

## Final Technical Report

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Title of award: CUSEC State Geologists Earthquake Hazard Mapping, Preparedness and Outreach Associated with Central U.S. Seismicity

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### **Abstract**

The Association of the State Geologists of the Central U.S. Earthquake Consortium (CUSEC-SG) was formed to work on projects related to earthquake hazard issues through coordination of the eight states activities. This grant provided funds for yearly meetings to coordinate work activities, partial funding to support production of multi-state products, develop earthquake response plans in individual states and multi-state coordinated plans, assist state emergency managers with earthquake exercise development for the 2011 National Level Exercise and the 2014 CAPSTONE eight state earthquake exercise, development of a CUSEC-SG website for access to CUSEC-SG maps and reports, provide earthquake information during the New Madrid Bicentennial activities and general outreach activities. This final report summaries these activities by project and individual states.

### **Investigations and programs undertaken**

#### **CUSEC State Geologists multi-state maps**

The CUSEC State Geologists prepared multistate maps and individual databases of each state's earthquake events in order to produce general maps or the ability to generate general maps during earthquake response for our own use or use with press coverage. Events near any of our individual state borders are out of context without neighboring

state earthquake events. Several states had assembled new earthquake catalogues for their state for production of state maps and in preparation for a multistate map. Since the new EPRI-DOE-NRC report, "CEUS Seismic Source Characterization (SSC) for Nuclear Facilities 2012" was released, it was decided to hold back on states' releases and cross reference individual state catalogues events with the SSC catalogue. The SSC catalogue provides one magnitude scale for all events instead of the mix of multiple scales of moment, felt area, surface, etc. But a review of the SSC catalogue found many problems. Below is the review of SSC events with problems in and near the state of Illinois.

April 9, 1917 Earthquake, M 4.86 - One possible mis-located event is the main shock of the April 9, 1917 earthquake on the Missouri/Illinois border. Information on this event was documented and published (Finch, 1917). TMP03610 matches the time of the main shock at 20:52 but has a latitude-longitude of 37 -90. The aftershock (TMP03612) at 23:38 has a latitude-longitude of 38.1 -90.2. This aftershock location is in agreement with the published location of the main shock – a little south of Valmeyer, IL. The (37 - 90) location is 123 km south of (38.1 -90.2) and is about 70 km directly west of Cairo. This does not agree with the publications or description of the estimated location for the main shock based on shaking (intensity).

As was explained, it appears that combining catalogue resulted in this problem with one catalogue taken over another. The problem main shock location appears to have come from NCEER91 catalogue, while Stover & Coffman (1993) appear to have it match published intensity data and the aftershock location used in SSC.

Charleston MO 31 Oct 1895, M 6.0 The SSC Catalogue of earthquake events has the Charleston MO 31 Oct 1895, Mag. 6.0 event located 13 km NW of Carbondale IL or 6 km north of Murphysboro, IL at (37.82 -89.32). That is 95 km north of all the damage in Cairo, IL which is close to the same distance from this SSC epicenter to St. Louis (110 km). Sunk land and liquefaction features are only near Charleston & Bertrand, MO which is about 110 km south from this epicenter and these liquefaction features were produced during the summer of 1895 which experienced a severe drought. Creek beds were dry throughout the entire state of Indiana and people were walking across the Ohio River. Main shock was moved north in the SSC catalogue but the many aftershocks remain near Charleston, MO 110 km south of main shock at (36.78 to 37.05 -89.2 to -89.4).

Other problems were found such as a magnitude 4.16 in Champaign County, Illinois in 1925. The only event on this date was a report of a felt event in Terra Haute, Indiana with NO damage. It appears that rounding of decimal places or the lack of decimal places has this misplaced by about 90 km and placed in another state.

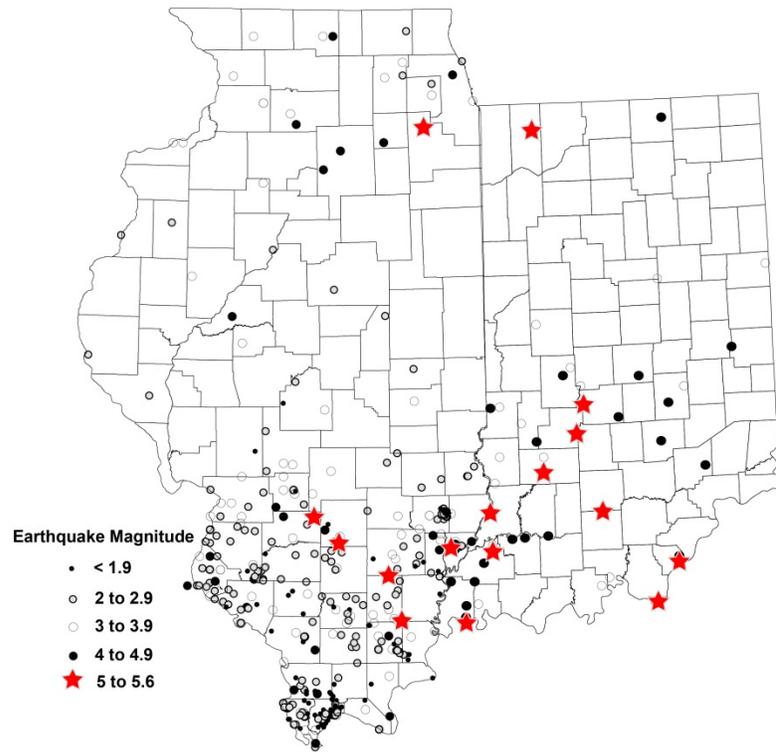
Other noted problems were missing events in the SSC catalogue, such as 6 events in the magnitude 4s, 16 events in the 3s and 7 of those events are greater than 3.7 and 2 in the magnitude 5s. Also some magnitude 2s are in the SSC but many, many more are not and there does not appear to be a cutoff criteria based on magnitude. Other parts of the nation

may not consider magnitude 2s but in areas of few events in the CEUS, they may form patterns of interest.

With all these problems found during one state's review of the SSC catalogue, the CUSEC State Geologists decided to use our individual states' catalogues even though the magnitudes would not all be the same and not even the same within our individual databases, but epicenters would not be missing or mis-located in general and between main shocks and aftershocks. Our use of the database and general maps is not for hazard map production but for the use of whole integer numbers for magnitudes plotted on multi-state maps.

Each individual state geological survey, provided a database of events in their state to the Indiana Geological Survey (IGS) who used these database in compilation of multi-state epicenter maps and produced a map of seismograph locations in the CUSEC states using a number of catalogues for the stations. All have been plotted using ArcGIS 10.1. As of the end of December 2013, both the locations of the historic epicenters and the active seismic monitoring stations are near completion and will be hosted on the IGS Website. Federally compliant FGDC metadata will be included with the maps. Additionally, copies will be sent to all eight CUSEC states for individual Website posting. These will be posted at: <http://igs.indiana.edu/CUSEC-SG> and posted at CUSEC State Geologists website: <http://isgs.illinois.edu/?q=association-central-us-earthquake-consortium-state-geologists>

Below is an example displaying an early version of the databases of Illinois (magnitude down into 2s) and Indiana (magnitude down into 3s) showing the historical and instrumental epicenters across a region.



