8. EARTHQUAKE

8.1 HAZARD PROFILE

8.1.1 Hazard Description

An earthquake is the vibration of the earth's surface following a release of energy in the earth's crust. This energy can be generated by a sudden dislocation of the crust or by a volcanic eruption. Most destructive quakes are caused by dislocations of the crust. The crust may first bend and then, when the stress exceeds the strength of the rocks, break and snap to a new position. The process of breaking generates vibrations called seismic waves. These waves travel outward from the source of the earthquake at varying speeds and ultimately result in potentially damaging movement of the earth's surface.

Earthquake Geology

Tectonic Plates

The earth's crust, which is the rigid outermost shell of the planet, is broken into seven or eight major tectonic plates (depending on how they are defined) and many minor plates. Where the plates meet, they move in one of three ways along their mutual boundary: convergent (two plates moving toward one another), divergent (two plates moving apart), or transform (two plates moving parallel to one another). Earthquakes, volcanic activity, mountain-building, and oceanic trench formation occur along these plate boundaries. Subduction is a geological process that takes place at convergent boundaries of tectonic plate, in which one plate moves under another. Regions where this process occurs are known as subduction zones, and they have the potential to generate highly damaging earthquakes.

Faults

Geologists have found that earthquakes reoccur along faults, which are zones of weakness in the earth's crust. When a fault experiences an earthquake, there is no guarantee that all the stress has been relieved. Another earthquake can still occur. In fact, relieving stress along one part of a fault may increase it in another part.

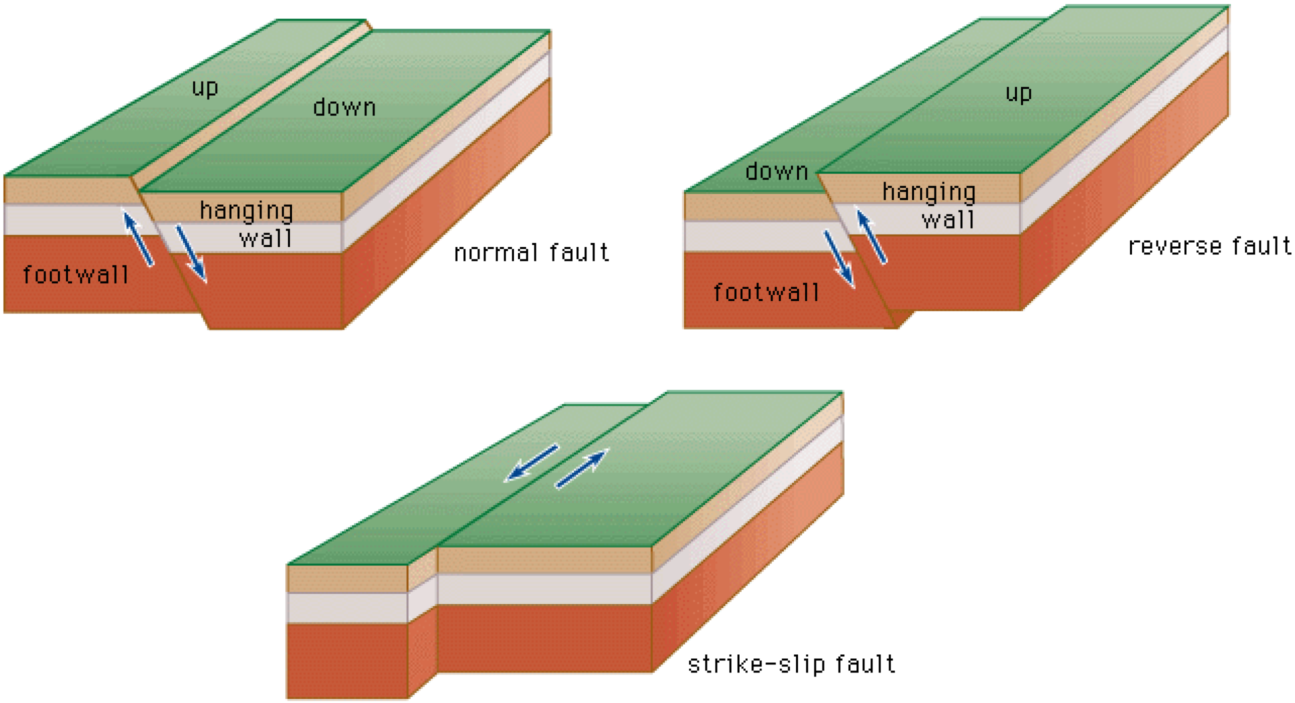
Faults are more likely to have future earthquakes on them if they have more rapid rates of movement, have had recent earthquakes along them, experience greater total displacements, and are aligned so that movement can relieve the accumulating tectonic stresses. Geologists classify faults by their relative hazards. "Active" faults, which represent the highest hazard, are those that have ruptured to the ground surface during the Holocene period (about the last 11,000 years). "Potentially active" faults are those that displaced layers of rock from the Quaternary period (the last 1,800,000 years) (Machette 2000).

Earthquake-Related Hazards

An earthquake hazard is anything associated with an earthquake that may affect people's normal activities. This includes the following (Earthquake Hazard Program n.d.):

- **Surface Faulting**—Displacement that reaches the earth's surface during slip along a fault. Commonly occurs with shallow earthquakes, those with an epicenter less than 12 miles. Figure 8-1 illustrates three types of surface faults.

Figure 8-1. Surface Fault Types



Source: Encyclopedia Britannica, Inc., 1994

- **Ground Motion (shaking)**—The movement of the earth's surface produced by waves that are generated by sudden slip on a fault and travel through the earth from the fault to the surface.
- **Liquefaction**—A process by which water-saturated soils temporarily lose strength and act as a fluid. Earthquake shaking can cause this effect. When liquefaction occurs, the strength of the soil decreases and the soil's ability to support foundations for buildings and bridges is reduced. Liquefaction has been responsible for tremendous amounts of damage in historical earthquakes around the world.

