

Hydraulic Fracturing “Fracking”

Geologic Considerations and Questions That Need Answers



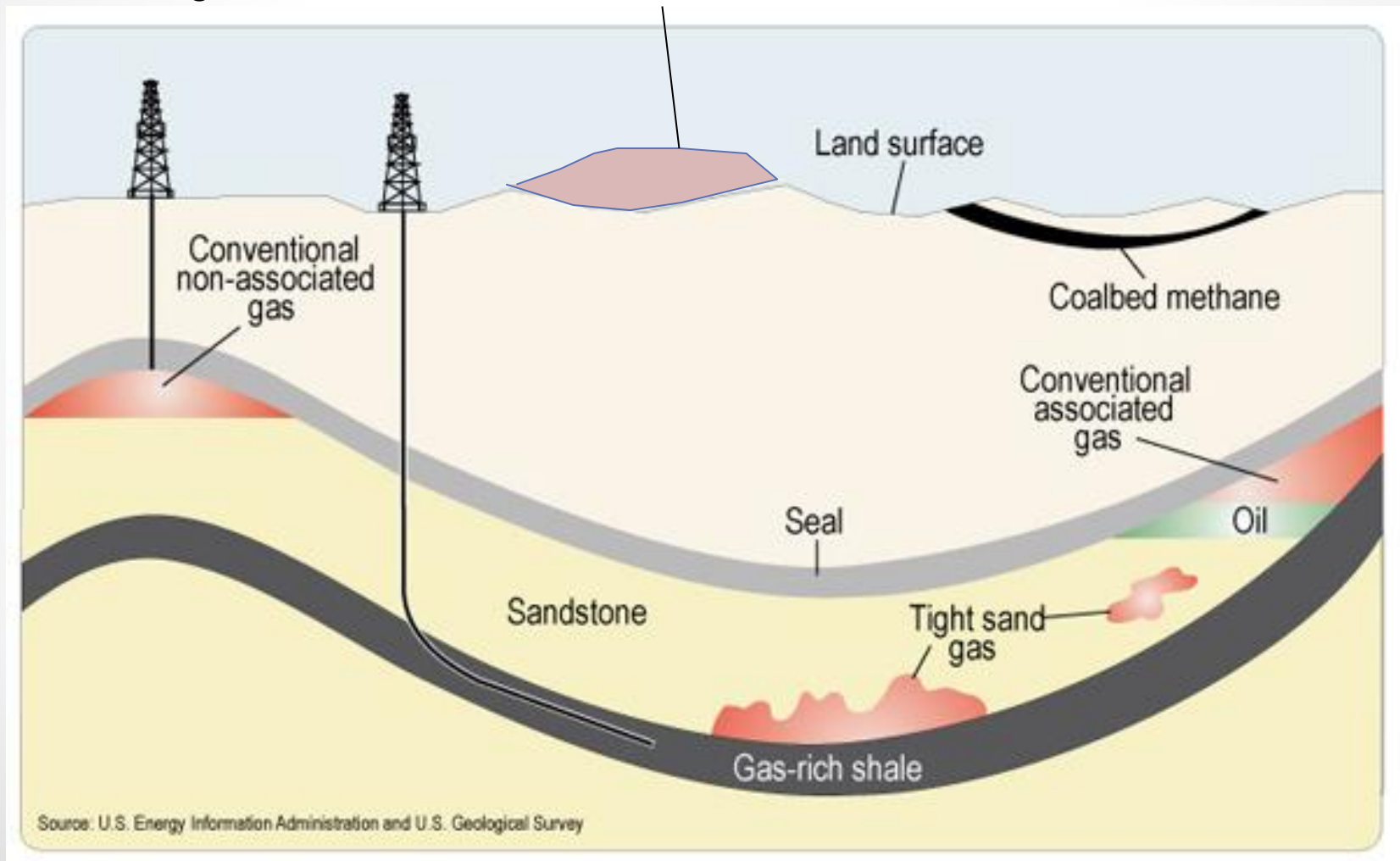
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Natural Gas Sources

Organic methane from landfills and other surface sources



What is Fracking?

