



USGS in nehrp

National Earthquake Conference
April 23, 2008

USGS Stafford Act roles and responsibilities

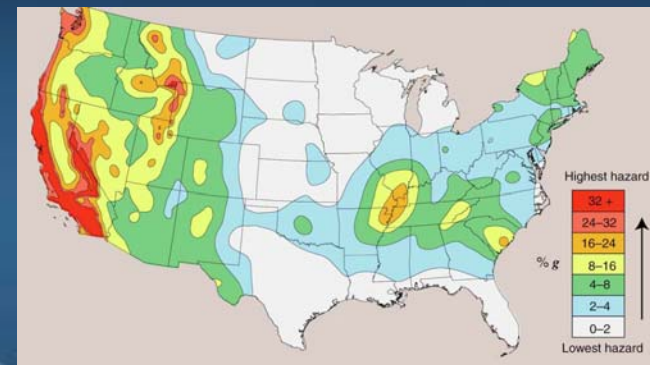
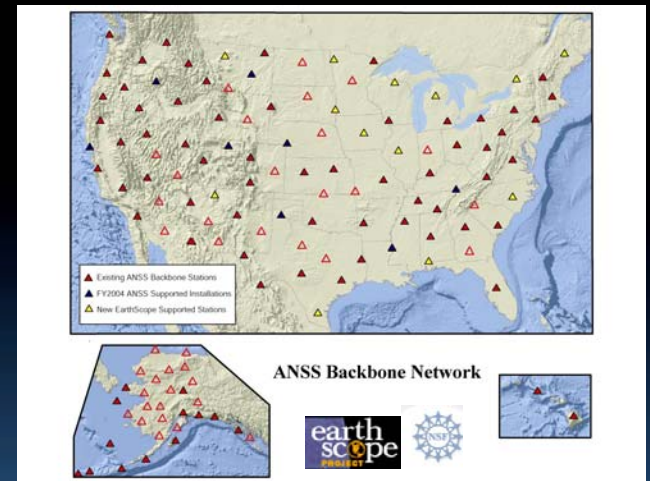
- USGS has the lead federal responsibility to provide notification and warnings for **earthquakes**, **volcanoes**, and **landslides**.
- In addition, USGS seismic networks support NOAA in carrying out its **tsunami** warning responsibility; USGS streamgages and storm surge monitors support NOAA's **flood** and **severe storm** (including **hurricane**) warnings; and our geomagnetic observatories support **space weather** forecasts.
- USGS geospatial information supports response operations for **wildfire** and other hazards.



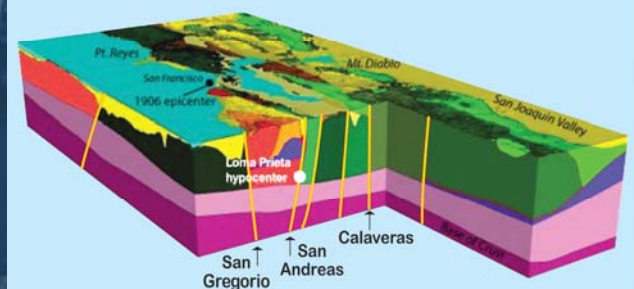
The USGS role in NEHRP

Statute: The United States Geological Survey shall conduct research and other activities necessary to characterize and identify earthquake hazards, assess earthquake risks, monitor seismic activity, and improve earthquake predictions.

- Provide earthquake monitoring and notifications,
- Assess seismic hazards, and
- Conduct research needed to reduce the risk from earthquake hazards nationwide.



3D Geologic "fault and block" model



Bob Jachens, Russ Graymer, Bob Simpson, and Carl Wentworth

Provide earthquake monitoring and notifications



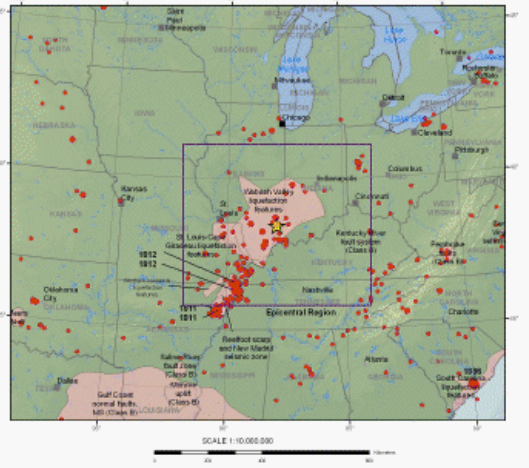
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

M5.2 Mount Carmel, Illinois, Earthquake of 18 April 2008



EARTHQUAKE SUMMARY MAP XXXX
Prepared in cooperation with the Global Seismographic Network
GSN

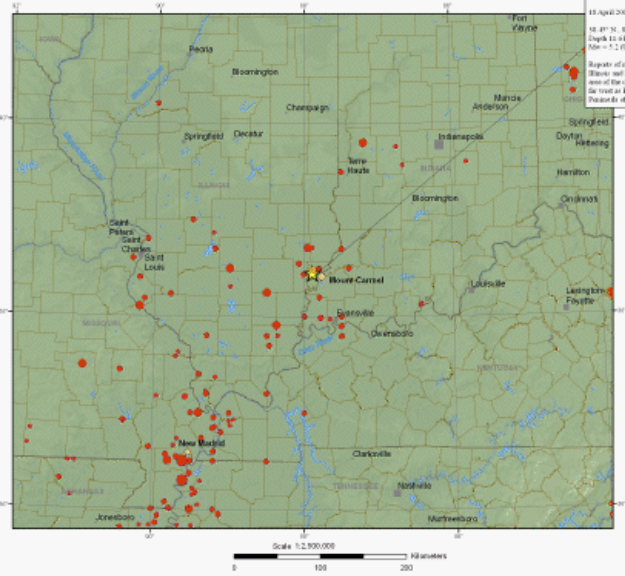
Tectonic Setting



EXPLANATION

- ★ Main Shock
- M4.6 Aftershock
- Historical
 - M 3.5 - 4.9
 - 5.0 - 5.9
 - 6.0 - 6.9
 - 7.0 - 7.9
- ▭ Fault zones

Epicentral Region



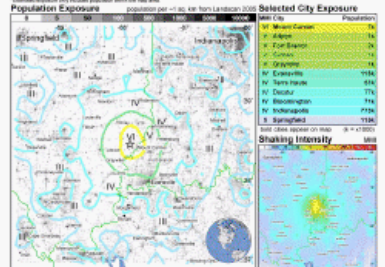
Block Dates
18 April 2008 07:47:00 UTC
M 5.2, 18 APR 08
Depth 10 km
Mag = 5.2 (USGS)
Report of severe structural damage in West Salem, Illinois, and Linton, Kentucky. Felt over a wide area of the central United States with 100 reports of the most at Kansas, 60 events at the Upper Peninsula of Michigan and 20 each in Georgia.