Assistance to state, communities (data & scenarios)

**Arkansas** Geological Survey continues to provide assistance to the communities of Guy and Greenbrier in Faulkner County, Arkansas due to the Guy-Greenbrier earthquake swarm, although there has been a significant decrease in activity.

**Illinois** State Geological Survey assisted the Ohio Geological Survey in producing Soil Site Class, Liquefaction Susceptibility and Soil Response maps for use in a state wide assessment. Funding did not come through for the completion of the project in Ohio. Illinois is also assisting the Department of Insurance with definitions and impacts associated with the New Madrid seismic zone and their required coverage areas for insurance companies.

The **Missouri** Geological Survey completed mapping of the geologic limitations and environmental vulnerability in the Poplar Bluff and Bootheel regions of Missouri. Funded by the Missouri State Emergency Management Agency, this map gives local community planners and early responders the simple tools to make informed and timely decisions in the face of geologic hazards or other natural disasters, such as an earthquake or tornado, by identifying the geological suitability for development of short-term debris storage or long-term solid waste disposal. This map depicts general geologic features such as gaining and losing streams, confining layers, karsted areas or significant fractures in the bedrock that may or may not be suitable for landfill conditions.

In conjunction with Missouri SEMA, the **Missouri** Geological Survey developed three informational displays on the topics of Preparedness, Science of Earthquakes and

Earthquakes in Missouri. The displays were designed to use at conferences, meetings and museums.

#### Landslide Susceptibility maps

**Alabama** Geological Survey produced a state landslide susceptibility map and GIS data compatible with HAZUS using a NEHRP grant. The methodology, poster, and geospatial data can be found on our new geological hazards landslide webpage - <http://gsa.state.al.us/gsa/geologichazards/Landslides.htm>.

**Arkansas** Geological Survey continues to be in the preliminary stages of preparing a Landslide Susceptibility Map of Arkansas. Arkansas has investigated numerous landslides across the state. Case studies can be found at: [http://www.geology.ar.gov/geohazards/landslides\\_casestudies.htm](http://www.geology.ar.gov/geohazards/landslides_casestudies.htm)

The **Indiana** Geological Survey collaborated with the Kentucky and Ohio Geological Surveys and the University of Cincinnati to co-publish a landslide awareness brochure for the greater Cincinnati area encompassing the three states entitled, "Landslides and your property." The glove-box-sized, fold-out brochure was written by P.E. Potter, M. Bowers, J.B. Maynard, M.M. Crawford, G.A. Weisenfluh, T. Agnello. It is available through the Indiana Geological Survey as Miscellaneous Item 111 and the Kentucky Geological Survey as Publication 17740.

**Kentucky** Geological Survey developed an earthquake-induced landslide hazard map and procedures and produced a short report to share with the other CUSEC State Geologists. This was a pilot effort out of our CUSEC-SG April 2011 meeting in order to assist some of the other states in reducing their development time.

The **Missouri** Geological Survey finalized maps for the nine Missouri State Emergency Management Agency (SEMA) regions depicting landslide susceptibility, along with liquefaction and collapse potential. Landslide susceptibility is considered probable if the slope is 12 percent or greater and correlated with a formation known to contain shale, unconsolidated sediments or surficial materials greater than or equal to 20 feet in thickness; or if the slope is greater than 20 percent.

#### State earthquake webpages

**Alabama** updated its geological hazards webpages with more current regional and local earthquake information: <http://gsa.state.al.us/gsa/geologichazards/index.htm>

**Illinois** State Geological Survey added a highlight on their homepage each week of the New Madrid bicentennial for the history of the main shocks and total of aftershocks per week from Dec 16, 2011 through March 15, 2012. The earthquake webpage was updated with a summary of what occurred and new state map each time Illinois or areas in other states along the Illinois border had events, which totaled 28 events over the past 3 years. This was also added to our Facebook account which is tied to our website.

The **Indiana** Geological Survey is expanding its webpage to include earthquake preparedness content and educational activities. Indiana Geological Survey has produced a map displaying earthquake epicenters occurring since 1817 and known faults within the state boundaries. The *Earthquakes in Indiana* brochure was updated with recent epicenter events. A bookmark and business card were created to advertise resources available on its Web site.

**Kentucky** Geological Survey maintains an earthquake webpage at [www.uky.edu/KGS/geologichazards/](http://www.uky.edu/KGS/geologichazards/) with links to USGS webpage and also maintains a real-time seismic data and other related publications and maps for Kentucky at [www.uky.edu/KGS/geologichazards/](http://www.uky.edu/KGS/geologichazards/).

**Missouri** earthquake web page has been updated with links to information about the National Level Exercise, CERI earthquake catalog, USGS “Did you feel it”, Earthscope and Great American Shake Out. An informational video was produced and distributed online (702 views since Jan 18, 2012): <http://dnr.mo.gov/shakeout/>. The Department of Natural Resources sponsored an earthquake preparedness video contest. The webpage has been updated with information and links about recent earthquakes, USGS “Threat of Earthquakes Occurring in Central United States Still Alive,” the Great Central U.S. ShakeOut and a new Geologic Hazards brochure.

**Tennessee** Geological Survey added links to Central US Shake Out, New Madrid Bicentennial and National Level Exercise 2011 (FEMA)

#### *CUSEC State Geologists data & map accessible repository*

Server space was secured at Illinois Geological Survey for storage and accessibility of CUSEC State Geologists data and products. Text, thumbnails of maps with links and list of products have been added to a redesigned CUSEC State Geologists’ webpages (<http://isgs.illinois.edu/?q=association-central-us-earthquake-consortium-state-geologists>) This link has been supplied to the CUSEC (Memphis) office for the Associations webpage. Many consultants or state agencies request GIS files for various individual states for model runs. These files are found per state on this website for soil type classification and liquefaction potential both formatted for use in HAZUS. The multi-state epicenter maps will also be linked through this website.

The shear wave database of values per formation throughout many CUSEC states was provided to the Next Generation Attenuation – East subcommittee on characterizing of near surface soils and bedrock. Also contacts in other states in the Central U.S. with known similar data for this project were provided to subcommittee members.

#### *States Bicentennial outreach activities*

**Alabama** was communicating with the Alabama Museum of Natural History to explore a potential earthquake program related to the New Madrid Seismic Zone and earthquakes, but this was postponed to a later date, thus far undefined. Instead, GSA is currently providing the museum with posters and aerial imagery for an exhibit on the April 2011

tornado response in which they had a major role with their GIS assistance as they would during an earthquake response.

**Arkansas** Geological Survey invited three distinguished speakers knowledgeable on the NMSZ and its history to speak at a Town Hall Meeting on the Arkansas State University (ASU) campus on January 19, 2012 as part of their commemoration the NMSZ Bicentennial. This meeting was held in conjunction with the Arkansas Governor's Advisory Committee (AGEAC) meeting held earlier in the day at the same location.

