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First-Ever Environmental Characterization of Hydraulic Fracturing for Shale Oil and Gas Production

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Local Study With Global Implication

- **Global Importance**
  - Countries with shale basins following US lead
  - Economic, geopolitical, and climate change advantages to shale oil and gas production
  - Concerns about Social License to Operate

- **This Study provides**
  - Data-rich response to fear-based concerns
  - Ability to scale study results globally
Hydraulic Fracturing Environmental Study

- Largest urban oil field in the world, in the center of Los Angeles, California
- Feasibility and environmental impacts of hydraulic fracturing
- Peer-reviewed, data-driven information on the effects of hydraulic fracturing

Concerns of a diverse urban community required a comprehensive study design
Los Angeles Basin is the richest in oil worldwide by size

A need for coexistence
Environmental Baseline:

Venice Beach, California in 1930's

Urban growth overlain on Historic oil development
Comprehensive Measurements before, during, and after hydraulic fracturing:

- Hydrogeology
- Water Use
- Water Quality
- Containment of Fractures
- Well Integrity
- Slope Stability
- Subsidence
- Ground Movement
- Induced Seismicity
- Methane
- Air Emissions
- Noise
- Vibration
- Community Health*

Results applicable to other parts of the world

www.eenews.net/assets/2012/10/11/document_ew_01.pdf
Fluids Used in Hydraulic Fracturing

Water and Sand 99.51%

Oil Field consists of shales and sandstones, folded and faulted.
Nodular Shale: Fracturing Target

1 Mile
Newport-Inglewood Fault (Strike-Slip)

Thrust Faults

1 Mile
Newport-Inglewood Fault (Strike-Slip)

Normal Faults

Thrust Faults

1 Mile
Discontinuous Groundwater Lenses
Discontinuous Groundwater Lenses

Hydrocarbon Seal

1 Mile
The zone affected by hydraulic fracturing is approximately 2,500 m feet beneath fresh water (1 ½ miles)
Discontinuous Water Bodies

Newport Inglewood Fault

Pico Surface (Freshwater Base)

Vickers "H" Sand

Rindge Surface

Rubel Surface

Sentous Surface

Well 2 Microseismic & Frac Model

Well 1 Microseismic & Frac Model

Nodular Shale: Target Zone

Well 2 Microseismic & Frac Model

Nodular Shale: Target Zone
"... the Baldwin Hills [we]re modeled as a no-flow cell." (USGS 2003)

"The Baldwin Hills form a complete barrier to groundwater movement where the essentially nonwater-bearing Pico formation crops out." (DWR 1961)
Water Quality

• 2/3 of water for the vicinity of Oil Field comes from 560 km (350 miles) away
• Remainder is from sources greater than 1.5 miles away
• All public water is:
  – Tested quarterly and reported
  – Must meet drinking standards

Further Information: http://www.westbasin.org/water-reliability2020/groundwater/overview
Groundwater quality consistently meets drinking water standards, before and after hydraulic fracturing.
Ground Movement and Induced Seismicity

- Microseismic effects: Richter M 0.01 to 0.001
- Insufficient to induce tectonic earthquakes
- Tectonic quakes have deeper source
- Induced seismicity linked to injection at few sites
- Field has operated a water flood since 1971 without seismicity
Methane Migration

- Oil Field is adjacent to known “Methane Zone”
- Methane in shallow soil gas is biogenic
- Methane detected in groundwater has been thermogenic
- No change due to hydraulic fracturing
Measurements before, during, and after hydraulic fracturing did not detect effects to:

- Hydrogeology
- Water Use
- Water Quality
- Containment of Fractures
- Well Integrity
- Slope Stability
- Subsidence
- Ground Movement
- Induced Seismicity
- Methane (soil gas and groundwater)
- Air Emissions
- Noise
- Vibration
- Community Health*

Study Provides Data-Rich Source Responding to Public Concerns
Application of the Study So Far

• First Study to address all environmental concerns of hydraulic fracturing quantitatively; finding no new adverse effects compared to current oil and gas operations

• Local public agency with jurisdiction over the Oil Field did not require additional protective measures for hydraulic fracturing

• State public agency relying on the Study for independent review of hydraulic fracturing (Tormey on Steering Committee)

• Federal public agency relied on the Study as basis for evaluating Hydraulic Fracturing
Your Feedback is Important

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