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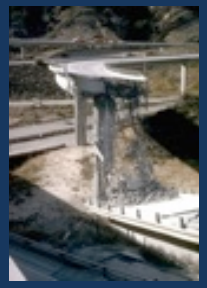
NATURAL HAZARDS MISSION AREA

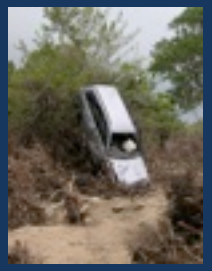



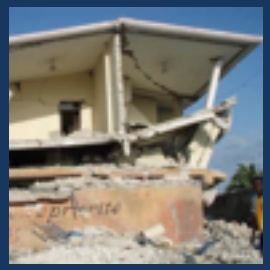

Science Application for Risk Reduction (SAFRR)

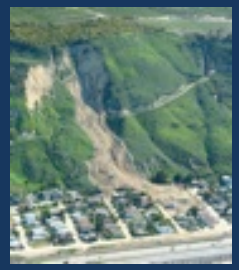
Dale Cox, Project Manager (USGS SAFRR)

Anne Wein, Keith Porter, Laurie Johnson, Kennth Hudnut & 65+ Contributors

HAYWIRED
OUTSMART DISASTER








The SAFRR Scenarios

ShakeOut: San Andreas fault (southern California) earthquake scenario (2008)

ARkStorm: winter storm scenario impacting U.S. West Coast (2010)

Tsunami Scenario: tsunami generated by an Alaskan earthquake and impacting the U.S. West Coast (2013)

HayWired: Hayward fault (northern California) earthquake scenario (in progress; April 18, 2018 - *release date*)

ARkStorm Retrospective: 2017 ARs, disaster declarations, beach loss, extreme storms, snow pack & melt runoff

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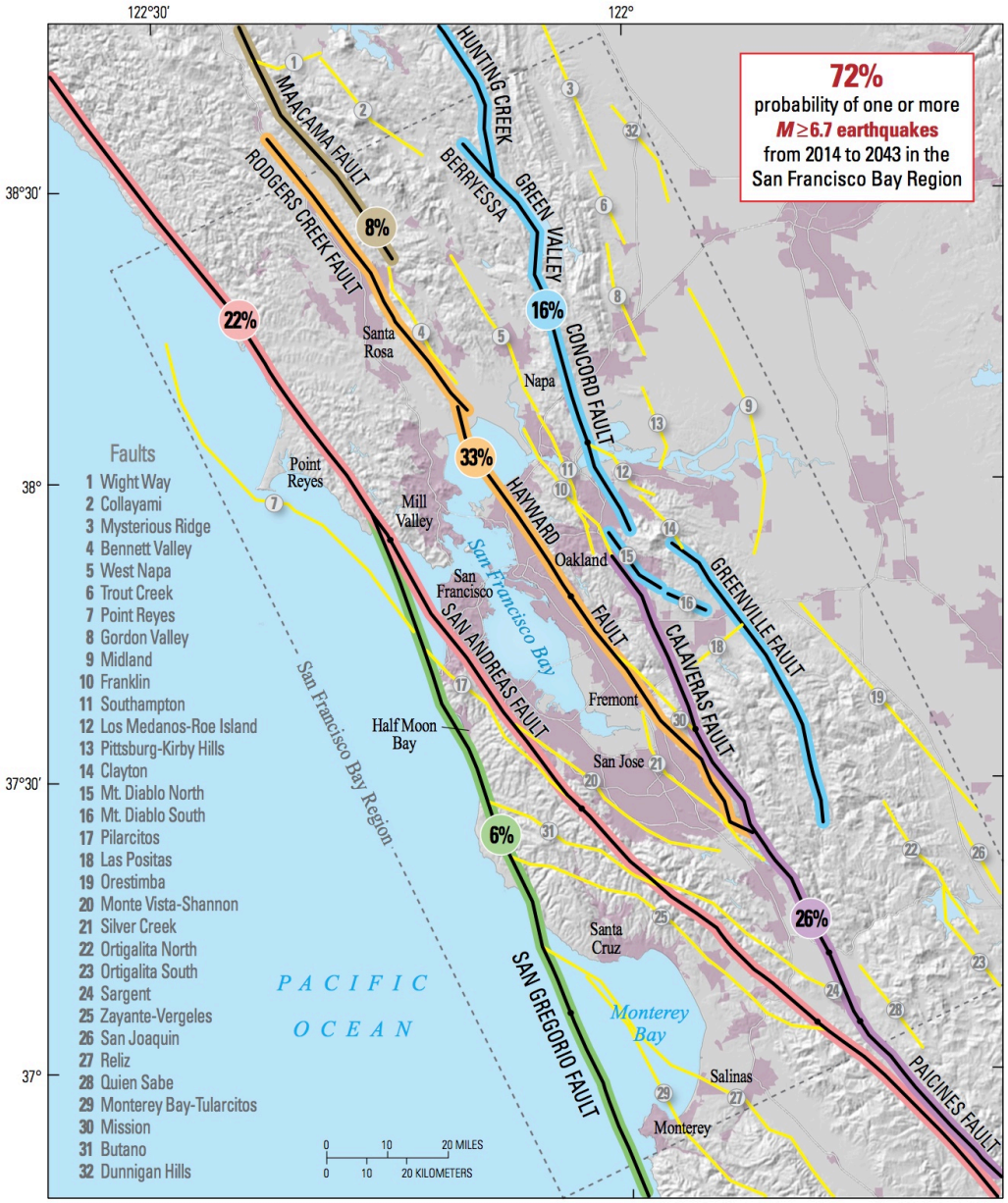

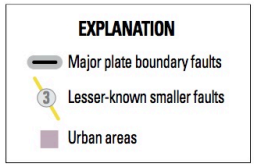

Figure 2. Map of known active geologic faults in the San Francisco Bay region, California, including the Hayward Fault. The 72 percent (%) probability of a magnitude (*M*) 6.7 or greater earthquake in the region includes well-known major plate-boundary faults, lesser-known faults, and unknown faults. The percentage shown within each colored circle is the probability that a magnitude 6.7 or greater earthquake will occur somewhere on that fault system by the year 2043. The probability that a magnitude 6.7 or greater earthquake will involve one of the lesser known faults is 13 percent. (From Aagaard and others, 2016.)

The Hayward Fault is arguably the most urbanized active fault in the United States.

It offers an informative case study of the effects of a large urban earthquake on a modern U.S. metropolis.

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Building the HayWired Scenario

