Alabama Catastrophic Earthquake Annex

Updated: June 2010

I. Introduction

A. Overview

The Alabama Catastrophic Earthquake Annex was developed with the assistance of the 12 critical New Madrid Seismic Zone (NMSZ) counties, seven secondary counties, and various State and local government representatives who attended and participated in the State planning workshop. Additionally, the annex has been developed in concert with the eight states of the Central United States Earthquake Consortium (CUSEC) and the Federal Emergency Management Agency (FEMA) in order to increase not only the State's readiness to an NMSZ catastrophic earthquake event, an Eastern Tennessee Seismic Zone (ETSZ) catastrophic event, or a Bahamas Fracture Seismic Zone event (BFSZ), but also to improve regional and national readiness. The annex defines the answer to the question, "What will the State of Alabama do if an earthquake should impact the state tomorrow?" It focuses on the major issues the State of Alabama expects to encounter for a catastrophic earthquake:

- Coordinating Direction and Control activities for the affected counties, as well as coordinating with other affected states and FEMA
- Quickly gaining situational awareness of damages and identifying locations with the most pressing needs
- Developing a Common Operational Picture (COP) so that all State agencies are able to rapidly respond and manage the various "Stages of the Incident"

For the purpose of annex development, the scientific communities—including the Mid-America Earthquake (MAE) Center located at the University of Illinois and the Institute for Crisis, Disaster and Risk Management (ICDRM) located at George Washington University in Washington, DC—have collaborated in the development of worst-case earthquake scenarios using HAZUS-MH (Hazards United States (Multi-Hazard)) earthquake modeling estimates. This work has provided the operational information—such as the number of injuries and deaths, and building and infrastructure damage—that has allowed Alabama Emergency Management Agency (AEMA) personnel to develop detailed plans to begin addressing the response needs established by the models.

Earthquake loss estimates are forecasts of damage and human and economic impacts that may result from future earthquakes. These estimates are based on current scientific and engineering knowledge and ongoing studies.

The FEMA HAZUS Earthquake Loss Estimation Methodology is a software program that uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake.[1] HAZUS

[1] Doug Bausch, FEMA Region VIII, Denver Federal Center, Bldg. 710, Denver, CO 80225. http://www.gisdevelopment.net/proceedings/gita/2003/disman/dism09pf.htm.

uses ArcGIS[2] to map and display ground shaking, the pattern of building damage, and demographic information about a specific community or region. Once the location and size of a hypothetical earthquake is identified, HAZUS will estimate the violence of the following[3]:

- Ground shaking
- The number of buildings damaged
- The number of casualties
- The amount of damage to transportation systems
- Disruption to the electrical and water utilities
- The number of people displaced from their homes
- The estimated cost of repairing projected damage and other effects

As Northwest Alabama lies within the NMSZ, Northeast Alabama lies within the ETSZ, and South Alabama lies within the BFSZ, it is critical that an estimate of loss from a future earthquake be prepared and used during the planning process. Without this estimation of loss, accurate response plans cannot be developed and the operational aspects of response and recovery will not meet the needs of the citizens of Alabama. Furthermore, a loss estimate that leads to linked operational plans assists decision makers in structuring an appropriate response and properly facilitating good decision making at the local, regional, State, and national levels of government. A HAZUS estimate of earthquake losses provides vital tools for the following[4]:

- Land-use planning and facility site decisions (e.g., a map-based analysis of the potential intensity of ground shaking from a postulated earthquake that identifies those parts of the community that will experience the most violent shaking and the buildings at greatest risk of damage)
- Prioritization of retrofit or abatement programs (e.g., an estimate of building damage that provides the basis for establishing programs to mitigate or strengthen buildings that may collapse in earthquakes by providing estimates of damages and casualties)
- Local, regional, and State emergency response and contingency planning (e.g., estimates of casualties and damage to buildings and utilities)
- Medical and relief agency preparedness and response (e.g., estimates of casualties and homelessness)

[2] ArcGIS is a system for authoring, serving, and using geographic information.
[3] Doug Bausch, FEMA Region VIII, Denver Federal Center, Bldg. 710, Denver, CO 80225. http://www.gisdevelopment.net/proceedings/gita/2003/disman/dism09pf.htm.
[4] Doug Bausch, FEMA Region VIII, Denver Federal Center, Bldg. 710, Denver, CO 80225. http://www.gisdevelopment.net/proceedings/gita/2003/disman/dism09pf.htm.

- Assistance planning (e.g., an estimate of dollar losses that will help the State and Federal Government plan for assistance to jurisdictions and disaster victims)

As additional revisions to the State Catastrophic Earthquake Annex occur, local counties and the Federal Government will be able to refine their catastrophic earthquake documents using the newest planning and response concepts. This will allow for a seamless response strategy linking all levels of government from the local level to the State, and then on to the Federal response.

B. Purpose

This document provides guidance about earthquake response for an earthquake in the State of Alabama. The plan is designed for use at the State level and for organizations that support the Emergency Support Functions (ESFs). Primary and support ESF organizations can use the plan for development of Standard Operating Procedures (SOPs).

C. Scope

The annex was further refined by using the Scenario-Driven Planning Process. This process uses a detailed and realistic scenario to help achieve planning objectives. It is based on a worst-case NMSZ seismic event for Alabama as determined by the MAE Center and ICDRM. It provides the operational framework for implementing the response strategies contained within the Alabama Emergency Operations Plan (EOP). This version of the annex now reflects the information extrapolated from the catastrophic planning workshop and lessons learned from past disasters within and outside the State of Alabama. It also reflects new planning concepts identified for no-notice catastrophic events and the lessons learned from Hurricanes Katrina and Rita.

The intent of this annex is to reduce the loss of life, property damage, and impact on the environment while supporting a jurisdictional response to a catastrophic incident. Therefore, this annex defines the State's response to an earthquake and applies to all State departments and agencies identified within the EOP.

II. Background Information

A. Earthquakes

An earthquake is a phenomenon that results from the sudden release of stored energy in the earth's crust that creates seismic waves.[5] At the earth's surface, earthquakes may manifest themselves by a shaking or displacement of the ground, which may lead to loss of life and destruction of property. Earthquakes may occur naturally or as a result of human activities. In its most generic sense, the word earthquake is used to describe any seismic event, whether a natural phenomenon or an event caused by humans, that generates seismic waves. The sudden release

[5] http://en.wikipedia.org/wiki/Quake_(natural_phenomenon).

of stored energy results in ground shaking, surface faulting, and/or ground failures.

B. Geology in Alabama

Earthquakes are not uncommon in the State of Alabama. According to the Geological Survey of Alabama, most Alabama earthquakes originate along faults deep within basement rocks. Little is known about basement rocks in Alabama, due to lack of drilling to basement depths.[6]

Alabama is also susceptible to damage from liquefaction and amplification. Liquefaction is a phenomenon that can occur during an earthquake when seismic waves pass through saturated, unconsolidated material causing sediment particles to move in relation to each other. This can be particularly damaging to buildings and structures built on thick sediments, especially in areas where the sediments are saturated with water. Shaking levels at a site may be increased, or amplified, by the focusing of seismic energy caused by the geometry of the sediment velocity structure, such as basin subsurface topography, or by surface topography.

Maps of the liquefaction risks, amplification, and basement faults can be found in Appendix E to this Annex.

C. Historical Overview

1. New Madrid Seismic Zone

The NMSZ is a 150-mile-long fault zone spanning four states in the midwestern United States. Historic earthquakes in the region, such as the 1811–1812 earthquakes, are believed to have had magnitudes of approximately 8.0 or greater. Since the central United States geology is susceptible to soil liquefaction, earthquake damage is magnified over a potentially wider area. The NMSZ is the most seismically active area east of the Rocky Mountains.

[6] Geological Survey of Alabama, 2008

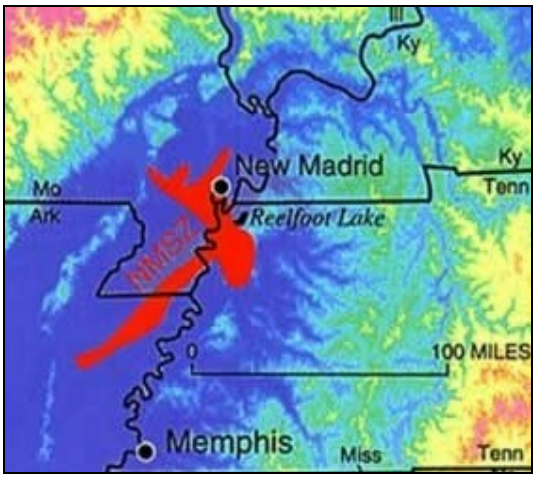

Figure 1: New Madrid Seismic Zone[7]

The NMSZ saw some of the largest North American earthquakes in recorded history, with magnitude estimates greater than 8.0 on the seismograph. These earthquakes occurred over a four-month period. Many of the published accounts describe the cumulative effects of all the earthquakes, known as the New Madrid Sequence; thus, finding the individual effects of each earthquake can be difficult.

- The first earthquake occurred on December 16, 1811, at 2:15 a.m., and had a severity of magnitude 8.1 to 9.0. It caused only slight damage to man-made structures, mainly because of the sparse population in the epicenter area. However, landslides and geological changes occurred along the Mississippi River, and large localized waves occurred due to fissures opening and closing below the earth's surface.
- The second major earthquake occurred later that morning at 8:15 a.m., with a magnitude 7.8.
- The third earthquake was at 9 a.m. on January 23, 1812. Although the intensity was slightly less, the second and third earthquakes were just as violent as the earlier earthquake.
- The last of this series of earthquakes occurred on February 7, 1812, at 4:45 a.m., with an estimated magnitude of 8.0 to 11.0. As the epicenter for this quake was near New Madrid, Missouri, the town was destroyed. At St. Louis, many houses were severely damaged and their chimneys were toppled. The meizoseismal area[8] was characterized by general ground warping, ejections, fissuring, severe landslides, and caving of stream banks.

[7] United States Geological Survey. www.usgs.gov.
[8] The *meizoseismal area* in an earthquake is the area of maximum damage.

