

## 2.9 EARTHQUAKE

Earthquakes occur as a result of the constant motion of the earth. Current science describes the earth in three major regions: the core, mantle and crust. Figure 2.9a provides a three dimensional representation of the earth's regions. The core is hot and consists of two subsections. The very center of the planet's core is hottest and solid. Surrounding the solid center is a liquid (i.e. molten material/magma) layer. The mantle is cooler than the core and although solid, circulates with the consistency of malleable plastic. Through convection, the portion of the mantle closest to the core heats and subsequently rises in the same manner as the air in the earth's atmosphere. Conversely, the upper portion of the mantle transfers its heat to the crust, cools and descends back toward the core.

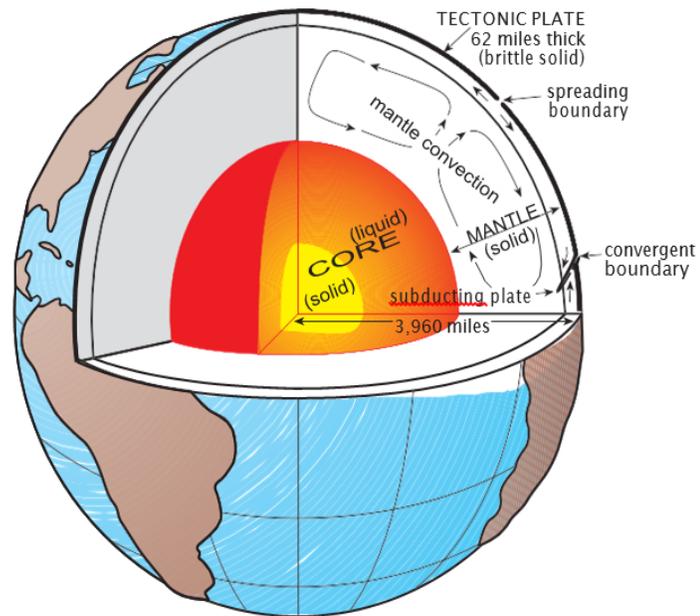
The crust is also solid; however, unlike the mantle it is rigid and brittle. The crust consists of a number of individual plates, each in constant motion, resting on the mantle. The boundaries where plates meet are the locations where new crust develops (spreading boundary) and alternately existing crust material returns to the mantle (convergent boundary).

Understanding the composition of the earth is crucial because earthquakes are often associated with boundaries where the plates slide against, rise over or sink under each other. The movement at many of the plate boundaries is not smooth and consistent, but rather grinds and jerks. As entire plates move the boundaries become locked together and enormous amounts of tension build until a sudden release occurs, realigning the plate edges and creating the observed earthquake.

The locations where the crust is fractured and sliding are called faults. California has several famous faults (e.g. the San Andreas Fault), which can be clearly observed though aerial photography. In cases where the crust is pulling apart, the location is called a rift. The Reelfoot Rift and associated rift valley located in Missouri is one of the largest in North America. Ohio geologically contains both fault and rift zones.

Another significant source of earthquakes is associated with large bodies of magma, which are located near the earth's crust. The Hawaiian archipelago and Yellowstone National Park are examples where magma deposits are altering the crust and generating both volcanic activity and earthquakes.

Figure 2.9a

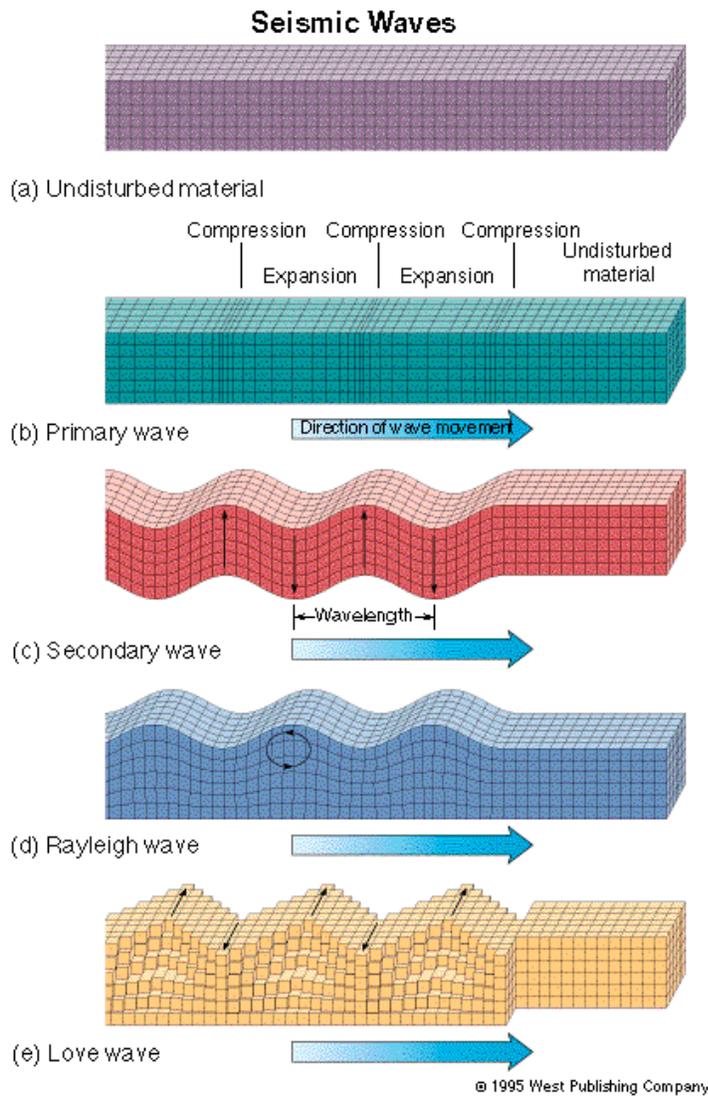


*Interior zones of Earth. Earth's crust consists of great plates that slowly move across the surface of Earth in response to convection cells in the mantle. Most earthquakes occur where plates meet, such as at spreading or convergent boundaries. Modified from Washington Division of Geology and Earth Resources, Information Circular No. 85, 1988.*

Source: [Educational Leaflet No. 9 Revised Edition 2015 Division of Geological Survey](#)

Earthquake locations are recorded based on the latitude and longitude of the occurrence, called the epicenter, and the associated depth underneath the earth’s surface. The energy released in earthquakes travels from the epicenter in seismic waves through the earth. The four major types of waves are often referred to as primary, secondary (body waves), Rayleigh and Love (surface waves) (Figure 2.9.b). Primary waves compress the earth’s surface in front of it as they travel. Secondary waves cause the earth’s surface to rise and fall perpendicular to its line of travel. Rayleigh waves travel in a circulating pattern similar to those in an ocean wave. Finally, Love waves cause the earth’s surface to oscillate from side to side perpendicular to its line of travel. The primary and secondary waves travel faster than the Rayleigh and Love waves providing the initial evidence of an event.

Figure 2.9b



Source: West Publishing Company

Figure 2.9c

Modified Mercalli Intensity		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 feel like passing truck.	2.5
IV	Felt indoors by many, outdoors by few, at night some awoken; 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 minor.	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, and chimneys fall; sand and mud ejected; drivers of autos disturbed.	5
IX	Buildings shifted off foundations, cracked, or 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

Scale showing general relationship between epicentral Modified Mercalli Intensities and magnitude. Intensities can be highly variable, depending on local geologic conditions. Modified from D. W. Steeples, 1978, Earthquakes: Kansas Geological Survey pamphlet.

Source: [Educational Leaflet No. 9 Revised Edition 2015](#)  
[Division of Geological Survey](#)

Each wave affects structures differently. For example, secondary waves have much greater impact in tall structures. Additionally, each wave has unique characteristics. The secondary wave, for example, cannot travel through fluids, including the molten outer core.

Location of earthquake events has the added dimension of land / crust composition. Within the United States, areas like southern California are primarily young, hot rock that is broken by mountain ranges. Under these conditions seismic waves are somewhat limited in their ability to travel (attenuation) reducing the overall area of impact. Conversely, seismic zones in the central and eastern United States have flat-lying, cold, brittle rocks with much thicker deposits of soil and sediments. Loosely consolidated materials such as sand and soil cause seismic waves to amplify ground motion.

When seismic waves travel through unconsolidated materials it can have the effect of turning solid land into quicksand. When this phenomenon, called liquefaction, occurs, any object located in the affected area may slide over or sink into the soil. Entire buildings, roadways and bridges may be significantly damaged. One factor which greatly determines the extent of damage from an event is duration. Events can last anywhere from a few seconds to minutes. The longer the event is promulgating seismic waves the greater the opportunity for damage.

According to the US Geological Survey, The Modified Mercalli Intensity Scale (MMI) (Figure 2.9.c) was developed in 1931 and is currently used to evaluate the effects of earthquakes. It is composed of increasing levels of intensity that does not have a mathematical basis—only an arbitrary ranking based on observed effects.