**Illinois** State Geological Survey conducted a two day open houses in March 2012 & 2013 where they presented an earthquake display showing locations, affects, videos of liquefaction principals, promoted the Central US ShakeOuts and Bicentennial information and products to over 2,000 grade school students and public per year. Also ISGS advertised the Great Central U.S. ShakeOuts of Feb. 2012 & 2013 through homepage and Facebook postings along with flyers. Illinois's facebook started in about 2011 and all recent earthquake postings are presented there. Homepage each week of the New Madrid bicentennial was updated with the history of the 1811-1812 main shocks and total of aftershocks per week from Dec 16, 2011 through March 15, 2012.

The **Indiana** Geological Survey worked closely with the Indiana Department of Homeland Security and Indiana Department of Public Education to promote the Great Central US ShakeOut and Bicentennial events. A proposal has been submitted to and is under consideration by Indiana Department of Homeland Security requesting funds to develop an extensive Earthquake Outreach Program.

The Great Central US ShakeOut was publicized with a sign and handouts by the **Mississippi** Office of Geology at their booth in the Mississippi Gem and Mineral Society's Rock Show.

**Missouri** Geological Survey Museum is currently hosting an Earthquake Kiosk onsite from 2010-2012 loaned from NSF/IRIS. Also the survey has produced and distributed a one page (front and back) Informational Sheet on Bicentennial events throughout the central U.S. and on this year's The Great Central U.S. ShakeOut.

**Tennessee** Geological Survey promoted and participated in the 2011 & 2012 Great Central US Shakeout.

#### *Response plan development & incorporation in state plans*

**Alabama** has continued to update its earthquake response plan, building in additional maps, data, equations, data source locations, and contact information to strengthen the response plan. Additional information found useful during the April 2011 tornado response has also been incorporated into the plan. During 2013, Alabama reviewed their plan and made communications updates (emergency management and geologist contact information).

**Arkansas** Geological Survey continues to develop and refine their EQ Response Plan.

**Illinois** State Geological Survey continued to develop and refine their EQ Response Plan. They developed a Memorandum of Understanding (MOU) with their Champaign County Amateur Radio Emergency Services group in the county of the geological survey's headquarters for communications with the state EOC and locations near the earthquake damage area.

The **Indiana** Geological Survey has been asked to provide technical support related to response planning and exercises planned by Indiana Department of Homeland Security. Indiana Geological Survey has reviewed the state emergency response plan and provided reviews comments to the Indiana Department of Homeland Security for final editing.

**Kentucky** Geological Survey has developed a draft earthquake response plan, and is working with the Planning Section of Kentucky Emergency Management (KyEM) to integrate that plan with the statewide plan. In the event of an earthquake, the Kentucky Geological Survey is making plans to send a liaison/representative to the state EOC, process seismic data from the Kentucky seismic network, assist with assessment of survivable ground for the establishment of response and recovery centers, and coordinate any in-state scientific response to the event. The KGS is also working with KyEM on preparations for the 2011 New Madrid NLE, as well as scenarios for future exercises and planning.

**Missouri** Geological Survey completed its Emergency Response Plan and the Post Earthquake Technical Information Clearinghouse plan. The plans are being reviewed with Missouri Department of Natural Resources Emergency Management Officer and incorporated into department and state response plans. These plans have been shared with Kentucky Emergency Management as well as CUSEC. Missouri shared an inject template and developed mock scenario injects as a guide for Kentucky Emergency Management to provide some understanding of the clearinghouse mission and how their survey could be utilized. Missouri Geological Survey also made wallet size cards of contact information of the CUSEC State Geologists involved in earthquake response and distributed them to all CUSEC surveys.

**Tennessee** Geological Survey continues to develop a draft response plan working with CERI, TEMA and Tenn. Dept. of Transportation.

### **Preparation for National Level Exercise 2011 (NLE-11) and CAPSTONE-14 Central U.S. Earthquake Consortium States exercise in 2014**

#### *Develop and exercise CUSEC SG response plans in prep for NLE-11*

**CUSEC State Geologists** ran two table top exercises with difference scenarios on April 12, 2011 in Memphis to detect possible changes to plans and to finalize some multi-state communications and coordination. One table top exercise was for no power in the area of

the state geological surveys' headquarters. This produced many changes to individual state plans.

**Alabama** continued to work on data sharing protocols with Alabama Emergency Management Agency.

**Missouri** assisted other state agencies in preparing for the exercise and participated in a communications exercise before the NLE-11. They had a major role in message development for the communications exercise.

**Tennessee** Geological Survey participated in the TTX scenarios on April 12th in Memphis.

#### *Exercise of CUSEC SG response plans during NLE-11*

**CUSEC Technical Director** set up procedures for daily situation conference calls between the State and Federal Geological Surveys during earthquake response. During the NLE-11 exercise for the first four days, conference calls were initiated, based on the plan, for exchange of pertinent information from State and National exercise participants. An After Action Report is being assembled and will be reviewed during the 12 Apr 2012 meeting. We also participated in the USGS-NEHRP After Action Report, which many participants were on the CUSEC daily situation awareness conference calls. The After Action Report can be found on the CUSEC State Geologists website: [http://isgs.illinois.edu/sites/isgs/files/files/NLE\\_CUSEC-SG\\_Report.pdf](http://isgs.illinois.edu/sites/isgs/files/files/NLE_CUSEC-SG_Report.pdf)

**Alabama Geological Survey's** continued work with the Alabama Emergency Management Agency provided their established contacts and expertise for the response to the damage inflicted from the May 2011 tornadoes that precluded Alabama from exercising the NLE-11. Instead the Alabama Geological Survey had real world experience for weeks working in the Alabama Emergency Operations Center.

Two geologists with **Arkansas** Geological Survey participated in NLE 2011 held at the Arkansas Department of Emergency Management (ADEM) EOC on 16-20 May 2011.

**Illinois** Emergency Managers were engaged in flood response during the NLE-11. Illinois Geological Survey (ISGS) assisted in the flood and participated in the State of Illinois's state-wide 3 day earthquake exercise which was held in the fall (Nov 15-17) which was their postponed NLE-11 exercise. ISGS served as the subject matter expert and liaison in the state's Emergency Operations Center (EOC) interpreting information, writing news releases and providing messages on aftershocks. The MOU with their county Amateur Radio Emergency Services was exercised and communications was established with the ISGS headquarters and the state EOC and county EOCs near the damage areas in southern Illinois.

The **Mississippi** Office of Geology had planned for a limited participation in NLE 2011. The primary participation was to have been the State Geologist serving as a subject

matter expert in the state EOC during the day shift for two or three days of the exercise. Deadly tornadoes in late April and a record-breaking Mississippi River flood starting in early May caused MEMA to cancel their participation in NLE 2011. The Mississippi Office of Geology also cancelled its activities, except for participation in the Association of CUSEC State Geologists daily situation awareness conference calls during the exercise.

**Missouri** participated in the NLE and set up a Post-Earthquake Technical Clearinghouse which was also provided information on closed roads and possible location for the USGS instrument deployment team.

