Earthquake Hazards in Henderson

Craig M. dePolo

Nevada Bureau of Mines and Geology

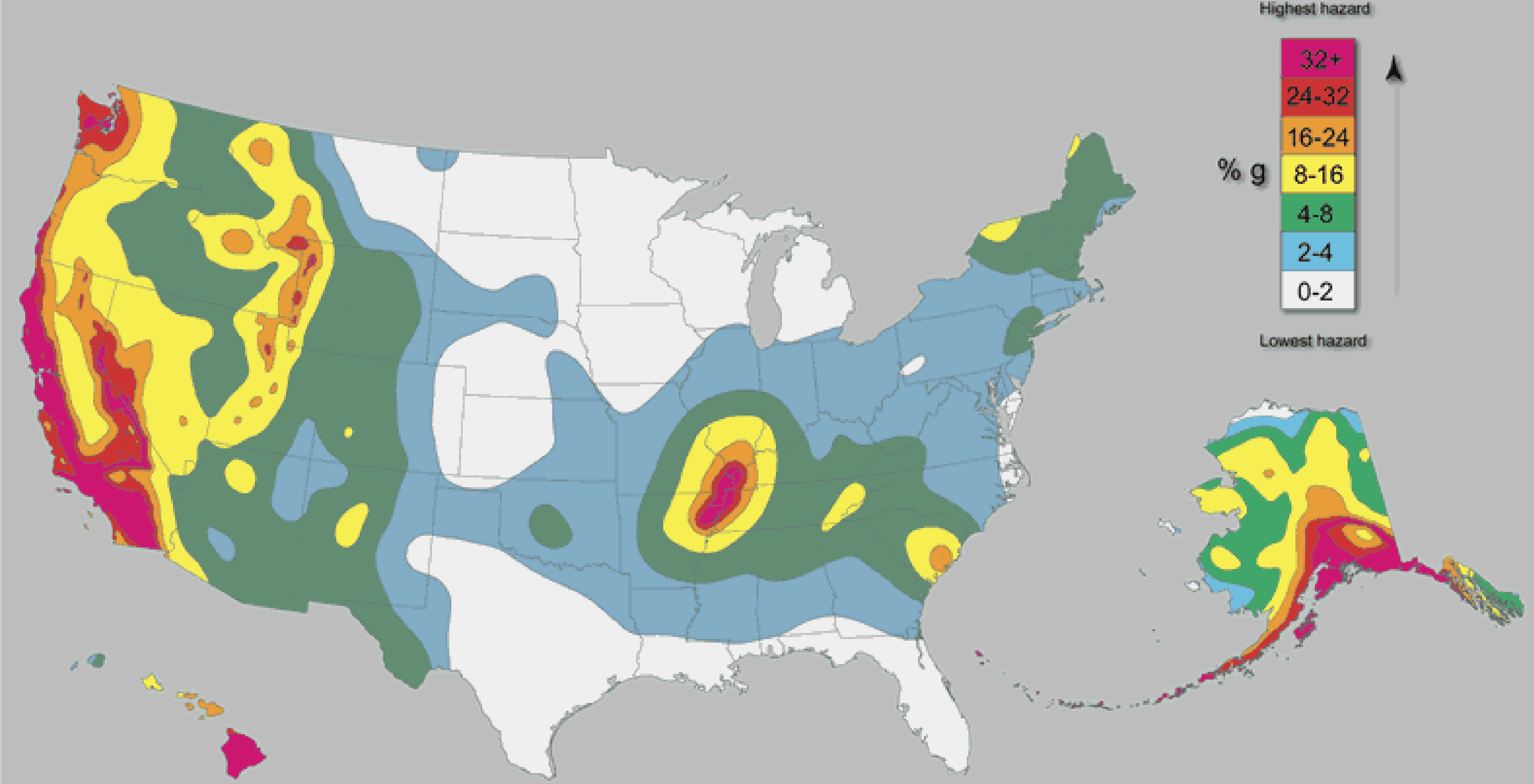
Nevada Hazard Mitigation Planning Committee

November 15, 2012

Earthquake Truths

- The consequences of bad earthquakes to unprepared communities are unacceptable.

- We know how to plan for, prepare for, and mitigate against disastrous earthquake effects. We know how to minimize injuries and property loss.



The USGS integrates (1) faults, (2) earthquakes, and (3) geodetic data into its probabilistic seismic hazard analysis.

The Earthquake Hazard

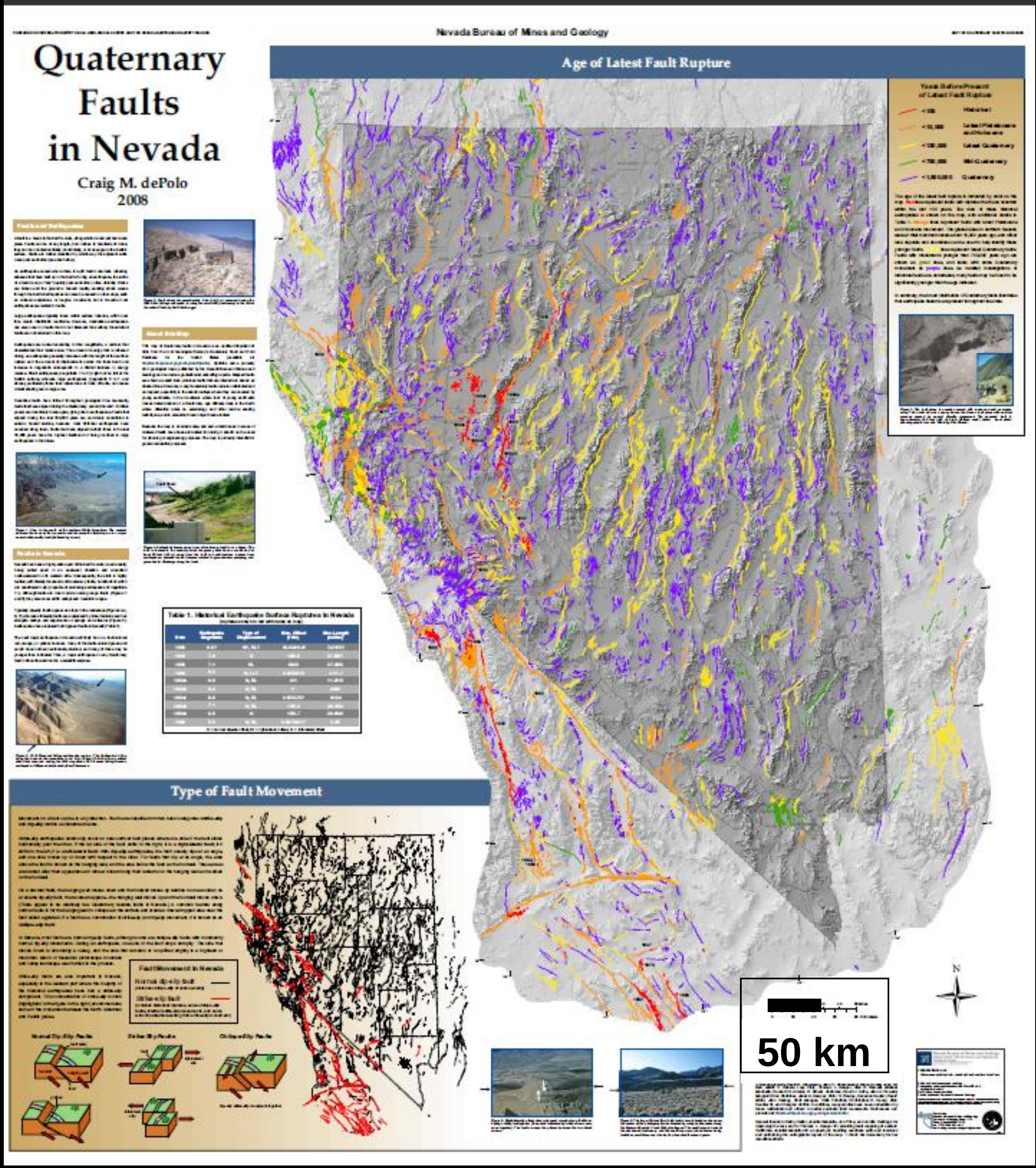
Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities.

NBMG Map 167, *Quaternary Faults in Nevada*, is available as a poster and as an interactive map (Open-File Report 09-9) on line at www.nbmg.unr.edu. You can use it to locate your home or business.

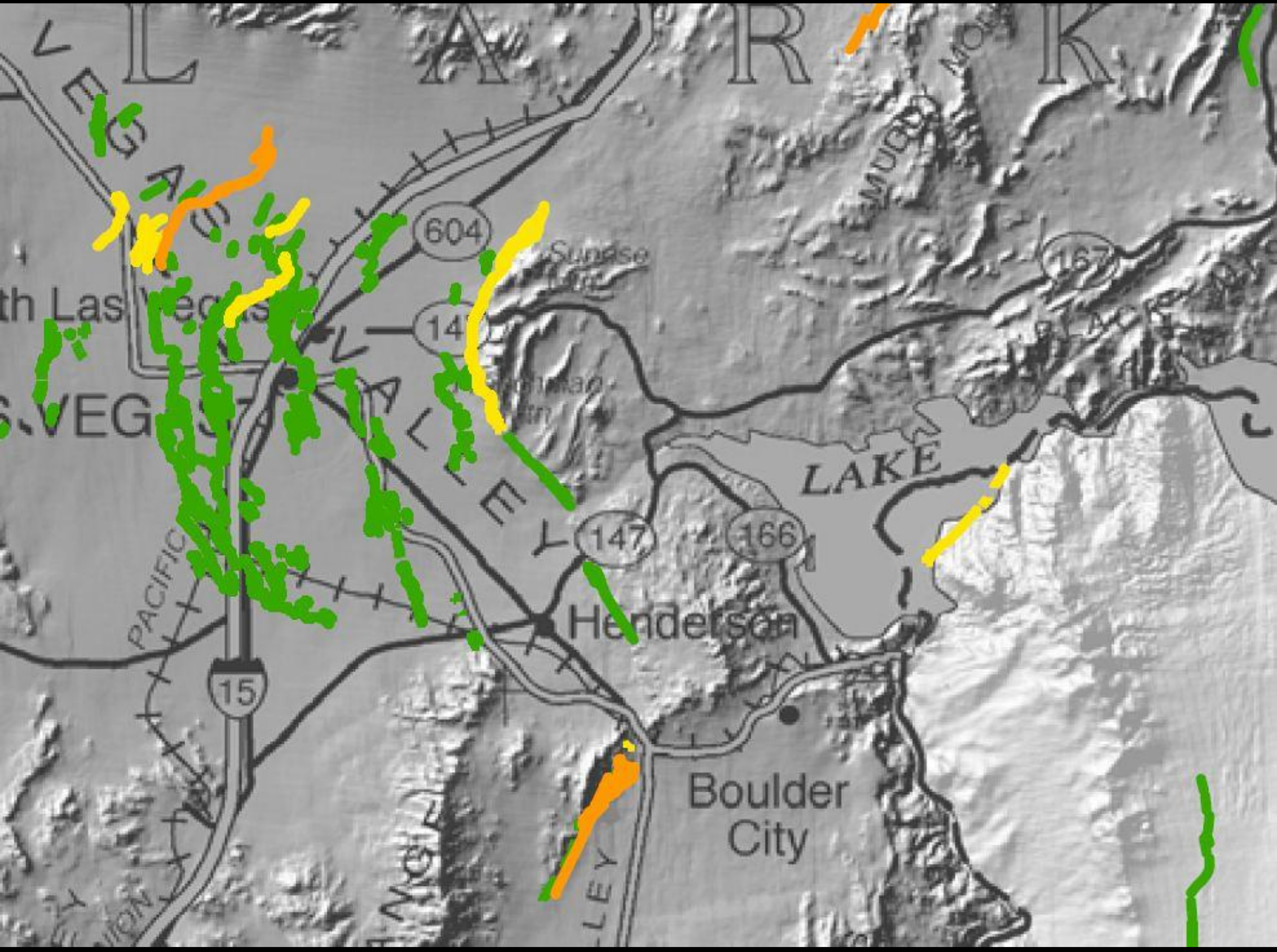
Age of Latest Fault Rupture

- < 150 years (historical)
- < 15,000 years
- < 130,000 years
- < 750,000 years
- < 1,800,000 years (Quaternary)