## **RISK ASSESSMENT**

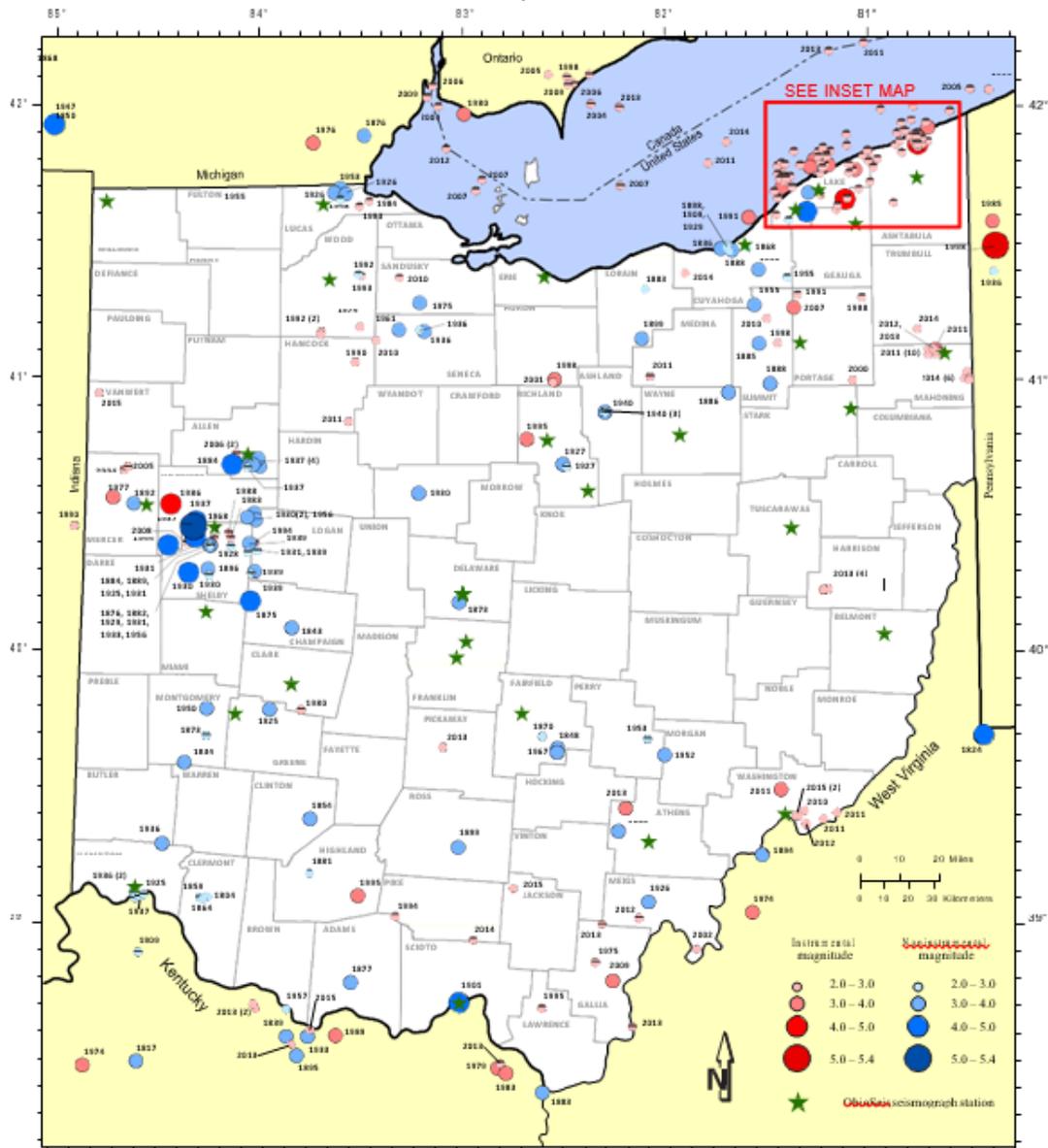
### **LOCATION**

Earthquakes in Ohio are primarily located in the northeast and far west- central portions of the state and historically have not exceeded 5.4 magnitude (Map 2.9a). The map of historical epicenters lists all the events with magnitudes greater than 2.0. The size of the location marker increases with the magnitude of the event. Red circles represent instrumentally recorded events. Blue circles represent non-instrument recorded.

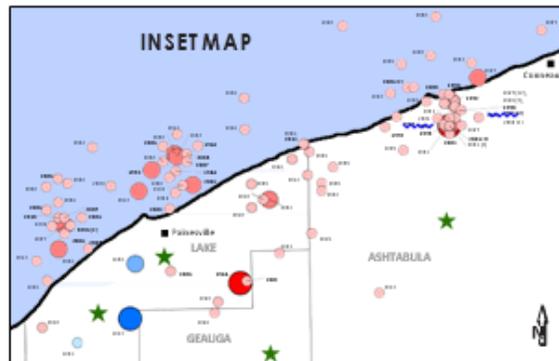
The epicenter map clearly identifies the northeast Ohio counties of Ashtabula, Geauga and Lake as one of the most earthquake-prone areas. Similarly, another earthquake-prone area is located in the west-central Counties of Auglaize, Champaign, Logan, Mercer, and Shelby. Although there are clear clusters of activity, a limited number of events have occurred and are spread over a large portion of the state.

According to information published by the ODNR Division of Geological Survey, the origins of Ohio earthquakes, as with earthquakes throughout the eastern United States, are poorly understood at this time. Those in Ohio appear to be associated with ancient zones of weakness in the Earth's crust that formed during continental collision and mountain-building events about one billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the tectonic plates that make up the Earth's crust.

Map 2.9a

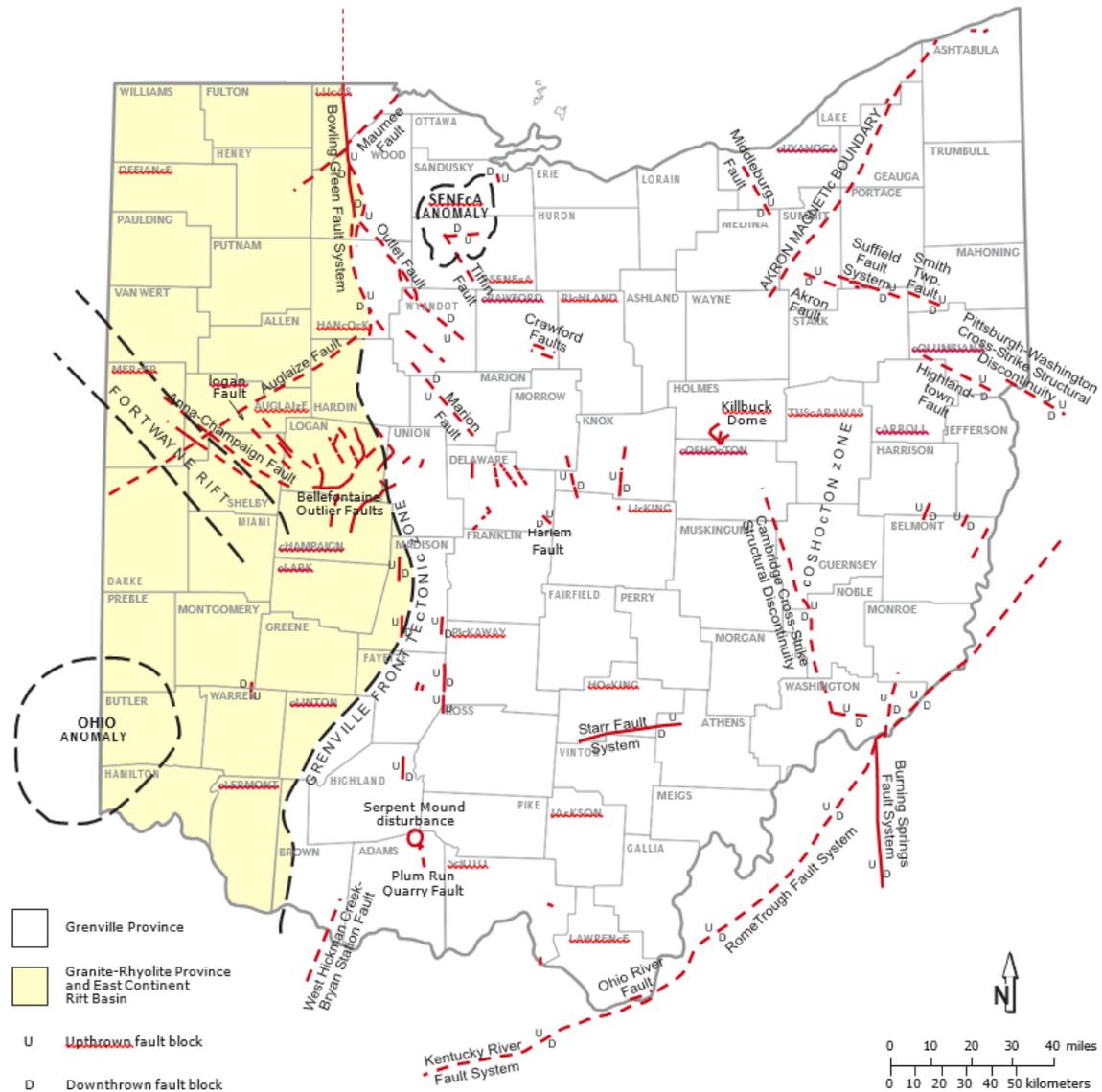


Locations of felt earthquakes or those with magnitudes of 2.0 or greater in Ohio and its border areas. Locations and magnitudes of historic earthquakes are represented by symbols corresponding to felt area or maximum epicentral MMI. Noninstrumental locations may be in error by a considerable distance,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



