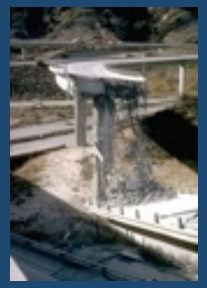
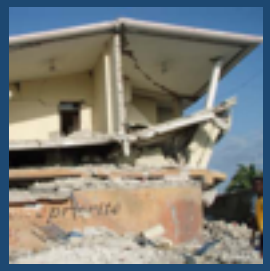




SAFRR Tsunami and HayWired Scenarios

Anne Wein
Western Geographic Science Center
U. S. Geological Survey
Science Application for Risk Reduction (SAFRR) Project

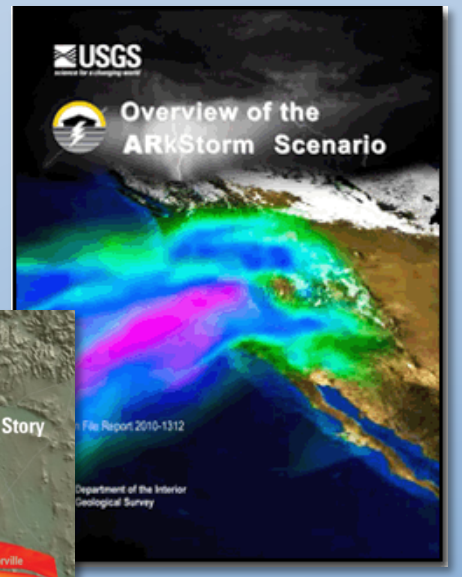


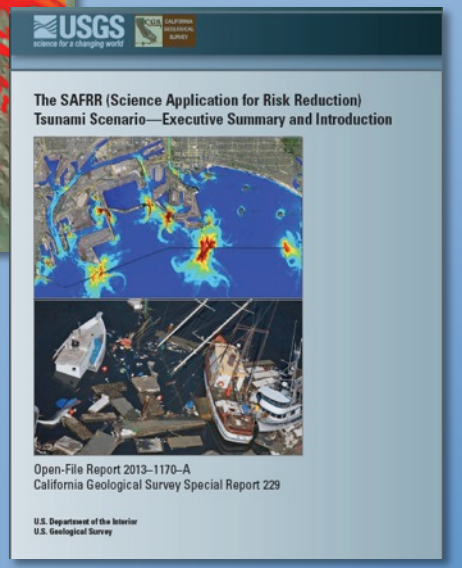



Principles of a Scenario

1. A single, large but plausible event (realistic but not worst case)
2. An event to be ready for
3. Best hazards science
4. Integrate across many disciplines
5. Consensus among leading experts
6. Crafted with community partners
7. Results presented in products that fit the user

…A tool to help visualize, plan, & prepare.



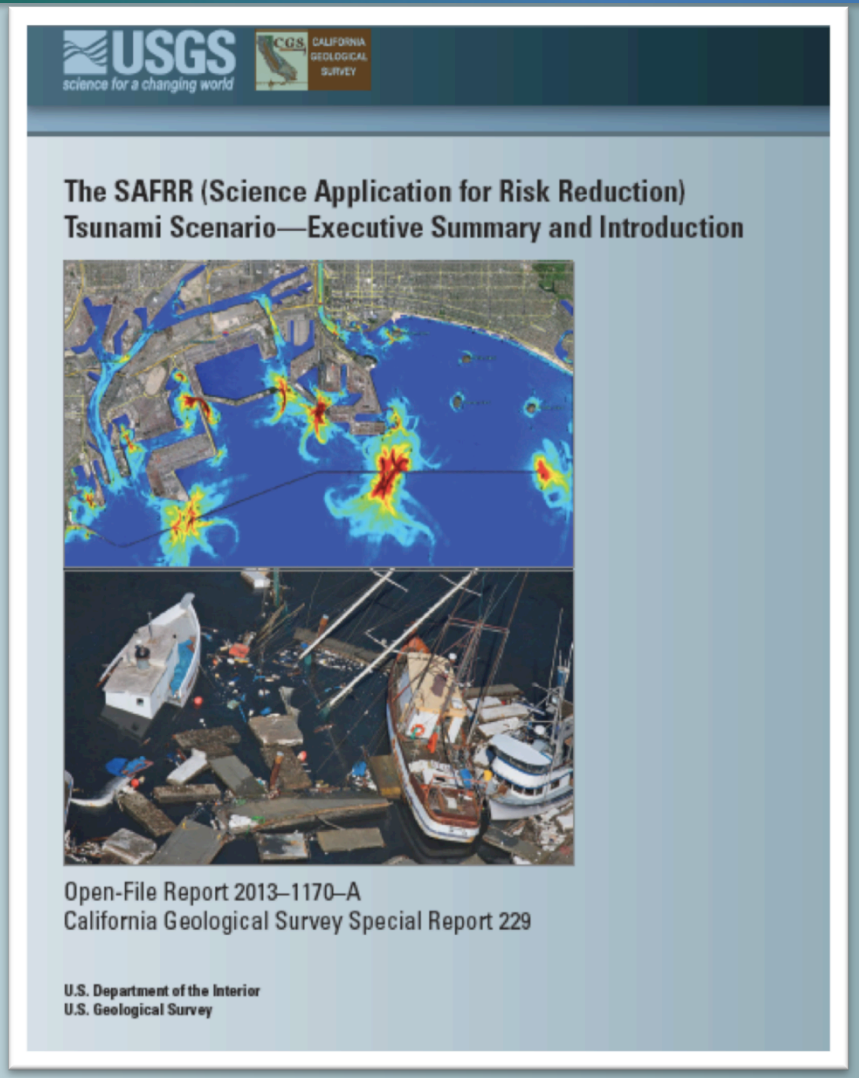


SAFRR Tsunami Scenario:

Improving Resilience for CA using a Plausible M9 Earthquake near the Alaska Peninsula

A project in partnership with CGS, Cal OES, NOAA and others

S. L. Ross, L. M. Jones, R. I. Wilson, B. Bahng, A. Barberopoulou, J. C. Borrero, D. M. Brosnan, J. T. Bwarie, E. L. Geist, L. A. Johnson, S. H. Kirby, W. R. Knight, K. Long, P. Lynett, K. Miller, C. E. Mortensen, D. J. Nicolsky, D. D. Oglesby, S. C. Perry, G. S. Plumlee, K. A. Porter, C. R. Real, K. Ryan, E. Suleimani, H. K. Thio, V. V. Titov, A. Wein, P. M. Whitmore, N. J. Wood



http://pubs.usgs.gov/of/2013/1170/

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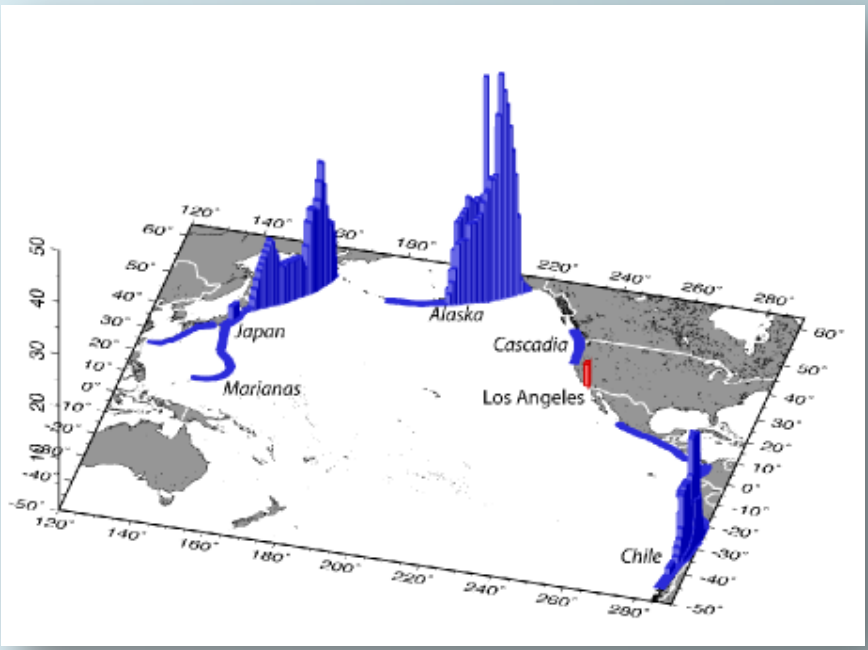
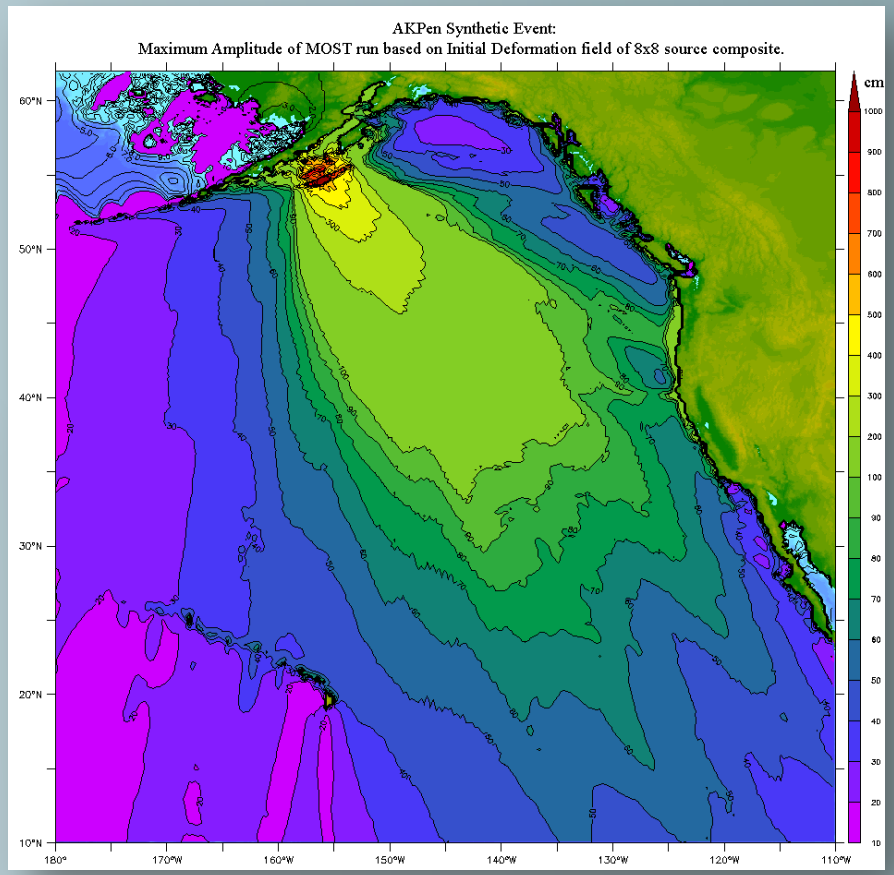
Tsunami Scenario: M_w 9.1 Offshore of Alaska

- Biggest contribution to LA's tsunami hazard
- Similar geologic and tectonic setting to Tohoku
- Waves hit near high tide
- Inundation in CA is within county tsunami evacuation zones