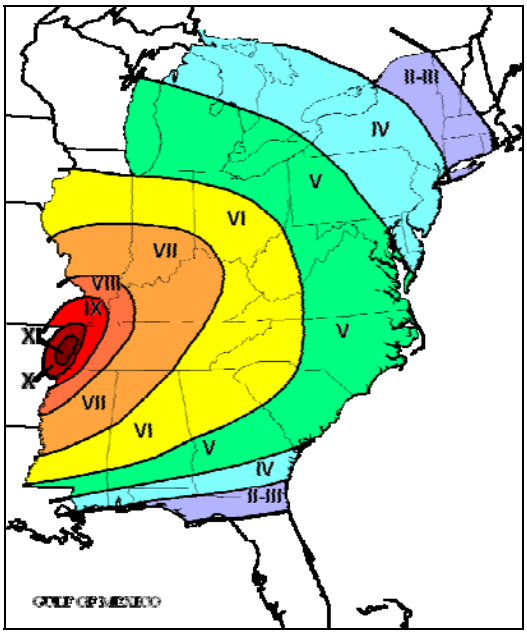

Figure 2: Modified Mercalli Intensity Scale for a New Madrid Seismic Zone Event[9]

This period of earthquakes caused permanent changes in the course of the Mississippi River, which flowed backwards temporarily. These earthquakes were felt as far away as New York City and Boston, Massachusetts, causing church bells to ring. Large areas sank into the earth, fissures opened, lakes permanently drained, new lakes were formed, and over 150,000 acres of forests were destroyed. Hundreds of aftershocks followed over a period of several years.

In terms of response, it has been reported that the probability of a repeat of the 1811–1812 earthquakes (magnitude 7.5–8.0) is from 7–10% and the probability of a magnitude 6.0 or larger is from 25–40%.[10] However, it is understood that a large magnitude event grows more probable with each passing day. A catastrophic seismic event on the NMSZ could trigger a national response on a larger scale than any recorded earthquake event in modern United States history.

Within Alabama, there are 624,368 people who live in the 12 critical counties of the NMSZ. Those counties are:

Colbert	Lamar	Marion
Cullman	Lauderdale	Morgan
Fayette	Lawrence	Walker
Franklin	Limestone	Winston

[9] Geological Survey of Alabama, 2007.
[10] United States Geological Survey Fact Sheet. http://pubs.usgs.gov/fs/fs-131-02/fs-131-02.pdf.

2. East Tennessee Seismic Zone

The ETSZ, also known as the Southern Appalachian Seismic Zone (SASZ), extends from near Roanoke in southwestern Virginia southwestward toward Birmingham in central Alabama. Considered a zone of moderate risk, the ETSZ includes the Appalachian Mountains. The hypocenters of earthquakes in this zone are probably on deeply buried faults. The greatest earthquake in the zone occurred in 1897 near Pearisburg, Virginia, with an estimated magnitude of 5.8. In Alabama, on April 29, 2003, a 4.9 magnitude earthquake occurred in DeKalb County. The quake was felt in 13 states. The earthquake damaged weaker chimneys and formed cracks in some structures.

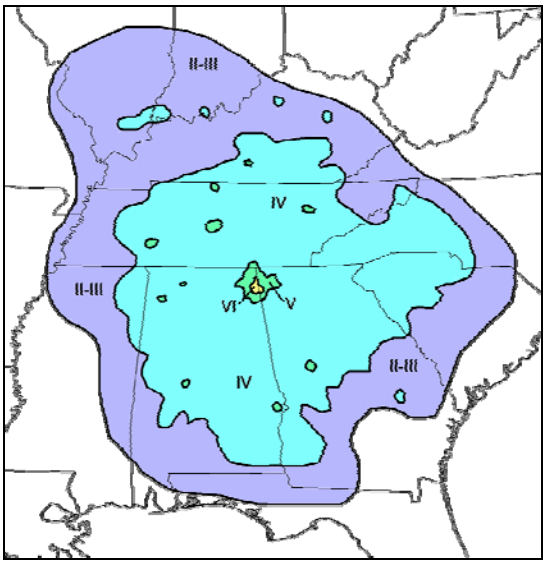

Figure 3: Fort Payne Earthquake, 2003[11]

The largest known earthquake in Alabama occurred in the ETSZ, near Birmingham, in 1916. Although no seismographs existed in the state at the time, the magnitude of the earthquake was calculated to be approximately 5.1 with an epicenter near the Irondale area.

[11] Geological Survey of Alabama, 2007.

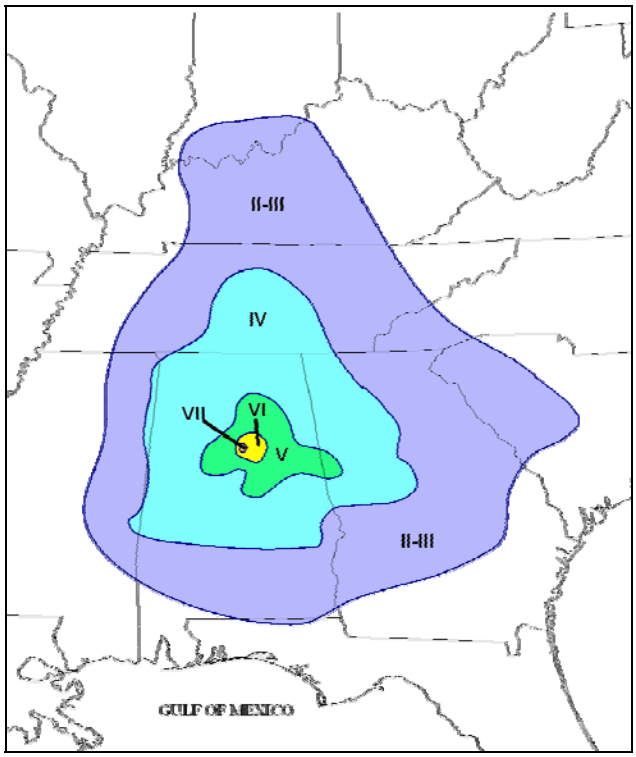

Figure 4: Irondale Earthquake, 1916[12]

Within Alabama, there are 1,751,879 people who live in the 13 critical counties of an ETSZ event. Those counties are:

Blount	DeKalb	Jefferson	Marshall
Calhoun	Etowah	Limestone	Morgan
Cherokee	Jackson	Madison	St. Clair
			Talladega

3. Bahamas Fracture Seismic Zone

The BFSZ extends from the panhandle of Florida through Alabama and into Mississippi. It is responsible for the 4.9 magnitude earthquake that occurred on October 24, 1997 in Escambia County, Alabama. In recent years, there has been an increase in earthquakes from the BFSZ. Historically, the southwestern part of Alabama has had minimal seismic activity, but this quake indicates activity on the BFSZ, an ancient basement fault zone that underlies the area. It is not expected that an event on this fault line would create a catastrophic event.

[12] Geological Survey of Alabama, 2007.

The 4.9 magnitude earthquake was the largest quake at that time recorded by seismographs in Alabama and the largest in the Southeast in the last 30 years.

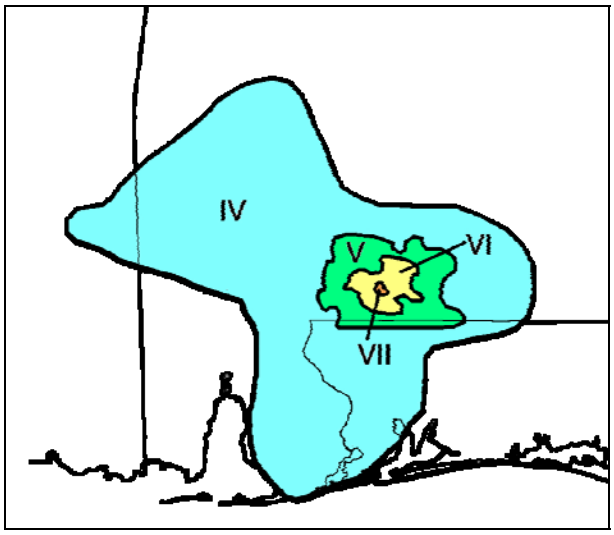

Figure 5: Escambia Earthquake[13]

Within Alabama, there are 744,702 people who live in the nine counties of the BFSZ. These counties are:

Baldwin	Conecuh	Mobile
Choctaw	Covington	Monroe
Clarke	Escambia	Washington

III. Emergency Support Function Crosswalk

As various governmental agencies need to exercise and use this annex, the following crosswalk is provided to assist the user in properly linking the State's ESFs to the National Response Framework (NRF).

[13] Geological Survey of Alabama, 2007.

Table 1: Emergency Support Function Crosswalk between the National Response Framework and the Alabama Emergency Operations Plan

National Response Framework[14]	Alabama Emergency Operations Plan[15]
ESF 1: Transportation Lead Agency: ▪ Department of Transportation (DOT)	**ESF 1: Transportation** Lead Agency: ▪ Alabama Emergency Management Agency
ESF 2: Communications Lead Agency: ▪ Department of Homeland Security, National Protection and Programs Directorate, Cybersecurity and Communications, National Communications System	**ESF 2: Communications** Lead Agency: ▪ Alabama Emergency Management Agency
ESF 3: Public Works and Engineering Lead Agencies: ▪ Department of Defense (DOD) ▪ U.S. Army Corps of Engineers (USACE)	**ESF 3: Public Works and Engineering** Lead Agency: ▪ Alabama Department of Transportation (ALDOT)
ESF 4: Firefighting Lead Agency: ▪ U.S. Department of Agriculture, Forest Service (USDA)	**ESF 4: Firefighting** Lead Agency: ▪ Alabama Forestry Commission
ESF 5: Emergency Management Lead Agency: ▪ Department of Homeland Security, Federal Emergency Management Agency	**ESF 5: Emergency Management** Lead Agency: ▪ Alabama Emergency Management Agency
ESF 6: Mass Care, Emergency Assistance, Housing, and Human Services Lead Agency: ▪ Department of Homeland Security, Federal Emergency Management Agency	**ESF 6: Mass Care, Emergency Assistance, Housing, and Human Services** Lead Agency: ▪ Alabama Department of Human Resources
ESF 7: Logistics Management and Resource Support Lead Agencies: ▪ General Services Administration (GSA) ▪ Department of Homeland Security, Federal Emergency Management Agency	**ESF 7: Logistics Management and Resource Support** Lead Agency: ▪ Alabama Emergency Management Agency
ESF 8: Public Health and Medical Services Lead Agency: ▪ Department of Health and Human Services (HHS)	**ESF 8: Public Health and Medical Services** Lead Agency: ▪ Alabama Department of Public Health (ADPH)

[14] Overview: ESF and Support Annexes Coordinating Federal Assistance in Support of the National Response Framework, January 2008.
[15] Alabama Emergency Operations Plan, November 2008 Draft.

