Brackish Groundwater: Perspectives on Potentially Favorable Development Areas & Deep Brine Injection

Governor’s Water Augmentation Council Desalination Committee

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Why Look at Brackish GW in Arizona?

• Largest unallocated water resource
• More than 600 million AF of recoverable brackish groundwater in storage
• Almost 100 times current total annual AZ water use
• Desalination is proven technology and economical under certain circumstances
• Brine disposal via deep injection may be feasible and protective in some hydrogeologic settings
Maximum TDS in Upper 50 – 500 Feet of Aquifer
2008 AZ Brackish GW Study Scope

• Identify, quantify, and characterize brackish groundwater reserves using existing data sets
• Evaluate areas based on established set of criteria
• Select areas for further study based on degree to which criteria are fulfilled and absence of fatal flaws
  ➢ Focus on potential to replace or augment CAP supplies
• Identify data gaps
• Make recommendations for future investigations in favorable areas
2008 Brackish GW Study Ranking Criteria

- Water quality
  - 1,000 – 10,000 mg/L TDS (~1,600 – 17,000 uS/cm)
  - Lower concentrations of constituents that make RO expensive
  - Lack of naturally-occurring or human-caused contaminants not removed with RO

- Sustainability
  - Ability to supply up to 10,000 AFY
  - Sufficient groundwater in storage above 1,200 feet

- Economic feasibility
  - Depth to water not excessive
  - Adequate well yields
  - Brine injection potential

- Environmental factors
  - No anticipated subsidence impacts
  - No adverse impacts to existing users
M&A 2008 – Brackish Groundwater in Arizona

Electrical Conductivity (USGS Data)

EXPLANATION

Electrical Conductivity (Estimated TDS Equivalent)
- 0 - 1,600 μS/cm (0 - 1,000 mg/L)
- 1,601 - 5,000 μS/cm (1,001 - 3,000 mg/L)
- 5,001 - 8,000 μS/cm (3,001 - 5,000 mg/L)
- 8,001 - 17,000 μS/cm (5,001 - 10,000 mg/L)
- > 17,000 μS/cm (>10,000 mg/L)

- Interstate Highway
- CAP Canal

Data Source: USGS National Water Information System (NWIS)
# Brackish Groundwater Area Ranking

