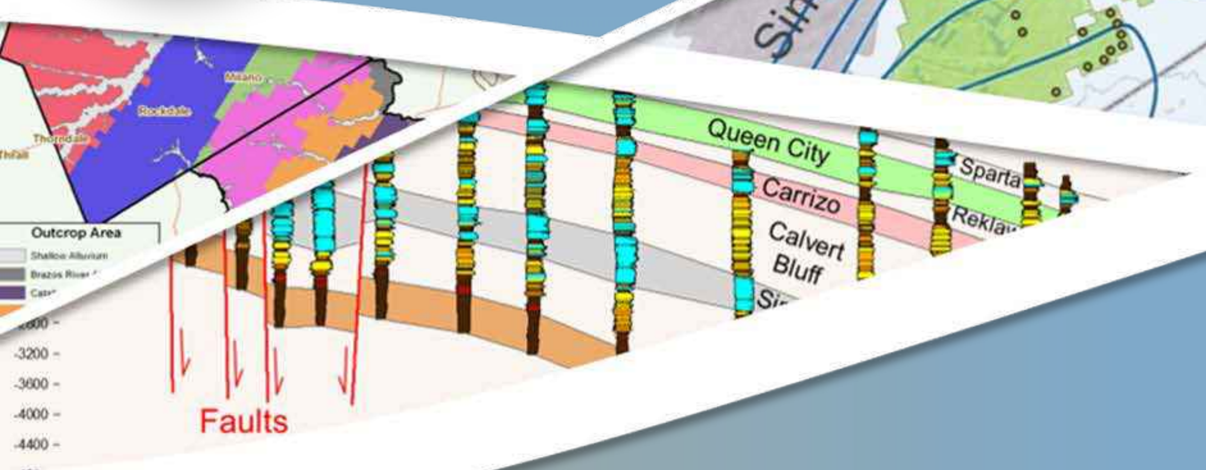
# Research Topics Related to Establishing and Managing Desired Future Conditions

Presented : POSGCD DFC Committee
POSGCD Office, Milam, TX


Presented by: Steve Young

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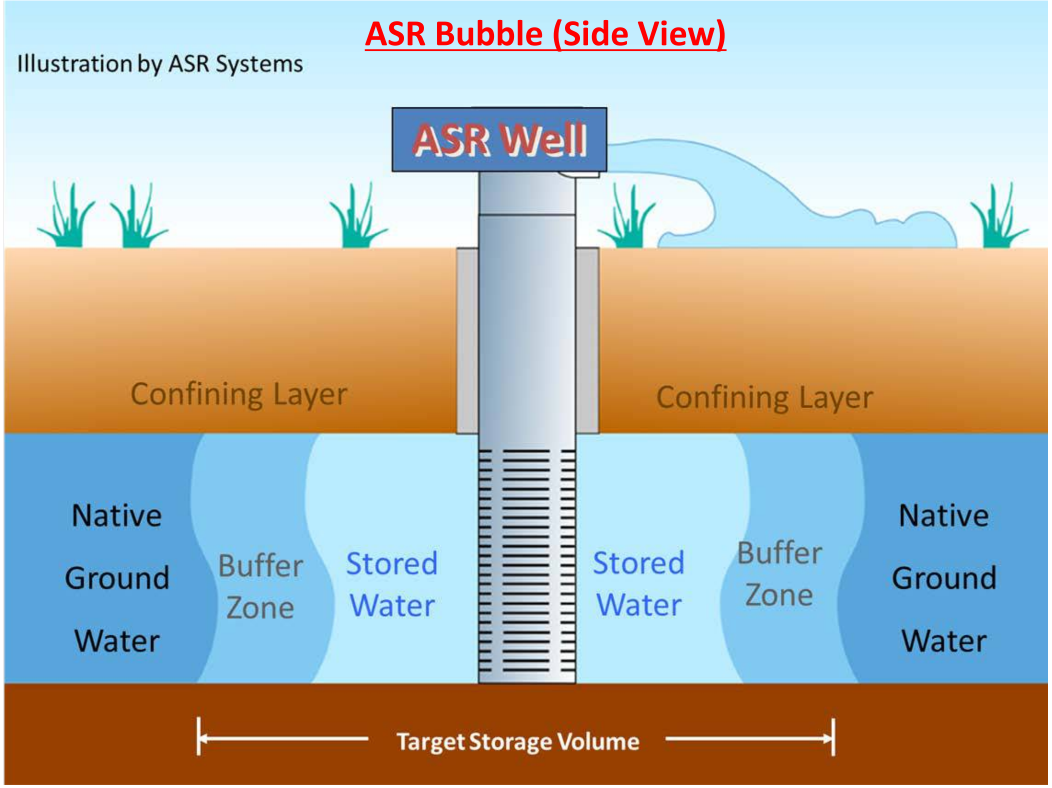
October 3, 2017

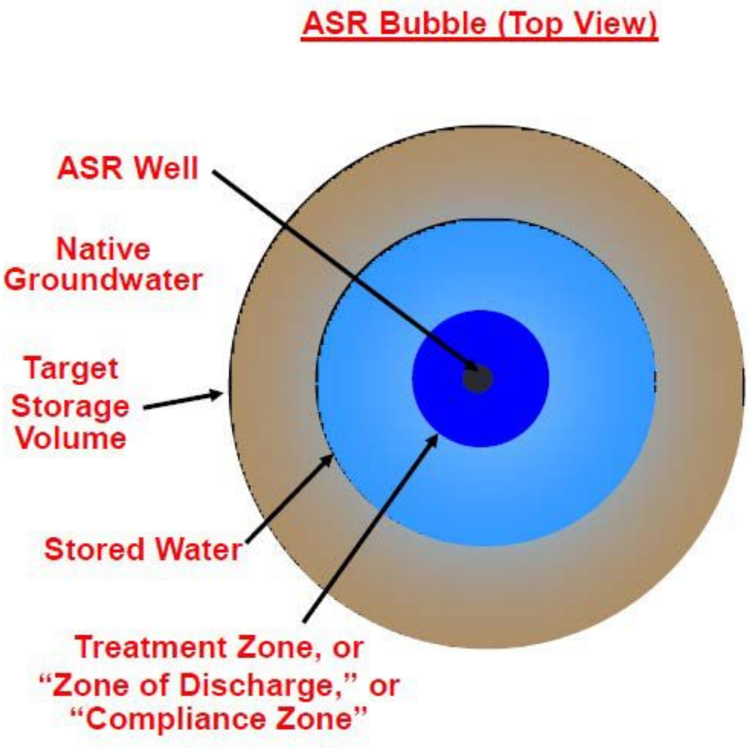
# Outline

- Aquifer Storage and Recovery
- Enhanced Recharge
- Surface Water-Groundwater Interaction
- Groundwater Quality, including Brackish Groundwater