National Response Framework[14]	Alabama Emergency Operations Plan[15]
ESF 9: Search and Rescue Lead Agency: ▪ Department of Homeland Security, Federal Emergency Management Agency	**ESF 9: Search and Rescue** Lead Agency: ▪ Alabama Emergency Management Agency
ESF 10: Oil and Hazardous Materials Response Lead Agency: ▪ Environmental Protection Agency (EPA)	**ESF 10: Oil and Hazardous Materials Response** Lead Agency: ▪ Alabama Department of Environmental Management
ESF 11: Agriculture and Natural Resources Lead Agency: ▪ Department of Agriculture	**ESF 11: Agriculture and Natural Resources** Lead Agency: ▪ Alabama Department of Agriculture and Industries
ESF 12: Energy Lead Agency: ▪ Department of Energy (DOE)	**ESF 12: Energy** Lead Agency: ▪ Alabama Department of Economic and Community Affairs (ADECA)
ESF 13: Public Safety and Security Lead Agency: ▪ Department of Justice (DOJ)	**ESF 13: Public Safety and Security** Lead Agency: ▪ Alabama Department of Public Safety
ESF 14: Long-Term Community Recovery Lead Agency: ▪ Department of Homeland Security, Federal Emergency Management Agency	**ESF 14: Long-Term Community Recovery** Lead Agency: ▪ Governor's Office
ESF 15: External Affairs Lead Agency: ▪ Department of Homeland Security	**ESF 15: External Affairs** Lead Agency: ▪ Governor's Office

IV. Assumptions

A. Plan Development Assumptions

The following general assumptions pertain to the overall development of this annex. They are global in nature and are further supported by functional specific assumptions for each ESF.

1. This annex is based on a catastrophic earthquake.

2. The Director of AEMA will direct implementation of the Catastrophic Event Annex and will provide plan information to the various State departments and agencies.

3. AEMA is the State agency responsible for coordinating with local, State, and Federal agencies in the mitigation of, preparedness for, response to, and recovery from a catastrophic earthquake event that may occur within Alabama.

4. There will be new earthquakes and/or aftershocks potentially as large or larger than the initial earthquake and they may occur for many months. Multiple incidents may occur simultaneously or sequentially in contiguous and/or noncontiguous areas.

5. Response operations must be automatic and begin without the benefit of a detailed assessment of the situation, as full reconnaissance and situational assessments may not be immediately completed or available.

6. If air assets are available, reconnaissance via fixed wing and rotary aircraft must be considered early on. These early reconnaissance missions will be vital in developing full situational awareness. Satellites, drones, and unmanned aerial devices may also be used.

7. As this event is anticipated to be catastrophic in nature, it brings unique management issues and response operations that will require plans to be flexible, be easily adaptable to the situation, and effectively address emerging and unanticipated needs and requirements.

8. Alabama recognizes that a catastrophic earthquake in the southeast United States will have the potential to affect other adjoining states and that an immediate Presidential Disaster Declaration will be required along with the establishment of a Joint Field Office (JFO).

9. Other ongoing disasters/emergencies, combined with maintaining a reserve capability for potential subsequent events (e.g., aftershocks, weather-related events, terrorist events, or other types of man-made disasters), must be factored into State planning capabilities.

B. Planning/Operations Assumptions by ESF

1. ESF 1: Transportation

a. Damage to transportation systems may severely hamper recovery efforts following an earthquake. The loss or impairment of major rail, highway, and bridge links serving the city may significantly increase the difficulty of rescue and relief efforts, and may also have a long-term disrupting effect upon regional and national commerce.

b. River port cities built on alluvial soil may sustain substantial damage to their infrastructure that limits the usefulness of the facilities in relief efforts.

c. Partial or limited availability of airport facilities is expected following an earthquake. Facilities that rely on electrical power (i.e., navigation aids and runway lighting) may be out of commission for some time, even if emergency power is available.

Runways may be available at least for limited use, even in severely affected areas.

d. Ingress and egress routes may not be usable.

e. Debris removal may be a major problem.

f. In the event rubble and debris resulting from an earthquake prevent access to the affected area for a prolonged time, helicopters and alternate forms of transportation may be necessary to bring rescue teams in and remove casualties from the area.

g. Transportation routes, such as highways and bridges, may be destroyed or damaged. This may include roads buckling or shifting out of alignment and areas reduced to rubble. Bridges that appear to be structurally sound may in actuality need structural reinforcement prior to resumption of use. Additional modes of transportation—including rail, navigable waterways and ports, and airport runways—may sustain damage that will render them unusable.

2. ESF 2: Communications

a. Commercial telephone service is vulnerable, particularly due to the possible rupture of underground cables that cross faults. Should the public switched telephone network (PSTN) fail, satellite phones and the Amateur Radio Emergency System (ARES) and/or Radio Amateur Civil Emergency Service (RACES) may be implemented to support relief efforts. Southern LINC, Cellular telephone, two-way radio towers and associated circuits may be inoperable. The State Emergency Operations Center (SEOC) has amateur radio equipment installed, as well as approximately half of the county Emergency Management Agency (EMA) offices located in the listed critical counties.

b. AEMA Regional Communications vehicles may be deployed. Regional communication vehicles are located in the following critical counties: Lauderdale, Calhoun, and Mobile. There are other vehicles located throughout the state that can be brought in as needed.

c. In the case where communications infrastructure is not damaged, there will be an overload of the communication systems after an earthquake.

d. AEMA will have the following equipment pre-staged in Northern Alabama:

i. One 100’ tower trailer with repeaters

ii. One radio cache with 50 VHF, 50 UHF, 25 800 MHz, and 6 multiband portable radios

iii. Other state-owned tower trailers and radio caches located throughout the state that may be deployed as needed

e. AEMA has satellite telephone units assigned to all area coordinators and additional units are located at the SEOC.

3. ESF 3: Public Works and Engineering

a. In the non-governmental sector, there may be minimal communications for a considerable length of time.

b. Many natural gas lines are buried in Alabama. These are vulnerable to rupture, which may result in an explosion and fire.

c. A number of crude oil pipelines are in operation in Alabama. A break in one of these lines could cause significant environmental damage and could have an impact on potable water service.

d. If high water conditions exist during the time an earthquake occurs, levees may be sufficiently damaged to allow flooding to occur behind them, especially in low-lying areas.

e. Earthen dams are not expected to be damaged to the extent they will lose their reservoirs.

f. One or more dams may fail. An inventory of Alabama dams maintained by the U.S. Army Corps of Engineers and the Alabama Department of Economic and Community Affairs, Office of Water Resources listed 171 dams as “high hazard,” 427 as “significant hazard,” and 1,506 as “low hazard.” Counties should contact the U.S. Army Corps of Engineers and the Alabama Department of Economic and Community Affairs, Office of Water Resources to determine the status of dams.

g. Water and sewage systems are vulnerable to ground movement. Disruption of the water system can lead to loss of potable water and a loss of water for firefighting. Disruption of the sewage system can result in environmental damage and increased health risks.

4. ESF 4: Firefighting

   a. Fires, burning out of control, involving major portions of a city are possible in the business sections because of the nature and density of construction in the affected areas. Large, uncontrolled fires are less likely in residential areas because the housing density is less than in the business sections. However, there may be some individual or small group fires that occur as the result of miscellaneous damage-related factors or weather conditions.

   b. The total number of ignitions/responses in a jurisdiction may increase immediately after an earthquake due to ruptured utility lines and injuries sustained during the event.

   c. Prioritization of calls and responses will be required. Matching resource type to incidents where they can provide the most benefit may be used, with lower priority calls not being immediately addressed. Additionally, the type of incident and security considerations will also influence decision making when triaging a particular emergency response.

   d. Personnel will be deployed for longer durations, increasing the fatigue factor.

   e. Response time will be increased due to debris and road damage. Downed power lines may make roads difficult to navigate.

5. ESF 5: Emergency Management

   a. It may be several hours before personnel and equipment can be mobilized and initial teams deployed to affected areas. Therefore, regional and local resources will be relied upon heavily in the period immediately following the earthquake.

   b. During a major earthquake, there is an increased need for the coordination of all activities relevant to the emergency response and recovery efforts. This increased coordination will take place at the SEOC.

6. ESF 6: Mass Care, Emergency Assistance, Housing, and Human Services

   a. Food supply lines could break down.

   b. Emotional, spiritual, and mental health needs will be great.

   c. Shelter workers in affected areas may not be able to report for assignments. This will require an immediate request for outside assistance.

7. ESF 7: Logistics Management and Resource Support

   a. Affected counties will need to pre-identify base locations for replenishing depleted resources to further manage the incident. The methods for replenishment (air or ground) will need to be communicated to the SEOC.

   b. Assistance from private contractors and voluntary agencies will be forthcoming to help during the incident. Pre-contracted services may be necessary and are encouraged through public- and private-sector organizations and partnerships.

   c. Supply chain coordination and planning must occur at all levels (local, State, and Federal) within the logistics management process.

   d. Interstate and intrastate mutual aid agreements will be used.

   e. The Emergency Management Assistance Compact (EMAC) will be implemented based on State and Federal declarations.

8. ESF 8: Public Health and Medical Services

   a. A major earthquake would create extraordinary requirements for emergency medical services.

   b. Health care may be seriously impaired by damage, limiting the number of hospital beds and medical supplies that are available immediately following an earthquake.

   c. The number of health care professionals available may also be limited in the event of an earthquake because some professionals may be isolated from their work places or injured.

   d. Depending on the nature of the incident, supplies of preventive and therapeutic pharmaceuticals and treatments will be insufficient or unavailable to meet the demand, both real and perceived. Additionally, there will be insufficient numbers of qualified medical personnel to administer available treatment to both the affected and adjacent populations. Timely provision of treatment may be able to forestall additional people becoming ill and reduce the impact of disease among those already exposed.

   e. The number of fatalities may overwhelm the local mortuary services and the county coroner. Federal assistance, provided by a Disaster Mortuary Operational Response Team, may be needed.

f. Deaths and injuries are expected to be principally the result of the failure of man-made structures, particularly older, multi-story, and un-reinforced brick masonry buildings built before the adoption of earthquake resistant building codes.