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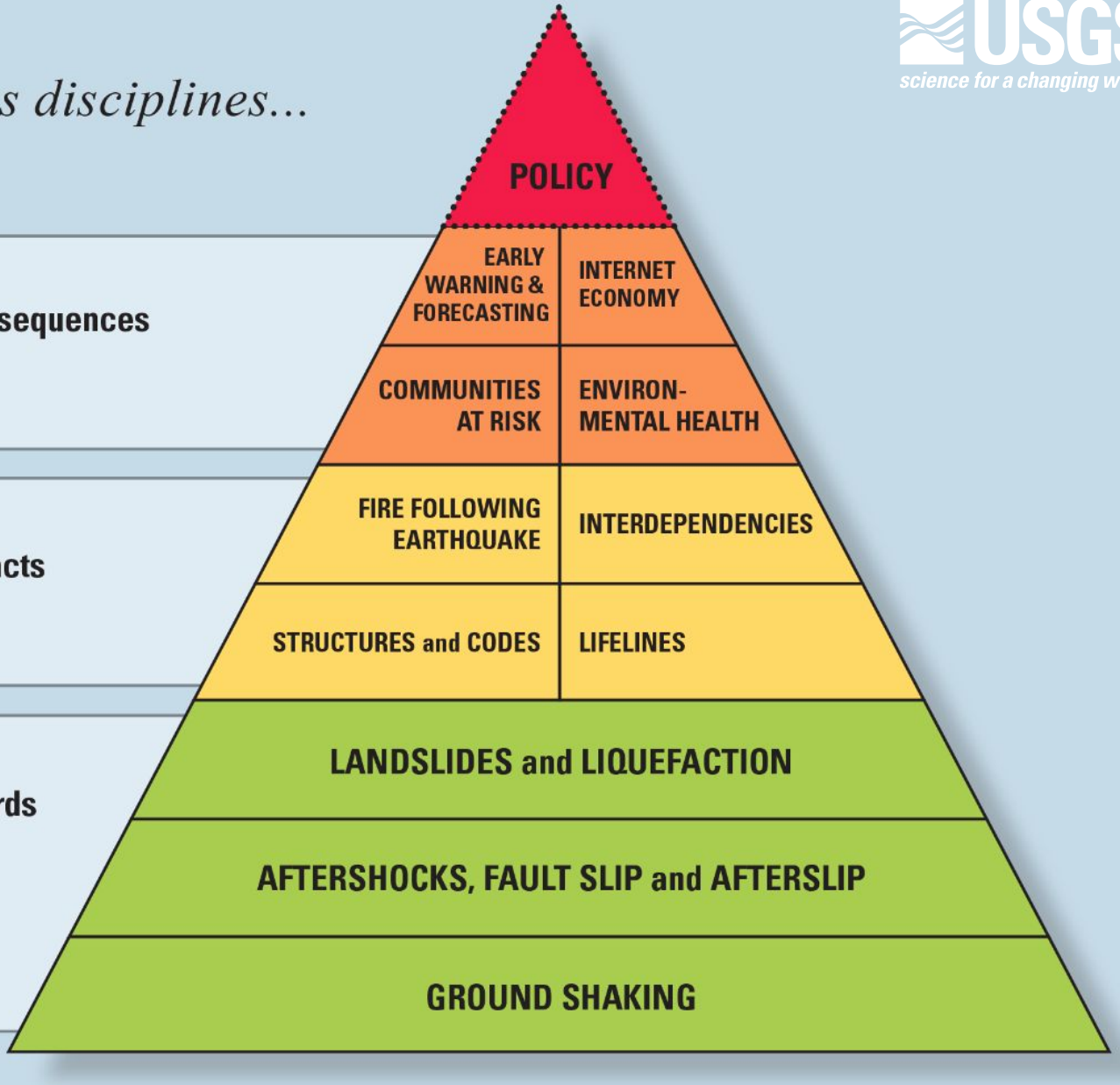
Integrating across disciplines...

SOCIAL SCIENCES
HayWired Volume III: Consequences

ENGINEERING
HayWired Volume II: Impacts

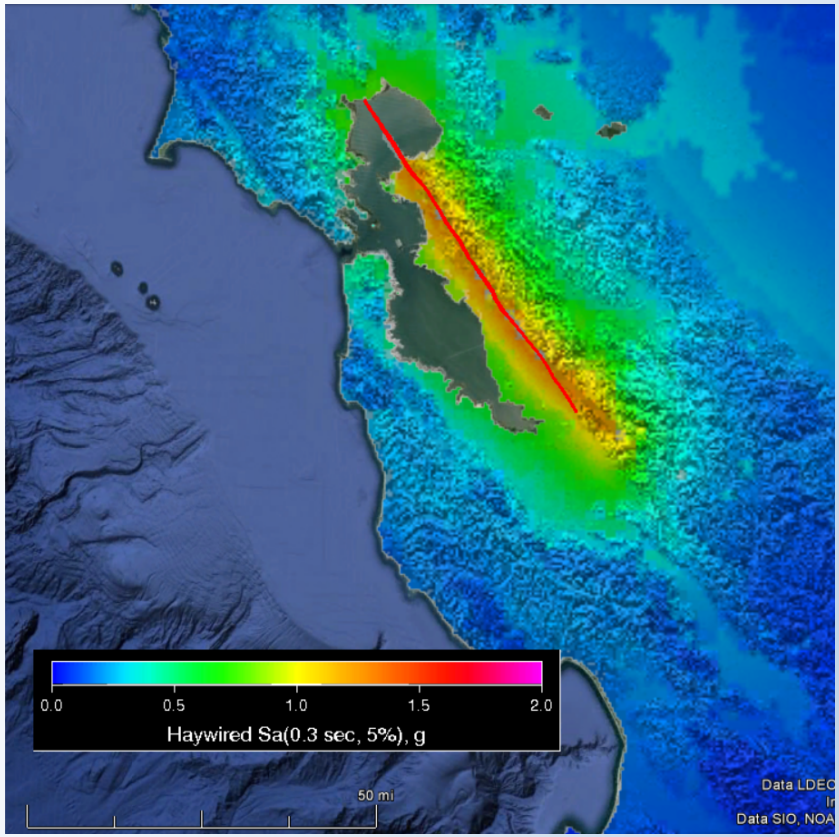
EARTH SCIENCE
HayWired Volume I: Hazards

