 2000-2004 baseline are six inches by the 2020s, 16 inches by the 2050s, 29 inches by the 2080s, and 36 inches by 2100. Low estimates are 4, 11, 18, and 22 inches respectively whereas high estimates are 10, 30, 58, and 75 inches respectively (NYSDEC 2020).

Table 5.4.5-8. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA 2011

Assumptions about a river's flow behavior, expressed as hydrographs are influences for dam design. 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 possibility that floodwaters would overtop the dam or create unintended loads, which could lead to a dam failure.

Increases in sea level rise will impact Putnam County's coastal floodplain. The Hudson River in the vicinity of Putnam County is tidally influenced and subject to changes in global sea level. The table below shows the estimated increase in square miles of floodplain based on the extent of Putnam County's current floodplain (NYSERDA 2016).

Table 5.4.5-9. Increase in Acreage of Floodplain Due to Sea Level Rise in Putnam County

		Sea Level Rise (Feet)						
		1	1.5	2	3	4	5	6
Annual Chance Flood Elevations	10%	57.6	70.4	83.2	102.4	128	153.6	179.2
	2%	25.6	38.4	51.2	76.8	102.4	121.6	140.8
	1%	25.6	38.4	51.2	76.8	96	115.2	128
	0.2%	25.6	32	38.4	57.6	70.4	89.6	102.4

Source: NYSERDA 2016

Probability of Future Occurrences

Based on the historic and more recent flood events in Putnam County, and the future climate projections for this region, the County has a moderate probability of future flooding. It is anticipated that Putnam County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences. Additionally, climate change is expected to increase the severity and frequency of heavy rain events in Putnam County. This is likely to lead to an increase in flooding events and dam failure events.

As defined by FEMA, Putnam County's 1-percent annual chance flood area is estimated to have a one-percent chance of flooding in any given year. A structure located within a 1-percent annual chance flood area has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Similarly, the 0.2-percent annual chance flood has a 6-percent chance of occurring during a 30-year time period.

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 and/or frequency of maintenance decreases.

According to the NOAA NCEI, Putnam County experienced 35 flood events between 1954 and April 2020, including 17 floods, 14 flash floods, one dam failure, and three ice jams. The table below shows these statistics, as well as the annual average number of events and the percent chance of these individual flood hazards occurring in Putnam County in future years based on the historic record (NOAA NCDC 2020.

Table 5.4.5-10. Probability of Future Occurrence of Flooding Events

Hazard Type	Number of Occurrences Between 1954 and 2019	% chance of occurrence in any given year
Flash Flood	14	21.2%
Flood	17	25.8%
Dam Failure	1	1.5%
Ice Jam	3	4.6%
TOTAL	**35**	**53.0%**

Source: NOAA-NCEI 2020; CRELL 2020; NPDP 2020; FEMA 2020
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act (Public Law 81-875), and selected flood events since 1996. Due to limitations in data, not all flood events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

In Section 5.3, the identified hazards of concern for Putnam County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records, the probability of occurrence for flood in the county is considered 'occasional' (hazard event has between 10% and 100% annual probability of occurring). In consultation with the Planning Committee, this was revised to "Frequent" for risk ranking. This is due to the fact that many localized flood events are not documented but contribute to the overall probability of flood events.

5.4.5.2 Vulnerability Assessment

To assess Putnam County's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. The 1-percent annual chance flood event was examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA HAZUS-MH v4.2 riverine model. These results are summarized below. Refer to Section 5.1 (Methodology) for additional details on the methodology used to assess flood risk.

Impact on Life, Health and Safety

The impact of flooding on life, health and safety is dependent upon several factors including the severity of the event and whether 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 limited to persons who reside in a defined hazard zone, but includes 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.

894 Residents Exposed to 1% Annual Flood Event

Based on the spatial analysis, there are an estimated 894 people living in the 1-percent annual chance flood event hazard area (refer to Table 5.4.5-11. 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 Town of Philipstown has the greatest percentage of its population located in the 1-percent annual chance flood event hazard area; approximately 2.7-percent. The Town of Putnam Valley has the greatest number of residents located in the 1- and the 0.2-percent annual chance flood event hazard area; approximately 203 persons and 248 persons, respectively. Overall, 1.1-percent of the Putnam County's residence live in the 0.2-percent annual chance flood event hazard area.

Highest Population Exposure (2.7%) **Philipstown**

For this project, the potential population exposed is used as a guide for planning purposes.