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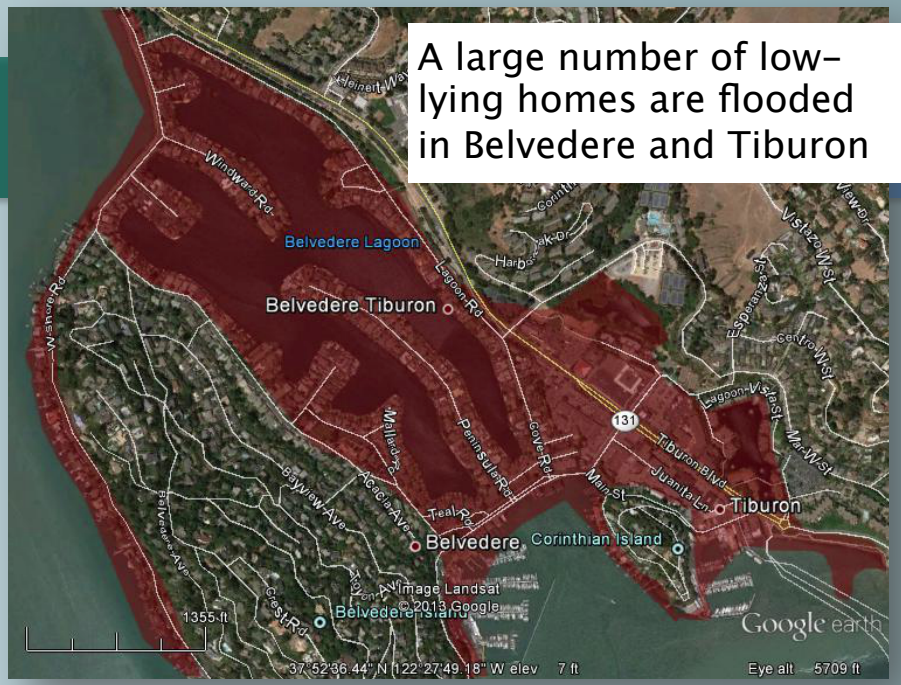
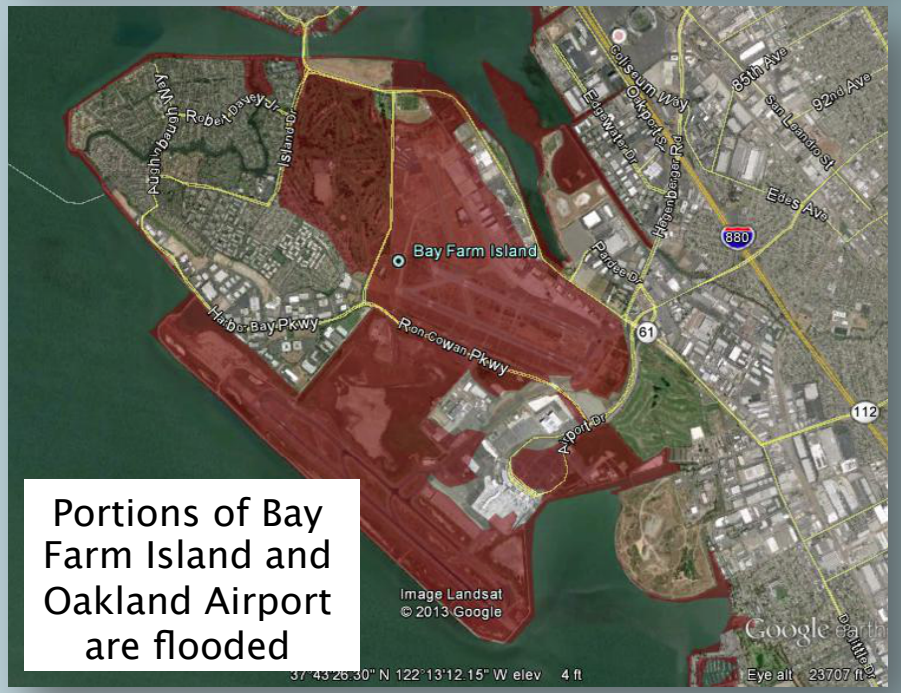
Inundation Maps

Flooding in parts of San Francisco Marina district

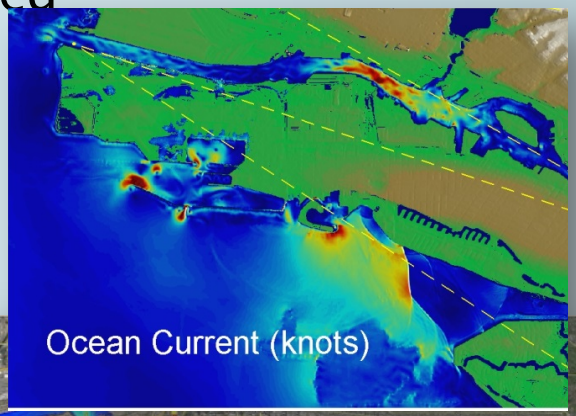
Piling height vulnerability in Pillar Point, Half Moon bay

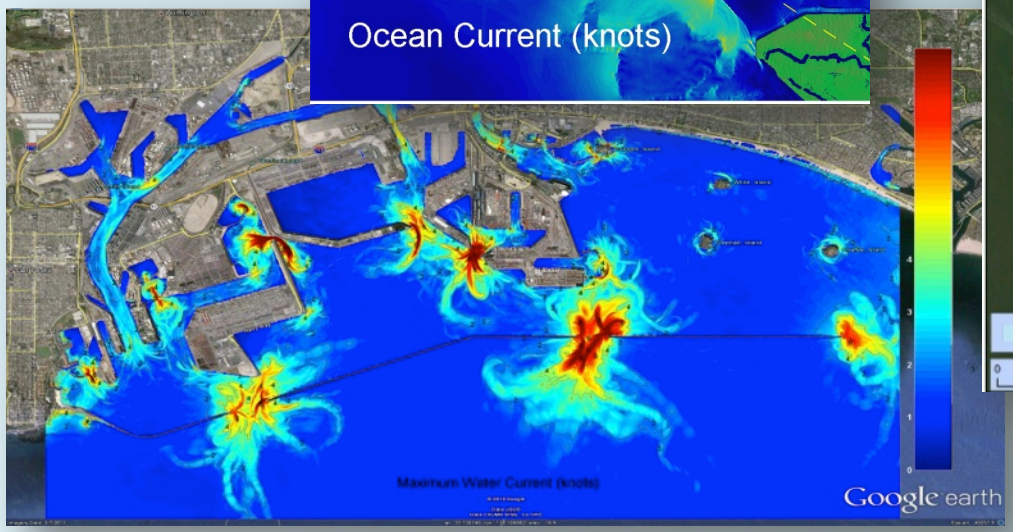


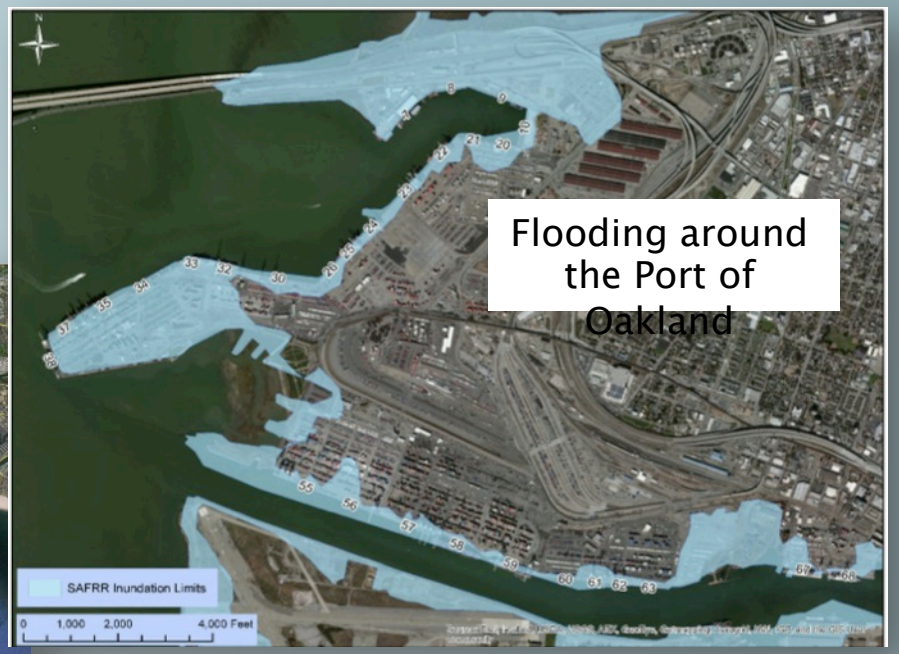


Inundation & Currents in Harbors/Ports

- Marina/harbor damages
  - Boats: 15% sink; 20% damage
  - Docks: 20% destroyed; 40% damaged
- Port/cargo damages
  - $100M in POLA/LB
  - $ 47M in Oakland







Flooding around the Port of Oakland

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Inundation & Currents in Harbors/Ports

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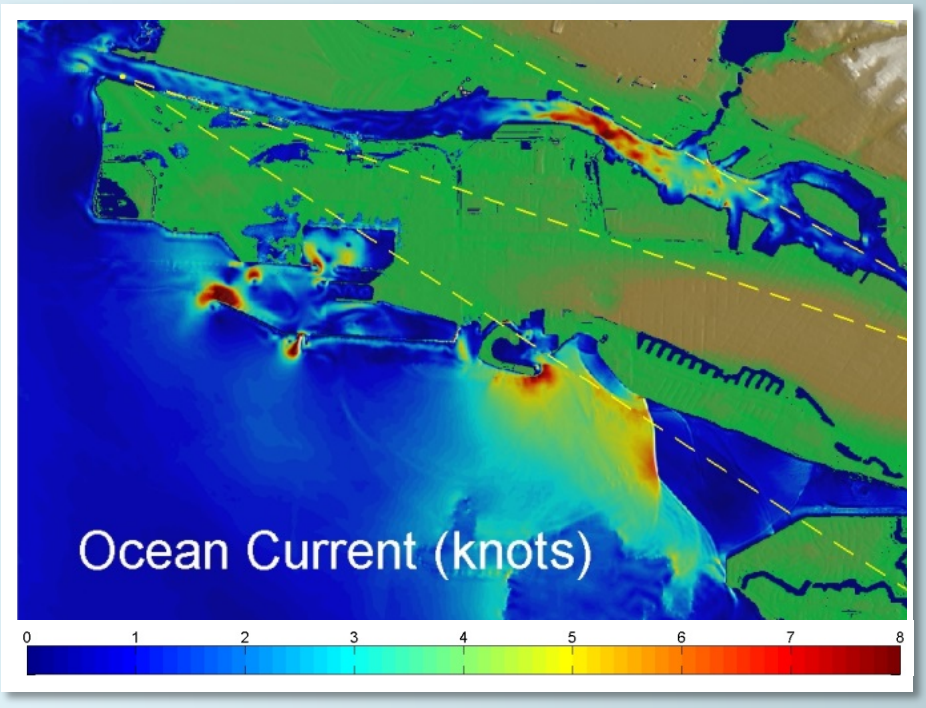

