



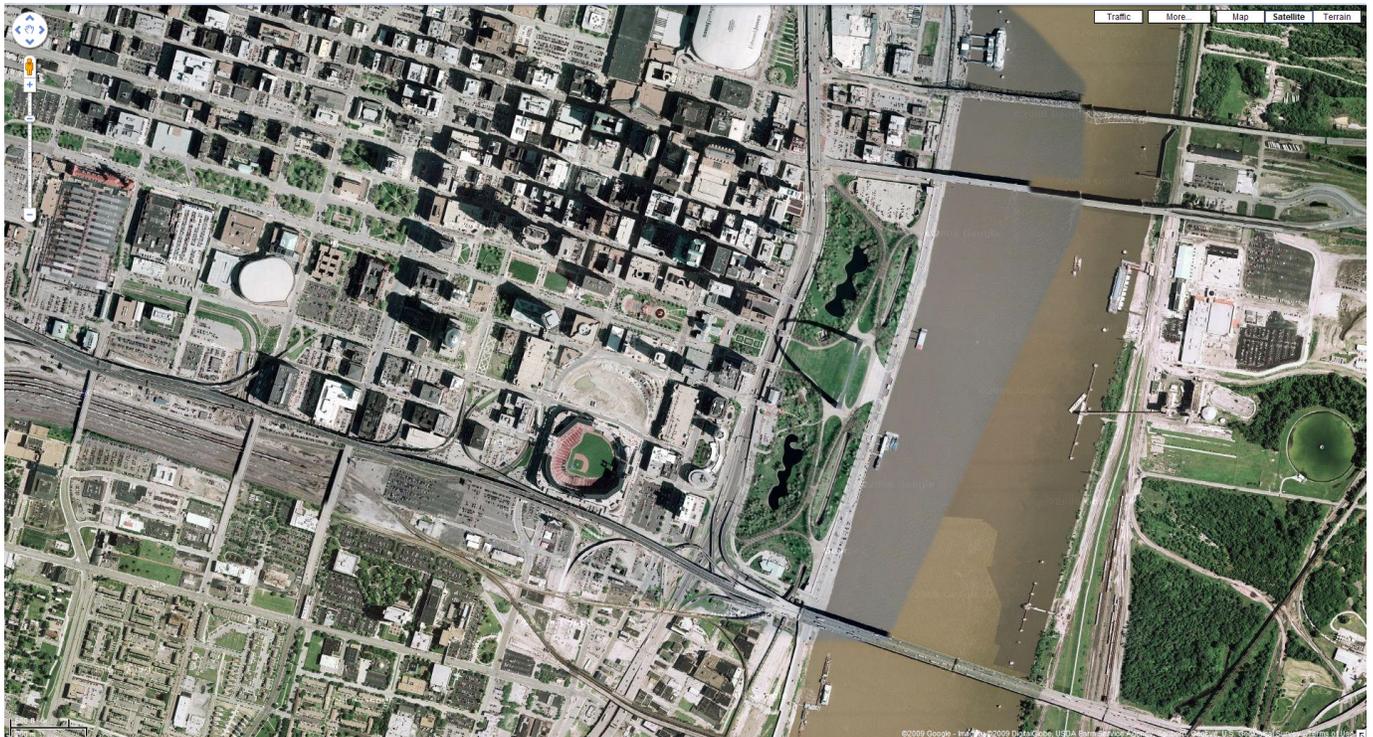
Missouri  
Department of  
Natural Resources



# St. Louis Area Earthquake Hazards Mapping Project— December 2008–June 2009 Progress Report

By R.A. Williams, R.A. Bauer, O.S. Boyd, J. Chung, C.H. Cramer, D.A. Gaunt, D. Hoffman, G.L. Hempen, N.S. McCallister, J.L. Prewett, J.D. Rogers, P.J. Steckel, and C.M. Watkins

In collaboration with the St. Louis Area Earthquake Hazards Mapping Project (SLAEHMP)



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**Cover:** 2009 Google Maps image of downtown St. Louis, Mo., and the Mississippi River.