# Aquifer Storage and Recovery

# Overview of Aquifer Storage and Recovery

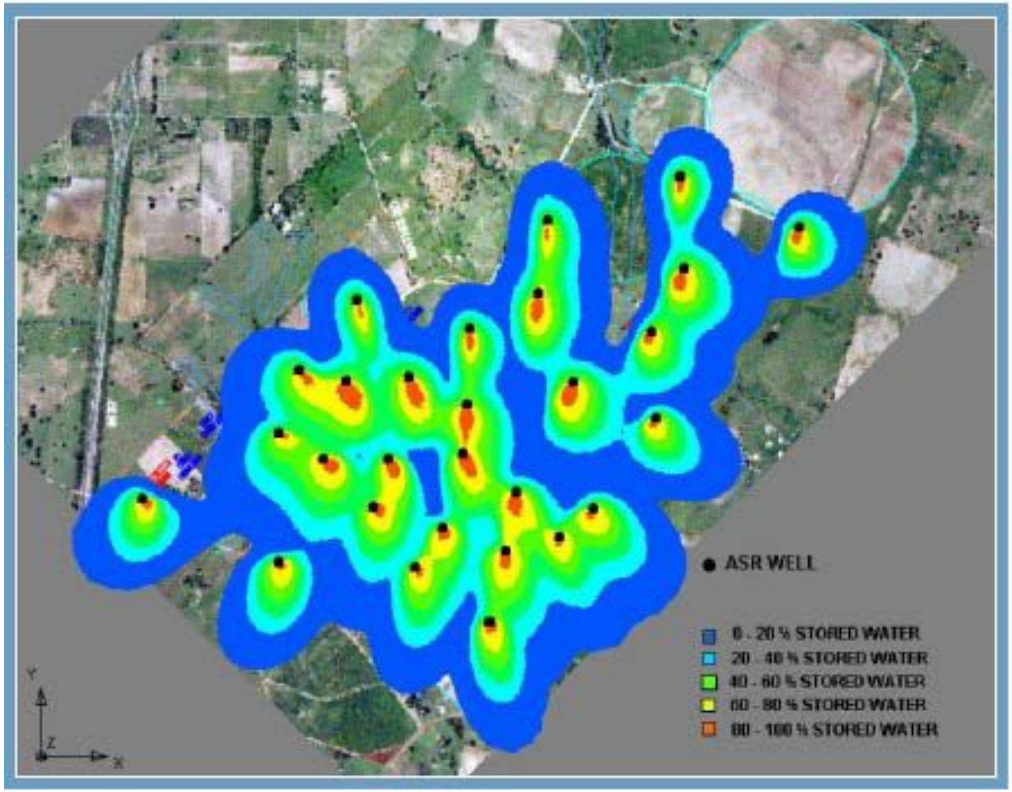


# Modeling Results from Twin Oaks Facility

**volume stored at each well**


**mixing between injected and natural groundwater**



# TCEQ Application for Class V Underground and Injection Control (UIC) Well for ASR

Aquifer Storage and Recovery

Any permit or authorization issued by the TCEQ for an ASR project must be for aquifer storage and recovery in accordance with the following definitions in Title 30 of the Texas Administrative Code (30 TAC), Chapter 331:

> Aquifer Storage and Recovery [30 TAC §331.2(8)]: "The injection of water into a geologic formation, group of formations, or part of a formation that is capable of underground storage of water for later retrieval and beneficial use."
>
> Aquifer Storage and Recovery Project [30 TAC §331.2(11)]: A project involving the injection of water into a geologic formation for the purpose of subsequent recovery and beneficial use by the operator.

## Section VIII. Demonstration of Recoverability*

In order for the commission to make a determination as to whether injection of water into a geologic formation will result in a loss of injected water or native groundwater, as required under TWC, §27.154(b), please provide an analysis of the volume of injected water that will be recovered. This analysis should consider the geologic, hydrogeologic, and hydrochemistry of the injection zone, the quality of the injected water, and the operational conditions proposed for the project. The commission anticipates that this analysis will require groundwater modeling. Please provide a detailed discussion of how the applicant estimated the percentage of injected water that will be recovered. If this estimated percentage of the injected water volume that is estimated is based on groundwater modeling, please describe the modeling performed, with justification for all assumptions and input parameter values.



* From TCEQ application

# ASR: Recovery Efficiency

- Recovery Efficiency (RE)

$$RE = \frac{V_r}{V_i} * 100\%$$

$V_i$ is the volume injected

$V_r$ is the volume recovered

- RE typically decreases with
  - -Increased density contrast
  - -Increased dispersivity
  - -Increased storage time
  - -Increased natural gradient
  - -Decreased bubble radius (thick aquifer and/or small storage volume)
  - -Poor vertical confinement
  - -Various geochemical issues may have an impact

# Proposed ASR Project

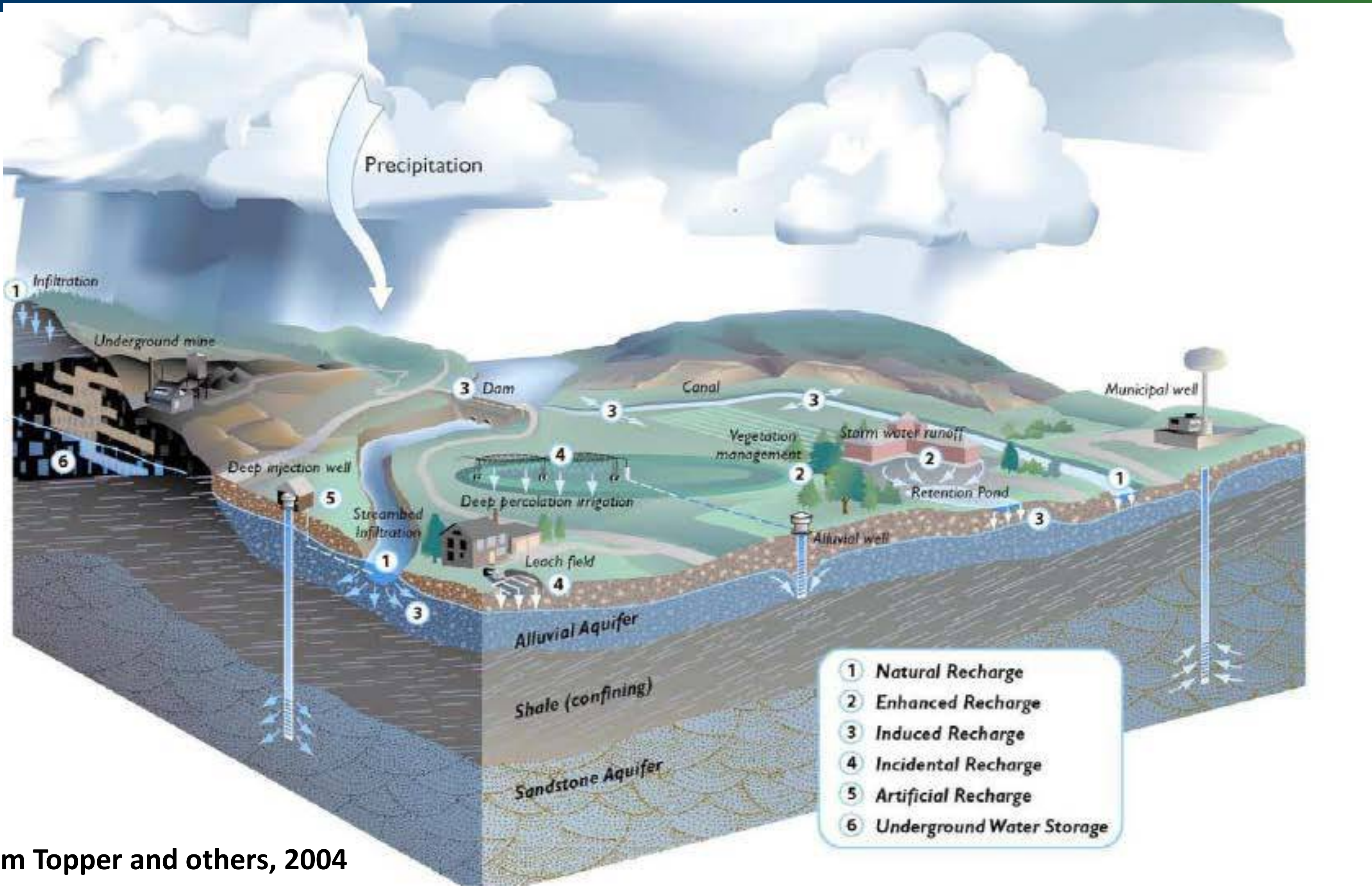
- Application Site: Carrizo-Wilcox Aquifer
  - Brazos River Water or other surface water
  - Rainwater or water reuse
- Objective(s)
  - Kickstart possible future ASR projects in District
  - Develop knowledge base for managing ASR projects
  - Evaluate approaches for modeling and predicting ASR performance
  - Gain insight into designing monitoring programs