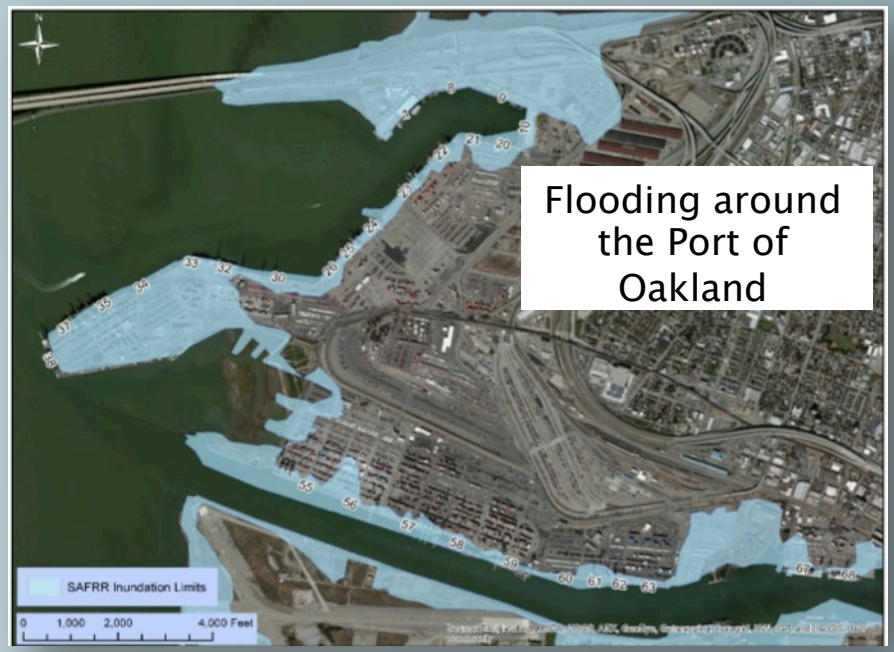

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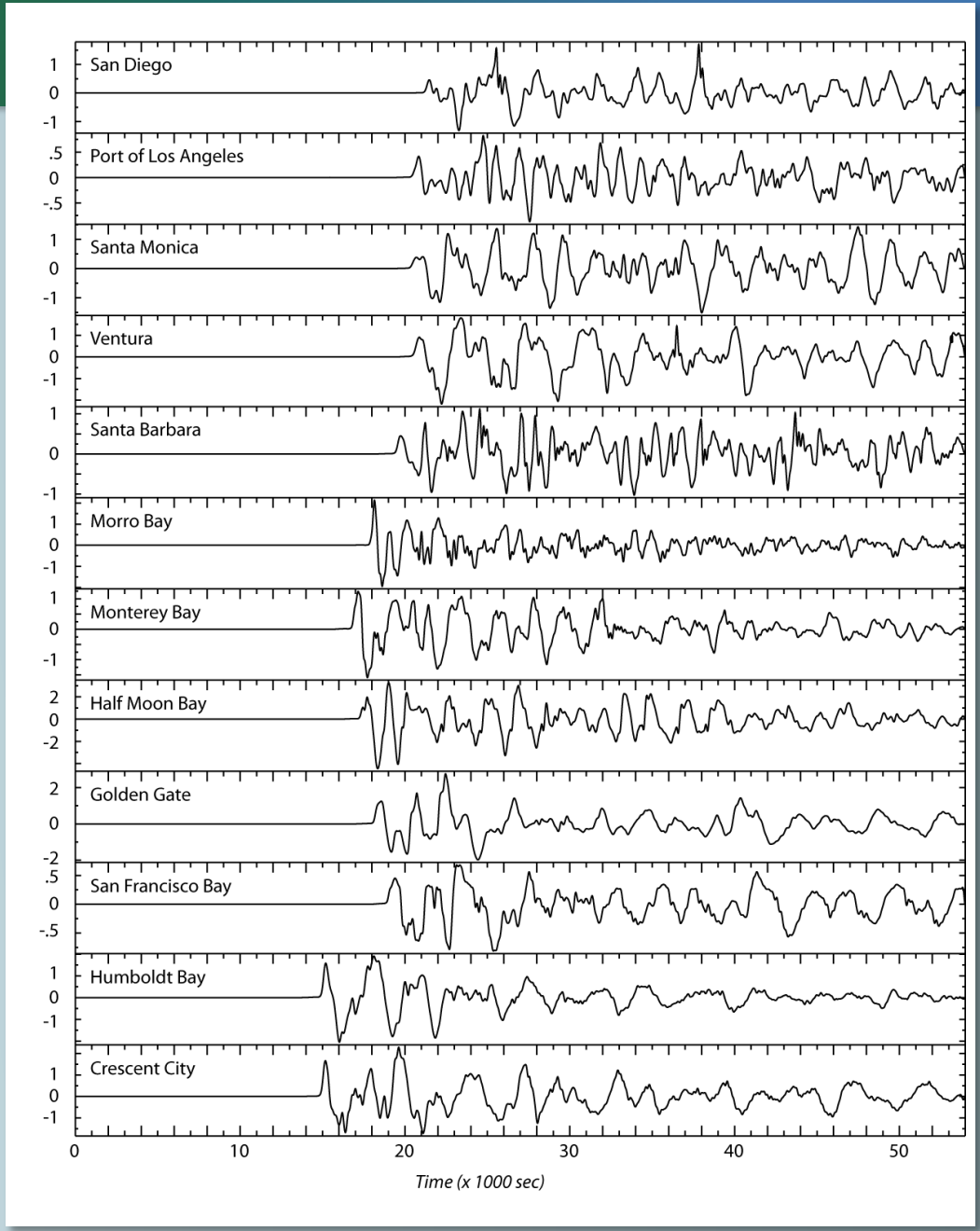
What Matters?

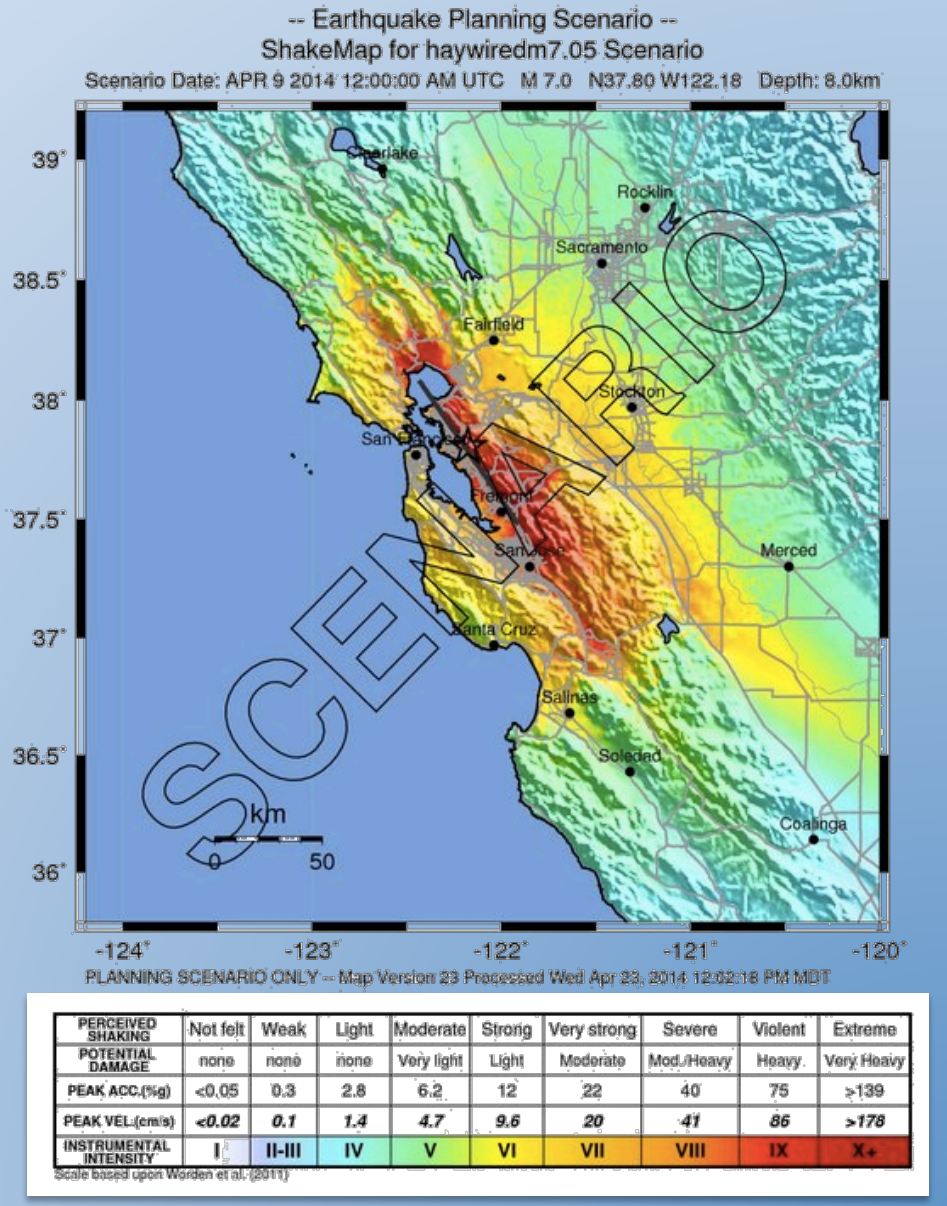
- Tides
- Location & elevation
- Time
- Multiple waves
- Currents
- People
- Response & recovery

You end up controlling the bottom line: $5-10 B damages/ losses



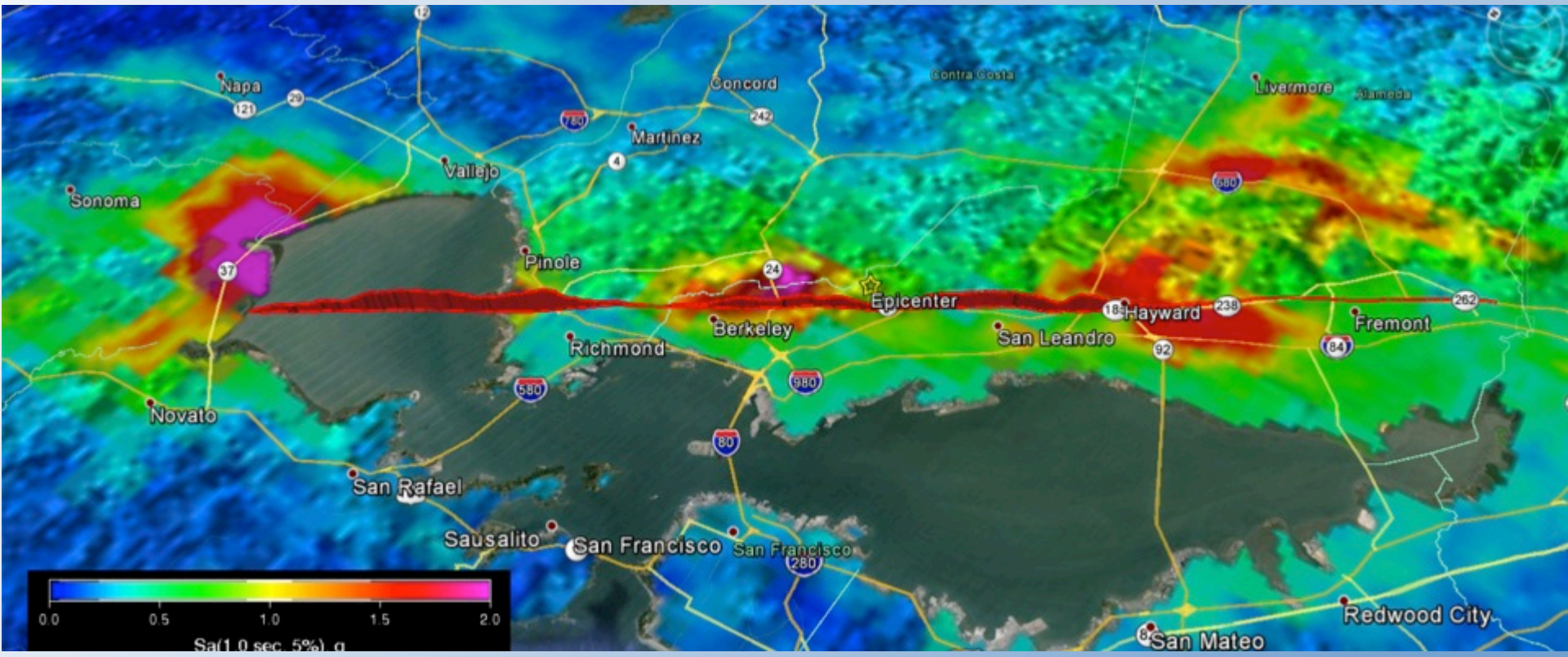
HayWired Scenario

- Best available science
  - Surface rupture
  - Afterslip
  - Shakemap
  - Liquefaction
  - Landslides
  - Fire following EQ
  - Environmental health
  - Aftershock sequence
- New analyses