Table 5.4.5-11 Estimated Population Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Jurisdiction	Total Population	Population Exposed to the 1-Percent Annual Chance Flood Event		Population Exposed to the 0.2-Percent Annual Chance Flood Event	
		Number	Percent of Total	Number	Percent of Total
Brewster (V)	2,087	0	0.0%	0	0.0%
Carmel (T)	34,227	73	0.2%	122	0.4%
Cold Spring (V)	1,862	42	2.2%	54	2.9%
Kent (T)	13,325	25	0.2%	27	0.2%
Nelsonville (V)	699	17	2.5%	23	3.3%
Patterson (T)	11,922	170	1.4%	192	1.6%
Philipstown (T)	7,163	191	2.7%	237	3.3%
Putnam Valley (T)	11,654	203	1.7%	248	2.1%
Southeast (T)	16,131	173	1.1%	194	1.2%
Putnam County (TOTAL)	**99,070**	**894**	**0.9%**	**1,097**	**1.1%**

Sources: FEMA DFIRM 2013; American Community Survey 2018 (ACS 2014-2018)
Note: T = Town; V = Village

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 age 65. Economically disadvantaged populations may be 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 Putnam County, there are approximately 16,053 people over the age of 65 and 5,191 people below the poverty level (American Community Survey 2018).

The Centers for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Putnam County's overall score is 0.117, indicating that its communities have a relatively low social vulnerability (CDC 2016). However, portions of the Town of Patterson and the Town of Southeast have scores of 0.5369 and 0.6227, respectively, indicating these communities have a relatively high social vulnerability (CDC 2016). These scores indicate that some County residents may not have enough resources to respond to flood events.

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 83 households will be displaced, and 0 people will seek short-term sheltering. These statistics are presented in Table 5.4.5-12 by jurisdiction. 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. Displaced population accounts for households in the inundation area that would be displaced due to evacuations or restricted access due to flooded roadways.

Table 5.4.5-12 Estimated Population Displaced or Seeking Short-Term Shelter from the 1-Percent Annual Chance Flood Event Hazard Area

Jurisdiction	Population (American Community Survey 5-Year estimates 2014 - 2018)	1-Percent Annual Chance Flood Event	
		Displaced Population*	Persons Seeking Short-Term Sheltering*
Brewster (V)	2,087	0	0
Carmel (T)	34,227	19	0
Cold Spring (V)	1,862	3	0
Kent (T)	13,325	15	0
Nelsonville (V)	699	0	0
Patterson (T)	11,922	4	0
Philipstown (T)	7,163	0	0
Putnam Valley (T)	11,654	26	0
Southeast (T)	16,131	16	0
Putnam County (TOTAL)	**99,070**	**83**	**0**

Sources: HAZUS v4.2; FEMA 2013; American Community Survey 2018 (ACS 2014-2018)
Note: T = Town; V = Village
**Population results generated by HAZUS-MH v4.2 are using 2010 Census population statistics and may be underestimated*

Injuries and Casualties

Total number 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, ice jam, and dam failure 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.

Public Health Impacts

Cascading impacts of flooding and dam failure inundation 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 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 v4.2 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 or those that are built downstream in other flood inundation areas such as dam failure inundation areas. Potential damage is the modeled loss that could occur to the exposed inventory measured by the structural and content replacement cost value.

There are an estimated 359 buildings located in the 1-percent annual chance flood event hazard area with a value of approximately $439 million of building and contents (based on replacement cost value). This represents approximately 1.1-percent of the County's total general building stock inventory replacement cost value (approximately $439 billion). The Town of Philipstown has the greatest percentage of its buildings located in the floodplain; 2.9-percent or 81 buildings of its total building stock. Table 5.4.5-13 presents a summary of 1- and 0.2 percent flood inundation area exposure results by jurisdiction. Table 5.4.5-14 and Table 5.4.5-15 break down the 1-percent and 0.2-percent annual chance flood event exposure results for residential structures and commercial structures, respectively.

Furthermore, HAZUS-MH v4.2 estimates approximately $76.5 million in building and content damage as a result of the 1-percent annual chance flood event (or 0.3-percent of the total building stock replacement cost value). Of the $76.5 million in potential loss, approximately $31.3 million losses are estimated to occur to residential structures. Refer to Table 5.4.5-16 for the potential losses from the 1-percent annual chance flood event for all occupancies estimated by jurisdiction. Table 5.4.5-17 and Table 5.4.5-18 summarize HAZUS-MH v4.2 estimated damages for residential and commercial occupancy classes, respectively.

