States have been regulating the full life cycle of hydraulic fracturing for decades

- Geology of each sedimentary basin is different
- States Have Water Appropriation Regulation
  - North Dakota Water Commission
- States Have Oil & Gas Regulation
  - North Dakota Industrial Commission
- States Have Health and Environmental Regulation
  - North Dakota Health Department
What Do Voters Know About Hydraulic Fracturing and Horizontal Drilling?
Only 28% of voters would say they are extremely or very familiar with “fracing” and another 40% are somewhat familiar. The term “horizontal or directional drilling” has a very similar level of familiarity among voters, with 22% who would say they are extremely or very familiar, and 43% are somewhat familiar.

Familiarity with “Fracing” Versus “Horizontal or Directional Drilling”

Are Voters Concerned About Hydraulic Fracturing?
When asked to rate their level of concern about fracing from zero to ten – not concerned to extremely concerned – voters are only moderately concerned with an average mean score of 5.27 overall. Despite what critics may claim, currently there is limited intensity behind voters’ concerns.

Using a scale from 0 to 10, where 0 means it is “not at all concerned” and 10 means it is “extremely concerned,” how concerned are you about the use of fracing?
(MEAN SCORE: 5.27)
What Are Voters Most Concerned About?
The 57% of voters who rated their level of concern as a five or higher were asked to provide in an open-ended question “what concerns them most about the use of fracing?” Verbatim responses were analyzed into thematic categories.

<table>
<thead>
<tr>
<th>Open-Ended Responses - Concerns most about the use of fracing:</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water - ground water pollution and contamination</td>
<td>16%</td>
</tr>
<tr>
<td>Tap water - can be lit on fire from contamination</td>
<td>1%</td>
</tr>
<tr>
<td>Chemicals - contaminate land and water / undisclosed</td>
<td>6%</td>
</tr>
<tr>
<td>Environmental impact - pollution / damage</td>
<td>14%</td>
</tr>
<tr>
<td>Pollution - general concern</td>
<td>2%</td>
</tr>
<tr>
<td>Rehabilitation of drilling / reclamation</td>
<td>1%</td>
</tr>
<tr>
<td>Land instability - Earthquakes / Sink holes</td>
<td>5%</td>
</tr>
<tr>
<td>Unknown long term impacts / new technology / need studies / untested</td>
<td>5%</td>
</tr>
<tr>
<td>Safety concerns - personal safety, not safe for environment</td>
<td>4%</td>
</tr>
<tr>
<td>Community proximity - impact on health, dangerous, harmful nearby</td>
<td>5%</td>
</tr>
<tr>
<td>Location - where it is done and type of land used</td>
<td>2%</td>
</tr>
<tr>
<td>Property rights - local community should have a say</td>
<td>1%</td>
</tr>
<tr>
<td>Regulation - who is in charge, can’t trust to do it right, mistakes made</td>
<td>2%</td>
</tr>
<tr>
<td>Costs - impact on taxes, cost to drill, cost vs. benefit</td>
<td>3%</td>
</tr>
<tr>
<td>Want renewables - will impede developing other energy sources</td>
<td>2%</td>
</tr>
<tr>
<td>Not concerned / worried</td>
<td>4%</td>
</tr>
<tr>
<td>Don’t know about fracing / not familiar enough / need more info</td>
<td>21%</td>
</tr>
<tr>
<td>Unsure / No opinion</td>
<td>9%</td>
</tr>
</tbody>
</table>
Who is Unsure or Opposed to Hydraulic Fracturing?
While 49% of voters initially support the use of fracking in the development of oil and natural gas, there are key voter blocks that need education to increase support. These targetable voter blocks are the same who are less supportive of increased energy production overall.

- Opposition is driven largely by segments of women, voters under 45 years old, and Democrats.
- Party affiliation clearly divides support, with Republicans driving support – (65%) compared to 35% of Democrats, and Democrats driving opposition at 39%, compared to 11% of Republicans.
- While men drive support for fracking at 63%, this drops to just 36% of women. Women are driving the “unsure” position at 37%, compared to just 14% of men. This indicates why it is so important for women to receive effective messages about fracking. While 27% of women initially oppose fracking, segments of women driving this opposition include employed women (31%) and women with a college education (31%).
- Voters over the age of 65 are driving support for fracking at 54% compared to only 47% among voters under 65 years old. Opposition is strongest among voters 18-34 (32%) and women under 45 (30%).
- Hispanic voters are more likely to oppose the use of fracking (31%).
How Do Voters Respond to the Facts About Fracing?
Prior to any presentation of facts about fracing, almost a majority (49%) of voters support its use. The remaining voters split evenly between unsure (26%) and opposed (25%).

