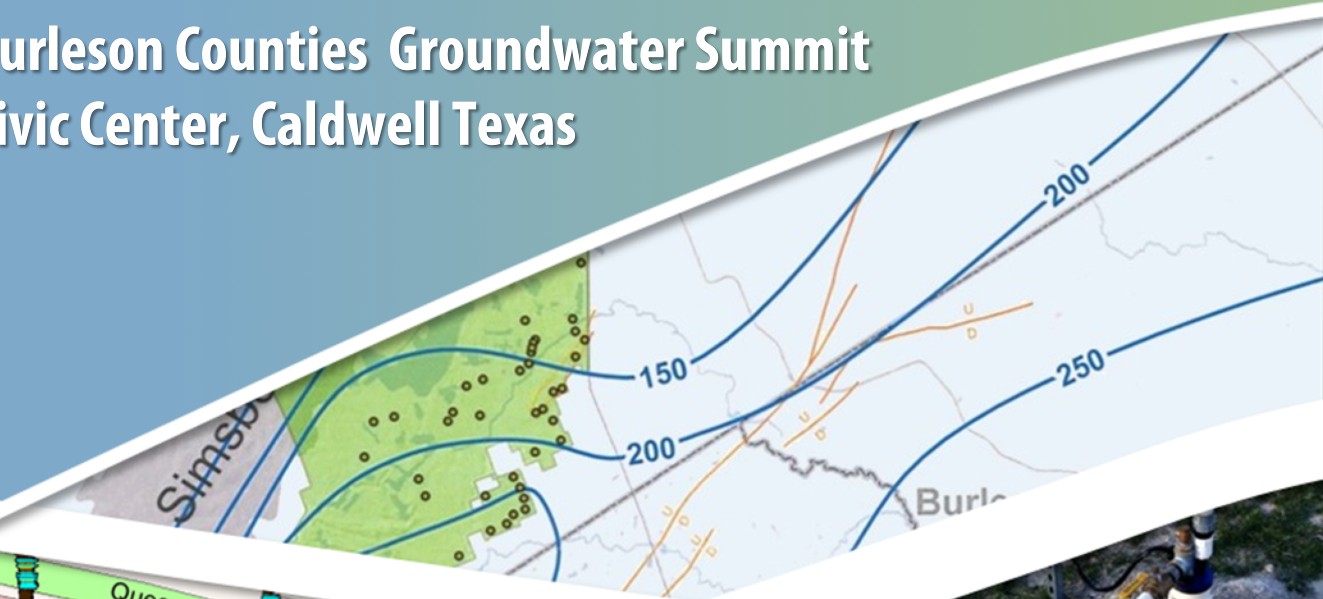
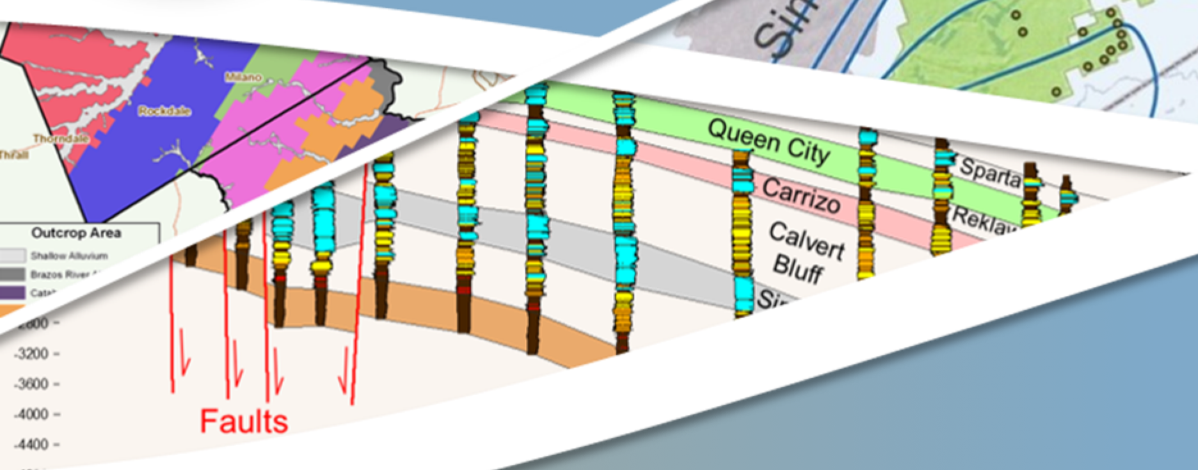
Update to the Carrizo-Wilcox Groundwater Availability Model (GAM)

Presented : Milam & Burleson Counties Groundwater Summit
Caldwell Civic Center, Caldwell Texas





Presented By:
Toya Jones
Steve Young
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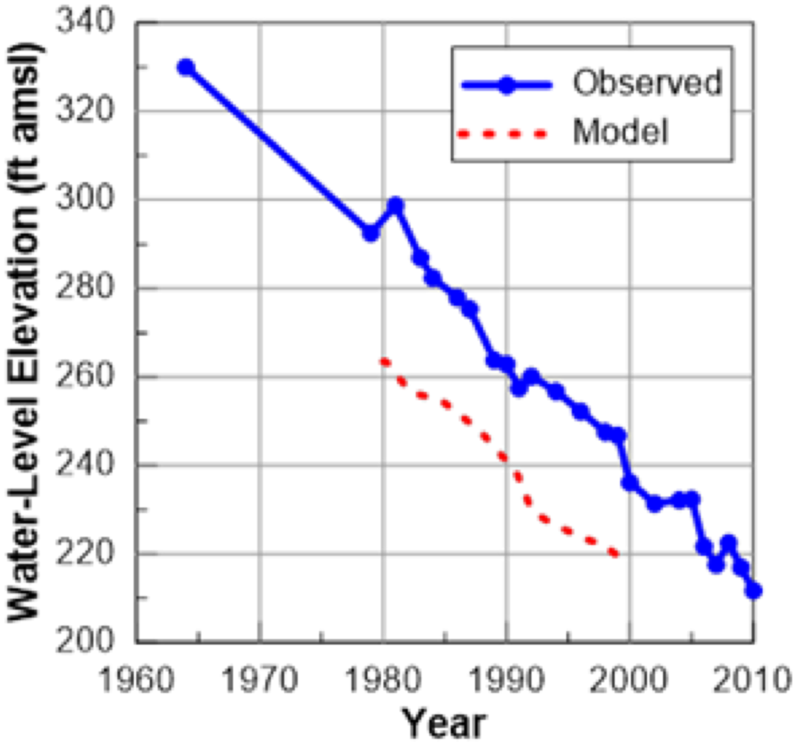
August 15, 2018

Outline

- **Data**
  - Geologic Fault
  - Aquifer Pumping Tests
  - Historical Pumping
- **Groundwater Model**
  - What is a Model and How it is Used
  - Construction
  - Calibration
  - Uses