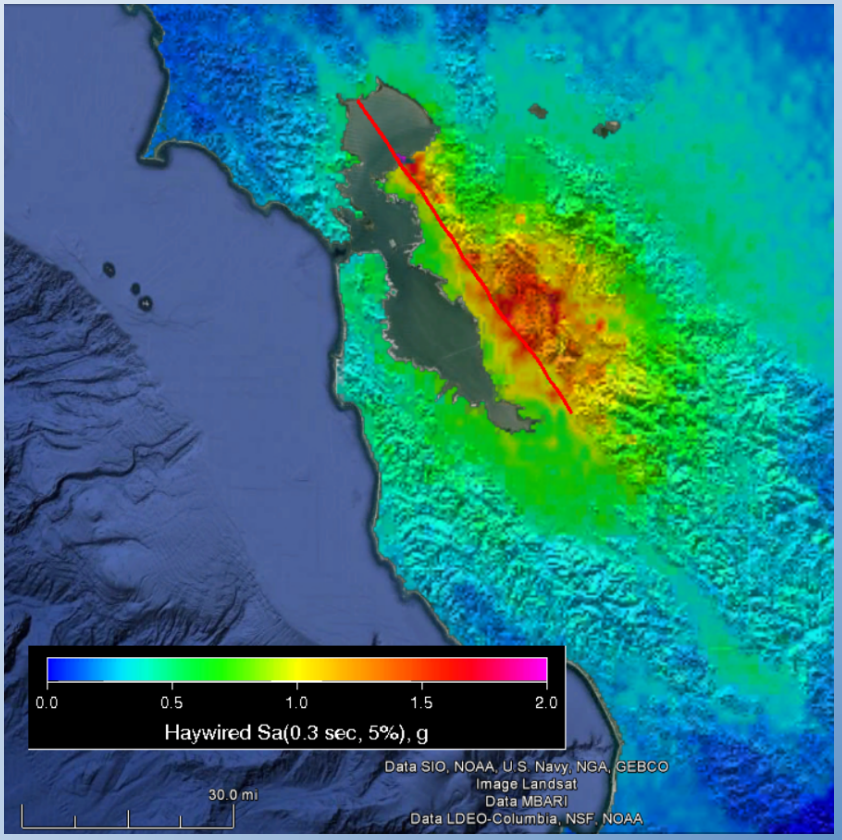


Hay**Wired:** Physics-Based Scenario

Hayward Mw 7.0 median

Same earthquake, bilateral rupture, physics-based model





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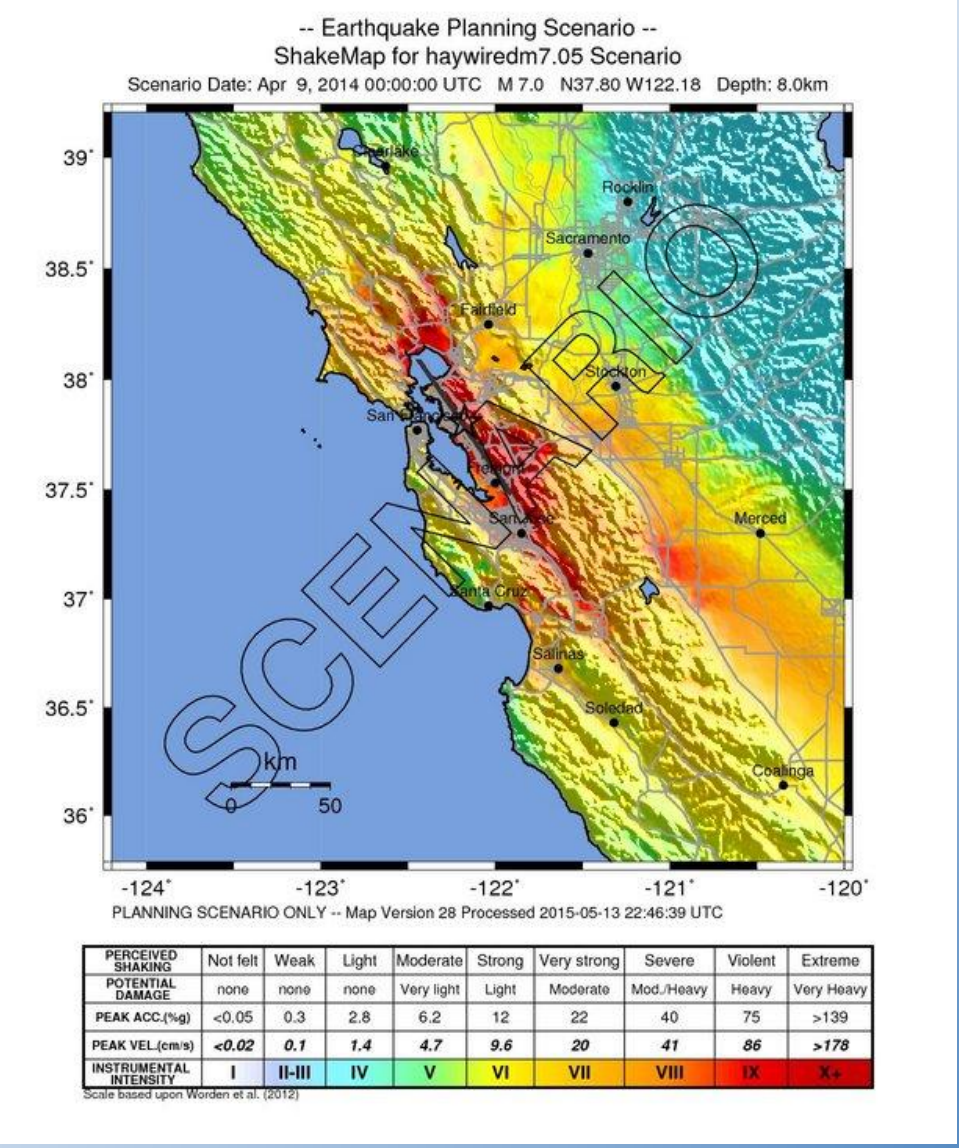
HayWired: Mainshock Ground Motions

M7.0 earthquake occurring on April 18, 2018, at 4:18 p.m, wind Is mild, no rain, temperature avg.

Rupture starts under Oakland, north into San Pablo Bay and south to the city of Fremont (53 miles)

The HayWired scenario describes a M 7.0 earthquake, 83-km (51 mile) rupture, with up to 2 meters (6.5 feet) of fault offset either in the form of coseismic slip or afterslip



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

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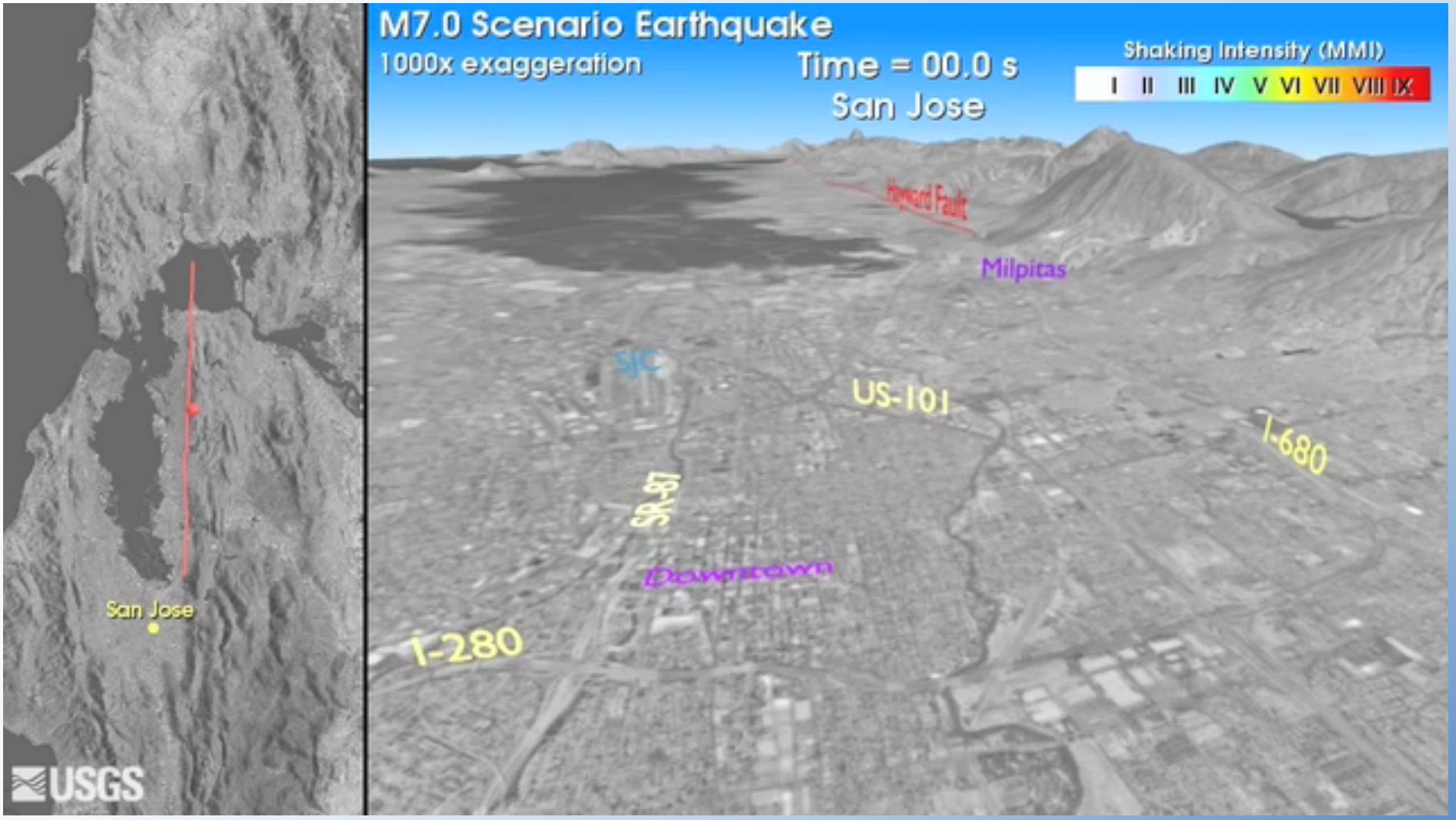
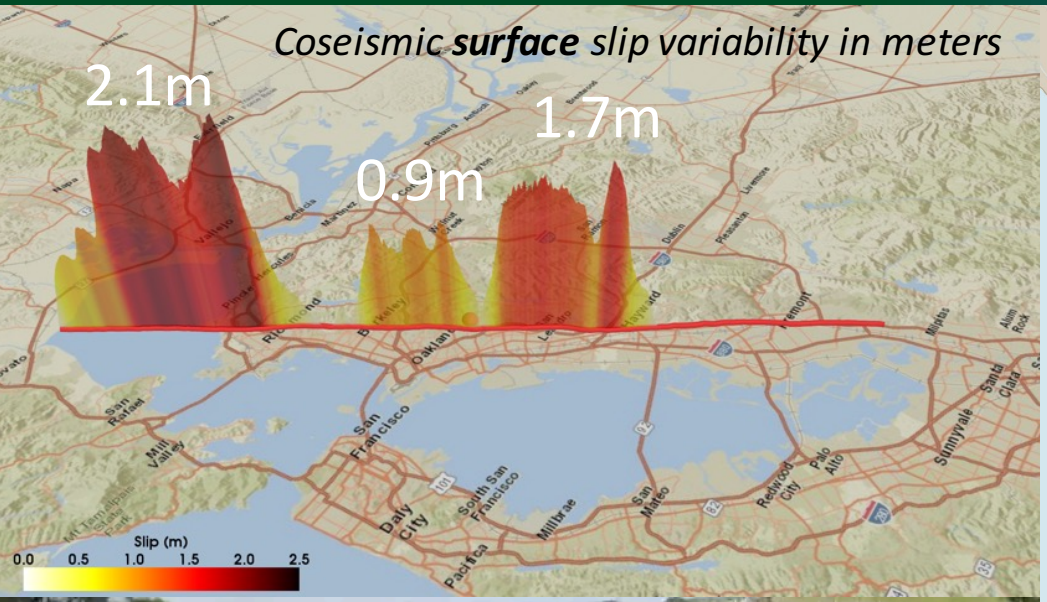
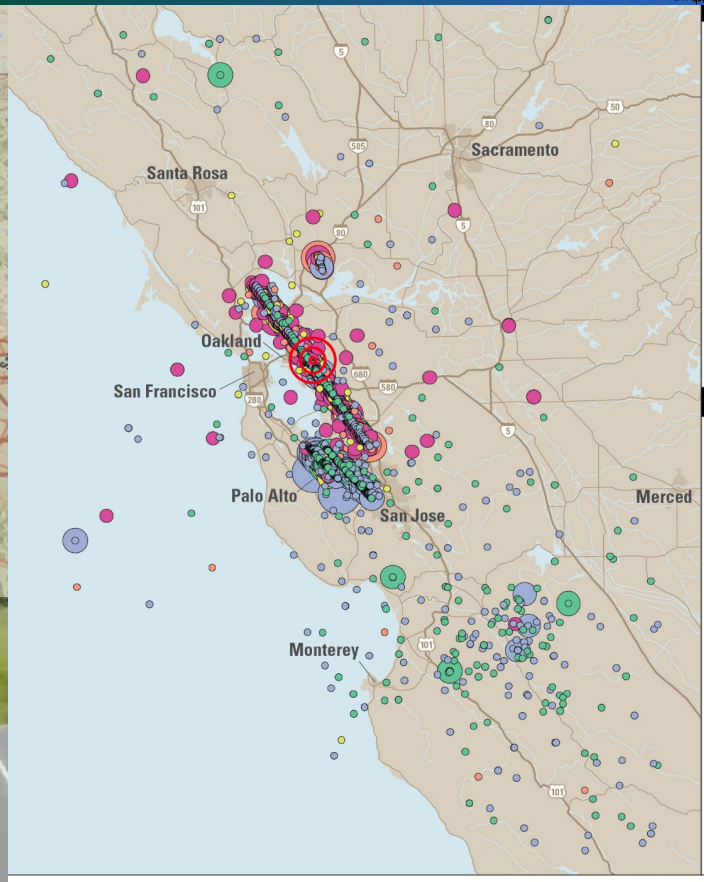
HayWired shaking animation