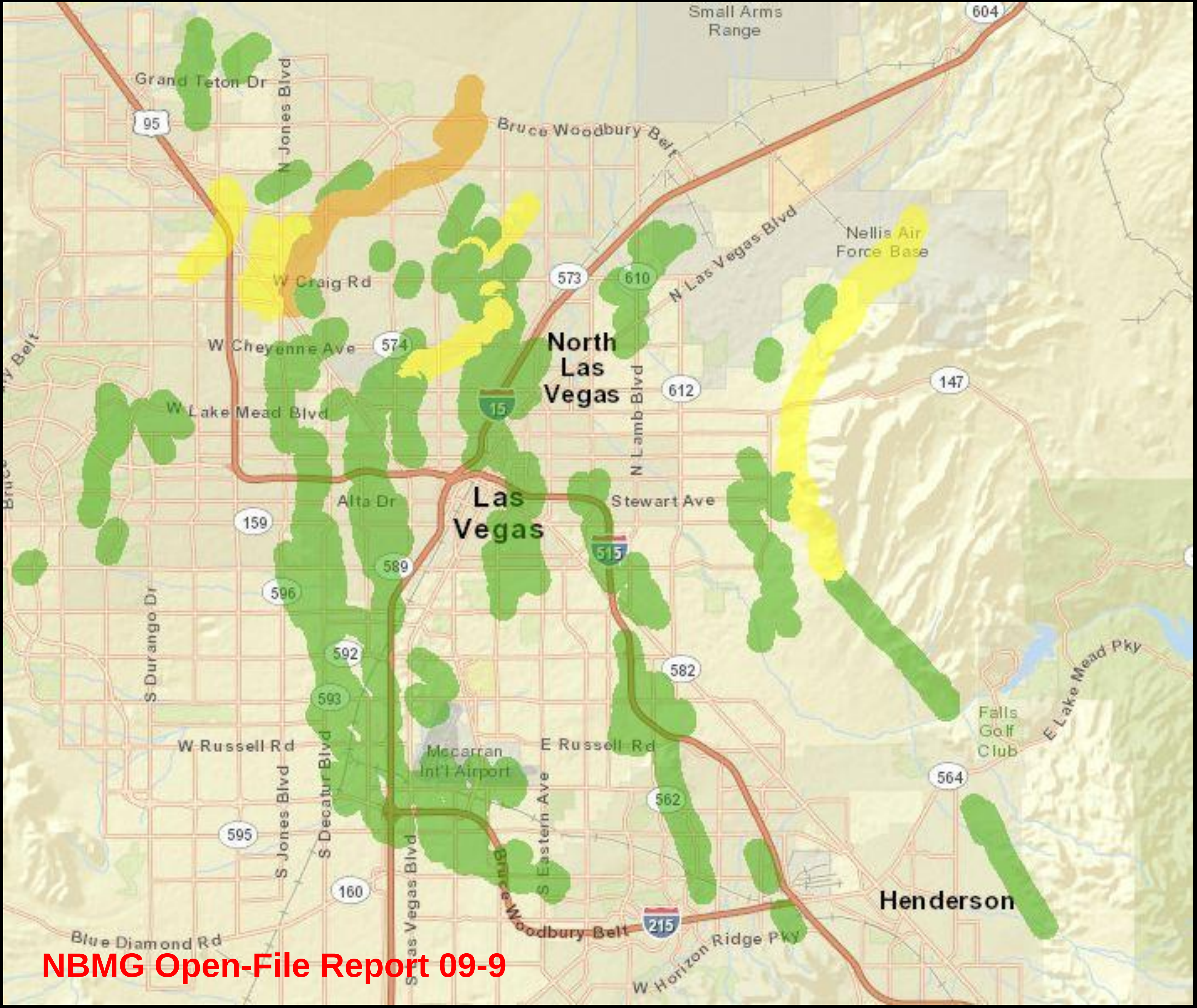
Active faults are nearly everywhere in Nevada.
A magnitude 6.0 earthquake can occur anywhere in Nevada.



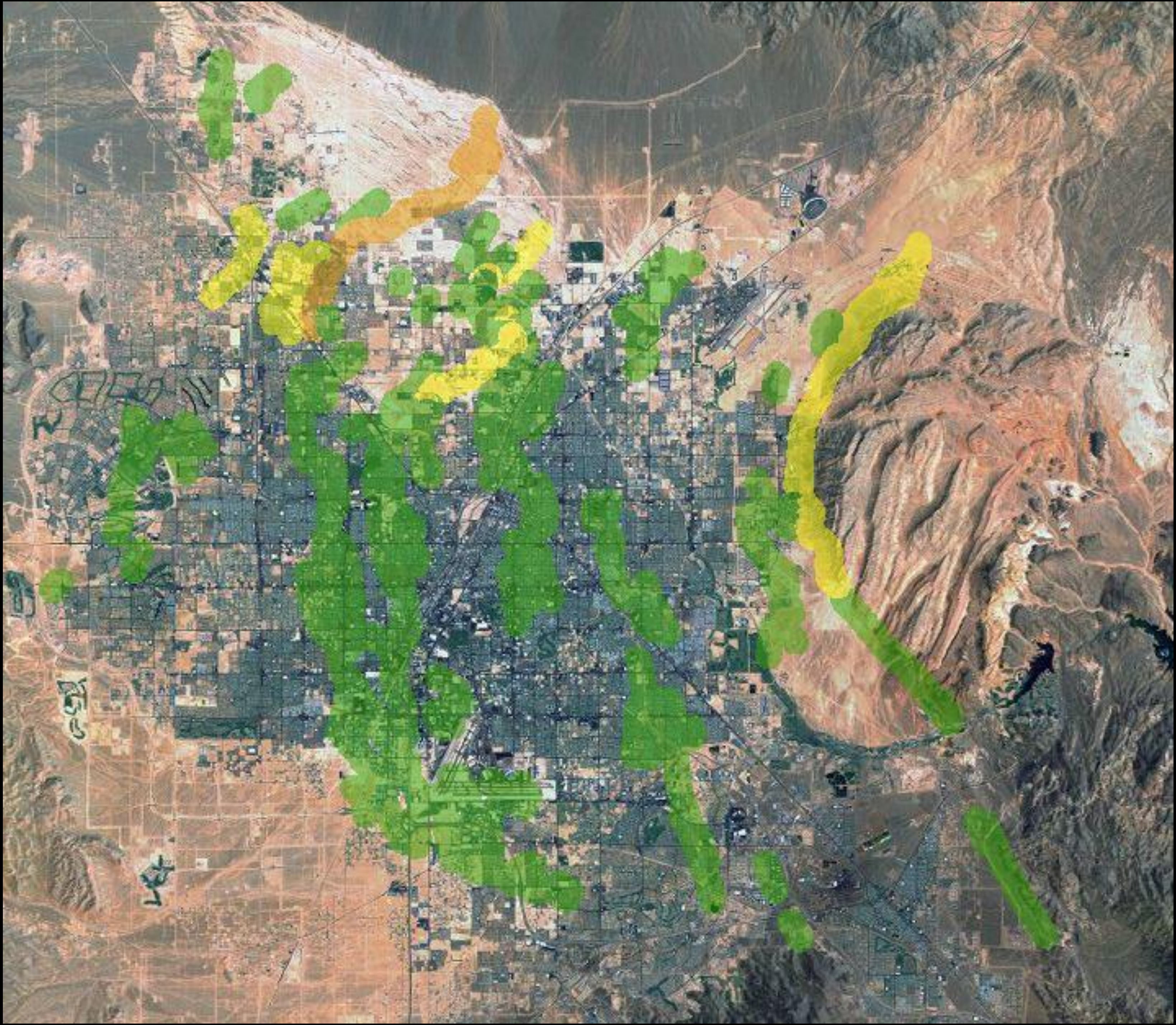
www.nbmg.unr.edu

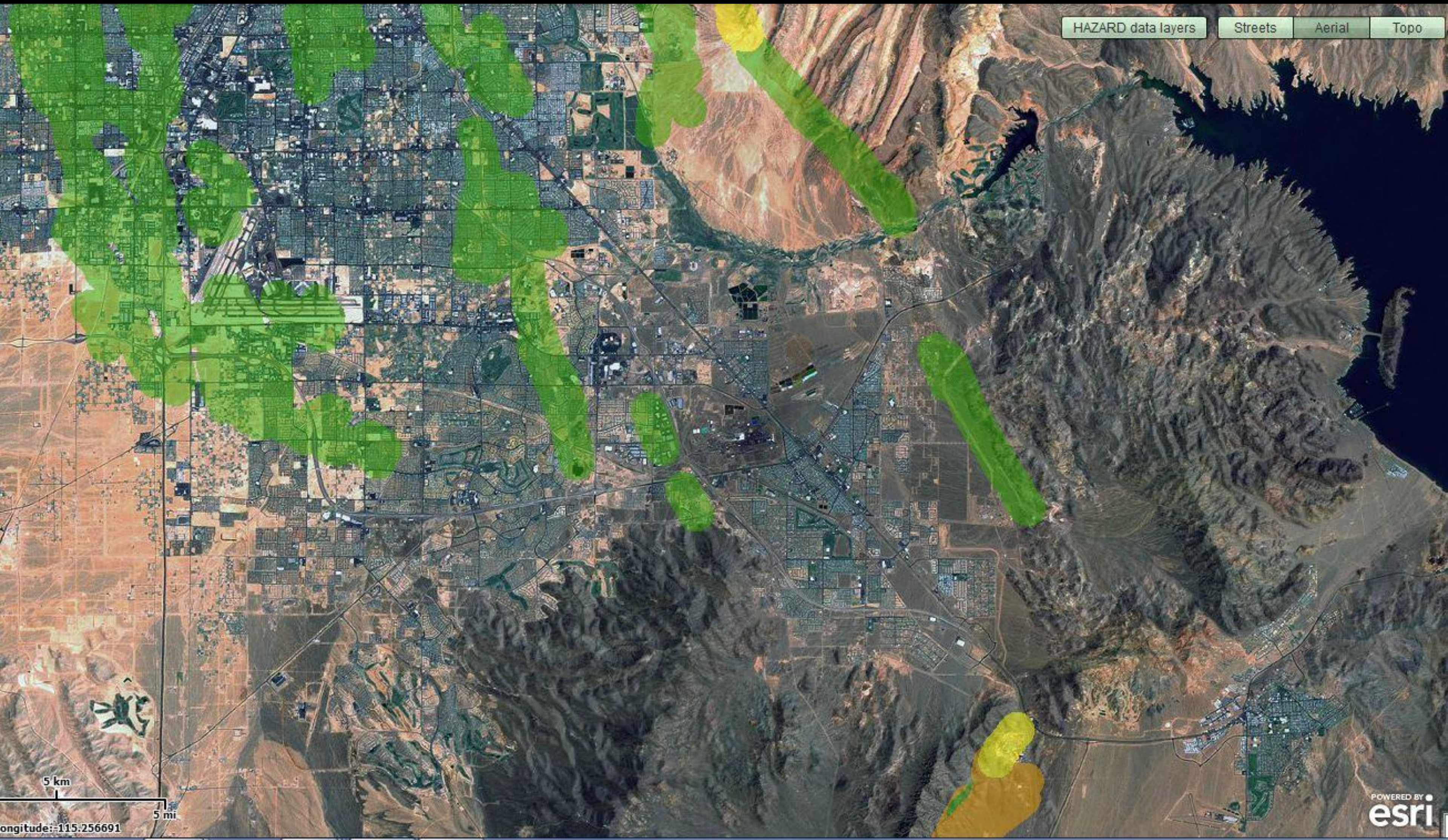


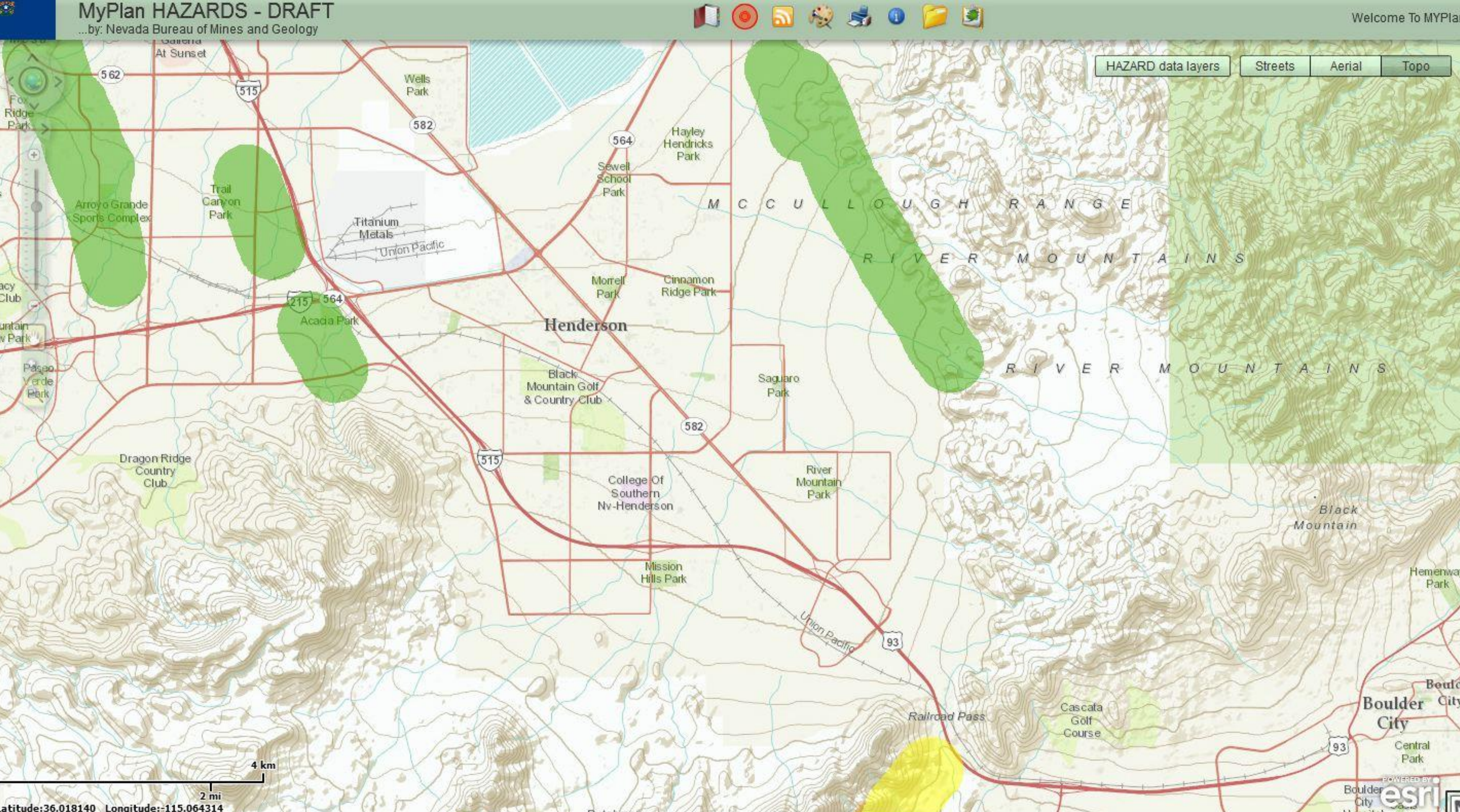
LAS VEGAS VALLEY
LAKE
604
147
147
166
167
15
th Las Vegas
S.VEGAS
Henderson
Boulder City
MUDDY
PACIFIC



