An Independent Assessment of Scientific and Technical Information on Advanced Well Stimulation Technologies in California

Webinar Nov 17, 2014

California Council on Science and Technology
BERKELEY LAB

Agenda

12:00	**Welcome and Overview**	**Amber Mace**
12:15	Study Topics and Previous Results	Jane Long
12:40	Clarifying questions from audience	

Purpose of the Webinar

This meeting provides transparency on how CCST is conducting its study on advanced well stimulation technologies in California and what will be covered in the study.

Please see our webpage for access to information about CCST's work on well stimulation http://ccst.us/projects/fracking_public/processSB4.php

How to Participate

If time and number of participants permit, we will accept written questions during the final question and answer session.

Please submit your question through the chat function.

The moderator will address as many questions as time allows.

In Case of Technical Difficulties

Call Hilary Ahearn at (916) 492-0996

California Council on Science and Technology

- CCST is a nonpartisan, impartial, not-for-profit 501(c)(3) corporation established via Assembly Concurrent Resolution (ACR 162) in 1988 by a unanimous vote of the California Legislature

- It is designed to offer expert advice to the state government and to recommend solutions to science and technology-related policy issues.

- CCST is governed by a Board of Directors composed of representatives from its sponsoring academic institutions, from the corporate and business community, as well as from the philanthropic community

CCST's Independent Review of Scientific and Technical Information on Well Stimulation Technologies in California

- Purpose of the study is to conduct an independent scientific assessment of the past, present and potential future uses of well stimulation and its impacts in California

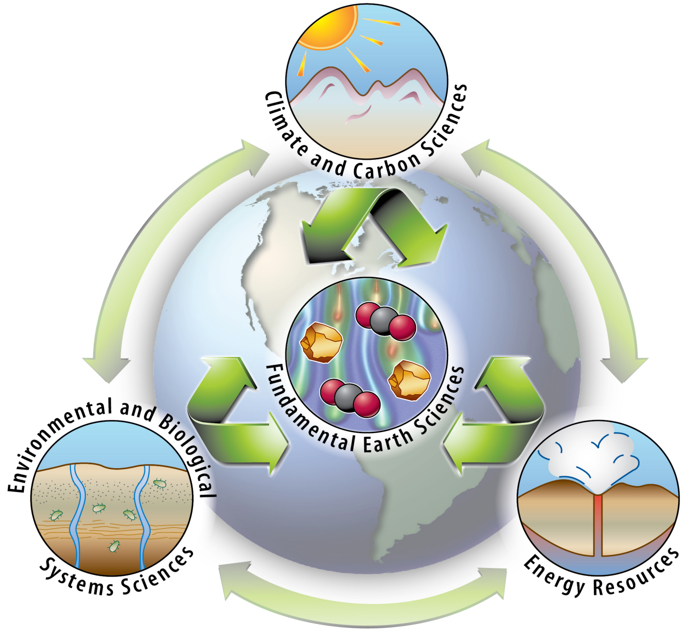
- This is an independent scientific expert study
  - An assessment of published literature and analysis of available data
  - No new data collection
  - Interested parties nominated literature to the study

Who Performed the Study

- **The CCST's California Well Stimulation Steering Committee**
  - provided oversight, scientific guidance and input for the project
- **Lawrence Berkeley National Laboratory (Berkeley Lab)**
  - Performed the majority of the analysis
- **Subcontractors**:
  - The Pacific Institute
  - Physicians, Scientists and Engineers for Healthy Energy
  - Stanford University
  - Dan Gautier (USGS retired)
  - Scripps Institute of Oceanography
  - CSU Stanislaus Endangered Species Recovery Program

Lawrence Berkeley National Laboratory

- Discovery science, energy innovation and environmental solutions
- ~$800 Million Budget; 4,200 Employees; 1,000 Students
- 13 Nobel Prizes – most recent in 2011 for the discovery of dark energy
- 70 members of the National Academy of Sciences (~3% of the Academy)
- 10,000 researchers from industry/universities annually use the Lab's unique research facilities.



Earth Sciences at Berkeley Lab

MISSION

...to create new knowledge and capabilities needed to enable sustainable stewardship of **critical environmental systems** and judicious use of the Earth's **natural energy resources.**

Steering Committee Members

- Jane C. S. Long (Chair)
- Jens Birkholzer (LBNL Lead)
- Peter Gleick (Impacts to Water)
- Dan Tormey (Impacts of WST in CA)
- Larry Lake (Petroleum Engineering)
- Seth Shonkoff (Public Health)
- Dan Hill (WST)
- Don Gautier (Petroleum Geology)
- Tom McKone (Risk Assessment)
- William Minner (WST Design and Practice in CA)
- Roger Aines (Geochemistry)
- Amy Myers Jaffe (Environmental Practice in Petroleum, Oil Business)
- Sam Traina (Environmental Engineering)

Ex Officio:

- Laura Feinstein (Project Manager)

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The Basis of our Assessment

- Prior work for Bureau of Land Management (BLM).
- Peer-reviewed published literature.
- Analysis of available data from California Divison of Oil, Gas and Geothermal Resources (CDOGGR) and other publicly available sources.
- Other relevant publications including reports and theses. We state the qualifications of the information used in the report.
- The expertise of the committee and scientific community to identify issues.
- CCST solicited nominations of information from the public.

The study will be produced in three volumes

Title	Deliver to CNRA
VOLUME I: Well Stimulation Technologies and their Past, Present and Potential Future Use in California	Jan 1, 2015
VOLUME II: Generic and Potential Environmental Impacts of Well Stimulation Treatments	July 1, 2015
VOLUME III: Case Studies with Selected Evaluations of Environmental and Public Health Risk	July 1, 2015

A Prior Study for BLM

- What is past, current and potential future practice in onshore well stimulation technologies including hydraulic fracturing, acid fracturing and matrix acidizing in California?

- Where might these technologies allow expanded production of oil onshore in California?

- What are the potential direct environmental hazards of these specific technologies in California?

- http://www.ccst.us/BLMreport

San Joaquin Valley Field Trip

- Tues Oct 28
  - Occidental Elk Hills
  - Chevron Lost Hills
- Wed Oct 29
  - Community Organizers
  - Center for Race, Poverty and the Environment
  - Clean Water Action

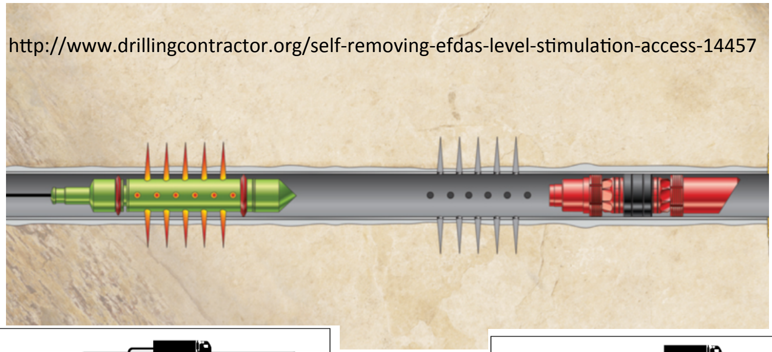
Volume I

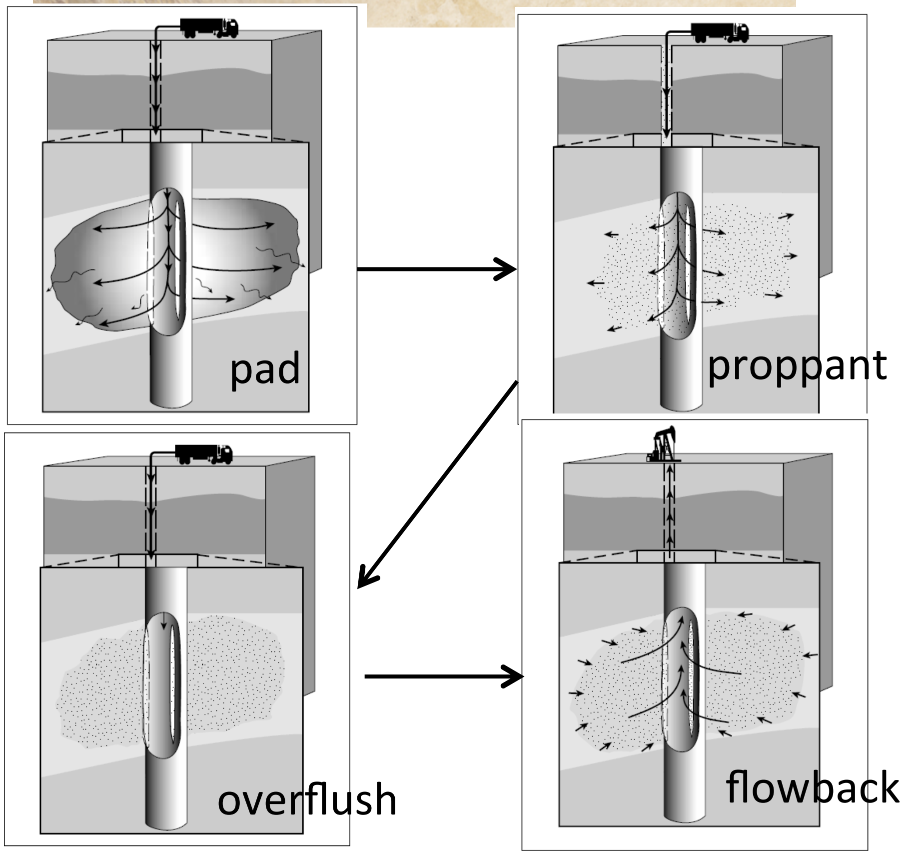
- Chapter 1 Introduction
- Chapter 2 Technology
- Chapter 3 WST statistics
- Chapter 4 Geology and WST