9. ESF 9: Search and Rescue

a. The first few hours following an earthquake are critical in saving the lives of people trapped in collapsed buildings. Therefore, the use of local resources during the initial response period will be essential until State and Federal support is available.

b. In situations that entail structural collapse, people may require rescue and medical care, which will need to be coordinated with ESF 8: Public Health and Medical Services.

c. During the course of a catastrophic earthquake, rescue personnel may encounter extensive damage to the local infrastructure, such as buildings, roadways, public works, communications, and utilities. Such damage can create environmental safety and health hazards, such as downed power lines, unsafe drinking water, and un-refrigerated food. This could slow the rescue response.

d. Following an earthquake, the aftershocks, secondary events, and/or other hazards (e.g., fires, landslides, flooding, and HazMat releases) may compound problems and threaten both disaster victims and rescue personnel.

e. Weather conditions such as temperature extremes, snow, rain, and high winds may pose additional hazards for disaster victims and rescue personnel.

f. In some circumstances, rescue personnel may be at risk from terrorism, civil disorder, or crime.

g. Local residents, workers, and/or converging volunteers may initiate Search and Rescue efforts, but will usually lack specialized equipment and training. Spontaneous volunteers will require coordination and direction within the local incident command structure.

h. Community Emergency Response Team (CERT) volunteers may be used to assist with Search and Rescue.

i. Access to damaged areas will be limited. Some sites may be initially accessible only by air or water.

j. Following a catastrophic earthquake, both disaster victims and rescue personnel may be threatened by aftershocks, secondary events, and/or other environmental disturbances.

10. ESF 10: Oil and Hazardous Materials Response

a. Hazardous material releases ranging from minor environmental impact to major environmental impact may occur.

b. HazMat decontamination priorities and cleanup will be established using the following priorities, in order of importance: life safety, incident stabilization, and property conservation.

c. Damaged underground storage tanks and natural gas wells may further impede first responder response efforts.

11. ESF 11: Agriculture and Natural Resources

a. Pets may be displaced with their owners, potentially requiring evacuation or sheltering. A significant number of pets will likely be housed with their caretakers.

b. Following a major or catastrophic disaster, there may be widespread damage and destruction to the infrastructure and homes/buildings, resulting in transportation routes being impassable, widespread and prolonged power outages, and contaminated food and drinking water.

c. Normal food processing and distribution capabilities will be disrupted.

d. As a result of power outages, many commercial cold storage and freezer facilities within the impacted area will be inoperable.

e. Shelters should have food and water supplies to manage for 72 hours after the disaster.

12. ESF 12: Energy

a. Electrical power systems are among the most fragile in the event of an earthquake. Because they are also among the most essential of the utilities, even a short-term loss can be a major setback to a community. The loss of electric power during an earthquake may mean no water to fight fires or for drinking water, no light or heat, no communications, no sewage pumps, etc.

b. Petroleum shortages should be anticipated.

13. ESF 13: Public Safety and Security

    a. First responder staffing may be reduced due to the nature of the earthquake and how it has adversely affected them on a personal level.

    b. Accountability for personnel must be considered for response and recovery operations including a check-in process/system for off-duty staff.

    c. Communication systems may be affected and Amateur Radio Emergency System (ARES) and/or Radio Amateur Civil Emergency Service (RACES) may need to be used.

    d. Disasters naturally bring out the curiosity of people in areas both affected and non-affected. The uncontrolled inward flow of unauthorized personnel is detrimental to the efficient handling of traffic flow in affected areas.

    e. In some situations, especially during civil disturbances, firefighters and EMS personnel are expected or required to work in areas that are subject to hostile action (e.g., sniper fire, throwing of bricks and other objects). Security must be provided for these personnel.

    f. Following a disaster, criminals often move into an area in a proactive and sometimes organized attempt to take advantage of the situation for their own benefit.

14. ESF 14: Long-Term Community Recovery

    a. Business and industry may not be prepared for adequate response to an earthquake. Businesses that rely on computer-based systems are particularly vulnerable.

    b. Failure of banking systems, which use electronic fund transfers, could result in widespread economic problems.

    c. A damaging earthquake may cause a serious loss of employment, which could impact economic factors at the local, State, and national levels.

    d. Interagency recovery expertise will be needed to provide for strategic guidance across all facets of recovery operations. This would include areas of recovery in individual assistance, public and privately owned public infrastructure, and business redevelopment and organization.

15. ESF 15: External Affairs

    a. The public (e.g., students, business owners, faith-based and civic groups, and home health/hospice groups) will need to be educated on how to act and how to help each other and their communities.

    b. A catastrophic earthquake may terrify the population, both in the incident area and nationally. Therefore, any catastrophic event, regardless of cause, will result in intense and immediate media attention.

    c. The public may accept hearsay, rumors, and half-truths as fact during periods in which no credible source of emergency public information is available.

    d. Emergency public information is essential to guiding the actions of disaster victims to ensure that they are able to effectively understand what is going on and develop appropriate responses to the threats and circumstances imposed upon them by the disaster.

    e. A joint information system (JIS) will be established with the Governor's Communication Director, other state agency Public Information Officers (PIOs) (who will have a role in releasing information), and State PIOs in the Central United States Earthquake Consortium states. After the JIS is established, the Joint Information Center (JIC) will be established in a safe place, using all the PIOs in the system.

V. Concept of Operations

Emergency responsibilities assigned to State agencies for earthquake response parallel those for other disaster operations.

When an earthquake occurs, local authorities within damaged areas will use available resources to protect life and property and reduce, to the extent possible, the suffering and hardships on individuals. If local resources prove to be inadequate or are exhausted, assistance will be requested from other jurisdictions through mutual aid procedures.

These procedures need to be in place before the incident to ensure legal and financial conditions are delineated. Jurisdictions in the areas sustaining little or no damage will be called upon to support the affected areas.

When requirements are beyond the capability of local government, requests for assistance will be forwarded to AEMA in accordance with this plan.

When resource requirements cannot be met with State resources, AEMA will request Federal assistance in accordance with applicable Federal laws, policies, procedures, and plans.

Emergency operations will begin with the occurrence of a damaging earthquake and continue until emergency operations are no longer required.

VI. Phases of the Operation

An earthquake response and recovery operation will be conducted in three major phases. Some phases are continuous and all have a predictable amount of overlap. The response operation may generally flow in this order:

- Catastrophic Situation Awareness
- Catastrophic Activation and Response
- Recovery

A. Phase 1: Catastrophic Situation Awareness

Situational awareness refers to the continual process of collecting, analyzing, and disseminating intelligence, information, and knowledge to allow organizations and individuals to anticipate response requirements and to react effectively to those requirements. It involves an interactive process of sharing and evaluating information from multiple sources to include the fusion of domestic and international intelligence and operational reports into a coherent picture. It includes communications and reporting activities and tasks to forecast or predict incidents and to detect and monitor threats and hazards.

Situational awareness can also cover public education. Awareness activities are the basis for advice, alert and warning, intelligence and information sharing, technical assistance, consultations, notifications, and informed decision making at all interagency and intergovernmental levels, as well as within the private sector and the public.

Given that an earthquake is a no-notice event, it is critical to quickly obtain situational awareness of the event so that the appropriate resources can be deployed quickly and efficiently into the affected areas.

1. Catastrophic Earthquake Initial Assessment (0–24 hours)

While the ability to quickly perform reconnaissance and to gather, verify, consolidate, and distribute confirmed situation information is vital to the response, it is equally important that initial response strategies are developed with an accurate picture of the potential scope of the disaster. Resource requests must quickly be made from the local level to the State, and then on to the Federal level without delay. Quickly identifying the potential scope of damage following a major earthquake is critical to mounting an effective response; however, this may be extremely difficult initially due to limited communications capability, information overload, limited staff, and fragmented or conflicting damage reports.

Immediately following the earthquake, it may be possible to establish an initial assessment of the impact using available analytical tools. This assessment can be used to direct initial response activities toward those areas that are most likely to be seriously affected, given the location and magnitude of the earthquake and shaking potential. Key information about the earthquake should include the following:

- Source fault (e.g., New Madrid)
- Location of the epicenter
- Magnitude
- Shaking potential
- Duration of shaking

If Internet access is available through existing networks or satellite backup systems, information about the earthquake can be found at the following Web sites:

- Cooperative Mid-America Madrid Seismic Network – NM
  http://www.eas.slu.edu/Earthquake_Center/NM/
- Center for Earthquake Research and Information
  http://www.ceri.memphis.edu/
- United States Geological Survey (USGS)
  http://earthquake.usgs.gov/
  The USGS provides information on earthquake characteristics within minutes of the event. They also operate a notification service, with subscription details found at
  https://sslearthquake.usgs.gov/ens/?page=help.

If the magnitude, source fault, or epicenter location varies significantly from the potential earthquake scenarios, initial damage assessment assumptions may be based on the perceived shaking and damage potentials identified on the Modified Mercalli Scale map for the State of Alabama in the Historical Overview section on page 5 of this Annex.

The Geological Survey of Alabama (GSA) will be contacted during this phase as subject matter experts to assist in hazard analysis and any interpretation of scientific data related to the seismic event.

2. SEOC Operations Information List for Initial Situation Assessment

The SEOC Operations Information List (see Table 2) is a tool designed to serve as a reference document for the SEOC and it can easily be adapted for local use. It provides a starting point for assisting with information collection and can be used when an earthquake is felt or reported.

NOTE: The **"Target Time"** in the following table is designed to provide a logical progression for organizing the response. It is understood that due to the catastrophic nature of a major earthquake, some information may come in immediately, while other information may not be available within the specified Target Time. In order to keep the incident planning process and operational response moving forward, every attempt should be made to follow up on missing or non-detailed information. Additionally, the information collection process may be conducted simultaneously with other critical assignments as applicable and as directed by AEMA Operations. The number assigned to each task is for tracking purposes only and does not denote a level of task priority.

