Overview of Brine Disposal Issues

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RO Basics

- Removes wide range of contaminants and dissolved salts (measured as conductivity or Total Dissolved Solids - TDS)
- Typically > 98% TDS removal
- Effective for nitrate and many trace contaminants
- Hydraulic performance limited by fouling (scale formation)
- Requires extensive pre-treatment to prevent membrane fouling
- Produces substantial volume of waste flow with concentrated salts – disposal is an issue
A Membrane is a Selective Barrier That Permits the Separation of Species in a Fluid
What Happens at the Membrane Surface
Sparing Soluble Foulants

• Carbonates
  – Calcium carbonate

• Sulfates
  – Calcium sulfate
  – Barium sulfate
  – Strontium sulfate

• Others
  – Silica
  – Calcium fluoride

The presence of these foulants limits the recovery of the membrane.
Membrane Element
Typical Membrane Configuration

Feed → 3 to 6 Elements per Pressure Vessel → Retentate 15 - 20% Flow

Permeate 80 - 85% Flow

4, 2, 1 Array Configuration
Typical Surface Water RO Drinking Water Process

Pretreatment
- Conventional
- Coagulation microfiltration
- Others

Anti-scalant
pH adjustment

RO Stage 1 → RO Stage 2

Post treatment
- Degas
- pH adjustment

Concentrate Disposal

Disinfection

Blend

Blending will control treated water quality
Concentrate Characteristics

• Recovery is percentage of usable water produced
  – Typically 80% to 85%
  – 15% to 20% lost as “concentrate” or “brine”
• Contaminants concentrated in the brine
• Contaminants of possible concern in brine
  – Nitrate
  – TDS
  – Trace organics, PPCP, and EDC
  – Radionuclides
  – Selenium

Basic issue: large volume of moderately concentrated waste stream
Relationship Between Recovery and Brine Concentration

Assuming Treatment of 1 MGD and Raw Water TDS 1000 mg/L
Concentrate Disposal Options

• Surface water body
• Municipal sewer
• Deep well injection
• Evaporation pond
• Land application
• Zero liquid discharge
How are Desalting Systems Disposing of Brine?

Ref Mickley 2000
## Concentrate Disposal Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Considerations</th>
</tr>
</thead>
</table>
| Surface Water Discharge | - NPDES required  
                        - Limited flow assimilative capacity of Colorado surface water bodies (such as S. Platte)  
                        - Nitrate  
                        - TDS  
                        - Sodicity (?)  
                        - Non-impairment for other users |
| Municipal Sewer      | - Potential for blending  
                        - Possible performance impacts to WWTP  
                        - Primary settling  
                        - Corrosion  
                        - Limited number of major dischargers  
                        - Location of major dischargers  |
## Concentrate Disposal Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Considerations</th>
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<tbody>
<tr>
<td>Deep Well Injection</td>
<td>- UIC Class 1 permit required</td>
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<td>- Sufficient capacity</td>
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<td>- Isolation from drinking water aquifers</td>
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<td>- Only 1 Class 1 permit in NE Colorado</td>
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<tr>
<td></td>
<td>- Small capacity</td>
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<tr>
<td></td>
<td>- Lack of appropriate hydrogeology in NE Colorado (?)</td>
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<tr>
<td>Land Application</td>
<td>- Large land area required</td>
</tr>
<tr>
<td></td>
<td>- Seasonal operation</td>
</tr>
<tr>
<td></td>
<td>- Solicity and impact on plants</td>
</tr>
<tr>
<td></td>
<td>- Soil permeability</td>
</tr>
<tr>
<td></td>
<td>- Groundwater impacts</td>
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<td></td>
<td>- Accumulation of trace contaminants</td>
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## Concentrate Disposal Options

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<tr>
<td>Evaporation Ponds</td>
<td>- Possibly effective for very high evaporation rates</td>
</tr>
<tr>
<td></td>
<td>- NE Colorado evaporation not high enough</td>
</tr>
<tr>
<td></td>
<td>- requires 1 acre of pond for 2-3 gpm brine produced</td>
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<tr>
<td></td>
<td>- Seasonal limitations</td>
</tr>
</tbody>
</table>
Zero Liquid Discharge (ZLD)

- Seen as key technical issue for in-land desalination projects
- Current practice limited to industrial processes and power plants
  - Tens to hundreds of gallons per day
- Focus of current research effort
  - Ongoing combined AwwaRF, WERF, WateReuse project
- Capital cost estimated at 15% to 75% of treatment process (Mickley)
- Operating cost up to $3.00/1000 gallons disposed (Bond)
Zero Liquid Discharge Techniques

• Improve membrane recovery rate
  – Increase temperature/pH (HERO process)
  – Control divalent cations which form carbonate or sulfate precipitates

• Improve evaporation rates of water from concentrate (evaporators and concentrators)
  – Energy intensive
    • Heating
    • Vacuum
    • Vapor compression

• Promote the formation of precipitates (crystallizers)
Some ZLD Options

- Nanofilter
- RO
- Evap Pond
- Brine
- Recovered water
- RO Stage 1
- Crystallizer
- Filter
- RO Stage 2
- Product water
- Evap Pond
- Pretreated water
- Evaporator
- Salt
- Recovered water
## Disposal Options Compared - Large Scale Colorado Applications

<table>
<thead>
<tr>
<th>Option</th>
<th>Maturity</th>
<th>Feasibility</th>
<th>Permitting</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface water body</td>
<td>High</td>
<td>Low</td>
<td>Maybe for very small flow</td>
<td>+</td>
</tr>
<tr>
<td>Municipal sewer</td>
<td>High</td>
<td>Low</td>
<td>Maybe for small flow</td>
<td>++</td>
</tr>
<tr>
<td>Deep well injection</td>
<td>High</td>
<td>Low (?)</td>
<td>Unknown</td>
<td>+++</td>
</tr>
<tr>
<td>Surface spreading</td>
<td>Low</td>
<td>Low(?)</td>
<td>Unknown</td>
<td>+++</td>
</tr>
<tr>
<td>Evaporation pond</td>
<td>High</td>
<td>Low</td>
<td>Maybe</td>
<td>++</td>
</tr>
<tr>
<td>Zero liquid discharge</td>
<td>Low</td>
<td>Low</td>
<td>Likely</td>
<td>++++++</td>
</tr>
</tbody>
</table>
Final Thoughts

• No demonstrated disposal methods in Colorado at present for large scale RO systems
• Unlikely that developing ZLD processes will be suitable for large scale RO systems in near future
  – High cost
  – High complexity
  – Technically risky
Final Thoughts

- Suggested areas of investigation for this workgroup
  - Mapping of known and planned RO discharges to S. Platte
  - Estimate of future volume of RO brine production in S. Platte Basin (now to 2030)
  - Technical assessment potential disposal options in NE Colorado
    - Existing capacity in S Platte
    - Surface spreading
    - Deep well injection
  - Monitoring of ZLD techniques