Source: [Educational Leaflet No. 9 Revised Edition 2015 Division of Geological Survey](#)

Map 2.9b



Source: [Educational Leaflet No. 9 Revised Edition 2015. ODNR - Division of Geological Survey](#)

The Division of Geological Survey has developed a map of geologic features, referred to as basement structures, which lie far below the earth’s surface (see Map 2.9.b). Several geologists have speculated the Akron Magnetic boundary is a fracture zone in crystalline rocks lying more than 6,000 feet below the surface. The Fort Wayne Rift along with the Anna-Champaign, Logan and Auglaize faults, though still poorly understood, can be evaluated using the existing understanding of how these structures behave.

**LHMP DATA**

Of the top 10 earthquakes in terms of magnitude that happened in Ohio, five occurred in Shelby County, two occurred in Ashtabula County, and Auglaize, Coshocton, Allen, and Lake each had one occurrence. Of the 384 earthquakes documented by the Ohio Department of Natural Resources, Lake, Ashtabula, and Shelby had the most occurrences of all counties in the state.

Shelby County, considered to be one of the most active seismic zones within the state, experienced more than 39 earthquakes averaging 2.80 magnitude, which includes the most damaging earthquake to strike the state at a 5.4 magnitude. The Shelby County Hazards Mitigation Plan of 2016 states that Shelby County has a moderate risk of incurring damage from earthquakes across all five vulnerability assessment categories of infrastructure, population, property, injuries/loss of life, and economic losses.

Ashtabula County experienced 53 events averaging 2.6 magnitude with their largest event having a magnitude at 4.5. The Ashtabula Hazard Mitigation Plan of 2012 states that many of the smaller magnitude earthquakes that have occurred since 1987 can be associated with a deep, now abandoned, Class I injection well located in the City of Ashtabula. The northeastern portion of Ohio is the second most seismically active area in the state.

Lake County experienced 64 events with an average of 2.53 magnitude and the second highest magnitude earthquake in the state at 5.0. The Lake County Multi-Jurisdictional Hazards Mitigation Plan updated in 2017 used HAZUS-MH to analyze a scenario of 5.0 magnitude located 10km underground and centered just off of Mentor Road, between Mentor High School and the Lakeland Freeway. It estimated that 18,273 residential, 8,679 non-residential, and 203 critical facilities are vulnerable to a loss of up to \$7,275,468,199.

### **NATIONAL LEVEL EXERCISE, 2011 (NLE-11)**

In September 2010, Ohio EMA's Mitigation Section was consulted to provide HAZUS runs for an earthquake tabletop exercise scenario. The scenario was designed for selected counties in southwest Ohio in preparation for NLE-11 (National Level Exercise 2011). The purpose is to test critical resource logistics and catastrophic planning in conjunction with FEMA Region V and participating States. HAZUS runs were produced for Hamilton, Butler, Clermont, Darke, Scioto and Warren Counties with a 5.7 moment magnitude scale epicenter in downtown Cincinnati to a depth of 10 kilometers.

The aggregate HAZUS runs resulted in 79,070 buildings with moderate damage and 4,418 buildings beyond repair. Four hundred eighty-seven (487) essential facilities would be less than 50% functional. One thousand four hundred sixty-eight (1,468) transportation systems and 201 utility systems would be damaged. Destruction is projected to produce 3.513 million tons of debris and 93 fire ignitions resulting 13,490 people displaced from their residences with \$1,248,000,000 in damage. The social impact estimates 179 fatalities, 123 people with life-threatening injuries, 901 people would have to be hospitalized and 3,871 would have to be treated with first aid or at an aid station. Eight thousand eight hundred six (8,806) people would seek temporary shelter. The economic impact is projected to result in \$10,828,490,000 in lost income and, \$2,050,500,000 in capital stock loss. It is estimated to take 15 years for economic recovery from this event.

### **PAST OCCURENCES**

Earthquakes are a continuously occurring hazard in Ohio. Data are available for events dating back almost 250 years. Most of Ohio's earthquake events are small, registering between 2 and 4 magnitudes. Significant events are discussed in Geological Survey document Educational Leaflet No. 9, which follows. The Ohio Department of Natural Resources have documented 384 earthquakes that have occurred since 1776.

**September 19, 1884:** An earthquake in the vicinity of Lima (Allen County) had an epicentral Modified Mercalli Intensity Scale (MMI) of VI. There were reports of fallen ceiling plaster as far away as Zanesville

(Muskingum County) and Parkersburg, West Virginia. On the basis of area feeling the earthquake (140,000 square miles), it is estimated to have had a magnitude of 4.8. Workmen on top of the Washington Monument in Washington, D.C., reported feeling this earthquake.

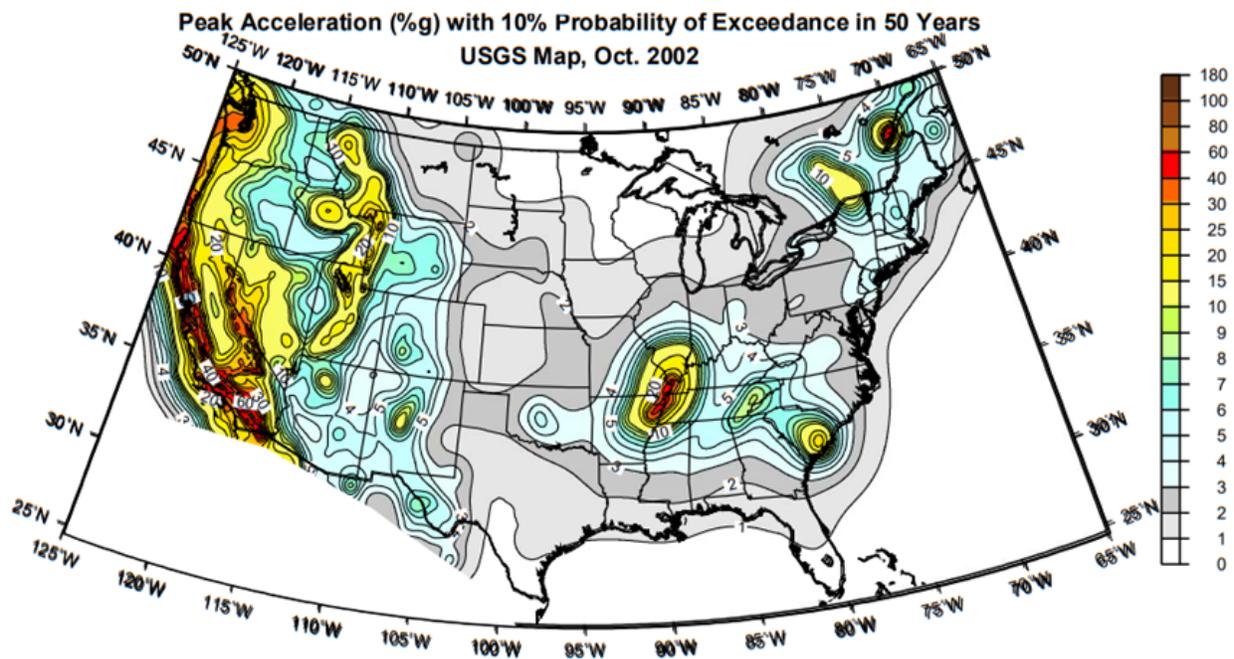
**September 20, 1931:** In this event, Anna and Sidney in Shelby County experienced toppled chimneys and cracked plaster. Store merchandise and crockery were knocked off shelves, and stones were jarred loose from the foundation of the Lutheran church in Anna. A ceiling collapsed in a school at Botkins, north of Anna. An MMI of VII and a magnitude of 4.7 have been assigned to this earthquake.

