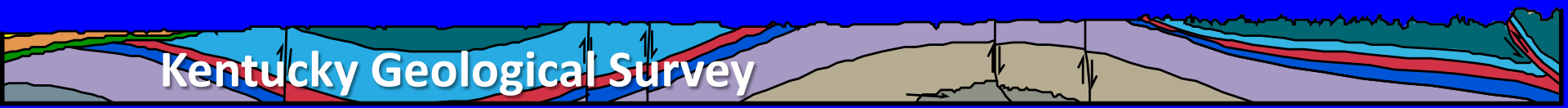
Seismic Hazard and Policy in the Central U.S.

James C. Cobb,
State Geologist and Director
Kentucky Geological Survey
University of Kentucky

ACEHR Meeting
November 9, 2010
Memphis, TN

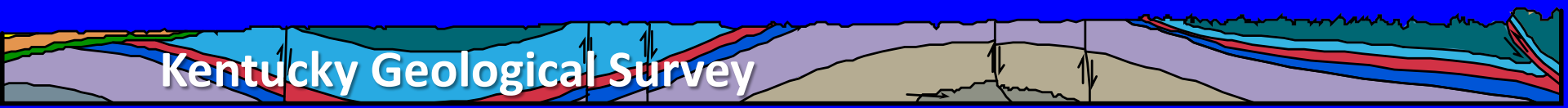


Problems caused by high seismic hazard assessment and policy

- Kentucky has lost more than $1 billion in lost industrial development (PACRO, 2010)

- Permit for a landfill for clean-up and closure of the Super-fund site at the Paducah Gaseous Diffusion Plant has been delayed for more than 10 years (KEEC, 2010)

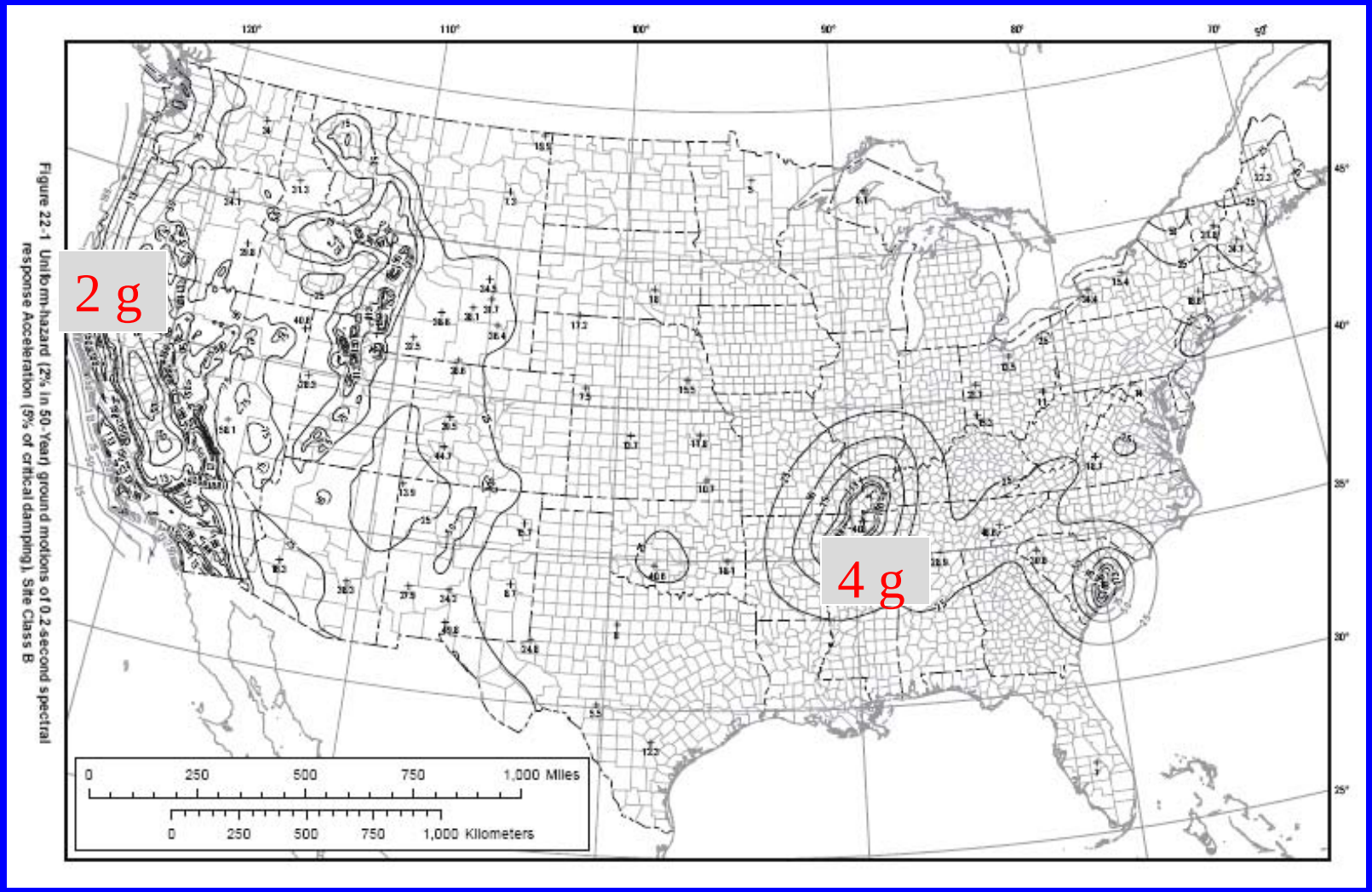
- Professional services (geo-tech and structural engineers) will be required for construction of single-family house in western KY (SEAOK, 2002)



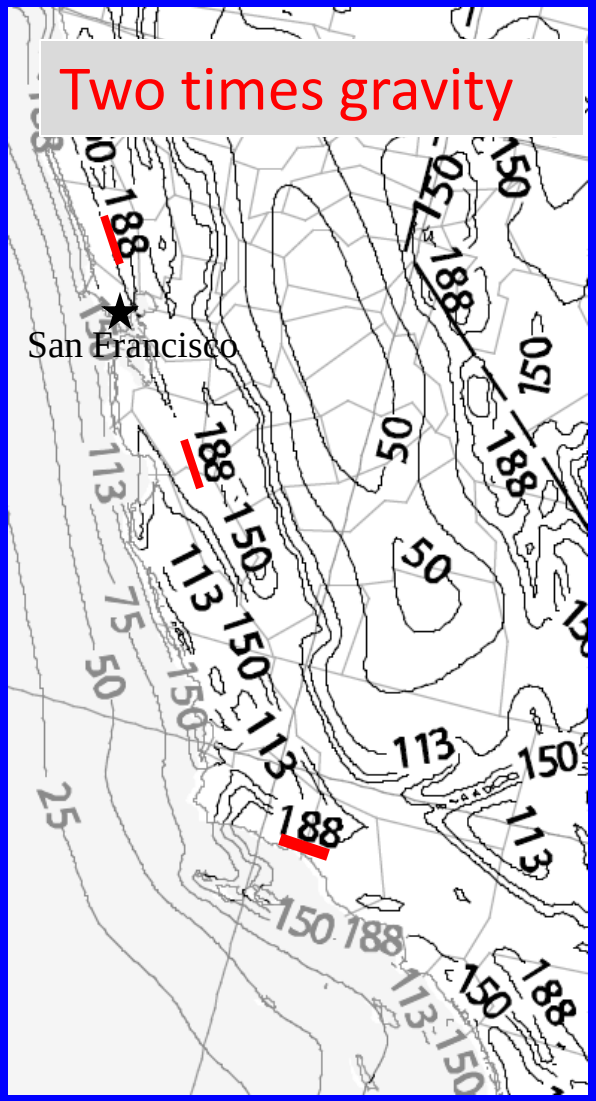
KGS Efforts Chronology

- Hosted a workshop on the NEHRP hazard and design maps in November 2002 in Lexington, KY
- Made a presentation to the SESAC in June 2004 in Memphis, TN
- Met and discussed with USGS staff the national hazard maps in 2004, 05, 06, 07, 08, 09 and as recently as last week in Denver
- Made a presentation at the hazard mapping workshop in May 2006 in Boston, MA
- Wrote a letter to ACEHR in October 2007

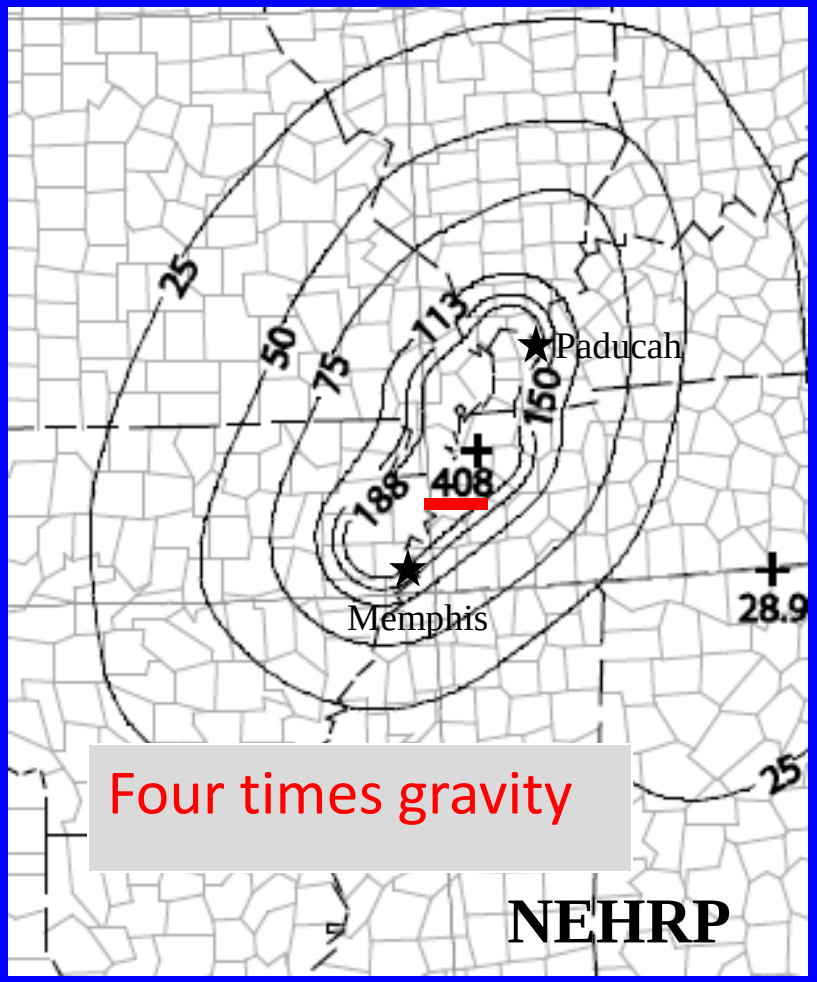
NEHRP Design Map 0.2 sec Spectral Response Acceleration for the U.S. (2% PE in 50 yrs., NEHRP)



