SECTION 5: FLOOD RISK ASSESSMENT

This section provides a profile and vulnerability assessment for the flood hazard in order to quantify the description, location, extent, history, probability, and impact of flood events in the Town of Shandaken.

5.1 HAZARD PROFILE

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

5.1.1 Description

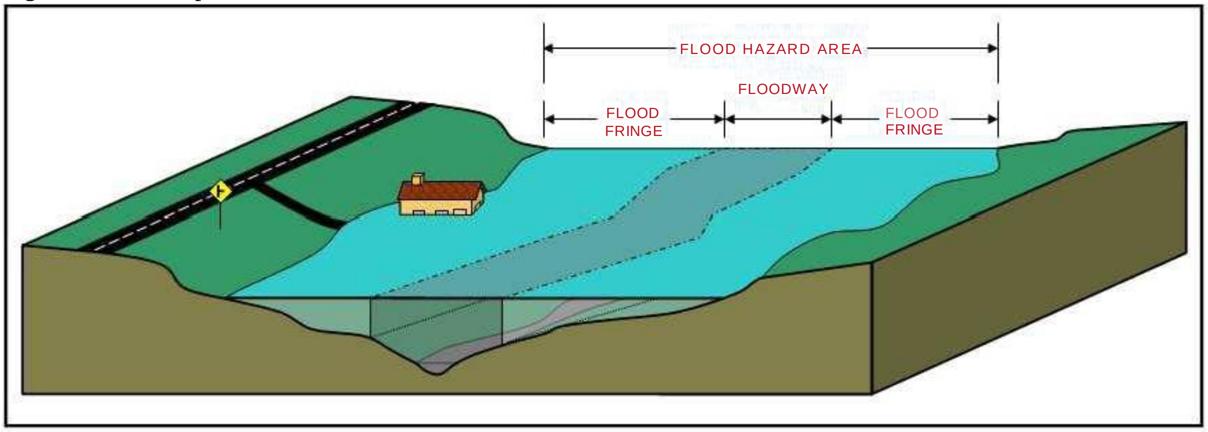
Floods are one of the most common natural hazards in the U.S. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (Federal Emergency Management Agency [FEMA], 2010). 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. As defined in the NYS HMP, flooding is a general and temporary condition of partial or complete inundation on normally dry land from the following:

- Riverine flooding, including overflow from a river channel, flash floods, alluvial fan floods, dam- break floods and ice jam floods;
- Local drainage or high groundwater levels;
- Fluctuating lake levels;
- Coastal flooding;
- Coastal erosion (NYS HMP, 2011 – need proper reference)
- 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, 2012);
- Sea Level Rise; or
- Climate Change (USEPA, 2012).

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 one-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, 2005).

Figure 5-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 5-1. Floodplain



Source: NJDEP, Date Unknown

Many floods fall into three categories: riverine, coastal and shallow (FEMA, 2008). 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 County, riverine/flash, dam failure and ice jam 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, and include overbank and flash flooding. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (FEMA, 2008; The Illinois Association for Floodplain and Stormwater Management, 2006).

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, 2009).

Ice-Jam Floods – An ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snow melt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (NESEC, Date Unknown; FEMA, 2008).

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt or warmer temperatures (USACE, 2002).

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

(FEMA, 2003). They are built for the purpose of power production, agriculture, water supply, recreation, and flood protection. Dam failure is any malfunction or abnormality outside of the design that adversely affect a dam's primary function of impounding water (FEMA, 2011). 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, 2010).

5.1.2 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, 2011).

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. 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).

5.1.3 Location

Flooding is the primary natural hazard in New York State because the State exhibits a unique blend of climatological and meteorological features that influence the potential for flooding. These factors include topography, elevations, latitude and water bodies and waterways. Flooding is the primary natural hazard in New York State and they occur in every part of the State. Some areas are more flood prone than others, but no area is exempt, including the Town of Shandaken. There are over 52,000 miles of river and streams in New York State, 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 areas subject to flooding. Areas outside recognized and mapped flood hazard zones can also experience flooding (NYS HMP, 2011).

The NYSDEC conducted a vulnerability assessment that depicted how vulnerable a county may be to flood hazards. This was determined by a rating score; each county accumulated points based on the value of each vulnerability indicator. The higher the indication for flood exposure, the more points assigned, resulting in a final rating score. The result of this assessment presented an indication of a county's vulnerability to the flood hazard. Ulster County's rating is 28, out of a possible 35. The rating was based on number of NFIP insurance policies, number of NFIP claims, total amount of NFIP claims, total amount of NFIP policy coverage, number of repetitive flood loss properties, and number of flood disasters (NYS HMP, 2011).

Riverine flooding is most severe in the Delaware, Susquehanna, Chemung, Erie-Niagara, Genesese, Allegany, Hudson and Mohawk River Basins (NYS HMP, 2011). The Town of Shandaken is located with the Upper Hudson River Basin (NYSDEC, Date Unknown).

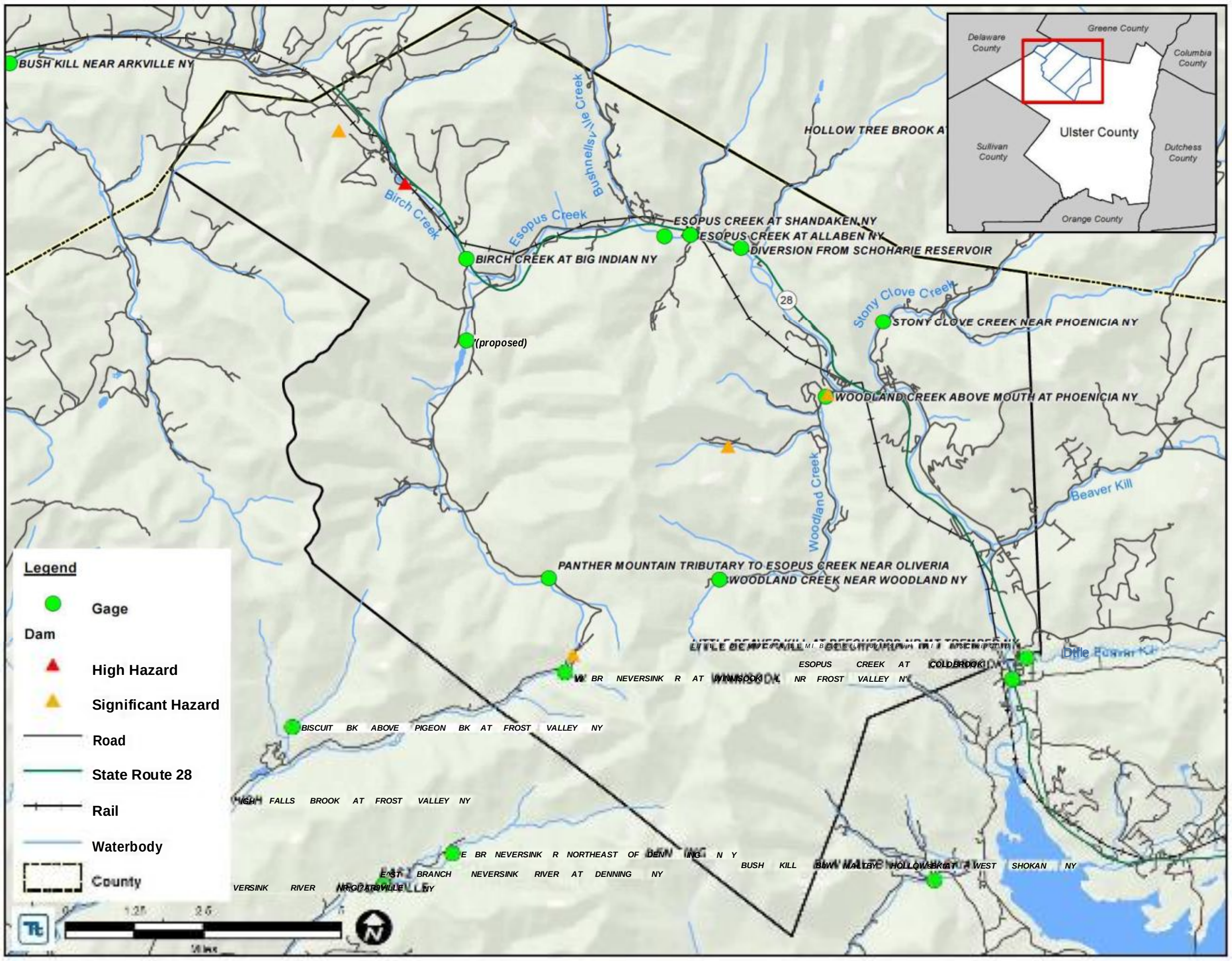
The majority of the Town's development is located in the valleys of Esopus Creek and its tributaries, which creates a high potential for significant flood impacts (Town of Shandaken Comprehensive Plan, 2005). Esopus Creek, Woodland Valley, Birch Creek and Stony Clove are the main watercourses in the Town of Shandaken, and those most vulnerable to flash flooding. Other tributaries include Beaver Kill, Birch Creek, Neversink River, and Giggle Hollow. The Town has indicated that the hamlets of Phoenicia, Mt Pleasant, Allaben, Mt. Tremper, Oliverea, Shandaken, Chichester and Woodland Valley have experienced extensive flooding resulting from riverine reaches in the Upper Esopus Watershed.

Flood stages on Esopus Creek tributaries may be further elevated in the vicinity of the tributary confluence with Esopus Creek. This is particularly so, in settings such as the village of Phoenicia, in which development occupies much of the available flood plain and the channel is confined. In this instance, Stony Clove Creek has a relatively low slope and the flood stage on Esopus Creek can be higher than Stony Clove's flood stage, inducing a backwater effect that raises the Stony Clove stage. The consequence is locally enhanced inundation in the village.
Main Street, Bridge Street, High Street, Plank Road and Station Road in the village of Phoenicia are particularly acute hazard problem areas for flooding. Figure 5- shows the Main Street Bridge over Stony Clove Creek in Phoenicia.

Highway infrastructure construction has also contributed to flood vulnerability. For example, below the hamlet of Big Indian, the Esopus Creek flows along Route 28, and is locally impacted by the road corridor, especially where former meander bends were cut off by installation of the roadway.

The town relies on input from stream gages in the area to predict potential flooding and flash flooding. Locations USGS gages in the area are noted in the map below.

Figure 5-2. USGS Gages and Dams in the Town of Shandaken



Source: NID, 2012; NYCDEP, 2012

Figure 5-3. Main Street Bridge Over Stony Clove Creek in the Hamlet of Phoenicia, New York

Source: Upper Esopus Creek Management Plan. Available at:
http://www.ashokanstreams.org/stream%20management%20plans-esopus.html

5.1.4 Frequency

Floods are commonly described as having a 10-, 50-, 100-, and 500-year recurrence interval meaning that floods of these magnitudes have (respectively) a 10-, 2-, 1-, or 0.2-percent chance of occurring in any given year. These measurements are statistical averages only; it is possible for two or more rare floods (with a 100-yer or higher recurrence interval) to occur within a short time period.

Recent history has shown that the Town of Shandaken can expect an average of 7 episodes of major river flooding each 10 years. 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 indicated 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 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, 2005; 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 B and X (shaded), C and X (unshaded) A, AE, A1-30, AH, AO, AR, A99, V, VE, V1-30, and. (FEMA, 2013). 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. The BFE on a FIRM is the elevation of a base flood event, or a flood which has a 1-percent chance of occurring in any given year as defined by the NFIP. 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 where $P=1-[1-1/T)]^n$ where P=probability, T=return period (100), and n=number of years (30)

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, 2005; FEMA, 2003).

5.1.5 Severity

The principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity is often evaluated by examining peak discharges.

In addition to FIRMs, FEMA also provides FISs for entire counties and individual jurisdictions. These studies aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. They are narrative reports of countywide flood hazards, including descriptions of the flood areas studied and the engineered methods used, principal flood problems, flood protection measures and graphic profiles of the flood sources (FEMA, Date Unknown). A town-wide FIS for the Town of Shandaken has been completed however digitized FIRMs are not available at this time and are projected to be completed in 2013. The 1989 Town of Shandaken FIS discussed the principal flood problems in the Town. The FIS stated that the Esopus Creek has a long history of flooding upstream of Ashoken Reservoir.

Table 5-1 lists peak flows used by FEMA to map the floodplains of the planning area as noted in the effective Flood Insurance Study for the town. Updated discharges are expected to be made available pending release of final FEMA flood mapping in the Summer of 2013.

