



5.4.2 Earthquake

This section provides profile information, including description, location, extent, previous occurrences and losses, probability of future occurrences, and climate change impacts, as well as the vulnerability assessment for the earthquake hazard in Livingston County.

5.4.2.1 Hazard Profile

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 a manmade explosion (Federal Emergency Management Agency [FEMA] 2013; Shedlock and Pakiser 1995). 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 1995).

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 earthquake-related activity is provided below:

- *Surface faulting*: Displacement that reaches the earth’s surface during slip along a fault. This commonly occurs with shallow earthquakes, 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 (like 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 n.d.).

Extent

An earthquake’s magnitude and intensity are used to describe the size and severity of the event. Magnitude describes the size at the focal point 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. Magnitude was formerly expressed by ratings on the Richter scale but is now most commonly expressed using the moment magnitude (Mw) scale. This scale is based on the total moment release of the earthquake (the product of the distance a fault moved and the force required to move it). The scale is as follows:

- Great Mw > 8
- Major Mw = 7.0 – 7.9
- Strong Mw = 6.0 – 6.9



- Moderate Mw = 5.0 – 5.9
- Light Mw = 4.0 – 4.9
- Minor Mw = 3.0 – 3.9
- Micro Mw = 3.0 – 3.9

The most commonly used intensity scale is the modified Mercalli intensity scale. Ratings of the scale, as well as the perceived shaking and damage potential for structures, are shown in Table 5.4.2-1. The modified Mercalli intensity scale is generally represented visually using shake maps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter. An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake because of complexities in the structure of the earth’s crust. Table 5.4.2-2 displays the Modified Mercalli Intensity (MMI) scale and its relationship to the areas peak ground acceleration.

Table 5.4.2-1. 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 motor cars may rock slightly. Vibrations are similar to the passing of a truck. Duration estimated.
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 is similar to a heavy truck striking a building. Standing motor cars 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	Damage negligible in buildings of good design and construction; slight to moderate damage in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	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	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	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Source(s): USGS 2020

Table 5.4.2-2. 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



Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
X	>124	Extreme	Very Heavy

Source: Freeman et al. (Purdue University) 2004

Note: PGA Peak ground acceleration

The ground experiences acceleration as it shakes during an earthquake. Peak ground acceleration (PGA) expresses the severity of an earthquake and is a measure of how hard the earth shakes, or accelerates, in each geographic area. PGA is expressed as a percent acceleration force of gravity (%g). For example, 1.0%g PGA in an earthquake (an extremely strong ground motion) means that objects accelerate sideways at the same rate as if they had been dropped from the ceiling. An earthquake with a 10%g PGA means that the ground acceleration is 10 percent that of gravity (Freeman, et al. 2004). Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in Table 5.4.2-3.

Table 5.4.2-3. Damage Levels Experienced in Earthquakes

Ground Motion Percentage	Explanation of Damage
1-2%g	Motions are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
Below 10%g	Usually causes only slight damage, except in unusually vulnerable facilities.
10 - 20%g	May cause minor-to-moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poorly constructed buildings would be subject to potential collapse.
20 - 50%g	May cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
≥50%g	May causes higher levels of damage in many buildings, even those designed to resist seismic forces.

Source: Freeman et al. (Purdue University) 2004

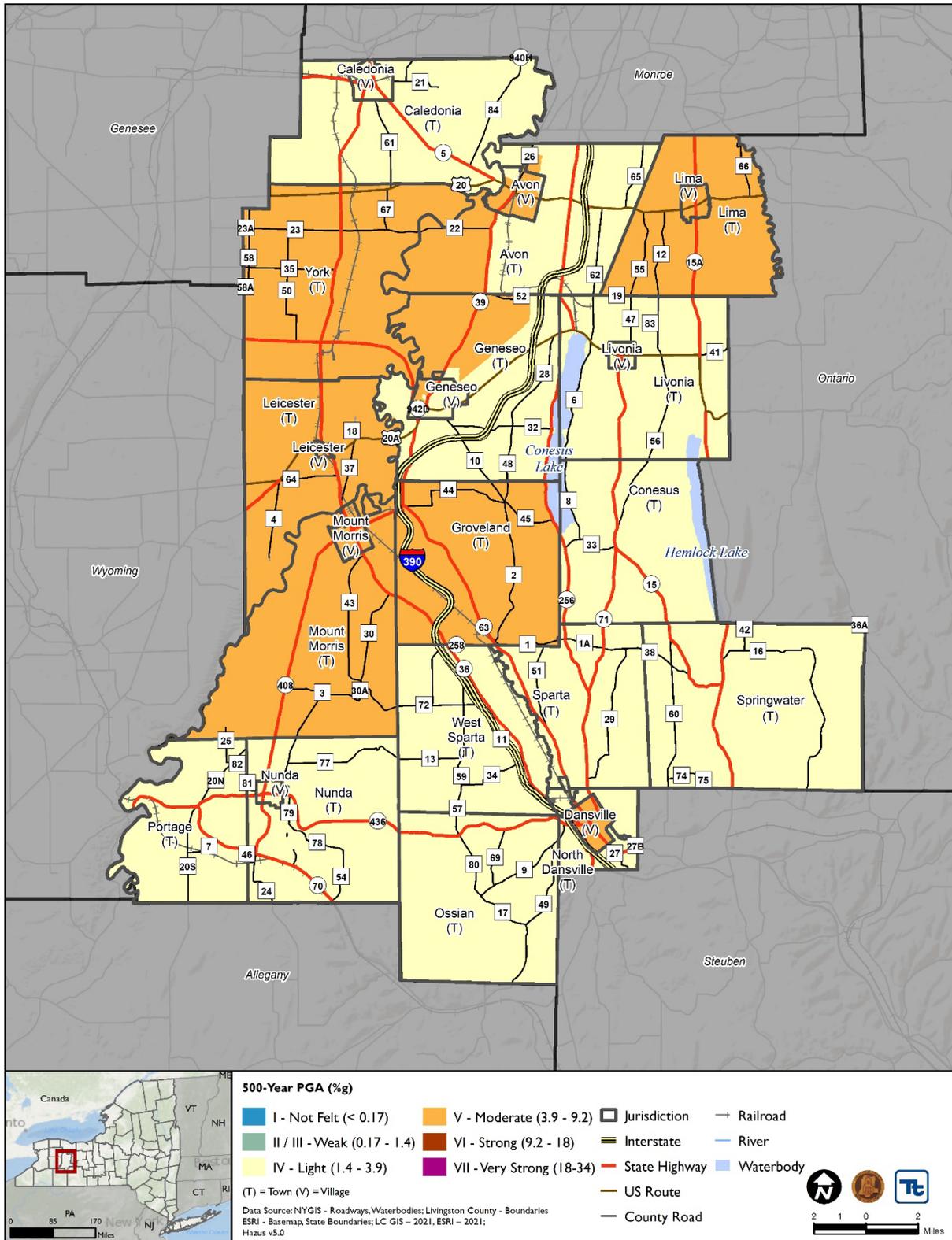
Note: %g Percent acceleration force of gravity

National maps of earthquake shaking hazards have been produced since 1948. They 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 used in 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 damage 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 (USGS 2016).