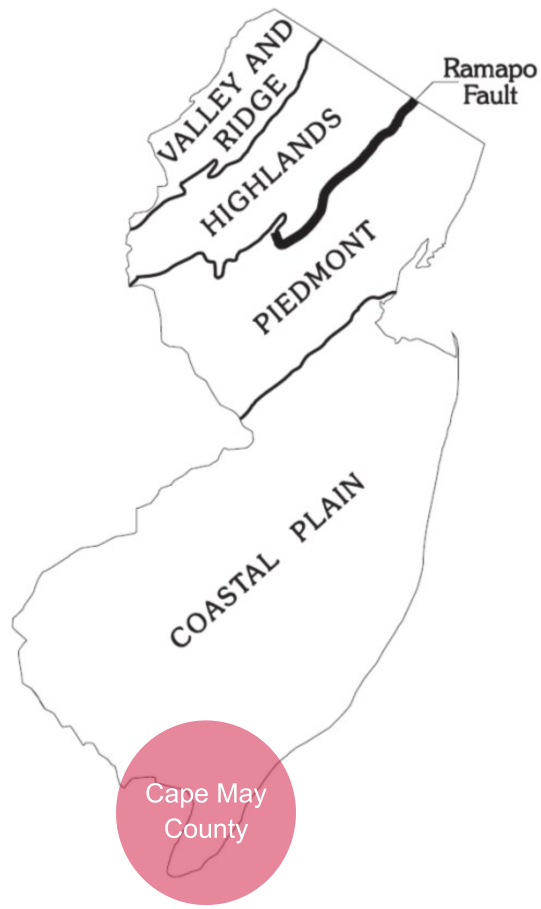
Shaking behavior and liquefaction susceptibility of soils are determined by their grain size, thickness, compaction, and degree of saturation. These properties, in turn, are determined by the geologic origin of the soils and their topographic position. Earthquake damage is least likely on rock or dense soils that resist motion and most likely on softer soils that can amplify ground shaking because they are susceptible to movement and liquefaction. One contributor to this amplification is the velocity at which the rock or soil transmits shear waves. The National Earthquake Hazard Reductions Program (NEHRP) has classified soils as follows, based on their shear-wave velocity:

- A—Hard Rock (greatest shear-wave velocity and least amplification of earthquake impacts)
- B—Rock
- C—Very dense soil and soft rock
- D—Stiff soils
- E—Soft soils (lowest shear-wave velocity and greatest amplification of earthquake impacts)
- F—Special soil requiring site-specific analysis

8.1.2 Location

Earthquakes in New Jersey are most likely in the northern part of the state where significant fault lines are concentrated. Most earthquakes in the state have occurred along faults in the central and eastern Highlands, with the Ramapo fault being the most seismically active fault in the region. The Ramapo Fault separates the Piedmont and Highlands Physiographic Provinces, as shown in Figure 8-2. Due to the distance between the Ramapo Fault and Cape May County, the County will likely not feel the effects of an earthquake along the Ramapo Fault due to its proximity (Volkert and Witte 2015).

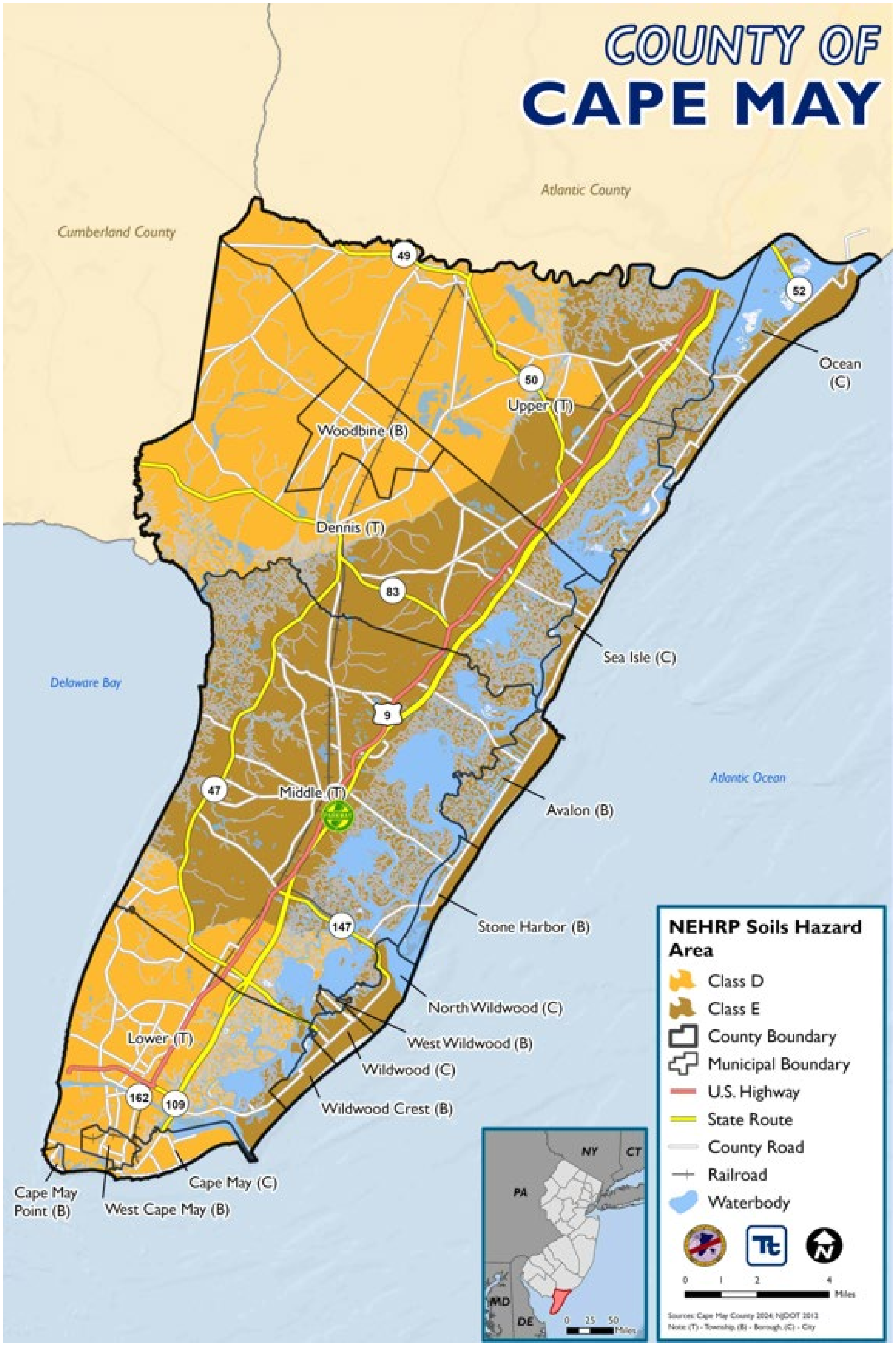
Figure 8-2. Physiographic Provinces of New Jersey and the Ramapo Fault Line



