5.4.2 FLOOD

This section provides a profile and vulnerability assessment for the flood hazard.

HAZARD PROFILE

This section provides profile information including description, location, extent, previous occurrences and losses and the probability of future occurrences.

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) (Federal Emergency Management Agency [FEMA], 2008). Most communities in the U.S. have experienced some kind of flooding, after spring rains, heavy thunderstorms, coastal storms, or winter snow thaws (George Washington University, 2001). Floods are the most frequent and costly natural hazards in New York State in terms of human hardship and economic loss, particularly to communities that lie within flood prone areas or flood plains of a major water source.

The FEMA definition for flooding is "a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from the overflow of inland or tidal waters or the rapid accumulation of runoff of surface waters from any source (FEMA, Date Unknown)." The New York State Disaster Preparedness Commission (NYSDPC) and the National Flood Insurance Program (NFIP) indicates that flooding could originate from one of the following:

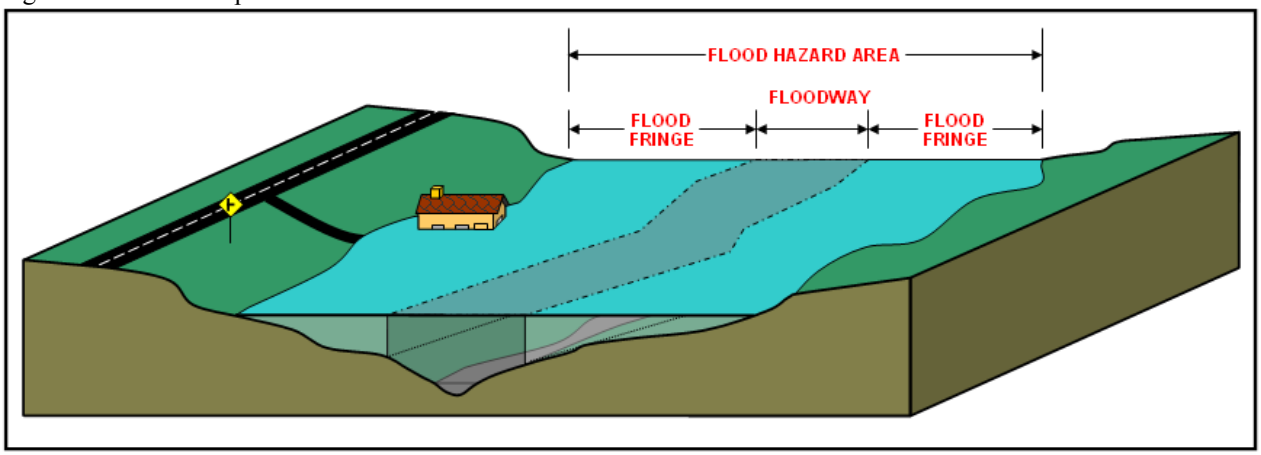
- Riverine flooding, including overflow from river channels, flash floods, alluvial fan floods, ice-jam floods and dam-break floods;
- Local drainage or high groundwater levels;
- Fluctuating lake levels;
- Coastal flooding from storm surge or coastal storms;
- Coastal erosion (NYSDPC, 2008);
- Unusual and rapid accumulation or runoff of surface waters from any source;
- Mudflows (or mudslides);
- Collapse or subsidence of land along the shore of a lake or similar body of water caused by erosion, waves or currents of water exceeding anticipated cyclical levels that result in a flood as defined above (Floodsmart.gov, 2010);
- Sea Level Rise (USEPA, 2010); or
- Climate Change (Global Warming) (USEPA, 2010)

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. Most often floodplains are referred to as 100-year floodplains. A 100-year floodplain is not the flood that will occur once every 100 years, rather it is the flood that has a one-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. With this term being misleading, FEMA has properly defined it as the 1 percent annual chance flood. This one percent annual

chance flood is now the standard used by most Federal and State agencies and by the National Flood Insurance Program (NFIP) (FEMA, 2002).

Figure 5.4.2-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 5.4.2-1. Floodplain



Source: NJDEP, Date Unknown

As presented by FEMA in the NFIP Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials (FEMA-480), most floods fall into three categories: riverine, coastal and shallow (FEMA, 2005). Other types of floods may include ice-jam floods, alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater (as indicated in the previous flood definition). For the purpose of this HMP and as deemed appropriate by the Planning Area, riverine/flash, dam failure and stormwater flooding are the main flood types of concern for the Planning Area. These types of flood or further discussed below.

Riverine/Flash Floods – Riverine floods are the most common flood type and occur along a channel. They include overbank and flash flooding. Channels are defined features on the ground 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. Theses floods usually occur after heavy rains, heavy thunderstorms, or snowmelt, and can be slow or fast-rising, and generally develop over a period of hours to days (FEMA, Date Unknown; The Illinois Association for Floodplain and Stormwater Management, 2006).

According to the National Weather Service (NWS), flash floods are "a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters" (NWS, 2005). FEMA's "Are You Ready" Flood Preparedness Guide, indicates that flash floods often have a dangerous wall of roaring water that carries rocks, mud, and other debris and can sweep away most things in its path. They usually result from intense storms dropping large amounts of rain within a brief period with little or no warning; can reach their peak in only a few minutes. They normally occur in the summer during the thunderstorm season. The most severe flooding conditions usually occur when direct rainfall is augmented by snowmelt. If the soil is saturated or frozen, stream flow may increase due to the inability of the soil to absorb additional precipitation. Flooding can also occur when a dam fails or breaks, producing effects similar to flash floods. Areas

that are most susceptible to the effects of floods are low-lying areas that are near water or downstream from a dam (FEMA, 2006).

Dam Failure Floods – 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, 2010). Dams are man-made structures built across a stream or river that impound water and reduce the flow downstream. They are often used to create retention basins, reservoirs and ponds (FEMA, 2003).

Dams are man-made structures built for the purpose of power production, agriculture, water supply, recreation, and flood protection. A levee is a natural or artificial barrier that diverts or restrains the flow of a stream or other body of water for the purpose of protecting an area from inundation by flood waters. According to FEMA, dam failure is a catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release. It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action. A dam failure can result in severe loss of life, economic disaster and extensive environmental damage, primarily due to their unexpected nature and high velocity floodwater (FEMA, 2004). According to FEMA, 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);
- 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, 2009).

Extent

In the case of riverine or flash flooding, 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, 2008).

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. One element is the size of rivers and streams in an area; but an equally important factor is the land's absorbency. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration into the ground slows and any more water that accumulates must flow as runoff (Harris, 2001).

Flood severity from a dam failure can be measured with a low, medium or high severity, which are further defined as follows:

- Low severity - No buildings are washed off their foundations; structures are exposed to depths of less than 10 feet.
- Medium severity - Homes are destroyed but trees or mangled homes remain for people to seek refuge in or on; structures are exposed to depths of more than 10 feet.
- High severity - Floodwaters sweep the area clean and nothing remains. Locations are flooded by the near instantaneous failure of a concrete dam, or an earthfill dam that turns into "jello" and washes out in seconds rather than minutes or hours. In addition, the flooding caused by the dam failure sweeps the area clean and little or no evidence of the prior human habitation remains after the floodwater recedes (Graham, 1999).

Two factors which influence the potential severity of a full or partial dam failure include (1) The amount of water impounded; and (2) The density, type, and value of development and infrastructure located downstream (City of Sacramento Development Service Department, 2005).

Location

Flooding has always been and continues to be a statewide concern for New York State. Flooding is the primary natural hazard in the State. Although some areas are more prone to certain types of flooding than others, there is no area of the State that is exempt from flood hazards altogether, including Westchester County. In New York State, there are over 52,000 miles of river and streams, and along their banks there are 1,480 communities that are designated as flood prone. It is estimated that 1.5 million people live in these flood prone areas. Millions more work, travel through or use recreational facilities located in these areas. Areas outside recognized and mapped flood hazard zones can also experience flooding (NYSDPC, 2008).

New York State exhibits a unique blend of weather (climatological and meteorological) features that influence the potential for flooding. Factors include: temperature, which is affected by latitude, elevation, proximity to water bodies and source of air masses; and precipitation which includes snowfall and rainfall. Precipitation intensities and effects are influenced by temperature, proximity to water bodies, and general frequency of storm systems (NYSDPC, 2008).

The Cornell Climate Report indicates that the geographic position of New York State, in the northeast U.S., makes it vulnerable to frequent precipitation events. This is because nearly all storms and frontal systems moving eastward across the U.S. pass through, or in close proximity to, New York State. Additionally, the potential for prolonged periods of heavy precipitation is increased due to the available moisture from the Atlantic Ocean. The heavy rain can quickly saturate the ground, leading to increased runoff and flooding. Heavy rain in New York State is subject to come in the form of coastal storms (Nor'Easters, tropical storms, and hurricanes) as well as thunderstorms. Flood problems in the State are most acute in the Susquehanna, Genessee, Chemung, Hudson, Mohawk, and Alleghany River Basins.

These major waterways, along with their tributary streams in the basins, are subject to direct flooding throughout the New York State (NYSDPC, 2008).

As indicated in the Regional Profile (Section 4), the Greater Greenburgh Planning Area lies in the southern portion of Westchester County. Communities of Westchester County, including the Greater Greenburgh Planning Area, have experienced flooding events during all seasons. Some have been associated with high stream stages and others with high tidal stages. The most severe riverine floods in the past have been associated with intense rains caused by localized and transcontinental storms, land-falling hurricanes originating in the Caribbean Sea or heavy rain falling on previously frozen or saturated grounds (FEMA, 2007).

According to the U.S. Environmental Protection Agency (EPA), Westchester County is part of five different watersheds: Saugatuck, Long Island Sound, Hudson-Wappinger, Lower Hudson and Bronx (U.S. EPA, 2010). These watersheds consist of rivers and streams that have experienced flooding events. As a result of the flooding that has historically occurred within the County, the County has been ranked as the 4th most vulnerable county to flood hazards. Nearly 11-percent of the County is located within the 100-year (NYSDPC, 2008). The major rivers within the Greater Greenburgh Planning Area include the Saw Mill River and the Bronx River.

The Saw Mill River is located entirely in the Westchester County and is the major watercourse and source of flooding in the County. It has a watershed of 26.5 square miles. The River is approximately 25 miles in length and of those 25 miles; nine miles and nearly half of the watershed are located in Unincorporated Greenburgh. The basin of the Saw Mill River encompasses parts of the City of Yonkers; Villages of Hastings-on-Hudson, Dobbs Ferry, Ardsley, Irvington, Elmsford, Pleasantville, Sleepy Hollow, and Tarrytown; and the Towns of Greenburgh, Mount Pleasant, and New Castle. Some reaches of the Saw Mill River, areas north of the Village of Elmsford, are twice the width of the stream in other reaches, near the Village of Hastings-on-Hudson where it is confined in a narrow valley (Sidney B. Bowne & Son, 2001; FEMA, 2007). Table 5.4.2-1 displays stream discharges for various storms. The data was collected from the USGS stream gaging station in the Village of Elmsford. The flows for the River are given by storm return period, which is the expected occurrence of a given rainfall event (Sidney B. Bowne & Son, 2001).

Table 5.4.2-1. Saw Mill River Flows

Storm Return Period (years)	Exceedance Probability	Flow (cfs)
1	0.995	180
2	0.50	394
5	0.20	570
10	0.10	709
25	0.04	913
50	0.02	1086
100	0.01	1279
500	0.005	1495

Source: Sidney B. Bowne & Son, 2001

The Bronx River flows southward for 23 miles from the Village of Valhalla near the Kenisco Reservoir and empties into the East River, between the Soundview and Hunts Point neighborhoods in the South Bronx. The River flows through two states, three counties and 15 municipalities (Bronx River Alliance, 2010). The Bronx River Watershed drains approximately 48.3 square miles of urbanized areas in Westchester County. The natural hydrologic function of the Bronx River has been modified as a result of

urbanization, channel relocation, and the construction of impoundments that divert water from the River. In 1915, the Kensico Dam was constructed in the Town of Mount Pleasant, reducing the total stream flow by one quarter. The Bronx River has three major impoundments below the Kensico Dam: White Plains Reservoirs and the Grassy Sprain Reservoir (partially located in Unincorporated Greenburgh). These impoundments control approximately 5.3 square miles of the River's drainage area (Center for Watershed Development; Biohabitats, Inc., 2007).

Federal Emergency Management Agency (FEMA)

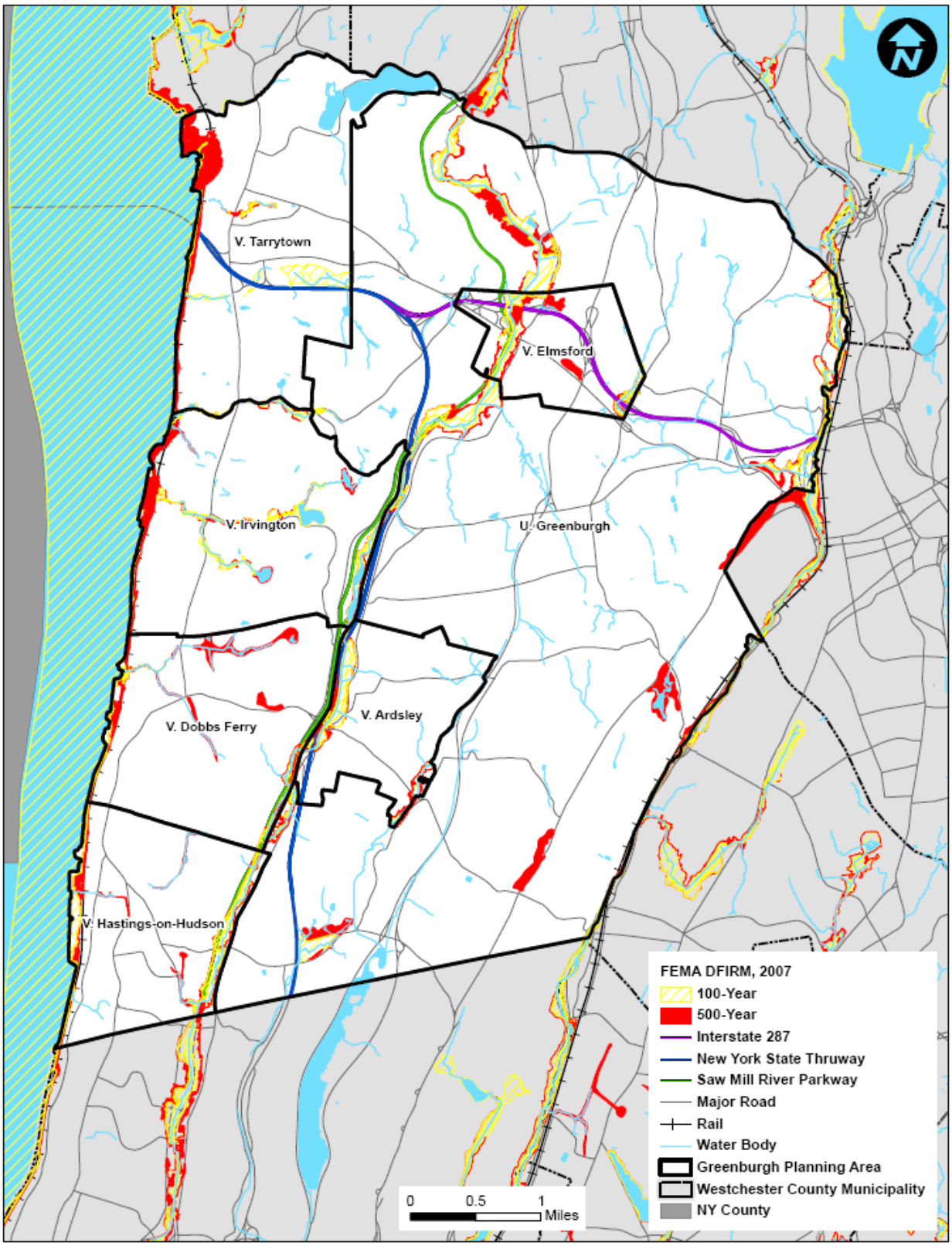
According to FEMA, flood hazard areas are defined as areas that are shown to be inundated by a flood of a given magnitude on a map. These areas are determined using statistical analyses of records of riverflow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Flood hazard areas are delineated on FEMA's Flood Insurance Rate Maps (FIRM), which are official maps of a community on which the Federal Insurance and Mitigation Administration has delineated both the Special Flood Hazard Areas (SFHA) and the risk premium zones applicable to the community. These maps identify the SFHAs; the location of a specific property in relation to the SFHA; the base (100-year) flood elevation (BFE) at a specific site; the magnitude of flood a flood hazard in a specific area; the undeveloped coastal barriers where flood insurance is not available and locates regulatory floodways and floodplain boundaries (100-year and 500-year floodplain boundaries) (FEMA, 2003; FEMA, 2004; FEMA, 2006; FEMA, 2008).

The land area covered by the floodwaters of the base flood is the SFHA on a FIRM. It is the area where the National Flood Insurance Programs (NFIP) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies. The SFHA includes Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, V1-30, VE, and V (FEMA, 2007). This regulatory boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities since many communities have maps showing the extent of the base flood and likely depths that will be experienced.

The base flood is often referred to as the "100-year" flood designation. As defined by NFIP, the BFE on a FIRM is the elevation of a base flood event, or a flood which has a one-percent chance of occurring in any given year. The BFE describes the exact elevation of the water that will result from a given discharge level, which is one of the most important factors used in estimating the potential damage to occur in a given area. A structure located within a 100-year floodplain has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. The 100-year flood is a regulatory standard used by federal agencies and most states, to administer floodplain management programs. The 100-year flood is used by the NFIP as the basis for insurance requirements nationwide. FIRMs also depict 500-year flood designations, which is a boundary of the flood that has a 0.2-percent chance of being equaled or exceeded in any given year (FEMA, 2003; FEMA, 2006).