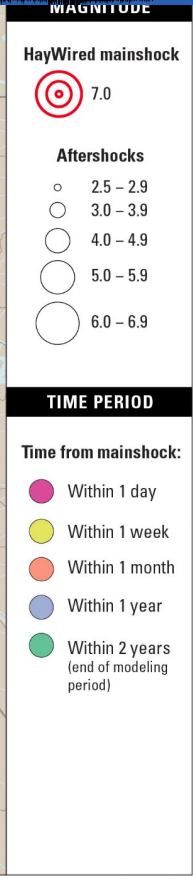


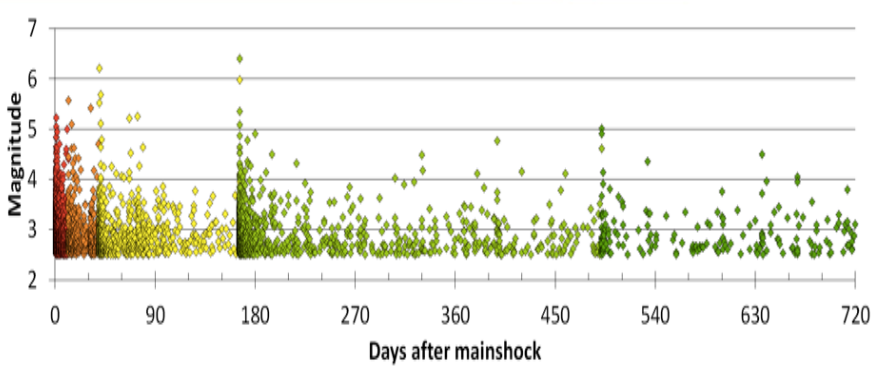
Hay**Wired**: Fault Slip, Afterslip and Aftershocks



2016 M 7.8 Kaikoura,NZ earthquake







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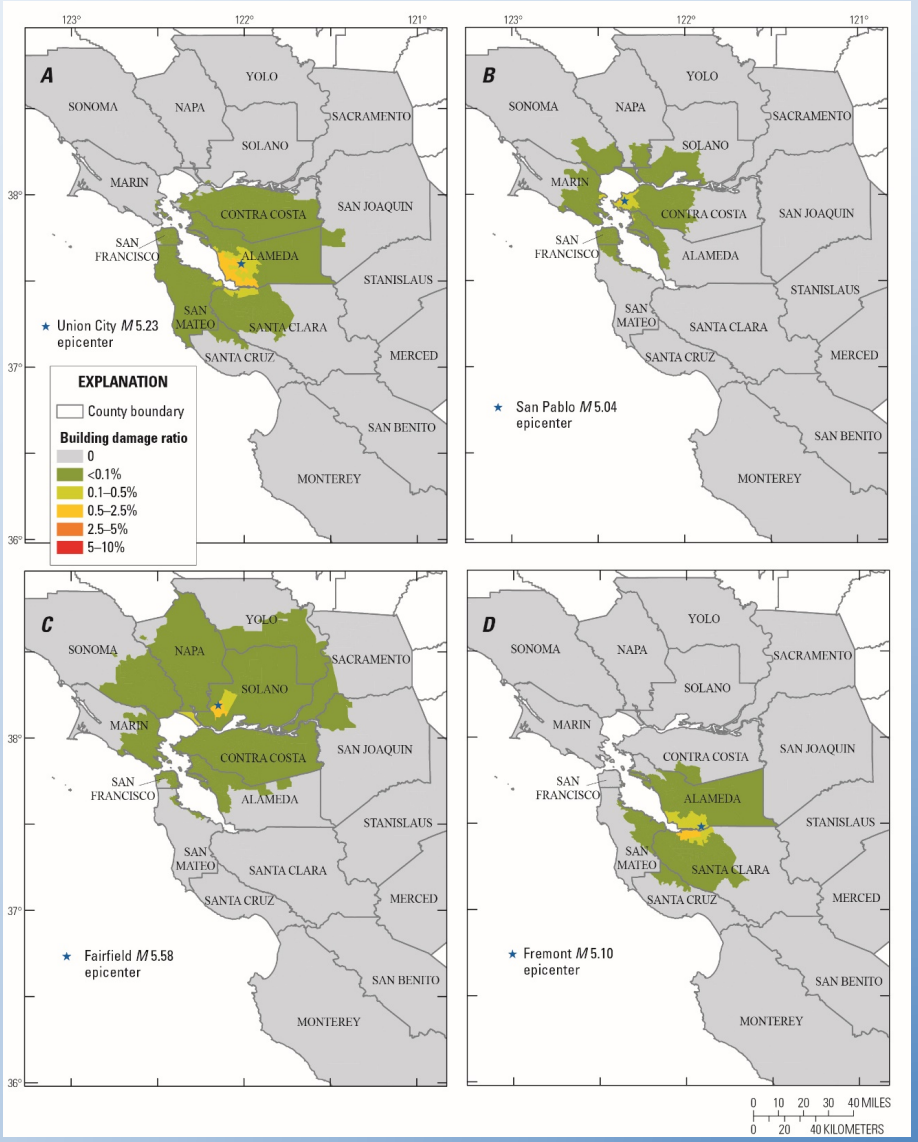
HayWired: Hazus aftershock analysis