A probabilistic assessment was conducted for the 500-year mean return period (MRP) in Hazards U.S.—Multi-Hazard (HAZUS-MH) v4.2 to analyze the earthquake hazard for Livingston County. The HAZUS analysis evaluates the statistical likelihood that a specific event will occur and what consequences will occur. The USGS updated the National Seismic Hazard Maps in 2018, which superseded the 2014 maps. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps. The 2018 map represents the best available data as determined by the USGS. According to the data, Livingston County has a PGA between 6%g and 10%g (USGS 2018).



Figure 5.4.2-1. Peak Ground Acceleration Modified Mercalli Scale for a 500-Year MRP Earthquake Event





The New York State Geological Survey conducted seismic shear-wave tests of the state’s surficial geology. 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 (Table 5.4.2-4). 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 (as noted in Table 5.4.2-4), where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. Class E soils include water-saturated mud and artificial fill. The strongest amplification of shaking is expected for this soil type. Seismic waves travel faster through hard rock than through softer rock and sediments. As the waves pass from harder to softer rocks, the waves slow down and their amplitude increases. Shaking tends to be stronger at locations with softer surface layers where seismic waves move more slowly. Ground motion above an unconsolidated landfill or soft soils can be more than 10 times stronger than at neighboring locations on rock for small ground motions (NYS DHSES 2019).

Table 5.4.2-4. NEHRP Soil Classifications

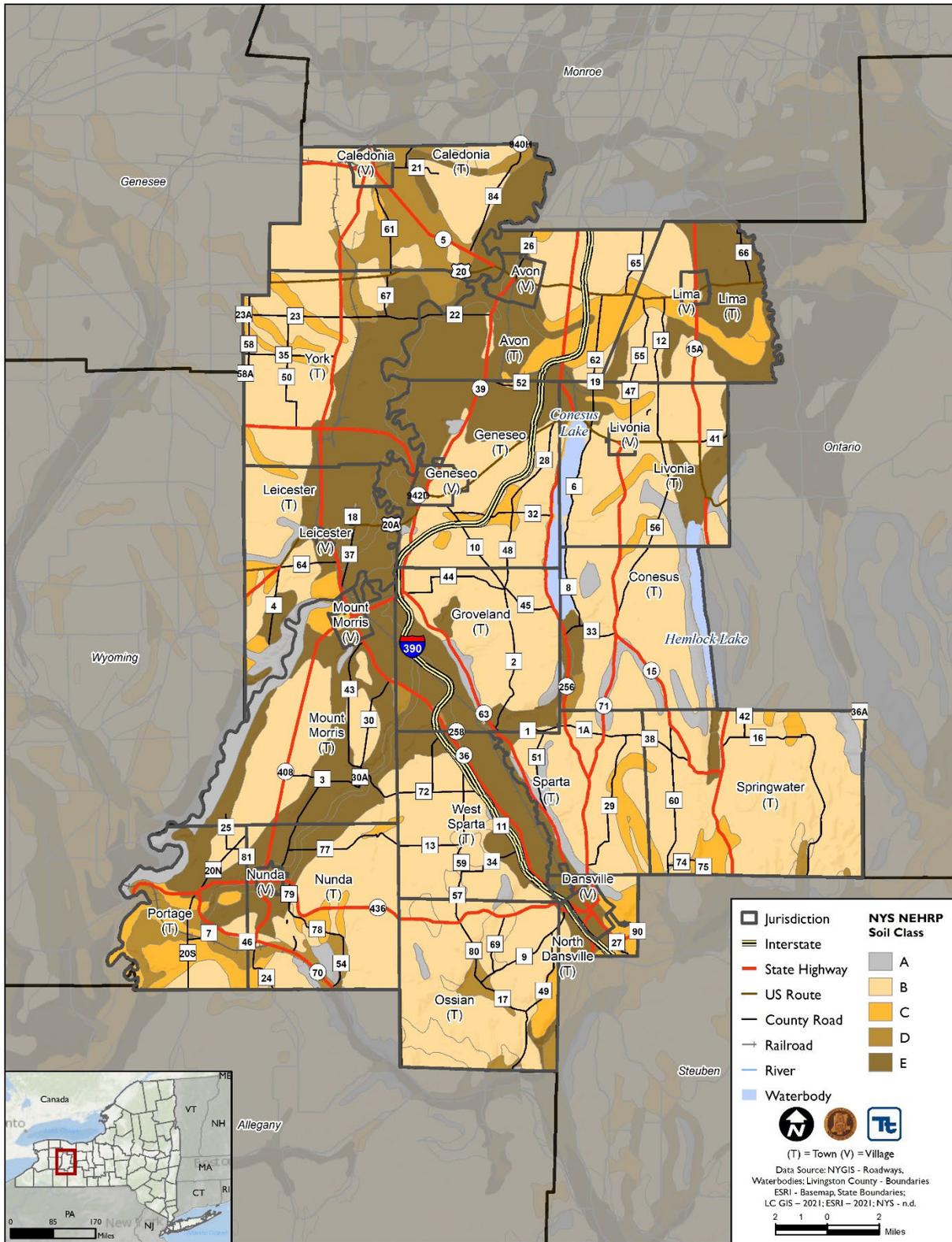
Soil Classification	Description
A	Very hard rock (e.g., granite, gneisses; and most of the Adirondack Mountains)
B	Rock (sedimentary) or firm ground
C	Stiff clay
D	Soft to medium clays or sands
E	Soft soil, including fill, loose sand, waterfront, lakebed clays

Source: NYS DHSES 2019

Figure 5.4.2-2 illustrates the NEHRP soils located throughout Livingston County, according to NYS DHSES data. The available NEHRP soils information is incorporated into the HAZUS-MH v4.2 earthquake model for the risk assessment (discussed in further detail later in this section). According to this figure, Livingston County is predominately underlain by Type B soils. The NEHRP soils of interest, Types D and E, are found throughout the Genesee Valley, Canaseraga Valley, and smaller valleys in the county. A concentration of Type E soils is located on the county’s southwest border and along the Genesee River.



