5.4.2 Earthquake

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

5.4.2.1 Hazard Profile

Profile information is provided below (including description, extent, location, previous occurrences and losses, probability of future occurrences, and impacts of climate change).

Description

An earthquake is the sudden movement of the earth's surface caused by the release of stress accumulated within or along the edge of the earth's tectonic plates, a volcanic eruption, or by a manmade explosion (Federal Emergency Management Agency [FEMA], 2013; Shedlock and Pakiser, 1997). Most earthquakes occur at the boundaries where the earth's tectonic plates meet (faults); however, less than 10 percent of earthquakes occur within plate interiors. New York State is in an area where plate interior-related earthquakes occur. As plates continue to move and plate boundaries change over geologic time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within the continents can cause earthquakes from stresses that originate at the edges of the plate or in the deeper crust (Shedlock and Pakiser, 1997).

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the earth's surface to the region where an earthquake's energy originates (the focus or hypocenter). The epicenter of an earthquake is the point on the earth's surface directly above the hypocenter (Shedlock and Pakiser, 1997). Earthquakes usually occur without warning and their effects can impact areas a great distance from the epicenter (FEMA, 2001).

According to the U.S. Geological Society (USGS) Earthquake Hazards Program, an earthquake hazard is anything associated with an earthquake that may affect a resident's normal activities. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches. A description of each of these is provided below.

- *Surface faulting*: Displacement that reaches the earth's surface during slip along a fault. This commonly occurs with shallow earthquake, which are those with an epicenter less than 20 kilometers.
- *Ground motion (shaking):* The movement of the earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves generated by sudden slip on a fault or sudden pressure at the explosive source; waves then travel through the earth and along its surface.
- *Landslide*: A movement of surface material down a slope.
- *Liquefaction*: A process by which water-saturated sediment temporarily loses strength and acts as a fluid (similar to wiggling your toes in the wet sand near the water at the beach). This effect can be caused by earthquake shaking.
- *Tectonic Deformation*: A change in the original shape of a material due to stress and strain.
- *Tsunami*: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands.
- *Seiche*: The sloshing of a closed body of water from earthquake shaking (USGS, 2012).

Extent

An earthquake's magnitude and intensity are used to describe the size and severity of the event. Magnitude describes the size at the focus of an earthquake and intensity describes the overall severity of shaking felt during the event. The earthquake's magnitude is a measure of the energy released at the source of the earthquake and is expressed by ratings on the Richter scale and/or the moment magnitude scale. The Richter Scale measures magnitude of earthquakes and has no upper limit; however, it is not used to express damage (USGS 2012c). Table 5.4.2-1 presents the Richter scale magnitudes and corresponding earthquake effects.

Table 5.4.2-1. Richter Scale

Richter Magnitude	Earthquake Effects
2.5 or less	Usually not felt, but can be recorded by seismograph
2.5 to 5.4	Often felt, but only causes minor damage
5.5 to 6.0	Slight damage to buildings and other structures
6.1 to 6.9	May cause a lot of damage in very populated areas
7.0 to 7.9	Major earthquake; serious damage
8.0 or greater	Great earthquake; can totally destroy communities near the epicenter

Source: USGS, 1989

The moment magnitude scale (MMS) is used to describe the size of an earthquake. It is based on the seismic moment and is applicable to all sizes of earthquakes (USGS 2012d). The Richter Scale is not commonly used anymore, as it has been replaced by the MMS which is a more accurate measure of the earthquake size (USGS 2012c). The MMS uses the following classifications of magnitude:

- Great—$M_W \geq 8$
- Major—$M_W = 7.0 - 7.9$
- Strong—$M_W = 6.0 - 6.9$
- Moderate—$M_W = 5.0 - 5.9$
- Light—$M_W = 4.0 - 4.9$
- Minor—$M_W = 3.0 - 3.9$
- Micro—$M_W < 3$

The intensity of an earthquake is based on the observed effects of ground shaking on people, buildings, and natural features, and it varies with location. The Modified Mercalli (MMI) scale expresses intensity of an earthquake and describes how strong a shock was felt at a particular location in values. Table 5.4.2-2 summarizes earthquake intensity as expressed by the MMI scale. Table 5.4.2-3 displays the MMI scale and its relationship to the areas peak ground acceleration.

Table 5.4.2-2. Modified Mercalli Intensity Scale

Mercalli Intensity	Shaking	Description
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing automobiles may rock slightly. Vibrations are similar to the passing of a truck. Duration estimated.

Mercalli Intensity	Shaking	Description
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing automobiles rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very Strong	Felt by all. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Felt by all. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Felt by all. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Felt by all. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Source(s): USGS 2014

Table 5.4.2-3. Modified Mercalli Intensity (MMI) and PGA Equivalents

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	< .17	Not Felt	None
II	.17 – 1.4	Weak	None
III	.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy
IX	65-124	Violent	Heavy
X	>124	Extreme	Very Heavy

Source: Freeman et al. (Purdue University) 2004
Note: PGA Peak Ground Acceleration

Seismic hazards are often expressed in terms of peak ground acceleration (PGA) and spectral acceleration (SA). USGS defines PGA and SA as the following: PGA is what is experienced by a particle on the ground. Spectral Acceleration (SA) is approximately what is experienced by a building, as modeled by a particle mass on a massless vertical rod having the same natural period of vibration as the building' (USGS, 2012). Both PGA and SA can be measured in *g* (the acceleration due to gravity) or expressed as a percent acceleration force of gravity (%g). PGA and SA hazard maps provide insight into location-specific vulnerabilities (NYS DHSES 2011).

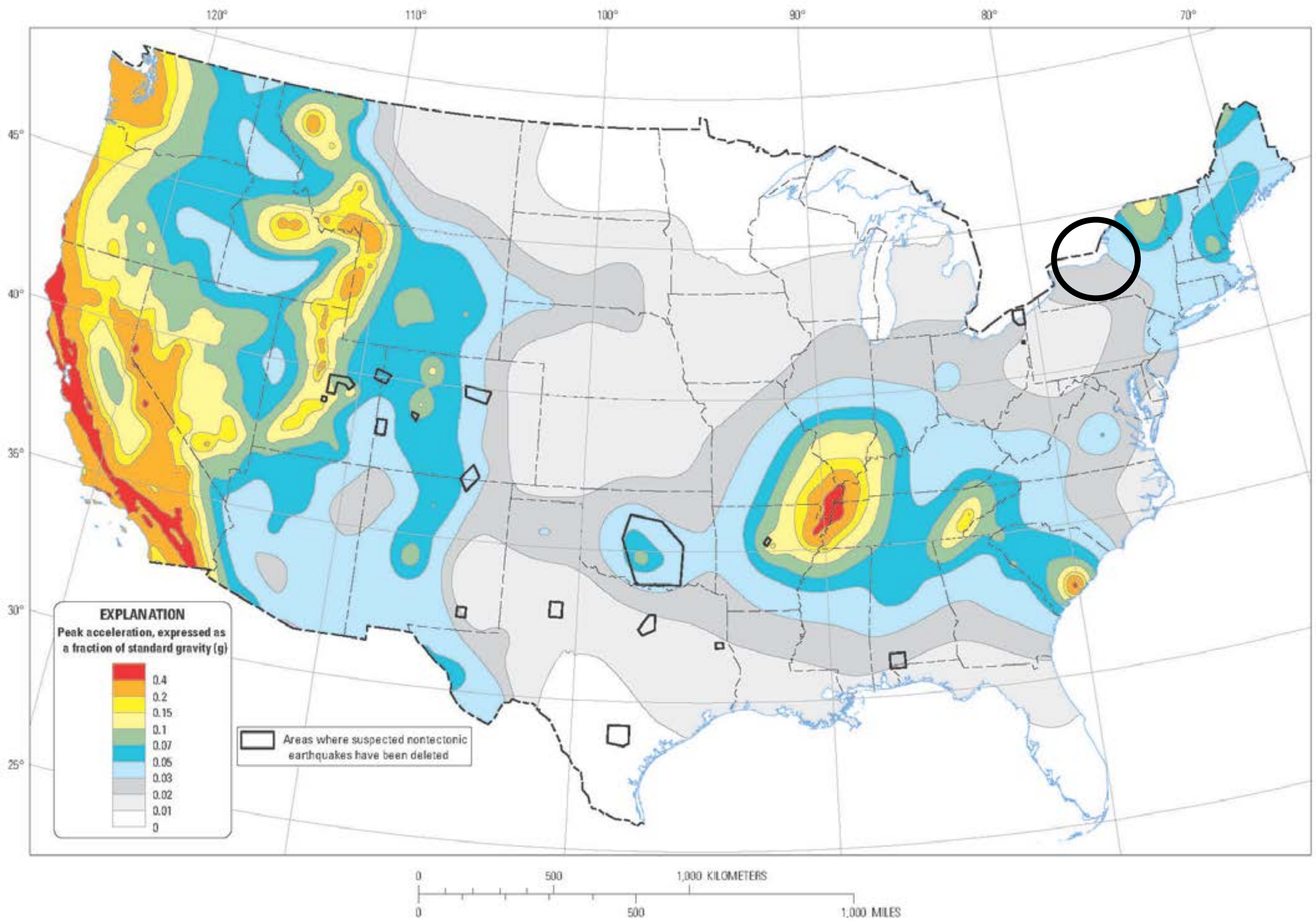
More specifically, PGA is a common earthquake measurement that shows three things: the geographic area affected, the probability of an earthquake of each given level of severity, and the strength of ground movement (severity) expressed in terms of percent of acceleration force of gravity (%g). In other words, PGA expresses the severity of an earthquake and is a measure of how hard the earth shakes (or accelerates) in a given geographic area (NYS DHSES 2011).

Since 1948, national maps of earthquake shaking hazards have been produced. These maps provide information essential to creating and updating the seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning for the United States. Scientists frequently revise these maps to reflect new information and knowledge. Buildings, bridges, highways, and utilities built to meet modern seismic design requirements are typically able to withstand earthquakes better, with less damages and disruption. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (Brown et al., 2001).

The USGS updated the National Seismic Hazard Maps in 2014, which supersede the 2008 and 2002 maps. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2014 map represents the best available data as determined by the USGS.

The 2014 Seismic Hazard Map shows that Monroe County has a PGA between 0.02g and 0.03g (Figure 5.4.2-1). This map is based on peak ground acceleration (g) with 10% probability of exceedance in 50 years.

Figure 5.4.2-1. Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years (USGS 2014)



Ten-percent probability of exceedance in 50 years map of peak ground acceleration

Source: USGS, 2014
Note: The black circle indicates the approximate location of Monroe County. The figure indicates that the County has a PGA between 0.02g and 0.03g.

The New York State Geological Survey conducted seismic shear-wave tests of the state's surficial geology (glacial deposits). Based on these test results, the surficial geologic materials of New York State were categorized according to the National Earthquake Hazard Reduction Program's (NEHRP) Soil Site Classifications (see Table 5.4.2-4.) The NEHRP developed five soil classifications that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking, increasing building damage and losses.

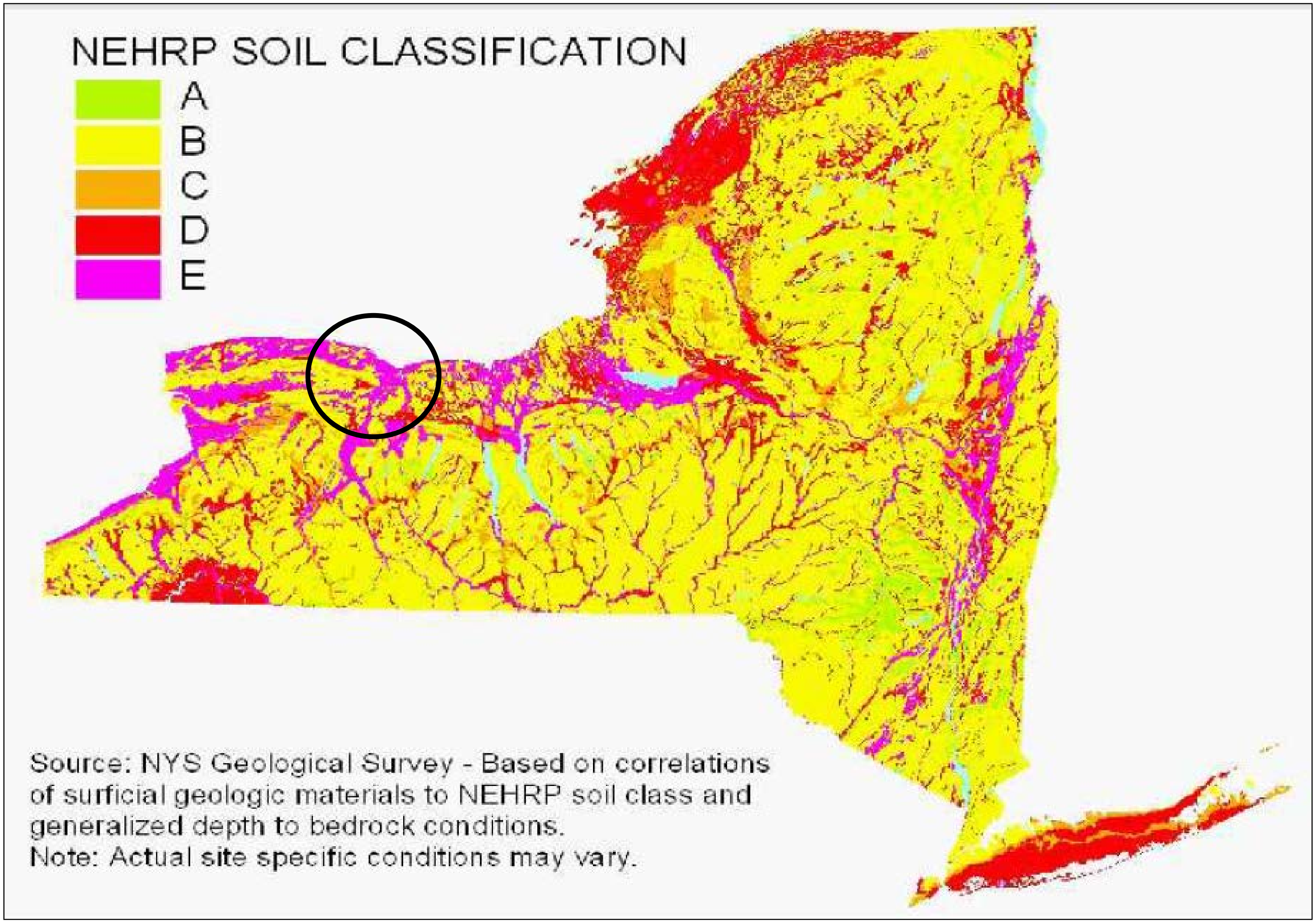
Figure 5.4.2-2 illustrates the NEHRP soil classifications in Monroe County. Table 5.4.2-5 summarizes the NEHRP soil classifications shown on Figure 5.4.9-3.

