4.4 Earthquakes

4.4.1 Description

Earthquakes are a result of a sudden movement of the Earth's crust and are caused by the abrupt rupture and rebound of accumulated stress along geologic faults. These movements vary in length and may last from a few seconds to several minutes.

The seismicity, or seismic activity, of an area refers to the frequency, type, and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The Moment Magnitude Scale (MMS), which was developed in the 1970s, is the most common scale on which earthquakes larger than approximately 5.0 in magnitude are reported for the entire world. Earthquakes smaller than magnitude 5.0, which are more numerous, are reported by national seismological observatories and measured most commonly on the local magnitude scale – also referred to as the Richter Scale. These two scales are numerically similar over their range of validity. Earthquakes of magnitude 3.0 or lower are often almost imperceptible or weak, while earthquakes of magnitude 7.0 or greater can potentially cause serious damage over larger areas.

Damage from an earthquake also depends on the earthquake's depth in the Earth's crust. The shallower an earthquake's epicenter, the more damage to structures it will cause. Alternatively, an earthquake can also be measured by its intensity. The Modified Mercalli Intensity Scale (MMI) ranges in value I to XII, in roman numerals (**Table 4.4.1**).

Major earthquakes are low-probability, high-consequence events. Most major earthquakes in the U.S. have occurred in California and other western states. There have been recorded earthquakes throughout the U.S., and the Ohio River Valley has experienced earthquakes exceeding the 3.0 magnitude within the last 25 years.

4.4.2 Location

Earthquakes are countywide hazards and can affect all areas and jurisdictions within Clinton County. According to the Ohio Department of Natural Resources, Ohio is located on the periphery of the New Madrid Seismic Zone, an area in and around Missouri that was the site of the largest earthquake sequence to occur in the country. Additionally, West Central Ohio is the area of Ohio with the highest risk for earthquakes in the State.