FEMA partnered with the New York State Department of Environmental Conservation (NYSDEC) to update all FIRMs and Digital FIRMs (DFIRMs) for Westchester County as a part of a nationwide FEMA Map Modernization Program. These maps for the County were completed and adopted on September 28, 2007 (FEMA, 2008; Fidelity National Information Services, 2008). Figure 5.4.2-2 illustrates the FEMA regulatory 100-year and 500-year flood zones of the Greater Greenburgh Planning Area.

Figure 5.4.2-2. 100- and 500-Year Regulatory Floodplains within the Greater Greenburgh Planning Area



Source: FEMA DFIRM, 2007

A Flood Insurance Study (FIS) was prepared by FEMA for Westchester County on September 28, 2007, which covers most of the geographic area of the County. This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. According to the FIS, records in Westchester County show that substantial flooding conditions have been experienced on the following dates: July 1889, October 1903, November 1927, March 1936, September 1938, September 1944, May 1946, March 1953, August 1955, October 1955, March 1962, May 1968, August 1971, June 1972, September 1975 and September 1999. Some floods have been associated with high stream stages and others with high tidal stages (FEMA, 2007).

According to the FIS, records in Westchester County show that substantial flooding conditions have been experienced on: July 1889, October 1903, November 1927, March 1936, September 1938, September 1944, May 1946, March 1953, August 1955, October 1955, March 1962, May 1968, August 1971, June 1972, September 1975, and September 1999. NOAA reported that between 1901 and 1955, 10 hurricanes damaged Westchester County (FEMA, 2007).

Communities in Westchester County have experienced floods during all seasons. Some have been associated with high stream stages and others with high tidal stages. The most severe riverine floods have been associated with heavy rains caused by localized or transcontinental storms, land-falling hurricanes originating in the Caribbean, or heavy rain falling on frozen or previously saturated ground (FEMA, 2007).

In the Village of Ardsley, along the Saw Mill River, the flood of record occurred with Hurricane Floyd in September 1999, with a 75-year flood frequency. The Sprain Brook has suffered flooding; but not to any large extent. If a large recurrence interval flood was to occur along the Sprain Brook, it would result in damage to several residences and a school. There are currently no structural measures for flood protection in the Village of Ardsley. Prior to 1972, the New York State Department of Public Works realigned and widened portions of the Saw Mill River and constructed culverts and retaining walls during construction of the New York State Thruway (FEMA, 2007).

The Village of Dobbs Ferry has experienced flooding associated with intense rains caused by storms, land-falling hurricanes or heavy rain falling on frozen or saturated ground. The maximum stream flow occurred in July 1984 on the Saw Mill River, with a stream flow of 1,450 cfs. In the Village of Dobbs Ferry, no flood protection projects have been requested or identified that would relief the existing level of flooding along the Saw Mill River or the Hudson River. There is no official flood warning system along the Rivers (FEMA, 2007).

In the Village of Elmsford, flooding has occurred along the Saw Mill River, south of Tarrytown-White Plains Road. Floods of 1955, 1972 and 1975 caused damage to the Village. Traffic was temporarily blocked at the Tarrytown-White Plains Road crossing during the 1975 flood. The Village of Tarrytown's flooding typically occurs mainly from hurricanes. Most of the damage is caused by flooding from the Hudson River due to poor downstream drainage and high water stages (FEMA, 2007).

In the Villages of Hastings-on-Hudson and Elmsford and Unincorporated Greenburgh, there are no major flood protection measures. Unincorporated Greenburgh had a consultant design flood protection works for Manhattan Park Brook. It was completed and resulted in containing the 100-year flood in the channel, from Kensico Aqueduct to County Center Road (FEMA, 2007).

Dam Break Hazard Areas

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

NYCRR Part 673.3. 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 misoperation 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 misoperation 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 more than 6 lives would be in jeopardy and excessive economic loss (urban area including extensive community, industry, agriculture, or outstanding natural resources) would occur as a direct result of dam failure (NYSDEC, 2006).

According to information provided by Westchester County, NYSDEC, HAZUS, and the National Inventory of Dams (NID), there are six dams in the Greater Greenburgh Planning Area. Of the six dams identified in the Planning Area, two dams are classified as high, one classified as significant, one classified as low and two are unknown. Refer to Table 4-18 and Figure 4-19 in the Regional Profile (Section 4) for additional information regarding these dams and for the location of the dams within the Planning Area.

The Tarrytown Reservoir is the result of the Tarrytown Waterworks Dam (also known as Tarrytown Lakes Dam), which is located on a tributary of Saw Mill River. The Reservoir is used for drinking water. Construction of this dam was completed in 1897 and has a surface area of 81 acres. The Tarrytown Lakes Dam is approximately 18 feet in height and 315 feet in length. Maximum discharge is 590 cubic feet per second (cfs) and has a capacity of 1,100 acre feet (NYSDEC, Date Unknown; FindLakes.com, Date Unknown).

The Woodlands Lake Dam is located on the Saw Mill River. It is used for recreation purposes. Construction of the dam was completed in 1840 and has surface area of 13 acres. The Woodlands Lake Dam is approximately 20 feet in height and 200 feet in length. Maximum discharge is 0 cfs and has a capacity of 87 acre feet (NYSDEC, 2010; FindLakes.com, Date Unknown).

The Irvington Waterworks Dam (also known as Irvington Reservoir Dam) is used for fire protection, stock and small farm pond. It was constructed in 1900. It measures approximately 20 feet in height and 650 feet in length (NYSDEC, 2010).

The Manor Pond Dam is used for flood control and storm water management. The date of its construction is unknown. The Manor Pond Dam is approximately 15 feet in height with a maximum capacity of 12.27 acre feet (NYSDEC, 2010).

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with flooding throughout New York State and Westchester County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1954 and 2010, FEMA declared that New York State experienced 36 flood-related disasters classified as one or a combination of the following disaster types: flooding, heavy rains, severe storms, coastal storms or high tides (FEMA, 2010). Of those events, the NYS HMP and FEMA indicate that Westchester County has been declared as a disaster area as a result of 11 flood-related events between 1954 and April 2010 (FEMA, 2010; SEMO, 2009).

Table 5.4.2-2 summarizes the FEMA Presidential Disaster (DR) or Emergency (EM) Declarations for flood events in Westchester County, which encompasses the Greater Greenburgh Planning Area. Many of these federal disasters were the remnants of severe storms or tropical or extra tropical disturbances (hurricanes, tropical storms, Nor'Easters) either passing over or located within proximity to the State. These disasters resulted in flooding in the County, hence the reason for the occasional categorization by FEMA as "severe storms and flooding" event. Because flooding was the primary impact of many of these types of hazard events, only the severe flooding impact of major events are discussed in this Hazard Profile and are also mentioned in their designated sections of this HMP: Section 5.4.1 (Severe Storm) and Section 5.4.3 (Severe Winter Storm).

Table 5.4.2-2. Presidential Disaster Declarations for Flooding Events in Westchester County

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Severe Storms and Flooding (Tropical Storm Doria)	September 1971	DR-311	This storm caused seven deaths and $147.6 M in damage throughout its path. New York State experienced approximately $7.4 M in total eligible damages. Westchester County experienced approximately $29 K in property and crop damages.
Tropical Storm Agnes	June 20-25, 1972	DR-338	New York State experienced approximately $703 M in total eligible damages. Storm either severely damaged or destroyed 5,000 homes and killed 24 people. Westchester County experienced approximately $806 K in property and crop damages. Approximately 5.2 inches of rain fell within a 12 hour period in the Planning Area. The storm caused flooding along the Bronx River. Losses in the Planning Area are unknown.
Severe Storms, Heavy Rain, Landslides, Flooding (Hurricane Eloise)	September 25-27, 1975	DR-487	New York State experienced approximately $25 M in property damages and 2 fatalities. Total rain amounts exceeded 10 inches within southeastern New York State (including Westchester County).
Coastal Storms and Flood	April 5, 1984	DR-702	New York State experienced approximately $11.9 M in property damages. In the Greater Greenburgh Planning Area, Route 9A and properties to the west were flooded after more than five inches of rain fell in one day. Losses in the Planning Area are unknown.

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Coastal Storm, High Tides, Heavy Rain, Flooding	December 11-14, 1992	DR-974	New York State experienced approximately $31.2 M in property damages, mostly due to flooding. Flooding in New York City and Boston was recorded between four and five feet. In Westchester County, between eight and 11 inches of rain, causing flooding. All public schools were closed. Several major roadways were closed due to flooding. Overall, Westchester County had approximately $7.1 M in flood damages. Over 20,000 power failures occurred throughout the County. Estimated losses in the Greater Greenburgh Planning Area are unknown.
Severe Storms / Flooding	October 19-20, 1996	DR-1146	Coastal flooding event that caused over $16.1 M in property damages throughout Westchester and Suffolk Counties. Approximately $3.5 M in disaster aid to the two counties. Flooding caused the closures of the Hutchinson River Parkway between Wolfs Lane and East 3rd Street and the Bronx River Parkway between Sprain Brook Parkway and Scarsdale Road. Rainfall totals in Westchester County ranged from 2.37 inches at Ossining to 4.98 inches at Dobbs Ferry.
Hurricane Floyd	September 14-17, 1999	DR-1296	New York State experienced approximately $62.2 M in eligible damages as a result of property damage and debris accumulation (NYSDPC). The worst damage in the New York metropolitan region occurred in Rockland and Westchester Counties. Orange, Putnam, Rockland and Westchester Counties were declared disaster areas. NOAA-NCDC, SHELDUS and other sources indicated that Westchester County experienced between $6.6 and $14.6 million in damages. Many Westchester County officials proclaimed the storm as one of the worst storms ever to hit the area at that time, with the most rain ever recorded dropped on the county in 24 hours. Nearly all of the state-controlled parkways in Westchester County flooded during Floyd, causing about $2.8 million in damage. As of December 6, 1999, FEMA indicated that the County was approved for over $1.8 M in public assistance. Other sources indicate that Westchester municipalities were reimbursed about $14 M by FEMA for damages; local businesses received $2.3 M, and homeowners received approximately $1.6 M. A total of 7.62 inches of rain fell and caused flooding in Unincorporated Greenburgh. The Saw Mill River near the Village of Elmsford was hit the hardest. Homes on Babbitt Court, south of the Village of Elmsford, were flooded. Debris was washed into the Town's storm system within the Saw Mill River watershed. Flooding occurred in the Troublesome Brook area near Claredon Place and Winthrop Lane. Edgemont Road was severely impacted due to a backup in the Bronx River. Manhattan Brook overflowed its banks along Randolph Road, Benedict Road, and County Center Road. Homes were flooded near the confluence of the Bronx River and Manhattan Brook. Flood levels in the Saw Mill River area reach 500-year inundation and the Bronx River reached the elevation of a 125-year flood. Damage to businesses alone exceeded $1 M.
Severe Storms and Flooding	April 2-4, 2005	DR-1589	New York State experienced approximately $66.2 M in eligible damages. FEMA approved more than $5 M in disaster aid to the State to help fund recovery efforts in several counties and jurisdictions. In Westchester County, Unincorporated Greenburgh was reimbursed $4,420 for debris removal. Total rainfall in New York State ranged between one and four inches. NOAA-NCDC and SHELDUS indicated that Westchester County experienced approximately $4.3 M in flood damages.

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Severe Storms and Flooding	June 26 – July 10, 2006	DR-1650	This event was the largest and most costly natural disaster that New York State encountered since Hurricane Agnes in 1972. Resulted in a Disaster Declaration for 19 New York State counties. New York State experienced approximately $246.3 M in eligible damages. As of December 29, 2006, more than $227 M in disaster aid was approved for the State.
Severe Storms and Inland and Coastal Flood (also identified as a Nor'Easter)	April 14-18, 2007	DR-1692	New York State experienced millions in eligible damages. FEMA gave out more than $61 million in assistance to affected counties within the State. Private property losses in Westchester County were estimated at $83 M and public property losses were estimated at $2 M. Disaster assistance to the County totaled $30 M as of July 23, 2007. Westchester County was one of the hardest hit counties in the area. In Unincorporated Greenburgh, along East Hartsdale Avenue, flooding was so severe, some businesses and homes were flooded with eight to nine feet of water. A few businesses had to close permanently.
Severe Storms and Flooding (also identified as a Nor'Easter)	March 13-15, 2010	DR-1899	On April 16, 2010, FEMA announced that federal disaster aid was made available for the State of New York due to the severe storms and flooding that struck between March 13 and 15. Nassau, Orange, Richmond, Rockland, Suffolk and Westchester Counties were all included in this declaration (FEMA, 2010). This storm caused seven deaths in Northeast U.S. and more than 300,000 customers were without power. Hurricane-force winds knocked down trees and power lines. Heavy rain caused flooding across the region. Flood warnings were issued from northern Virginia to southern New Hampshire. Some coastal areas received more than six inches of rain. Con Ed reported that more than 86,000 customers were without power in New York City and Westchester County. Wind speeds reached 75 mph at JFK airport in New York City and 72 mph winds were reported in Atlantic City. In Westchester County, schools were closed. Unincorporated Greenburgh was one of the hardest hit areas in the County.

Source(s): FEMA, 2010; NYSDPC, 2008; Hazards & Vulnerability Research Institute (SHELDUS), 2008; NCDC, 2008; NYSEMO, 2006

* The 'Type of Event' is the disaster classification that was assigned to the event by FEMA.

** Represents the date of the event

Note (1): Dollars rounded to nearest thousand. Recorded losses indicate the dollar value of covered losses paid, as available through the public records reviewed. Some of these events overlap with events shown under the Severe Storm and Severe Winter Storm hazard profiles of this Plan.

K Thousand

M Million

Based on all additional sources researched, known flooding events that have impacted the Greater Greenburgh Planning Area and its neighboring cities, towns and villages (Sleepy Hollow, Mount Pleasant, White Plains, Scarsdale, and Yonkers) are identified in Table 5.4.2-3. With flood documentation for the State being so extensive, not all sources may have been identified or researched. Therefore, events in Table 5.4.2-3 may not indicate all events that have impacted the County or the Planning Area. Loss information is generally provided for the County as a whole for an event; therefore, damages for just the Greater Greenburgh Planning Area may be limited or scarce.

Table 5.4.2-3. Flooding Events between 1971 and 2011 in Westchester County / Greater Greenburgh Planning Area

Event Date / Name	Location	Losses / Impacts	Source(s)
Remnants of Tropical Storm Doria August 27-29, 1971 (FEMA DR-311)	Countywide	See FEMA Disaster Declarations (Table 5.4.2-2)	Hazards & Vulnerability Research Institute (SHELDUS), FEMA, MARFC, HPC, Kocin
Flood June 28, 1973	Countywide	The Northeast U.S. was affected by flooding, causing 40 counties in New Hampshire, Vermont, New York and Pennsylvania to be declared major disaster areas by FEMA. In New York State, six counties were declared (FEMA DR-401); however, Westchester County was not included in this declaration. According to SHELDUS, the County experienced approximately $38 M in property damages from this event. However, no other sources were found that indicated this information.	Hazards & Vulnerability Research Institute (SHELDUS)
Remnants of Tropical Storm Eloise September 27, 1975 (FEMA DR-487)	Countywide	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, MARFC, Hebert
Flash Flood November 7, 1977	Countywide	Westchester County experienced approximately $833 K in property damages.	Hazards & Vulnerability Research Institute (SHELDUS)
Flash Flood May 23, 1979	Countywide	Westchester County experienced approximately $1.3 M in property damages.	Hazards & Vulnerability Research Institute (SHELDUS)
Flash Flood December 12, 1983	Countywide	Westchester County experienced approximately $227 K in property damages.	Hazards & Vulnerability Research Institute (SHELDUS)
Major Flood April 5-7, 1984 (FEMA DR-702)	Countywide	See FEMA Disaster Declarations (Table 5.4.2-2)	USGS WSP 2502, FEMA, AHPS, MARFC.
Flash Flood May 28, 1984	Countywide	Westchester County experienced approximately $2.4 M in property damages.	Hazards & Vulnerability Research Institute (SHELDUS), Stuart et al.
Flash Flood March 14, 1986	Countywide	Westchester County experienced approximately $238 K in property damages.	Hazards & Vulnerability Research Institute (SHELDUS)
Flash Flood / Heavy Rain March 31, - April 8, 1987	Southeastern New York State	Intense rainfall in New York State during April 3 and 5 caused widespread flooding in the State. Five counties in southeastern New York State were declared disaster areas by FEMA (FEMA DR-801). A total of ten deaths resulted from this storm when a New York State Thruway bridge collapsed over the Schoharie Creek. Westchester County was not included in the disaster declaration. The County received between 7 and 8 inches of rain from this storm.	NWS, Zembrzuski and Evans (USGS)
Flood / Nor'Easter December 11-12, 1992 (FEMA DR-974)	Multi-State	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, NYSDPC, NYSEMO, NY Times, The Associated Press, McFadden
Severe Storm / Flooding October 28, 1995	Village of Elmsford	A line of storms struck the New York City area, bringing heavy rain and strong winds. In eastern Staten Island, the storms produced a tornado which knocked down trees and slightly damaged homes and cars. These storms also caused	NOAA-NCDC

