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science for a changing world

NATURAL HAZARDS MISSION AREA   SAFRR Project: Science Application for Risk Reduction

SAFRR Scenarios and Sea Level Rise

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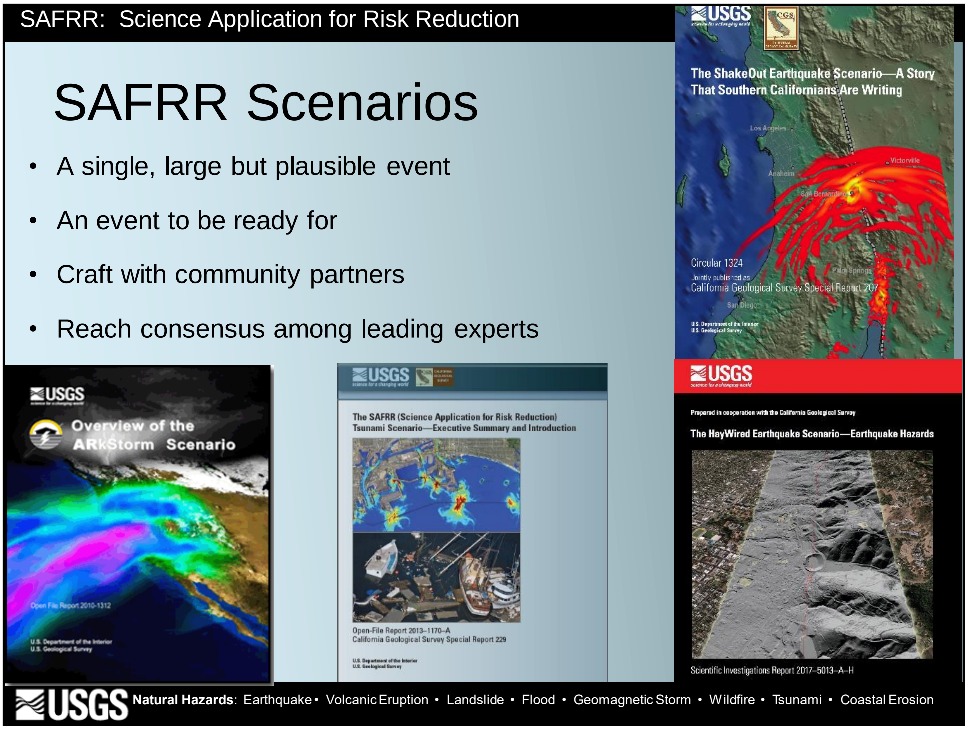
Natural Hazards: Earthquake • Volcanic Eruption • Landslide • Flood • Geomagnetic Storm • Wildfire • Tsunami • Coastal Erosion



The HayWred scenario is the fourth multi-hazard scenario the USGS has lead. The first three were ShakeOut, modeling a large EQ on the Southern San Andreas Fault; ARkStorm, which looked at what would happen if storms from the mid-1800's happened today; SAFFR tsunami that modeled a far-field tsunami, originating in the Aluetians, ShakeOut -has become an annual drill and involved over 9 million people in CA last year, and has also gone national and international.

The principles for all of the scenarios are:
To model a single large but plausible event, something we need to be ready for. We're not looking at worst case, but something worse than experienced in CA in our lifetimes.
Even though these events won't likely happen exactly as in the scenario, planning for it will also prepare us for other events.