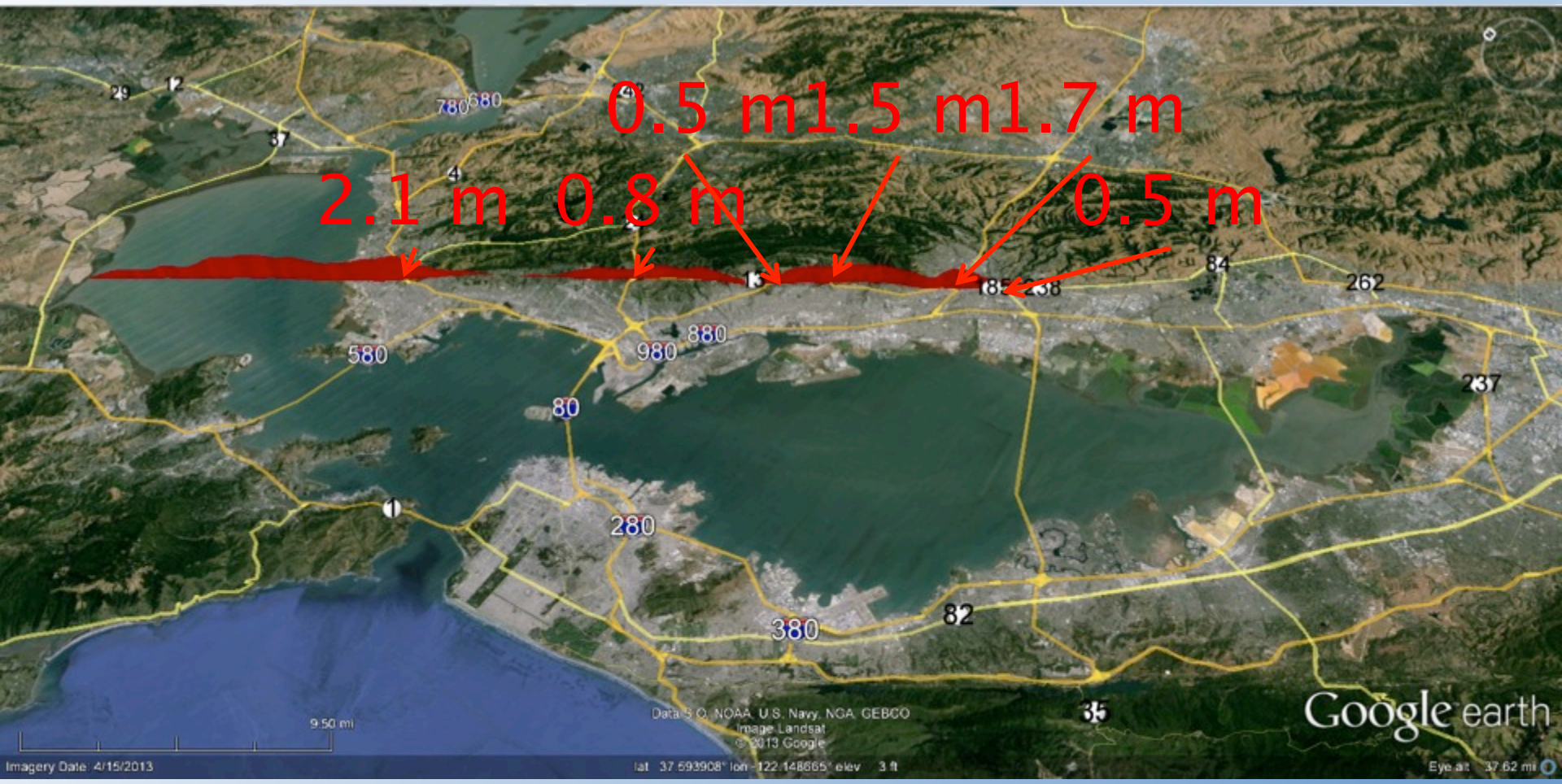
Hayward Fault Rupture

N+S @ Oakland
4:18 pm Wed 18 April, 2018



- Aagaard et al (2010) BSSA
- 13 PhDs; 300+ yrs experience
- 39 M6.6–7.2 ruptures
- UCERF3 M7.05: 0.5%/yr

Hayward Fault: Surface Rupture



Fault Afterslip (e.g., Napa)

August 24, 2014:
11 hours after S. Napa earthquake;
11 ½ inches fault slip

January 12, 2015:
About 15 inches total slip

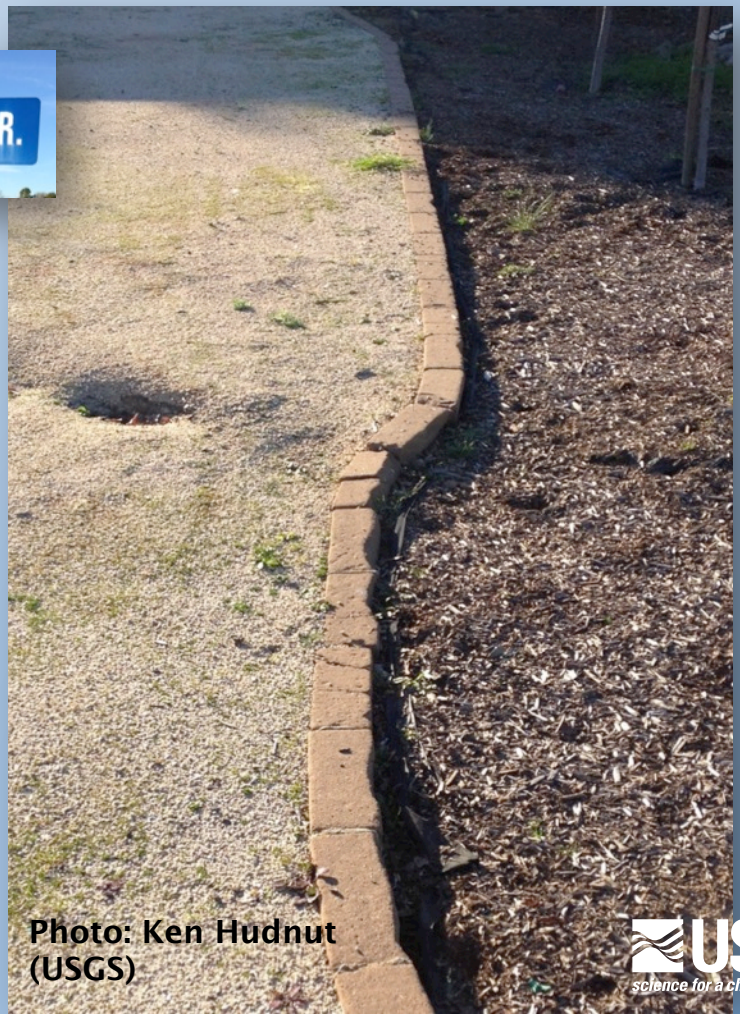


Photo: Alex Morelan
(UC Davis)

Photo: Ken Hudnut
(USGS)

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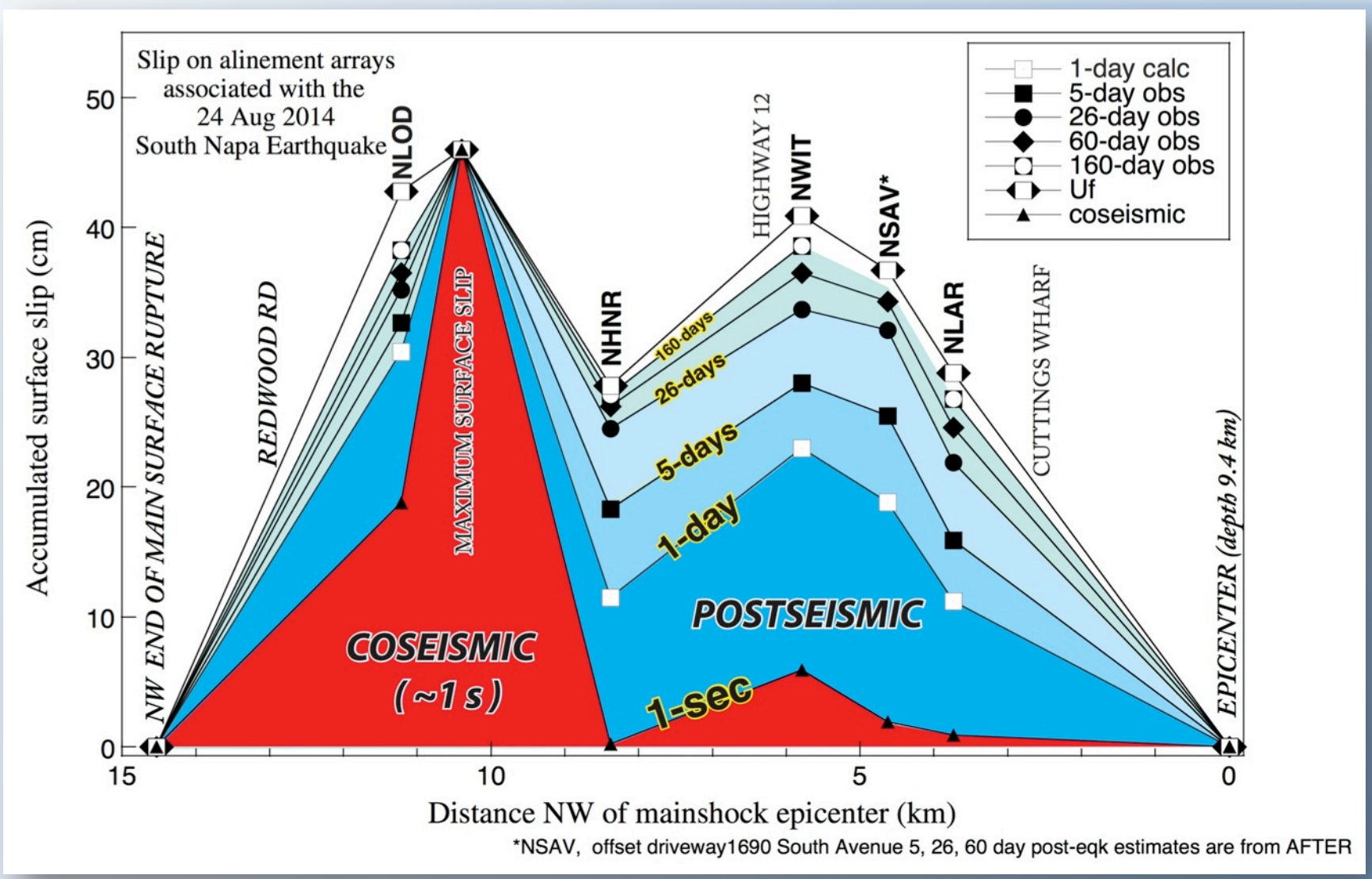
Fault Afterslip (e.g., Napa)



Alinement arrays re-surveyed Jan. 31, 2015 by Jim Lienkaemper (USGS)

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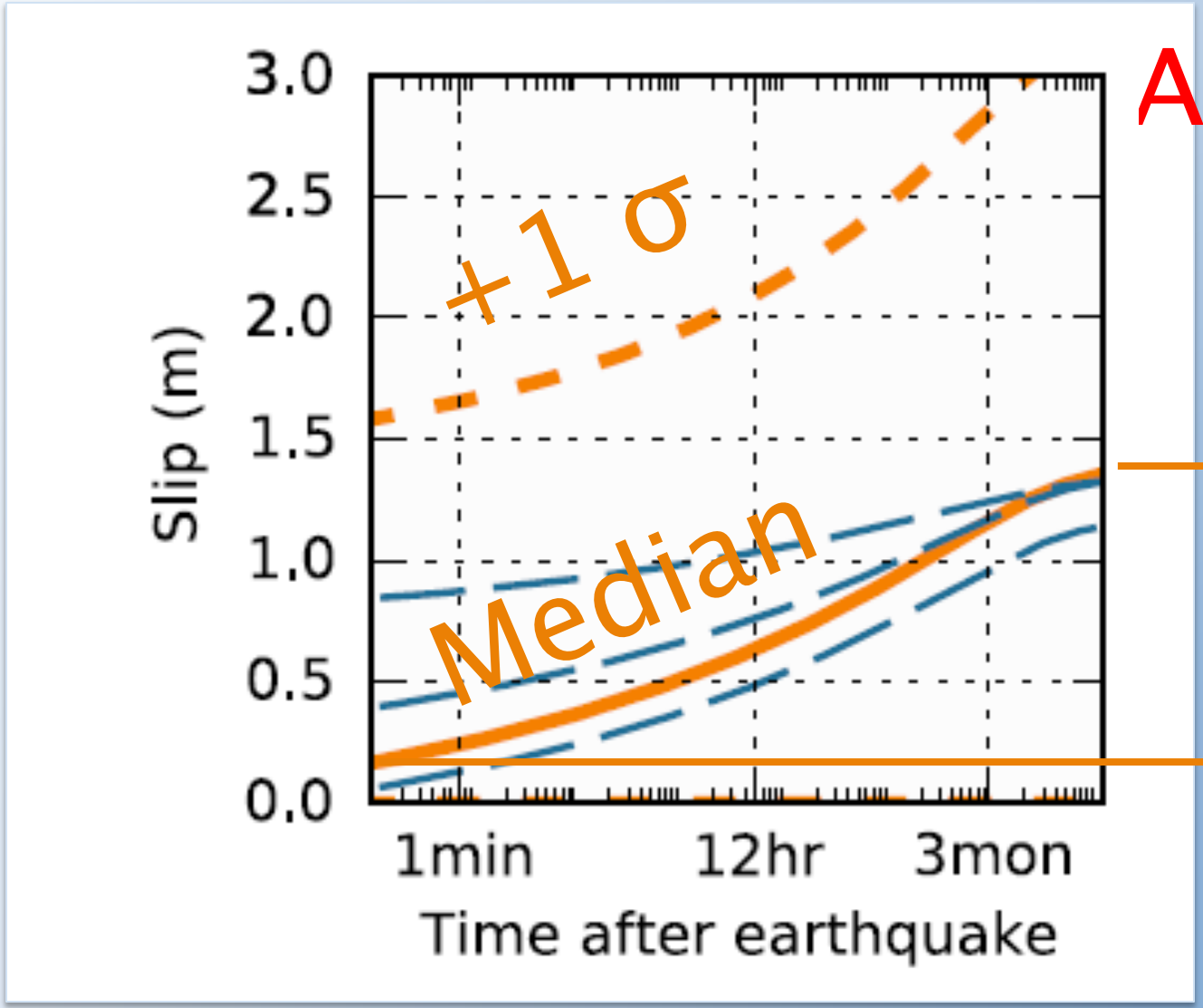
Hayward Fault: Afterslip