California

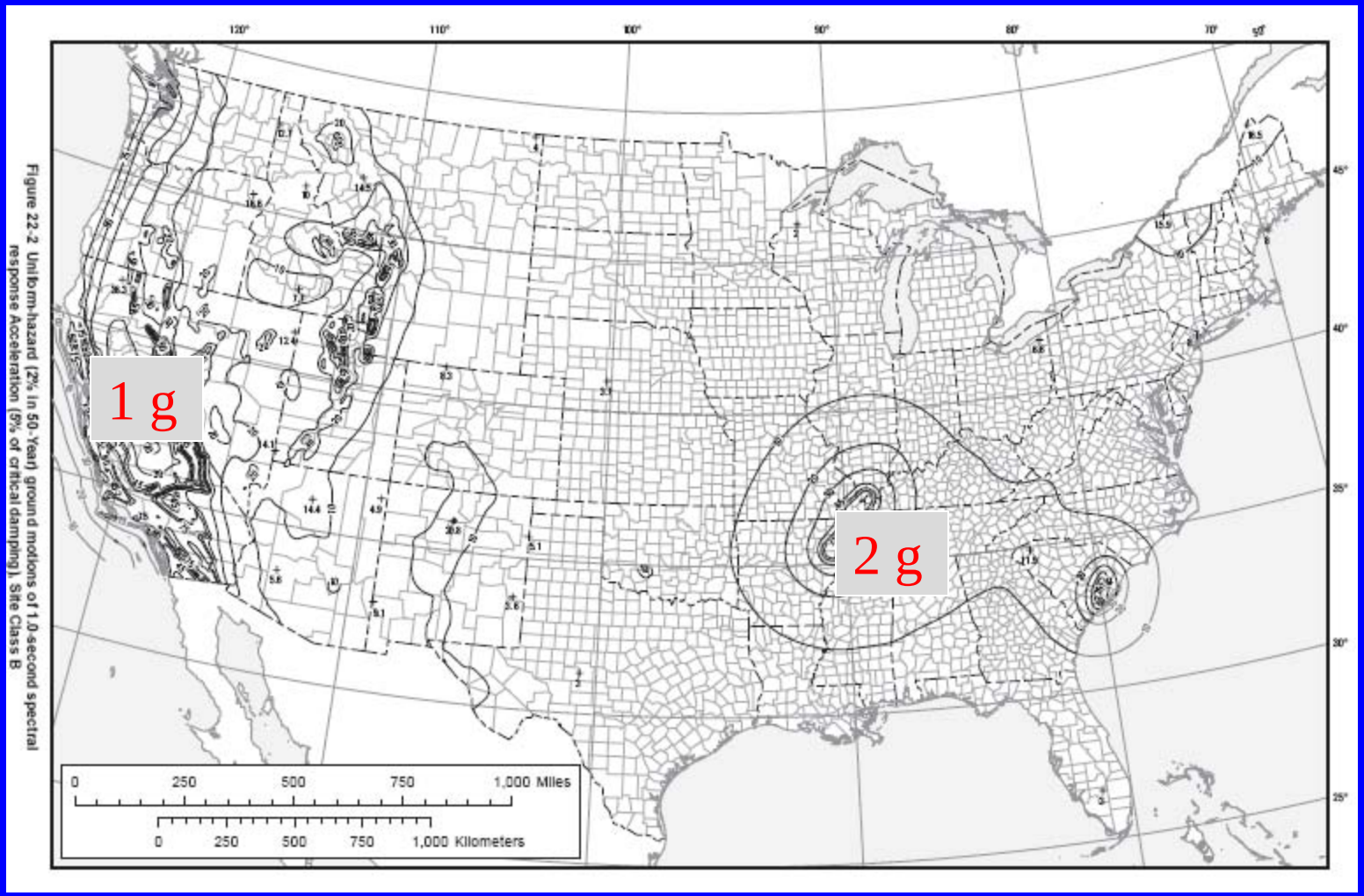


Central U.S.

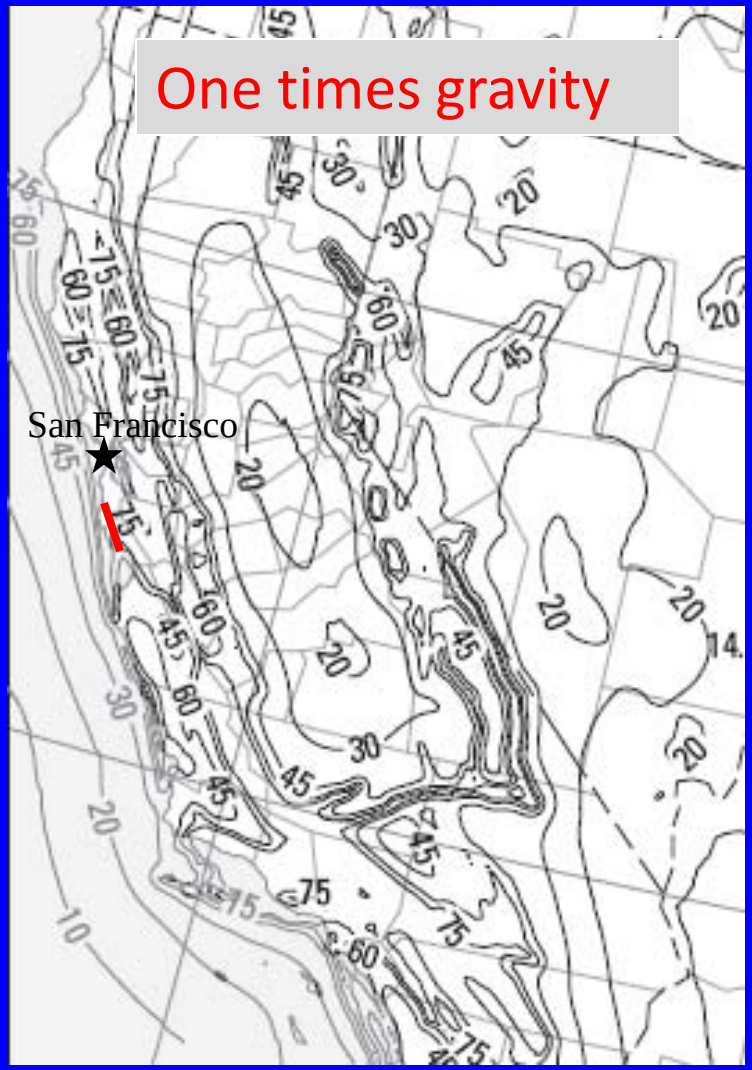


0.2 sec Spectral Response Acceleration

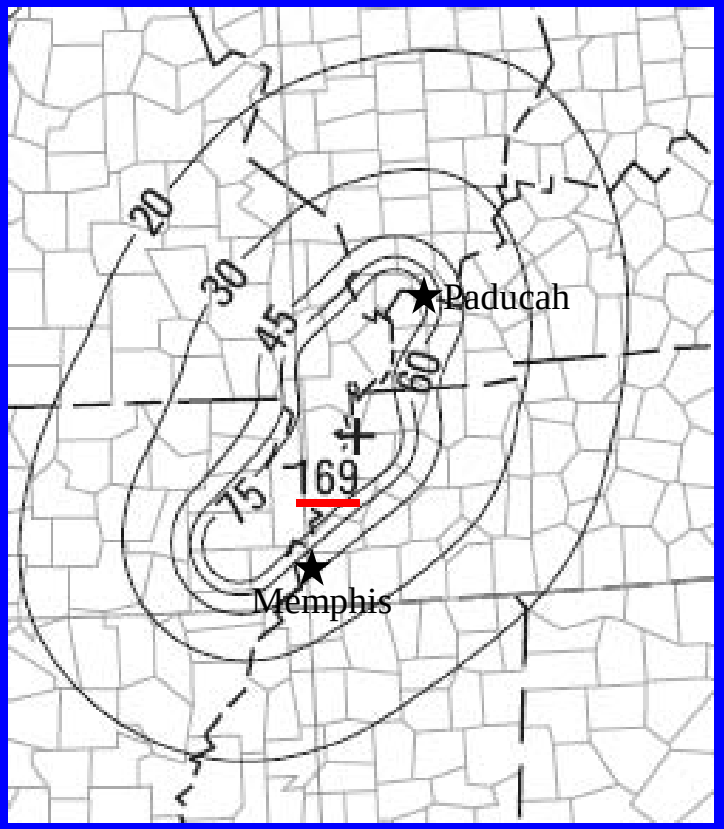
NEHRP Design Map 1.0 sec Spectral Response Acceleration for the U.S. (2% PE in 50 yrs., NEHRP)



California



Central U.S.



Two times gravity

1.0 sec Spectral Response Acceleration

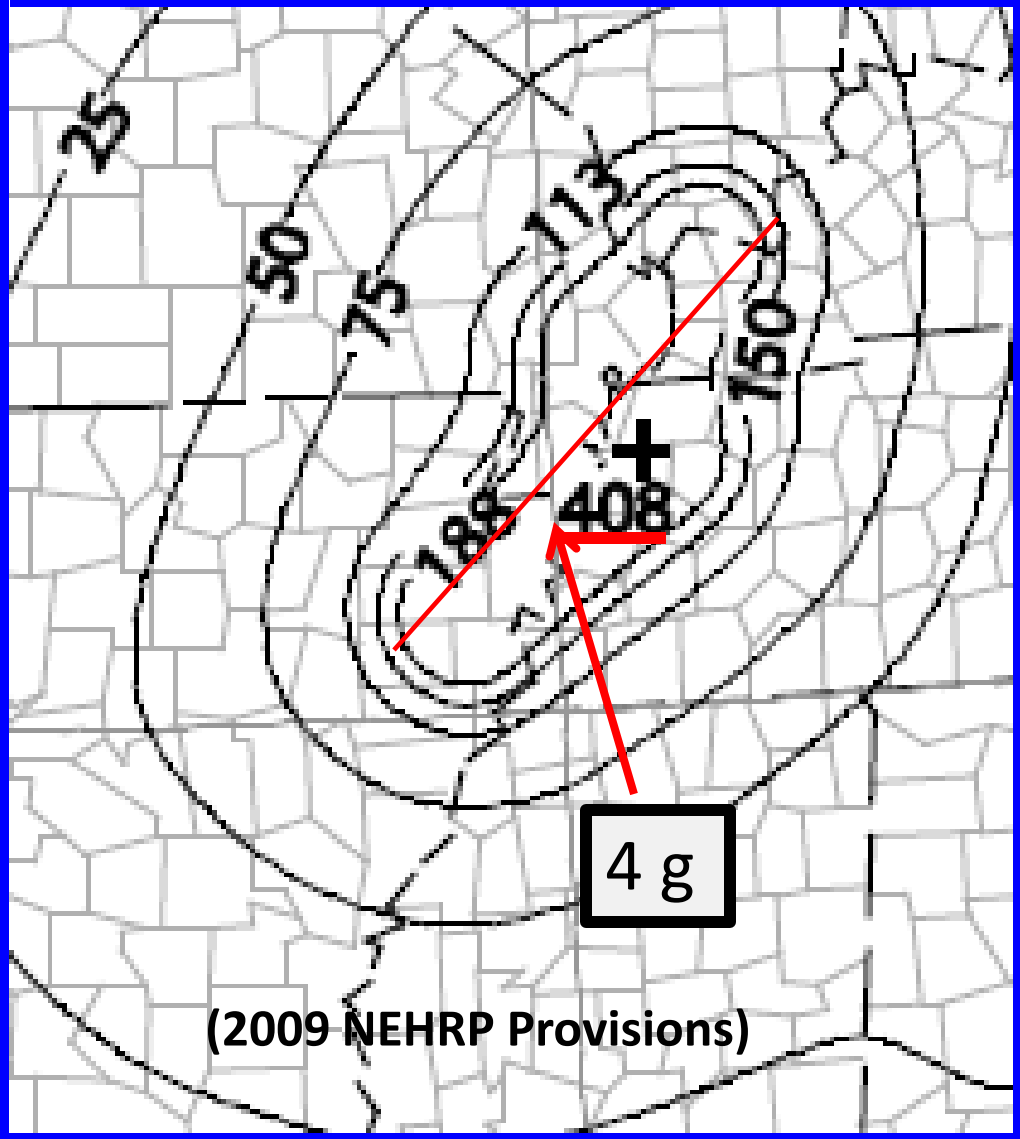
Rebuilding after 2008 8.0M Wenchuan earthquake near Longnam, Gansu Province, China