Figure 5.4.2-2. NEHRP Soils in Livingston County





Location

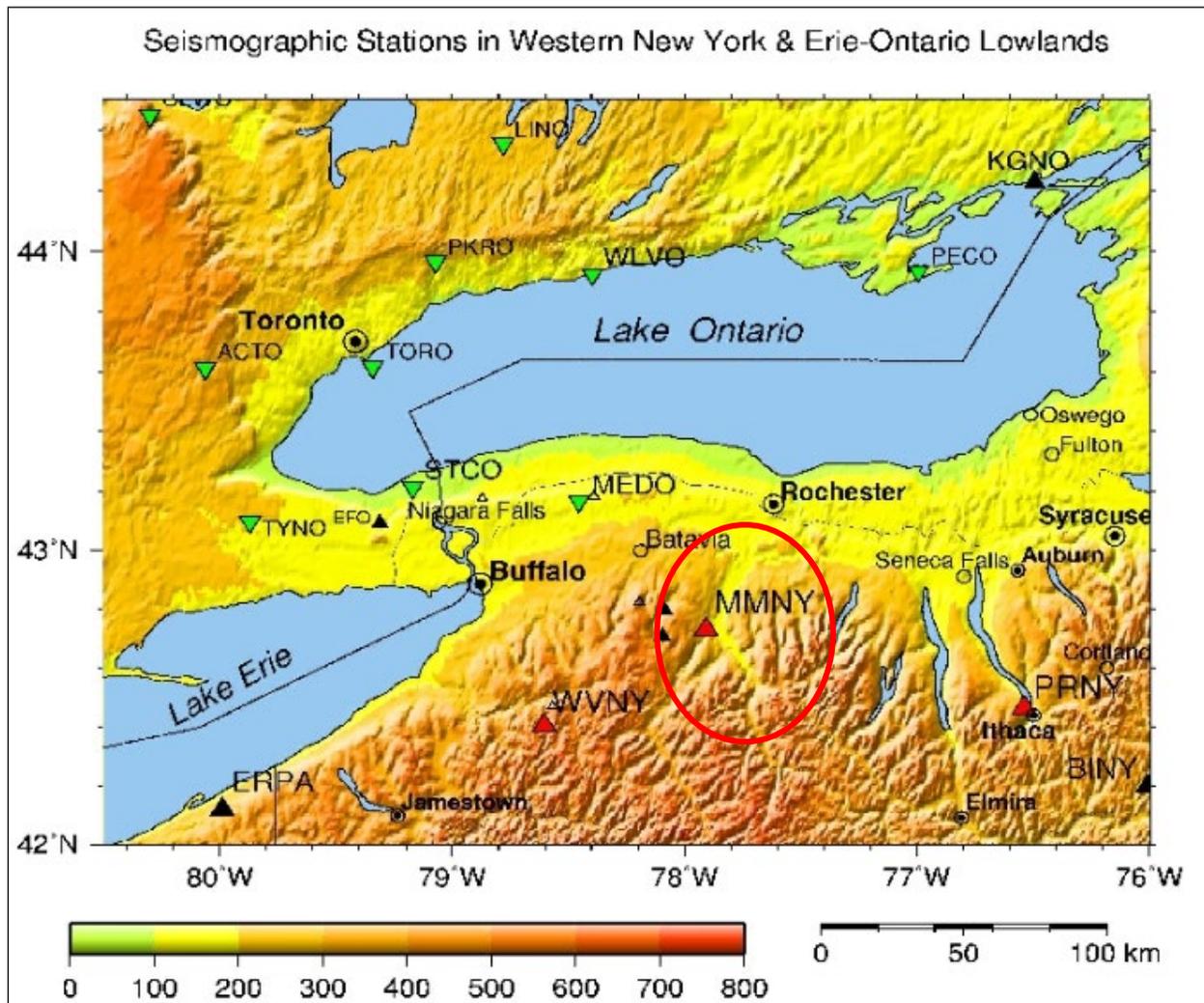
The potential for earthquakes exists across all of New York State and four general regions would experience an amplification of ground motion during seismic activity. These regions are (1) Northwest NY – Northern Erie County, North Central; (2) Northeast NY – Jefferson, St. Laurence, and Northern Franklin Counties; (3) Upper Hudson River area of Eastern NY – Northern Saratoga, Washington, and Southern Warren Counties; and (4) Southeastern NY – Western Nassau County and New York City. Overall, these four regions are the most seismically active areas of the state. Livingston County is location in Region 1 (NYS DHSES 2021).

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes (USGS 2016). The USGS updated the National Seismic Hazard Maps in 2018. New seismic, geologic, and geodetic information on earthquake rates and associated ground shaking were incorporated into these revised maps.

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 present in Livingston County; however, there are several within the vicinity of the county. Figure 5.4.2-3 shows the location of these stations in the western New York State area (LCSN 2014).



Figure 5.4.2-3. Lamont-Doherty Seismic Station Locations in the Western New York State Area



Source: LCSN 2014

Note: The red oval indicates the approximate location of Livingston County.
 The red triangles indicate secondary school, college, and university facility stations.
 The green triangles indicate public places or state geological survey centers.
 The black triangles indicate environmental research and education centers.

In addition to the Lamont-Doherty seismic stations, 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 5.4.2-4 shows locations of USGS seismic stations near New York State.



Figure 5.4.2-4. USGS Seismic Stations Near New York State



Source: USGS 2020

Note: The red circle indicates the approximate location of Livingston County.