**March 2 and 9, 1937:** These two earthquakes are the most damaging to have struck Ohio. Maximum intensities were experienced at Anna (Shelby County), where an MMI of VII was associated with the March 2 event and an MMI of VIII with the March 9 event. In Anna, chimneys were toppled, organ pipes were twisted in the Lutheran church, the masonry school building was so badly cracked that it was razed, water wells were disturbed, and cemetery monuments were rotated. Both earthquakes were felt throughout a multi-state area—plaster was cracked as far away as Fort Wayne, Indiana. The March 9<sup>th</sup> event was felt throughout an area of about 150,000 square miles. Analysis of seismograms from these earthquakes by the U.S. Geological Survey (Stover and Coffman, 1993) assigned magnitudes of 4.7 and 4.9, respectively, to these events. On the basis of felt area, these earthquakes have been assigned magnitudes of 4.9 and 5.4, respectively.

**January 31, 1986:** This earthquake, which had a magnitude of 5.0 and an MMI in the high VI range, occurred in Lake County, east of Cleveland, in the general vicinity of a 1943 event with 4.5 magnitude. The 1986 earthquake cracked plaster and masonry, broke windows, and caused changes in water wells. The epicenter was only a few miles from the Perry nuclear power plant. It is the most intensively studied earthquake in Ohio and was the subject of several scientific reports (i.e., Nicholson and others, 1988).

## PROBABILITY OF FUTURE EVENTS

Map 2.9c



Earthquakes have affected Ohio as early in history as written and oral records exist. There is clear precedence to expect Ohio will continue to experience seismic events for the foreseeable future. Probabilities of future events have been developed and mapped by the USGS (Map 2.9.c). The measurement used in this estimation is based on the chance of ground shaking (e.g. peak ground acceleration) as a percentage of the natural force of gravity over time. In this analysis the extreme southwestern portion of Ohio has one in ten chance of experiencing an earthquake equal in force to three percent of the earth's gravity in the next 50 years due to its proximity to the New Madrid seismic zone.

Since 1950, Ohio experienced 233 earthquakes across the three regions. Region 1 had the least number of earthquakes at 34 events, Region 2 had 77 events, and Region 3 had 121 events. Dividing the number of events by the 68 years since 1950, we get a 50 percent (.50) probability of an earthquake happening in Region 1, 100 percent (1.13) in Region 2, and a 100 percent (1.78) probability of an earthquake happening in the region in any given year. The average magnitude for Region 1 is 2.76, Region 2 is 2.56, and Region 3 is 2.49. Although future earthquake events are highly likely to occur in Ohio, fortunately the state has not experienced any recorded loss of life due to earthquakes. Damages are commonly limited to poorly built structures.

## **VULNERABILITY ANALYSIS & LOSS ESTIMATION**

### **METHODOLOGY**

Loss estimates for Ohio's earthquake hazard were developed using FEMA's hazard analysis and loss estimation software HAZUS-MH 4.2 and its ability to simulate arbitrary events. HAZUS has been used successfully for over a decade in California's earthquake preparation and response efforts. For the purpose of this initial effort, level one analyses were completed using the program; un-manipulated, census-tract-level data were used. Results should be interpreted as estimates and cannot be considered precise losses.

There were two methods used in analyzing the vulnerabilities and loss estimates of all counties across Ohio. Because the largest earthquake that happened in Ohio was measured at a 5.4 magnitude and the average magnitude of all 384 earthquakes since 1776 is 2.58, both methods involved simulating an arbitrary event at the program's minimum magnitude of 5.0, and the depth at 5 kilometers.

The first method assessed Map 2.9a for historical hotspots of seismic activity. Based on this information, HAZUS was used to simulate events within a Lake County in Northeast Ohio, and Shelby County in Western Ohio. Shelby County had experienced Ohio's strongest earthquake to date at 5.4 magnitude while Lake County had experienced the state's second strongest at 5.0 magnitude. The epicenters of the simulated events will be set at the projected locations of their respective historical events. It is expected that losses will expand outward contiguously to other counties across the state. The cost of the damage to the surrounding area will vary greatly on which county the earthquake is located. According to HAZUS and the 2010 census, the total building stock for Shelby County is \$5,866,000,000 and is surrounded by six counties whose total building stock adds up to an estimated \$38,767,000,000. Lake County has a total estimated building stock at \$29,673,000,000 and is surrounded by 3 counties whose total building stock adds up to \$206,281,000,000. This method estimates the damages to all Ohio counties from the earthquake event.

Unlike the first method, the second method runs an individual earthquake analysis for each county. Each analysis set the epicenter at the county seat of their respective county. These individual runs assessed only the damages specific to that county. For the total building stock value for each county, see Map 2.9d or "Total Building Value" column on the tables in the results.

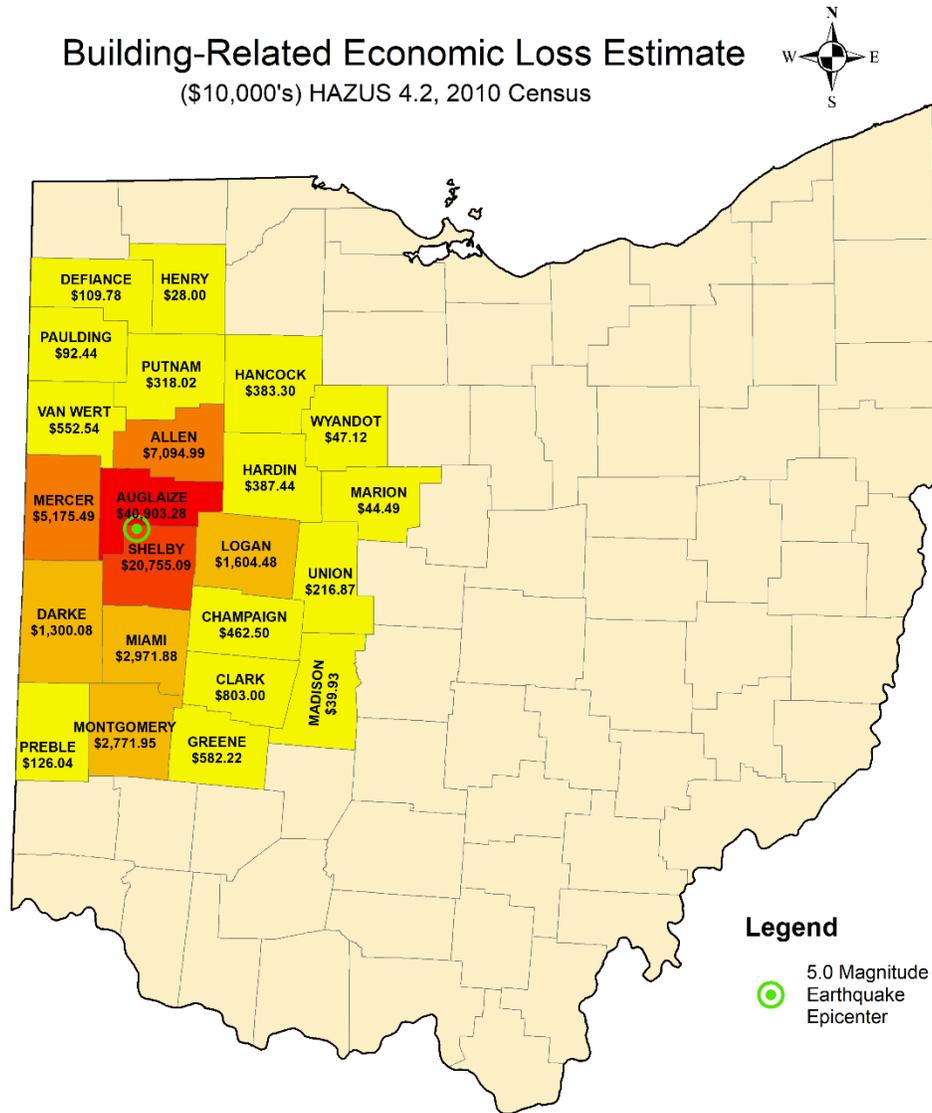


There are four damage classifications used for each HAZUS run: Slight, Moderate, Extensive, and Complete. The descriptions for each would vary depending on the type of building damaged. For the complete definitions for different types of building category, refer to section 5.3.1 of the [HAZUS Earthquake Model Technical Manual](#).