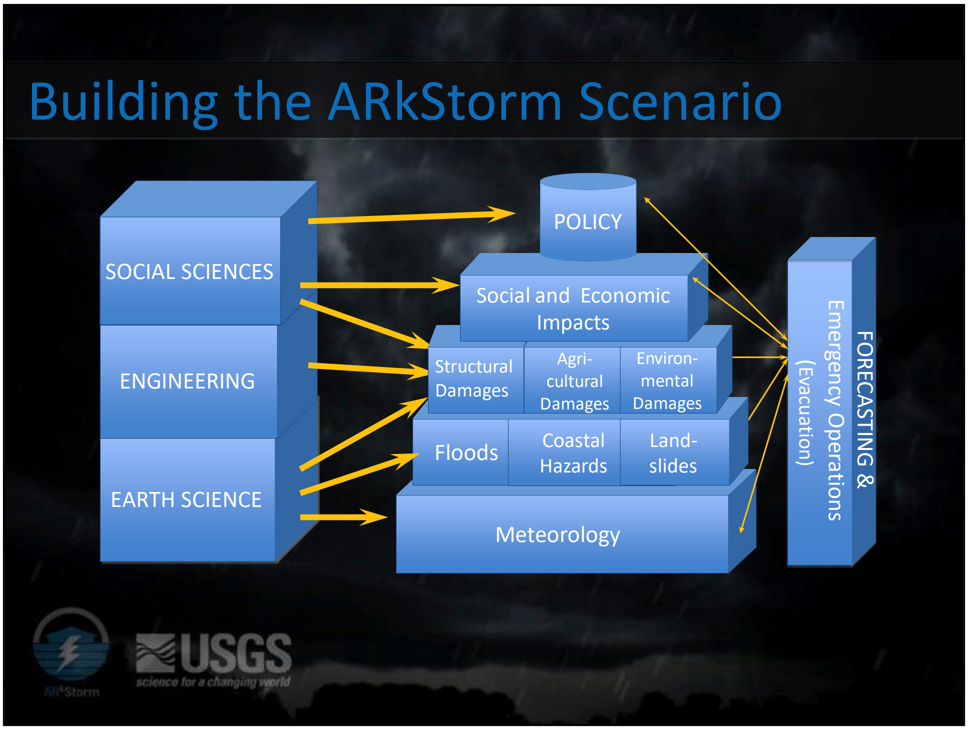
Consensus among leading experts:
[The scientific process is based on scientists arguing with each other to get at the truth. What we're showing you here are things experts have agreed on at the end of those arguments.]

Craft the study with community partners:
When we wanted to know about coastal bridges, we went to CalTrans. When we

wanted to know about ports and harbors, we went to harbor masters. We talked with fishermen. Reaching out to get information from the community is an important part of our process.

We want to provide the best science to support coastal communities as they prepare for damaging multi hazard events, and put it in a form emergency managers and planners can use.

Atmospheric River
1861-62 – 45 days of rain – flooding 300 miles long



Scientific foundation of Meteorology (two recent storms stitched together)

Precipitation and winds are translated into floods, coastal waves, and landslides.

Engineers and agriculture experts estimate the damages from these hazards to buildings and infrastructure, crops and livestock, and toxic releases.

Economists and geographers translated damages into economic impacts and affected populations.

The exercise for emergency management involves forecasts in addition to the unravelling situations.

Flooding from Precipitation & Run-off

Source: Porter, Wein and others, 2010, Overview of the Arkstorm Scenario, https://pubs.usgs.gov/of/2010/1312/

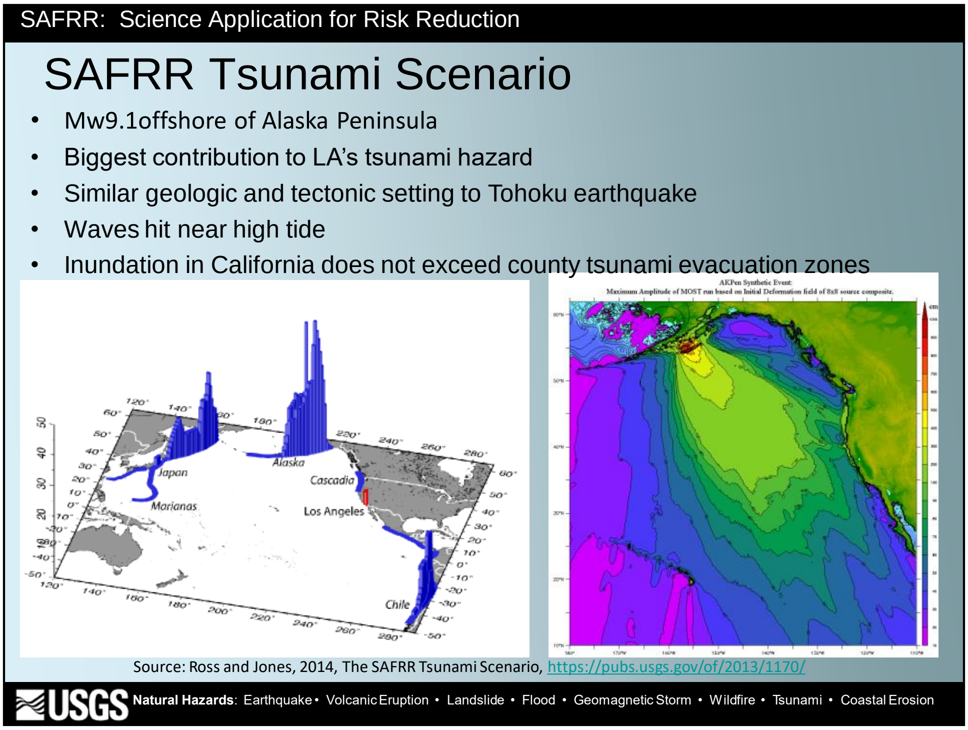
Figure 8. Blue areas indicate ARkStorm flooding as projected by models used in the scenario.