Relevant results from the BLM study

Typical Hydraulic Fracturing Process

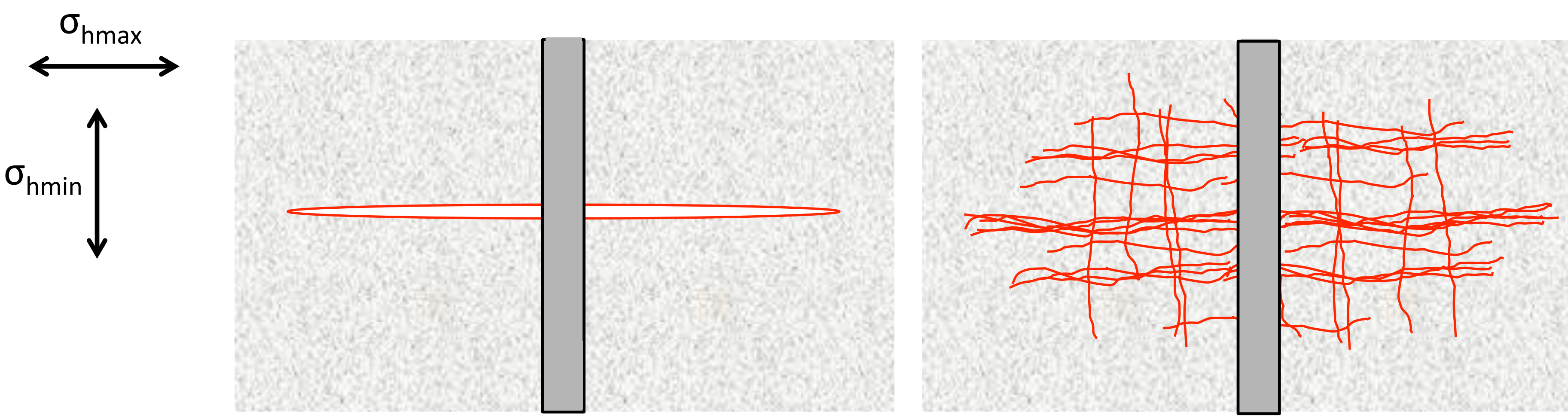
- Isolate stage and perforate
- Pre-flush with HCl to clean out perforations and weaken rock
- Inject fracturing fluid called the "pad" to initiate and propagate fractures
- Add proppant to fluid to retain fracture permeability (or use acid for acid fracturing)
- Overflush after fracturing to displace proppant from well
- Flowback to remove fracturing fluid





modified from Economides and Nolte (2000)

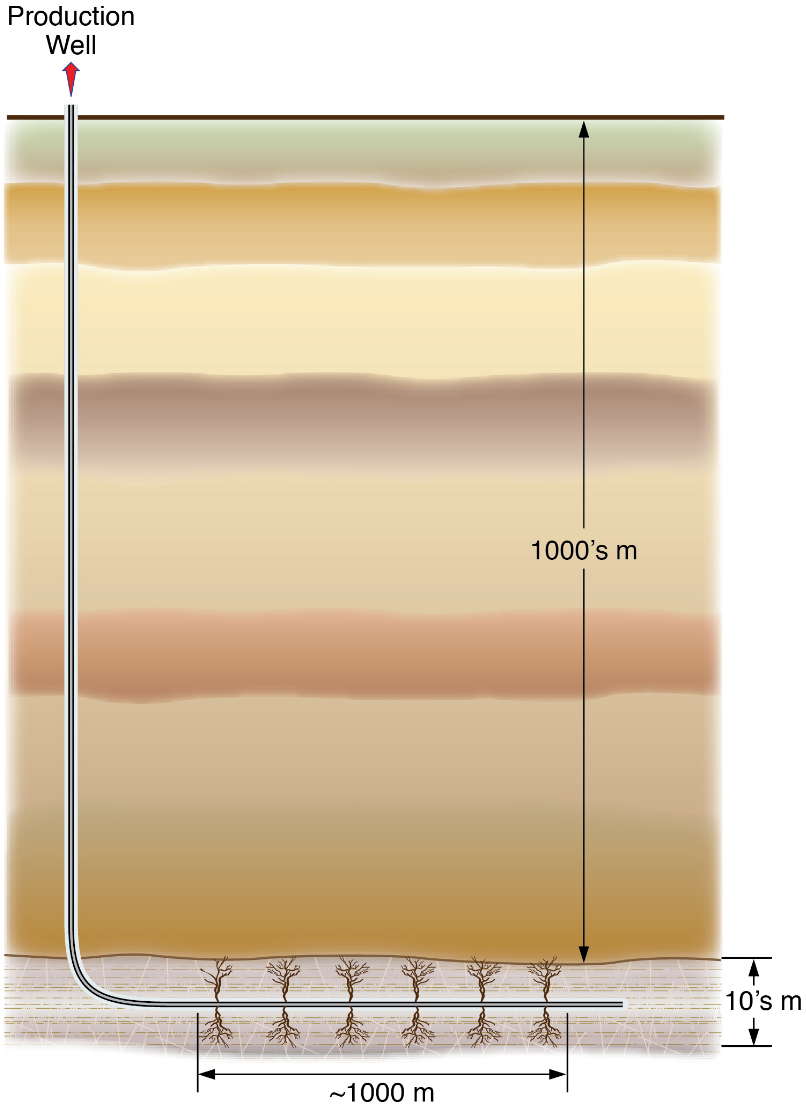
Fracturing Fluid Viscosity, Rock Properties and Fracture Complexity



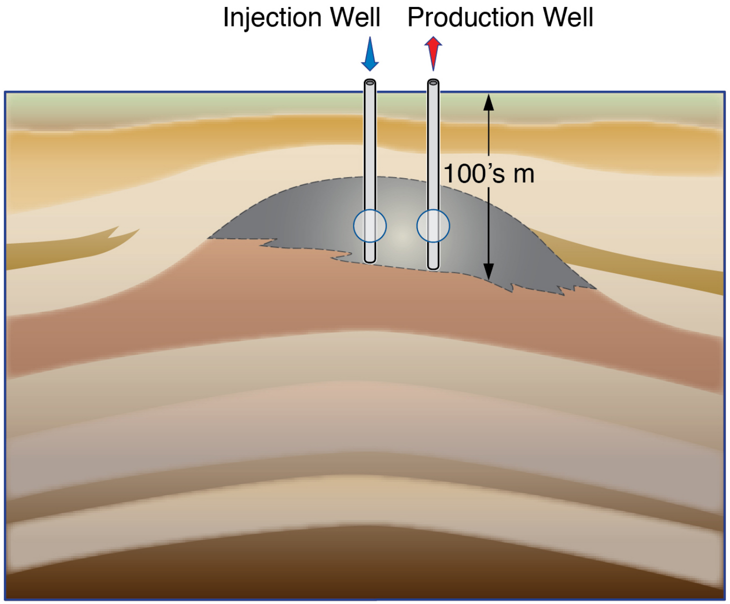
Fracturing Fluid	Higher viscosity cross-linked gel	Lower viscosity slickwater
	Lower injected volume and rate	Higher injected volume and rate
Rock Properties	Higher permeability	Lower permeability
	Less brittle	More brittle
Fracture Geometry	Simpler bi-wing	More complex networks
	Larger fracture aperture	Smaller fracture aperture

Stimulated Wells in California Tend to be Vertical

Typical Source Rock Stimulation



Typical California (Migrated Oil) Stimulation



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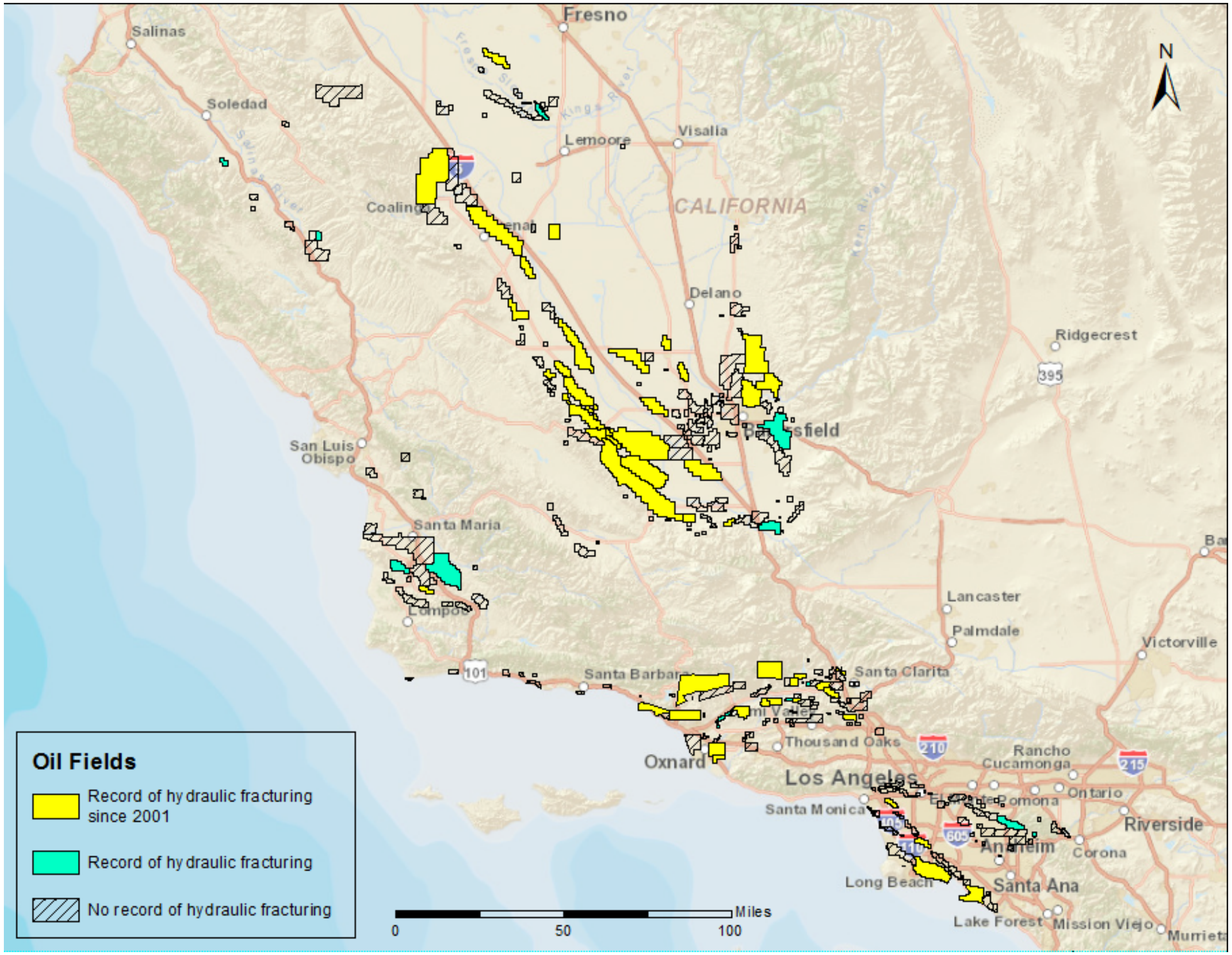
Well stimulation in California is different than other states.

- Differences in the geology of the petroleum reservoirs.
- Generally, hydraulic fracturing in California tends to be performed in shallower wells which are vertical as opposed to horizontal, requires much less water, but uses fluids with more concentrated chemicals than hydraulic fracturing in other states.
- Consequently, the experiences with hydraulic fracturing in other states do not necessarily apply to current hydraulic fracturing in California.