**RESULTS**

**Method 1, Scenario A: Shelby County 5.0 Magnitude Earthquake Event (40.47°, -84.28°)**

**Map 2.9e**



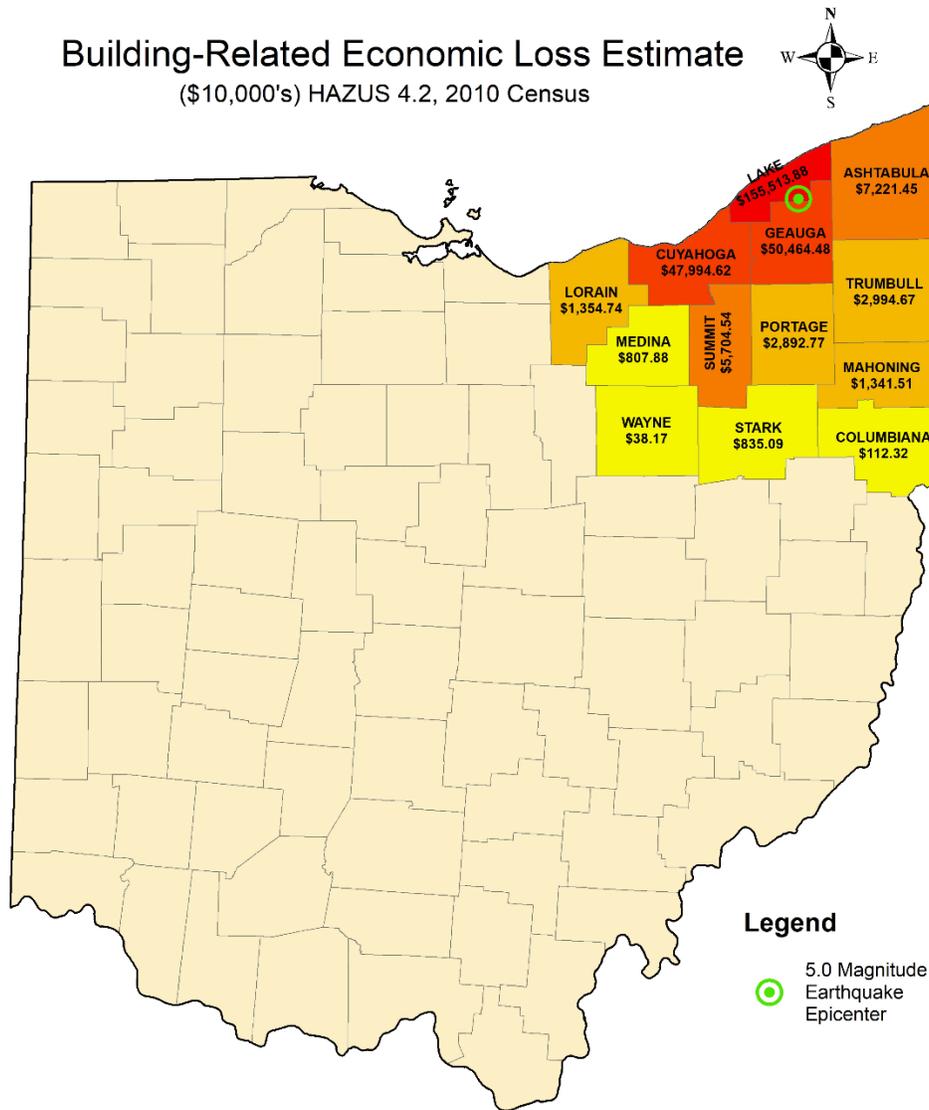
Estimate of Potential Losses to Earthquake									
Shelby County 5.0 Magnitude Earthquake Event (40.47°, -84.28°)									
County	2010 Population	Total Building Value	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Loss	Property Loss	Total Building-Related Loss
Auglaize	45,949	\$5,577,000,000	4,057	2,165	639	143	\$72,156,000	\$336,877,000	\$409,033,000
Shelby	49,423	\$5,866,000,000	2,849	1,342	339	72	\$34,139,000	\$173,412,000	\$207,551,000
Allen	106,331	\$13,050,000,000	2,106	690	106	11	\$17,878,000	\$53,072,000	\$70,950,000
Mercer	40,814	\$4,895,000,000	1,423	530	87	10	\$10,812,000	\$40,943,000	\$51,755,000
Miami	102,506	\$13,098,000,000	1,093	331	47	4	\$7,837,000	\$21,882,000	\$29,719,000
Montgomery	535,153	\$68,649,000,000	1,456	402	42	3	\$10,467,000	\$17,252,000	\$27,719,000
Logan	45,858	\$5,472,000,000	867	293	34	3	\$4,025,000	\$12,020,000	\$16,045,000
Darke	52,959	\$5,959,000,000	597	185	23	2	\$3,312,000	\$9,689,000	\$13,001,000
Clark	138,333	\$15,813,000,000	529	146	13	1	\$2,752,000	\$5,278,000	\$8,030,000
Greene	161,573	\$20,143,000,000	320	88	9	1	\$1,955,000	\$3,867,000	\$5,822,000
<b>ALL OTHER COUNTIES</b>			1,741	495	53	5	\$8,562,900	\$19,519,200	\$28,082,100
<b>TOTAL</b>			17,038	6,667	1,392	255	\$173,895,900	\$693,811,200	\$867,707,100

HAZUS results for building counts indicate 17,038 slight, 6,667 moderate, 1,392 extensive and 255 completely impacted structures. The total loss of income is estimated at \$173,895,900 and total property losses are estimated at \$693,811,200. Auglaize, Shelby, Allen, Mercer, Miami, Montgomery, Logan, Darke, Clark, and Greene are the top ten of 23 counties estimated to see damages from this event. These ten counties have a total population of 1,278,899 people. Auglaize and Shelby had the highest losses and together accounted for 71 percent of the estimated \$867,707,100 in total building-related losses. Damage is likely to extend out to counties located in eastern Indiana.

Results indicated minimal losses of utility, transportation and critical facilities. HAZUS estimates that there will be one hospital, two schools, one police station, and two fire stations that will see at least moderate damage (>50 percent). Additionally, there will be three bridges, one railway facility, and one airport facility that will see at least moderate damage. On the first day, 103 households will be without potable water service and 7,353 households without electric power. Within one week, the numbers will drop to 0 and 1,295 households respectively.

**Method 1, Scenario B: Lake County 5.0 Magnitude Earthquake Event (41.65°, -81.16°)**

**Map 2.9f**



HAZUS results for building counts indicate 43,983 slight, 17,127 moderate, 3,783 extensive and 751 completely impacted structures. The total loss of income is estimated at \$542,298,760 and total property losses are estimated at \$2,230,462,376. Lake, Geauga, Cuyahoga, Ashtabula, Summit, Trumbull, Portage, Lorain, Mahoning, and Stark are the top ten of 13 counties estimated to see damages from this event. These ten counties have a total population of 3,534,326 people. Lake, Geauga, and Cuyahoga had the highest losses and together accounted for 92 percent of the estimated \$2,772,761,136 in total building-related losses. The building-related losses in the Lake County Scenario are much greater than in the Shelby County Scenario due to having much greater building stock values in the general area. The total number of impacted counties are less than that of the Shelby County event as Lake County is situated along the southern shores of Lake Erie. Damages are likely to extend out to counties located in western Pennsylvania.

Estimate of Potential Losses to Earthquake									
Lake County 5.0 Magnitude Earthquake Event (41.65°, -81.16°)									
County	2010 Population	Total Building Value	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Loss	Property Loss	Total Building-Related Loss
Lake	230,041	\$29,673,000,000	15,769	7,517	2,008	459	\$268,296,148	\$1,286,842,603	\$1,555,138,751
Geauga	93,389	\$12,396,000,000	5,344	2,704	827	201	\$82,706,223	\$421,938,582	\$504,644,805
Cuyahoga	1,280,122	\$182,175,000,000	12,755	3,864	577	57	\$125,551,130	\$354,395,097	\$479,946,228
Ashtabula	101,497	\$11,710,000,000	2,328	812	122	14	\$15,852,078	\$56,362,452	\$72,214,530
Summit	541,781	\$73,277,000,000	2,398	679	80	6	\$17,529,907	\$39,515,443	\$57,045,350
Trumbull	210,312	\$25,215,000,000	1,562	459	53	5	\$9,155,358	\$20,791,374	\$29,946,732
Portage	161,419	\$18,773,000,000	1,322	402	45	4	\$7,549,739	\$21,377,938	\$28,927,676
Lorain	301,356	\$39,738,000,000	682	187	19	1	\$4,685,319	\$8,862,076	\$13,547,395
Mahoning	238,823	\$29,181,000,000	789	218	23	2	\$4,964,738	\$8,450,316	\$13,415,054
Stark	375,586	\$45,070,000,000	482	132	14	1	\$2,973,399	\$5,377,504	\$8,350,903
<b>ALL OTHER COUNTIES</b>			552	152	16	1	\$3,034,719	\$6,548,993	\$9,583,712
<b>TOTAL</b>			43,983	17,127	3,783	751	\$542,298,760	\$2,230,462,376	\$2,772,761,136

Results indicated minimal losses of utility, transportation and critical facilities. HAZUS estimates that there will be one hospital, two schools, and three fire stations that will see at least moderate damage (>50 percent). Additionally, there will be one bridge and one airport facility that will see at least moderate damage. On the first day, 468 households that will be without potable water service and 27,451 households without electric power. Within one week, the numbers will drop to 0 and 5,204 households respectively.