## Contents

Introduction.....	1
Progress.....	2
Significant Findings.....	3
Outreach Presentations.....	3
Future Plans and Challenges.....	4
References.....	6

## Figures

1. Seismicity of the central United States and the New Madrid and Wabash Valley Seismic Zones.....	5
2. Map of 29 quadrangle SLAEHMP study area showing progress of geologic mapping.....	6

## Table

1. Recently acquired boring data for the SLAEHMP.....	2
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## Introduction

This report summarizes the mission, the project background, the participants, and the progress of the St. Louis Area Earthquake Hazards Mapping Project (SLAEHMP) for the period from December 2008 through June 2009. During this period, the SLAEHMP held five conference calls and two face-to-face meetings in St. Louis, participated in several earthquake awareness public meetings, held one outreach field trip for the business and government community, collected and compiled new borehole and digital elevation data from partners, and published a project summary.

Because of St. Louis' proximity to known active earthquake zones (fig. 1), the SLAEHMP is producing digital maps that show the aerial variability of earthquake hazards, including liquefaction and ground shaking, for the St. Louis area. Liquefaction can occur when water-saturated loose sand and silt is shaken by an earthquake and causes it to behave like a liquid, thus resulting in a loss of strength and load-bearing capacity. Aerial variability of earthquake ground shaking results from the natural and man-made variability of soil conditions and natural variability of geologic deposits. Soft gravels, sand, clay, and silt can amplify ground shaking. The maps will be available free over the Internet. Although not site-specific enough to indicate the earthquake hazard at a house-by-house resolution, the maps can be customized by the user (such as business and government planning groups) to show neighborhoods or transportation routes and will allow these groups to better plan for earthquakes.

Although earthquakes currently cannot be predicted, scientists can estimate how strongly the ground is likely to shake as the result of an earthquake. St. Louis has experienced minor earthquake damage at least 12 times in the past 200 years (Saint Louis University, 1999). Earthquake hazard maps provide an estimate of ground shaking that may occur in future earthquakes. The U.S. Geological Survey (USGS), which produces earthquake hazard maps for the Nation, is working with local partners to develop detailed maps for urban areas vulnerable to strong ground shaking. These partners of the USGS include: Missouri University of Science & Technology (Missouri S&T), Missouri Department of Natural Resources (MoDNR), Illinois State Geological Survey (ISGS), University of Memphis Center for Earthquake Research and Information (CERI), Saint Louis University, Missouri State Emergency Management Agency, and URS Corporation.

The SLAEHMP is a key part of the USGS Earthquake Hazards Program, which seeks to reduce the Nation's risk from earthquake hazards. Other metropolitan areas that are a part of this national program include Seattle, Wash., Evansville, Ind., Memphis, Tenn., Reno, Nev., and the urban corridor along Utah's Wasatch Front. A USGS Web site focusing on the SLAEHMP, which provides links to project results and relevant earthquake hazard information, can be found at:

*[http://earthquake.usgs.gov/regional/ceus/urban\\_map/st\\_louis/index.php](http://earthquake.usgs.gov/regional/ceus/urban_map/st_louis/index.php)*

## Progress

The first compilation of project accomplishments produced thus far was published as a USGS Open-File Report in 2009 (Karadeniz and others, 2009). The report summarized university, USGS, and contractor findings on liquefaction hazards mapping, bedrock geology and depth, shear-wave velocity measurements, and earthquake ground motion hazard around St. Louis.

Geologic mapping and the collection of subsurface information for the St. Louis area has continued. The MoDNR will soon publish surficial geologic maps of the Wentzville, Alton, Grafton, and Elsah USGS quadrangles (fig. 2). Fifteen quadrangles of the 29-quadrangle study area have been geologically mapped and are either published or in review. A quadrangle mapping priority list has been developed and will be used to guide future mapping efforts. In collaboration with the SLAEHMP, the MoDNR is also beginning work on the O'Fallon quadrangle with an expected completion date in 2010.

