CONSIDERATIONS FOR TREATING WATER ASSOCIATED WITH SHALE GAS DEVELOPMENT

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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.
NETL: Program designed to promote domestic natural gas production by providing technologies to overcome the technical challenges associated with unconventional resources.
PW Treatment Catalog/Tool

- Major Treatment Technologies:
  - Capabilities
  - Availability by Play
    - Vendors
  - Cost Estimates/Ranges
- Mixing and Scale Affinity Model
- Regulatory Considerations
- Disposal Considerations
INTRODUCTION

• Shale gas holds tremendous potential for U.S. energy supply.
• High volume hydraulic fracturing (HVHF) is an important key to developing this resource.
• Managing water for HVHF can be a challenge.
• Treatment can alleviate source and disposal issues.
• Water is treated for many reasons, the right technology varies!
SHALE GAS FOCUS AREAS

- Barnett
- Fayetteville
- Haynesville
- Marcellus
- Woodford
HYDRAULIC FRACTURING

- Horizontal wells completed in shale use 3 to 5 Million gallons of water to hydraulically fracture
- High Volume HF is typically done in 6-18 consecutive stages
- Water is obtained from varies sources and delivered by truck or pipeline
- On site storage is in tanks or centralized impoundments
- 15 to 50 %(or more) of the fracture fluid is recovered
Water Considerations

- Pre-completion
  - Withdrawal
  - Transport
  - Storage
- Completion
- Post-completion
  - Storage
  - Transportation
  - Treatment for disposition
PRE-COMPLETION
Options available to meet water needs for drilling and fracturing

- Surface Water
- Groundwater
- Municipal Water
- Recycled Produced Water
- Collected Water
- Private Water Purchases

Total Water in Gallons to Drill and Fracture

Drilling performed with an air mist/water based/oil based mud for deep horizontal well completions.
**Sourcing Challenges**

- **Withdrawal:**
  - Access
  - Timing
  - Permitting - regulations are complex and changing
  - Other uses

- **Transport:**
  - Cost
  - Potential Road and community impacts

- **Storage:**
  - Cost
  - Surface disturbance
  - Permitting

- **Cumulative Impacts**

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**Barnett Shale Water Uses**

- Public Supply 82.70%
- Irrigation 6.30%
- Livestock 2.30%
- Power Generation 3.70%
- Industrial and Mining 4.50%
- Shale Gas Wells 0.40%

Groundwater Use in Barnett shale counties ranges from 1.95 percent in Somervall County to 85 percent in Cooke County

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COMPLETION
HF Fluid Composition

- Fracture fluid chemicals are in the headlines
- Other parameters have significant implications
  - TDS concentration
  - Scale tendencies
  - Biocide requirements

Regulatory agencies are pressing for disclosure (e.g. AR, NY, PA, TX, WY, and others)

Additives for fracturing are considered “treatment”

Source: Compiled from Data collected at a Fayetteville Shale Fracture Stimulation by ALL Consulting 2008.
PW MANAGEMENT OPTIONS

• Four Basic Options
  – Injection
  – Surface discharge
  – Beneficial use
  – Reuse in HVHF

• All options have challenges

• All options may require some level of treatment
Injection Challenges

• Limited UIC well capacity
  – Geologic limitations
  – Timing – few wells in newly developed areas
• Lack of near-by wells creates transportation issues
INJECTION CHALLENGES

• Limited UIC well capacity
  – Geologic limitations
  – Timing – few wells in newly developed areas
• Lack of near-by wells creates transportation issues
DISCHARGE/BENEFICIAL USE CHALLENGES

- Treatment required
- Disposal of treatment concentrate
- Changing regulatory requirements
- Potential environmental impacts
- Potential liability issues
**Reuse Benefits**

- Reduced withdrawals (and associated concerns)
- Reduced Disposal needs
- Reduced cost
- Reduced environmental concerns
REUSE CHALLENGES

• Blended water must be suitable for fracture fluid
• TDS concentration – effect on friction reducers
• Scale tendencies
• Bio-fouling
Three primary treatment goals

- Reduce TDS (desalination) for discharge/beneficial use
- Reduce volume for disposal
- Reduce scaling and bio-fouling for reuse or UIC

Produced water quality varies

- Between basins
- Within basins
- Over time

High TDS concentrations limit treatment options
**Produced Water Quality**

**Barnett**
- 50,000 - 250,000 mg/L TDS

**Marcellus**
- TDS Highly variable (50,000-300,000 mg/L)

**Fayetteville**
- 8,000 - 30,000 mg/L TDS

**Haynesville**
- 150,000 - 250,000 mg/L TDS
TREATMENT – DESALINATION

• Thermal Distillation
  – Mechanical Vapor Recompression (MVR)
  – Condenses steam for reuse
  – Corrosion/scale can be problems
  – TDS <200,000 mg/L

• Reverse Osmosis
  – Force water through an osmotic membrane
  – Membrane fouling and replacement costly
  – TDS <40,000 mg/L
TREATMENT - VOLUME REDUCTION

- Thermal Evaporation
  - Reduced volume
  - Dispose of concentrate
- Crystallization
  - No limit on TDS
  - Zero Liquid Discharge
  - Dispose of solids
PRE-TREATMENT/CONDITIONING

- Flocculation – remove suspended solids
- Scale inhibitors
- pH adjustments

- Biocides
  - Liquid chemical biocides
  - Ozone
    - Kills microbes
    - Affected by COD
    - Limited residual kill
  - Ultraviolet Light
    - Kills microbes
    - No residual kill
  - Ultrasound
    - Reduces biological growth.
    - Can reduce concentrations of heavy metals, TSS and turbidity levels
    - More effective when it is applied with ultraviolet light or ozone
# Treatment/Constituent

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<th>Water Treatment Process</th>
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<th>Suspended Solids</th>
<th>Biologics (bacteria &amp; algae)</th>
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<th>Med TDS (&lt;50,000 mg/L)</th>
<th>High TDS (&gt;50,000 mg/L)</th>
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## Matrix Table

![Matrix Table Image](image-url)
MANAGEMENT/TREATMENT DRIVERS

• Social
• Environmental
  – Conservation of Resources
  – Aquatic Impacts
• Economic
  – Cost of withdrawals
  – Cost of transportation
• Technical
  – Lack of injection capacity
  – Treatment limitations
• Company policies
TREATMENT

- Availability varies by basin
- New vendors entering the market
- Several pilots underway/planned

- Treatment for shale gas water remains in its infancy
Key Messages

• Shale Gas is going to remaining an important source of energy
• Large volumes of water are necessary for production
• Treatment can conserve source water and reduce waste stream
• Treatment is more than desalination
• Desalination options are limited
• Reuse is an important option
• Treatment technologies are advancing and changing
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