How many disposal wells does PA need and where can they be located?

Shale Network 2017 Workshop
Penn State University
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Introduction

- EPA classifies brine disposal wells (aka saltwater injection or saltwater disposal wells) as UIC Class IID Wells
- Regulated under the Safe Drinking Water Act
- Approximately 30,000 UIC Class IID wells
- Approximately 280 such wells in Marcellus and Utica Shale Play area with most in OH (~220)
Introduction

- Both Marcellus Shale Play and conventional operators need these wells
- Currently vast majority of non-recycled brine shipped to OH resulting in extra cost and truck traffic
- EPA and State approved disposal method
- Over the past few years, concern over induced seismicity has increased
OH and WV Have Many More Brine Disposal Wells Than PA

Source: OH DNR, WVDEP and USEPA Region 3 UIC Class IID well databases.
Overall Brine Movement is Westward

Source: OH DNR, WVDEP and USEPA Region 3 UIC Class IID well databases.
Brine Disposal Wells Pennsylvania

- Total: 10 permitted by both EPA and PADEP
- Only one commercial facility (in NW PA)
- Formations
  - Upper Devonian (Tiona, Speechley and Elk Sands)
  - Huntersville Chert – Oriskany Sandstone
  - Medina Sandstone
- Depth – 1900 to 8900 ft.
- EPA has primacy for permitting
- PADEP approval now also required via new UIC Well approval program.
Brine Disposal Wells in PA

Source: USEPA Region 3 UIC Class IID well database
Trend in Unconventional Brine Generation in PA

Unconventional Produced/Flowback Water Generated in Pennsylvania

Graph showing the trend in produced and flowback water from 2010 to 2016. The production increases over time, with a significant rise in 2016.
## Est. UIC Class IID Wells Needed in PA
### Based on 2016 Disposed Volumes

<table>
<thead>
<tr>
<th>Total Unconventional Brine to UIC Wells (Bbls)</th>
<th>6,300,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Unconventional Brine to UIC Wells in PA (Bbls)</td>
<td>300,000</td>
</tr>
<tr>
<td>Total Not Disposed in PA (Bbls)</td>
<td>6,000,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injection Rate - Avg Barrels / Day</th>
<th>No. of Wells Needed</th>
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</thead>
<tbody>
<tr>
<td>250</td>
<td>69</td>
</tr>
<tr>
<td>500</td>
<td>34</td>
</tr>
<tr>
<td>750</td>
<td>23</td>
</tr>
<tr>
<td>1000</td>
<td>17</td>
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</tbody>
</table>
• A common myth is that Pennsylvania geology not conducive to siting injection wells
• In general, geology does require more “surgical” approach than in certain other states (e.g., Texas)
• There is great opportunity to “recycle” depleted oil and gas wells/fields for safe disposal
• In some areas, potential also exist for drilling new wells to access favorable formations
• Site wells based on geologic conditions and proximity to producing areas, while being sensitive to public concerns (e.g., regarding residential areas, truck traffic, etc.)
Where to Find the Disposal Capacity? (Cont’d)

- Finding the needed lateral extent, porosity, permeability and thickness can depend on
  - Trend of individual sand interval (e.g., many Upper Devonian Sandstones)
  - Structural position (e.g., Oriskany Sandstone and Huntersville Chert)
- Site wells to avoid faults and reduce the risk of induced seismicity
- Beware of poorly plugged wells to target depth
- Injectivity testing can help confirm viability of candidate wells/intervals
### Potential Injection Targets - PA

- **Upper Devonian Sandstones***
- **Huntersville Chert***
- **Oriskany Sandstone***
- **Bass Island**
- **Lockport Dolomite**
- **Medina – Tuscarora Sandstones***
- **Bald Eagle Sandstone**
- **Trenton – Black River**
- **Gatesburg Formation***

*Existing injection well in PA

Source: Stratigraphic Column from PADCNR
Natural Gas Storage Fields
Certain Depleted O&G Wells/Fields Can Be “Recycled” For Brine Disposal
<table>
<thead>
<tr>
<th>Formation</th>
<th>Analog Field</th>
<th>Volumetric (Net Ft Porosity / Areal Extent) Approach (Million bbls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Devonian Sandstone</td>
<td>Council Run (Fifth Elk), Centre and Clinton Counties</td>
<td>45</td>
</tr>
<tr>
<td>Formations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onondaga Limestone</td>
<td>Cyclone, McKean County</td>
<td>2.5</td>
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<tr>
<td>Oriskany Sandstone</td>
<td>Meade Gas Storage, Erie County</td>
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<tr>
<td>Oriskany Sandstone</td>
<td>Ulysses, Potter County</td>
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<tr>
<td>Oriskany Sandstone/Huntersville Chert</td>
<td>Strongstown, Indiana County</td>
<td>302</td>
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<tr>
<td>Bass Island Carbonates</td>
<td>Greenley, Erie County</td>
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<tr>
<td>Lockport Dolomite</td>
<td>Wolf Creek – Kilgor Mercer County</td>
<td>4</td>
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<tr>
<td>Medina/Whirlpool Sandstone</td>
<td>Lake Shore, Warren and Erie Counties</td>
<td>-</td>
</tr>
<tr>
<td>Tuscarora Sandstones</td>
<td>Devils Elbow, Centre County</td>
<td>46</td>
</tr>
<tr>
<td>Bald Eagle Sandstone</td>
<td>Grugan Field, Clinton and Lycoming Counties</td>
<td>109</td>
</tr>
<tr>
<td>Trenton – Black River</td>
<td>Gloades Corner, Steuben County, NY</td>
<td>-</td>
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</tbody>
</table>
Bear Lake Properties Brine Disposal Well Permits
Warren County, PA

- Depleted Medina Group (Grimsby and Whirlpool) gas well field
- Over 11,000 acres
- Approx. 20 wells potential conversion to injection
- Existing wells permitted for approx. 1,000 bbls/d
- 2 wells operational
- 3 wells pending
- Only commercial brine disposal wells in PA
• There is substantial need in PA for more brine disposal wells on the order of 17 (at 1,000 bbls/d) to 34 (at 500 bbls/d) to meet current demands.

• Many existing O&G wells and fields have potential to be “recycled” for such use.

• Successfully siting such wells includes both considering geologic conditions and public concerns.

• Having more in-state wells can overall reduce truck traffic and help sustain the conventional and unconventional oil and gas business in PA.
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