Several hundred new borings have been collected from partners and sources in the St. Louis area. These data have been included in the project GIS database, which is stored and backed up at the USGS offices in Rolla, Mo., and, independently, by Missouri S&T in Rolla, Mo. (table 1).

**Table 1. Recently acquired boring data for the SLAEHMP.**

Location	USGS Quadrangle	Notes
I-270 and Coldwater Creek	Florissant, Mo.	Contains two borings to rock 90+ feet through Lake Florissant lacustrine deposits north of Lambert Intl. Airport.
I-270 and McDonnel Blvd. in Hazelwood	Florissant, Mo.	Contains more borings in Lake Florissant deposits.
Mississippi River Bridge (proposed site)	Granite City, Ill. and Mo.	Borings and Shear- and P-wave velocities (Vs and Vp) information on Mo. and Ill. side of Mississippi River along with borings in mid-channel.
AmerenUE Labadie Power Plant	Labadie, Mo.	Numerous borings to bedrock within Missouri River floodplain; borders study area.
AmerenUE Meramec Power Plant	Oakville, Mo. and Ill.	Borings to rock north of Meramec and Mississippi River confluence in combined floodplain.
AmerenUE Sioux Power Plant	Elsah, Ill. and Mo.	Modern report (2006) containing borings to bedrock, Shear- and P-wave velocities, and liquefaction studies in the vicinity of the Miss.-Mo. river confluence.
Monarch-Chesterfield Levee District	Chesterfield and Creve Coeur, Mo.	Borings to bedrock along much of the levee alignment in Mo. River floodplain.
Wood River/Confluence Area Borings	Wood River and Columbia Bottom, Mo. and Ill.	Deep borings in the vicinity of Wood River and the confluence in both Mo. and Ill. related to pipelines.
Arnold/Tenbrook Rd.	Oakville, Mo. and Ill.	Borings to rock on Meramec River floodplain.
St. Peters Water Treatment/Storage Tank	Kampville, Mo.	Borings at margin of Miss. River floodplain.
Downtown St. Louis Site 1	Granite City, Ill. and Mo.	Borings near riverfront (bedrock profile on Mo. side of Miss. River just north of downtown St. Louis).
Downtown St. Louis Site 2	Granite City, Ill. and Mo.	Downtown St. Louis borings to bedrock between Pine and Chestnut Sts. along 12th. and Tucker St.
South St. Louis City	Cahokia, Ill. and Mo.	Borings to rock south of downtown St. Louis near Budweiser brewery.

## Significant Findings

Key findings result from comparing the 18 April 2008 M5.4 Mt. Carmel, Ill., earthquake with a January 2006 M3.6 earthquake, located in southeastern Illinois, at two Advanced National Seismograph System sites in the St. Louis area (operated by Saint Louis University). One site, SLM, is located on the Saint Louis University campus and is classified by Karadeniz and others (2009) as an upland-bedrock site. The second site, STIL, is located at the East St. Louis, Ill., Education Center and is classified as Mississippi River floodplain (lowland), with unconsolidated deposits underlying the seismometer. Preliminary results comparing the ground motion time recordings, which were presented at the May 2009 Earthquake Insight Field Trip, show that ground motion at STIL was, generally, three to four times that of SLM (Williams, 2009). There are also short time intervals when STIL ground motion was more than 10 times greater. Comparison of spectral amplitudes for the two sites shows a strong resonance at about 2.1 Hz, and its associated harmonics, at STIL. The strong resonance is probably caused by energy trapped in the Quaternary alluvium above the hard Paleozoic rock underlying St. Louis. This amplification and strong resonance on floodplain sites at frequencies in the range of the natural period of low-rise buildings has now been observed in two earthquakes.