Table 5-1, Summary of Discharges within the Town of Shandaken

Flooding Source and Location	Drainage Area (Sq. miles)	Peak Discharges (cfs)			
		10-year	50-year	100-year	500-year
ESOPUS CREEK at downstream corporate limits	169.7	36,000	72,000	92,599	165,000
At the confluence Beaver Kill	132.7	30,000	60,000	74,619	142,000
At the confluence Woodland Creek	84.2	20,000	39,000	48,801	89,500
At the confluence Broad Hollow Creek	59.4	16,000	30,000	37,529	67,000

(FEMA FIS, 1989)

According to the Draft Hydrologic Analysis Technical Support Data Notebook (FEMA, July 2012), Floods in Ashokan Reservoir Watershed can occur anytime during a year. The floods that occur in summer and fall seasons are caused mainly by heavy rainfall produced by hurricanes and tropical storms. Floods that occur in winter or spring are mainly due snowmelt caused by rising temperatures and or due to mixing of rain with snow. The largest storm on the record occurred due to the passing Hurricane Irene in August 2011. The estimated peak discharge on Esopus Creek at Coldbrook is 75,800 cubic feet per second (cfs). This peak discharge is highest on the record, beating the previous highest of 65,300 cfs, which occurred in March 1980. The peak discharge records at several other gages in the basin were also broken by the damaging discharges caused by Hurricane Irene. Other notable locations include Esopus Creek at Allaben, Stony Clove Creek at Chichester. The flood damages incurred due to the March 1980 flood were estimated at 6 million dollars. A flood similar intensity occurred on March 30, 1951. According to local and newspaper accounts, the flood resulted in a dam break on Birch Creek (FEMA, 1989). Some of the other notable floods that recorded at the Coldbrook gage include the flooding events of April 2005, January 1996 and April 1987 and April 1984, which rank 4th, 7th, 8th and 11th respectively. Some of the floods that occurred before 1980's include the flooding events of August 1933, October 1955 and December 1957. Table 5-2 provides a summary of discharges recorded at Coldbrook gage on Esopus Creek for the top floods.

Table 5-2: Historic Flood Discharges in Ashokan Reservoir Watershed

Rank	Date	Peak (cfs)
1	28-Aug-11	75,800
2	21-Mar-80	65,300
3	30-Mar-51	59,600
4	3-Apr-05	55,200
5	24-Aug-33	55,000
6	15-Oct-55	54,000
7	19-Jan-96	53,600
8	4-Apr-87	51,700
9	21-Dec-57	46,900
10	2-Mar-36	38,500
11	5-Apr-84	37,400

Source: Draft Hydrologic Analysis Technical Support Data Notebook (FEMA, July 2012)

Warning Time

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 24 and 48 hours. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

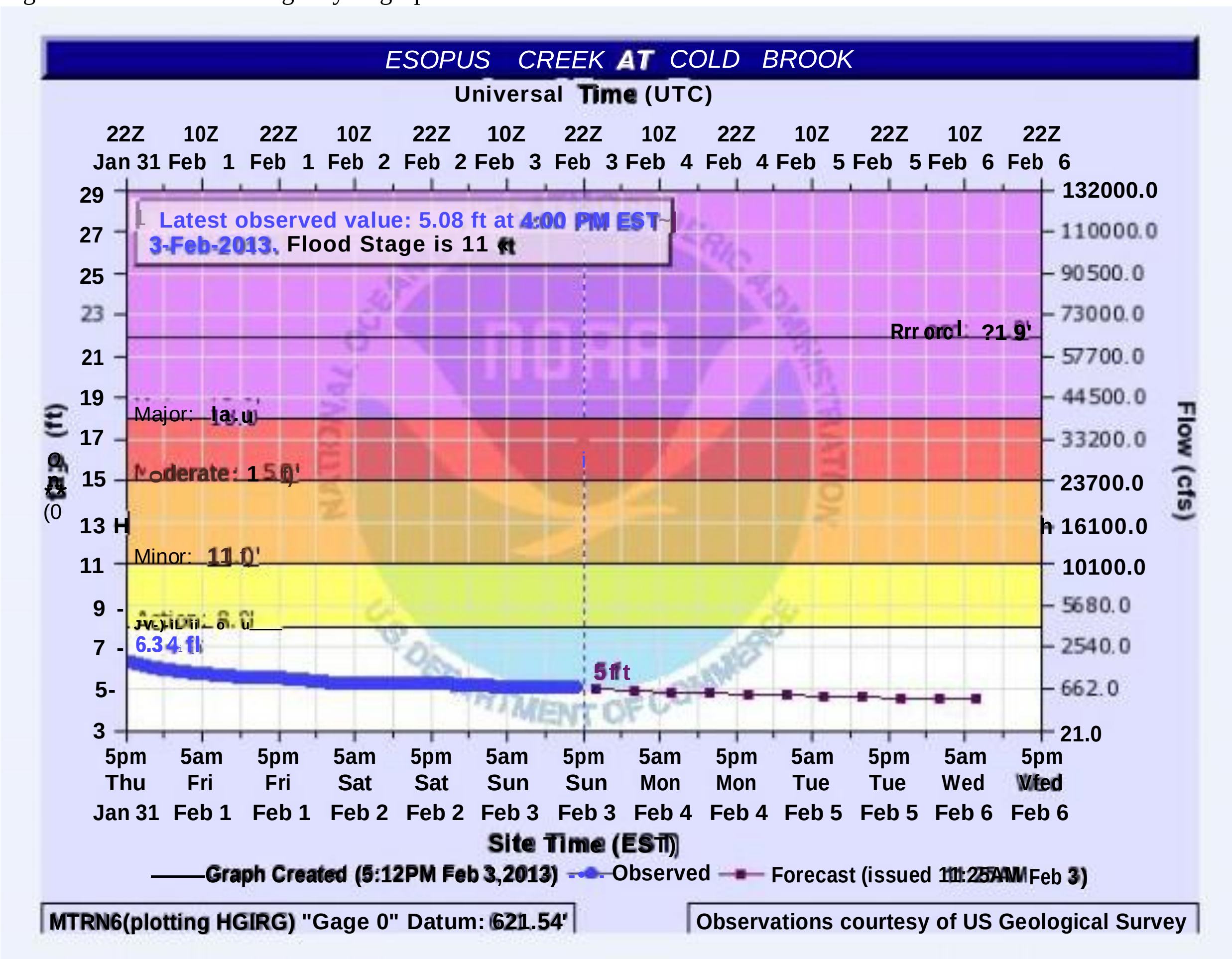
Each watershed has unique qualities that affect its response to rainfall. A hydrograph, which is a graph or chart illustrating stream flow in relation to time (see Figure xx), is a useful tool for examining a stream's response to rainfall. Once rainfall starts falling over a watershed, runoff begins and the stream begins to rise. Water depth in the stream channel (stage of flow) will continue to rise in response to runoff even after rainfall ends. Eventually, the runoff will reach a peak and the stage of flow will crest. It is at this point that the stream stage will remain the most stable, exhibiting little change over time until it begins to fall and eventually subside to a level below flooding stage.

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time to the time that a community has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage.

The Town of Shandaken relies on data and flood warning information is provided by the National Weather Service (NWS) Cold Brook gage. This information is analyzed to evaluate the flood threat and possible evacuation needs. Other gages within the watershed provide historical information, but do not supply real-time information that can be utilized pending a flood event. A hydrograph from the

Coldbrook gage is provided in Figure 5-4 below.

Figure 5-4-Cold Brook Gage Hydrograph

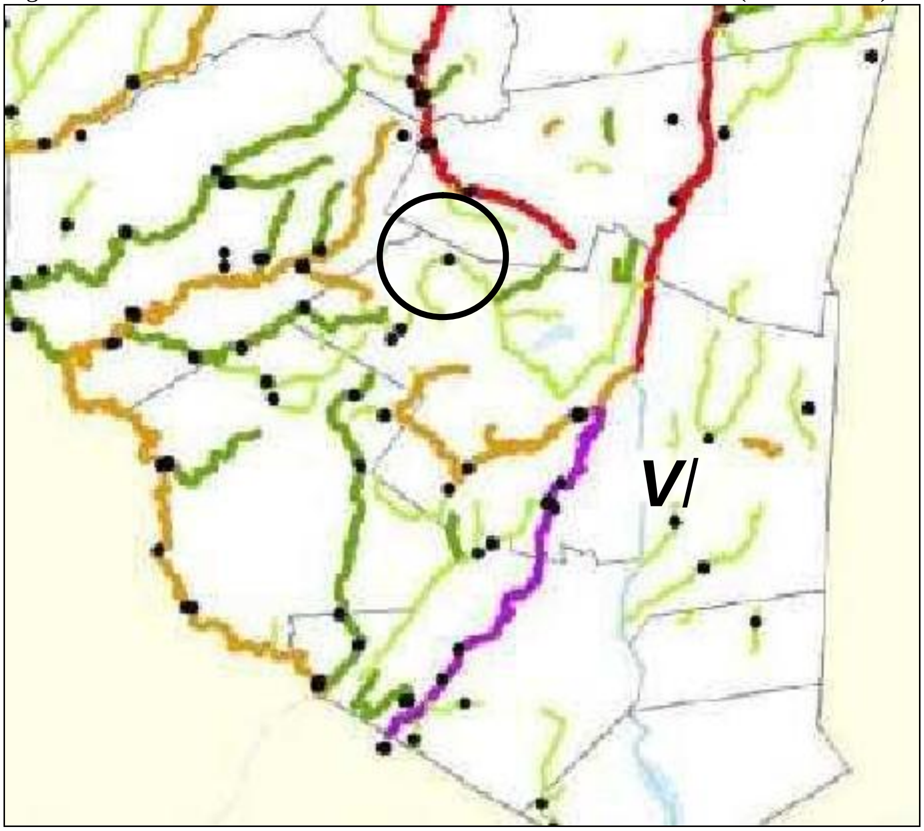


Source: USGS

5.1.6 Ice Jam Hazard Areas

Ice jams are common in the Northeast U.S. and New York is not an exception. In fact, according to the USACE, New York State ranks second in the U.S. for total number of ice jam events, with over 1,500 incidents documented between 1867 and 2010. Areas of New York State that include characteristics lending to ice jam flooding include the northern counties of the Finger Lakes region and far western New York, the Mohawk Valley of central and eastern New York State and the North Country (NYS HMP, 2011). Figure 5-5 presents the general location and number of ice jam incidences within the vicinity of Ulster County between 1875 and 2007.

Figure 5-5. Number of Ice Jam Incidents on New York State Rivers (1875 – 2007)



Source: NYS HMP, 2011
Note (1): Circle indicates location of the Town of Shandaken
Note (2): This map displays the number of instances a river was referenced as being the location for an ice jam in the USACE Cold Regions Research and Engineering Laboratory (CRREL) database.
Note (3): Multiple instances of ice jams can be associated to a single point location.

5.1.7 Dam Break Hazard Area

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, Date Unknown).

There are five dams located within the Town of Shandaken, one of which is classified as a high hazard dam (Pine Hill Lake Dam). Refer to the Town Profile (Section 4) for dams located in the Town of Shandaken.

5.1.8 Flash Flooding Hazard Areas

Flash flooding hazards can be assumed to be present on all streams in the Town of Shandaken, given the hydrology and topography of the watershed. Due to the geography of the Town of Shandaken, steep mountainous slopes with narrow stream valleys and severely varying slopes on these channels, many of the smaller valleys, especially along tributaries to the Esopus Creek, have the propensity for flash flooding, whether due to a large storm encompassing the entire Town or very small isolated storm cells effecting smaller portions of the Town. Vulnerable areas are Fox Hollow, Birch Creek, Broad Street Hollow, Peck Hollow, Warner Creek, Stony Clove, Giggle Hollow, Bushnellsville, the Bush Kill, and the Esopus Creek in the hamlet of Oliverea.

Secondary Hazards

The most problematic secondary hazard for flooding is bank erosion, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides when high flows over-saturate soils on steep slopes, causing them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, or rivers.