# ASR Investigation:  Proposed Tasks

- Select site(s) with interested parties
- Assemble geophysical logs and characterize aquifer properties, including chemistry
- Evaluate modeling approaches to determine recovery efficiency (RE)  and management area
- Conduct workshop for GMA 12 and for TCEQ
- Design monitoring options
- Prepare report and recommend Phase 2

# Enhanced Recharge

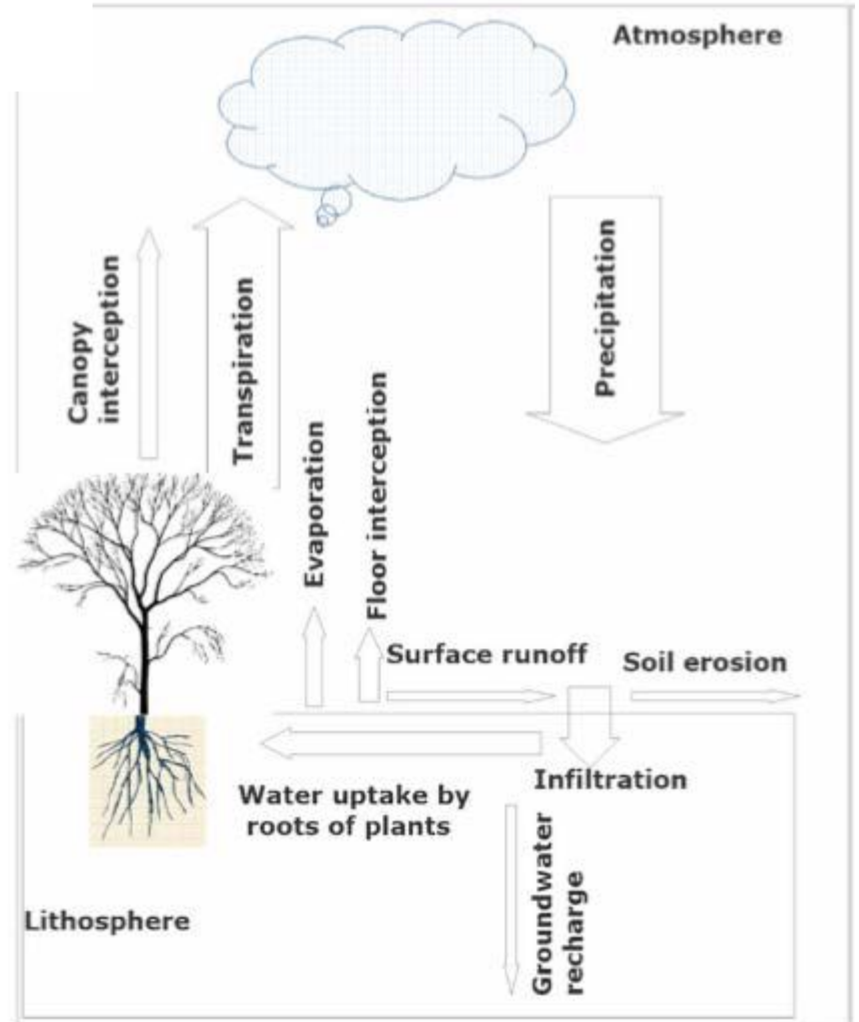
# Natural and Enhanced Recharge




**From Topper and others, 2004**

# Overview of Brush Control

- Adjust vegetation to reduce evapotranspiration or increase recharge
  - Replace deep-rooted woody species with shallow-rooted herbaceous vegetation
  - Remove dense shrub and replace with grassland
  - \$100 to \$300 per additional acre-foot in Carrizo-Wilcox in South Central Texas (Texas A&M, 2009)
- Rangeland Restoration Requirements
  - Minimum precipitation of 18 inches/yr
  - Sandy soils like those associated with the Carrizo
  - After initial treatment, followed by maintenance at 3-6 year intervals



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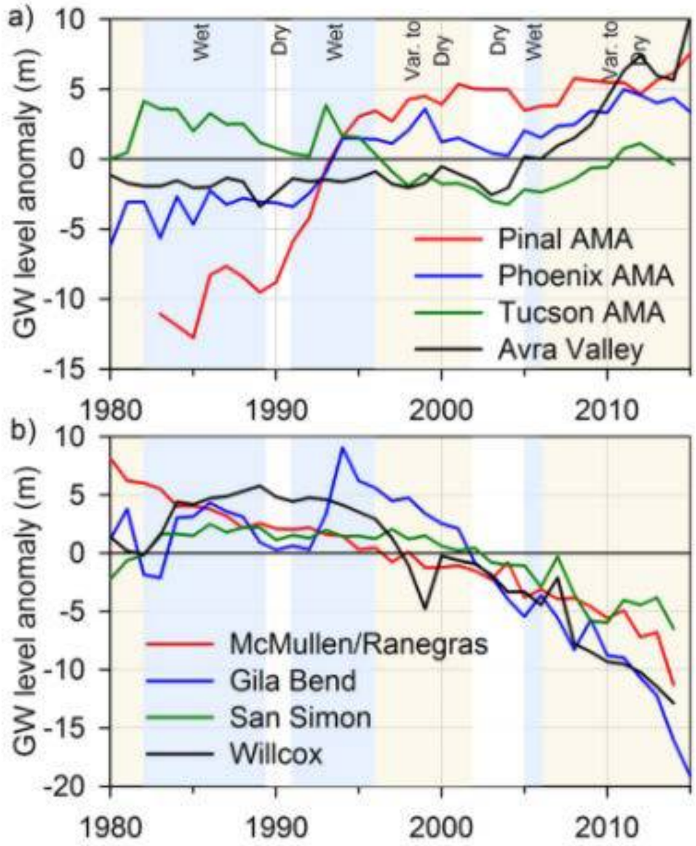
# Overview of Recharge Basins

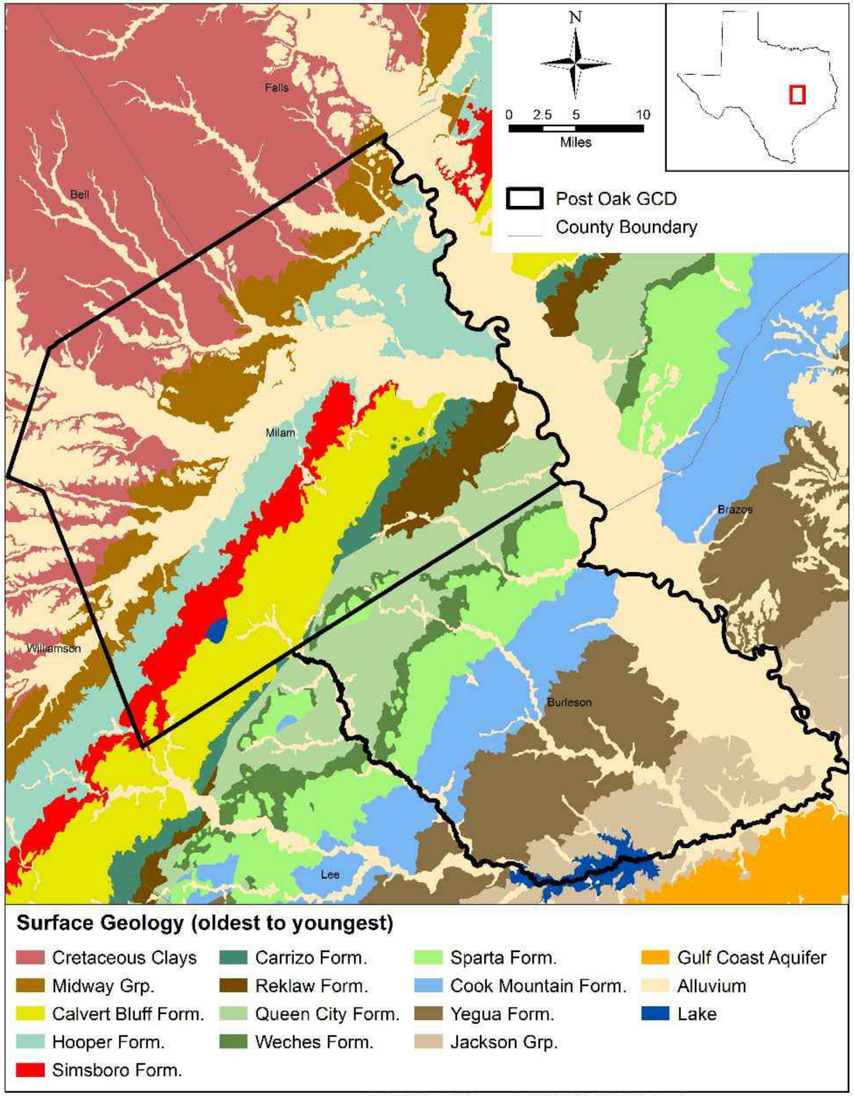
- Permeable sediments at surface
- Surface treatment can include removal of vegetation and clay layers
- Infiltrating water that is relatively free of silts
- Long-term water supply at surface to promote continual recharge