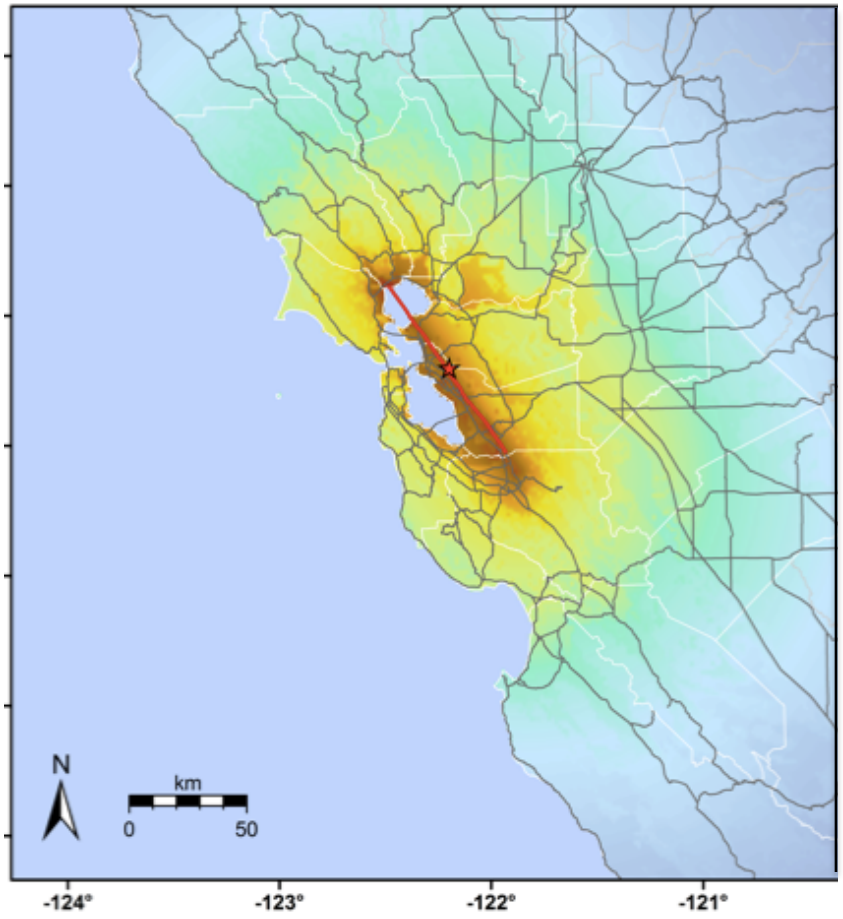


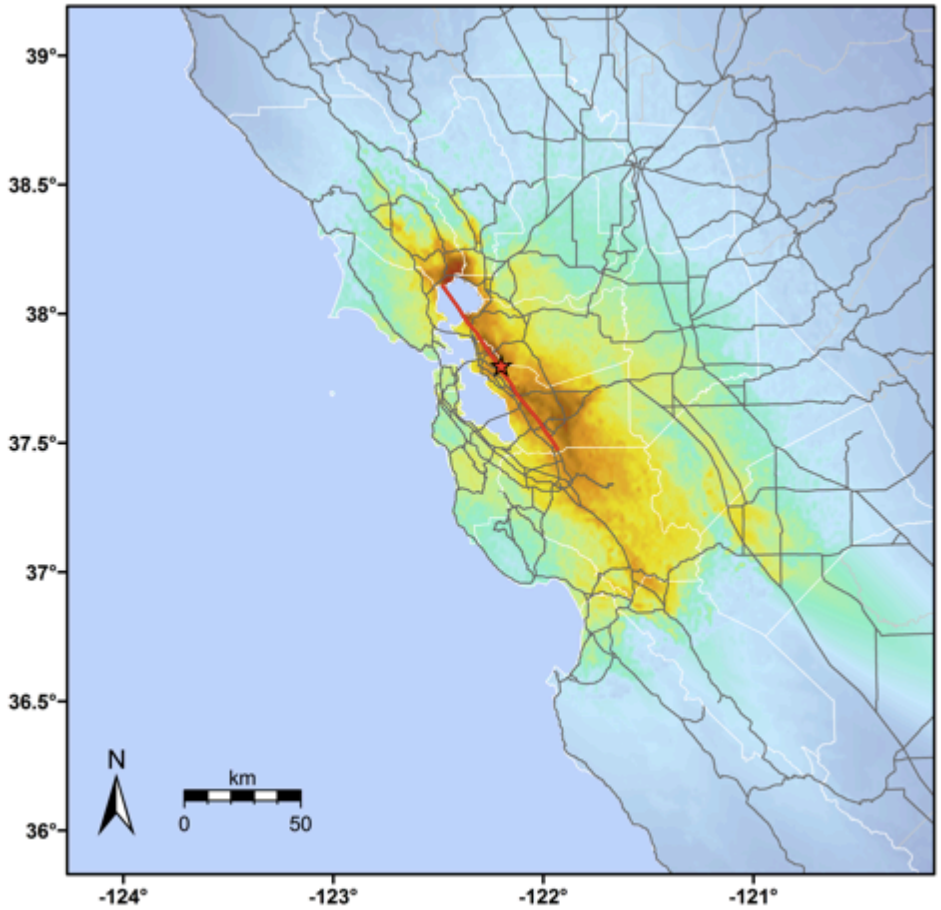
Aagaard et al. (2012) 90Km, Mw 7.1 EQ

HayWired: ShakeMaps

Attenuation (median)