Method 2: Epicenter in County Seat

Estimate of Potential Losses to Earthquake											
Region 1											
County	2010 Population	Total Building Value	5.0 Magnitude Earthquake Epicenter	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Loss	Property Loss	Total Building-Related Loss	Percentage of Total Building Value
Allen	106,331	\$13,050,000,000	Lima	10,731	6,727	2,420	718	\$340,039,700	\$1,439,687,900	\$1,779,727,600	11.03%
Auglaize	45,949	\$5,577,000,000	Wapakoneta	3,943	2,263	769	212	\$71,750,000	\$361,590,000	\$433,340,000	7.77%
Champaign	40,097	\$3,766,000,000	Urbana	3,786	2,316	808	226	\$74,620,000	\$378,820,000	\$453,440,000	12.04%
Clark	138,333	\$15,813,000,000	Springfield	14,231	8,695	2,988	880	\$358,740,000	\$1,623,060,000	\$1,981,800,000	12.53%
Crawford	43,784	\$5,316,000,000	Bucyrus	3,916	2,172	700	189	\$67,860,100	\$353,616,300	\$421,476,400	7.93%
Darke	52,959	\$5,959,000,000	Greenville	5,214	3,052	1,023	272	\$100,500,600	\$454,991,900	\$555,492,500	9.32%
Defiance	39,037	\$4,750,000,000	Defiance	3,639	2,334	864	254	\$105,843,400	\$488,064,700	\$593,908,100	12.50%
Erie	77,079	\$10,525,000,000	Sandusky	7,852	4,694	1,609	468	\$243,047,800	\$977,979,100	\$1,221,026,900	11.60%
Fulton	42,698	\$5,702,000,000	Wauseon	3,914	2,412	836	216	\$93,335,300	\$478,339,000	\$571,674,300	10.03%
Hancock	74,782	\$9,489,000,000	Findlay	7,578	4,854	1,787	515	\$230,190,100	\$1,041,613,300	\$1,271,803,400	13.40%
Hardin	32,058	\$3,398,000,000	Kenton	2,917	1,775	601	166	\$60,016,800	\$280,151,800	\$340,168,600	10.01%
Henry	28,215	\$3,154,000,000	Napoleon	2,742	1,722	621	165	\$56,832,500	\$270,484,900	\$327,317,400	10.38%
Huron	59,626	\$6,546,000,000	Norwalk	4,834	2,897	983	260	\$101,017,000	\$448,546,000	\$549,563,000	8.40%
Logan	45,858	\$5,472,000,000	Bellefontaine	5,076	3,064	981	262	\$102,276,900	\$459,393,100	\$561,670,000	10.26%
Lucas	441,815	\$58,013,000,000	Toledo	42,442	24,769	8,211	2,341	\$1,201,811,700	\$5,298,319,500	\$6,500,131,200	11.20%
Marion	66,501	\$7,113,000,000	Marion	6,955	4,377	1,545	453	\$173,421,200	\$771,246,000	\$944,667,200	13.28%
Mercer	40,814	\$4,895,000,000	Celina	4,281	2,698	987	277	\$92,836,100	\$434,887,200	\$527,723,300	10.78%
Marietta	102,506	\$13,098,000,000	Troy	10,366	5,874	1,892	520	\$250,053,200	\$1,242,551,000	\$1,492,604,200	11.40%
Ottawa	41,428	\$7,007,000,000	Port Clinton	4,914	3,343	1,259	302	\$94,156,800	\$405,834,600	\$499,991,400	7.14%
Paulding	19,614	\$2,138,000,000	Paulding	2,208	1,456	519	125	\$36,283,600	\$196,514,800	\$232,798,400	10.89%
Preble	42,270	\$4,677,000,000	Eaton	4,236	2,423	780	210	\$69,693,900	\$375,902,700	\$445,596,600	9.53%
Putnam	34,499	\$4,057,000,000	Ottawa	3,200	1,900	636	173	\$60,648,600	\$312,804,000	\$373,452,600	9.21%
Sandusky	60,944	\$7,612,000,000	Fremont	5,846	3,569	1,255	353	\$152,490,600	\$715,835,900	\$868,326,500	11.41%
Seneca	56,745	\$6,465,000,000	Tiffin	5,126	2,964	971	261	\$108,406,800	\$491,019,500	\$599,426,300	9.27%
Shelby	49,423	\$5,866,000,000	Sidney	4,302	2,599	908	255	\$95,385,600	\$516,262,900	\$611,648,500	10.43%
Van Wert	28,744	\$3,330,000,000	Van Wert	3,289	2,053	720	205	\$72,727,900	\$342,020,600	\$414,748,500	12.45%
Williams	37,642	\$4,857,000,000	Bryan	3,821	2,423	864	236	\$88,186,000	\$468,580,200	\$556,766,200	11.46%
Wood	125,488	\$16,617,000,000	Bowling Green	6,443	3,479	1,059	247	\$128,857,300	\$594,686,000	\$723,543,300	4.35%
Wyandot	22,615	\$2,604,000,000	Upper Sandusky	2,456	1,545	555	156	\$55,477,600	\$256,189,100	\$311,666,700	11.97%

Estimate of Potential Losses to Earthquake											
Region 2											
County	2010 Population	Total Building Value	5.0 Magnitude Earthquake Epicenter	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Loss	Property Loss	Total Building-Related Loss	Percentage of Total Building Value
Ashland	53,139	\$6,014,000,000	Ashland	5,154	3,221	1,068	288	\$111,583,600	\$540,923,000	\$652,506,600	8.99%
Butler	368,130	\$43,670,000,000	Hamilton	28,806	15,846	4,955	1,355	\$624,184,500	\$30,870,858,000	\$3,087,085,800	7.07%
Clinton	42,040	\$4,691,000,000	Wilmington	3,815	2,352	812	218	\$85,237,400	\$386,703,200	\$471,940,600	10.06%
Cuyahoga	1,280,122	\$182,175,000,000	Cleveland	101,005	51,979	15,495	4,064	\$2,961,934,500	\$12,808,180,500	\$15,770,115,000	8.66%
Delaware	174,214	\$24,771,000,000	Delaware	12,994	6,787	2,090	550	\$248,588,700	\$1,389,884,900	\$1,638,473,600	6.61%
Fairfield	146,156	\$16,911,000,000	Lancaster	10,940	6,152	2,032	573	\$236,586,300	\$1,053,697,200	\$1,290,283,500	7.63%
Fayette	29,030	\$3,149,000,000	Washington CH	3,230	2,028	717	206	\$71,509,100	\$354,333,600	\$425,842,700	13.52%
Franklin	1,163,414	\$149,070,000,000	Columbus	93,203	50,401	15,713	4,262	\$2,707,203,600	\$11,494,786,200	\$14,201,989,800	9.53%
Geauga	93,389	\$12,396,000,000	Chardin	7,319	3,888	1,209	308	\$133,999,300	\$681,662,200	\$815,661,500	6.58%
Greene	161,573	\$20,143,000,000	Xenia	13,904	7,318	2,174	563	\$252,201,800	\$1,311,451,700	\$1,563,653,500	7.76%
Hamilton	802,374	\$108,968,000,000	Cincinnati	60,895	31,815	9,580	2,545	\$1,818,884,300	\$7,769,951,900	\$9,588,836,200	8.80%
Knox	60,921	\$6,994,000,000	Mt. Vernon	5,782	3,380	1,106	296	\$128,390,000	\$588,422,600	\$716,812,600	10.25%
Lake	230,041	\$29,673,000,000	Painesville	19,503	40,488	3,195	873	\$405,108,700	\$2,080,489,600	\$2,485,598,300	8.38%
Licking	166,492	\$19,664,000,000	Newark	13,236	7,701	2,530	700	\$329,645,000	\$1,398,438,400	\$1,728,083,400	8.79%
Lorain	301,356	\$39,738,000,000	Elyria	28,256	15,921	5,165	1,421	\$667,101,000	\$3,173,150,400	\$3,840,251,400	9.66%
Madison	43,435	\$4,489,000,000	London	3,278	1,910	615	164	\$64,493,900	\$327,032,600	\$391,526,500	8.72%
Medina	172,332	\$22,003,000,000	Medina	15,555	8,326	2,529	687	\$306,796,500	\$1,688,169,300	\$1,994,965,800	9.07%
Montgomery	535,153	\$68,649,000,000	Dayton	52,232	29,290	9,392	2,657	\$1,405,237,800	\$5,902,113,100	\$7,307,350,900	10.64%
Morrow	34,827	\$3,253,000,000	Mt. Gilead	3,326	2,098	714	169	\$48,484,000	\$237,263,900	\$285,747,900	8.78%
Pickaway	55,698	\$5,473,000,000	Circleville	4,635	2,856	973	263	\$87,323,700	\$411,002,400	\$498,326,100	9.11%
Portage	161,419	\$18,773,000,000	Ravenna	13,162	7,875	2,705	702	\$282,285,500	\$1,417,867,300	\$1,700,152,800	9.06%
Richland	124,475	\$14,927,000,000	Mansfield	12,608	7,699	2,680	780	\$333,128,700	\$1,469,984,200	\$1,803,112,900	12.08%
Stark	375,586	\$45,070,000,000	Canton	35,574	20,105	6,427	1,813	\$935,438,900	\$3,845,042,300	\$4,780,481,200	10.61%
Summit	541,781	\$73,277,000,000	Akron	51,673	29,334	9,502	2,738	\$1,424,697,000	\$6,346,478,100	\$7,771,175,100	10.61%
Union	52,300	\$6,356,000,000	Marysville	4,509	2,788	1,000	286	\$106,640,000	\$596,520,000	\$703,160,000	11.06%
Warren	212,693	\$26,040,000,000	Lebanon	16,959	8,628	2,513	643	\$276,483,500	\$1,623,221,600	\$1,899,705,100	7.30%
Wayne	114,520	\$12,755,000,000	Wooster	9,324	5,606	1,892	496	\$207,515,400	\$952,870,100	\$1,160,385,500	9.10%