Predicted Shaking

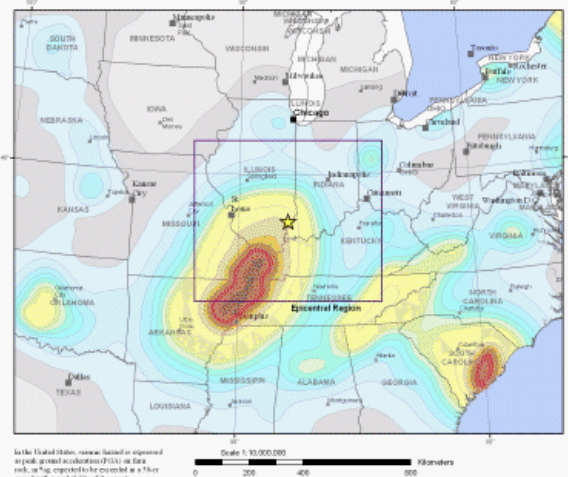
USGS USAID
M 5.2, ILLINOIS
Origin Time: Fri 2008-04-18 09:37:00 UTC
Location: 38.453 N 87.851 W, Depth: 11 km
PAGER Version 7

Estimated Population Exposed to Earthquake Shaking

Intensity	II	III	IV	V	VI	VII	VIII	IX	X
Population Exposed	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000



Seismic Hazard



In the United States, seismic hazard is expressed as peak ground acceleration (PGA) on a site peak, as they are expected to be exceeded in a 2-year period with a probability of 2 percent.

DECU-EMER
Seismicity data, study on active zones and potential locations, are not from available data and the present is only a general indication and should not be used for engineering design purposes.

DATA SOURCES
EARTHQUAKES AND SEISMIC HAZARD
USGS, National Earthquake Information Center
Secretary of the United States, 1989
Shimizu and Collins, 1991
Centers for Environmental and Estuarine Science (Chesapeake Biological Laboratory)
National Science Foundation (2002)

BASE MAP
USGS and ERDC, Digital Chart of the World
USGS, Digital Data Center
NOAA (2007) and GEBCO (2008) Bathymetric Map

REFERENCES
Shimizu, C.T., and Collins, J.L., 1985. Seismicity of the United States, 1780-1980 (Revised). USGS Professional Paper 1157.

USGS, 2008. Quakes: Fast and Furious in the United States. <http://earthquake.usgs.gov/earthquakes/>

National Science Foundation
<http://www.nsf.gov/pubs/2008/2008-1000/>

TECTONIC SUMMARY

EARTHQUAKES IN THE WABASH VALLEY SEISMIC ZONE
These earthquakes occur in the Wabash Valley Seismic Zone. The earthquake in this zone are scattered over a large area of southeastern Illinois and northern Indiana. The zone had at least eight prominent earthquakes over the past 20,000 years with estimated magnitudes ranging from about 6.5 to 7.5, based on geologic evidence. Earthquakes of the size of the recent quake (M=5.2) can produce smaller aftershocks over the following days. A few might be large enough to be felt. Typically earthquakes of this size (M=5.2) can cause light damage within a few tens of miles from the epicenter. Central and eastern US earthquakes generally shake areas about 10 times as large as those that occur in California. It is not surprising that this earthquake was felt as far south as Florida.

The Wabash Valley Seismic zone is adjacent to the more seismically active New Madrid seismic zone on the seismic zone's north and west. The recent earthquake is also within the Illinois basin - Great Lakes region that covers parts of Indiana, Kentucky, Illinois, Missouri, and Arkansas and extends from Indianapolis and St. Louis to Memphis. Moderately frequent earthquakes occur at regular intervals throughout the region. The largest historical earthquake on the Illinois basin region (magnitude 5.4) occurred in southern Illinois in 1963. Moderately damaging earthquakes strike somewhere in the region each decade or two, and smaller earthquakes are felt about once or twice a year.

Earthquakes in the central and eastern U.S. are typically less frequent than in the western U.S. and typically fall over much broader regions. East of the Rockies, an earthquake can be felt over an area as small as ten times larger than similar magnitude earthquakes on the west coast. A magnitude 4.0 eastern U.S. earthquake typically can be felt at many places as far as 100 km (60 mi) from where it occurred, and it infrequently causes damage near its source. A magnitude 5.5 eastern U.S. earthquake usually can be felt for as 500 km (300 mi) from where it occurred, and sometimes causes damage as far as 80 km (50 mi).

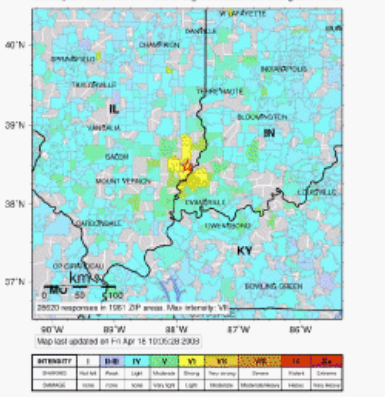
FAULTS
Earthquakes everywhere occur on faults or fracture zones, usually under stress. Most faulting in the Illinois basin - Great Lakes region was formed as several generations of mountain rose and more eroded-down again over the last billion or so years.

At or related to plate boundaries like the San Andreas fault system in California, scientists can often determine the sense of the slip, but that is not possible for an earthquake in the central part of the Rocky Mountain Basin or the Great Lakes - Great Lakes basin. The Illinois basin - Great Lakes region is far from the nearest plate boundaries, which are in the eastern United States, in the Caribbean Sea, and in the Gulf of California. The region has had well known faults for centuries and is deeply tectonically stressed. Even the known faults are poorly located at earthquake depths. Accordingly, few earthquakes in the region can be linked to named faults. It is difficult to determine if a known fault is still active and could slip and cause an earthquake. As in most other areas east of the Rockies, the best guide to earthquake likelihood in the Illinois basin - Great Lakes region is the earthquake distribution.

see <http://earthquake.usgs.gov/earthquakes/rapid/#> for more information

Did You Feel It?

USGS Community Internet Intensity Map (21 miles SW of Vincennes, Indiana)



INTENSITY

Intensity	I	II	III	IV	V	VI	VII	VIII	IX	X
Damage	None	None	None	None	None	None	None	None	None	None

Map prepared by USGS on August 2008
Map of Earthquake Intensity Center
Map prepared by USGS on August 2008
Map prepared by USGS on August 2008

Assess seismic hazards



2008 United States National Seismic Hazard Maps

The U.S. Geological Survey's National Seismic Hazard maps are the basis for seismic design provisions of building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land-use planning. Incorporating these hazard maps into designs of buildings, bridges, highways, and critical infrastructure allows these structures to withstand earthquake shaking without collapse. Properly engineered designs not only save lives, but also reduce disruption to critical activities following a damaging event. By estimating the likely shaking for a given area, the maps also help engineers avoid costs from over-design for unlikely levels of ground motion.



