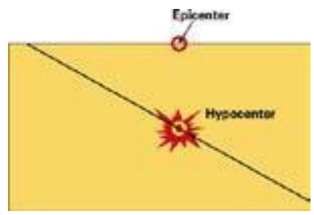
3.10: Earthquake Risk Assessment

Hazard Description

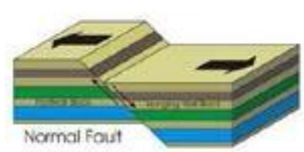


The United States Geographic Survey (USGS) defines an earthquake as a sudden motion or trembling of the earth caused by an abrupt release of stored energy beneath the earth's surface. A description of technical terms associated with earthquakes is provided below:

Epicenter - The epicenter is the geographic location directly above the hypocenter on the earth's surface. Ideally, the epicenter and the highest Modified Mercalli Intensity Scale (MMI) values on the isoseismic map coincide; however, this relationship is not always consistent.

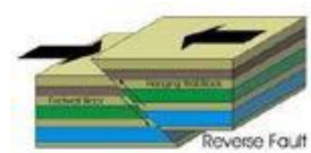
Modified Mercalli Intensity Scale - The size of an earthquake can be expressed in several ways, the most commonly used are the various magnitude scales and the Modified Mercalli Intensity Scale (MMI). There are several intensity scales, but the MMI is most commonly used in this country. The intensity scales differ from magnitude scales in that they measure the effects of seismic waves as they are perceived by people in the "felt" area of the earthquake. The first question, for example, is usually "Did you feel the earthquake?" If the answer is "yes" then a set of questions are asked that will help the interviewer determine the level of intensity at that site (referred to as site intensity). Intensity levels vary from an MMI intensity level I, where the earthquake was not felt to an MMI value of XII which is described as total damage.

Hypocenter - The hypocenter is the location in the subsurface where the rupture took place.

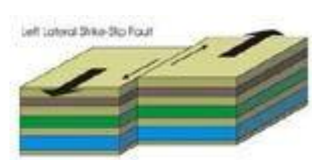


Fault - Faults can be defined as a rupture in subsurface geological materials where there is relative movement on the opposing sides of the rupture. The origin of this movement is stress built up in the earth's crust from plate movement or other geological forces.

Normal Fault -. A normal or gravity fault is one where a fault block has moved downward as gravity moves a fault block down along an inclined fault plane.



Reverse Fault - A reverse fault is the opposite of a normal fault where a fault block has moved up an inclined fault plane, opposite of the movement that would be expected if gravity were the main force acting on the block.



Strike Slip Fault - A strike-slip fault is one where the movement is largely horizontal and oriented in the same direction as the fault trends. Normal faults are the result of an extension of the earth's crust, reverse faults are a result of a shortening or compression of the earth's crust and strike-slip faults result from forces acting horizontally.

Fault Plane - The rupture along which the movement of the fault blocks takes place can be a sharp planar feature, referred to as a fault plane. In this case, the direction the fault blocks moved (up, down, or sideways) can be fairly straightforward.

Fault Zone - It is also common for the movement of fault blocks to take place across a zone consisting of multiple fault planes with small individual displacements. This zone of displacement is referred to as a fault zone and it can be a few inches wide or it can consist of a series of large faults and may be measured in miles.

Isoseismal Map - Typically, site intensities are plotted on a map, and similar intensities are grouped. The groupings are separated by lines referred to as isoseismal and the map itself is referred to as an isoseismal map. Intensities are always denoted by Roman numbers to distinguish them from magnitude values which are always in Arabic numerals. The assigned intensity value for any particular earthquake represents the highest MMI value assigned in the felt area.

Liquefaction - Liquefaction is an earthquake-related hazard involving geological conditions that pose a potential hazard to structures. Liquefaction is a complex process resulting in soils losing their bearing strength (i.e. they act more like a liquid than a solid) due to seismic-induced vibrations. The major concern is that during an earthquake the liquefaction soils become “liquid” and move laterally away from the foundation of buildings causing foundation failure or causing them to topple over.

Peak Ground Acceleration (PGA) - The maximum level of vertical or horizontal ground acceleration caused by an earthquake. The PGA is typically expressed as a percent of the acceleration due to gravity.

Magnitude - There are several magnitude scales. All are different from intensity scales as they measure completely different aspects of the earthquake *i.e*. the strength of the earthquake source (Reiter, 1990). Reiter (1990, p. 34) also defines the difference between intensity and magnitude stating that “... magnitude is determined by quantitatively analyzing instrumental recordings utilizing specific, explicitly defined formulas ...” Magnitude scales were originally devised in 1934 for use in California. This scale came to be known as the Richter or Local Magnitude Scale. A comparison of magnitude and intensity is shown in the chart below followed by abbreviated descriptions for each intensity level.

Magnitude	Modified Mercalli Intensity*
1.0-2.0	I
2.0-3.0	II
3.0-4.0	III
4.0	IV
4.0-5.0	V
5.0-6.0	VI
6.0	VII
6.0-7.0	VIII
7.0	IX
7.0-8.0	X
8.0	XI
8.0 or Greater	XII

*Based on a typical maximum Modified Mercalli Intensity Scale as defined below Source: USGS Earthquake Hazards Program

Intensity Scale
I. Not felt except by a very few under especially favorable conditions.
II. Felt only by a few persons at rest, especially on upper floors of buildings.
III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations are similar to the passing of a truck. Duration estimated.
IV. Felt indoors by many, outdoors by a few during the day. At nights, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation is like a heavy truck striking building. Standing motor cars rocked slightly.
V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects over-turned. Pendulum clocks may stop.
VI. Felt by all; many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage is slight.
VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII. Damage slight – especially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage is great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX. Damage considerable in specially-designed structures; well-designed, frame structures thrown out of plumb. Damage is great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII. Damage total. Lines of sight and level are distorted. Objects are thrown in the air.

Hazard Description

Earthquakes originating in Mississippi are not the only threat; those originating in surrounding states have also affected Mississippi in the past. The greatest potential threat to Mississippi from earthquakes is from a strong event in the New Madrid Seismic Zone (NMSZ). The earthquakes of 1811-1812, which originated along the NMSZ, shook many areas in Mississippi, reaching as far south as the Gulf Coast. The vibrations from these earthquakes were so powerful they rang church bells in Boston, Massachusetts more than 1,000 miles away.

Although the NMSZ is the primary seismic activity source for the Southeastern United States, there are other potential earthquake sources in Mississippi. The USGS has recorded more than 40 earthquakes originating within the boundaries of Mississippi since 1911. Though none of these Mississippi-centered earthquakes have inflicted severe damage, they should not be disregarded.

One area of notable earthquake activity is in east-central Mississippi in Lauderdale and Clarke counties. This area is not well known, but it has produced more than 14 earthquakes in the past 30 years, according to data gathered by the Mississippi Department of Environmental Quality (MDEQ). Most of these events occurred within Clarke County.

