Water Management Planning for Unconventional Resource Development

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Understanding Unconventionals and Water

- Unconventional plays are growing rapidly, but many are still in the early stages.
- Concerns regarding water sourcing are growing.
- Water disposal alternatives vary by play and present substantial/unique challenges by area.
- Water management planning for the lifecycle is a critical development element.
Water Issues are Unique to Each Play

- Marcellus covers multiple states, river basin commissions, and has ultra-sensitive watersheds.
- The Eagle Ford of south Texas is in an area of severe drought with groundwater being the primary water source.
- Plays such as the Marcellus, Fayetteville, and Haynesville are limited in disposal well capacities.
- Water sourcing in some parts of the Woodford are challenged due to drought.
- Several plays have challenges of operating in urban environments.

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Even “Sheltered” Plays are Under Scrutiny

San Antonio Current
“Final projections for the Eagle Ford have since been shifted up as high as 45,000 acre-feet (14.6 billion gallons) at peak production — now expected to hit seven years earlier in 2024. Last year, the formation required around 6,000 acre-feet of water. This year’s activity has been considerably more demanding that that, creating a market for water sales from the region’s ranches.”

Texas Water Development Board
“A report released in July by the TWDB estimated that industry uses about 12 billion gallons of water annually for hydrofracking in Texas now, but that demand will grow to 39.1 billion gallons before 2030.”

Standard-Examiner
“Amid the brutal drought, competing users and local groundwater conservation districts in this part of the state see the industry's unregulated, glutinous use of fresh water as a huge problem. "I want them to quit using fresh water for fracking," said Slate Williams, general manager of the Crockett Groundwater Conservation District.”

Texas Oil & Gas Accountability Project
“Amid increasing scarcity of water supplies, the immense quantities of water required for hydraulic fracturing are not sustainable. Huge volumes of water are needed to extract shale gas. Estimates range from 1.5 million to five million gallons of water per well, and wells may be refracked several times over the life of each well. Recently, the oil and gas industry announced a new 12-stage completion method that uses over 9 million gallons of water per well.”

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Water Management is Simple – Right?

Non-Saline Water
- Surface water
- Groundwater
- Alternative Sources

Gas Production & Transportation
Land Owner Concerns
Seismic Operations
Road and Lease Construction
Well Drilling

Produced Water
Droughts
Timing

Economics
Disposal Well

Frac Fluid Flowback
Well Drilling

Reuse
Evolveing Regulations

Compliance
Well Completions

Gas Production & Transportation
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Well Completions

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A lifecycle approach is needed to address the many issues important to industry:

- Regulatory timing & vulnerabilities
- Legislative changes
- Public opposition
- Historical Activities
- Competition for resources
- Flowback recovery
- Third-party options and risks
- Environmental risks
- Etc...

**Lifecycle Water Management Planning**

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Pre-Development Assessment</td>
</tr>
<tr>
<td>2.</td>
<td>Water Sourcing Availability &amp; Issues</td>
</tr>
<tr>
<td>3.</td>
<td>Well Site Construction &amp; Drilling</td>
</tr>
<tr>
<td>4.</td>
<td>Water Conditioning/Pre-Treatment</td>
</tr>
<tr>
<td>5.</td>
<td>Well Completion/Fracturing</td>
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<tr>
<td>6.</td>
<td>Flowback/Produced Water</td>
</tr>
<tr>
<td>7.</td>
<td>Reuse/Disposal/Beneficial Use</td>
</tr>
</tbody>
</table>

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Evaluating Surface Water Sourcing Options

Options vary by Play!
Eagle Ford Example

Availability:
- Resource is well managed through system of reservoirs and water right permitting.
- Drought is increasing strain on supplies.

Sourcing Considerations:
- Little water is available for appropriation through TCEQ.
- Some river authorities are permitted to sell water for oil and gas use.
Assessing Groundwater Alternatives

Availability:
- The Carrizo-Wilcox is the largest aquifer in the play.
- Minor aquifers are more susceptible to drawdown.
- The Gulf Coast Aquifer is a brackish water source in the eastern portion of the play.

Sourcing Considerations:
- Permits may be required depending on the depth and specific Groundwater Conservation District Rules.