Development of CoSMoS

- Coastal processes modeled for ARkStorm now available for rest of the state with Sea Level Rise interaction at https://www.usgs.gov/apps/hera/

Figure 10. Extent of the CoSMoS model applied to the ARkStorm scenario. See Barnard and others (2009) for details and additional maps.

There are other models out there – BCDC.



The SAFRR tsunami scenario is a product of the USGS in partnership with California Geological Survey, Cal OES, NOAA, and others. The many authors are the Tsunami Scenario's Coordinating Committee.

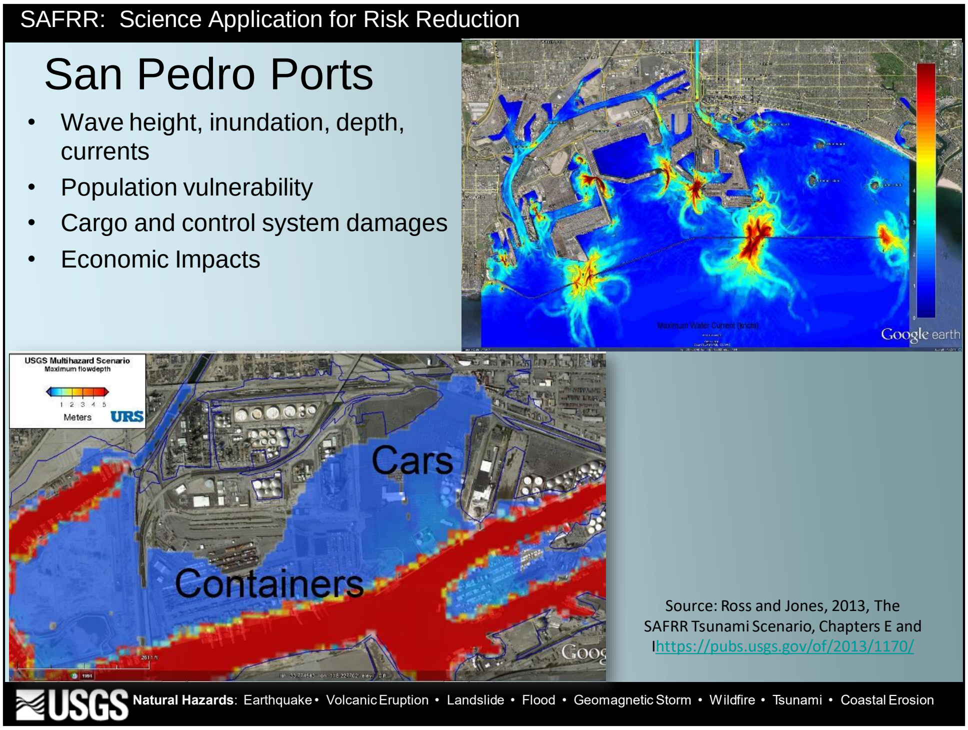
The disaggregation plot on the left shows the contribution of different source regions to the tsunami hazard in southern CA. We chose the source location with a focus on southern CA due to the economic importance of the ports of Los Angeles and Long Beach. However, that source region, off the Alaska Peninsula, is also the most important distant tsunami source area for central CA and for northern CA south of Cape Mendocino. In fact the waves from the source would be larger in central and northern CA than in southern CA, with max heights of 2-3 m in SoCal, and 3-8m in central and NorCal.