Table 5.4.5-13 Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Total (All Occupancies) 1-Percent Annual Chance Flood Event Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total	0.2-Percent Annual Chance Flood Event Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total
Brewster (V)	406	$665,633,363	1	0.2%	$733,092	0.1%	2	0.5%	$1,825,794	0.3%
Carmel (T)	10,170	$9,304,370,987	33	0.3%	$84,258,333	0.9%	49	0.5%	$104,244,301	1.1%
Cold Spring (V)	679	$790,405,963	16	2.4%	$40,093,857	5.1%	21	3.1%	$46,595,102	5.9%
Kent (T)	5,021	$2,983,284,562	14	0.3%	$24,997,267	0.8%	19	0.4%	$33,438,156	1.1%
Nelsonville (V)	261	$209,404,256	7	2.7%	$5,928,853	2.8%	9	3.4%	$8,686,669	4.1%
Patterson (T)	3,393	$2,927,865,178	63	1.9%	$70,912,044	2.4%	71	2.1%	$86,535,212	3.0%
Philipstown (T)	2,767	$2,629,391,554	81	2.9%	$64,879,264	2.5%	100	3.6%	$74,457,453	2.8%
Putnam Valley (T)	4,521	$3,314,750,529	83	1.8%	$75,890,276	2.3%	100	2.2%	$93,571,147	2.8%
Southeast (T)	4,128	$4,717,511,487	61	1.5%	$72,147,560	1.5%	66	1.6%	$75,750,050	1.6%
Putnam County (TOTAL)	**31,346**	**$27,542,617,878**	**359**	**1.1%**	**$439,840,545**	**1.6%**	**437**	**1.4%**	**$525,103,885**	**1.9%**

Sources: FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

Table 5.4.5-14 Estimated General Building Stock Exposure to the 1-percent and 0.2- Percent Annual Chance Flood Events – Residential Occupancy Class

Jurisdiction	Total Number of Buildings (Residential Structures Only)	Total Replacement Cost Value (Residential Structures Only)	Residential 1-Percent Annual Chance Flood Event Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total	0.2-Percent Annual Chance Flood Event Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total
Brewster (V)	347	$62,396,916	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Carmel (T)	9,793	$829,296,526	21	0.2%	$15,407,545	1.9%	35	0.4%	$31,411,737	3.8%
Cold Spring (V)	625	$63,876,437	14	2.2%	$35,608,164	55.7%	18	2.9%	$41,239,017	64.6%
Kent (T)	4,891	$184,979,508	9	0.2%	$12,542,679	6.8%	10	0.2%	$13,631,256	7.4%
Nelsonville (V)	244	$13,715,502	6	2.5%	$5,274,285	38.5%	8	3.3%	$8,032,102	58.6%
Patterson (T)	3,231	$335,719,651	46	1.4%	$27,777,363	8.3%	52	1.6%	$33,023,894	9.8%
Philipstown (T)	2,627	$285,557,538	70	2.7%	$51,109,904	17.9%	87	3.3%	$58,954,341	20.6%
Putnam Valley (T)	4,412	$157,180,603	77	1.7%	$61,979,413	39.4%	94	2.1%	$79,660,284	50.7%
Southeast (T)	3,829	$876,664,459	41	1.1%	$38,232,009	4.4%	46	1.2%	$41,834,500	4.8%
Putnam County (TOTAL)	**29,999**	**$2,809,387,140**	**284**	**0.9%**	**$247,931,363**	**8.8%**	**350**	**1.2%**	**$307,787,131**	**11.0%**

Sources: FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

Table 5.4.5-15 Estimated General Building Stock Exposure to the 1-percent and 0.2- Percent Annual Chance Flood Events – Commercial Occupancy Class

Jurisdiction	Total Number of Buildings (Commercial Buildings Only)	Total Replacement Cost Value (Commercial Buildings Only)	Commercial							
			1-Percent Annual Chance Flood Event				0.2-Percent Annual Chance Flood Event			
			Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total	Number of Buildings	Percent Total	Replacement Cost Value (RCV)	Percent Total
Brewster (V)	39	$62,396,916	0	0.0%	$0	0.0%	1	2.6%	$1,092,703	1.8%
Carmel (T)	278	$829,296,526	10	3.6%	$57,619,488	6.9%	12	4.3%	$61,601,265	7.4%
Cold Spring (V)	31	$63,876,437	2	6.5%	$4,485,693	7.0%	3	9.7%	$5,356,085	8.4%
Kent (T)	96	$184,979,508	3	3.1%	$6,601,020	3.6%	6	6.3%	$9,931,566	5.4%
Nelsonville (V)	8	$13,715,502	1	12.5%	$654,567	4.8%	1	12.5%	$654,567	4.8%
Patterson (T)	114	$335,719,651	13	11.4%	$38,399,178	11.4%	15	13.2%	$48,775,814	14.5%
Philipstown (T)	107	$285,557,538	11	10.3%	$13,769,360	4.8%	13	12.1%	$15,503,112	5.4%
Putnam Valley (T)	77	$157,180,603	5	6.5%	$13,010,517	8.3%	5	6.5%	$13,010,517	8.3%
Southeast (T)	194	$876,664,459	5	2.6%	$14,119,563	1.6%	5	2.6%	$14,119,563	1.6%
Putnam County (TOTAL)	**944**	**$2,809,387,140**	**50**	**5.3%**	**$148,659,387**	**5.3%**	**61**	**6.5%**	**$170,045,192**	**6.1%**