(unconventional gas recovery)

- Enhanced oil and gas recovery through hydraulic fracturing of methane-bearing shale (and other rock types).
- Shale has low permeability so fluids and gasses have a difficult time moving toward oil and gas wells.
- Hydraulic fracturing increases the permeability through creating, and maintaining, a network of fractures.

Shale and Fracking

Shale at the surface is often very fractured but at depth (1000's of feet) there are few open fractures.

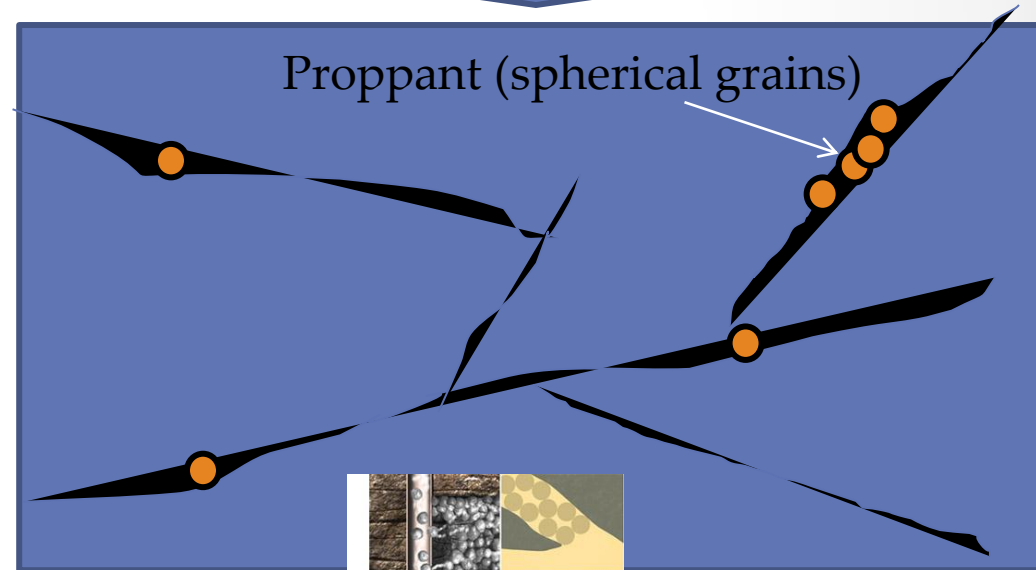


Photo of Marcellus Shale on the surface

Source: <http://www.wvsoro.org/resources/images/MarcellusShaleOutcrop4.jpg>

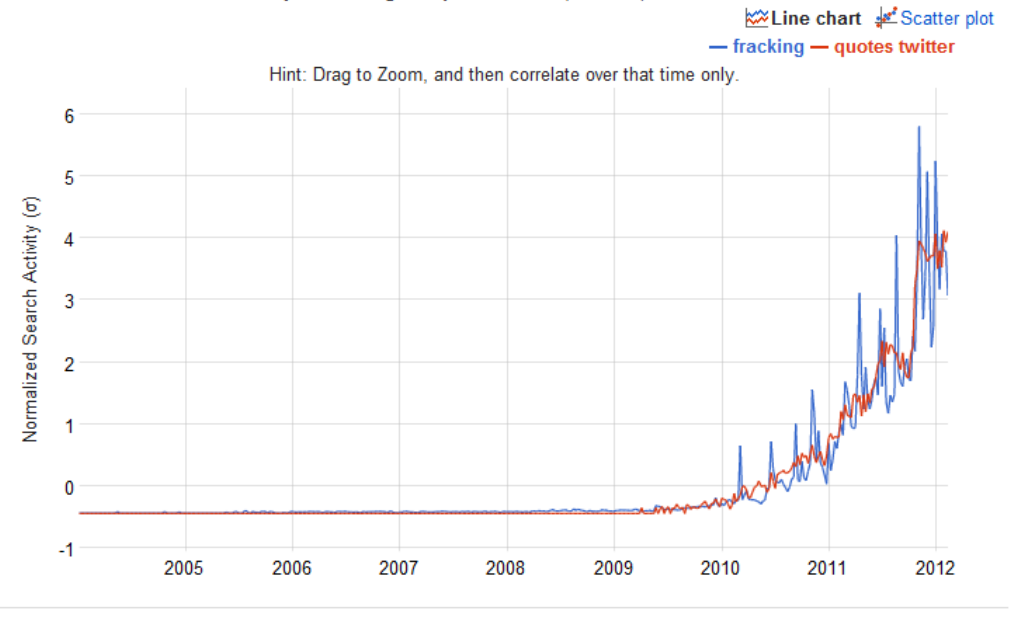
Shale with oil and gas (CH_4)