The geologic and tectonic setting of Tohoku is similar to this part of the Alaskan Trench. We were in the process of defining our source event when the Tohoku earthquake happened. Given the geologic similarities between the two areas, our source working group decided it would be plausible to have an earthquake the size of the Tohoku event in our source region in Alaska, between Kodiak Island and the Shumagins.

Tides: in 1964, 2010, and 2011, the maximum waves hit CA at low tide. We planned the SAFRR tsunami scenario at high tide to help make sure we're prepared.

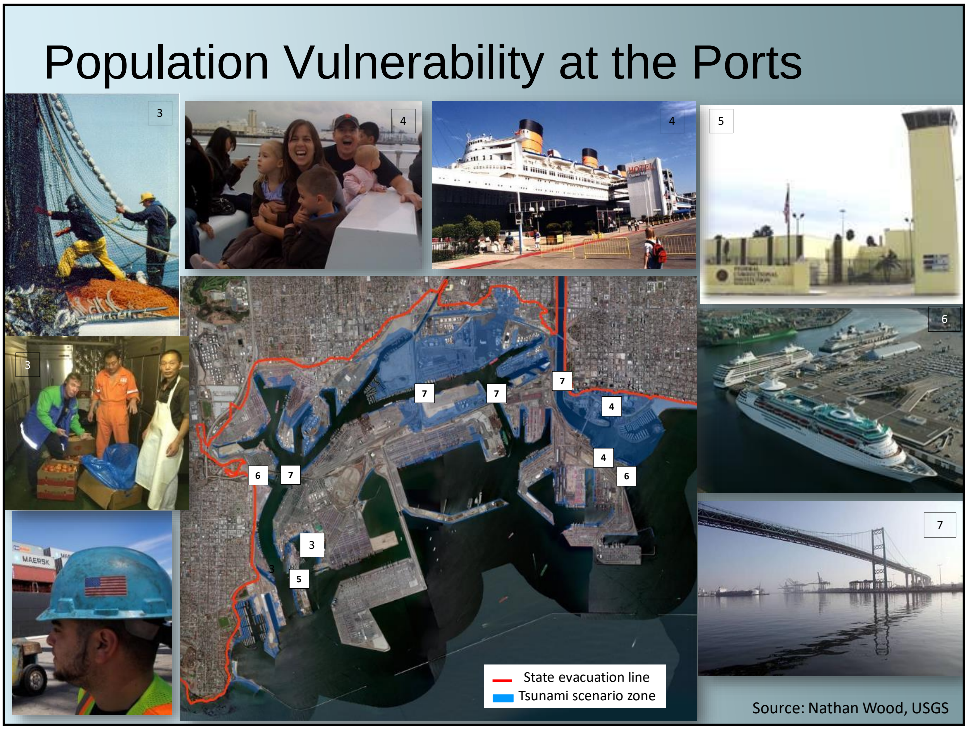
The righthand plot shows the maximum tsunami height for the SAFRR tsunami as it propagates across the Pacific. *[point out Alaska, CA, SF, LA]* Our source earthquake is located between the 1964 and 1946 earthquakes, both of which produced significant tsunamis in California. This model, by Vasily Titov at NOAA, is just one of the models done for the scenario. Kenny Ryan will be discussing his dynamic rupture modeling after the break.

[Geologic similarities: narrow frontal prsims of deformed sediments (folds and thrust faults), basement rocks close to trench, regional branch faults with normal faulting, shelf sedimentary basins defined by gravity lows.)



Moffett and Nichol (trusted by the ports) evaluated the cargo and control system damage and value.
Economic impacts of flood damage to ports and property was assessed on the order of a billion dollars.
Effort was put into incorporating economic resilience e.g., ships waiting out the tsunami, oil inventories.