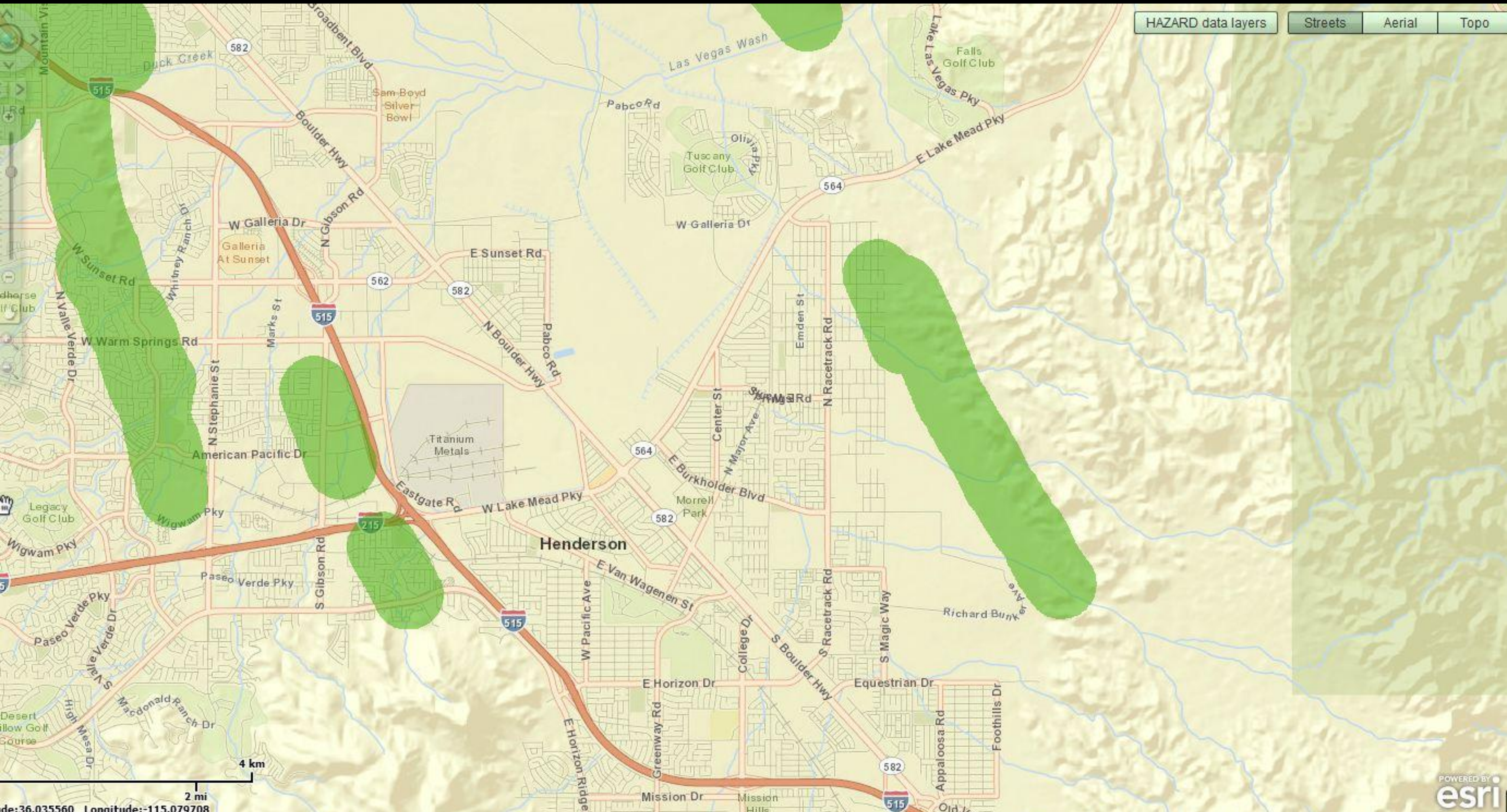
NBMG Open-File Report 09-9




HAZARD data layers
Streets
Aerial
Topo
5 km
5 mi
ongitude:-115.256691
POWERED BY
esri



MyPlan HAZARDS - DRAFT
...by: Nevada Bureau of Mines and Geology
Welcome To MYPlan
HAZARD data layers
Streets
Aerial
Topo
Wells Park
Hayley Hendricks Park
Sewell School Park
Trail Canyon Park
Arroyo Grande Sports Complex
Titanium Metals
Union Pacific
M C C U L L O U G H R A N G E
R I V E R M O U N T A I N S
Morrell Park
Cinnamon Ridge Park
Acacia Park
Henderson
Black Mountain Golf & Country Club
Saguaro Park
Paseo Verde Park
Dragon Ridge Country Club
College Of Southern Nv-Henderson
River Mountain Park
Black Mountain
Mission Hills Park
Hemenway Park
Railroad Pass
Cascata Golf Course
Boulder City
Central Park
4 km
2 mi
Latitude:36.018140 Longitude:-115.064314


HAZARD data layers
Streets
Aerial
Topo
Las Vegas Wash
Duck Creek
Broadbent Blvd
Sam Boyd Silver Bowl
Pabco Rd
Falls Golf Club
Lake Las Vegas Pky
E Lake Mead Pky
Tuscany Golf Club
Olivia Pky
Boulder Hwy
N Gibson Rd
W Galleria Dr
Galleria At Sunset
Whitney Ranch Dr
W Sunset Rd
E Sunset Rd
N Valle Verde Dr
W Warm Springs Rd
Marks St
N Boulder Hwy
Pabco Rd
Emden St
N Racetrack Rd
N Stephanie St
American Pacific Dr
Titanium Metals
Center St
N Major Ave
E Burkholder Blvd
Eastgate Rd
W Lake Mead Pky
Morrell Park
Legacy Golf Club
Wigwam Pky
Henderson
Paseo Verde Pky
S Gibson Rd
E Van Wagenen St
W Pacific Ave
College Dr
S Boulder Hwy
S Racetrack Rd
S Magic Way
Richard Bunker Ave
E Horizon Dr
Equestrian Dr
Foothills Dr
Appaloosa Rd
Greenway Rd
E Horizon Ridge
Macdonald Ranch Dr
High Mesa Dr
S Valle Verde Dr
Mission Dr
Mission Hills
Old Vegas
4 km
2 mi
de:36.035560 Longitude:-115.079708
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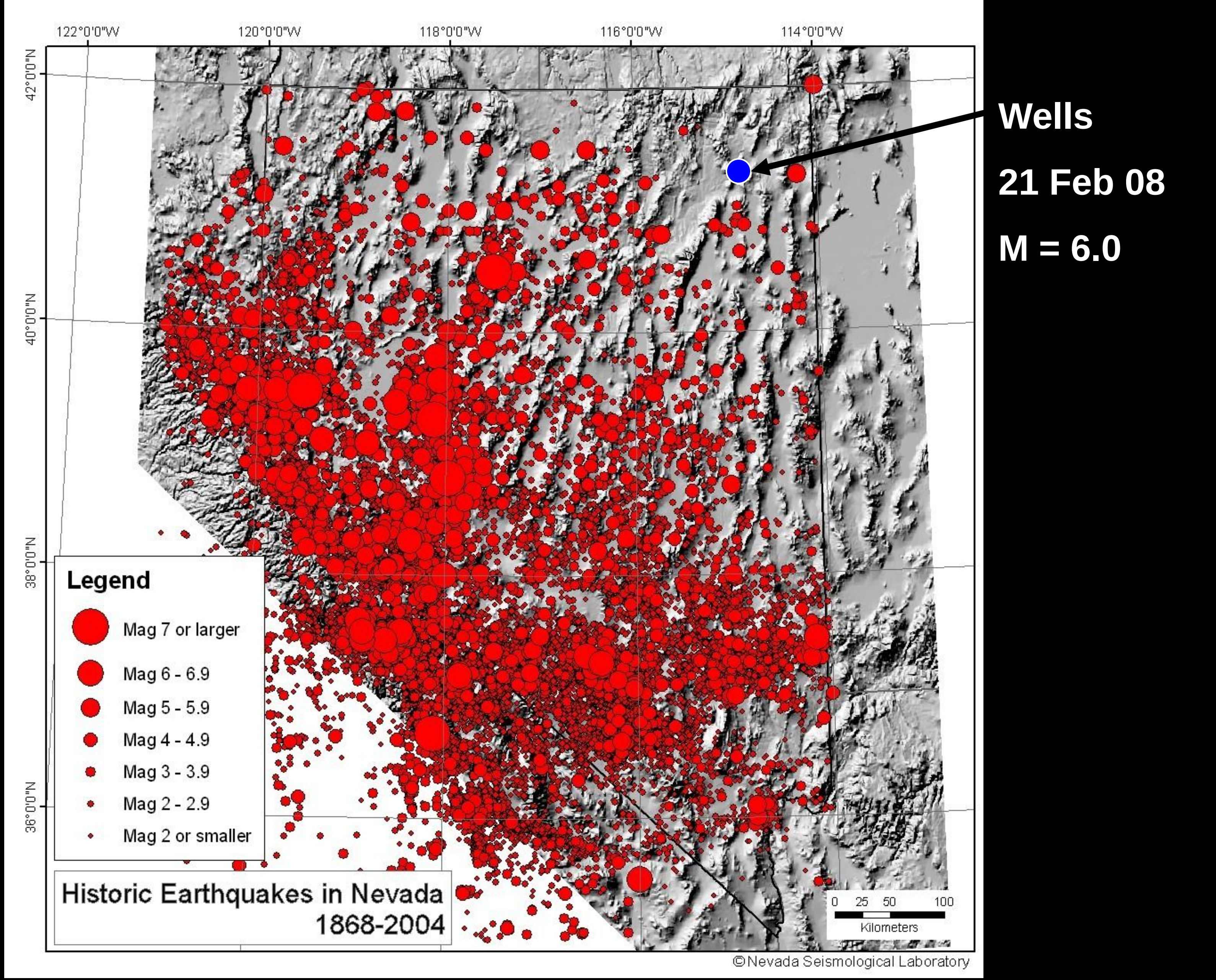
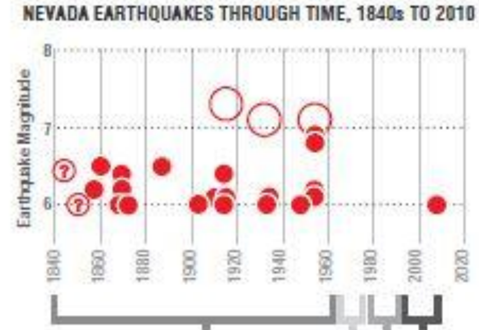


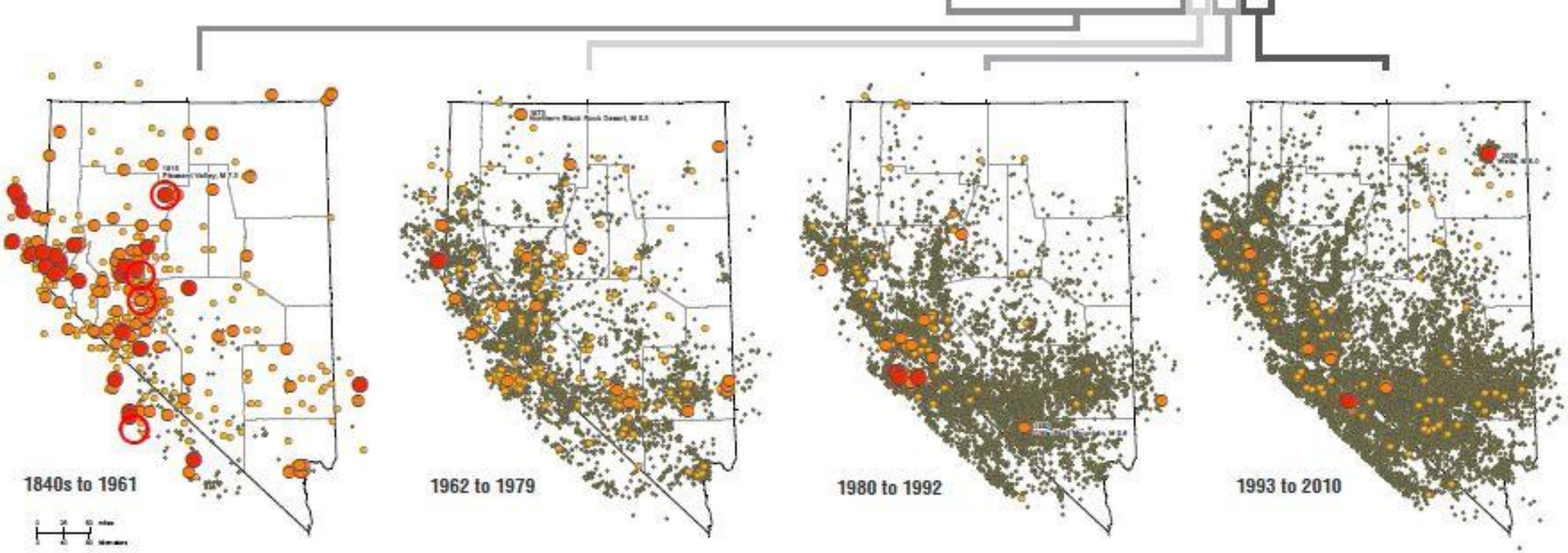
(2) Earthquakes have occurred throughout Nevada.

Earthquakes Through Time

170 Years of Earthquake History in Nevada

Although the number of earthquakes recorded has increased through time due to an increase in the number of seismic monitoring stations, the occurrence of the larger, well-recorded events has been variable through the last 170 years with recent years exhibiting relative quiescence. Larger earthquakes in Nevada have occurred as individual events or in groups. There have also been decades without them. To illustrate this temporal variability, we show earthquake epicenters over four time periods and a graph of magnitude ≥6 earthquakes over time. The time periods for the maps are selected based on the number of seismic stations and their density and, thus, the earthquake-locating capability. The precision of earthquake locations and the number of recorded events improves with time.