4.4.3 Extent

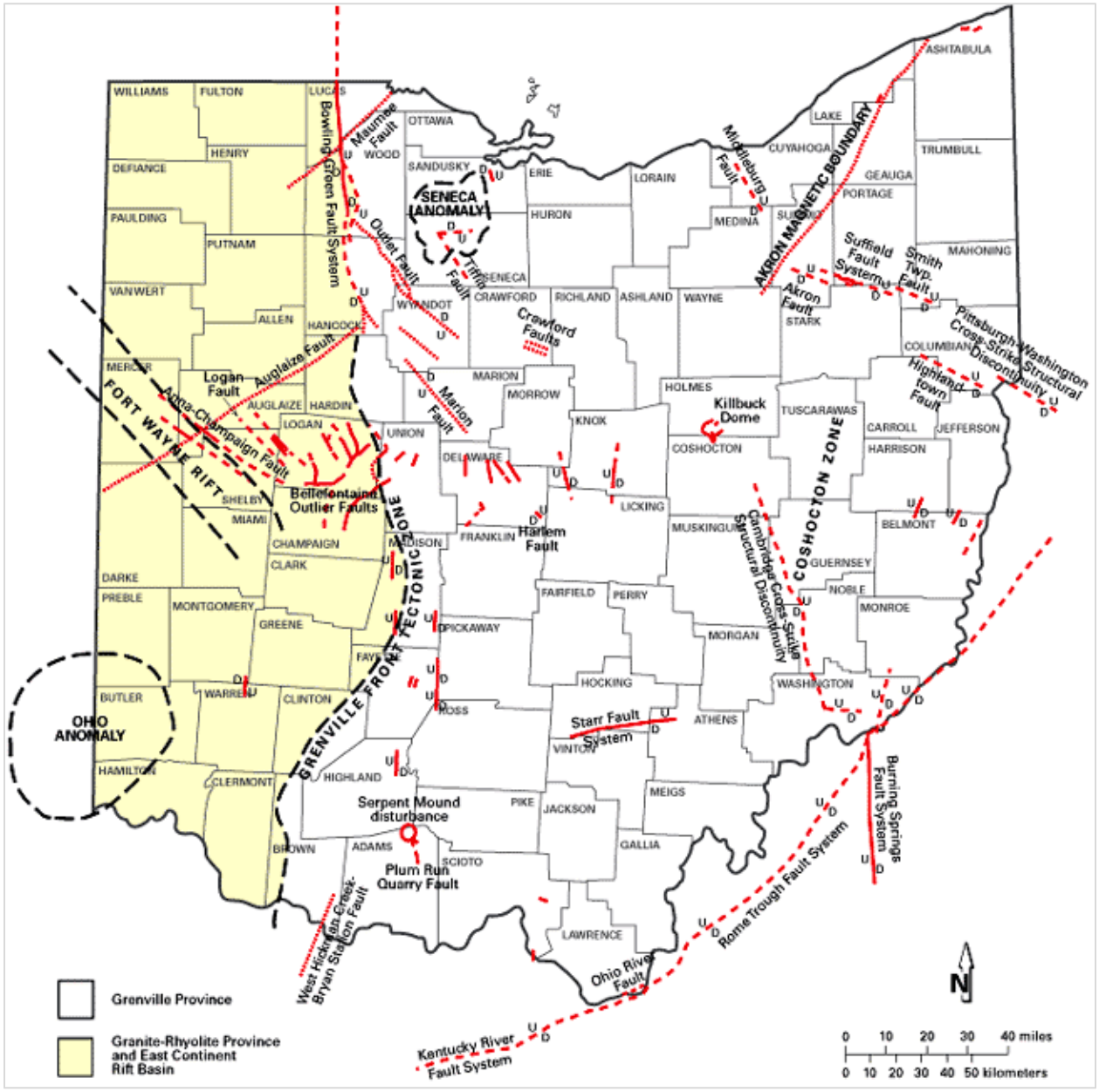
Earthquakes post a risk to life and property depending on the severity. To monitor earthquakes, the State of Ohio has deployed several seismometers to record ground-shaking activity (**Figure 4.4.2**). The Stonelick State Park Station (SLSO) seismometer is located in the closest proximity to Clinton County and is situated in Stonelick State Park in Clermont County.

Table 4.4.1: Modified Mercalli Intensity Scale

Modified Mercalli Intensity Scale		Magnitude
I	Detected only by sensitive instruments.	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing.	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibrations like passing truck.	2.5
IV	Felt indoors by many, outdoors by few, at night some awaken; dishes, windows, doors disturbed; standing autos rock noticeably.	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects.	3.5
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small.	4
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of autos.	4.5
VIII	Panel walls thrown out of frames; walls, monuments, chimneys fall; sand and mud ejected; drivers of autos disturbed.	5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken.	5.5
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides.	6
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent.	6.5
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air.	7 7.5 8