- Aftershocks contribute 20% of loss
  - 12% from 3 aftershocks M_w 6.0 to 6.4
  - 8% to 13 aftershocks M_w 5.0 to 5.9
- Some areas more damaged by aftershocks
- Repeat liquefaction is a concern
- 1st Hazus-MH analysis of entire earthquake sequence in a scenario



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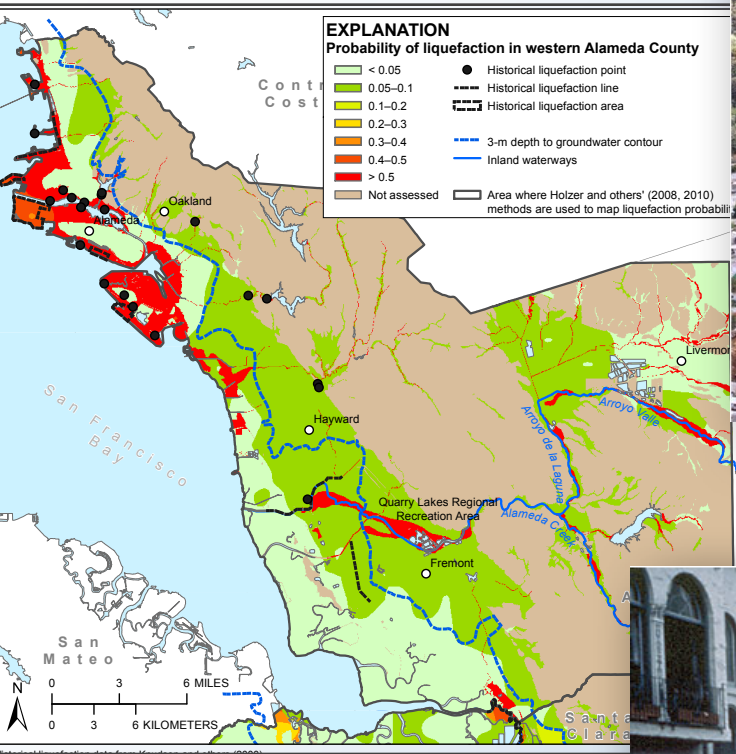
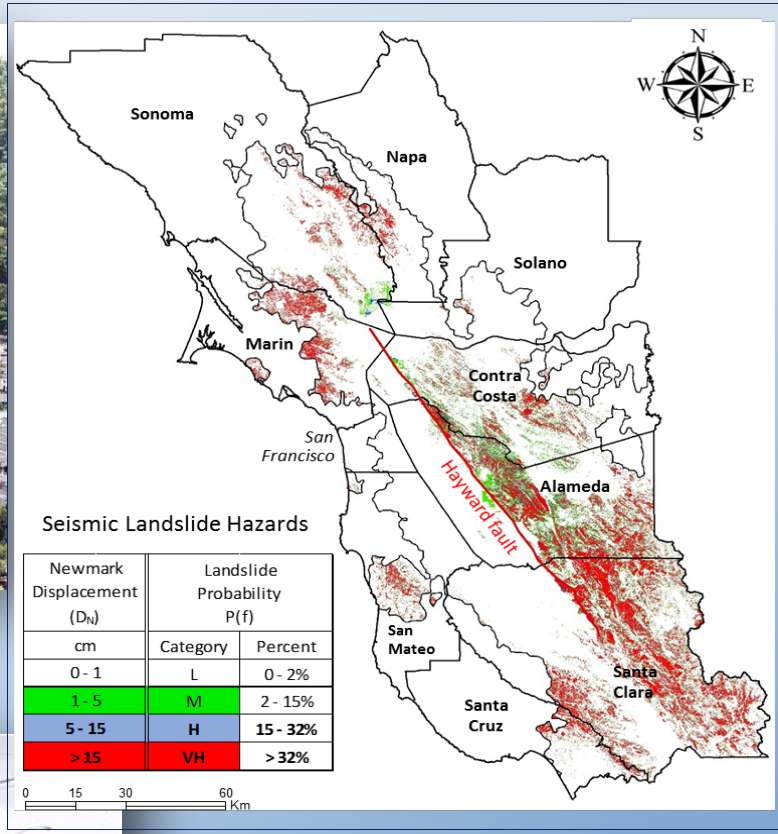
Hay**Wired**: Landslide & Liquefaction

2001 El Salvador earthquake-induced landslide





Seismic Landslide Hazards

Newmark Displacement (D_N)	Landslide Probability P(f)	
cm	Category	Percent
0 - 1	L	0 - 2%
1 - 5	M	2 - 15%
5 - 15	H	15 - 32%
> 15	VH	> 32%

Liquefaction in San Francisco Marina, Loma Prieta Earthquake 1989

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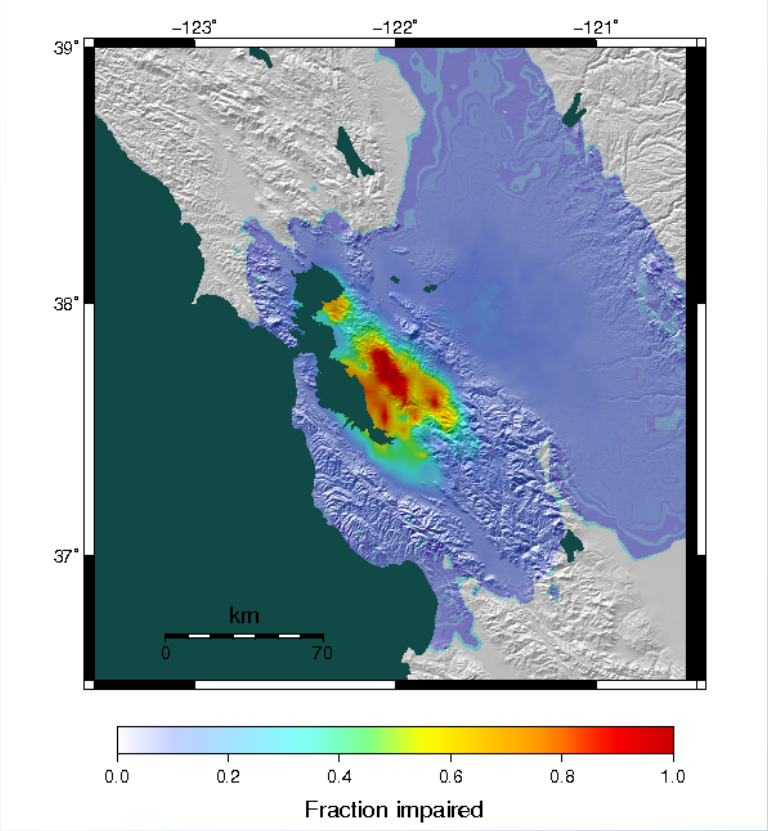
An immediate occupancy code? Build 50% stronger & stiffer; cost 1% more; reduce impairment by 3/4th