Table 2: SEOC Operations Information List for Initial Situation Assessment

Target Time 0–8 Hours	**SEOC Information List for assisting in the development of Initial Situation Assessment**		
Objective	**Gather and Obtain Information on the Earthquake.**		**Lead for this Objective**
			SEOC
Task 1	Continually monitor SEOC information resources and check appropriate Web sites for earthquake information.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC/State Geologist
Task 2	Confirm magnitude with USGS.	☒ *One Time* ☐ *Continuing*	**Lead for this Task** SEOC/State Geologist
Task 3	Confirm epicenter location and approximate distance from Alabama.	☒ *One Time* ☐ *Continuing*	**Lead for this Task** SEOC/State Geologist
Task 4	*As information becomes available*: Begin collection of damage estimates.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 5	*As information becomes available*: Begin collection of number and locations of deaths and injuries.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 6	*As information becomes available*: Begin collection and determine location and extent of secondary event(s), including fires, landslides, and hazardous materials events.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC/State Geologist
Task 7	*As information becomes available*: Begin collection and location of severely damaged or collapsed structures.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 8	*As information becomes available*: Determine location and estimated number of people trapped in collapsed structures.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 9	*As information becomes available*: Determine requirement for major evacuation and estimated number of people displaced.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC

Target Time 0–8 Hours	SEOC Information List for assisting in the development of Initial Situation Assessment		
Task 10	*As information becomes available*: Determine critical resource shortfalls affecting public safety.	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Objective	**Determine Status of Communication Systems.**		**Lead for this Objective** **All Agencies**
Task 1	Public switched telephone network (PSTN) and wireless systems	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 2	AEMA, Public Safety Radio Systems, Southern Linc	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 3	Public Safety Answering Points	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Objective	**Determine Damage to Critical Buildings.**		**Lead for this Objective** **SEOC**
Task 1	Police and fire facilities	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 2	Hospitals and skilled nursing facilities	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 3	Schools	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 4	Jails/prisons	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 5	Local EOCs	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 6	Roads, bridges, major surface streets, public transportation systems, airports, rail lines	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Objective	**Determine Damage to Major Utilities.**		**Lead for this Objective** **SEOC**
Task 1	Water systems	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 2	Sanitation and sewer	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 3	Power	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC
Task 4	Natural gas	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC

Target Time 0–8 Hours	SEOC Information List for assisting in the development of Initial Situation Assessment		
Task 5	Underground pipelines	☐ *One Time* ☒ *Continuing*	**Lead for this Task** SEOC

B. Phase 2: Catastrophic Activation and Response

Direction and Control of disasters that impact the citizens of Alabama will be exercised by the Governor through the Director of AEMA. The activation and deployment of State assets for a catastrophic earthquake will be formally initiated by the Operations Section at the SEOC.

The SEOC is responsible for forwarding all requests that the State is unable to fulfill to the State Coordinating Officer (SCO), who will eventually be located at the JFO. Until the JFO is established, the SEOC will forward these requests directly to FEMA Region IV.

The SCO passes the State's needs to the Federal Coordinating Officer (FCO), who is also located at the JFO. The FCO is responsible for integrating and coordinating the resources of the entire Federal Government and serving as the Federal single point of contact to the SCO and SEOC.

As outlined in the NRF, the Governor will still maintain overall responsibility for requesting Federal assistance for a catastrophic earthquake event within the state. Even though the Federal response may be automatic using a "pushed" Logistics System, the State will formally document all requests for Federal assistance.

C. Phase 3: Recovery

There are usually no clear distinctions between when the Response Phase ends and the Recovery Phase begins. There is typically a time period after the earthquake in which both phases are in effect simultaneously. The Recovery Phase begins a few days after the earthquake and can last as long as ten years for a catastrophic disaster. During this phase, the Federal government provides disaster relief upon Presidential Disaster Declaration. Functions during this phase include Federal relief under PL 93-288 for public and individual assistance, establishment of Disaster Recovery Centers, establishment of temporary housing facilities, and Federal disaster loans and grants. Long-term recovery includes restoration of affected areas to their normal or an improved state.

Appendix A: State Loss Estimates for a New Madrid Seismic Zone (NMSZ) Event

Loss Estimates for an NMSZ Event

The loss estimates referenced in order to define the scenario are based on the Mid-America Earthquake Center *Impacts of Earthquakes on the Central United States* Phase II Report, 2009.

These numbers were developed for use in planning workshops only and are intended to display a worst-case scenario based on available data for an NMSZ event in Alabama. It is not meant to negate or diminish the relevance of previous scenarios. The NMSZ can be affected by a number of possible, credible scenarios and it is likely that the damage and loss estimates presented in this scenario are different from other scenarios in the NMSZ. Neither this scenario nor others should be considered as the "correct" scenario since each one represents a possible earthquake and its corresponding damage and loss. Loss estimates continue to be revised as new information and methods are made available.

Table 3: NMSZ Event Building Damage by Occupancy Type for State of Alabama

General Occupancy Type Damage			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,342,900	3200	3000
Other Residential	368,400	11,400	700
Commercial	29,100	500	60
Industrial	8,100	200	20
Other	9,800	100	40
Total	1,758,300	15,400	3820

Table 4: NMSZ Damage by Occupancy Type for the 21 Critical Counties

General Occupancy Type Damage (12 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	183,790	358	0
Other Residential	57,508	2,490	0
Commercial	1,630	57	0
Industrial	293	13	0
Other	198	5	0
Total	243,419	2,923	0

Table 5: NMSZ Event Damage by Building Type for State of Alabama

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,258,071	6,679	3000	0	2960
Steel	11,399	439	700	3	50
Concrete	3,156	100	200	0	<20
Precast	857	28	<100	1	<20
Reinforced Masonry	5,178	70	<100	1	20
Unreinforced Masonry	74,050	3,436	400	18	200
Mobile Home	278,809	31,026	11,100	48	570
Total	1,631,520	41,778	15,400	71	3820

Table 6: Essential Facilities Damage and Functionality for NMSZ Event in the State of Alabama

Essential Facilities Damage & Functionality					
Essential Facility Type	**Total No. Facilities (State)**	**Total No. Facilities No county info**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage <50%)**	**Functionality >50% at Day 1**
Hospitals	210	7472	0	0	210
Schools	1,903	563	0	0	1,903
EOCs	27	36	0	0	27
Police Stations	496	143	0	0	496
Fire Stations	1,388	402	0	0	1,388

Table 7: NMSZ Pipeline Damage

Pipeline Damage				
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**	**Repairs**
Potable Water – Local	124,800	460	292	752
Wastewater – Local	74,900	364	231	595
Natural Gas – Regional	5300	5	11	16
Natural Gas – Local	49,900	389	247	636
Oil – Regional	1,800	2	5	7

Table 8: NMSZ Event Shelter Requirements for the State of Alabama

Displaced and Shelter Seeking Population			
	Total Population	**At risk Population**	**Shelter Seeking Population**
21 Socially Impacted Counties	1,287,441	178,951	56,094
Other Remaining Counties	3,159,659	422,610	117,318
Total State	4,447,100	601,561	173,412

Table 9: NMSZ Event Casualties for the State of Alabama

Worst-Case Casualties (5:00 PM)					
Severity Level	**Level 1 Green (Minor)**	**Level 2 Yellow (Delayed)**	**Level 3 Red (Immediate)**	**Level 4 Black (Deceased)**	**Total**
21 Socially Impacted Counties	596	161	15	22	794
Other Remaining Counties	130	18	1	6	155
Total State	726	179	16	28	949

Appendix B: Loss Estimates for an Eastern Tennessee Seismic Zone (ETSZ) Event

Loss Estimates for an ETSZ Event

The loss estimates referenced in order to define the scenario are based on the Mid-America Earthquake Center *Impacts of Earthquakes on the Central United States* Phase I Report, 2008.

These numbers were developed for use in planning workshops only and are intended to display a worst-case scenario based on available data for an ETSZ event in Alabama. Loss estimates continue to be revised as new information and methods are made available.

Table 10: ETSZ Event Building Damage by Occupancy Type for State of Alabama

General Occupancy Type Damage (State Level)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	1,303,224	2,431	410
Other Residential	354,031	3,241	127
Commercial	18,249	61	5
Industrial	2,048	48	2
Other	2,014	5	0
Total	1,679,566	5,786	544

Table 11: ETSZ Event Building Damage by Occupancy Type for 13 Critical Counties

General Occupancy Type Damage (13 Critical Counties)			
General Occupancy Type	**Total No. Buildings**	**Moderate to Severe Damage**	**Complete Damage**
Single Family	535,829	2,427	410
Other Residential	106,769	3,216	127
Commercial	10,454	60	5
Industrial	815	48	2
Other	777	5	0
Total	654,644	5,756	544

Table 12: ETSZ Event Building Damage by Building Type for the State of Alabama

Building Damage by Building Type					
Building Type	**None**	**Slight**	**Moderate**	**Extensive**	**Complete**
Wood	1,255,446	7,365	1,596	69	392
Steel	11,814	64	42	14	4
Concrete	3,247	16	11	4	2
Precast	879	8	5	2	0
Reinforced Masonry	5,234	19	14	5	3
Unreinforced Masonry	76,394	1,127	371	81	38
Mobile Home	305,185	6,983	2,276	352	105
Total	1,658,199	15,582	4,715	527	544

Table 13: ETSZ Event Essential Facilities Damage for the State of Alabama

Essential Facilities Damage & Functionality				
Essential Facility Type	**Total No. Facilities**	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage <50%)**	**Functionality >50% at Day 1**
Hospitals	137	1	0	136
Schools	1,870	8	0	1,856
EOCs	27	0	0	27
Police Stations	496	6	0	485
Fire Stations	1,388	12	0	1,366

Table 14: ETSZ Event Damage to Communication Facilities

Communication Damage Assessments				
	Total No. of Communication Facilities	**At Least Moderate Damage (Damage >50%)**	**Complete Damage (Damage <50%)**	**Functionality >50% at Day 1**
13 Critical Counties	5,180	162	0	5,149
Remaining Counties	10,161	0	0	10,161
Total State	15,341	162	0	15,310

Table 15: ETSZ Event Pipeline Damage

Pipeline Damage			
System	**Total Pipelines (mi)**	**No. Leaks**	**No. Breaks**
Potable Water – Local	124,755	188	71
Wastewater – Local	74,853	149	56
Natural Gas – Regional	5,306	0	0
Natural Gas – Local	4,990	159	60
Oil – Regional	1,809	0	0

Table 16: ETSZ Event Utility Service Interruptions

Utility Service Interruptions Number of Households without Service						
	No. Households	**Day 1**	**Day 3**	**Day 7**	**Day 30**	**Day 90**
Electric Power	1,737,080	7,389	4,367	1,715	349	10
Potable Water		0	0	0	0	0

Table 17: ETSZ Event Shelter Requirements for the State of Alabama

Displaced and Shelter Seeking Population			
	Total Population	**Displaced Population**	**Shelter Seeking Population**
13 Critical Counties	1,751,879	1,625	440
Other Remaining Counties	2,695,221	0	0
Total State	4,447,100	1,625	440

Table 18: ETSZ Event Casualties for the State of Alabama

Worst-Case Casualties (2:00 AM)					
Severity Level	**Level 1 Green (Minor)**	**Level 2 Yellow (Delayed)**	**Level 3 Red (Immediate)**	**Level 4 Black (Deceased)**	**Total**
13 Critical Counties	153	32	3	4	192
Other Remaining Counties	1	0	0	0	1
Total State	154	32	3	4	193

Appendix C: Glossary

Active Fault:
A fault is active if, because of its present tectonic setting, it can undergo movement from time to time in the immediate geologic future. This active state exists independently of the geologists' ability to recognize it. Geologists have used a number of characteristics to identify faults, such as historic seismicity or surface faulting, geological recent displacement inferred from topography, or physical connection with an active fault.