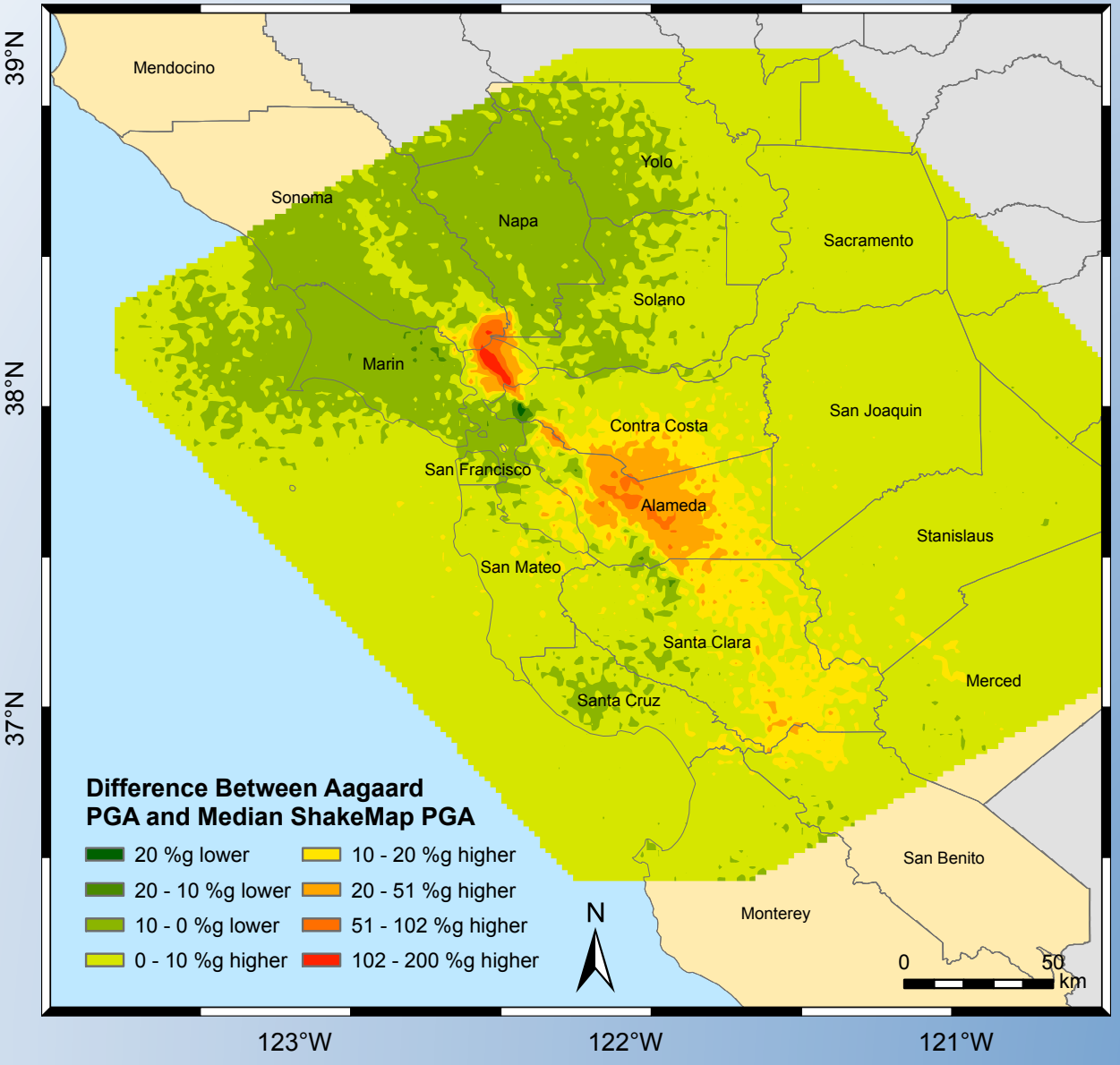
3-D event simulation





PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

HayWired: Difference Ma



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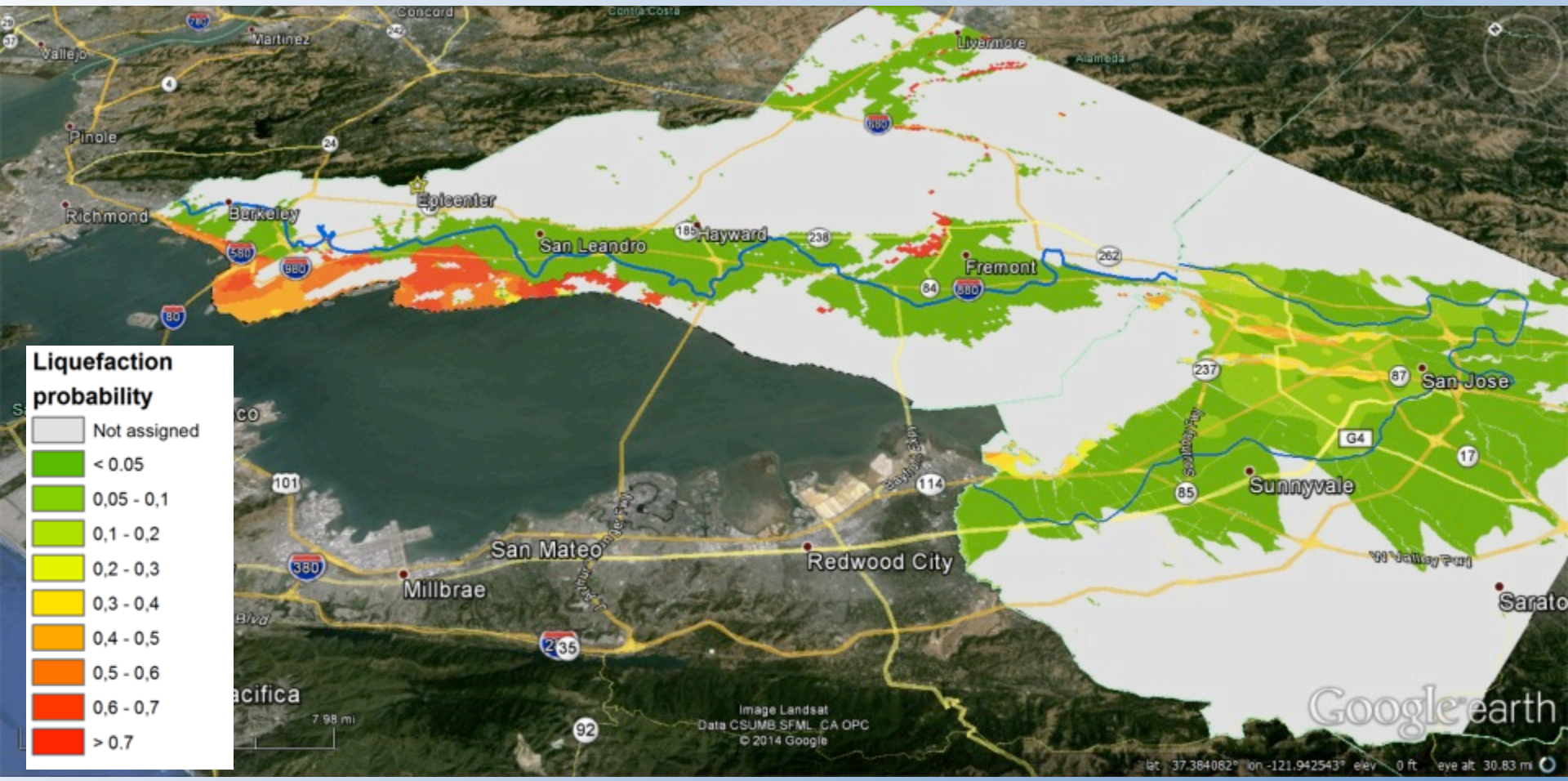
HayWired: Liquefaction



Adapted from Holzer, Noce, Bennett 2010

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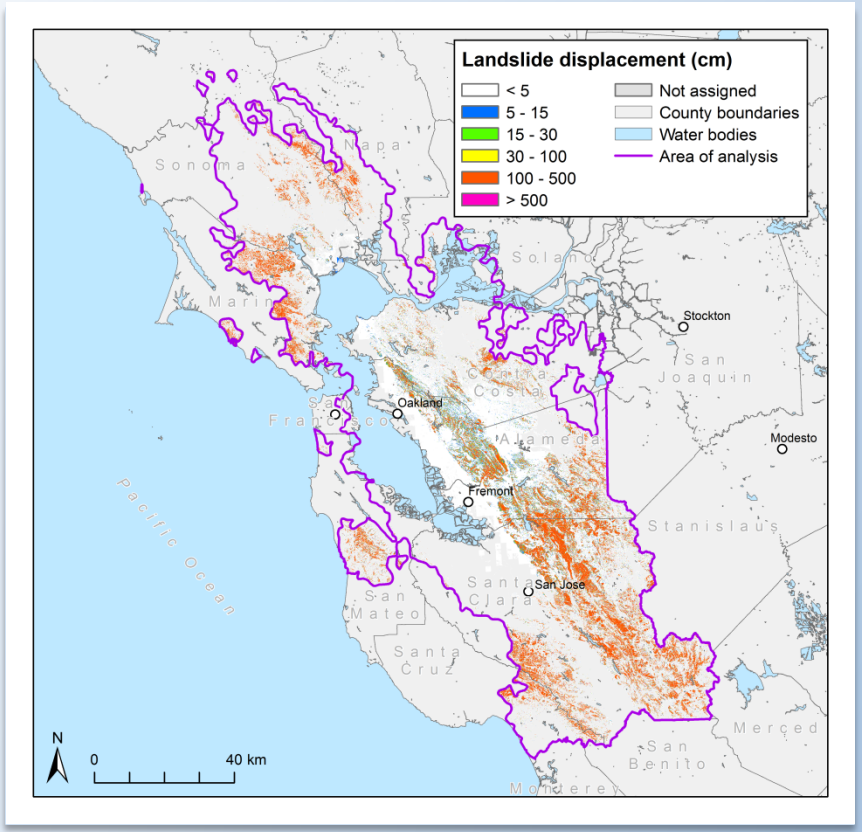
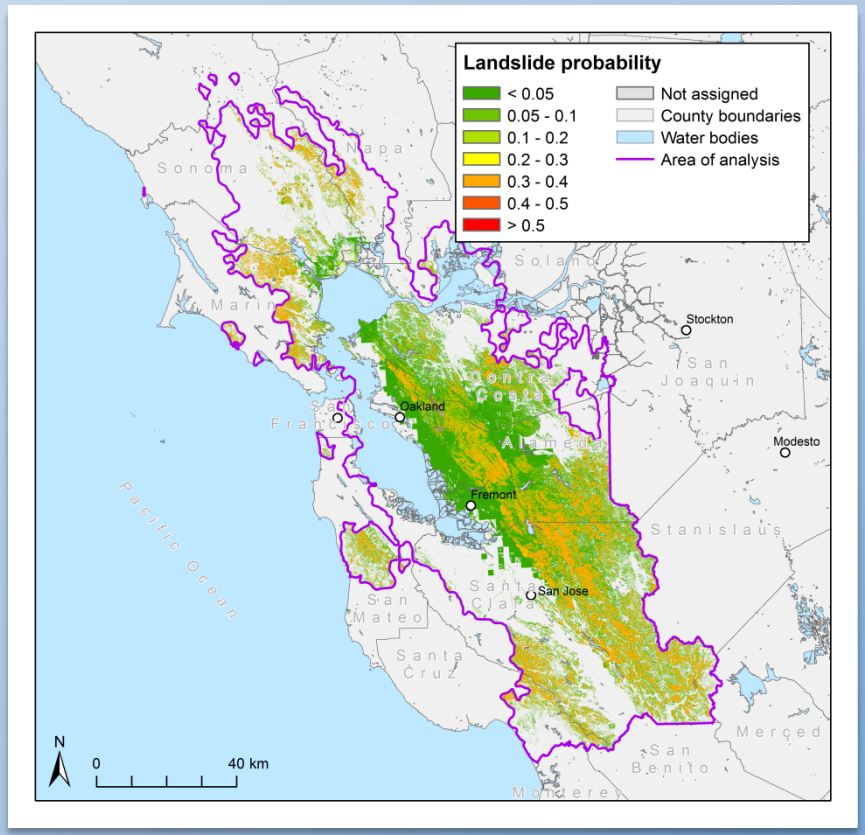
HayWired: Landslides

Displacement



Probability



- First time **earthquake-induced landslide displacements and probabilities** calculated by CGS for a scenario on a regional basis
  - Availability of rock strength measurements
  - 10m resolution
- Some ground motions larger than model calibration

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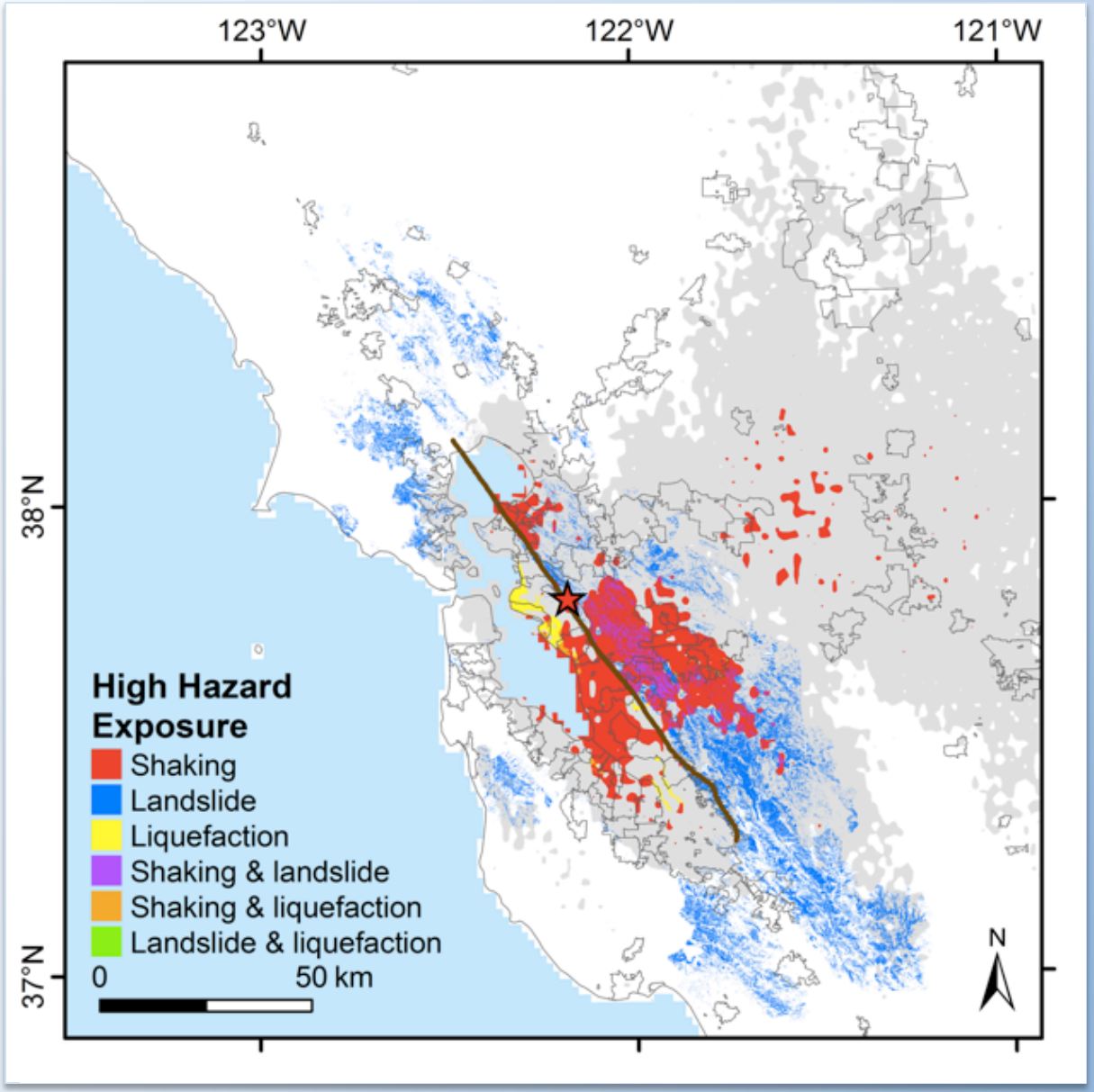
HayWired Mainshock Hazard Scape



- Shaking: 50% of the International short building code design map
- Liquefaction probability > 10%
- Landslide probability > 10%

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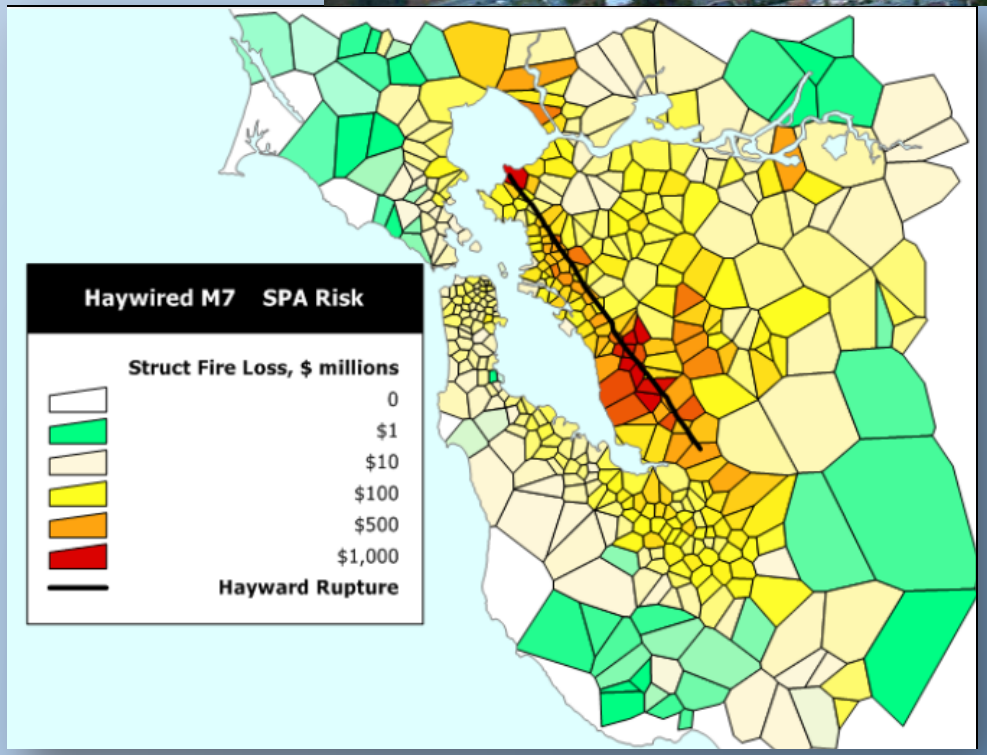
Fire Following Earthquake