The White River Fault Zone (WRFZ) is another notable seismic zone that was identified in 1944. The Charleston earthquake of 1931 in Tallahatchie County, Mississippi may have been centered along this fault. This is the largest recorded Mississippi-centered earthquake with a magnitude of 5.0. The WRFZ runs from Grenada, Mississippi northward approximately 280 miles to Newport, Arkansas. Many of Mississippi's epicenters are in the northwest quadrant of the state; some may be associated with the WRFZ. The WRFZ is an area that should be assessed as a significant seismic hazard.

Earthquakes do not occur solely from naturally active faults. Volcanoes and oil and gas production are also potential sources of earthquakes. Mississippi has not experienced volcanic activity in the modern era; therefore, this impact is minimal. Oil and gas production is common in Mississippi and might produce small earthquakes with minimal hazard impacts.

Education and Outreach

The Great Central U.S. ShakeOut is an annual opportunity to practice how to be safer during significant earthquakes: "Drop, Cover, and Hold On." The ShakeOut has also been organized to encourage individuals, communities, schools, and organizations to review and update emergency preparedness plans and supplies and to identify a sheltering space to prevent damage and injuries. Registration for this event is located at www.shakeout.org.

The ShakeOut website also includes numerous educational resources such as 20 Cool Facts about the New Madrid Seismic Zone which summarizes a few significant facts about the series of large earthquakes that struck the NMSZ of southeastern Missouri, northeastern Arkansas, and adjacent parts of Tennessee and Kentucky from December 1811 to February 1812.

History of Mississippi Earthquakes

Historically, not many earthquakes are centered in Mississippi. As seen in **Table 3.10.1** many earthquakes that originated in Mississippi had a magnitude of 3.5 or less. Damage typically begins to occur when an earthquake reaches a magnitude of 4.0 or greater. Nevertheless, every earthquake is unique and potentially dangerous. Since the 2013 plan update, there were four events in 2015. **Table 3.10.1** shows earthquakes that have originated and impacted Mississippi.

Table 3.10.2 shows representative earthquakes originating in other states but have been powerful enough for residents of Mississippi to feel the effects. Based on the best available data, there appear to be no changes or seismic activity since the last plan update. **Table 3.10.3** provides seismic activity for Mississippi's neighboring states during those years. It is not known if any effects of this activity were felt in Mississippi. **Figure 3.10.1** shows the epicenter distribution of events originating in and near Mississippi.

Table 3.10.1
Mississippi Earthquakes

Date	Latitude	Longitude	Magnitude	City/Town
December 24, 2022	34.67	-88.51	2.5	Booneville
August 9, 2019	32.53	-90.03	2.8	Madison
January 8, 2019	33.19	-90.93	3.7	Hollandale
August 17, 2015	32.54	-90.12	2.6	Madison
June 29, 2015	32.56	-90.07	3.2	Canton
May 3, 2015	32.58	-90.11	3.0	Canton
May 3, 2015	32.58	-90.07	3.2	Canton
August 30, 2013	32.99	-88.46	2.0	Farmington
October 10, 2012	34.33	-90.52	2.3	Jonestown
July 30, 2012	32.54	-88.64	1.6	Meridian Station
July 27, 2012	32.56	-88.64	2.1	Meridian Station
May 10, 2008	34.35	-88.83	3.1	Sherman
October 26, 2002	34.03	-90.68	3.1	Duncan
August 11, 2002	34.34	-90.17	2.8	Batesville
May 10, 2008	34.35	-88.83	3.1	Sherman
October 26, 2002	34.03	-90.68	3.1	Duncan
August 11, 2002	34.34	-90.17	2.8	Batesville
February 25, 1999	34.1	-89.87	2.9	Oakland
August 11, 1996	33.58	-90.87	3.5	Meltonia
September 25, 1984	34.06	-89.82	Not available	Long Branch
February 5, 1983	34.70	-88.37	2.9	Cairo
October 12, 1980	34.26	-89.13	Not available	Turnpike
June 9, 1978	32.09	-88.58	3.3	Quitman
November 4, 1977	33.83	-89.28	3.4	Calhoun City
October 23, 1976	32.20	-88.73	3.0	Meridian
September 9, 1975	30.66	-89.25	2.9	Riceville
May 25, 1973	33.94	-90.63	Not available	Lombardy
January 1, 1973	33.78	-90.62	3.5	Ruleville
June 29, 1967	33.55	-90.81	Not available	Shaw
June 4, 1967	33.55	-90.84	4.4	Shaw
October 22, 1964	31.23	-89.56	Not available	Pine Grove
June 1, 1962	34.98	-90.18	Not available	Walls
September 27, 1956	31.9	-88.50	Not available	Shubuta

February 1, 1955	30.4	-89.10	Not available	Gulfport
June 28, 1941	32.4	-90.9	Not available	Vicksburg
December 17, 1931	33.8	-90.1	4.6	Oxberry
November 13, 1927	32.8	-90.20	Not available	Linwood
October 28, 1923	34.9	-88.10	Not available	Eastport
March 27, 1923	34.6	-89.8	Not available	Barr
March 31, 1911	34	-91.8	4.7	Tutwiler

Source: USGS

Table 3.10.2
Earthquakes Affecting Mississippi 2006 - 1812

Date	Origin	Magnitude	Maximum Intensity	Intensities Reported in MS	Counties Affected
September 10, 2006	253 miles SSW of Apalachicola, FL	6	VI	I, II, III, IV	Alcorn, Bolivar, Covington, Desoto, Forrest, George, Hancock, Harrison, Hinds, Jackson, Jones, Lauder- dale, Lee, Marion, Pearl River, Rankin, Scott, Walthall, Warren, and Webster
June 2, 2005	10 miles NNW of Dyersburg, TN	4	III	I	Alcorn, Desoto, Tate, Tishomingo, Tunica, and Yalobusha
May 1, 2005	15 miles WSW of Blytheville, AR	4.1	VI	I, II, III	Bolivar, Tate and Tunica
February 10, 2005	22 miles WSW of Blytheville, AR	4.1	V	I, II, III	Alcorn, Benton, Coahoma, Desoto, Itawamba, Jones, Lafayette, Lee, Marshall, Pontotoc, Prentiss, Tate, Tippah, Tishomingo, Tunica, and Union
November 7, 2004	25 miles SW of Tuscaloosa, AL	4	V	I, II, III, IV	Clay, Coahoma, Desoto, Lauderdale, Leake, Oktibbeha, Monroe, Newton, and Scott
April 29, 2003	8 miles ENE of Fort Payne, AL	4.6	V	I, II, III, IV	Alcorn, Chickasaw, Clay, Desoto, Hancock, Harrison, Itawamba, Lafayette, Lauderdale, Lee,