Event Date / Name	Location	Losses / Impacts	Source(s)
		several inches of rain to fall, causing areas to flood. In the Village of Elmsford, flooding occurred along the Saw Mill River.	
Severe Storms / Flooding October 18-23, 1996 (FEMA DR-1146)	Multi-State	See FEMA Disaster Declarations (Table 5.4.2-2)	NOAA-NCDC, Associated Press, USGS, FEMA, Stuart et al, NYSDPC
Heavy Rain May 8-11, 1998	Countywide	A slow moving storm caused heavy rain to fall across the area, causing urban flooding of streets, poor drainage and low-lying areas. Rainfall amounts ranged between 2.5 inches to 5.5 inches.	NOAA-NCDC
Flash Flood June 17, 2001	Countywide	Excessive rainfall also led to severe flooding conditions across portions of Westchester County. In Greenburgh, 23 residential structures experienced basement flooding, causing thousands of dollars of property damage in the Babbitt Court area. In Ossining, the Sparta Brook overflowed its banks around 5 AM EDT, washing away a backyard and flooding an adjoining basement and garage. Flooding also was reported in Mt. Kisco, particularly near Shoppers Park, where several stores reported damage from the flooding. Damage to several municipal buildings was also reported in other portions of downtown Mt. Kisco.	NOAA-NCDC
Remnants of Hurricane Charley August 9-15, 2004	Multi-County	Significant flooding throughout the County.	Rubenstein
Remnants of Hurricane Jeanne September 13-27, 2004	Multi-County	Nearly a foot of rain fell on Westchester county within a 24-hour period. The result was severe, widespread damage, especially in northern areas of the County, where the landscape was transmogrified by floating cars, downed trees, collapsed railroad embankments and impassable roadways. In Cortlandt, several of major roadways were submerged.	Rubenstein
Severe Storm / Flooding April 1-4, 2005 (FEMA DR-1589)	Multi-County	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, Hazards & Vulnerability Research Institute (SHELDUS), USACE, MARFC, NOAA-NCDC
Flooding June 29, 2005	Multi-Jurisdictional	Heavy rain caused major damage to municipalities in southern Westchester County along the Hudson River. Roads buckled, parks flooded and cars were submerged. More than 70 submerged cars had to be towed along the New York State Thruway from the Villages of Tarrytown to Ardsley. Parts of Unincorporated Greenburgh experienced heavy flooding, with officials stating that this flooding was worst than Hurricane Floyd. The roads in Greenburgh flooding very quickly without warning. Twenty seven people and three dogs were rescued during the flood. In the Village of Tarrytown, the Double Tree Hotel was flooded. Some areas of the hotel had eight feet of water.	Medina (New York Times), Maxons Restoration, Feiner
Severe Storms and Flood June 25 - July 12, 2006	Countywide	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, NYSDPC, NYSEMO, Times Herald-Record, USGS, MARFC

Event Date / Name	Location	Losses / Impacts	Source(s)
(FEMA DR-1650)			
Severe Storm / Inland and Coastal Flooding April 14-17, 2007 (also identified as a Nor'Easter) (FEMA DR-1692)	Multi-County	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, Chas. H. Sells, Inc., The Associated Press
Flash Flood June 14, 2008	Village of Elmsford	A cold front moved across the New York City area, producing heavy rain and widespread flash flooding across portions of the Lower Hudson Valley and New York City. All lanes were blocked on Route 119 near South French Avenue in the Village of Elmsford.	NOAA-NCDC
Flooding July 23, 2008	Village of Tarrytown	A tropical air mass passed over the area, bringing torrential rainfall and flash flooding. Route 9 at Gordon Avenue in the Village of Tarrytown was impassable due to the flooding.	NOAA-NCDC
Severe Storms and Flooding March 13-15, 2010 (also identified as a Nor'Easter) (FEMA DR-1899)	Multi-County	See FEMA Disaster Declarations (Table 5.4.2-2)	FEMA, CNN.com, Fox News, NOAA-NCDC
Severe Storms March 29 – 31, 2010	Multi-State	A significant rain storm socked the region, causing widespread flooding. On Long Island, the Atlantic Ocean inundated a 20-mile stretch of an oceanfront road in Southampton. A mudslide in the Bronx interrupted service on the Metro-North commuter railroad. Flooding suspended service on part of the Staten Island railway. The Sheldrake River in the Village of Mamaroneck closed an exit off of I-95. In Westchester County, rainfall totals ranged between 3.20 inches and 4.83 inches. Saw Mill River Road in the Village of Elmsford was closed due to flooding at Worthington Road and White House Road.	NOAA-NCDC, NWS, NBC New York
Heavy Rain and Flooding March 6 – 7, 2011	Multi-State	Heavy rain caused widespread flooding throughout the area. Many rivers flowed over their banks. Major roadways in the area were closed due to flooding. Rainfall totals in Westchester County ranged between 2.15 inches and 4.64 inches. Numerous road closures were reported within the Greater Greenburgh Planning Area.	NWS, Lohud.com
Heavy Rain and Flooding March 10 – 11, 2011	Multi-State	Rainfall totals in Westchester County ranged between 2.99 inches and 3.13 inches. Multiple roads in the Village of Elmsford were closed due to flooding.	NWS
Heavy Rain and Flooding May 13-17, 2011	Multi-County	Heavy rain fell in Westchester County, causing NWS to issue a flood watch on May 17th, with warnings that another 2.5 inches of could fall by May 18th. Road closures were reported throughout the County, including the Saw Mill and Bronx River Parkways. Rain totals in the County ranged between 2.69 inches to 5.5	Lohud.com, NWS, NYS DOT

Event Date / Name	Location	Losses / Impacts	Source(s)
		inches. In the Greater Greenburgh Planning Area, the Saw Mill River Parkway and the Bronx River Parkway was closed due to flooding	

Note (1): This table does not represent all events that may have occurred throughout the County. NOAA-NCDC storm query indicated that Westchester County has experienced 108 flood events between January 1, 1950 and November 30, 2010 (including flash, urban, coastal and stream floods). However, not all of these events were identified in this table due to a lack of detail and their minor impact upon the County and/or the Greater Greenburgh Planning Area.

Note (2): Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of increased U.S. Inflation Rates.

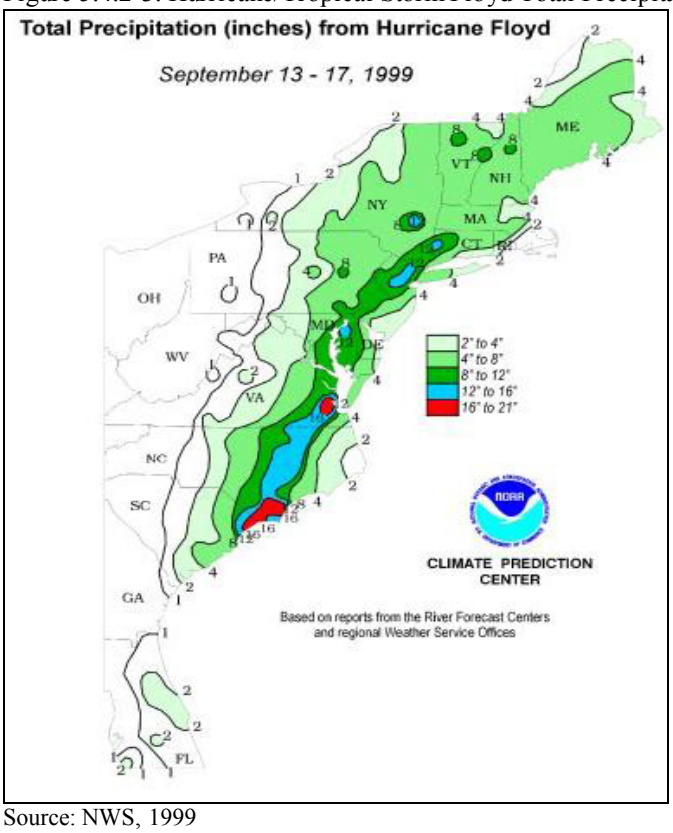
AHPS	Advanced Hydrologic Prediction Service
DR	Federal Disaster Declaration
DOT	Department of Transportation
FEMA	Federal Emergency Management Agency
HPC	Hydrometeorological Prediction Center
K	Thousand ($)
M	Million ($)
MARFC	Middle Atlantic Forecast Center
NCDC	National Climate Data Center
NOAA	National Oceanic Atmospheric Administration
NWS	National Weather Service
NYS	New York State
NYSDPC	New York State Disaster Preparedness Commission
NYSEMO	New York State Emergency Management Office
SHELDUS	Spatial Hazard Events and Losses Database for the U.S.
USGS	U.S. Geological Survey
WSP	Water Supply Paper

Further descriptions of select flood events that have impacted Westchester County and the Greater Greenburgh Planning Area are provided below for selected events where details regarding their impact were available. Although Planning Area specific information is relatively scarce, these descriptions are provided to give the reader a context of the flood events that have affected the County and City and to assist local officials in locating event-specific data for their municipality based on the time and proximity of these events. Flood impacts associated with hurricanes, tropical storms or Nor'Easters, are discussed in this profile and are also mentioned in their designated hazard profiles (Section 5.4.1 Severe Storm and Section 5.4.3 Severe Winter Storm).

Monetary figures within the event descriptions were U.S. Dollar (USD) figures calculated during or within the approximate time of the event (unless present day recalculations were made by the sources reviewed). If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.

September 16, 1999 (Hurricane/Tropical Storm Floyd) (FEMA DR-1296): According to the NOAA NHC, this event was a large and intense storm that pounded the central and northern Bahama islands, seriously threatened Florida, struck near the coast of North Carolina and moved up the east coast of the U.S. into New England as a tropical storm. It neared the threshold of a Category 5 on the Saffir/Simpson Hurricane Scale as it approached the Bahamas, and caused a flood disaster of immense proportions in the eastern U.S., particularly from the eastern coast of North Carolina through New Jersey (Pasch et al., 1999). Much of Floyd's impact was due to heavy rainfall, creating major losses from floodwaters throughout the eastern U.S. Common rainfall totals ranged between 4 and 12 inches (Figure 5.4.2-3) (NWS, 1999). Ten states were declared major disaster areas, which included Connecticut, Delaware, Florida, Maryland, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia (NCDC, 2000).

Figure 5.4.2-3. Hurricane/Tropical Storm Floyd Total Precipitation



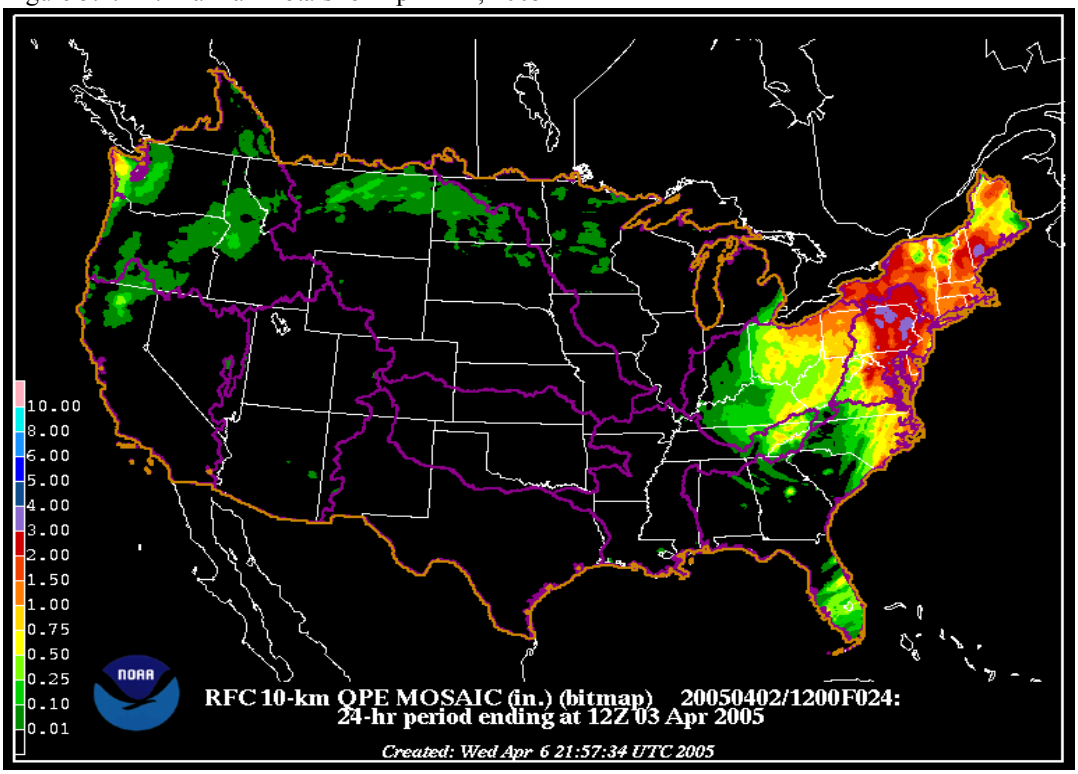
Source: NWS, 1999

New York State experienced approximately $62.2 million in property damages from this event (NYSDPC, 2008). The worst damage in the New York Metropolitan region reportedly occurred in Rockland and Westchester Counties (Chen, 1999). NOAA-NCDC, SHELDUS and other sources indicated that Westchester County experienced between $6.6 and $10 million in flood damages. Many Westchester County officials proclaimed the storm as one of the worst storms ever to hit the area at that time, with the most rain ever recorded dropped on the county in 24 hours (Brenner, 1999). In Westchester County, rainfall totals ranged between 8 and 12 inches (NWS, 1999).

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1296) on September 19, 1999. Through this declaration, the following 15 counties were declared eligible for Federal and State disaster funds: Albany, Dutchess, Essex, Greene, Nassau, Orange, Putnam, Rensselaer, Rockland, Schenectady, Schoharie, Suffolk, Ulster, Warren and Westchester counties (NYSEMO, 2006; FEMA, 2008; NYSDPC, 2008). Disaster assistance for all counties affected in the State has not been clearly documented. As of December 6, 1999, 921 Disaster Housing grants totaling $1,682,634 and 104 Individual and Family Grants (IFG) grants totaling $114,902 were approved out of 1,859 total registrations from the County (FEMA, 1999). However, other sources indicate that Westchester municipalities were reimbursed about $14 million by FEMA for damages with local businesses receiving $2.3 million from FEMA and homeowners receiving nearly $1.6 million (Rubenstein, 2004).

April 2-4, 2005 (FEMA DR-1589): A slow moving storm moved up through the Appalachians and into the northeast U.S. The heavy rainfall from this event produced flooding throughout New York, New Jersey and Pennsylvania (NCDC, 2005). Prior to this storm, the rivers and streams in the area had high flow-rates due to a previous rainstorm on March 28th and snowmelt. This substantially increased flooding and caused additional damage, along with the damage produced by this storm. Figure 5.4.2-4 shows rainfall totals from this event for the northeast U.S.

Figure 5.4.2-4. Rainfall Totals for April 2-4, 2005



Source: NCDC, 2005

New York State experienced approximately $66.2 M in eligible damages during this event with the heaviest rain falling in Ulster and Greene Counties (NYSDPC, 2008). Total Rainfall amounts in New York State ranged from around 1 inch on parts of Long Island to nearly 4 inches across parts of the Lower Hudson Valley. In Westchester County, NOAA-NCDC and SHELDUS indicated that the County experienced approximately $4.3 million in flood damages (NCDC, 2008; Hazards & Vulnerability Research Institute, 2007).

This storm resulted in a FEMA Disaster Declaration (DR-1589) on April 19, 2005. Through this declaration, the following 20 counties were declared eligible for Federal and State disaster funds: Broome, Cayuga, Chautauqua, Chenango, Columbia, Cortland, Delaware, Greene, Madison, Montgomery, Niagara, Orange, Otsego, Putnam, Rensselaer, Schoharie, Sullivan, Tioga, Ulster and Westchester (NYSDPC, 2008; FEMA, 2008). In a September 14, 2005 Press Release, FEMA indicated that nearly $35 million in disaster aid was made available to all declared counties as result of this event. In this press release, FEMA approved $76,136 in public assistance reimbursements for the County (FEMA, 2005).

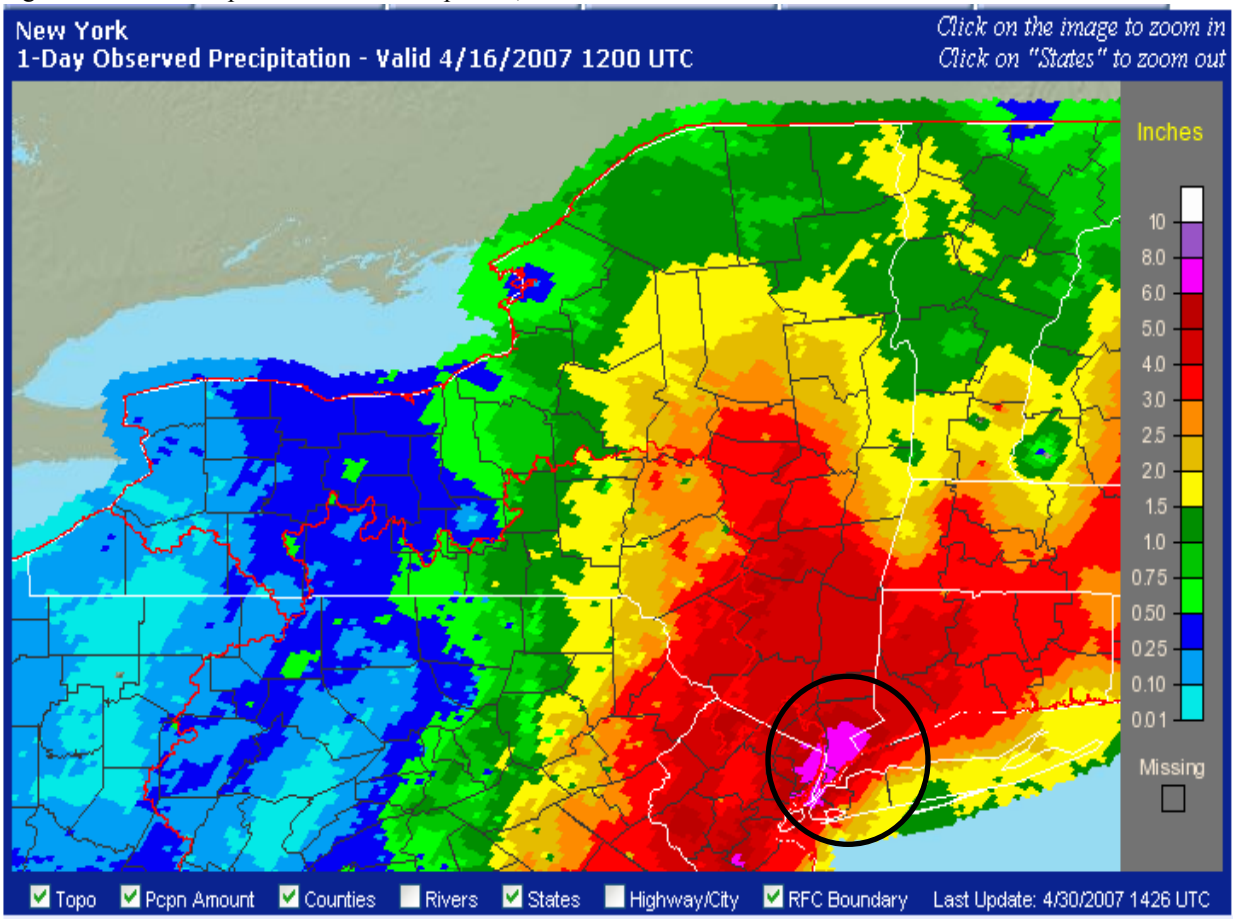
June 29, 2005: Slow moving thunderstorms developed over the Lower Hudson Valley during the afternoon of June 29th. Thunderstorms produced significant hourly rainfall rates of greater than two inches. Within two to four hours, areas in Rockland County and southern Westchester County had between three and six inches of rain (NOAA-NCDC, 2010). The torrential rainfall caused major flooding across Westchester County. Many of the major roadways in the County were closed: Saw Mill River Parkway, Bronx River Parkway and the Hutchinson River Parkway (Foderaro, 2005).

