• Water quantity / water use: how much is too much?

• Water quality / water contamination: what are the contamination potential sources?
>30,000 wells fraced in the past 5 years
Bureau of Economic Geology

>30,000 wells fraced in the past 5 years

Barnett Shale

Haynesville Shale

Bossier Shale

Eagle Ford Shale

Pearsall Shale

Marcellus Shale

100’s of Wells
Bureau of Economic Geology

>30,000 wells fraced in the past 5 years

SHALES

TIGHT GAS

BARNETT SHALE

HAYNESVILLE SHALE

BOSSIER SHALE

Canyon Sands

Olmos

EAGLE FORD SHALE

PEARSALL SHALE

Granite wash, Cleveland, Marmaton

Cotton Valley, Travis Peak Bossier Sands

Vicksburg, Frio

Wilcox

The University of Texas at Austin

School of Geosciences
What is a frac job?

- Very low matrix permeability: $\mu d$ for tight gas sands and nd for gas shale (>1d good aquifer)
- Create a fracture network by injecting large amounts of water at high pressure.
- Add additives to enhance performance
- Add proppant (sand) to keep fractures open after frac job
- Conjunction of horizontal drilling and slick water frac (as opposed to gel, x-linked water fracs)
Bureau of Economic Geology

From Devon Energy, 2006

Barnett Horizontal wells

Frac Water Use (Mgal)

Annual Number of Frac Jobs

Calendar Year

Frac Water Use (Mgal)

Calendar Year

Annual Number of Frac Jobs


0 500 1000 1500 2000 2500 3000

0 1 2 3 4 5 6 7

Average 5th Percentile 30th Percentile Median 70th Percentile 95th Percentile

Barnett Horizontal wells
Haynesville = 700 AF and Eagle Ford = 2,600 AF for 8 months of 2010
How much so far this year?

- 10,268 wells completed
- 7,650 wells stimulated
- 3,841 >0.1 Mgal

Total water use of 6,238,000,000 gallons (18.5 MAF)

Barnett Shale: ~60% of water use
Permian Basin: ~18%
Gulf Coast: ~12%
Is that a lot?

State of Texas Water Use

TWDB Projections Yr 2010

Total = ~18,300 1000’s AF

Mining water use (TX):
- Oil and Gas = ~45 1000’s AF
- Coal/Lignite = ~25 1000’s AF
- Aggregates = ~20 1000’s AF
- Others
2005-2007: ~50% GW - ~50% SW
Accurate figures are very hard to come by
• Individual water use: ~150 gal/day/capita
• Family of 4 for a year: 220,000 gal = 0.67 AF/yr
• Typical frac job = 4,000,000 gal = 12.3 AF/3days
• 0.67 AF/yr vs. 12.3 AF in 2 weeks
• 0.67 AF/yr vs. 12.3 AF in 2 weeks
• 0.67 AF/yr vs. 12.3 AF in 2 weeks (several times?)
Industry actively working on reducing its water footprint

- Recycling of flow-back water
- Use of brackish water + appropriate additives
- Alternative water sources: WWTP, rain+stock ponds
- Less water-intensive techniques / different fluid
Contamination Issues
Mud Pits & Surface Operations

Water Disposal

Truck Traffic & Pipelines

…but all auxiliary activities
Well casing integrity

- Need to protect USDW (<10,000 mg/L) – surface casing
- Surface injection pressures are high: 3,000-5,000 psi
- Risk for each well is low but there are tens of thousands of wells
- Still, only a few documented cases of defective surface casing: need to review all alleged cases of groundwater contamination
Well construction

Soil, unconsolidated material

Conductor casing ~20” - ~30”

Cement
Steel
Well construction

USDW

Surface casing - ~13”
Well construction

Intermediate Casing – 7” - 9”

Drilling mud / Cement
Well construction

Production casing

Production interval
Well construction

Production casing
Tubing
Annulus
Liner
Another Issue: Natural Fractures

• Hazen and Sawyer (2009) is a consultant report that critically evaluates the Environmental Impact Survey of shale gas production produced by the New York state to the New York City Department of Environmental Protection.
Hazen and Sawyer (2009) asserts that "extensive hydraulic fracturing will present subsurface contamination risks via naturally occurring faults and fracture systems."
Microseismic – no impact
Small seismic events seem to be linked to disposal not fracing

Courtesy Kevin Fisher, Pinnacle
Barnett Shale Mapped Fracture Treatments (TVD)

Depth (ft)

Frac Stages (Sorted on Perf Midpoint)

Courtesy Kevin Fisher, Pinnacle
What I’d like to do:

- **Obj.:** Assess connectivity of induced and natural fracture system potentially leading to fresh water contamination during a frac job
- **Approach:** sampling of overlying saline aquifers to detect mixing**
Some confining layer
Saline Aquifer 1
Saline Aquifer 2
Gas Shale
Fresh Water
Some confining layer
Saline Aquifer 1
Gas Shale
Saline Aquifer 2
Fresh Water
Some confining layer
Saline Aquifer 1
Saline Aquifer 2
Fresh Water
Gas Shale
Fracing
The diagram illustrates the geological layers related to hydrological systems. At the top is the Fresh Water layer, followed by a non-detect zone. Beneath this layer are two saline aquifers, referred to as Saline Aquifer 1 and Saline Aquifer 2. There is a layer labeled "Some confining layer" between these aquifers. At the bottom is the Gas Shale layer. The diagram also includes a section labeled "Fracing," indicating the process of hydraulic fracturing.
Production

Saline Aquifer2

Some confining layer

Saline Aquifer1

Gas Shale

Fresh Water
Production

Saline Aquifer 1
Some confining layer
Saline Aquifer 2
Gas Shale
Fresh Water
Some confining layer
Saline Aquifer1
Gas Shale
Saline Aquifer2
Fresh Water
Production
To detect potential leaks before they impact a fresh-water well: direct sampling of overlying aquifers not likely to be useful/successful.

Detection of contribution of overlying aquifers mixed in the flow back / produced water stream. using natural isotopes as natural tracers.

Chemical and isotopic characterization of frac water, produced water, and overlying aquifers:
Sampling along lineamenta
Other ideas for further work

• Shallow horizontal well through a lineament ~above frac job(s)
• Better understanding of the role of natural fractures
• Study of natural attenuation of contaminants / additives (batch, column experiments & field and modeling verification) – Composition of frac fluids
• ......
Questions, comments?