#### Assist SEMAs in developing NLE-11

**Mississippi** in the months and weeks preceding the exercise, staff of the Mississippi Office of Geology met with the director and various staff of the Mississippi Emergency Management Agency (MEMA) to discuss geological aspects of the earthquake scenario. Discussion focused on statewide maps of soil class and amplification potential and liquefaction susceptibility. Other agencies and organizations participated in these meetings and discussions. The State Geologist presented the *Central US is Earthquake Country* PowerPoint to two groups of MEMA staff and associated organizations and companies (area coordinators and logistics).

**Missouri** Geological Survey assisted other state agencies in preparing for the exercise and participated in a communications exercise before the NLE-11. Missouri was heavily involved in messages and situation development for the communications exercise.

#### Assist SEMAs in developing CAPSTONE-14

Geological Survey of **Alabama** has also been involved in communications with our state emergency management agency related to the upcoming CAPSTONE14 exercise. We have helped examine some of tabular and geospatial data for use in the exercise. GSA is also gaining more practice and education in using ESRI ArcGIS online for data sharing and real-time geospatial data for common operation picture (for use in CAPSTONE) as well as GeoCONOPS for use in future exercises and event response.

The **Illinois** State Geological Survey is working with the U.S. Geological Survey and the Illinois Emergency Management Agency who is the lead for sending out the exercise driven messages from the Control Cell, in developing the usual USGS earthquake notification documents of first notification, map location, Did You Feel It?, and PAGER. These will have to be emailed out to a specific list of participants in the exercise with appropriate markings of EXERCISE-EXERCISE-EXERCISE so there are no mis-communications.

The **Indiana** Geological Survey planned (in 2013) and will provide a three-day workshop for EMA attendees in preparation for Capstone 2014. The workshop provides participants with the historical knowledge of seismic events in the central US, HAZUS modeling

practices, and table top exercises. The IGS provided the SEMA with the modeling scenario for exercise purposes and technical support.

The **Missouri** Geological Survey is assisting other state agencies in preparing for the exercise and is providing injects for the scenarios. The MGS will participate in data sharing and coordination.

#### *CUSEC State Geologists developments for CAPSTONE-14*

Several states' members worked with the members of the CUSEC office on development of Mission Ready Packages (MRP) for assistance to state geological surveys during an earthquake emergency response. Mission Ready Packages are a detail Microsoft Excel spreadsheet with description of team members capabilities, equipment, area of operation, conditions of operation and support provided. These packages are contained in the Mutual Aid Support System for emergency response in the nation. CUSEC State Geologists developed the first MRPs in the nation for assistance to geological surveys. Three packages were developed for Post-Earthquake Field Reconnaissance Team, Support Team for Operation of Post-Earthquake Technical Clearinghouse, and Assistance for State Geological Survey's EOC Representative. During a response a state may request help for one of these areas. The request goes out and other states and their teams fill in the remainder of the forms which are submitted to the requesting state. The requesting state can look through the submittals and pick ones based on cost and expertise. This is part of the Emergency Management Assistance Compact which is a law passed by all US States and Territories to facilitate sharing resources during disasters and other times of need. Further information can be found at:

Emergency Management Assistance Compact (EMAC) web

site: <http://www.emacweb.org/>

EMAC Mission Ready Packages

(MRPs) [http://emacweb.org/index.php?option=com\\_content&view=article&id=129&Itemid=254](http://emacweb.org/index.php?option=com_content&view=article&id=129&Itemid=254)

#### *CUSEC State Geologists meetings - summary*

**12 April 2011** Memphis, TN – Most of the meeting was in final preparation for National Level Exercise 2011:

Objectives to be tested – discuss objectives your survey will be testing

Run through table top exercise on response plans for:

- Worst case scenario for earthquake impacts in central US
- Scenario for most likely impact with continued communications and power functioning
- List of Possible Electronic Files for EOC

Finalize communications plans:

- Contact list for CUSEC SGs
- Provide EOC amateur radio call signs
- Plan for CUSEC SG Situational Awareness Call

- Inside EOC
- In state kick off plans for participation
- Pre-scripted messages

New Madrid Expert Panel Draft Document

**10 April 2012** Memphis, TN - CUSEC State Geologists reviewed the contents of the newly released EPRI-DOE-NRC report, “CEUS Seismic Source Characterization (SSC) for Nuclear Facilities”.

1. Review of NLE-11 experiences – what additional to add to plans
2. Capstone 14 – next exercise
3. State Project Reports
  - Indiana’s earthquake awareness project. New earthquake simulator, the Quake Cottage.
  - Indiana historic epicenters and known faults map (draft).
4. Eight state products
  - 8-state version of earthquakes & faults. Indiana to coordinate production, deadlines, formats.
  - Seismograph station map and table. Indiana will coordinate production, deadlines, formats.
5. Review of CUSEC State Geologists Webpage
6. EPRI-DOE-NRC report
7. USGS – next generation of National Hazard Probability Maps

**13-14 May 2013** St. Louis - CUSEC-State Geologists meeting centered around tools for earthquake emergency response and presentations of state surveys’ examples of response of the Utah Geological Survey. The Utah Geological Survey has developed a web based data collection system for hazard response. It also allows public input of information which is screened before adding to the database. The web based system is also being modified to be able to function on smart phones or tablets.

1. Half day on Utah Geological Survey clearinghouse software program and real life response
2. Defining Emergency Management Assistance Compact (EMAC) support requirements for State Geologists’ Assistance - Mission Ready Packages
3. Alabama presents
  - CAPSTONE and the ESRI/VirtualUSA setup
  - Experiences within EOC during tornadoes that apply to earthquake response
4. CAPSTONE-14
  - Schedule
  - Review of Individual State Plans
5. Multi-State Earthquake Compilation map – review of databases & production
6. Review of issues in individual state for:
  - Induced/triggered earthquakes
  - High Volume Hydraulic fracturing experiences & legislation

- Deep waste disposal wells & regulations in light of possible triggered earthquakes
- 7. 1 in 4 plan for EarthScope instrument stations adoption into national network
- 8. Erroneous theory of 1811 Great Comet strikes earth to cause New Madrid 1811-1812 events – review of celestial mechanics for 1811 Great Comet and dates of New Madrid events find no match for encountering tail of comet.