					Lowndes, Monroe, Oktibbeha, Panola, Prentiss, Tate, Tishomingo, and Yalobusha
March 29, 1972	New Madrid Seismic Zone	Not available	IV	I, II, III, IV	Bolivar, Desoto, and Panola
1811-1812	New Madrid Seismic Zone	7.8 - 8.1	XI	Not available	Affected counties as far as the Gulf Coast

Source: USGS and MDEQ Office of Geology

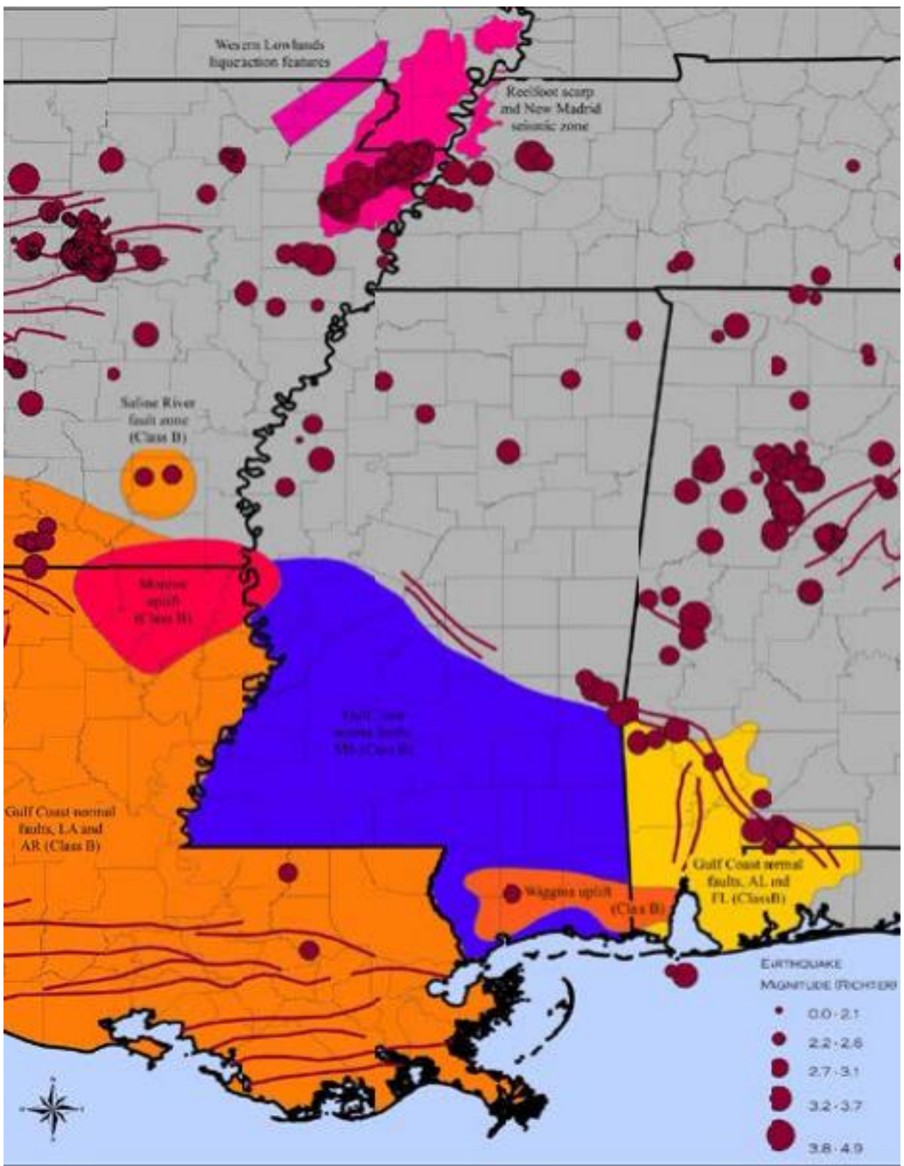
Table 3.10.3
Seismic Activity in Neighboring States
2010 – 2023

Year	State	Occurrences	Range of Magnitudes
2023	Tennessee	5	2.5-2.78
2022	Tennessee	9	2.5-3.21
2021	Tennessee Alabama	9 2	2.5-4.3 2.6-3.1
2020	Arkansas Tennessee Alabama	2 16 5	2.8 2.5-3.8 2.5-3.8
2019	Tennessee Alabama	20 5	2.5-3.69 2.5-3.1
2018	Alabama Tennessee	17 4	1.7 – 2.7 1.5 – 2.4
2017	Arkansas	75	.05 – 3.6
2016	Arkansas Tennessee	49	.09 – 2.8
2015	Arkansas Tennessee	64 5	1.3 – 2.5 2.5 – 3.5
2014	Arkansas Tennessee	126 5	1.3 – 2.7 2.5 – 3.1
2013	Arkansas Tennessee	181 1	1.5 – 3.2 2.6

2012	Arkansas Alabama Tennessee Arkansas	9 5 2 175	2.1 – 3.9 1.7 – 2.7 2.0 – 2.5 2.2 – 4.1
2011	Alabama Arkansas	8 70	1.8 – 3.5 1.8 – 4.0
2010	Alabama Louisiana	5 1	2.6 – 3.2 3

Source: USGS

Figure 3.10.1
Regional Earthquakes, Normal and Quaternary Faults and Fault Areas



Summary of Previous Events

Although the number of earthquakes known to have been centered within Mississippi's boundaries is small, the state has been affected by numerous shocks located in neighboring States. In the winter of 1811 and 1812, the NMSZ generated a sequence of earthquakes that lasted for several months and included three very large earthquakes estimated to be between magnitude 7 and 8. The three largest 1811-1812 earthquakes destroyed several settlements along the Mississippi River, caused minor structural damage as far away as Cincinnati, Ohio, and St. Louis, Missouri, and were felt as far away as Hartford, Connecticut, Charleston, South Carolina, and New Orleans, Louisiana. In the New Madrid region, the earthquakes dramatically affected the landscape. They caused bank failures along the Mississippi River, landslides along Chickasaw Bluffs in Kentucky and Tennessee, and uplift and subsidence of large tracts of land in the Mississippi River floodplain. One such uplift related to faulting near New Madrid, Missouri, temporarily forced the Mississippi River to flow backward. In addition, the earthquakes liquefied subsurface sediment over a large area and at great distances resulting in ground fissuring and violent venting of water and sediment. One account of this phenomenon stated that the Pemiscot Bayou "blew up for a distance of nearly fifty miles."