Water + Proppants +
Chemicals + Pressure

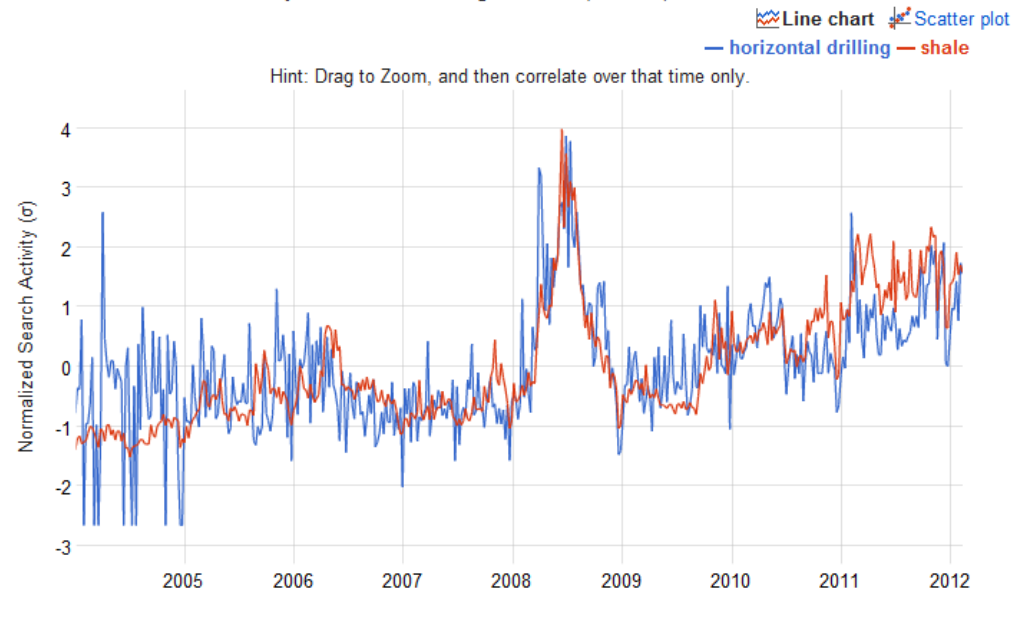


Why is Fracking Booming?

United States Web Search activity for **fracking** and **quotes twitter** ($r=0.9577$)

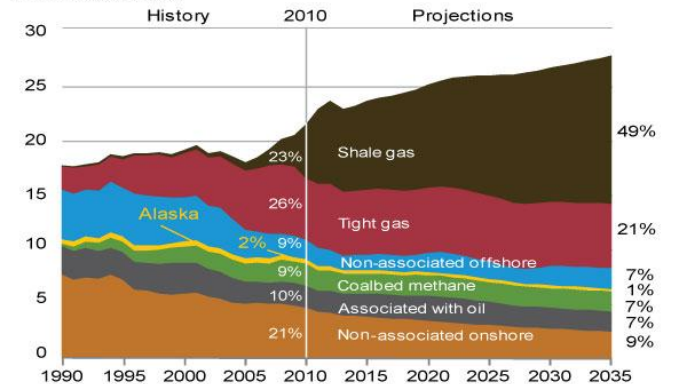


United States Web Search activity for **horizontal drilling** and **shale** ($r=0.7235$)



U.S. Natural Gas Production, 1990-2035

trillion cubic feet



Source: U.S. Energy Information Administration, AEO2012 Early Release Overview, January 23, 2012.