Table 5.4.2-6. NEHRP Soil Classifications

Soil Classification	Description
A	Very hard rock (e.g., granite, gneisses; and most of the Adirondack Mountains)
B	Rock (sedimentary) or firm ground
C	Stiff clay
D	Soft to medium clays or sands
E	Soft soil including fill, loose sand, waterfront, lake bed clays

Source: NYS DHSES, 2014

Figure 5.4.2-2. NEHRP Soils in New York



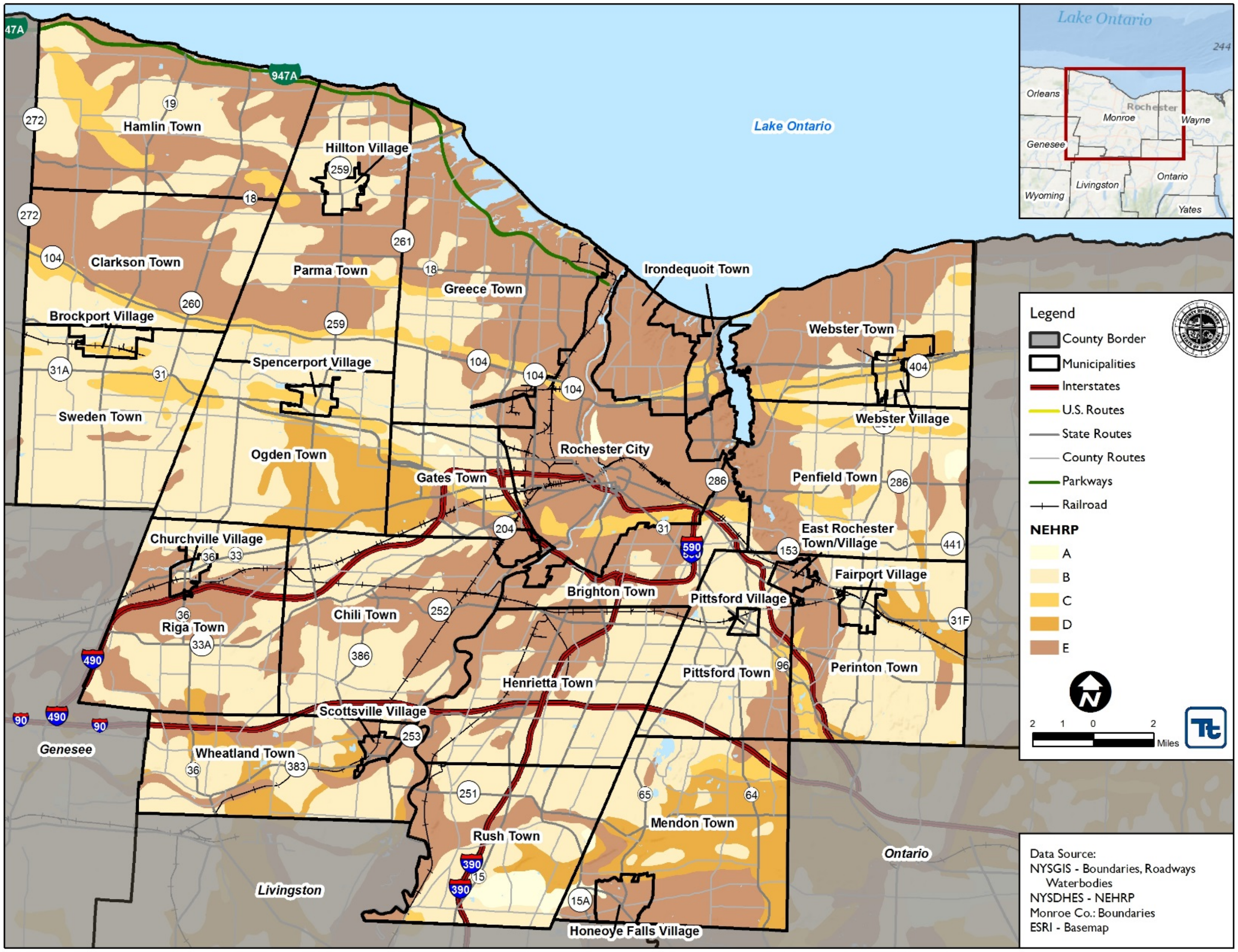
Source: NYS DHSES, 2014
Note: The black circle indicates the approximate location of Monroe County. The figure shows that the County's NEHRP soil classifications include B, D, and E soils.

As illustrated in Figure 5.4.2-3, Monroe County is primarily comprised of NEHRP Soil Classes B, D, and E. The majority of the county is Soil Class B.

A probabilistic assessment was conducted for the 100-, 500- and 2,500-year mean return periods (MRP) through a Level 2 analysis using the HAZUS-MH, Version 2.2 (HAZUS-MH) probabilistic model to analyze the earthquake hazard for Monroe County. The Level 2 HAZUS analysis evaluates the statistical likelihood that a specific event will occur and what consequences will occur. A 100-year MRP event is an earthquake with a 1% chance that the mapped ground motion levels (PGA) will be exceeded in any given year. For a 500-year MRP, there is a 0.2% chance the mapped PGA will be exceeded in any given year. For a 2,500-year MRP, there is a 0.04% chance the mapped PGA will be exceeded in any given year

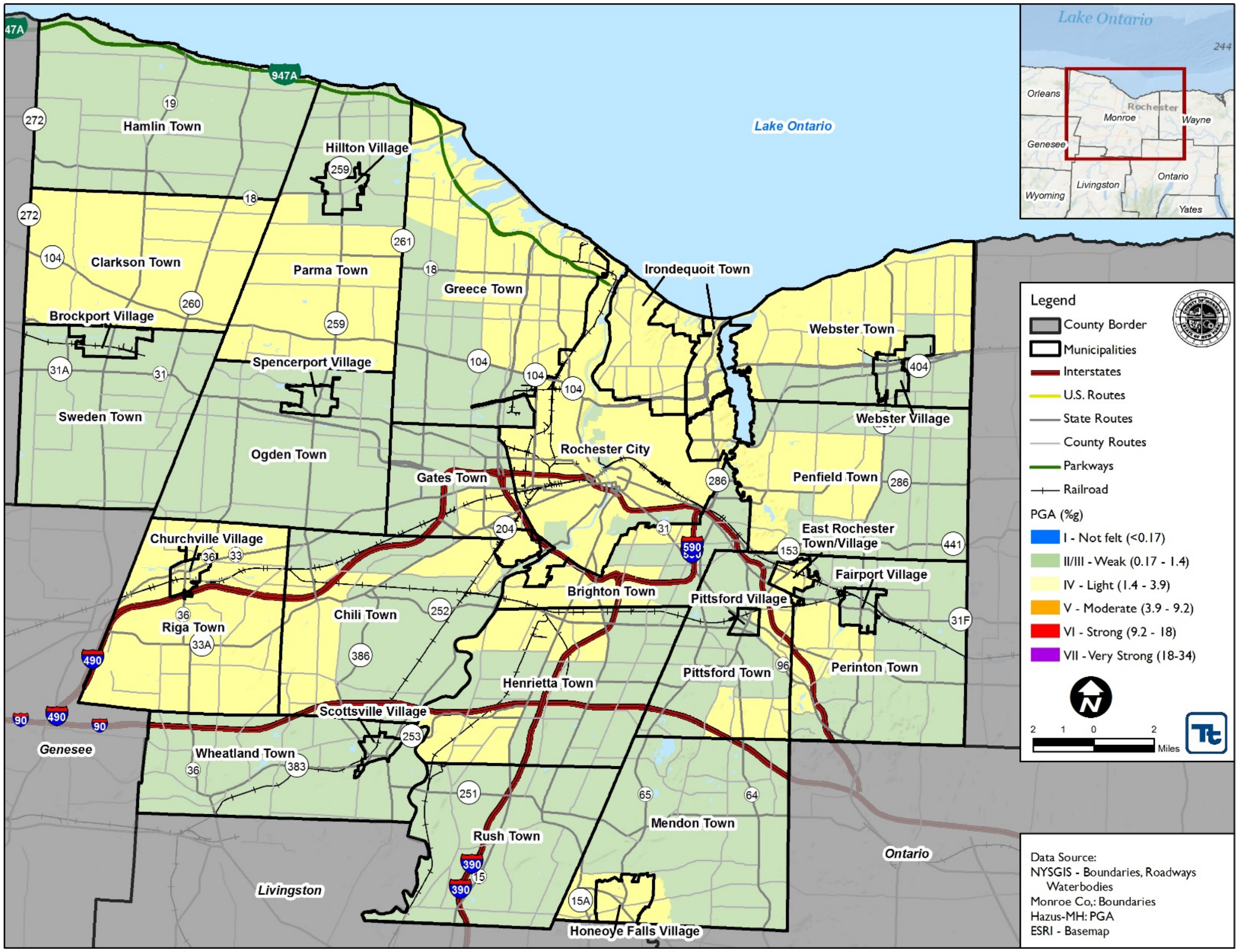
Figure 5.4.2-4 through Figure 5.4.2-6 illustrate the geographic distribution of PGA (*g*) across Monroe County for 100-, 500- and 2,500-year MRP events at the census-tract level.

Figure 5.4.2-3. NEHRP Soils in Monroe County



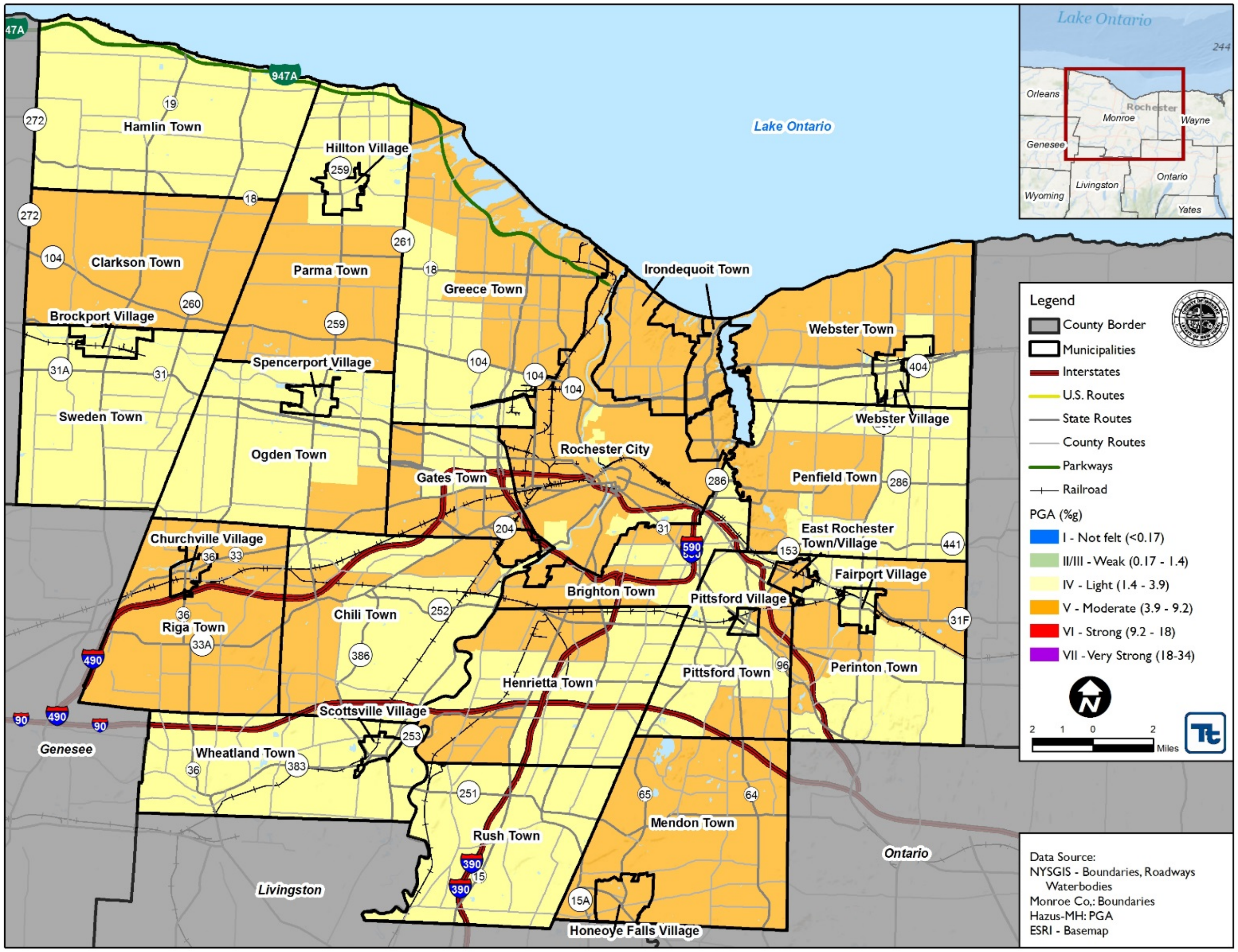
Source: NYS DHSES, 2008

Figure 5.4.2-4. Peak Ground Acceleration Modified Mercalli Scale for a 100-Year MRP Earthquake Event