Reasons for Model Update

- Model assessment
  - Data gaps exist with defining faults and aquifer properties
  - Did not adequately match water levels around faults and rivers
  - The period for matching historical water levels was only from 1980 to 2000



- Updating model to incorporate more data and information provides an improved planning tool

How Model was Improved

- Conducted detailed investigation of fault locations and behavior
- Updated aquifer properties using recent aquifer pumping tests
- Increased model time period for comparison to observed water levels
  - Required collection of historical pumping date for a longer time period
- Enhanced model predictive capabilities near streams
- Enhanced representation of recharge

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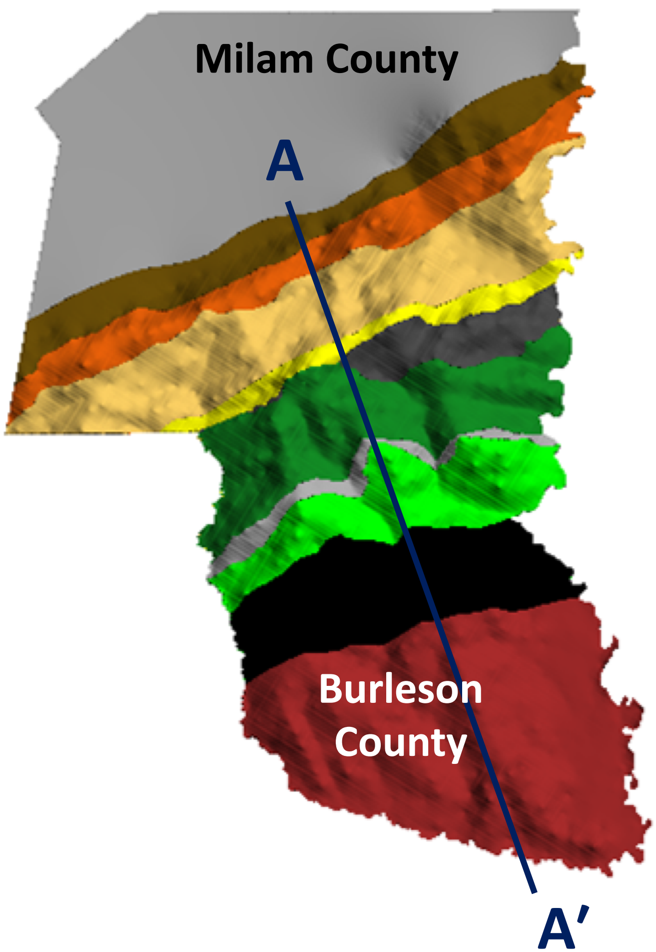
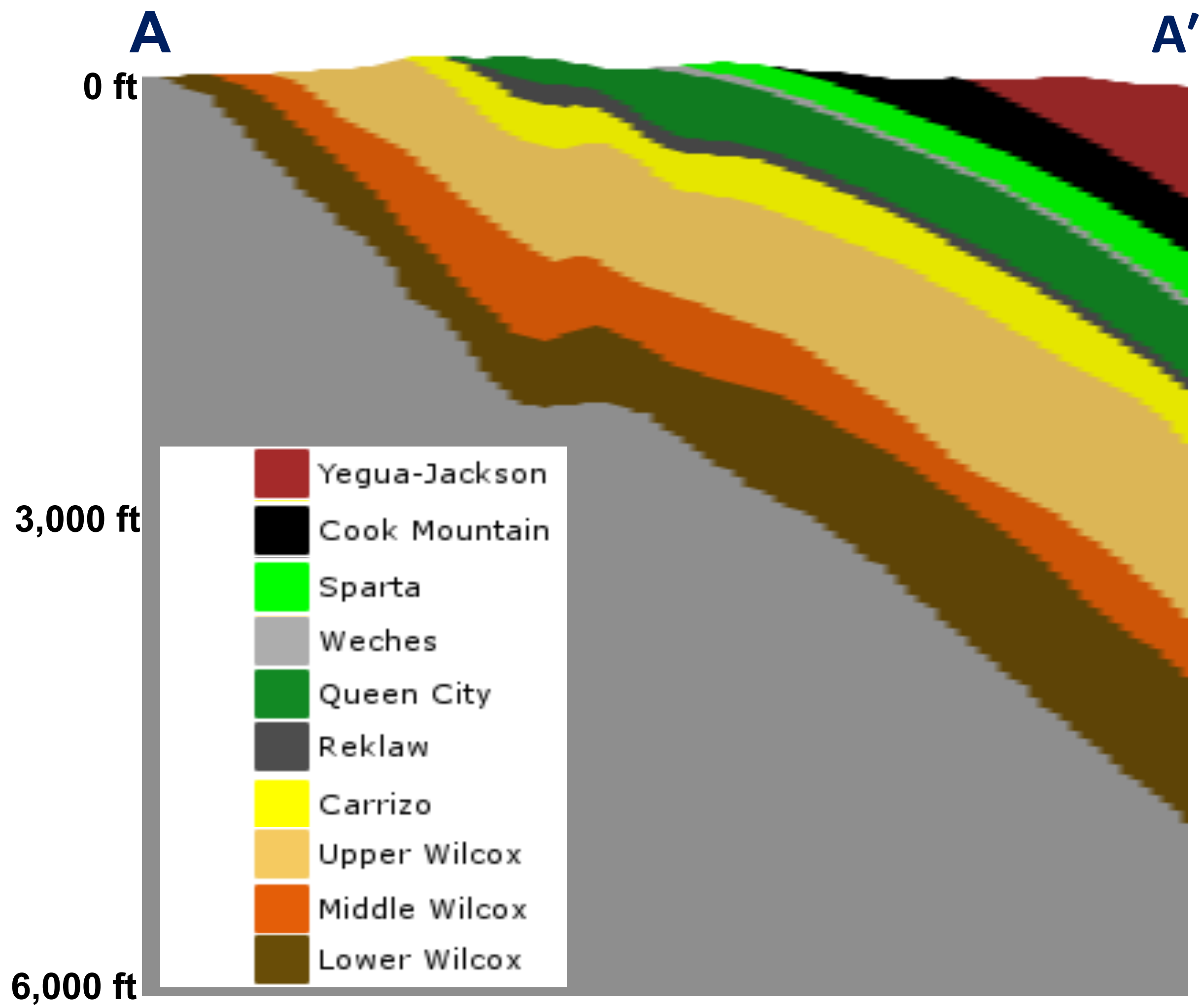
POSGCD Aquifers/Formations