5.1.9 Previous Occurrences and Losses

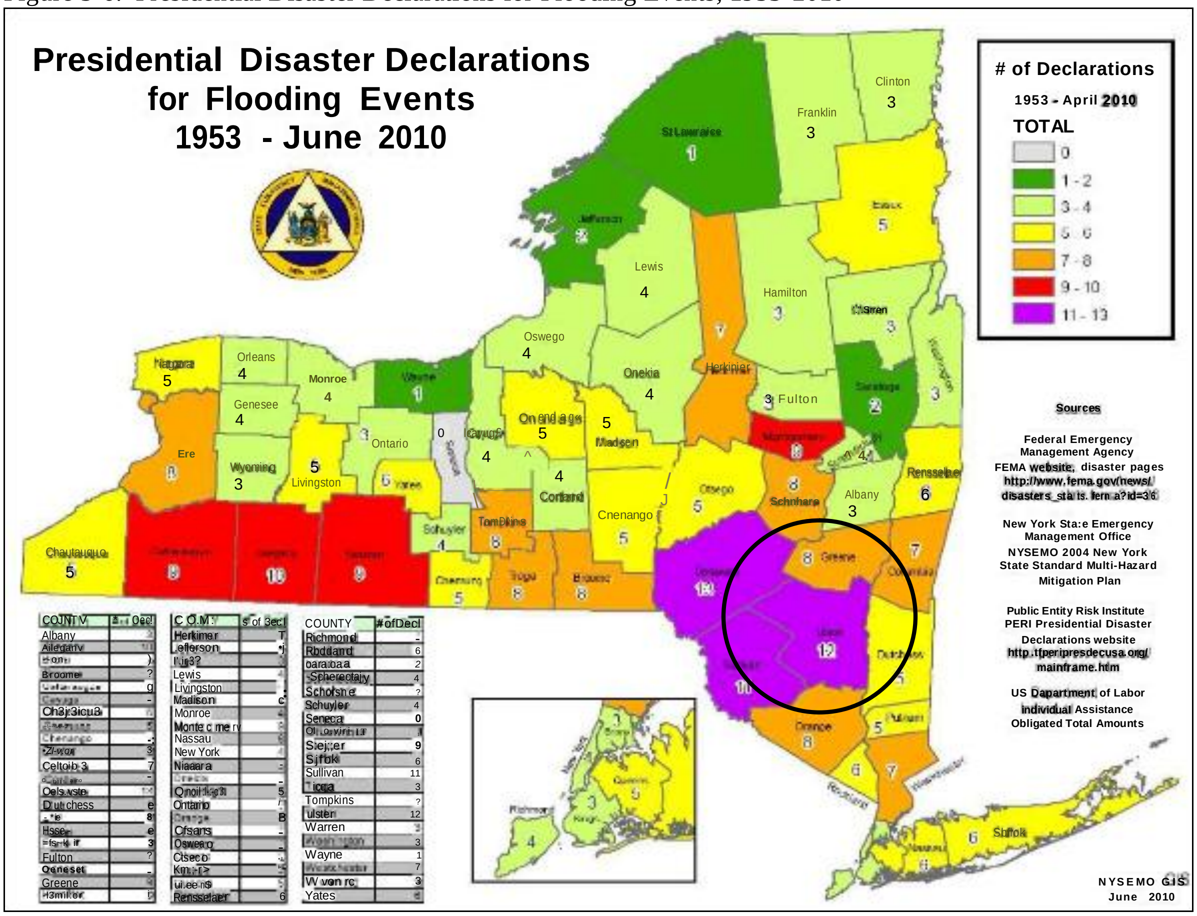
Many sources provided historical information regarding previous occurrences and losses associated with flooding events throughout New York State, Ulster County and the Town of Shandaken. With many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending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

According to NOAA’s NCDC storm events database, Ulster County experienced 97 flood events between April 30, 1950 and April 2012. Total property damages, as a result of these flood events, were estimated at $12.3 million. There were no crop damages reported. This total also includes damages to other counties. According to the Hazard Research Lab at the University of South Carolina’s Spatial Hazard Events and Losses Database for the U.S. (SHELDUS), between 1960 and 2010, 81 flood events occurred within the County. The database indicated that severe storm events and losses specifically associated with Ulster County and its municipalities totaled over $69 million in property damage and over $1 million in crop damage. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

Between 1954 and 2011, FEMA declared that New York State experienced 40 flood-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, coastal storms, flash flooding, heavy rain, tropical storm, hurricane, high winds, ice jam, wave action, high tide and tornado. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the NYS HMP and other sources indicate that Ulster County has been declared as a disaster area as a result of 13 flood events (FEMA, 2012; NYSOEM, 2012).

Figure 5-6 shows the FEMA disaster declarations (DR) for flooding events in New York State, from 1953 to June 2010. This figure indicates that Ulster County was included in 12 disaster declarations. Since the date of this figure, Ulster County has been included in one additional FEMA disaster declarations for flooding.

Figure 5-6. Presidential Disaster Declarations for Flooding Events, 1953-2010



Source: D R A F T NYS HMP, 2011

Note: The black circle indicates the approximate location of Ulster County.

Based on all sources researched, known flooding events that have affected the Town of Shandaken are identified in Table 5-3. With flood documentation for New York State being extensive, not all sources have been identified or researched. Therefore, Table 5-3 may not include all events that have occurred throughout the Town and region.

Table 5-3. Flooding Events Between 1950 and 2012

Dates of Event	Event Type	Declaration Number	County Designated?	Losses / Impacts	Source(s)
December 8, 1950	Flooding	N/A	N/A	During a storm event, the Esopus Creek did a devastating job and by the time it reached Oliverea, it took out bridges and rushed over the road four feet deep. Where the Hatchery Stream crosses Oliverea Road, the little bridge remained but the roadway was washed out on either side. Where the Esopus Creek reaches the turn near Platt's barn, it tore out a corner and carried away a car. It cut gouges out of the bank within one or two feet of some tourist cottages just above the Dunham Bridge. The Stream, as it joined the Birch Creek, it completed flooded the Fennelly meadow with eight to ten feet of water. A home was lifted from its foundation and took out the Weybridge and undermined a barn.	Catskill Mountain News, Town Input
April 6, 1951	Flooding	N/A	N/A	Heavy rains and melting snow caused the Esopus Creek to raise above its November highwater mark. It caused widespread damage in Ulster County. Most of the damage was at Phoenicia and areas below. The Chichester and Woodland Valley streams combined in this area. The streets of Phoenicia were flooded and some people had to leave their homes. Many businesses were flooded as well. A bridge was carried away near the Stony Clove Notch. In Lanesville, residents called this event one of the worst floods. The Stony Clove Valley Stream 50 feet deep.	Catskill Mountain News, Town Input
October 18-20, 1955	Heavy Rain and Flooding	N/A	N/A	Heavy rains flooded the Oliverea Valley, completely destroying the post off and a small cottage in Oliverea. Land and roads washed away. Telephone and electricity were cut off. Guests at the Valley View House and at the Slide Mountain House were caught in the Valley and were unable to return home. A bridge was washed out behind a home in the Big Indian Mountain club. The Manor House bridge was almost impassable due to debris and gravel. In Pine Hill, a bank behind a home gave way and slide down, breaking through kitchen doors and spreading through the entire first floor. Several other people experienced damages to their homes. Many basements were flooded, oil burners were put out and several lawns washed out. One water main was broken which caused a few homes to be without water.	Catskill Mountain News, Town Input

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				Several residents in Woodland Valley had to evacuate due to the rising waters of the Esopus and its tributaries. Many roadways were blocked and traffic had to be rerouted. Road damage due to undermining was severe along sections of Route 28. Other damage included the washing away of part of the Shandaken Manor Hotel. In Bushnellville, Route 42 was closed with large sections washed out. Homes near the Bushnellville Creek were the hardest hit. The Creek overflowed its banks and flowed towards the main street. The Shandaken post office was flooded. The road from Route 28 to Fox Hollow was under four feet of water. Small bridges were washed out in this area, which included the Percy White Bridge over the Esopus and the Claude Gossco Bridge and bridges at Rossingers and at Mountain Lodge Inn on Bushnellville Road. This flooding event caused one fatality in Woodland Valley.	
September 13, 1971	Severe Storms and Flooding	DR-311	Yes	N/A	FEMA
June 23, 1972	Tropical Storm Agnes	DR-338	Yes	Tropical Storm Agnes caused some damage in the Catskill area. Several bridges and roads suffered minor damage and there were reports of damage to private properties in the Town of Shandaken. Esopus Creek and its tributaries crested during the morning. Four campers had to be rescued from Woodland Valley when their exit was cut off and one of them suffered leg burns from a gas lantern explosion. Ulster County highway crews cleared fallen trees from county roads in the Woodland Valley and Phoenicia area. In Oliverea Valley, the main damage was seen on the property of Suzie's Cabins, where several feet of lawn and fill next to the stream were washed was made by federal and state officials.	FEMA, Town Input
July 20, 1973	Severe Storms, Flooding	DR-401	Yes	N/A	FEMA
December 27, 1973	Severe Storms, Flooding	N/A	N/A	Torrential rain fell in the Town of Shandaken, causing large amounts of damage due to water running off the mountain side. Residents in the area of the Woodland Valley county bridge reported to the supervisor's office Friday morning that water was up to the floor of the bridge and the span seemed to be swaying	Town Input

Dates of Event	Event Type	Declaration	County Designated?	Losses / Impacts	Source(s)
				in the current of the Esopus. Two 8-foot by 50-foot culvert pipes, each weighing several tons, were washed away from the property of Ray Smith, where contractors are replacing a highway bridge on Route 212, Willow Road. One of the pipes wedged under the old Route 28 bridge was Mount Tremper Four Corners was partially sticking out, diverting the water to Brookside Road, which became flooded. Plank Road, the former Route 28, was washed out and closed to traffic. The worst flooding conditions was at the O'Donnell Five-Star camp near Mount Tremper. The former Hoffman diner and a property in the vicinity of the Hoffman bridge were flooded. Three trailers were damaged by water, and two cars were towed out. A new housing development off Plank Road was hit hard. A new road was being completed, with bridges and culvert installations, and these were destroyed. The Sleepy Hollow campsite below Phoenicia had two or three feet of water by the parked trailers, and three trailers were flooded at their foundations. The site of the proposed Odell shopping area on new Route 28 had slight flooding. The Mount Tremper fire trail was completely washed out.	
March 28 – April 8, 1984	Coastal Storms, Flooding	DR-702	Yes	N/A	FEMA
April 3-6, 1987	Flooding	DR-792	Yes	A low-pressure system associated with a cold front produced heavy rain over the Catskills on March 30 and 31 and showers on April 1. More than three inches fell over the headwaters of the Schoharie and Esopus basins, while generally less than two inches fell elsewhere. The maximum rain recorded during the 24-hour period that ended on April 5 exceeded six inches and was centered on the highest peaks in the Catskills, Slide Mountain (4,204 ft) and Hunter Mountain (4,025 ft). Prevailing winds from the east and southeast and orographic effects of the Catskills combined to generate the greatest rainfall totals on the eastern slopes of the mountains. Five counties in southeastern New York were declared major disaster areas after intense rainfall on April 3-5, 1987, caused widespread flooding. Severe frontal storms often cause flooding in the narrow, steep valleys of the Catskill Mountains. This storm occurred at a time when soils were saturated, reservoir storage was near capacity, and stream discharge was high from	FEMA, Town Input

Dates of Event	Event Type	Declaration	County Designated?	Losses / Impacts	Source(s)
				snowmelt. Rainfall during the storm period totaled 9.09 inches at Slide Mountain and 8.20 inches at Tannersville. Schoharie, Cat.skill, Esopus, and Rondout Creeks and East Branch Delaware and Neversink Rivers and their tributaries underwent the most severe flooding.	
November 11, 1995	Flooding	N/A	N/A	Between three and four inches of rain fell in eastern New York State which resulted in flooding. In the hamlet of Phoenicia, the Esopus Creek flooded and a state of emergency was declared. Several families were evacuated in the hamlet of Woodland Valley. Ulster County had approximately $100 K in damages.	NOAA-NCDC, Ulster County HMP
January 19 – 21, 1996	Flooding	N/A	N/A	Warm temperatures caused rapid snowmelt in Ulster County. Along with the melting snow, a storm brought one to three inches of rain, resulting in widespread flooding in the County. Small streams flooded across the County, washing out roads. Extensive flooding occurred along the Hudson River and Esopus Creek. Many towns in Ulster County experienced flooding. In the Town of Shandaken, five town roads were destroyed and several homes were damaged. Evacuations occurred in the hamlets of Phoenicia and Shandaken. Ulster County experienced $10 M in damages.	NOAA-NCDC, Ulster County HMP
January 27-28, 1996	Flooding	DR-1095	Yes	One to two inches of rain fell across eastern New York State, with some areas in the Catskills receiving three inches of rain. This storm, on top of already saturated soils, caused many small streams to flood in Ulster County. The Wallkill River and Rondout and Esopus Creeks flooded in the County. Evacuations occurred along the Esopus Creek and Route 28. Along the Rondout Creek at Eddyville, flooding was severe and widespread. In the Town of Shandaken, numerous roads were Overall, the County experienced $400 K in damages.	NOAA-NCDC, FEMA, Ulster County HMP
June 12-14, 1998	Flooding	N/A	N/A	Heavy rain fell across the Catskills and eastern Mohawk Valley. Three-day precipitation totals ranged from eight to 10 inches. Flooding of creeks and tributaries occurred in Ulster, Fulton, Montgomery and Greene Counties. In Ulster County, the Esopus Creek above the Ashokan Reservoir flooded. At the hamlet of Mount Tremper, the creek crested at 12.5 feet (flood approximately $45 K in damages.	NOAA-NCDC, Ulster County HMP
September 16-18, 1999	Hurricane Floyd	DR-1296	Yes	Rainfall totals for Ulster County ranged from 4.56 inches in the Town of Kingston to 6.57 inches at Slide Mountain. In the hamlet of Phoenicia, 5.91 inches of rain was reported.	FEMA, NWS