Mitigation (engineering design) makes a big difference

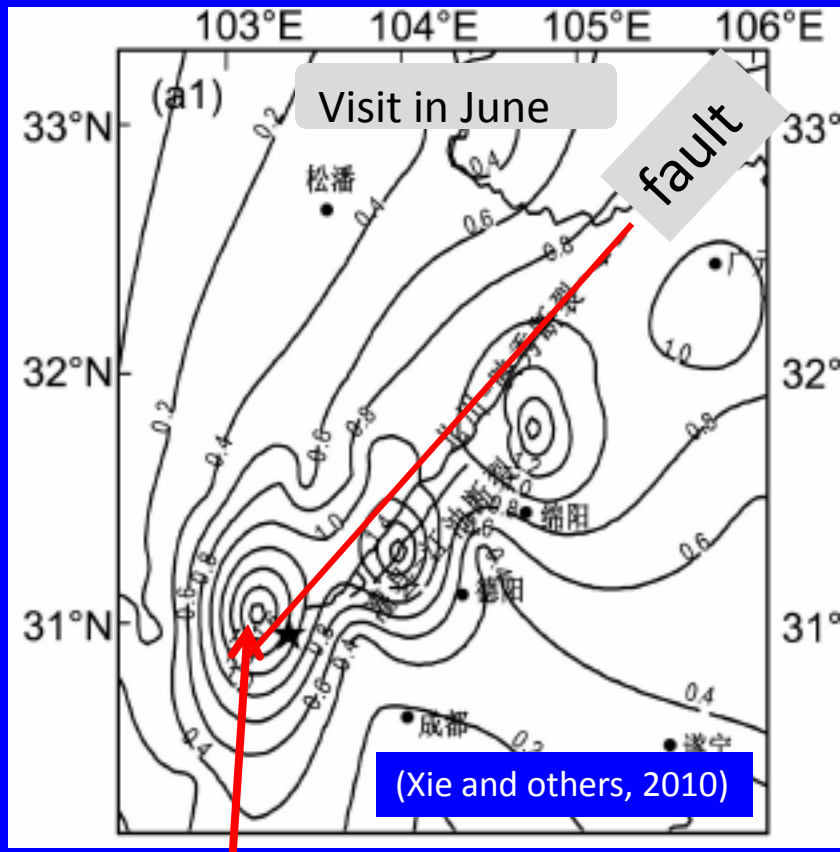
No damage

DAMAGE!

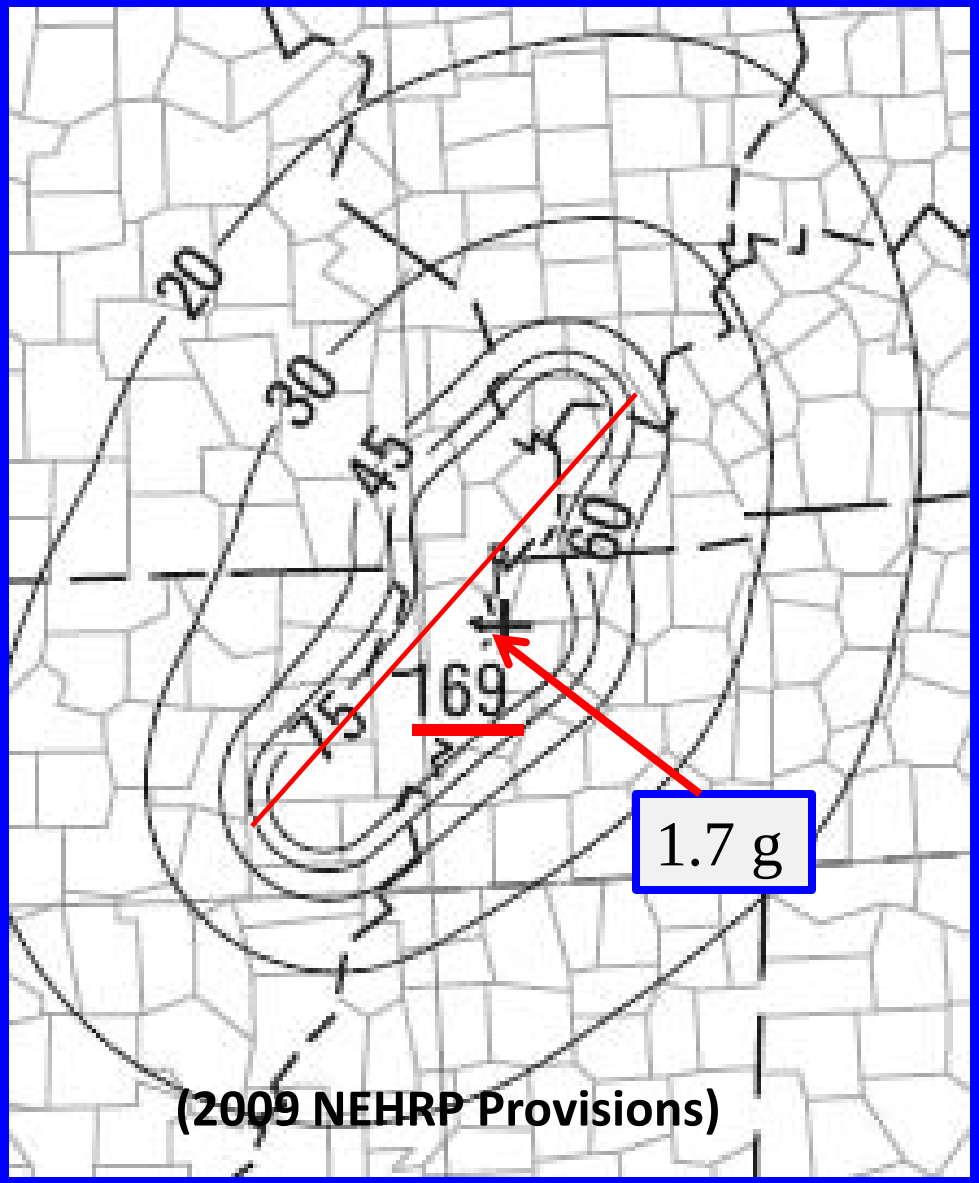
NEHRP Design map with 0.2 sec PSA (%g, with 2% PE in 50 years)



Actual record 2008 Wenchuan earthquake (M8.0, 0.2s PSA g)

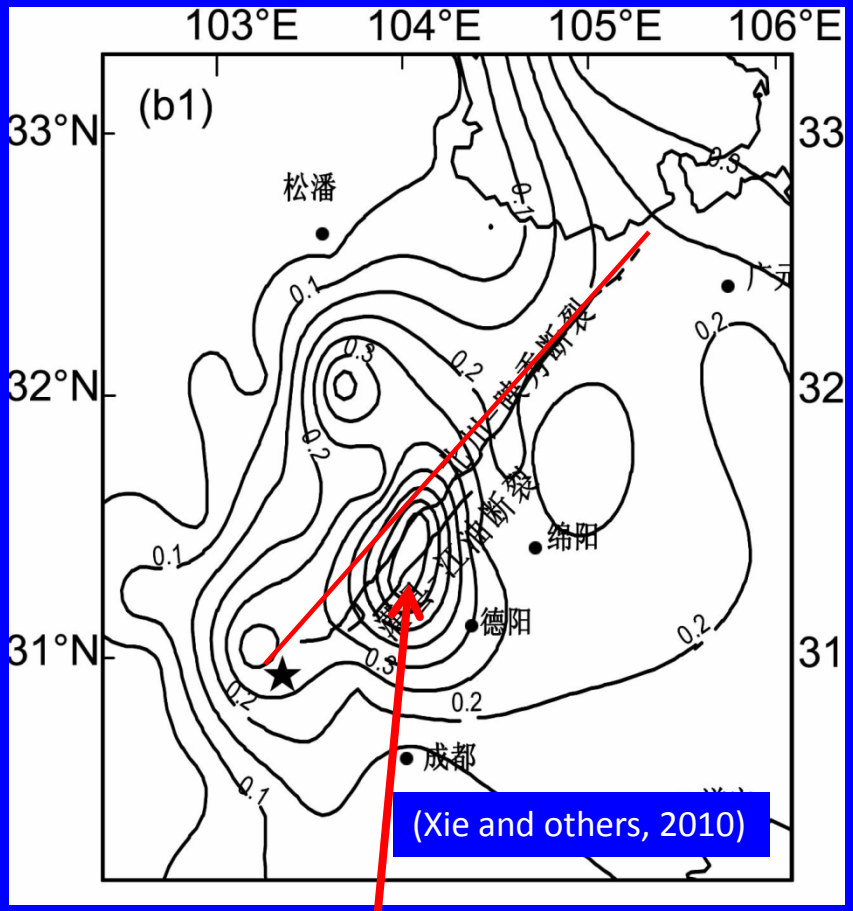


NEHRP Design map with 1.0 sec PSA (%g, with 2% PE in 50 years)



(2009 NEHRP Provisions)

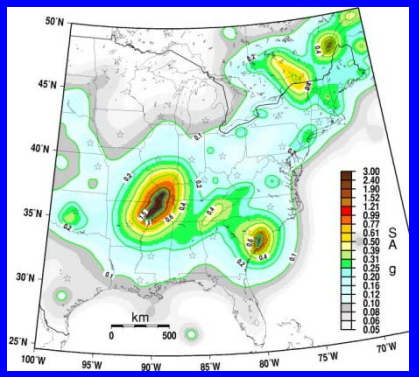
Actual record 2008 Wenchuan earthquake (M8.0, 1.0s PSA g)



Development of *Design Ground Motion Policy*

Science

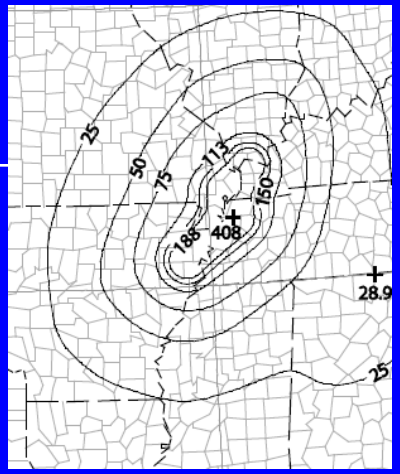
Seismic Hazard Map
(USGS)



BSSC – engineers,
seismologists, and others

Policy

Seismic *Design Ground Motions*
(FEMA)