Colors on this map show the levels of horizontal shaking that have a 1-in-10 chance of being exceeded in a 50-year period. Shaking is expressed as a percentage of g (g is the acceleration of a falling object due to gravity).

The Update Process

The U.S. Geological Survey recently updated the National Seismic Hazard Maps by incorporating new seismic, geologic, and geodetic information on earthquake rates and associated ground shaking. These 2008 maps supersede versions released in 1996 and 2002. Updating the maps involved interactions with hundreds of scientists and engineers at regional and topical workshops. USGS also solicited advice from working groups, expert panels, State geological surveys, Federal agencies, and hazard experts from industry and academia. The Pacific Earthquake Engineering Research Center developed new crustal ground-motion models; the Working Group on California Earthquake Probabilities revised the California earthquake rate model; the Western States Seismic Policy Council submitted recommendations for the Intermountain West; and three expert panels were assembled to provide advice on best available science.

Changes to the Maps

The most significant changes to the 2008 maps fall into two categories, as follows:

- Changes to earthquake source and occurrence rate models.
 - In California, the source model was updated to account for new scientific information on faults. For example, models for the southern San Andreas Fault System were modified to incorporate new geologic data. The source model was also modified to better match the historical rate of magnitude 6.5 to 7 earthquakes.
 - The Cascadia Subduction Zone lying offshore of northern California, Oregon, and Washington was modeled using a distribution of large earthquakes between magnitude 8 and 9. Additional weight was given to the possibility for a catastrophic magnitude 9 earthquake that ruptures, on average, every 500 years from northern California to Washington, compared to a model that allows for smaller ruptures.

U.S. Department of the Interior
U.S. Geological Survey

Printed on recycled paper

Fact Sheet 2008-3018
April 2008



USGS Earthquake Hazard Assessment Products and Tools

U.S. National Probabilistic Ground-Motion Maps.



This Web site contains maps and associated input/output data and documentation for probabilistic hazard maps for the 48 Conterminous States, Alaska, Hawaii, and Puerto Rico. http://earthquake.usgs.gov/hazmaps/products_data/

Hazard Mapping and Analysis Tools.

USGS offers a number of on-line Web tools that allow an individual to assess which sources pose the greatest hazard in a particular region, look up hazard values using latitude/longitude or Zip code, make customized USGS probabilistic hazard maps for an area of interest, map probability of a given magnitude within a certain distance from a site, and access computer software for seismic hazard analysis. <http://earthquake.usgs.gov/hazmaps/interactive/>

Seismic Design Values for Buildings.

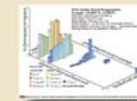
This Web site allows users to determine design ground motion at a site for various building codes, using latitude/longitude or Zip code. In addition, one can display and download a hazard curve or uniform hazard spectrum for a site. <http://earthquake.usgs.gov/hazmaps/design/>

Urban Probabilistic Ground-Motion Maps.

These maps show more detailed probabilistic seismic hazard maps for urban areas that take into account near-surface geologic conditions, sedimentary basin structure, and directivity effects. http://earthquake.usgs.gov/hazmaps/products_data/

Deterministic or Scenario Ground-Motion Maps.

Maps predict the median level of ground shaking from a particular "scenario" event. They do not take into account the likelihood of that scenario occurring, but they are helpful when assessing the potential impact of a particular event. [Need URL]



Time-Dependent Earthquake Probability Maps.

These maps forecast the likelihood of an earthquake rupture occurring during an interval of time in the future. Time-dependent maps are considered research tools and are not currently applied in building codes.

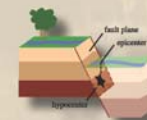
U.S. Quaternary Fault and Fold Database.

This Web site contains information on faults and associated folds in the United States that are believed to be sources of M>6 earthquakes during the Quaternary (the past 1,600,000 years). Maps of these geologic structures are linked to detailed descriptions and references. <http://earthquake.usgs.gov/qafaults/>



Earthquake Hazards 101.

USGS provides a wealth of explanatory materials for the layperson, including information on concepts behind earthquake maps, the use of probability, what the maps mean, how they are made, and answers to frequently asked questions. <http://earthquake.usgs.gov/research/hazmaps/haz101/index.php>



Acknowledgments

The following team contributed to this Fact Sheet: Mark D. Petersen, Arthur D. Frankel, Stephen C. Harmsen, Charles S. Mueller, Kathleen M. Haller, Russell L. Wheeler, Robert L. Wesson, Yuehua Zeng, David M. Perkins, Nicolas Luco, Kenneth S. Rukstales (USGS, Golden, Colo.); Oliver S. Boyd (USGS, Memphis, Tenn.); Edward H. Field (USGS, Pasadena, Calif.) and Chris J. Wills (California Geological Survey, Sacramento, Calif.).

For more information, see the Web site for the U.S. Geological Survey Earth Hazards Program at

<http://earthquake.usgs.gov/research/hazmaps/>

Assess seismic hazards



2008

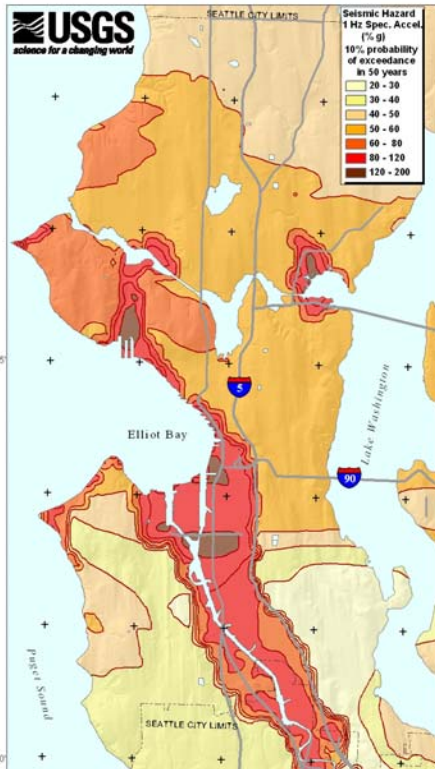
The U.S. National maps are the design provisions, codes, insurance earthquake priorities, a ming. Incorporating maps into d bridges, high cal infrastru structures t quake shak Properly en only save li disruption t following a estimating t for a given help engine over-design ground mot

The U.S.

The U.S. geodetic in and 2002. USGS also from indus els; the We Seismic Po advice on P

Chang

The m I. Chang
 • In C
 sout
 bett
 • The
 of l



Seattle urban hazard map

USGS Earthquake Hazard Assessment Products and Tools

U.S. National Probabilistic Ground-Motion Maps.



This Web site contains maps and associated input/output data and documentation for probabilistic hazard maps for the 48 Conterminous States, Alaska, Hawaii, and Puerto Rico. http://earthquake.usgs.gov/hazmaps/products_data/

Hazard Mapping and Analysis Tools.