The principal physical damages that result in disruption of the California economy are (1) about $100 million in damages to the twin Ports of Los Angeles (POLA) and Long Beach (POLB), (2) about $700 million in damages to marinas, and (3) about $2.5 billion in damages to buildings and contents (properties) in the tsunami inundation zone on the California coast. The economic disruption is estimated at just under $6 billion, largely affected by a two-day port shutdown. However, various forms of resilience suggest potential reduction to 15-20% of the GDP loss.



Port employees told to evacuate but expected to secure assets
Foreign vessel staff don't speak english
3 Fisherman
4 thousands of tourists around and near ports
5 federal correction institution on terminal island
6. Cruise ships
7 limited egress options out of ports

SAFRR: Science Application for Risk Reduction

All Ports

Table 5-7: Summary of Study Port Damages

Ports	Damage ($, Millions)
Port of Richmond	0.6
Port of Oakland	47.3
Port Hueneme	0
Port of San Diego	0.5
Port of Long Angeles*	44.2
Port of Long Beach*	68.9

*Source M&N 2012

Figure 2.3. Inundation Map during SAFRR Tsunami Scenario for the Port of Oakland

Location	Projected throughput on March 27, 2014 (TEUs)	Projected throughput on March 27, 2014 (Bulk MTs)	Damage Assessment	Value of Damage (US Dollar)	Vessel at Berth (Y/N)	Measure to Improve resilience	Approximate Terminal Elevation (feet, WGS84 or MSL)
BERTHS 57, 58 and 59	1,293	-	5% damage to product.	$1,115,431	Y	Raise terminal/bulkhead elevation. Develop tsunami preparedness plan.	14
Berths 60, 61, 62, 63	1,724	-	5% damage to product.	$1,487,241	N	Raise terminal/bulkhead elevation. Develop tsunami preparedness plan.	14
Berth 65	-	12,429	100% damage to product. One month operational impact. Trade capacity increases incrementally during period.	$19,714,219	N	Raise revetment elevation.	12
Berths 67 and 68	447	-	No containers present; thus, no damage to product. One week operational impact (50% trade capacity).	$0	Y	Raise terminal/bulkhead elevation. Develop tsunami preparedness plan.	13
Total	6,734	12,429		$47,332,397	4		

Source, Moffett & Nichol, 2014

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Moffet and Nichol complete analyses of other ports following the release of the SAFRR tsunami scenario. They applied the same approach described in physical damage chapter of the scenario. The report can be requested from awein@usgs.gov.

SLR + Tsunami

- Far-field tsunamis
  - sea level rise + tsunami waves is approximately linear
  - wave dynamics less affected
- Very large amplitude near-field tsunami
  - non-linear effects of wave dynamics would result in a larger tsunami than predicted by a linear combination

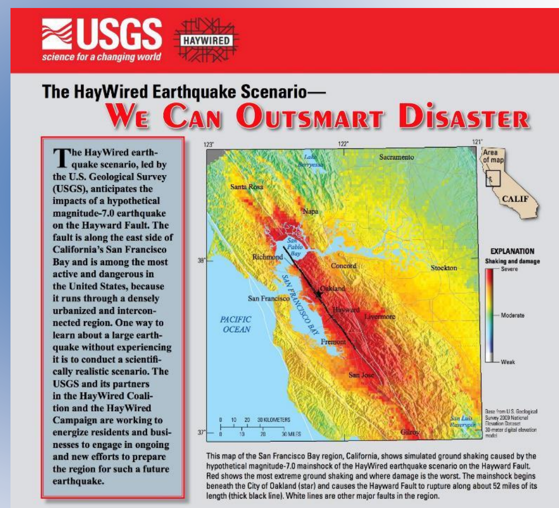
Source: Eric Geist, USGS

An area affected by 'liquefaction following the tsunami in Palu, Indonesia caused all structures to collapse. And buried people (dw.com)

- liquefaction?