Major damage from the storm was reported along the Hudson River in the southern communities of Westchester County. In the Greater Greenburgh Planning Area, Unincorporated Greenburgh experienced flooding, with some saying it was the worse than the flooding from Hurricane Floyd in 1999. A total of 27 people and three dogs were rescued by the Town's police department (Feiner, 2005). More than 70 cars were submerged along the New York State Thruway between the Villages of Tarrytown and Ardsley (Medina, 2005). In the Village of Tarrytown, the heavy rains caused a drainage creek to overflow and flood the parking lot of a Double Tree Hotel, causing the basement, ballroom and hallways of the hotel to flood. Water in some areas reached as high as eight feet.

April 14-18, 2007 (FEMA DR-1692): An intense and powerful Nor'Easter brought flooding rains and heavy wet snowfall to the northeast U.S. Rainfall totals of six to eight inches were reported across the eastern Catskill Mountains, mid-Hudson Valley and western New England, resulting in widespread flooding. Snowfall accumulations of one to one and a half feet were reported across the southern Adirondacks, eastern Catskills, Berkshires, and southern Green Mountains (NWS, Date Unknown). The combined effects of high winds and heavy rainfall during this event led to flooding, storm damages, power outages, evacuations, and disrupted traffic and commerce.

Various counties in the eastern Catskills and Mid-Hudson Region of New York State were impacted by several inches of rain during this event, particularly in the southeastern section of the State (NOAA, 2008). Westchester County experienced between 4 and 8 inches of rainfall during this event (Figure 5.4.2-5).

Figure 5.4.2-5. Precipitation Totals for April 16, 2007



Source: NOAA, 2008
Note: The black circle within New York State indicates the approximate location of Westchester County.

New York State experienced millions in damages from this event (NYSDPC, 2008; Alarcon-The Daily Mail). In Westchester County, private property losses were estimated at $83 million and public property losses were estimated at $2 million (Chas. H. Sells, Inc., 2007). Disaster assistance to the County totaled $30 million as of July 23, 2007. FEMA Project Application Summaries for this disaster indicating that repair costs after the storm for the Town of Cortlandt were estimated at over $254,000 (FEMA, 2007). Many roads were damaged, drainage systems were compromised and the Sprout Lake Park and Beach was completely overflowed with floodwaters from a nearby brook. It was a combination of unusual high tides and floodwaters that caused rivers to spill their banks in Westchester County (The Associated Press, 2007).

Along East Hartsdale Avenue in Unincorporated Greenburgh, flooding was so severe that some businesses and homes were inundated with eight or nine feet of water. A few businesses closed permanently (Foderaro, 2007).

This Nor'Easter resulted in a FEMA Emergency Declaration (FEMA DR-1692) on April 24, 2007. Through this declaration, the following 13 Counties were declared eligible for Federal and State disaster funds: Albany, Columbia, Dutchess, Essex, Greene, Montgomery, Orange, Putnam, Rockland, Schoharie, Suffolk, Ulster and Westchester Counties (FEMA, 2008). As of August 13, 2007, FEMA indicated that nearly $61 million in total disaster aid was made available to all declared counties as result of this event

(FEMA, 2007). Earlier on July 30, 2007, FEMA approved over $30 million in disaster assistance for Westchester County (FEMA, 2007). The monies include individual assistance (IA) grants, U.S. Small Business Administration (SBA) loans, and public assistance (PA) funding for damage sustained during the storm. The monies are broken down as follows:

- More than $6.7 million was approved for 2,731 households through the FEMA Housing Program (HA).
- More than $840,000 was approved for 599 households under the FEMA/State Other Needs Assistance Program (ONA).
- The SBA approved $20,225,700 in low-interest disaster loans for 384 homeowners, renters and business owners.
- More than $2.4 million was approved for public assistance (PA) funding (FEMA, 2007).

March 13-15, 2010 (FEMA DR-1899): A Nor'Easter affected the east coast of the U.S., which brought heavy rain, snow, sleet, ice, and wind to the area. Flooding, power outages, downed trees and storm surge all resulted from the storm. Over 300,000 customers were without power due to the hurricane-force winds. The heavy rain caused flooding across the northeast, with flood warnings in effect from northern Virginia to southern New Hampshire. Some coastal areas received over six inches of rain (Courson et al., 2010). In higher elevations, snow, sleet and freezing rain fell across the eastern Catskills, Helderbergs, southern Adirondacks, Berkshires, Litchfield Hills and southern Vermont (NOAA, 2010). This Nor'Easter caused seven deaths: two in New Jersey, one in Rhode Island, one in New Hampshire, one in Connecticut, one in West Virginia, and one in New York (Courson et al., 2010).

In the New York City area, Con Edison stated that more than 86,000 customers were without power in New York City and Westchester County. Long Island Power Authority said over 64,000 customers were without power on Long Island (Courson et al., 2010).

Unincorporated Greenburgh was one of the hardest hit areas in Westchester County (Wall Street Journal, 2010). Numerous downed trees, power lines and closed roads were reported in the Town (Feiner, 2010). Figure 5.4.2-6 shows flooding that occurred in Unincorporated Greenburgh.

This Nor'Easter resulted in a FEMA Emergency Declaration (FEMA EM-1899) on April 16, 2010. Through this declaration, the following nine counties were declared eligible for Federal and State disaster funds: Nassau, Orange, Otsego, Richmond, Rockland, Schoharie, Suffolk, Warren and Westchester (FEMA, 2010). As of February 3, 2011, FEMA indicated that over $83 million in total public assistance grants was made available for those counties included in the disaster declaration (FEMA, 2011).

Figure 5.4.2-6. Flooding in Unincorporated Greenburgh, New York

Source: New York Times, 2010

March 6-7, 2011: Heavy rain fell throughout the day on March 6th in the New York Metropolitan Area, bringing almost five inches to some areas. Many river, creeks and streams were flowing out of their banks on March 7th. Many rivers in New York and New Jersey crested at moderate to major flood stages (Thompson et al., 2011).

The NWS issued a flood warning on March 6th for Westchester County, including the municipalities of Yonkers, White Plains, Tarrytown, Rye, Port Chester, Peekskill, Ossining, North Tarrytown, New Rochelle and Dobbs Ferry (Guzman, 2011).

In Westchester County, flooding closed parts of the Saw Mill, Bronx River, Hutchinson River and Taconic State Parkways. School districts in Bedford, Chappaqua, Hendrick Hudson, Katonah-Lewisboro and Yorktown had delayed openings due to the storm conditions. Power outages were reported in several areas of Westchester County (Ryser, 2011).

In the Greater Greenburgh Planning Area, the Saw Mill River Parkway was closed southbound at Exit 22 for Interstate 287 in the Village of Elmsford. Interstate 287 at the ramp for Exit 2 was closed due to flooding in the Village of Elmsford, along with Route 9A, between Route 911 and Payne Street (lohud.com, 2011). In the Village of Tarrytown, the Saw Mill River Parkway southbound ramp was flooded to Manville Road and NY 117 was closed due to flooding. The Taconic State Parkway was flooded in both directions. The Bronx River Parkway entrance and Sprain Brook Parkway had all lanes closed in the Village. In the Village of Elmsford, flooding on the southbound side of the Saw Mill River Parkway at I-287 and the ramp at Greenburgh, had two lanes blocked (NWS, 2011). Figures 5.4.2-7 and 5.4.2-8 shows the flooding that occurred in the Village of Elmsford.

Figure 5.4.2-7. Flooding Along the Saw Mill River Parkway Near I-87 in the Village of Elmsford.

Source: Meuse (The Journal News), 2011

Figure 5.4.2-8. Flooding at Route 9A southbound in the Village of Elmsford.

Source: Harrison (The Journal News), 2011

National Flood Insurance Program (NFIP)

According to FEMA's 2002 *National Flood Insurance Program (NFIP): Program Description*, the U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968. The NFIP is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. The NFIP collects and stores a vast quantity of information on insured structures, including the number and location of flood insurance polices number of claims per insured property, dollar value of each claim and aggregate value of claims, repetitive flood loss properties, etc. NFIP data presents a strong indication of the location of flood events among other indicators (NYSDPC, 2008).

Participation in the NFIP is based on an agreement between communities and the Federal Government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new

construction and substantial improvements in floodplains, the Federal Government will make flood insurance available within the community as a financial protection against flood losses. This insurance is designed to provide an insurance alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods (FEMA, 2002).

There are three components to NFIP: flood insurance, floodplain management and flood hazard mapping. Nearly 20,000 communities across the U.S. and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary. Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion each year through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80-percent less damages annually than those not built in compliance (FEMA, 2008).

According to the most recent NFIP statistics for New York State (July 31, 2009), there are 80,268 claims (open and closed) since the inception of the program in 1978. New York State is ranked within the top five states of the U.S. with the highest number of claims and is also amongst the highest in repetitive flood claims (as defined by FEMA/NFIP). In Westchester County, all cities, towns and villages participate in the NFIP (FEMA, 2009). The Greater Greenburgh Planning Area filed 480 total flood claims (open and closed) and has received approximately $4.1 million (FEMA, 2009). Additional NFIP data for the Greater Greenburgh Planning Area is presented in Table 5.4.2-X in the Vulnerability Assessment section of this hazard profile.

The NFIP program also tracks properties that file several claims of a certain value over a specific period of time, termed Repetitive Loss (RL) properties. These properties, as defined by FEMA, are NFIP-insured properties that, since 1978 and regardless of any changes in ownership during that period, have experienced any of the following:

- Four or more paid losses in excess of $1,000
- Two paid losses in excess of $1,000 within any rolling 10-year period
- Three or more paid losses that equal or exceed the current value of the insured property (FEMA, 2005; FEMA, 2006)

RL properties make up only one to two percent of the flood insurance policies currently in force nationally, yet they account for 40-percent of the country's flood insurance claim payments. The NFIP is concerned with RL properties because structures that flood frequently strain the National Flood Insurance Fund. In fact, the RL properties are the biggest draw on the Fund by not only increasing the NFIP's annual losses and the need for borrowing; but they drain funds needed to prepare for catastrophic events. Community leaders and residents are also concerned with the RL property problem because residents' lives are disrupted and may be threatened by the continual flooding (FEMA, 2005). As of February 2010, the Greater Greenburgh Planning Area has 44 RL properties, 14 of which is a SRL property (FEMA Region II, 2010). See Figure 5.4.2-15 and Table 5.4.2-11 in the Vulnerability Assessment section for more detailed information.

As an additional component of NFIP, the CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS: (1) reduce flood losses; (2) facilitate accurate

insurance rating; and (3) promote the awareness of flood insurance. According to the 2008 Flood Insurance Agent's Manual containing current and historical listings of all CRS communities, only the Village of Scarsdale in Westchester County has participated in CRS since 1993 (FEMA, 2008; NYSDPC, 2008).

Probability of Future Events

Given the history of flood events that have impacted Westchester County and the Greater Greenburgh Planning Area, it is apparent that future flooding of varying degrees will occur. The fact that the elements required for flooding exist and that major flooding has occurred throughout the County in the past suggests that many people and properties are at risk from the flood hazard in the future.

As defined by FEMA, geographic areas within the 100-year floodplain in Westchester County are estimated to have a one-percent chance of flooding in any given year. A structure located within a 100-year floodplain has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Geographic areas in Westchester County located within the 500-year flood boundary are estimated to have a 0.2-percent chance of being flooded in any given year (FEMA, 2003; FEMA, 2006). As noted, Figure 5.4.2-2 illustrates the FEMA DFIRM 100-year and 500-year flood zones for the Greater Greenburgh Planning Area.

According to NYSEMO, historic flood disaster and emergency declaration records indicate Westchester County has experienced 11 federally declared flood related disasters between 1953 and 2011. Therefore, to estimate the probability of future disasters, on average, the County can estimate one flood event meeting disaster criteria every 5- to 6 years or so (NYSDPC, 2008). However, the period of record indicates smaller flooding events occur more frequently.

In Section 5.3, the identified hazards of concern for the Greater Greenburgh Planning Area were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records, FIRMs provided through FEMA, and the Planning Committee. The probability of occurrence for flood events in the Greater Greenburgh Planning Area is considered ‘frequent’ (likely to occur within 25 years, as presented in Table 5.3-3).

It is estimated that the Greater Greenburgh Planning Area will continue to experience flooding annually. Some of the flooding events may induce secondary hazards such as: water quality and supply concerns and experience evacuations, infrastructure deterioration and failure, utility failures, power outages, transportation delays/accidents/inconveniences and public health concerns.

The Role of Global Climate Change on Future Probability

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts, storms and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Human-induced climate change has the potential to alter the prevalence and severity of extremes such as heat waves, cold waves, severe storms, floods and droughts. Though predicting changes in these types of events under a changing climate is difficult, understanding vulnerabilities to such changes is a critical part of estimating future climate change impacts on human health, society and the environment.

It is important to understand that directly linking any one specific extreme event (e.g., flood, severe hurricane) to climate change is not possible. However, climate change and global warming may increase the probability of some ordinary weather events reaching extreme levels or of some extreme events becoming more extreme (U.S. Environmental Protection Agency [EPA], 2006). It remains very difficult to assess the impact of global warming on extreme weather events, in large part because this analysis depends greatly on regional forecasts for global warming. Global warming will almost certainly have different effects on different regions of the Earth, so areas will not be equally susceptible to increased or more intense extreme weather events. Although regional climate forecasts are improving, they are still uncertain (Climate.org, Date Unknown). These many uncertainties may exist regarding magnitude or severity; however, many sources indicate that future weather patterns and increased intensities are anticipated as a result of climate change, along with atmospheric, precipitation, storm and sea level changes (USEPA, 2007).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the flood hazard, the hazard areas identified in the Greater Greenburgh Planning Area include the 100- and 500-year regulatory FEMA floodplains. The following text evaluates and estimates the potential impact of flooding on the Planning Area including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact, including: (1) impact on life, safety and health of residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time
- Overall vulnerability conclusion

Overview of Vulnerability

Flood is a significant concern for the Greater Greenburgh Planning Area. To assess vulnerability, potential losses were calculated for the 100-year and 500-year MRP flood events. The flood hazard exposure and loss estimate analysis is presented below.

Data and Methodology

A modified Level 1 HAZUS-MH analysis was performed to analyze the flood hazard in the Greater Greenburgh Planning Area, using HAZUS-MH MR4 and the Digital Flood Insurance Rate Maps (DFIRMs), effective September 28, 2007 for Westchester County. A Level 1 analysis is a basic estimate of flood losses based on national databases and using the default data in the model (i.e., demographics, general building stock and critical facility inventory). To customize the analysis and results for the Planning Area, HAZUS-MH MR4 default critical facility inventory was updated with facilities provided by the County, participating municipalities and Planning Committee. Data collected and reviewed for the flood hazard included local spatial data from historical flood events, FEMA DFIRM data, best-available digital elevation data, data available through Westchester County's GIS web page and input from the residents and the Planning Committee. Although the data generated by HAZUS-MH MR4 is considered to be an estimate, its level of accuracy is acceptable for planning purposes.

A ***flood polygon*** is a GIS vector file outlining the area exposed to the flood hazard. HAZUS-MH generates this polygon at the end of the flood computations in order to analyze the at-risk inventory.

A ***GIS shape file*** is a type of GIS vector file that was developed by ESRI for its ArcView software. This type of file contains a table and a graphic. The records in the table are linked to corresponding objects in the graphic.

HAZUS-MH MR4 was used to run the hydrology and hydraulics for the selected riverine reaches, using the DFIRMs as a guide and USGS one-third ArcSecond DEMs (10 meter resolution. HAZUS-MH MR4 generated the flood-depth grid and flood boundary for the specified return periods (annualized losses and the 100- and 500-year mean return periods [MRP]) and calculated the estimated damages to the general building stock and critical facilities based on this depth grid.

The FEMA DFIRM polygon data and HAZUS-MH MR4 flood model were used to estimate exposure and losses associated with the flood hazard. The default demographic and general building stock data in HAZUS-MH MR4 and the FEMA DFIRM were used to estimate population and building exposure, and

the HAZUS-MH MR4 generated 100- and 500-year flood depth grids and boundaries were used to estimate losses. These mean return period (MRP) flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

The default demographic data in HAZUS-MH MR4, based on the 2000 U.S. Census, was used for analysis. The valuation of general building stock and the loss estimates determined in the Greater Greenburgh Planning Area were based on the default general building stock database provided in HAZUS-MH MR4. The general building stock valuations provided in HAZUS-MH MR4 are Replacement Cost Value from RSMeans as of 2006. The critical facility inventory (essential facilities, utilities, transportation features, high-potential loss facilities and user-defined facilities) was updated for the flood, earthquake and wind hazard models. This comprehensive inventory was developed by gathering input from numerous sources including HAZUS-MH, Westchester County and input from the Planning Committee.

The 11 residential and 10 commercial occupancy classes available in HAZUS-MH were condensed into the following occupancy classes (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single family dwellings. In addition, impacts to critical facilities were evaluated for the 100-year and 500-year MRP flood events.