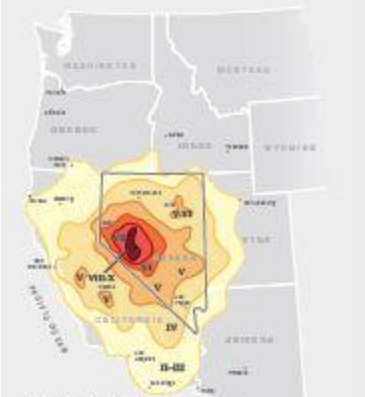
Damaging Earthquakes in Nevada

1840s to 2008

Craig M. dePolo
Nevada Bureau of Mines and Geology

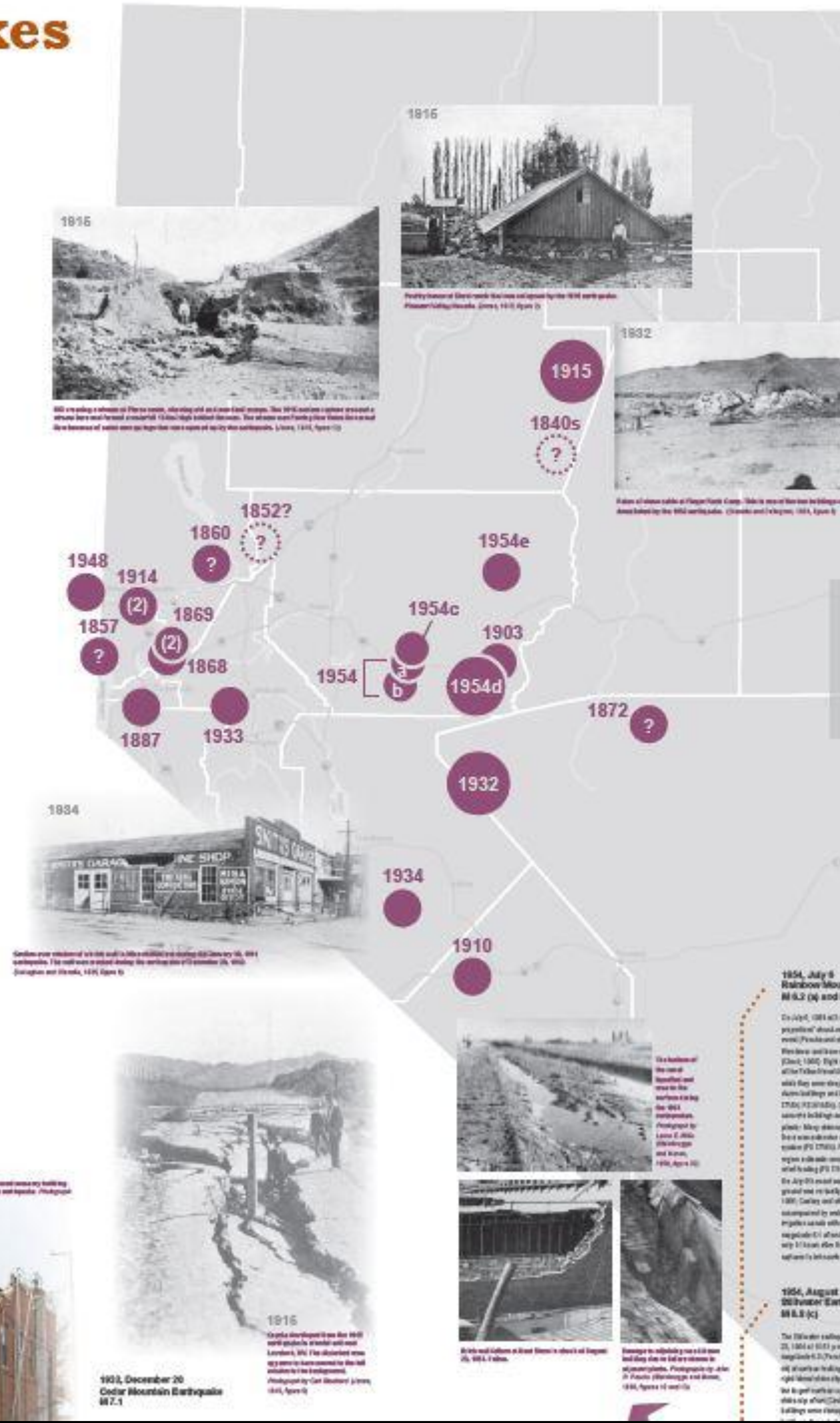
2012

December 16, 1954
Fairview Peak-Dixie Valley Earthquakes
M 7.1 and M 6.9

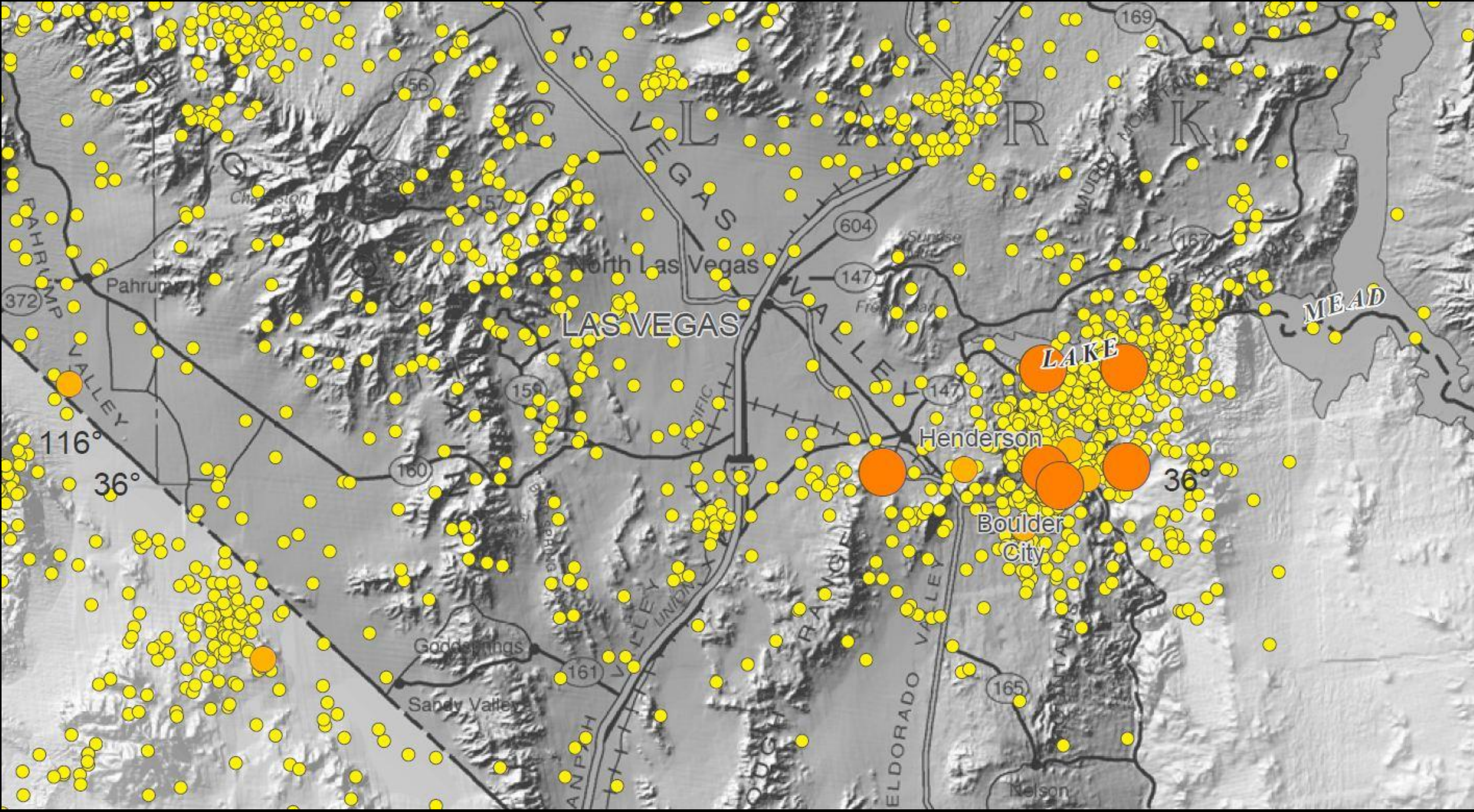


December 21, 1932
Cedar Mountain Earthquake
M 7.1

The damaging earthquakes briefly described on this map occurred during the period from the mid-1800s to 2008. They are the largest historical examples, but do not include all significant and damaging earthquake events in the state. These events and their descriptions remind us that Nevada is earthquake country and that earthquakes will produce strong shaking within our communities in the future. A wise course of action for Nevadans is to heed the lessons of past events, know how to react to an earthquake, and actively prepare for earthquakes. Many ideas to stay safe and protect your property from earthquakes can be found in *Living with Earthquakes in Nevada* on the web at www.nbmg.unr.edu (NBMG Special Publication 27).



1932, December 20
Cedar Mountain Earthquake
M7.1



LAS VEGAS
North Las Vegas
Henderson
Boulder City
Pahrump
Goodsprings
Sandy Valley
Nelson
LAKE
MEAD
VALLEY
EL DORADO VALLEY
116°
36°
36°
372
156
604
147
147
159
160
161
165
167
169

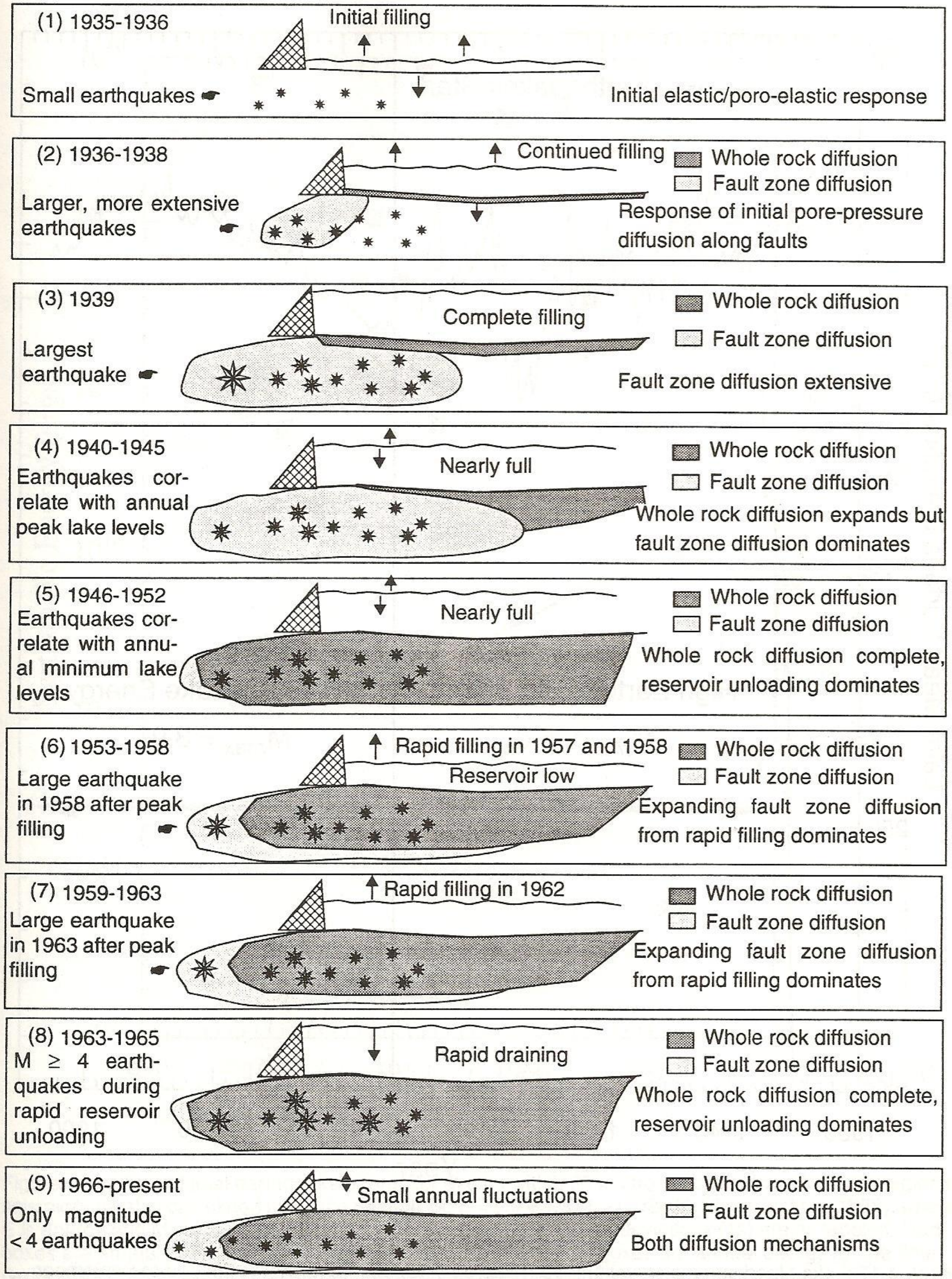


Figure 4-16. Schematic diagram of the time evolution of reservoir-induced seismicity near Hoover Dam.