The 1811-1812 New Madrid sequence consisted of three large earthquakes:

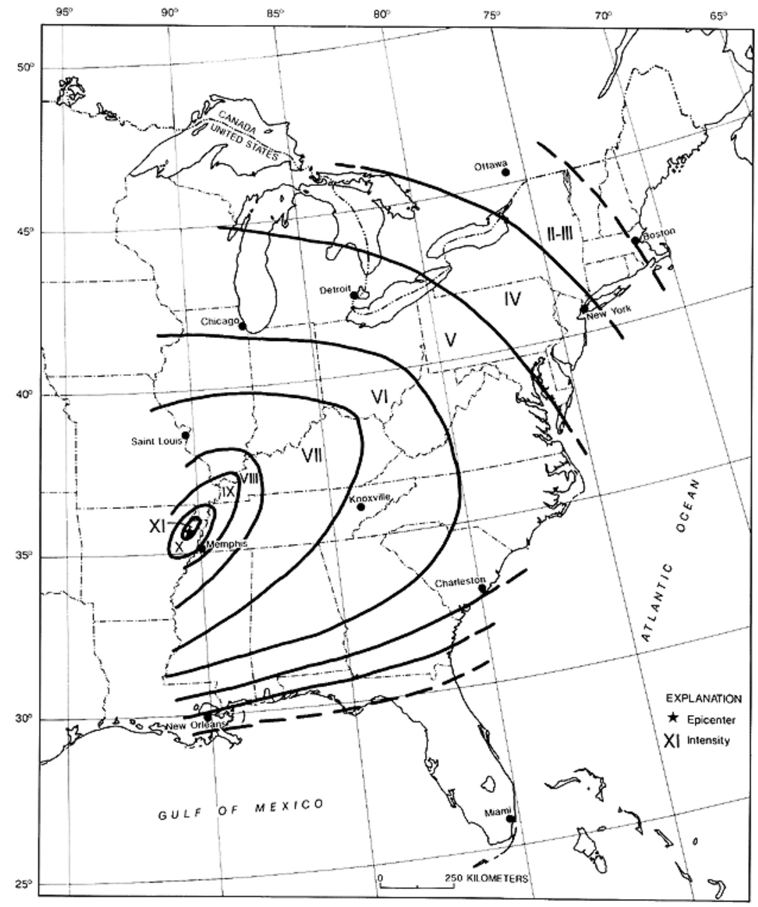
1. M-7.5 on December 16, 1811
2. M-7.3 on January 23, 1812
3. M-7.5 on February 7, 1812

According to some reports, the earthquakes of 1811-12 made the land roll like waves. There are letters and descriptions which tell how the land "rocked." The story of the first steamer trip down the Ohio and Mississippi Rivers has many times been told including anecdotes related to the Roosevelts on board finding themselves rocked and tossed about on the agitated waters.

A 19th-century print of New Madrid earthquake chaos. (Granger Collection, NYC)

Source: The Smithsonian

Figure 3.10.2
Isoseismal Map 1811 – 1812
(Isoseismal map for the Arkansas earthquake of December 16, 1811, 08:15 UTC (first of the 1811-1812 New Madrid series). – USGS)



The earliest and strongest earthquake reported in Mississippi occurred on December 16, 1931, at about 9:36 p.m. in Charleston. In the area of maximum intensity, the walls and foundation of the agricultural high school cracked, and several chimneys collapsed (intensity –VI-VII). At Belzoni, plaster fell and several chimneys were damaged (intensity VI). In Tillatoba, one chimney toppled and a vase was thrown to the floor (intensity VI). At Water Valley, several chimneys were damaged (intensity VI). The shock was perceptible over a 65,000-square-mile area including the northern two-thirds of Mississippi and adjacent portions of Alabama, Arkansas, and Tennessee.

On February 1, 1955, an earthquake was felt by many people along a 30-mile strip of the Mississippi Gulf Coast. In Gulfport, houses shook, windows and dishes rattled, and deep rumbling sounds were heard by many (intensity V). In Biloxi, several persons were alarmed and a rumbling noise was heard. Similar effects were noted at Mississippi City and Pass Christian. The tremor was reported by many persons in Bay St. Louis, where buildings creaked, and loose objects and windows rattled.

In June 1967, two earthquakes occurred about 18 miles northeast of Greenville, Mississippi. The first, on June 4, measured a magnitude of 3.8 on the Richter Scale and was felt over approximately 25,000 square miles. The region affected by this tremor included the northwest quadrant of Mississippi and parts of Arkansas, Louisiana, and Tennessee. A few instances of cracked plaster were reported in the epicentral region. One resident near the epicenter reported a ground crack 1/4 to 1/2-inch-wide and 39 feet long on his lawn.

On June 29, a second earthquake occurred in the same region with a magnitude of 3.4. The shocks were limited to parts of Bolivar, Sunflower, and Washington Counties.

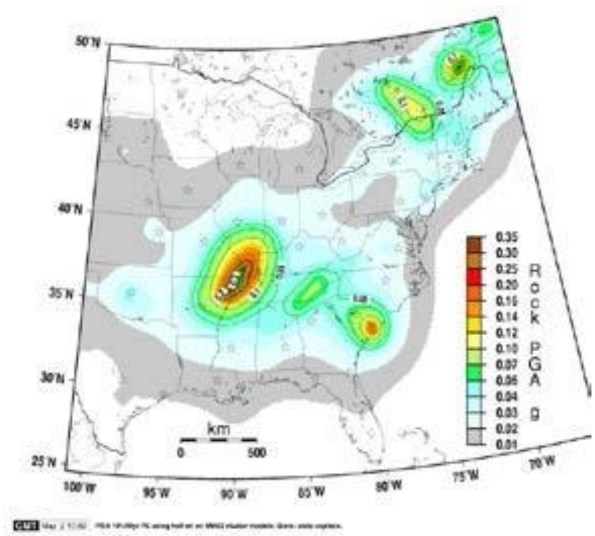
Another earthquake felt in Mississippi occurred on March 29, 1972. This shock, which was centered in the New Madrid, Missouri region, reached a peak intensity of IV in Mississippi at Hillhouse, Mineral Wells, and Pleasant Grove. Intensity I to III effects were noted in Horn Lake.

Potential Damages from Earthquakes

The potential for an earthquake to produce damage depends on many factors, such as the condition or construction of the affected structures, soil characteristics, and earthquake characteristics. Earthquake characteristics include magnitude, peak ground acceleration, and distance from the epicenter. The epicenter of an earthquake is located on the ground surface directly above the focus, or the location, where the earthquake begins. In most cases, the damage incurred by an earthquake is greatest near the epicenter and decreases with distance. Peak Ground Acceleration (PGA) is the maximum acceleration of a particle during an earthquake. More simply, PGA is the measure of the strength of the ground movement. An earth- quake's PGA is greatest near its epicenter, which explains why earthquake damage is greatest near the epicenter. Figure 3.10.3 provides the PGA potential for a ten percent in 50-year rupture of the New Madrid Fault along with the frequency at which the ground will shake. **Figures 3.10.4-a-b** on the subsequent page provide spectral acceleration for one and five-hertz ruptures.

