Brackish Groundwater Characterization (BRACS)

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Texas Ground Water Association
Annual Convention
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Unless specifically noted, this presentation does not necessarily reflect official Board positions or decisions.
Outline

A. What is the Texas Water Development Board?
B. Why do we study brackish groundwater?
C. How do we study brackish groundwater?
D. What are some study results?
E. What data is available to me?
What is the Texas Water Development Board (TWDB)?
What is the Texas Water Development Board (TWDB)?

Mission: to provide leadership, information, education, and support for planning, financial assistance, and outreach for the conservation and responsible development of water for Texas

• Created in 1957 in response to the “drought of record”
• Supports development of regional water plans, culminates in State Water Plan
• Provides financial assistance for various water supply projects
• Researches water resources and collects data
State Water Plan

- Issued every 5 years
- Predicts the population and water needs of Texas for the next 50 years
- Summarizes projects from regional water planning
- Identifies potential water deficits
TWDB Water Science and Conservation

• Research and data gathering wing
  – Innovative Water Technologies
    • Aquifer Storage and Recovery
    • Brackish Resources Aquifer Characterization System (BRACS)
      • Desalination
      • Water Reuse
  – We look at unconventional sources of water as a potential new water supply
Why do we study brackish groundwater?
What is brackish groundwater?

Saltier than fresh water, less saline than seawater

<table>
<thead>
<tr>
<th>Groundwater salinity classification</th>
<th>Salinity class code</th>
<th>Total Dissolved Solids (TDS) concentration, mg/L</th>
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<tr>
<td>Fresh</td>
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<tr>
<td>Slightly Saline</td>
<td>SS</td>
<td>1,000 to 3,000</td>
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<tr>
<td>Moderately Saline</td>
<td>MS</td>
<td>3,000 to 10,000</td>
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<tr>
<td>Very Saline</td>
<td>VS</td>
<td>10,000 to 35,000</td>
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<tr>
<td>Brine</td>
<td>BR</td>
<td>Greater than 35,000</td>
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</table>

*Modified from Winslow and Kister, 1956*
Why study brackish groundwater?

• Fresh water supplies are decreasing
  – Significant depletion in some aquifers
  – Sedimentation of reservoirs
• “Easy” reservoirs already built in 60s, new ones unlikely
  – expensive
  – unfeasible
• 2017 State Water Plan identified 3.1 million acre-feet of unmet water supply needs by 2070
How much brackish groundwater is available?

- Estimated 2.7 billion acre-feet of brackish groundwater in Texas (LBG-Guyton, 2003)
- Available throughout the state
- Less expensive than seawater
- “drought-proof”
- However, less data and knowledge exists for brackish aquifers
Existing brackish groundwater desalination

- Current municipal capacity = 85 million gallons per day (95,212 acre-feet per year)
- Largest capacity plant is Kay Bailey Hutchison in El Paso (27.5 MGD)
- 35 of 49 plants in desalination database
Why study brackish groundwater?

- We need more refined estimates of:
  - Quantity
  - Quality
  - Location
- 8 of the 16 Regional Water Planning Areas identified brackish desalination as a strategy.
- Estimated 111,000 acre-feet per year by 2070.
- Study results can help identify:
  - Where brackish groundwater is
  - Areas for site specific studies to develop desalination well fields.
How do we study brackish groundwater?
General methodology

Area (Extent) \times \text{Thickness (Net Sand)} \times \text{Porosity (Specific Yield)} = \text{Volume (acre-feet)}
BRACS Study outline

• Collect well logs (water, oil/gas)
• Build geologic datasets (database, GIS)
• Compile aquifer properties (chemistry; productivity)
• Map aquifer extent from outcrop to 10,000+ mg/L TDS
• Estimate volumes of groundwater by salinity
• Provide data to stakeholders
• Each aquifer will require unique analysis based on data availability and local hydrogeology
BRACS Database

• MS Access database
• Information saved in BRACS database
  – Geophysical well logs and well locations
  – Aquifer top and bottom depths
  – Interpreted lithology
  – Well test data
  – Lab analyzed water quality
• Available to download
  
Brackish groundwater mapping source data
What is a geophysical well log?

- Tool or combination of tools lowered into a borehole on a wireline
- Measurements of the surrounding rock are made as the tools are retrieved to the surface
- Tools designed to read specific parameters
- Tool response recorded in left and right tracks
- Logs must be corrected for a number of parameters
- Complete and accurate header information vital to performing corrections

BRACS 39472
More examples of data sources


BRACS 39367
More examples of data sources

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<tr>
<th>PARAMETER</th>
<th>RESULTS</th>
<th>UNITS</th>
<th>STORET #</th>
<th>PQL in WATER</th>
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BRACS 48793
Brackish groundwater mapping
Aquifer framework