Sources: FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

Table 5.4.5-16 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Total Replacement Cost Value (RCV)	All Occupancies 1-Percent Annual Chance Flood Event	
		Estimated Loss Replacement Cost Value (RCV)	Percent of Total
Brewster (V)	$665,633,363	$0	0.0%
Carmel (T)	$9,304,370,987	$15,156,994	0.2%
Cold Spring (V)	$790,405,963	$2,135,921	0.3%
Kent (T)	$2,983,284,562	$2,919,076	0.1%
Nelsonville (V)	$209,404,256	$671,585	0.3%
Patterson (T)	$2,927,865,178	$18,849,379	0.6%
Philipstown (T)	$2,629,391,554	$9,970,050	0.4%
Putnam Valley (T)	$3,314,750,529	$11,016,386	0.3%
Southeast (T)	$4,717,511,487	$15,866,008	0.3%
Putnam County (TOTAL)	$27,542,617,878	$76,585,399	0.3%

Sources: HAZUSv4.2; FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

Table 5.4.5-17 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Residential Occupancy Class

Jurisdiction	Total Replacement Cost Value (Residential Only)	Residential Losses Only 1-Percent Annual Chance Flood Event	
		Estimated Loss Replacement Cost Value (RCV)	Percent of Total
Brewster (V)	$406,206,533	$0	0.0%
Carmel (T)	$1,001,461,770	$1,346,193	0.1%
Cold Spring (V)	$234,785,887	$196,734	0.1%
Kent (T)	$180,659,340	$995,932	0.6%
Nelsonville (V)	$46,137,022	$439,526	1.0%
Patterson (T)	$208,480,245	$5,263,471	2.5%
Philipstown (T)	$65,257,013	$7,508,099	11.5%

Jurisdiction	Total Replacement Cost Value (Residential Only)	Residential Losses Only 1-Percent Annual Chance Flood Event Estimated Loss Replacement Cost Value (RCV)	Percent of Total
Putnam Valley (T)	$104,416,176	$8,675,519	8.3%
Southeast (T)	$300,078,084	$6,890,246	2.3%
Putnam County (TOTAL)	$2,547,482,070	$31,315,720	1.2%

Sources: HAZUSv4.2; FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

Table 5.4.5-18 Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Commercial Occupancy Class

Jurisdiction	Total Replacement Cost Value (Commercial Only)	Commercial Losses Only 1-Percent Annual Chance Flood Event Estimated Loss Replacement Cost Value (RCV)	Percent of Total
Brewster (V)	$62,396,916	$0	0.0%
Carmel (T)	$829,296,526	$9,982,455	1.2%
Cold Spring (V)	$63,876,437	$1,939,187	3.0%
Kent (T)	$184,979,508	$615,531	0.3%
Nelsonville (V)	$13,715,502	$232,060	1.7%
Patterson (T)	$335,719,651	$12,281,863	3.7%
Philipstown (T)	$285,557,538	$2,461,951	0.9%
Putnam Valley (T)	$157,180,603	$1,991,219	1.3%
Southeast (T)	$876,664,459	$2,354,874	0.3%
Putnam County (TOTAL)	**$2,809,387,140**	**$31,859,140**	**1.1%**

Sources: HAZUSv4.2; FEMA 2013, Putnam County GIS 2014; RS Means 2019
Note: T = Town; V = Village

NFIP Statistics

FEMA Region 2 provided a list of NFIP policies, past claims, and repetitive loss properties (RL) in Putnam 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 5.4.5-19 shows that there are more NFIP claims than policies in Putnam County reported. This is likely because multiple repetitive loss properties submitted more than one flood loss claim under their NFIP policy. Note that specific locations of repetitive loss properties were not made available for this Plan.

