Moving Produced Water From A Waste to a Resource

RICK MCCURDY
SENIOR ENGINEERING ADVISOR
AGENDA

• Chesapeake Energy
• Water Use In Oil & Gas Operations
• Water Intensity of Various Energy Sources
• Water Use in Value Creation
• Water Reporting in Oil and Gas Operations
  > What are we doing well?
  > Where can we improve?
• Case Study – Industry Partnering With a State to Reduce Fresh Water Demand
WHO WE ARE

• 2nd largest US Natural Gas Producer
• 13th largest US Crude Oil Producer

Data taken from 2017 CHK Annual Report
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FRESH WATER
LIFE CYCLE OF WATER: OIL & GAS OPERATIONS

Source: Local, POWT, 3rd Party Surface, Groundwater, AMD

Oil and Natural Gas Drilling, Completions and Production Water Lifecycle

Color Denotes Agency Jurisdiction

State/Local

Federal
COMMON WATER USE AREAS IN OIL AND GAS OPERATIONS

Drilling
• Used as a base fluid for drilling mud
• Common volume is 1 barrel (42 US gal) per foot of well depth
• Smaller volumes use for cleaning rigs and dust suppression

Hydraulic Fracturing
• Single largest usage
  • 8-10 years ago – common usage was 3-5 million gallons per well
  • Current longer laterals, denser completions are requiring 5-15 million gallons per well

Other Operations
• Well workovers, Drill outs
• Displacement fluid in remedial operations such as acidizing

Chemical Treatments
• Salt removal in wells prone to salting
• Flush for regularly scheduled batch treatments such as application of corrosion inhibitors
RECENT EVOLUTION OF WATER USE IN HYDRAULIC FRACTURING

- **2008** – Only freshwater suitable for high volume, high rate hydraulic fracturing
- **2009** – High cost of brine disposal in the Marcellus Shale incentivize operators to experiment with brine tolerant completion fluids
- **2011** – Exceptional droughts in several O&G areas result in expansion of brine treatment and reuse
- **2015** – Texas Legislature passes bills encouraging more reuse of produced brine in operations
- **2018** – Brine treatment and reuse and brackish water use continues to grow throughout the O&G industry
PRODUCED WATER IN THE U.S.

• Data from John Veil, April 2015, “U.S. Produced Water Volumes and Management Practices in 2012”

• In 2012, onshore and offshore U.S. oil and gas wells produced 21,180,646,000 barrels of water.
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BEST PRACTICES

• Efficient Use of Water

> High rate hydraulic fracturing in horizontal wells can be water intensive

> Ten years ago volumes per well were in the 3-5 million gallons range

> With longer laterals denser completion profiles, we are now seeing 5-15 million gallons per well

> However, water efficiency (gal/mmbtu) is staying flat or improving on a gallon of water per million British Thermal Units of energy standpoint

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Gallons of Water per Dollar of Economic Value Generated: Orders of Magnitude