Composite groundwater levels in active management areas in Arizona (top) compared to areas without active management (bottom). *Bridget Scanlon*

# Proposed Enhanced Recharge Project

- Application Site: Simsboro & Carrizo Outcrop
  - Desktop study on options
  - Field work to confirm field conditions
- Objectives
  - Evaluate enhanced recharge options for region (brush control, recharge basin, former quarries, sand & gravel pits)
  - Determine potential role of enhanced recharge in managing water levels



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# Enhanced Recharge: Proposed Tasks

- Desktop
  - Literature review on enhanced recharge projects for similar climate & soils
  - Develop metrics for measuring enhanced recharge and for developing cost-benefit of increased recharge rate (costs per AFY)
  - Propose methods for POSGCD to implement recharge enhancement projects in District
  - Develop SOW for experimental plan at different levels of funding
- Field Work
  - Field visits to check/modify vegetation and soils maps
  - Design and cost for a weather monitoring station

# Groundwater Quality Including Brackish Groundwater

# Groundwater Quality and Brackish Groundwater

- US Drinking Water Regulations :useable groundwater includes water with TDS less than 10,000 mg/L

- Texas Railroad Commission uses TDS of 3,000 mg/L as standard for protection for disposal wells but TRC committed to EPA in 1982 to protect to 10,000 mg/L (EPA is working with TRC to investigative potential problems)
    - TWDB HB 30 BRAC study identify cases where injection wells were determined to be in “protected zone”
    - Several districts actively monitor and protest new Class II permits to protect GW from contamination from injection wells

# Groundwater Quality and Brackish Groundwater

- Brackish groundwater is a resource that is actively being managed differently by some GCDs and will it likely be treated differently by the Texas legislature in near future

- Potential benefits of characterizing brackish groundwater :
  - Production Limits (incentives to pump deeper)
  - Management Zones
  - ASR monitoring
  - Measure of Aquifer Condition



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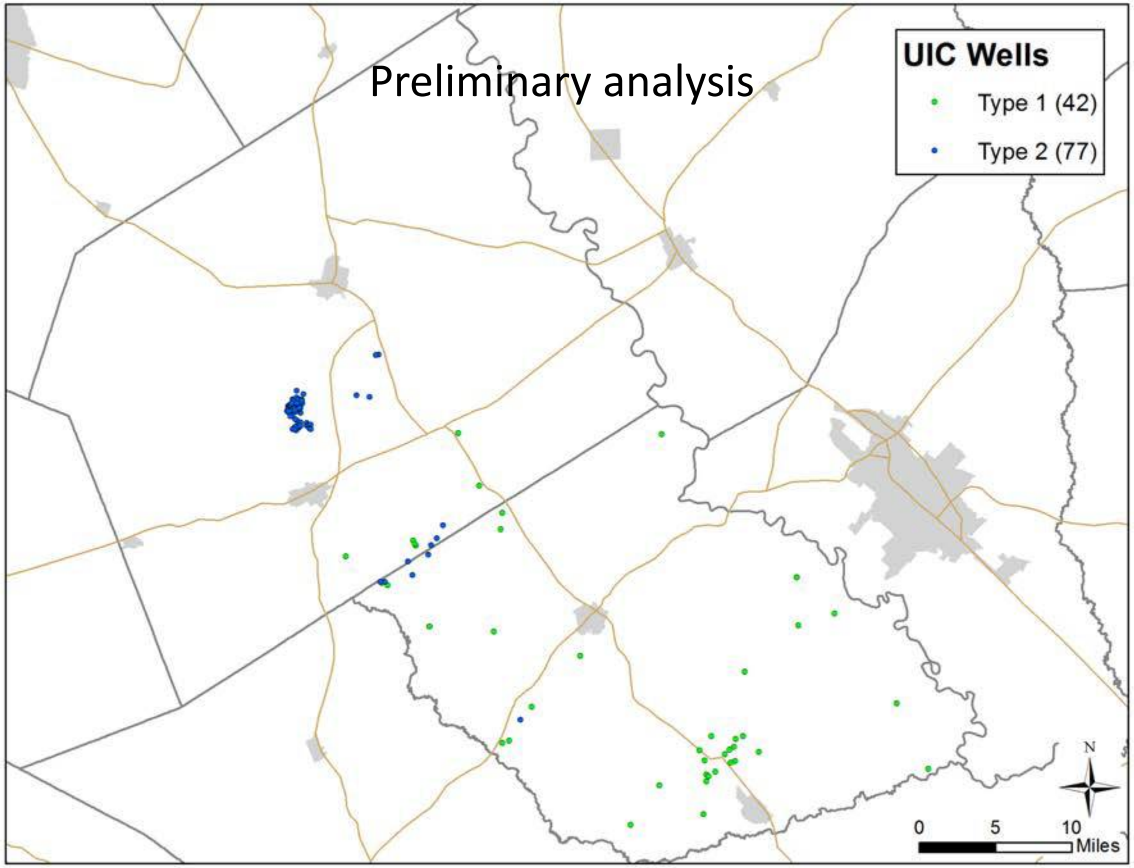
# UIC – Underground Injection Control

- Class II Wells – inject fluids (primarily brines) that are brought to the surface while producing oil and gas (TRC)
  - Type I – disposal into a nonproductive zone
  - Type II – disposal into a productive zone