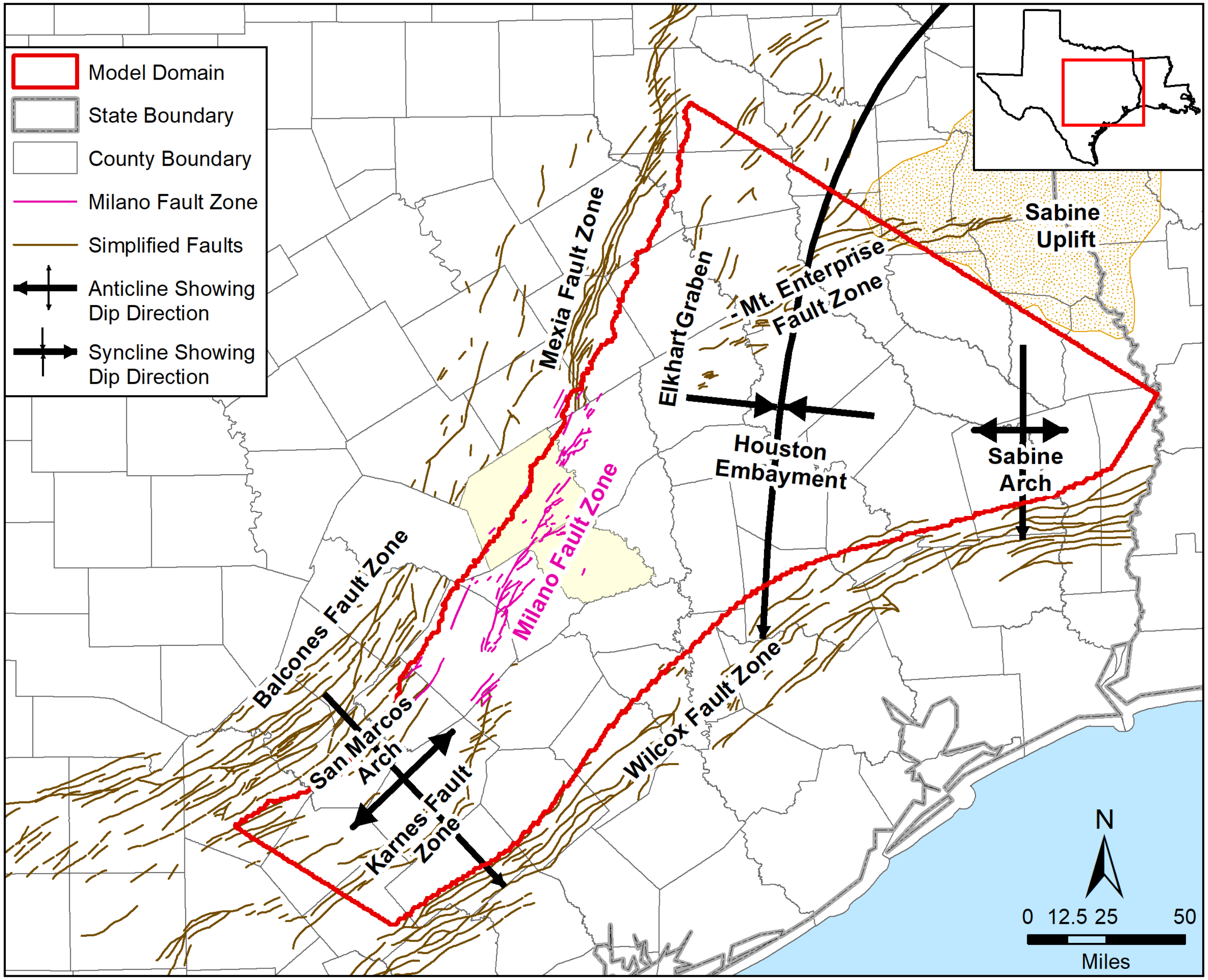
Aerial View



Vertical Cross-Section View Looking From Side



Fault Zone of Interest



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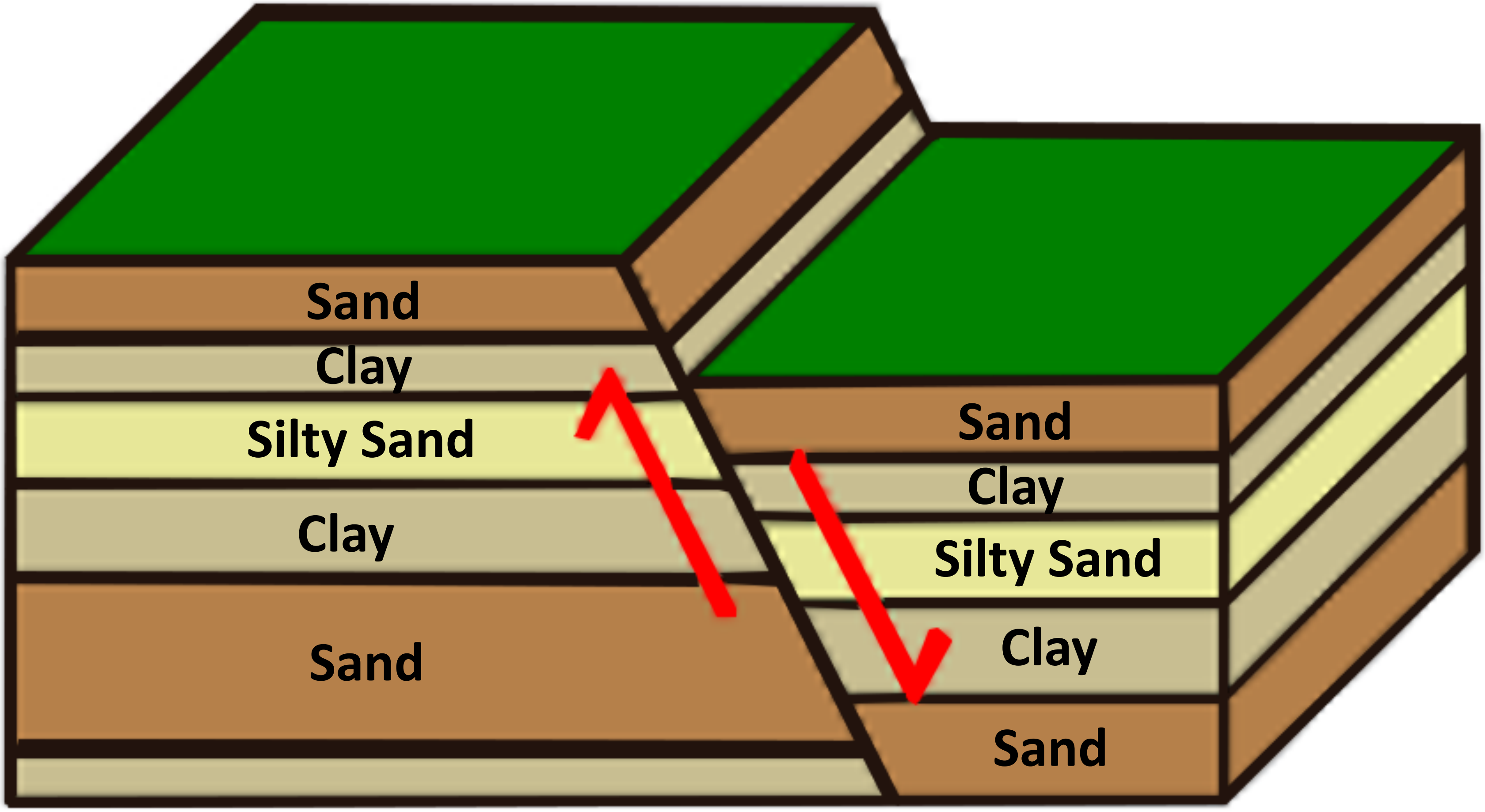
Normal Fault