Figure 3.10.3
Peak Ground Acceleration Rupture of the New Madrid Fault
10% in 50 Years Probability

The acceleration is measured as a percent of the acceleration due to gravity (g's)



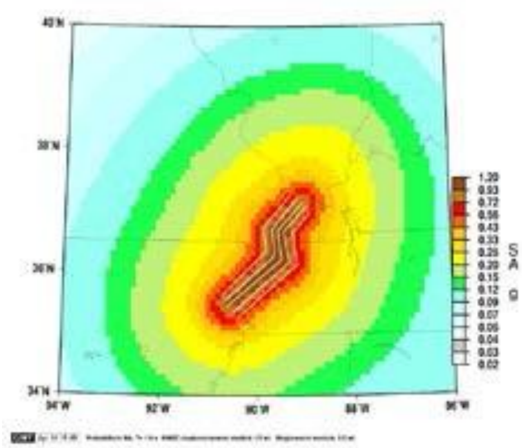
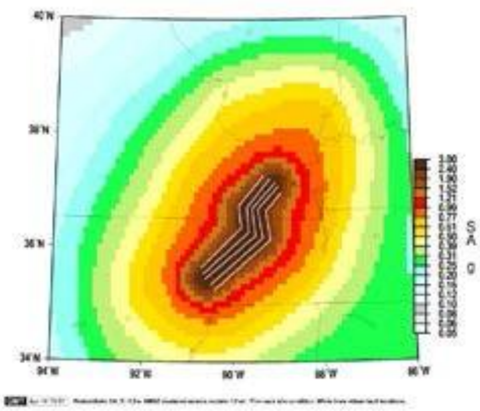


Figure 3.10.4-a
Spectral Acceleration at one Hz
Rupture of the New Madrid Fault
2% in 50 Years Probability

Figure 3.10.4-b
Spectral Acceleration at five Hz Rupture of the New Madrid Fault 2% in 50 Years Probability

Hz: Hertz, or cycles per second (frequency of ground shaking) SA measured in g's



Seismic waves may also create other earthquake-related hazards such as liquefaction and slope failure. Liquefaction occurs when loose sand and silt that is saturated with water is shaken by earthquake energy. The mixture takes on the qualities of a liquid when shaken and can result in a lack of structural support and eventual failure of a structure built upon the liquid-like soil. In Mississippi, liquefaction is more likely to occur where there is a significant floodplain. The rivers with significant floodplains located in seismic areas of concern in Mississippi include the Mississippi River, Yalobusha River, Yocona River, Tallahatchie River, and Coldwater River. As shown in **Table 3.10.4**, counties were evaluated based on their location within the aforementioned floodplains and seismic zone. This data has not been updated since the last plan. The liquefaction potential listed in the table references the HAZUS scenario for liquefaction potential in each county. Since the liquefaction data has not changed, the HAZUS scenario will remain the same.

Slope failure during a seismic event can result in extensive damage. The areas most likely to experience slope failure during an earthquake are the bluffs that bound the Mississippi River floodplain, river banks, steep slopes in the Bluff Hills, levees, earth-filled embankments, and transportation embankments.

Table 3.10.4
High Liquification Hazard by County

County	Seismic Source[1]	Geographic Area of Concern[2]	Liquefaction Potential
Benton	NMSZ	CRFP, WoRFP	Very High, Very Low
Bolivar	NMSZ	MRFP	Very High
Carroll	NMSZ, WRFZ	MRFP	Very High, Very Low
Coahoma	NMSZ, WRFZ	MRFP	Very High
DeSoto	NMSZ, WRFZ	MRFP, CRFP	Very High, Very Low
Grenada	NMSZ, WRFZ	MRFP, YaRFP	Very High, Very Low
Holmes	NMSZ	MRFP	Very High, Very Low
Humphreys	NMSZ	MRFP	Very High
Issaquena	NMSZ	MRFP	Very High
Lafayette	NMSZ, WRFZ	TRFP	Very High, Very Low
Leflore	NMSZ, WRFZ	MRFP, YaRFP	Very High
Marshall	NMSZ, WRFZ	CRFP	Very High
Panola	NMSZ, WRFZ	MRFP, TRFP, YRFP	Very High, Very Low
Quitman	NMSZ, WRFZ	MRFP, CRFP, TRFP, YRFP	Very High
Sharkey	NMSZ, WRFZ	MRFP	Very High
Sunflower	NMSZ, WRFZ	MRFP	Very High
Tallahatchie	NMSZ, WRFZ	MRFP, CRFP	Very High, Very Low
Tate	NMSZ, WRFZ	MRFP, CRFP	Very High, Very Low
Tunica	NMSZ, WRFZ	MRFP, CRFP	Very High
Union	NMSZ	TRFP	Very High, Very Low
Washington	NMSZ	MRFP	Very High

[1]NMSZ = New Madrid Seismic Zone

WRFZ = White River Fault Zone

[2]CRFP = Coldwater River Floodplain

MRFP = Mississippi River Floodplain

TRFP = Tallahatchie River Floodplain

WoRFP = Wolf River Floodplain (Major River originating in Tennessee)

YaRFP = Yalobusha River Floodplain

YRFP = Yocona River Floodplain

Earthquake Effects on Dams

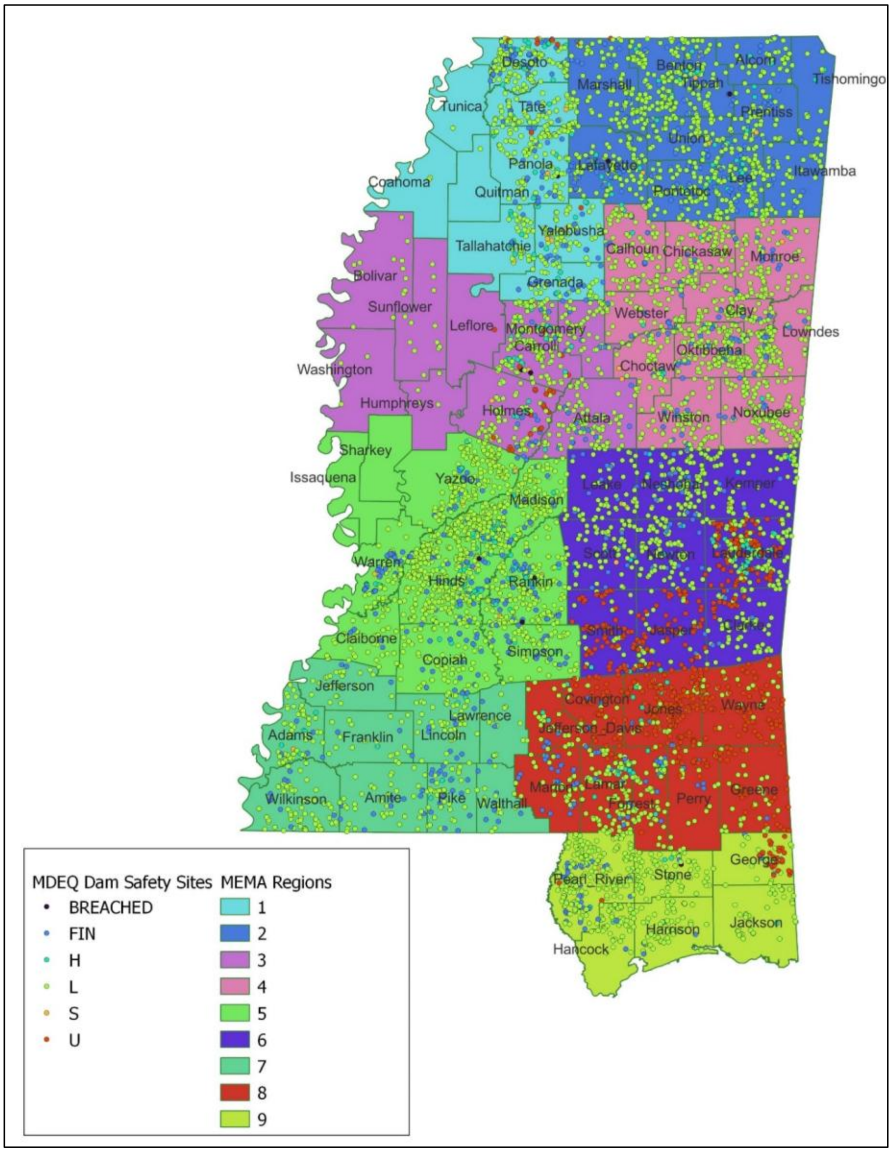
A review of the potential impacts of earthquakes for the 2023 plan update, revealed that the vulnerability of dams to the effects of earthquakes should continue to be addressed. To assess this potential threat, the inventory of dams for MEMA Regions 1 and 3 is provided in **Table 3.10.5** (the complete inventory of dams for all counties is provided in **Section 3.4**). These counties are located in areas that experienced impacts from previous tremors or are geographically susceptible to future impacts. **Figure 3.10.4** overlays the significant and high-hazard dams with the historic seismic recordings.

