Drivers for Shale Gas Produced Water Treatment

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Project Funding

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- ALL Consulting is the primary research organization with the Ground Water Protection Council serving as a research partner.
- Other cooperators include state agencies, treatment companies, and industry.
Project Goals

Promote domestic unconventional gas production by providing an on-line decision tool that will allow shale gas operators to make sound water treatment decisions.
PW Treatment Catalog/Tool

• Describe the major treatment technologies available:
  – Capabilities (constituents treated, volumes, and efficiency)
  – Operating parameters (mobile/stationary, temperature limitations, etc.)
  – Cost estimates/ranges (both capital and operating costs)
• Assess technical characteristics
  – Scale Affinity Model
• Assess regulatory regime of each state
• Considerations for disposal (including options)
• Designed to aid industry and regulatory officials
Primary Focus

- Eastern Shale Gas Basins including:
  - Marcellus
  - Fayetteville
  - Haynesville
  - Woodford
  - Barnett
- General applicability to other basins
Key Technologies

• Horizontal drilling and hydraulic fracturing have been the key to economic recovery of shale gas reserves.

• Hydraulic fracturing requires large volumes of water. Small amounts of chemicals and sand are added to create fracture fluid.
## Water Needs

<table>
<thead>
<tr>
<th>Play</th>
<th>Typical Volume of Fracturing Water (gal)</th>
<th>Total Volume of Fracturing and Drilling Water (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barnett</td>
<td>2,300,000</td>
<td>2,700,000</td>
</tr>
<tr>
<td>Fayetteville</td>
<td>2,900,000</td>
<td>3,060,000</td>
</tr>
<tr>
<td>Haynesville</td>
<td>2,700,000</td>
<td>3,700,000</td>
</tr>
<tr>
<td>Marcellus</td>
<td>3,800,000</td>
<td>3,880,000</td>
</tr>
</tbody>
</table>

*Source: All Consulting 2009*

**NOTE:** Water volumes shown above are for general reference purposes only as actual volumes may vary significantly from what is specified above based on length of lateral, perforations, and overall fracture design. However, ALL has noted general increases in the volume of water used for hydraulic fracturing in several shale gas basins.

[ALL Consulting logo]
Water Management Challenges

- **Withdrawal**: Access to supply sources, timing, permitting
- **Transport**: Cost, impact on roads and traffic
- **Storage**: Cost, surface disturbance, permitting
- **Drilling and Fracturing**: Surface handling
- **Treatment**: Cost, volume of resulting concentrate
- **Reuse/Recycle**: Reuse for HF, other markets for recycled water, demand characteristics (quantity, quality, timing)
- **Surface Discharge**: Cost, permitting
- **Disposal**: Availability/permitting of injection zones, capacity at commercial/municipal plants, discharge permits
Concurrent Water Concerns

• Availability of fresh water is a concern across the country
• Chemical characteristics of produced water is a concern and may be able to be addressed using treatment?
• Regional droughts have impacted water management practices
• Many are concerned that global climate change will only make matters worse
• These challenges and concerns affect the need to treat shale gas produced water
Treatment Drivers

• Social/Regulatory
• Environmental
  – Conservation of Resources
  – Aquatic Impacts
• Economic
  – Cost of withdrawals
  – Cost of disposal
• Technical
  – Treatment in lieu of additives
  – Lack of disposal options
Treatment Targets

- Purpose for treating
  - Reuse/Recycling
  - Discharge/Beneficial use
  - Disposal
- Technical and regulatory considerations
- Environmental Considerations
  - Reducing/eliminating fracturing additives
Reuse/Recycling

- Reduces water sourcing requirements
- Reduces water disposal costs
- Has the potential to lower transportation and storage costs
## Water Targets for Fracture Fluid

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS</td>
<td>0 – 40,000 mg/L</td>
</tr>
<tr>
<td>pH</td>
<td>5.5 – 8.5</td>
</tr>
<tr>
<td>Chlorides</td>
<td>0 – 25,000</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>0 – 500 mg/L</td>
</tr>
<tr>
<td>Iron</td>
<td>0 – 50 mg/L</td>
</tr>
<tr>
<td>Calcium</td>
<td>0 – 3,000 mg/L</td>
</tr>
<tr>
<td>Bi-carbonate</td>
<td>0 – 500mg/L</td>
</tr>
</tbody>
</table>

Source: ALL Consulting from discussions with various operators, 2009

**NOTE:** The above is a representation of target water quality levels that several companies are considering and evaluating in an effort to use lower quality water for hydraulic fracturing. These targets are likely to change as technical feasibility continues to be analyzed in various basins.
Treatment for Re-use

- Water recovery volumes of produced water (including flow back water) vary greatly – perhaps 5% to 100% of the volumes used for fracturing.
- In many instances, recovery volumes being observed are in the 5-35% range, which tends to improve the feasibility for reuse.
- For reuse, produced water is likely to require treatment for metals, scale and bacteria.
## Blending for Re-use

<table>
<thead>
<tr>
<th>Produced Water TDS (mg/L)</th>
<th>Theoretical Volume of PW that could be used to create a blended water of 5,000 mg/L TDS (gal)</th>
<th>Theoretical Volume of PW that could be used to create a blended water of 40,000 mg/L TDS (gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30,000</td>
<td>508,474</td>
<td>900,000 (+)</td>
</tr>
<tr>
<td>50,000</td>
<td>303,030</td>
<td>900,000 (+)</td>
</tr>
<tr>
<td>100,000</td>
<td>150,753</td>
<td>900,000 (+)</td>
</tr>
<tr>
<td>150,000</td>
<td>100,334</td>
<td>802,675</td>
</tr>
<tr>
<td>200,000</td>
<td>75,187</td>
<td>593,984</td>
</tr>
</tbody>
</table>

NOTE: For example purposes only, the above data assumes 3-million gallon fracture fluid volume, 30% recovery of fracturing fluids, and combining that recovered water with fresh water having a TDS of 500 mg/L to create a blended water for fracturing totally 3 million gallons. *Source: ALL Consulting*
Discharge/Beneficial Use Options

- Stream discharge
- Land Application/Irrigation
- Livestock/industrial
- Returns water to local system
- Must meet:
  - State-specific NPDES limits
  - End use requirements
Discharge/Beneficial Use Treatment

- Desalination usually required
  - Reverse Osmosis - Capabilities are improving, generally “reasonable” up to about 40,000 ppm TDS
  - Thermal – “reasonable” up to about 200,000 ppm TDS, but also improving
- Both require pre-treatment and have disposal challenges
Disposal

• Where injection capacity is limited, volume reduction may be considered

• Disposal using injection to Class IID wells may require pre-treatment
  – Suspended Solids
  – Scale
  – Bacteria
  – pH, etc
Perspectives on Treatment

- Treatment of shale gas water can vary significantly from other resource plays (e.g., CBM) and may not involve desalination.
- Additives for fracturing is considered "treatment".
- Treatment for shale gas water remains in its infancy and developing technically for commercial use.
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