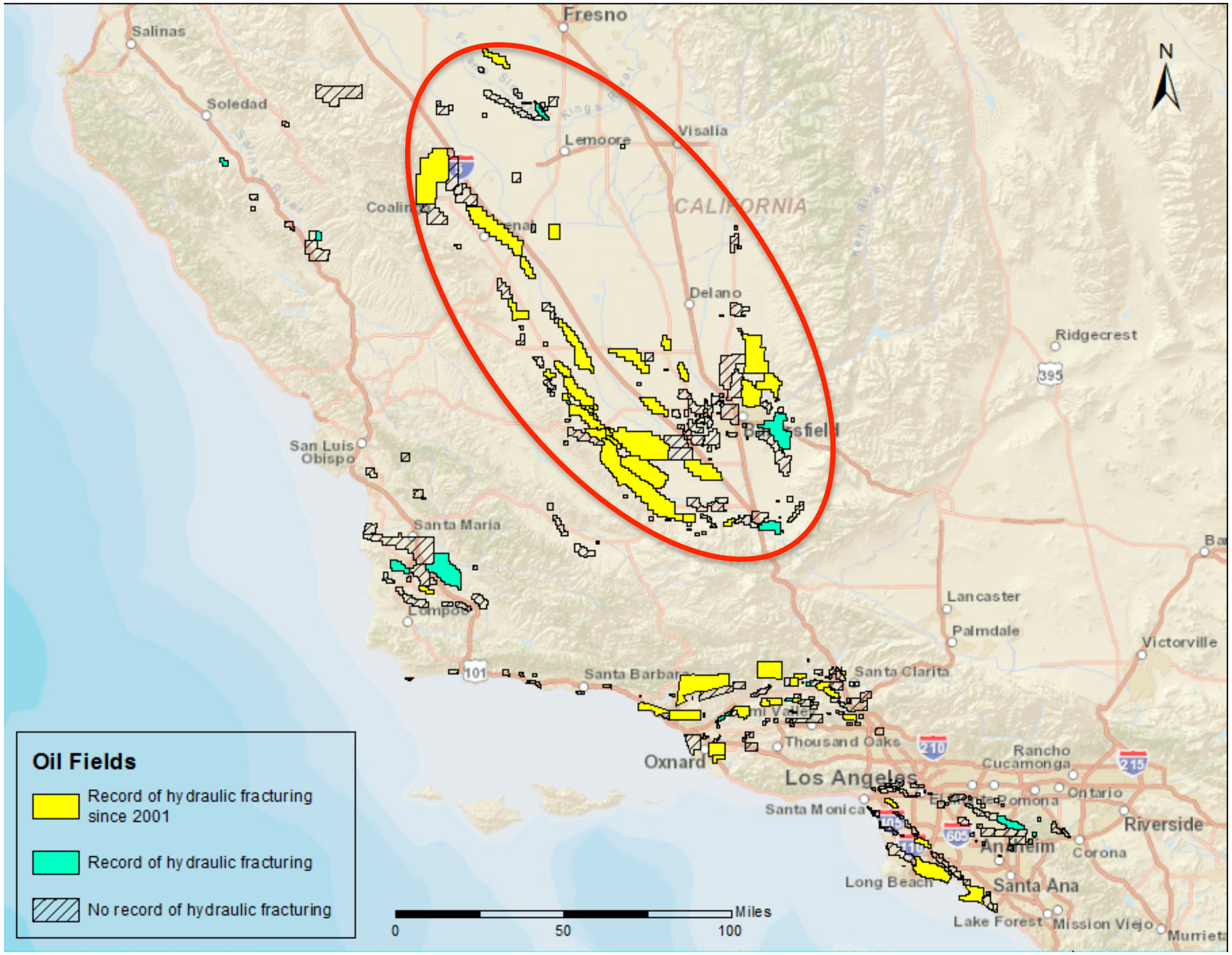
Where might these technologies allow expanded production of oil onshore in California?

Fields With Fracturing Reported



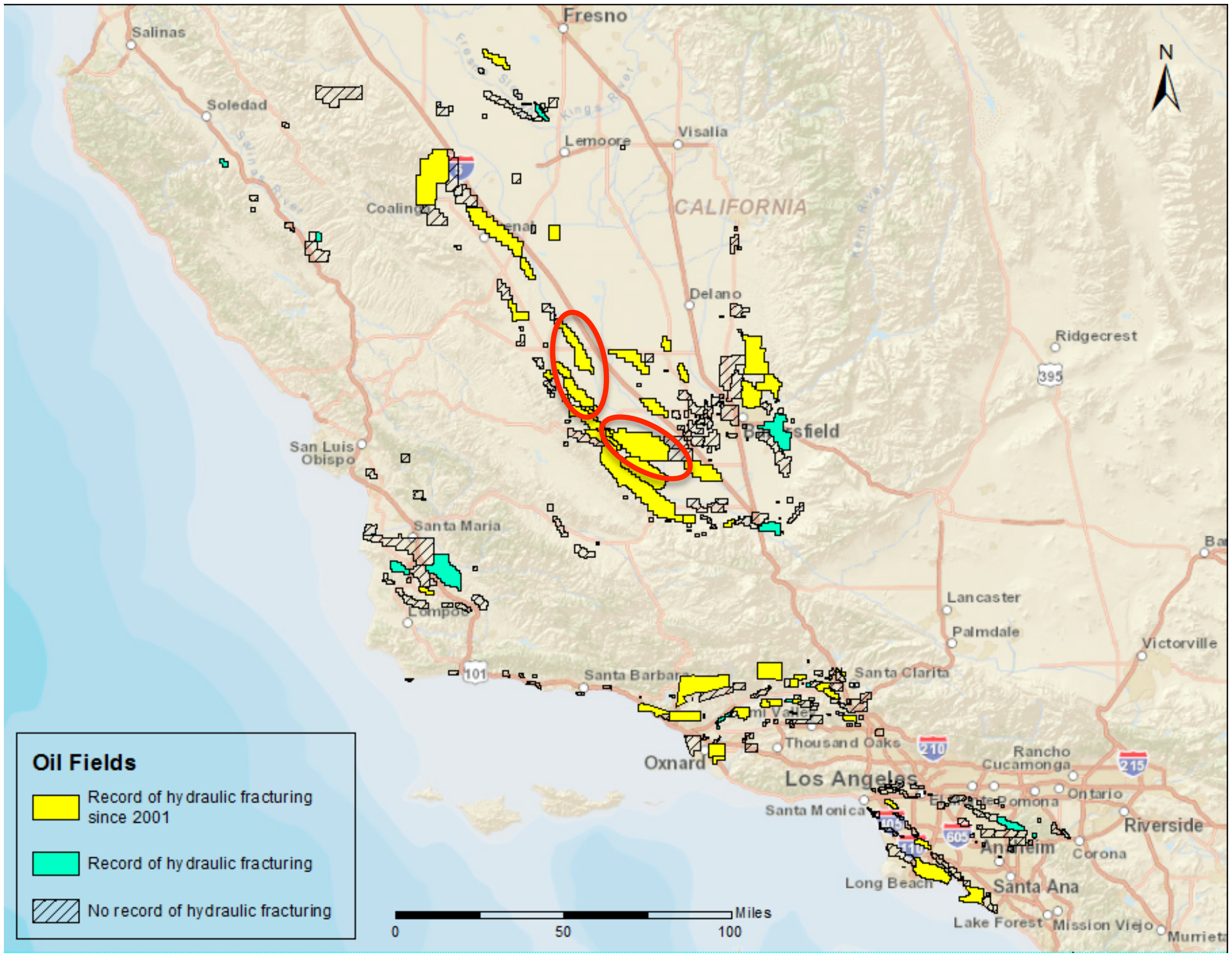
Onshore oil fields with at least one hydraulically fractured well according to DOGGR all well file, DOGGR well record sample search, FracFocus and/or reported in literature

Fields With Fracturing Reported



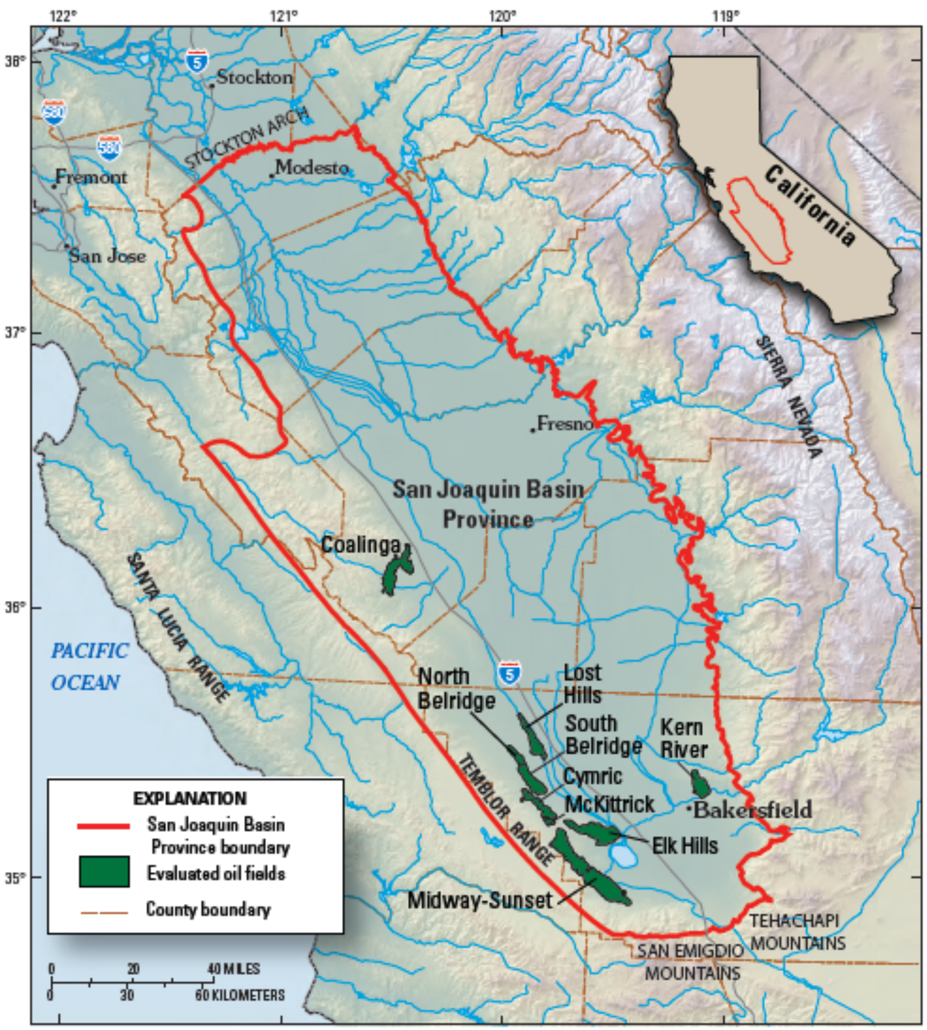
98% of hydraulic fracturing operations in 2012-2013 occurred in the San Joaquin basin according to FracFocus, DOGGR's well layer, and the well record search.