Table 3.10.5
Dam Inventory in Relation to Earthquake Prone Counties

MEMA District 1						
	2023					
County	S	H	L	U	FIN	Total
Coahoma	0	0	2	0	0	2
DeSoto	1	24	120	5	54	204
Grenada	0	3	32	0	20	55
Panola	1	9	95	1	23	129
Quitman	0	0	1	0	0	1
Tallahatchie	1	11	35	0	2	49
Tate	1	4	65	0	8	78
Tunica	0	0	1	0	0	1
Yalobusha	3	8	53	1	12	77
Total	7	59	404	7	119	596

MEMA District 3						
	2023					
County	S	H	L	U	FIN	Total
Atalla	1	1	88	0	14	104
Bolivar	0	0	14	0	0	14
Carroll	4	24	114	4	5	151
Holmes	1	4	64	16	12	97
Humphreys	0	0	4	0	0	4
Leflore	0	0	0	1	0	1
Montgomery	0	2	48	0	7	57
Sunflower	0	0	12	0	0	12
Washington	0	0	3	0	0	3
Total	6	31	347	21	38	443

Figure 3.10.5
Significant and High Hazard Dam Locations



Bridge Retrofit Program

The Mississippi Department of Transportation (MDOT) conducts biennial inspections of all bridge structures. In anticipation of a future earthquake resulting from activity in the New Madrid Fault, it also monitors and inspects bridges that it has “retrofitted,” or upgraded, to perform better as a result of newer technology developed to address a seismic event. The bridge retrofit program is concentrated on primary and secondary access routes in Northwest Mississippi. Retrofit activities consist basically of securing bridge caps to piers, thus increasing the probability of the structure will remain standing after an earthquake. Today, all new bridges are constructed using earthquake-resistant technology. **Table 3.10.6** provides a listing of bridges in Northwest Mississippi that have been upgraded to seismic retrofit.

Table 3.10.6
Bridges Retrofitted in Northwest Mississippi

Bridge ID	Feature Inspection	County	Highway
10932	Creek	Desoto	US 51
10941	Lake Cormorant	Desoto	US 61
10950	Coldwater River	Desoto	US 78
10951	Coldwater River	Desoto	US 78
10970	Horn Lake Creek	Desoto	SR 302
10983	Coldwater River	Desoto	SR 305
13155	Barrow Creek	Marshall	US 78
13156	Barrow Creek	Marshall	US 78
13167	Spring Creek	Marshall	US 78
13172	Spring Creek	Marshall	US 78 13173
14612	Canal & Shands Bottom Road	Tate	I-55
14615	Hickahala Creek	Tate	I-55
14616	Hickahala Creek	Tate	I-55
14617	Hickahala Relief	Tate	I-55
14618	Hickhala Relief	Tate	I-55
14621	Coldwater River	Tate	I-55
13156	Barrow Creek	Marshall	US 78
13167	Spring Creek	Marshall	US 78
13172	Spring Creek	Marshall	US 78 13173
14612	Canal & Shands Bottom Road	Tate	I-55
14615	Hickahala Creek	Tate	I-55
14616	Hickahala Creek	Tate	I-55
14617	Hickahala Relief	Tate	I-55
14618	Hickhala Relief	Tate	I-55
14621	Coldwater River	Tate	I-55
14622	Coldwater River	Tate	I-55
14631	Coldwater River	Tate	SR 3
14633	Arkabutla Canal	Tate	SR 3
13634	CNIC RR	Tate	SR 3
15413	Johnson Creek	Desoto	US 61

Probability of Future Events

The Central U.S. does not have as many earthquakes as the Western U.S. As a result, statistically valid data are not yet available for determining the probabilities of future earthquake events in this region. The USGS has stated that there are marked differences in determining probabilities of future earthquakes in California as opposed to along the NMSZ. On the west coast, locations of future earthquakes can be anticipated based on measurements of land deformation. Such predictions are much more difficult with earthquakes along the NMSZ. The NMSZ generates very little surface deformation over time; therefore, as seismic events occur along the New Madrid, data are collected and probabilities can be calculated. According to a study by the Center for Earthquake Research and Information (CERI) at the University of Memphis in 2002, the probability of a repeat of the 1811-1812 earthquakes in 50 years is 7-10%. In the same study, the probability of a magnitude 6.0 or greater earthquake within 50 years was estimated to be 25-40%.

Local Plan Risk Assessment Summary

Below is a summary of the risk classification identified in the individual local mitigation plans by MEMA Region.

MEMA Region	Low	Medium	High	MEMA Region	Low	Medium	High
1		9		6		9	
2		12		7		9	
3	9	1		8		5	1
4		10	1	9		6	
5		45	1				

Vulnerability Assessment

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to predict earthquake losses on a regional scale. These loss estimates are used primarily by local, state, and regional officials to mitigate the risks from earthquakes and to prepare for emergency response and recovery. The earthquake loss estimates provided in this report were based on a region that includes all of Mississippi's counties.

