Key Points

Requirements
Conventional versus unconventional

Sources
Balancing regulatory considerations with operational flexibility

Reuse
Surface aesthetics versus downhole performance

Storage
Tanks, pit, impoundments...

Transfer
Reducing truck traffic while ensuring integrity
Requirements

Substantially Larger Volumes
4-6 million gallons per well

Increased Pump Rates
80-100 bpm
**Requirements**

**Simplified Fluid Design**
- Slickwater with corrosion inhibitor and bactericide

**Water Quality**
- Shale permeability
- Production mechanism
- Water mobility

**Challenge conventional rules of thumb**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional Limits</th>
<th>Considerations</th>
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<tbody>
<tr>
<td>pH</td>
<td>6.0 to 8.0</td>
<td>Fluid Stability, Scaling</td>
</tr>
<tr>
<td>Chlorides</td>
<td>&lt;20,000 mg/L</td>
<td>Fluid Stability</td>
</tr>
<tr>
<td>Iron</td>
<td>&lt;20 mg/L</td>
<td>Fluid Stability</td>
</tr>
<tr>
<td>Ca, Mg, Ba, SO₄, CO₃, ...</td>
<td>f(P,T,pH) (+/- 350 mg/L)</td>
<td>Scaling</td>
</tr>
<tr>
<td>Bacteria Count</td>
<td>&lt;100/100 mg/L</td>
<td>Bacteria Growth</td>
</tr>
<tr>
<td>Suspended Solids</td>
<td>&lt;50 mg/L</td>
<td>Skin</td>
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<tr>
<td>Oil &amp; Soluble Organics</td>
<td>&lt;25 mg/L</td>
<td>Fluid Stability</td>
</tr>
</tbody>
</table>

nanodarcy, nD, $1 \times 10^{-9}$ D

milidarcy, mD, $1 \times 10^{-3}$ D
Sources

Water Network

- Raccoon Valley Sportsman Club Pond
- Nancy Stewart Impoundment (270,000 bbls)
- Lehman Impoundment (150,000 bbls)
- Clingerman Impoundment (205,000 bbls)
- Carol Baker Impoundment (325,000 bbls)
- Carol Baker Pad
- S. Hewitt Road Metering Vault - DEP Approved
- Old Hickory Ridge Road Metering Vault - DEP Approved
- Plum Road Metering Vault
- Worstell (proposed)
- Johnston #1 Impoundment (130,000 bbls)
- Chartiers Run (CR4) DEP Approved
- Plum Creek Lake (CC1) DEP Approved
- DEP Approved
- Sugar Camp Run
- Best Impoundment (325,000 bbls)
- Rush (proposed)
- Bednarski Impoundment (265,000 bbls)
- Miller (proposed)
- Zappi Impoundment (98,000 bbls)
- Buffalo Creek 2
- Dutch Fork Lake
- Hewitt (proposed)
- Buffalo Creek 1
- Dutch Fork 1
- US Census Bureau

Imagery Dates: Jun 8, 2009 - Jul 3, 2010
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Sources

Surface water
Sources

Municipal
Sources

“Super Sources”
Range Resources Reuses 100% of Our Flowback

Potential Downhole Issues:
- Fluid Stability
- Bacteria
- Scaling

Non-issues - Supported by well performance

TDS Build-up Concerns
- Not an issue because of required dilution

Known Surface Issues…Aesthetics
- Solids
- Bacteria (anaerobic)
Reuse

Keys to Remediating Surface Issues

- **Solids – Clarification**
- **Bacteria (anaerobic/SRBs)**
  - Remove Food Source
  - Chlorinate
  - Maintain with Aeration

Pre-Aeration

Post-Aeration
Impoundments vs. Tanks
The Goal is Maintenance

- Double Liner System w/Runway
- Permanent Fill/Withdrawal Manifold System
- Under-Drain Catch Basin System with Leak Alarm
- Front-End Weir Tank Battery for Solids and Condensate Capture
Storage

- Aeration System
- Bird Netting
- Remote Level Monitoring System
- Security/Privacy Perimeter Fencing
Transfer

Minimize Trucking Pumping and Pipelines

Temporary
Integrity
Distance
Permanent network
Link super sources to storage locations
Noise Mitigation
Questions?