Life Safety

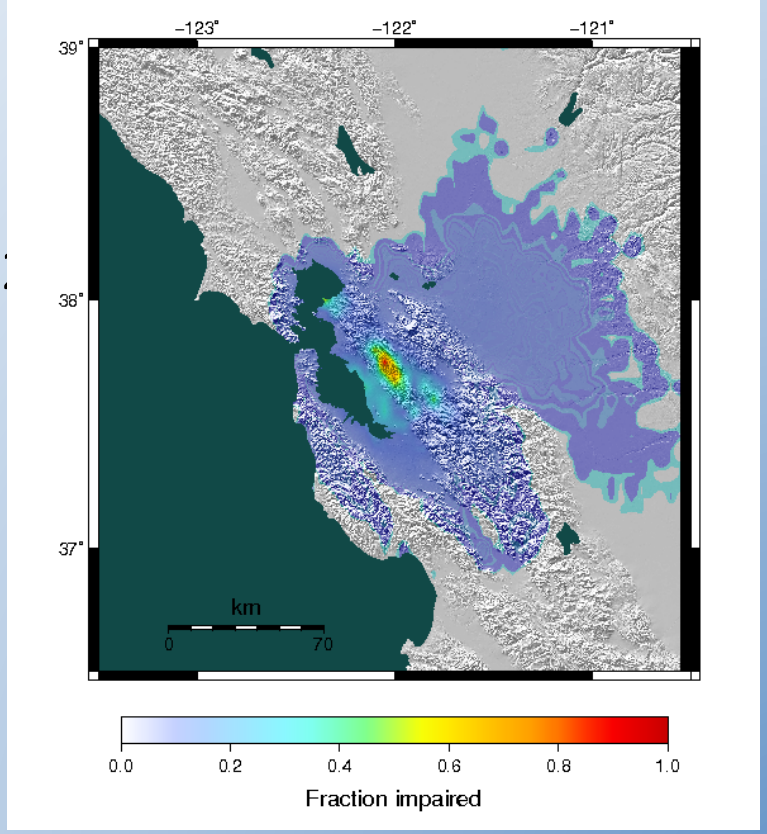
8,000 buildings (0.4%) collapse
490,000 (24%) red or yellow tag



Vs.

Immediate Occupancy

95% shelter in place, collapse, red, and yellow tags reduced by 3/4



Preliminary information subject to revision. Do not cite.

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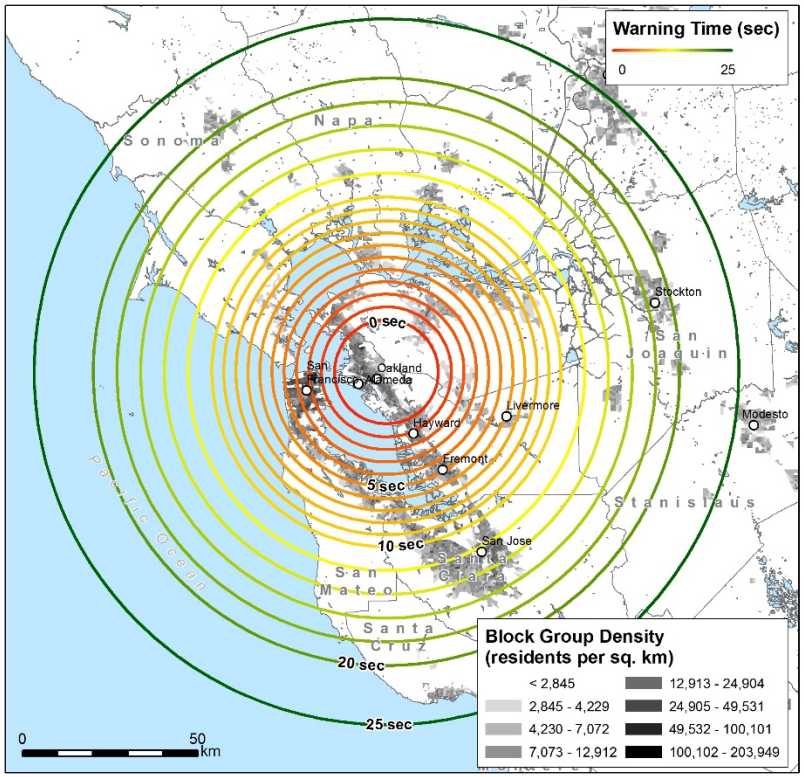
Hay**Wired:** EEW and DCHO

Earthquake early warning (EEW) time in HayWired



Drop, cover, and hold on (DCHO) reaction time

EEW + DCHO could prevent 1,500 injuries "worth" $300M in Mw 7.0 Hayward

Preliminary information subject to revision. Do not cite.

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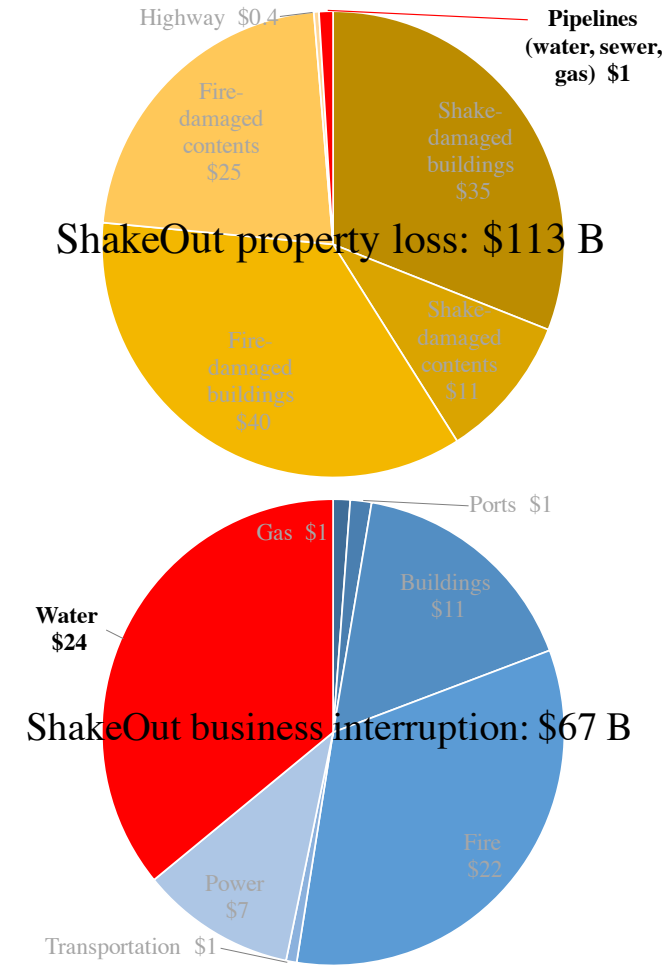
Hay**Wired:** Water dominates EQ risk to society



- Water causes economic losses far out of proportion to the utility's repair cost
- Some Bay Area agencies have >50% brittle pipe
- Aggressive pipe replacement: 1% per year
- Equals decades until resilient water supply

What happens in HayWired?

Preliminary information subject to revision. Do not cite.

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Hay**Wired: New** Water Network Resilience Model

- Measures lost service-days
- Lifeline interaction & resource limits
- Vetted by EBMUD & SJWC
- Requires only GIS & spreadsheet

Condition	Lost service days	Resilience benefit (service days)	Avg restoration (days)	Resilience benefit
As-is	17,000,000	0	44	0
Fuel plan	16,800,000	200,000	43	$150 million
Replace all fragile pipe	8,800,000	8,200,000	22	$6 billion

Preliminary information subject to revision. Do not cite.