Source: Company Reports, EIA, FracFocus, Hoekstra & Mekonnen, Journal Articles, TWDB, USDA
<table>
<thead>
<tr>
<th>Product</th>
<th>Direct economic value generated per gallon of water used</th>
<th>Gallons of water needed to create $1 in direct economic value</th>
<th>AF of Water Consumed Per Billion USD in Economic Value Created</th>
<th>Depth of Coverage Over City of Houston’s Physical Area, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas, Marcellus Shale</td>
<td>$3.804</td>
<td>0.3</td>
<td>807</td>
<td>0.02</td>
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<tr>
<td>Morphine</td>
<td>$2.847</td>
<td>0.4</td>
<td>1,078</td>
<td>0.03</td>
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<tr>
<td>Pickup Truck Tire, High</td>
<td>$1.845</td>
<td>0.5</td>
<td>1,663</td>
<td>0.05</td>
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<tr>
<td>Crude Oil, Delaware Basin</td>
<td>$1.692</td>
<td>0.6</td>
<td>1,814</td>
<td>0.05</td>
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<tr>
<td>Semiconductors</td>
<td>$1.170</td>
<td>0.9</td>
<td>2,623</td>
<td>0.08</td>
</tr>
<tr>
<td>Houston, Texas MSA</td>
<td>$1.008</td>
<td>1.0</td>
<td>3,045</td>
<td>0.09</td>
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<tr>
<td>Pickup Truck Tire, Low</td>
<td>$0.465</td>
<td>2.2</td>
<td>6,604</td>
<td>0.19</td>
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<tr>
<td>Ford Focus</td>
<td>$0.313</td>
<td>3.2</td>
<td>9,808</td>
<td>0.28</td>
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<tr>
<td>Pork</td>
<td>$0.111</td>
<td>9.0</td>
<td>27,578</td>
<td>0.79</td>
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<tr>
<td>Steel (ArcelorMittal)</td>
<td>$0.098</td>
<td>10.2</td>
<td>31,359</td>
<td>0.90</td>
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<tr>
<td>Beer</td>
<td>$0.097</td>
<td>10.3</td>
<td>31,577</td>
<td>0.90</td>
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<tr>
<td>Levi’s 501 Jeans</td>
<td>$0.046</td>
<td>22.0</td>
<td>67,447</td>
<td>1.93</td>
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<td>Chicken Meat</td>
<td>$0.017</td>
<td>58.5</td>
<td>179,422</td>
<td>5.14</td>
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<tr>
<td>Drip-irrigated Pecans, Pecos Valley</td>
<td>$0.008</td>
<td>123.9</td>
<td>380,275</td>
<td>10.89</td>
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<tr>
<td>Flood-Irrigated Pecans, Pecos</td>
<td>$0.006</td>
<td>160.8</td>
<td>493,488</td>
<td>14.13</td>
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<tr>
<td>Avocados</td>
<td>$0.004</td>
<td>232.6</td>
<td>713,695</td>
<td>20.43</td>
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<td>Alfalfa, Pecos Valley</td>
<td>$0.003</td>
<td>348.5</td>
<td>1,069,458</td>
<td>30.61</td>
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<td>Cotton (West Texas)</td>
<td>$0.001</td>
<td>678.8</td>
<td>2,083,168</td>
<td>59.63</td>
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<td>Refined Sugar</td>
<td>$0.001</td>
<td>1111.1</td>
<td>3,409,875</td>
<td>97.61</td>
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<td>Eggs</td>
<td>$0.001</td>
<td>1207.6</td>
<td>3,706,080</td>
<td>106.09</td>
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<td>Coffee (green)</td>
<td>$0.001</td>
<td>1428.6</td>
<td>4,384,125</td>
<td>125.50</td>
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<td>Rice</td>
<td>$0.001</td>
<td>1434.4</td>
<td>4,401,954</td>
<td>126.01</td>
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<tr>
<td>Peanuts (in shell)</td>
<td>$0.001</td>
<td>1666.7</td>
<td>5,114,812</td>
<td>146.42</td>
</tr>
</tbody>
</table>

Gabrielle Collins, J.D., Baker Institute for Public Policy, Rice University, “How Much Water Does It Take To Produce a Billion Dollars of Economic output?”
Acre-Feet of Water per Billion Dollars of Economic Value Generated

Source: Company Reports, EIA, FracFocus, Hoekstra & Mekonnen, Journal Articles, TWDB, USDA
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WHAT ARE WE DOING WELL?

• Water Usage on Hydraulic Fracturing Activities
  > Usually Required by States or BLM

• FracFocus™
  > Created and maintained by GWPC
  > Initially, voluntary submissions by Operators but many States now mandate its use
  > Data submitted includes
    • Water volume for completion
    • Sand (proppant) volume
    • Chemical composition and quantity for each HF additive

Photo courtesy of BJ Services Company
WHAT CAN WE IMPROVE?

• More Transparency in Base Fluid for Completions
  > Produced water
  > Brackish groundwater
  > Municipal effluent streams
  > Industrial wastewater
  > FracFocus reporting
  > States request
WHAT CAN WE IMPROVE?

• Spill Reporting
  > Required by States and BLM
  > Reporting requirements vary
  > Many Operators track more stringently
    • You can’t improve what you don’t track!
  > Industry discussion in incubation phase regarding a universally acceptable, more robust method
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Brackish Groundwater Production Zone Designation Status

The effort of identifying and designating Brackish Groundwater Production Zones is in response to House Bill 30 (84th Legislature, 2015) requirements which included the exclusion of specific aquifers and districts.

On October 20, 2016, the Board designated brackish groundwater production zones in the following aquifers: no zones in the Blaine Aquifer, one zone in the Carrizo-Wilcox Aquifer south of the Colorado River, four zones in the Gulf Coast Aquifer (and bordering sediments), and three zones in the Rustler Aquifer. In May 2018, the Board will consider the Executive Administrator’s recommendation for brackish groundwater production zone designations in the Blossom, Lipan, and Nacatoch aquifers at a TWDB Board meeting.
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Thank You!