The geographical size of the region is 47,651.55 square miles and contains 664 census tracts. There are over 1.117 million households in the region which has a total population of 2.93 million people (2022 Census Bureau data).

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There are an estimated 1,241 thousand buildings in the region with a total building replacement value (excluding contents) of 280,518 (millions of dollars). Approximately 92.00 % of the buildings (and 75.00% of the building value) are associated with residential housing. The replacement value of the transportation and utility lifeline systems is estimated to be 95,370 and 27,142 (millions of dollars), respectively.

Results of the Earthquake Impact Assessment

Mississippi NMSZ Scenario

The HAZUS information estimates that about 72,788 buildings will be at least moderately damaged. This is over 6.00 % of the buildings in the region. There are an estimated 14,407 buildings that will be damaged beyond repair.

A NMSZ event in the southwest region of the NMSZ has the potential to cause intense shaking in Mississippi's northern counties. As a result, 25 counties are identified as critical and most of the damage incurred by the state of Mississippi is expected to occur in this set of counties. These 25 critical counties are highlighted in Figure 16 and are listed below:

- ✓ Alcorn
- ✓ Benton
- ✓ Bolivar
- ✓ Calhoun
- ✓ Chickasaw
- ✓ Coahoma
- ✓ DeSoto
- ✓ Grenada
- ✓ Itawamba
- ✓ Lafayette
- ✓ Lee
- ✓ Marshall
- ✓ Monroe
- ✓ Panola
- ✓ Pontotoc
- ✓ Prentiss
- ✓ Quitman
- ✓ Sunflower
- ✓ Tallahatchie
- ✓ Tate
- ✓ Tippah
- ✓ Tishomingo
- ✓ Tunica
- ✓ Union
- ✓ Yalobusha

Buildings in the northern portion of Mississippi are expected to incur moderate damage, with limited cases of complete damage confined to the critical counties listed above. 13,991 buildings are estimated to incur complete damage, all of which are in the 25 critical counties. Approximately 55,000 of the 58,000 moderate and severe damage cases occur in critical counties. Table 3.10.7 illustrates the distribution of building damage by occupancy type. Nearly all complete and moderate to severe damage is expected to affect residential structures, leaving 45,000 of the one million residential structures in Mississippi damaged.

As with many other NMSZ states, wood frame buildings and mobile homes are the most common structural systems. Less common in Mississippi are buildings constructed in the Unreinforced Masonry (URM) method. In Mississippi, approximately 7.5% of the total building inventory is URM construction. Nearly 71% of all complete damage occurs in mobile homes. Approximately 37% of all moderate damage is attributed to wood frame buildings, as shown in Table 3.10.8. It is also relevant to note that while steel, concrete, and precast (concrete) structures are a much smaller portion of the building inventory in Mississippi, approximately 9% of each of these building types experiences at least moderate damage, while 63% of mobile homes incur extensive damage.

Table 3.10.7
NMSZ Event Building Damage by Occupancy Type for the State of Mississippi

General Occupancy Type Damage			
General Occupancy Type	Total No. of Buildings	Moderate to Severe Damage	Complete Damage
Single-Family	834,634	54,383	562
Other Residential	177,552	15,747	10,317
Commercial	51,200	4,585	2,169
Industrial	12,470	1,087	717
Other	15,928	1,436	643
Total	**1,091,784**	**77,238**	**14,408**

Table 3.10.8
NMSZ Event Building Damage by Building Type for the State of Mississippi

Building Damage by Building Type					
Building Type	None	Slight	Moderate	Extensive	Complete
Wood	835,196	53,218	14,221	1,791	317
Steel	21,795	1,568	2,311	2,370	2,320
Concrete	6,143	495	536	420	335
Precast	6,218	425	551	405	306
Reinforced Masonry	2,577	141	180	138	94
Unreinforced Masonry	75,870	8,023	5,821	2,221	844
Mobile Home	144,006	13,367	14,689	12,726	10,193
Total	**1,091,784**	**77,237**	**38,309**	**20,071**	**14,409**

HAZUS indicates that the northernmost counties in Mississippi are vulnerable to damage and functional losses to essential facilities. Statewide, over 58 schools may potentially experience moderate damage, and over 1,151 may be damaged beyond the ability to function normally on the day after the earthquake, as shown in Table 3.10.9. Nearly all of these potentially damaged schools are located in Desoto, Tunica, Tate, Marshall, and Benton Counties. Lafayette, Union, Tippah, Alcorn, and Prentiss Counties may potentially experience substantial functional loss to schools immediately after the earthquake. There are potentially 27 moderately damaged fire stations and nearly 353 not functioning the day after the earthquake. Approximately, 103 hospitals will be potentially unable to function after the earthquake. Not only will this region be without medical care services for those injured by the earthquake, but care for existing patients will likely require transport to fully functioning facilities outside the critical counties.

On the day of the earthquake, the model estimates that only 14,695 hospital beds (82.00%) will be available for use by patients already in the hospital and those injured by the earthquake. After one week, 91.00% of the beds will be back in service. After 30 days, 97.00% will be operational.

The model also estimates that northwestern Mississippi transportation infrastructure will potentially experience damage. Table 3.10.10 illustrates that there are over 13,692 bridges statewide. Of this number, 347 bridges will potentially experience at least moderate damage and 13,359 bridges will not be functional the day after the earthquake. Most of these non-functional bridges are in Desoto, Tunica, Tate, and Marshall Counties. Five airports in northwest Mississippi will potentially incur at least moderate damage, though they are expected to remain fully functional. In some cases, damage to structures may not affect the functionality of the facility. Using airports as an example, some portion of the facility may be damaged, though enough of the facility's structure would remain undamaged so that the facility can remain operational, despite some damage to one portion of the facility.

Table 3.10.9
NMSZ Event Essential Facilities Damage
for the State of Mississippi

Essential Facilities Damage & Functionality				
Essential Facility Type	Total No. Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% on Day 1
Hospitals	111	3	0	103
Schools	1,288	58	0	1,151
EOCs	37	1	0	34
Police Stations	368	13	0	330
Fire Stations	399	27	0	353

Table 3.10.10
NMSZ Event Highway Bridge Damage
for the State of Mississippi

Highway Bridge Damage Assessments				
	Total No. of Bridges	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% on Day 1
Total No. of Bridges for State	**13,692**	**347**	**0**	**13,359**

Table 3.10.11
NMSZ Event Communication Facilities Damage
for the State of Mississippi

Communication Damage Assessments				
	Total No. of Communication Facilities	At Least Moderate Damage (Damage >50%)	Complete Damage (Damage >50%)	Functionality >50% on Day 1
Total State	**299**	**0**	**0**	**299**

The HAZUS model predicts that utility infrastructure will likely experience substantial losses, especially in the northwestern-most critical counties. Potential damage to communication infrastructure is shown in Table 3.10.11, which illustrates that nearly 300 communication facilities(mostly in Desoto and Tate Counties), would be at least moderately damaged. However, the model does indicate that damage to these facilities is not severe enough to cause a substantial loss of functionality.