Previous Occurrences and Losses

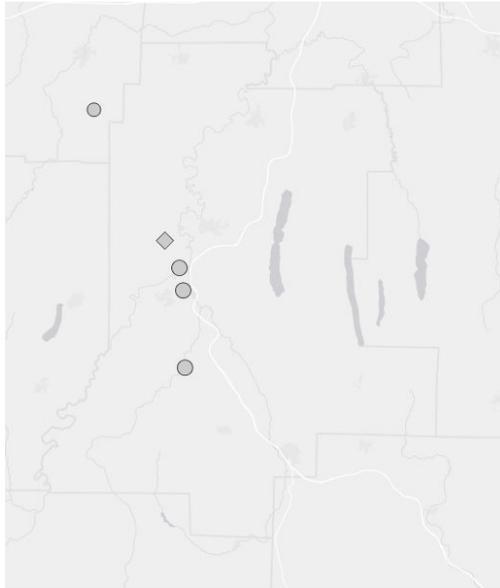
Many sources provided historical information on previous occurrences and losses associated with earthquakes throughout New York State. Therefore, with so many sources reviewed for the purpose of this HMP update, loss and impact information for many events could vary depending on the source. According to the NYS Geological Survey and the New York State 2019 HMP update, approximately 551 significant earthquakes affected New York State between 1737 and 2016 (NESEC 2020). (NYS DHSES 2019).

Between 1954 and 2019, New York State was included in one earthquake-related major disaster (DR) or emergency (EM) declaration; DR-1415: Earthquake. 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. Livingston County was not included in any earthquake-related DRs or EMs (FEMA 2020).

Figure 5.4.2-5 illustrates historic earthquake epicenters in Livingston County between 1950 and 2020. According to this figure one earthquake with an epicenter in Livingston County occurred during that time. In addition to these earthquakes in Livingston County, numerous events have originated outside of the county that have been felt within the county. Table 5.4.2-5 includes details regarding these events.



Figure 5.4.2-5. Earthquake Epicenters in Livingston County and the Surrounding Area, 1950 – 2019



Source: USGS 2021

For this 2022 HMP update, known earthquake events that have impacted areas in and around Livingston County between 2015 and 2021 are identified in Table 5.4.2-5. It should be noted that many sources were researched for historical information regarding earthquake events in Livingston County; therefore, Table 5.4.2-5 may not include all earthquake events that have impacted the county. Additionally, not all sources have been identified or researched. Loss and impact information 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 update.

Table 5.4.2-5. Earthquake Events in Livingston County, 2015 and 2021

Dates of Event	Magnitude (Modified Mercalli Scale)	Location	FEMA Declaration Number	County Designated?	Losses / Impacts
May 28, 2021	2.4	Ossian	-	-	Information not provided

Note: All magnitudes listed refer to the Modified Mercalli Scale, unless otherwise specified.

N/A Not Applicable

USGS U.S. 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 2017 (the date of the most recent analysis), Livingston County had a PGA of 0.17%g to 3.9%g for earthquakes with a 2-percent probability of an occurrence within 50 years.

The New York State Disaster Preparedness Commission (NYS DPC) indicates that the earthquake hazard in New York State is often understated because other natural hazards occur more frequently (e.g., hurricanes, tornadoes, and flooding) and are much more visible. However, the potential for earthquakes does exist across the entire northeastern United States, and New York State is no exception.



In Section 5.3, the identified hazards of concern for Livingston 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 Partnership, the probability of occurrence for earthquakes of any magnitude in the county is considered “rare” (between 1 and 10% annual probability of occurring in any given year). With very few incidents having occurred within or affecting Livingston County, it is anticipated that the county will experience few direct and indirect impacts from earthquakes in the future.

Climate Change

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 (NASA 2007).

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water according to a revised hydrograph could fail during seismic events. During the 1989 Loma Prieta, California, earthquake, liquefaction of the soils and debris used to fill a lagoon caused major subsidence, fracturing, and horizontal sliding of the ground surface (USGS n.d.). There are currently no models available to estimate these impacts.

5.4.2.2 Vulnerability Assessment

A probabilistic assessment was conducted for the 500-year Mean Return Period (MRP) earthquake event through a Level 2 analysis in Hazus v5.0 to analyze the earthquake hazard and provide a range of loss estimates. Figure 5.4.2-2 shows the geographic distribution of the NEHRP soil types in the County. Section 5.1 (Methodology and Tools) provides additional details on the methodology used to assess earthquake risk.

Impacts on Life, Health, and Safety

The entire County may experience an earthquake. However, the degree of impact is dependent on many factors including the age and type of construction people live in, the soil types their homes are located on, and the intensity of the earthquake. Whether directly or indirectly impacted, residents could be faced with business closures, road closures that could isolate populations, and loss of function of critical facilities and utilities.

According to the 2015-2019 ACS 5-year population estimate, Livingston County had a population of 63,591 people. Overall, risk to public safety and loss of life from an earthquake in the County is minimal for low magnitude events. However, there is a higher risk to public safety for those inside buildings due to structural damage or people walking below building ornamentations and chimneys that may be shaken loose and fall because of an earthquake.

Populations considered most vulnerable are those located in/near the built environment, particularly those near unreinforced masonry construction. Of these most vulnerable populations, socially vulnerable populations, including the elderly (persons over age 65) and individuals living below the poverty threshold, are most susceptible. Factors leading to this higher susceptibility include decreased mobility and financial ability to react or respond during a hazard, and the location and construction quality of their housing. According to the 2015 – 2019 5-year ACS estimates, there are approximately 7,572 total persons living below the poverty level and 10,929 persons over the age of 65 years in Livingston County.



As noted earlier, NEHRP Soil Classes D and E can amplify ground shaking to damaging levels even during a moderate earthquake, and thus increase risk to the population. Populations within municipalities located on NEHRP Class D and E soils were estimated and are listed in Table 5.4.2-6. Approximately 25,751 residents (40.5-percent of the County’s population) are located on NEHRP Class D and E soils. The Villages of Leicester and Nunda have the greatest proportion of its population residing on NEHRP Class D and E soils (i.e., 100-percent).