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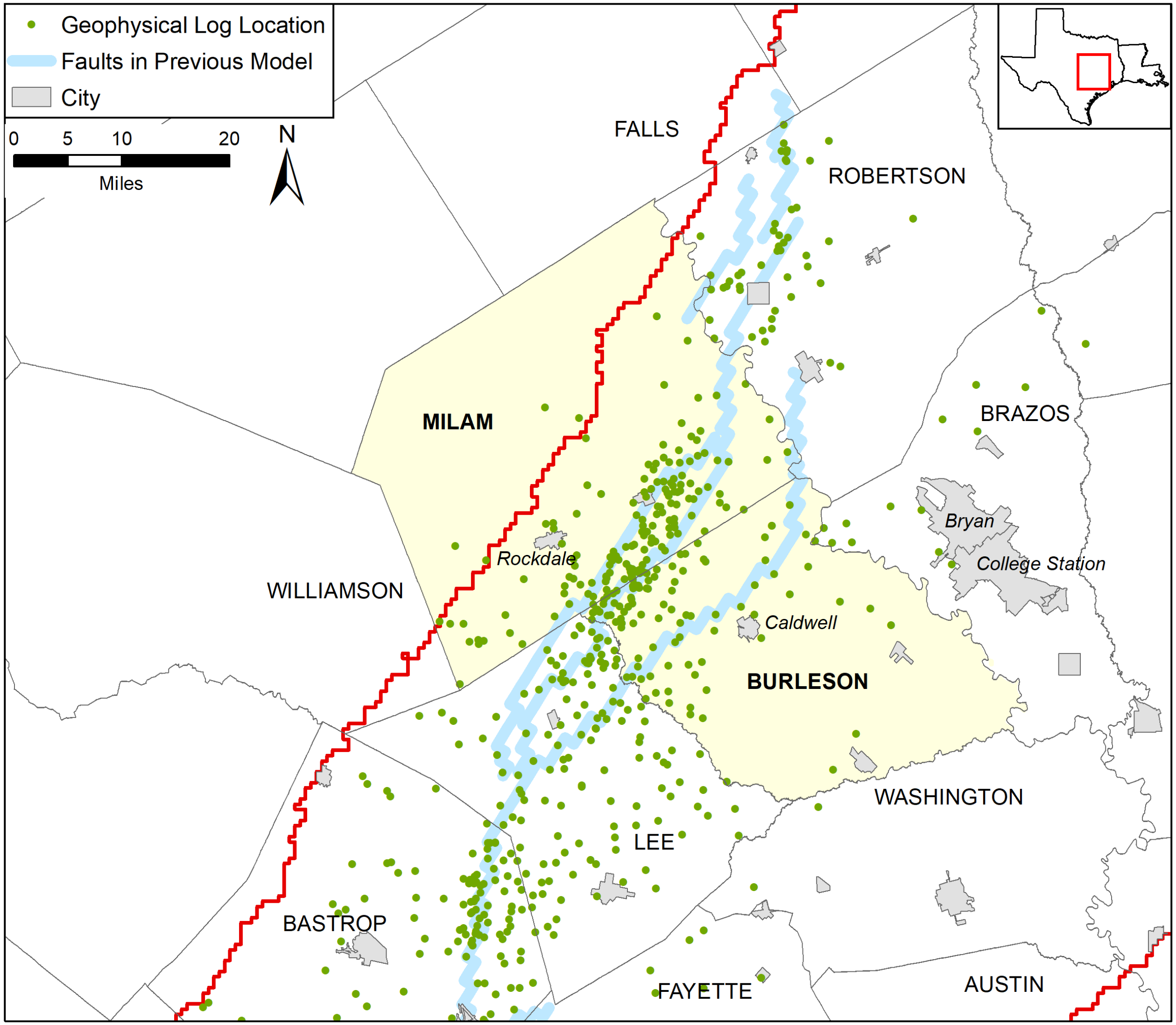
Faults in Previous Model



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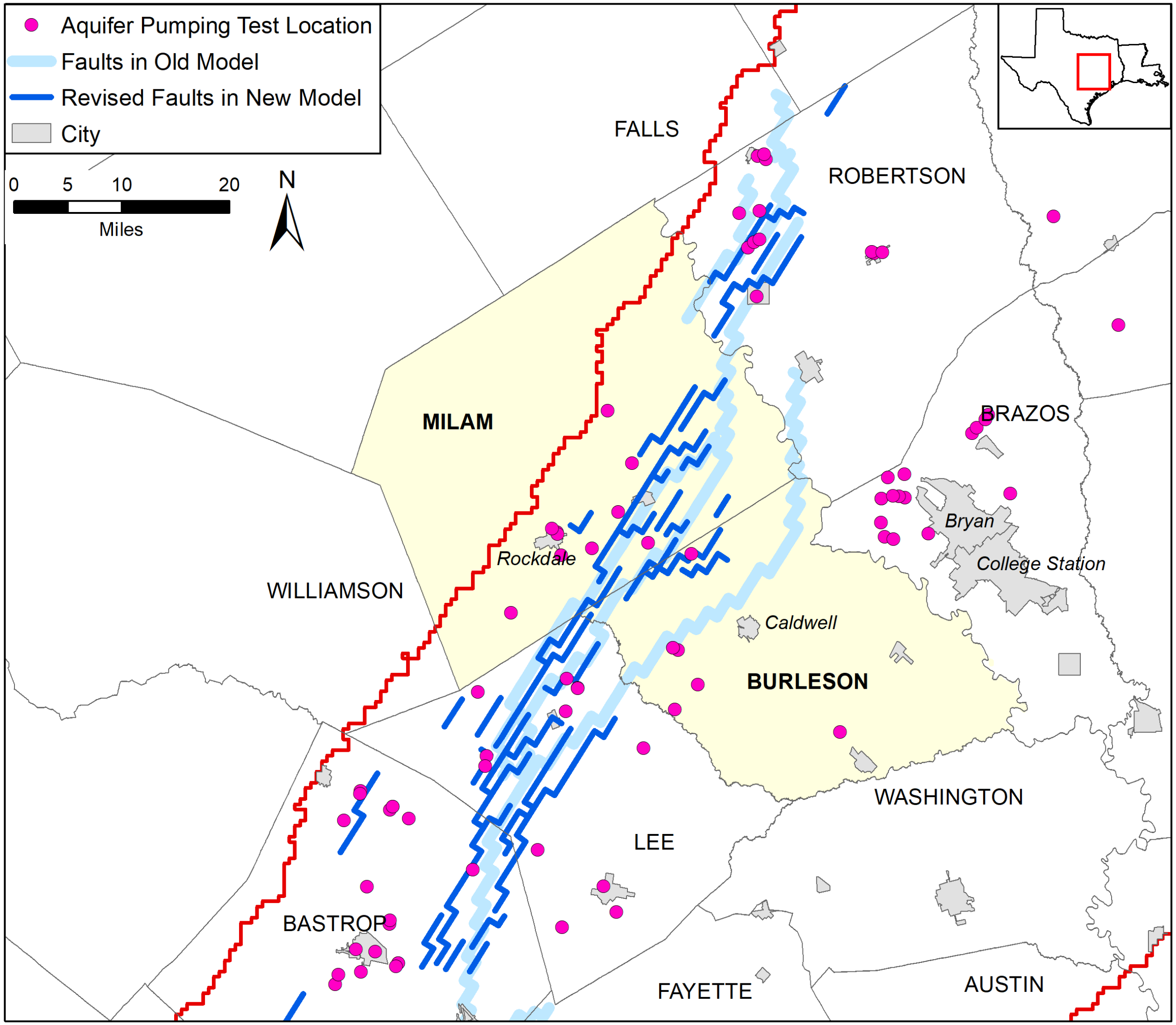
Location of Aquifer Pumping Tests Used for Fault Study