HayWired Scenario

- Scientific advances since 1989 LP EQ
- Connectivity and collaboration

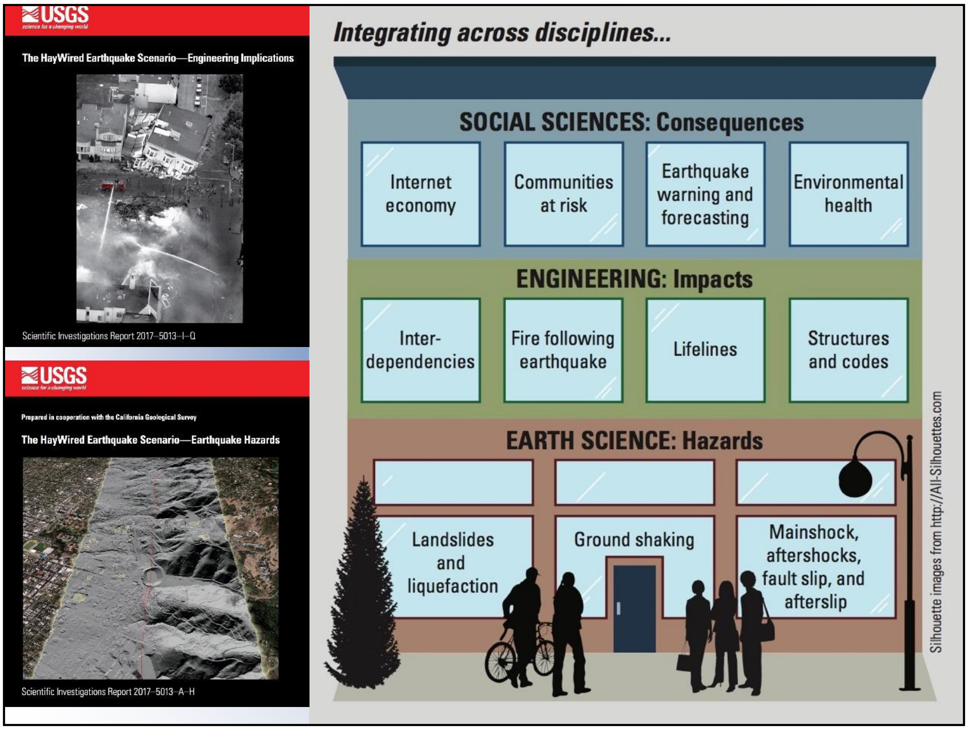

USGS science for a changing world HAYWIRED

The HayWired Earthquake Scenario—
WE CAN OUTSMART DISASTER

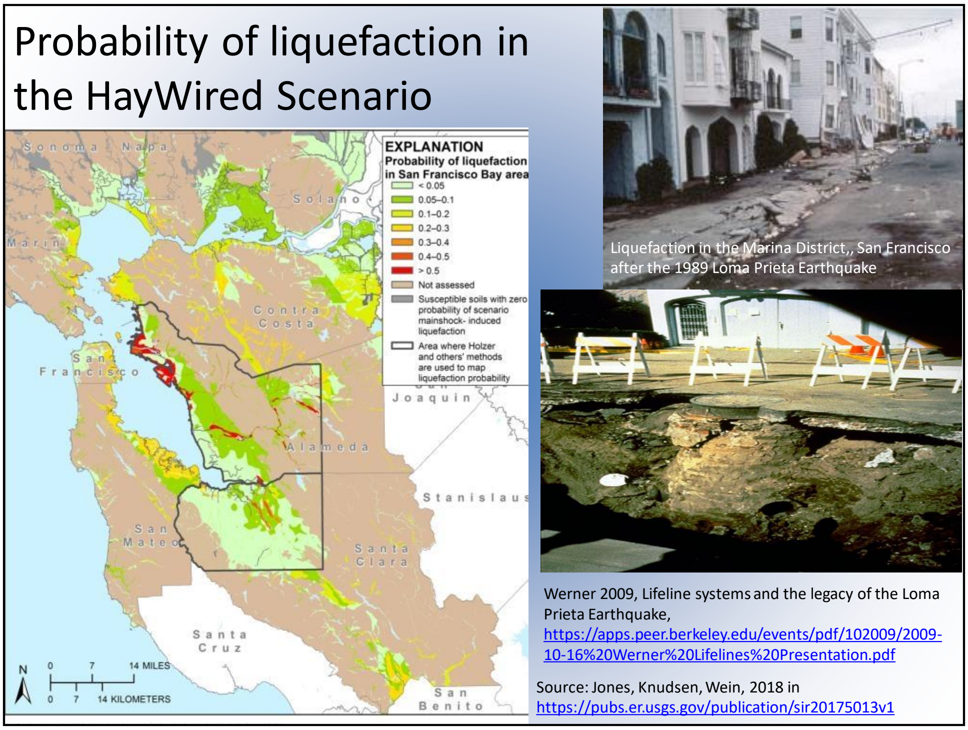
The HayWired earthquake scenario, led by the U.S. Geological Survey (USGS), anticipates the impacts of a hypothetical magnitude-7.0 earthquake on the Hayward Fault. The fault is along the east side of California's San Francisco Bay and is among the most active and dangerous in the United States, because it runs through a densely urbanized and interconnected region. One way to learn about a large earthquake without experiencing it is to conduct a scientifically realistic scenario. The USGS and its partners in the HayWired Coalition and the HayWired Campaign are working to energize residents and businesses to engage in ongoing and new efforts to prepare the region for such a future earthquake.