<table>
<thead>
<tr>
<th>Basin</th>
<th>Sub-basin or Area</th>
<th>Estimated Desalination Potential</th>
<th>Fatal Flaws</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEST SALT RIVER VALLEY</td>
<td>Buckeye</td>
<td>Most promising</td>
<td>None</td>
</tr>
<tr>
<td>GILA BEND BASIN</td>
<td>Gila Bend</td>
<td>Most promising</td>
<td>None</td>
</tr>
<tr>
<td>YUMA</td>
<td>Yuma Mesa and Yuma Valley</td>
<td>Most promising</td>
<td>Existing desalting plant</td>
</tr>
<tr>
<td>LOWER SANTA CRUZ</td>
<td>Picacho-Eloy</td>
<td>Most promising</td>
<td>None</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Winslow-Leupp</td>
<td>Most promising</td>
<td>None</td>
</tr>
<tr>
<td>WILCOX BASIN</td>
<td>Willcox Playa</td>
<td>Most promising</td>
<td>Brackish storage unknown</td>
</tr>
<tr>
<td>COL. RIVER-HOOVER TO IMPERIAL DAMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Concho-Petrified National Forest</td>
<td>Potentially promising</td>
<td>Possibly Indian water rights</td>
</tr>
<tr>
<td>GILA-PAINTED ROCK TO TEXAS HILL</td>
<td>Painted Rock Reservoir to Texas Hill</td>
<td>Potentially promising</td>
<td>Small groundwater storage</td>
</tr>
<tr>
<td>GILA-TEXAS HILL TO DOME</td>
<td>Wellton-Mohawk</td>
<td>Potentially promising</td>
<td>Surface water particulates; other uses</td>
</tr>
<tr>
<td>HARQUAHALA PLAINS</td>
<td>Harquahala</td>
<td>Potentially promising</td>
<td>Generally low TDS</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Holbrook-Joseph City</td>
<td>Potentially promising</td>
<td>None</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Hopi Reservation</td>
<td>Potentially promising</td>
<td>Depth to water, excessive salinity</td>
</tr>
<tr>
<td>HUALAPAI VALLEY</td>
<td>Red Lake</td>
<td>Potentially promising</td>
<td>Volume of brackish groundwater unknown</td>
</tr>
<tr>
<td>LOWER HASSAYAMPA</td>
<td>Tonopah Desert/Centennial Wash</td>
<td>Potentially promising</td>
<td>Low TDS</td>
</tr>
<tr>
<td>LOWER SAN PEDRO</td>
<td>San Manuel-Winkelman</td>
<td>Potentially promising</td>
<td>Small well yields and storage</td>
</tr>
<tr>
<td>RANEGRAS PLAIN (RAN)</td>
<td>Ranegras Plain</td>
<td>Potentially promising</td>
<td>Low TDS</td>
</tr>
<tr>
<td>SAFFORD BASIN</td>
<td>Gila Valley</td>
<td>Potentially promising</td>
<td>None</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Cameron-Wupatki N.M.</td>
<td>Potentially promising</td>
<td>None</td>
</tr>
<tr>
<td>SAFFORD BASIN</td>
<td>San Simon</td>
<td>Potentially promising</td>
<td>None</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>St. Johns-Springerville</td>
<td>Potentially promising</td>
<td>None</td>
</tr>
<tr>
<td>TUCSON AMA</td>
<td>Avra Valley</td>
<td>Less promising</td>
<td>Mostly low TDS</td>
</tr>
<tr>
<td>BIG SANDY VALLEY</td>
<td>Big Sandy</td>
<td>Less promoting</td>
<td>Low TDS, small yield</td>
</tr>
<tr>
<td>DOUGLAS BASIN</td>
<td>Douglas</td>
<td>Less promoting</td>
<td>Low TDS</td>
</tr>
<tr>
<td>DUNCAN BASIN</td>
<td>Duncan Valley</td>
<td>Less promoting</td>
<td>Low TDS</td>
</tr>
<tr>
<td>UPPER SAN PEDRO</td>
<td>Sierra Vista</td>
<td>Less promoting</td>
<td>Low TDS, base flow protection</td>
</tr>
<tr>
<td>TUCSON AMA</td>
<td>Tucson</td>
<td>Less promoting</td>
<td>Low TDS (?)</td>
</tr>
<tr>
<td>MIDDLE VERDE RIVER</td>
<td>Camp Verde</td>
<td>Less promoting</td>
<td>Small well yields and storage</td>
</tr>
<tr>
<td>VIRGIN RIVER</td>
<td>Littlefield</td>
<td>Less promoting</td>
<td>Small storage</td>
</tr>
<tr>
<td>WATERMAN WASH</td>
<td>Rainbow Valley</td>
<td>Less promoting</td>
<td>Low TDS, small storage</td>
</tr>
<tr>
<td>WESTERN MEXICAN DRAIN</td>
<td>Ajo</td>
<td>Less promising</td>
<td>Low TDS, small well yields and storage</td>
</tr>
<tr>
<td>Basin</td>
<td>Sub-basin or Area</td>
<td>Estimated Desalination Potential</td>
<td>Estimated Available Groundwater Storage (AF)</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------</td>
<td>----------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>WEST SALT RIVER VALLEY</td>
<td>Buckeye</td>
<td>Most promising</td>
<td>20,000,000</td>
</tr>
<tr>
<td>GILA BEND BASIN</td>
<td>Gila Bend</td>
<td>Most promising</td>
<td>25,000,000</td>
</tr>
<tr>
<td>YUMA</td>
<td>Yuma Mesa and Yuma Valley</td>
<td>Most promising</td>
<td>49,000,000</td>
</tr>
<tr>
<td>LOWER SANTA CRUZ</td>
<td>Picacho-Eloy</td>
<td>Most promising</td>
<td>24,000,000</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Winslow-Leupp</td>
<td>Most promising</td>
<td>16,000,000 (brackish)</td>
</tr>
<tr>
<td>WILLCOX BASIN</td>
<td>Willcox Playa</td>
<td>Most promising</td>
<td>20,000,000 (brackish)</td>
</tr>
<tr>
<td>RANEGRAS PLAIN</td>
<td>Ranegras Plain</td>
<td>Potentially promising</td>
<td>20,000,000</td>
</tr>
<tr>
<td>SAFFORD BASIN</td>
<td>Gila Valley</td>
<td>Potentially promising</td>
<td>35,000,000</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>Cameron-Wupatki N.M.</td>
<td>Potentially promising</td>
<td>6-10 million</td>
</tr>
<tr>
<td>SAFFORD BASIN</td>
<td>San Simon</td>
<td>Potentially promising</td>
<td>30,000,000</td>
</tr>
<tr>
<td>LITTLE COLORADO RIVER</td>
<td>St. Johns-Springerville</td>
<td>Potentially promising</td>
<td>20,000,000 (?)</td>
</tr>
</tbody>
</table>

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**Notes:**
- **Evaporation:** Evaporation of brine as a natural process.
- **Irrigation and effluent:** Evaporation of brine in conjunction with irrigation and effluent disposal.
- **Irrigation and evaporites:** Evaporation of brine in conjunction with irrigation and the use of evaporites (bedded halite and anhydrite).
- **Nearby injection:** Injection of brine near the site of brine disposal.
- **Existing:** Capacities already in place or potential capacity.
- **Near CAP canal:** Potential for brine disposal near an existing or planned canal system.
- **Navajo water rights, municipal, power:** Potential for brine disposal using existing Navajo water rights, municipal, or power facilities.
- **Sierra Vista supply, power:** Potential for brine disposal using existing Sierra Vista supply or power facilities.
Areas for Further Study