Source: Dombroski 1973 (revised 2005)

The New Jersey Department of Transportation (NJDOT) developed a Geotechnical Database Management System, which contains soil boring data across New Jersey. The soil boring logs were used to classify soil sites. Through this analysis, NJDOT developed a map of soil site classes according to ZIP codes in the state where each ZIP code was assigned a class based on its predominant soil condition. In Cape May County, most ZIP codes were classified as “C,” and a few were rated as “D”, as shown in Figure 8-3 (NJOEM 2024).

Figure 8-3. NEHRP Soils in Cape May County



8.1.3 Extent

The severity of an earthquake can be determined by factors such as amount of seismic energy released; duration of shaking; depth of focus (hypocenter); distance from epicenter; geological, geographic, and topographic setting; population and building density; and even time of day (Reger 2023). These factors define earthquake magnitude and intensity. The magnitude is the energy released at the location of the earthquake-generating event. Intensity is the earthquake energy felt at any given location within the range of the earthquake's impacts. An earthquake has only one magnitude and one epicenter, but its intensity varies throughout the region, depending on the distance from the earthquake, local rock and soil conditions, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust.

Magnitude

Earthquake magnitude is commonly expressed by ratings on the moment magnitude scale (M_W). 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 (U.S. Geological Survey 2021):

- 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

Intensity

The Modified Mercalli Scale is the most commonly used scale of earthquake intensity. Ratings of the scale, as well as the perceived shaking and damage potential for structures, are shown in Table 8-1. Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in Table 8-2.

Ground Motion

During an earthquake when the ground is shaking, it also experiences acceleration. Instruments called seismometers record levels of ground acceleration due to earthquakes at stations throughout a region. From this data, estimates are developed of the annual probability that certain ground motion accelerations will be exceeded (USGS 2019). The most commonly mapped ground motion parameters are horizontal and vertical peak ground accelerations (PGA) for a given soil type. PGA is a measure of how hard the earth shakes, or accelerates, in a given geographic area. PGA is measured as a percentage of the acceleration due to gravity (%g). These readings are recorded by state and federal agencies that monitor and predict seismic activity (USGS 2019).

Maps of PGA values form the basis of seismic zone maps that are included in building codes such as the International Building Code. Building codes that include seismic provisions specify the horizontal force due to lateral acceleration that a building should be able to withstand during an earthquake. Short-period seismic motions are of concern for smaller structures such as single-family dwellings. Longer period response components determine the lateral forces that damage larger structures (apartment buildings, factories, high-rises, bridges) (USGS 2019). Table 8-3 lists damage potential and perceived shaking by PGA factors, compared to the Mercalli scale.

Table 8-1. Modified Mercalli Scale

Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like passing truck.
V	Felt by almost everyone, some people awakened. Small objects move; trees and poles may shake.
VI	Felt by everyone; people have trouble standing. Heavy furniture can move; plaster can fall off walls. Chimneys may be slightly damaged.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Some walls collapse.
IX	Considerable damage to specially built structures; buildings shift off their foundations. The ground cracks. Landslides may occur.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. The ground cracks in large areas.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Source: USGS 1989

Table 8-2. Damage Levels Experienced in Earthquakes

Ground Motion	Explanation of Damages
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 poor 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: NJOEM 2024

Note: %g = Peak Ground Acceleration as a percentage of the acceleration due to gravity

Table 8-3. Modified Mercalli Scale and PGA Equivalents

Mercalli Intensity	PGA (%g)	Perceived Shaking	Potential Damage
I	<0.17%	Not Felt	None
II-III	0.17% - 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 - XII	>124%	Extreme	Very Heavy

Source: USGS 1989

National Seismic Hazard Map

USGS has developed National Seismic Hazard Maps that provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning. The 2023 map, shown in Figure 9-6, represents the best currently available data as determined by the USGS.

Shake Maps

The USGS Earthquake Hazards Program produces maps called ShakeMaps that map ground motion and shaking intensity following significant earthquakes. ShakeMaps focus on the ground shaking caused by the earthquake, rather than on characteristics of the earthquake source, such as magnitude and epicenter. A ShakeMap shows the extent and variation of ground shaking across the surrounding region following significant earthquakes. Such mapping is derived from peak ground acceleration amplitudes recorded on seismic sensors, with interpolation where data is lacking based on estimated amplitudes. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. In addition to the maps of recorded events, the USGS creates the following:

- Scenario ShakeMaps of hypothetical earthquakes of an assumed magnitude on known faults.
- Probabilistic ShakeMaps, based on predicted shaking from earthquakes over a 10,000-year period. In a probabilistic map, information is combined to make a forecast for the future. The maps indicate the ground motion at any given point that has a given probability of being exceeded in a given timeframe.

8.1.4 Previous Occurrences

FEMA Major Disaster and Emergency Declarations

Between 1954 and 2025, Cape May County was not included in any disaster (DR) or emergency (EM) declarations for geological-related events (FEMA 2025).

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in contiguous counties. Between August 2019 and March 2025, Cape May County was not included in any USDA geologic-related agricultural disaster declarations.