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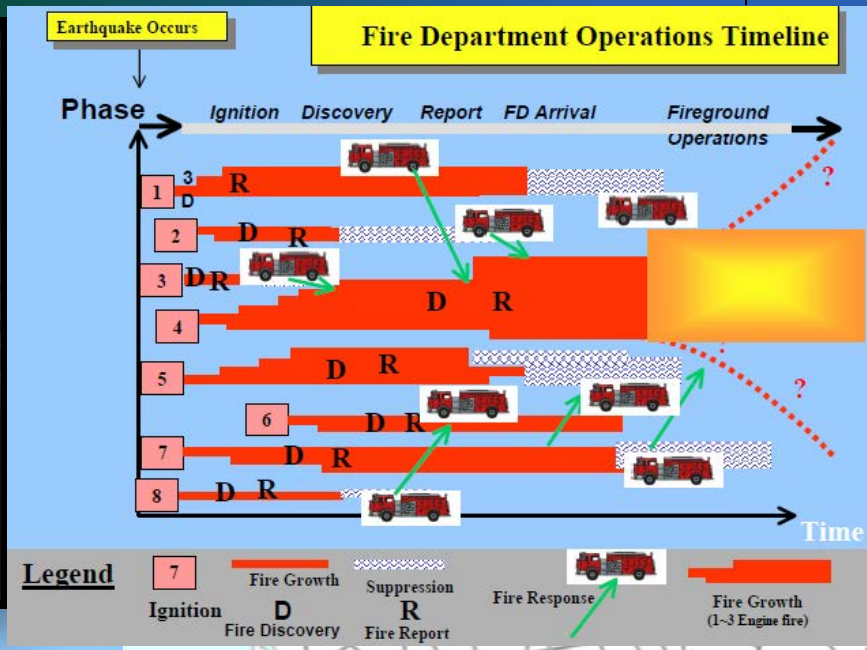
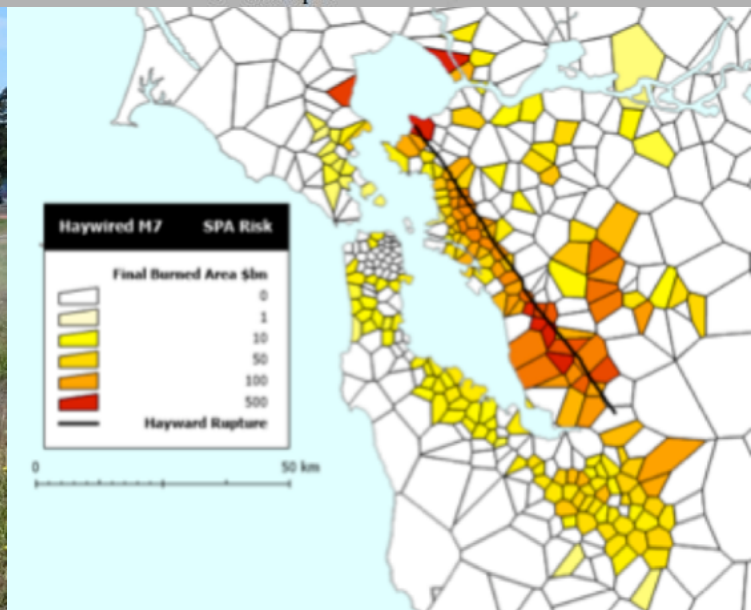
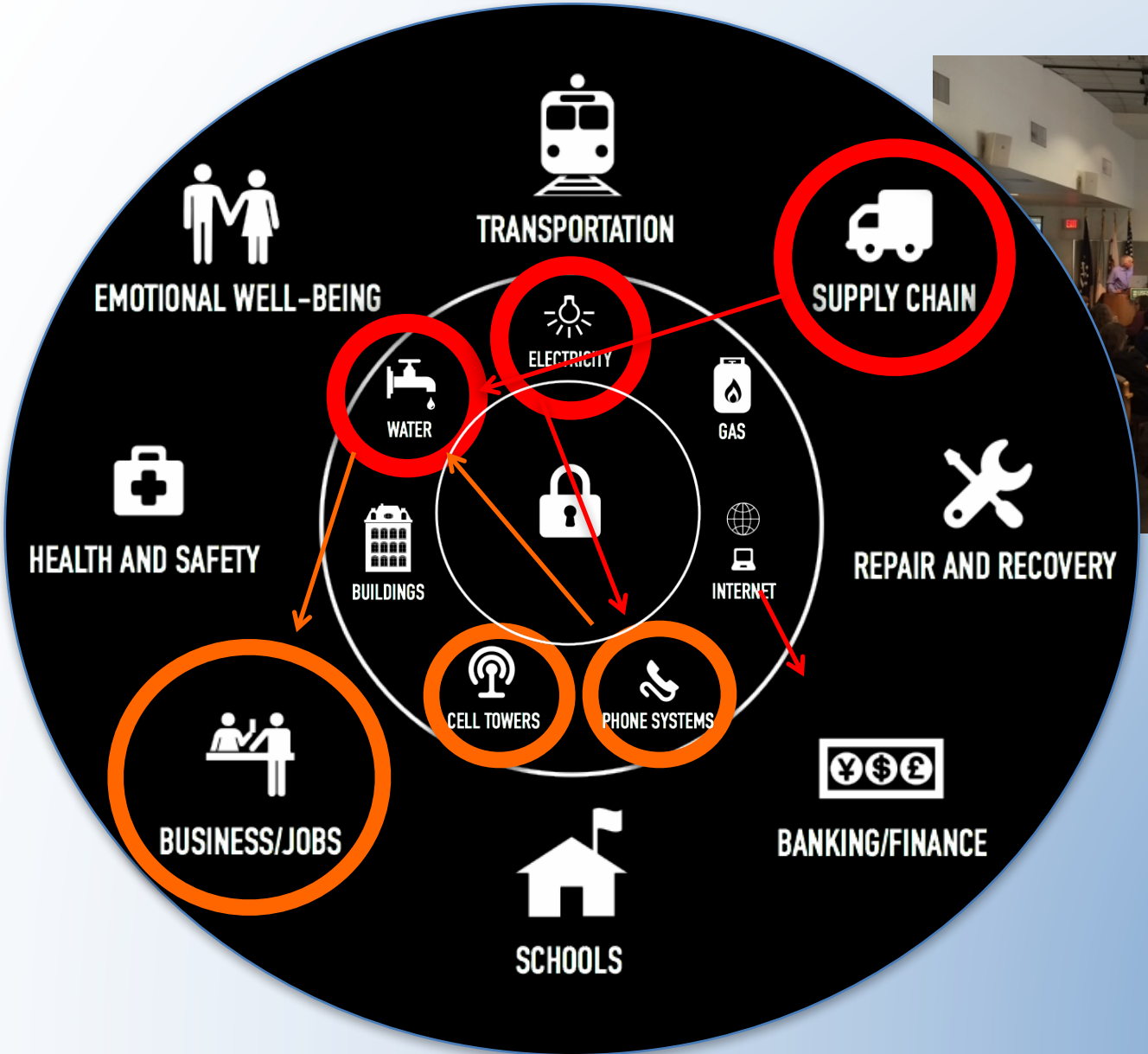
Hay**Wired:** Fire Following Earthquake





Hay**Wired:** Our Interconnected World



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HayWired Objectives:

- Improve the communication of earthquake hazard science in risk reduction

- Advance basic knowledge of, and inform actions to reduce earthquake risks

- Help build community capacity to respond and recover from earthquakes

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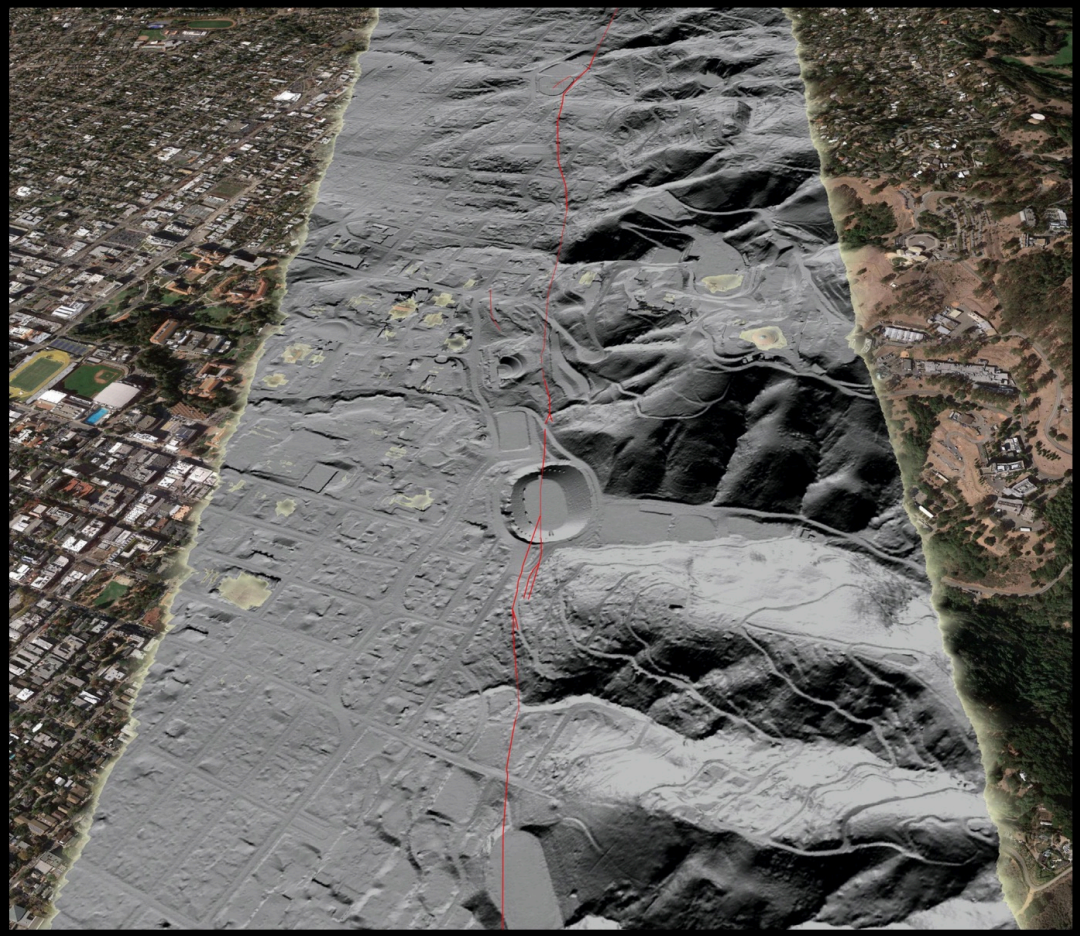
Prepared in cooperation with the California Geological Survey

The HayWired Earthquake Scenario—Earthquake Hazards

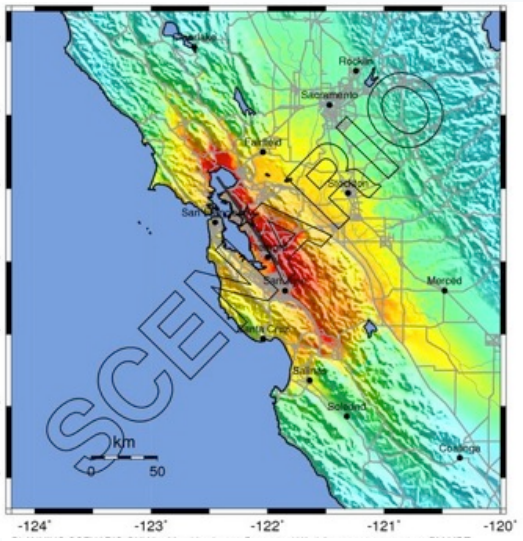


Scientific Investigations Report 2017–5013–A–H

Hay**Wired:** Objectives

- Improve understanding of the benefits of earthquake early warning
- Facilitate conversations about lifeline restoration interdependencies (exercises on-going)
- Educate about building code performance and public preferences for the building code
- Help anticipate environmental health issues
- Engage stakeholders in the discussions about the vulnerabilities and resilience in cyber infrastructure & the internet economy
- Provide materials for emergency response, business continuity and recovery exercises

Hay**Wired** Roll Out



The HayWired Earthquake Scenario—Earthquake Hazards
Edited by Shane T. Detweiler and Anne M. Wein
Scientific Investigations Report 2017–5013–A–H
[Also see https://doi.org/10.3133/sir20175013]

The HayWired Scenario—How Can the San Francisco Bay Region Bounce Back from or Avert an Earthquake Disaster in an Interconnected World?

By Kenneth W. Hudnut,[1] Anne M. Wein,[1] Dale A. Cox,[1] Suzanne C. Perry,[1] Keith A. Porter,[2] Laurie A. Johnson,[3] and Jennifer A. Strauss[4]

Introduction

The HayWired scenario is a hypothetical yet scientifically realistic and quantitative depiction of a moment magnitude (M_w) 7.0 earthquake (mainshock) occurring on April 18, 2018, at 4:18 p.m. on the Hayward Fault in the east bay part of the San Francisco Bay area, California. The hypothetical earthquake has its epicenter in Oakland, and strong ground shaking from the scenario causes a wide range of severe impacts throughout the greater bay region. In the scenario, the Hayward Fault is ruptured along its length for 83 kilometers (about 52 miles).

Building on a decades-long series of efforts to reduce earthquake risk in the San Francisco Bay region, the hypothetical HayWired earthquake is used to examine the well-known earthquake hazard of the Hayward Fault, with a focus on newly emerging vulnerabilities. After a major life-saving response functions can be compromised. For these reasons, the name Hay**Wired** was chosen for this scenario to emphasize the need to examine our interconnectedness and reliance on telecommunications and other lifelines (such as water and electricity) toward the goal of making the San Francisco Bay region more resilient in future earthquakes.

Earthquake risk in the San Francisco Bay region has been greatly reduced as a result of previous concerted efforts; for example, a roughly $50 billion investment in strengthening infrastructure was motivated in large part by the 1989 magnitude (M) 6.9 Loma Prieta earthquake. The earthquake hazard from the Hayward Fault remains high, however, and much work still needs to be done to ensure that the region is ready for a major earthquake like that modeled in the HayWired scenario. Already, there is a renewed commitment from the newly formed HayWired Coalition—consisting of numerous government, academic, utility-

Mon. 4/24/17

All-Partner
Kick-Off meeting

Year-long series of
- workshops
- exercises
- reduce risk

Creation of a
HayWired Partner
Package

Public Rollout
April 18, 2018

ShakeOut:
Oct. 18, 2018

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HAYWIRED

OUTSMART DISASTER

ARUP—Design and Engineering Consultants
Association of Bay Area Governments
Aurecon
Bay Area Center for Regional Disaster Resilience
Bay Area Rapid Transit Authority
Boston University
California Department of Public Health
California Department of Transportation
California Earthquake Authority
California Earthquake Clearinghouse
California Geological Survey
California Governor's Office of Business and Economic Development
California Governor's Office of Emergency Services
California Public Utilities Commission
California Resiliency Alliance
California Seismic Safety Commission
Carnegie Melon University Silicon Valley
City of Berkeley
City of Oakland
City of San Francisco, Department of Emergency Management
City of Walnut Creek
Earthquake Country Alliance
Earthquake Engineering Research Institute
East Bay Municipal Utilities District
Federal Emergency Management Agency
Joint Venture Silicon Valley
Laurie Johnson Consulting
MMI Engineering
Pacific Earthquake Engineering Research Center
Pacific Gas and Electric
Palo Alto University
Red Cross
Rockefeller Foundation—100 Resilient Cities
San Jose Water Company
Southern California Earthquake Center
SPA Risk LLC
San Francisco Bay Area Planning and Urban Research Association
Strategic Economics
Structural Engineers Association of Northern California
University of California Berkeley Seismological Laboratory
University of Colorado Boulder
University of Southern California
U.S. Geological Survey

PEER

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS

Joint Venture SILICON VALLEY

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Questions?

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