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

To estimate the population exposed to the 100- and 500-year flood events, the FEMA DFIRM flood zones were overlaid upon the population data available in HAZUS-MH MR4 (U.S. Census 2000). The Census blocks with their center within the flood boundary were used to calculate the estimated population exposed to this hazard. Table 5.4.2-4 lists the estimated population located within the 100- and 500-year flood zones and Figures 5.4.2-9 through 5.4.2-11 illustrate the population density relative to the regulatory FEMA floodplains.

Table 5.4.2-4. Estimated Population Exposed to the Flood Hazard

Municipality	Total Pop.	Population in 100-Year SFHA		Population in 500-Year Flood Zone	
		Total Number in SFHA	% of Total	Number	% of Total
Unincorporated Greenburgh	41,828	313	0.7	594	1.4
Village of Ardsley	4,269	90	2.1	90	2.1
Village of Dobbs Ferry	10,622	0	0.0	703	6.6
Village of Elmsford	4,676	139	3.0	257	5.5
Village of Hastings-on-Hudson	7,648	88	1.2	128	1.7
Village of Irvington	6,631	63	1.0	1,308	19.7
Village of Tarrytown	11,090	411	3.7	745	6.7
Planning Area Total	**86,764**	**1,104**	**1.3**	**3,825**	**4.4**

Sources: HAZUS-MH MR4; FEMA DFIRM
Note: SFHA = Special Flood Hazard Area

The table above shows that approximately one-percent (1.3%) of the total Planning Area population is exposed to the 100-year flood and that approximately 4.4-percent of the total Planning Area population is exposed to the 500-year flood. The Village of Irvington has the most general population exposed with nearly 20-percent (500-year).

HAZUS-MH MR4 estimates the number of people who may be displaced and seek temporary shelter as a result of the 100- and 500-year MRP flood events. For the 100-year event, HAZUS-MH MR4 estimates 3,163 people will be displaced and 2,514 people will seek temporary shelter. For the 500-year event, HAZUS-MH MR4 estimates 3,359 people will be displaced and 2,663 will seek temporary shelter. Because the estimated population exposed to flooding does not include storm surge, this may be a conservative estimate and may be higher if multiple impacts occur (see Section 5.4.1 Severe Storm). Please refer to Table 5.4.2-5 which summarizes the displaced population by participating municipality.

Table 5.4.2-5. Estimated Population Displaced or Seeking Short-Term Shelter from the 100-Year and 500-Year MRP Events

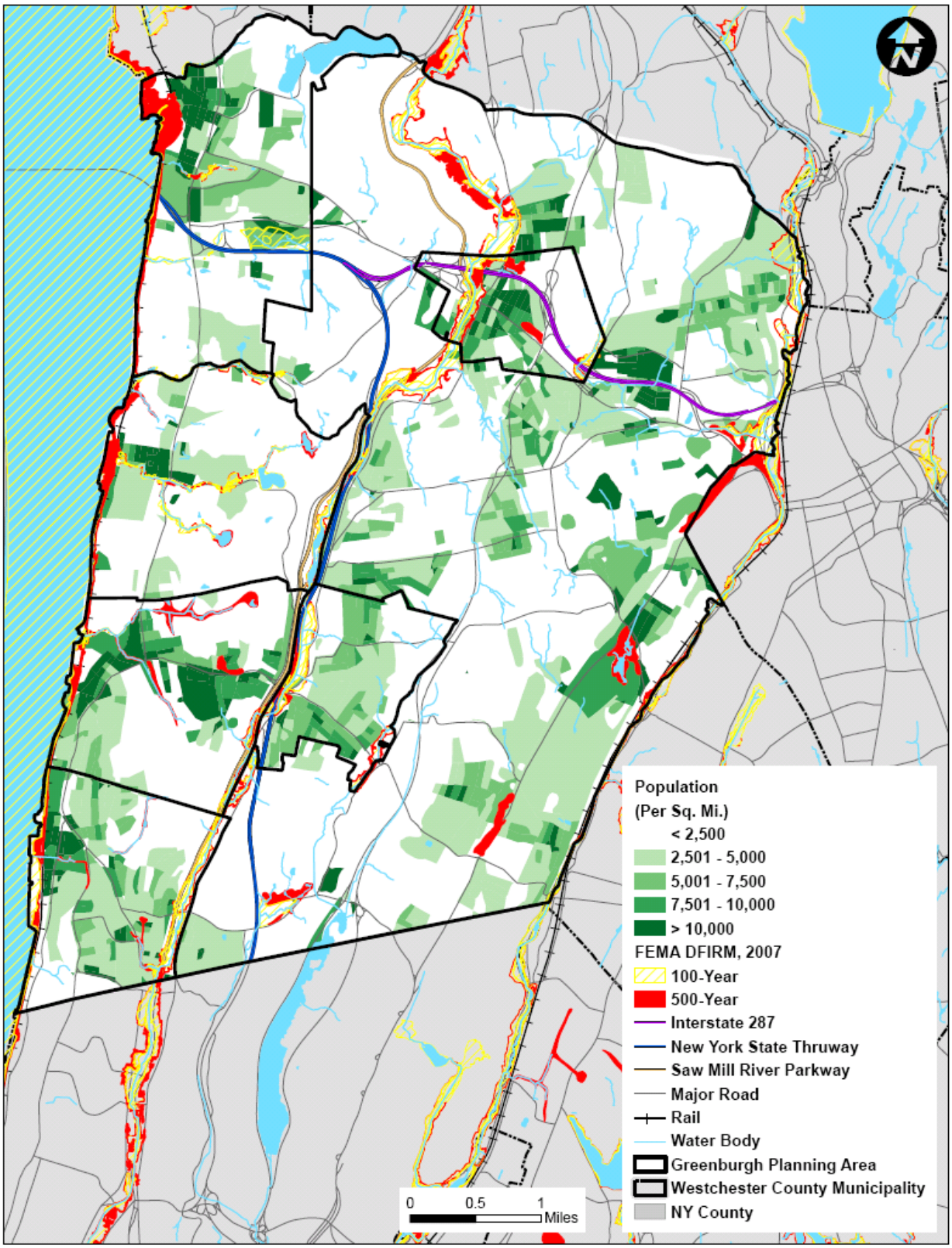
Municipality	Total Population	100-Year		500-Year	
		Displaced Persons	Persons Seeking Short-Term Sheltering	Displaced Persons	Persons Seeking Short-Term Sheltering
Unincorporated Greenburgh	41,828	2,062	1,694	2,188	1,806
Village of Ardsley	4,269	59	8	69	10
Village of Dobbs Ferry	10,622	20	5	21	5
Village of Elmsford	4,676	175	95	201	102
Village of Hastings-on-Hudson	7,648	474	429	534	480
Village of Irvington	6,631	204	147	152	99
Village of Tarrytown	11,090	169	136	194	161
Planning Area Total	**86,764**	**3,163**	**2,514**	**3,359**	**2,663**

Source: HAZUS-MH MR4

Of the population exposed, the most vulnerable include the economically disadvantaged (households with an income of less than $20,000) and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available to due isolation during a flood event and they may have more difficulty evacuating.

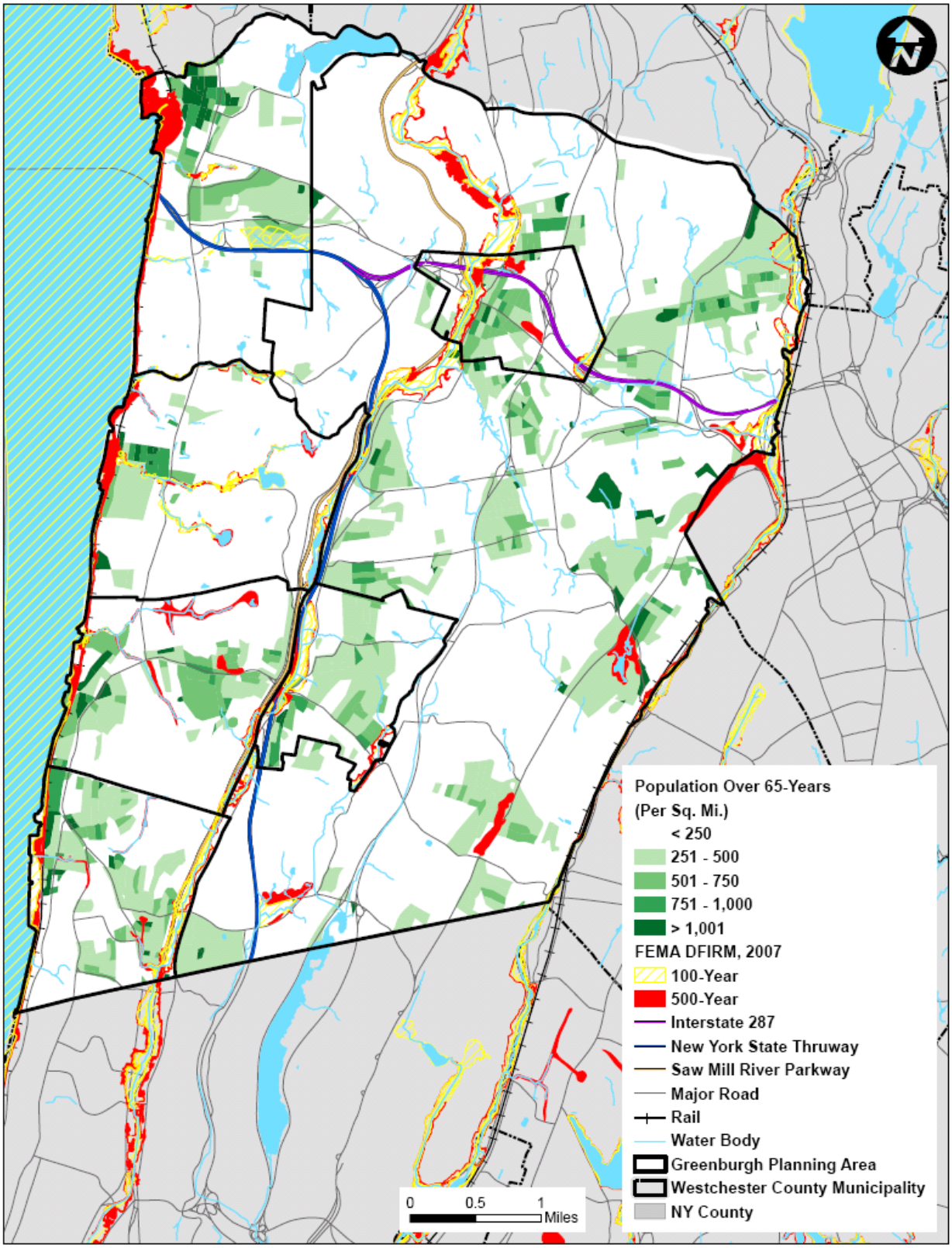
The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to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

Figure 5.4.2-9. Distribution of Population Density Relative to the 100- and 500-Year FEMA Floodplains in the Greater Greenburgh Planning Area



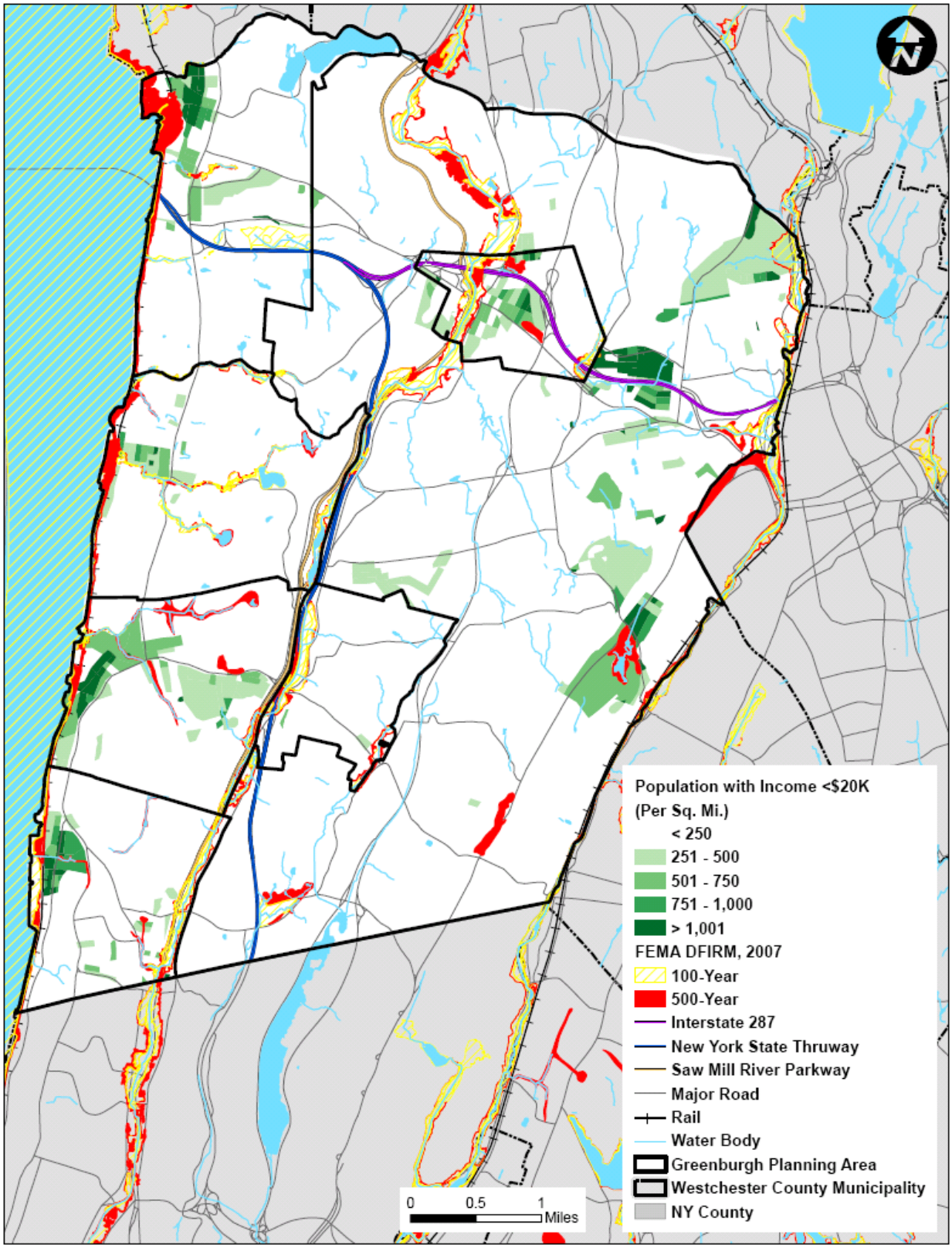
Source(s): HAZUS-MH MR4; FEMA DFIRMs, 2007

Figure 5.4.2-10. Distribution of Elderly Population Density Relative to the 100- and 500-Year FEMA Floodplains in the Greater Greenburgh Planning Area



Source(s): HAZUS-MH MR4; FEMA DFIRMs, 2007

Figure 5.4.2-11. Distribution of Low-Income Population Density Relative to the 100- and 500-FEMA Floodplains in the Greater Greenburgh Planning Area



Source: HAZUS-MH MR4; FEMA DFIRMs, 2007

Impact on General Building Stock

After considering the population vulnerable to the flood hazard, the HAZUS-MH MR4 default value of general building stock exposed to, and damaged by, the 100- and 500-year MRP flood events was evaluated. In addition, annualized losses for the general building stock using HAZUS-MH MR4 were also examined for the Planning Area. Exposure in the flood zone includes those buildings located in the flood zone that are exposed to the flood hazard. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

HAZUS-MH MR4 does not estimate general building stock exposure to the flood hazard. To provide a general exposure building count estimate, the 100- and 500-year regulatory floodplains were overlaid upon 2004 structure GIS layers provided by Westchester County GIS for each of the participating municipalities in the Greater Greenburgh Planning Area. According to these 2004 datasets, there are 26,844 'buildings' of the 27,159 structures in the Planning Area (antennas, tanks, towers, train stations, train platforms and miscellaneous structures were excluded). The buildings with their center located within the flood boundary were used to estimate the building count exposed to this hazard.