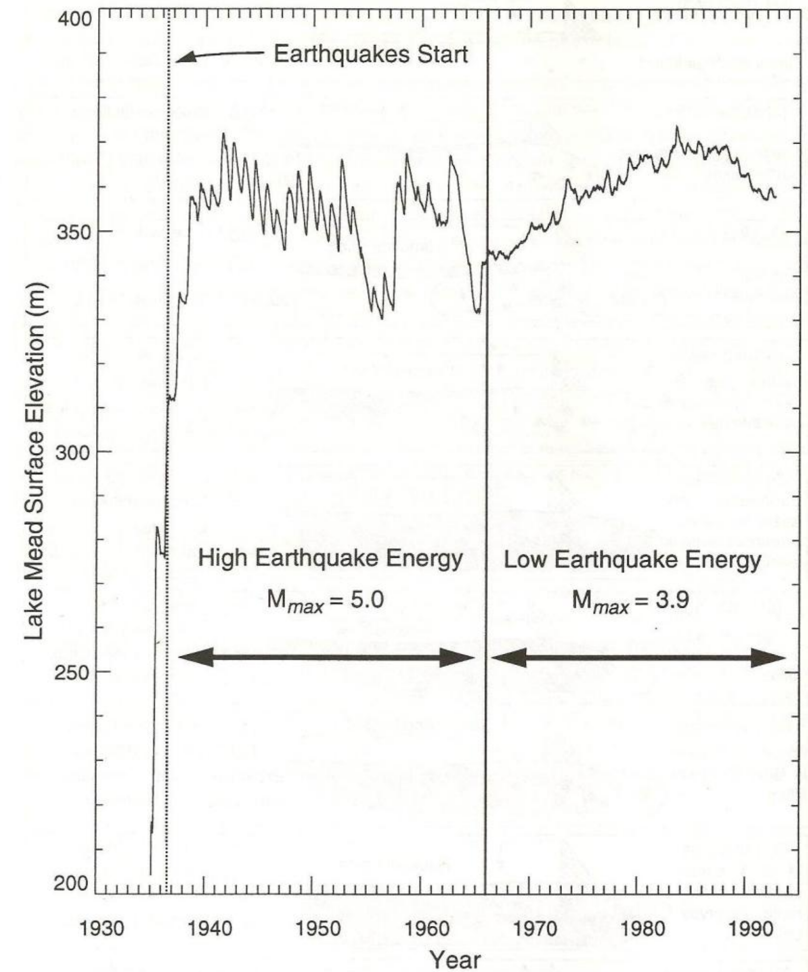


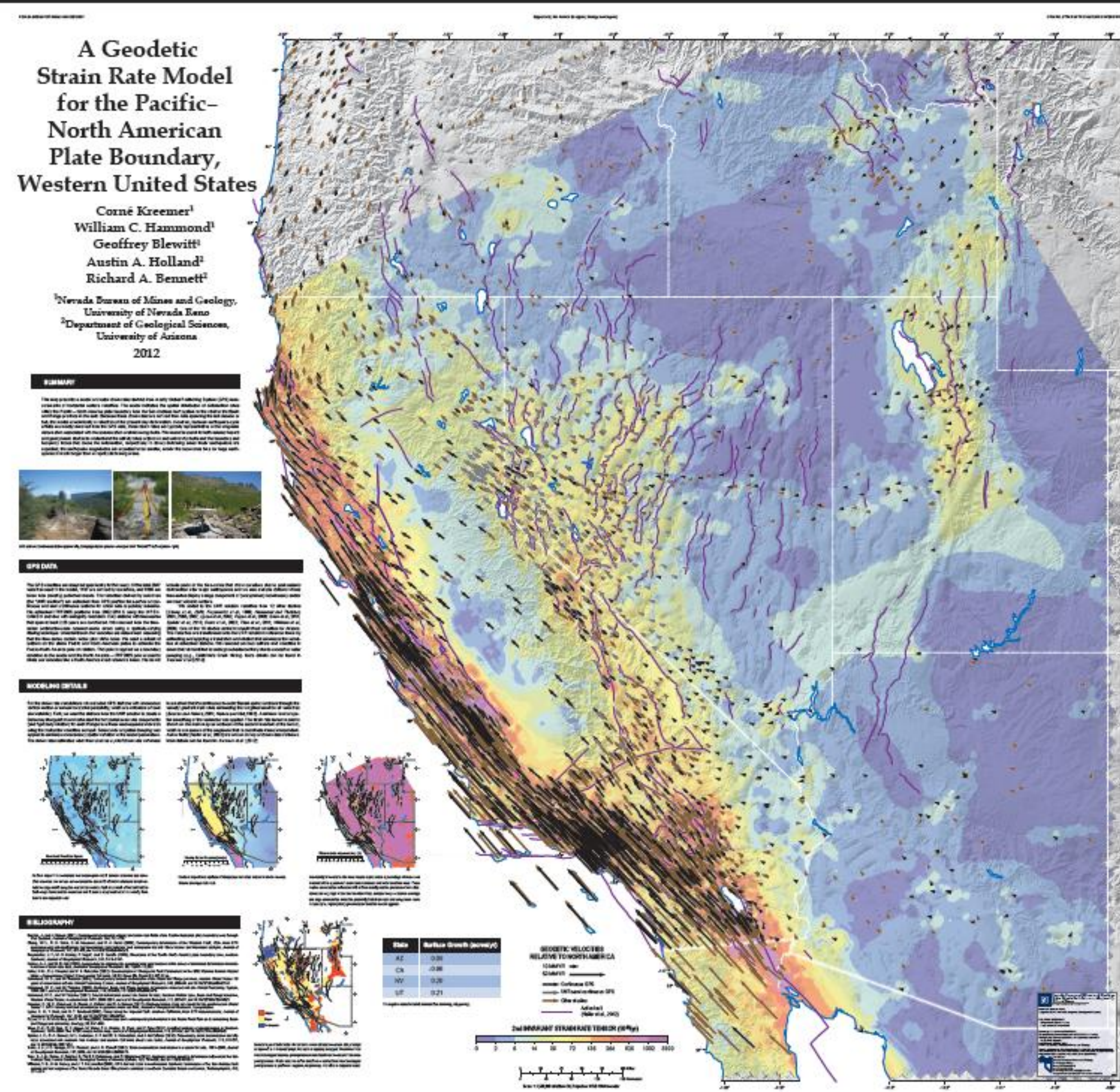
Figure 4-17. Lake Mead surface elevations from February 1935 (initial filling) to the end of September 1992. See Fig. 4-18 for annual earthquake energy for the same time period.

Reservoir-Induced Earthquakes

U.S. Bureau of Reclamation (1993)

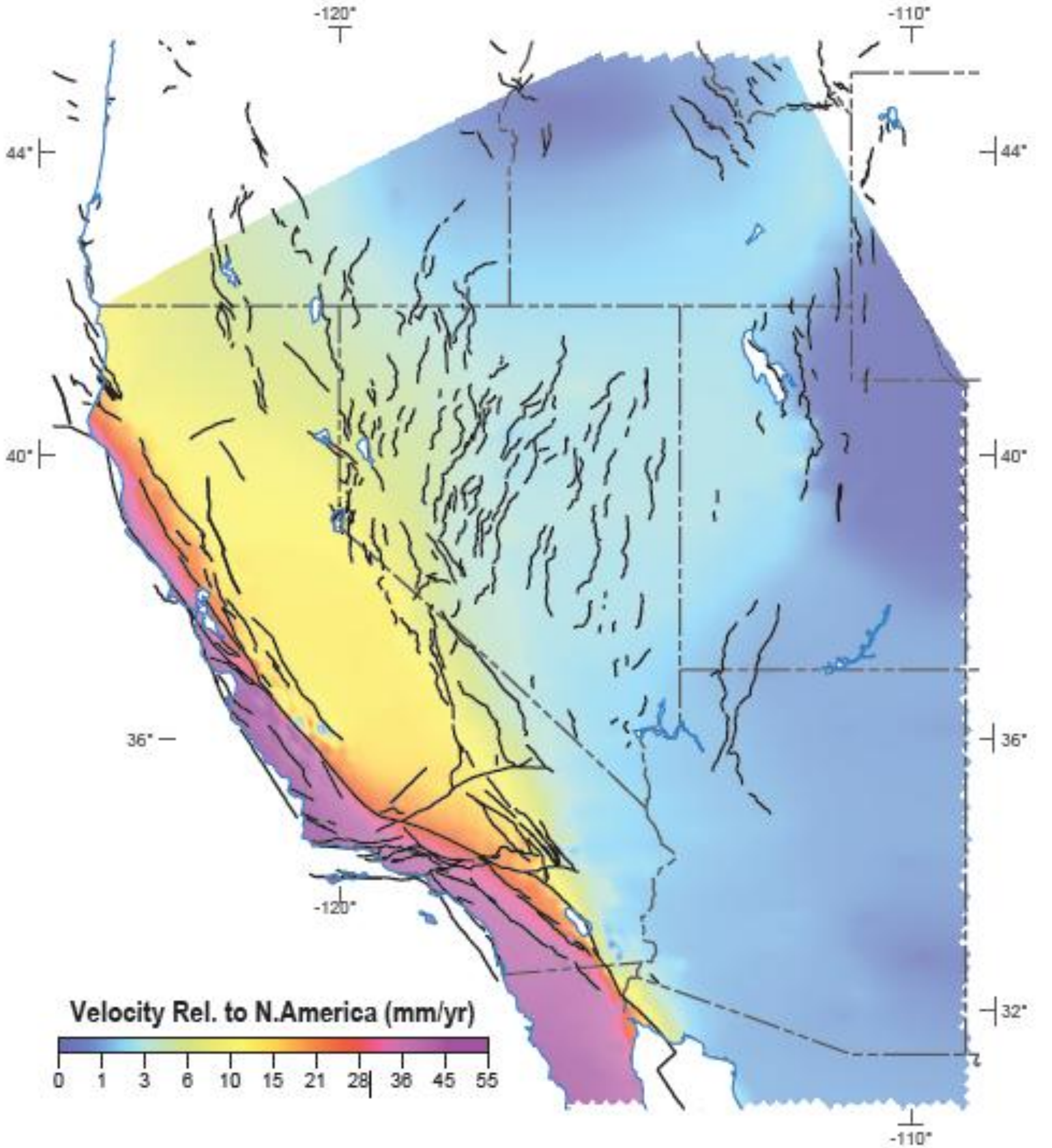
Earthquakes within Las Vegas Valley

Jan. 8, 1989	M3.5	N. Las Vegas
Feb. 3, 2001	M3.5	W. Las Vegas V.



Kreemer et al. (2012)

Geodetic data indicate that the Nevada is gaining about 0.2 acre of area per year through crustal extension, and that western Nevada is accommodating ~20% of the North American-Pacific plate interaction.



Contour map of the amplitude of interpolated velocities relative to North America. Results are clipped at coast.

West of the San Andreas fault in California, the Pacific Plate is moving northwest relative to the North American Plate.

Kreemer et al. (2012)

The hazard: expressed in terms of probability of an earthquake of a given magnitude occurring within 50 years and within 50 km (31 miles) of the community.

% Probability of > or = magnitude

Community	5.0	5.5	6.0	6.5	7.0
Dayton	>90	~80	70-75	50-55	12-15
Carson City	>90	~80	70	50-55	12-15
Reno	>90	~80	67	50	12-15
Incline Village	>90	~80	60-70	40-50	10-12
Stateline	>90	~80	60-70	40-50	10
Fallon	80-90	~60	35	20-25	6-8
Henderson	50-60%	~30%	12%	4-5%	<0.5%
Las Vegas	40-50	~30	12	4-5	<0.5
Elko	30-40	~25	10-15	6-8	0.5-1
Wells	30-40	~20	9	6	0.5-1
Laughlin	10-20	~5	2-3	0.5-1	<0.5

Data are from the USGS at http://eqint.cr.usgs.gov/eqprob/2002/index.php .
Values for magnitude 5.5 are extrapolated between 5.0 and 6.0.

Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities.

NBMG Open-File Report 09-8, *Estimated Losses from Earthquakes near Nevada Communities*, demonstrates that the consequences of earthquakes can be huge in Nevada, particularly if individuals are not prepared.

HAZUS scenarios for magnitude 5.0, 5.5, 6.0, 6.5, and 7.0 earthquakes near 38 communities in Nevada

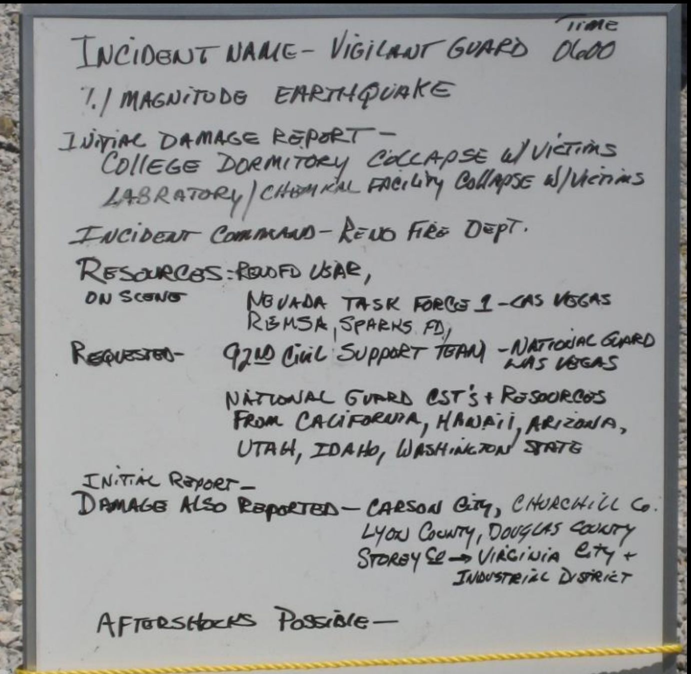
Earthquake RISKS in Nevada

NBMG OFR-09-8

used the Federal Emergency Management Agency's loss-estimation model, HAZUS-MH,

and the U.S. Geological Survey's probabilistic seismic hazard analysis.

These loss estimates are useful in hazard-mitigation planning, in building scenarios for emergency response and recovery exercises, and in helping emergency managers and the Governor make decisions on official disaster declarations after an actual earthquake.