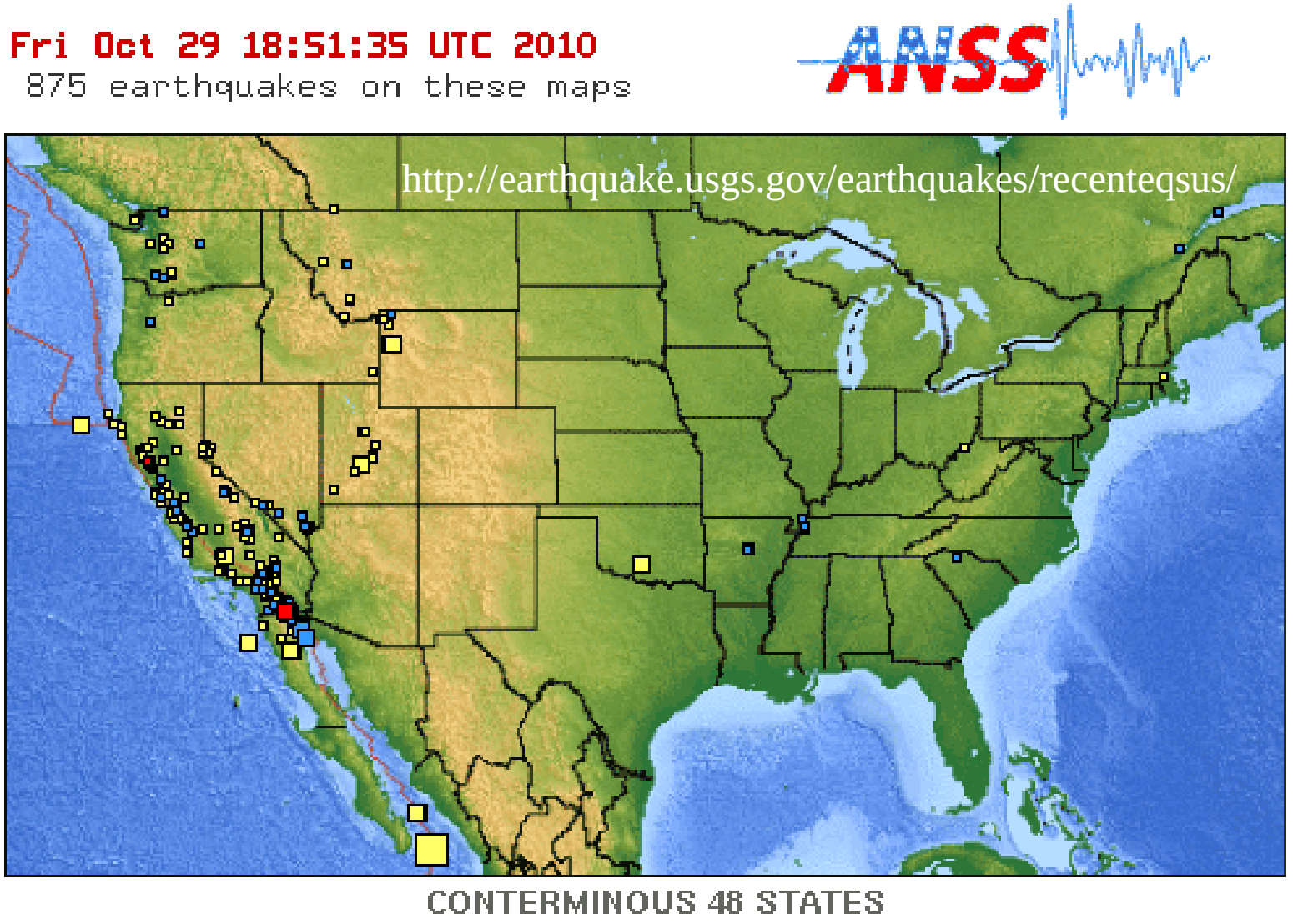


Federal agencies

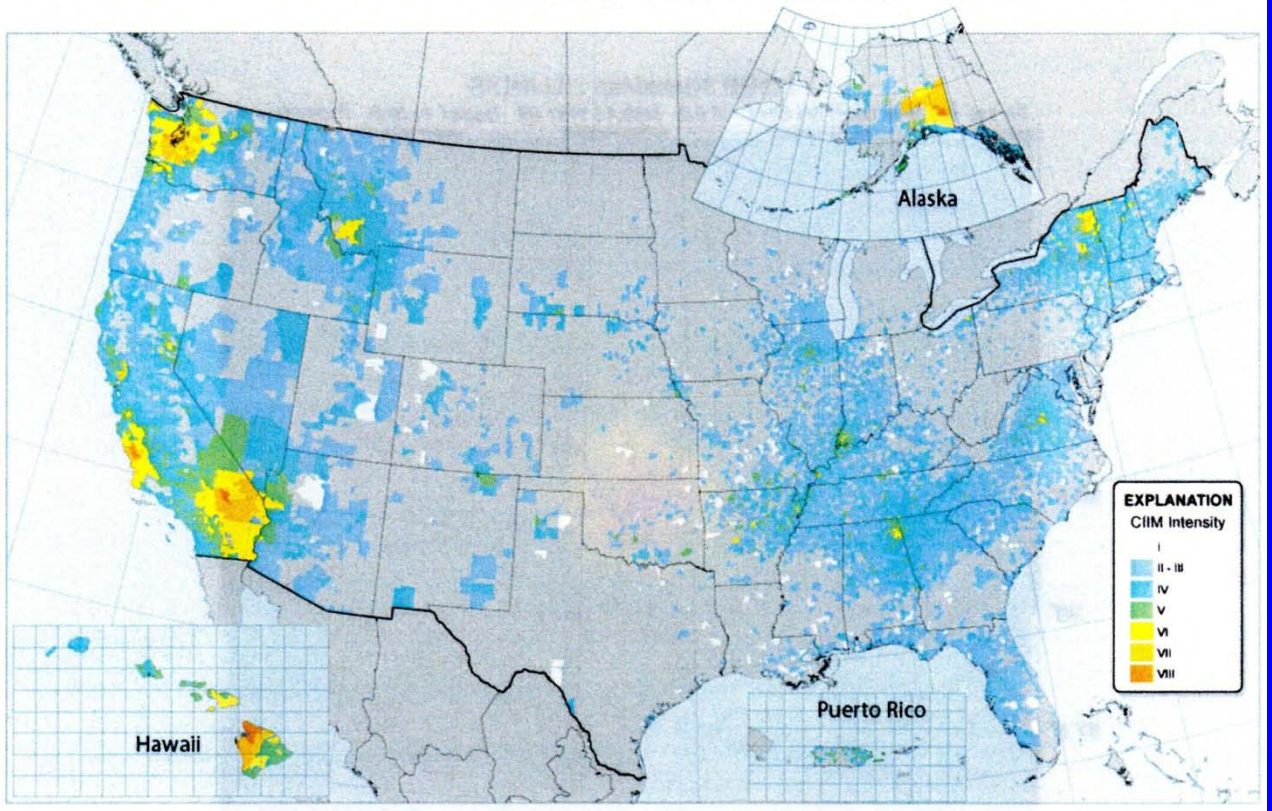
State Agencies

Other organizations

USGS 7-Day Seismicity in the U.S.



USGS Twenty-Year Did You feel It

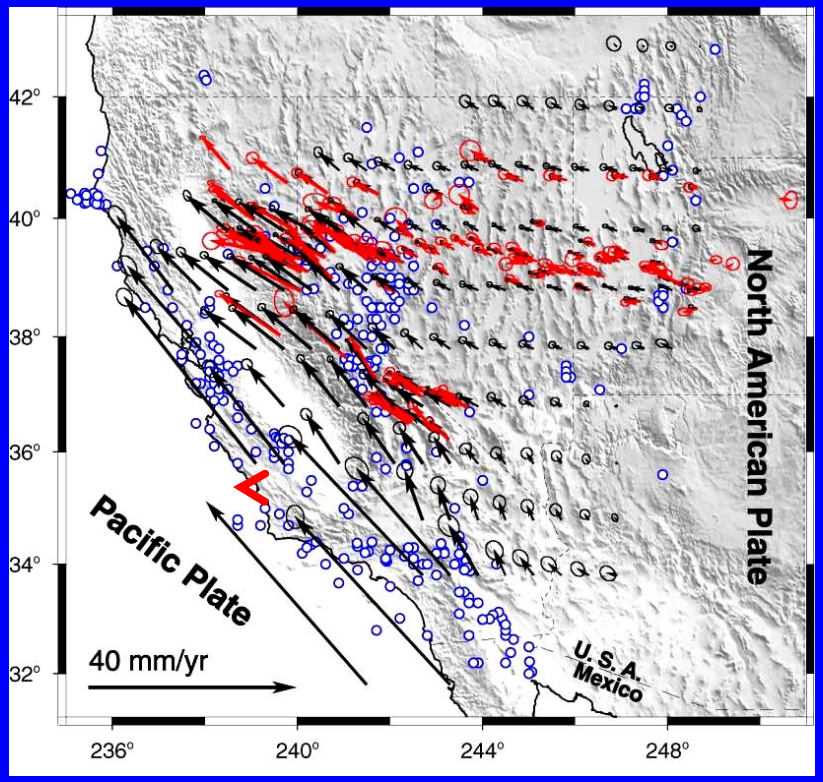


U.S. G.S. (Leith and others, 2009)

Figure 9. Composite DYFI? map of the U.S. (1988–2007) showing the maximum credible intensity reported by the public for each zip code for which there is reported felt information. To date, there are more than one million DYFI? entries for the U.S.

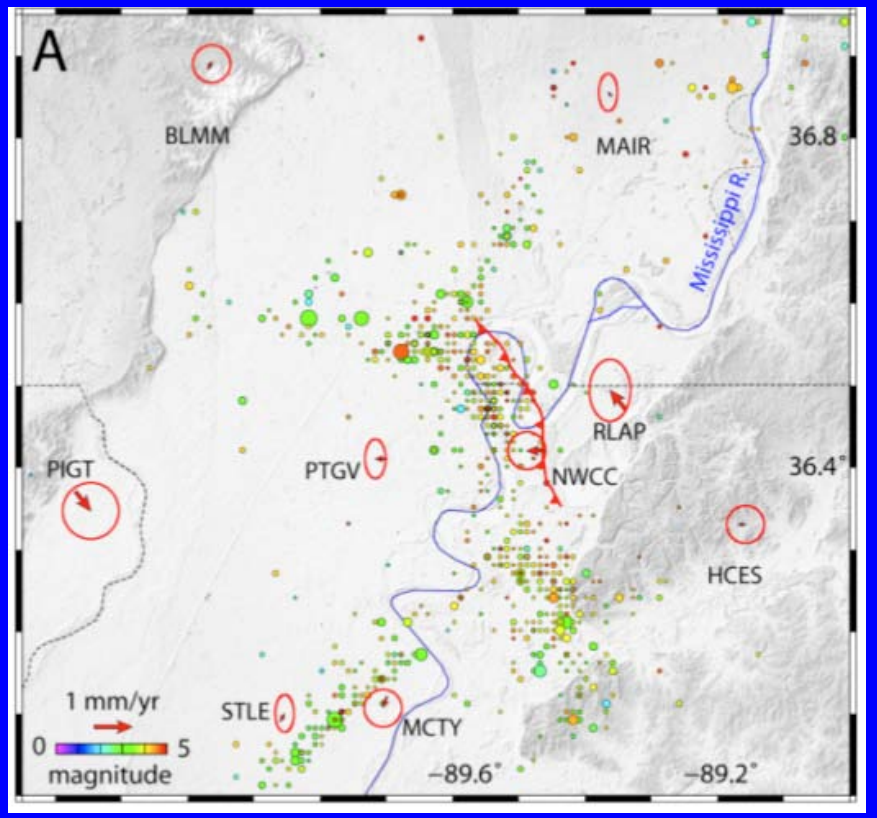
GPS results

California



Deformation rate: > 30 mm/y

Central U.S.