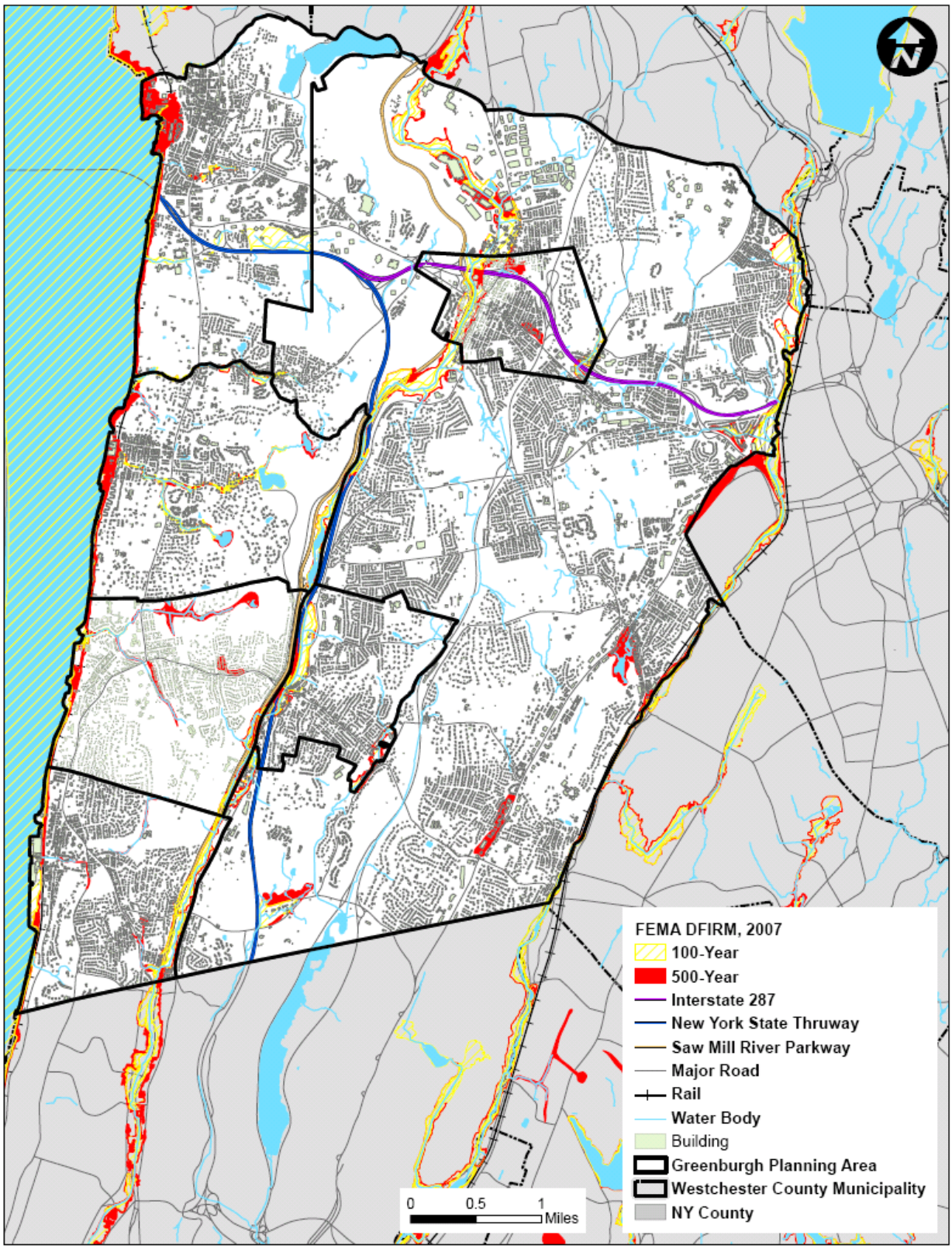
There are 370 buildings (1.4-percent of the total buildings) located within the 100-year floodplain boundary and 754 buildings (2.8-percent of the total buildings) within the 500-year floodplain boundary (Table 5.4.2-6 below). Because no other attribute data was provided with the building GIS layer, the number of buildings per occupancy class (i.e., residential, commercial, etc.) or the building/contents replacement values cannot be specified. Figure 5.4.2-12 illustrates the buildings in the Planning Area relative to the regulatory floodplains.

Table 5.4.2-6. Number of Buildings in the Greater Greenburgh Planning Area FEMA Floodplain Boundaries

Municipality	Total Number of Buildings	100-Year		500-Year	
		# in Zone	% of Total	# in Zone	% of Total
Unincorporated Greenburgh	13,049	157	1.2	264	2.0
Village of Ardsley	1,670	42	2.5	57	3.4
Village of Dobbs Ferry	2,859	7	0.2	80	2.8
Village of Elmsford	1,509	52	3.4	131	8.7
Village of Hastings-on-Hudson	2,813	24	0.9	55	2.0
Village of Irvington	2,063	66	3.2	90	4.4
Village of Tarrytown	2,881	22	0.8	77	2.7
Planning Area Total	**26,844**	**370**	**1.4**	**754**	**2.8**

Source: NYSEMO; Westchester GIS, 2004

Figure 5.4.2-12. Buildings in the Greater Greenburgh Planning Area Relative to the 100- and 500-Year FEMA Floodplains



Source(s): FEMA DFIRMs, 2007; WC GIS, 2004

To provide a general estimate of building/content replacement value exposure, the 100- and 500-year FEMA floodplain boundaries were overlaid upon the HAZUS-MH MR4 general building stock data inventory. The Census blocks with their center within the flood boundary were used to estimate the building count (for residential single-family dwellings and manufactured housing only) and replacement cost value exposed to this hazard (Tables 5.4.2-7 and 5.4.2-8). Only RES1 and RES2 occupancy class building counts are provided because they are based on census housing unit costs. All other occupancy class building counts are calculated in HAZUS-MH MR4 based on regional average square footage values for specific occupancy class/building types, and may significantly over- or under-estimate actual structure counts and therefore, those building counts were not included in the summary table. Figures 5.4.2-13 and 5.4.2-14 illustrate the residential and building stock density relative to the regulatory floodplains.

Table 5.4.2-7. Estimated Number of Residential Buildings (Single-Family Dwellings and Manufactured Housing) Located in the DFIRM 100- and 500-year Flood Boundaries

Municipality	Total		RES1		RES2	
	RES1	RES2	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	9,900	0	119	225	0	0
Village of Ardsley	1,364	2	24	24	0	0
Village of Dobbs Ferry	1,972	0	0	72	0	0
Village of Elmsford	1,043	0	27	49	0	0
Village of Hastings-on-Hudson	1,830	0	28	42	0	0
Village of Irvington	1,566	0	8	308	0	0
Village of Tarrytown	1,948	0	130	178	0	0
Planning Area Total	**19,623**	**2**	**336**	**898**	**0**	**0**

Source: HAZUS-MH MR4
Notes: RES 1 = Single-Family Dwellings; RES2 = Manufactured Housing

There is approximately $553 million of building/contents exposed to the 100-year flood in the Greater Greenburgh Planning Area. This represents approximately 3.3-percent of the Planning Area's total general building stock replacement value inventory (nearly $17 billion; see Section 4). For the 500-year event, it is estimated there is greater than $1 billion of buildings/contents exposed to the flood hazard in the Greater Greenburgh Planning Area. This is approximately 7-percent of the Planning Area's total general building stock replacement value inventory. Refer to Table 5.4.2-8 for the exposure estimates for each occupancy class.

Table 5.4.2-9 summarizes the general building stock estimated losses as a result of the 100- and 500-year flood events as calculated by HAZUS-MH MR4. The estimated total loss for the 100-year flood event is approximately $279 Million or 1.7-percent of the Greater Greenburgh Planning Area's building stock replacement value; 500-year flood event is greater than $319 Million or nearly two-percent (2%) of the Planning Area's building stock replacement value.

Table 5.4.2-8. Estimated General Building Stock Replacement Value (Structure and Contents) Located in the DFIRM 100- and 500-Year Flood Boundaries

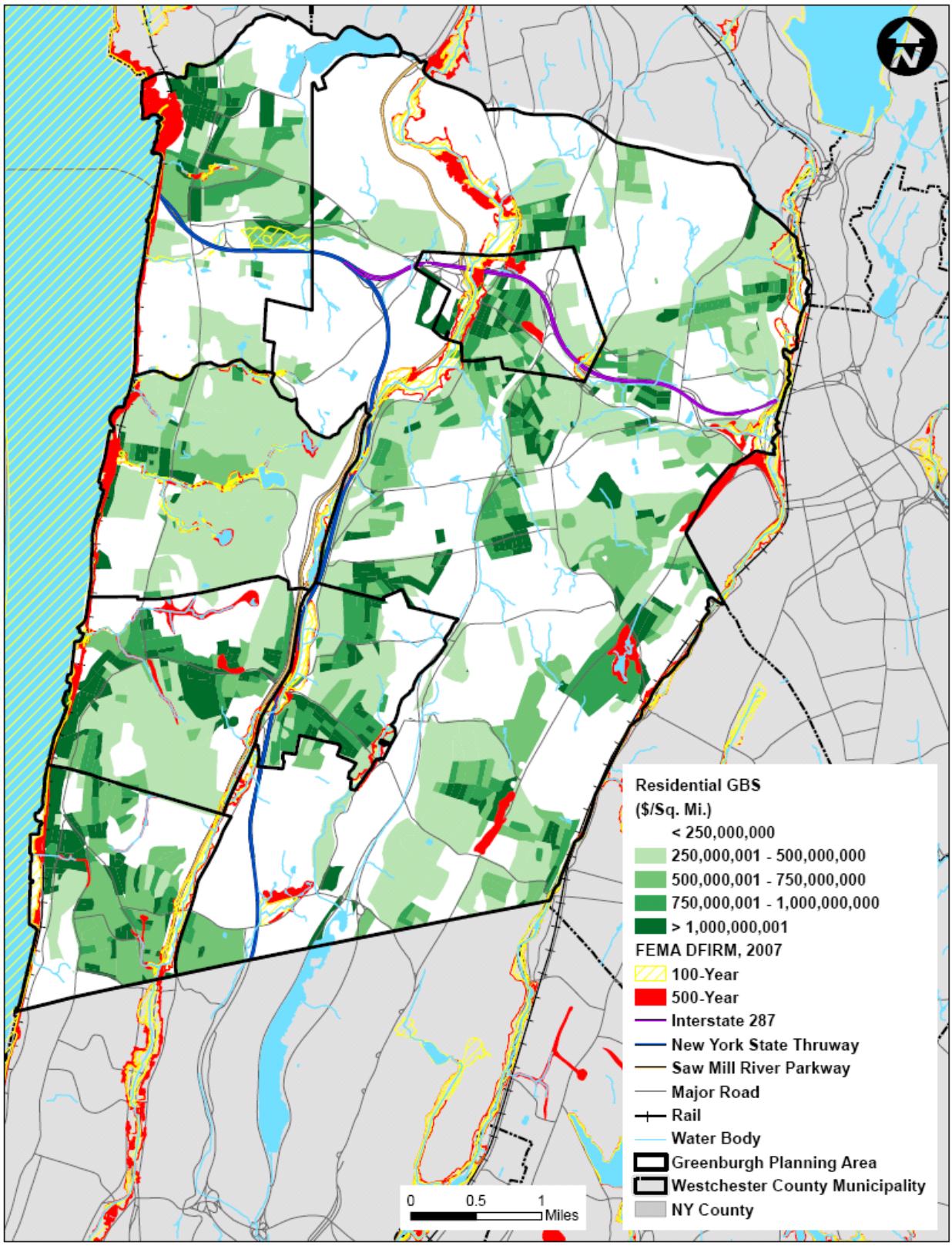
Municipality	Total GBS RV	Total (All Occupancy Classes) in SFHA		Total (All Occupancy Classes) in 500-Year Flood Zone	
		RV	% of Total	RV	% of Total
Unincorporated Greenburgh	$869,545,000	$130,457,000	15.0	$299,212,000	34.4
Village of Ardsley	$1,890,873,000	$28,697,000	1.5	$33,806,000	1.8
Village of Dobbs Ferry	$1,028,560,000	$0	0.0	$133,131,000	12.9
Village of Elmsford	$7,923,763,000	$123,157,000	1.6	$150,038,000	1.9
Village of Hastings-on-Hudson	$1,469,469,000	$164,946,000	11.2	$171,677,000	11.7
Village of Irvington	$1,194,043,000	$4,675,000	0.4	$248,938,000	20.8
Village of Tarrytown	$2,451,976,000	$101,466,000	4.1	$144,081,000	5.9
Planning Area Total	**$16,828,229,000**	**$553,398,000**	**3.3**	**$1,180,883,000**	**7.0**

Municipality	Residential Buildings		Commercial Buildings		Industrial Buildings	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	$54,448,000	$104,089,000	$59,264,000	$131,849,000	$12,565,000	$46,228,000
Village of Ardsley	$12,507,000	$16,308,000	$15,326,000	$16,250,000	$636,000	$1,020,000
Village of Dobbs Ferry	$0	$95,365,000	$0	$28,122,000	$0	$2,628,000
Village of Elmsford	$14,453,000	$24,793,000	$85,669,000	$101,325,000	$13,807,000	$14,362,000
Village of Hastings-on-Hudson	$14,291,000	$21,022,000	$105,784,000	$105,784,000	$36,345,000	$36,345,000
Village of Irvington	$4,183,000	$163,326,000	$394,000	$78,954,000	$0	$6,074,000
Village of Tarrytown	$56,829,000	$85,036,000	$39,137,000	$48,737,000	$3,954,000	$5,728,000
Planning Area Total	**$156,711,000**	**$509,939,000**	**$305,574,000**	**$511,021,000**	**$67,307,000**	**$112,385,000**

Municipality	Agricultural Buildings		Religious Buildings		Government Buildings		Educational Buildings	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	$0	$314,000	$2,672,000	$2,672,000	$0	$10,286,000	$1,508,000	$3,774,000
Village of Ardsley	$228,000	$228,000	$0	$0	$0	$0	$0	$0
Village of Dobbs Ferry	$0	$498,000	$0	$6,518,000	$0	$0	$0	$0
Village of Elmsford	$168,000	$498,000	$2,168,000	$2,168,000	$6,522,000	$6,522,000	$370,000	$370,000
Village of Hastings-on-Hudson	$150,000	$150,000	$1,372,000	$1,372,000	$0	$0	$7,004,000	$7,004,000
Village of Irvington	$98,000	$196,000	$0	$0	$0	$0	$0	$388,000
Village of Tarrytown	$208,000	$374,000	$412,000	$412,000	$0	$2,868,000	$926,000	$926,000
Planning Area Total	**$852,000**	**$2,258,000**	**$6,624,000**	**$13,142,000**	**$6,522,000**	**$19,676,000**	**$9,808,000**	**$12,462,000**

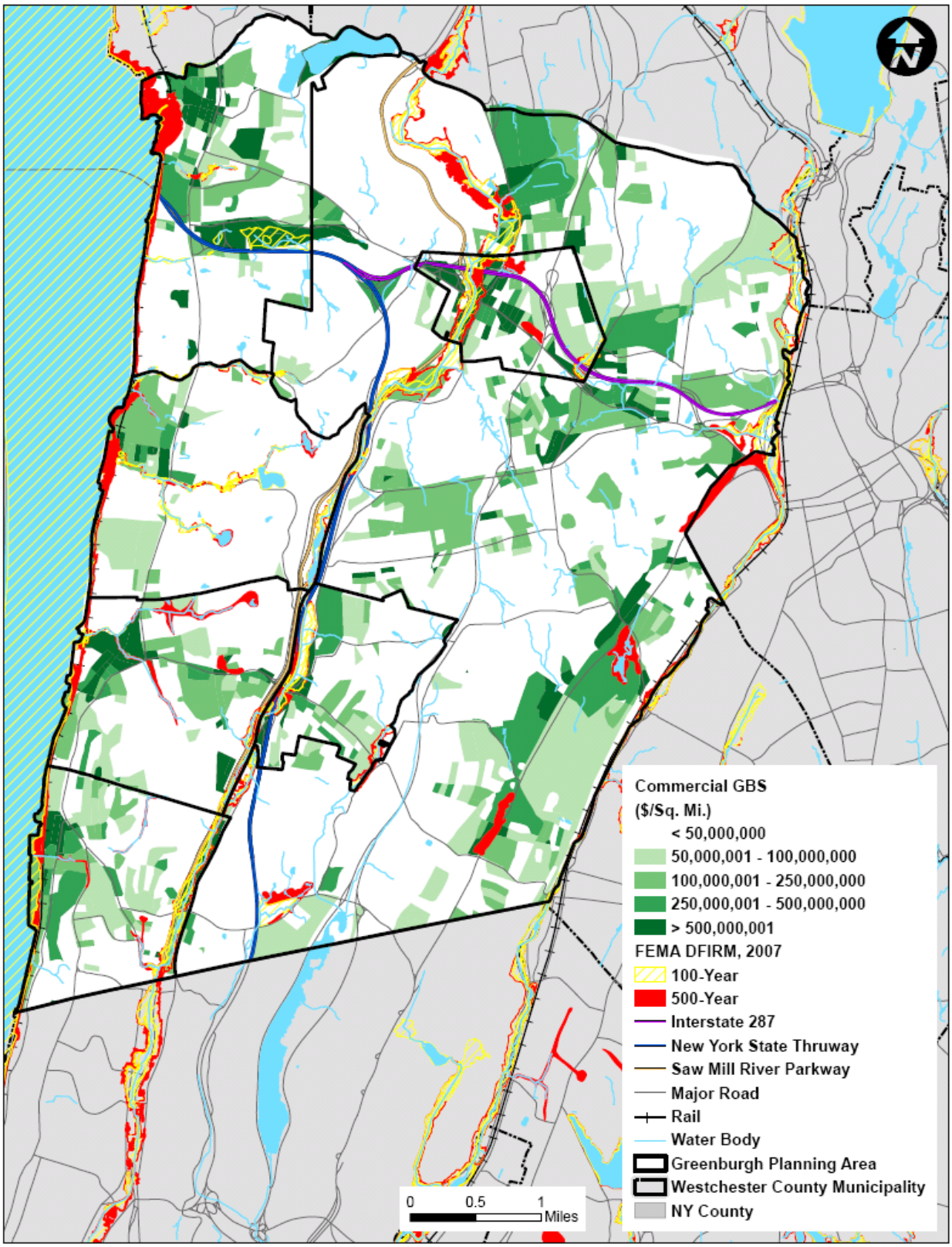
Source: HAZUS-MH MR4; FEMA, 2007
Notes: GBS = General Building Stock. RV = Replacement Value. SFHA = Special Flood Hazard Area.

Figure 5.4.2-13. Distribution of Residential General Building Stock Density Relative to the 100- and 500-Year MRP Regulatory Floodplains in the Greater Greenburgh Planning Area.



Source(s): HAZUS-MH MR4; FEMA DFIRMs, 2007

Figure 5.4.2-14. Distribution of Commercial General Building Stock Density Relative to the 100- and 500-Year MRP Regulatory Floodplains in the Greater Greenburgh Planning Area.