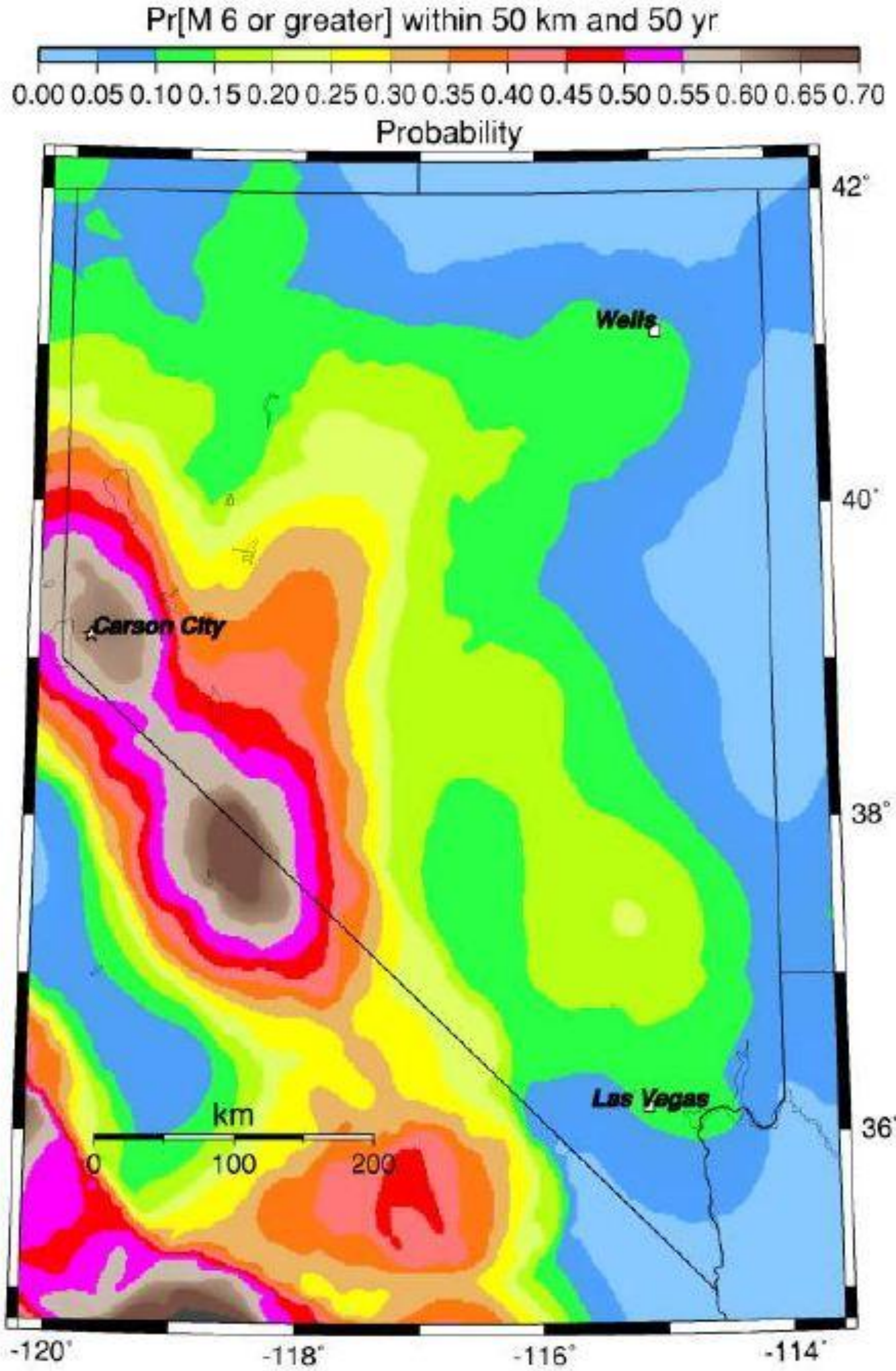
Uncertainties in the location of epicenters, depths, and magnitude, combined with changing population, uncertainties in local effects (soil and rock types, assumptions about attenuation, basin geometry, liquefaction potential, and directivity), make loss estimates generally consistent within one order of magnitude (a factor of 10), although experience with urban earthquakes in the US has generally yielded numbers within a factor of 2 or 3 of the actual damages.

2008 Mw 6.0 Wells Earthquake

HAZUS estimates for total economic loss from a magnitude 6.0 earthquake and probability of an earthquake of this magnitude or greater occurring within 50 years and within 31 mi (50 km) of the community.

Community	Estimated Total Economic Loss	Probability M6 in 50 yrs w/in 31 mi
Las Vegas	$7.2 billion	12%
Henderson	$2.5 billion	12%
Reno	$1.9 billion	67%
Carson City	$650 million	70%
Minden	$340 million	67%
Elko	$160 million	10-15%
Fallon	$110 million	35%
Wells	$30 million	12%

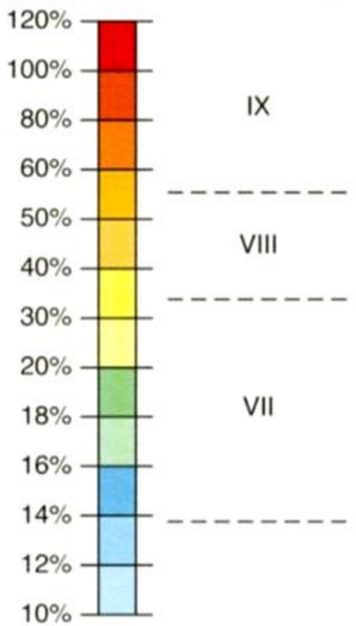
Total economic loss is from HAZUS. Probabilities are from the USGS at http://eqint.cr.usgs.gov/eqprob/2002/index.php.



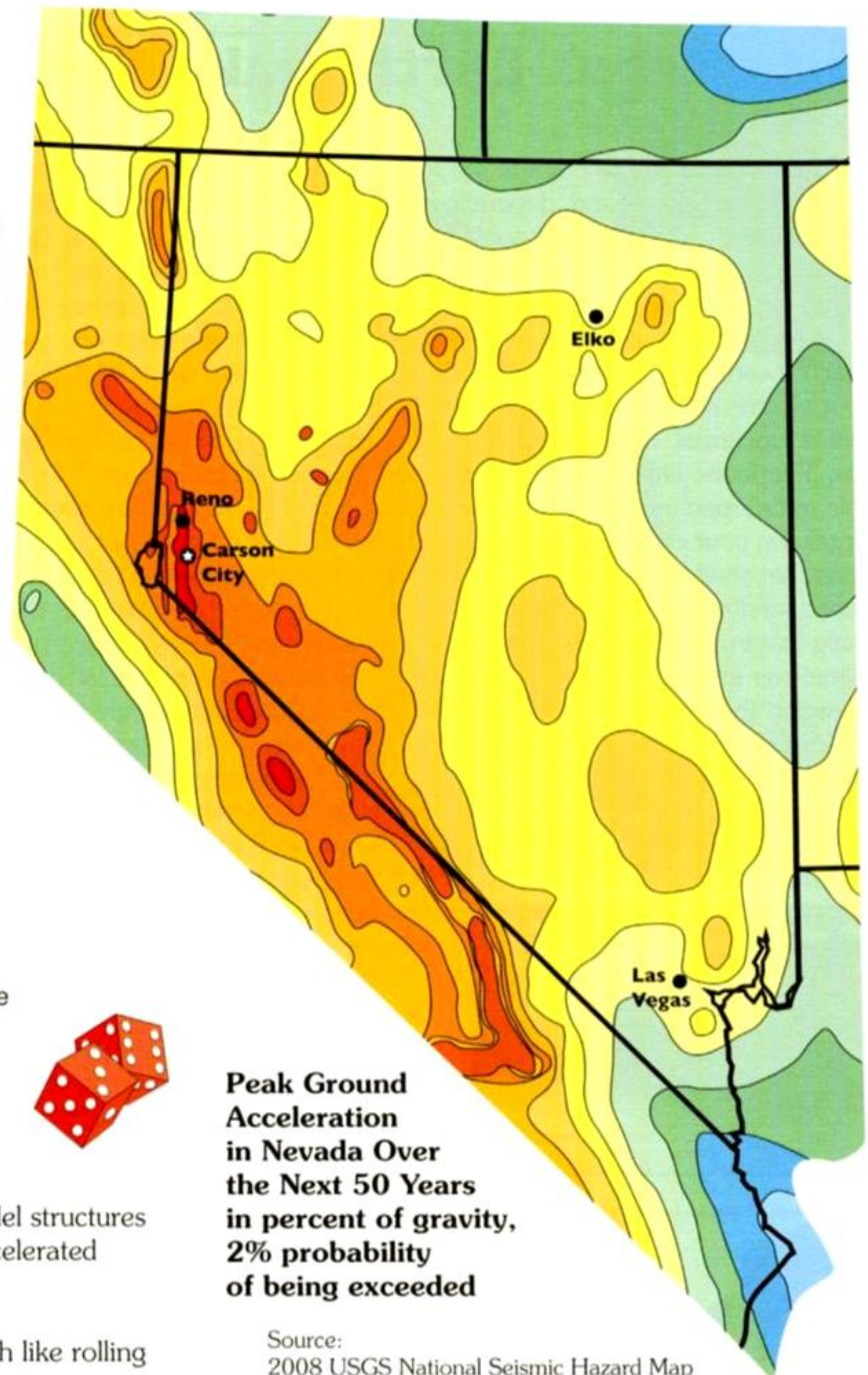
Wells 12% chance

M6 earthquake occurred Feb. 21, 2008

Shaking Potential Map for Nevada



* See page 4 for descriptions of Intensity VII and VIII. In Intensity IX, general panic occurs and there may be damage to some well-built structures.



Peak Ground Acceleration in Nevada Over the Next 50 Years in percent of gravity, 2% probability of being exceeded

Source:
2008 USGS National Seismic Hazard Map

Engineers use computer models and model structures to see how buildings hold up to being accelerated sideways by a seismic wave.

The notion of a map like this is very much like rolling the dice and calculating odds. If a rarer, but

Earthquake faults occur throughout Nevada, and potential losses from earthquakes are high for many communities.

The consequences of earthquakes can be huge in Nevada, particularly if individuals are not prepared.

A. Be prepared to respond.

B. Mitigate structural risks, largely through building codes and avoiding faults and areas of liquefaction.

C. Mitigate nonstructural risks.

Unreinforced Masonry Buildings

Unreinforced masonry building (URM) that collapsed during the Wells earthquake on 21 February 2008

View from back, 20 May 2009

View from front, 20 May 2009


BAR
306
302
RENO

Definition of potential unreinforced masonry (URM) buildings in Nevada:

buildings listed by County Assessors or State Public Works as built before 1974 with brick, stone, or block masonry structure.

Caution: This is a preliminary study based on data provided by the County Assessors and the State of Nevada. We know there are errors in the database:

- **URMs missed - not recorded as masonry structures**
- **URMs missed – ones on federal or Indian lands**
- **URMs counted due to wrong building type in the database**
- **Wrong locations due to poor address coding**
- **Misidentifications due to lack of construction date**
- **Buildings that may have been seismically retrofitted**
- **Buildings that have been removed.**

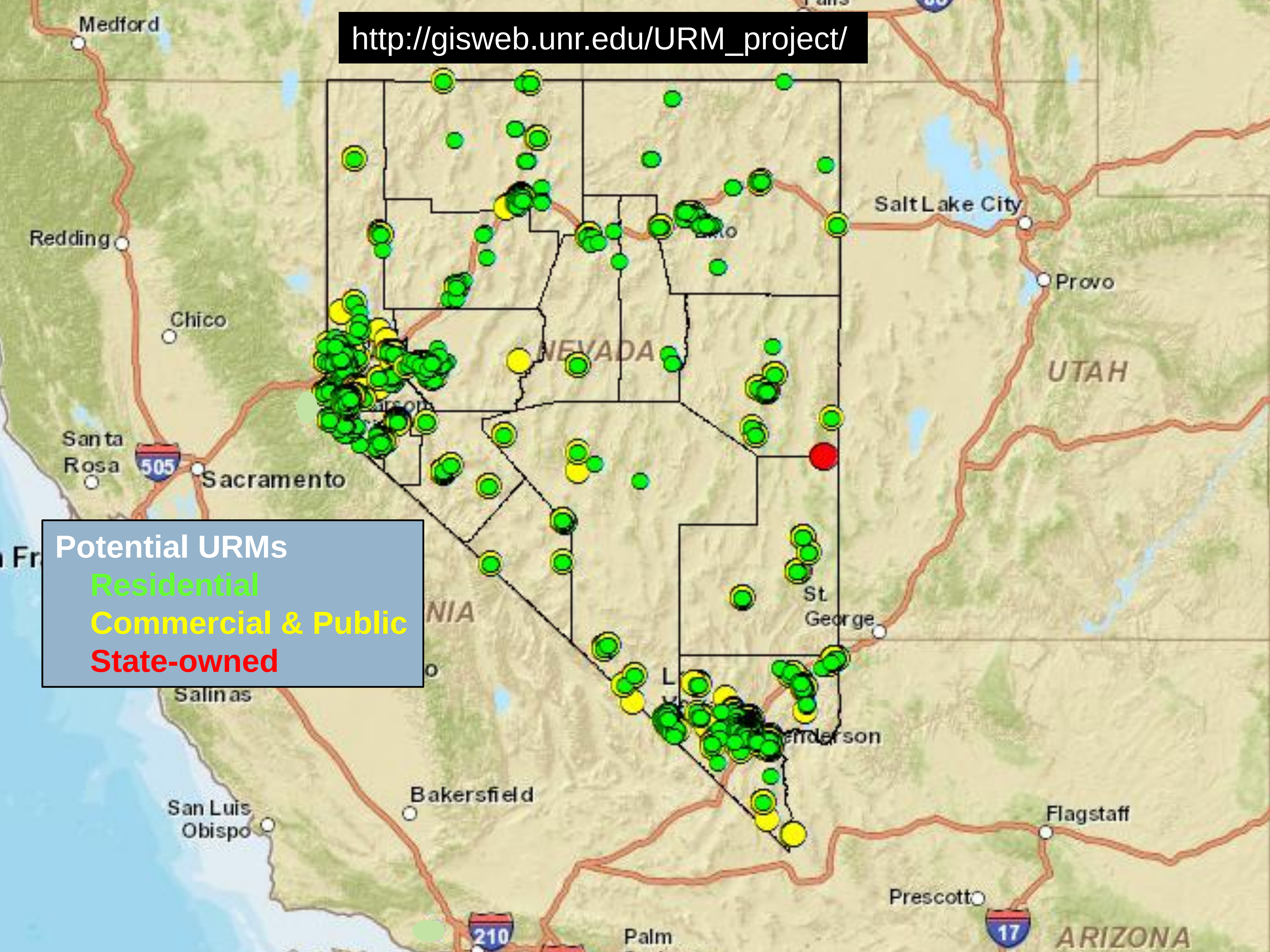
Recommendation 1 (draft): Jurisdictions (cities, counties, state) should use this County Assessors' data to follow up with on-the-ground inspections and checks of building plans. Individuals should determine if their buildings are URMs.