_Upon hearing the following..._

“Horizontal drilling is a modernized technique that involves first drilling down and then drilling sideways for up to two miles. This reduces the number of wells that need to be drilled and reduces the amount of land used.”

73%

“In the 20-30 year life of an oil and natural gas well, fracing is a carefully regulated process that usually takes only a few days to complete.”

71%

“Fracing is heavily regulated by state government and has been used to safely and effectively extract oil and natural gas since 1947.”

71%

“The Environmental Protection Agency is responsible for protecting air and water quality and has never found an incident of water contamination due to the use of fracing.”

71%

“Before a well is fraced, there are seven separate layers of cement and steel used to protect underground sources of drinking water while drilling a well. Fracing is one of the final stages and typically occurs over two miles underground, thousands of feet below water tables.”

67%

“More than 90% of all oil and natural gas wells undergo fracing at some point during their lifespan.”

64%

“Horizontal drilling is a modernized technique used in combination with fracing that has unlocked oil and natural gas deposits so vast that by 2035, less than 1% of the nation’s overall natural gas usage is projected to come from foreign imports.”

65%

After being presented with these facts, support for fracing increased from 49% to 71%.
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• Why
• How
• Risks and Regulations
  • Sustainability of water supply
  • Geology of confining zones
  • Well construction
  • Chemicals and flow-back water handling
Hydraulic Fracturing
Lifeline to Domestic Energy

• Why
  • Easy oil and gas that flow without fracturing are already developed
  • Unconventional Reserves reservoirs are tight (look at pictures) uneconomic to produce without fracing must create a path for oil to flow
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• How
5) Technology = horizontal well + multi stage hydraulic fracturing

Producing Interval 1000’s of feet

Bakken

Three Forks
The 6½ minute horizontal drilling/hydraulic fracturing video is available to download for free from this web site (you will need Real Player to view it).

http://www.voyageroil.com/drilling
“1,000 gallons of thickened gasoline and sand from the Arkansas River.”

Not New

> 65 years
> 1 million wells fractured

Greatly Improved

Performing hydraulic fracture stimulation south of Tioga
- all Bakken wells must be hydraulically fractured to produce
- 2-4 million gallons of water
- 3-5 million pounds of sand and ceramic
- cost $2-5 million
Thousands of fractures are created
• pumping water at 6,000-9,000 psi
• millions of pounds of sand and ceramic beads are pumped with the water to hold the fractures open.

Ball and Sleeve
• up to 40 stages
• ball opens the liner sleeve
Purposes of frac fluid
- crack the reservoir
- gel strength to carry sand

Frac fluid is produced back as flowback and produced water
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• Risks and Regulations
  • Sustainability of water supply
  • Geology of confining zones
  • Well construction
  • Chemicals and flow-back water handling
Unconventional Resource Wells are Thirsty

In North Dakota

2,000 - 3,000 wells / year
15 - 25 years duration
20 - 30 million gallons water / day
Water Commission
Regulate water appropriations
Guard against withdrawals >> recharge

Glacial Drift Aquifers
Frac Water Needs ± 20-30 million gallons per day

Ground water maximum ±7 million gallons per day

Lake Sakakawea (Missouri River) is the best water resource

- one inch contains ±10 billion gal water
  - enough to fracture 2,500-5,000 wells

- ±10 million gallons flows through Bismarck every minute
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• Risks and Regulations
  • Sustainability of water supply
  • Geology of confining zones
• Well construction
• Chemicals and flow-back water handling
The properties of geologic confining zone(s) can be determined by science:

- Minimum thickness
- Maximum pressure
- Vertical fracture height
Microseismic events are imaged via PSET, a migration based imaging algorithm.
“Excellent ‘frac saturation’....”

- 24-Stage Frac / IP: 2,558 BOE/D
- Excellent “frac saturation” evidenced by minimal gaps of unfraced rock along the wellbore with some stages impacting the same rock volume.
- Minimal gaps along NE trending natural fractures where the frac follows large regionally extensive fractures. These areas already have good naturally occurring fractures.
- Lateral frac wings that average 750’ on either side of the wellbore. This is consistent with our other fracs and planned spacing pattern for full field development.
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• Risks and Regulations
  • Sustainability of water supply
  • Geology of confining zones
• Well construction
• Chemicals and flow-back water handling
TYPICAL HORIZONTAL OIL WELL

- Drilled with fresh water
- 9 5/8” surface casing
- cement
- 7” production casing
- cement
- 4.5” liner & frac string
- 30-40 swell packers
- sliding sleeves
= 5 layers of protection

Potable Waters

4.5” liner

Frac String

Upper Bakken Shale

Middle Bakken 10,000’