Table 5.4.2-6. Total Population Located on NEHRP Class D or E Soils

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Class D and E NEHRP Soil Hazard Area	
		Number of People	Percent of Total
Avon (T)	3,637	984	27.1%
Avon (V)	3,260	3,257	99.9%
Caledonia (T)	2,060	971	47.2%
Caledonia (V)	2,078	1,298	62.5%
Conesus (T)	2,325	298	12.8%
Dansville (V)	4,586	4,152	90.5%
Geneseo (T)	2,540	553	21.8%
Geneseo (V)	8,095	1,040	12.8%
Groveland (T)	3,241	598	18.5%
Leicester (T)	1,798	1,274	70.9%
Leicester (V)	518	518	100.0%
Lima (T)	1,833	921	50.3%
Lima (V)	2,278	954	41.9%
Livonia (T)	6,231	1,356	21.8%
Livonia (V)	1,353	0	0.0%
Mount Morris (T)	1,340	597	44.6%
Mount Morris (V)	2,931	1,795	61.3%
North Dansville (T)	696	411	59.1%
Nunda (T)	1,716	743	43.3%
Nunda (V)	1,211	1,211	100.0%
Ossian (T)	701	63	9.0%
Portage (T)	837	419	50.1%
Sparta (T)	1,591	117	7.3%
Springwater (T)	2,233	150	6.7%
West Sparta (T)	1,229	399	32.4%
York (T)	3,273	1,670	51.0%
Livingston County (Total)	63,591	25,751	40.5%

Sources: NYS GIS n.d.; American Community Survey 2019

Notes: T – Town; V – Village; % - Percent; NEHRP - National Earthquake Hazard Reduction Program

As a result of a significant earthquake event, 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. Hazus estimates that there will be zero displaced households and zero persons seeking short-term sheltering caused by the 500-year MRP event.



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 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., with peak commute time at 5:00 p.m. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could prevent people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself. Table 5.4.2-7 summarizes the estimated number of injuries or casualties caused by the 500-year MRP event.

Table 5.4.2-7. 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	1	2	1
Hospitalization	0	0	0
Casualties	0	0	0

Sources: Hazus v5.0

Notes: MRP = Mean Return Period

Impacts on General Building Stock

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 during a moderate earthquake (NYCEM 2003). Therefore, buildings located on NEHRP Classes D and E soils are at increased risk of damage from an earthquake. Table 5.4.2-8 summarizes the number and replacement cost value of buildings in Livingston County located on NEHRP Class D and E soils. Overall, approximately 40.9-percent of Livingston County’s buildings are built on NEHRP Class D and E soils.

Table 5.4.2-8. Number and Replacement Cost Value of Buildings Located on NEHRP Class D or E Soils

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Es Building Stock Located in the Class D or Class E NEHRP Soil Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Avon (T)	2,149	\$1,324,846,766	601	28.0%	\$385,464,344	29.1%
Avon (V)	1,245	\$1,365,771,007	1,235	99.2%	\$1,331,626,745	97.5%
Caledonia (T)	1,362	\$792,755,652	643	47.2%	\$336,138,873	42.4%
Caledonia (V)	979	\$735,609,120	606	61.9%	\$420,769,508	57.2%
Conesus (T)	1,774	\$625,005,723	214	12.1%	\$64,638,178	10.3%
Dansville (V)	1,950	\$1,341,807,175	1,777	91.1%	\$1,256,204,418	93.6%
Geneseo (T)	1,753	\$1,161,720,041	446	25.4%	\$319,898,184	27.5%
Geneseo (V)	1,329	\$1,570,704,963	229	17.2%	\$767,823,600	48.9%
Groveland (T)	1,330	\$1,203,662,583	360	27.1%	\$533,416,455	44.3%
Leicester (T)	1,214	\$715,987,145	797	65.7%	\$447,070,653	62.4%
Leicester (V)	240	\$142,879,953	240	100.0%	\$142,879,953	100.0%
Lima (T)	1,436	\$859,636,929	730	50.8%	\$490,528,533	57.1%
Lima (V)	777	\$452,768,112	317	40.8%	\$165,601,268	36.6%
Livonia (T)	3,888	\$1,866,897,181	943	24.3%	\$574,180,177	30.8%



Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Es Building Stock Located in the Class D or Class E NEHRP Soil Hazard Area			
			Number of Buildings	Percent of Total	Replacement Cost Value (RCV)	Percent of Total
Livonia (V)	569	\$371,319,429	0	0.0%	\$0	0.0%
Mount Morris (T)	1,115	\$646,574,328	503	45.1%	\$306,661,046	47.4%
Mount Morris (V)	1,337	\$785,505,655	837	62.6%	\$577,984,450	73.6%
North Dansville (T)	607	\$497,159,183	397	65.4%	\$419,189,366	84.3%
Nunda (T)	1,354	\$544,934,442	605	44.7%	\$292,321,594	53.6%
Nunda (V)	641	\$392,488,596	641	100.0%	\$392,488,596	100.0%
Ossian (T)	817	\$488,703,931	86	10.5%	\$85,538,348	17.5%
Portage (T)	620	\$338,465,763	311	50.2%	\$191,121,571	56.5%
Sparta (T)	1,151	\$449,674,840	86	7.5%	\$33,394,574	7.4%
Springwater (T)	1,822	\$702,256,303	118	6.5%	\$38,850,065	5.5%
West Sparta (T)	1,010	\$423,213,015	352	34.9%	\$181,269,890	42.8%
York (T)	2,183	\$1,677,949,006	1,101	50.4%	\$803,953,703	47.9%
Livingston County (Total)	34,652	\$21,478,296,842	14,175	40.9%	\$10,559,014,091	49.2%

Source: NYS GIS n.d.; Livingston County 2021; RS Means 2021

Notes: T – Town; V – Village; % - Percent; NEHRP - National Earthquake Hazard Reduction Program

There is a strong correlation between PGA and damage a building might undergo (NYCEM 2019). The Hazus model is based on best available earthquake science and aligns with these statements. The Hazus probabilistic earthquake model was applied to analyze effects from the earthquake hazard on general building stock in Livingston County. See Figure 5.4.2-1 earlier in this profile which illustrates the geographic distribution of PGA (g) across the County for the 500-year MRP event at the Census-tract level.

A building’s construction determines how well it can withstand the force of an earthquake. The NYCEM Hazard Mitigation Plan indicates that unreinforced 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 affect a building’s capability to withstand an earthquake’s force include its age, number of stories, and quality of construction. Hazus considers building construction and age of building as part of the analysis. Because a custom general building stock was used for this Hazus analysis, the building ages and building types from the inventory were incorporated into the Hazus model.

Potential building damage was evaluated by Hazus across the following damage categories: none, slight, moderate, extensive, and complete. Table 5.4.2-9 provides definitions of these five categories of damage for a light wood-framed building. Definitions for other building types are included in the Hazus technical manual documentation. The results of potential damage states for buildings in Livingston County categorized by general occupancy classes (i.e., residential, commercial, industrial, etc.) from Hazus are summarized in Table 5.4.2-10 for the 500-year MRP events.