• Map extent of the aquifer, i.e. aquifer top and bottom depths
• Primary data source is geophysical well logs
  – Mostly oil and gas logs
• Interpret logs to get aquifer top pick, a.k.a. stratigraphic pick
• Record interpretations in the BRACS database
• Interpolate picks to generate aquifer top and bottom GIS surfaces
• Stratigraphic surfaces make study framework
## Geophysical Well Log

### BRACS Database geology table

### Stratigraphic Description

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<th>Geologic Pick</th>
<th>Top Depth</th>
<th>Bottom Depth</th>
<th>Stratigraphic Description</th>
<th>Source of Data</th>
<th>Insite</th>
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<td>Geophysical Well Log</td>
<td>2/6/2015</td>
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</tbody>
</table>
- Stratigraphic interpretations saved in the BRACS database
- Stratigraphic picks used to make GIS raster surfaces
- Surfaces are reviewed and more interpretations are made
- Surfaces are regenerated with new well control

- *Logs used to make interpretations are available for download*
Aquifer Determination

- Assign aquifer(s) to each well in the project area
- Use screen top/bottom or well depth or total depth of hole
- Use the GIS-derived 3-D formation surfaces as vertical control

Why?
- Compare wells completed in same aquifer
- Consistent evaluation of aquifer water quality and properties
- Many new wells do not have TWDB aquifer code
- Some TWDB wells have incorrect aquifer code
Aquifer determination example

BRACS 39405/SWN 6728704

Carrizo Top Depth
585 ft

Carrizo Bottom Depth
1116 ft

Ground surface

Carrizo Formation

https://www3.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer
Aquifer determination form

# BRACS Aquifer Determination Code
## CzWx Project, South-Central Texas

### Aquifer Information
- **Aquifer**: 12AC882
- **Aquifer (New)**: C2
- **Aquifer Decision**: Computer analysis of Well Screen (depth) and Aquifer Surfaces (GIS)
- **SQL Code for Aquifer Analysis**: S: Z

### Aquifer Details

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<th>Aquifer</th>
<th>Depth</th>
<th>Top Interval</th>
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<td>Jackson Gp.</td>
<td>Y_T_D:</td>
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<td>Y_B_D:</td>
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<tr>
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<td>W_B_D:</td>
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</tbody>
</table>

### Additional Information
- **Process Aquifer Determination**
Lithologic analysis

• Interpret geophysical well logs for lithology picks
• Summarize Submitted Driller’s Reports into “Simplified Lithologic Descriptions”
• Build net sand data sets by formation
• Used to help get groundwater volume numbers

• Why use both geophysical well logs and Submitted Driller’s Reports?
Net sands example: geophysical well log

- Interpret logs for sand, clay, and mixtures of sand and clay
- Geophysical tools cannot read through surface casing
- Surface casing in this well from ground surface to 500 feet below ground surface
Net sands example continued

Submitted Driller’s Report

DESCRIPTION AND COLOR OF FORMATION MATERIAL

From (ft.) To (ft.) Description

0-8 sand
8-16 red & tan clay w/carrizo
16-45 lignite/gray shale & sand
45-91 dark gray shale with small sand strk.

91-92 rock
92-131 gray shale w/sand & rock streaks
131-165 fine-medium gray sand (carrizo)
165-412 large carrizo w/coal
412-413 rock
413-445 blue shale
445-460 gray shale w/rock streaks
460-520 fine-medium sharp multi color sand w/some shale
520-525 brown & gray shale
525-555 fine-medium sand

BRACS 14270
Carrizo Top: 138 ft
Carrizo Bottom: 419 ft

<table>
<thead>
<tr>
<th>From</th>
<th>Simplified lithologic description</th>
<th>% sand</th>
<th>Lithologic pick thickness (ft)</th>
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151 ft of net sand for the Carrizo
Example of a project net sands form

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31
Geophysical well logs and Submitted Driller’s Reports

- Oil and Gas surface casing installed to protect shallow groundwater
- We rely on Submitted Driller Report sediment descriptions in and near the outcrop!
• Use net sands analysis to determine groundwater volumes

BRACS 14270
Aquifer properties

- Pump tests, specific yield, etc
- Harvested from GWDB, Submitted Driller’s reports, published reports
- Recorded in BRACS database
Static water level

- Static water level is used in the outcrop to modify the saturated thickness (i.e. water is unlikely to be at the ground surface)
- Data harvested primarily from GWDB and Submitted Driller’s Records
Water chemistry data

- Use water quality measurements from the GWDB
  – Use aquifer code from the “aquifer determination” process
- Use water quality measurements not in the GWDB, saved in BRACS water quality tables
Estimate TDS from well logs

• Handful of methods to estimate water quality from geophysical well logs
• Complete well headers necessary
  – Mud resistivity
  – Type of mud in the borehole
  – Temperature of bottom hole
  – Tool scales
• Need measured water quality data to calibrate calculations

1. Select method
2. Read log header
3. Select appropriate interval for analysis
4. Perform calculations
5. Record information in BRACS database
Estimating TDS from well logs