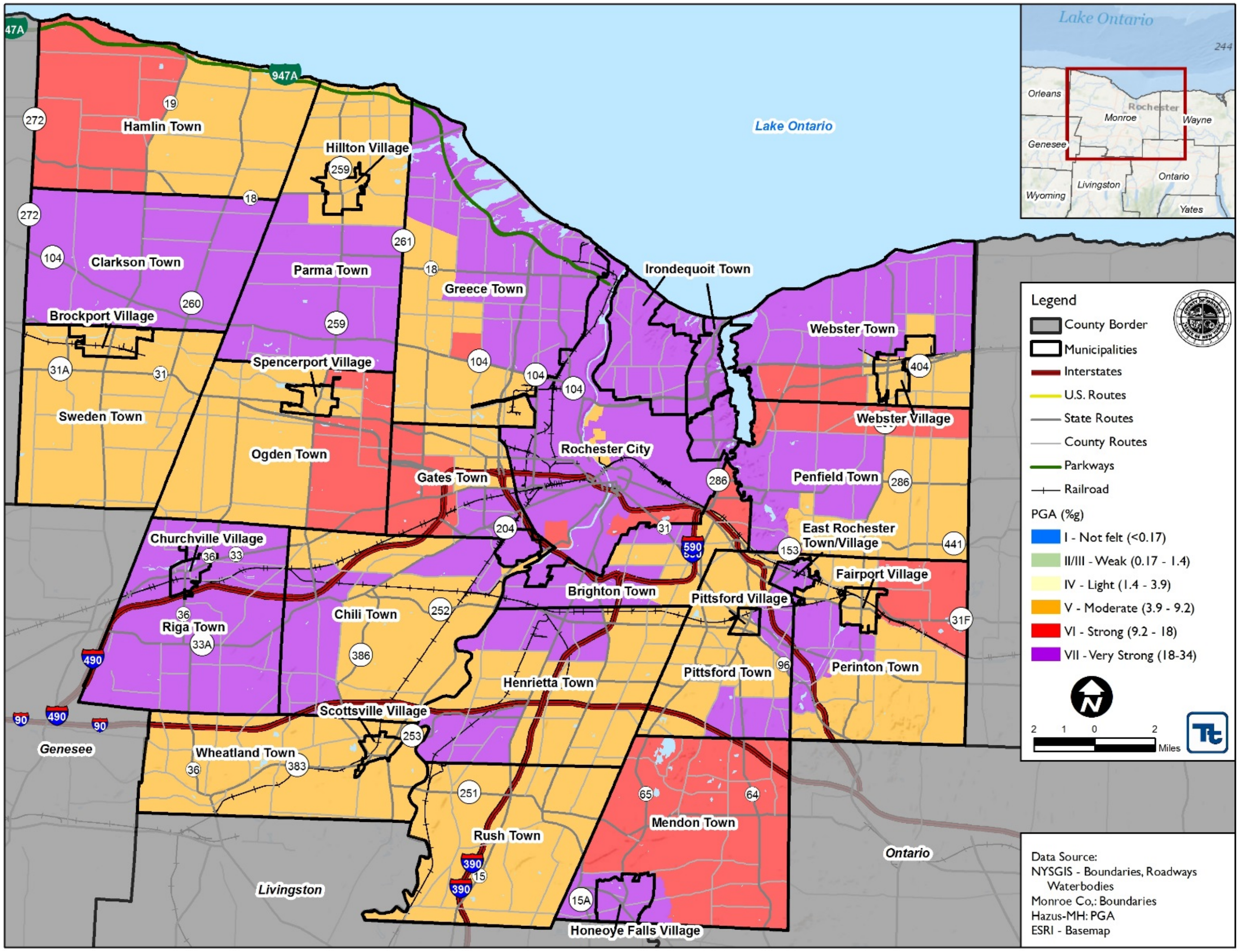
Source: HAZUS-MH 2.2
Note: The peak ground acceleration for the 100-year MRP is 0.68 to 2.2 %g.

Figure 5.4.2-5. Peak Ground Acceleration Modified Mercalli Scale for a 500-Year MRP Earthquake Event



Source: HAZUS-MH 2.2
Note: The peak ground acceleration for the 500-year MRP is 2.1 to 6.5%g.

Figure 5.4.2-6. Peak Ground Acceleration Modified Mercalli Scale for a 2,500-Year MRP Earthquake Event



Source: HAZUS-MH 2.2
Note: The peak ground acceleration for the 2,500-year MRP is 6.9 to 22.8%g.

Location

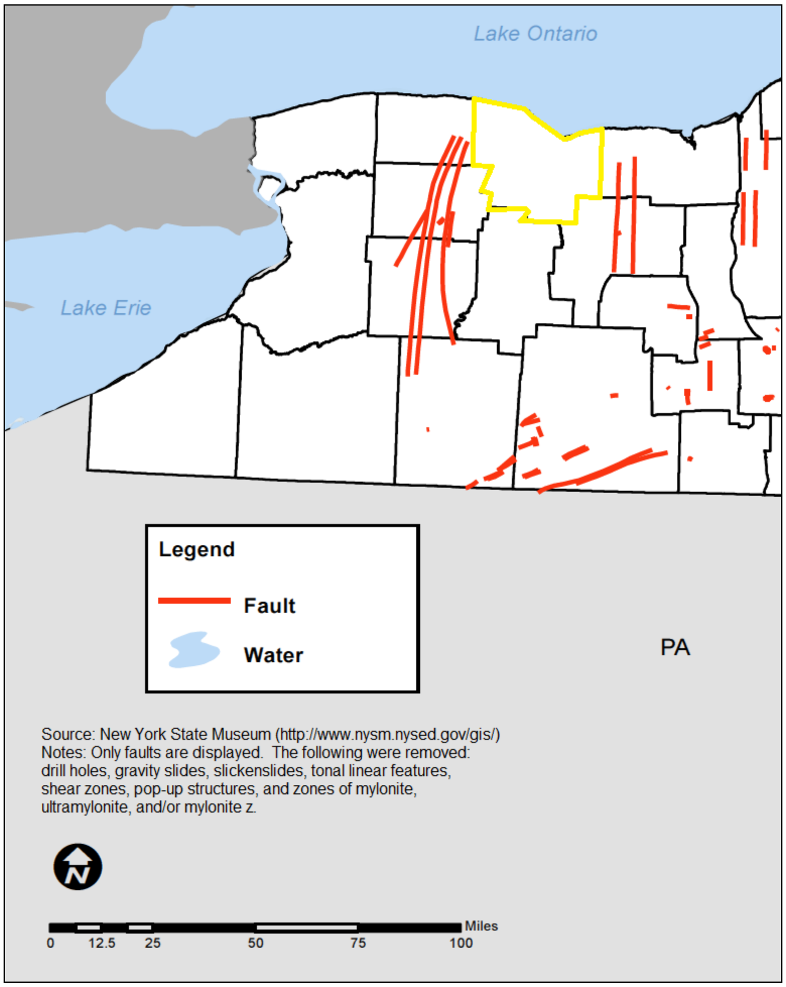
As noted in the 2014 NYS HMP, the importance of the earthquake hazard in New York State is often underestimated because other natural hazards (for example, hurricanes and floods) occur more frequently and because major hurricanes and floods have occurred more recently than a major earthquake event (NYS DHSES 2011). However, the potential for earthquakes exists across all of New York State and the entire northeastern United States. The New York City Area Consortium for Earthquake Loss Mitigation (NYCEM) ranks New York State as having the third highest earthquake activity level east of the Mississippi River (Tantala et al., 2003).

Three general regions in New York State have a higher seismic risk than other parts of the state. These regions are: (1) the north and northeast third of the state, which includes the North Country/Adirondack region and a portion of the greater Albany-Saratoga region; (2) the southeast corner, which includes the greater New York City area and western Long Island; and (3) the northwest corner, which includes Buffalo and its surrounding area. Overall, these three regions are the most seismically active areas of the state, with the north-northeast portion having the higher seismic risk, and the northwest corner of the state having the lower seismic risk (NYS DHSES 2014).

Fractures or fracture zones along with rocks on adjacent sides have broken and moved upward, downward, or horizontally are known as faults (Volkert and Witte 2015). Movement can take place at faults and cause an earthquake. There are numerous faults throughout New York State, and Figure 5.4.2-7 illustrates the faults relative to Monroe County (New York State Museum, 2012).

The closest plate boundary to the East Coast is the Mid-Atlantic Ridge, which is approximately 2,000 miles east of Pennsylvania. Over 200 million years ago, when the continent Pangaea rifted apart forming the Atlantic Ocean, the northeast coast of America was a plate boundary. Being at the plate boundary, many faults were formed in the region. Although these faults are geologically old and are contained in a passive margin, they act as pre-existing planes of weakness and concentrated strain. When a strain exceeds the strength of the ancient fault, it ruptures causing an earthquake (PA DCNR 2007).

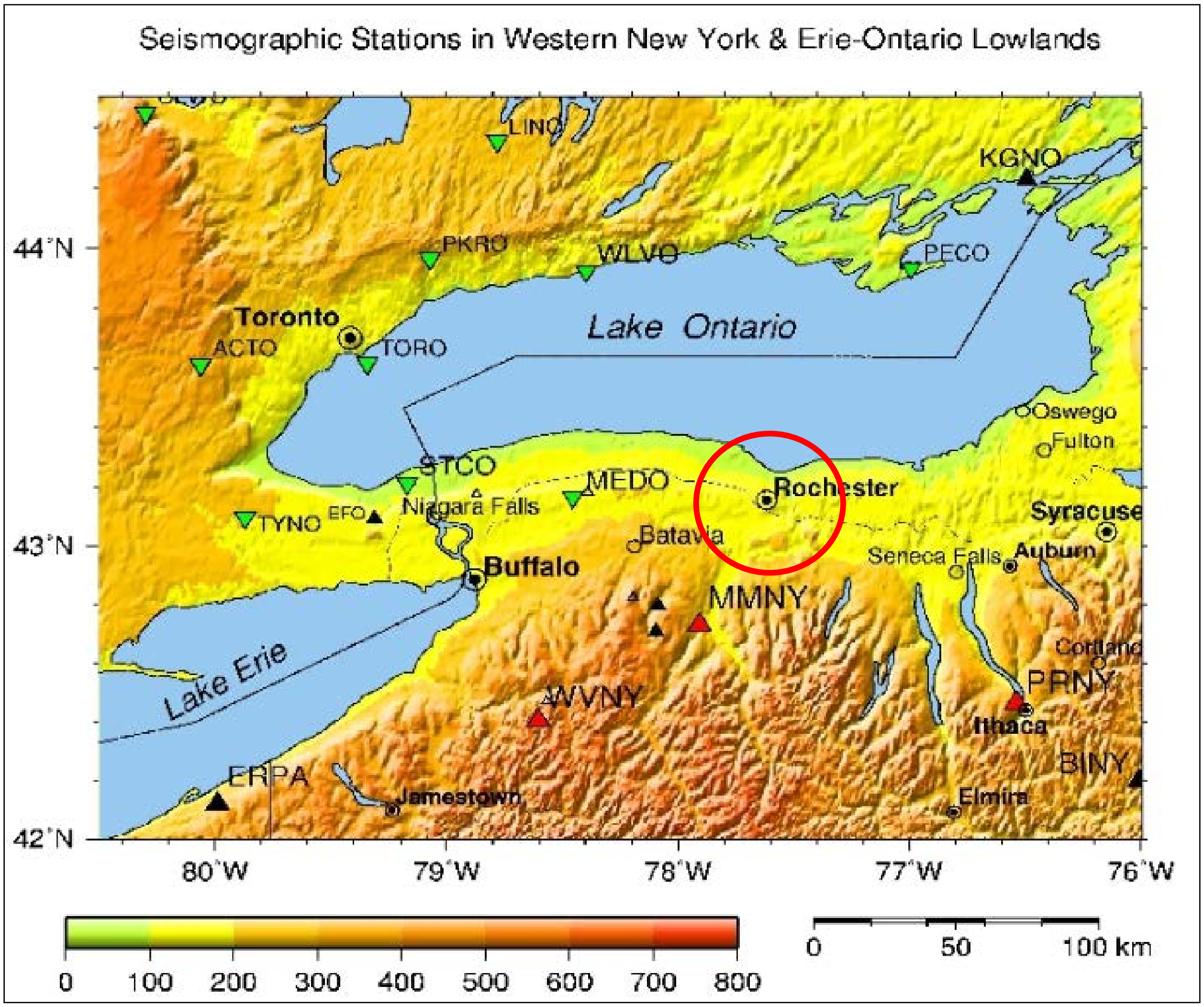
Figure 5.4.2-7. Faults in New York State



Source: New York State Museum, 2012
Note: Monroe County is outlined in yellow.

The Lamont-Doherty Cooperative Seismographic Network (LCSN) monitors earthquakes that occur primarily in the northeastern United States. The goals of the monitoring project are to compile a complete earthquake catalog for this region, to assess the earthquake hazards, and to study the causes of the earthquakes in the region. The LCSN operates 40 seismographic stations in the following seven states: Connecticut, Delaware, Maryland, New Jersey, New York, Pennsylvania, and Vermont. No seismographic stations are located in Monroe County; however, there are several within the vicinity of the county. Figure 5.4-2-8 shows the location of these stations in the western New York State area (LCSN 2014).