Previous Events

There has not been any reported earthquake events in Cape May County from August 2019 to March 2025. However, according to the USGS Did You Feel It? map, there is at least one record of having a felt an earthquake in Cape May County associated within an earthquake which was epi-centered in Tuckerton, New Jersey (Burlington County) on June 9, 2021 (USGS 2024).

8.1.5 Probability of Future Occurrences

Historically, the State of New Jersey and Cape May County have not experienced a major geological hazard event. However, there have been a number of earthquakes of relatively low intensity. The majority of earthquakes that have occurred in New Jersey have occurred along faults in the central and eastern Highlands, with the Ramapo fault being the most seismically active fault in the region (Volkert and Witte 2015). Small earthquakes may occur several times a year and generally do not cause significant damage.

The probability of future occurrences was calculated for geological hazards, as shown in Table 8-4. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for earthquake in the County is considered '*rare*'.

Table 8-4. Probability of Future Earthquake Events in Cape May County

Hazard Type	Number of Occurrences Between 1954 and 2025	Percent Chance of Occurring in Any Given Year
Earthquake	0	0.00%

Source: NOAA-NCEI 2024, NJDEP 2024, USGS 2024; NJOEM 2024

Climate Change Projections

Predicting the potential impacts of global climate change on earthquake probability is challenging. It is not well understood how change in the climate is or is not related to seismic activity. Some scientists believe melting glaciers could induce tectonic activity. As ice melts and water runs off, massive amounts of weight are shifted on the Earth's crust. As newly freed crust may alter shape, it could cause seismic plates to slip (NJOEM 2024).

Scientists know earthquakes can be triggered or inhibited by changes in the amount of stress on a fault. Climate variables that could alter fault stress loads include rain and snowfall, drought, and groundwater depletion, although the potential magnitude of these variables is unclear. Additionally, secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms or sea level rise could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts (NJOEM 2024).

8.1.6 Cascading Impacts on Other Hazards

Earthquakes can cause large and sometimes disastrous landslides and mudslides, as they create stresses that make weak slopes fail. Any steep slope is vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils.

Earthen dams are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes. The most common mode of earthquake-induced dam failure is slumping or settlement of earth-fill dams where the fill has not been property compacted. If the slumping occurs when the dam is full, then overtopping of the dam, with rapid erosion leading to dam failure is possible. Dam failure is also possible if strong ground motions heavily damage concrete dams. Earthquake-induced landslides into reservoirs have also caused dam failures.

8.2 VULNERABILITY AND IMPACT ASSESSMENT

Ground shaking is the primary cause of earthquake damage to structures, and soft soils amplify ground shaking. The National Earthquake Hazard Reductions Program (NEHRP) has developed soil classifications defined by their ability to amplify ground shaking. The soil classification system ranges from Type A to Type E, where Type A represents hard rock that reduces ground motions from an earthquake and Type E represents soft soils that amplify ground shaking and increase building damage (an additional classification, Type F, represents soils with special circumstances that require additional analysis for seismic evaluations). Types D and E are the NEHRP soil types most susceptible to amplified ground motion during an earthquake.

A vulnerability analysis was conducted for the county's assets using NEHRP soil data sourced from NJDOT 2012. The vulnerability analysis defined the hazard area as all areas with Type D and E soil types (the two most vulnerable soil types present in Cape May County). Assets with their centroid in the hazard areas were totaled to estimate the numbers and values vulnerable to these soil types.

8.2.1 Life, Health, and Safety

Overall Population

The entire County may experience the impacts of an earthquake. However, the degree of impact is dependent on many factors including the age and type of construction people live in, the soil type(s) which 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.

Overall, the 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. NEHRP Soil Classes D and E amplify ground shaking to damaging levels even during a moderate earthquake and thus increase risk to the population.

As shown on Figure 8-3 the hazard area for this analysis, defined as areas of NEHRP Type D and E soils, covers all of Cape May County. As shown in Table 8-5, 37,195 persons live within the NEHRP Soils Class D hazard areas. The Township of Lower has the greatest population in the hazard area with 20,809 people. As shown in Table 8-6, 57,954 persons live within the NEHRP Soils Class E hazard areas. The Township of Middle has the greatest population in the hazard area with 15,162 people.

Table 8-5. Estimated Population Living in the NEHRP Soils Class D and E Hazard Areas

Jurisdiction	Total Population (U.S. Census Bureau 2020 Decennial)	Population in the NEHRP Class D Soils Hazard Area	
		Number of Persons	% of Jurisdiction Total
Avalon (B)	1,243	0	0.0%
Cape May (C)	2,768	2,768	100.0%
Cape May Point (B)	305	304	99.7%
Dennis (T)	6,285	2,140	34.0%
Lower (T)	22,057	20,809	94.3%
Middle (T)	20,380	5,176	25.4%
North Wildwood (C)	3,621	0	0.0%
Ocean (C)	11,229	0	0.0%
Sea Isle (C)	2,104	0	0.0%
Stone Harbor (B)	796	0	0.0%
Upper (T)	12,539	2,860	22.8%
West Cape May (B)	1,010	1,010	100.0%
West Wildwood (B)	540	0	0.0%
Wildwood (C)	5,157	0	0.0%
Wildwood Crest (B)	3,101	0	0.0%
Woodbine (B)	2,128	2,128	100.0%
Cape May County	**95,263**	**37,195**	**39.0%**

Source: U.S. Census Bureau 2020; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

Table 8-6. Estimated Population Living in the NEHRP Soils Class E and E Hazard Areas

Jurisdiction	Total Population (U.S. Census Bureau 2020 Decennial)	Population in the NEHRP Class E Soils Hazard Area	
		Number of Persons	% of Jurisdiction Total
Avalon (B)	1,243	1,236	99.4%
Cape May (C)	2,768	0	0.0%
Cape May Point (B)	305	0	0.0%
Dennis (T)	6,285	4,144	65.9%
Lower (T)	22,057	1,238	5.6%
Middle (T)	20,380	15,162	74.4%
North Wildwood (C)	3,621	3,619	99.9%
Ocean (C)	11,229	11,218	99.9%
Sea Isle (C)	2,104	2,097	99.7%
Stone Harbor (B)	796	791	99.4%
Upper (T)	12,539	9,676	77.2%
West Cape May (B)	1,010	0	0.0%
West Wildwood (B)	540	534	98.9%
Wildwood (C)	5,157	5,144	99.7%
Wildwood Crest (B)	3,101	3,088	99.6%
Woodbine (B)	2,128	0	0.0%
Cape May County	**95,263**	**57,947**	**60.8%**