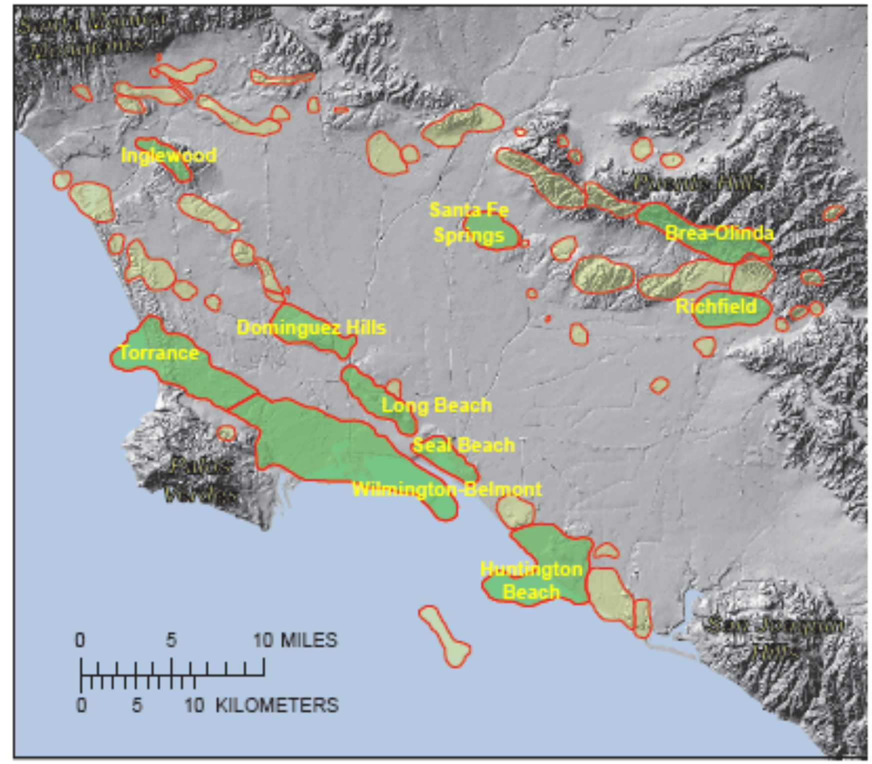
Fields With Fracturing Reported



Over 85% of hydraulic fracturing operations in 2012-2013 occurred in four fields on the west side of the San Joaquin Valley: South Belridge, Elk Hills, Lost Hills and North Belridge according to FracFocus, DOGGR's well layer and the well record search results

Current Technology Could Add 4.9 to 15.6 BBO (Mean Estimate of 9.4 BBO) From Just 19 Giant San Joaquin and L.A. Basin Fields

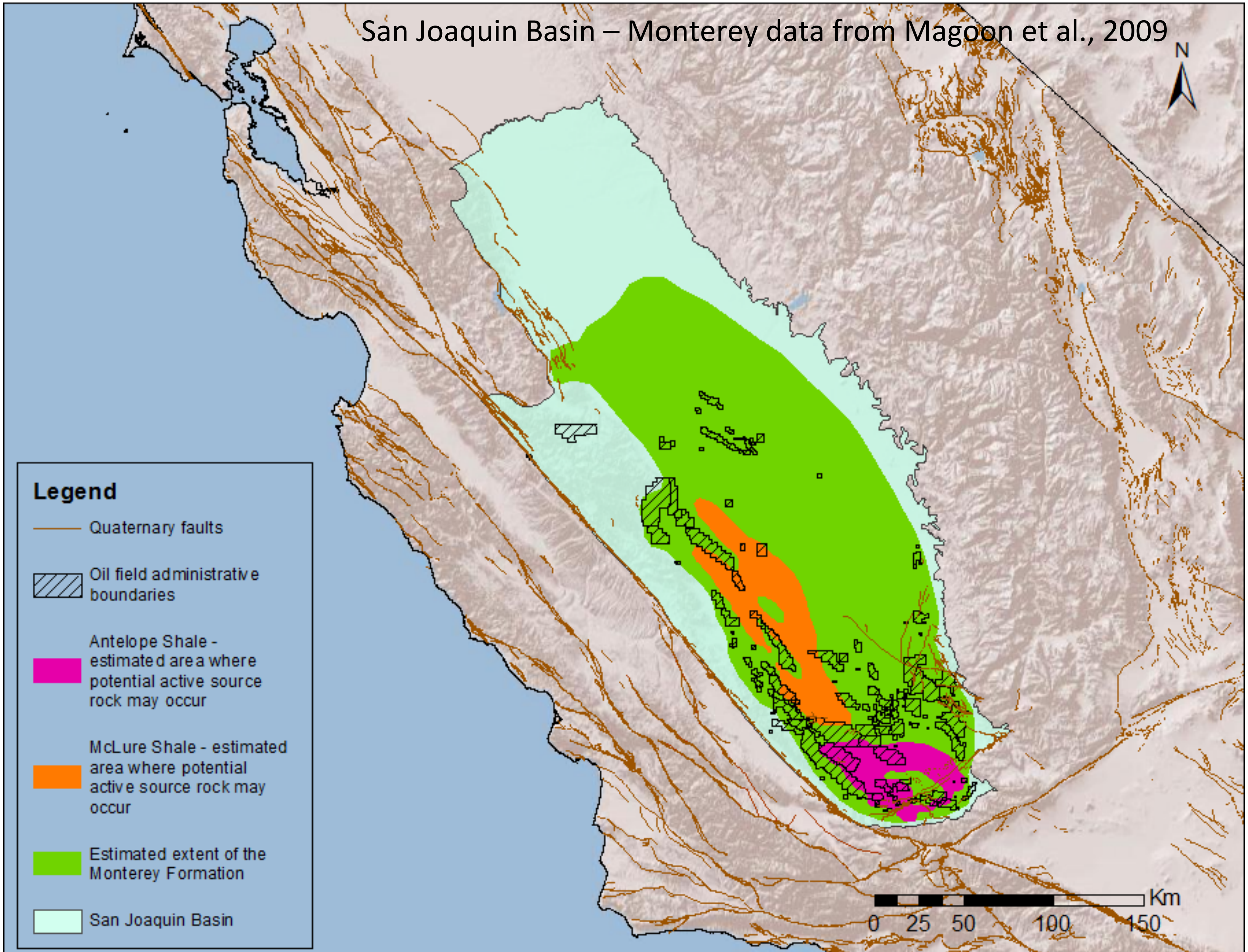




The most likely scenario for future oil recovery is expanded production in and near existing oil fields in the San Joaquin and Los Angeles basins in a manner quite similar to the production practices of today.

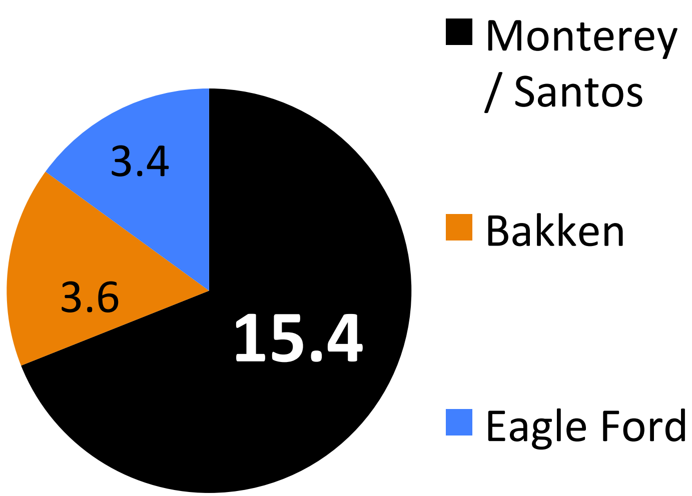
- The vast majority of well stimulation currently occurs in the San Joaquin Valley,
- Expanded production in similar reservoirs in the San Joaquin Valley would also likely use this technology.
- Current production in the Los Angeles Basin does not depend heavily on well stimulation and
- Similar future production could likely occur without these technologies.

Conventional vs. Unconventional Resources



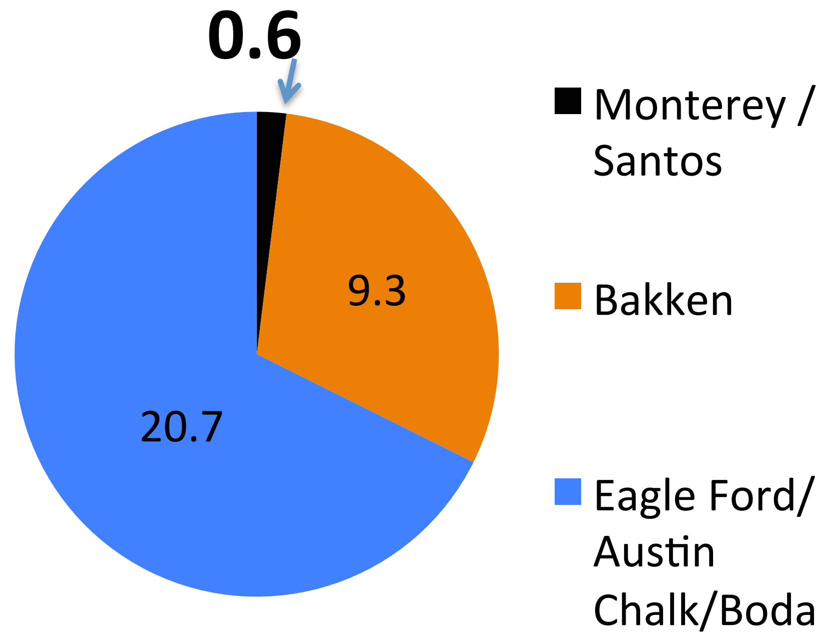
Estimates of Technically Recoverable Oil Shale Resources (EIA)

EIA/INTEK (2011)



Total: 22.4

EIA (2014)



Total: 30.6

(Unproved estimates – BBO)

EIA estimates are highly uncertain

- The 2011 EIA report suggested 15 billion barrels of recoverable oil
- The 2014 correction by EIA reduced the estimate to 0.5 billion barrels.
- **The study's review of resource projections from deep source rocks in the Monterey Formation developed by EIA concluded that both these estimates are highly uncertain.**
- Investigators found no reports of successful production from deep source rocks.