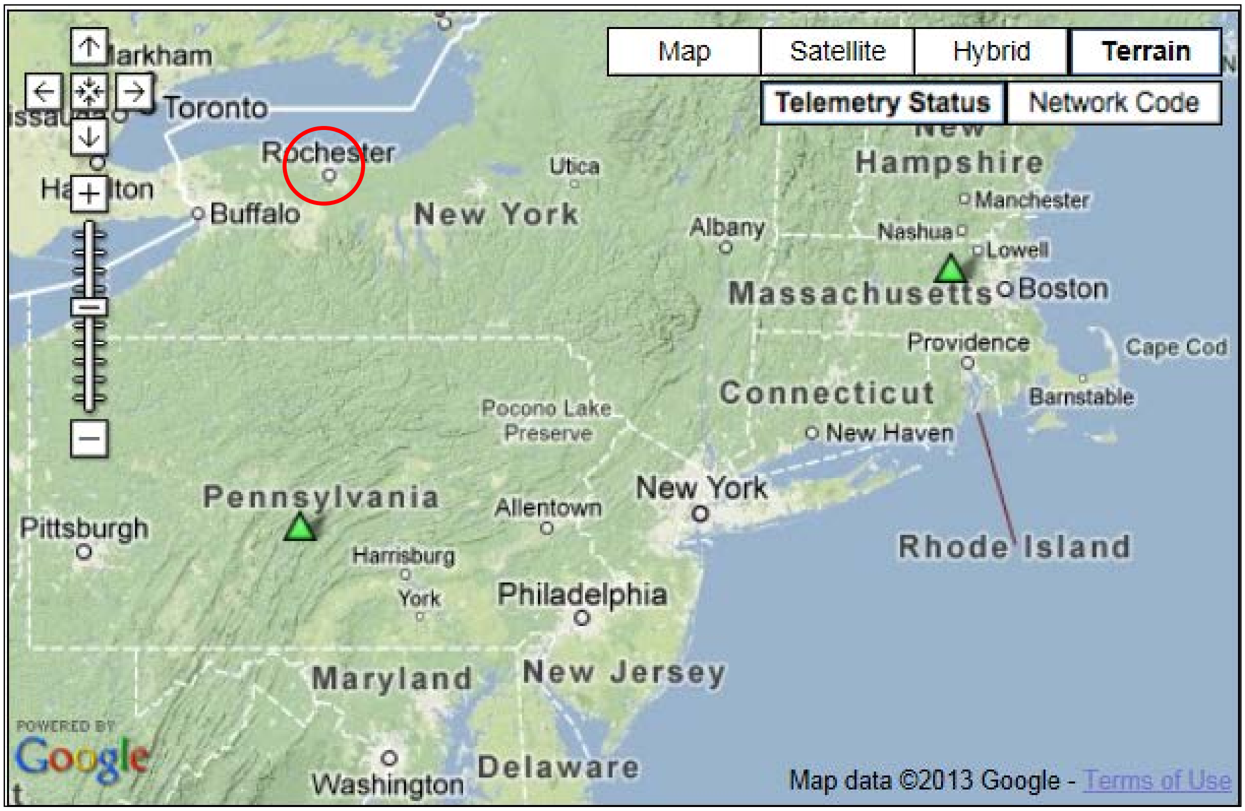
Figure 5.4.2-8. Lamont-Doherty Seismic Station Locations in the Western New York State Area



Source: LCSN 2012
Note: The red circle indicates the approximate location of Monroe County.

In addition to the Lamont-Doherty Seismic Stations, the USGS operates a global network of seismic stations to monitor seismic activity. While no seismic stations are located in New York State, nearby stations are positioned in State College, Pennsylvania, and Oak Ridge, Massachusetts. Figure 5-4-2-9 shows locations of USGS seismic stations near New York State.

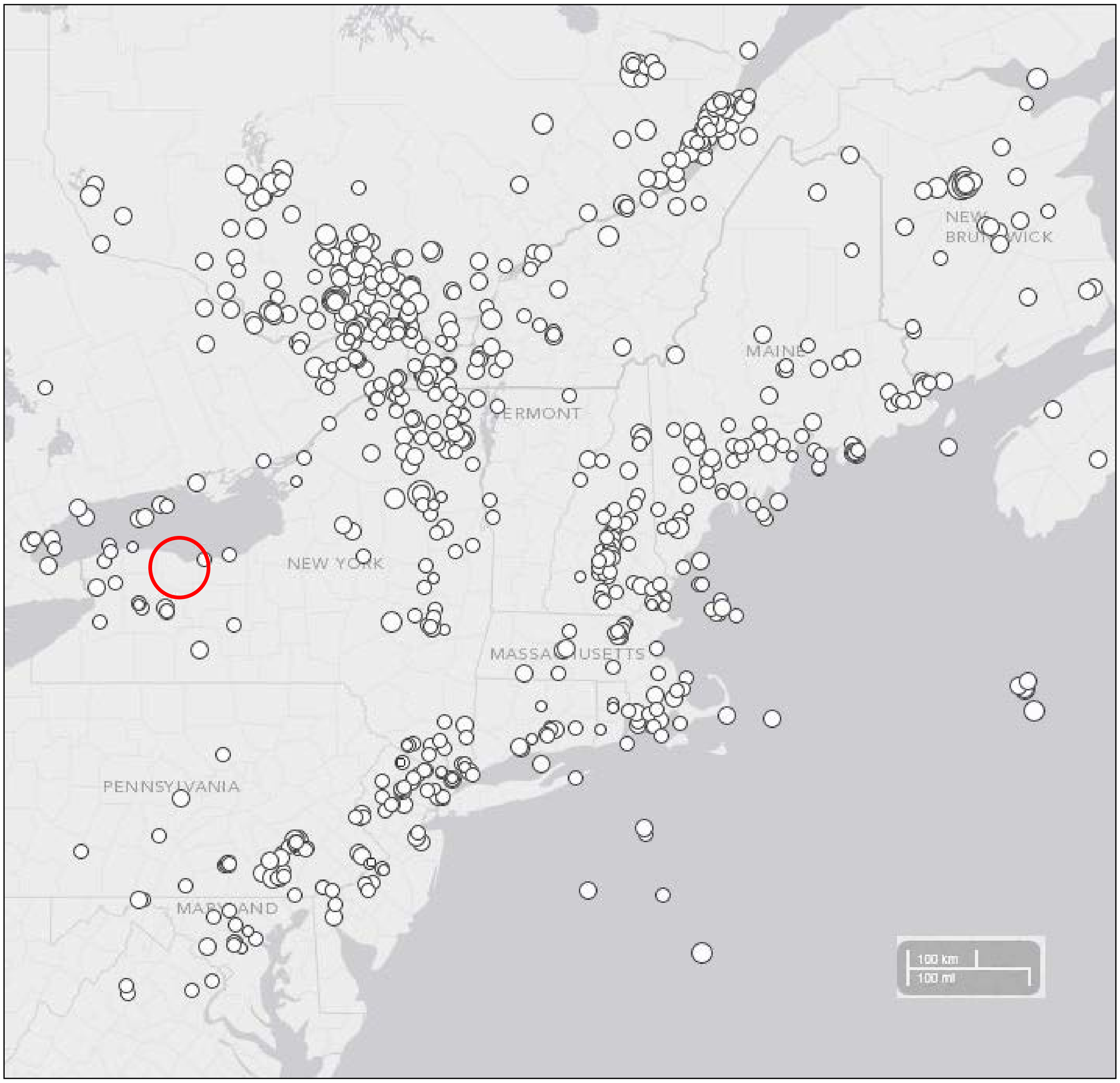
Figure 5.4.2-9. USGS Seismic Stations near New York State



Source: USGS 2015
Note: The red circle indicates the approximate location of Monroe County.

Figure 5.4.2-10 illustrates historic earthquake epicenters across the northeast United States and in New York State between October 1975 and September 2013. There have been multiple earthquakes originating outside New York's borders that have been felt within the state. These quakes have come from Quebec, Canada; and Massachusetts. According to the NYS HMP, such events are considered significant for hazard mitigation planning because they could produce damage within the state in certain situations.

Figure 5.4.2-10. Earthquake Epicenters in the Northeast U.S., October 1975 to September 2013



Source: USGS, 2013
Note: The red circle indicates the approximate location of Monroe County.

Previous Occurrences and Losses

Many sources provided historical information on previous occurrences and losses associated with earthquakes throughout New York State. Therefore, with so many sources reviewed for the purpose of this HMP update, loss and impact information for many events could vary depending on the source. According to the NYS Geological Survey and the New York State 2014 HMP update, approximately 36 significant earthquakes affected New York State between 1737 and 2005. Furthermore, between 1973 and 2012, 189 earthquakes were epicentered in New York State. Of those 189 earthquakes, none were officially reported in Monroe County (NYS DHSES 2014). However, two notable earthquakes were felt in western New York on June 23, 2010, and in northern New York on May 17, 2013; both of which originated in Canada with tremors reaching 5.0 or greater magnitudes (NYS DHSES 2014). According to local news reports, these events were felt in Monroe County.

Between 1954 and 2015, New York State was included in one earthquake-related major disaster (DR) or emergency (EM) declaration. 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 declaration. Monroe County was not included in any DRs or EMs (FEMA, 2015).

For this 2017 HMP Update, earthquakes events were summarized from 1857 to 2015. Based on all sources researched, no known earthquake events have occurred within Monroe County and its municipalities between 2008 and 2015, and two earthquakes have impacted Monroe County within that time. Not all sources have been identified or researched; therefore, other events may have occurred throughout the county and region.

Table 5.4.2-7. Earthquake Events in Monroe County, 1857 to 2015

Dates of Event	Magnitude (Richter Scale)	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
May 17, 2013	Magnitude-4.4	13 miles northeast of Shawville, Quebec, Ontario, Canada	N/A	No	A 4.4-magnitude earthquake in Ontario, Canada, was felt starting at 9:43 a.m. May 17 from upstate New York to the Vermont border. People in communities along the St. Lawrence River and as far east as Lake Champlain on New York-Vermont border reported feeling their homes shake. In Monroe County, the Rochester City 911 dispatch center received a small handful of calls in the half hour after the earthquake. No injuries or damage to critical infrastructure were reportd.
Jun. 23, 2010	Magnitude-5.0	Centered north of Ottawa, Canada	N/A	No	A magnitude-5.0 earthquake struck at the Ontario-Quebec border region of Canada, shaking homes and businesses from Toronto to the states of New York, Michigan, and Vermont, according to the U.S. Geological Survey. The earthquake was centered at a depth of about 12 miles. Monroe County's 911 center had more than 80 calls about the earthquake just minutes after it occurred. The tremor was felt at numerous buildings in the City of Rochester, and some buildings were briefly evacuated.
June 5, 2009	Magnitude 2.9	Attica, Wyoming County, New York	N/A	No	A 2.9-magnitude earthquake centered in Attica, Wyoming County, occurred at 11:07 a.m. The epicenter was 3 miles SSE of Attica and 5 miles south of Alexander, Genesee County. No damage was reported. (Democrat & Chronicle, 6.6.09).
March 8, 2008	Magnitude 2.7	10 miles north-northeast of Lancaster, New York	N/A	No	An earthquake with a depth of 6 kilometers had its epicenter 10 miles north-northeast of Lancaster, New York (Erie County) and a magnitude of 2.7. The USGS website indicated that there were 25 reports from people having felt this event, with a majority of reports located in the Buffalo, New York area (Erie County) (NWS, Judy Levan, e-mail, 3.19.08).
October 31, 2005	Magnitude 2.6	Wayne County, New York	N/A	No	Two earthquakes occurred in Wayne County, New York, rattling the area over the course of 3 hours. USGS confirmed that the first of the 'micro-earthquakes,' which was felt about 7:00 p.m., had a magnitude of 2.6 and was centered in the Town of Ontario. The second was weaker, and struck at 11:38 p.m. under Lake Ontario, 15 miles northwest of the Town of Sodus (Wayne County). The second quake had a magnitude of 1.5, according to the USGS. The quakes did not produce enough disturbance to show on the Ginna Nuclear Power Plant's seismic register. (Democrat & Chronicle, 12.24.05).
April 20, 2002	Magnitude 5.1	Town of Black Brook, Clinton	N/A	No	An earthquake with its epicenter roughly 15 miles southwest of Plattsburgh in the Town of Black Brook, Clinton County, New York, measured 5.1 on the Richter Scale and produced shaking which lasted

Dates of Event	Magnitude (Richter Scale)	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
		County, New York			about 30 seconds. Two aftershocks were reported. More than 300 people called Monroe County's 911 Center within 30 minutes of the quake. No reported injuries or damage in the County, although the State EOC was activated (Democrat & Chronicle, 4-21-02). (SEMO, "Emergency Management Times," Spring 2002, p.1).
January 1, 2000	Magnitude 4.5	North Bay, Ontario, Canada	N/A	No	A magnitude-4.5 whose epicenter was North Bay, Ontario, Canada, produced tremors felt in the Rochester area (Democrat & Chronicle, 4-2-02).
September 25, 1998	Magnitude 5.2	15 miles north of Sharon, Pennsylvania	N/A	No	A magnitude-5.2 earthquake whose epicenter was 15 miles north of Sharon, Pennsylvania, resulted in damage at two Monroe County residences, one with ceiling damage and one with front porch damage. (Gene Lenhardt, U.S. Army Corps of Engineers, telephone interview, 1-6- 99)(County Office of Emergency Management Response File).
June, 1991	Magnitude 3.9	Schoharie County, New York	N/A	No	A magnitude-3.9 earthquake centered in Schoharie County, 40 miles west of Albany, New York, was felt by residents in the Monroe County towns of Irondequoit and Greece (Democrat & Chronicle, 6.24.10).
October, 1990	Magnitude 4.7	120 miles northwest of Montreal, Canada	N/A	No	A magnitude-4.7 earthquake centered 120 miles northwest of Montreal, Canada, occurred. (Democrat & Chronicle, 9-26-98).
November 25, 1988	Magnitude 6.0	95 miles west of Quebec City, Canada	N/A	No	The epicenter of this earthquake was 95 miles west of Quebec City, in Canada. Measure was 6.0 on the Richter Scale (County Office of Emergency Management file).
October 7, 1983	Magnitude 5.2	Adirondacks, Blue Mountain Lake area, New York	N/A	No	A magnitude-5.2 earthquake in the Adirondacks, New York, Blue Mountain Lake area prompted RG&E to declare an "Unusual Event" Classification at Ginna Station (Peter Polfleit letter, 8-11-03). At the time, this was the third-largest earthquake ever recorded in the State of New York (Democrat & Chronicle, 9-26-98, 6.24.10) (Democrat & Chronicle, 6.24.10).
June 13, 1967	Magnitude 4.4	Attica, Wyoming County, New York	N/A	No	A magnitude-4.4 earthquake was recorded in Attica, Wyoming County.
January 1, 1966	Magnitude 4.7	Attica, Wyoming County, New York	N/A	No	A magnitude-4.7 earthquake in Attica, Wyoming County, New York, damaged the smokestack at the Attica Correctional Facility (Democrat & Chronicle, 11.3.05).
1944	Magnitude 5.8	Massena, St. Lawrence County, New York	N/A	No	A magnitude-5.8 earthquake centered near Massena, St. Lawrence County was recorded as New York's largest earthquake to date. Its epicenter was near Massena, St. Lawrence County. Shaking was felt from Canada to Maryland and from Indiana to Maine. $2 million in damage was reported in Massena and in Cornwall, Canada (Democrat & Chronicle, 11.3.05).