### Participation in meetings

#### Alabama Geological Survey

- 16 Mar 2011 Alabama Internal NLE Coordination Meeting
- 4 Apr 2011 National Level Exercise 2011 (NLE 11) Scenario Working Group (SWG) Meeting via teleconferencing and web data exchange
- 12 April 2011 Memphis, TN - CUSEC State Geologists ran a table top exercise of several scenarios to detect possible changes to plans and to finalize some multi-state communications and coordination.
- 19 Apr 2011 State NLE Weekly Coordination Meeting

#### Arkansas Geological Survey

- 12 Apr 2011 Memphis, TN - Association of Central U.S. Earthquake Consortium (CUSEC) State Geologists Meeting.
- 13-16 Apr 2011 Memphis, TN – Seismological Society of America Annual Meeting
- 16-18 Oct 2011 Little Rock, AR 83<sup>rd</sup> Annual Meeting of the Eastern Section of the Seismological Society of America.
- 31 Jan 2012 Little Rock, AR - Attended API Workshop on Hydraulic Fracturing at Peabody Hotel.
- 3 Feb 2012 St. Louis, MO - participated in Earthquakes: Mean Business seminar at Saint Louis University and set-up AGS earthquake booth in exhibit hall.
- 22-23 Feb 2012 Memphis, TN - participated in a 2-day U.S. Geological Survey workshop for the next set of National Seismic Hazard Maps.
- 20-21 Mar 2012 Ft. Smith, AR – 2012 Fayetteville Shale Symposium

#### Illinois State Geological Survey

- 15-16 Mar 2011 Memphis, TN – CUSEC Communications Officers Meeting
- 4 Apr 2011 National Level Exercise 2011 (NLE 11) Scenario Working Group (SWG) Meeting via teleconferencing and web data exchange
- 12 April 2011 Memphis, TN - CUSEC State Geologists ran a table top exercise of several scenarios to detect possible changes to plans and to finalize some multi-state communications and coordination.
- 31 May 2011 – participated in the NEHRP-USGS After Action Report conference call and summarized CUSEC State Geological Surveys' actions
- 23 Jun 2011 – CUSEC Technical Working Group After Action Report conference call to summarize NLE-11 experiences

- 5 Oct 2011 – Champaign Amateur Radio Emergency Services participated in meeting plans for SLE-11 exercise.
- 7 Feb 2012 - outreach meeting which presented completed materials for the Evansville (IN) Urban Hazard Mapping Project. The all-day event on Feb. 7<sup>th</sup> included presentations to professionals with afternoon talks and workshops and an evening presentation to the public. A total of 200+ people attended.
- 22-23 Feb 2012 Memphis, TN - participated in a 2-day U.S. Geological Survey workshop for the next set of National Seismic Hazard Maps.
- 14 Aug 2012 - 3 day workshop in Hoffman Estates of 230 representatives from emergency managers and public sector corporations and non-profits for preparations for CAPSTONE-14 exercise.
- 1 Feb 2013 - Earthquakes: Mean Business, St. Louis, MO
- 13-14 May 2013 - CUSEC-State Geologists meeting in St. Louis.
- 1 Jun 2013 - Initial planning conference for CAPSTONE 14, Indianapolis, IN.
- 14-15 Aug 2013 – IL, AR & MS meeting Memphis CUSEC Office for development of Mission Ready Packages for Mutual Aid Support System
- 8 Oct 2013 - Midwest Geological Sequestration Science Conference in Champaign, IL.

#### **Indiana Geological Survey**

- 12 April 2011 Memphis, TN - CUSEC State Geologists ran a table top exercise of several scenarios to detect possible changes to plans and to finalize some multi-state communications and coordination.
- 9 May 2011 Kentucky Geological Survey, KGS Advisory Board
- 18-20 July 2011 Carbondale, IL – OIINK Project Training and Installation Meeting
- 28 July 2011 NRCS Office-Indianapolis, Natural Resources Conservation Service
- 12 September 2011 Bloomingdale, Illinois, American Institute of Professional Geologists annual meeting
- 11 October 2011 Edinburgh, IN – Indiana Department of Homeland Security Training and Exercise Planning Workshop
- 30 November 2011 Indiana Geological Survey, IGS Advisory Board
- 13 January 2012 Bloomington, IN – Indiana Department of Homeland Security Capability Meeting
- 17 February 2012 Indianapolis, IN – OIINK Project Update and Planning Meeting
- 1 March 2012 University of Cincinnati, Department of Geology Colloquium
- 2 March 2012 Indianapolis, IN – Indiana Department of Homeland Security Emergency Response Team Meeting
- Monthly meetings with Indiana Department of Homeland Security
- Indiana Geological Survey participated in multiple meetings at each of the eight Indiana University campuses to identify potential earthquake risks at those sites and develop mitigation strategies.

### **Kentucky Geological Survey**

- 15 Nov 2011 Paducah, KY - "Earthquakes, seismic hazards, and Building Codes in Kentucky," Kentucky Professional Engineer Training Class.
- 22-23 Feb 2012 Memphis, TN - participated in a 2-day U.S. Geological Survey workshop for the next set of National Seismic Hazard Maps.

### **Missouri Geological Survey**

- 12 April 2011 Memphis, TN - CUSEC State Geologists ran a table top exercise of several scenarios to detect possible changes to plans and to finalize some multi-state communications and coordination.
- 3 Feb 2012 St. Louis - Earthquakes: Mean Business

## **Publications and Presentations**

### **Publications**

#### **CUSEC State Geologists**

CUSEC State Geologists brochure on history and products are on the CUSEC SG website.

### **Arkansas Geological Survey**

- AGS Publications: Working in cooperation with the Arizona Geological Survey on U.S. Department of Energy geothermal research grant – AGS deliverables include compilation of maps depicting eight (8) seismic regions of Arkansas – expected to be completed by the end of 2012 with final version available for download at address below.
- Updated "Three Centuries of Earthquakes" historical seismicity map of Arkansas which is available at address below:

[http://www.geology.ar.gov/geohazard\\_maps/ark\\_earthquakes.htm](http://www.geology.ar.gov/geohazard_maps/ark_earthquakes.htm)

### **Illinois State Geological Survey**

Haase, J.S., Y. S. Choi, R.L. Nowack, C.H. Cramer, O.S. Boyd, R.A. Bauer, 2011, Liquefaction hazard for the region of Evansville, Indiana, U.S. Geological Survey Open-File Report 2011-1203, 38 p.

Haase, J.S., T. Bowling, R.L. Nowack, Y. S. Choi, C.H. Cramer, O.S. Boyd, R.A. Bauer, 2011, Probabilistic seismic hazard assessment including site effects for Evansville, Indiana, and the surrounding region, U.S. Geological Survey Open-File Report 2011-1231, 29 p.

Haase, J.S., R.L. Nowack, C.H. Cramer, O.S. Boyd, R.A. Bauer, 2011, Earthquake Scenario Ground Motions for the Urban Area of Evansville, Indiana, U.S. Geological Survey Open-File Report 2011-1260, 17 p.

Bauer, R.A., 2012, Central U.S. Earthquake Consortium State Geologists' Clearinghouse Plans, NEC-EERI Annual Meeting Abstracts, April 10-13, 2012, Memphis, TN.

Bauer, R.A., 2012, Resilience assessed by comparing Scenarios' Losses, NEC-EERI Annual Meeting Abstracts, April 10-13, 2012 Memphis, TN.

Williams, R.A., C.H. Cramer, J.D. Rogers, R.A. Bauer, J. Chung, D.L. Gaunt, G.L. Hempen, , P.J. Steckel, D. Hoffman, C.M. Watkins, O.L. Boyd, and N.S. McCallister, 2012, The St. Louis Area Earthquake Hazards Mapping Project, (abstract), in Program and Abstracts for Seismological Society of America Annual Meeting, San Diego, CA, 2012, Seismological Research Letters, Vol. 83, No. 2, pp. 458-459.

**Kentucky Geological Survey**

“Ground Motion Time Histories for Seismic Design of Bridge and Highway Structure in Kentucky” and “A Case Study on Probabilistic Methods in Seismic Hazard Assessment: Probabilistic Seismic Hazard Analysis,” abstracts at the SSA 2011 Annual Meeting, April 13 – 15, 2011, Memphis, TN.