Coming in Vol I

- Off shore practice
- WST in gas production
- New data on acid use
- More data from DOGGR and FracFocus
- Deeper analysis of geologic potential

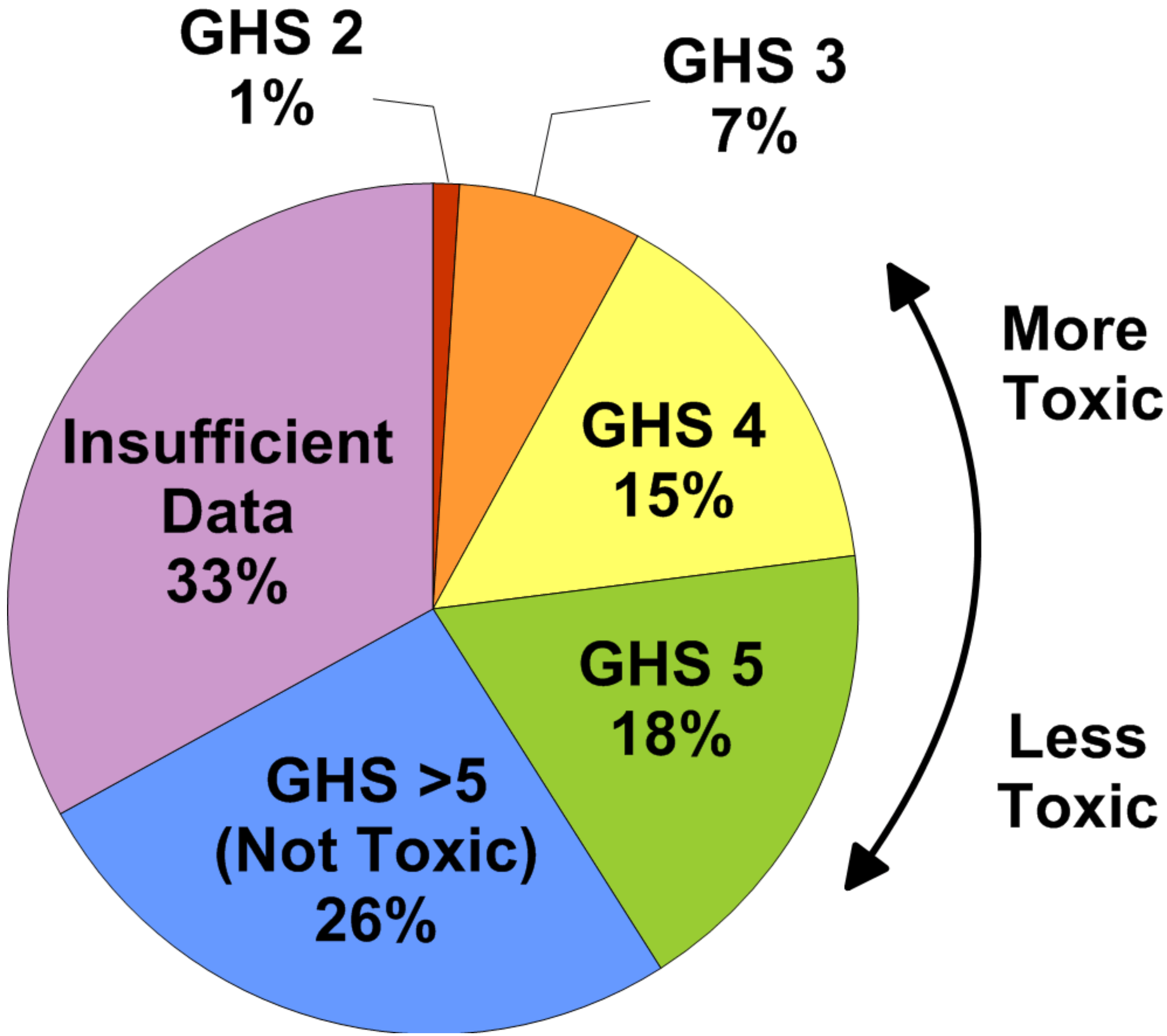
Volume II Potential Impacts of WST

- Water Impacts
- Atmospheric Impacts
- Induced Seismicity
- Traffic, Noise and Light
- Human Health
- Ecological Impacts
- Hazard Analysis
- What do we know?
- Alternative Practices
- Data Gaps

Some results from the BLM Study

Each of these issues had a first level of assessment in the BLM study.

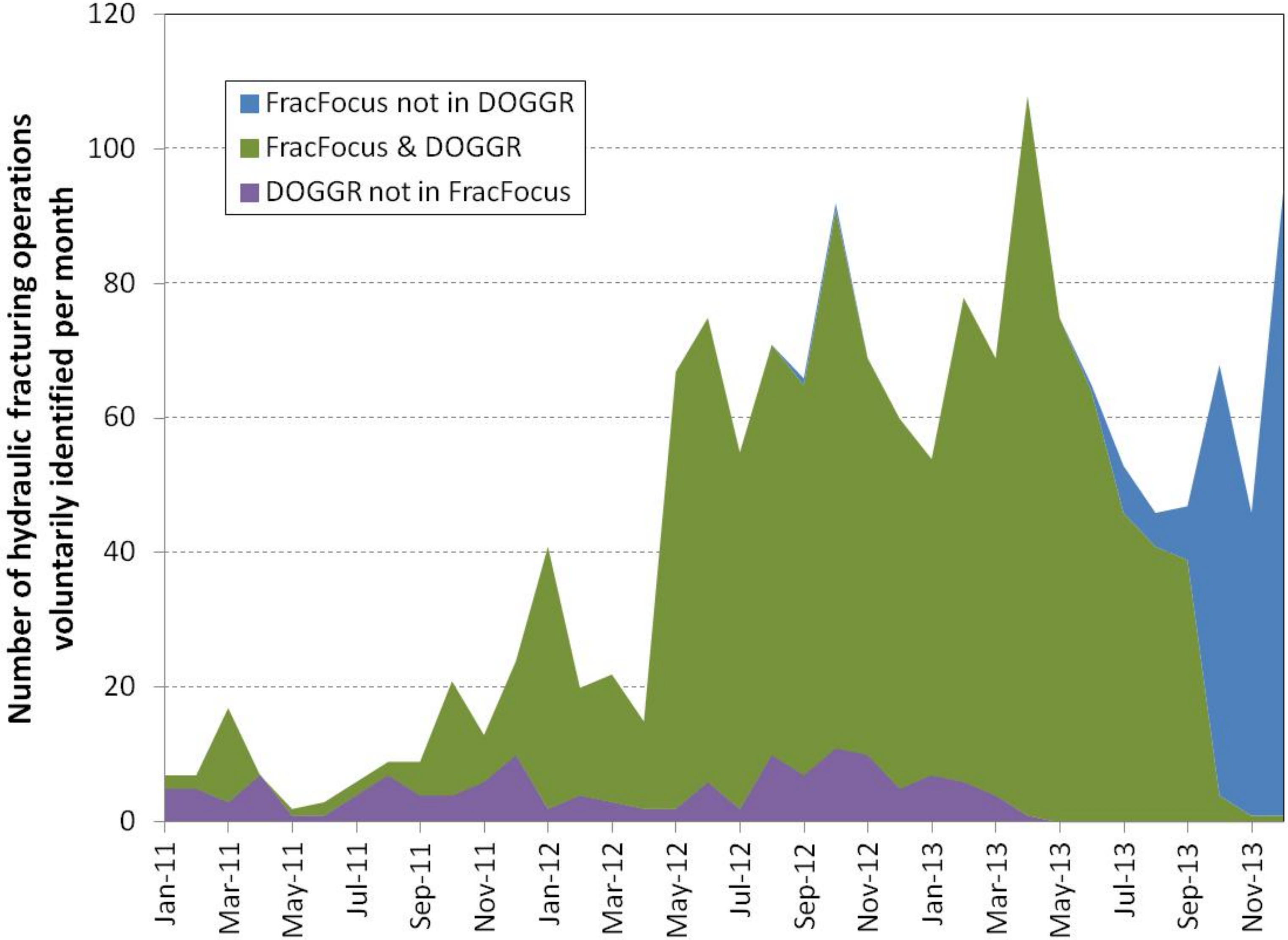
Mammalian Toxicity of WST Chemicals



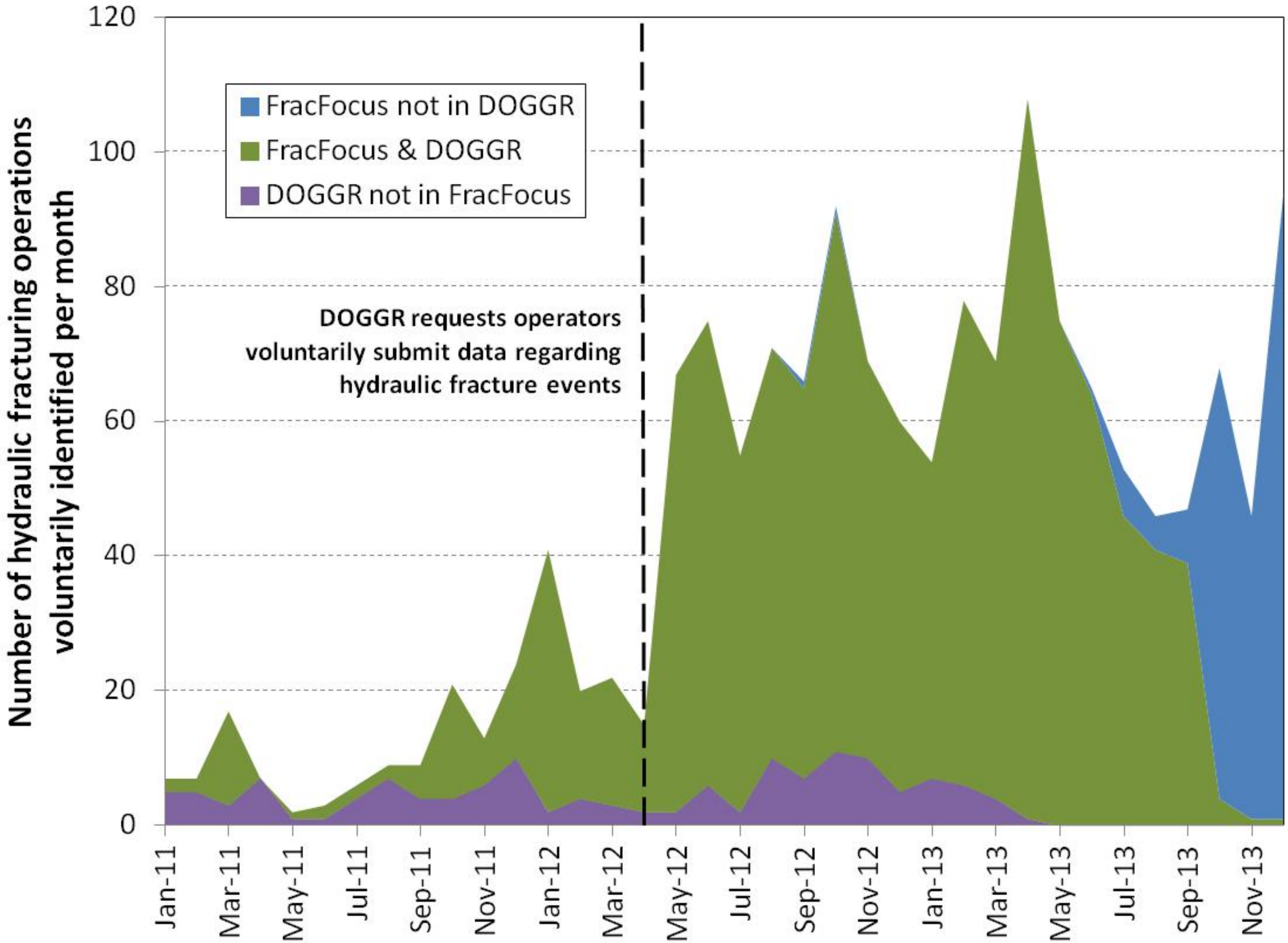
The toxicity of chemicals used in hydraulic fracturing warrants further review now that disclosure is required.