Table 5.4.5-19 . Repetitive Loss Properties and NFIP Data for Putnam County

Jurisdiction	Number of Repetitive Loss Properties	Number of Policies	Number of Claims	Total Losses Claimed
Brewster (V)	0	1	7	$41,241
Carmel (T)	10	73	122	$288,727

Jurisdiction	Number of Repetitive Loss Properties	Number of Policies	Number of Claims	Total Losses Claimed
Cold Spring (V)	10	21	29	$1,906,668
Kent (T)	2	17	19	$28,812
Nelsonville (V)	0	3	3	$32,205
Patterson (T)	0	20	11	$20,454
Philipstown (T)	13	72	47	$1,119,896
Putnam Valley (T)	22	52	82	$1,307,412
Southeast (T)	2	43	13	$27,544
Putnam County (Total)	**59**	**302**	**333**	**$4,772,959**

Source: FEMA Region 2, 2020
Note: NFIP = National Flood Insurance Program, V = Village, T = Town

Impact on Land Uses

An exposure analysis was completed to determine the acres of developed residential land and developed non-residential land use types located in the 1-percent flood hazard area. To estimate exposure for developed residential and non-residential land use types to the 1-percent flood hazard area, the floodplain boundary was overlaid upon land use data. Refer to Table 5.4.5-20 for a complete summary of this analysis.

Table 5.4.5-20 Developed Residential and Non-Residential Land Use Exposed to 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

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	10,273	259	2.5%	307	3.0%
Non-Residential Land	138,249	6,713	4.9%	7,067	5.1%
Natural Land	117,687	6,026	5.1%	6,314	5.4%
Putnam County (Total Land)	**148,522**	**6,972**	**4.7%**	**7,374**	**5.0%**

Sources: FEMA 2013, Putnam County GIS 2020; NLCD 2016
Notes: Land use areas do not include areas of water. Non-residential area = Agriculture, Barren, Developed – Open Space, Forest, Wetlands; This analysis does not incorporate areas delineated as water. Residential area = Developed – low intensity, Developed – medium intensity, and Developed – high intensity.

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 reach vulnerable populations or to make repairs.

Approximately 28.7% of all roadways are located within the 1-percent annual chance flood event.

Major roadways that may be impacted by the 1-percent annual chance flood event include the U.S. Routes 6 and 9, Interstate 684 and 84, State Roads NY-164, NY-22, NY-292, NY-301, NY-311, NY-52, NY-6N, and NY-9D and various county roads. Approximately 28.7 percent of all roadways are located within the 1-percent annual chance flood event. Table 5.4.5-21 summarizes the road types and mileage located within the 1-percent annual chance flood event. Overall, over 420 miles of roadway would be impacted by the 1-percent annual chance flood in which the majority of roads are local (390 miles).

Issues associated with floodprone roadway include:

- **Isolation**: Bridges washed out or blocked by floods or debris also can cause isolation.
- **Insufficient Sewer Capacity**: Water and sewer systems can be flooded or backed up, causing health problems. Floodwaters can get into drinking water supplies, causing contamination.
- **Debris Blockages**: 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.

Table 5.4.5-21 Road Miles Located in the 1-Percent Annual Chance Flood Hazard Area

Road Type	Total Miles for County	1-Percent Annual Chance Event	
		Miles	Percent of Total
Local and Private Roads	1,207	390	32.3%
County Roads	117	15	12.8%
State Routes	73	10	13.7%
Interstate	34	4	11.8%
US Route	29	3	10.3%
Bikeway	11	1	9.1%
Putnam County (Total)	1,471	423	28.7%

Critical facility exposure to the 1-percent annual chance flood hazard event boundary 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. HAZUS-MH v4.2 results can be found in Volume II, Jurisdiction Annexes. Table 5.4.5-22 summarizes the number of critical facilities exposed to the 1-percent and 0.2-percent flood inundation areas by jurisdiction. Table 5.4.5-23 and Table 5.4.5-24 provides the distribution of critical facilities in the 1-percent and 0.2-percent annual chance flood event boundary. Of the 37 critical facilities located in the 1-percent annual chance flood event boundary, 31 are considered lifelines for the County (Table 5.4.5-25). Refer to Section 4 (County Profile) for more information about the critical facilities and lifelines in Putnam County.