Dates of Event	Event Type	Declaration	County Designated?	Losses / Impacts	Source(s)
				Throughout the County, many trees and wires were down. by downed trees.	
May 18, 2000	TSTM	N/A	N/A	TSTM winds knocked down trees and powerlines at several locations in Albany, Columbia, Greene, Montgomery, Saratoga, $87,000 in property damage.	NOAA-NCDC
December 17, 2000	Flooding	N/A	N/A	A record-breaking rainstorm struck eastern New York State, bringing between two and four inches of rain. Ulster County has hit hard. Six towns declared a state of emergency. In the Town of Shandaken, a boy drowned when he attempted to cross the experienced $500 K in damages.	NOAA-NCDC
May 3 - August 12, 2000	Severe Storms and Flooding	DR-1335	Yes	N/A	FEMA
May 13 – June 17, 2004	Severe Storms and Flooding	DR-1534	Yes	In the Town of Shandaken, Birch Creek flooded, topping the Academy Street Bridge and closing Main Street. Birch Creek Road washed out between Academy and Upper Birch Roads. Numerous culverts were washed out and roads were closed due to flooding. The Town had approximately $500 K in damages.	NOAA-NCDC, FEMA, Ulster County HMP
2004	Severe Storms and Flooding	DR-1564	Yes	In the hamlet of Phoenicia, streams in the area flowed over County Route 40.	FEMA, NOAA-NCDC
September 17-18, 2004	Tropical Depression Ivan	DR-1565	Yes	Streams overflowed onto Route 40 in Phoenicia.	FEMA, Town Input
April 2-4, 2005	Severe Storms and Flooding	DR-1589	Yes	A state of emergency was declared, due to flooding, throughout Ulster County. Rainfall totals in the County ranged from 2.67 inches in Saugerties and 6.15 inches in West Shokan. In the Town of Shandaken, Bushnellsville Creek overflowed its banks and flooded Route 42. Overall, the County had approximately assistance for Ulster County.	NOAA-NCDC, FEMA, NWS
June 26 – July 10, 2006	Severe Storms and Flooding	DR-1650	Yes	N/A	FEMA
April 15-16, 2007	Severe Storms and Inland/Coastal Flooding	DR-1692	Yes	An intense storm brought flooding, heavy rain and wet snow to the region. Rainfall amounts of six to eight inches were reported across the eastern Catskills, mid-Hudson Valley and western New England. Rainfall totals for Ulster County ranged	FEMA, NWS

Dates of Event	Event Type	Declaration	County Designated?	Losses / Impacts	Source(s)
				from 4.30 inches in Kingston to 7.43 inches in West Shokan.	
June 19, 2007	Severe Storms and Flooding	DR-1710	Yes	FEMA approved over $960 K in disaster assistance for Ulster County.	FEMA
September 30 – October 1, 2010	Severe Storms and Flooding	N/A	N/A	Rainfall totals in Ulster County ranged from 3.14 inches in Saugerties to 8.27 inches in the hamlet of Phoenicia. In the Town of Shandaken, Route 214 was closed in both directions due to flooding.	NWS
December 2010	Flood	N/A	N/A	N/A	Town of Shandaken
April 25 – 30, 2011	Severe Storms, Flooding, Tornadoes and Winds	DR-1993	Yes	Rainfall totals in Ulster County ranged from 0.75 inches in Kingston to 2.24 inches in the hamlet of Phoenicia.	FEMA, NWS
August 28-29, 2011	Tropical Storm Irene	DR-4020	Yes	Tropical Storm Irene tracked across eastern New York State, producing widespread flooding and damaging winds. Rainfall totals ranged between eight and 12 inches, with higher amounts in the eastern Catskills and Schoharie Valley. In the Town of Shandaken, Route 42 was closed due to the flooding, between of Shandaken.	NOAA-NCDC, FEMA
September 7-11,	Remnants of Lee	DR-4031	Yes	Remnants of Tropical Storm Lee caused minor flooding along Ashokan Reservoir.	NOAA-NCDC
September 18, 2012	Flood	N/A	N/A	Flooding in the hamlet of Oliverea washed out a recently repaired road on County Route 47, below the intersection of McKinley Hollow Road.	Town of Shandaken

Note (1): 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.

DR Federal Disaster Declaration
EM Federal Emergency Declaration
FEMA Federal Emergency Management Agency
K Thousand ($)
M Million ($)
N/A Not applicable/available
NCDC National Climate Data Center
NOAA National Oceanic Atmospheric Administration
NWS National Weather Service

The Ice Jam Database, maintained by the Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL), currently consists of over 18,000 records from across the U.S. According to the USACE-CRREL, Ulster County experienced 61 historic ice jam events between 1780 and 2012. According to the CRREL database, ice jams have historically formed at various points in Ulster County along Allen Creek, Esopus Creek, Genesee River, Rondout Creek, Sandburg Creek and the Wallkill River, with two ice jams occurring along Esopus Creek in the Town of Shandaken (Ice Engineering Research Group, 2011). Locations of historical ice jam events are indicated in Figure 5-7 below.

Figure 5-7. Historic Ice Jams in the Town of Shandaken and Ulster County.

Source: CRREL, 2012
Note: The red circle indicates the approximate location of the Town of Shandaken.

Based on review of the CRREL Database, Table 5-4 lists the ice jam events that have occurred in the Town between 1780 and 2012. Information regarding losses associated with these reported ice jams was limited.

Table 5-4. Ice Jam Events in the Town of Shandaken between 1780 and 2012

Event Date	River / Location	Gage Number	Description	Source(s)
1981	at Shandaken		and discharge of 120 cfs.	CRREL
February 11, 1981	Esopus Creek at Shandaken	1362198	An ice jam occurred resulting in a gage height of 7.78 and discharge of 450 cfs.	CRREL

Source: CRREL, 2012
Note: Although many events were reported for Ulster County, information pertaining to every event was not easily ascertainable; therefore this table may not represent all ice jams in the Town of Shandaken.

National Flood Insurance Program

The U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968 (FEMA's 2002 *National Flood Insurance Program (NFIP): Program Description*). 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. As stated in the NYS HMP, the NFIP collects and stores a vast quantity of information on insured structures, including the number and location of flood insurance policies, 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).

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 a year through communities implementing sound floodplain management requirements and property owners purchasing of flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance (FEMA, 2008).

NFIP data for the Town of Shandaken is presented further in the Vulnerability Assessment section of this profile.

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 (FEMA, 2007). According to FEMA, the Town of Shandaken does not participate in the CRS; therefore specific repetitive loss areas other than those identified by FEMA are not available for the Town (FEMA, 2011).

5.1.10 Probability of Future Events

Given the history of flood events that have impacted the Town of Shandaken, 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 Town in the past suggests that many people and properties are at risk from the flood hazard in the future.

In addition to riverine flooding, ice jams frequently occur in New York State and Ulster County is no exception. According to the New York State HMP, New York State is ranked as the second highest state with the highest number of ice jam events compared to the remainder of the U.S. (DRAFT NYSHMP, 2011). Please refer to the Vulnerability Assessment for a complete discussion of vulnerable population, facilities, utilities and infrastructure in the Town.

It is estimated that the Town of Shandaken will continue to experience direct and indirect impacts of floods annually. Table 5-5 summarizes the occurrences of flood events and their annual occurrence (on average).

Table 5-5. Occurrences of Flood Events in the Town of Shandaken, 1950 - 2012

Event Type	Total Number of Occurrences	Annual Number of Events (average)
Flash Flood	8	0.13
Flood	3	0.05
Total:	**11**	**0.18**

Source: NOAA-NCDC, 2011
Note: On average, the Town of Shandaken experiences 0.18 flood events each year.

The Role of Global Climate Change on Future Probability

"Climate change" refers to changes over a long period of time in patterns of temperature, precipitation, humidity, wind and seasons. Climate change is expected to have significant impacts on the Pacific Northwest by mid-21st century. Climate plays a fundamental role in shaping ecosystems and the human economies and cultures that depend on them. It is generally perceived that climate change will have a measurable impact on the occurrence and severity of flooding. As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, floodways, bypass channels and levees, as well as the design of local sewers and storm drains.

.Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt in the State. ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the State's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. The Town of Shandaken is part of Region 2, Catskill Mountains and West Hudson River Valley. Some of the issues in this region, affected by climate change, include: the watershed for New York City's water supply, spruce/fir forests disappear from mountains, decline in popular apple varieties, winter recreation declines/summer opportunities increase, Hemlock wooly adelgid destroys trees, and native brook trout decline and replaced by bass (NYSERDA, 2011).

Temperatures are expected to increase throughout the State, by 1.5 to 3ºF by the 2020s, 3 to 5.5ºF by the 2050s and 4 to 9ºF by the 2080s. The lower ends of these ranges are for lower greenhouse gas emissions scenarios and the higher ends for higher emissions scenarios. Annual average precipitation is projected to increase by up to five-percent by the 2020s, up to 10-percent by the 2050s and up to 15-percent by the 2080s. During the winter months is when this additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Table 5-6 displays the projected seasonal precipitation change for the Catskill Mountains and West Hudson River Valley ClimAID Region (NYSERDA, 2011).

Table 5-6. Projected Seasonal Precipitation Change in Region 2, 2050s (% change)

Winter		Summer	Fall
0 to +15	0 to +10	-5 to +10	-5 to +10

Source: NYSERDA, 2011

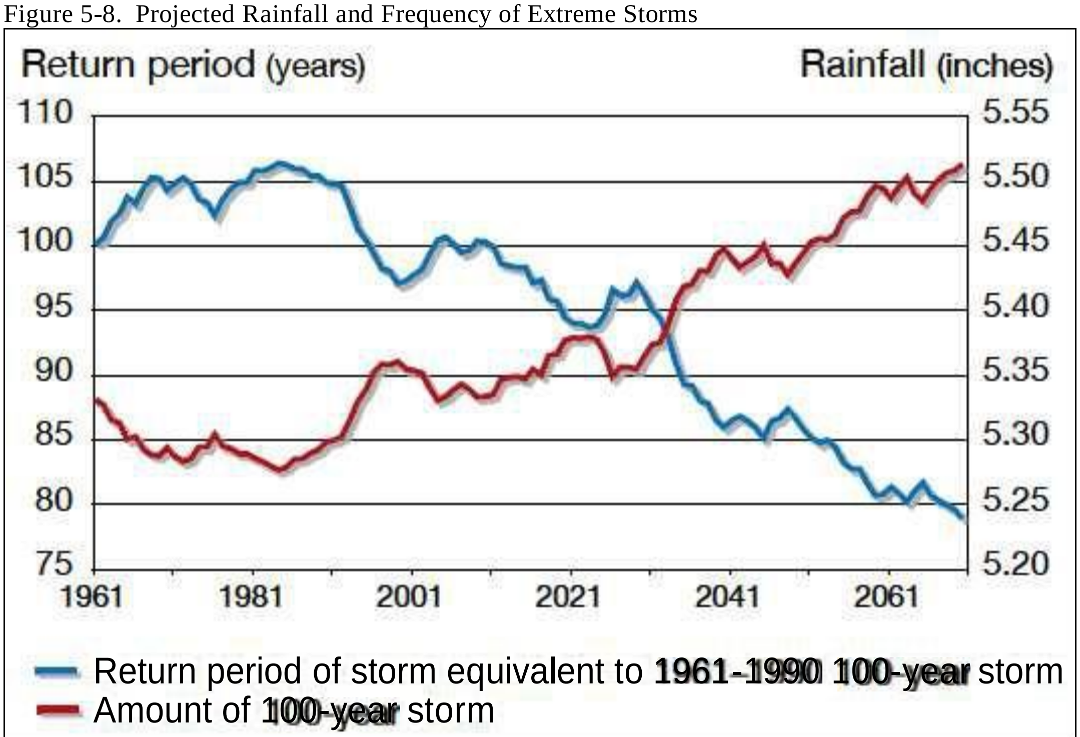
The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways and transportation hugs; and increase delays and hazards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

Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA, 2011).