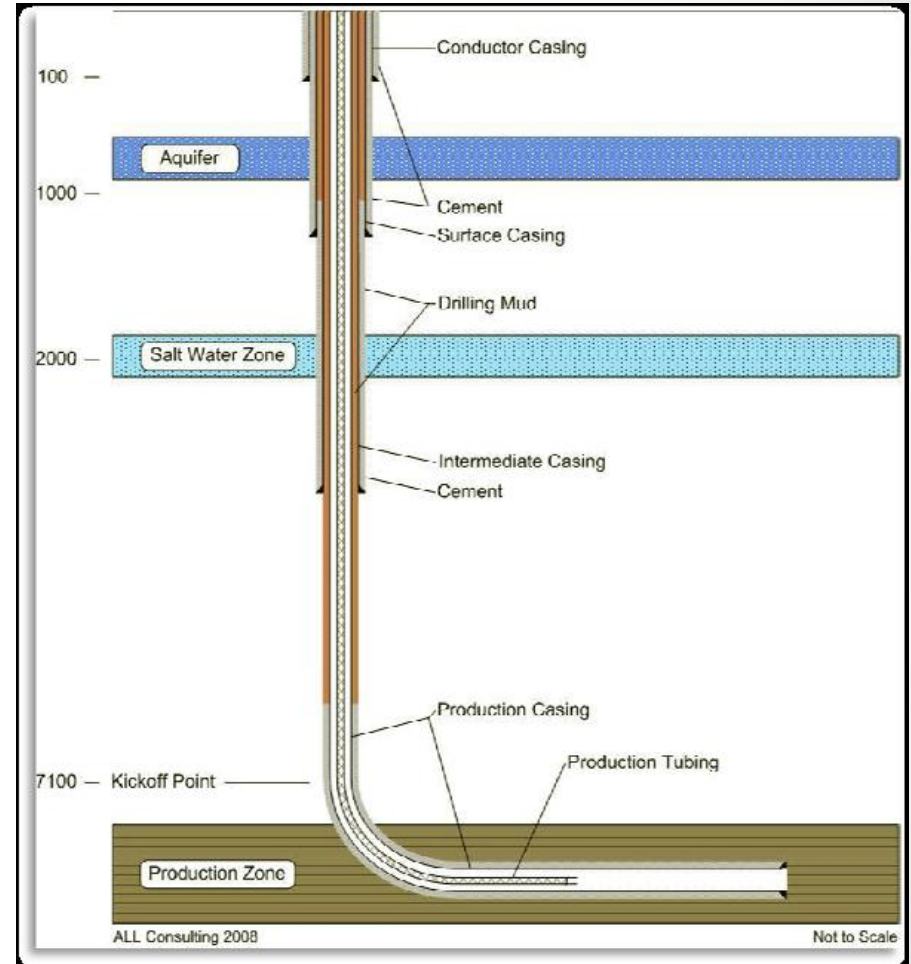
Source: Google Trends;
www.google.com/trends

Directional Drilling

- Advances in drilling technology have changed the way oil and gas wells are drilled
- Special drilling tools can control the direction and determine drill hole position.
- Horizontal shale layers can be accessed and many holes can be drilled from one main drill hole.