- Earthquake damage causes multiple simultaneous ignitions
- Fire Spread
- Communication breakdowns
- Competition for resources (medical, SAR, hazmat)
- Water supply vs. fire fighting
- 1200 ignitions; 1000 large fires
- Structural losses
  - 9% of Alameda
  - 3% of Contra Costa
  - 2% Santa Clara


Source: http://blogs.villagevoice.com/runninscared/SanBrunoExplosion.jpg



Fire Following Earthquake

Mitigation Opportunities:

- Fire department response
- Water service reliability
- Building standards
- Reducing fires arising from the energy sector

Photos by Charles Scawthorn, SPA Risk

Workshop on Fires following a M7 earthquake on the Hayward Fault held Wed. Oct 29, 2014 at UC Richmond Field Station 5

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Environmental Health

Environmental Contamination:

- Smoke, gases, other combustion products
- Releases of raw sewage
- Landslides & dusts containing the soil fungus *C. Immitis.*
- Hazardous chemicals released from damaged industrial facilities
- Toxicants in dusts and debris from building collapse

Environmental Health Impacts:

- Short term increase in heart attacks, strokes, asthma likely
- Gastrointenstinal illnesses, skin infections
- Area not considered endemic for Valley Fever outbreak (e.g., 1994 Northridge)
- Long term impacts of chemical and toxicant exposures not well studied

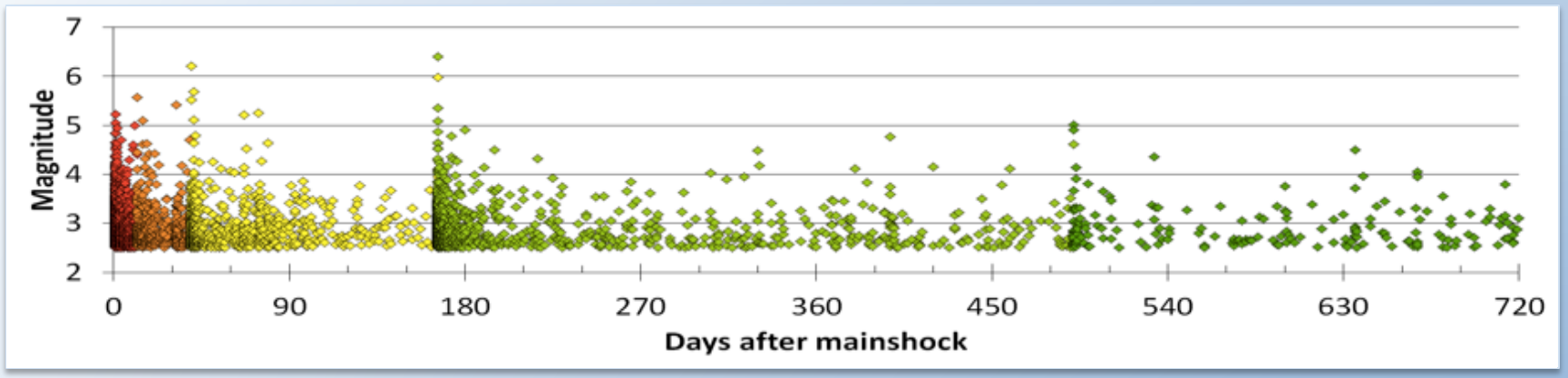
Aftershock Forecasts

- Improving risk communication: How would you use forecasts?

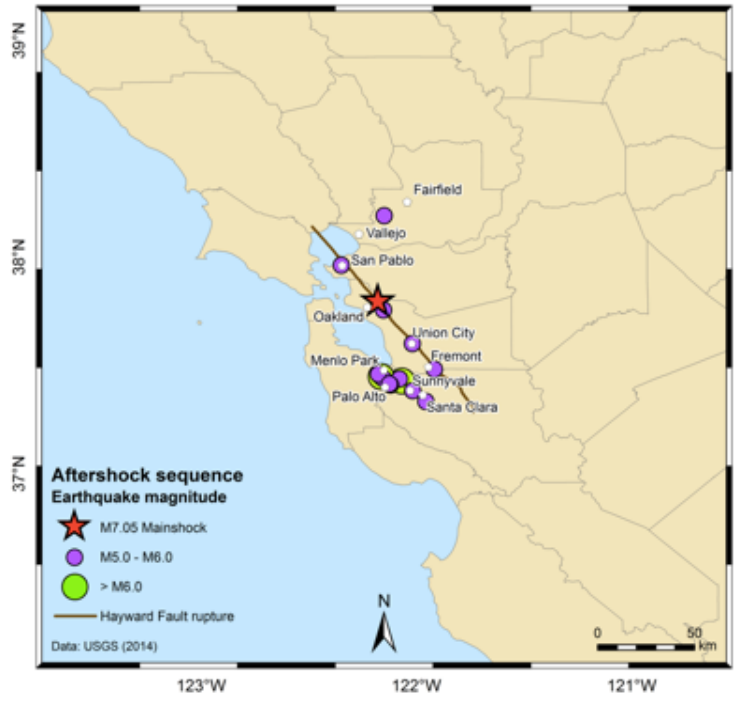
Table 1. Aftershock forecast immediately after the M 7 scenario mainshock for the next day, week, month and year.

Forecast time period	Number of aftershocks[1]		Aftershock probability[2]		Increase in the seismicity rate relative to the rate before the mainshock
	M ≥ 4	M ≥ 5	M ≥ 6	M ≥ 7	
Next 24 hours	33 (20—51)	3 (0—8)	30%	3%	2000
Next week	50 (33—125)	5 (1—13)	39%	5%	300
Next month	57 (40—126)	5(2—15)	43%	6%	86
Next year	71 (52—138)	7 (3—16)	47%	6%	9