Potential URMs in Nevada – totals*

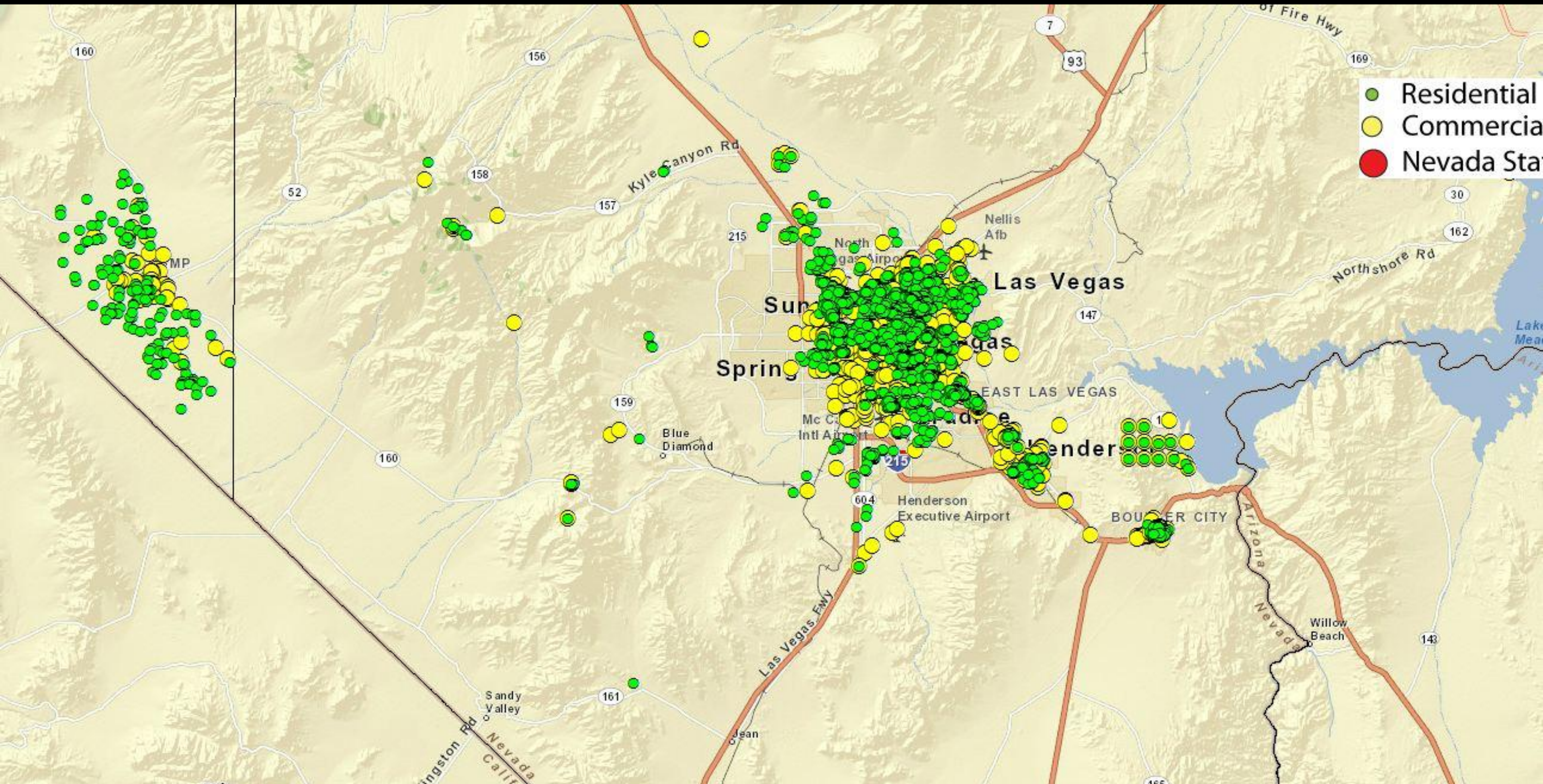
7,354	Residential
16,145	Commercial & Public (city and county)
98	State-owned
23,597	TOTAL*

* The total does not include buildings owned by the federal government.

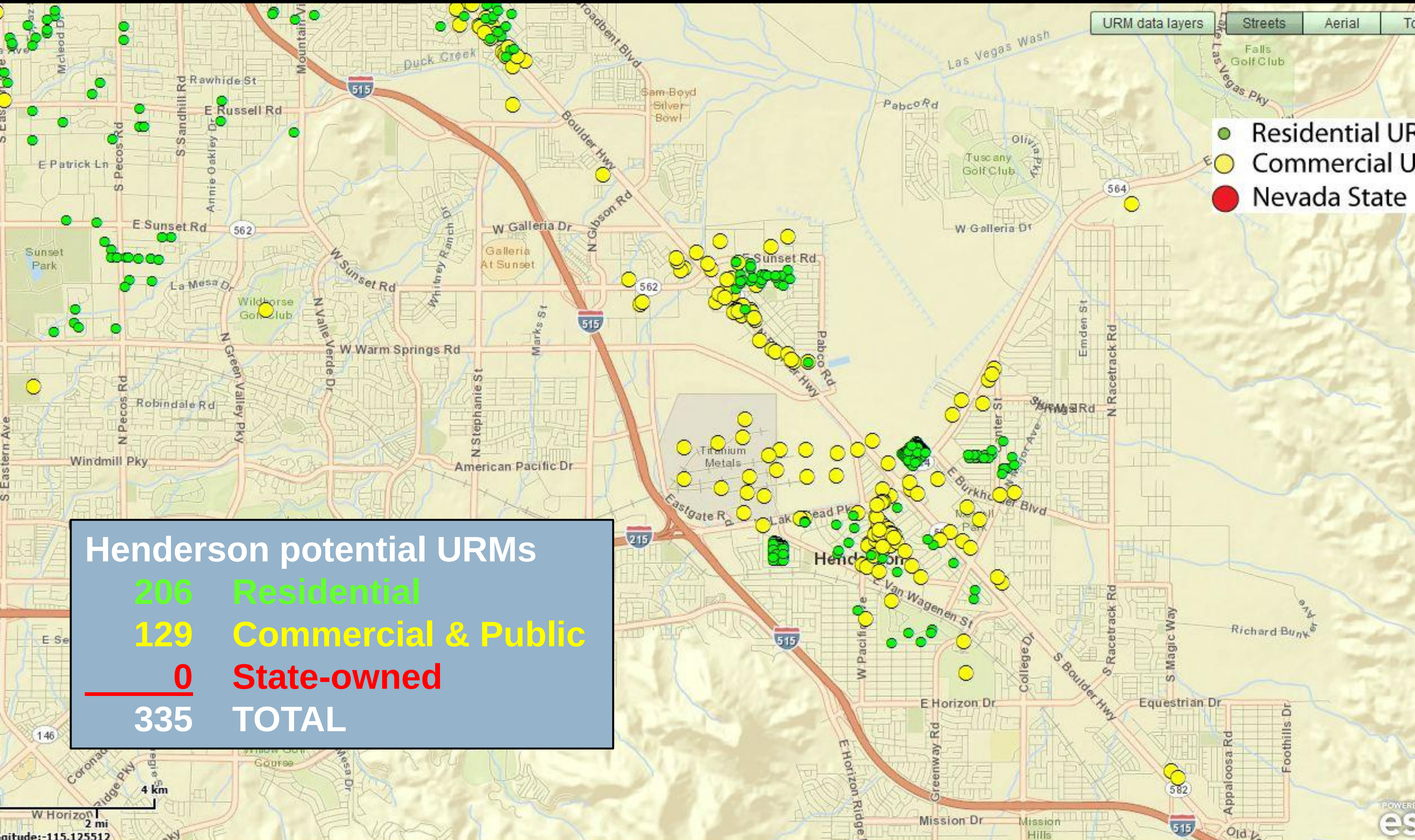
http://gisweb.unr.edu/URM_project/



http://gisweb.unr.edu/URM_project/
Potential URMs
Residential
Commercial & Public
State-owned
Medford
Redding
Chico
Santa Rosa
Sacramento
Salinas
San Luis Obispo
Bakersfield
Palm
NEVADA
Salt Lake City
Provo
UTAH
St. George
Henderson
Flagstaff
Prescott
ARIZONA
505
210
17



Residential
Commercia
Nevada Stat
Las Vegas
Spring
Nellis Afb
EAST LAS VEGAS
Henderson Executive Airport
BOULDER CITY
Blue Diamond
Sandy Valley
Jean
Willow Beach
Kyle Canyon Rd
Northshore Rd
Las Vegas Fwy
Kingston Rd
30 km



Henderson potential URMs

206	Residential
129	Commercial & Public
0	State-owned
335	TOTAL

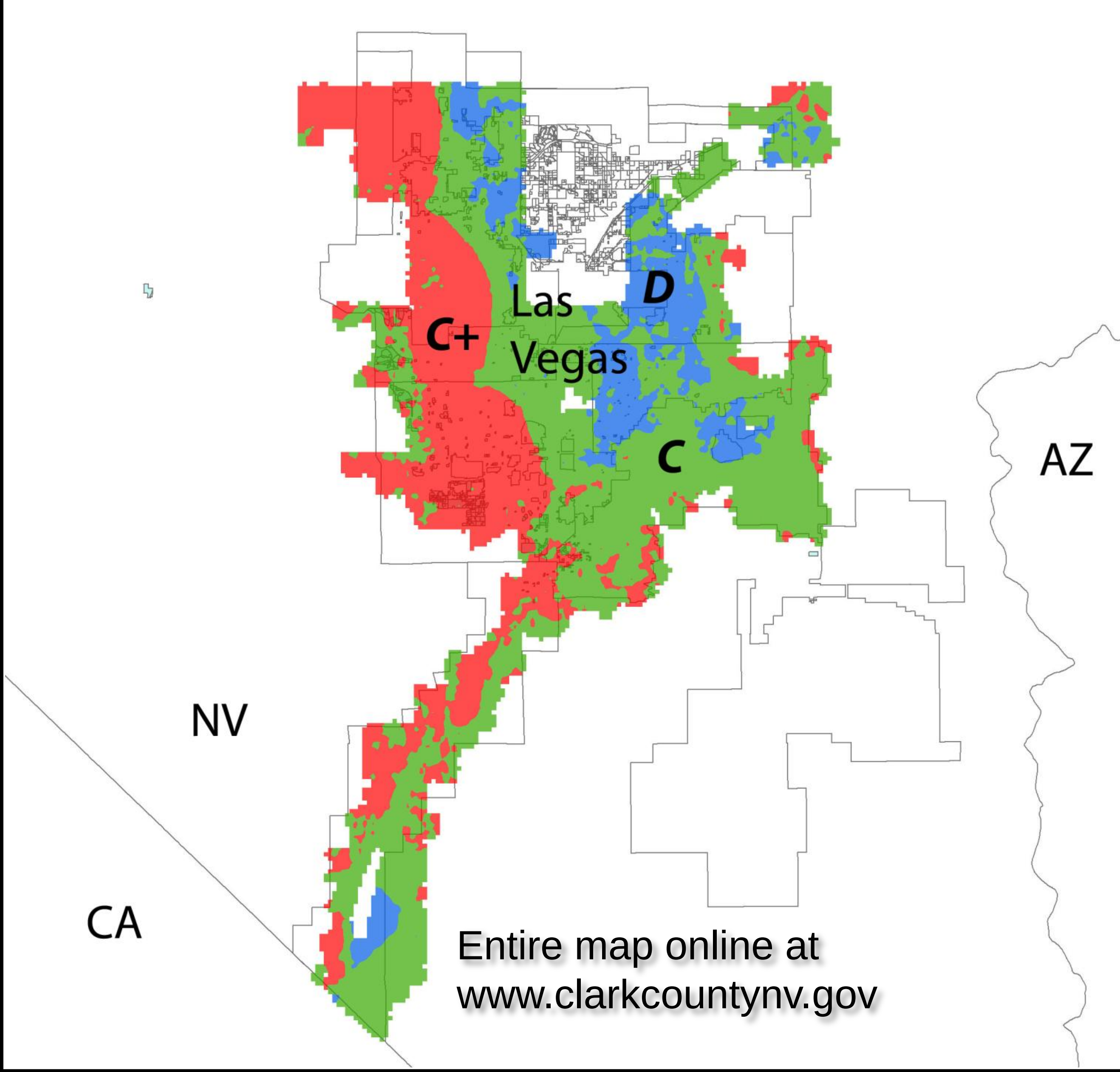

URM data layers
Streets
Aerial
Topo
Residential URM
Commercial UR
Nevada State U
1 km
0.5 mi
44578 Longitude: -114.986809
POWERED BY
esri

