Produced Water in Southern Colorado: Charting a New Course

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*This presentation is done in my capacity as a private individual and does not reflect the views of my employer, the Bureau of Land Management.
Why southern Colorado?

- Produced water volumes high outstrip onsite needs
- Exposure to severe drought for agriculture, industry
  - Fruitland: Largely fresh water (<10,000 mg/l TDS)
- Demand growth from residential population increase
Dangerously low levels at Lemon Dam

- Operated by Florida Water Conservancy District.

- Uses include irrigation, livestock watering, recreation (USFS), but increasingly residential.

- At 17% of capacity in Summer 2018

Graph source: U.S. Geological Survey (USGS). Additional information from the Water Information Program (WIP).

USGS link: https://nwis.waterdata.usgs.gov/co/nwis/uv?cb_00054=on&format=gif_default&site_no=09362800&period=&begin_date=2017-10-01&end_date=2019-02-22

WIP link: https://waterinfo.org/program-partners/florida-water-conservancy-district/
What do we need to know?

- Operator needs and conditions
- Water quality parameters
- Treatment needs
- Potential buyers
Operator needs and conditions: UIC

- 34 active, injecting C2d wells, none being permitted. No known capacity constraints.
- Most pipe PW to their own UIC wells.
- Some smaller operators truck PW to SWD wells; can be expensive: $.03/bbl/mile (Coday, 2015).

Source: Well data imported from the EIA and Ground Water Protection Council's National Oil and Gas Gateway Initiative.
Water quality parameters

- **Free methane** Dissolves oxygen, creates IRBs (precipitation), SRBs (corrosion) (Gorody, 2001).

- **Polycyclic aromatic hydrocarbons** (Orem, Tatu, Lerch, 2007).
  - Some low-weight, non-carcinogenic PAHs found in some CBM produced water from Gilette, Wyoming. Long-term effects unclear.

- **Dissolved BTEX**
  - Benzene, Toluene, Ethyl benzene, Xylene) organics.

- **Other elements to test for**
  - Iron, manganese, dissolved nitrogen, bromine, and fluorine, select potentially hazardous metals.

Treatment needs

- Special samples for dissolved methane – isotopic analysis, chromatography.
- Need to test for sodicity (for irrigation).
- Heterogeneous bicarbonate content. How to handle aggregation across wells?

*Sodium Adsorption Ratio (SAR)*

\[
\text{Na} / \sqrt{\left(\frac{(Ca+Mg)}{2}\right)}
\]

Purple = issue

Source: U.S. Geological Survey Produced Water Database.
SAR calculations done with USGS produced water data.

Source: Presentation from British Petroleum.
Potential buyers: Agriculture


- Surface-drip irrigation works in Wyoming PRB (National Academy of Sciences, 2010).

- $1,000/acre foot would be “too much” (about $0.13/barrel).


*Includes deoiling, air stripping, nanofiltration, sodium adjustment, evap ponds, brine disposal.

Potential buyers: Ranchers

- Sodicity (SAR) not an issue. Prices likely still are.
- TDS <1,000 mg/L best, works with some issues at up to 7,000 mg/L.
- La Plata County: 2nd statewide in horse, pony, mule, burro sales.

Tire tank used for stock watering. Overflow of treated CBM produced water can supply livestock over greater area.

Effect on livestock at different TDS levels.

Potential Buyers: Power Plants

- Ignacio combined heat and power (CHP) plant at Harvest Midstream processing plant – presents great possibility.

- Uses Florida River for cooling. Some water captured onsite entrained in gas stream.

- Low calcium content an advantage – less likely to scale on stainless steel.

- San Juan Generating Station (National Energy Technology Laboratory, 2006): Worked with $1,000/acre-foot ($0.13/bbl) tax credit under higher-recovery scenarios.

Conclusions

• **Operator Needs and Conditions** Revenue alone not enough of an incentive. Must also provide avoided transportation and injection costs.

• **Water Quality Parameters** Low-TDS, but BTEX, PAH, SAR, methane all issues.

• **Treatment Needs** Heterogeneity creates complications. Aggregation an issue.

• **Potential Buyers** Power plant reuse may be economic w/o desal, and/or with state/Federal credits. May not require desalination (Co-Vap).

• Continued demand, drought issues, could bring alternative reuse back in-play.

• Whole testing suite costs about $800 per sample, 25 well samples = $20,000. Potential benefit for industry, agriculture, developers, conservation, CWCB goals.
Questions?
Bonus slides
Legal / Regulatory Issues

Drivers
- Rule 907 (2 CRR 404-1 907)
  - “Waste minimization” plan approval from COGCC for beneficial use.
  - Discharge, evaporation ponds are allowed as disposal methods.
- Vance v. Wolfe
  - 2009 (CO Supreme Court).
  - Dewatering is beneficial use.
    - If tributary, requires permit, augmentation plan from CDPHE.