Over the past 50 years, heavy downpours have increased and this trend is projected to continue. This can cause an increase in localized flash flooding in urban areas and hilly regions. Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable facilities located within floodplains. Less frequent rainfall during the summer months may impact the ability of water supply systems. Increasing water temperatures in rivers and streams will affect aquatic health and reduce the capacity of streams to assimilate effluent wastewater treatment plants (NYSERDA, 2011).

Figure 5-8 displays the project rainfall and frequency of extreme storms in New York State. The amount of rain fall in a 100-year event is projected to increase, while the number of years between such storms (return period) is projected to decrease. Rainstorms will become more severe and more frequent (NYSERDA, 2011).

Figure 5-8. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA, 2011

Total precipitation amounts have slightly increased in the Northeast U.S., by approximately 3.3 inches over the last 100 years. There has also been an increase in the number of two-inch rainfall events over a 48-hour period since the 1950s (a 67-percent increase). The number and intensity of extreme precipitation events are increasing in New York State as well. More rain heightens the danger of localized flash flooding, streambank erosion and storm damage (DeGaetano et al [Cornell University], 2010).

The amount of snow is critical for water supply and environmental needs, but so is the timing of snowmelt runoff into rivers and streams. Rising snowlines caused by climate change will allow more mountain area to contribute to peak storm runoff. High frequency flood events in particular (e.g. 10-year floods) will likely increase with a changing climate. Along with reductions in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding.

Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As stream flows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildfires due to climate change, there is potential for more floods following fire, which increase sediment loads and water quality impacts.

Scenario

The primary water courses in the planning area have the potential to flood at regular intervals, generally in response to a succession of intense winter rainstorms. Storm patterns of warm, moist air usually occur between early November and late March. A series of such weather events can cause severe flooding in the planning area. The worst-case scenario is a series of storms that flood numerous drainage basins in a short time. This could overwhelm response and floodplain management capabilities within the planning area. Major roads could be blocked, preventing critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the case of multi-basin flooding, the Town of Shandaken would not be able to make repairs quickly enough to restore critical facilities and infrastructure. The floodplains mapped and identified by the Town of Shandaken will continue to be impacted by these floods.

Issues

Important issues associated with flood hazards in the planning area include but are not limited to the following issues identified by the planning team:

- There needs to be a sustained effort to gather historical damage data, such as high water marks on structures and damage reports, to measure the cost-effectiveness of future mitigation projects.
- Ongoing flood hazard mitigation will require funding from multiple sources.
- There needs to be a coordinated hazard mitigation effort between the town, county and state and local agencies
- Floodplain residents need to continue to be educated about flood preparedness and the resources available during and after floods.
- The potential impact of climate change on flood conditions in the planning area needs to be better understood.
- The capability for prediction forecast modeling needs to be enhanced.
- Flood warning capability should be tied to flood phases. Action stages on the Cold Brook gage should be tied to observed flood levels at critical areas in the town.
- Action stages must be established for all gages it the Ashoken Watershed
- There needs to be enhanced modeling to better understand the true flood risk.
- Post-flood disaster response and recovery actions need to be solidified.
- Staff capacity is required to maintain the existing level of floodplain management within the planning area.
- Floodplain management actions require interagency coordination.

5.2 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 Town of Shandaken include the 100- and 500- year regulatory FEMA floodplains. The following text evaluates and estimates the potential impact of flooding on the Town including:

- Data and methodology used for the evaluation
- Impact, including: (1) impact on life, health and safety 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

5.2.1 Data and Methodology

The 1-percent and 0.2-percent annual chance flood events were examined to evaluate the Town of Shandaken's risk and vulnerability to the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP. Hazards U.S. Multi-Hazard or HAZUS (Hazards United States)-MH version 2.1 was used to generate the Town of Shandaken's potential loss estimates.

HAZUS-MH is a geographic information system (GIS)-based natural hazard loss estimation software package developed and distributed free of cost by the Federal Emergency Management Agency (FEMA). In 1997, FEMA developed the HAZUS standardized model for estimating losses caused by earthquakes. HAZUS was developed in response to the need for more effective national-, state-, and community-level planning and the need to identify areas that face the highest risk and potential for loss. HAZUS was expanded into a multi-hazard (MH) methodology with new models for estimating potential losses from wind (hurricanes including a storm surge option) and flood (riverine and coastal) hazards.

HAZUS-MH applies engineering and scientific risk calculations that have been developed by hazard and information technology experts to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards. HAZUS-MH can serve as a basis to quantify risk and to allocate limited resources for prioritization of mitigation projects. Refer to the Methodology section of this Plan for further details on HAZUS-MH.

The HAZUS-MH flood model is designed for three levels of analysis. A Level 1 analysis is the simplest type of analysis based on default data provided with the software. A Level 2 HAZUS-MH riverine flood analysis was performed for the Town of Shandaken. The default general building stock in HAZUS- MH was updated and replaced with data available from Ulster County including assessor data, parcels, address points and detailed structure-specific information. The buildings were incorporated into the HAZUS-MH flood model as individual buildings so that more accurate potential loss estimates could be obtained versus running the mode and reporting results at the aggregate level (Census block). An updated critical facility inventory was used in place of the HAZUS-MH defaults for essential facilities and utilities. As DFIRMs and other data are available in the future, enhanced Level 2 and Level 3 analyses can be performed for the Town of Shandaken. Please refer to the 'Additional Data and Next Steps' subsection below.

Flood Insurance Rate Maps (FIRMs) show floodways and other floodplain management information, such as cross-sections, that were previously provided on separate Flood Boundary and Floodway maps. They also include simplified flood insurance zones designations. Digital FIRMs (DFIRMs) contain the same information as the previous FIRMs in a digital format which provide many benefits. For example, they can be revised and updated easily and can be incorporated into the community's mapping system and tied with other geographic information systems, such as the zoning map. It is noted that the simple conversion of FIRMs to a digital format does not improve the engineering quality of the product (FEMA 480, Floodplain Management Requirements, February 2005).

FEMA Digital Flood Insurance Rate Maps (DFIRMs) are not yet available for the Town of Shandaken. The Town has digital Quality 3 (Q3) mapping. The Q3 data was developed to support insurance related activities and are designed to show the general location of floodplains or special flood hazard areas (SFHAs). The Q3 data used for this analysis included SFHA (1-percent annual chance flood) and 0.2-percent annual chance floodplain boundaries. Updated maps are expected in 2013 and the Town intends to review the outcomes of this plan in the context of the new maps, when they are available.

The available Q3 floodplain boundaries, the Flood Insurance Rate Study (February 1989), the 2009 3-meter Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) from the New York City Department of Environmental Protection (NYCDEP) and discharge rates for each riverine reach as provided by NYCDEP were used to generate flood boundaries and flood depth grids for the 1-percent and 0.2-percent annual chance flood events in the HAZUS-MH 2.1 riverine flood model. Please note that several areas of the Q3 do not align with the riverine reaches in the Town and were therefore only used as a guide to identify the riverine reaches with flood risk as determined by FEMA to select in the HAZUS model. Because of this misalignment, the Q3 boundaries were not used to estimate exposure. Instead, the flood boundaries generated by HAZUS were used. The resulting 1-percent and 0.2-percent flood boundaries and depth grids generated b y HA Z US follow the riverine reaches based on the terrain used and are considered an estimate of the flood hazard areas in the Town of Shandaken until DFIRMs are available.

To estimate exposure, the HAZUS-generated flood boundaries, an updated list of buildings and facilities provided by Ulster County and updated by the SAFARI group and the Town of Shandaken tax assessor, and 2010 U.S. Census population data were used. HAZUS-MH 2.1 estimated sheltering needs (based on 2000 U.S. Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS damage functions in the flood model. Figure 5- illustrates the flood boundaries used for this vulnerability assessment. Estimated potential exposure and loss estimates were provided for the Town as a whole, as well as by zip code.

During the development of this plan and after the vulnerability analysis was performed, the preliminary Ulster County FEMA Flood Insurance Rate Maps were made available in PDF to compare to the estimated flood boundaries HAZUS-MH generated for the 1-percent and 0.2-percent annual chance flood events.

In the Hamlet of Phoenicia, the preliminary FEMA maps indicate a larger 1-percent and 0.2-percent annual chance floodplain north of Main Street and east of Route 24 when compared with the estimated HAZUS flood boundaries. The floodplains along the Esopus Creek, between Main Street and State Route 28, appear very similar.

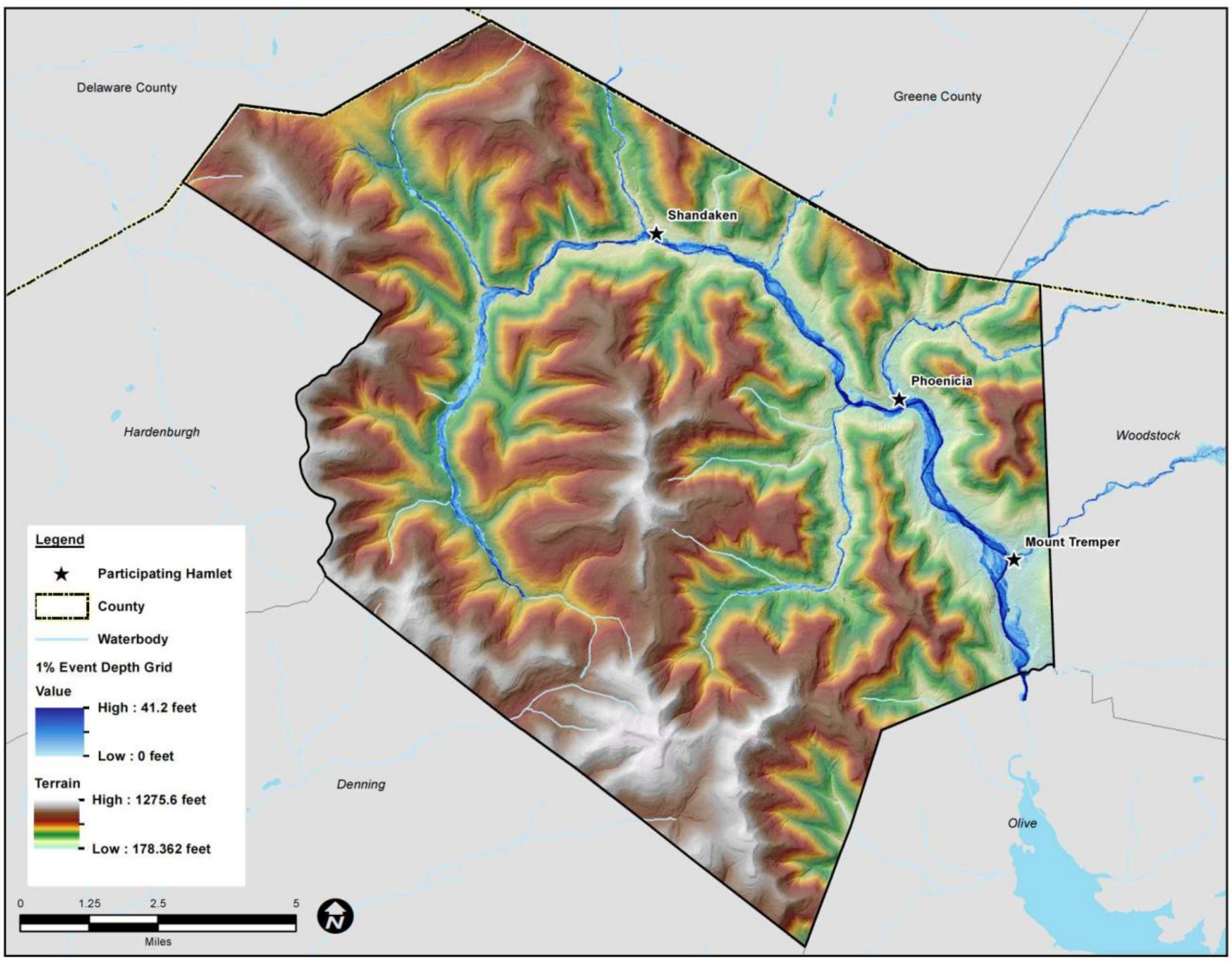
In the Hamlet of Mt. Tremper, the estimated 1-percent flood boundaries generated by HAZUS are similar to the preliminary FEMA maps 1-percent annual probability floodplain. However, greater differences appear with the 0.2-percent annual chance flood boundaries where the HAZUS-generated area is smaller in some areas (e.g., near Hudler Road and State Route 28) and larger in others (e.g., along Mt Pleasant Road west of State Route 28).

Further analysis to determine the exposure or estimated damages based on the updated maps is included as an action item in the mitigation strategy in Section 6 of this plan.