Dates of Event	Magnitude (Richter Scale)	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
1935	Magnitude 6.1	Along the Northern New York-Western Quebec Seismic Zone	N/A	No	A magnitude-6.1 earthquake occurred along the Northern New York-Western Quebec Seismic Zone (Democrat & Chronicle, 6.24.10).
August 12, 1929	Magnitude 5.2	Attica, Wyoming County, New York	N/A	No	A magnitude-5.2 earthquake occurred in Attica, Wyoming County, new York (HAZNY, 1999).
October 23, 1857	"VI" on the Modified Mercalli Scale	Darien, Genesee County, New York	N/A	No	An earthquake in Darien, Genesee County, was measured as a "VI" on the Modified Mercalli Scale (HAZNY, 1999).

Source(s): *FEMA 2014; IRIS 2015; USA Today 2013; Democrat and Chronicle 2010*
Note: All magnitudes referenced refer to the Richter Scale, unless otherwise specified.

DR *Disaster Declaration*
EOC *Emergency Operations Center*
FEMA *Federal Emergency Management Agency*
HAZNY *Hazards New York*
N/A *Not Applicable*
NWS *National Weather Service*
SEMO *State Emergency Management Office*
USGS *United States Geological Survey*

Probability of Future Events

Earthquake hazard maps illustrate the distribution of earthquake shaking levels that have a certain probability of occurring over a given time period. According to the USGS, in 2014 (the date of the most recent analysis), Monroe County had a PGA of 0.06g to 0.1g for earthquakes with a 10 percent probability of an occurrence within 50 years.

The NYSDPC indicates that the earthquake hazard in New York State is often understated because other natural hazards occur more frequently (such as hurricanes, tornadoes, and flooding) and are much more visible. However, the potential for earthquakes does exist across the entire northeastern United States, including New York State and Monroe County (NYS DHSES 2011).

Earlier in this section, the identified hazards of concern for Monroe County were ranked. NYS DHSES conducts a similar ranking process for hazards that affect the state. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for earthquakes in the county is considered “frequent” (likely to occur within 25 years, as presented in Table 5.3-3). With no known incidents having occurred within Monroe County, and few incidents reportedly affecting Monroe County, it is anticipated that the county will experience some direct and indirect impacts from earthquakes that may affect the general building stock and local economy, and may induce secondary hazards such as igniting fires and causing utility failure.

Impacts of Climate Change

Providing projections of future climate change for a specific region is challenging. Shorter-term projections are more closely tied to existing trends making longer-term projections even more challenging. The further out a prediction reaches, the more subject to changing dynamics it becomes. The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth’s crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of increased saturation. Dams storing increased volumes of water from changes in flow rates could fail during seismic events. There are currently no models available to estimate these impacts.

5.4.2.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the earthquake hazard, the entire county has been identified as the exposed hazard area. Therefore, all assets in Monroe County (population, structures, critical facilities, and lifelines), as described in the County Profile (Section 4), are vulnerable. The following section includes an evaluation and estimation of the potential impact of the earthquake hazard on Monroe County, including the following:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety, and health of residents; (2) general building stock; (3) critical facilities; (4) economy; and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2011 Monroe County Hazard Mitigation Plan
- Further data collection that will assist understanding of this hazard over time.

Overview of Vulnerability

Earthquakes usually occur without warning and can impact areas a great distance from their point of origin. The extent of damage depends on the density of population and building and infrastructure construction in the area shaken by the quake. Some areas may be more vulnerable than others based on soil type, the age of the buildings, and building codes in place. Compounding the potential for damage, historically, the Building Officials Code Administration (BOCA) regulations used in the northeast states were developed to address local concerns, including heavy snow loads and wind. Seismic requirements for design criteria are not as stringent as those of the west coast of the United States, which relies on the more seismically focused Uniform Building Code. As such, a smaller earthquake in the northeast can cause more structural damage than if it occurred out west.

The entire population and general building stock inventory of the county is at risk of damage or loss due to impacts of an earthquake. Potential losses associated with the earth shaking were calculated for Monroe County for three probabilistic earthquake events, the 100-year, 500- and 2,500-year mean return periods (MRP). The impacts on population, existing structures, critical facilities, and the economy within Monroe County are presented below, following a summary of the data and methodology used.

Data and Methodology

A probabilistic assessment was conducted for Monroe County for the 100-, 500- and 2,500-year MRPs using HAZUS-MH to analyze the earthquake hazard and provide a range of loss estimates for Monroe County. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by the census tract. According to the NYCEM, probabilistic estimates are best for urban planning, land use, zoning and seismic building code regulations (NYCEM, 2003). The default assumption is a Magnitude 7.0 earthquake for all return periods. In addition, an annualized loss run was conducted in HAZUS-MH to estimate the annualized general building stock dollar losses for Monroe County.

Ground shaking is the primary cause of earthquake damage to manmade structures, and soft soils amplify ground shaking. One contributor to the site amplification is the velocity at which the rock or soil transmits shear waves (S-waves). The NEHRP developed five soil classifications defined by their shear-wave velocity that impact the severity of an earthquake. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking, increasing building damage and losses. Monroe County is comprised of NEHRP Soil Classes A through E, or very hard rock to soft soils. Table 5.4.9-2 illustrates the NEHRP soil classifications in Monroe County. According to NYCEM, soft soils (NEHRP Soil Classes D and E) can amplify ground shaking to damaging levels even in a moderate earthquake (NYCEM, 2003).

Data from the local soil map was entered into HAZUS-MH 2.2 to replace default soil conditions. These data updates allowed for a Level 2 earthquake analysis. Groundwater was set at a depth of 5 feet (default setting). Damage and loss due to liquefaction, landslide, or surface fault rupture were not included in this analysis.

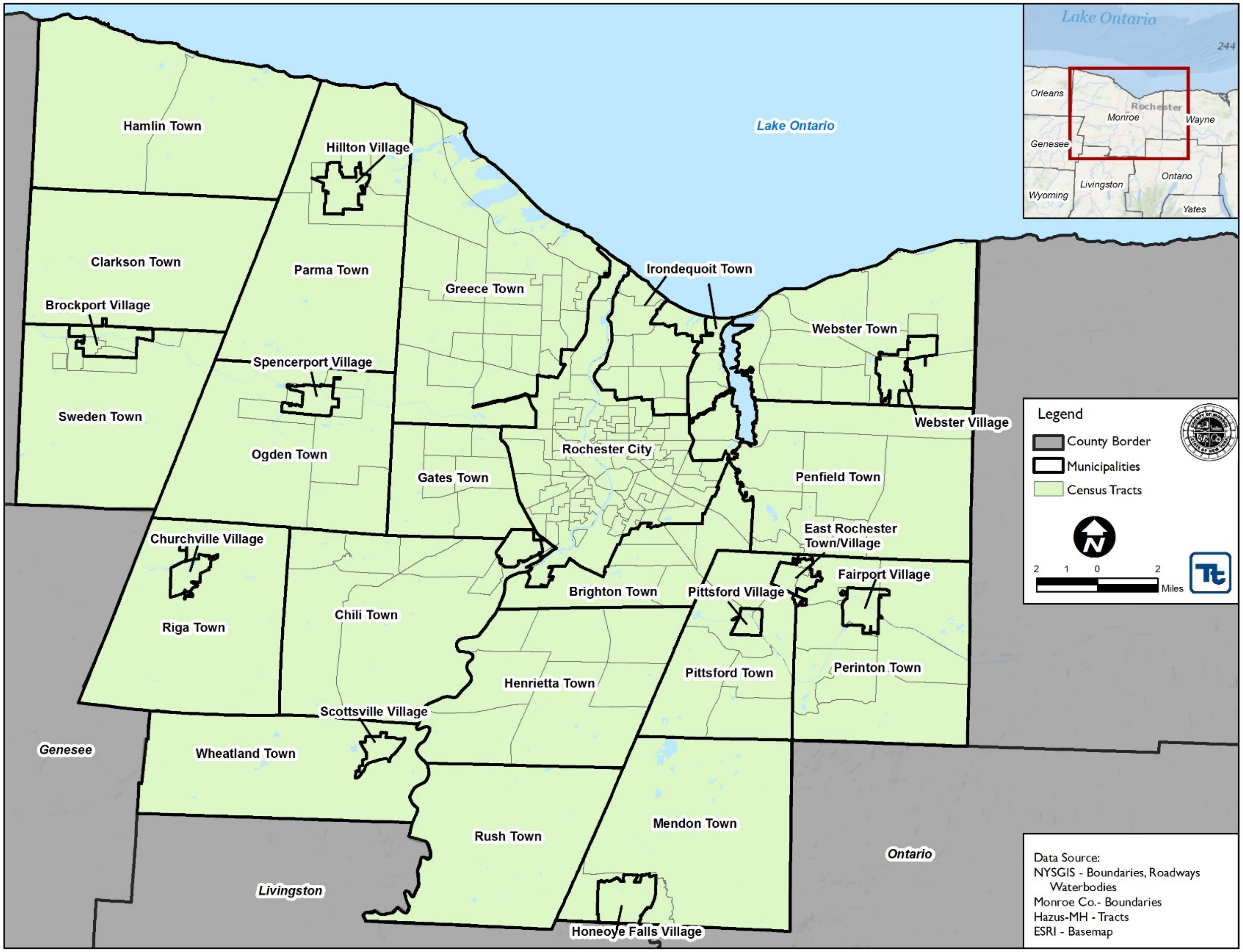
In addition to the probabilistic scenarios mentioned, a loss run was conducted in HAZUS MH 2.2 to estimate the annualized general building stock dollar losses for the county. The loss methodology combines the estimated losses associated with ground shaking for eight return periods: 100, 250, 500, 750, 1,000, 1,500, 2,000, and 2,500-year, which are based on values from the USGS seismic probabilistic curves. Annualized losses are useful for mitigation planning because they provide a baseline upon which to (1) compare the risk of one hazard across multiple jurisdictions and (2) compare the degree of risk of all hazards for each participating jurisdiction.

As noted in the HAZUS-MH Earthquake User Manual '*Uncertainties are inherent in any loss estimation methodology. They arise in part from incomplete scientific knowledge concerning earthquakes and their effects upon buildings and facilities. They also result from the approximations and simplifications that are necessary for comprehensive analyses. Incomplete or inaccurate inventories of the built environment, demographics and economic parameters add to the uncertainty. These factors can result in a range of uncertainly in loss estimates produced by the HAZUS Earthquake Model, possibly at best a factor of two or more*.' However, HAZUS' potential loss estimates are acceptable for the purposes of this HMP.

The occupancy classes available in HAZUS-MH were condensed into the following categories (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single family dwellings. Impacts to critical facilities and utilities were also evaluated.

All exposure and loss estimates discussed in the assessment below are for Monroe County. HAZUS-MH 2.2 generates results at the census-tract level. The boundaries of the census tracts are not always coincident with the town and village boundaries in Monroe County. The results in the tables below are presented for the census tracts with the associated towns and villages listed for each tract. Figure 5.4.2-11 shows the spatial relationship between the census tracts and the town and village boundaries.

Figure 5.4.2-11. Hazus-MH Census Tracts in Monroe County



Source: Hazus-MH 2.2

Impact on Life, Health and Safety

Overall, the entire population of Monroe County is exposed to the earthquake hazard event. According to the 2010 U.S. Census, Monroe County had a population of 744,344 people. The impact of an earthquake on life, health, and safety is dependent upon the severity of the event. Risk to public safety and loss of life from an earthquake in the county is minimal. However, a higher risk would occur in for those inside buildings, due to structural damage, or people walking below building ornamentation and chimneys that may be loose and fall as a result of the earthquake.

Populations considered most vulnerable are located in the built environment, particularly near unreinforced masonry construction. In addition, the vulnerable population includes the elderly (persons over the age of 65) and individuals living below the census poverty threshold. These socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard, and the location and construction quality of their housing.

An exposure analysis was performed using the NEHRP soils data and the 2010 Census population data. The sum of the population by census block within the NEHRP Class D and E soil types were calculated and summarized in Table 5.4.2-8 below. Overall, approximately 5-percent of the county's population is located on NEHRP Class D and E soils.