Source(s): HAZUS-MH MR4; FEMA DFIRMs, 2007

Table 5.4.2-9. Estimated General Building Stock Replacement Value (Structure and Contents) Damaged by the 100-Year and 500-Year MRP Flood Events

Municipality	All Occupancies					Residential	
	Total GBS RV	100-Year	% of Total RV	500-Year	% of Total RV	100-Year	500-Year
Unincorporated Greenburgh	$869,545,000	$118,276,000	13.6	$142,548,000	16.4	$48,775,000	$55,599,000
Village of Ardsley	$1,890,873,000	$5,091,000	0.3	$6,211,000	0.3	$1,161,000	$1,452,000
Village of Dobbs Ferry	$1,028,560,000	$731,000	0.1	$883,000	0.1	$309,000	$386,000
Village of Elmsford	$7,923,763,000	$34,573,000	0.4	$41,751,000	0.5	$1,380,000	$2,517,000
Village of Hastings-on-Hudson	$1,469,469,000	$82,740,000	5.6	$95,832,000	6.5	$26,785,000	$31,599,000
Village of Irvington	$1,194,043,000	$25,263,000	2.1	$31,408,000	1.4	$7,049,000	$13,107,000
Village of Tarrytown	$2,451,976,000	$12,564,000	0.5	$15,660,000	0.6	$2,554,000	$3,365,000
Planning Area Total	**$16,828,229,000**	**$279,238,000**	**1.7**	**$319,293,000**	**1.9**	**$88,013,000**	**$99,025,000**

Municipality	Commercial		Industrial		Agriculture	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	$46,330,000	$57,054,000	$13,456,000	$18,213,000	$1,377,000	$1,687,000
Village of Ardsley	$3,699,000	$4,477,000	$191,000	$240,000	$37,000	$38,000
Village of Dobbs Ferry	$256,000	$287,000	$49,000	$54,000	$0	$1,000
Village of Elmsford	$26,179,000	$30,943,000	$4,527,000	$5,257,000	$117,000	$147,000
Village of Hastings-on-Hudson	$40,812,000	$46,967,000	$9,916,000	$11,100,000	$32,000	$36,000
Village of Irvington	$14,710,000	$17,134,000	$3,353,000	$1,021,000	$39,000	$42,000
Village of Tarrytown	$8,377,000	$10,362,000	$1,125,000	$1,333,000	$49,000	$54,000
Planning Area Total	**$140,363,000**	**$161,224,000**	**$32,617,000**	**$37,218,000**	**$1,651,000**	**$2,005,000**

Table 5.4.2-9. Estimated General Building Stock Replacement Value (Structure and Contents) Damaged by the 100-Year and 500-Year MRP Flood Events (Continued)

Municipality	Religious		Government		Education	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	$3,288,000	$4,063,000	$728,000	$951,000	$4,310,000	$4,983,000
Village of Ardsley	$3,000	$3,000	$0	$1,000	$0	$0
Village of Dobbs Ferry	$4,000	$6,000	$0	$0	$113,000	$149,000
Village of Elmsford	$961,000	$1,142,000	$1,238,000	$1,546,000	$171,000	$199,000
Village of Hastings-on-Hudson	$1,003,000	$1,195,000	$1,548,000	$1,791,000	$2,644,000	$3,144,000
Village of Irvington	$27,000	$30,000	$16,000	$7,000	$260,000	$67,000
Village of Tarrytown	$402,000	$480,000	$11,000	$13,000	$46,000	$53,000
Planning Area Total	**$5,688,000**	**$6,919,000**	**$3,541,000**	**$4,309,000**	**$7,544,000**	**$8,595,000**

Source: HAZUS-MH MR4
Notes: The total replacement value is the sum of all seven general occupancy classifications.
GBS = General Building Stock
RV = Replacement Value.

Annualized losses are useful for mitigation planning because they provide a baseline upon which to 1) compare the risk of one hazard across multiple jurisdictions and 2) compare the degree of risk of all hazards for each participating jurisdiction. Please note that annualized loss does not predict what losses will occur in any particular year. Table 5.4.2-10 summarizes the estimated annualized general building stock losses as a result of the flood hazard.

Table 5.4.2-10. Summary of Estimated Annualized Flood General Building Stock Losses for the Greater Greenburgh Planning Area

Municipality	Total (Buildings + Contents)	Buildings	Contents
Unincorporated Greenburgh	$4,929,000	$1,703,000	$3,094,000
Village of Ardsley	$688,000	$235,000	$438,000
Village of Dobbs Ferry	$194,000	$73,000	$120,000
Village of Elmsford	$216,000	$49,000	$165,000
Village of Hastings-on-Hudson	$1,166,000	$637,000	$523,000
Village of Irvington	$5,057,000	$2,796,000	$2,202,000
Village of Tarrytown	$3,035,000	$1,180,000	$1,813,000
Planning Area Total	**$15,285,000**	**$6,673,000**	**$8,355,000**

Source: HAZUS-MH MR4

In addition to total building stock modeling, individual data available on flood policies, claims, RLP and severe RLP (SRL's) were analyzed. FEMA Region 2 provided a list of properties with NFIP policies, past claims and multiple claims (RLPs). According to the metadata provided: "The NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than $1,000 for each loss. The two losses must be within 10 years of each other and be as least 10 days apart. Only losses from (*sic* since) 1/1/1978 that are closed are considered."

Severe RLP were then examined in the Greater Greenburgh Planning Area. According to section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a, a severe RLP property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both of the above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

A summary table of NFIP Loss Claims and Payment Data, including outstanding claims as of February 2010 is displayed below in Table 5.4.2-11. This table also displays Repetitive Loss and Severe Repetitive Loss Property statistics (refer to Figure 5.4.2-15). According to FEMA, there are 44 RL properties in the Greater Greenburgh Planning Area. Of these 44 RL properties, 17 RL properties are classified as 'single family', 4 RL properties are '2-4 family', 11 RL properties are 'assumed condominiums', 11 RL properties are 'non-residential' and one (1) property is 'other residential'. Additionally, this data indicates there are 14 Severe RL properties in the City (FEMA Region 2, 2010).

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded by FEMA with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others. This data is more current than the properties reported in the New York State HMP which may explain any difference in property count between these sources.

Impact on Critical Facilities

HAZUS-MH MR4 estimates the probability critical facilities may sustain damage as a result of a 100-year and 500-year MRP flood event. The following tables list critical facilities and utilities that may be impacted by 100-year and 500-year MRP flood events; if a damage estimate was not calculated by HAZUS-MH MR4, and the facility is located within the FEMA DFIRM flood boundaries, it is also included in the tables below.

Table 5.4.2-11. NFIP Policies, Claims and Repetitive Loss Statistics

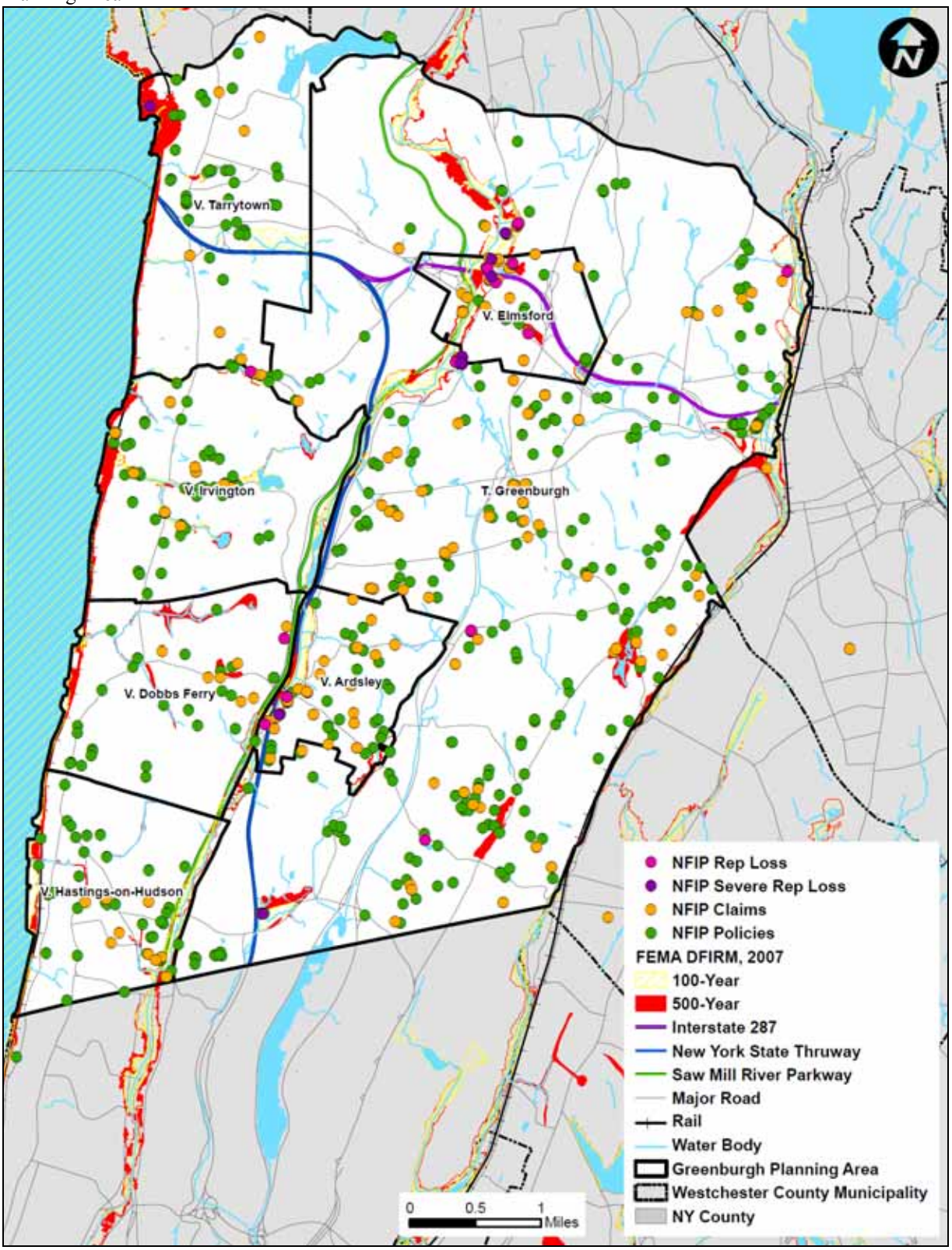
Municipality	# Policies (1)	Insurance (2)	# Claims (Losses) (1)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Polices in 100-year Boundary (1)	# Polices in 500-Boundary (1)	# Policies Outside the 500-year Flood Hazard (1)
Unincorporated Greenburgh	267	$72,700,700	195	18	4	27	32	235
Village of Ardsley	38	$10,700,800	225	5	1	4	8	30
Village of Dobbs Ferry	28	$5,183 ,000	10	1	0	0	1	27
Village of Elmsford	49	$8,186 ,200	227	18	8	21	26	23
Village of Hastings-on-Hudson	37	$9,892,800	19	0	0	2	5	32
Village of Irvington	70	$22,496,300	47	1	0	7	11	59
Village of Tarrytown	47	$12,374,400	17	1	1	7	11	36
Planning Area Total	**536**	**$128,165,000**	**740**	**44**	**14**	**68**	**94**	**442**

Source: FEMA NFIP

(1) Policies provided by FEMA Region 2, February 2010 using the "comm_name" field. To calculate policies located within the FEMA DFIRM flood boundaries were used. Policies in the 500-year boundary include those in the 100-year boundary.

(2) FEMA, 2011 (as of March 31, 2011)

Figure 5.4.2-15. Polices, Claims, Repetitive and Severe Repetitive Loss Properties in the Greater Greenburgh Planning Area



Source: FEMA, 2010
Note: NFIP statistics provided by FEMA Region 2 in February 2010

Table 5.4.2-12. Estimated Critical Facility Damage Due to a 100-year MRP Flood Event

Facility Name	Municipality	Description	% Structure Damaged	% Contents Damaged
Montefiore Westchester DIV	Elmsford (V)	Senior Center	NA	NA
Greenburgh Gas Storage	Greenburgh (U)	Municipal	5.8	38.0
Theodore D Young Comm Center	Greenburgh (U)	Shelter	6.8	28.3
Leisure Time Club	Irvington (V)	Senior Center	23.8	100

Source: HAZUS-MH MR4; FEMA DFIRM, 2007
Notes: NA = Not available. HAZUS-MH MR4 did not calculate damages for this facility; however, this facility is located within the FEMA flood boundary (September 2007) and vulnerable to the flood hazard.
T = Town. V = Village.

Table 5.4.2-13. Estimated Critical Facility Damage Due to a 500-year MRP Flood Event

Facility Name	Municipality	Description	% Structure Damaged	% Contents Damaged
Ardsley Village Salt Shed	Ardsley (V)	Municipal	NA	NA
Montefiore Westchester DIV	Elmsford (V)	Senior Center	NA	NA
Greenburgh Gas Storage	Greenburgh (U)	Municipal	6.9	48.6
Theodore D Young Comm Center	Greenburgh (U)	Shelter	7.1	29.2
Hartsdale F.D.	Greenburgh (U)	Fire	NA	NA
Leisure Time Club	Irvington (V)	Senior Center	NA	NA
Tarrytown P.D.	Tarrytown (V)	Police	NA	NA
Tarrytown F.D.	Tarrytown (V)	Fire	NA	NA
Tarrytown Seniors	Tarrytown (V)	Senior Center	NA	NA
Tarrytown Village Hall	Tarrytown (V)	Village Hall	NA	NA

Source: HAZUS-MH MR4; FEMA DFIRM, 2007
Notes: NA = Not available. HAZUS-MH MR4 did not calculate damages for this facility; however, this facility is located within the FEMA flood boundary (September 2007) and vulnerable to the flood hazard.
T = Town. V = Village.

Table 5.4.2-14. Utilities Damage Due to a 100-year MRP Flood Event

Facility Name	Municipality	Description	% Damage
Chauncy WWPS	Dobbs Ferry (V)	WW Pump Station	4.4
Greenburgh Sewage PS	Greenburgh (U)	WW Pump Station	4.2

Source: HAZUS-MH MR4; FEMA DFIRM, 2007
Notes: NA = Not available. HAZUS-MH MR4 did not calculate damages for this facility; however, this facility is located within the FEMA flood boundary (September 2007) and vulnerable to the flood hazard.
T = Town. V = Village.

Table 5.4.2-15. Utilities Damage Due to a 500-year MRP Flood Event

Facility Name	Municipality	Description	% Damage
Chauncy WWPS	Dobbs Ferry (V)	WW Pump Station	6.2
Elmsford Pump Station	Elmsford (V)	Potable Water	NA
Greenburgh Sewage PS	Greenburgh (U)	WW	NA

Source: HAZUS-MH MR4; FEMA DFIRM, 2007
Notes: NA = Not available. HAZUS-MH MR4 did not calculate damages for this facility; however, this facility is located within the FEMA flood boundary (September 2007) and vulnerable to the flood hazard.
T = Town. V = Village.

As listed in Tables 5.4.2-12 through 5.4.2-15, there are critical facilities and utilities vulnerable to the flood hazard. Transportation features are not included in Tables 5.4.2-16 and 5.4.2-17. Because the roads vulnerable to flooding are too numerous to list, Figure 5.4.2-16 illustrates the FEMA DFIRM boundaries with the local roads and highways throughout the Planning Area. Please note that this figure does not convey whether or not the road/highway is already designed and built above the base flood elevation.

To estimate the highway bridges exposed to the flood hazard, the FEMA DFIRM flood boundaries were overlaid upon the major bridge inventory provided by HAZUS-MH MR4. HAZUS-MH MR4 lists 89 highway bridges located in the Greater Greenburgh Planning Area. Of the 89 bridges, 19 bridges are located within the FEMA DFIRM 100-year flood boundary; 29 bridges are located within the FEMA DFIRM 500-year flood boundary. The majority of these bridges are located along the Saw Mill River and Bronx River. This listing does not convey whether or not the bridge is designed and built above the base flood elevation.

In addition, there are four rail facilities in the Greater Greenburgh Planning Area located within the FEMA regulatory 500-year flood boundaries and thus vulnerable to the flood hazard. HAZUS-MH MR4 did not estimate damages for these facilities. These facilities are listed in Table 5.4.2-16.

Table 5.4.2-16. Railroad Facilities in the Greater Greenburgh Planning Area Located Within the FEMA DFIRM 500-Year Flood Boundaries

Facility Name	Municipality
Dobbs Ferry MTA Station	Dobbs Ferry (V)
Hartsdale Train Station	Greenburgh (U)
Irvington MTA Rail Station	Irvington (V)
Tarrytown Metro North Station	Tarrytown (V)

Source: FEMA DFIRM, 2007
Notes: T = Town. V = Village.

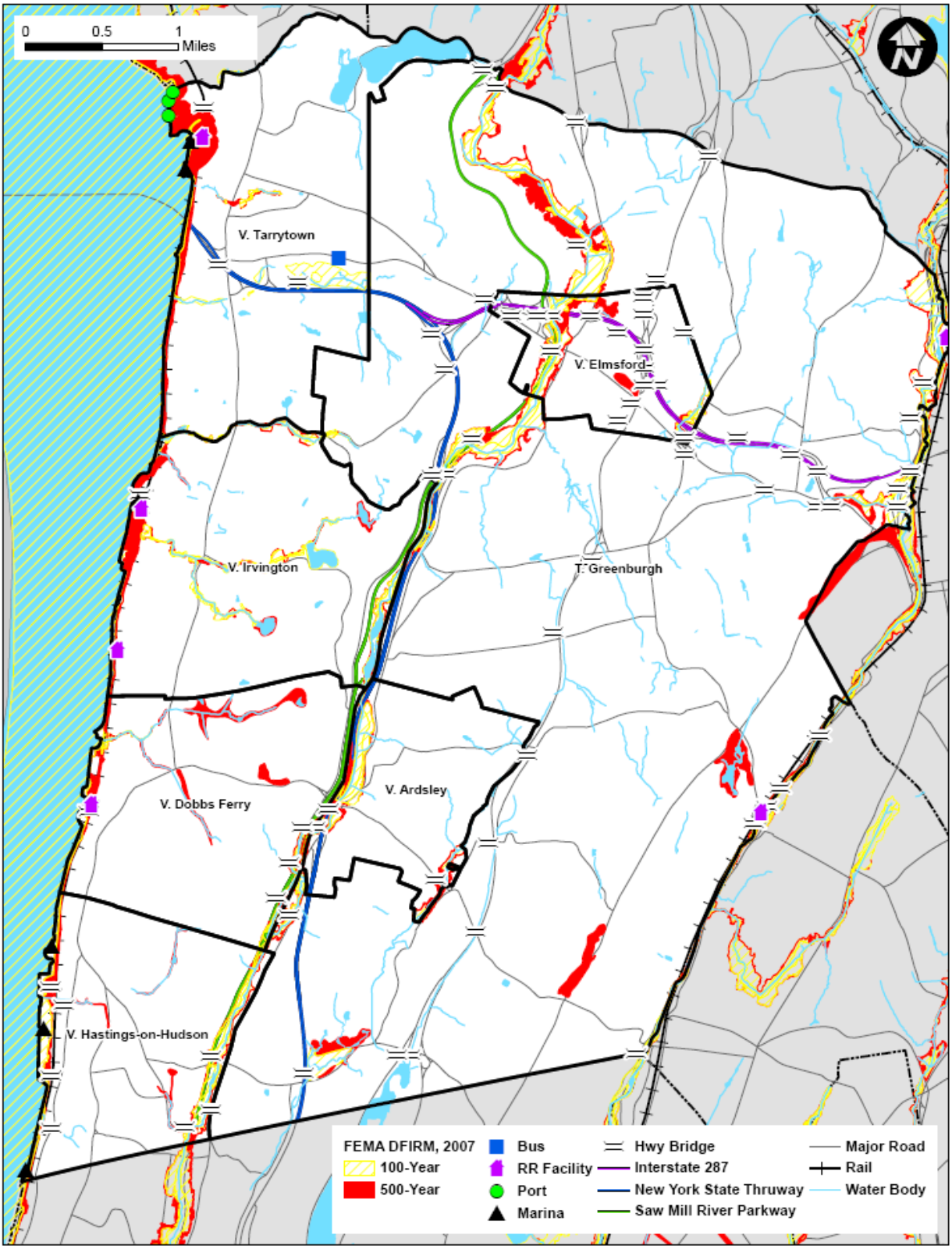
Marinas and ports located along the Hudson River in the Planning Area are also vulnerable to the flood hazard. The following table lists the marinas and ports in the Planning Area and located within the FEMA flood boundaries (September 2007).