“The Central U.S. Seismic Observatory: Some Preliminary Results” and “Earthquake Science and Mitigation Policy: Design Ground Motion for Facilities at the Paducah Gaseous Diffusion Plant,” Abstracts The 83th Annual Meeting of the Eastern Section of the Seismological Society of America, October 16-18, 2011 Little Rock, AR.

**Mississippi Office of Geology**

Bograd, Michael B. E., 2012, Mississippi earthquakes and the New Madrid Bicentennial: Environmental News (MDEQ), v. 9, issue 2, February 2012, p. 3-6.

**Missouri Geological Survey**

Haselwander, A., 2013a; Geologic Hazards Map of Region A, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-616-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013b; Geologic Hazards Map of Region B, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-617-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013c; Geologic Hazards Map of Region C, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-618-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013d; Geologic Hazards Map of Region D, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-619-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013e; Geologic Hazards Map of Region E, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-620-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013f; Geologic Hazards Map of Region F, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-621-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013g; Geologic Hazards Map of Region G, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-622-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013h; Geologic Hazards Map of Region H, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-623-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013i; Geologic Hazards Map of Region I, State Emergency Management Agency: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-624-GS, scale 1:250,000, 1 sheet.

Haselwander, A., 2013j; Geologic Hazards Map of the Missouri Portions of Grafton and Elsau 7.5' Quadrangles, St. Charles and St. Louis Counties, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-625-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013k; Geologic Hazards Map of Florissant, Columbia Bottom, and the Missouri Portion of Alton and Wood River 7.5' Quadrangles, St. Charles and St. Louis Counties and St. Louis City, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-626-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013l; Geologic Hazards Map of Wentzville and O'Fallon 7.5' Quadrangles, St. Charles County, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-627-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013m; Geologic Hazards Map of Kampville and St. Charles 7.5' Quadrangles, St. Charles and St. Louis Counties, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-628-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013n; Geologic Hazards Map of Weldon Spring and Chesterfield 7.5' Quadrangles, St. Charles and St. Louis Counties, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-629-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013o; Geologic Hazards Map of Creve Coeur, Clayton, and the Missouri Portion of Granite City 7.5' Quadrangles, St. Louis County and St. Louis City,

Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-630-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013p; Geologic Hazards Map of Manchester and Kirkwood 7.5' Quadrangles, Jefferson and St. Louis Counties, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-631-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013q; Geologic Hazards Map of Webster Groves and The Missouri Portion of Cahokia 7.5' Quadrangles, St. Louis County and St. Louis City, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-632-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2013r; Geologic Hazards Map of House Springs, Maxville, and the Missouri Portion of Oakville 7.5' Quadrangles, Jefferson and St. Louis Counties, Missouri: Missouri Department of Natural Resources, Division of Geology and Land Survey, Open File Map OFM-13-633-GS, scale 1:24,000, 1 sheet.

Haselwander, A., 2014; General Geological Limitations for Sanitary and Demolition Landfills in the Poplar Bluff, Missouri Area: Missouri Department of Natural Resources, Missouri Geological Survey, Open File Map OFM-13-641-GS, scale 1:250,000, 1 sheet.

#### Presentations and Exhibits on Earthquakes and Hazard Preparedness

##### Alabama Geological Survey

- 6 April 6 2011 Tuscaloosa YMCA, *Earthquakes: Historical Events and Potential Damage in Alabama and the Southeast*
- 11 Nov 2011 *Geologic Hazards and Earthquakes in Alabama*, presented to the University of Alabama Geography Department Natural Hazards class

##### Arkansas Geological Survey

- April 6<sup>th</sup> Earthquake 101, Batesville Chamber of Commerce, Batesville, 25 in Attendance
- April 9<sup>th</sup> Earthquake 101, ATC-20 Post Earthquake Safety Evaluation of Buildings Training Workshop, Univ. of Central Arkansas, Conway
- April 12<sup>th</sup> Central United States Earthquake Consortium (CUSEC) Geologists Meeting, University of Memphis, Memphis
- April 13<sup>th</sup> thru April 15<sup>th</sup> - Seismological Society of America (SSA) Annual Meeting, University thru 15<sup>th</sup> of Memphis, Memphis
- April 20<sup>th</sup> - Earthquake 101, Indian Rock Village Health Center and Nursing Home, Fairfield Bay, 75 in Attendance
- May 5<sup>th</sup> - Earthquake 101, North Little Rock Health Department, North Little Rock, 25 in Attendance
- May 16<sup>th</sup> thru May 19<sup>th</sup> - Participation in National Level Exercise 2011 (NLE 2011) simulation of catastrophic earthquake in the central U.S. region of the New

Madrid seismic zone (NMSZ), Arkansas Dept. of Emergency Management (ADEM) Emergency Operations Center (EOC), Camp Robinson, North Little Rock

- June 2<sup>nd</sup> - Earthquake 101 (Four Sessions), First Security Bank, Conway, 104 in Attendance
- June 7<sup>th</sup> - Earthquake 101, Pulaski County Tea Party, Terry Library, Little Rock, 26 in Attendance
- June 8<sup>th</sup> - Earthquake 101, Kiwanis Club Meeting, Ryan's, Conway, 23 in Attendance
- June 9<sup>th</sup> - Earthquake 101, ATC-20 Post Earthquake Safety Evaluation of Buildings Training Workshop, Mountain Home, 34 in Attendance
- June 22<sup>nd</sup> - Earthquake 101, First Security Bank, Little Rock Ranch Location, 22 in Attendance
- June 28<sup>th</sup> - Arkansas Seismic Network (ASN) Talk to Teachers from the Damascus Area and Tour of Seismic Station, Woolly Hollow State Park, 20 in Attendance
- June 30<sup>th</sup> - Earthquake 101, Clarksville Rotary Club Meeting, Walker Hall at College of the Ozarks, Clarksville, 30 in Attendance
- July 5<sup>th</sup> - Earthquake 101, Conway Lions Club, UCA Campus, Conway, 29 in Attendance
- July 14<sup>th</sup> - Earthquake 101, Malvern-Hot Spring County Library, Malvern, 3 in Attendance
- July 16<sup>th</sup> - Earthquake 101, Pulaski County Office of Emergency Management, Little Rock, 4 in Attendance
- July 18<sup>th</sup> - Earthquake 101, Arkansas Continuity of Operations Program Quarterly Planners Meeting, Little Rock, 21 in Attendance
- June 22<sup>nd</sup> - Earthquake 101, First Security Bank, Little Rock Ranch Location, 22 in Attendance
- June 28<sup>th</sup> - Arkansas Seismic Network (ASN) Talk to Teachers from the Damascus Area and Tour of Seismic Station, Woolly Hollow State Park, 20 in Attendance
- June 30<sup>th</sup> - Earthquake 101, Clarksville Rotary Club Meeting, Walker Hall at College of the Ozarks, Clarksville, 30 in Attendance
- July 5<sup>th</sup> - Earthquake 101, Conway Lions Club, UCA Campus, Conway, 29 in Attendance
- July 14<sup>th</sup> - Earthquake 101, Malvern-Hot Spring County Library, Malvern, 3 in Attendance
- July 16<sup>th</sup> - Earthquake 101, Pulaski County Office of Emergency Management, Little Rock, 4 in Attendance
- July 18<sup>th</sup> - Earthquake 101, Arkansas Continuity of Operations Program Quarterly Planners Meeting, Little Rock, 21 in Attendance
- July 20<sup>th</sup> - Earthquake 101, Gifted and Talented Fifth Grade Students, UALR Center for Gifted Education, Presented at AGS in Little Rock, Tour of AGS Office Mineral and Fossil Displays, 16 in Attendance