Deformation rate: < 3 mm/y

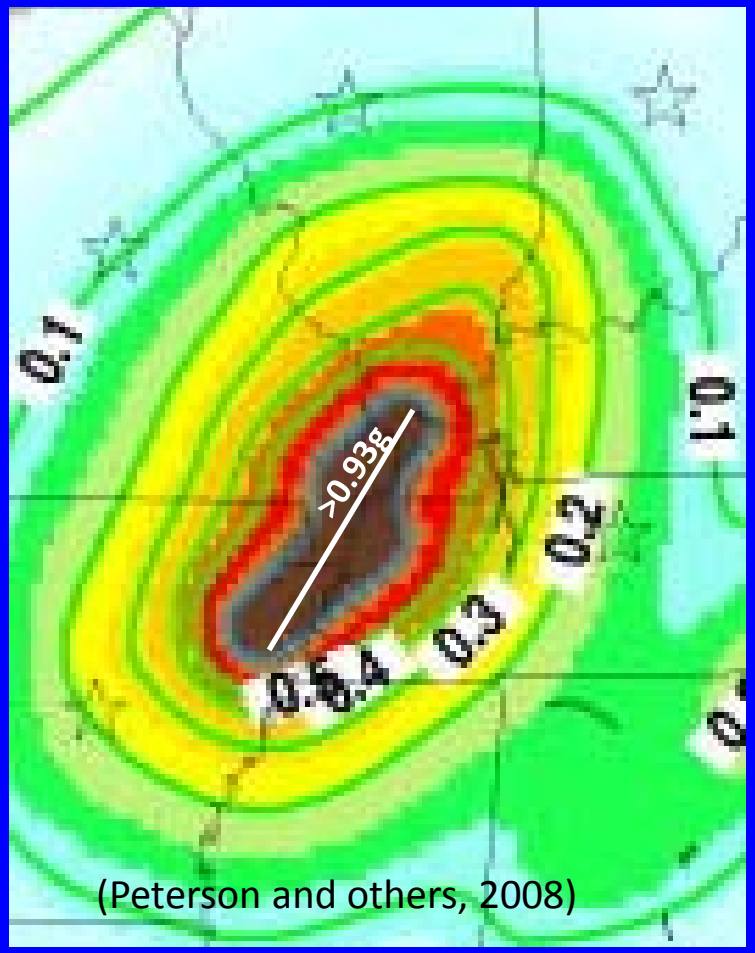
Active Plate Tectonics

Deformation rate: > 30 mm/y

Intra-Plate tectonics

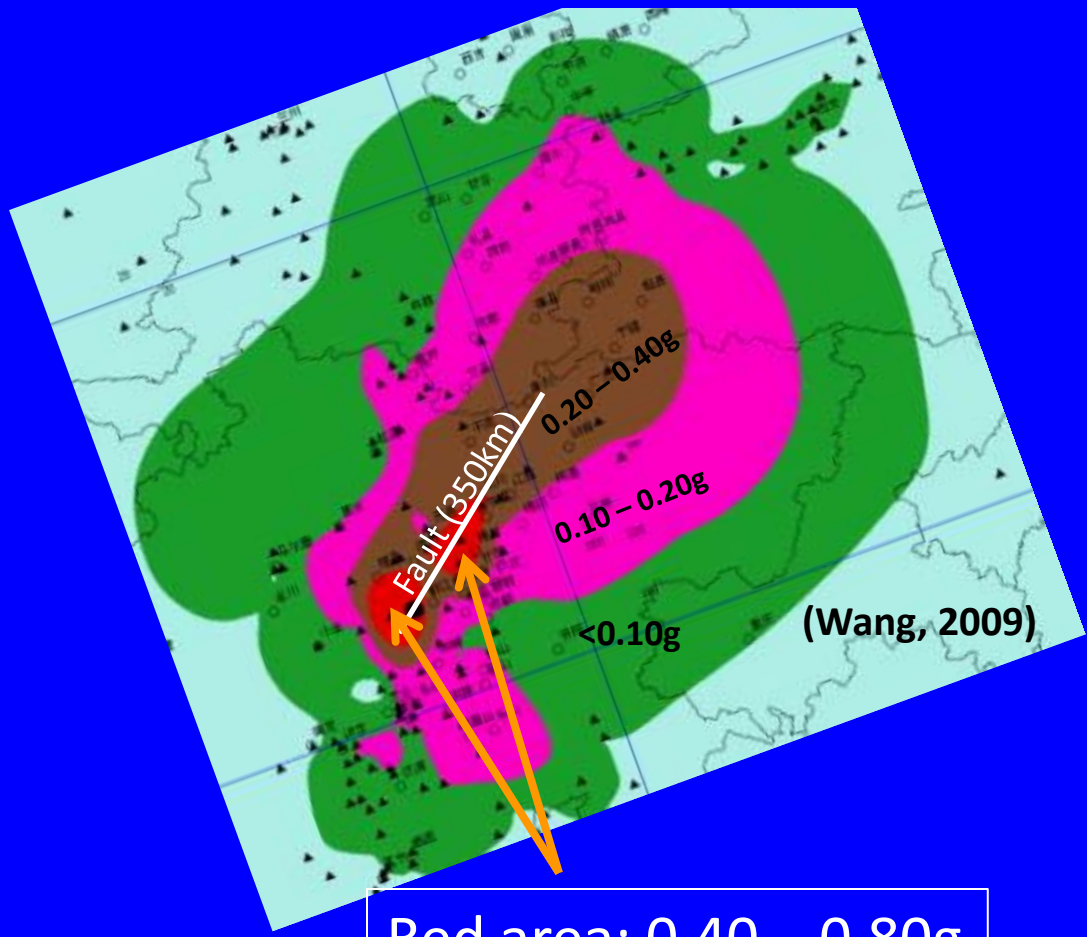
Deformation rate: < 3 mm/y

National Seismic Hazard map for Central U.S. - PGA with 2% PE in 50 years



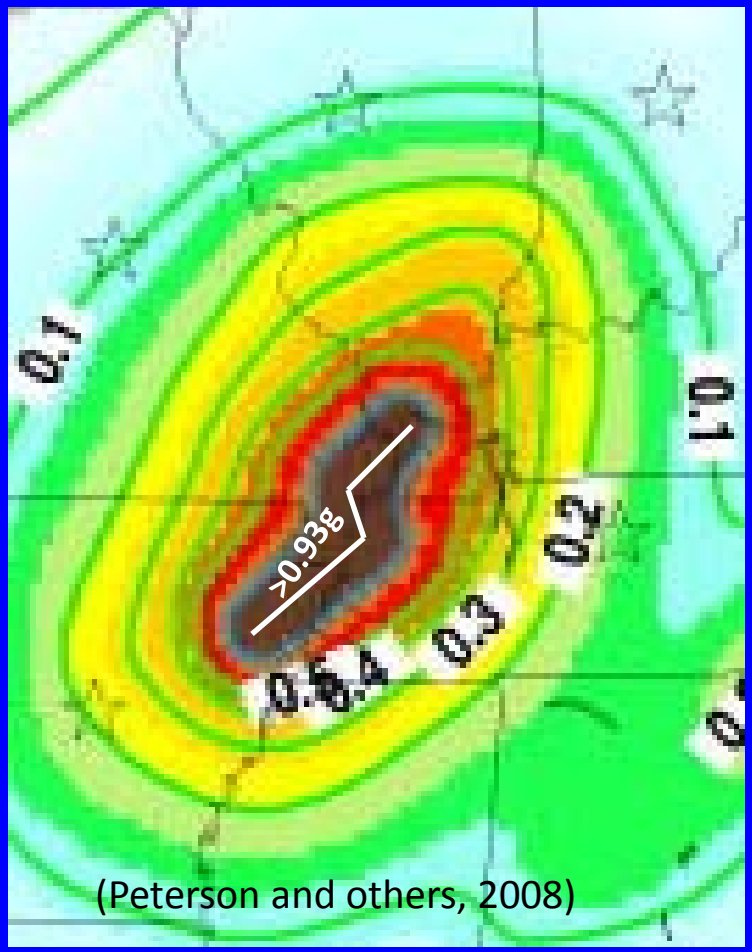
(Peterson and others, 2008)

China - Wenchuan earthquake Actual (M8.0) PGA map



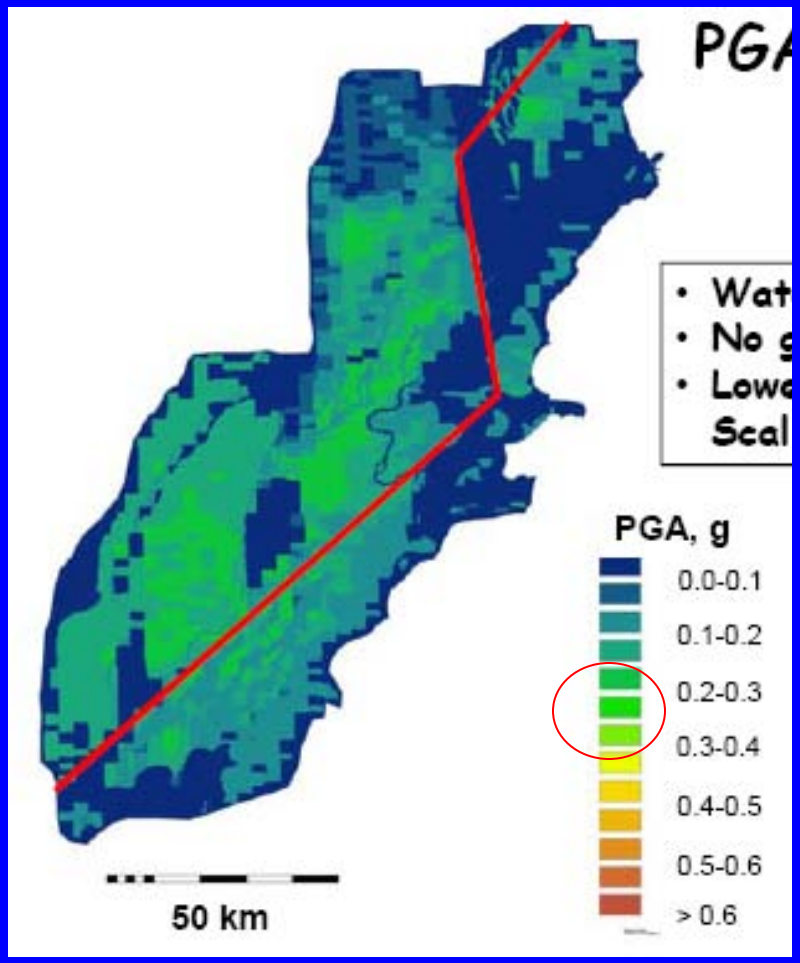
Red area: 0.40 – 0.80g

National Seismic Hazard map for Central U.S. - PGA with 2% PE in 50 years



(Peterson and others, 2008)

PGA inferred from liquefaction for M7.7 NM earthquake



(Holzer and others, 2010)

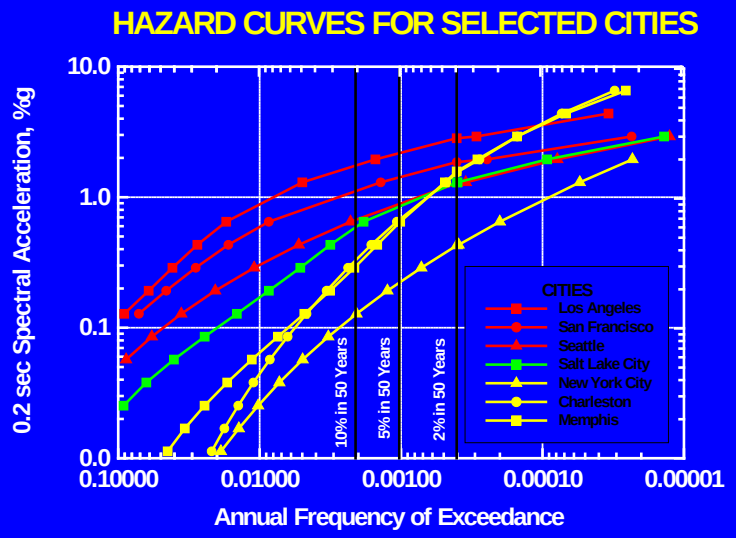
The National Seismic Hazard Maps

Inputs

Modeling (computer)