Using the site amplification distributions of Karadeniz (2007), scenario seismic hazard maps for the three pilot quadrangles have been updated to the USGS 2008 national seismic hazard map source model, attenuation relations, and weights (Cramer, 2009). The two scenarios are for a M7.7 earthquake on the northeast segment of the New Madrid seismic zone and for a M6.0 earthquake at the Shoal Creek paleoseismic liquefaction site east of St. Louis. Scenario seismic hazard maps were produced for peak ground acceleration (PGA) and 0.2 seconds and 1.0 second spectral acceleration (Sa). Updated computer codes were used to rerun the three pilot quadrangles of SLAEHMP, and comparisons were made with the 2007 versions which were created using the 2002 national seismic hazard model. Generally, because the ground motion attenuation relations used in the 2008 national model lowered the 2-percent-in-50-year hazard ground motions by 10–20 percent relative to the 2002 national model, the new SLAEHMP pilot quadrangle 2 percent-in-50-year ground motions were also lowered relative to the older model results. For PGA, overall ground motion levels are reduced by 15–20 percent using the new 2008 hazard model. For 0.2 s Sa, the loess/till covered uplands are reduced by only 10 percent or less compared to the 2007 maps due to less nonlinear deamplification from the reduced input ground motions. For 1.0 s Sa there is little change in ground motion levels between the old and new versions of the national maps and the urban hazard maps (Cramer, 2009).

## Outreach Presentations

### Earthquakes Mean Business Workshop

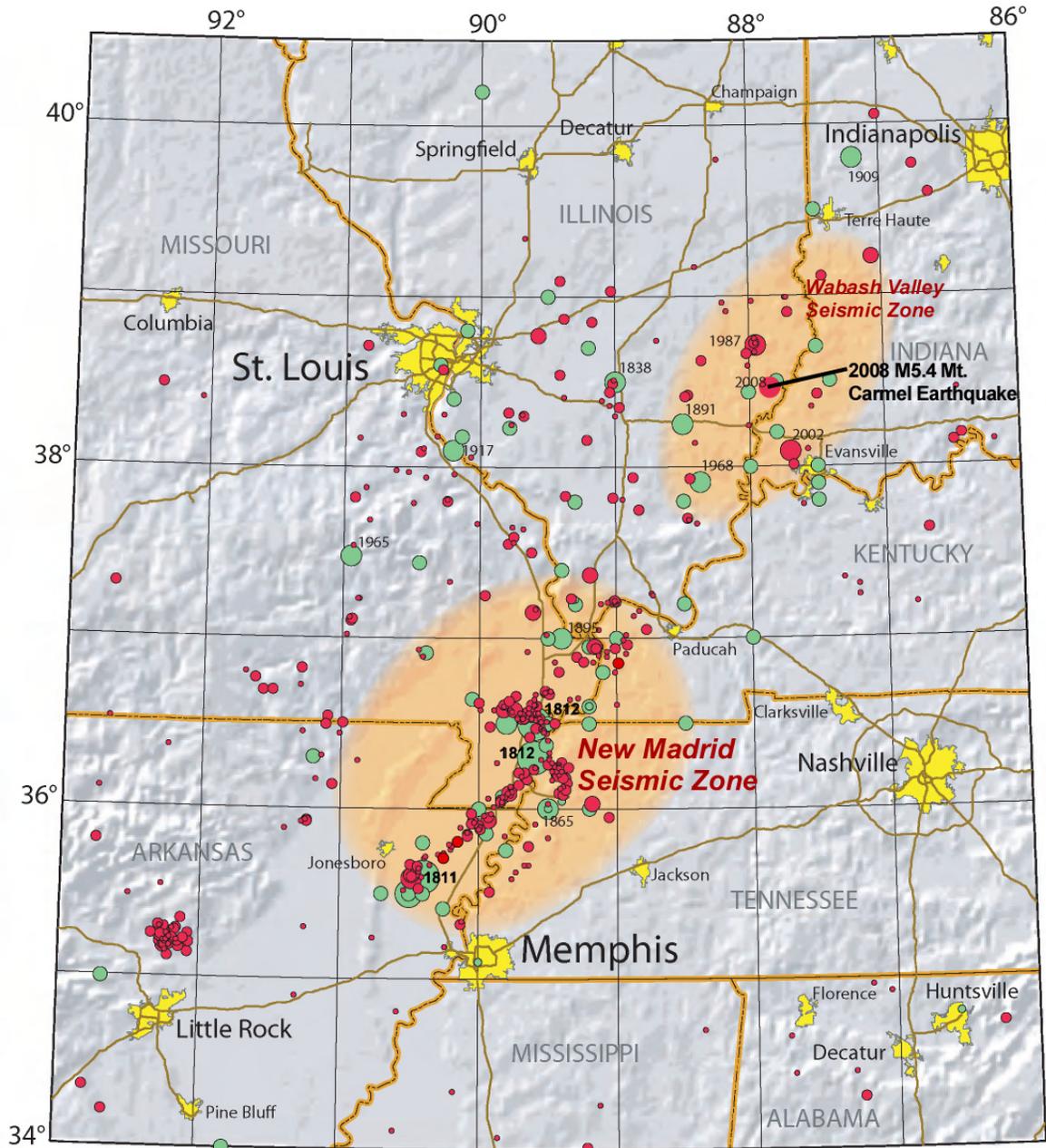
In February 2009, a summary of the mission and significant findings of the SLAEHMP were presented at the 15<sup>th</sup> annual Earthquakes Mean Business workshop in St. Louis, an event in which the SLAEHMP participates regularly. The event, which was hosted by AT&T, annually presents regional earthquake hazards and mitigation strategies to the St. Louis community. This workshop was attended by about 330 business and government community members who heard SLAEHMP staff and others give presentations on New Madrid regional earthquake hazards, St. Louis area earthquake hazard, and the SLAEHMP.