Source: Various Sources (August 2011)

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**Water Sourcing Going Forward (ALL PLAYS)**

**Fresh Water**
- Percentage of fresh water utilization should decrease over time

**Recycled Water**
- Anticipate increased utilization of recycled water as technology develops
- Highly dependent on companies’ scale of development

**Alternative Water Sourcing**
- Anticipate increased use of lower-quality groundwater, where available and feasible
- Utilization of alternative sources could supplement water demand

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<table>
<thead>
<tr>
<th>Shale Basin/Play</th>
<th>Maximum Observed Water Usage</th>
<th>Minimum Observed Water Usage</th>
<th>Well Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakken</td>
<td>3,000,000</td>
<td>1,000,000</td>
<td>54</td>
</tr>
<tr>
<td>Barnett</td>
<td>8,250,000</td>
<td>1,000,000</td>
<td>103</td>
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<tr>
<td>Barnett-Woodford</td>
<td>3,600,000</td>
<td>500,000</td>
<td>60</td>
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<tr>
<td>Eagle Ford</td>
<td>13,700,000</td>
<td>2,000,000</td>
<td>199</td>
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<tr>
<td>Fayetteville</td>
<td>9,600,000</td>
<td>1,500,000</td>
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<tr>
<td>Haynesville</td>
<td>8,000,000</td>
<td>3,600,000</td>
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<tr>
<td>Hilliard-Baxter-Mancos</td>
<td>1,300,000</td>
<td>1,000,000</td>
<td>8</td>
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<tr>
<td>Marcellus/Utica</td>
<td>9,250,000</td>
<td>1,500,000</td>
<td>74</td>
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<tr>
<td>Woodford</td>
<td>16,300,000</td>
<td>2,000,000</td>
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<tr>
<td>Woodford-Caney</td>
<td>7,400,000</td>
<td>3,500,000</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: Various Sources (August 2011)

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### Utilizing Benchmarking for Planning

**Operator (Eagle Ford Shale)** | **Maximum Observed Water Usage** | **Minimum Observed Water Usage** | **Well Sample**
---|---|---|---
Anadarko Petroleum Corporation | 9,500,000 | 3,500,000 | 27
Cabot Oil & Gas Corp | 5,200,000 | 3,150,000 | 5
Chesapeake Operating, Inc. | 8,500,000 | 2,650,000 | 61
ConocoPhillips Company | 3,900,000 | 2,400,000 | 30
El Paso E&P Company | 6,900,000 | 4,150,000 | 9
Forest Oil Corporation | 5,250,000 | 2,700,000 | 5
Penn Virginia Oil & Gas Corporation | 5,400,000 | 4,000,000 | 6
Petrohawk Energy Corporation | 6,850,000 | 2,700,000 | 24
Pioneer Natural Resources | 3,900,000 | 2,000,000 | 3
Plains Exploration & Production | 4,250,000 | 3,750,000 | 2
Rosetta Resources | 6,100,000 | 5,500,000 | 6
Shell Exploration & Production | 3,600,000 | 2,750,000 | 8
SM Energy | 13,700,000 | 6,200,000 | 10
XTO Energy/ExxonMobil | 4,250,000 | 3,600,000 | 3

*Source: Various Sources (August 2011)*

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Well Drilling and Hydraulic Fracturing

- Hydraulic fracturing uses more water than drilling.
- Fracturing fluid is >99% water and sand.
- Understanding water requirements in relation to development pace is critical.
- Pre-treatment and water conditioning increasingly important.
- Chemical Screening a priority!

Image: EnergyinDepth.org 2009
Source: Compiled from Data collected at a Fayetteville Shale Fracture Stimulation by ALL Consulting 2008.
Planning for Disposal Alternatives

- Benchmarking more mature plays can be beneficial.
- Because disposal zones vary considerably by play, planning SWD needs requires detailed data evaluation.
- If commercial disposal systems are planned as short- or long-range solutions, detailed auditing is recommended.
Planning for Disposal Alternatives

- Publically available data provides a wealth of information that can be used for assessing disposal options
- Most states collect detailed information on injection zones, pressures, rates, depths, history, monitoring, etc.
- GIS tools provide an excellent means of assessing data!

Source: Texas RRC (August 2011)
Beneficial Use Alternatives

- Beneficial uses in unconventional plays such as CBM have been common.
- Beneficial uses for water produced from shale gas wells has potential (similar to CBM).
- Expect beneficial uses in unconventional plays to grow (but not like CBM).

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Conclusions

- Planning is crucial!
- Utilizing data in new ways can be extremely beneficial
- Planning for the lifecycle is a necessity
  - Pre-development assessments
  - Baseline/background analyses
  - Identifying regulatory weaknesses early
  - Participating in regulatory changes and rule revisions
  - Disposal/Recycling
- Structuring designs and documents to be “Environmentally Informed”
- Training, quality assurance & auditing improve performance
- Benchmarking as activity develops yields benefits
- Plan for the area and avoid doing things based solely on past success in other areas

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