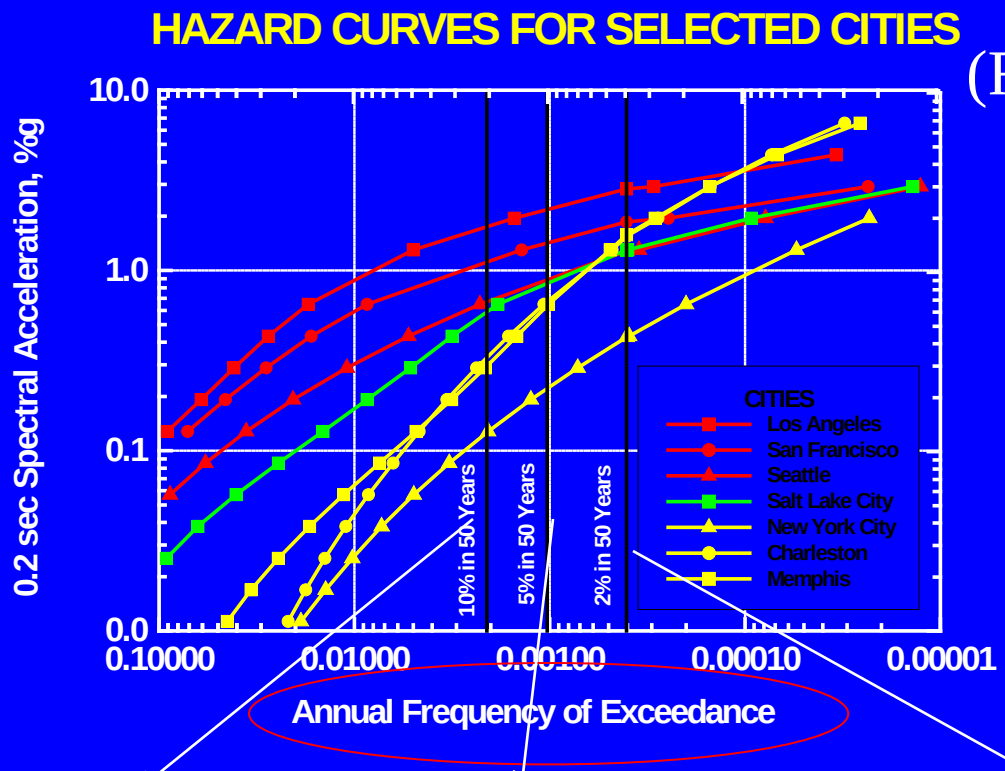
Outputs

Scientific data → PSHA → Hazard curves



(Frankel et al., 1996)

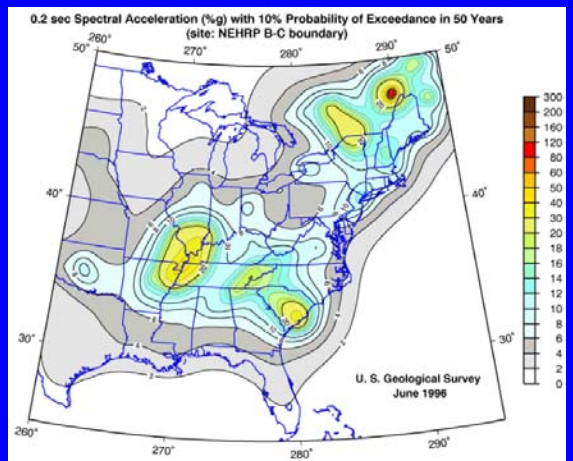
PSHA End Results: Seismic Hazard Curves

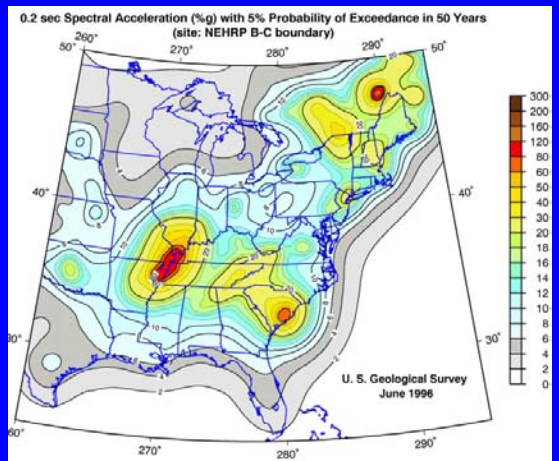


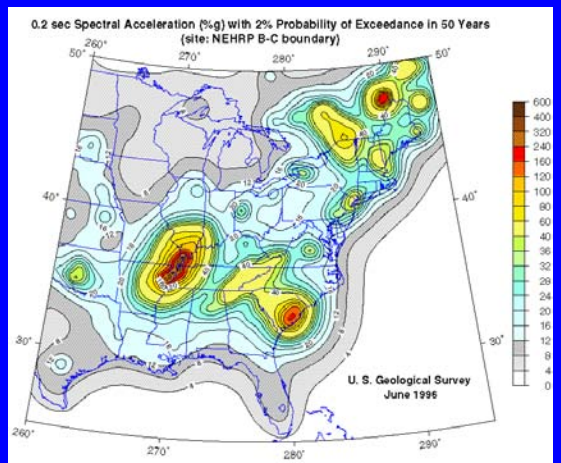
(Frankel et al., 1996)

Hazard curves

Hazard maps







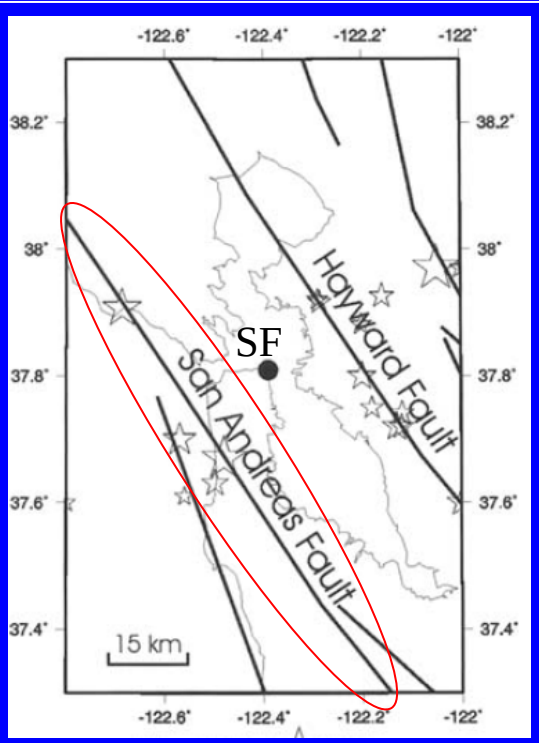
Sensitivity Test on PSHA

Input

PSHA

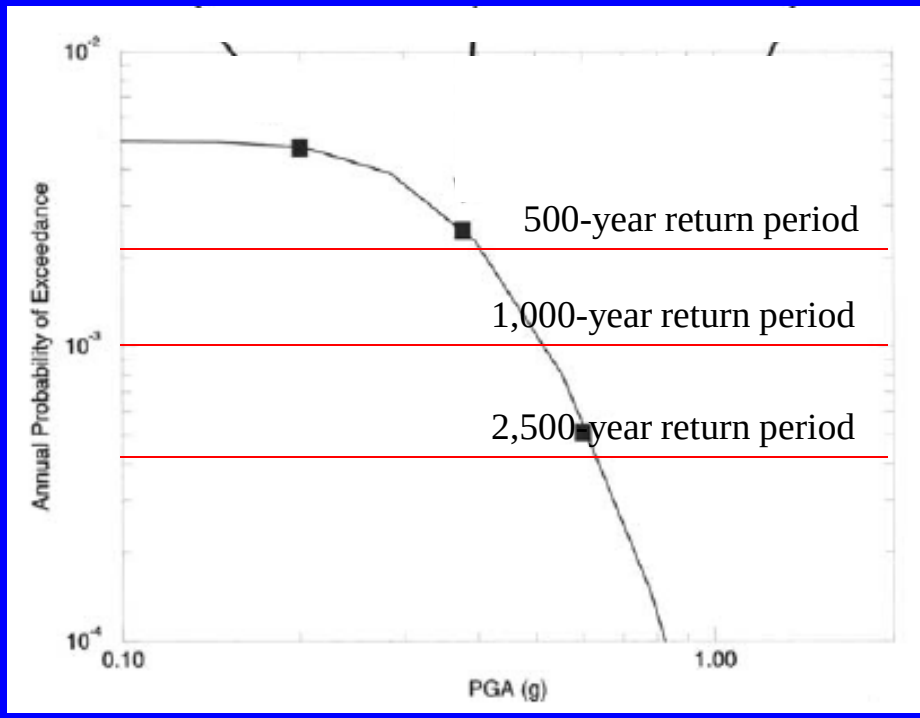
Output

A single earthquake → "Computer model" → Infinite ground motions



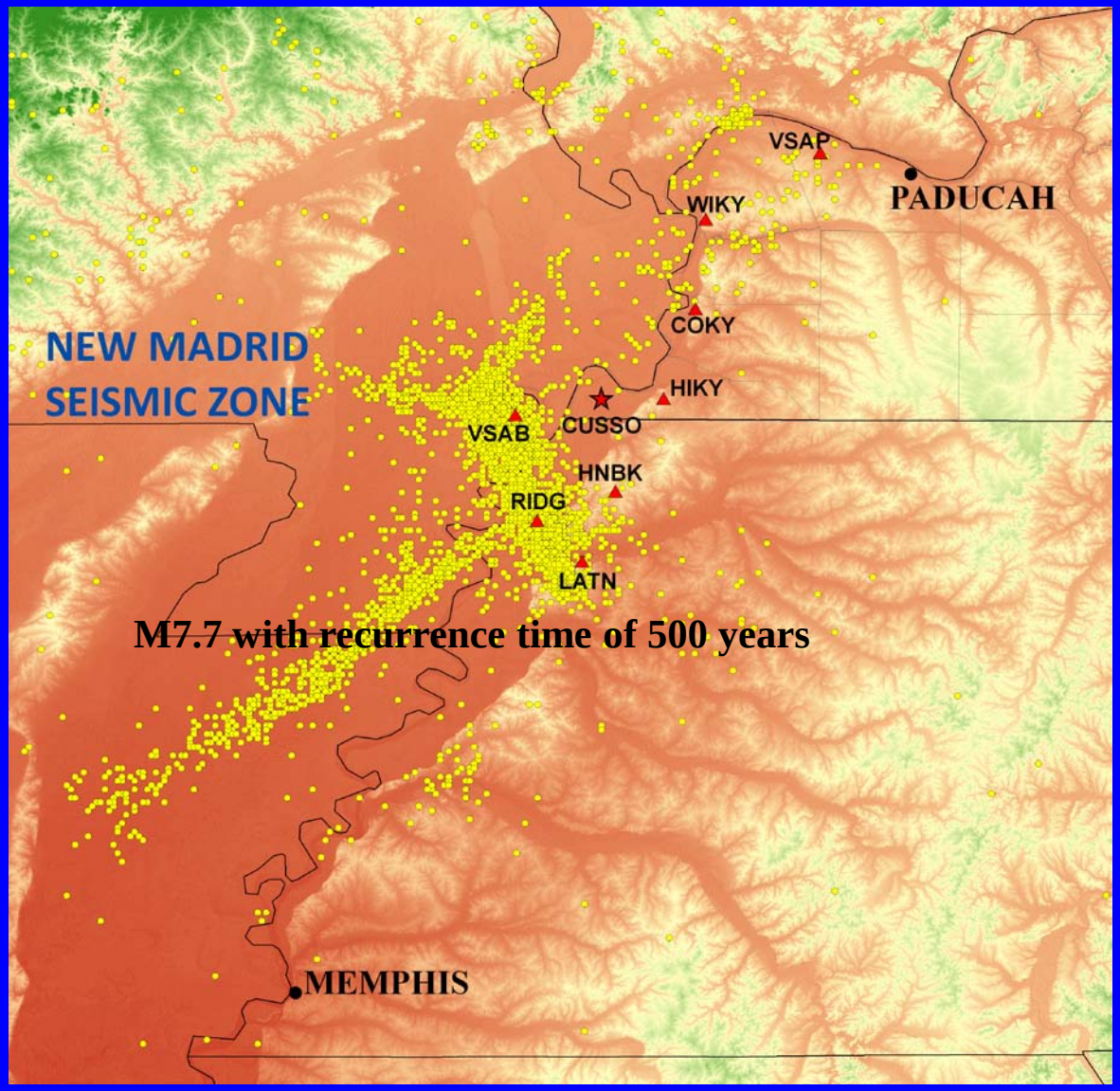
(Frankel, 2004)