- Most of the chemicals reported in Fracfocus are not considered to be highly toxic.
- A few of these chemicals, especially the biocides and corrosion inhibitors, are acutely toxic to mammals.
- No information could be found about the toxicity of about a third of the chemicals
- Few of the chemicals have been evaluated to see if animals or plants would be harmed by chronic exposure. Moreover, data acquired from FracFocus may not be complete or always accurate.

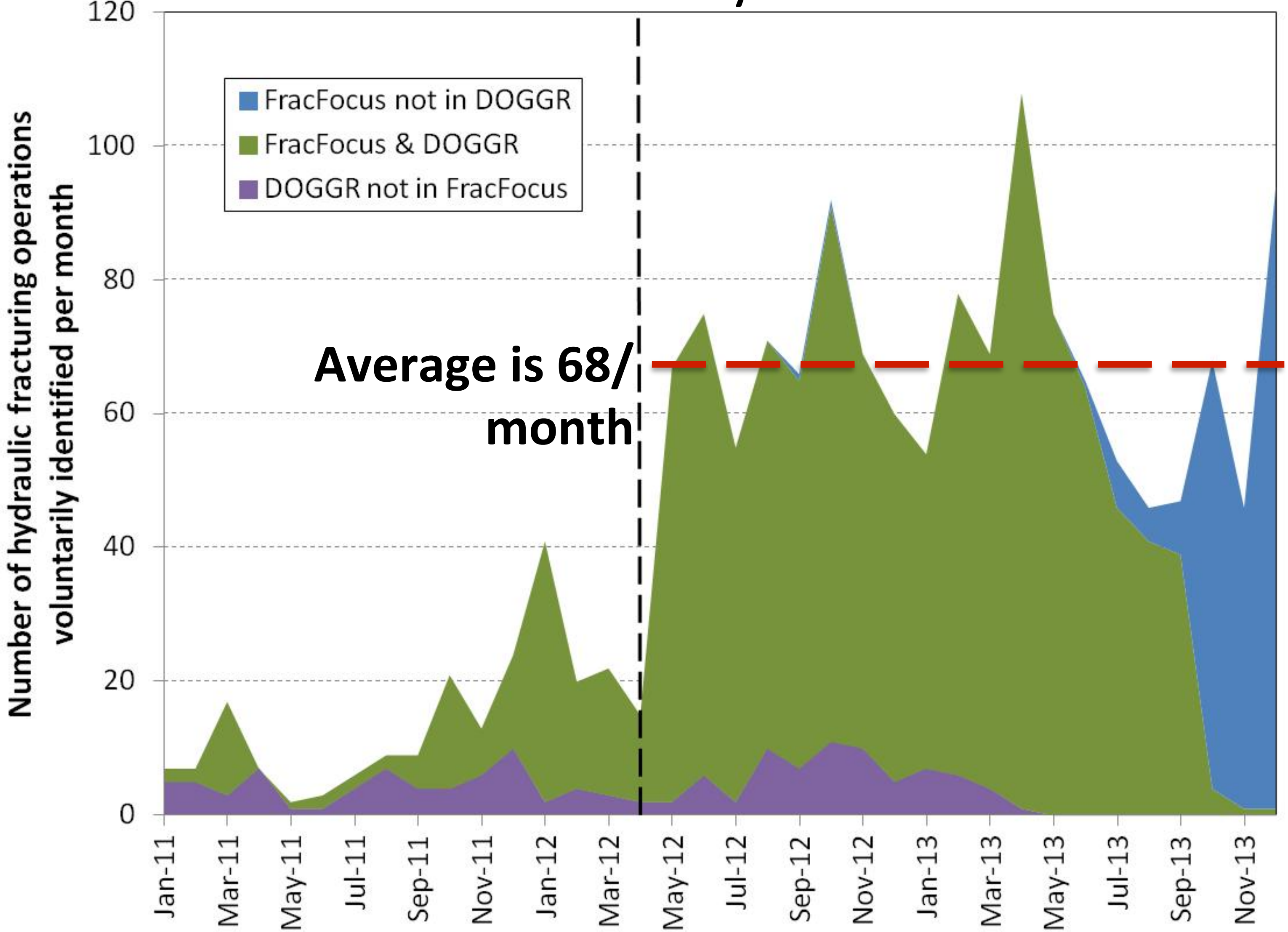
Activity - FracFocus and DOGGR



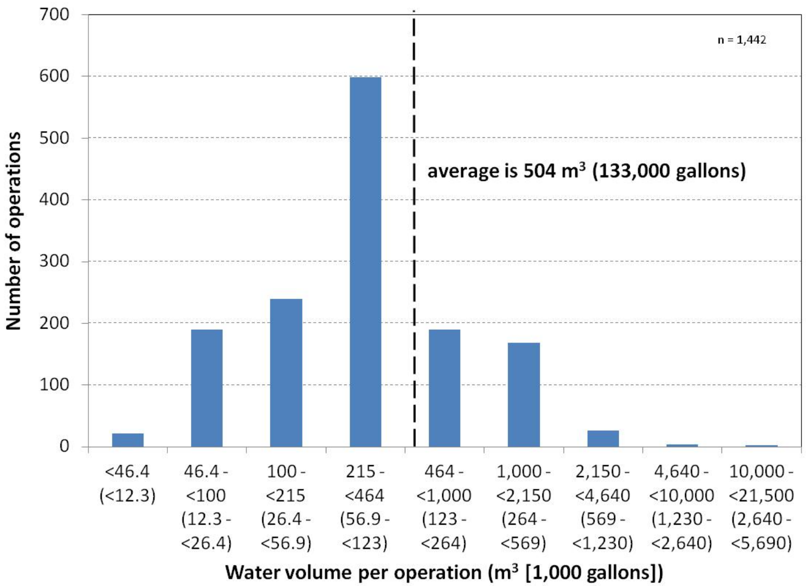
Activity - FracFocus and DOGGR



With other sources (notices and well records), suggests 100-150 hydraulic fracturing operations per month, or about 4% of the total nationally



FracFocus Water Volume per Hydraulic Fracture

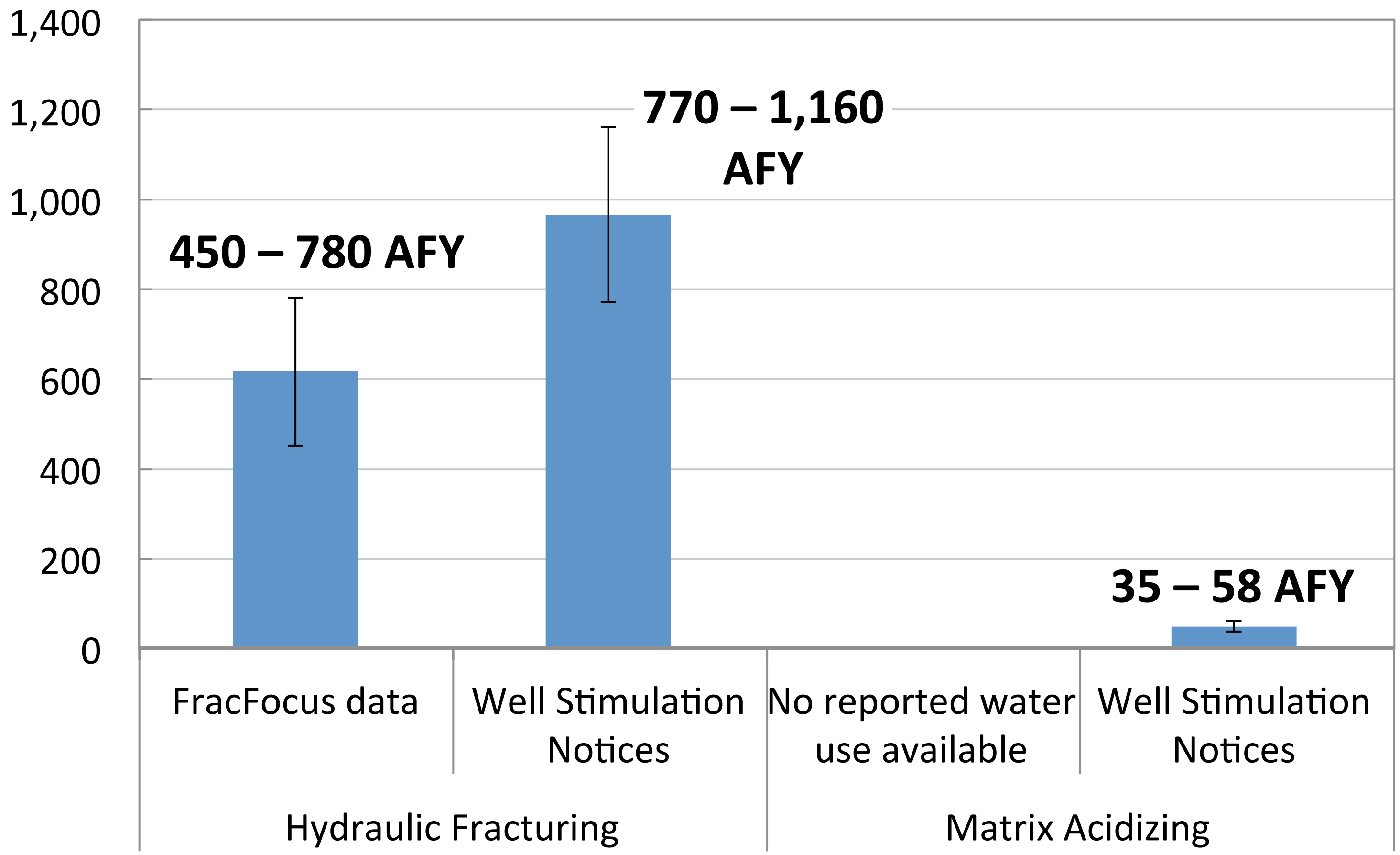


Average water per operation is 504 m^3 or 133,000 gallons which is

about 1/30 of the 16,100 m^3 (4.25 million gallons) average per well in the Eagle Ford, TX