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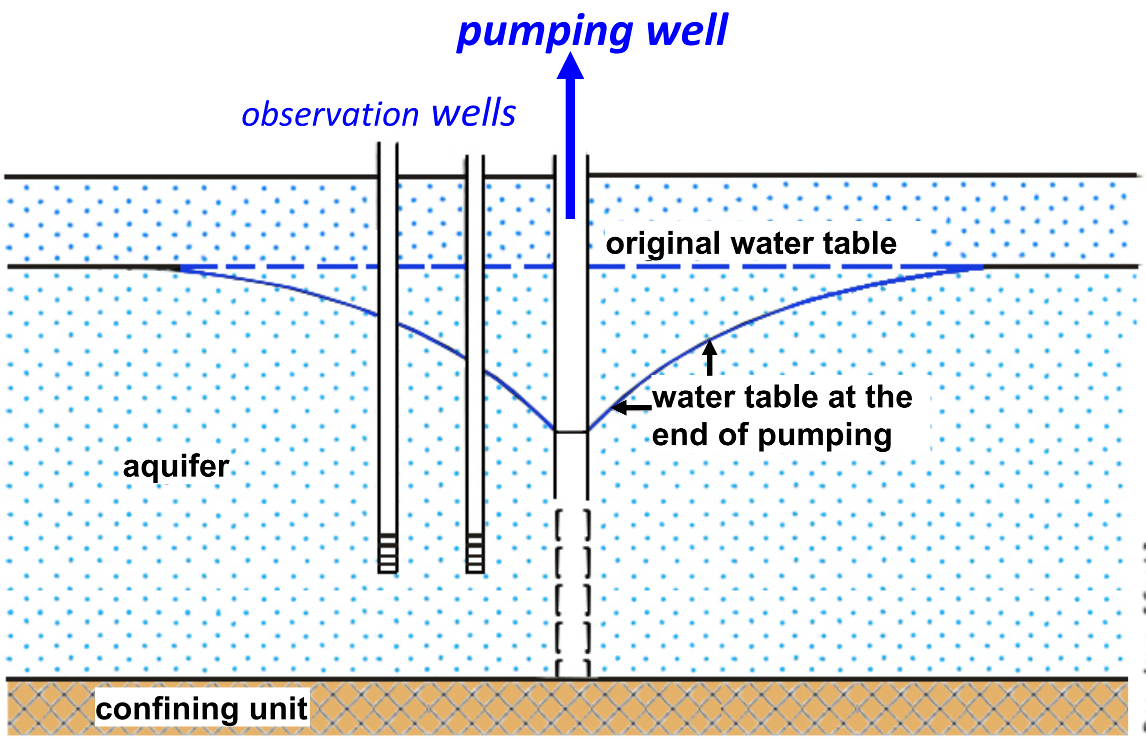
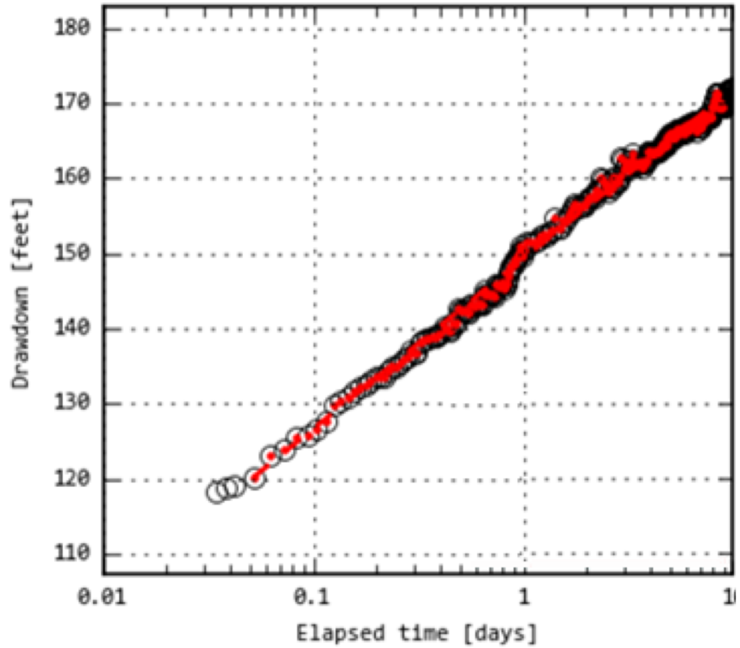
Pumping Drawdown