Table 5.4.2-9. 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.



Damage Category	Description
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 occur.

Source: Hazus Technical Manual

Table 5.4.2-10. Estimated Buildings Damaged by General Occupancy for 500-year MRP Earthquake Events

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	Earthquake 500-Year	
			Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	28,577	None	28,242	98.8%
		Slight	281	1.0%
		Moderate	53	0.2%
		Extensive	1	<0.1%
		Complete Destruction	0	0.0%
Commercial Buildings	2,323	None	2,291	98.6%
		Slight	27	1.2%
		Moderate	4	0.2%
		Extensive	0	0.0%
		Complete Destruction	0	0.0%
Industrial Buildings	224	None	221	98.8%
		Slight	2	0.9%
		Moderate	1	0.3%
		Extensive	0	0.0%
		Complete Destruction	0	0.0%
Government, Religion, Agricultural, and Education Buildings	3,528	None	3,467	98.3%
		Slight	55	1.6%
		Moderate	6	0.2%
		Extensive	0	0.0%
		Complete Destruction	0	0.0%

Source: Hazus v5.0; Livingston County 2021; RS Means 2021

Notes: MRP – Mean Return Period; % - Percent

Building damage as a result of the 500-year MRP earthquake was estimated for each municipality using Hazus. Table 5.4.2-11 summarizes estimated total building and content losses caused by the 500-year MRP event by jurisdiction. This table also summarize losses for structures categorized as residential, commercial, and all other occupancy classes. Less than 0.1-percent of the County’s structures are impacted by the 500-year MRP event (i.e., approximately \$7.8 million in replacement cost value). Majority of the losses are estimated to occur in the Village of Avon.



Table 5.4.2-11. Estimated Replacement Cost Value (Building and Contents) Damaged by the 500-Year MRP Earthquake Event

Jurisdiction	Replacement Cost Value (RCV)	500-Year MRP				
		Estimated Total Damage	Percent of Total Building and Contents Replacement Cost Value	Estimated Residential Damage	Estimated Commercial Damage	Estimated Damages for All Other Occupancies
Avon (T)	\$1,324,846,766	\$318,676	<0.1%	\$122,120	\$78,198	\$118,357
Avon (V)	\$1,365,771,007	\$1,225,818	0.1%	\$296,627	\$331,855	\$597,336
Caledonia (T)	\$792,755,652	\$186,313	<0.1%	\$61,734	\$33,053	\$91,527
Caledonia (V)	\$735,609,120	\$133,921	<0.1%	\$44,374	\$23,758	\$65,789
Conesus (T)	\$625,005,723	\$31,978	<0.1%	\$24,232	\$2,109	\$5,637
Dansville (V)	\$1,341,807,175	\$1,088,843	0.1%	\$309,716	\$427,844	\$351,283
Geneseo (T)	\$1,161,720,041	\$286,786	<0.1%	\$106,108	\$61,939	\$118,738
Geneseo (V)	\$1,570,704,963	\$671,202	<0.1%	\$28,307	\$9,513	\$633,382
Groveland (T)	\$1,203,662,583	\$625,644	0.1%	\$66,561	\$36,813	\$522,269
Leicester (T)	\$715,987,145	\$172,776	<0.1%	\$67,976	\$37,615	\$67,185
Leicester (V)	\$142,879,953	\$34,157	<0.1%	\$13,438	\$7,436	\$13,282
Lima (T)	\$859,636,929	\$316,761	<0.1%	\$146,755	\$53,317	\$116,689
Lima (V)	\$452,768,112	\$171,545	<0.1%	\$79,481	\$28,878	\$63,187
Livonia (T)	\$1,866,897,181	\$318,155	<0.1%	\$134,189	\$41,463	\$142,502
Livonia (V)	\$371,319,429	\$46,561	<0.1%	\$19,638	\$6,068	\$20,855
Mount Morris (T)	\$646,574,328	\$158,686	<0.1%	\$62,432	\$34,548	\$61,706
Mount Morris (V)	\$785,505,655	\$731,869	0.1%	\$227,222	\$252,945	\$251,701
North Dansville (T)	\$497,159,183	\$31,699	<0.1%	\$16,629	\$4,924	\$10,145
Nunda (T)	\$544,934,442	\$135,629	<0.1%	\$63,412	\$17,539	\$54,678
Nunda (V)	\$392,488,596	\$64,209	<0.1%	\$30,020	\$8,303	\$25,885
Ossian (T)	\$488,703,931	\$41,980	<0.1%	\$22,205	\$6,342	\$13,434
Portage (T)	\$338,465,763	\$62,105	<0.1%	\$29,037	\$8,031	\$25,037
Sparta (T)	\$449,674,840	\$59,233	<0.1%	\$31,311	\$8,957	\$18,964
Springwater (T)	\$702,256,303	\$32,843	<0.1%	\$24,887	\$2,166	\$5,789
West Sparta (T)	\$423,213,015	\$51,897	<0.1%	\$27,450	\$7,840	\$16,607
York (T)	\$1,677,949,006	\$753,241	<0.1%	\$232,111	\$87,445	\$433,686
Livingston County (Total)	\$21,478,296,842	\$7,752,525	<0.1%	\$2,287,974	\$1,618,900	\$3,845,651

Source: Hazus v5.0; Livingston County - 2021; RS Means 2021
 Notes: T – Town; V – Village; % - Percent; < - Less Than; MRP – Mean Return Period

Historically, Building Officials Code Administration (BOCA) regulations 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 rely on the more seismically focused Uniform Building Code. As such, a smaller earthquake in the northeast can cause more structural damage than if it would occur in the west.

Impact on Critical Facilities and Lifelines

All critical facilities and lifelines in Livingston County are considered exposed to the earthquake hazard. Refer to subsection “Critical Facilities and Lifelines” in Section 4 (County Profile) of this HMP for a complete inventory of critical facilities in Livingston County.

The number of critical facilities and lifelines built on NEHRP Class D and Class E soil types was assessed. Overall, there are 459 critical facilities located on soils prone to ground shaking during an earthquake event. Of these critical facilities, 413 are considered lifelines for the County. Refer to Table 5.4.2-12 and Table 5.4.2-13 which summarize the number of facilities by jurisdiction and the number of lifelines categorized by FEMA





lifeline categories located on NEHRP Class D and Class E soil types, respectively. Appendix E provides a table summarizing the distribution of critical facilities by critical facility type within each jurisdiction located on these soil types. More than 54-percent of the critical facilities and lifelines in Livingston County are at risk to ground shaking during an earthquake event. The Village of Dansville has the greatest number of critical facilities at risk.