- July 26<sup>th</sup> - Earthquake 101, Greenbrier School District Earthquake Safety Preparedness Meeting, Greenbrier Middle School, 54 in Attendance
- July 29<sup>th</sup> - Earthquake 101, ATC-20 Post Earthquake Safety Evaluation of Buildings Training Workshop, Arkansas Electric Cooperative Corp., Little Rock, 36 in Attendance
- Aug 10<sup>th</sup> - Earthquake 101, Society of American Military Engineers (SAME), Franke’s Cafeteria, Little Rock, 19 in Attendance
- Sep 10<sup>th</sup> - Earthquake 101, North Central Chapter of the Arkansas Master Naturalists, James A. Gaston Visitor Center, Bull Shoals State Park, 29 in Attendance
- Oct 11<sup>th</sup> - Earthquake 101, Searcy Rotary Club Meeting, Searcy Country Club, Searcy, 21 in Attendance
- Oct 14<sup>th</sup> - Earthquake 101, Arkansas Crisis Response Team (ARCRT), Arkansas State Police Headquarters, Little Rock, 82 in Attendance
- Oct 17<sup>th</sup> thru Oct 18<sup>th</sup> - Earthquake Booth Set-up and Guy-Greenbrier Swarm Earthquake Presentation, Eastern Section of the Seismological Society of America Annual Meeting, Peabody Hotel, Little Rock
- Oct 19<sup>th</sup> - Earthquake 101, Cabot Jr. High School, Eighth Grade Oral Communications and Science Classes, Cabot, approximately 1000 in Attendance
- Oct 19<sup>th</sup> - Earthquake 101, Central Arkansas Chapter of Sigma Xi Scientific Research Society, Biomedical 1 Building, University of Arkansas for Medical Sciences (UAMS), Little Rock, approximately 30 in Attendance
- Dec 2<sup>nd</sup> - Earthquake 101, ATC-20 Post Earthquake Safety Evaluation of Buildings Training Workshop, Arkansas Electric Cooperative Corp., Fayetteville, 42 in Attendance
- Dec 7<sup>th</sup> - Earthquake 101, Ramsey Jr. High School, Eighth Grade Science Classes, Ft. Smith, 325 in Attendance
- Dec 14<sup>th</sup> - Earthquake 101, Gardenia Garden Club, Hillcrest Hall, Little Rock, 24 in Attendance

### Illinois State Geological Survey

- 19 April 2011 Champaign, IL - 2011 Illinois GIS Association Spring Conference special session on Emergency Response and Planning “The Central U.S. Earthquake Consortium and Its Use of GIS in Emergency Planning”.
- 26 Apr 2011 Kane County, Illinois newspaper report concerning earthquakes in northern Illinois and the two upcoming exercises and their use.
- 18 May 2011 interview for Farm Week magazine on historic New Madrid earthquakes and NLE-11 exercise
- 20 May 2011 Public radio interview on NLE-11 exercise
- 24 May 2011 St. Charles, Missouri - presented information on earthquakes throughout the US and preparation for staying safe during a response to 200 fire chiefs at the International Association of Fire Chiefs – National Mutual Aid Stakeholders meeting.
- 5 Oct 2011 – Champaign Amateur Radio Emergency Services presentation on history and affects from earthquakes for Central U.S.

- 2-4 Nov 2011 - provided historical Illinois and Wabash Valley earthquake information on an Insight field trip across southern Illinois from Cahokia to Mt. Carmel, Illinois and New Harmony to Vincennes, Indiana (Nov 2-4). The 30 participants were from across the US and associated with industries and government; FEMA, insurance, pipelines, National Guard and river barges.
- 3 Dec 2011 – Illinois State Journal Register newspaper interview on New Madrid historical earthquakes.
- 6 Feb 2012 – University of Illinois campus seminar on Central U.S. Earthquakes: History, Loss Estimation and Preparedness
- 7 Feb 2012 - outreach meeting which presented completed materials for the Evansville (IN) Urban Hazard Mapping Project. The all-day event on Feb. 7<sup>th</sup> included presentations to professionals with afternoon talks and workshops and an evening presentation to the public. A total of 200+ people attended.
- 11 Mar 2012 Macomb, IL - presented a talk on Central U.S. Earthquakes: Past Events and What We Might Expect at the Geodeland Earth Science Club's rock and mineral show.
- 10-13 Apr 2012 - three invited presentations at the National Earthquake Conference in Memphis, TN: presentation "Central U.S. Eight State Geological Surveys' Earthquake Response Clearinghouse Plans" and panel discussion; plenary presentation "Cities Resiliency assessed by comparing Earthquake Scenarios' Losses" and workshop presentation "Comparison of the Varied Earthquake Scenarios' Loss Estimations for Seven Central U.S. Cities".
- 24 April 2012 - presentation on impact of earthquakes in Illinois to Dept of Insurance staff concerning legislative language on required earthquake coverage.
- 17 Oct 2012 - presentation to State Attorney General office staff on Hydraulic Fracturing & Waste Disposal: Earthquakes/Microseismicity/Acoustic Emissions. Presentation was key to legislation & earthquake monitoring.
- Oct 2012 - presented an overview of earthquakes in the central US and why many events require a multi-state response at a 3 day workshop in Hoffman Estates of 230 representatives from emergency managers and public sector corporations and non-profits for CAPSTONE-14 exercise
- 2 Nov 2012 - presented a talk on the difference between hydraulic fracturing and deep waste water disposal wells that have induced earthquakes in several locations in the US. This was presented to 70 participants of the Illinois Emergency Management Agency, Region 11 quarterly meeting held in Marion, Illinois.
- 1 Feb 2013 - Earthquakes: Mean Business, St. Louis, MO – two presentations on role of ISGS mapping, shear wave velocity modeling of sediments for 13 quadrangles in Illinois for the St. Louis Urban Hazard Mapping project. This has been used to produce ground motion maps for 17 quadrangles (13 Illinois & 4 Missouri) for various earthquake scenarios.
- 6 Feb 2013 - Earthquake information to Chicago Tribune for article on ShakeOut exercise for Feb 7th.
- 7 Feb 2013 - WICD tv interview and Chicago Tribune materials on earthquakes in Northern Illinois

- 11 Mar 2013 - Southern Illinoisan Newspaper on March 11th Mag 2.7 earthquake event. Graphics sent & interview.
- 6 Jun 2013 - Initial planning conference for CAPSTONE 14 – presentation about post-earthquake data gathering to CUSEC directors. Indianapolis, IN.
- 8 Oct 2013 - Presented talk on Review of Earthquakes in the Illinois Area for the 100 participants of the 2013 Midwest Geological Sequestration Science Conference in Champaign, IL.
- 30 Jan 2014 – Jonesboro, AR - presentation to the Arkansas Governor's Earthquake Advisory Council on Wabash Valley seismic zone and the Mt. Carmel 2008 earthquake.