However, not enough is known about the behavior of faults to ensure identification of all active faults by such characteristics. Selection of the criteria to identify active faults for a particular purpose must be influenced by the consequences of fault movement on the engineering structures involved.

Aftershock:
An earthquake that follows a larger earthquake or the main shock and is in the same general region. A large shock normally has many aftershocks, generally decreasing in frequency and size with time.

Amplification:
Shaking levels at a site may be increased, or amplified, by focusing of seismic energy caused by the geometry of the sediment velocity structure, such as basin subsurface topography, or by surface topography.[16]

Basement Fault:
Harder and usually older igneous and metamorphic rocks that underlie the main sedimentary rock sequences (softer and usually younger) of a region and extend downward to the base of the crust.[17]

Fault:
The area of contact between two blocks of rock that have moved relative to each other is called a fault. The direction of relative motion of the blocks may be horizontal, vertical, or a combination of these motions. The force that causes the stress within the rock that makes it break along a fault is a result of the movement of giant sections (or plates) of the earth's outer layer.[18]

Liquefaction:
Liquefaction is a phenomenon in which the strength and stiffness of a soil is reduced by earthquake shaking or other rapid loading. Liquefaction occurs in saturated soils, that is, soils in which the space between individual particles is completely filled with water.[19]

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[16] United States Geological Survey
[17] United States Geological Survey
[18] Geological Survey of Alabama
[19] University of Washington

Magnitude:
A quantity characteristic of the total energy released by an earthquake, as contrasted to intensity that describes its effects at a particular place. Magnitude is expressed in terms of the motion that would be measured by a standard type of seismograph located 100 km from the epicenter of an earthquake. Several other magnitude scales in addition to local magnitude (ML) are in use; for example, body wave magnitude (mb) and surface-wave magnitude (MS), which utilize body waves and surface waves, and ML. The scale is theoretically open-ended. The largest known earthquakes have had MS magnitudes near 8.9.

Modified Mercalli Intensity Scale:
In seismology, a scale of seismic intensity is a way of measuring or rating the *effects* of an earthquake at different sites. The Modified Mercalli Intensity Scale is commonly used in the United States by seismologists seeking information on the severity of earthquake effects. Intensity ratings are expressed as Roman numerals between I at the low end and XII at the high end. The Intensity Scale differs from the Richter Magnitude Scale in that the effects of any one earthquake vary greatly from place to place, so there may be many Intensity values (e.g., IV, VII) measured from one earthquake. Each earthquake, on the other hand, should have just one Magnitude, although the several methods of estimating it will yield slightly different values.[20]

Richter Scale:
The Richter Scale measures the energy of an earthquake by determining the size of the greatest vibrations recorded on a seismogram. On this scale, one step up in magnitude (from 5.0 to 6.0, for example) increases the energy more than 30 times.[21]

Seismic Waves:
Seismic waves are waves that travel through the Earth, most often as the result of a tectonic earthquake, sometimes from an explosion.

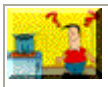
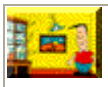
Seismic Zone:
A generally large area within which seismic design requirements for structures are uniform.

[20] John N. Louie, Ph.D. University of Nevada at Reno.
[21] The Regents of the University of California.

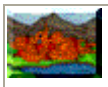
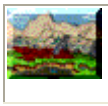
Appendix D: General Earthquake Information

Table 19

Modified Mercalli Intensity Scale[22]

MMI Value		Description of Shaking Severity	Summary Damage Description Used on 1995 Maps	Full Description
	I.			Not felt. Marginal and long period effects of large earthquakes.
	II.			Felt by persons at rest, on upper floors, or favorably placed.
	**III.**			Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
	**IV.**			Hanging objects swing. Vibration like passing of heavy trucks, or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, and doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frames creak.
	V.	**Light**	**Pictures Move**	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, and/or open. Shutters and/or pictures move. Pendulum clocks stop, start, and/or change rate.
	VI.	**Moderate**	**Objects Fall**	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, and/or glassware broken. Curios, books, etc. off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry D cracked. Small bells ring (church, school). Trees and bushes shaken (visibly, or heard to rustle).

[22] Association of Bay Area Governments and Campagna Mulitmediale di Informazione of the Osservatorio Geofisico Sperimentale

	VII.	**Strong**	**Nonstructural Damage**	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices, and un-braced parapets and architectural ornaments. Some cracks in masonry C. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
	**VIII.**	**Very Strong**	**Moderate Damage**	Steering of motor cars affected. Damage to masonry C; partial collapse. Some damage to masonry B; none to masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, and/or elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
	IX.	**Violent**	**Heavy Damage**	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas, sand and mud ejected, earthquake fountains, and/or sand craters.
	X.	**Very Violent**	**Extreme Damage**	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, and/or embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
	XI.			Rails bent greatly. Underground pipelines completely out of service.
	**XII.**			Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces.
Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces.
Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces.
Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.

Table 20

Richter Scale[23]

Magnitude	Earthquake Effects	Estimated Number Each Year
2.5 or less	Usually not felt, but can be recorded by seismograph.	900,000
2.5 to 5.4	Often felt, but only causes minor damage.	30,000
5.5 to 6.0	Slight damage to buildings and other structures.	500
6.1 to 6.9	May cause a lot of damage in very populated areas.	100
7.0 to 7.9	Major earthquake. Serious damage.	20
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.	One every 5 to 10 years

[23] UPEeis

Table 21
Earthquake Magnitude and Energy[24]

Richter Magnitude	TNT for Seismic Energy Yield	Example (approximate)
-1.5	6 ounces	Breaking a rock on a lab table
1.0	30 pounds	Large blast at a construction site
1.5	320 pounds	
2.0	1 ton	Large quarry or mine blast
2.5	4.6 tons	
3.0	29 tons	
3.5	73 tons	
4.0	1,000 tons	Small nuclear weapon
4.5	5,100 tons	Average tornado (total energy)
5.0	32,000 tons	
5.5	80,000 tons	Little Skull Mountain, NV Quake, 1992
6.0	1 million tons	Double Spring Flat, NV Quake, 1994
6.5	5 million tons	Northridge, CA Quake, 1994
7.0	32 million tons	Hyogo-Ken Nanbu, Japan Quake, 1995; largest thermonuclear weapon
7.5	160 million tons	Landers, CA Quake, 1992
8.0	1 billion tons	San Francisco, CA Quake, 1906
8.5	5 billion tons	Anchorage, AK Quake, 1964
9.0	32 billion tons	Chilean Quake, 1960
10.0	1 trillion tons	(San Andreas-type fault circling Earth)
12.0	160 trillion tons	(Fault Earth in half through center, OR Earth's daily receipt of solar energy)

[24] John N. Louie Ph.D., University of Nevada at Reno

Appendix E: Alabama Geology

Figure 6
Alabama Seismic Amplification Classifications
(1:250,000 Scale)

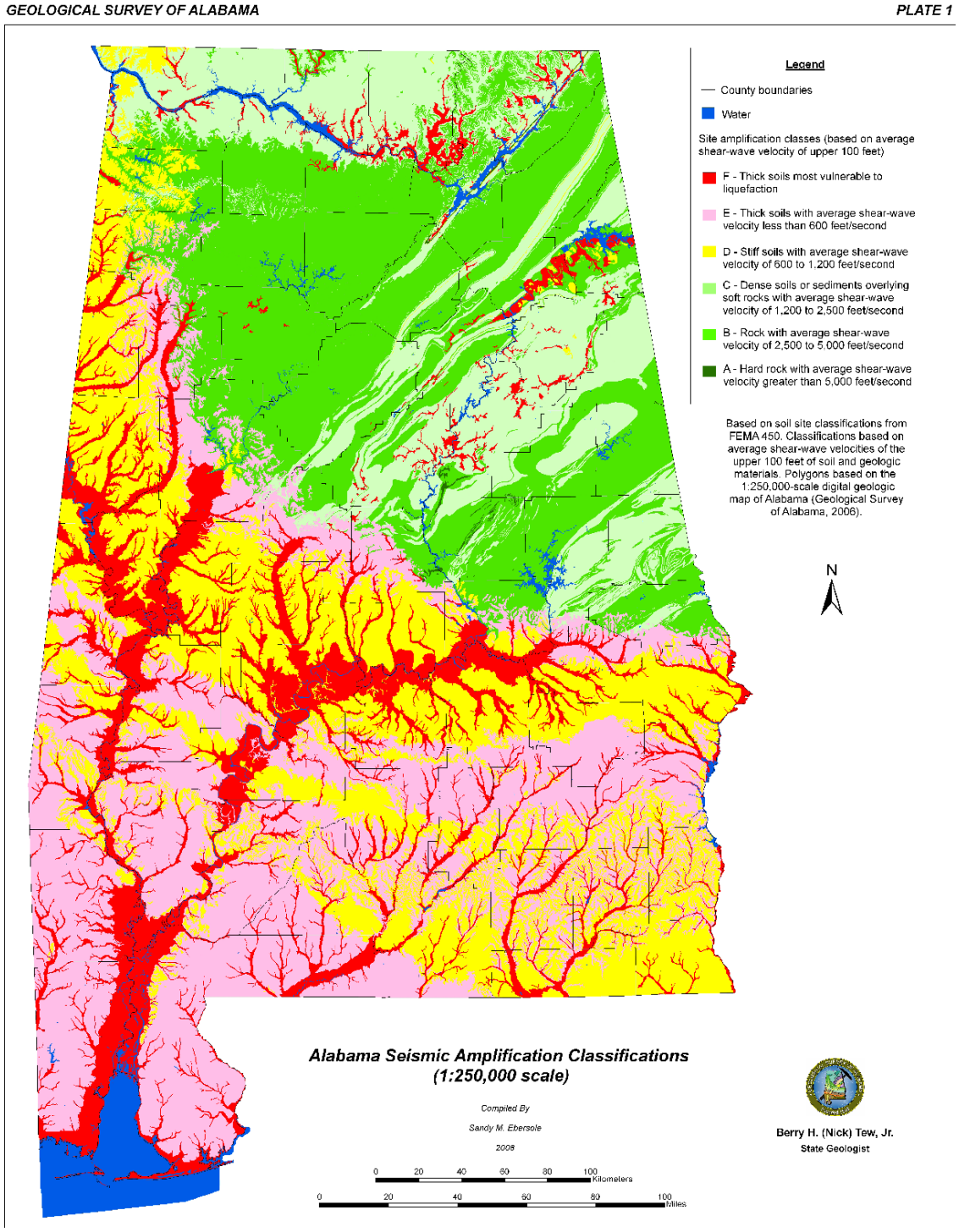


Figure 7
Alabama Seismic Amplification Classifications
(1:2,000,000 Scale)