Estimate of Potential Losses to Earthquake											
Region 3											
County	2010 Population	Total Building Value	5.0 Magnitude Earthquake Epicenter	Slight Damage Count	Moderate Damage Count	Extensive Damage Count	Complete Damage Count	Income Loss	Property Loss	Total Building-Related Loss	Percentage of Total Building Value
Adams	28,550	\$2,389,000,000	West Union	2,694	2,037	832	215	\$45,890,000	\$183,830,000	\$229,720,000	9.62%
Ashabula	101,497	\$11,710,000,000	Jefferson	7,891	4,096	1,105	232	\$113,116,000	\$509,387,600	\$622,503,600	5.32%
Athens	64,757	\$5,911,000,000	Athens	5,249	3,798	1,451	364	\$137,544,200	\$593,587,700	\$731,131,900	12.37%
Belmont	70,400	\$7,555,000,000	St. Clairsville	661	3,770	1,179	291	\$119,894,500	\$507,205,900	\$627,040,400	8.30%
Brown	44,846	\$4,266,000,000	Georgetown	3,776	2,453	855	208	\$59,778,100	\$256,354,900	\$316,133,000	7.41%
Carrroll	28,836	\$3,222,000,000	Carrlilton	3,432	2,263	801	188	\$55,473,600	\$257,928,800	\$313,402,400	9.73%
Clermont	197,363	\$22,678,000,000	Batavia	16,230	9,401	3,013	762	\$332,814,500	\$1,678,040,300	\$2,010,854,800	8.87%
Columbiana	107,841	\$11,350,000,000	Lisbon	8,493	4,697	1,437	325	\$118,951,900	\$538,422,700	\$657,374,600	5.79%
Coshoccon	36,901	\$3,805,000,000	Coshoccon	3,958	2,716	1,028	273	\$86,426,400	\$374,156,000	\$460,582,400	12.10%
Gallia	30,934	\$2,974,000,000	Gallipolis	3,011	2,057	691	173	\$70,628,000	\$260,583,900	\$331,211,900	11.14%
Guernsey	40,087	\$4,980,000,000	Cambridge	4,655	3,261	1,261	339	\$145,872,400	\$542,275,200	\$688,147,600	13.82%
Harrison	15,864	\$1,668,000,000	Cadiz	1,869	1,214	440	115	\$30,972,200	\$129,899,800	\$160,872,000	9.64%
HIGHLAND	43,589	\$4,059,000,000	Hillsboro	4,283	2,933	1,064	246	\$70,324,200	\$307,422,100	\$377,746,300	9.31%
Hocking	29,380	\$2,898,000,000	Logan	3,186	2,355	947	244	\$64,461,700	\$280,080,000	\$344,541,700	11.89%
Holmes	42,366	\$3,854,000,000	Millersburg	3,232	2,027	712	181	\$67,446,700	\$308,950,100	\$376,396,800	9.77%
Jackson	33,225	\$2,935,000,000	Jackson	3,487	2,557	969	236	\$66,671,600	\$277,082,700	\$343,754,300	11.71%
Jefferson	69,709	\$7,521,000,000	Steubenville	7,239	4,406	1,489	414	\$164,410,100	\$690,997,200	\$855,407,300	11.37%
Lawrence	62,450	\$5,438,000,000	Ironton	5,001	3,122	1,066	281	\$77,797,300	\$341,092,100	\$418,889,400	7.70%
Mahoning	238,823	\$29,181,000,000	Youngstown	25,087	14,306	4,575	1,346	\$636,105,700	\$2,736,222,600	\$3,372,328,300	11.56%
Meigs	23,770	\$2,021,000,000	Pomeroy	2,372	1,599	568	143	\$34,764,100	\$144,791,900	\$179,556,000	8.88%
Monroe	14,642	\$1,446,000,000	Woodsfield	1,810	1,204	433	112	\$24,918,700	\$118,006,600	\$142,925,300	9.88%
Morgan	15,054	\$1,459,000,000	McConnelsville	2,033	1,550	640	162	\$30,786,100	\$144,818,100	\$175,604,200	12.04%
Muskingum	86,074	\$9,255,000,000	Zanesville	8,400	5,466	1,979	550	\$230,867,000	\$880,869,000	\$1,111,736,000	12.01%
Noble	14,645	\$1,319,000,000	Caldwell	1,468	1,014	387	105	\$26,468,800	\$122,868,300	\$149,327,100	11.32%
Perry	36,058	\$3,237,000,000	New Lexington	3,439	2,440	985	254	\$54,876,500	\$272,520,700	\$327,397,200	10.11%
Pike	28,709	\$2,641,000,000	Waverly	2,729	1,878	642	163	\$64,492,500	\$248,255,700	\$312,748,200	11.84%
Ross	78,064	\$7,574,000,000	Chillicothe	7,017	4,515	1,518	390	\$170,530,000	\$663,536,100	\$834,066,100	11.01%
Scioto	79,489	\$7,556,000,000	Portsmouth	6,809	4,231	1,371	351	\$144,352,600	\$592,121,000	\$736,473,600	9.75%
Trumbull	210,312	\$25,215,000,000	Warren	20,475	11,930	3,940	1,086	\$497,402,800	\$2,177,593,500	\$2,674,996,300	10.61%
Tuscarawas	92,582	\$10,330,000,000	New Philadelphia	9,007	5,723	2,011	527	\$210,656,700	\$875,000,800	\$1,085,657,500	10.51%
Vinton	13,435	\$1,185,000,000	McArthur	1,619	1,279	547	140	\$25,479,700	\$123,603,400	\$149,083,100	12.58%
Washington	61,778	\$6,706,000,000	Marietta	5,198	3,067	976	259	\$109,787,200	\$460,990,900	\$570,778,100	8.51%

In Region 2, the counties with the most building-related losses are Cuyahoga County at \$15,770,115,000, Franklin County at \$14,201,989,800, and Hamilton County at \$9,588,836,200. Relative to the total building value, the counties with the highest percentage of total building-related loss are Fayette at 13.52 percent, Richland County at 12.08 percent, and Union County at 11.06 percent.

In region 1, the counties with the most building-related losses are Lucas County at \$6,500,131,200, Clark County at \$1,981,800,000, and Allen County at \$1,779,727,600. Relative to the total building value, the counties with the highest percentage of total building-related loss are Hancock County at 13.40 percent, Marion County at 13.28 percent, and Clark County at 12.53 percent.

In region 3, the counties with the most building-related losses are Mahoning County at \$3,372,328,300, Trumbull County at \$2,674,996,300, and Clermont County at Clermont. Relative to the total building value, the counties with the highest percentage of total building-related loss are Guernsey at 13.82 percent, Vinton County at 12.58 percent, and Athens County at 12.37 percent.

#### **STATE-OWNED AND STATE-LEASED CRITICAL FACILITIES VULNERABILITY ANALYSIS & LOSS ESTIMATION**

Method 2 of the Vulnerability Analysis and Loss Estimation above estimated the damage to each county with a scenario where a 5.0 magnitude earthquake occurred with the epicenter in each of their respective county seats. A "Percentage of Total Building Value" was determined by taking the Total Building-Related Losses and dividing it by the Total Building Value in that county. To estimate the losses for State-owned and State-leased critical facilities, the total value of State-owned and State-leased Critical Facilities of each county was multiplied by the county's respective percentage of Total Building Value.

#### **RESULTS**

In Region 1, Lucas County is estimated to have the most damage to State-owned and State-leased Critical Facilities at \$30,991,663. In Region 2, Franklin County is estimated to have the most damage by far at \$204,615,249. In Region 3, Ross County is estimated to have the most damage at \$29,246,770.