USGS offers a number of on-line Web tools that allow an individual to assess which sources pose the greatest hazard in a particular region, look up hazard values using latitude/longitude or Zip code, make customized USGS probabilistic hazard maps for an area of interest, map probability of a given magnitude within a certain distance from a site, and access computer software for seismic hazard analysis. <http://earthquake.usgs.gov/hazmaps/interactive/>

Seismic Design Values for Buildings.



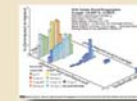
This Web site allows users to determine design ground motion at a site for various building codes, using latitude/longitude or Zip code. In addition, one can display and download a hazard curve or uniform hazard spectrum for a site. <http://earthquake.usgs.gov/hazmaps/design/>

Urban Probabilistic Ground-Motion Maps.



These maps show more detailed probabilistic seismic hazard maps for urban areas that take into account near-surface geologic conditions, sedimentary basin structure, and directivity effects. http://earthquake.usgs.gov/hazmaps/products_data/

Deterministic or Scenario Ground-Motion Maps.



Maps predict the median level of ground shaking from a particular "scenario" event. They do not take into account the likelihood of that scenario occurring, but they are helpful when assessing the potential impact of a particular event. [Need URL]

Time-Dependent Earthquake Probability Maps.

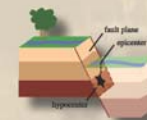
These maps forecast the likelihood of an earthquake rupture occurring during an interval of time in the future. Time-dependent maps are considered research tools and are not currently applied in building codes.

U.S. Quaternary Fault and Fold Database.



This Web site contains information on faults and associated folds in the United States that are believed to be sources of M>6 earthquakes during the Quaternary (the past 1,600,000 years). Maps of these geologic structures are linked to detailed descriptions and references. <http://earthquake.usgs.gov/qafaults/>

Earthquake Hazards 101.



USGS provides a wealth of explanatory materials for the layperson, including information on concepts behind earthquake maps, the use of probability, what the maps mean, how they are made, and answers to frequently asked questions. <http://earthquake.usgs.gov/research/hazmaps/haz101/index.php>

Acknowledgments

The following team contributed to this Fact Sheet: Mark D. Petersen, Arthur D. Frankel, Stephen C. Harmsen, Charles S. Mueller, Kathleen M. Haller, Russell L. Wheeler, Robert L. Wesson, Yuehua Zeng, David M. Perkins, Nicolas Luco, Kenneth S. Rukstales (USGS, Golden, Colo.); Oliver S. Boyd (USGS, Memphis, Tenn.); Edward H. Field (USGS, Pasadena, Calif.) and Chris J. Wills (California Geological Survey, Sacramento, Calif.).

For more information, see the Web site for the U.S. Geological Survey Earth Hazards Program at

<http://earthquake.usgs.gov/research/hazmaps/>

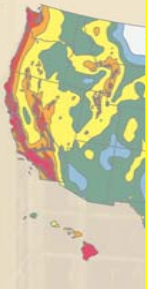


Assess seismic hazards



2008 United States National

The U.S. Geological Survey's National Seismic Hazard maps are the basis for seismic design provisions of building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land-use planning. Incorporating these hazard maps into designs of buildings, bridges, highways, and critical infrastructure allows these structures to withstand earthquake shaking without collapse. Properly engineered designs not only save lives, but also reduce disruption to critical activities following a damaging event. By estimating the likely shaking for a given area, the maps also help engineers avoid costs from over-design for unlikely levels of ground motion.



Colors on this map show... in a 50-year period. Shaking due to gravity).

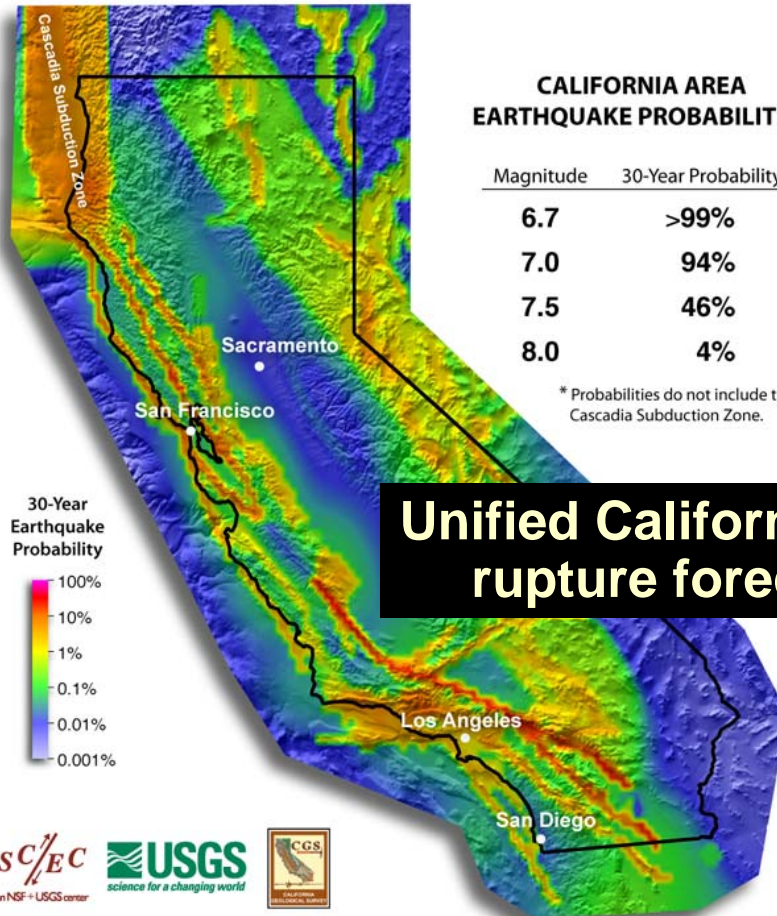
The Update Process

The U.S. Geological Survey recently updated the National geodetic information on earthquake rates and associated ground motion in 2002. Updating the maps involved interactions with hundreds of USGS also solicited advice from working groups, expert panels from industry and academia. The Pacific Earthquake Engineers; the Working Group on California Earthquake Probabilities; the Seismic Policy Council submitted recommendations for the USGS advice on best available science.

Changes to the Maps

1. Changes to earthquake source and occurrence rate models
 - In California, the source model was updated to account for the southern San Andreas Fault System were modified to better match the historical rate of magnitude 6.5 to 7 earthquakes.
 - The Cascadia Subduction Zone lying offshore of northern California was updated to account for large earthquakes between magnitude 8 and 9. Added earthquakes that rupture, on average, every 500 years for smaller ruptures.

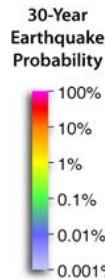
U.S. Department of the Interior
U.S. Geological Survey



CALIFORNIA AREA EARTHQUAKE PROBABILITIES

Magnitude	30-Year Probability*
6.7	>99%
7.0	94%
7.5	46%
8.0	4%

* Probabilities do not include the Cascadia Subduction Zone.