There are approximately 1.117 million households in the State of Mississippi and nearly 42,000 of those would potentially be without potable water the day after the earthquake. In addition, 33,000 would not have electricity. Approximately 39,000 households would have potable water service restored after a week and approximately 6,000 households would have electricity restored in that same time. A lack of potable water service for an extended period may force some families to leave their homes, even if the home is not significantly damaged.

Table 3.10.12
NMSZ Event Utility Service Interruptions
for the State of Mississippi

Utility Service Interruptions Number of Households without Service						
	No. Households	Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	1,046,434	41,790	40,256	39,782	28,749	0
Electric Power		32,601	18,416	6,452	1,276	44

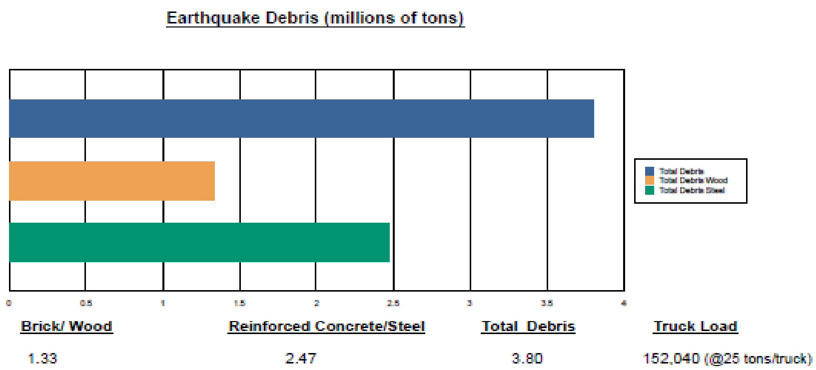
Social Impact and Direct Economic Loss

This section provides social impacts and direct economic losses for Mississippi from the scenario developed in the NMSZ Catastrophic Event Planning project. Induced damage is also included in this section and is quantified by various types of debris resulting from infrastructure damage. Social impacts include displaced residents, temporary shelter populations, various food, medical and housing requirements for sheltered populations, and casualties. Lastly, direct economic losses include estimates of building, transportation, and utility losses plus building loss ratios.

Mississippi New Madrid Seismic Zone Scenario

HAZUS estimates the amount of debris that will potentially be generated by the earthquake. The model sorts the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to manage the debris. The model estimates that a total of 3.80 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 35.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 152,040 truckloads (at 25 tons/truck) to remove the debris generated by the earthquake.

Figure 3.10.6
Debris Totals



HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates that 2,705 households will be displaced due to the earthquake. Of these, 2,085 people (out of a total population of 2,967,297) will seek temporary shelter in public shelters, as shown in Table 3.10.12. To care for this sheltered population, 2.7 million square feet of space are required, with 334,000 square feet reserved just for sleeping.

Table 3.10.12
NMSZ Event Shelter Requirements
for the State of Mississippi

Displaced and Shelter Seeking Population			
	Total Population	Displaced Population	Shelter Seeking Population
Total Nos. of State	**2,967,297**	**2,705**	**2,085**

Structural damage to buildings and infrastructure would potentially lead to approximately 1,000 injuries throughout the State of Mississippi. Over 75% of all injuries would be minor (Level 1) and 25% would potentially require delayed or immediate medical attention (Levels 2 & 3, respectively). Table 3.10.13 shows that 574 fatalities would potentially result in the modeling scenario.

The total economic loss estimated for the earthquake would potentially reach $9,206.92 million, including building and infrastructure losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

Potential building losses are divided into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. Business interruption losses are the losses associated with the inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

HAZUS estimates the total building losses at $8,791 million. 24% of the estimated losses were related to potential business interruptions in the region. The largest potential loss would be sustained by the residential occupancies which made up over 33 % of the total loss.

Table 3.10.13
NMSZ Event Casualties
for the State of Mississippi

Worst Case Casualties (2:00 PM)					
Severity Level	Level 1 (Green)	Level 2 (Yellow)	Level 3 (Red)	Level 4 (Black)	Total
Total State	**7,351**	**2,041**	**301**	**574**	**10,267**

Table 3.10.14
NMSZ Event Total Direct Economic Losses
for the State of Mississippi

Total Direct Economic Losses		
System	Inventory Value	Total Direct Economic Loss
Buildings	$6,675,238,000	$2,116,211,000
Transportation	$95,370,000	$159,500,000
Utility	$27,142,090	$255,980,000
Total	**$129,187,328,000**	**$417,596,211,000**

Transportation and Utility Lifeline Losses

For the transportation and utility infrastructure systems, HAZUS only computes the direct repair cost for each component. HAZUS does not predict losses for business interruption due to infrastructure outages. Tables 3.10.15 and 3.10.16 provide a detailed breakdown of the expected lifeline losses.

Figure 3.10.7
Transportation System Economic and Loss Ratio
(Millions of Dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	77,061.57	$0.00	0.00
	Bridges	10,003.59	$128.54	1.28
	Tunnels	0.00	$0.00	0.00
	Subtotal	**87,065.00**	**$128.50**	
Railways	Segments	4,469.84	$0.00	0.00
	Bridges	6.09	$0.02	0.33
	Tunnels	0.09	$0.00	0.00
	Facilities	71.90	$1.00	1.39
	Subtotal	**4,548**	**$1.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0**	**$0.00**	
Bus	Facilities	25.02	$0.81	3.25
	Subtotal	**25**	**$0.80**	
Ferry	Facilities	5.32	$0.02	0.46
	Subtotal	5	**$0.00**	
Port	Facilities	413.38	$6.56	1.59
	Subtotal	**413**	**$6.60**	
Airport	Facilities	617.76	$22.53	3.65
	Runways	2,695.44	$0.00	0.00
	Subtotal	**3,313**	**$22.50**	
	Total	**95,370.00**	**$159.50**	

Figure 3.10.8
Utility System Economic and Loss Ratio
(Millions of Dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Portable Water	Pipelines	0.00	$0.00	0.00
	Facilities	481.20	$0.97	0.20
	Distribution Lines	2,313.70	$0.00	0.00
	Subtotal	**2,794.85**	**$0.97**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	18,964.40	$216.28	1.14
	Distribution Lines	1,388.20	$0.00	0.00
	Subtotal	**20,352.55**	**$216.28**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	51.00	$0.48	0.93
	Distribution Lines	925.50	$0.00	0.00
	Subtotal	**976.42**	**$0.00**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.90	$0.00	0.04
	Subtotal	0.85	**$0.00**	
Electrical Power	Facilities	2,992.00	$38.02	0.46
	Subtotal	**2,992.00**	**$38.02**	
Communication	Facilities	25.40	$0.23	1.59
	Subtotal	25.40	$0.23	0.91
	Total	**27,142.09**	**$255.98**	