## **Earthquake Insight Field Trip**

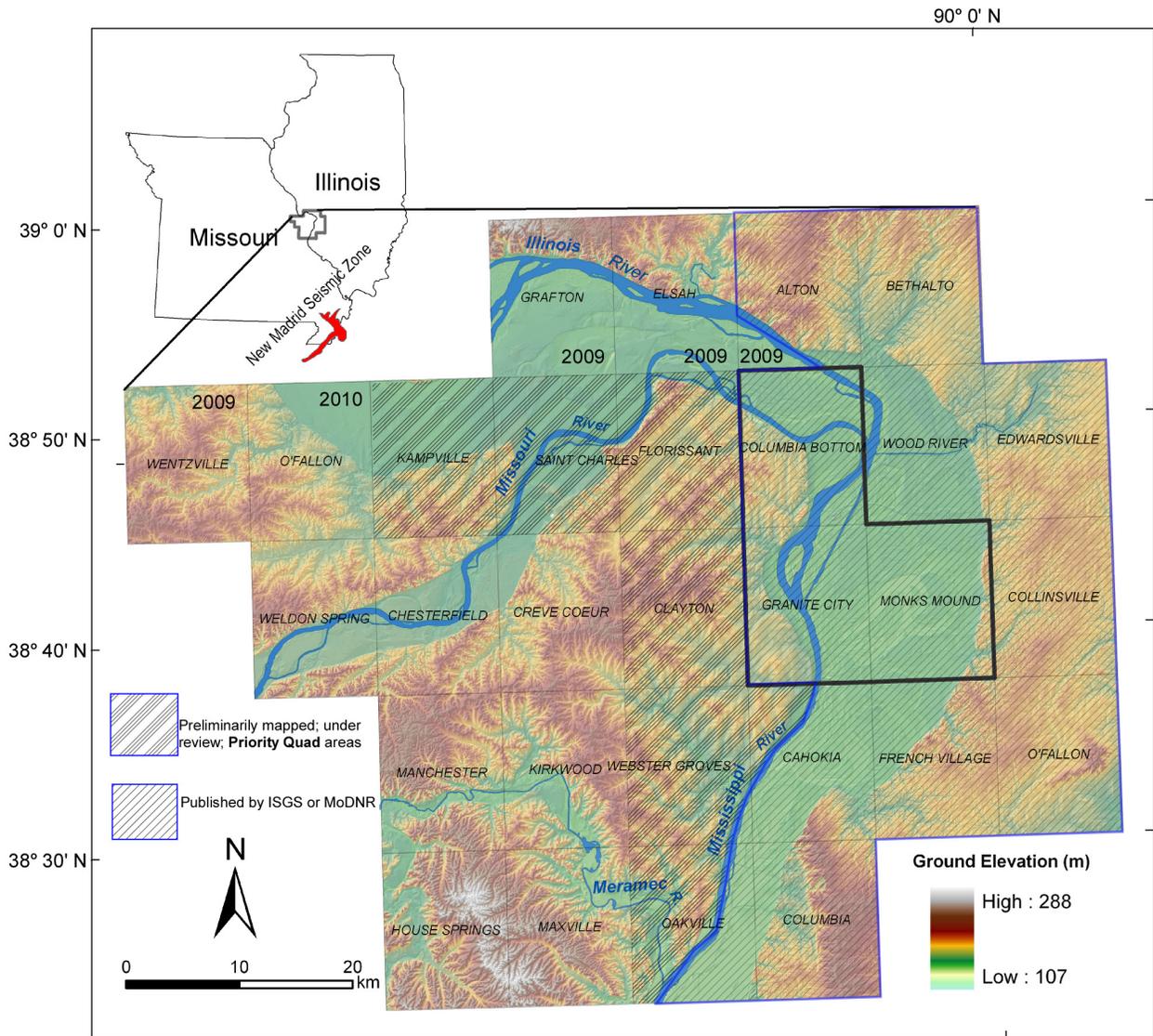
On May 28, 2009, Phyllis Steckel of the SLAEHMP led the sixth Earthquake Insight Field Trip through the St. Louis metro area. The field trips are intended to inform business and government personnel about earthquake hazards in the St. Louis area. There were 29 participants and 12 presenters. Participants first heard presentations on regional and St. Louis area earthquake hazards, a SLAEHMP overview, and historical earthquakes of the region. They then traveled to six stops to see and discuss engineered earthquake-mitigation projects, seismology research, and geologic features relevant to the SLAEHMP. Participants were from State Farm, Sandia National Laboratories, Boeing, Fireman's Fund, Enterprise Leasing, Department of Homeland Security, Guy Carpenter, Scottrade, BJC Healthcare, Wells Fargo, and other organizations from all over the country with interests in the St. Louis area. Critiques provided by both participants and presenters were all 4+ on a scale of 1 to 5 (5 being the highest).

## **Future Plans and Challenges**

The generation of hazard maps for new areas over the next year depends on the success of proposals submitted to the USGS National Earthquake Hazards Reduction Program external research section. In the meantime, geologic mapping, outreach, and publication will continue following the guidance of the SLAEHMP Technical Working Group and the quadrangle priority mapping list. We continue to seek out additional existing subsurface data, mainly from private sources in the region.



**Figure 1.** Map showing central United States and the location of St. Louis relative to the Wabash Valley and New Madrid seismic zones and other diffuse seismicity primarily in southern Illinois and south of St. Louis. Red circles are earthquakes that occurred from 1974 to 2002. Green circles are earthquakes that occurred prior to 1974. Larger earthquakes are represented by larger circles. Yellow patches show urban areas.



**Figure 2.** Twenty-nine quadrangle SLAEHMP study area showing progress of geologic mapping. Alton, Elsay, Grafton, and Wentzville quadrangles will be published in 2009 by MoDNR. MoDNR will publish the O’Fallon, Mo., quadrangle in 2010. Priority quadrangles for the SLAEHMP include Kampville, Saint Charles, Florissant, Clayton, Webster Groves, and Oakville. In the priority quadrangle area, all but Kampville and Saint Charles have been preliminarily mapped by Lettis & Associates and are now under review by the SLAEHMP (Pearce and Baldwin, 2008). The three quadrangles in the pilot study area are outlined by the heavy black line.

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