Source: U.S. Census Bureau 2020; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

Socially Vulnerable Population

Table 8-7 and Table 8-8 present the estimated socially vulnerable populations located within the NEHRP Soils Class D and E hazard areas, respectively. There are 26,529 persons over the age of 65 years, 4,117 persons under the age of 5 years, 1,408 non-English speakers, 14,049 persons with a disability, and 8,443 living in poverty located in NEHRP Class D soil hazard area. The Township of Lower has the highest population of persons over the age of 65 (94.3%), persons under the age of 5 (94.3%), persons with disability (94.3%), and persons living in poverty (5.6%) located in the NEHRP Class D soil hazard area. Township of Middle has the highest population of non-English speakers (25.4%) located in the NEHRP Class D soil hazard area.

There are 26,529 persons over the age of 65 years, 4,117 persons under the age of 5 years, 1,408 non-English speakers, 14,049 persons with a disability, and 8,443 living in poverty located in NEHRP Class E soil hazard area. The Township of Lower has the highest population of persons over the age of 65 (5.6%), persons under the age of 5 (5.6%), persons with disability (5.6%), and persons living in poverty (5.6%) located in the NEHRP Class E soil hazard area. Township of Middle has the highest population of non-English speakers (74.3%) located in the NEHRP Class E soil hazard area.

Table 8-7. Estimated Vulnerable Persons Located in the NEHRP D Soils Hazard Area

Jurisdiction	Estimated Number of Vulnerable Persons Located in the NEHRP D Soils Hazard Area (American Community Survey 2022)									
	Persons Over 65	% of Total	Persons Under 5	% of Total	Non-English Speaking Persons	% of Total	Persons with a Disability	% of Total	Persons in Poverty	% of Total
Avalon (B)	764	0.0%	21	0.0%	0	0.0%	160	0.0%	71	0.0%
Cape May (C)	774	99.9%	139	99.3%	43	97.2%	167	100.0%	139	99.3%
Cape May Point (B)	118	99.2%	0	0.0%	0	0.0%	43	97.7%	26	96.2%
Dennis (T)	1,305	34.0%	483	34.0%	35	31.8%	596	33.9%	325	33.8%
Lower (T)	5,517	94.3%	1,111	94.3%	218	94.0%	3,632	94.3%	2,369	94.3%
Middle (T)	4,833	25.4%	956	25.3%	497	25.4%	2,971	25.4%	1,783	25.4%
North Wildwood (C)	1,693	0.0%	0	0.0%	0	0.0%	702	0.0%	267	0.0%
Ocean (C)	3,821	0.0%	206	0.0%	41	0.0%	1,477	0.0%	1,142	0.0%
Sea Isle (C)	1,028	0.0%	6	0.0%	13	0.0%	263	0.0%	113	0.0%
Stone Harbor (B)	455	0.0%	19	0.0%	0	0.0%	83	0.0%	57	0.0%
Upper (T)	3,035	22.8%	709	22.7%	65	21.6%	1,177	22.8%	221	22.6%
West Cape May (B)	367	100.0%	42	97.6%	11	92.6%	126	100.0%	27	96.3%
West Wildwood (B)	179	0.0%	35	0.0%	0	0.0%	107	0.0%	18	0.0%
Wildwood (C)	799	0.0%	185	0.0%	374	0.0%	1,110	0.0%	903	0.0%
Wildwood Crest (B)	1,346	0.0%	56	0.0%	0	0.0%	673	0.0%	336	0.0%
Woodbine (B)	495	99.8%	149	100.0%	112	99.7%	762	100.0%	646	100.0%
Cape May County	**26,529**	**35.1%**	**4,117**	**47.2%**	**1,408**	**36.9%**	**14,049**	**40.9%**	**8,443**	**43.6%**

Source: U.S. Census Bureau, American Community Survey 2018-2022; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

Table 8-8. Estimated Vulnerable Persons Located in the NEHRP E Soils Hazard Area

Jurisdiction	Estimated Number of Vulnerable Persons Located in the NEHRP E Soils Hazard Area (American Community Survey 2022)									
	Persons Over 65	% of Total	Persons Under 5	% of Total	Non-English Speaking Persons	% of Total	Persons with a Disability	% of Total	Persons in Poverty	% of Total
Avalon (B)	764	99.3%	21	95.2%	0	0.0%	160	99.4%	71	98.6%
Cape May (C)	774	0.0%	139	0.0%	43	0.0%	167	0.0%	139	0.0%
Cape May Point (B)	118	0.0%	0	0.0%	0	0.0%	43	0.0%	26	0.0%
Dennis (T)	1,305	65.9%	483	65.8%	35	66.6%	596	65.9%	325	65.8%
Lower (T)	5,517	5.6%	1,111	5.6%	218	5.5%	3,632	5.6%	2,369	5.6%
Middle (T)	4,833	74.4%	956	74.4%	497	74.3%	2,971	74.4%	1,783	74.4%
North Wildwood (C)	1,693	99.9%	0	0.0%	0	0.0%	702	99.9%	267	99.6%
Ocean (C)	3,821	99.9%	206	99.5%	41	97.5%	1,477	99.9%	1,142	99.8%
Sea Isle (C)	1,028	99.6%	6	83.3%	13	92.6%	263	99.6%	113	99.1%
Stone Harbor (B)	455	99.3%	19	94.7%	0	0.0%	83	98.8%	57	98.2%
Upper (T)	3,035	77.2%	709	77.2%	65	77.2%	1,177	77.1%	221	76.9%
West Cape May (B)	367	0.0%	42	0.0%	11	0.0%	126	0.0%	27	0.0%
West Wildwood (B)	179	98.9%	35	97.1%	0	0.0%	107	98.1%	18	94.4%
Wildwood (C)	799	99.7%	185	99.5%	374	99.8%	1,110	99.7%	903	99.7%
Wildwood Crest (B)	1,346	99.6%	56	98.2%	0	0.0%	673	99.6%	336	99.4%
Woodbine (B)	495	0.0%	149	0.0%	112	0.0%	762	0.0%	646	0.0%
Cape May County	**26,529**	**64.7%**	**4,117**	**52.4%**	**1,408**	**62.4%**	**14,049**	**58.9%**	**8,443**	**56.1%**