M7.8 with repeat time of 200 years



PSHA produces infinite ground motions at a site from a single earthquake. NO, not possible

One earthquake can only generate one ground motion at a site

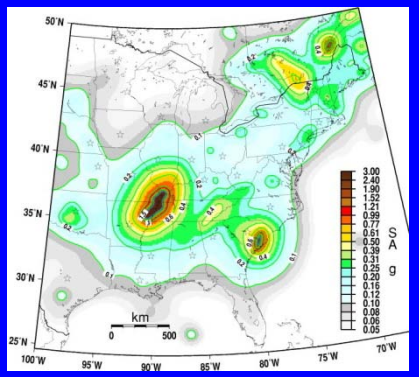


PSHA does not pass a simple sensitivity test

Development of Design Ground Motion Policy

Science ??????

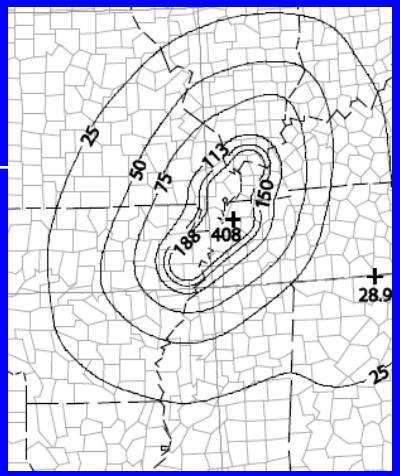
Seismic Hazard Map (USGS)



BSSC – engineers, seismologists, and others

Policy ??????

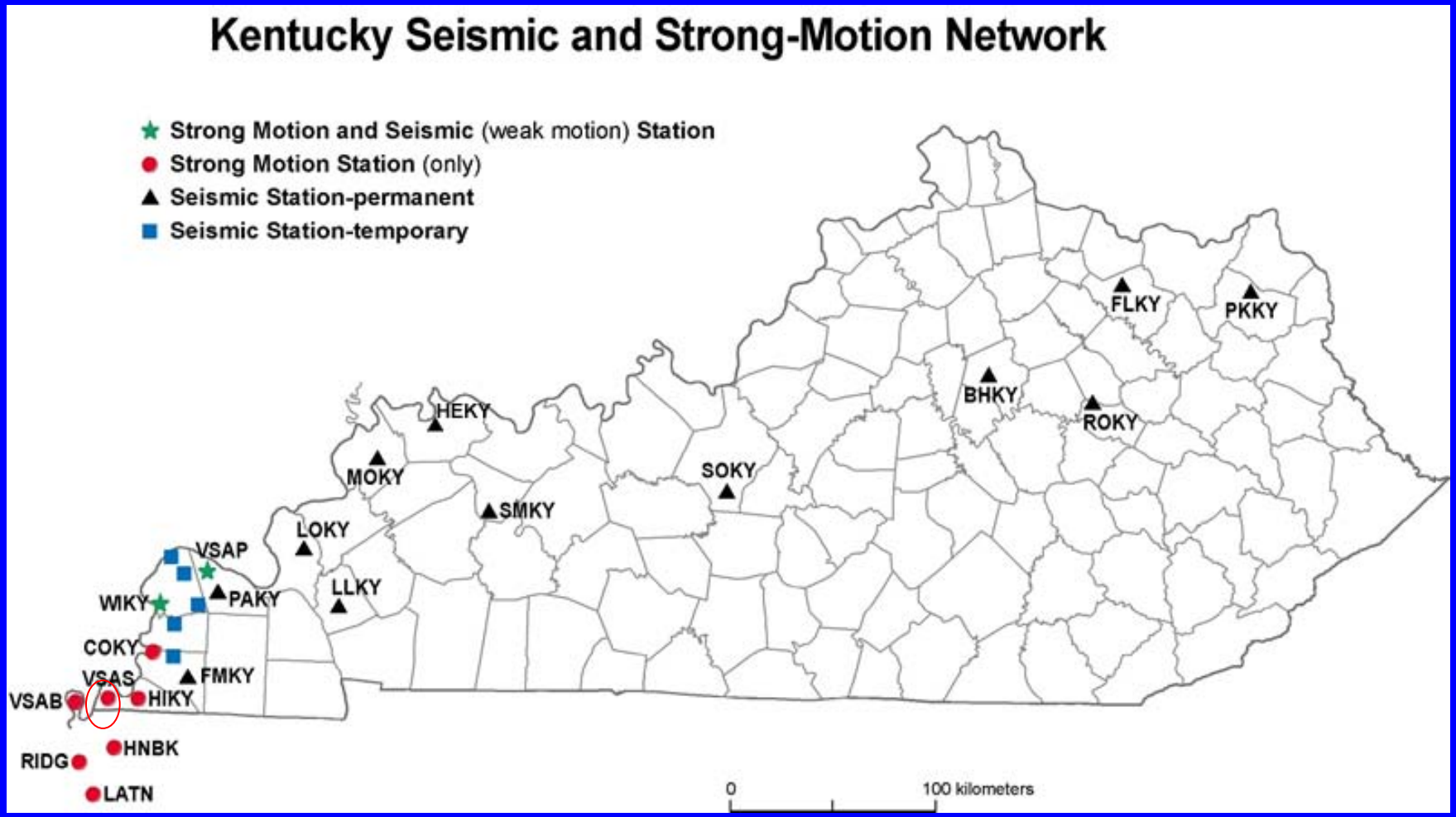
Seismic *Design Ground Motions* (FEMA)