Table 5.4.2-12. Number of Critical Facilities and Lifelines Located on NEHRP Class D or E Soils

Jurisdiction	Total Number of Critical Facilities	Total Number of Lifelines	Number of Critical Facilities and Lifeline Facilities Located Within the NEHRP Class D or Class E Earthquake Soil Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Avon (T)	51	46	22	43.1%	21	45.7%
Avon (V)	36	27	36	100.0%	27	100.0%
Caledonia (T)	19	16	12	63.2%	10	62.5%
Caledonia (V)	28	25	15	53.6%	12	48.0%
Conesus (T)	26	26	6	23.1%	6	23.1%
Dansville (V)	46	37	44	95.7%	35	94.6%
Geneseo (T)	48	45	12	25.0%	12	26.7%
Geneseo (V)	46	39	22	47.8%	19	48.7%
Groveland (T)	63	59	31	49.2%	30	50.8%
Leicester (T)	26	26	19	73.1%	19	73.1%
Leicester (V)	13	13	13	100.0%	13	100.0%
Lima (T)	16	14	9	56.3%	7	50.0%
Lima (V)	21	19	6	28.6%	6	31.6%
Livonia (T)	70	65	40	57.1%	36	55.4%
Livonia (V)	16	12	0	0.0%	0	0.0%
Mount Morris (T)	30	29	20	66.7%	20	69.0%
Mount Morris (V)	28	24	22	78.6%	19	79.2%
North Dansville (T)	35	31	29	82.9%	25	80.6%
Nunda (T)	25	25	14	56.0%	14	56.0%
Nunda (V)	23	20	23	100.0%	20	100.0%
Ossian (T)	20	20	6	30.0%	6	30.0%
Portage (T)	23	22	10	43.5%	10	45.5%
Sparta (T)	18	18	3	16.7%	3	16.7%
Springwater (T)	27	26	4	14.8%	3	11.5%
West Sparta (T)	25	25	14	56.0%	14	56.0%
York (T)	58	54	27	46.6%	26	48.1%
Livingston County (Total)	837	763	459	54.8%	413	54.1%

Source: NYS GIS timated; Livingston County Planning Partners 2021; HIFLD 2020

Notes: T – Town; V – Village; % - Percent; NEHRP - National Earthquake Hazard Reduction Program

Table 5.4.2-13. Number of Lifelines Categorized by FEMA Lifeline Category Located on NEHRP Class D or E Soils

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Class D or Class E NEHRP Soil Hazard Area
Communications	72	17
Energy	18	13
Food, Water, Shelter	100	44
Hazardous Materials	50	31
Health and Medical	36	16
Safety and Security	269	143



FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Class D or Class E NEHRP Soil Hazard Area
Transportation	218	149
Livingston County (Total)	763	413

Source: NYS GIS n.d.; Livingston County Planning Partners 2021; HIFLD 2020; FEMA 2020
 Notes: NEHRP - National Earthquake Hazard Reduction Program

The Hazus earthquake model was used to assign the range or average probability of each damage state category to the critical facilities in Livingston County for the 500-year MRP event. In addition, Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as a probability of being functional at specified time increments (days after the event). For example, Hazus might estimate that a facility has 5-percent chance of being fully functional at Day 3, and a 95-percent chance of being fully functional at Day 90. For percent probability of sustaining damage, the minimum and maximum damage estimated value for that facility type is presented.

As a result of a 500-Year MRP event, Hazus estimates that the functionality of critical facilities and lifelines in Livingston County can decrease as low as nine percent. Table 5.4.2-14 summarizes the damage state probabilities for critical facilities and lifelines during the 500-year MRP event.



Table 5.4.2-14. Estimated Damage for Critical Facilities 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
Essential Facilities									
EOC	99.9%	<0.1%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Medical Facilities	97.7% - 99.9%	0.1% - 2.2%	0.0% - <0.1%	0.0%	0.0%	97.7% - 99.8%	99.8% - 99.9%	99.9%	99.9%
Police Stations	94.5% - 99.7%	0.2% - 3.1%	0.1% - 2.0%	<0.1% - 0.4%	0.0%	94.5% - 99.6%	97.5% - 99.8%	99.6% - 99.9%	99.7% - 99.9%
Fire Stations/EMS	94.5% - 99.6%	0.3% - 3.1%	0.1% - 2.0%	<0.1% - 0.4%	0.0%	94.5% - 99.5%	97.5% - 99.8%	99.6% - 99.9%	99.7% - 99.9%
Schools	96.5% - 99.6%	0.3% - 2.3%	<0.1% - 1.1%	0.0% - 0.1%	0.0%	96.5% - 99.6%	98.7% - 99.9%	99.8% - 99.9%	99.9%
High Loss Facilities									
Military	99.7%	0.3%	<0.1%	0.0%	0.0%	99.7%	99.9%	99.9%	99.9%
Utilities									
Communication	91.0% - 99.9%	0.1% - 5.6%	0.0% - 3.1%	0.0% - 0.4%	0.0%	98.1% - 99.9%	99.7% - 99.9%	99.9%	99.9%
Electric Power	94.5% - 99.5%	0.3% - 3.1%	0.1% - 2.0%	<0.1% - 0.4%	0.0%	96.2% - 99.6%	99.7% - 99.9%	99.9%	99.9%
Potable Water	91.1% - 99.9%	0.1% - 5.5%	0.0% - 3.0%	0.0% - 0.4%	0.0%	93.5% - 99.9%	99.4% - 99.9%	99.7% - 99.9%	99.8% - 99.9%
Wastewater	94.5% - 99.5%	0.3% - 3.1%	0.1% - 2.0%	<0.1% - 0.4%	0.0%	95.7% - 99.6%	99.4% - 99.9%	99.6% - 99.9%	99.9%
Transportation									
Airports	97.8% - 99.9%	<0.1% - 2.1%	0.0% - <0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Bus Facilities	97.7% - 99.9%	0.1% - 2.2%	0.0% - <0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Highway Bridges	99.9% - 100.0%	0.0% - <0.1%	0.0%	0.0%	0.0%	99.9% - 100.0%	99.9% - 100.0%	99.9% - 100.0%	99.9% - 100.0%

Source: Hazus v5.0; Livingston County Planning Partners 2021; HIFLD 2020; FEMA 2020

Notes: % - Percent; < - Less Than; MRP – Mean Return Period; EOC – Emergency Operations Center; EMS – Emergency Medical Services



Impact on the Economy

Earthquakes also have impacts on the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Hazus estimates building-related economic losses, including income losses (wage, rental, relocation, and capital-related losses) and capital stock losses (structural, non-structural, content, and inventory losses). Economic losses estimated by Hazus are summarized in Table 5.4.2-15.