In terms of the dam failure hazard, there are five dams located within the Town of Shandaken. According to NYSDEC, one dam is classified as a high hazard dam (Pine Hill Lake Dam) or a class 'C'; and four dams are classified as intermediate hazard dams or class 'B' (Day Pond Dam, Muddy Brook Pond Dam, Winnisook Lake Dam, Snow Making Pond Dam). Refer to the Town Profile (Section 4) for dams located in the Town of Shandaken. The Stanford University's National Performance of Dams web site does not provide any information on 'dam incidents' related to these dams (i.e., safety related events). Pine Hill Lake Dam is the only dam that is required to have an Emergency Action Plan (EAP). Failure of this dam may cause loss of life, serious damage to buildings, public utilities, highways and economic loss.

There have been no recorded dam failures in the Town of Shandaken. Digitized dam inundation areas were not available at the time of this HMP. For dam failures of high hazard dams, inundation areas are likely to be similar to the 1-percent and 0.2-percent annual chance flood events downstream of each dam. A qualitative assessment of the dam failure hazard is provided below.

Figure 5-9 Town of Shandaken 1% Flood Event Depth Grid



Source: NYCDEP, 2009; Tetra Tech, 2012

5.2.2 Impact on Life, Health and Safety

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

To estimate the population exposed to the 1% and 0.2% annual chance flood events, the floodplain boundaries generated for this planning effort were overlaid upon the 2010 Census population data in GIS (U.S. Census 2010). Census blocks do not follow the boundaries of the floodplain. Similarly, Census blocks to not follow zip code boundaries. The Census blocks with their centroid in the flood boundaries were used to calculate the estimated population exposed to this hazard. Table 5-7 lists the estimated population located within the 1% and 0.2% flood zones for the Town as a whole and by zip code. Refer to Section 4 which discusses how the 2010 Census blocks were assigned to a zip code and to Figure 4-7 which displays the zip codes in the Town of Shandaken.

Table 5-7. Estimated Population Vulnerable to the 1% and 0.2% Flood Events

Zip Code	Total Population (U.S. Census 2010)	Population in 1% Hazard Area	Percent Population	Population in 0.2% Hazard Area	Percent Population
Big Indian	457	69	15.1	69	15.1
Chichester	345	8	2.3	8	2.3
Mt Tremper	478	41	8.6	98	20.5
Phoenicia	1,021	140	13.7	163	16.0
Pine Hill	242	4	1.7	4	1.7
Shandaken	542	62	11.4	73	13.5
Town of Shandaken	**3,085**	**324**	**10.5**	**415**	**13.5**

Source: Census, 2010
Note: Census Block 361119553001065, located entirely in the Town of Shandaken, has two zip codes: Phoenicia and Boiceville. For the purposes of this analysis, the entire block is considered within the Phoenicia zip code.

Of the population exposed, the most vulnerable include the economically disadvantaged and 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 due to isolation during a flood event and they may have more difficulty evacuating.

Using 2000 U.S. Census data, HAZUS-MH 2.1 estimates the potential sheltering needs as a result of the 1% and 0.2% flood events. For the 1% flood event, HAZUS-MH 2.1 estimates 902 people will be displaced and 461 people will seek short-term sheltering, representing 27.9% and 14.3% of the Shandaken 2000 population, respectively. For the 0.2% flood event, HAZUS-MH 2.1 estimates 990 people will be displaced and 547 people will seek short-term sheltering, representing 30.6% and 16.9% of the Shandaken 2000 population, respectively. Refer to Table 5-8.

Table 5-8. Estimated Population Displaced or Seeking Short-Term Shelter from the 1% and 0.2% Annual Chance Flood Events

	1% Annual Chance Event		0.2% Annual Chance Event	
Zip Code	Displaced Persons	Persons Seeking Short-Term Sheltering	Displaced Persons	Persons Seeking Short-Term Sheltering
Big Indian	71	27	80	34
Chichester	28	5	34	11
Mt Tremper	110	50	143	70
Phoenicia	280	157	363	226
Pine Hill	27	3	33	4
Shandaken	126	38	145	45
Town of Shandaken	**642**	**280**	**798**	**390**

Source: HAZUS-MH 2.1

Note: The percent of the population displaced and seeking shelter was calculated using the 2000 U.S. Census data

The total number of injuries and casualties resulting from typical riverine 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.

All population in a dam failure inundation zone is considered exposed and vulnerable. Similar to riverine flooding, of the population exposed to dam failure and flash flooding, the most vulnerable include the economically disadvantaged and the population over the age of 65.

There is often limited warning time for dam failure and flash flooding. These events are frequently associated with other natural hazard events such as earthquakes, landslides or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

5.2.3 Impact on General Building Stock

After considering the population exposed and vulnerable to the flood hazard, the built environment was evaluated. Exposure in the flood zone includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

The total land area located in the 1-percent and 0.2-percent annual chance flood zones created for this planning effort was calculated. Refer to Table 5-7 below. To provide a general estimate of number of structures, parcels, and structural/content replacement value exposure, the flood boundaries (1- and 0.2-percent annual chance flood zones) were overlaid upon Shandaken's parcel and the updated building stock inventory point shapefiles. The parcels that intersect the 1-percent and/or 0.2-percent annual chance flood zones were totaled for the municipality. The total number of buildings with their centroid located in the 1-percent and 0.2-percent flood boundaries was also determined and their estimated building stock replacement value (structure and contents) is listed as well. Refer to Table 5-9 through Table 5-1 below for exposure estimates for the Town of Shandaken. Figure 5-10 through Figure 5-11 illustrate the 1-percent flood event depth grid and the parcels that intersect.

Table 5-9. Area Located in the 1-Percent and 0.2-Percent Annual Chance Flood Boundaries

		1% Annual Chance Event		0.2% Annual Chance Event	
Zip Code	Total Area (sq. mi.)	Area Exposed (sq. mi.)	% of Total	Area Exposed (sq. mi.)	% of Total
Big Indian	42.7	0.72	1.7	0.84	2.0
Chichester	4.9	0.18	3.7	0.23	4.7
Mt Tremper		0.94	22.4	1.02	24.3
Phoenicia	51.3	1.41	2.7	1.64	3.2
Pine Hill	2	0.03	1.5	0.04	2.0
Shandaken	13.8	0.48	3.5	0.58	4.2
Town of Shandaken	**118.9**	**3.76**	**3.2**	**4.35**	**3.7**

Source: Tetra Tech, 2012
Note: sq.mi. = Square miles; % = Percent

Table 5-10. Estimated Number of Parcels that Intersect the 1-Percent and 0.2-Percent Annual Chance Flood Boundaries

	Total	1% Annual Chance Event		0.2% Annual Chance Event	
Municipality	Parcels	Number	% Total	Number	% Total
Town of Shandaken	3,547	1,216	34.3	1,382	39.0

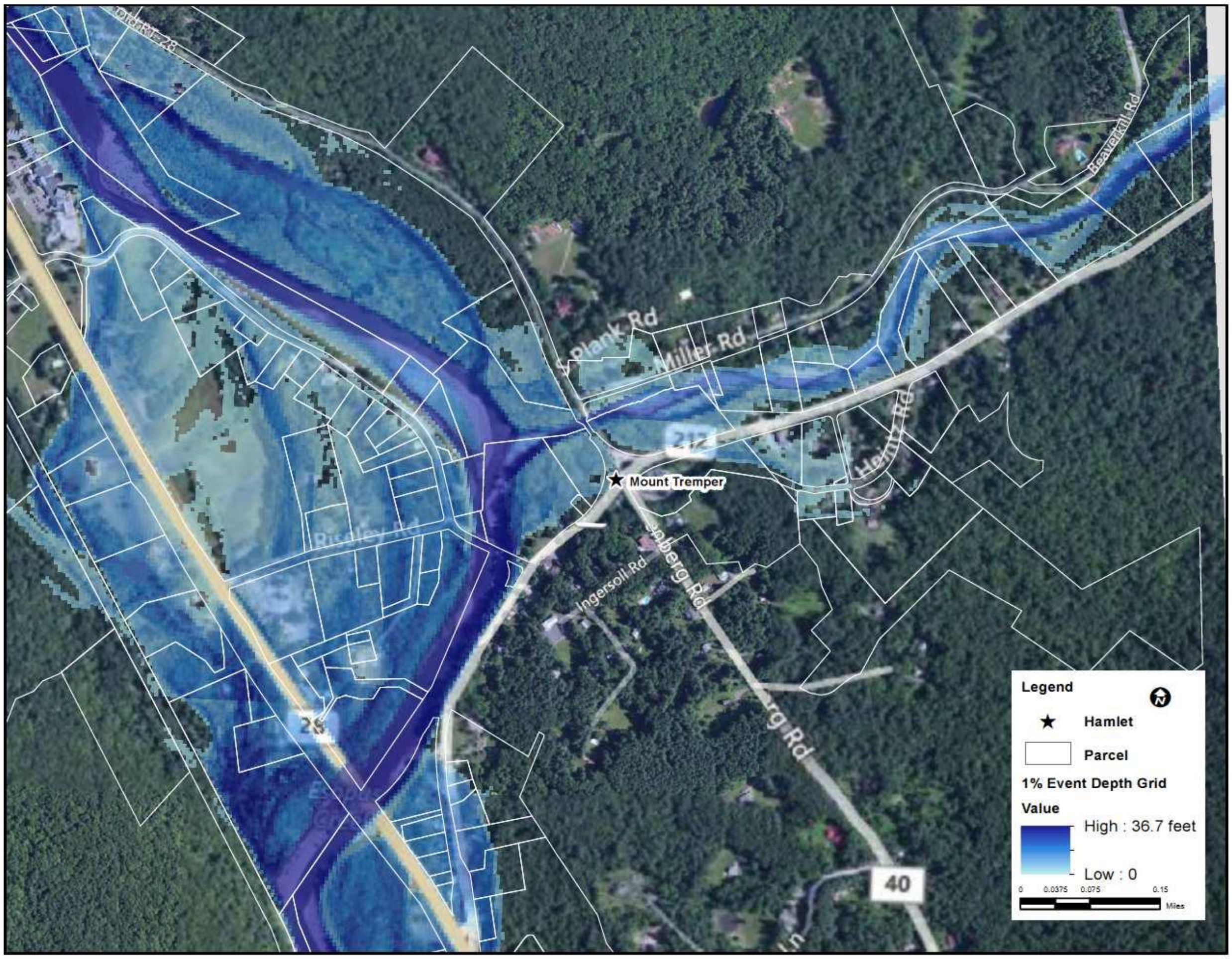
Source: Ulster County, 2012; Tetra Tech, 2012
Note: % = Percent

Table 5-11. Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events

Zip Code	Total Number of Buildings	Total RCV	1% Annual Chance Event				0.2% Annual Chance Event			
			Number of	% of	RCV	% of	of Buildings	% of Total	RCV	% of Total
Big Indian	443	$150,118,372	46	10.4	$15,385,739	10.2	64	14.4	$19,436,674	12.9
Chichester	276	$72,636,483	25	9.1	$5,096,270	7.0	43	15.6	$9,516,681	13.1
Mt Tremper	259	$90,876,459	60	23.2	$24,432,339	26.9	77	29.7	$29,039,894	32.0
Phoenicia	791	$289,931,165	136	17.2	$69,055,747	23.8	209	26.4	$94,006,610	32.4
Pine Hill	244	$96,548,248	14	5.7	$2,887,916	3.0	15	6.1	$3,808,642	3.9
Shandaken	368	$115,088,897	39	10.6	$14,339,876	12.5	63	17.1	$20,532,504	17.8
Town of Shandaken	**2,381**	**$815,199,625**	**320**	**13.4**	**$131,197,887**	**16.1**	**471**	**19.8**	**$176,341,005**	**21.6**