Obstacles
- Revenue split
  - Lease owners typically get a split of any revenue (part of contract).
- Tort litigation
  - Has followed CBM development.
  - Most claims unsubstantiated, but operators lack baseline data for defense. Need an environmental management system (EMS) in-place (Glantz, Gorody, and Mueller, 2002).
Water quality parameters

- Approximately two-thirds of 3,300 wells in Fruitland Coal formation.
- Additional conventional gas wells in Fruitland, Dakota, Hermosa, and Cutler.
- TDS<10,000 mg/l in 85% of well samples, <5,000 mg/l in 56% of samples.

Source: U.S. Geological Survey Produced Water Database.

Top-five produced water counties in Colorado

**Tight oil**
- **Weld County** – Denver-Julesburg

**Conventional Gas**
- **Rio Blanco County** – Uinta/Piceance
- **Garfield County** – Uinta/Piceance

**Coal Bed Methane / Conventional gas**
- **La Plata County** – San Juan/Fruitland
- **Las Animas County** – Raton/Vermejo

Basins layer from U.S. Energy Information Administration (EIA), U.S. Shale Plays Map.
Volumes exceed onsite demand

Note: Water volumes for hydraulic fracturing include only freshwater and recycled water for well completions. They do not include acids, foam, carbon dioxide, or other materials.

**Rio Blanco produced water volumes include multiple counting of water cycled for enhanced recovery at Chevron-Rangely field. Actual produced water-frac ratio likely much lower.

Basins layer from U.S. Energy Information Administration (EIA), U.S. Shale Plays Map. Graph info from Colorado Oil and Gas Conservation Commission, county data and FracFocus data. Imported from the EIA and Ground Water Protection Council’s National Oil and Gas Gateway Initiative.

*2018 data is January-June. Reporting delays impact completeness of July-December totals.
La Plata: Drought risk drives demand

$5 million pipeline to deliver water to 150 homes west of Durango next year ($30k/home).

Authorized in 1968, delayed decades and scaled back to just serve Ute reservations.


Article from the Durango Herald by Jonathan Romeo, 2/15/2019.

How much snowpack will make it to reservoirs?

Western La Plata County – Potable and recreational (Animas – La Plata) pipelines

In western La Plata County, tap water may soon flow

Groundbreaking held ahead of pipe-laying project

What you need to know about Lake Nighthorse opening

Area will be open only on weekends until May

Water from the Animas River will soon be delivered to western La Plata County.
Potential Buyers: Power Plants (cont.)

- Power plants in arid regions can pay up to $6/1,000 gallons ($0.22/bbl) for cooling tower water (but most pay much less – Palo Verde < $0.10/bbl).

- Could be economic if desal avoided.

- Testing would have to focus on meeting power plant specs.

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Fruitland water and gas production history

Density of Fruitland gas-in-place, 1994

- “Fairway” has thick, northwest-trending, high-rank coal deposits with coalbed methane (CBM) gas near Durango.

- Dugan, Williams begin commingled production in early 1970s, Aamco (now BP) begins drilling in mid-70s. Thousands of wells drilled by the early 90s.

- CBM gas released by dewatering. High (2,000 bbl/d) production of low-chloride, alkaline water continues near Durango. Injected or evaporated with brine injection.

- Drilling all but ceases with expiration of Windfall Tax Credit (2002), lower gas prices (post-2008).

Handling sodium through chlor-alkalai

- Electrolysis reaction transforms NaCl, H₂O into chlorine and caustic soda.


- Can add a hydrochloric acid resin that will absorb excess sodium, make use of all TDS and leave behind fresh water for agricultural, other uses.

- Question of whether TDS is high **enough**: may be in parts of the Fruitland.

## Properties of prime farmland soils

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Acres</th>
<th>Parent material</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>76</td>
<td>Witt loam, 3 to 8 percent slopes</td>
<td>52,421</td>
<td>Calcareous silty loess</td>
<td><em>Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)</em></td>
</tr>
<tr>
<td>66</td>
<td>Tefton loam</td>
<td>6,151</td>
<td>Mixed alluvium</td>
<td></td>
</tr>
</tbody>
</table>

Source: U.S. Department of Agriculture, Soil Surveys for La Plata County Area (CO669).
Cost of inaction

• “At present, however, water coproduced with CBM has been largely neglected for beneficial use, even where concentrations of dissolved solids and other contaminants are within regulatory guidelines for potable agricultural or livestock use.”

• “The societal and economic costs that may be incurred by not considering CBM water for beneficial use in an arid part of the United States are not usually discussed with regard to CBM produced water management.” (National Academy of Sciences, 2010)