Source: U.S. Census Bureau, American Community Survey 2018-2022; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

8.2.2 General Building Stock

When earthquakes occur, they can significantly impact physical structures, especially those located at the epicenter. However, the effects of ground shaking can extend over large areas, affecting numerous buildings. Older structures are particularly vulnerable due to less stringent building codes at the time of their construction and potential maintenance issues. The severity of the impacts also depends on the occupancy and timing of the earthquake. For example, if an earthquake strikes at 2 a.m., the primary concern is the impact on residential buildings. Conversely, an earthquake at 2 p.m. would raise more concerns for commercial, industrial, and educational buildings.

Table 8-9 and Table 8-10 display the buildings by general occupancy located within the NEHRP D and E hazard area. The exposure analysis estimates that the residential occupancy is the most exposed hazard area with 33,011 total buildings in NEHRP D soil and 69,953 in NEHRP E soil. The Township of Lower holds the highest number of resident buildings (17,639) in the NEHRP D hazard area. Ocean City holds the highest number of resident buildings (17,807) in the NEHRP E hazard area.

Table 8-9. Buildings in the NEHRP D Soils Hazard Area by General Occupancy

Jurisdiction	Buildings in the NEHRP D&E Soils Hazard Area by General Occupancy Class			
	Residential	Commercial	Industrial	Other
Avalon (B)	0	0	0	0
Cape May (C)	4,056	447	0	145
Cape May Point (B)	779	60	0	11
Dennis (T)	1,972	234	0	249
Lower (T)	17,639	6,081	0	404
Middle (T)	3,732	1,230	1	188
North Wildwood (C)	0	0	0	0
Ocean (C)	0	0	0	0
Sea Isle (C)	0	0	0	0
Stone Harbor (B)	0	0	0	0
Upper (T)	1,814	367	1	89
West Cape May (B)	1,377	344	0	39
West Wildwood (B)	0	0	0	0
Wildwood (C)	0	0	0	0
Wildwood Crest (B)	0	0	0	0
Woodbine (B)	1,642	211	7	247
Cape May County	**33,011**	**8,974**	**9**	**1,372**

Source: Cape May County 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township
Other = Government, Religion, Agricultural, and Education structures

Table 8-10. Buildings in the NEHRP E Soils Hazard Area by General Occupancy

Jurisdiction	Buildings in the NEHRP D&E Soils Hazard Area by General Occupancy Class			
	Residential	Commercial	Industrial	Other
Avalon (B)	5,783	834	0	44
Cape May (C)	0	0	0	0
Cape May Point (B)	0	0	0	0
Dennis (T)	3,818	2,321	0	106
Lower (T)	1,050	158	0	31
Middle (T)	10,932	3,746	5	812
North Wildwood (C)	4,598	1,143	0	98
Ocean (C)	17,807	1,250	1	156
Sea Isle (C)	6,634	726	0	36
Stone Harbor (B)	3,786	371	0	21
Upper (T)	6,136	2,391	12	122
West Cape May (B)	0	0	0	0
West Wildwood (B)	777	121	0	10
Wildwood (C)	3,262	1,057	9	104
Wildwood Crest (B)	5,370	740	0	28
Woodbine (B)	0	0	0	0
Cape May County	**69,953**	**14,858**	**27**	**1,568**

Source: Cape May County 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township
Other = Government, Religion, Agricultural, and Education structures

There are 130,012 buildings with a replacement cost value of approximately $237 billion built on lands in the NEHRP D soil hazard area. The Township of Lower has the greatest number of buildings built in the NEHRP D Soil hazard area; 24,124 buildings (95 percent of its total building stock) with an estimated replacement cost of $20 billion. Table 8-11 summarizes the number of buildings built on the NEHRP D Soil hazard area and the total replacement cost of these buildings by jurisdiction.

There are 130,012 buildings with a replacement cost value of approximately $237 billion built on lands in the NEHRP E soil hazard area. Ocean City has the greatest number of buildings built in the NEHRP E Soil hazard area; 19,214 buildings (99.9 percent of its total building stock) with an estimated replacement cost of $44 billion. Table 8-12 summarizes the number of buildings built on the NEHRP E Soil hazard area and the total replacement cost of these buildings by jurisdiction.

Table 8-11. Replacement Cost Values of Buildings in the NEHRP D Soils Hazard Area

Jurisdiction	Jurisdiction Total Buildings		Buildings in the NEHRP D Soils Hazard Area			
			Number of Buildings		Replacement Cost Value	
	Count	Replacement Cost Value	Count	% of Jurisdiction Total	Value	% of Jurisdiction Total
Avalon (B)	6,696	$25,723,512,232	0	0.0%	$0	0.0%
Cape May (C)	4,650	$16,203,622,284	4,648	100.0%	$16,202,019,663	100.0%
Cape May Point (B)	850	$1,686,539,666	850	100.0%	$1,686,539,666	100.0%
Dennis (T)	8,700	$8,299,131,210	2,455	28.2%	$2,496,178,153	30.1%
Lower (T)	25,387	$22,775,836,898	24,124	95.0%	$20,878,316,351	91.7%
Middle (T)	20,691	$27,392,475,766	5,151	24.9%	$6,170,479,627	22.5%
North Wildwood (C)	5,843	$11,753,681,214	0	0.0%	$0	0.0%
Ocean (C)	19,235	$44,649,077,467	0	0.0%	$0	0.0%
Sea Isle (C)	7,416	$23,896,778,328	0	0.0%	$0	0.0%
Stone Harbor (B)	4,202	$8,177,015,155	0	0.0%	$0	0.0%
Upper (T)	10,936	$14,864,714,357	2,271	20.8%	$2,862,701,789	19.3%
West Cape May (B)	1,760	$2,893,441,733	1,760	100.0%	$2,893,441,732	100.0%
West Wildwood (B)	920	$1,064,788,340	0	0.0%	$0	0.0%
Wildwood (C)	4,460	$12,875,631,194	0	0.0%	$0	0.0%
Wildwood Crest (B)	6,159	$11,797,908,652	0	0.0%	$0	0.0%
Woodbine (B)	2,107	$3,249,453,892	2,107	100.0%	$3,249,453,892	100.0%
Cape May County	**130,012**	**$237,303,608,388**	**43,366**	**33.4%**	**$56,439,130,873**	**23.8%**