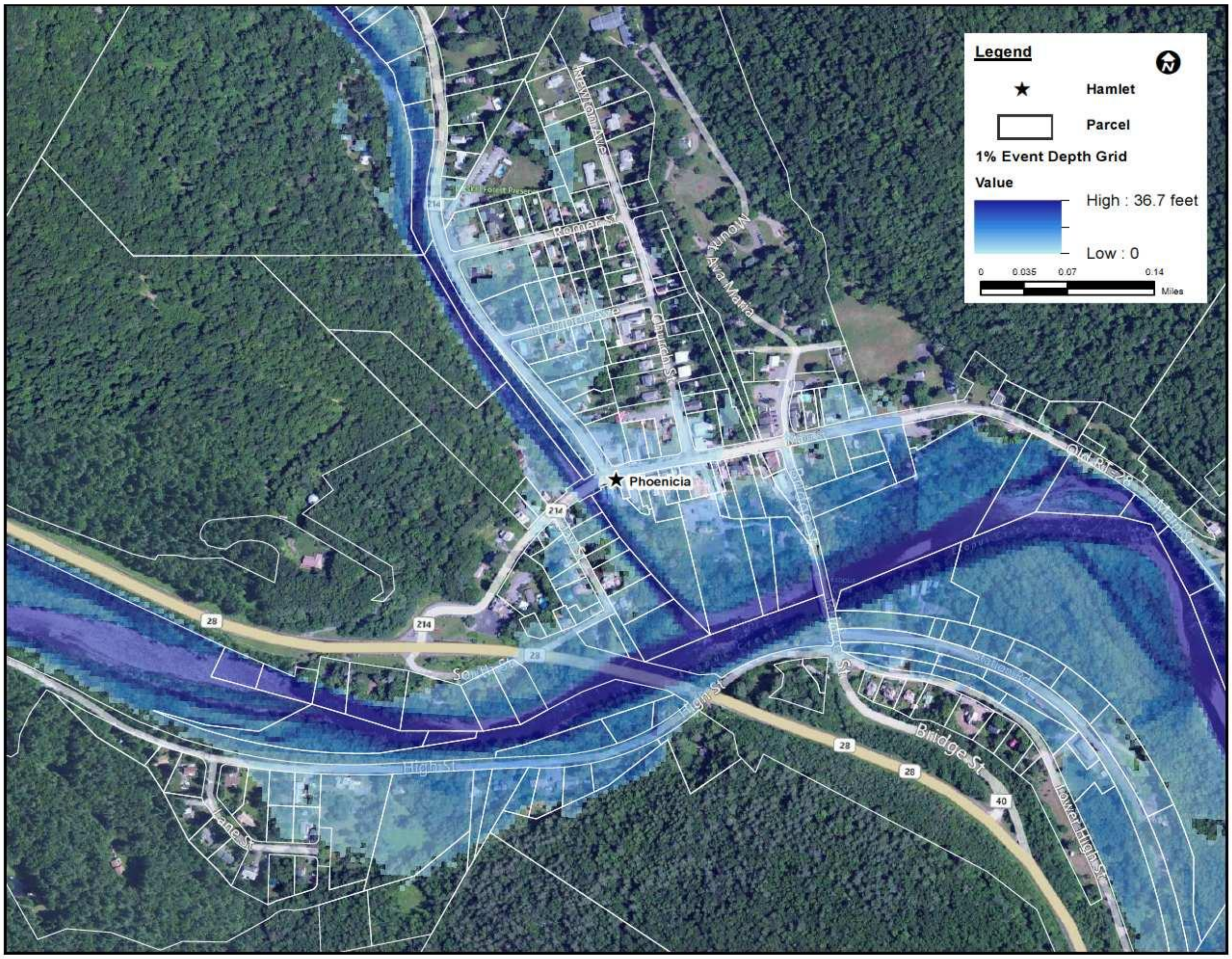
Source: Ulster County, 2012; Tetra Tech, 2012
Notes: Total RCV for Town = $815,199,625
% = Percent
RCV = Replacement cost value

Figure 5-10. Mount Tremper 1-Percent Flood Event Depth Grid and Parcels that Intersect the Grid



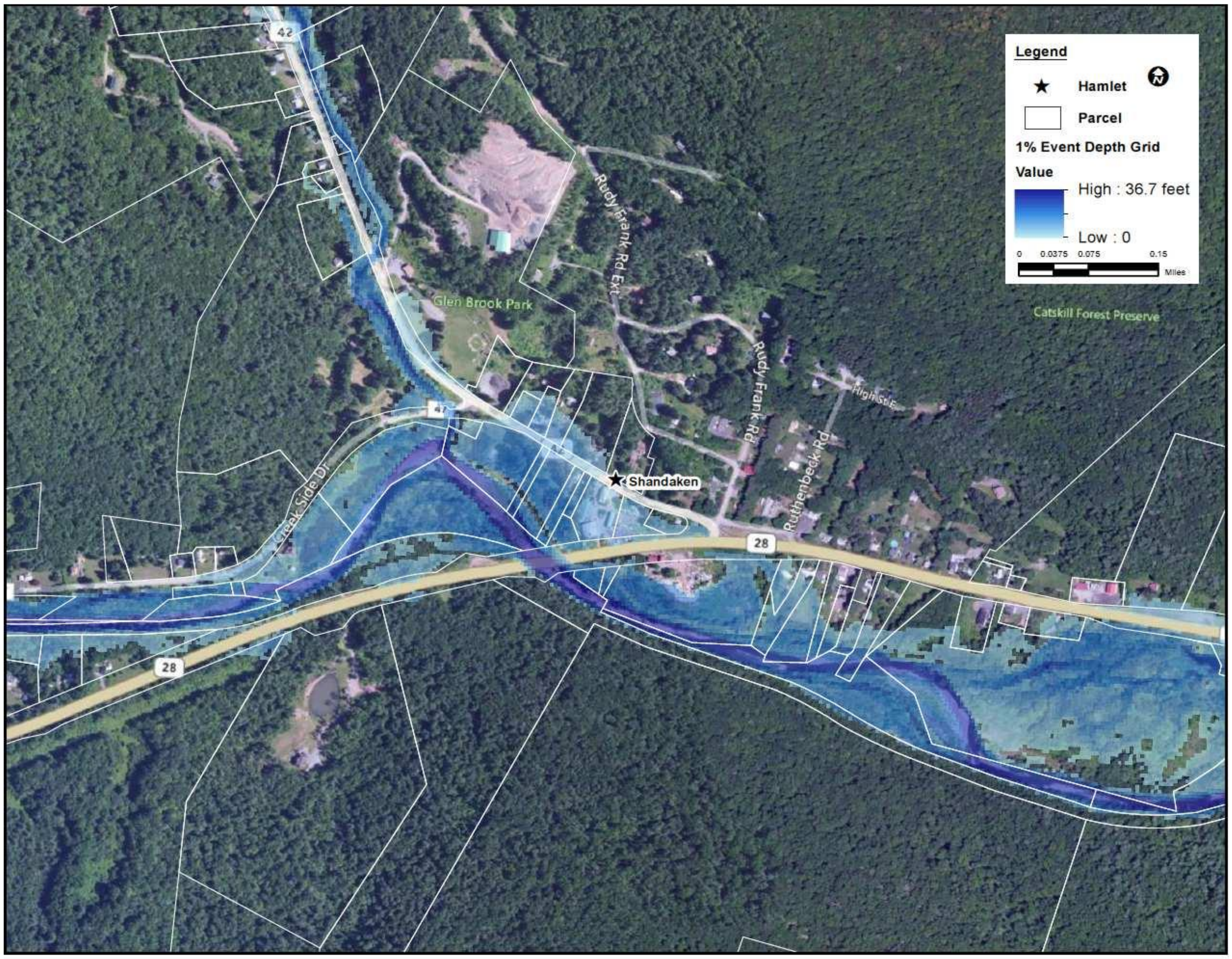
Source: Ulster County, 2012; Tetra Tech, 2012

Figure 5-11. The Hamlet of Phoenicia 1-Percent Flood Event Depth Grid and Parcels that Intersect the Grid



Source: Ulster County, 2012; Tetra Tech, 2012

Figure 5-12. Shandaken 1-Percent Flood Event Depth Grid and Parcels that Intersect the Grid



Source: Ulster County, 2012; Tetra Tech, 2012

Table 5-2 through Table 5- summarize the estimated potential general building stock damages (structure and contents) in the Town of Shandaken as a result of the 1-percent and 0.2-percent flood events, respectively.

Table 5-12. Estimated General Building Stock Replacement Value (Structure and Contents) Located in the 1-Percent and 0.2-Percent Annual Chance Flood Boundaries by Occupancy Class

Zip Code										
				% Total	1% Event	0.2% Event	1% Event	0.2% Event	1% Event	0.2% Event
Big Indian	$15,385,739	10.2	$19,436,674	12.9	$12,924,455	$16,054,663	$0	$920,727	$0	$0
Chichester	$5,096,270	7.0	$9,516,681	13.1	$4,175,543	$7,675,227	$920,727	$1,841,454	$0	$0
Mt Tremper	$24,432,339	26.9	$29,039,894	32.0	$18,457,496	$21,624,319	$822,022	$2,262,754	$0	$0
Phoenicia	$69,055,747	23.8	$94,006,610	32.4	$22,758,963	$38,341,604	$33,677,302	$38,477,124	$436,978	$436,978
Pine Hill	[illegible]	3.0	[illegible]	3.9	[illegible]	[illegible]	$0	[illegible]	$0	$0
Shandaken	$14,339,876	12.5	$20,532,504	17.8	$6,837,272	$11,589,168	$4,604,342	$6,045,075	$436,978	$436,978
Town of Shandaken	**$131,197,887**	**16.1**	**$176,341,005**	**21.6**	**$68,041,645**	**$98,172,897**	**$40,024,393**	**$50,467,860**	**$873,955**	**$873,955**

Zip Code	Agriculture		Religious		Government		Education	
	1% Event	0.2% Event	1% Event	0.2% Event	1% Event	0.2% Event	1% Event	0.2% Event
Big Indian	$0	$0	$0	$0	$2,461,284	$2,461,284	$0	$0
Chichester	$0	$0	$0	$0	$0	$0	$0	$0
Mt Tremper	$0	$0	$4,568,400	$4,568,400	$584,421	$584,421	$0	$0
Phoenicia	$0	$0	$9,136,800	$13,705,200	$3,045,705	$3,045,705	$0	$0
Pine Hill	$0	$0	$0	$0	$0	$0	$0	$0
Shandaken	$0	$0	$0	$0	$2,461,284	$2,461,284	$0	$0
Town of Shandaken	**$0**	**$0**	**$13,705,200**	**$18,273,600**	**$8,552,693**	**$8,552,693**	**$0**	**$0**

Source: Ulster County, 2012; Tetra Tech, 2012

Note: The 1-Percent and 0.2-Percent Annual Chance Flood Boundaries were generated by HAZUS-MH 2.1 based on the terrain, discharges and n-values input into the riverine flood model.

Table 5-13. Estimated Potential General Building Stock Loss (Structure and Contents) by the 1-Percent Annual Chance Flood Event

							Religious Buildings	Government Buildings	Education Buildings
	$946,684	<1	$946,684	$0	$0	$0	$0	$0	$0
Chichester	$572,016	<1	$546,577	$25,439	$0	$0	$0	$0	$0
	$3,951,526	4.3	$3,000,118	$440,330	$0	$0	$104,799	$406,278	$0
Phoenicia	$14,136,990	4.9	$3,089,271	$7,945,249	$245,438	$0	$2,469,051	$387,980	$0
Pine Hill	$441,562	<1	$441,562	$0	$0	$0	$0	$0	$0
Shandaken	$2,782,619	2.4	$1,219,144	$510,294	$109,297	$0	$0	$943,884	$0
Town of Shandaken	**$22,831,396**	**2.8**	**$9,243,357**	**$8,921,312**	**$354,735**	**$0**	**$2,573,850**	**$1,738,142**	**$0**

Source: HAZUS-MH 2.1

Notes: Values represent replacement values (RCV) for building structure and contents. Total RCV for Town = $815,199,625.

The 1-Percent and 0.2-Percent Annual Chance Flood Boundaries were generated by HAZUS-MH 2.1 based on the terrain, discharges and n-values input into the riverine flood model.

Table 5-14. Estimated Potential General Building Stock Loss (Structure and Contents) by the 0.2-Percent Annual Chance Flood Event

							Religious Buildings	Government Buildings	Education Buildings
	$2,073,665	1.4	$1,764,632	$11,911	$0	$0	$0	$297,122	$0
Chichester	$1,624,603	2.2	$1,326,036	$298,566	$0	$0	$0		$0
	$7,366,566	8.1	$5,835,879	$550,427	$0	$0	$534,646	$445,614	$0
Phoenicia	$26,782,711	9.2	$7,307,045	$14,287,489	$283,362	$0	$4,095,733	$809,082	$0
Pine Hill	$737,901	<1	$642,455	$95,446	$0	$0	$0		$0
Shandaken	$5,344,752	4.6	$2,233,045	$1,521,828	$186,670	$0	$0	$1,403,208	$0
Town of Shandaken	**$43,930,197**	**5**	**$19,109,092**	**$16,765,668**	**$470,032**	**$0**	**$4,630,379**	**$2,955,027**	**$0**

Source: HAZUS-MH 2.1

Notes: Values represent replacement values (RCV) for building structure and contents. Total RCV for Town = $815,199,625.