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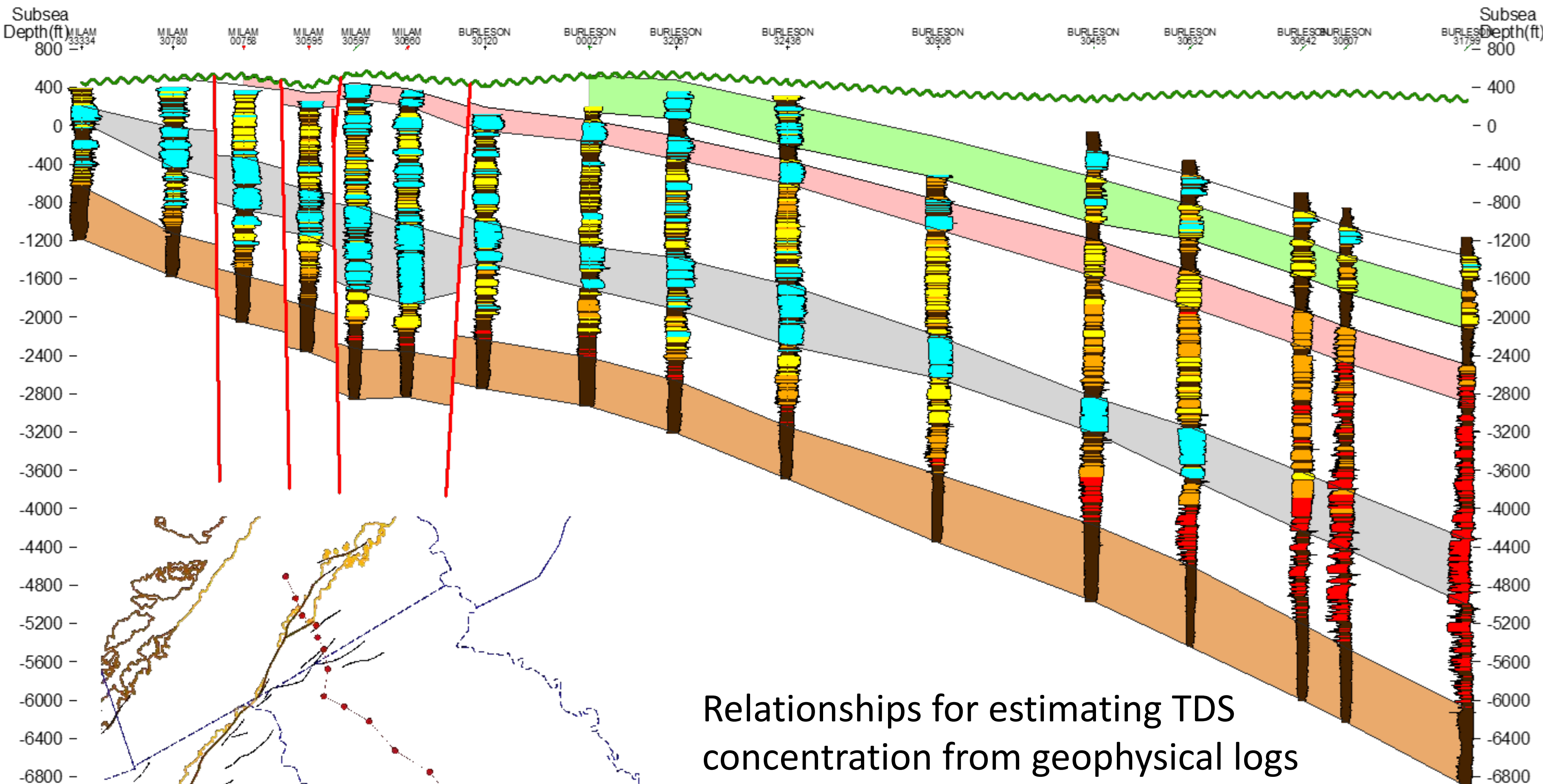
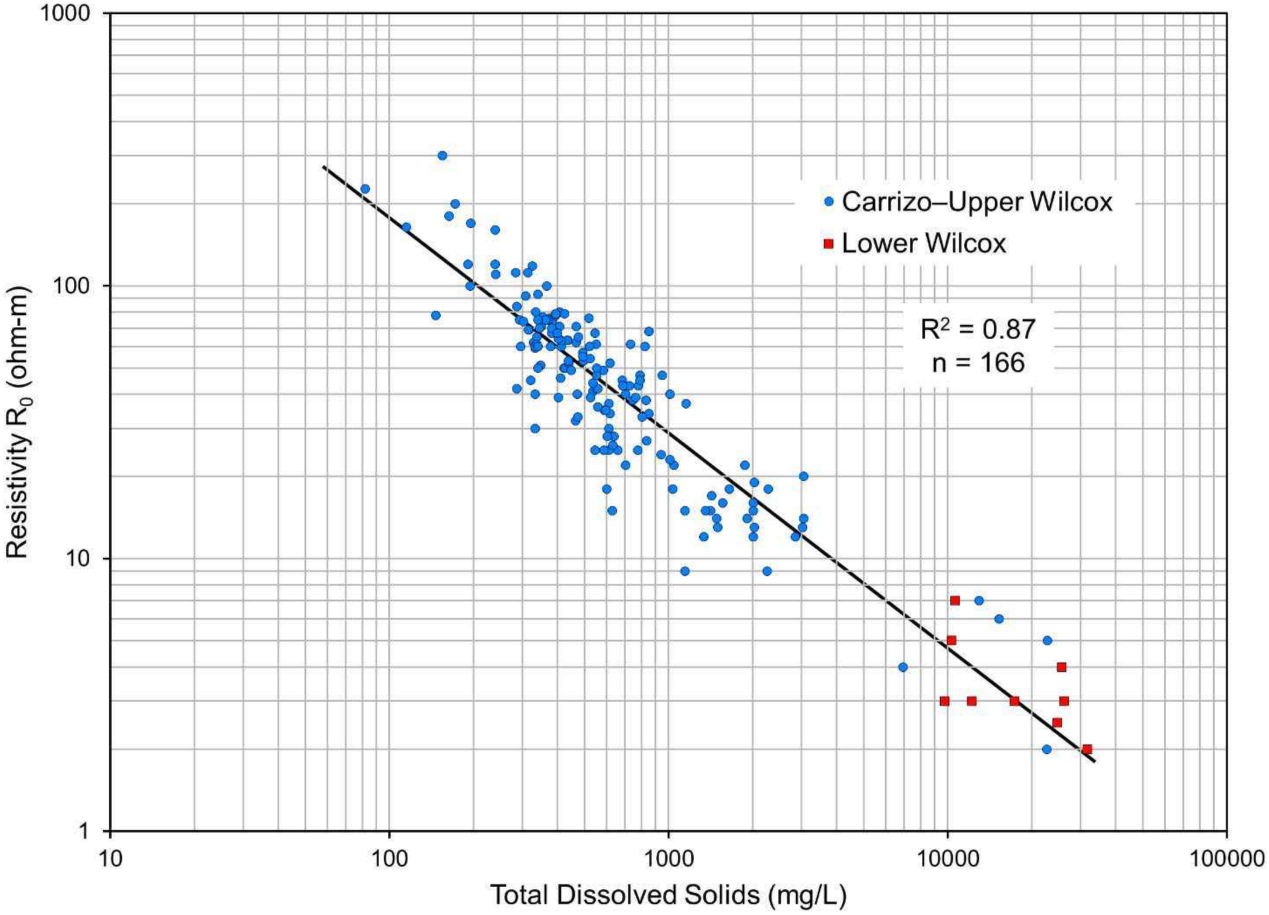
# Limited Work in POSGCD: One Cross-Section



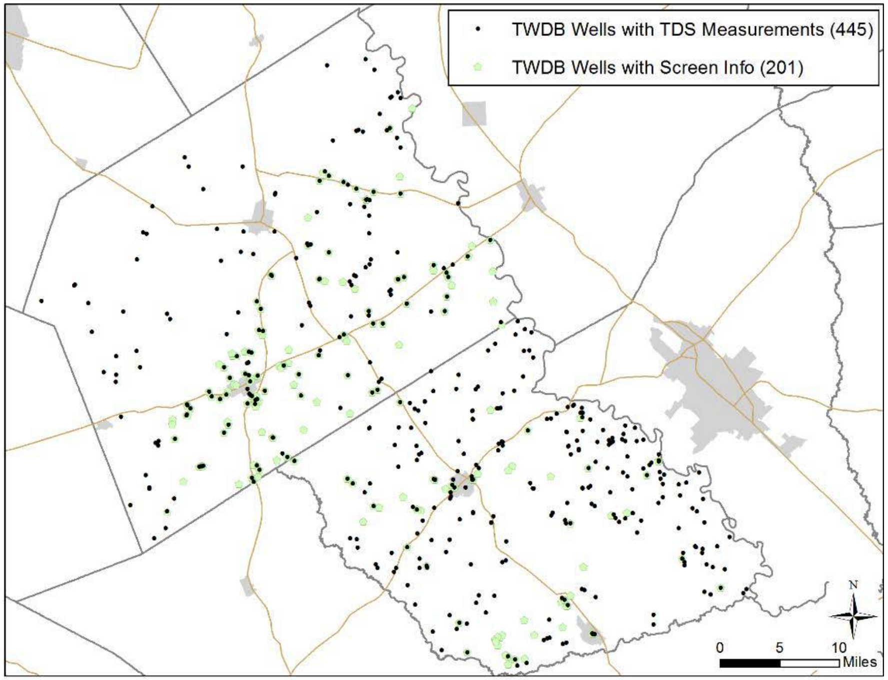

Relationships for estimating TDS concentration from geophysical logs are based on wells outside of District and therefore approximate