- Buckeye Area
- Gila Bend Basin
- Yuma Mesa and Yuma Valley
- Picacho Basin
- Winslow-Leupp Area (Little Colorado River Basin)
- Willcox Playa Area (Willcox Basin)
Areas for Further Investigation

- Buckeye Area
- Gila Bend Basin
- Yuma Mesa / Yuma Valley
- Picacho Basin
- Winslow-Leupp Area
- Willcox Playa Area

EXPLANATION

20 Millions of Acre-feet Brackish Groundwater in Storage

Total Dissolved Solids, in mg/l

- 1,000-5,000
- 5,000-10,000
- >10,000

(Modified from Daniel, 1981)
EC in Buckeye Area

**EXPLANATION**

**WELL DEPTH (feet)**
- 0 - 100
- 101 - 300
- 301 - 500
- 501 - 1,000
- 1,001 - 5,000
- Well Depth Unknown

**ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)**
- 0 - 1,600 μS/cm (0 - 1,000 mg/L)
- 1,601 - 5,000 μS/cm (1,001 - 3,000 mg/L)
- 5,001 - 8,000 μS/cm (3,001 - 5,000 mg/L)
- 8,001 - 17,000 μS/cm (5,001 - 10,000 mg/L)
- > 17,000 μS/cm (> 10,000 mg/L)

Data Source: ADWR Groundwater Site Inventory (GWIS)
Buckeye Area Pros / Cons

Pros
- Large area of groundwater in optimal TDS range
- Coincides with water logged area
- Current and anticipate demand for fresh water supplies
- Multiple sources of TDS

Cons
- Future land use changes may affect brackish supply
- Groundwater chemistry (Ca, Mg) may pose challenges for desal
- Potential presence of pesticides and pharmaceuticals
- Brine disposal may be problematic
TDS in Gila Bend Area

EXPLANATION

WELL DEPTH (feet)
- 0 - 100
- 101 - 300
- 301 - 500
- 501 - 1,000
- 1,001 - 5,000
- Well Depth Unknown

ELECTRICAL CONDUCTIVITY (Estimated TDS Equivalent)
- 0 - 1,600 µS/cm (0 - 1,000 mg/L)
- 1,501 - 5,000 µS/cm (1,001 - 3,000 mg/L)
- 5,001 - 8,000 µS/cm (3,001 - 5,000 mg/L)
- 8,001 - 17,000 µS/cm (5,001 - 10,000 mg/L)
- > 17,000 µS/cm (>10,000 mg/L)
Gila Bend Area Pros / Cons

Pros
• Large volume of groundwater in storage with TDS concentrations in optimal range
• Water quality very consistent laterally/vertically
• Low Ca concentrations
• Recharge from runoff events and wastewater flows
• Irrigation demand and potential demand for solar power plant

Cons
• Potential presence of pesticides and pharmaceuticals
• Brine disposal may be problematic
Yuma Valley /Mesa Area Pros / Cons

Pros
• Long-term, sustainable supply of brackish groundwater
• Pumping could partially mitigate water logging
• Anticipated long-term demand for agricultural supplies

Cons
• Administration of Colorado River accounting surface during drought could be problematic
• Recent water quality data is lacking and can’t rule-out issues for desal
• Brine disposal may be problematic
EC in Picacho Basin
Picacho Basin Pros / Cons

Pros
- Long-term, sustainable supply of brackish groundwater
- Anticipated long-term demand for agricultural supplies, particularly during CAP shortages
- Deep injection may be feasible

Cons
- Recharge of imported CAP water could decrease TDS over time
- Documented subsidence and fissures
- Issues with permitting of deep brine injection
TDS in Winslow – Leupp Area
Winslow-Leupp Area Pros / Cons

Pros
• Significant supply of brackish groundwater
• Good data in some areas from recent testing
• Potential demand from Flagstaff and tribes
• Deep brine disposal potentially feasible

Cons
• Hydrogeologic and water quality conditions are variable
• Water quality may deteriorate and/or change over time
• Issues with permitting of deep brine disposal
Deep Brine Injection Opportunities/Challenges

- All subsurface water currently regulated as a drinking water aquifer in AZ
- APP process already encompasses injection wells
- Current structure provides potential pathways
  - Aquifer declassification
  - Application of existing regulatory structure
    - Use of narrative standards
    - Non-degradation demonstration
    - Protection of existing and foreseeable uses
Deep Brine Injection Opportunities/Challenges

• Permitting and implementation of deep brine injection will require:
  o Robust site conceptual model
  o Significant site characterization efforts
  o Development of reliable model to project aquifer interactions under current and foreseeable future conditions
  o Coordinated efforts between stakeholders
• Demonstration of technical and economic feasibility