Table 5.4.2-8. Approximate Population within NEHRP 'D" and 'E' Soils

Municipality	Total Population (2010 Census)	Population NEHRP Class "D" and "E" Soils	
		Total Population Exposed	% of Population Exposed
Brighton (T)	36,609	23,544	64.3%
Brockport (V)	8,366	0	0.0%
Chili (T)	28,625	11,100	38.8%
Churchville (V)	1,961	652	33.2%
Clarkson (T)	6,588	3,520	53.4%
East Rochester (V/T)	6,587	6,118	92.9%
Fairport (V)	5,353	534	10.0%
Gates (T)	28,400	6,142	21.6%
Greece (T)	96,095	66,050	68.7%
Hamlin (T)	9,045	3,967	43.9%
Henrietta (T)	42,581	19,237	45.2%
Hilton (V)	5,886	175	3.0%
Honeoye Falls (V)	2,674	2,674	100.0%
Irondequoit (T)	51,692	47,853	92.6%
Mendon (T)	6,478	4,291	66.2%
Ogden (T)	16,255	5,711	35.1%
Parma (T)	9,747	4,587	47.1%
Penfield (T)	36,242	13,487	37.2%
Perinton (T)	41,109	13,152	32.0%

Table 5.4.2-8. Approximate Population within NEHRP 'D" and 'E' Soils

Municipality	Total Population (2010 Census)	Population NEHRP Class "D" and "E" Soils: Total Population Exposed	Population NEHRP Class "D" and "E" Soils: % of Population Exposed
Pittsford (T)	28,050	6,220	22.2%
Pittsford (V)	1,355	0	0.0%
Riga (T)	3,629	1,699	46.8%
Rochester (C)	210,565	184,101	87.4%
Rush (T)	3,478	736	21.2%
Scottsville (V)	2,001	1,924	96.2%
Spencerport (V)	3,601	0	0.0%
Sweden (T)	5,957	0	0.0%
Webster (T)	37,242	23,750	63.8%
Webster (V)	5,399	64	1.2%
Wheatland (T)	2,774	1,011	36.4%
Monroe County (Total)	**744,344**	**452,299**	**60.8%**

Sources: NYS DHSES 2008; U.S. Census 2010
Notes: C City
T Town
V Village

Residents may be displaced or require temporary to long-term sheltering. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Table 5.4.2-9 and Table 5.4.2-10 estimate the number of households displaced, and population that may require short-term sheltering as a result of the 100-, 500- and 2,500-year MRP earthquake events.

Table 5.4.2-9. Summary of Estimated Sheltering Needs for Monroe County

Scenario	Displaced Households	Persons Seeking Short-Term Shelter
100-Year Earthquake	12	8
500-Year Earthquake	165	113
2,500-Year Earthquake	1,643	1,128

Source: HAZUS-MH 2.2

Table 5.4.2-10. Estimated Displaced Households and Population Seeking Short-Term Shelter from the 500- and 2,500-year MRP Events per Census Tract

2010 Census Tract – Municipality	500-Year MRP Event: Displaced Households	500-Year MRP Event: Persons Seeking Short-Term Sheltering	2,500-Year MRP Event: Displaced Households	2,500-Year MRP Event: Persons Seeking Short-Term Sheltering
Brighton (T)	8	5	82	49
Brockport (V) - Clarkson (T)	1	1	15	9
Brockport (V) - Sweden (T)	0	0	4	3
Chili (T)	2	1	25	13
Chili (T) - Rochester (C)	0	0	0	0

2010 Census Tract – Municipality	500-Year MRP Event		2,500-Year MRP Event	
	Displaced Households	Persons Seeking Short-Term Sheltering	Displaced Households	Persons Seeking Short-Term Sheltering
Churchville (V) - Riga (T)	1	1	11	6
East Rochester (V/T)	3	1	26	14
Fairport (V) - Perinton (T)	1	0	9	4
Gates (T)	2	1	20	11
Greece (T)	20	11	201	108
Hamlin (T)	0	0	2	1
Henrietta (T)	6	5	65	55
Hilton (V) - Parma (T)	0	0	2	1
Honeoye Falls (V) - Mendon (T)	1	1	13	7
Irondequoit (T)	13	7	125	72
Mendon (T)	0	0	1	1
Ogden (T)	0	0	5	3
Ogden (T) - Spencerport (V)	0	0	3	2
Parma (T)	1	0	8	5
Penfield (T)	3	1	28	13
Perinton (T)	3	2	31	15
Pittsford (T)	0	0	3	2
Pittsford (T) - Pittsford (V)	1	0	9	4
Rochester (C)	94	72	926	717
Rush (T)	0	0	0	0
Scottsville (V) - Wheatland (T)	0	0	1	1
Sweden (T)	0	0	0	0
Webster (T)	2	1	21	10
Webster (T) - Webster (V)	1	0	6	3
Monroe County (Total)	**165**	**113**	**1,643**	**1,128**

Source: HAZUS-MH 2.2
Notes: C City
T Town
V Village

According to the 1999-2003 NYCEM Summary Report (*Earthquake Risks and Mitigation in the New York / New Jersey / Connecticut Region*), a strong correlation exists between structural building damage and the number of injuries and casualties from an earthquake event. Further, the time of day also exposes different sectors of the community to the hazard. For example, HAZUS considers the residential occupancy at its maximum at 2:00 a.m., where the educational, commercial and industrial sectors are at their maximum at 2:00 p.m., and peak commute time is at 5:00 p.m. Whether directly impacted or indirectly impacted, the entire population will be affected to some degree. Business interruption could keep people from working, road closures could isolate populations, and loss of utilities could impact populations that suffered no direct damage from an event itself.

For the 100-year event, it is projected that three injuries would occur at 2:00 a.m., four injuries at 2:00 p.m., and three injuries at 5:00 p.m. Table 5.4.2-11 and Table 5.4.2-12 summarize the county-wide injuries and casualties estimated for the 500- and 2,500-year MRP earthquake events, respectively.

Table 5.4.2-11. Estimated Number of Injuries and Casualties from the 500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	38	48	37
Hospitalization	5	7	5
Casualties	1	1	1

Source: HAZUS-MH 2.2

Table 5.4.2-12. Estimated Number of Injuries and Casualties from the 2,500-Year MRP Earthquake Event

Level of Severity	Time of Day		
	2:00 AM	2:00 PM	5:00 PM
Injuries	274	462	330
Hospitalization	50	92	68
Casualties	10	18	13

Source: HAZUS-MH 2.2

Impact on General Building Stock

After considering the population exposed to the earthquake hazard, the value of general building stock exposed to and damaged by 100-, 500- and 2,500-year MRP earthquake events was evaluated. In addition, annualized losses were calculated using HAZUS-MH. The entire county's general building stock is considered at risk and exposed to this hazard.

As stated earlier, soft soils (NEHRP Soil Classes D and E) can amplify ground shaking to damaging levels even in a moderate earthquake (NYCEM, 2003). Therefore, buildings located on NEHRP Soil Classes D and E have an increased risk of damages from an earthquake. Table 5.4.2-13 summarizes the number and replacement cost value of buildings in Monroe County on the approximately located NEHRP Soil Classes D and E.

Table 5.4.2-13. Number and Replacement Cost Value of Buildings Located on NEHRP 'D' and 'E' Soils

Municipality	Total Number of Buildings	Total RCV (Structure and Contents)	Buildings NEHRP Class "D" and "E" Soils			
			Number Exposed	% of Total Number	RCV Exposed	% of Total RCV
Brighton (T)	10,545	$18,462,216,409	5,836	55.3%	$10,419,141,117	56.4%
Brockport (V)	1,604	$2,035,910,815	0	0.0%	$0	0.0%
Chili (T)	9,774	$8,342,622,610	3,556	36.4%	$3,562,371,124	42.7%
Churchville (V)	807	$920,696,714	217	26.9%	$350,551,799	38.1%
Clarkson (T)	2,040	$1,812,049,577	1,069	52.4%	$757,015,510	41.8%
East Rochester (V/T)	2,495	$2,846,820,718	2,313	92.7%	$2,658,482,110	93.4%
Fairport (V)	2,056	$2,449,020,743	184	8.9%	$132,380,339	5.4%

Table 5.4.2-13. Number and Replacement Cost Value of Buildings Located on NEHRP 'D' and 'E' Soils

Municipality	Total Number of Buildings	Total RCV (Structure and Contents)	Buildings NEHRP Class "D" and "E" Soils			
			Number Exposed	% of Total Number	RCV Exposed	% of Total RCV
Gates (T)	10,550	$9,547,208,635	2,369	22.5%	$3,048,967,974	31.9%
Greece (T)	32,375	$25,595,860,286	22,713	70.2%	$17,038,377,149	66.6%
Hamlin (T)	2,808	$1,737,395,194	1,493	53.2%	$937,740,662	54.0%
Henrietta (T)	12,657	$13,259,007,785	4,288	33.9%	$5,208,473,106	39.3%
Hilton (V)	1,884	$1,664,654,730	88	4.7%	$38,087,908	2.3%
Honeoye Falls (V)	922	$1,119,568,668	916	99.3%	$1,117,602,965	99.8%
Irondequoit (T)	19,765	$16,075,218,322	18,320	92.7%	$13,947,026,046	86.8%
Mendon (T)	2,366	$2,996,719,632	1,862	78.7%	$2,426,404,702	81.0%
Ogden (T)	5,331	$4,469,332,464	1,865	35.0%	$1,510,186,152	33.8%
Parma (T)	3,743	$2,595,035,929	1,516	40.5%	$1,006,560,181	38.8%
Penfield (T)	13,077	$14,501,168,927	4,520	34.6%	$5,559,922,252	38.3%
Perinton (T)	14,901	$17,896,609,894	4,814	32.3%	$6,791,038,762	37.9%
Pittsford (T)	9,159	$12,295,191,719	2,140	23.4%	$2,035,872,375	16.6%
Pittsford (V)	656	$2,204,429,074	0	0.0%	$0	0.0%
Riga (T)	1,271	$1,283,085,436	473	37.2%	$553,487,020	43.1%
Rochester (C)	58,996	$94,424,953,585	51,497	87.3%	$85,234,835,926	90.3%
Rush (T)	1,433	$1,453,693,815	330	23.0%	$336,146,172	23.1%
Scottsville (V)	747	$706,870,704	703	94.1%	$691,917,477	97.9%
Spencerport (V)	1,253	$1,862,825,476	0	0.0%	$0	0.0%
Sweden (T)	1,986	$1,771,453,297	3	<1%	$2,126,341	<1%
Webster (T)	13,477	$11,420,618,527	8,776	65.1%	$6,951,812,277	60.9%
Webster (V)	1,305	$1,799,326,797	22	1.7%	$75,232,038	4.2%
Wheatland (T)	991	$1,061,455,206	552	55.7%	$622,542,183	58.6%
Monroe County (Total)	**240,974**	**$278,611,021,689**	**142,435**	**59.1%**	**$173,014,301,668**	**62.1%**

Sources: NYS DHSES 2008, U.S. Census 2010
Note: RCV is the estimated replacement cost value of both structure and contents.
C City
T Town
V Village

The HAZUS-MH model estimates the value of the exposed building stock and the loss (in terms of damage to the exposed stock). Refer to the County Profile (Section 4) for general building stock data replacement value statistics (structure and contents).

For this HMP Update, a HAZUS-MH probabilistic model was run to estimate annualized dollar losses for Monroe County. Annualized losses are useful for mitigation planning because they provide a baseline upon which to (1) compare the risk of one hazard across multiple jurisdictions and (2) compare the degree of risk of all hazards for each participating jurisdiction. Annualized loss does not, however, predict what losses will occur in any particular year. The estimated annualized losses are approximately $4.3 million per year (building and contents) for the County.

According to NYCEM, where earthquake risks and mitigation were evaluated in the New York, New Jersey, and Connecticut region, most damage and loss caused by an earthquake is directly or indirectly the result of ground shaking (NYCEM, 2003). NYCEM indicates there is a strong correlation between PGA and the damage a building might experience. The HAZUS-MH model is based on the best available earthquake science and aligns with these statements. HAZUS-MH methodology and model were used to analyze the earthquake hazard for the general building stock for Monroe County. See Figure 5.4.2-4 through Figure 5.4.2-6 illustrating the geographic distribution of PGA (%g) across the County for 100-, 500- and 2,500-year MRP events at the census-tract level.

In addition, according to NYCEM, a building's construction determines how well it can withstand the force of an earthquake. The NYCEM report indicates that un-reinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy. Additional attributes that contribute to a building's capability to withstand an earthquake's force include its age, number of stories, and quality of construction. HAZUS-MH considers building construction and the age of buildings as part of the analysis. Because the default general building stock was used for this HAZUS-MH analysis, the default building ages and building types already incorporated into the inventory were used.

Potential building damage was evaluated by HAZUS-MH across the following damage categories (none, slight, moderate, extensive, and complete). Table 5.4.2-14 provides definitions of these five categories of damage for a light wood-framed building; definitions for other building types are included in HAZUS-MH technical manual documentation.

Table 5.4.2-14. Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: HAZUS-MH Technical Manual

Table 5.4.2-15 through Table 5.4.2-18 summarize the damage estimated for the 100-, 500- and 2,500-year MRP earthquake events. Damage loss estimates include structural and non-structural damage to the building and loss of contents.