No Fault

Actual Pumping Test Time-Drawdown Response



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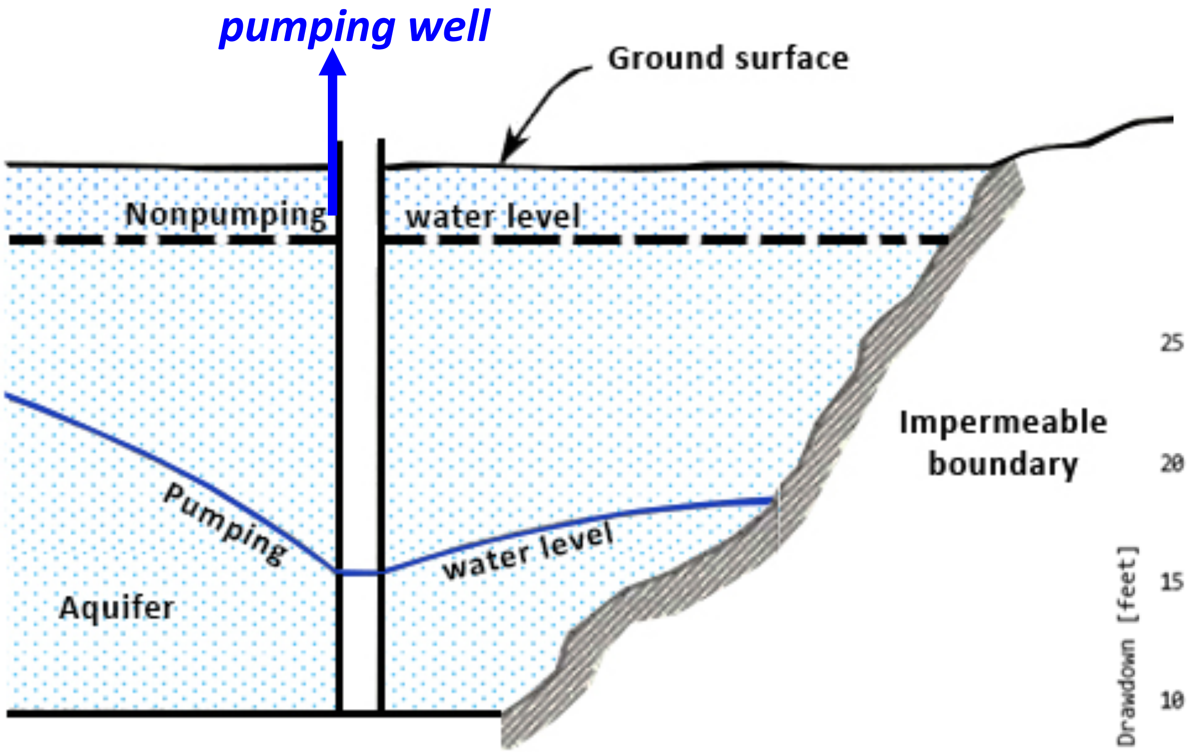
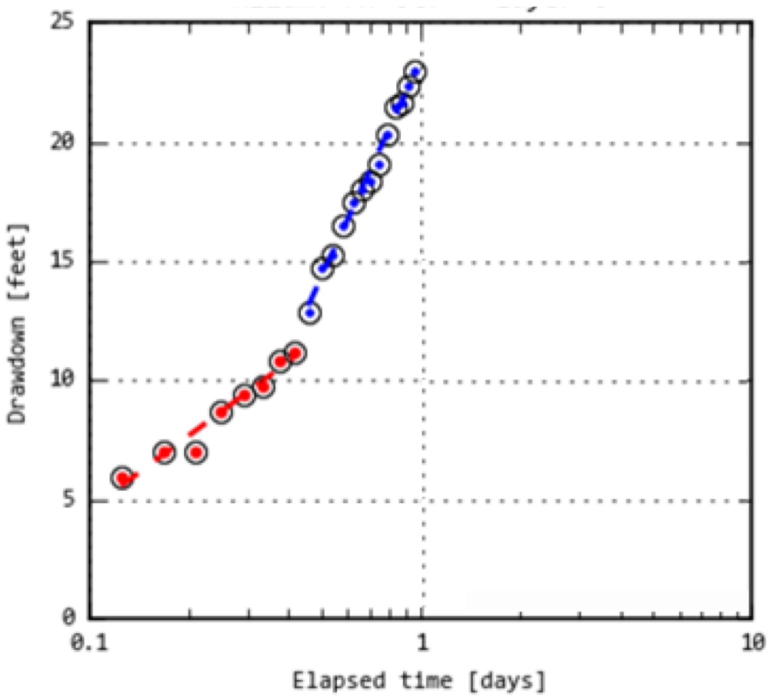
Pumping Drawdown



Fault Present

Actual Pumping Test Time-Drawdown Response



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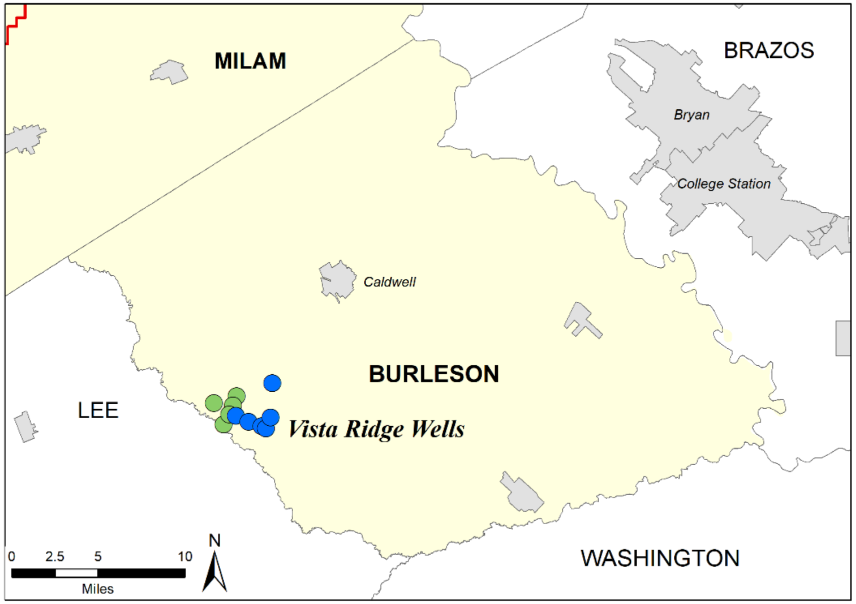
Vista Ridge Pumping Tests

Well	Aquifer	Estimated Transmissivity (gpd per foot)
CW-2	Carrizo	25,600
CW-3	Carrizo	17,700
CW-5	Carrizo	25,000
CW-7	Carrizo	28,000
CW-9	Carrizo	23,000
PW-10	Simsboro	127,000
PW-11	Simsboro	117,000
PW-13	Simsboro	137,000
PW-15	Simsboro	115,000
PW-16	Simsboro	100,000
PW-17	Simsboro	128,000



- **Pumping 100 gpm for 1 year**
  - 57 ft of drawdown in Carrizo
  - 15 ft of drawdown in Simsboro
- **Pumping 1,000 gpm for 1 year**
  - 570 ft of drawdown in Carrizo
  - 150 ft of drawdown in Simsboro

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Information from Pumping Tests

- Data
  - Presence or absence of faults
  - Transmissivity of aquifers
- Importance
  - Inaccurate representation of faults in models results in
    - Under prediction of drawdown if missing faults
    - Over prediction of drawdown if include faults that don't exists
  - Assignment of hydraulic properties representative of aquifer in model
    - Incorrect representation leads to incorrect predictions of drawdown