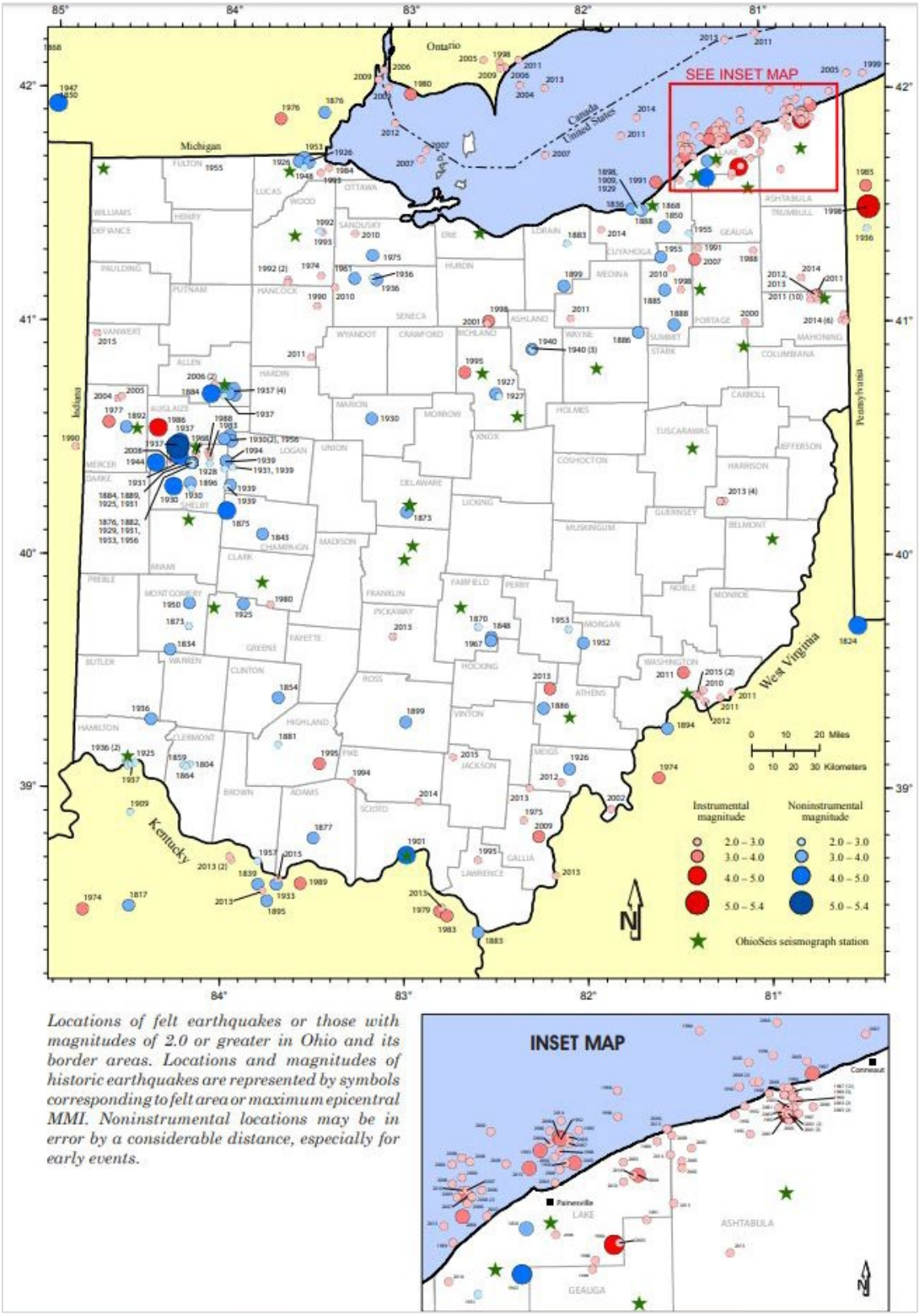
Source: ODNR

Figure 4.4.1 Map of Deep Structures in Ohio



Source: ODNR

Figure 4.4.2: Earthquake Epicenters and Seismometers in Ohio



Locations of felt earthquakes or those with magnitudes of 2.0 or greater in Ohio and its border areas. Locations and magnitudes of historic earthquakes are represented by symbols corresponding to felt area or maximum epicentral MMI. Noninstrumental locations may be in error by a considerable distance, especially for early events.

Source: ODNR

Earthquakes can yield a variety of different outcomes. With the ground shaking associated with earthquake events, buildings have the potential to be impacted. If soil liquefaction, or the mixing of sand and soil with groundwater occurs, buildings can sink into the ground. Earthquakes also have the potential to rupture dams or levees along a river, resulting in flooding (see Dam Failure section). Earthquakes can cause landslides in high-risk areas and can cause mines to subside. Furthermore, earthquakes that break gas and power lines can result in fires.