Source: Cape May County 2024; RS Means 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

Table 8-12. Replacement Cost Values of Buildings in the NEHRP E Soils Hazard Area

Jurisdiction	Jurisdiction Total Buildings		Buildings in the NEHRP E Soils Hazard Area			
			Number of Buildings		Replacement Cost Value	
	Count	Replacement Cost Value	Count	% of Jurisdiction Total	Value	% of Jurisdiction Total
Avalon (B)	6,696	$25,723,512,232	6,661	99.5%	$25,444,134,493	98.9%
Cape May (C)	4,650	$16,203,622,284	0	0.0%	$0	0.0%
Cape May Point (B)	850	$1,686,539,666	0	0.0%	$0	0.0%
Dennis (T)	8,700	$8,299,131,210	6,245	71.8%	$5,802,953,057	69.9%
Lower (T)	25,387	$22,775,836,898	1,239	4.9%	$1,864,951,115	8.2%
Middle (T)	20,691	$27,392,475,766	15,495	74.9%	$21,202,289,855	77.4%
North Wildwood (C)	5,843	$11,753,681,214	5,839	99.9%	$11,749,004,347	100.0%
Ocean (C)	19,235	$44,649,077,467	19,214	99.9%	$44,613,187,875	99.9%
Sea Isle (C)	7,416	$23,896,778,328	7,396	99.7%	$23,880,592,648	99.9%
Stone Harbor (B)	4,202	$8,177,015,155	4,178	99.4%	$8,150,872,253	99.7%
Upper (T)	10,936	$14,864,714,357	8,661	79.2%	$11,997,979,822	80.7%
West Cape May (B)	1,760	$2,893,441,733	0	0.0%	$0	0.0%
West Wildwood (B)	920	$1,064,788,340	908	98.7%	$1,050,093,459	98.6%
Wildwood (C)	4,460	$12,875,631,194	4,432	99.4%	$12,852,737,072	99.8%
Wildwood Crest (B)	6,159	$11,797,908,652	6,138	99.7%	$11,783,749,452	99.9%
Woodbine (B)	2,107	$3,249,453,892	0	0.0%	$0	0.0%
Cape May County	**130,012**	**$237,303,608,388**	**86,406**	**66.5%**	**$180,392,545,448**	**76.0%**

Source: Cape May County 2024; RS Means 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

8.2.3 Community Lifelines and Other Critical Facilities

Understanding the potential impacts of earthquakes and landslides on community lifelines is crucial for preparedness and resilience planning. These natural events can severely disrupt essential services such as power, water, transportation, and emergency response systems. When these facilities go offline, the community's ability to function and recover is significantly hindered. The following quantitative analysis explores the anticipated effects on various building types and the extent of damage expected under different scenarios. All critical facilities in Cape May County are considered exposed to the earthquake hazard.

In addition to buildings and facilities, earthquakes can severely impact roads and roadway infrastructure, which are included in the transportation lifeline. Table 8-13 and Table 8-14 show the total miles of evacuation routes within the County that is exposed to the NEHRP class D and E soils hazard area. There are 75 miles of evacuation routes within the County that are exposed to Class D soil hazard areas. Additionally, a significant portion of the evacuation routes, totaling 65.3%, are exposed to Class E soil hazards.

Table 8-13. Evacuation Routes Exposed to NEHRP Class D Soil Hazard Area

Total Miles of Evacuation Routes in the County	Total Miles of Evacuation Routes Exposed to the NEHRP Class D Soils Hazard Area	Percent of Total
224	75	33.6%

Source: Cape May County 2024; NJDOT 2012

Table 8-14. Evacuation Routes Exposed to NEHRP Class E Soil Hazard Area

Total Miles of Evacuation Routes in the County	Total Miles of Evacuation Routes Exposed to the NEHRP Class E Soils Hazard Area	Percent of Total
224	146	65.3%

Source: Cape May County 2024; NJDOT 2012

Table 8-15 and Table 8-16 show the number of critical facilities located in the NEHRP D and E soils hazard area for Cape May County, respectively. There are a total of 271 facilities located in this NEHRP D soil hazard area with the highest number among the Water Systems lifeline (82). The Township of Lower has the highest number of critical facilities (109) located in the NEHRP D soil hazard area. There are a total of 467 facilities located in this NEHRP E soil hazard area with the highest number among the Other Critical Facilities lifeline (121). The Township of Middle has the highest number of critical facilities (114) located in the NEHRP E soil hazard area.