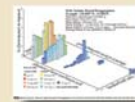


Unified California earthquake rupture forecast

Assessment Products and Tools

Ground-Motion Maps.

contains maps and data and documentation hazard maps for various States, Alaska, and Puerto Rico. http://earthquake.usgs.gov/products_data/



and Analysis Tools.

number of on-line tools for an individual to assess the greatest hazard in a region, look up hazard by latitude/longitude, and download customized USGS hazard maps for an area of interest at a given distance from

Deterministic or Scenario Ground-Motion Maps.

Maps predict the median level of ground shaking from a particular "scenario" event. They do not take into account the likelihood of that scenario occurring, but they are helpful when assessing the potential impact of a particular event. [Need URL]

Time-Dependent Earthquake Probability Maps.

These maps forecast the likelihood of an earthquake rupture occurring during an interval of time in the future. Time-dependent maps are considered research tools and are not currently applied in building codes.

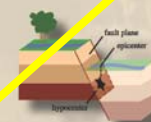
Primary Fault and Fold Database.

Web site contains information and associated folds in the United States are believed to be sources of earthquakes during the Quaternary (600,000 years). Maps of these geologic structures are linked to detailed descriptions and references. <http://earthquake.usgs.gov/qa/faults/>



Earthquake Hazards 101.

USGS provides a wealth of explanatory materials for the layperson, including information on concepts behind earthquake maps, the use of probability, what the maps mean, how they are made, and answers to frequently asked questions. <http://earthquake.usgs.gov/research/hazmaps/haz101/index.php>



Ground-Motion Maps.

Now more detailed hazard maps for California that take into account near-surface conditions, sedimentary directivity effects. <http://earthquake.usgs.gov/hazmaps/>

The following team contributed to this Fact Sheet: Mark D. Petersen, Arthur D. Frankel, Stephen C. Harmsen, Charles S. Mueller, Kathleen M. Haller, Russell L. Wheeler, Robert L. Wesson, Yuehua Zeng, David M. Perkins, Nicolas Luco, Kenneth S. Rukstales (USGS, Golden, Colo.); Oliver S. Boyd (USGS, Memphis, Tenn.); Edward H. Field (USGS, Pasadena, Calif.) and Chris J. Wills (California Geological Survey, Sacramento, Calif.).

For more information, see the Web site for the U.S. Geological Survey Earth Hazards Program at

<http://earthquake.usgs.gov/research/hazmaps/>



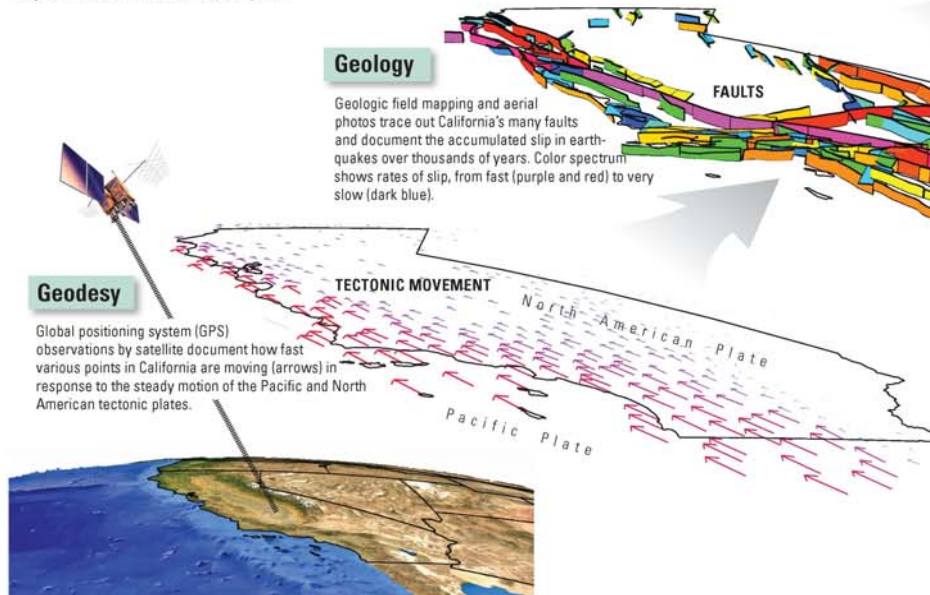
Conduct research needed to reduce the risk from earthquake hazards

How Did Scientists Make This Forecast?

California sits on the boundary between two of the Earth's major tectonic plates—the Pacific and North American Plates—which move inexorably past each other at a rate of about 2 inches per year. Much of this motion is accommodated from time to time by sudden slip on faults, producing earthquakes. Although the San Andreas Fault is the main locus of slip, hundreds, if not thousands, of other faults splay out from the plate boundary, spreading the threat of large earthquake ruptures through most of the State.

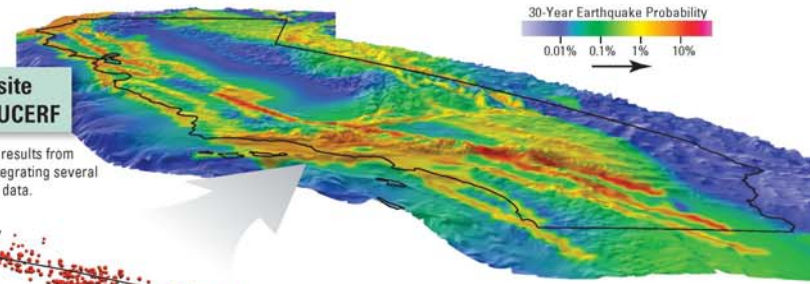
The new Uniform California Earthquake Rupture Forecast (UCERF) combines information from **geodesy** (precise data on the slow relative movement of the Earth's tectonic plates), **geology** (mapped locations of faults and documented offsets on them), **seismology** (occurrence patterns of past earthquakes), and **paleoseismology** (data from trenches across faults documenting the dates and offsets of past earthquakes on them). The first three kinds of data are shown here as layers in the diagram. All four kinds of data are combined mathematically to produce the final probability values for future ruptures in the California area, in regions of the State, and on individual faults.

Building on several previous studies and decades of data collection, UCERF was developed by a multidisciplinary group of scientists and engineers, known as the 2007 Working Group on California Earthquake Probabilities. Advice and comment was sought regularly from the broader community of earthquake scientists and engineers through open meetings and workshops. Where experts disagreed on aspects of the forecast, alternative options were accounted for in calculations to reflect these uncertainties. The final forecast is a sophisticated integration of scientific fact and expert opinion.



The Composite Forecast—UCERF

The final forecast results from evaluating and integrating several types of scientific data.



Paleoseismology

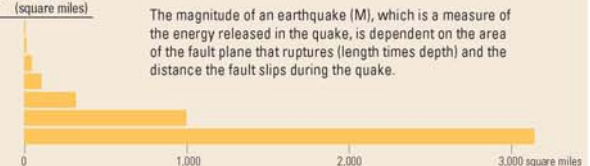
By analyzing the evidence for dates and amounts of slip of past earthquakes in the walls of a trench dug across a fault, scientists can extend the fault's earthquake record into prehistoric time.