4.4.4 History

The State of Ohio has experienced more than 120 earthquakes between 1776 and 2019. Fourteen of these earthquakes have caused minor-to-moderate damage. The largest historic earthquake in Ohio was centered in Shelby County in 1937. This event was estimated to have had a magnitude of 5.4 on the Richter scale. **Figure 4.4.2**, above, displays epicenters of all historical earthquakes with a magnitude greater than 2.0, as well as the location of seismometers in the State of Ohio. This image, provided by ODNR, shows that there was a magnitude 3.0 to 4.0 earthquake in Clinton County in 1854. No descriptions of damages associated with this 1854 event are available at this time.

ODNR maintains a record of all earthquake events in the State of Ohio. On February 19, 1995, a 3.6 magnitude earthquake occurred near Hillsboro, Ohio, which is in the neighboring Highland County. More recently, on March 3, 2019, a 2.5 magnitude earthquake occurred near Georgetown, Ohio, which is located in the neighboring Brown County, Ohio. It is possible that residents of Clinton County felt minor ground shaking as a result of these earthquakes.

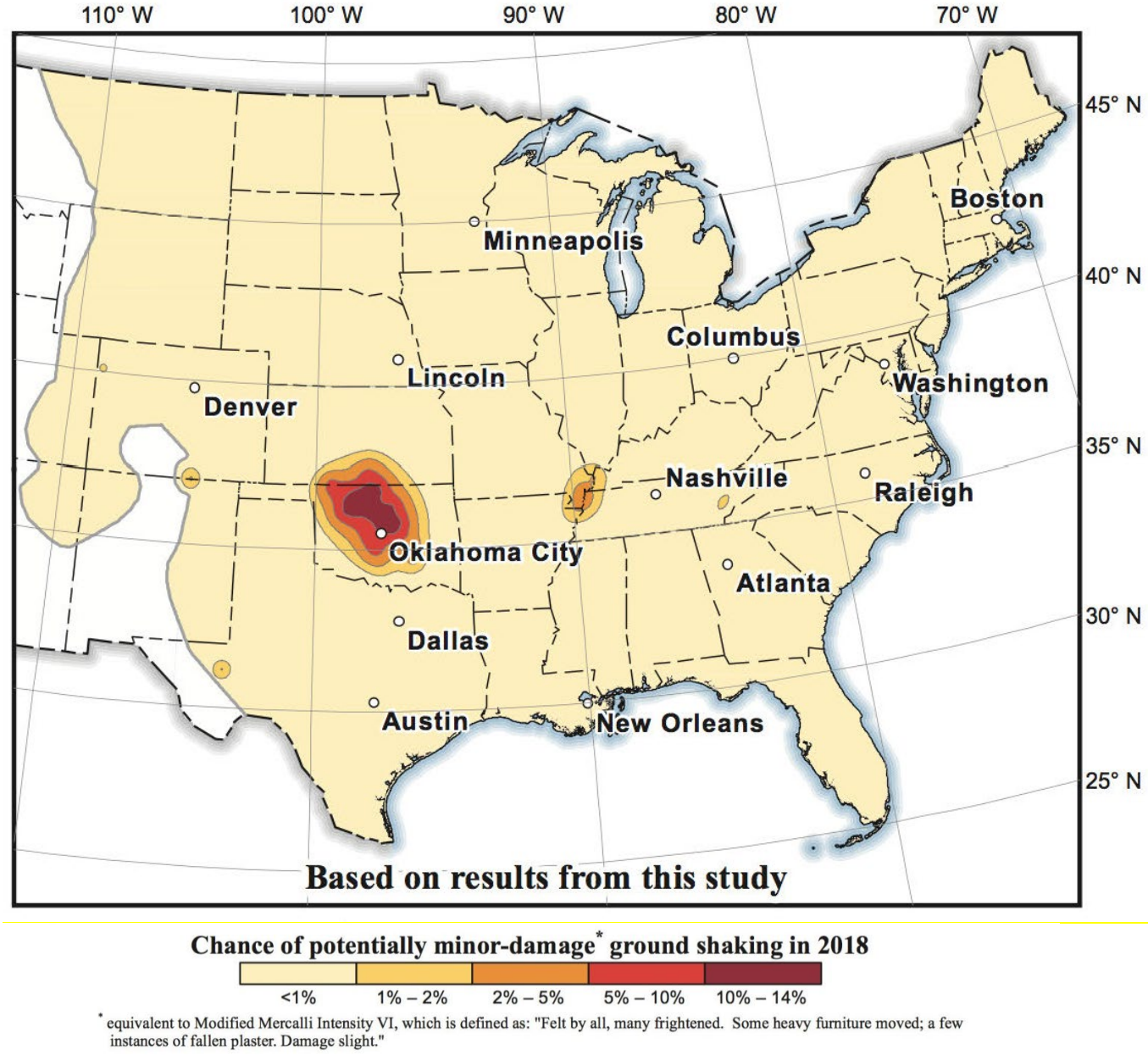
4.4.5 Probability

The USGS has both long-term and short-term probabilistic seismic hazard forecasts. In the 2018 one-year probabilistic seismic hazard forecast, the United States Geological Survey estimates that there is a less than one percent chance of potentially minor-damage ground shaking in 2018 for Clinton County (**Figure 4.4.3**).

The USGS also determined the long-term hazard of earthquakes for the United States (**Figure 4.4.4**). The measurement used in this estimation is based on the chance of ground shaking – peak ground acceleration – as a percentage of the natural force of gravity over time. This map identifies that most of Clinton County and surrounding areas in Ohio have the second to lowest hazard ranking for the nation.

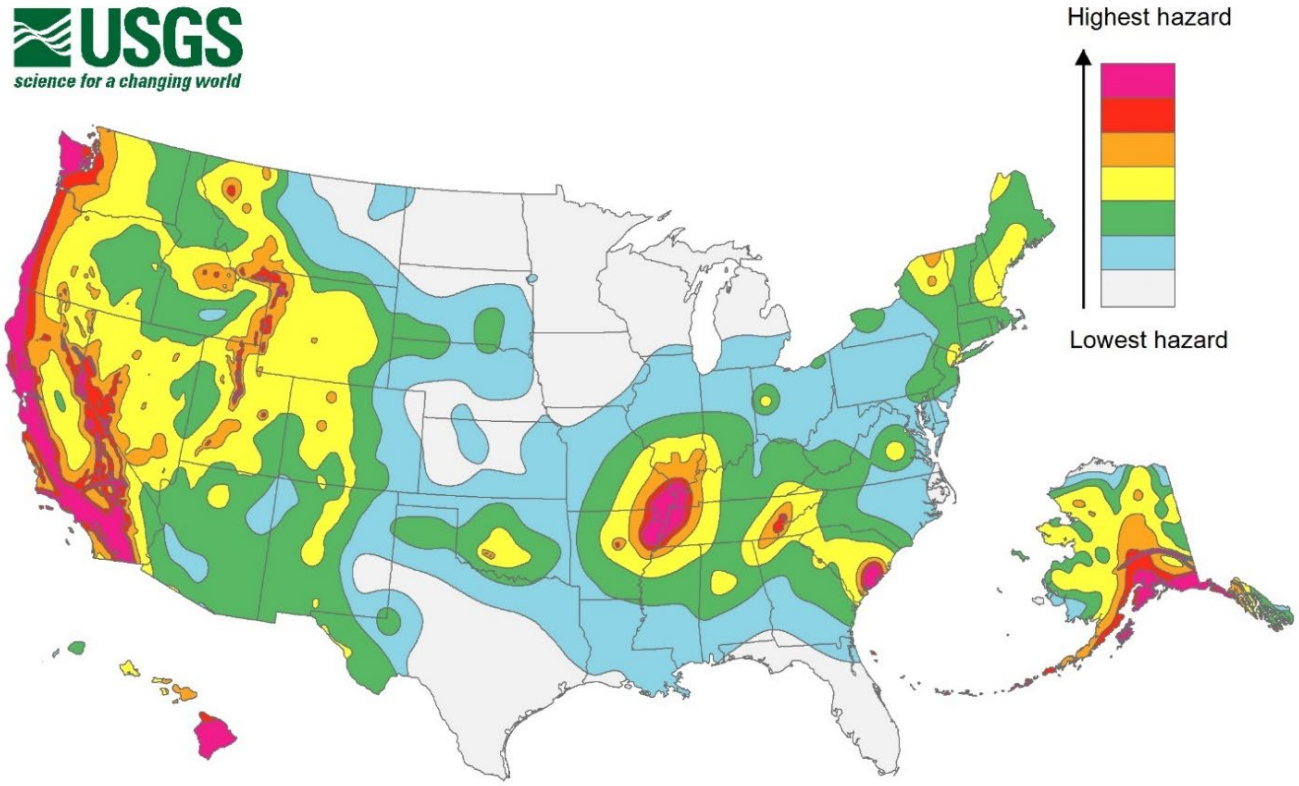
Furthermore, the ODNR indicates that the brief historic record of Ohio earthquakes suggests a risk of moderately damaging earthquakes in the western, northeastern, and southeastern parts of the State.