Lower Bakken Shale
Industrial Commission Regulation

- Well construction for Hydraulic fracturing
  - Two casing strings required
    - Both strings must be cemented
  - Fracturing string recommended
  - Pressure tests and monitoring required
  - Casing and cement evaluation logs required
    - Failure rate is zero with these requirements
- Well plugging and abandonment
In North Dakota state inspectors witness every well plugging
Hydraulic Fracturing
Lifeline to Domestic Energy

Hydraulic Fracturing
• Risks and Regulations
  • Sustainability of water supply
  • Geology of confining zones
• Well construction
• Chemicals and flow-back water handling
In North Dakota frac chemicals must be posted within 60 days of pumping.
In North Dakota frac chemicals must be posted within 60 days of pumping
• **Compound**
  – **Purpose**
    • Common application

• **Fresh Water** – 80.5%
• **Proppant** – 19.0%
  – Allows the fractures to remain open so the oil and gas can escape
    • Drinking water filtration, **play ground sand**

• **Acids** - 0.12%
  – Help dissolve minerals and initiate fractures in rock (pre-fracture)
    • **Swimming pool cleaner**

• **Petroleum distillates** – 0.088%
  – Dissolve polymers and minimize friction
    • **Make-up remover**, laxatives, and candy

• **Isopropanol** – 0.081%
  – Increases the viscosity of the fracture fluid
    • **Glass cleaner**, antiperspirant, and hair color

• **Potassium chloride** – 0.06%
  – Creates a brine carrier fluid
    • Low-sodium **table salt substitute**

• **Guar gum** – 0.056%
  – Thickens the water to suspend the sand
    • **Thickener used in cosmetics**, baked goods, ice cream, toothpaste, sauces, and salad dressing

• **Ethylene glycol** – 0.043%
  – Prevents scale deposits in the pipe
    • Automotive **antifreeze**, household cleansers, deicing, and caulk
• Sodium or potassium carbonate – 0.011%
  – Improves the effectiveness of other components, such as cross-linkers
    • Washing soda, detergents, soap, water softeners, glass and ceramics
• Sodium Chloride – 0.01%
  – Delays break down of the gel polymer chains
    • Table Salt
• Polyacrylamide – 0.009%
  – Minimizes friction between fluid and pipe
    • Water treatment, soil conditioner
• Ammonium bisulfite – 0.008%
  – Removes oxygen from the water to protect the pipe from corrosion
    • Cosmetics, food and beverage processing, water treatment
• Borate salts – 0.007%
  – Maintain fluid viscosity as temperature increases
    • Used in laundry detergents, hand soaps and cosmetics
• Citric Acid – 0.004%
  – Prevents precipitation of metal oxides
    • Food additive; food and beverages; lemon juice
• N, n-Dimethyl formamide – 0.002%
  – Prevents the corrosion of the pipe
    • Used in pharmaceuticals, acrylic fibers and plastics
• Glutaraldehyde – 0.001%
  – Eliminates bacteria in the water
    • Disinfectant; Sterilizer for medical and dental equipment
Industrial Commission Regulation

- Water flow back after frac
  - Storage in open pits prohibited
  - Disposal wells permitted through Underground Injection Program
- Disposal zone is 1/2 mile below potable waters with impermeable shale between and >2 miles above earthquake zone with many layers including salt between
Sedimentary Rocks of Western North Dakota

- Precambrian Basement
- Red River Formation
- Madison Group
- Tyler Formation
- Spearfish Formation
- Dakota Group
- Fresh Water Zone
- Shallow Gas Zone
- Bakken-Three Forks
- Prairie Formation
- Red River Formation
- Precambrian Basement

- Piper Formation: Dunham Salt
- Spearfish Formation: Pine Salt
- Opeche Formation: Salt A
- Charles Formation: A Salt, D Salt, F Salt
- Prairie Formation: Prairie Salt
- A Salt
- D Salt
- F Salt
The handling of flow back water can be carefully controlled:

License truckers as waste haulers
Use GPS to track trucking
Underground disposal zone(s) must be separated from drinking water and earthquake zones
Recycling of water must be encouraged
Health Department Regulation

• Cleanup of discharge to environment
• Coordinate with local Emergency Managers
• Emergency Planning and Community Right-to-know Act (EPCRA)
  Congress passed for storing and handling of chemicals

  Requires material safety data sheet (MSDS) for each chemical on location
1975

Two Movies
the SHARK:
Splendid Savage of the Sea

by Jacques-Yves Cousteau
and Philippe Cousteau

with 124 photographs in full color
Which movie would you rather watch?

Which should guide how we manage sharks and beaches?