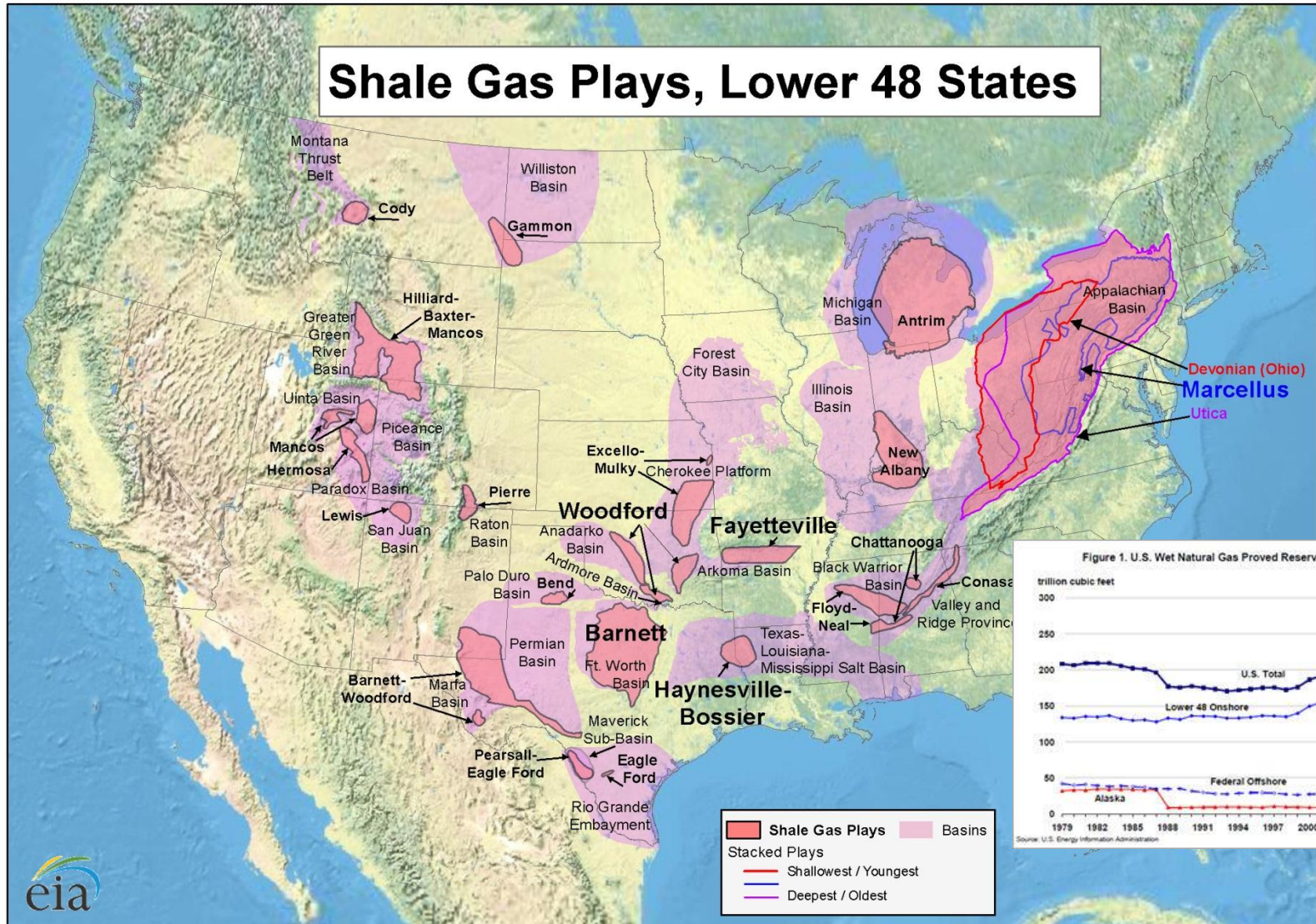
Fig. 5. Rotary Closed-Loop System (RCLS) Bottom-Hole Assembly (Baker Hughes)



Department of Energy, 2009

Lee et al., 2011

Possible Natural Gas "plays"



Source: Energy Information Administration based on data from various published studies.
Updated: March 10, 2010

Potential for a 100-year supply

Fracking Issues

- Micro-earthquakes and stability
- Groundwater contamination
 - Methane contamination, “Flaming” tap water, and potential explosions
 - Contamination from toxic additives
- Surface water contamination
 - Dewatering of saline aquifers to the surface
 - Contamination from additives
- Increased dependence on fossil fuels (“bridge fuel”)
 - Greenhouse gas emissions

Micro-earthquakes and stability

- Fracking is mostly applied to deep shale
 - Range is broad but from 2,000-10,000 feet
 - Most drinking water aquifers are < 500 feet. One of the most productive in Michigan (Marshall Sandstone) is only 120 feet deep below GVSU campus
- Can fracking cause earthquakes?
 - Likely yes, although size of quakes and risk of any damage is probably very small.
 - Evidence from wells in Oklahoma suggests that earthquakes initiation can be very sporadic and changes with time (Holland, 2011)
- Can fracking cause subsidence or instability?
 - Likely not much. Volume changes are probably not significant enough to cause surface changes.