M	Fault Plane Ruptured			
	Length (miles)	Depth (miles)	Average slip (feet)	Area (square miles)
5.0	1.8	1.8	0.5	
5.5	3.1	3.1	0.8	
6.0	5.6	5.6	1.5	
6.5	13	7.5	2.7	
7.0	42	7.5	4.8	
7.5	133	7.5	8.5	
8.0	420	7.5	15	

Earthquake Magnitudes and the Areas of Fault Rupture

The magnitude of an earthquake (M), which is a measure of the energy released in the quake, is dependent on the area of the fault plane that ruptures (length times depth) and the distance the fault slips during the quake.



NEHRP Draft Plan: Addressing the strategic priorities

In 2008, we are using multi-hazards initiative funds to make progress on two of the strategic priority areas:

- Fully implement Advanced National Seismic System (ANSS)
- Develop & conduct earthquake scenarios for effective earthquake risk mitigation



DRAFT FOR PUBLIC REVIEW AND COMMENT

www.nehrp.gov/plans/publiccomment.htm



Strategic Plan

for the

National Earthquake Hazards Reduction Program

Fiscal Years 2008–2012

April 2008

Draft for Public Review and Comment



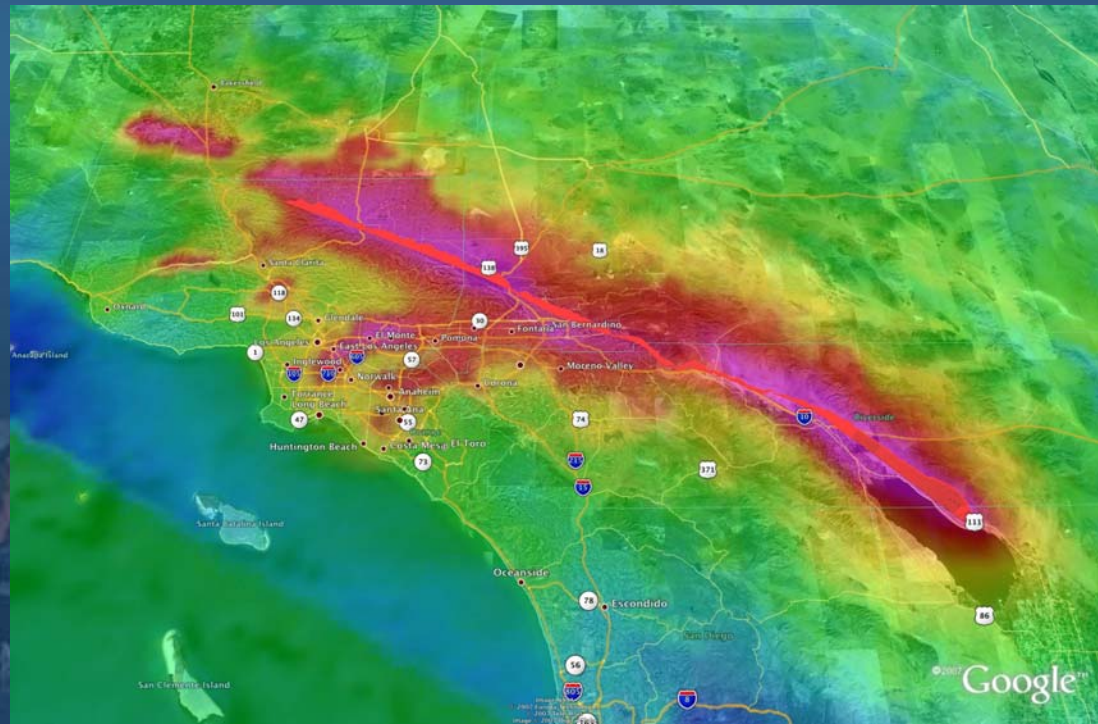
The Great Southern California ShakeOut

- USGS and partners will create complete “rupture-to-recovery scenario” for most likely earthquake
- Use scenario to run region-wide exercise in 2008
- Agreement with Office of Homeland Security to make this the 2008 “Golden Guardian Exercise”