With the method, the most prevalent variable in the estimated loss in the event of 5.0 magnitude earthquake is the existing value of these critical facilities.

**Results**

<b>Estimate of Potential Losses of State-owned and State-leased Critical Facilities to a 5.0 Magnitude Earthquake Event</b>				
<b>Region 1</b>				
<b>County</b>	<b>Percentage of Total Building Value</b>	<b>Number of State-owned and State-leased Critical Facilities</b>	<b>Value of State-owned and State-leased Critical Facilities</b>	<b>Estimated Damage to State-owned and State-leased Critical Facilities</b>
Allen	11.03%	120	\$ 90,950,176.00	\$ 10,033,706.35
Auglaize	7.77%	21	\$ 11,545,804.00	\$ 897,123.67
Champaign	12.04%	24	\$ 5,161,316.00	\$ 621,441.09
Clark	12.53%	17	\$ 8,868,061.00	\$ 1,111,409.81
Crawford	7.93%	13	\$ 10,357,812.00	\$ 821,213.94
Darke	9.32%	27	\$ 8,619,026.00	\$ 803,457.68
Defiance	12.50%	11	\$ 7,562,674.00	\$ 945,585.97
Erie	11.60%	54	\$ 162,265,731.00	\$ 18,824,781.24
Fulton	10.03%	16	\$ 4,397,188.00	\$ 440,855.73
Hancock	13.40%	23	\$ 16,195,898.00	\$ 2,170,723.80
Hardin	10.01%	12	\$ 4,141,282.00	\$ 414,577.43
Henry	10.38%	14	\$ 3,113,844.00	\$ 323,150.07
Huron	8.40%	22	\$ 10,543,997.00	\$ 885,210.91
Logan	10.26%	1	\$ 735,568.00	\$ 75,501.91
Lucas	11.20%	47	\$ 276,597,391.00	\$ 30,991,662.75
Marion	13.28%	100	\$ 128,613,896.00	\$ 17,081,024.75
Mercer	10.78%	26	\$ 7,655,738.00	\$ 825,354.71
Miami	11.40%	23	\$ 10,005,576.00	\$ 1,140,201.92
Ottawa	7.14%	75	\$ 65,291,745.00	\$ 4,658,956.90
Paulding	10.89%	3	\$ 1,387,796.00	\$ 151,111.64
Preble	9.53%	24	\$ 4,859,547.00	\$ 462,988.59
Putnam	9.21%	18	\$ 5,590,738.00	\$ 514,635.36
Sandusky	11.41%	15	\$ 5,519,069.00	\$ 629,578.81
Seneca	9.27%	49	\$ 33,546,722.00	\$ 3,110,407.96
Shelby	10.43%	35	\$ 26,824,309.00	\$ 2,796,973.81
Van Wert	12.45%	13	\$ 7,459,562.00	\$ 929,081.73
Williams	11.46%	13	\$ 5,459,757.00	\$ 625,861.26
Wood	4.35%	36	\$ 67,981,624.00	\$ 2,960,079.95
Wyandot	11.97%	19	\$ 10,280,904.00	\$ 1,230,497.47

Estimate of Potential Losses of State-owned and State-leased Critical Facilities to a 5.0 Magnitude Earthquake Event				
Region 2				
County	Percentage of Total Building Value	Number of State-owned and State-leased Critical Facilities	Value of State-owned and State-leased Critical Facilities	Estimated Damage to State-owned and State-leased Critical Facilities
Ashland	8.99%	143	\$ 64,539,880.00	\$ 5,804,972.65
Butler	7.07%	21	\$ 17,563,033.00	\$ 1,241,552.32
Clinton	10.06%	22	\$ 11,528,821.00	\$ 1,159,863.29
Cuyahoga	8.66%	84	\$ 248,840,544.00	\$ 21,541,067.63
Delaware	6.61%	37	\$ 46,217,477.00	\$ 3,057,047.19
Fairfield	7.63%	78	\$ 86,519,830.00	\$ 6,601,331.03
Fayette	13.52%	26	\$ 5,118,182.00	\$ 692,137.33
Franklin	9.53%	249	\$ 2,147,726,878.00	\$ 204,615,249.31
Geauga	6.58%	24	\$ 8,594,197.00	\$ 565,501.42
Greene	7.76%	25	\$ 10,629,296.00	\$ 825,127.14
Hamilton	8.80%	35	\$ 173,140,806.00	\$ 15,235,838.30
Knox	10.25%	34	\$ 40,507,246.00	\$ 4,151,573.39
Lake	8.38%	21	\$ 5,525,021.00	\$ 462,810.73
Licking	8.79%	64	\$ 168,043,312.00	\$ 14,767,740.95
Lorain	9.66%	90	\$ 110,138,241.00	\$ 10,643,679.46
Madison	8.72%	109	\$ 321,691,881.00	\$ 28,057,673.48
Medina	9.07%	22	\$ 18,601,644.00	\$ 1,686,571.99
Montgomery	10.64%	71	\$ 77,351,496.00	\$ 8,233,689.11
Morrow	8.78%	21	\$ 6,874,959.00	\$ 603,905.66
Pickaway	9.11%	133	\$ 195,643,558.00	\$ 17,813,683.77
Portage	9.06%	25	\$ 7,594,529.00	\$ 687,788.83
Richland	12.08%	73	\$ 109,750,465.00	\$ 13,257,351.06
Stark	10.61%	41	\$ 102,066,812.00	\$ 10,826,014.55
Summit	10.61%	67	\$ 201,182,298.00	\$ 21,335,792.47
Union	11.06%	53	\$ 88,869,557.00	\$ 9,831,579.25
Warren	7.30%	109	\$ 150,201,626.00	\$ 10,957,711.02
Wayne	9.10%	6	\$ 7,056,104.00	\$ 641,928.72

Estimate of Potential Losses of State-owned and State-leased Critical Facilities to a 5.0 Magnitude Earthquake Event				
Region 3				
County	Percentage of Total Building Value	Number of State-owned and State-leased Critical Facilities	Value of State-owned and State-leased Critical Facilities	Estimated Damage to State-owned and State-leased Critical Facilities
Adams	9.62%	24	\$ 6,622,981.00	\$ 636,848.55
Ashtabula	5.32%	62	\$ 20,008,110.00	\$ 1,063,631.13
Athens	12.37%	31	\$ 45,496,640.00	\$ 5,627,481.79
Belmont	8.30%	62	\$ 54,856,808.00	\$ 4,552,936.44
Brown	7.41%	18	\$ 36,403,605.00	\$ 2,697,698.28
Carroll	9.73%	17	\$ 3,661,999.00	\$ 356,200.89
Clermont	8.87%	38	\$ 17,885,810.00	\$ 1,585,932.04
Columbiana	5.79%	38	\$ 13,835,662.00	\$ 801,340.33
Coshocton	12.10%	19	\$ 12,943,450.00	\$ 1,566,760.91
Gallia	11.14%	71	\$ 35,860,837.00	\$ 3,993,791.51
Guernsey	13.82%	54	\$ 39,704,477.00	\$ 5,486,453.93
Harrison	9.64%	30	\$ 9,054,441.00	\$ 873,265.01
Highland	9.31%	8	\$ 9,690,902.00	\$ 901,872.97
Hocking	11.89%	19	\$ 7,123,096.00	\$ 846,861.15
Holmes	9.77%	25	\$ 10,336,112.00	\$ 1,009,465.36
Jackson	11.71%	18	\$ 15,130,501.00	\$ 1,772,120.88
Jefferson	11.37%	37	\$ 7,592,901.00	\$ 863,585.02
Lawrence	7.70%	27	\$ 11,760,373.00	\$ 905,902.09
Mahoning	11.56%	66	\$ 72,389,280.00	\$ 8,365,731.73
Meigs	8.88%	18	\$ 8,512,106.00	\$ 756,259.13
Monroe	9.88%	22	\$ 11,202,381.00	\$ 1,107,263.95
Morgan	12.04%	10	\$ 3,700,608.00	\$ 445,402.54
Muskingum	12.01%	25	\$ 10,647,135.00	\$ 1,278,963.08
Noble	11.32%	31	\$ 50,299,353.00	\$ 5,694,508.35
Perry	10.11%	16	\$ 3,884,728.00	\$ 392,909.81
Pike	11.84%	10	\$ 3,878,547.00	\$ 459,298.97
Ross	11.01%	142	\$ 265,584,512.00	\$ 29,246,770.29
Scioto	9.75%	55	\$ 171,351,723.00	\$ 16,701,432.01
Trumbull	10.61%	60	\$ 55,012,652.00	\$ 5,836,154.69
Tuscarawas	10.51%	53	\$ 56,132,900.00	\$ 5,899,429.22
Vinton	12.58%	20	\$ 5,854,782.00	\$ 736,581.48
Washington	8.51%	55	\$ 29,149,164.00	\$ 2,481,017.66