Table 8-15. Number of Facilities in the NEHRP D Soils Hazard Area, by Lifeline Category

Jurisdiction	Number of Facilities in the NEHRP D & E Soils Hazard Area, by Lifeline Category									Total Facilities in Hazard Area	
	Communications	Energy	Food, Hydration, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Water Systems	Other Critical Facilities	Count	% of Jurisdiction Total
Avalon (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Cape May (C)	2	0	0	3	4	9	0	10	14	42	100.0%
Cape May Point (B)	0	0	0	0	0	4	0	5	1	10	100.0%
Dennis (T)	3	0	0	0	2	9	0	5	2	21	36.2%
Lower (T)	0	0	3	3	7	14	5	47	30	109	89.3%
Middle (T)	5	0	1	2	6	6	0	7	5	32	20.8%
North Wildwood (C)	0	0	0	0	0	0	0	0	0	0	0.0%
Ocean (C)	0	0	0	0	0	0	0	0	0	0	0.0%
Sea Isle (C)	0	0	0	0	0	0	0	0	0	0	0.0%
Stone Harbor (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Upper (T)	3	1	1	1	1	9	4	0	2	22	30.6%
West Cape May (B)	0	0	0	0	1	3	1	1	1	7	100.0%
West Wildwood (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Wildwood (C)	0	0	0	0	0	0	0	0	0	0	0.0%
Wildwood Crest (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Woodbine (B)	1	0	1	3	4	4	1	7	7	28	100.0%
Cape May County	**14**	**1**	**6**	**12**	**25**	**58**	**11**	**82**	**62**	**271**	**34.9%**

Source: Cape May County 2022,2024; HIFLD 2024; USACE 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

Table 8-16. Number of Facilities in the NEHRP E Soils Hazard Area, by Lifeline Category

Jurisdiction	Number of Facilities in the NEHRP D & E Soils Hazard Area, by Lifeline Category									Total Facilities in Hazard Area	
	Communications	Energy	Food, Hydration, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Transportation	Water Systems	Other Critical Facilities	Count	% of Jurisdiction Total
Avalon (B)	1	0	0	0	1	6	0	12	8	28	87.5%
Cape May (C)	0	0	0	0	0	0	0	0	0	0	0.0%
Cape May Point (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Dennis (T)	6	0	0	0	1	4	2	19	4	36	62.1%
Lower (T)	0	0	0	0	0	0	0	4	0	4	3.3%
Middle (T)	14	0	0	6	12	35	5	21	21	114	74.0%
North Wildwood (C)	6	0	1	0	3	13	0	4	8	35	100.0%
Ocean (C)	2	0	0	3	8	11	5	16	30	75	97.4%
Sea Isle (C)	0	0	0	1	2	5	0	11	9	28	96.6%
Stone Harbor (B)	3	0	0	0	1	5	1	7	7	24	92.3%
Upper (T)	6	2	1	3	9	7	2	4	12	46	63.9%
West Cape May (B)	0	0	0	0	0	0	0	0	0	0	0.0%
West Wildwood (B)	0	0	0	0	0	3	0	1	2	6	60.0%
Wildwood (C)	0	1	2	2	7	10	2	6	13	43	95.6%
Wildwood Crest (B)	14	0	0	0	1	4	0	2	7	28	96.6%
Woodbine (B)	0	0	0	0	0	0	0	0	0	0	0.0%
Cape May County	**52**	**3**	**4**	**15**	**45**	**103**	**17**	**107**	**121**	**467**	**60.2%**

Source: Cape May County 2022,2024; HIFLD 2024; USACE 2024; NJDOT 2012
Note: (B) Borough; (C) City; (T) Township

8.2.4 Economy

Earthquakes can cause direct and indirect impacts on the economy. Direct costs include the actual damage sustained by buildings, property, and infrastructure due to ground failure, which also threatens transportation corridors, fuel and energy conduits, and communication lines. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity may also occur, but are difficult to measure.

More specifically, earthquakes can have significant impacts on the economy, affecting various sectors and aspects of community life. According to the U.S. Geological Survey (USGS), the economic repercussions of earthquakes include the loss of business function, damage to inventory, and the costs associated with relocating businesses and residents. Additionally, there are substantial wage losses and rental losses due to the repair or replacement of damaged buildings. These disruptions not only affect individual businesses but also have a broader impact on the local tax base and overall economy, as the financial strain spreads through the community (USGS 2023).

Earthquakes can lead to a range of secondary effects. These include blocking access to roads, which can isolate residents and businesses, thereby delaying commercial, public, and private transportation. The obstruction of transportation routes can hinder emergency response efforts, disrupt supply chains, and impede daily commuting, exacerbating the economic and social challenges faced by affected areas (USGS 2017). It is critically important to understand and mitigate these risks to protect communities and reduce economic losses (USGS 2022).

8.2.5 Natural, Historic and Cultural Resources

Natural

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. 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 it can disconnect habitats for miles, isolating animal species or tear apart plant roots (USGS n.d.).

Furthermore, soil liquefaction can impact soil pores and retention of water resources. 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 where there is 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 n.d.).

Historic

In Cape May County, the primary concern for historic resources in the event of an earthquake is the potential damage from ground shaking and soil liquefaction. The County's historic landmarks and older buildings, many of which may not be built to modern seismic standards, are particularly vulnerable to earthquake damage. These structures are more susceptible to damage compared to newer infrastructure designed to withstand seismic activity.

Cultural

The primary concern for cultural resources in the event of an earthquake is the potential damage from ground shaking and soil liquefaction. The County’s cultural landmarks and older buildings, many of which may not be built to modern seismic standards, are particularly vulnerable to earthquake damage. These structures are more susceptible to damage compared to newer infrastructure designed to withstand seismic activity

8.3 FUTURE CHANGES THAT MAY AFFECT RISK

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The following sections examine potential conditions that may affect hazard vulnerability.

8.3.1 Potential or Planned Development

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.

8.3.2 Projected Changes in Population

An increase in population density can impact the number of persons exposed to geological hazard areas. Changes in density can not only create issues for local residents during evacuation of a landslide or ground failure event but can also have an effect on commuters that travel into and out of the County for work that breaches major transportation corridors, which are also major commuter roads. Persons that move into older buildings may increase their overall vulnerability to earthquakes. Those moving into newer construction may decrease their vulnerability.

8.3.3 Climate Change

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 from changes in the hydrograph could fail during seismic events. County assets in 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. There are currently no models available to estimate these impacts (NJOEM 2024).

8.3.4 Other Identified Conditions

The impacts of climate change on earthquakes are not well understood, making it difficult to determine changes in the County's vulnerability. However, climate change has the potential to magnify secondary impacts of earthquakes. As a result, the County's assets located on saturated soils and at the base of steep slopes are at higher risk of landslides and mudslides due to seismic activity.