Table 5.4.2-15. Building-Related Economic Losses from 500-Year MRP Earthquake Events

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Building and Content Losses	Wages Losses	Rental Losses	Capital-Related Loss
500-year MRP	\$92,400	\$882,200	\$7,751,800	\$358,700	\$237,700	\$147,600

Source: Hazus v5.0

Notes: MRP – Mean Return Period

Although the Hazus analysis did not compute damage estimates for individual roadway segments and railroad tracks, assumedly these features would undergo damage due to ground failure, resulting in interruptions of regional transportation and of distribution of materials. Losses to the community that would result from damage to lifelines could exceed costs of repair (FEMA 2012).

Earthquake events can also significantly affect road bridges, many of which provide the only access to certain neighborhoods. Because softer soils generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. Another key factor in degree of vulnerability is age of facilities and infrastructure, which correlates with standards in place at times of construction.

Hazus 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 (FEMA 2020).

For the 500-year MRP event, Hazus estimates a total of 2,124 tons of debris will be generated county-wide. Table 5.4.2-16 summarizes the estimated debris generated by the 500-year MRP event for each jurisdiction in Livingston County. The Village of Geneseo would experience the greatest amount of debris during the 500-year MRP earthquake event (i.e., 353 tons).

Table 5.4.2-16. Estimated Debris Generated by the 500-year MRP Earthquake Event

Jurisdiction	500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)
Avon (T)	54	12
Avon (V)	221	93
Caledonia (T)	44	8
Caledonia (V)	31	6
Conesus (T)	7	1
Dansville (V)	251	67
Geneseo (T)	49	11
Geneseo (V)	303	50
Groveland (T)	30	34
Leicester (T)	22	4
Leicester (V)	4	1
Lima (T)	44	10



Jurisdiction	500-Year	
	Brick/Wood (tons)	Concrete/Steel (tons)
Lima (V)	24	6
Livonia (T)	120	21
Livonia (V)	18	3
Mount Morris (T)	20	4
Mount Morris (V)	188	51
North Dansville (T)	5	1
Nunda (T)	46	9
Nunda (V)	22	4
Ossian (T)	7	2
Portage (T)	21	4
Sparta (T)	9	3
Springwater (T)	7	1
West Sparta (T)	8	2
York (T)	133	25
Livingston County (Total)	1,689	435

Source: Hazus v5.0

Notes: T – Town; V – Village; MRP – Mean Return Period

Impact on the Environment

According to USGS, earthquakes can cause damage to the surface of the earth in various forms depending on the magnitude and distribution of the event (USGS n.d.). Surface faulting is one of the major seismic components to earthquakes that can create wide ruptures in the ground. Ruptures can have a direct impact on the landscape and natural environment because they can disconnect habitats for miles isolating animal species or tear apart plant roots.

Furthermore, ground failure, as a result of soil liquefaction, can have an impact on soil pores and retention of water resources (USGS 2020). The greater the seismic activity and liquefaction properties of the soil, the more likely drainage of groundwater can occur which depletes groundwater resources. In areas with higher pressure of groundwater retention, the pores can build up more pressure and make soil behave more like a fluid rather than a solid, increasing risk of localized flooding and deposition or accumulation of silt (USGS 2021).

Cascading Impacts to Other Hazards

The Global Geoengineering Research Group in USGS has been investigating the relationship earthquakes have with ground deformation, ground failure, and coastal erosion (USGS 2020). As mentioned in earlier sections, soft and loose soils are more susceptible to earthquake events. Ground failure can become exacerbated due to earthquake events, causing land sliding and coastal erosion. Areas of steep slopes are at greater risk of ground failure and potential erosion during earthquakes (USGS 2020).

Further, residual impacts from earthquakes could alter the floodplain extent for the county if ground failure and erosion occur. Damage could occur at coastal levees or canals may become breached as a result of an earthquake event, which could create flooding in the impacted areas.

Future Changes that May Impact Vulnerability

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

- Potential or projected development





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

Projected Development

As discussed and illustrated in Section 4 (County Profile), areas targeted for future growth and development have been identified across the County. Development built in areas with softer NEHRP soil classes, liquefaction, and landslide-susceptible areas may experience shifting or cracking in the foundation during earthquakes because of the loose soil characteristics of these soil classes. However, 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 to lower construction standards. Refer to Section 4, and Volume II Section 9 for more information about the potential new development in Livingston County.

Projected Changes in Population

According to the 2019 American Community Survey 5-year population estimates, the population of the County has decreased by approximately 3-percent since 2010. Although the population of Livingston County has decreased, persons that move into older buildings may increase their overall vulnerability to earthquakes. As noted earlier, if moving into new construction, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts.

Climate Change

Because the impacts of climate change on earthquakes are not well understood, a change in the County’s vulnerability as the climate continues to change is difficult to determine. However, climate change has the potential to magnify secondary impacts of earthquakes. As a result of the climate change projections discussed above, the County’s assets located on areas of saturated soils and on or at the base of steep slopes, are at a higher risk of landslides/mudslides because of seismic activity.

Change of Vulnerability since the 2015 HMP

Since the 2015 HMP, population statistics have been updated using the 5-Year 2015-2019 American Community Survey Population Estimates. The general building stock was also updated using 2021 building footprint and tax assessor data from Livingston County. Furthermore, the replacement cost values of the building inventory were updated using 2021 RS Means values. 2021 critical facility inventory data provided by the Livingston County Planning Partners and the Homeland Infrastructure Foundation-Level Data (HIFLD) were used to assess the number of critical facilities and lifelines at risk to ground shaking and the 500-year MRP earthquake event. The building stock and critical facility inventories created for this HMP were assessed in Hazus v5.0 to determine the effects of a 500-year MRP event.

Overall, this vulnerability assessment uses a more precise and thorough approach, which provides increased accuracy for estimated exposure and potential losses for Livingston County.