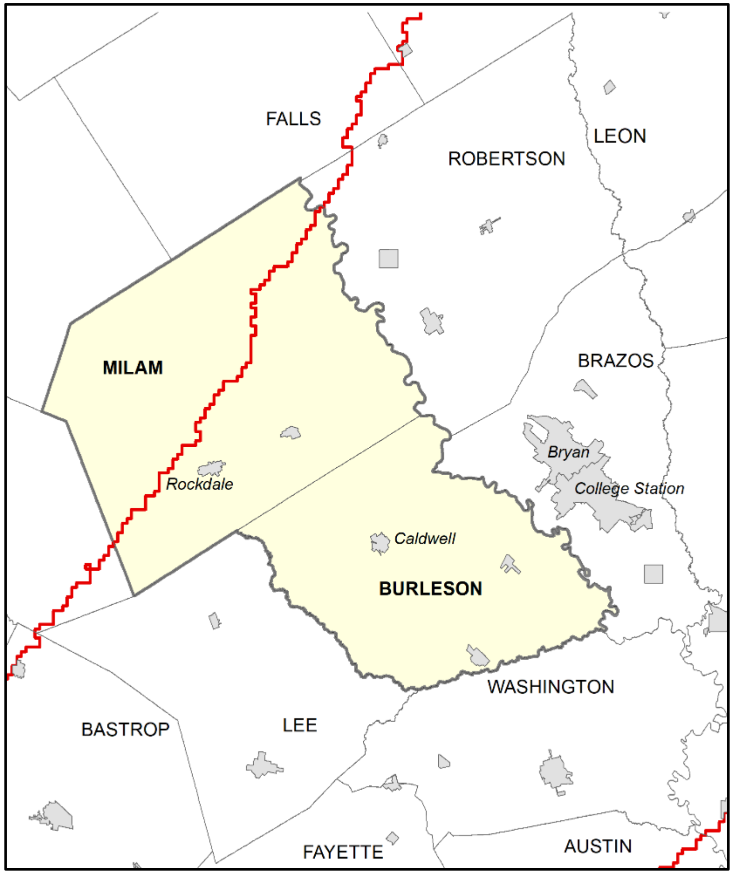
Pumping Introduction

- Unit of pumping is acre-feet per year or AFY
- AFY equals
  - The amount of water to cover 1 acre of land with water 1 foot deep
  - 325,851 gallons
  - Annual water use for 6 people in a large Texas city **(includes ALL MUNICIPAL USES)**

* 2016 Region C Water Plan

Reason for Historical Pumping and Pumping Plots

- Previous model simulated 20 years
  - 1980 through 1999
- Updated model simulates 80 years
  - 1930 through 2010
- Pumping needed for all 80 years
- Plots show the total pumping calculated by summing the pumping for all entities for that year