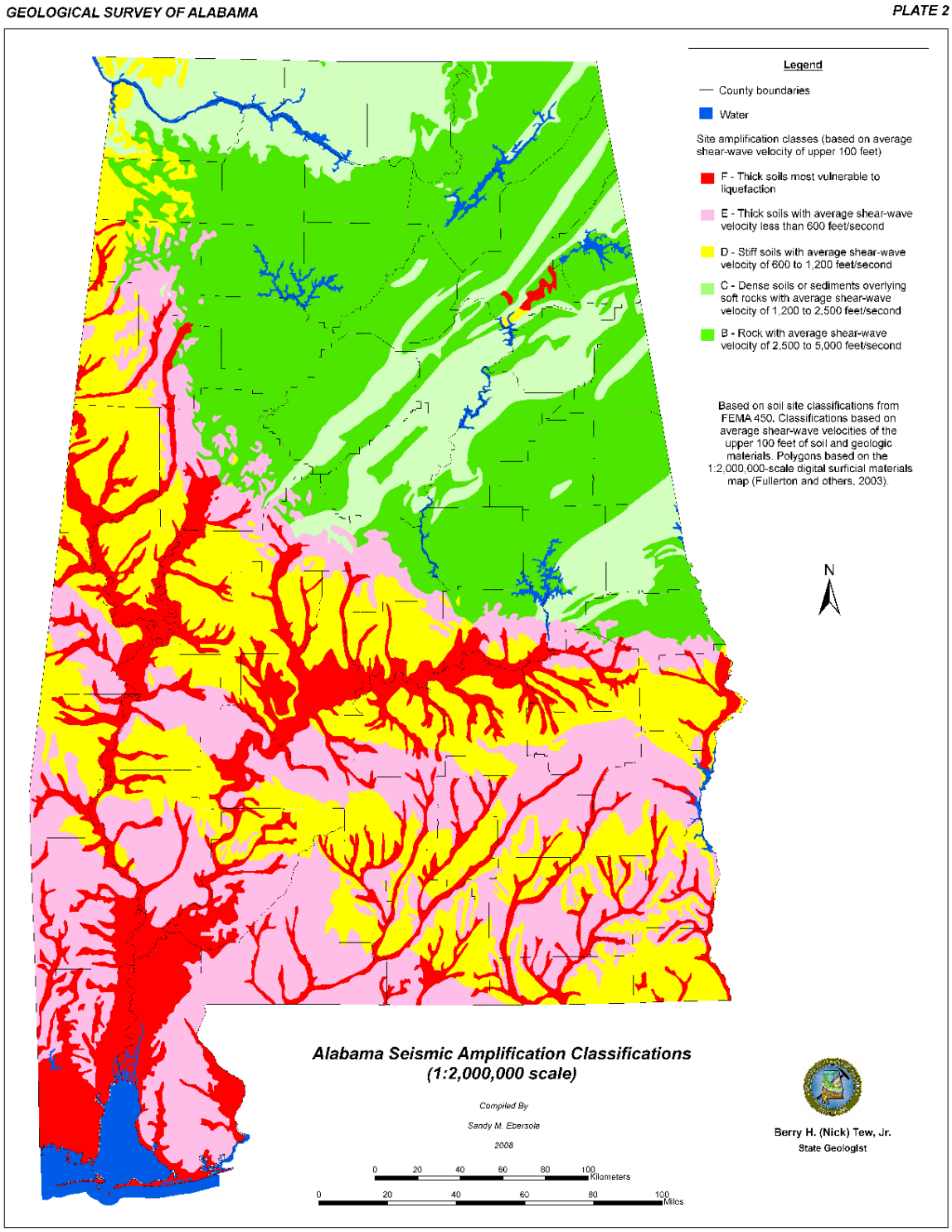


Figure 8
Liquefaction Susceptibility of Superficial Materials in Alabama (1:250,000 Scale)

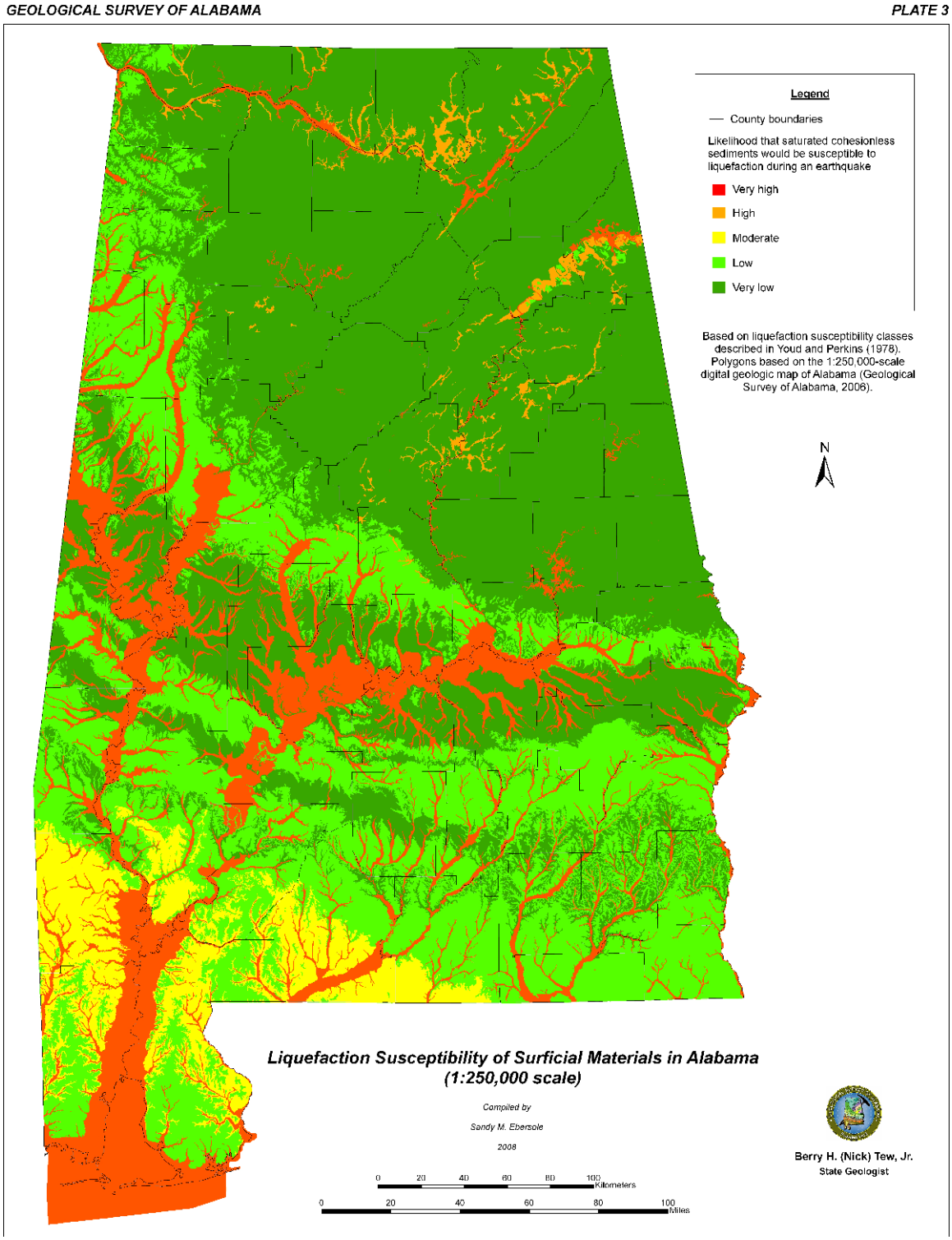


Figure 9
Liquefaction Susceptibility of Superficial Materials in Alabama
(1:2,000,000 Scale)