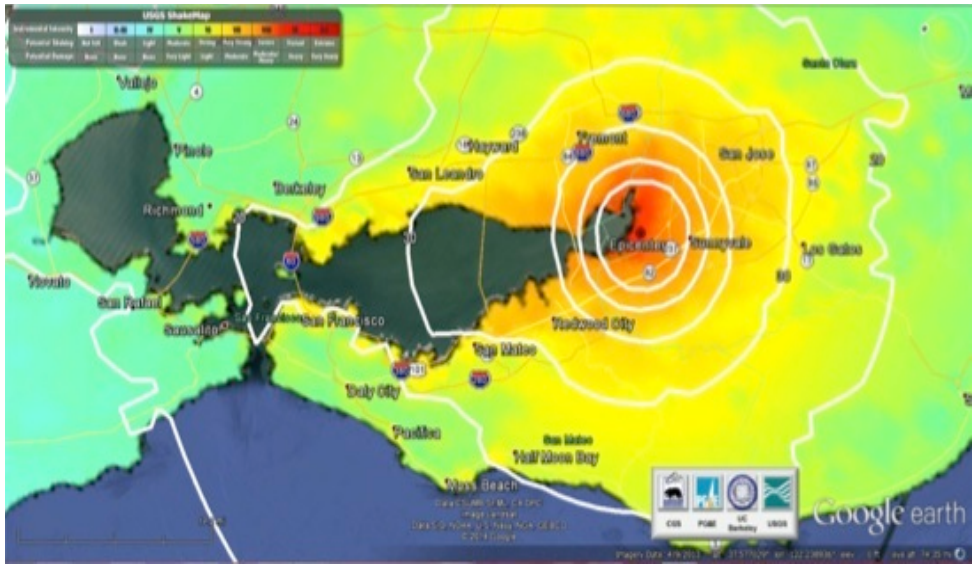
HayWired Scenario Aftershocks



M5+ aftershocks in HayWired sequence

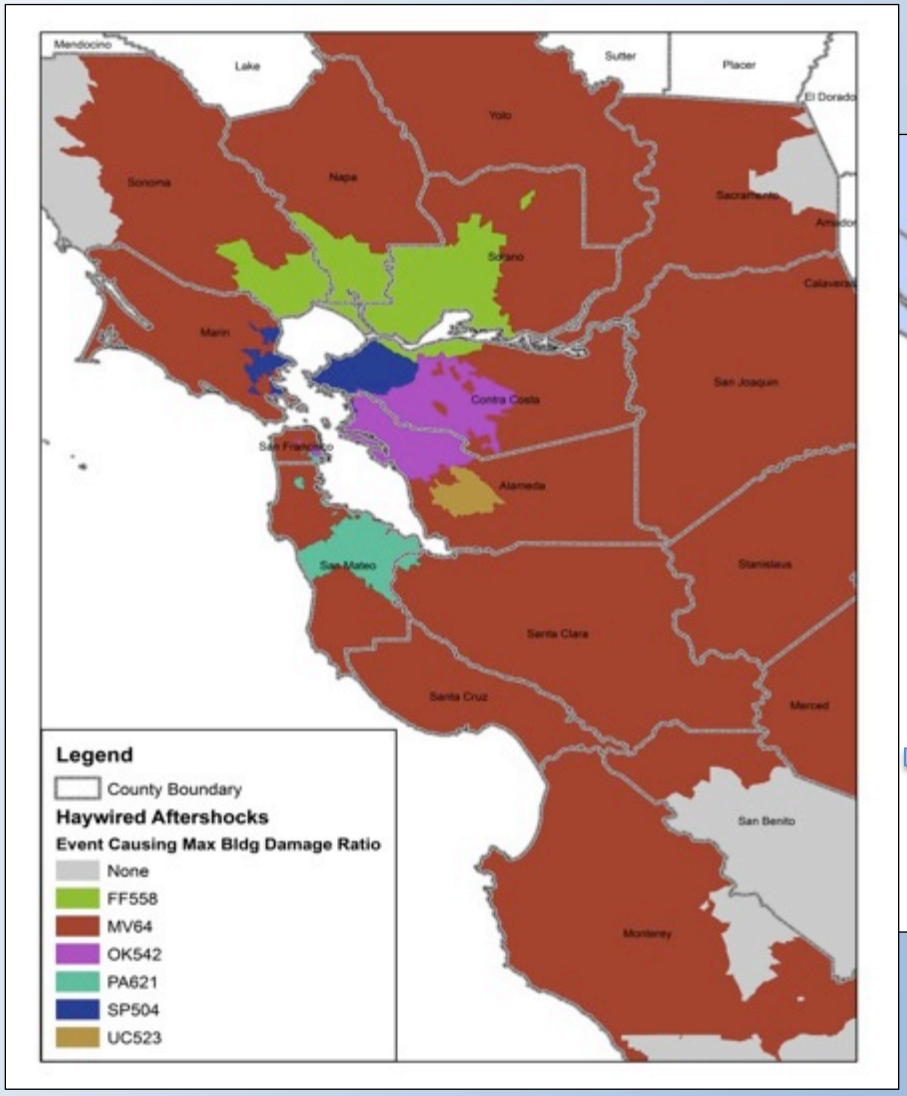


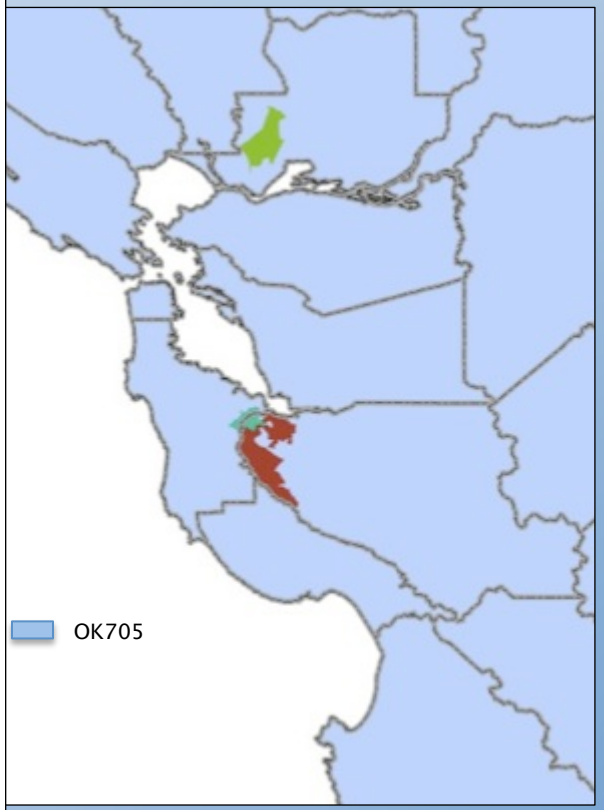
Mountain View M6.4 aftershock



Shaking Damage Factor Maximums

Aftershocks can cause physical damages & emotional stress





Event causing the maximum building damage factor

Aftershock causing the maximum building damage factor

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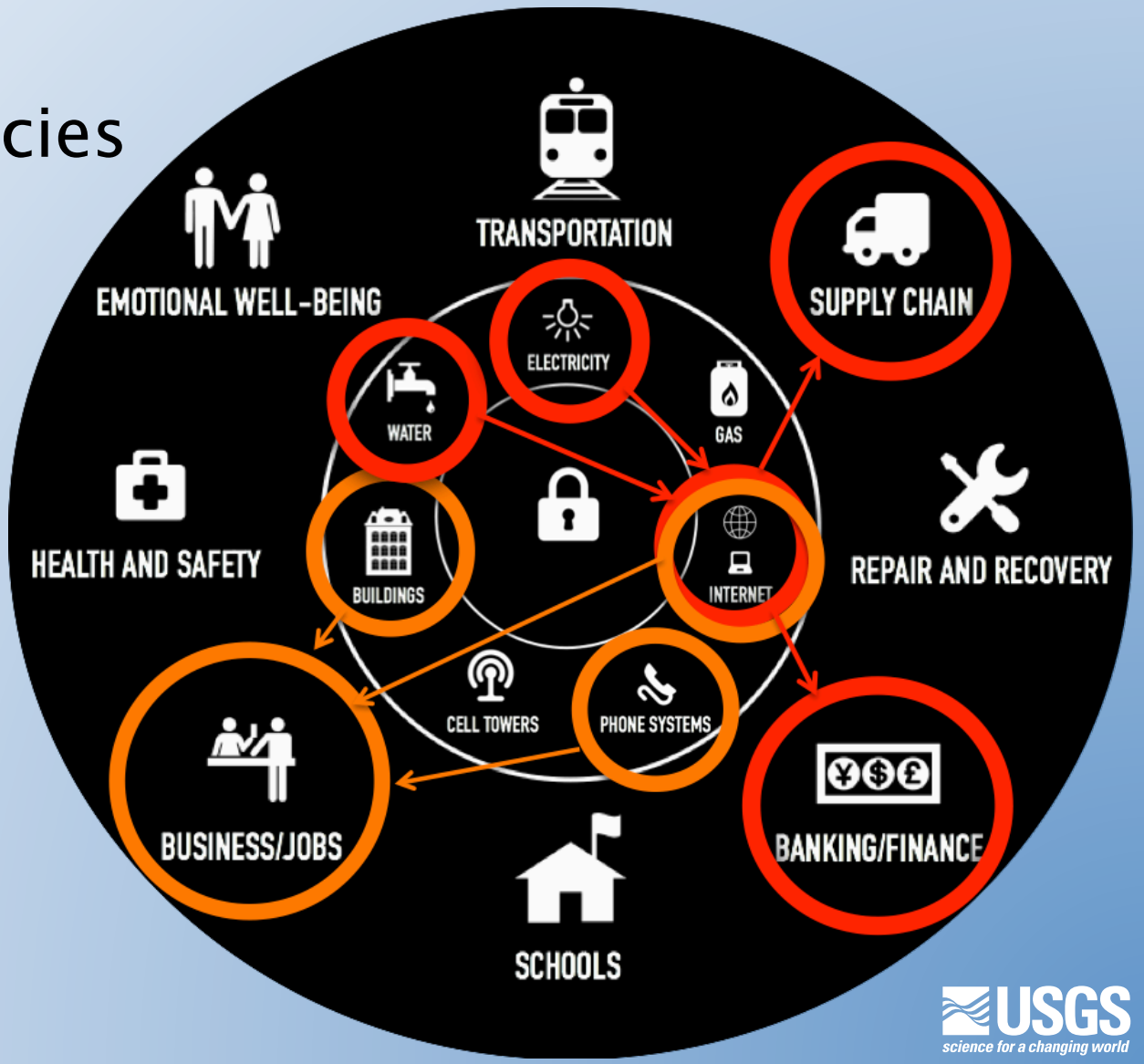
Hazus and FFE Building Losses

- **Shaking**: **$30 B** for Mainshock ($46 B incl. contents etc.)
- **Liquefaction**: **increases** by almost **20%** and likely repeats
- **Aftershocks**: collectively **add 10-25%** of damages
  - S. Napa earthquake damage ($0.35 B) is like an aftershock
  - Localized/concentrated damage of URM and Tilt Up buildings
- **Fire following** earthquake: **$100 B**

What else is new with HayWired?

- Lifeline interdependencies
- Communities at risk
- Internet economy
- Building code performance



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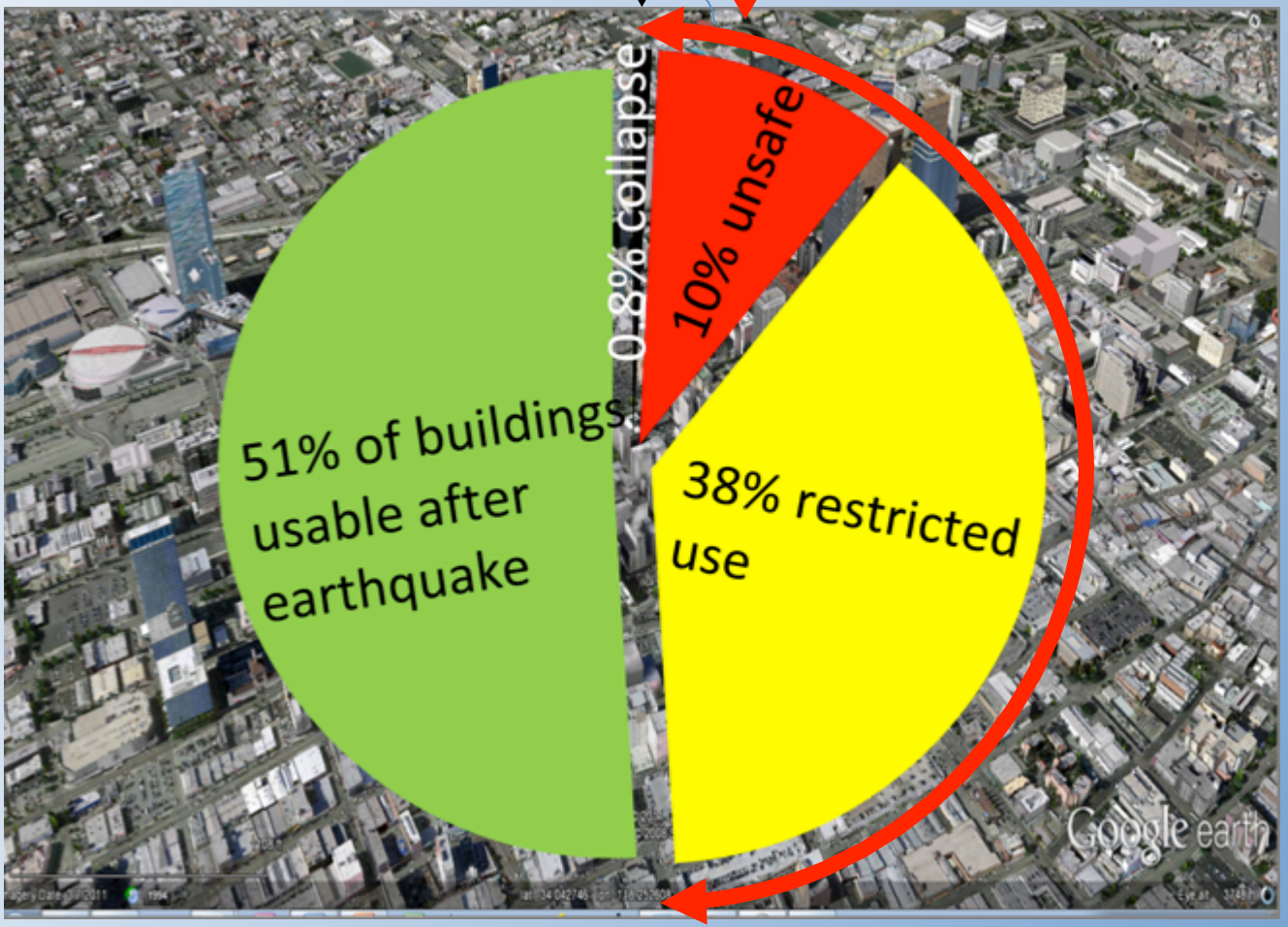
Building Code: Safe Enough

Code protects lives; not cities

Code implication

"Fraction impaired"



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Invitation to Participate

- Public preferences for building performance in earthquakes

My presentation today told you about research being conducted in part for the US Geological Survey. **I would like to invite you to participate in the research.** Part of the research is attempting to quantify public expectations for the performance of new buildings in natural disasters. By "the public," I mean the people whose lives and livelihoods depend on the performance of the buildings they use. I also include the public's representatives such as city councils and mayors who have a role in adopting and enforcing model building codes for their community. By "the public" I do not mean the engineers, contractors, and building officials whose colleagues already have a role in writing the code. I believe you, the people attending today, can be considered to be the public, under this definition. To help us in this research, would you please let us know your expectations for the performance of new buildings in earthquakes, by completing a survey form that is currently being passed (or located at http://goo.gl/NglKfh)? Your participation is voluntary and anonymous. When enough responses have been collected to be meaningful, the survey results will be compiled and presented in a peer-reviewed manuscript to the people who contribute to the building code and related provisions and guidelines. Those writers can then consider your understanding and preferences as they develop the next iteration of the building code. When the research is completed I will send a link to the study results to ABAG, who can inform you, so that you can learn what we find out. If you agree to participate, just fill out the survey form and bring it back to me at the end of the seminar. If you prefer not to participate, just don't take a form. Participating in the survey will take you less than 5 minutes. Are there any questions about the survey?

HayWired Contributors

- **USGS SAFRR:** Dale Cox (project manager), Lucy Jones, Erin Burkett, Sue Perry
- **Project leads:** Anne Wein (awein@usgs.gov) and Keith Porter
- **Physical scientists:** Shane Detweiler, Brad Aagaard, Jack Boatwright, Robert Graves, Thomas Holzer, Thomas Noce, Karen Felzer, Ken Hudnut (USGS)
- **Landslides:** Tim McCrinck and team (CGS)
- **GIS and ShakeMaps:** Jamie Ratlff, Tim MacDonald, Lori Dinitz
- **Shakecast:** David Wald and team
- **Graphics:** Matt Jamieson (USGS student contractor)
- **Physicals damages:** Keith Porter (UCB)
- **Fire Following:** Charles Scawthorn (SPA Risk LCC)
- **Hazus:** Hope Seligson (MMI Engineering)
- **Geochemistry:** Geoff Plumlee (USGS)
- **Economic consequences:** Anne Wein, Dan Wei & Adam Rose (USC)
- **Communities at risk and policy:** Laurie Johnson Consulting
- **Evaluation:** Liesel Ritchie (UCB)
- **Lifelines:** PG&E, EBMUD, BART, Caltrans, SJWC, Verizon
- **Funding of consequences:** Jonathan Smith (LCS)

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