Table 5.4.2-17. Marinas and Ports in the Greater Greenburgh Planning Area Located Within the FEMA DFIRM Flood Boundaries

Facility Name	Municipality	Type	100-Year Boundary	500-Year Boundary
Tower Ridge Yacht Club	Hastings-on-Hudson (V)	Marina	X	X
Hastings Pioneer Boat Club	Hastings-on-Hudson (V)	Marina	X	X
Palisade Boat Club	Hastings-on-Hudson (V)	Marina	X	X
Irvington Boat Club	Irvington (V)	Marina	X	X
Tarrytown Boat Club	Tarrytown (V)	Marina	X	X
New York Waterways Dock	Tarrytown (V)	Port	X	X
Westchester Industries Dock	Tarrytown (V)	Port	X	X
Washington Irvington Boat Club	Tarrytown (V)	Marina		X
Frank's Fuel Service Wharf	Tarrytown (V)	Port		X

Source: FEMA DFIRM, 2007
Notes: V = Village

Figure 5.4.2-16. FEMA DFIRM and Transportation Features in the Greater Greenburgh Planning Area



Source: FEMA DFIRM, 2007

According to Unincorporated Greenburgh Floodplain Management and Hazard Mitigation Plan (2001) and various other sources, the following areas and associated roadways are historically flood-prone (Figure 5.4.2-17):

Saw Mill River Watershed:

- Warehouse Lane and Payne Street (Unincorporated Greenburgh, north of the Village of Elmsford);
- Sawmill River Road at Payne Street and at Beaver Hill (Unincorporated Greenburgh);
- Sawmill River Parkway (Village of Elmsford);
- Route 9A corridor (Village of Elmsford, northern Elmsford);
- Mine Brook confluence;
- Payne Street, Vreeland Avenue, Hayes Street, Newman Avenue (Village of Elsmford, north Greenburgh);
- Lamont Street, Nepperhan Avenue, North Payne and Hayes Street (Unincorporated Greenburgh, north of the Village of Elmsford);
- Babbitt Court (Unincorporated Greenburgh and Village of Elmsford);
- Shelly Avenue, Lytton Avenue, Clements Place, Spencer Court (Unincorporated Greenburgh);
- Rum Brook from Secor Road to Route 100B; Unnamed tributary at Worthington Road;
- Pine Street, between Forest Boulevard and Secor Road (collapsing stream overpass);
- Railroad station (Unincorporated Greenburgh, southeast);
- South Central (Park) Avenue (Unincorporated Greenburgh, southeast); and
- New Central Park Avenue, Underhill Road, White Oak Lane (Unincorporated Greenburgh, southeast).

Hudson River Watershed:

- Unnamed tributary, Mulligan Lane and Taxter Road areas (Town of Greenbrugh, west);
- East and West Sunnyside Lane, Hudson View Park (Village of Irvington);
- Dunham Place, Meadow Way, Harriman Road, Station Road (Village of Irvingon); and
- Riverview Road, west of Broadway (Village of Irvington).

Sprain Brook:

- Jackson Avenue Old Jackson Avenue area (Town of Greenbrugh, south)

Bronx River Watershed:

- New York State Route 199 at Knollwood Road;
- Manhattan Brook confluence
- Kensico Road area (Unincorporated Greenburgh, northeast);
- Troublesome Brook, Route 100 from Mt. Joy Avenue to Route 100A;
- Pipeline Road and White Oak Lane areas;
- Tamarack Trail area;
- Maryton Road and Bronx River Parkway (Unincorporated Greenburgh); and
- Bronx River Parkway at Fenimore Road (Unincorporated Greenburgh, southeast).

In addition to the roadways identified above, the Planning Committee has identified mitigation projects on the following roadways that are vulnerable to flooding:

Unincorporated Greenburgh:

- West Hartsdale Road
- Washington Place
- Stadium Road
- Jackson, Old Jackson and Sprain Avenue
- Route 9A in the area of Beaver Hill
- East Hartsdale Avenue
- Hartsdale Brook in vicinity of East Hartsdale Avenue
- Babbitt Court
- Knollwood Road

Village of Ardsley:

- Ashford Avenue Bridge over NYS Thruway and Saw Mill Parkway
- Intersection of Sprain Brook and Cross Roads
- Route 9A just north of Revolutionary Road
- King Street

Village of Dobbs Ferry:

- Beacon Hill Drive and Ashford Avenue
- Washington Avenue

Village of Elmsford

- 119 and 9A
- Alma Place and Woodside Avenue
- 119, Old Road and Robbins Avenue intersection

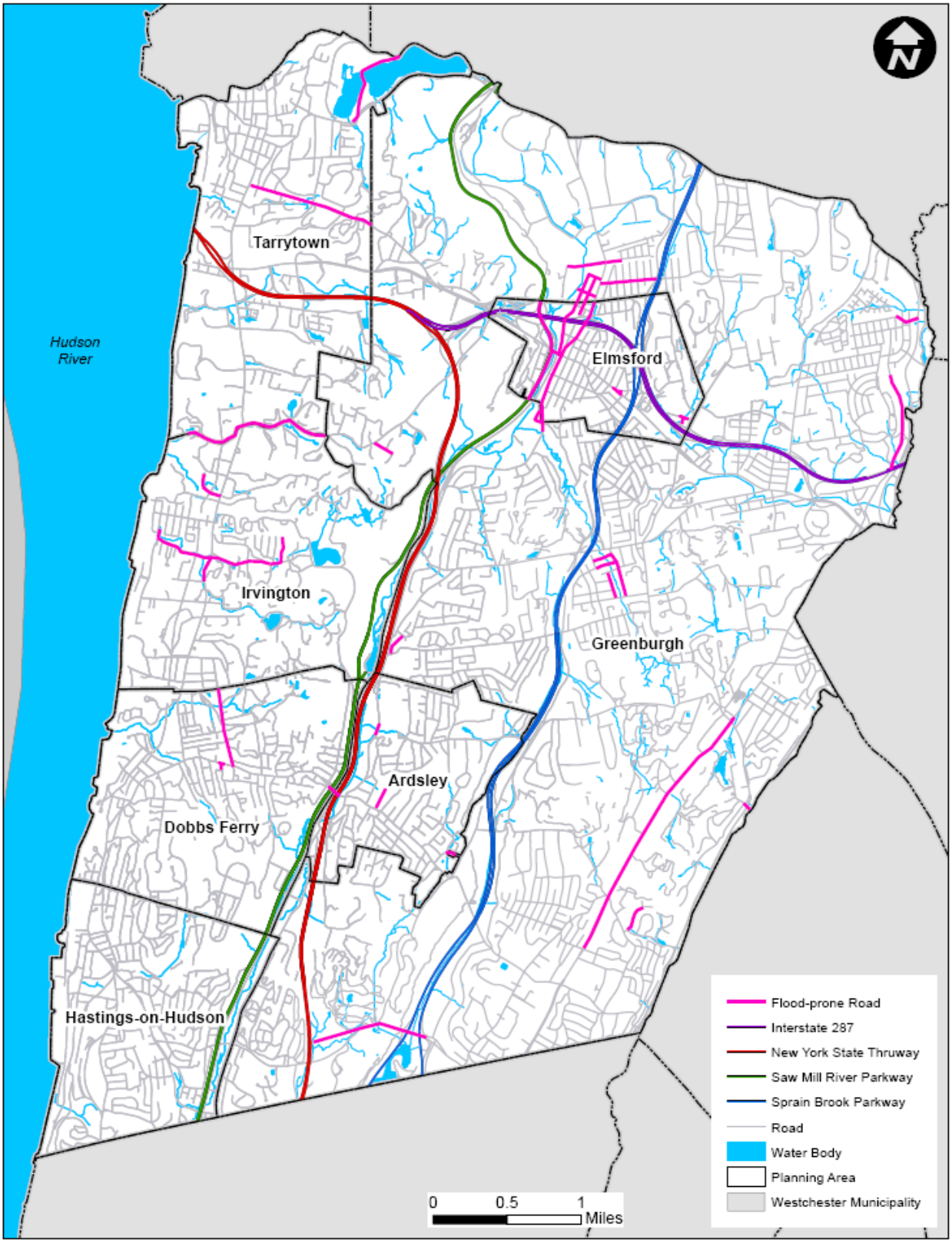
Village of Irvington

- Intersection of East Sunnyside Lane and Hudson View Park
- East of the intersection of South Buckhout Street and South Astor Street
- Station Road
- Between Station Road and Dows Lane
- Harriman Road between Parkside Way and Dunham Place

Village of Tarrytown

- Sunnyside Lane area (bordering both the Village of Tarrytown and Irvington)
- Neperan Road adjacent to Tarrytown Lakes (Skate Shack)
- Benedict Avenue

Figure 5.4.2-17. Flood-prone Roads in the Greater Greenburgh Planning Area



Source: Planning Committee, 2011; Sidney B. Bowne & Son, LLP, 2001

Impact on Economy

For impact on economy, estimated losses from a flood event are considered. Losses include but are not limited to general building stock damages, business interruption, impacts to tourism and tax base to the Greater Greenburgh Planning Area. Damages to general building stock can be quantified using HAZUS-MH as discussed above. Other economic components such as loss of facility use, functional downtime, loss of tourism revenue and social economic factors are less measurable with a high degree of certainty.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. The potential damage estimated to the general building stock inventory associated with the 100-year flood is $279 Million. This estimate represents approximately 50-percent of the Planning Area's total general building stock inventory exposed to the hazard. For the 500-year event, the potential damage estimate is greater than $319 Million (structure and contents), or approximately 27-percent of the Planning Area's total general building stock replacement value inventory exposed. These dollar value losses to the Planning Area's total building inventory replacement value would greatly impact the participating municipalities' tax base and the local economy.

HAZUS-MH MR4 estimates the amount of debris generated from the flood events as a result of 100- and 500-year MRPs. 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 5.4.2-18 summarizes the debris HAZUS-MH MR4 estimates for each participating municipality.

Table 5.4.2-18. Estimated Debris Generated from the 100- and 500-Year MRP Flood Events

Municipality	100-Year			500-Year		
	Finishes (tons)	Structural (tons)	Foundations (tons)	Finishes (tons)	Structural (tons)	Foundations (tons)
Unincorporated Greenburgh	10,044	26,662	15,268	11,151	28,861	17,419
Village of Ardsley	87	0	0	104	1	1
Village of Dobbs Ferry	28	0	0	33	0	0
Village of Elmsford	345	0	0	518	0	0
Village of Hastings-on-Hudson	5,131	11,794	9,641	6,522	14,952	12,588
Village of Irvington	1,002	833	811	521	155	111
Village of Tarrytown	324	253	198	406	346	267
Planning Area Total	**16,961**	**39,542**	**25,918**	**19,254**	**44,314**	**30,387**

Source: HAZUS-MH MR4

Future Growth and Development

As discussed in Section 4 and Section 9 within each jurisdiction's annex, areas targeted for future growth and development have been identified across the Planning Area. Any new development within the identified flood hazard areas will be at risk to flooding. Please refer to Figure 5.4.2-18 below and each jurisdictions' annex (Section 9) for hazard maps that illustrate where potential new development is located in relation to the FEMA regulatory flood boundaries. Based on each potential development's approximate location, the following are located in the FEMA flood boundaries: Village of Dobbs Ferry's Waterfront Revitalization Project; Village of Hastings on Hudson The Mobile/Uhlich Site, Zinsser Parking Lot, MacEachron Waterfront Park, Tower Ridge Yacht Club and Palisade Boat Club; and Village of Ardsley Harrington Subdivision and 649 Ashford LLC Subdivision.

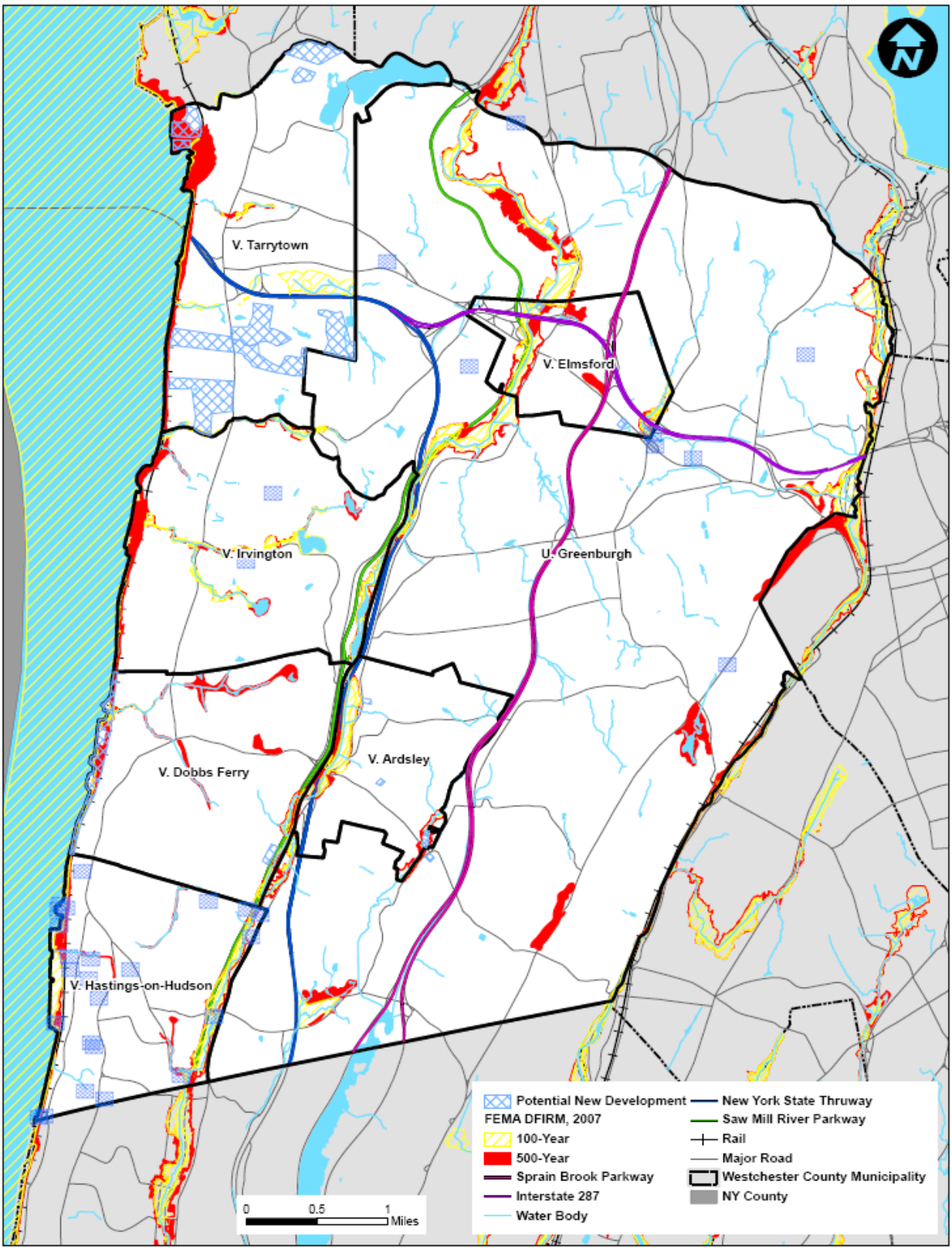
Additional Data and Next Steps

Over time, the Greater Greenburgh Planning Area will continue to work together with local, state, and federal entities to learn more about the flood hazard, enhance participation in FEMA's NFIP, and support further mitigation efforts as discussed in Section 9 to reduce the losses when future flood events occur. Refinement of floodplain maps and improvement of local inventory data will support refined analyses using the flood model over time. Future evaluations may use the DFIRMs and the Flood Information Tool in HAZUS or apply the HAZUS-MH model to study particular reaches of concern in greater detail. Also, the model may be used to estimate the impact of particular mitigation activities that could be implemented to reduce flood risk. Also, as new or refined flood maps (DFIRMs) are created and development and mitigation efforts occur, future evaluations (for example, through updates to this Plan) should consider any changes to the flood loss estimates presented in this Plan.

Overall Vulnerability Assessment

The flood hazard is evaluated as a significant threat, which was ranked overall for the Greater Greenburgh Planning Area as a "high" risk with a "frequent" probability of occurrence (see Table 5.3-3 and 5.3-6). This hazard can be managed and planned for through the mitigation strategy and specific activities outlined in Section 6, which build on efforts already undertaken by the Planning Area and County.

Figure 5.4.2-18. Potential Development and FEMA DIFRMs for the Greater Greenburgh Planning Area



Source: FEMA, 2007; Planning Committee, 2011