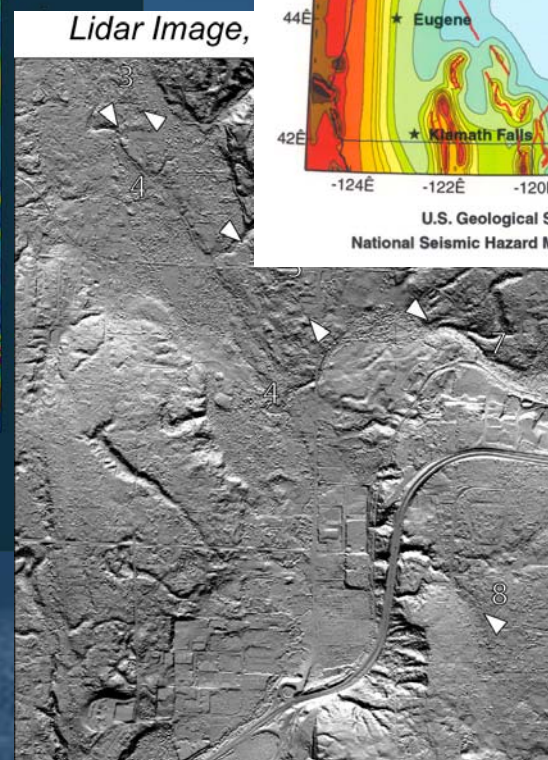
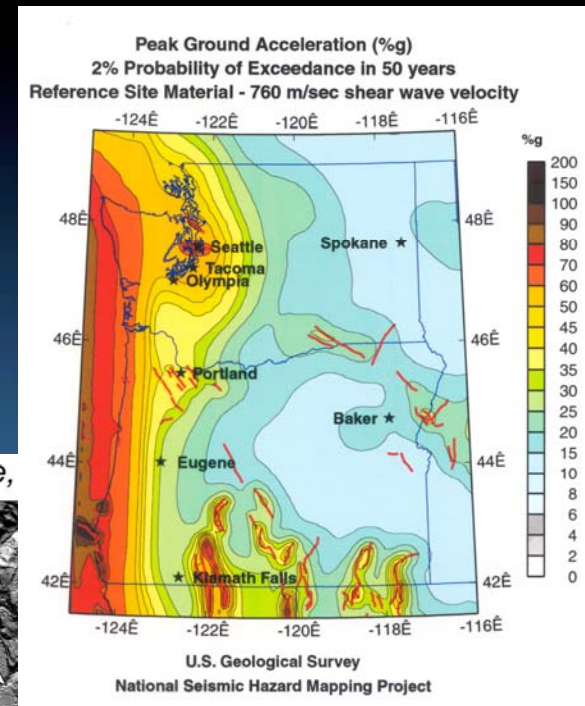
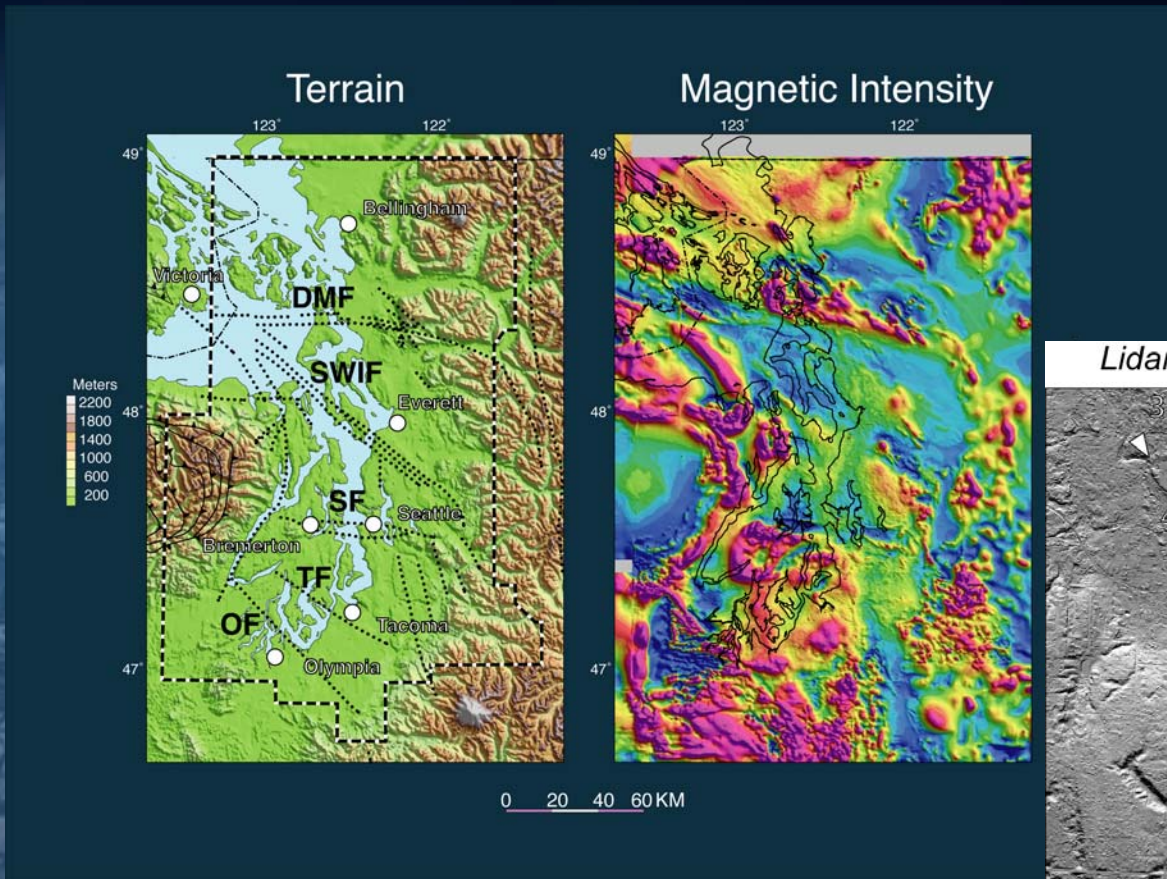