The 1-Percent and 0.2-Percent Annual Chance Flood Boundaries were generated by HAZUS-MH 2.1 based on the terrain, discharges and n-values input into the riverine flood model.

In addition to total building stock modeling, individual data available on flood policies, claims, RLP and severe RLP (SRLs) were analyzed. FEMA Region 2 provided a list of residential 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 & be as least 10 days apart. Only losses from (*sic* since) 1/1/1978 that are closed are considered."

Severe RLPs (SRL) were then examined for the Town. According to section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a, an SRL 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.

Table 5-15 and Figure 5-13 summarize the NFIP policies, claims and repetitive loss statistics for the Town of Shandaken. According to FEMA, there are 22 RL properties and two SRL properties in the Town of Shandaken. The two SRL properties are classified as 'single family' (FEMA Region 2, 2013). This information is current as of March 31, 2013.

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.

Table 5-15. NFIP Policies, Claims and Repetitive Loss Statistics

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in the estimated 1% Flood Boundary (3)	(3)	# Policies Flood Hazard (3)
Town of Shandaken	204	214	$5,496,910	22	2	123	128	76

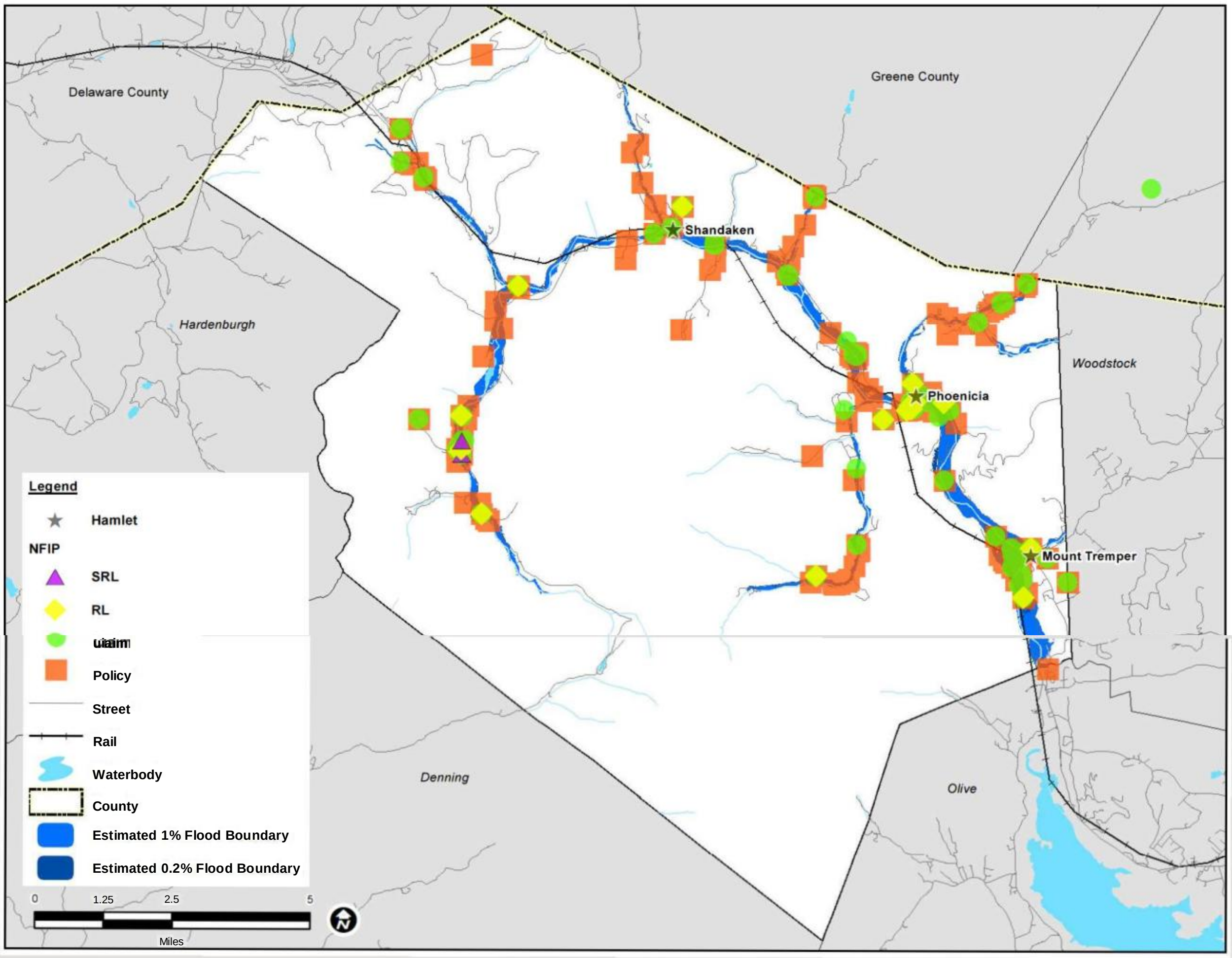
Source: FEMA Region 2, 2012

(1) Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, in May 2013. These statistics are current as of March 31, 2013. Please note the total number of repetitive loss properties includes the severe repetitive loss properties; only insured properties are included in these statistics. The number of claims represents the number of claims closed by March 31, 2013. Claims without payment are not included.

(2) Total building and content losses from the claims file provided by FEMA Region 2.

(3) The policies inside and outside of the flood zones is based on the latitude and longitude provided by FEMA Region 2 in the policy file.

Figure 5-13. NFIP Polices, Claims, Repetitive Loss and Severe Repetitive Loss Properties



Source: FEMA Region 2, 2013

5.2.4 Impact on Critical Facilities

In addition to considering general building stock at risk, the risk of flood to critical facilities, utilities and user-defined facilities was evaluated. HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, HAZUS estimates the percent of damage to the building and contents of critical facilities. Table 5-6 lists the critical facilities and utilities located in the FEMA flood zones and the percent damage HAZUS-MH 2.1 estimates to the facility as a result of the 1% and 0.2% events.

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Table 5-16. Critical Facilities Located in the 1-Percent and 0.2-Percent Annual Chance Flood Boundaries and Estimated Potential Damage

		Exposure		Potential Loss from 1% Flood Event			Potential Loss from 0.2% Flood Event		
Name	Type	1% Event	0.2% Event	Percent Damage	Percent Content Damage	Days to 100-Percent Functional	Percent Structure Damage	Percent Content Damage	Days to 100-Percent Functional
Phoenicia Fire House	Fire/EOC	X	X	10.2	24.0	480	11.6	47.8	480
Phoenicia Main Filtration Plant	Potable Water Facility	X	X	2	-	-	25.7	-	-
Phoenicia Water District Storage	Potable Water Facility	X	X	40	-	-	40	-	-
Town Hall	Municipal	X	X	2.3	2.5	-	24.9	38.8	-
Town Highway	Municipal	X	X	10.4	66.3	-	14.9	99.1	-

Source: HAZUS-MH 2.1
Note:
- = No loss calculated by HAZUS-MH 2.1

5.2.5 Impact on the Economy

For impact on economy, estimated losses from a flood event are considered. Losses include but are not limited to general building stock damages, agricultural losses, business interruption, impacts to tourism and tax base to the Town of Shandaken. 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 and social economic factors are less measurable with a high degree of certainty. For the purposes of this analysis, general building stock damages are discussed further.

Flooding can cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooded streets and road blocks make it difficult for emergency vehicles to respond to calls for service. Floodwaters can wash out sections of roadway and bridges (Foster, Date Unknown).

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 1-percent flood is approximately $105 Million. This estimated building damage represents approximately 13-percent of the Town's overall total general building stock inventory. The potential damage estimated to the general building stock inventory associated with the 0.2-percent flood is approximately $125 Million, or nearly 16- percent of the Town's total building inventory. These dollar value losses to the Town's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact the local economy.

HAZUS-MH estimates the amount of debris generated from the flood events as a result of 1% and 0.2% events. 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 5-7 summarizes the debris HAZUS-MH 2.1 estimates for these events. However, a major issue with debris in the Town includes gravel deposition and woody debris in stream beds, deposited after major storm and flood events. The Town indicates that the areas of concern are mostly at confluences in populated areas including the following areas:

- Stony Clove - Esopus in Phoenicia
- Woodland Valley - Esopus in Woodland Valley
- Beaverkill - Esopus in Mt. Tremper
- McKenley - Esopus in Oliverea
- Busnellsville - Esopus in Shandaken

There areas are significantly impacted by gravel deposition due to the effects on infrastructure and residential and commercial structures.

Below are summary estimates of debris generated from flood events. These estimates can provide a basis for estimation of Town debris removal costs for future events to support fiscal planning.

Table 5-17. Estimated Debris Generated from the 1-Percent and 0.2-Percent Flood Events

	1% Flood Event				0.2% Flood Event			
						Finish (tons)	Structure (tons)	Foundation (tons)
	257	205	27	26	486	303	111	71
Chichester	135	72	33	30	255	117	75	63
	960	342	363	255	1,558	494	634	430
Phoenicia	2,304	824	835	645	4,163	1,259	1,652	1,252
Pine Hill	58	52	4	2	101	87	9	6
Shandaken	370	175	109	85	697	266	244	187
Town of Shandaken	**4,085**	**1,670**	**1,371**	**1,043**	**7,260**	**2,526**	**2,725**	**2,008**

Source: HAZUS-MH 2.1

All buildings and infrastructure located in the dam failure inundation zone are considered exposed and vulnerable. Property located closest to the dam inundation area has the greatest potential to experience the largest, most destructive surge of water. All transportation infrastructures in the dam failure inundation zone are vulnerable to damage and potentially cutting off evacuation routes, limiting emergency access and creating isolation issues. Utilities such as overhead power lines, cable and phone lines could also be vulnerable. Loss of these utilities could create additional isolation issues for the inundation areas.

5.2.6 Future Growth and Development

As discussed in Section 4, no areas targeted for future growth and development have been identified across the Town. Growth, however is expected to be minimal due to the steep slope topography of available land parcels and the amount of state owned land which prohibits development. Any areas of growth could be potentially impacted by the flood hazard if located within the identified hazard areas. **Error! Reference source not found.** illustrates the identified areas of potential new development in relation to the flood boundaries.

5.2.7 Additional Data and Next Steps

A HAZUS-MH riverine flood analysis was conducted for the Town of Shandaken using the most current and best available data including updated building and critical facility inventories, FIS, and 2009 three-meter LiDAR DEM. For future plan updates, more accurate exposure and loss estimates can be produced by replacing the national default demographic inventory with 2010 U.S. Census data when it becomes available in the HAZUS_MH model. As Assessor databases continue to be updated, the building inventory should also be maintained.

FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) will be providing the flood depth and analysis grids as part of the publicly available DFIRM deliverable; estimated in 2013. According to NYC DEP, the DFIRM deliverable will include flood depth grids for the 10, 25, 50, 100 and 500-year recurrence intervals. The inundation from Hurricane Irene will be incorporated into the recurrence interval calculations. In addition the deliverable will include the ability to see the changes in the previous regulatory floodplains compared with the new/current floodplains. Once these depth grids are available, they can be incorporated into HAZUS and used to recalculate the potential losses to the Town's inventory for these recurrence intervals.

The preliminary Ulster County FEMA Flood Insurance Rate Maps were made available in PDF prior to the finalization of this plan to enable comparison of the estimated flood boundaries HAZUS-MH generated for the 1-percent and 0.2-percent annual chance flood events.

In the Hamlet of Phoenicia, the preliminary FEMA maps indicate a larger 1-percent and 0.2-percent annual chance floodplain north of Main Street and east of Route 24 when compared with the estimated HAZUS flood boundaries. The floodplains along the Esopus Creek, between Main Street and State Route 28, appear very similar.

In the Hamlet of Mt. Tremper, the estimated 1-percent flood boundaries generated by HAZUS are similar to the preliminary FEMA maps 1-percent annual probability floodplain. However, greater differences appear with the 0.2-percent annual chance flood boundaries where the HAZUS-generated area is smaller in some areas (e.g., near Hudler Road and State Route 28) and larger in others (e.g., along Mt Pleasant Road west of State Route 28).

For future plan updates, if digitized boundaries of dam inundation zones (extent/location) and water surface elevations are available, depth grids can be developed using LiDAR terrain data. These boundaries and depth grids can be incorporated into HAZUS-MH riverine flood model and run to estimate potential losses to population, buildings, utilities, infrastructure and shelter estimates generated. This data is generally available with the dam Emergency Action Plan. Once this data is available, the methodology outlined can be followed to estimate potential losses for the dam break hazard.Similar to the riverine flood hazard, using accurate building and infrastructure inventories for the dam failure hazard will create more accurate exposure and loss estimates.