Reducing the Environmental Footprint of Unconventional Reservoir Development

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Global Drilling Intensity Will Increase

2014 Liquids Related Activity

Production (MMbpd)
- Saudi: 11.4
- Russia: 10.9
- US: 11.7

Wells Drilled (# wells and sidetracks)
- Saudi: 399
- Russia: 8,688
- US: 35,699

Footage Drilled (Million ft.)
- Saudi: 3
- Russia: 83
- US: 297

Source: IEA, EIA, Spears, SLB Analysis
Emerging Unconventional Plays

Source: Schlumberger
## Evolution of North America Basin Development

<table>
<thead>
<tr>
<th>RIGS</th>
<th>WELLS</th>
<th>STAGES</th>
<th>CLUSTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="High Spec Rigs" /></td>
<td><img src="image" alt="Pad Drilling" /></td>
<td><img src="image" alt="Zipper Fracturing" /></td>
<td><img src="image" alt="Engineered Completions" /></td>
</tr>
</tbody>
</table>

- **RIGS**: 1,560 High Spec Rigs
- **WELLS**: ~32,000 Pad Drilling
- **STAGES**: ~400,000 Zipper Fracturing
- **CLUSTERS**: ~2,000,000 Engineered Completions

2013 North America average Horizontal Rig Count
Source: Schlumberger Analysis, RigData, June Warren-Nickle's
Why Hydraulic Fracturing?

Vertical, Perforated Well

315 Sq Ft
200 Ft High x 6” Wellbore

Vertical, Perforated Well with Single Hydraulic Fracture

160,000 Sq Ft
200 Ft High x (1) 200 Ft Frac with 2 Wings Each

Horizontal, Perforated Well with 15 Hydraulic Fractures

2,400,000 Sq Ft
200 Ft High x 6” Wellbore x (15) 200 Ft Frac with 2 Wings Each
How About the Water…

Direct Annual Use for Hydraulic Fracturing:

- Over 90 Billion Gallons in United States
- Average of 2.4 Million Gallons per Well
- Total Associated Costs over $6.4B

Best Practices Include:

- Recycling of Flowback
- Alternate Sources of Water
Production Contribution… Less than Optimal

- Zero Production from at least 10% of Clusters: 58% of Cases
- Decent Distribution: 6% of Cases
- Dominant Clusters: 29% of Cases
- Crossflow: 6% of Cases
Novel Completions Techniques
Novel Completions Techniques

Improvement of well performance
- Typical production increase of 20%

Significant reduction in logistics, safety risks and environmental footprint
- Typical water consumption reduction of 25%
- Typical proppant consumption reduction of 40%
Water Sourcing for Hydraulic Fracturing

Past
- Fresh Water
- Fracturing Location
- Disposal Well

Present
- Fresh Water
- Recycled Water
- Fracturing Location
- Disposal Well

Ideal
- Fresh Water
- Produced Water
- Recycled Water
- Fracturing Location
- Disposal Well
Water Sourcing for Hydraulic Fracturing

<table>
<thead>
<tr>
<th>Cation</th>
<th>Sample 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>80423</td>
</tr>
<tr>
<td>Calcium</td>
<td>18938</td>
</tr>
<tr>
<td>Potassium</td>
<td>6800</td>
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<tr>
<td>Magnesium</td>
<td>889</td>
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<tr>
<td>Iron</td>
<td>82.29</td>
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<tr>
<td>Boron</td>
<td>364</td>
</tr>
<tr>
<td>pH</td>
<td>5.68</td>
</tr>
<tr>
<td>SG</td>
<td>1.187</td>
</tr>
<tr>
<td>TDS</td>
<td>275000</td>
</tr>
</tbody>
</table>

- **Cation**
- **Sample 1**
  - Sodium: 80423
  - Calcium: 18938
  - Potassium: 6800
  - Magnesium: 889
  - Iron: 82.29
  - Boron: 364
  - pH: 5.68
  - SG: 1.187
  - TDS: 275000

**Graph:**
- BHST [degF] / Shear Rate [1/s] vs. Elapsed Time [hh:mm]
- Viscosity [cP] vs. Elapsed Time [hh:mm]
Development of Modern Chemistries

Increased Compound Restrictions

Time

Traditional Fracturing Additive Portfolio

Green Chemistry

Traditional Fracturing Additive Portfolio

Stimulation Fluids Engineering

Green Chemistry

Traditional Fracturing Additive Portfolio

Stimulation Fluids Engineering

Green Chemistry

Stimulation Fluids Engineering
The Schlumberger Definition

<table>
<thead>
<tr>
<th>Category</th>
<th>Constituents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority Pollutants &amp; SDWA (US EPA)</td>
<td>231 Constituents</td>
</tr>
<tr>
<td>Known Carcinogens (REACH)</td>
<td>1018 Constituents</td>
</tr>
<tr>
<td>Known Mutagens (REACH)</td>
<td>423 Constituents</td>
</tr>
<tr>
<td>Known Reprotoxins (REACH)</td>
<td>217 Constituents</td>
</tr>
<tr>
<td>Nonylphenol &amp; Alkylphenol Ethoxylates</td>
<td>31 Constituents</td>
</tr>
<tr>
<td>Suspected Carcinogens (REACH)</td>
<td>186 Constituents</td>
</tr>
<tr>
<td>Suspected Mutagens (REACH)</td>
<td>195 Constituents</td>
</tr>
<tr>
<td>Suspected Reprotoxins (REACH)</td>
<td>129 Constituents</td>
</tr>
</tbody>
</table>

91.6% Meets the Criteria

8.4% Does not meet the criteria
Transparency is a Must…

To Gain Public Trust…
… and to Allow Well Operators to Prioritize Appropriate Chemistries

- System-Style Disclosure
- Includes CAS Registry Numbers
- Process Widely Accepted:
  - Frac Focus (USA)
  - Frac Focus (Canada)
  - IOGP’s Voluntary Disclosure Process

List of Schlumberger Systems Pumped, including system volumes and additive descriptions for services provided during treatment

<table>
<thead>
<tr>
<th>Fluid Description(s)</th>
<th>Contains: Water, Activator, Bactericide, Breaker, Buffer, Clay Control, Crosslinker, Gelling Agent, Propping Agent, Scale Inhibitor, Stabilizing Agent, Surfactant</th>
</tr>
</thead>
<tbody>
<tr>
<td>OpenFRAC XL</td>
<td>100,000 Gal</td>
</tr>
</tbody>
</table>

List of chemical constituents with CAS numbers and mass fractions. Adds to 100% of known constituents

- 14808-60-7: Crystalline silica
- 9000-30-6: Guar gum
- 1310-73-2: Sodium hydoxide
- 67-48-1: Cholinium chloride
- 7772-98-7: Sodium thiosulphate
- 7789-18-0: Sodium bromate
- 1332-77-0: Potassium borate
- 31726-34-8: Polyethylene glycol monohexyl ether
- 65997-18-9: Calcium magnesium sodium phosphate frit
- 55566-30-8: Tetrakis(hydroxymethyl)phosphonium sulfate
- 1310-58-3: Potassium hydroxide
- 56-81-5: Glycerol
- 7631-86-9: Non-crystalline silica
- 61789-77-3: Dicoco dimethyl quaternary ammonium chloride
- 67-62-0: Propan-2-ol
- 9012-54-8: Hemicellulase enzyme
- 57-50-1: Sucrose
- 107-21-1: Ethane-1,2-diol

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