Table 5.4.2-15. Estimated Buildings Damaged by General Occupancy for 100-year and 500-year MRP Earthquake Events

Category	Average Damage State									
	100-Year MRP					500-Year MRP				
	None	Slight	Moderate	Extensive	Complete	None	Slight	Moderate	Extensive	Complete
Residential	229,734 (95.3%)	443 (<1%)	113 (<1%)	11 (<1%)	1 (<1%)	224,341 (93.1%)	4,641 (1.9%)	1,147 (<1%)	157 (<1%)	16 (<1%)
Commercial	7,236 (3.0%)	36 (<1%)	9 (<1%)	1 (<1%)	0 (0%)	6,903 (2.9%)	269 (<1%)	96 (<1%)	12 (<1%)	1 (<1%)
Industrial	1,471 (<1%)	7 (<1%)	2 (<1%)	0 (0%)	0 (0%)	1,402 (<1%)	54 (<1%)	21 (<1%)	3 (<1%)	0 (0%)
Education, Government, Religious and Agricultural	1,901 (<1%)	7 (<1%)	1 (<1%)	0 (0%)	0 (0%)	1,828 (<1%)	60 (<1%)	22 (<1%)	3 (<1%)	0 (0%)

Source: HAZUS-MH 2.2

Table 5.4.2-16. Estimated Buildings Damaged by General Occupancy for 2, 500-year MRP Earthquake Events

Category	Average Damage State				
	2,500-Year MRP				
	None	Slight	Moderate	Extensive	Complete
Residential	198,777 (82.5%)	22,882 (9.5%)	7,173 (3.0%)	1,278 (<1%)	192 (<1%)
Commercial	5,215 (2.2%)	1,047 (<1%)	794 (<1%)	197 (<1%)	28 (<1%)
Industrial	1,041 (<1%)	207 (<1%)	177 (<1%)	49 (<1%)	6 (<1%)
Education, Government, Religious and Agricultural	1,500 (<1%)	225 (<1%)	146 (<1%)	35 (<1%)	5 (<1%)

Source: HAZUS-MH 2.2

Table 5.4.2-17. Estimated Replacement Cost Value (Building and Contents) Damaged by the 100-, 500-, and 2,500-Year MRP Earthquake Events

Municipality	Total Replacement Cost Value (Building and Contents)	Estimated Total Damages*				Percent of Total Building and Contents *			
		Annualized Loss	100-Year	500-Year	2,500-Year	Annualized Loss	100-Year	500-Year	2,500-Year
Brighton (T)	$18,476,583,411	$269,321	$962,102	$16,749,350	$202,360,063	<1%	<1%	<1%	1.1%
Brockport (V) - Clarkson (T)	$1,887,190,577	$41,094	$0	$2,750,487	$34,032,850	<1%	0.0%	<1%	1.8%
Brockport (V) - Sweden (T)	$2,610,825,808	$3,507	$0	$239,222	$4,148,946	<1%	0.0%	<1%	<1%
Chili (T)	$8,196,135,826	$67,434	$122,318	$4,639,882	$59,178,607	<1%	<1%	<1%	<1%
Chili (T) - Rochester (C)	$428,609,703	$14,158	$29,999	$723,437	$10,022,103	<1%	<1%	<1%	2.3%
Churchville (V) - Riga (T)	$2,202,652,468	$54,071	$0	$3,337,624	$43,698,110	<1%	0.0%	<1%	2.0%
East Rochester (V/T)	$2,870,083,551	$71,859	$285,345	$4,645,739	$52,900,101	<1%	<1%	<1%	1.8%
Fairport (V) - Perinton (T)	$5,031,254,398	$18,475	$0	$1,372,378	$18,077,623	<1%	0.0%	<1%	<1%
Gates (T)	$9,531,696,700	$99,687	$261,975	$6,187,060	$81,253,441	<1%	<1%	<1%	<1%
Greece (T)	$25,377,748,491	$332,458	$1,395,588	$23,966,606	$268,605,527	<1%	<1%	<1%	1.1%
Hamlin (T)	$1,737,395,194	$4,141	$0	$273,307	$4,443,037	<1%	0.0%	<1%	<1%
Henrietta (T)	$13,259,007,785	$135,904	$298,849	$8,426,205	$107,714,979	<1%	<1%	<1%	<1%
Hilton (V) - Parma (T)	$1,927,177,643	$2,365	$0	$170,567	$2,761,431	<1%	0.0%	<1%	<1%
Honeoye Falls (V) - Mendon (T)	$1,295,074,492	$31,824	$113,584	$1,988,803	$24,366,669	<1%	<1%	<1%	1.9%
Irondequoit (T)	$16,147,789,329	$342,377	$1,493,366	$24,212,779	$263,865,663	<1%	<1%	<1%	1.6%
Mendon (T)	$2,821,213,808	$18,734	$0	$1,285,195	$18,002,003	<1%	0.0%	<1%	<1%
Ogden (T)	$2,636,647,637	$10,324	$0	$681,208	$10,534,647	<1%	0.0%	<1%	<1%
Ogden (T) - Spencerport (V)	$3,695,272,022	$7,907	$0	$516,357	$8,725,208	<1%	0.0%	<1%	<1%
Parma (T)	$2,332,513,016	$29,965	$121,969	$2,168,563	$25,228,867	<1%	<1%	<1%	1.1%
Penfield (T)	$14,494,081,508	$131,139	$504,988	$9,600,010	$107,209,283	<1%	<1%	<1%	<1%
Perinton (T)	$15,266,756,634	$110,756	$432,582	$7,855,790	$89,911,988	<1%	<1%	<1%	<1%
Pittsford (T)	$9,816,112,710	$40,046	$140,336	$3,038,784	$36,409,670	<1%	<1%	<1%	<1%

Table 5.4.2-17. Estimated Replacement Cost Value (Building and Contents) Damaged by the 100-, 500-, and 2,500-Year MRP Earthquake Events

Municipality	Total Replacement Cost Value (Building and Contents)	Estimated Total Damages*				Percent of Total Building and Contents *			
		Annualized Loss	100-Year	500-Year	2,500-Year	Annualized Loss	100-Year	500-Year	2,500-Year
Pittsford (T) - Pittsford (V)	$4,705,623,396	$22,636	$84,732	$1,743,698	$20,312,764	<1%	<1%	<1%	<1%
Rochester (C)	$94,292,313,826	$2,314,180	$8,722,518	$144,696,172	$1,711,000,131	<1%	<1%	<1%	1.8%
Rush (T)	$1,453,693,815	$1,808	$0	$122,300	$2,147,140	<1%	0.0%	<1%	<1%
Scottsville (V) - Wheatland (T)	$1,769,467,076	$2,309	$0	$149,626	$2,768,183	<1%	0.0%	<1%	<1%
Sweden (T)	$1,121,635,586	$1,430	$0	$91,518	$1,721,439	<1%	0.0%	<1%	<1%
Webster (T)	$8,681,696,551	$120,999	$545,269	$9,323,024	$97,250,621	<1%	<1%	<1%	1.1%
Webster (T) - Webster (V)	$4,544,768,728	$33,060	$154,986	$2,683,701	$27,639,241	<1%	<1%	<1%	<1%
Monroe County (Total)	**$278,611,021,689**	**$4,333,968**	**$15,670,506**	**$283,639,389**	**$3,336,290,332**	**<1%**	**<1%**	**<1%**	**1.2%**

Source: HAZUS-MH 2.2
Notes: C City
T Town
V Village
**Total Damages is the sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious, and government).*

Table 5.4.2-18. Estimated Value (Building and Contents) Damaged by the 100-, 500- and 2,500-Year MRP Earthquake Events (Continued)

Municipality	Total Replacement Cost Value (Building and Contents)	Estimated Residential Damage			Estimated Commercial Damage		
		100-Year	500-Year	2,500-Year	100-Year	500-Year	2,500-Year
Brighton (T)	$18,476,583,411	$178,501	$3,464,611	$39,331,196	$716,774	$11,852,639	$144,212,473
Brockport (V) - Clarkson (T)	$1,887,190,577	$0	$1,591,442	$18,510,944	$0	$830,167	$11,013,933
Brockport (V) - Sweden (T)	$2,610,825,808	$0	$104,046	$1,903,702	$0	$73,676	$1,176,645
Chili (T)	$8,196,135,826	$88,133	$3,134,033	$37,886,046	$16,507	$641,606	$8,625,098
Chili (T) - Rochester (C)	$428,609,703	$149	$2,637	$33,481	$6,987	$113,260	$1,408,801
Churchville (V) - Riga (T)	$2,202,652,468	$0	$1,502,427	$17,980,872	$0	$355,566	$4,797,560

Table 5.4.2-18. Estimated Value (Building and Contents) Damaged by the 100-, 500- and 2,500-Year MRP Earthquake Events (Continued)

Municipality	Total Replacement Cost Value (Building and Contents)	Estimated Residential Damage			Estimated Commercial Damage		
		100-Year	500-Year	2,500-Year	100-Year	500-Year	2,500-Year
East Rochester (V/T)	$2,870,083,551	$107,188	$1,716,530	$18,067,523	$99,879	$1,574,443	$18,376,852
Fairport (V) - Perinton (T)	$5,031,254,398	$0	$1,032,136	$13,221,089	$0	$105,807	$1,442,985
Gates (T)	$9,531,696,700	$71,094	$1,929,698	$24,333,564	$141,775	$2,769,817	$35,596,115
Greece (T)	$25,377,748,491	$920,323	$15,580,559	$165,853,262	$276,906	$4,686,186	$56,378,163
Hamlin (T)	$1,737,395,194	$0	$213,602	$3,386,537	$0	$26,170	$408,888
Henrietta (T)	$13,259,007,785	$59,415	$2,847,107	$34,184,238	$103,707	$2,419,156	$31,081,582
Hilton (V) - Parma (T)	$1,927,177,643	$0	$89,415	$1,478,407	$0	$33,507	$497,256
Honeoye Falls (V) - Mendon (T)	$1,295,074,492	$48,301	$812,437	$9,075,212	$17,393	$288,409	$3,641,161
Irondequoit (T)	$16,147,789,329	$866,405	$13,933,770	$142,599,606	$396,260	$6,223,859	$71,899,012
Mendon (T)	$2,821,213,808	$0	$849,555	$11,643,217	$0	$355,048	$5,012,079
Ogden (T)	$2,636,647,637	$0	$508,761	$7,749,871	$0	$88,302	$1,318,104
Ogden (T) - Spencerport (V)	$3,695,272,022	$0	$248,711	$4,128,913	$0	$105,642	$1,613,434
Parma (T)	$2,332,513,016	$96,771	$1,666,828	$18,589,361	$13,602	$224,136	$2,825,443
Penfield (T)	$14,494,081,508	$326,452	$5,929,052	$62,474,999	$103,035	$2,206,358	$26,651,358
Perinton (T)	$15,266,756,634	$219,168	$3,980,132	$43,195,586	$170,884	$3,109,836	$37,183,855
Pittsford (T)	$9,816,112,710	$112,575	$2,193,482	$25,128,105	$447	$283,681	$4,092,898
Pittsford (T) - Pittsford (V)	$4,705,623,396	$70,416	$1,277,531	$14,058,112	$10,618	$350,692	$4,636,296
Rochester (C)	$94,292,313,826	$2,855,644	$47,207,008	$513,946,072	$4,119,561	$66,370,956	$807,615,791
Rush (T)	$1,453,693,815	$0	$73,850	$1,292,932	$0	$23,183	$358,281
Scottsville (V) - Wheatland (T)	$1,769,467,076	$0	$73,447	$1,350,376	$0	$8,384	$138,930
Sweden (T)	$1,121,635,586	$0	$62,236	$1,144,265	$0	$7,291	$117,857
Webster (T)	$8,681,696,551	$432,326	$6,997,325	$69,271,330	$24,163	$597,304	$7,161,032
Webster (T) - Webster (V)	$4,544,768,728	$135,616	$2,182,190	$21,492,659	$752	$87,619	$1,145,859
Monroe County (Total)	**$278,611,021,689**	**$6,588,477**	**$121,204,557**	**$1,323,311,476**	**$6,219,249**	**$105,812,697**	**$1,290,427,739**

Source: HAZUS-MH 2.2

Notes: C City

T Town

V Village

HAZUS-MH 2.2 estimated approximately $16 million in damages as a resulted of the 100-year earthquake event. It is also estimated that there would be approximately $284 million in damages to buildings in the county during a 500-year earthquake event. This includes structural damage, non-structural damage and loss of contents, representing less than 1 percent of the total replacement value for general building stock in Monroe County. For a 2,500-year MRP earthquake event, HAZUS-MH estimates greater than $3 billion, 1.2- percent of the total general building stock replacement value. Residential and commercial buildings account for most of the damage for earthquake events.

Earthquakes can cause secondary hazard events such as fires. No fires are anticipated as a result of the 100-, 500- or 2,500-year MRP events.

Impact on Critical Facilities

After considering the general building stock exposed to, and damaged by, 100-, 500- and 2,500-year MRP earthquake events, critical facilities were evaluated. All critical facilities (essential facilities, transportation systems, lifeline utility systems, high-potential loss facilities, and user-defined facilities) in Monroe County are considered exposed and vulnerable to the earthquake hazard. Refer to subsection "Critical Facilities" in Section 4 (County Profile) of this Plan for a complete inventory of critical facilities in Monroe County. The following tables summarize the number of critical facilities by type located on NEHRP soil classes D and E.