- Rwa Minimum Method for these examples
  - Calculated TDS of 1751 mg/L
    - At 514 ft (QC), Ro = 22 ohm-meter
  - Calculated TDS of 1603 mg/L
    - At 877 ft (CZ), Ro = 24 ohm-meter
  - Calculated TDS of 639 mg/L
    - At 1010 ft (CZ), Ro = 60 ohm-meter
TDS calculations and inputs recorded in BRACS

BRACS 15534
Map water quality data

Measured water quality
- Fresh
- Slightly saline
- Moderately saline

Calculated water quality
- Fresh
- Slightly saline
- Moderately saline
- Very saline
- Brine

BRACS study area
Texas counties
Wilcox outcrop
Wilcox subcrop
Calculate groundwater volumes by salinity class

Extent of salinity class (area) \[ \times \]
Saturated thickness (net sands) \[ \times \]
Specific yield =
Groundwater volume by salinity class

Aquifer outcrop

Aquifer subcrop

SWL

Aquifer
Saturated thickness
Clay
What are some study results?
Examples from recently published studies

<table>
<thead>
<tr>
<th>Salinity class</th>
<th>Volume (acre-feet)</th>
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</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>240,000</td>
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<tr>
<td>Fresh and slightly saline</td>
<td>190,000</td>
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<tr>
<td>Slightly saline</td>
<td>350,000</td>
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<tr>
<td>Moderately saline</td>
<td>1,530,000</td>
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<tr>
<td>Moderately and very saline</td>
<td>790,000</td>
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<td>Very saline</td>
<td>6,840,000</td>
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<td>Very saline and brine</td>
<td>320,000</td>
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<tr>
<td>Total</td>
<td>10,260,000</td>
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</table>
Examples from recently published studies

<table>
<thead>
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<th>Salinity class</th>
<th>Volume (acre-feet)</th>
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<tbody>
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<td>Fresh</td>
<td>2,120,000</td>
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<tr>
<td>Fresh and slightly saline</td>
<td>30,000</td>
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<tr>
<td>Slightly saline</td>
<td>2,040,000</td>
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<tr>
<td>Moderately saline</td>
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<td>Very saline</td>
<td>8,190,000</td>
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<tr>
<td>Total</td>
<td>17,990,000</td>
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</table>
Examples from an upcoming study

- Upper Coastal Plains – Central, mapped the Yegua, Sparta, Queen City, Carrizo, and Wilcox aquifers between the Guadalupe and Colorado rivers
- Stratigraphic maps
- Lithologic maps
- Mapped salinity classes
- Brackish groundwater volume estimates
- 9 regional cross-sections
- GIS data
Example of a regional cross-section

- Left hand side is water quality
- Right hand side is lithology
- Useful to illustrate vertical complexity in stacked aquifer systems
Brackish Resources Aquifer Characterization System (BRACS) Program - Study Status

Completed studies and current studies
What data is available to me?
Report deliverables

• Peer-reviewed study reports detailing methodologies
• GIS datasets used in analysis and to prepare report figures
• Source data, like geophysical well logs and scanned well reports
• BRACS database and study tables

• Well logs may be downloaded from TWDB or requested in bulk by county!

http://www.twdb.texas.gov/innovativewater/bracs/WellLogs.asp
BRACS database

- MS Access
- Data dictionary available
- Relational table design
- Wells assigned unique well id (a.k.a. BRACS ID)
- Tracks other ids (foreign keys) to link to supporting databases
- Primarily oil and gas wells and water wells
BRACS Data Dictionary

- Describes tables in the BRACS database
- Defines and describes fields in the tables
Water Data Interactive

- https://www3.twdb.texas.gov/apps/WaterDataInteractive/groundwaterDataViewer/?map=bracs
- See BRACS well coverage
- Download individual logs
Other Contracted Reports

- http://www.twdb.texas.gov/innovativewater/desal/docs.asp
Conclusions

• Brackish groundwater desalination is part of the State Water Plan
• Detailed information about the brackish portions of aquifers is necessary
• BRACS studies can be used to find appropriate areas to do site-specific desalination well field studies
  – Also to support Aquifer Storage and Recovery evaluations
• BRACS study deliverables available on the TWDB website
  – Well logs
  – GIS data
  – BRACS database
• Bulk geophysical well log files available by county upon request
Questions?

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Hydrologist
Innovative Water Technologies
Texas Water Development Board
alyssa.suydam@twdb.texas.gov
(512) 936-9488

www.twdb.texas.gov/innovativewater/index.asp
References and useful links

Completed BRACS studies
• https://www.twdb.texas.gov/innovativewater/bracs/studies.asp

BRACS Database and documentation
• https://www.twdb.texas.gov/innovativewater/bracs/database.asp

TWDB Water Data Interactive
• https://www2.twdb.texas.gov/apps/waterdatainteractive/groundwaterdataviewer

BRACS reports, maps, and presentations
• https://www.twdb.texas.gov/innovativewater/bracs/docs.asp

Additional TWDB publications
• https://www.twdb.texas.gov/publications/index.asp