Table 5.4.5-22 Number of Critical and Lifeline Facilities Located in the 1-Percent and 0.2-Percent Annual Chance Flood Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to the 0.1-Percent Annual Chance Flood Event				Number of Critical Facilities and Lifeline Facilities Exposed to the 0.2-Percent Annual Chance Flood Event			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines	Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Brewster (V)	36	29	2	5.6%	2	6.9%	2	5.6%	2	6.9%
Carmel (T)	127	111	15	11.8%	14	12.6%	15	11.8%	14	12.6%
Cold Spring (V)	13	11	3	23.1%	1	9.1%	3	23.1%	1	9.1%
Kent (T)	41	31	3	7.3%	2	6.5%	3	7.3%	2	6.5%

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to the 0.1-Percent Annual Chance Flood Event				Number of Critical Facilities and Lifeline Facilities Exposed to the 0.2-Percent Annual Chance Flood Event			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines	Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Nelsonville (V)	4	4	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Patterson (T)	72	66	6	8.3%	6	9.1%	7	9.7%	7	10.6%
Philipstown (T)	23	22	1	4.3%	0	0.0%	1	4.3%	0	0.0%
Putnam Valley (T)	27	15	2	7.4%	1	6.7%	2	7.4%	1	6.7%
Southeast (T)	76	74	5	6.6%	5	6.8%	5	6.6%	5	6.8%
Putnam County (TOTAL)	**419**	**363**	**37**	**8.8%**	**31**	**8.5%**	**38**	**9.1%**	**32**	**8.8%**

Sources: FEMA 2013, Putnam County GIS 2020
Notes: T= Town; V= Village

Table 5.4.5-23 Distribution of Critical Facilities in the 1-Percent Annual Chance Flood Event Floodplain by Type and Jurisdiction

Jurisdiction	Facility Types											
	Cultural	Dam	Electric	Government	Highway Bridge	Marina	Medical	Potable Water	Rail Bridge	Rail Facility	Senior Facility	Wastewater Facility
Brewster (V)	0	0	0	0	0	0	0	0	0	1	0	1
Carmel (T)	1	4	0	2	0	0	2	3	0	0	1	2
Cold Spring (V)	0	1	0	0	0	1	0	0	0	0	0	1
Kent (T)	0	1	0	0	2	0	0	0	0	0	0	0
Nelsonville (V)	0	0	0	0	0	0	0	0	0	0	0	0
Patterson (T)	0	1	0	0	3	0	0	0	1	0	0	1
Philipstown (T)	0	1	0	0	0	0	0	0	0	0	0	0
Putnam Valley (T)	0	1	0	1	0	0	0	0	0	0	0	0
Southeast (T)	0	3	1	0	0	0	0	1	0	0	0	0
Putnam County (TOTAL)	**1**	**12**	**1**	**3**	**5**	**1**	**2**	**4**	**1**	**1**	**1**	**5**

Sources: FEMA 2013, Putnam County GIS 2020
Notes: T= Town; V= Village

Table 5.4.5-24 Distribution of Critical Facilities in the 0.2-Percent Annual Chance Flood Event Floodplain by Type and Jurisdiction

Jurisdiction	Facility Types												
	Cultural	Dam	Electric	Government	Highway Bridge	Marina	Medical	Natural Gas Facility	Potable Water	Rail Bridge	Rail Facility	Senior Facility	Wastewater Facility
Brewster (V)	0	0	0	0	0	0	0	0	0	0	1	0	1

Jurisdiction	Facility Types: Cultural	Dam	Electric	Government	Highway Bridge	Marina	Medical	Natural Gas Facility	Potable Water	Rail Bridge	Rail Facility	Senior Facility	Wastewater Facility
Carmel (T)	1	4	0	2	0	0	2	0	3	0	0	1	2
Cold Spring (V)	0	1	0	0	0	1	0	0	0	0	0	0	1
Kent (T)	0	1	0	0	2	0	0	0	0	0	0	0	0
Nelsonville (V)	0	0	0	0	0	0	0	0	0	0	0	0	0
Patterson (T)	0	1	0	0	3	0	0	1	0	1	0	0	1
Philipstown (T)	0	1	0	0	0	0	0	0	0	0	0	0	0
Putnam Valley (T)	0	1	0	1	0	0	0	0	0	0	0	0	0
Southeast (T)	0	3	1	0	0	0	0	0	1	0	0	0	0
Putnam County (TOTAL)	**1**	**12**	**1**	**3**	**5**	**1**	**2**	**1**	**4**	**1**	**1**	**1**	**5**

Sources: FEMA 2013, Putnam County GIS 2020
Notes: T= Town; V= Village

Table 5.4.5-25 Lifelines Exposed to the 1-Percent Annual Chance Flood Event Boundary

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Exposed to 1-Percent Annual Chance Flood Event
Communications	21	0
Energy	23	1
Food, Water, Shelter	150	17
Health and Medical	18	4
Safety and Security	114	2
Shelter	1	0
Transportation	35	7
Putnam County (TOTAL)	**362**	**31**

Sources: FEMA 2013, Putnam County GIS 2020
Notes: T= Town; V= Village

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, business interruption, and impacts on tourism. 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 Putnam County.