Estimated Annual Water Use

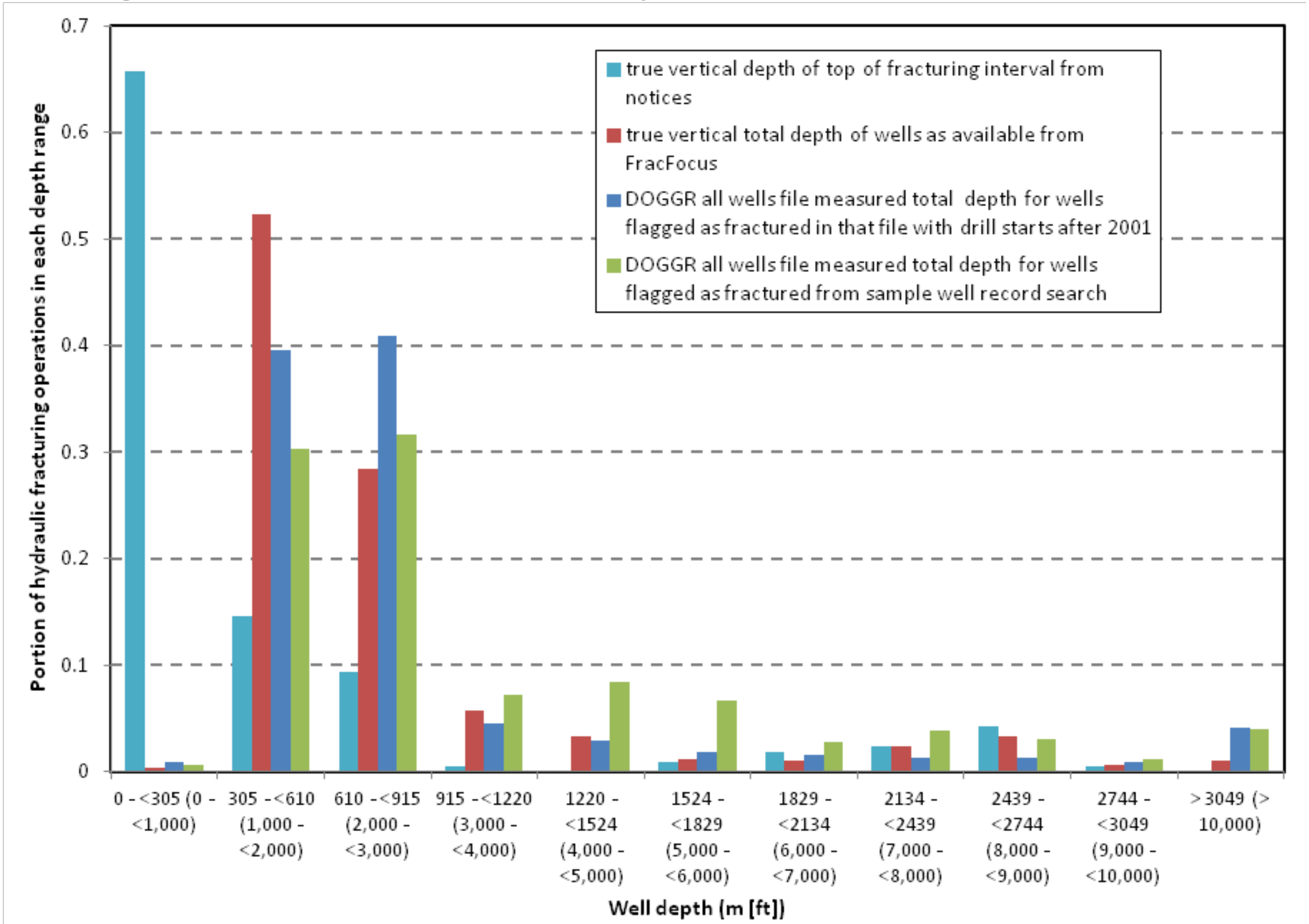
acre-feet per year



Current hydraulic fracturing operations in California require a small fraction of statewide water use.

- In California a hydraulic fracturing operation can consume between 130,000 to 210,000 gallons per well on average,
- 100-150 well stimulations are conducted per month
- current total annual water use for well stimulation in California is 450 – 1,200 acre-feet (146.6 million gallons – 391 million gallons).
- hydraulic fracturing can contribute to local constraints on water availability given the extreme drought in the state.

Portion of hydraulic fracturing operations vs. depth range (DOGGR data is only for wells drilled after 2001)



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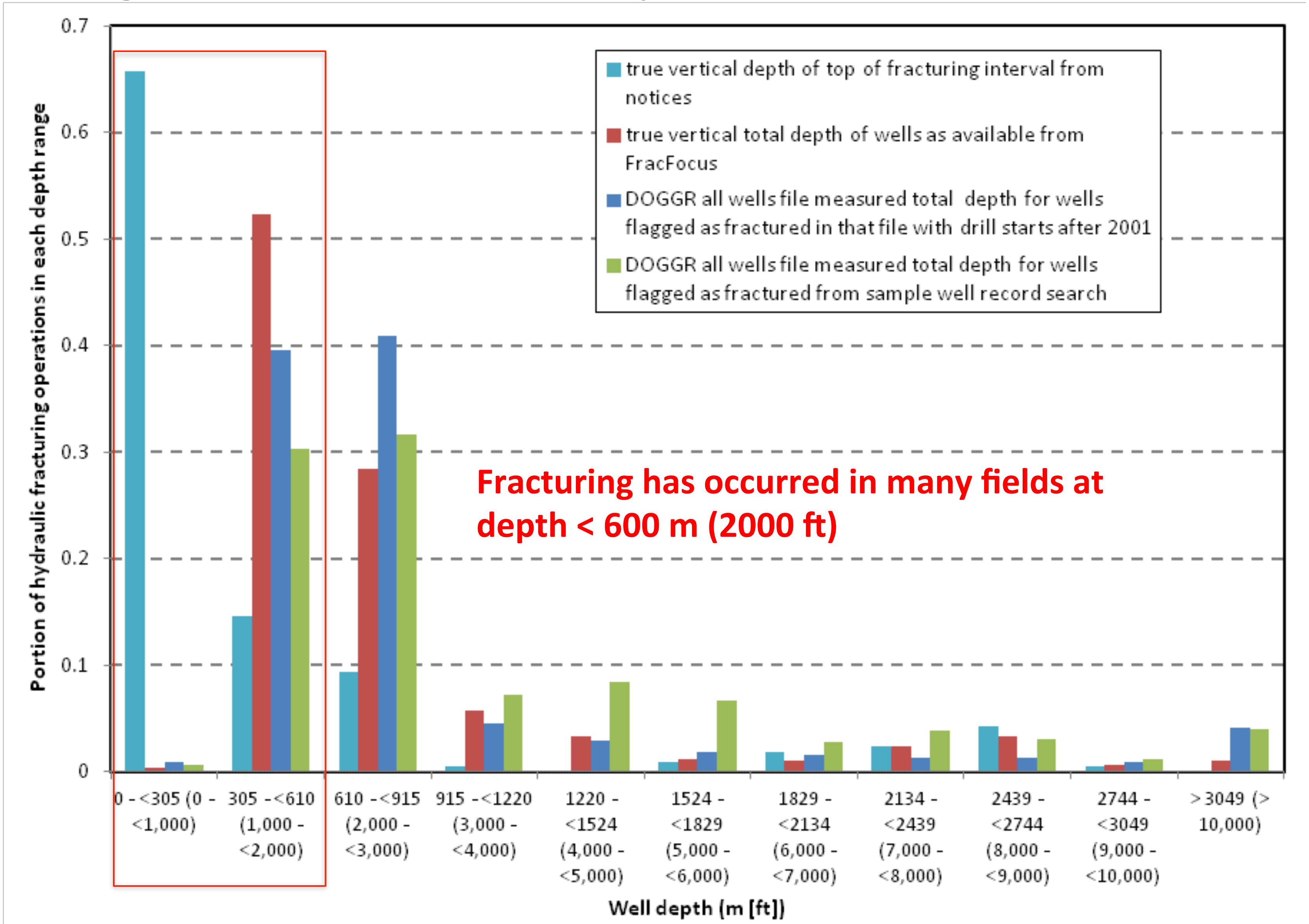
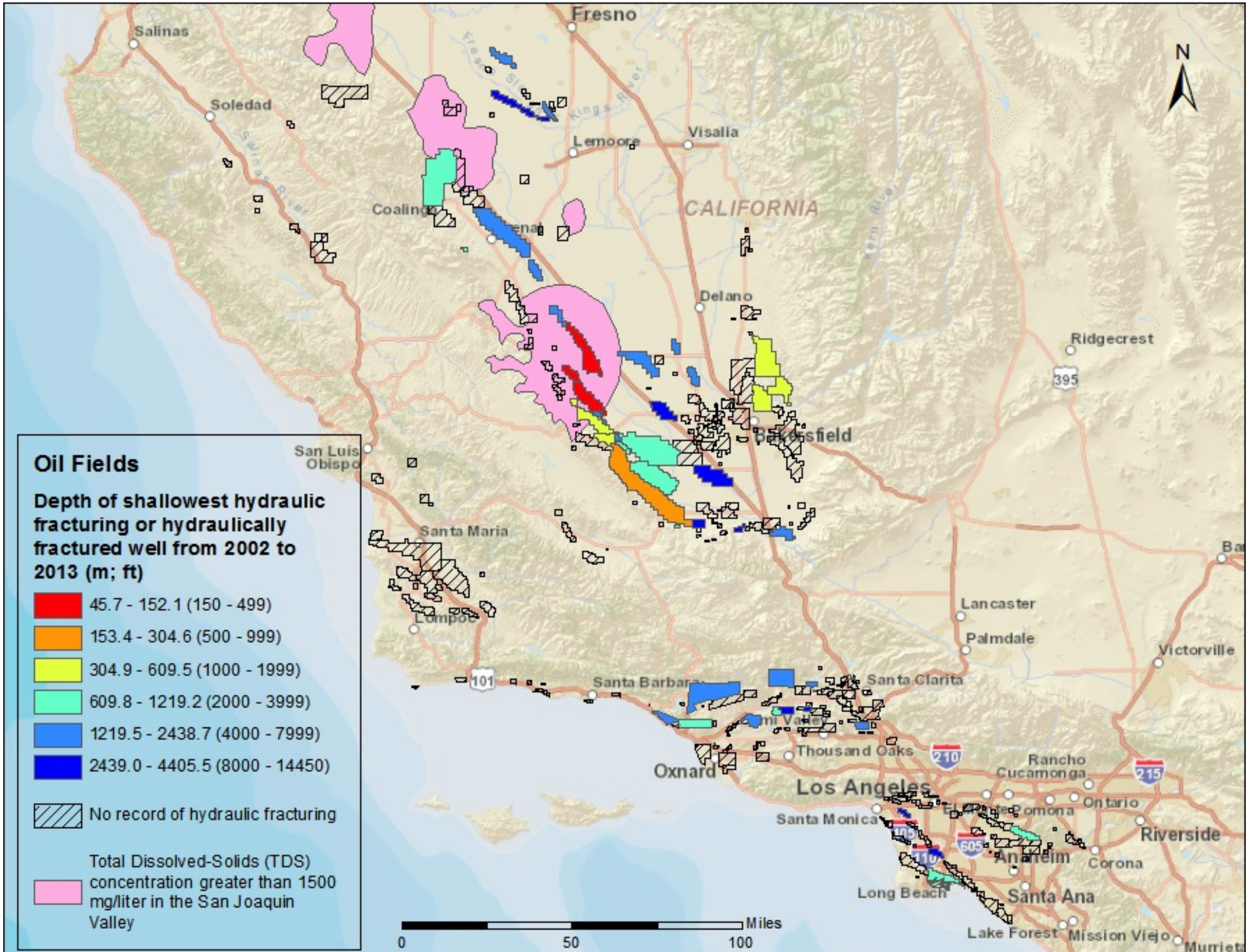


Shallowest hydraulic fracturing depth from the well stimulation notices or hydraulically fractured well depth in each field



Groundwater TDS Thresholds

Total Dissolved Solids (mg/l)	Thresholds
500	Fed EPA: secondary standard California recommended for drinking water
1,000	California upper for drinking water
1,500	California short term for drinking water
3,000	California suitable for use (protected)
10,000	Fed Safe Drinking Water Act: protected groundwater

Flowback and Produced Water

In California, produced water and flowback water are co-mingled and managed together. Current practice could allow flowback water to be mixed with produced water for use in irrigation and for the disposal of oil and gas wastewater into unlined pits.