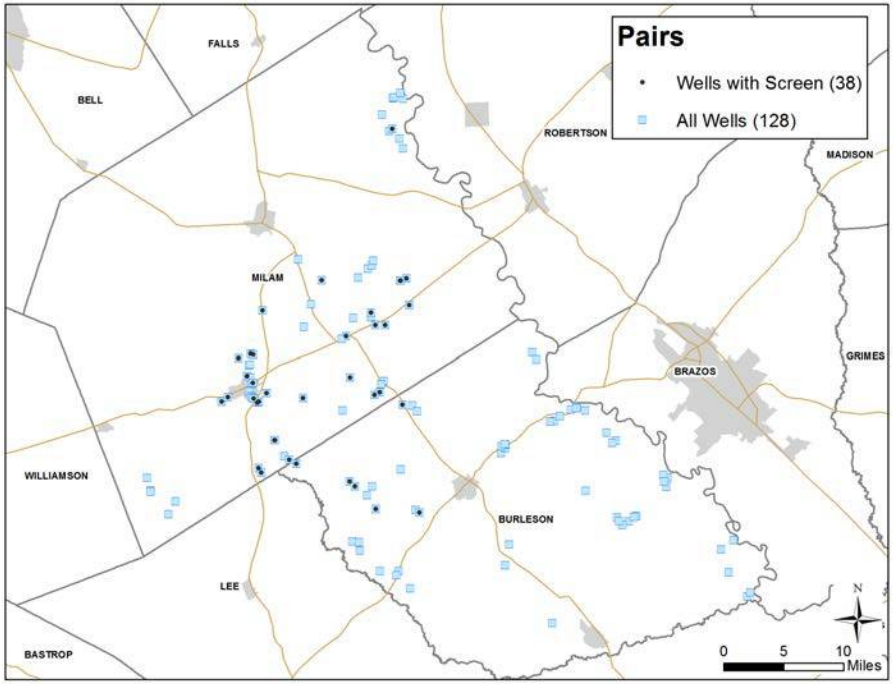
# Relationship Used to Estimate TDS Concentration in GW from Resistivity from a Geophysical Log

Data From GMA 13 TWDB Study



# Available TDS Information



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# Proposed Groundwater Quality Including Brackish Groundwater Project

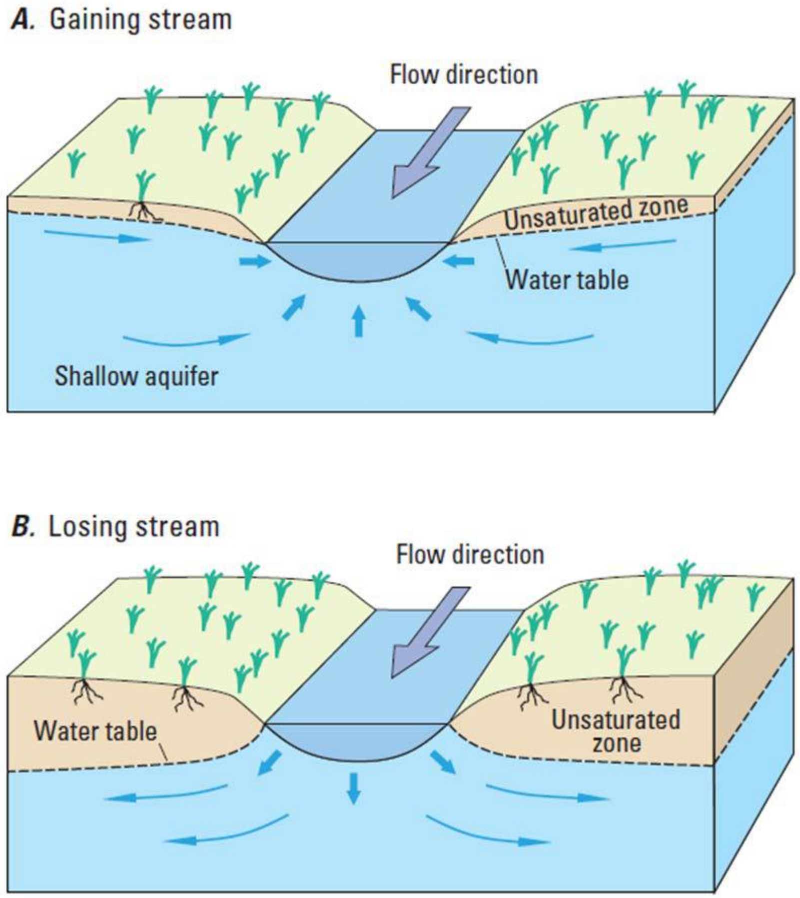
- Application: all Aquifers except Brazos Alluvium
  - Desktop Study: Analyze geophysical logs, TDS measurements, TCEQ contamination sites
  - Field Study: Sample monitoring wells for TDS and select geochemical parameters
- Objective
  - Define 1000 mg/L, 3000 mg/L & 10000 mg/L TDS limits and compare with injection wells
  - Develop water quality maps and correlate with faults, contamination sites, and aquifer
  - Establish baseline for water quality to help evaluate any changes in water quality conditions in aquifers

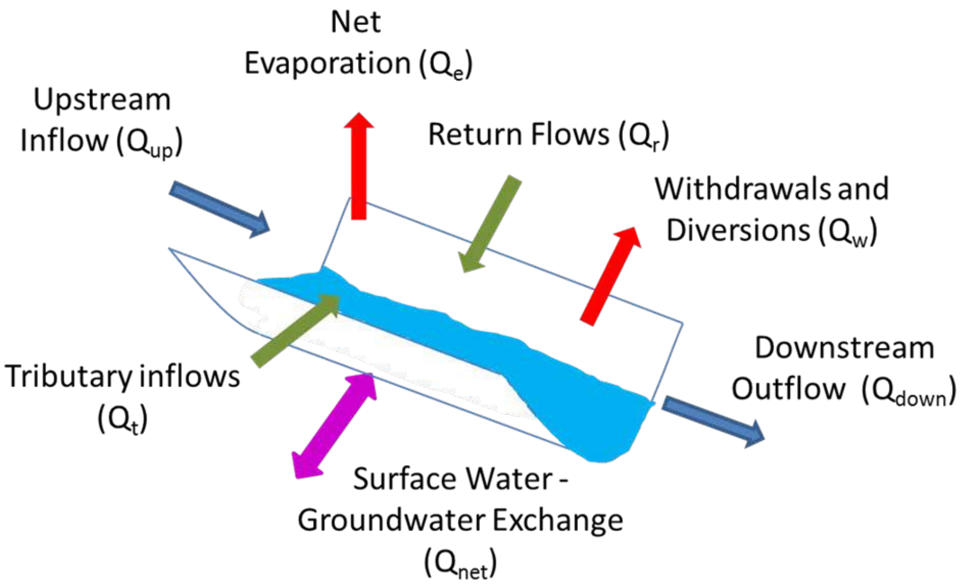
# Groundwater Quality Including Brackish Groundwater : Proposed Tasks