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 5.4.5-26 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. Overall, HAZUS-MH v4.2 estimates that there will be 2,241 tons of debris generated during the 1-percent annual chance flood event in Putnam County.

Table 5.4.5-26 Estimated Debris Generated from the 1-Percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Brewster (V)	0	0	0	0
Carmel (T)	282	94	102	87
Cold Spring (V)	1,447	1,134	189	125
Kent (T)	230	230	0	0
Nelsonville (V)	0	0	0	0
Patterson (T)	78	78	0	0
Philipstown (T)	0	0	0	0
Putnam Valley (T)	186	186	0	0
Southeast (T)	16	16	0	0
Putnam County (TOTAL)	**2,241**	**1,738**	**291**	**211**

Sources: HAZUSv4.2
Notes: T= Town; V= Village

Impact on the Environment

As Putnam County and its jurisdictions evolve with changes in population and density, 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 annual chance flood event will continue to evolve alongside natural occurrences such as climate change and/or severe weather events. These flood events will inevitably impact Putnam County's natural and local environment.

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

Overall, the acreage of natural land makes up 79-percent of the County's total land area (NLCD 2016). Natural land areas from the 2016 land use type dataset includes areas of forested land, and wetlands. Severe flooding will not only influence the habitat of these natural land areas, it can be disruptive to species that reside in these natural habitats. Overall, 5.1-percent and 5.4-percent of the natural land area in the County is exposed to the 1-percent and 0.2-percent annual chance flood event boundary, respectively.

Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of disease outbreaks and harmful algal blooms. Flooding of lawns and agricultural areas can flow into bays, rivers, and waterbodies and is linked to "overfeeding" harmful algal blooms with nutrients such as phosphorus and nitrogen (NOAA 2020). Flooding could increase the risk of transmitting water-borne and vector diseases by contaminating drinking water facilities (WHO 2020). See Sections 5.4.9 and 5.4.10 for more information on the harmful algal bloom and disease outbreak hazards of concern, respectively.

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. 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

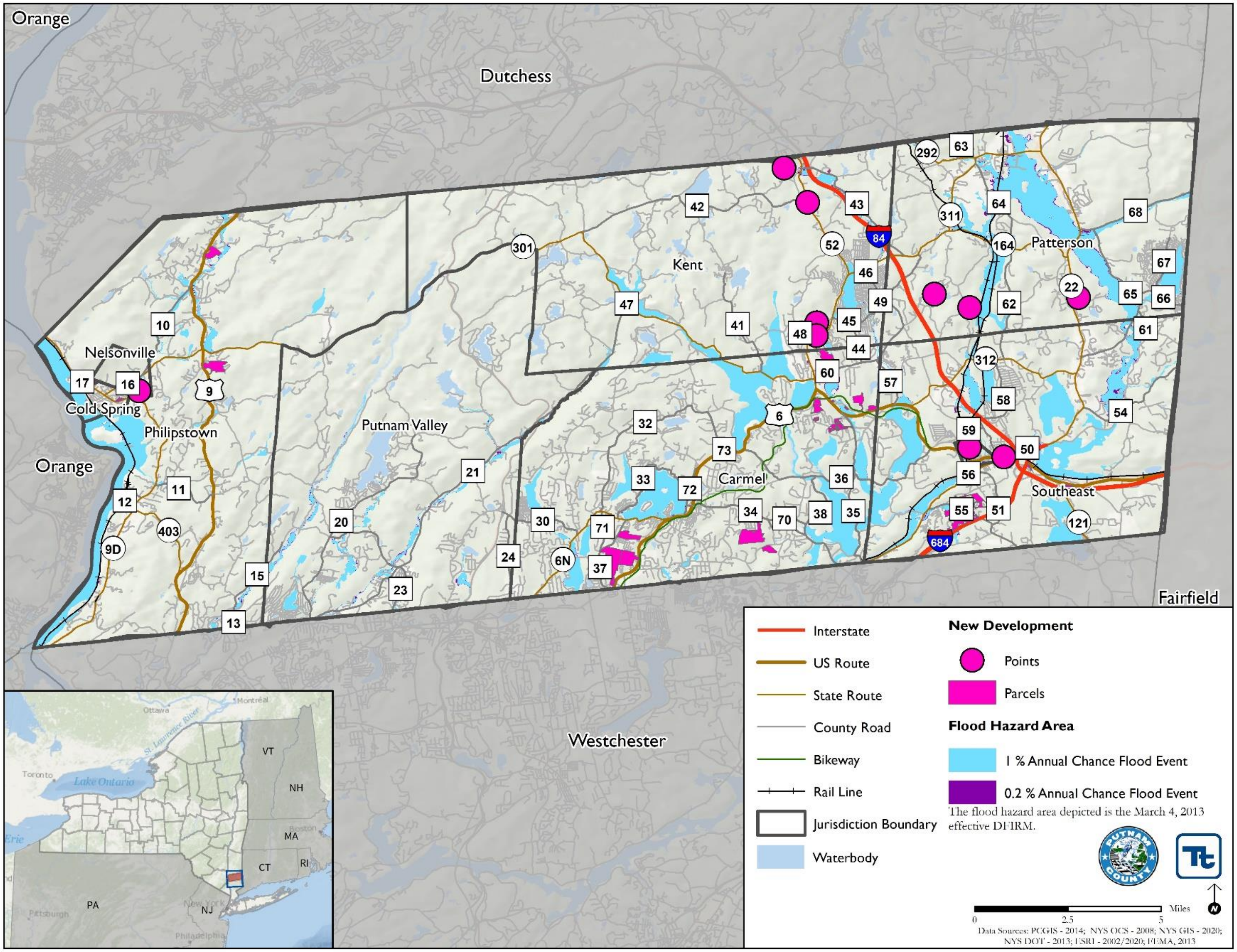
Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the flood inundation areas could be potentially impacted by flooding. There are 6 new development sites located within the 1-percent annual chance flood event hazard area and 7 new development sites located in the 0.2-percetn annual chance flood event hazard area.