### Indiana Geological Survey

- 28 March 2011 Lawrence, IN – 85 participants at Boy Scout meeting
- 6-21 August 2011 Indianapolis, IN – hosted an exhibit, along with the Indiana Department of Homeland Security, that focused on earthquakes in Indiana and emergency preparedness education. Visitors assumed to be over a thousand.
- 6 October 2011 Indianapolis, IN – 35 participants at the Emergency Management Alliance of Indiana, Inc.
- 8 October 2011 Indianapolis, IN – 225 participants at Celebrate Science Indiana
- 21-23 October 2011 Indianapolis, IN – 279 visitors to an exhibit booth at Indiana State Museum
- 26 October 2011 Indianapolis, IN – 25 participants at the Indiana Safe Schools Conference
- 1 November 2011 Terre Haute, IN – 11 participants for the Osher Learning Series at Indiana State University
- 3 November 2011 Evansville, IN – 56 participants at the Southern Indiana Master Naturalists Fall Meeting
- 7 February 2012 Evansville, IN – School-wide Great Central US ShakeOut Event at Good Shepard School
- 7 February 2012 Evansville, IN – 143 visitors for an exhibit at the Evansville Area Earthquake Mapping Project Rollout and Director conducted evening public meeting
- 16 February 2012 Fishers, IN – 225 visitors for an exhibit at the Brooks School Math and Science Night
- 18 February 2012 Fort Wayne, IN – 978 participants attended 14 presentations at the Lincoln School Math and Science Day
- 21 March 2013 - Kokomo High School in Kokomo, Indiana.
- 4 April 2013 - St. Peters Elementary School in Columbus, Indiana.
- 5 April 2013 - Central Elementary School in Columbus, Indiana.
- 11 April 2013 - St. Thomas Elementary School in Indianapolis, Indiana.
- 16 May 2013 - Homestead High School in Ft Wayne, Indiana.
- 17 May 2013 - Riverside Middle School in Huntington, Indiana.
- 18 May 2013 - St. Vincent Hospital in Randolph County, Indiana.
- 4 June 2013 – Midwest Integrated Systems Operations (MISO).

- 23 June 2013 – Midwest Integrated Systems Operations (MISO).
- 1 July 2013 – Bartholomew County Library in Columbus, Indiana.
- 2 August 2013 – Homeland Security Team meeting in Indianapolis, Indiana.
- 5 August 2013 - Indian Creek Middle School in Talgarfar, Indiana.
- 23 August 2013 - Praxair, Inc. Safety Day in Speedway, Indiana.
- 26 August 2013 - North Montgomery High School in Crawfordsville, Indiana.
- 30 August 2013 - Brady Shrum School in Salem, Indiana.
- 4 September 2013 – Indiana State University, Terre Haute, Indiana.
- 8 September 2013 – Celebrate Science event in Speedway, Indiana.
- 10 September 2013 - Wanatah School in Wanatah, Indiana.
- 17 September 2013 - Southridge High School in Huntingburg, Indiana.
- 17 October 2013 – Great Central US ShakeOut activities in Evansville, Indiana.
- 5 November 2013 – Indiana State GIS Day conference in Indianapolis, Indiana.
- 6 November 2013 – Provided a presentation related to the earthquake outreach program at the Indiana Geological Survey during the annual Geological Society of America meeting in Denver, Colorado.

#### Kentucky Geological Survey

- 13-15 April 2011 Memphis TN - “Ground Motion Time Histories for Seismic Design of Bridge and Highway Structure in Kentucky” and “A Case Study on Probabilistic Methods in Seismic Hazard Assessment: Probabilistic Seismic Hazard Analysis,” presented at the SSA 2011 Annual Meeting.
- 27-29 April 2011 Covington KY - “Seismic Issues and Building Codes for Kentucky,” was made at the 2011 Kentucky Society of Professional Engineers (KSPE) Annual Convention, Covington, Kentucky.
- 12-13 May 2011 Lexington KY - “Seismic Hazards and Building Codes in Kentucky,” was made at the 2011 Structural Engineer Association of Kentucky (SEAOK) Conference.
- 16-18 October 2011 Little Rock AR - “The Central U.S. Seismic Observatory: Some Preliminary Results” and “Earthquake Science and Mitigation Policy: Design Ground Motion for Facilities at the Paducah Gaseous Diffusion Plant,” Presentations at **The 83th Annual Meeting of the Eastern Section of the Seismological Society of America.**
- 22-23 February 2012 Memphis, TN - “Seismic Design and Public Policy in Western Kentucky: Issues and Alternatives,” was made at the USGS National Seismic Hazard Maps workshop.

#### Missouri Geological Survey

- 3 Feb 2012 St. Louis - Earthquakes: Mean Business
- 8 Feb 2012 Rolla - Great Central US Shake Out, Immanuel Lutheran School
- 18 Feb 2012 - The Earth Moves Under Our Feet, Onondaga Cave State Park
- February 1, 2013, Earthquakes: Mean Business
- March 6, 2013, City of Hannibal Town Hall Meeting on earthquake awareness
- April 23-26, 2013, Missouri SEMA Conference

- October 2013 Earth Science week
- November 14-15, 2013 Sustainable Disaster Recovery Conference
- Extensive participation in the Great Central U.S Shakeout in both February and October 2013

### Tennessee Geological Survey

- 22 Apr 2011 - presented *Central US is Earthquake Country* PowerPoint to Mid. Tenn. State Univ. students and guests for their Earth Day celebration.
- 1 Sep 2011 - presented *Central US is Earthquake Country* PowerPoint as part of Tenn. Wildlife Resources Agency's Nature at Noontime series.
- 29 Sep 2011 - presented *Central US is Earthquake Country* PowerPoint as part of Tenn. Dept. of Environment and Conservation's Lunch and Learn series.
- 17 Jan 2012 - presented *Central US is Earthquake Country* PowerPoint to 34 hospital and medical facility administrators, managers, and engineers at an Earthquake Mitigation for Hospitals Workshop.
- 18 Jan 2019 - presented *Central US is Earthquake Country* PowerPoint to more than 50 engineers with at least five years' experience in general building design, construction, or inspection at a combined FEMA 154 – Rapid Visual Screening of Buildings for Potential Seismic Hazards & ATC 20 – Post Earthquake Safety Evaluation of Buildings course presented by the Central US Earthquake Consortium.

### References

Finch, R.H., 1917, The Missouri Earthquake of April 9, 1917; The Bulletin of the Seismological Society of America, vol. 7, no. 3, pp. 91-96.

Stover, C.W. and J.L. Coffman, 1993, Seismicity of the United States, 1568-1989 (Revised); U.S. Geological Survey Professional Paper 1527, 427 p.