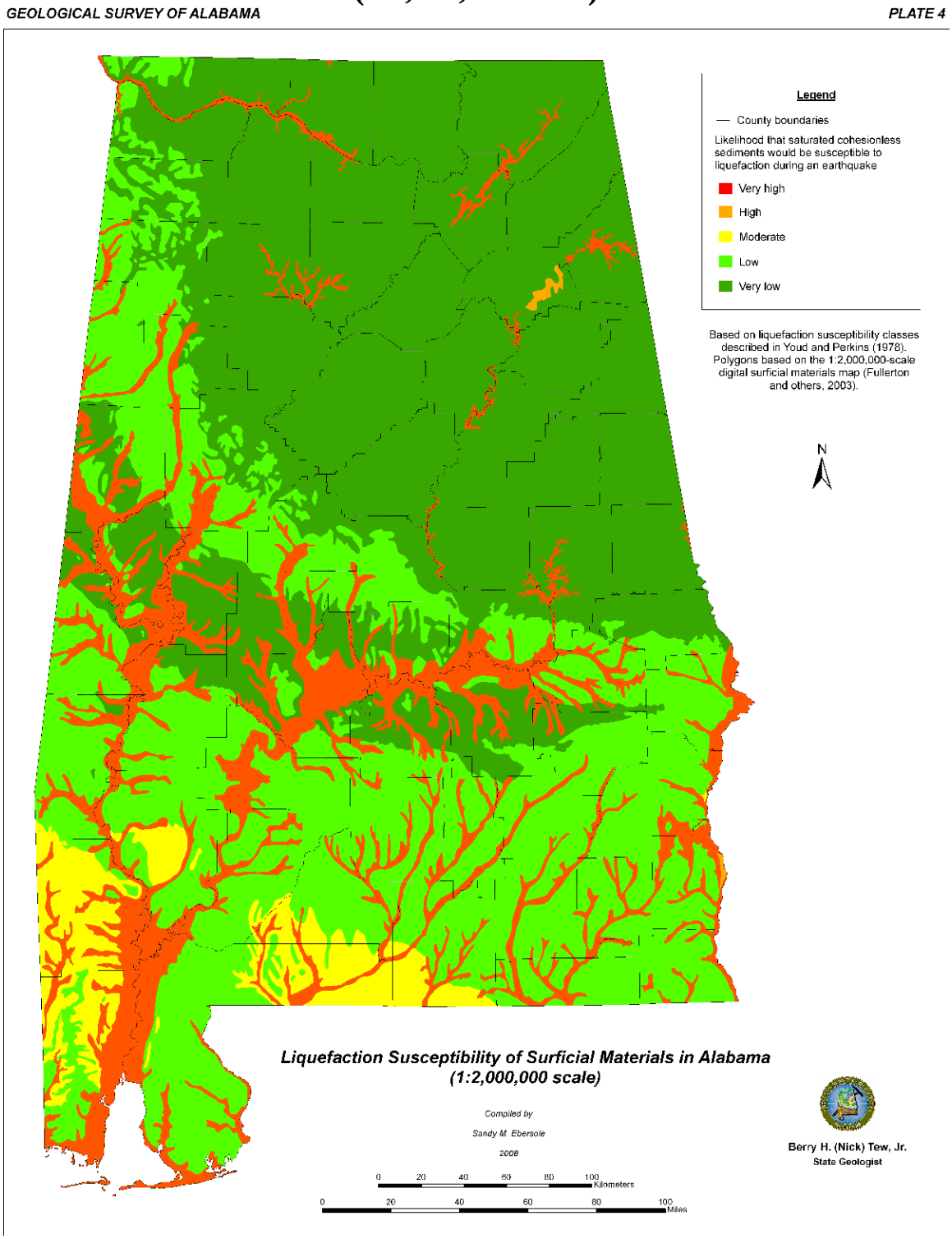


Figure 10
Pre-Cambrian to Early Cambrian Basement Faults of Alabama

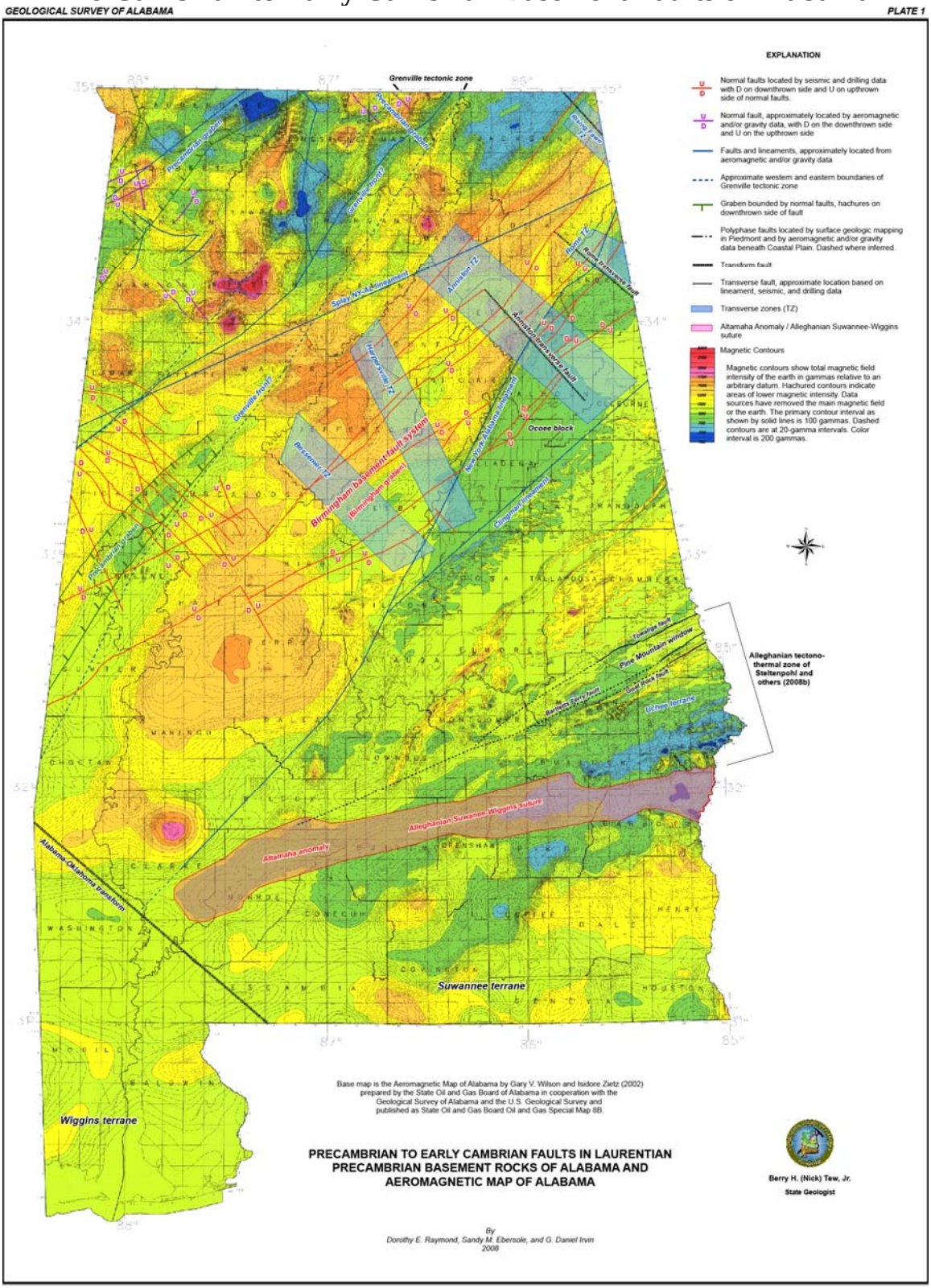
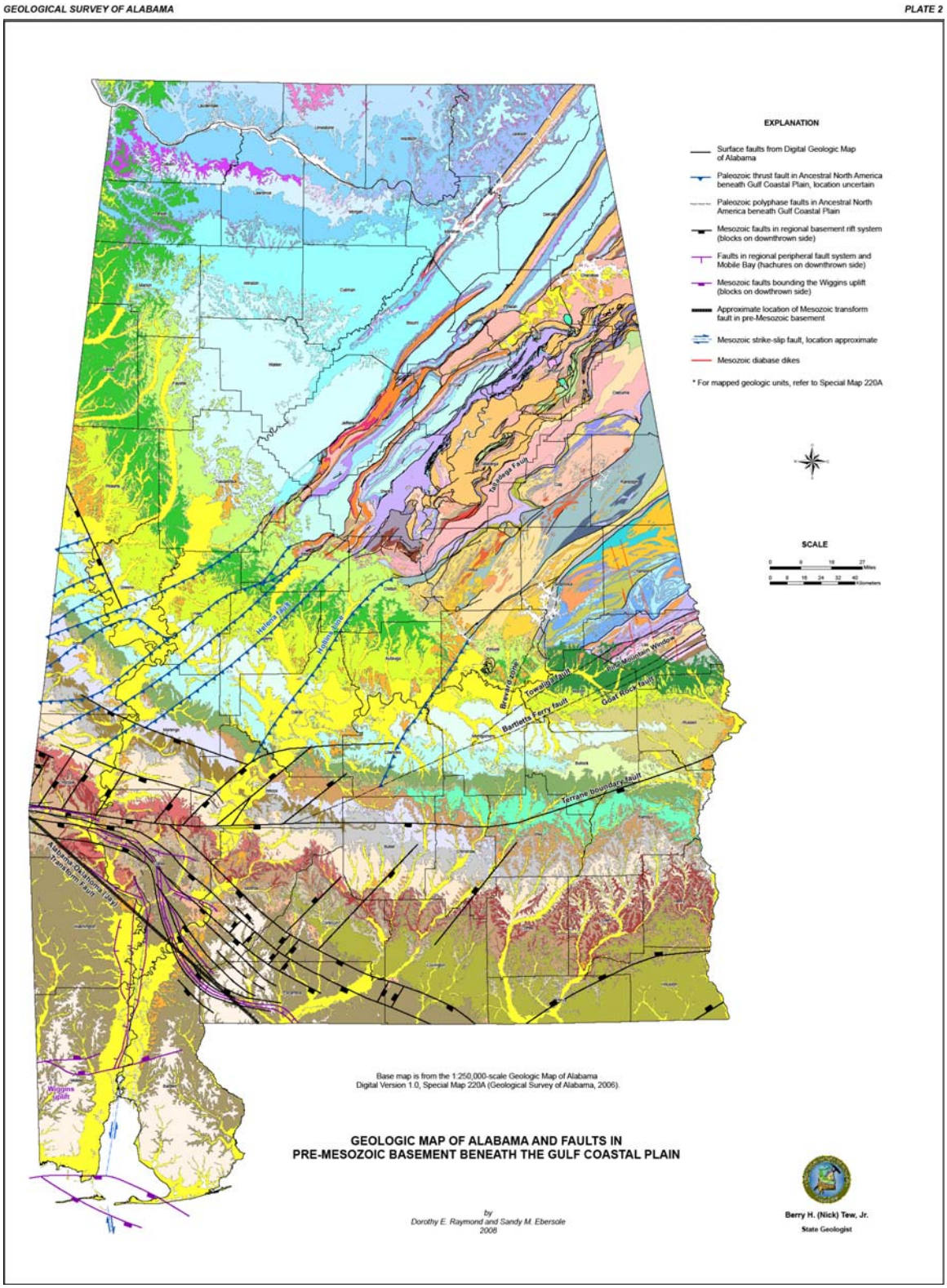



Figure 11
Pre-Mesozoic Basement Faults of Alabama