Clark County & Henderson Parcel Map

Parcel Classification for IBC

NEHRP C & D classes

"C+" class for NEHRP B velocities with soft surface

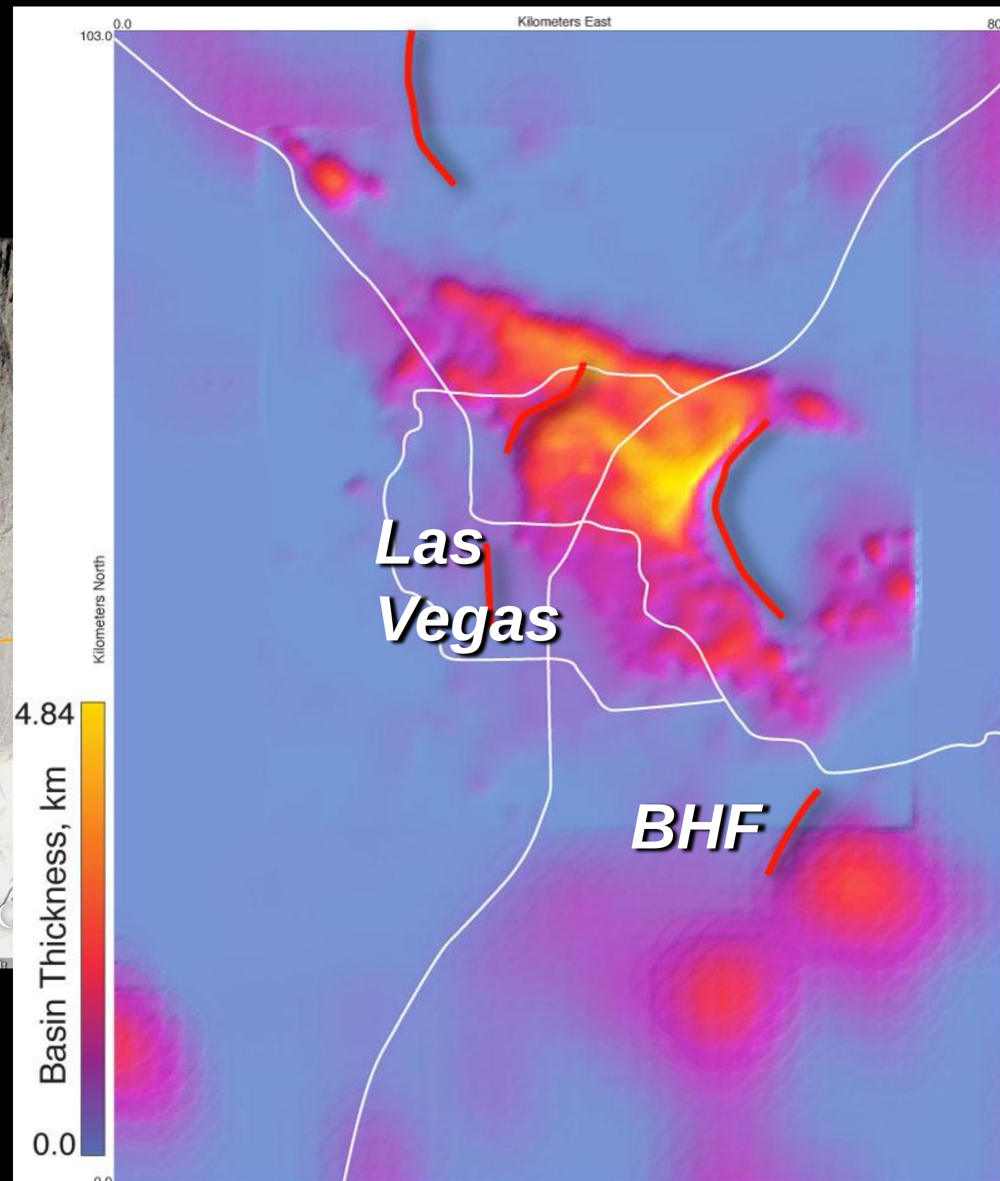


Dr. John Louie Nevada Seismological Laboratory

ShakeZoning: Adding Faults and Basin Geology

Black Hills Fault in Google Earth with USGS Qfaults trace

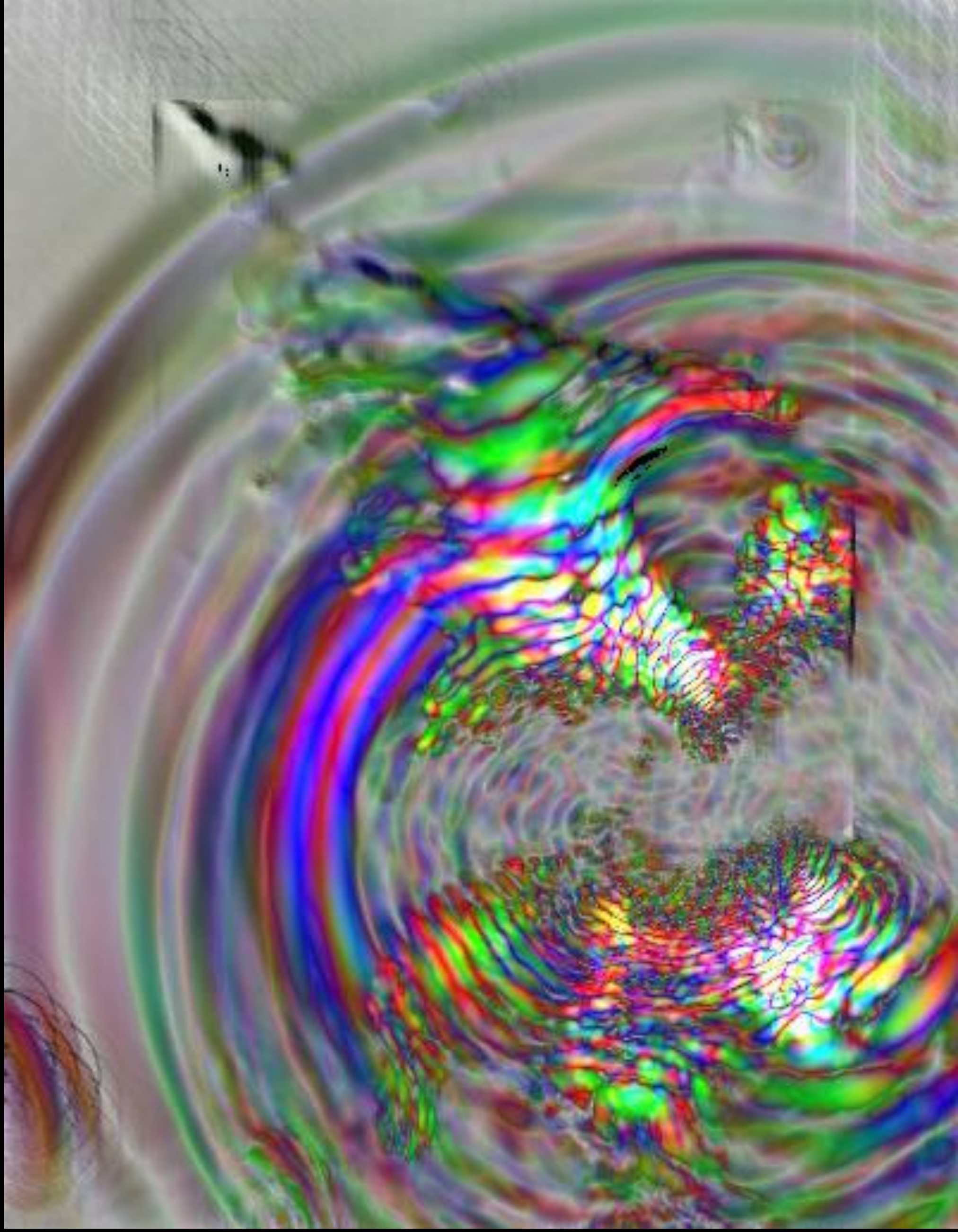
USGS Basin Map



Dr. John Louie
Nevada Seismological Laboratory

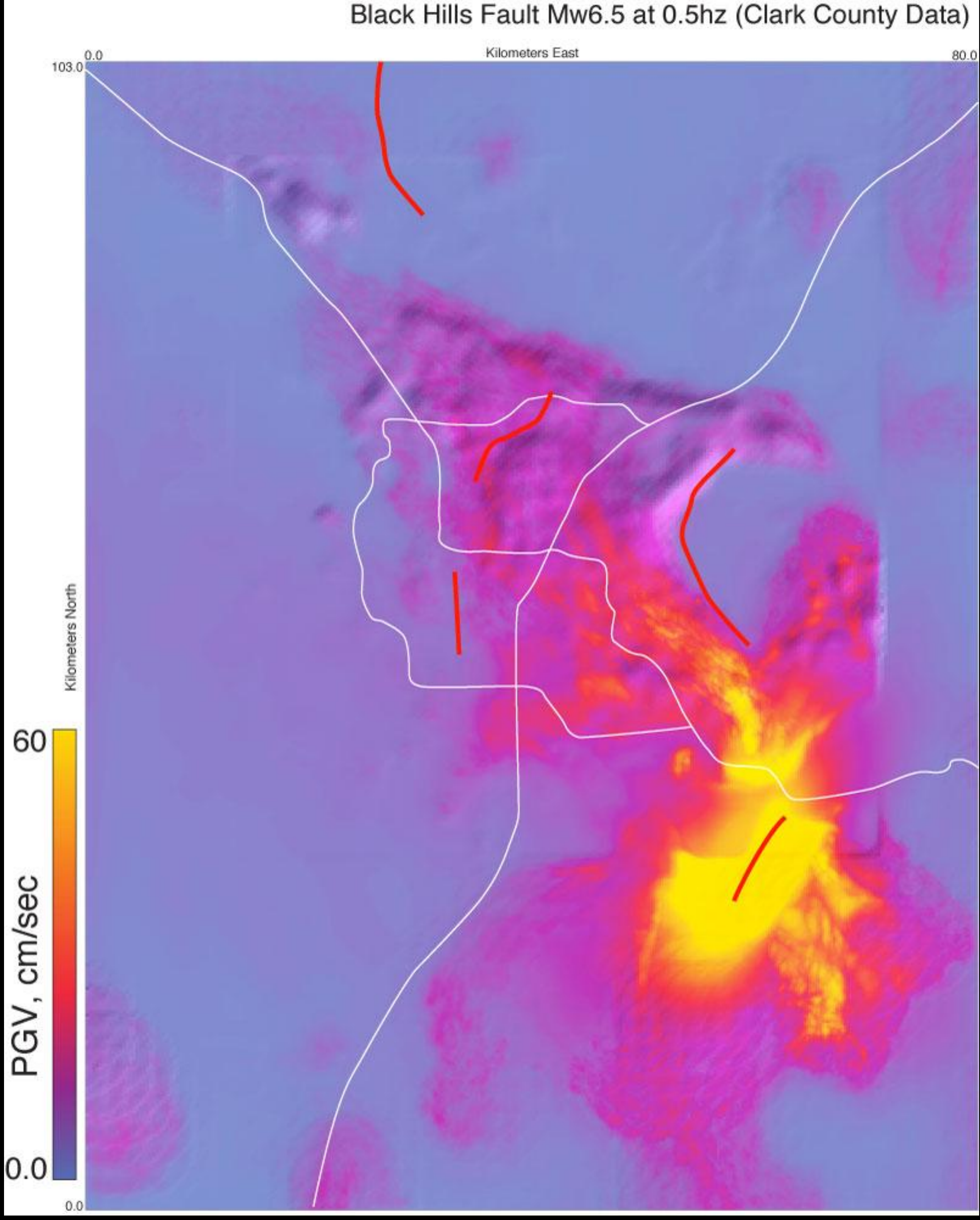
Adding Physics

- Black Hills M6.5 scenario
  - Short trace but 4-m scarps noted
- Viscoelastic finite-difference solution
  - 0.5-Hz frequency
  - 0.20-km grid spacing
  - A few hours on our small cluster
- Mode conversion, rupture directivity, reverberation, trapping in basins



Black Hills M6.5 Scenario Results

- Max Peak Ground Velocity (PGV) >140 cm/sec
- PGV over 60 cm/sec (yellow) bleeds into LVV through Railroad Pass
- Serious event for a short fault
  - Unlikely, but adds to hazard probabilistically
- Need to know how unlikely



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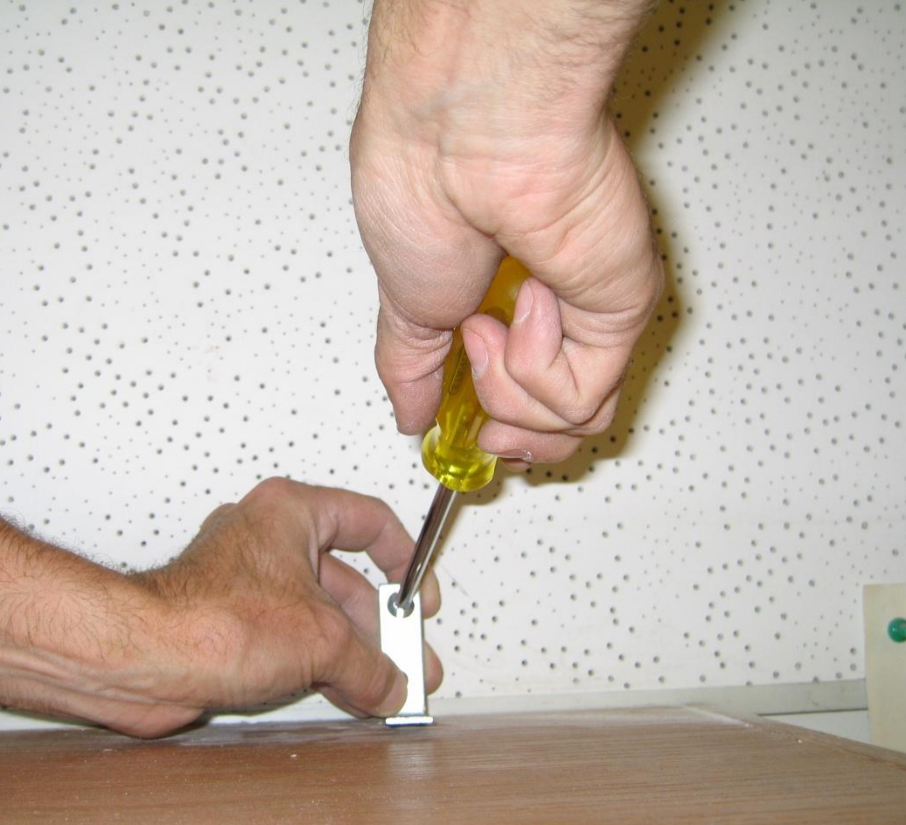
Nevada Seismological Laboratory

Nonstructural damage often can be easily prevented.



Earthquake-secure bookshelves in the office of the State Geologist

Secured computers at the Clark County Building Department


- Continue Seatwork
choose a book

Thank you!

And thanks to Jon Price, Gary Johnson, Christine Ballard, Heather Armeno, Irene Seeley, Linda D. Goar, and Jordan T. Hastings for their work on the open-file reports (OF 09-8 and 09-9), which are available as online documents at www.nbmg.unr.edu.

From there, go to online documents at http://www.nbmg.unr.edu/dox/dox.htm, then scroll down to OF 09-8 or 09-9. Link to the fault map from OF 09-9.

Web Addresses

- Earthquake Fault Map
  - http://gisweb.unr.edu/OF09_9