Table 5.4.2-19. Number of Critical Facilities Located in the NEHRP Soil Class D and E

Municipality	Facility Types																			
	Agriculture	Air	Alcohol/Drug Rehabilitation	Bridge	Bus	Chemical	Commercial	Communication	Correctional Facility	Court	Dam	Defense Industrial	DPW	DMV	Electric Power Facility	EOC	Fire Station	Golf Course	Government Building	Homeless Shelter
Brighton (T)	0	0	2	0	0	0	0	0	1	1	0	0	1	0	0	0	4	0	0	0
Brockport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chili (T)	1	0	0	0	0	0	0	0	0	1	6	0	1	0	0	0	3	1	2	0
Churchville (V)	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Clarkson (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
East Rochester (V/T)	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
Fairport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gates (T)	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0
Greece (T)	1	0	2	0	0	0	1	4	0	1	1	0	1	1	0	0	9	3	0	0
Hamlin (T)	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0
Henrietta (T)	0	0	0	0	0	0	1	1	0	1	1	0	1	0	1	0	2	2	0	0
Hilton (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Honeoye Falls (V)	0	0	0	0	0	0	0	1	0	1	2	0	1	0	0	0	1	0	0	0
Irondequoit (T)	0	0	1	1	0	0	0	3	0	1	2	0	1	1	0	0	6	0	1	1
Mendon (T)	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	1	0	0
Ogden (T)	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0
Parma (T)	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Penfield (T)	0	0	0	0	0	0	0	0	0	0	3	0	1	0	0	0	1	0	0	0
Perinton (T)	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Pittsford (T)	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Pittsford (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.4.2-19. Number of Critical Facilities Located in the NEHRP Soil Class D and E

Municipality	Facility Types																			
	Agriculture	Air	Alcohol/Drug Rehabilitation	Bridge	Bus	Chemical	Commercial	Communication	Correctional Facility	Court	Dam	Defense Industrial	DPW	DMV	Electric Power Facility	EOC	Fire Station	Golf Course	Government Building	Homeless Shelter
Riga (T)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Rochester (C)	2	1	24	0	2	1	2	15	1	1	6	0	1	1	0	1	16	2	15	13
Rush (T)	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	1	0	0	0
Scottsville (V)	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0	0
Spencerport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Webster (T)	0	0	0	0	0	0	0	2	0	0	2	0	1	0	0	0	2	0	0	0
Webster (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Wheatland (T)	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	1	0	0	0
Monroe County (Total)	**7**	**1**	**29**	**1**	**2**	**1**	**5**	**29**	**3**	**13**	**37**	**1**	**15**	**3**	**1**	**1**	**51**	**12**	**18**	**14**

Source: NYS DHSES, 2008, Monroe County

Notes: *C* *City*
T *Town*
V *Village*

Table 5.4.2-20. Number of Critical Facilities Located in the NEHRP Soil Class D and E Continued

Municipality	Facility Types																			
	Industrial	Information Technology	Library	Major Employer	Manufacturing	Military	Natural Gas	Oil	Police	Post Office	Potable Treatment Facility	Potable Pump	Rail Facility	Recreation Center	Religious Center	School	Senior	Shelter	Town Hall	Wastewater Pump Station	Wastewater Treatment Facility
Brighton (T)	0	0	1	1	0	0	0	0	1	0	0	0	0	0	13	11	1	3	1	2	0
Brockport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chili (T)	0	0	0	0	0	1	0	0	1	0	1	2	0	0	4	2	1	1	0	10	0
Churchville (V)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
Clarkson (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
East Rochester (V/T)	0	0	1	1	0	0	0	0	1	1	0	0	0	0	12	4	2	2	1	0	0
Fairport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gates (T)	0	0	1	1	0	0	0	0	0	1	2	1	0	0	3	1	0	0	0	1	0
Greece (T)	1	1	2	2	0	1	1	0	3	2	2	3	0	0	29	23	4	5	1	5	0
Hamlin (T)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	0	1	1	1	0	0
Henrietta (T)	0	1	1	0	0	0	0	0	1	0	0	0	0	0	9	4	1	2	1	2	0
Hilton (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Honeoye Falls (V)	0	0	1	0	0	0	0	0	0	1	0	0	0	0	2	2	1	1	2	0	1
Irondequoit (T)	0	0	1	0	0	1	0	0	1	1	0	1	0	1	28	25	1	6	1	2	0
Mendon (T)	0	0	0	0	0	0	0	0	0	1	1	1	0	0	3	1	0	1	0	0	0
Ogden (T)	0	0	1	0	0	0	0	0	1	0	0	0	0	0	4	0	1	1	1	5	0
Parma (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
Penfield (T)	0	0	0	1	0	0	0	0	0	1	0	1	0	0	6	5	0	0	0	0	0
Perinton (T)	0	1	0	0	0	0	0	0	0	0	0	3	0	1	3	1	1	0	0	1	0
Pittsford (T)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	0	0
Pittsford (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riga (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
Rochester (C)	1	1	10	14	1	1	1	2	12	9	1	3	1	3	279	92	9	8	2	14	1

Table 5.4.2-20. Number of Critical Facilities Located in the NEHRP Soil Class D and E Continued

Municipality	Facility Types																			
	Industrial	Information Technology	Library	Major Employer	Manufacturing	Military	Natural Gas	Oil	Police	Post Office	Potable Treatment Facility	Potable Pump	Rail Facility	Recreation Center	Religious Center	School	Senior	Shelter	Town Hall	Wastewater Pump Station	Wastewater Treatment Facility
Rush (T)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1	1	0
Scottsville (V)	0	2	1	0	0	0	0	0	0	1	0	0	0	0	3	1	1	0	1	0	0
Spencerport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Webster (T)	0	0	0	0	0	0	0	0	0	0	2	0	0	0	9	8	0	3	0	0	2
Webster (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Wheatland (T)	1	0	1	0	0	0	0	0	0	0	1	0	0	0	3	1	0	1	0	1	2
Monroe County (Total)	**3**	**6**	**22**	**20**	**1**	**4**	**2**	**2**	**21**	**19**	**12**	**15**	**1**	**5**	**417**	**188**	**25**	**35**	**14**	**45**	**6**

Source: NYS DHSES, 2008, Monroe County

Notes: *C* *City*
T *Town*
V *Village*

HAZUS-MH 2.2 estimates the probability that critical facilities may sustain damage as a result of 100-, 500- and 2,500-year MRP earthquake events. Additionally, HAZUS-MH estimates percent functionality for each facility days after the event. As a result of a 100-Year MRP event, HAZUS-MH 2.2 estimates that emergency facilities (police, fire, EMS and medical facilities), schools, utilities and specific facilities identified by Monroe County as critical will be nearly 100 percent functional. Therefore, the impact to critical facilities is not significant for the 100-year event. Table 5.4.2-21 through Table 5.4.2-22 list the percent probability of critical facilities sustaining the damage category as defined by the column heading and percent functionality after the event for the 500- and 2,500-year MRP earthquake events.

Table 5.4.2-21. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities for the 500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Critical Facilities									
Medical	93-99	0.6-5	0.1-2	<1	0	93-99	98-100	100	100
Police	93-99	0.6-5	0.1-2	<1	0	93-99	98-100	100	100
Fire	97-100	0.1-2	<1	0	0	97-100	99-100	100	100
EOC	92.7	5.2	1.9	<1	0	93	98	100	100
School	97-100	0.1-2	<1	0	0	97-100	99-100	100	100
Utilities									
Potable Water	97-100	0.1-2	<1	0	0	98-100	100	100	100
Wastewater	97-100	0.1-2	<1	0	0	98-100	100	100	100
Oil	97-100	0.1-2	<1	0	0	98-100	100	100	100
Natural Gas	97	2.6	<1	0	0	99	100	100	100
Electric Facility	97	2.3	<1	0	0	98	100	100	100
Communication	97-100	0.1-2	<1	0	0	100	100	100	100

Source: HAZUS-MH 2.2
Notes: C City
T Town
V Village

Table 5.4.2-22. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities for the 2,500-Year MRP Earthquake Event

Name	Percent Probability of Sustaining Damage					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Critical Facilities									
Medical	70-93	5-18	2-10	0.2-2	<1	69-93	87-98	97-100	98-100
Police	69-94	5-18	2-10	0.2-2	<1	69-93	87-98	97-100	98-100
Fire	62-99	1-18	0.3-18	0-2	<1	62-98	79-10	97-100	99-100
EOC	69.3	17.8	10.3	2.4	<1	69	87	97	98
School	62-99	1-18	0.3-18	0-2	<1	62-98	79-100	97-100	99-100
Utilities									
Potable Water	62-99	1-18	0.3-18	0-2	<1	71-99	97-100	98-100	99-100
Wastewater	63-99	1-18	0.3-17	0-2	<1	71-99	97-100	98-100	99-100
Oil	65-99	1-17	0.3-16	0-2	<1	78-99	90-100	99-100	100
Natural Gas	65-66	17	14-16	2	<1	79-80	97	100	100
Electric Facility	64.8	17.1	16.1	1.7	<1	75	99	100	100
Communication	62-99	1-18	0.3-18	0-2	<1	89-100	99-100	100	100

Source: HAZUS-MH 2.2

Impact on Economy

Earthquakes also impact the economy, including: loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair and replacement of buildings. A Level 2 HAZUS-MH analysis estimates the total economic loss associated with each earthquake scenario, which includes building- and lifeline-related losses (transportation and utility) based on the available inventory (facility [or GIS point] data only). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" section discussed earlier. Lifeline-related losses include the direct repair cost to transportation and utility systems and are reported in terms of the probability of reaching or exceeding a specified level of damage when subjected to a given level of ground motion. Additionally, economic loss includes business interruption losses associated with the inability to operate a business due to the damage sustained during the earthquake as well as temporary living expenses for those displaced. These losses are discussed below.

For the 100-year event, HAZUS-MH 2.2 estimates $19.2 million in income loss (wage, rental, relocation and capital-related losses) and capital stock losses (structural, non-structural, content and inventory losses. It is significant to note that for the 500-year event, HAZUS-MH 2.2 estimates the County will incur nearly $39.3 million in income losses (wage, rental, relocation and capital-related losses) in addition to the 500–year event structural, non-structural, content and inventory losses ($323 million).

For the 2,500-year event, HAZUS-MH 2.2 estimates the county will incur approximately $353 million in income losses, mainly to the residential and commercial occupancy classes associated with wage, rental, relocation and capital-related losses. In addition, the 2,500-year event structural, non-structural, content, and inventory losses equate to greater than an estimated $3.7 billion.

The HAZUS-MH analysis conducted did not compute any damage estimates for roadway segments and railroad tracks; however, it is assumed these features may experience damage due to ground failure and regional transportation and distribution of these materials will be interrupted as a result of an earthquake event. Losses to the community that result from damage to lifelines can be much greater than the cost of repair (FEMA 2012).

Earthquake events can significantly impact road bridges, which often provide the only access to certain neighborhoods. Since softer soils can generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. A key factor in the degree of vulnerability will be the age of the facility or infrastructure, which will help indicate to which standards the facility was built. HAZUS-MH estimates the long-term economic impacts to the county for 15-years after the earthquake event. In terms of the transportation infrastructure, HAZUS-MH estimates $60.7 million in direct repair costs to highway bridges as a result of a 2,500-year event; it also estimates less than $3 million for the 500-year event and no damages for the 100-year event.

HAZUS-MH 2.2 also estimates the volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break it up before it can be transported, and (2) brick, wood and other debris that can be loaded directly onto trucks with bulldozers (HAZUS-MH Earthquake User's Manual).

For the 100-year MRP event, HAZUS-MH 2.2 estimates over 8,000 tons of brick and wood debris and approximately 5 tons of concrete and steel debris will be generated. For the 500-year MRP event, HAZUS-MH 2.2 estimates nearly 80,000 tons of debris will be generated. For the 2,500-year MRP event, HAZUS-MH 2.2 estimates approximately 575,000 tons of debris will be generated.

Table 5.4.2-23. Estimated Debris Generated by the 100-, 500-, and 2,500-year MRP Earthquake Events

Municipality	100-Year		500-Year		2,500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)	Brick/Wood (tons)	Concrete/Steel (tons)	Brick/Wood (tons)	Concrete/Steel (tons)
Brighton (T)	472	140	3,960	1,716	20,798	22,490
Brockport (V) - Clarkson (T)	0	0	649	235	3,442	3,112
Brockport (V) - Sweden (T)	0	0	109	28	757	261
Chili (T)	67	16	1,203	399	6,731	5,017
Chili (T) - Rochester (C)	13	7	103	82	659	1,585
Churchville (V) - Riga (T)	0	0	710	301	3,997	4,723
East Rochester (V/T)	132	37	976	428	4,835	5,455
Fairport (V) - Perinton (T)	0	0	462	128	2,631	1,170
Gates (T)	147	48	1,835	814	10,201	10,572
Greece (T)	692	153	5,708	1,812	28,843	20,383
Hamlin (T)	0	0	117	28	762	262
Henrietta (T)	140	45	2,040	828	11,422	11,249
Hilton (V) - Parma (T)	0	0	86	22	587	195
Honeoye Falls (V) - Mendon (T)	57	16	439	192	2,304	2,706
Irondequoit (T)	685	159	5,115	1,759	24,889	20,515
Mendon (T)	0	0	407	115	2,305	1,130
Ogden (T)	0	0	263	75	1,609	761
Ogden (T) - Spencerport (V)	0	0	232	68	1,532	660
Parma (T)	66	15	541	173	2,829	2,090
Penfield (T)	236	53	2,220	691	11,300	7,460
Perinton (T)	220	52	2,070	685	10,834	7,565
Pittsford (T)	59	11	781	205	4,451	2,007
Pittsford (T) - Pittsford (V)	43	8	504	136	2,772	1,328
Rochester (C)	3,025	902	23,132	10,470	117,370	140,145
Rush (T)	0	0	66	17	461	157
Scottsville (V) - Wheatland (T)	0	0	79	23	549	208
Sweden (T)	0	0	49	12	344	109
Webster (T)	257	57	2,138	665	10,324	7,040
Webster (T) - Webster (V)	73	14	662	183	3,298	1,722
Monroe County (Total)	**6,385**	**1,735**	**56,658**	**22,288**	**292,838**	**282,079**

Source: HAZUS-MH 2.2
Notes: C City
T Town
V Village

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the county. It is anticipated that the human exposure and vulnerability to earthquake impacts in newly developed areas will be similar to those that currently exist within the county. Current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts than older, existing construction that may have been built using lower construction standards.

Effect of Climate Change on Vulnerability

Providing projections of future climate change for a specific region is challenging. Shorter-term projections are more closely tied to existing trends making longer-term projections even more challenging. The further out a prediction reaches, the more subject to changing dynamics it becomes. The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. NASA and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of increased saturation. Dams storing increased volumes of water from changes in the climate could fail during seismic events. There are currently no models available to estimate these impacts.

Change of Vulnerability

The 2011 HMP summarized past events and indicated Monroe's earthquake vulnerability compared to the other counties in New York State. A HAZUS-MH analysis was not conducted as part of the 2011 HMP, which incorporated updated population data and an updated general building stock into the HAZUS-MH model. The county's vulnerability to an earthquake event remains unchanged since the previous HMP.

Additional Data and Next Steps

Monroe County can identify un-reinforced masonry critical facilities and privately owned buildings (i.e., residences) using local knowledge and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response/recovery efforts for these properties can be set in place. Further mitigation actions include training of county and municipal personnel to provide post-hazard event rapid visual damage assessments, increase of county and local debris management and logistic capabilities, and revised regulations to prevent additional construction of non-reinforced masonry buildings.