Halliburton Produced Water Recycle – Current Considerations

- Produced water does not have to be treated to a discharge quality level to be reused as a frac fluid for well stimulation. Halliburton treats for only the incompatible solids to minimize surface waste generation and return all the remaining produced water components back into the reservoir as a frac fluid.

- Produced water can be recycled to offset freshwater requirements. Current challenges include logistics, storage, disparate blending, contaminant removal/conditioning and H₂S neutralization.

- Operators need economic volumes of water to encourage PW recycle.

- Regulators around the country are amending rules to accommodate produced water for recycle versus historic waste management directives.

- The economic incentives to recycle produced water considers sourcing, disposal and logistic costs.
Water Solutions Products & Services

Markets
- Unconventional
- Offshore
- Mature Fields

CleanWave™

SeaWave™- Offshore

High TDS FR’s
FDE-1078

UniStim™ & MC Scale
inhibitors, Biocides etc

CleanStream™
H2O Forward – Fluid System Integrity Process

Impaired water sources to cost efficient recovery / reuse.....

Flowback
Produced
Comingled
Saline Water
Treated Water
Fresh & Surface
Industrial Waste
Municipal Waste

Analytical
Testing

Subsurface
Compatibility

Mix Water
Compatibility

Dynamic
Loop
Testing

Fluid System
Confirmation

Lab Rheology

Fluid System
Design

Field Process
Protocol

Field Fluid System
Testing and
Confirmation

Field Process
Execution and
Verification

Stable
X-Link
System
### UniStim™ - Delaware Basin & Bakken Fracs Using 100% CleanWave™ Treated Produced Water

<table>
<thead>
<tr>
<th>Source (mg/L)</th>
<th>Delaware</th>
<th>Bakken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>1.207</td>
<td>1.186</td>
</tr>
<tr>
<td>pH</td>
<td>6.87</td>
<td>7.20</td>
</tr>
<tr>
<td>Bicarbonate</td>
<td>160.94</td>
<td></td>
</tr>
<tr>
<td>Carbonate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td><strong>179,469</strong></td>
<td><strong>170,624</strong></td>
</tr>
<tr>
<td>Sulfate</td>
<td>8</td>
<td>260</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1.49</td>
<td>6.28</td>
</tr>
<tr>
<td>Boron</td>
<td>21.9</td>
<td>376</td>
</tr>
<tr>
<td>Barium</td>
<td>4.76</td>
<td>24.9</td>
</tr>
<tr>
<td>Calcium</td>
<td><strong>28,877</strong></td>
<td><strong>15,700</strong></td>
</tr>
<tr>
<td>Iron</td>
<td>4.2</td>
<td>1.10</td>
</tr>
<tr>
<td>Potassium</td>
<td>1,814</td>
<td>5,970</td>
</tr>
<tr>
<td>Magnesium</td>
<td>4,287</td>
<td>992</td>
</tr>
<tr>
<td>Sodium</td>
<td>67,596</td>
<td>81,900</td>
</tr>
<tr>
<td>Strontium</td>
<td>1,690</td>
<td>1,230</td>
</tr>
<tr>
<td>TDS (mg/L)</td>
<td><strong>280,398</strong></td>
<td><strong>270,432</strong></td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>11.2</td>
<td>126.3</td>
</tr>
</tbody>
</table>

**WATER CLASSIFICATIONS, BY THE AMOUNT OF TDS (mg/L):**
- Fresh water: < 1,000
- Brackish water: 1,000 to 10,000
- Saline water: 10,000 to 30,000
- Brine water: > 30,000
- Ocean water: > 30,000 to <40,000
- Produced water: 2,000 to 320,000

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**Graphs:**

- Graph showing viscosity vs. time.
- Graph showing temperature vs. time.
http://murchisonoil.com/about/permian-basin
2013 SPE Papers on High TDS Recycle PW

- SPE #163824 “Development and use of High TDS Recycled Produced Water for Crosslink-Gel Based Hydraulic Fracturing”

- SPE #165085 “Effects of Total Suspended Solids on Permeability of Proppant Pack”

- JPT Magazine Technology Update – June 2013 “Treatment Enables High-TDS Water Use as Base Fluid for Hydraulic Fracturing”

- SPE # 165641 “Recycling Water: Case Studies in Designing Fracturing Fluids Using Flowback, Produced, and Nontraditional Water Sources”
Thank You

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