Federal agencies

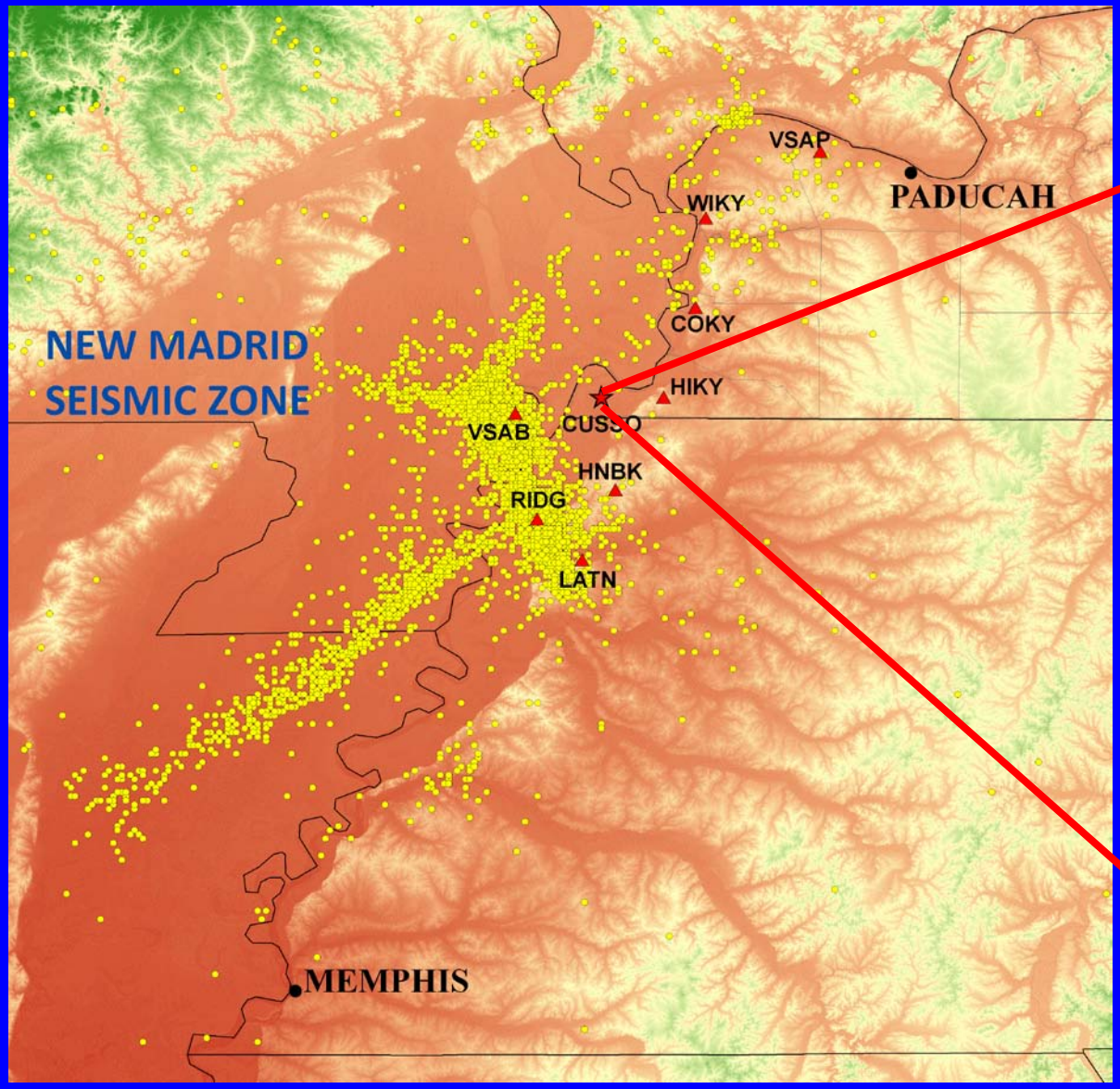
State Agencies

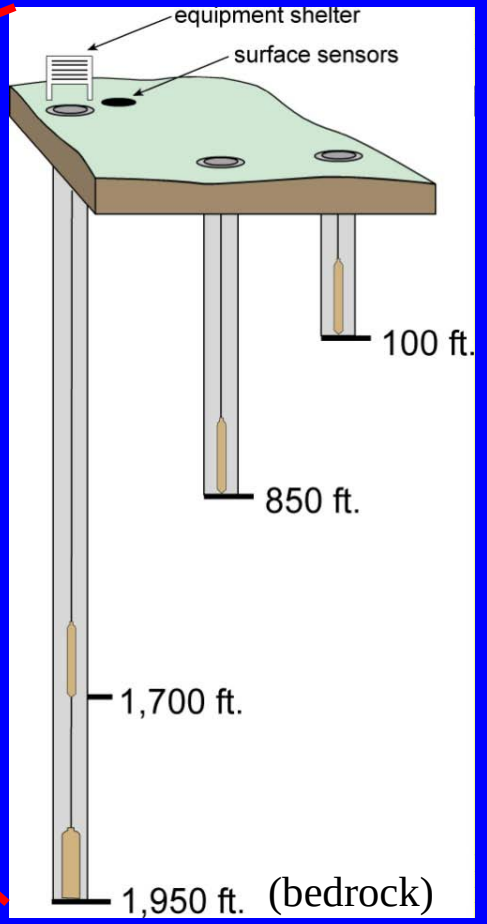
Other organizations



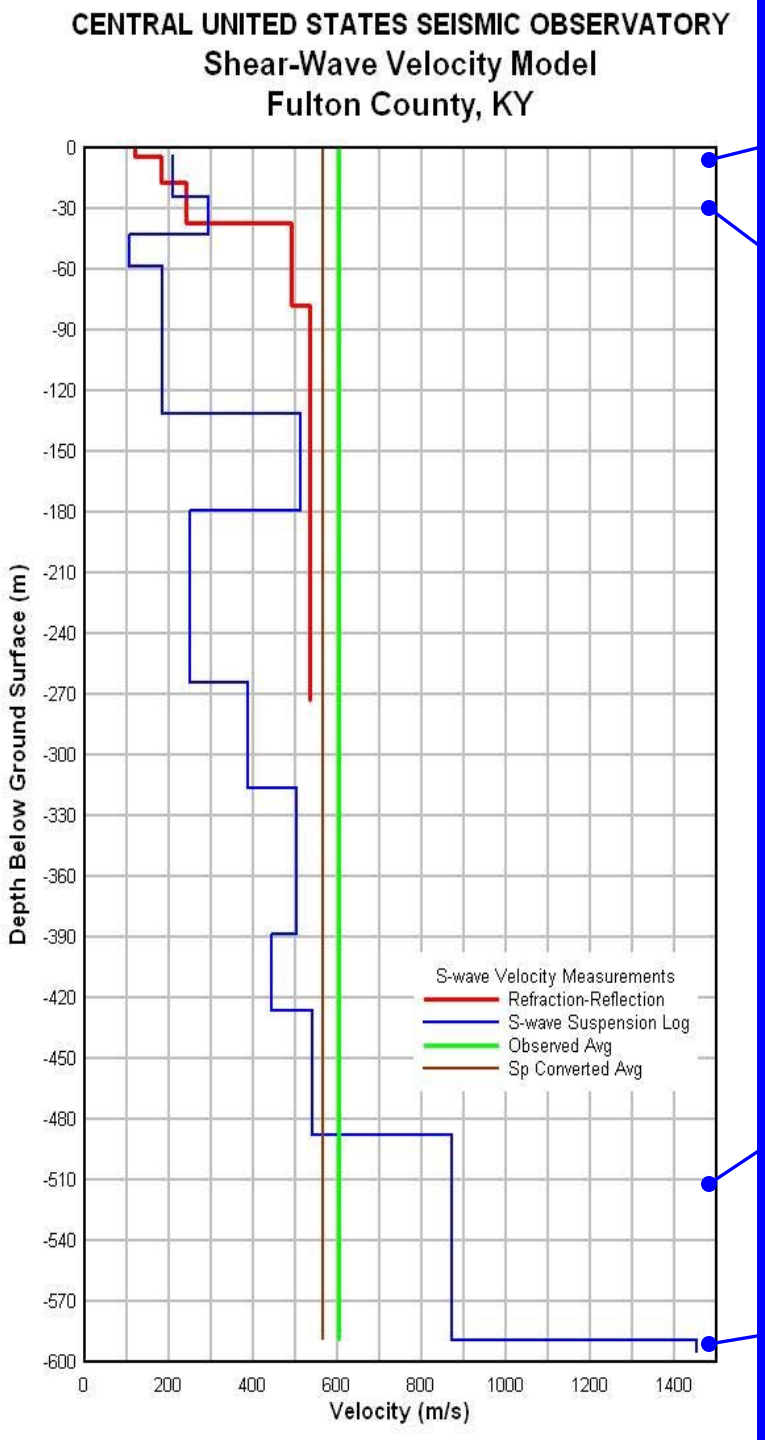
http://www.uky.edu/KGS/geologichazards/equake3.htm

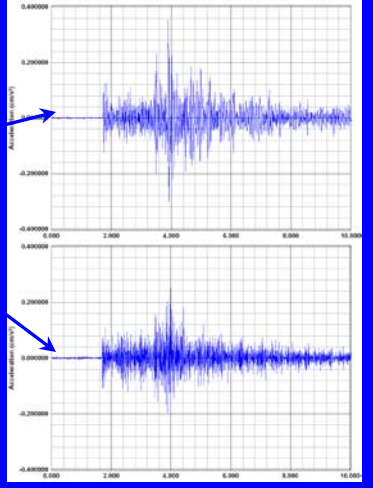
The Central U.S. Seismic Observatory

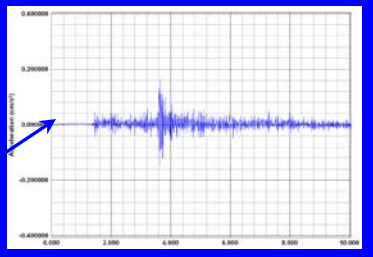


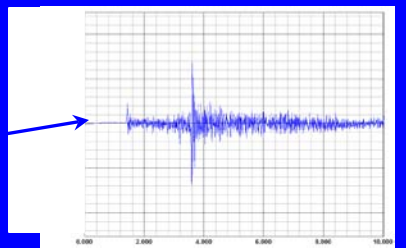


Stratigraphy	Drillers Log
Quaternary	Topsoil
	Fine brown sand
	Coarse red sand
	Coarse sand blue
	Coarse sand LG and PG
	Coarse sand and gravel
	Black clay
Jackson Fm (Eocene)	Brown sandy clay
	Gray clay
	Clay and sand streaks
	Sand and clay streaks
	Sand small clay streaks
	Green sandy clay
Claiborne Fm (Eocene)	Clay
	Sand
	Sand streaks, hard clay and lignite
	Sand
	Sand and shale streaks
	Sand
	Cemented sand
Wilcox Fm (Eocene)	Clay and soft shale
	Green clay, hard shale streaks
	Sandy shale and clay
	Sand and clay streaks
	Sandy clay
Porters Creek Clay (Paleocene)	Black shale
	Shale and clay
	Sandy clay and hard shale streaks
	Rock of slate
	Clay
	Rock
Clayton & McNairy Fms. (Paleocene)	Sandy shale and rock streaks
	Sand traces of shale
	Sand and cemented streaks
Bedrock (Paleozoic)	Rock
	Cavity









Alternative methods deterministic/scenario based

(Wang, 2010)

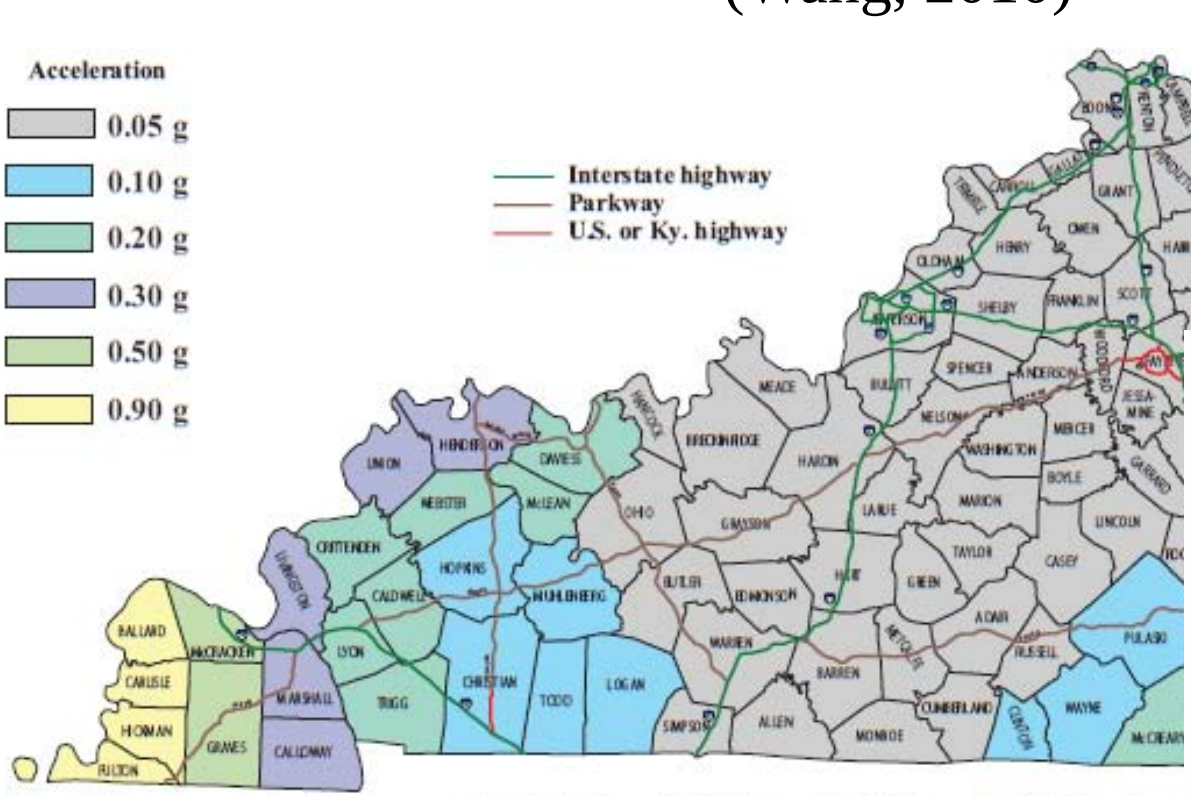
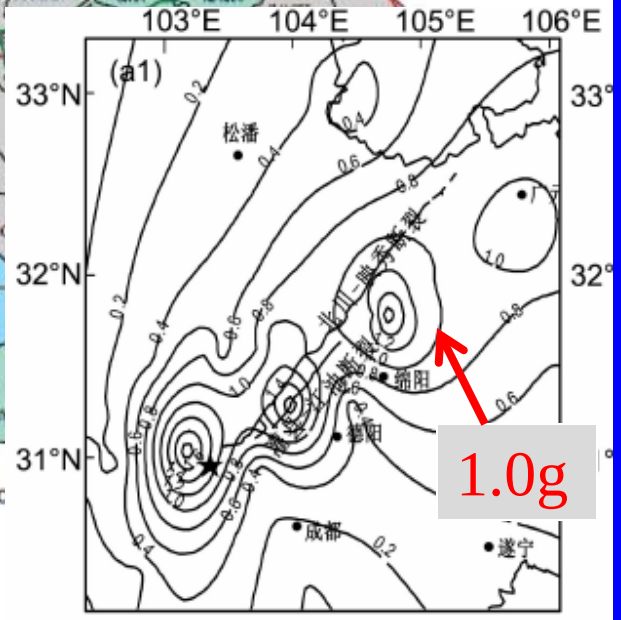


Figure 3. Response acceleration, measured in *g*, for short-period (0.2 second) with 5 percent critical damping c
in Kentucky.

.2 sec response acceleration



Conclusions

•By comparisons and sensitivity test the Central U.S. seismic hazard is too high. The USGS National Seismic Hazard Maps portray the Central U.S. as a worst case.

• Comparisons to real-world-worst-cases such as Wenchuan China shows the NMSZ still twice as dangerous –this is not reasonable.

• Kentucky should not be placed in a hazard category twice as dangerous as California or China – not reasonable!

• The scientific inputs to the NEHRP Provisions for the Central U.S. are not consistent with observations.
• There must be changes to the NEHRP maps. Kentucky has been and is being harmed by the NEHRP maps.

Thank You