- Map Class II Injection Wells
- Map TCEQ contamination sites
- Assemble Existing TDS Information and Water Quality Information
  - Input into POSGCD well database
  - Evaluate for spatial and temporal patterns
- Develop protocols for collecting water quality data and sample selected wells
- Develop TDS – resistivity relationship for different aquifers
  - Assemble geophysical logs and build off of relationships developed for GMA 13
  - Map Salinity zones based on TDS (1000 mg/L, 3000 mg/L, 1000 mg/L)

# Groundwater – Surface Water Interaction

# Surface-Groundwater Interaction: Brazos River Alluvium




Equation to Determine Whether Stream is Gaining or Losing

$$Q_{net} = Q_{up} + Q_t + Q_r - Q_{down} - Q_w - Q_e$$

If $Q_{net} > 0$, then stream gaining
If $Q_{net} < 0$, then stream losing

# Key Aspect of Texas Statutes Relevant to Well Pumping Near Rivers

- The term "**groundwater**" can include percolating water or artesian water, **but not the underflow of a surface water river or stream** or the underground flow of water in confined channels. Groundwater is presumed to be percolating, unless proven otherwise.
- "Underflow" is that portion of the flow of a surface watercourse that flows through the sand and gravel deposits beneath the surface of the bed of a stream. Underflow is hydrologically connected to the surface flow of the stream and moving in the same direction as the surface water. Underflow is considered to be property of the State, and the principles governing allocation and use of surface water apply.
- Historically, the underflow exemption has not been well recognized by the courts. In large measure, this may be due to the fact that our understanding of underflow in alluvial valleys is incomplete.

# Surface-Groundwater Interaction: Recent Legal Cases

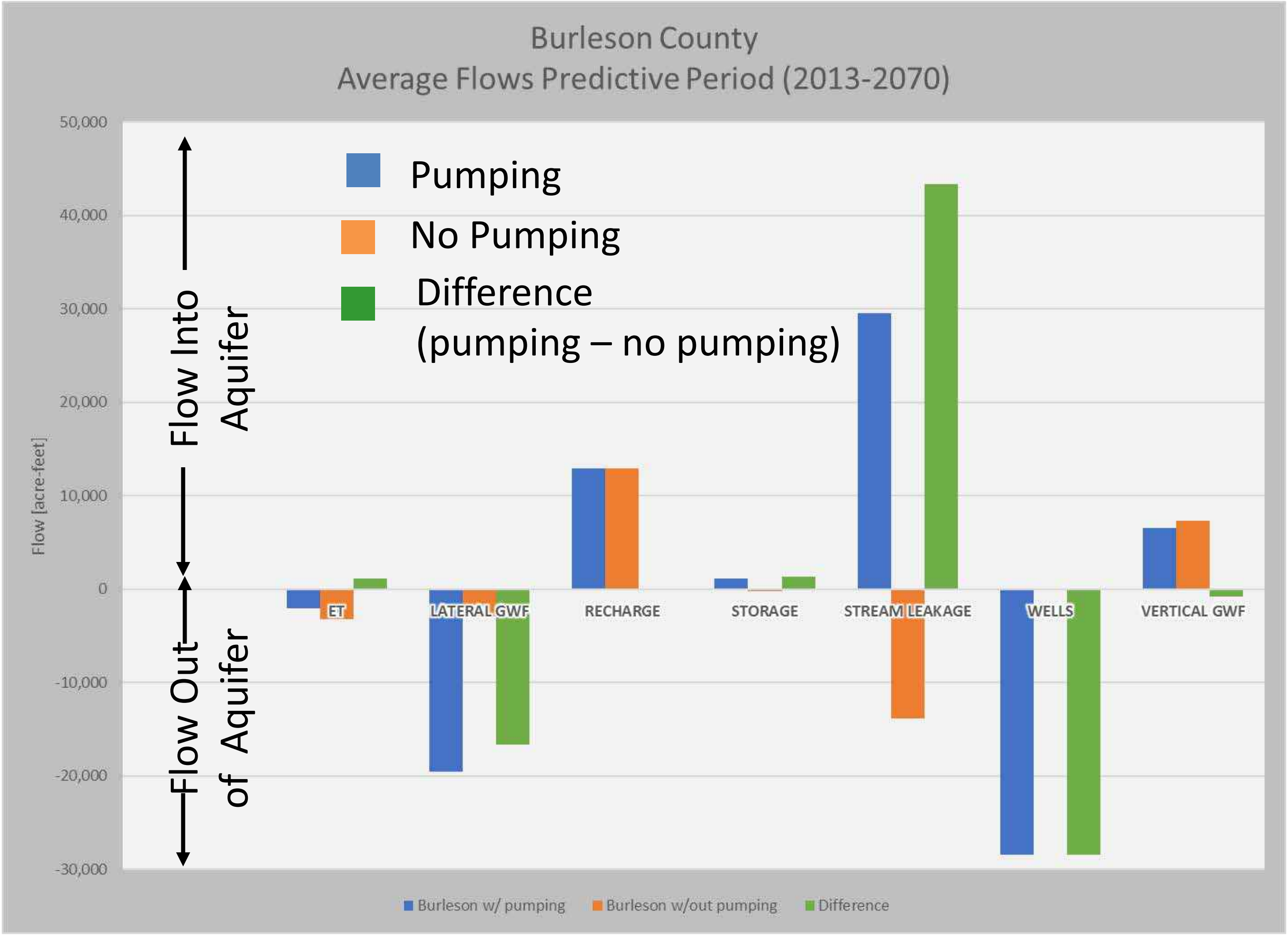
- San Saba River
  - Complaint to TCEQ regarding water rights
  - TCEQ: response (9/07/2015) "the on-site investigation, it was concluded that the water obtained from the water wells located at the WR Kniffen Orchard is underflow of the San Saba River and is therefore state water."

- Texas 2013 of New Mexico Violation of Rio Grande Compact
  - Issue: "Texas is deprived of water apportioned to it in the Compact because New Mexico has 2 authorized and permitted wells that have been developed near the Rio Grande in New Mexico. These wells (estimated at over 3,000) pump as much as 270,000 acre-feet of water annually. In addition, New Mexico has permitted wells that would facilitate water use, which in the future will likely significantly exceed these amounts. The pumping has both a direct and indirect effect on Texas' ability to obtain the water the Compact apportioned to it."
  - Status: United States Supreme Court