This map of the San Francisco Bay region, California, shows simulated ground shaking caused by the hypothetical magnitude-7.0 mainshock of the HayWired earthquake scenario on the Hayward Fault. Red shows the most extreme ground shaking and where damage is the worst. The mainshock begins beneath the City of Oakland (star) and causes the Hayward Fault to rupture along about 52 miles of its length (thick black line). White lines are other major faults in the region.

Source, Hudnut, Wein and others, 2018, https://pubs.er.usgs.gov/publication/fs20183016



Building shows the construction of the scenario.
The first two volumes about the hazards and engineering aspects, respectively, can be found from the project website at https://www.usgs.gov/natural-hazards/science-application-risk-reduction/science/haywired-scenario?qt-science_center_objects=0#qt-science_center_objects



Both photos are in the Marina district despite the distance from the 1989 Loma Prieta EQ epicenter in the Santa Cruz mountains.

The map shows the probability of liquefaction for the HayWired scenario shaking and water table data from CGS.

You can think about probability in the sense of how much area might liquefy on average.

The mapping in Alameda and Santa Clara county used methods developed by USGS Scientist Thomas Holzer (see Jones and other reference on the slide). The rest of the area was mapped using FEMA's software tool Hazus (see App 1 in https://pubs.usgs.gov/sir/2017/5013/vol3/t/sir20175013t.pdf

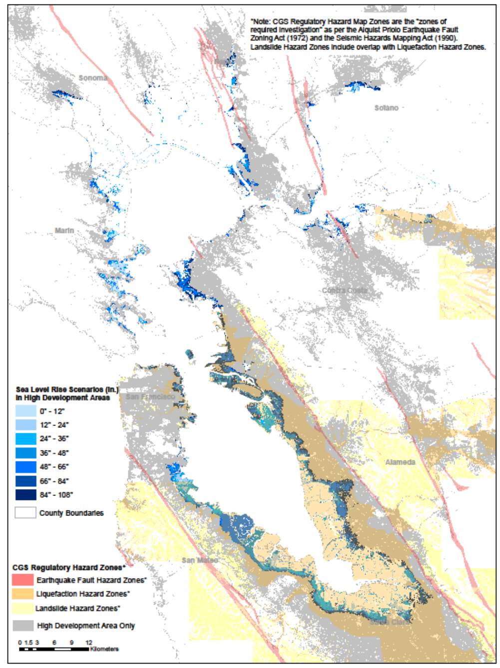
Liquefaction probability + SLR?

- Groundwater levels will rise, but artificial fills are already saturated in the Bay Area
- RiskyWorld Proposal
  - Effects of rising water tables on liquefaction probability and ground displacement
    - Bay Area locations in the HayWired Scenario
  - An information product for stakeholders
    - What questions do you have?
    - What format for the results?

Sea level rise and CGS regulatory zones

- Where sea level rise overlaps (blue) with developed land (gray) on liquefaction susceptible soils (orange) (*courtesy of Joseph Toland*)

Sea Level Rise Scenarios in High Development Areas with CGS Regulatory Hazard Zones* in the San Francisco Bay Area



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