Groundwater contamination

Table 1. Chemical Components Appearing Most Often in Hydraulic Fracturing Products Used Between 2005 and 2009

Chemical Component	No. of Products Containing Chemical
Methanol (Methyl alcohol)	342
Isopropanol (Isopropyl alcohol, Propan-2-ol)	274
Crystalline silica - quartz (SiO ₂)	207
Ethylene glycol monobutyl ether (2-butoxyethanol)	126
Ethylene glycol (1,2-ethanediol)	119
Hydrotreated light petroleum distillates	89
Sodium hydroxide (Caustic soda)	80

Table 2. States with the Highest Volume of Hydraulic Fracturing Fluids Containing 2-Butoxyethanol (2005-2009)

State	Fluid Volume (gallons)
Texas	12,031,734
Oklahoma	2,186,613
New Mexico	1,871,501
Colorado	1,147,614
Louisiana	890,068
Pennsylvania	747,416
West Virginia	464,231
Utah	382,874
Montana	362,497
Arkansas	348,959

Source: U.S. House of Representatives, 2011

Surface water contamination

- Formation water from deep shale formations is typically saline and may contain contaminants (As, Pb, Fe, etc.)

Sea water
~35,000 mg/L

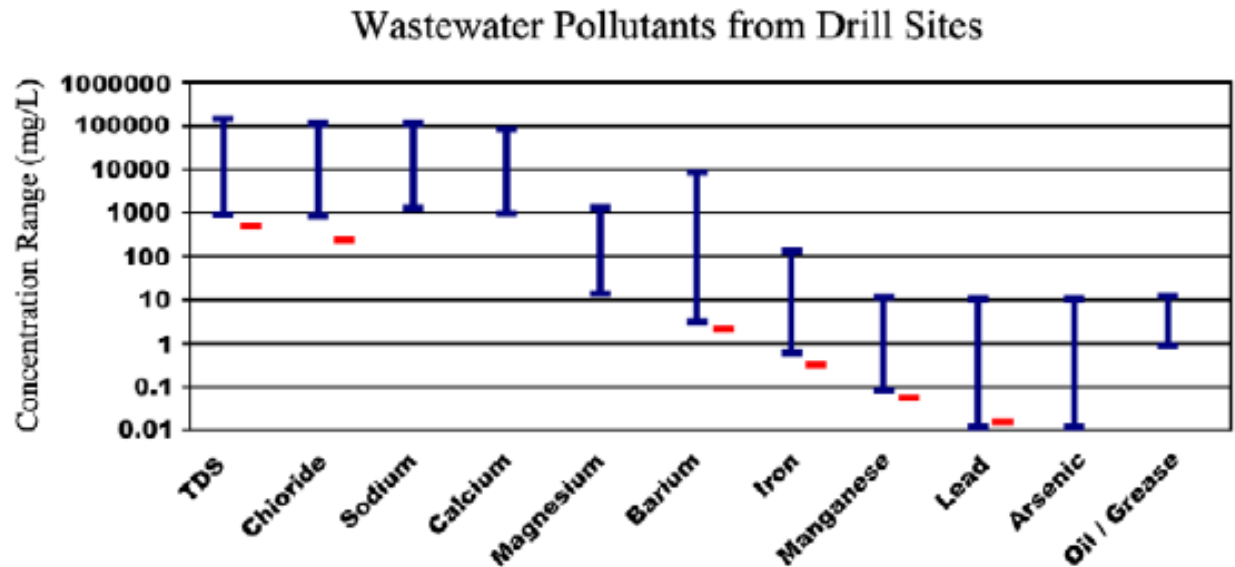


Fig. 9. Range of Contaminant Measurements in Twenty Samples of Marcellus Wastewater (Swistock, 2009)

Conclusions

Questions that need answers



- **Monitoring**
 - Seismic
 - Methane and other potential contaminants in surface water and drinking water wells
- **Accountability**
 - Oil companies should bear the cost and responsibility to demonstrate that fracking is safe and sustainable
- **Reporting**
 - **All** fluids and additives used.
 - Fluid and additive recovery data.
 - Formation water discharge quality and quantity.
- **Support for research and information dissemination**
 - Royalty or tax to support research

MARS

References

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