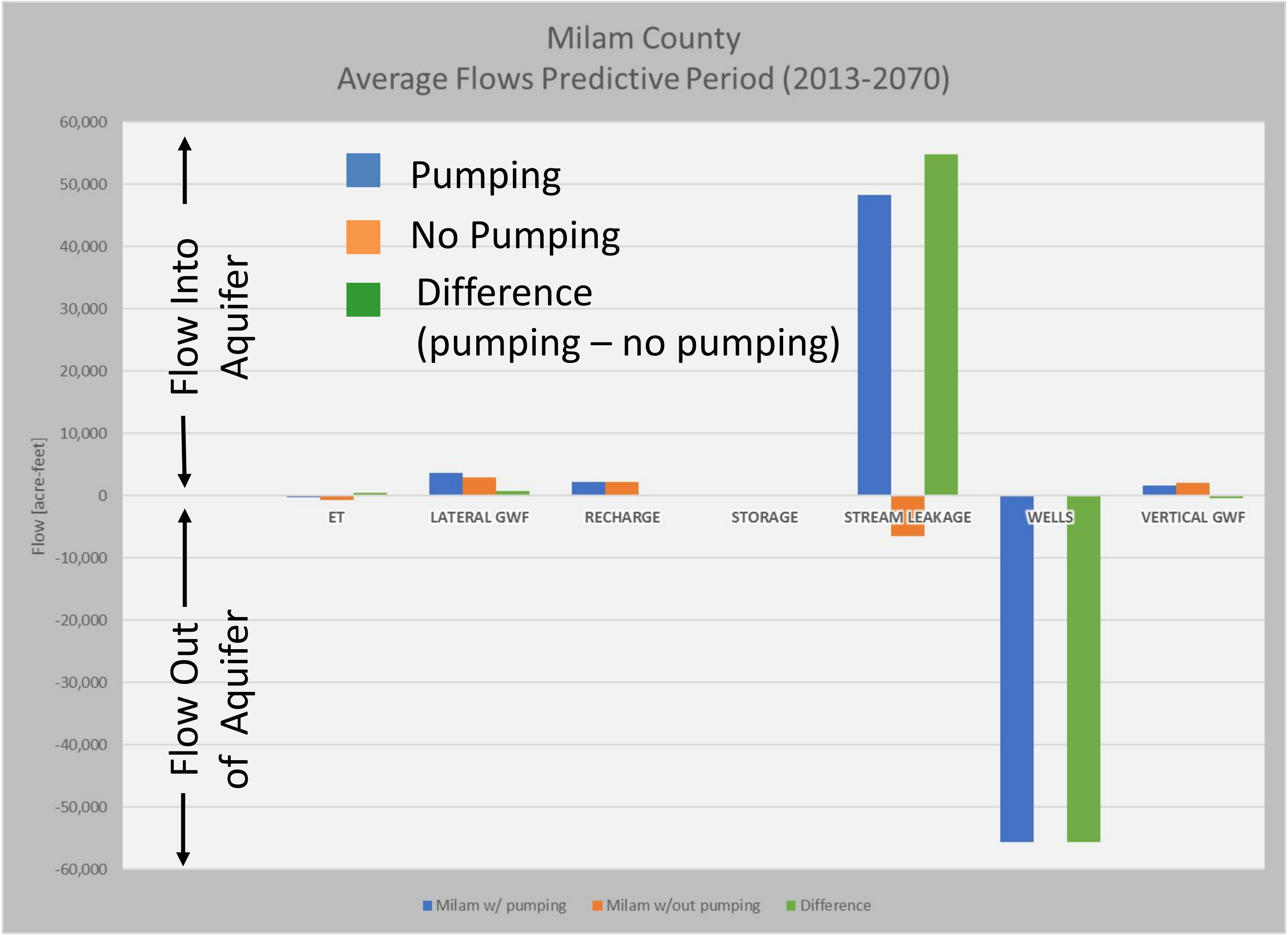
# Surface-Groundwater Interaction: Recent Reports

- TWDB Report (2016) on Contributory Aquifers to Streams
- TWDB Report (2017) on Assessment of SW-GW Interaction for Colorado River and Proposed Field Studies
  - Bank storage is important process that complicates analysis of SW-GW interaction
  - Proposed field studies to investigate bank storage and quantify SW-GW interaction
- TWDB Brazos River Alluvium GAM (2016) and GMA 12 MAGs (2017)
  - Water budgets for Brazos River Alluvium Aquifer
  - MAGs for POSGCD and BVGCD

# Water Budget for Brazos River Alluvium for MAG Run



# Water Budget for Brazos River Alluvium for MAG Run



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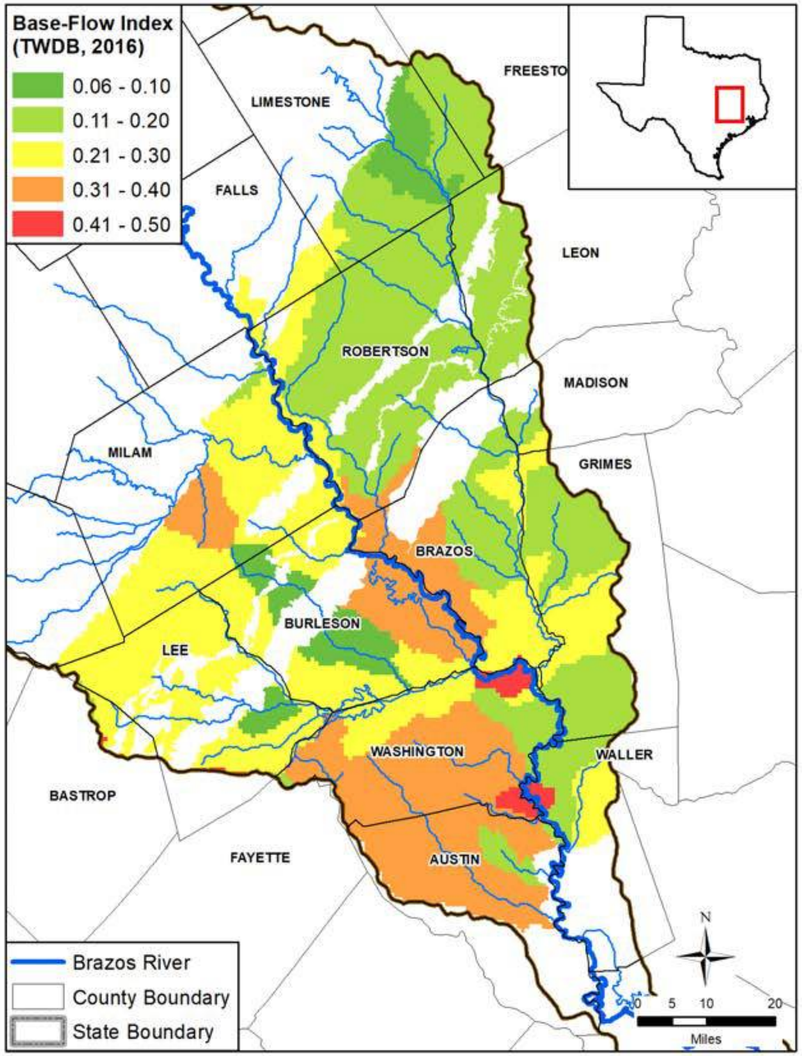
# TWDB Report On Contributory Aquifers

$$BFI = \frac{V_b}{V_a}$$

$BFI$ = baseflow index

$V_b$ = volume of water calculated as baseflow

$V_a$ = total volume of streamflow



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# Proposed Surface-Groundwater Interaction Project

- Focus is Brazos River
  - Desktop Study: Reanalyze USGS Brazos River Gain-Loss Study & Model Bank Flow
  - Field Study:  Joint field work with BVGCD & USGS
- Objective
  - Reanalyze concept of underflow with consideration of bank flow
  - Collect chemistry and water level data to quantify SW-GW exchange (follow TWDB field design)
  - Work with TCEQ on moving forward with managing pumping in Brazos River Alluvium

# Surface-Groundwater Interaction: Proposed Tasks

- Desk top Study
  - Literature review on bank flow
  - Enhance BRAA GAM or Updated QCSP GAM to model bank flow
- Field Study
  - Instrument wells and gages to measure water levels and chemistry to determine if flow and chemical signature agree
  - Install pairs of river gages and wells for improved data to test SW-GW models
  - Develop possible test facility to promote research by universities (including A&M) and state agencies (including TWDB)


Questions ?

# Aquifer Storage and Recovery

- Water Resource Benefits
  - Capture river water that would be lost to ocean
  - Increase firm yield of surface water right
  - Long-term aquifer recharge
  - Manage drawdown of specific management zones
- Economic and Operational Benefit
  - Small footprint
  - Low cost relative to traditional water supply and water supply storage options
- Proven Technology and Performance
  - About 450 operating ASR well nationwide
  - Very few failures

# Schematic of TWDB Proposed Field Study