DARE
to prepare

2007 Earthquake Readiness Campaign



Taking the multi-hazard initiative on the road: Pacific Northwest



Urban hazard mapping in the Central U.S. involves many local and state partners



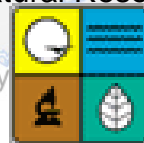
St. Louis

Memphis

Evansville



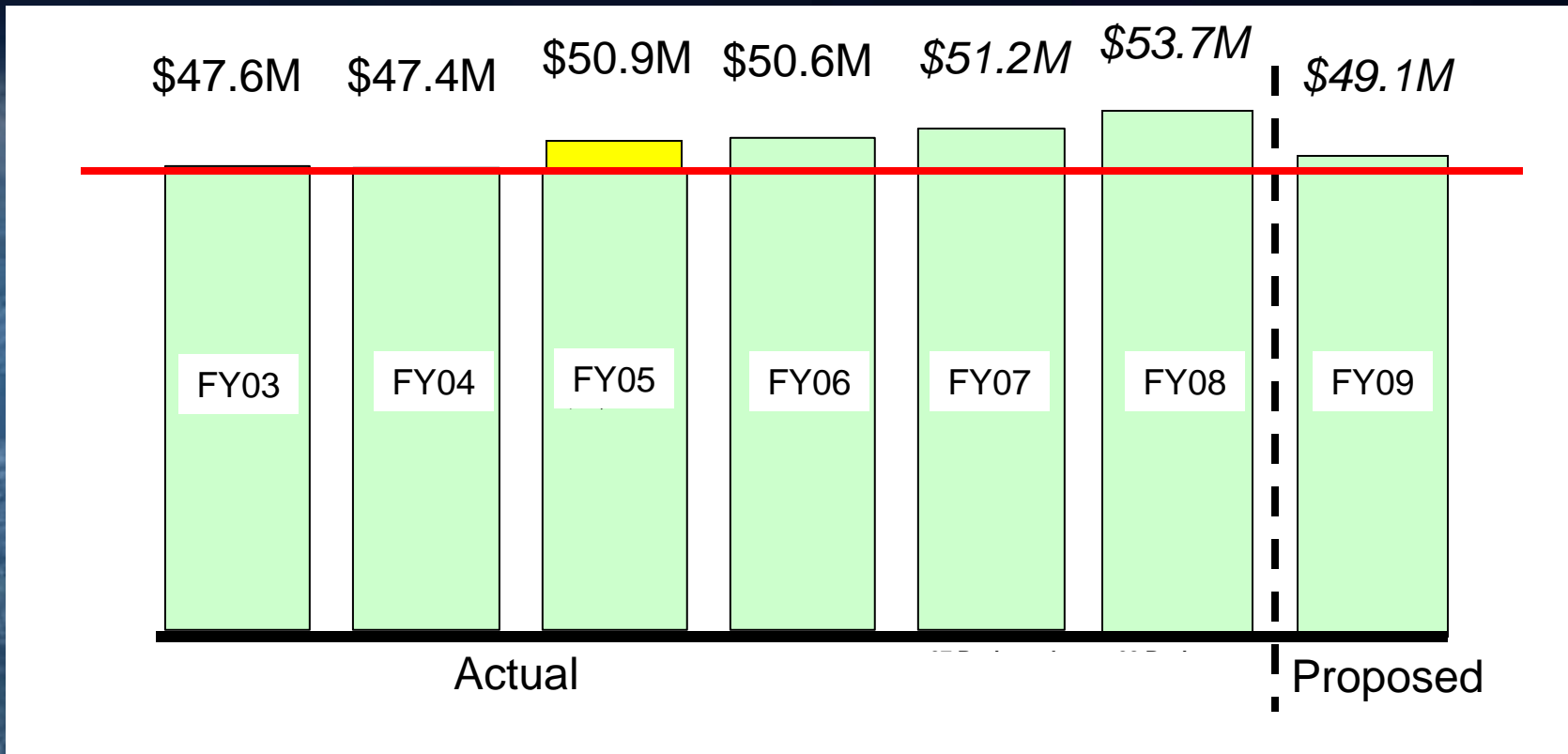
THE UNIVERSITY OF
MEMPHIS



Scientific Earthquake Studies Advisory Committee 2007 report recommendations

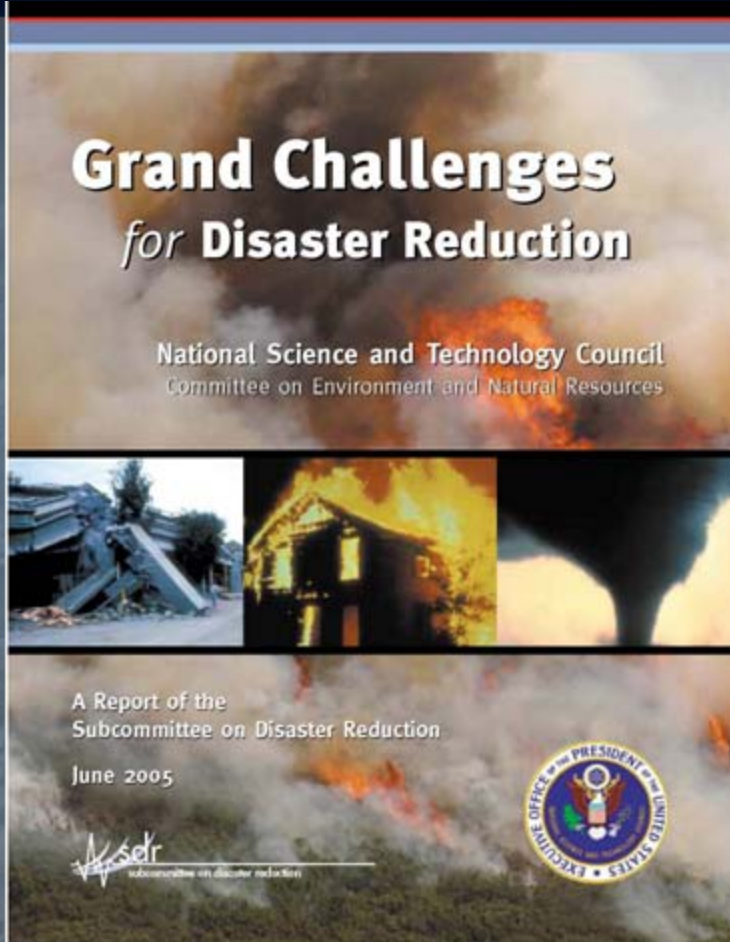
1. Full funding of the ANSS at authorized levels.
2. Endorsement of multi-hazards demonstration project and encourage expansion to include other high-risk areas.
3. USGS should develop comprehensive monitoring, analysis and research program to study the significance of episodic tremor and slip events.
4. Need for hiring in order to maintain ability of USGS to fulfill its NEHRP responsibilities.

Recent Earthquake Hazards Program funding history and FY09 request



Grand Challenges for Disaster Reduction

National Science & Technology Council
Subcommittee on Disaster Reduction



1. Provide hazard and disaster information where and when it is needed.
2. Understand the natural processes that produce hazards.
3. Develop hazard mitigation strategies and technologies.
4. Recognize and reduce vulnerability of interdependent critical infrastructure.
5. Assess disaster resilience using standard methods.
6. Promote risk-wise behavior.

Implementation plans

Grand Challenges for Disaster Reduction

National Science and Technology Council
Committee on Environment and Natural Resources

A Report of the
Subcommittee on Disaster Reduction

June 2005
Second Printing January 2008

 sdr
subcommittee on disaster reduction



EARTHQUAKE



HUMAN AND
ECOSYSTEM HEALTH



FLOOD



COASTAL
INUNDATION



TECHNOLOGICAL
DISASTERS



HEAT WAVE



WILDLAND FIRE



VOLCANO



DROUGHT



WINTER STORM



TSUNAMI



HURRICANE



TORNADO



LANDSLIDE AND
DEBRIS FLOW

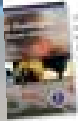


Table of Contents



Introduction
1. Grand Challenges for Disaster Reduction
2. Grand Challenge 1: Earthquake
3. Grand Challenge 2: Human and Ecosystem Health
4. Grand Challenge 3: Flood
5. Grand Challenge 4: Coastal Inundation
6. Grand Challenge 5: Technological Disasters
7. Grand Challenge 6: Heat Wave
8. Grand Challenge 7: Wildland Fire
9. Grand Challenge 8: Volcano
10. Grand Challenge 9: Drought
11. Grand Challenge 10: Winter Storm
12. Grand Challenge 11: Tsunami
13. Grand Challenge 12: Hurricane
14. Grand Challenge 13: Tornado
15. Grand Challenge 14: Landslide and Debris Flow
Appendix A: Glossary
Appendix B: Acronyms
Appendix C: Abbreviations
Appendix D: References
Appendix E: Contributors
Appendix F: Acknowledgments
Appendix G: Disclaimer
Appendix H: Contact Information
Appendix I: Executive Summary
Appendix J: Introduction
Appendix K: Grand Challenges
Appendix L: Summary
Appendix M: Glossary
Appendix N: Acronyms
Appendix O: Abbreviations
Appendix P: References
Appendix Q: Contributors
Appendix R: Acknowledgments
Appendix S: Disclaimer
Appendix T: Contact Information



Introduction
1. Grand Challenges for Disaster Reduction
2. Grand Challenge 1: Earthquake
3. Grand Challenge 2: Human and Ecosystem Health
4. Grand Challenge 3: Flood
5. Grand Challenge 4: Coastal Inundation
6. Grand Challenge 5: Technological Disasters
7. Grand Challenge 6: Heat Wave
8. Grand Challenge 7: Wildland Fire
9. Grand Challenge 8: Volcano
10. Grand Challenge 9: Drought
11. Grand Challenge 10: Winter Storm
12. Grand Challenge 11: Tsunami
13. Grand Challenge 12: Hurricane
14. Grand Challenge 13: Tornado
15. Grand Challenge 14: Landslide and Debris Flow
Appendix A: Glossary
Appendix B: Acronyms
Appendix C: Abbreviations
Appendix D: References
Appendix E: Contributors
Appendix F: Acknowledgments
Appendix G: Disclaimer
Appendix H: Contact Information

More information
available at
www.sdr.gov