It is recommended that the County and municipal partners implement design strategies that mitigate against the risk of flooding. Refer to the maps in the jurisdictional annexes (Section 9) to view the new development locations throughout the County and their proximity to the 1-percent annual chance flood hazard event boundary.

Please refer to Figure 5.4.5-5 for potential new development in the County and their proximity to the flood hazard areas.

Figure 5.4.5-5 New Development and 1- and 0.2-Percent Annual Chance Flood Event Hazard Area in Putnam County



Projected Changes in Population

According to the U.S. Census Bureau, the population in Putnam County has decreased by approximately 0.7-percent between 2010 and 2018 (US Census Bureau 2020). Estimated population projections provided by the 2017 Cornell Program on Applied Demographics indicates that the County's population will increase slowly into 2040, increasing the total population to approximately 100,435 persons (Cornell University Program on Applied Demographics 2017). As more people will reside in the County, there are possibilities that people will move to locations that are more susceptible than others to flooding. 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 (County Profile) for additional discussion on population trends.

Climate Change

As discussed earlier, 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 (NYSERDA 2014). 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.

Change of Vulnerability Since 2015 HMP

Since the 2015 analysis, population statistics have been updated using the 5-Year 2014-2018 American Community Survey Population Estimates. The general building stock was also updated using RS Means 2019 building valuations that estimated replacement cost value for each building in the inventory and critical facilities were updated by Putnam County. In addition, the FEMA 2013 Effective DFIRMs were referenced to assess the 1-percent and 0.2-percent annual chance flood extents. The updated building stock inventory and flood data was imported into HAZUS-MH v4.2 to complete a riverine analysis for the 1-percent annual chance flood event.

Overall, this vulnerability assessment uses a more accurate and updated building inventory which provides more accurate estimated exposure and potential losses for Putnam County.

Identified Issues

Putnam County's waterways are locally and regionally important, providing drinking water, recreational opportunities, and ecological benefits for millions of visitors and New York State residents. Locally, floodplain development is most concentrated in Philipstown and Cold Spring where historic development patterns have clustered along the Hudson River. Despite the proliferation of lakes and reservoirs throughout the County, waterfront development along these bodies has occurred largely outside of the floodplain. However, unmapped areas of flood hazard and localized drainage issues contribute to flood hazards throughout the County along creeks and lakeshores.

The County's municipalities have varying rates of uptake for flood insurance based on the number of buildings in the Special Flood Hazard Area. The Town of Patterson is estimated to have the lowest percentage of flood insurance given the number of buildings in the floodplain, with approximately one-third of buildings in the flood zone being insured. In Nelsonville, Putnam Valley, Philipstown, and Southeast, the estimated percentage of insured buildings in the floodplain ranges between two-thirds and 86 percent.