Figure 4.4.3: Chance of Potentially Minor-Damage Ground Shaking in 2018



Source: USGS

Figure 4.4.4: Probability of Earthquakes in the United States



Source: USGS

4.4.6 Vulnerability Assessment

Infrastructure Impact

Since there are no recent earthquake events with recorded damages, exact damages to infrastructure are unknown. Buildings, roadways, and gas and power lines have the potential to be affected. Since the probability of an earthquake occurring in Clinton County is less than one percent, there is a low risk of impact to infrastructure as a result.

Population Impact

There is a low risk of earthquakes occurring in Clinton County. Accordingly, there is low risk of impact to the population. If an earthquake would occur within the County, the population could be impacted by loss of homes, as well as potential loss of utilities.

Property Damage

With any earthquake event, there is potential for property damage to occur, as ground shaking can lead to damaged buildings. Due to the non-site-specific nature of this hazard, **Table 4.4.2** lists all structures within Clinton County as having potential impacts from earthquakes. It also provides values for two worst-case scenarios valued at one percent damage and five percent damage.

Loss of Life

Clinton County has no recorded earthquake events that have resulted in loss of life; however, in the event that an earthquake occurs, there is potential for loss of life. Loss of life can be mitigated by

educating the public on proper protection in the event of an earthquake. For example, the Ready Campaign (Ready.gov) is a national public service campaign designed to educate and empower the American people to prepare for, respond to, and mitigate disasters. The Ready Campaign provides materials for how to educate the public on earthquake preparedness.

Economic Losses

Earthquakes have the potential to damage infrastructure, resulting in economic burden of clean up and repairs. Potential economic losses and damages associated with Clinton County structures and potential worst-case scenarios are recorded in **Table 4.4.2**, below. Compared with other hazards, earthquakes are relatively unlikely to occur, meaning there is low risk of economic loss as a result of an earthquake.

Table 4.4.2: Structure Vulnerability from Earthquakes

Structure Type	Number of Properties Exposed	Total Value of Structures	Damage for 1% Scenario	Damage for 5% Scenario
Residential	17,871	$516,675,550	$5,166,756	$25,833,778
Non-Residential	8,935	$887,711,440	$8,877,114	$44,385,572
Critical Facilities	102	$63,454,190	$634,542	$3,172,710
Total	**26,806**	**$1,404,386,990**	**$14,043,870**	**$70,219,350**

**Note: Critical Facilities are non-residential structures and their value is incorporated into the non-residential totals as well. Calculated totals are determined by summing the residential and non-residential values.*

4.4.7 Land Use and Development Trends

While incidence and likelihood of earthquakes is low in Clinton County, all communities are at risk. As such, all new developments should be built up to code to reduce risk.