Produced water used for irrigation in Cawelo water district

Source: Lauren Sommers

Unlined pits in Kern County

Source : Google Earth

California needs to develop an accurate understanding about the location, depth and quality of groundwater in oil- and gas-producing regions in order to evaluate the risk of well stimulation to groundwater.

- More than half of the stimulated oil wells in California have shallow depth (less than 2,000 feet).
- Shallow hydraulic fracturing poses a potential risk for groundwater if fractures can intersect nearby usable aquifers.
- There are no publicly reported instances of potable water contamination from subsurface releases in California
- A lack of studies, consistent and transparent data collection, and reporting make it difficult to evaluate the extent to which it may have occurred.

Induced Seismicity Related to Hydraulic Fracturing

Observed increases in WST-related induced seismicity cases since 2010 nationally

- building damage
- temporary or permanent shut down of operations
- public alarm

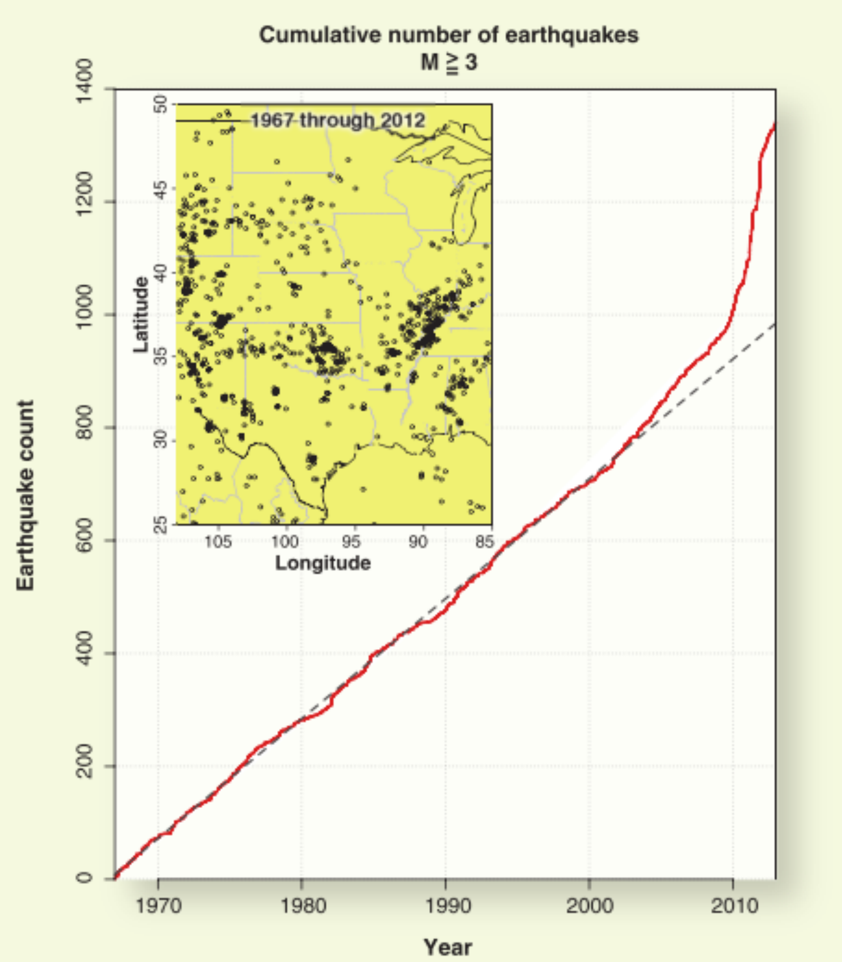
M_{max} from hydrofracture creeping up…currently M3.6

M_{max} from wastewater disposal…at least M5

California

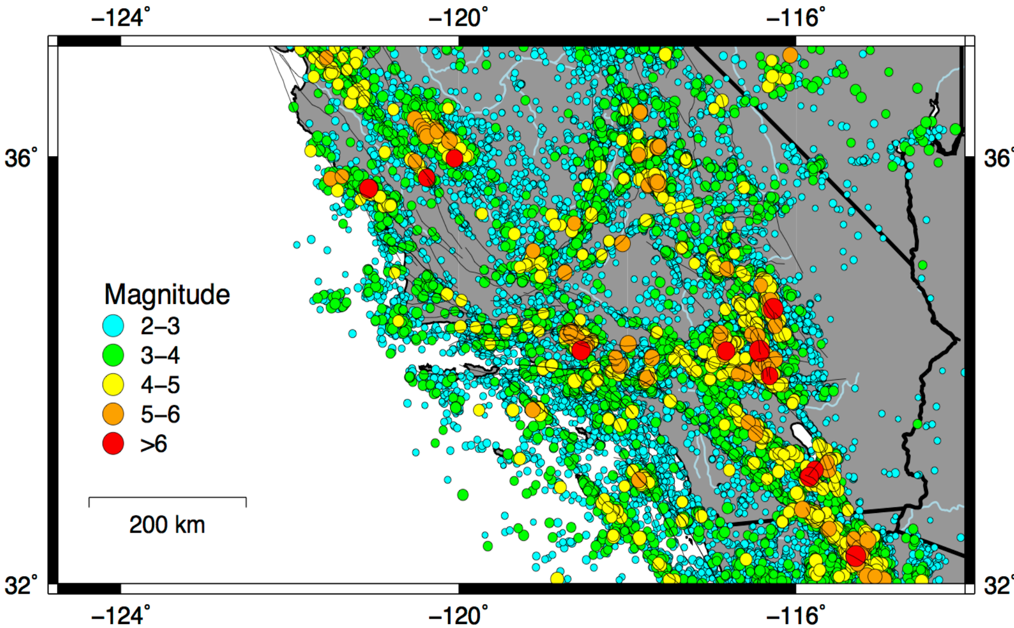
Only one documented case to date (19910, but…

- high rate of natural seismicity, many active faults
- perceived potential for triggering large earthquakes

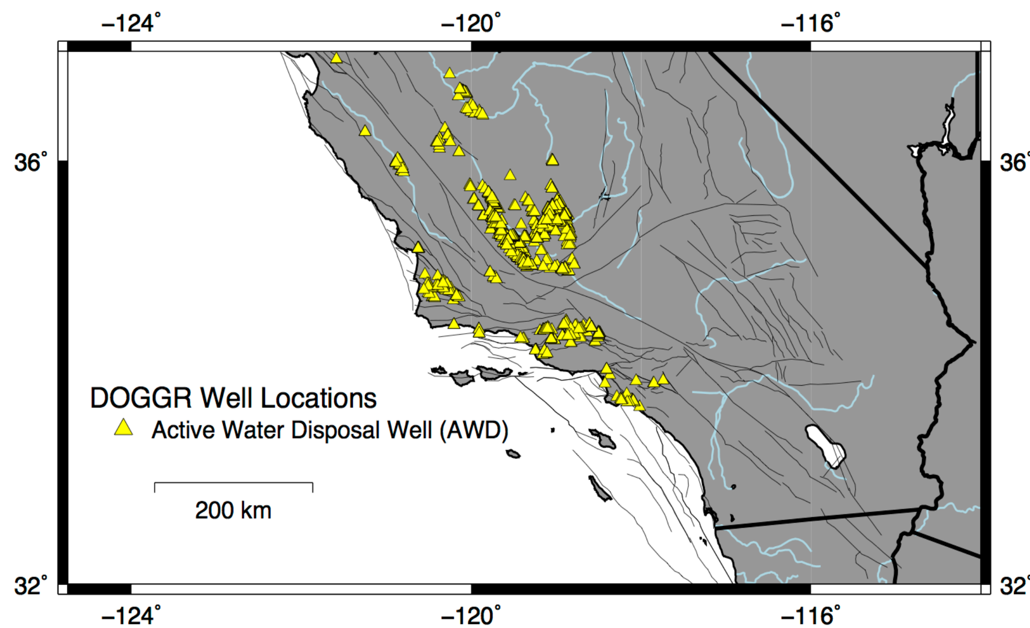


Ellsworth (2014)

California Seismicity and Wastewater Disposal Wells



High-precision earthquake locations 1981-2011 from Hauksson et al. (2012)



Locations of 1509 active water disposal wells from DOGGR with UCERF3 FM3.1 faults (Field et al., 2014)

Well stimulation technologies, as currently practiced in California, do not result in a significant increase in seismic hazard.

- The pressure increases from hydraulic fracturing are too small and too short in duration to be able to produce a felt, let alone damaging, earthquake.
- Only one minor, anomalous earthquake (which occurred in 1991) has been linked to hydraulic fracturing to date.
- Expanded oil production for any reason, including expanded use of hydraulic fracturing would lead to increased injection volumes for disposal, and this could increase seismic hazards.

In California, for industry practice of today, the direct environmental impacts of well stimulation practice appear to be relatively limited and will likely be limited in the future if proper management practices are followed.

- If these well stimulation technologies enable a significant increase in production in the future, the primary impacts on California's environment will likely be caused by the increase in production activities in general.
- Impacts of increased production will vary
  - Where this production occurs–
    - in existing areas (both rural and urban)
    - in regions that have not previously been
  - The nature of the ecosystems, geology, and groundwater in the vicinity.

Coming in Vol II

- Deeper analysis of water disposition
- Deeper analysis of air emissions elsewhere and in CA
- Seismic correlation study
- Ecological impact study
- Human Health hazard assessment

Vol III The case studies

- Los Angeles
  - Urban environment
  - Acid use
  - Comparison of oil left vs shale oil
- San Joaquin Valley
  - Disposition of water containing fracking fluids
  - Other issues
  - The future as a projection of the present
- Oil shale potential of the Monterey
  - Potential impacts in the geography of the shale oil window
  - How to make a good estimate
- Offshore production
  - What do we know about what is happening?

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The moderator will call as possible.