* 2016 Region C Water Plan

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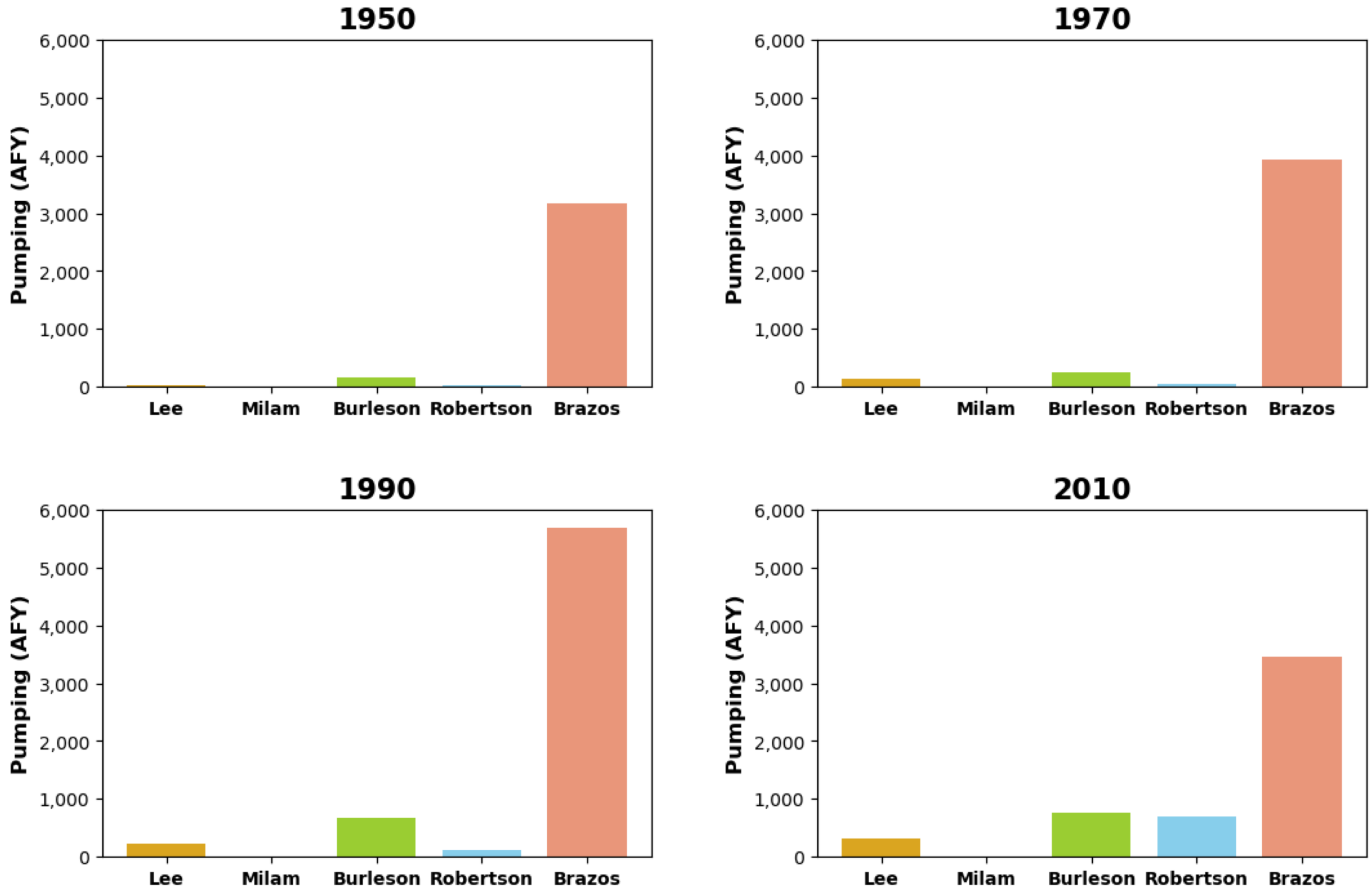
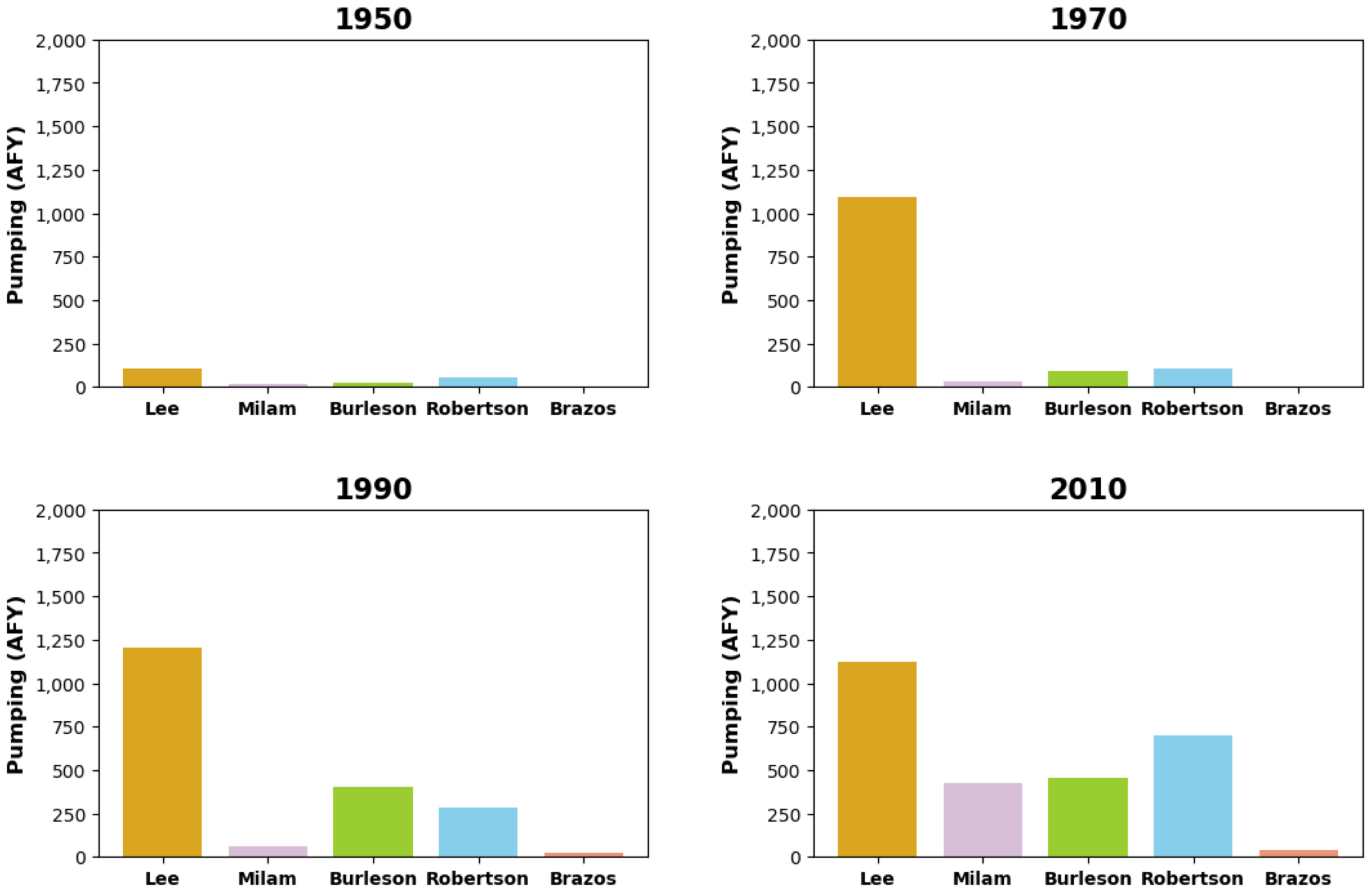
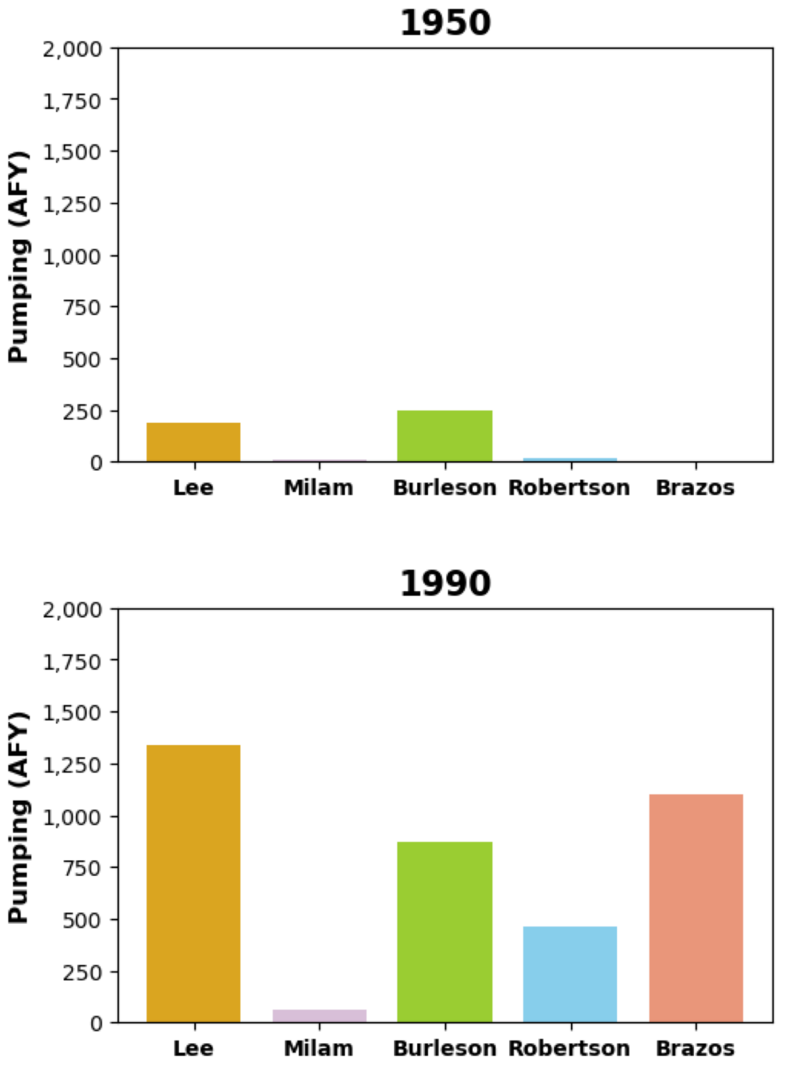
Historical Pumping from Sparta Aquifer



Historical Pumping from Queen City Aquifer



Historical Pumping from Carrizo Aquifer



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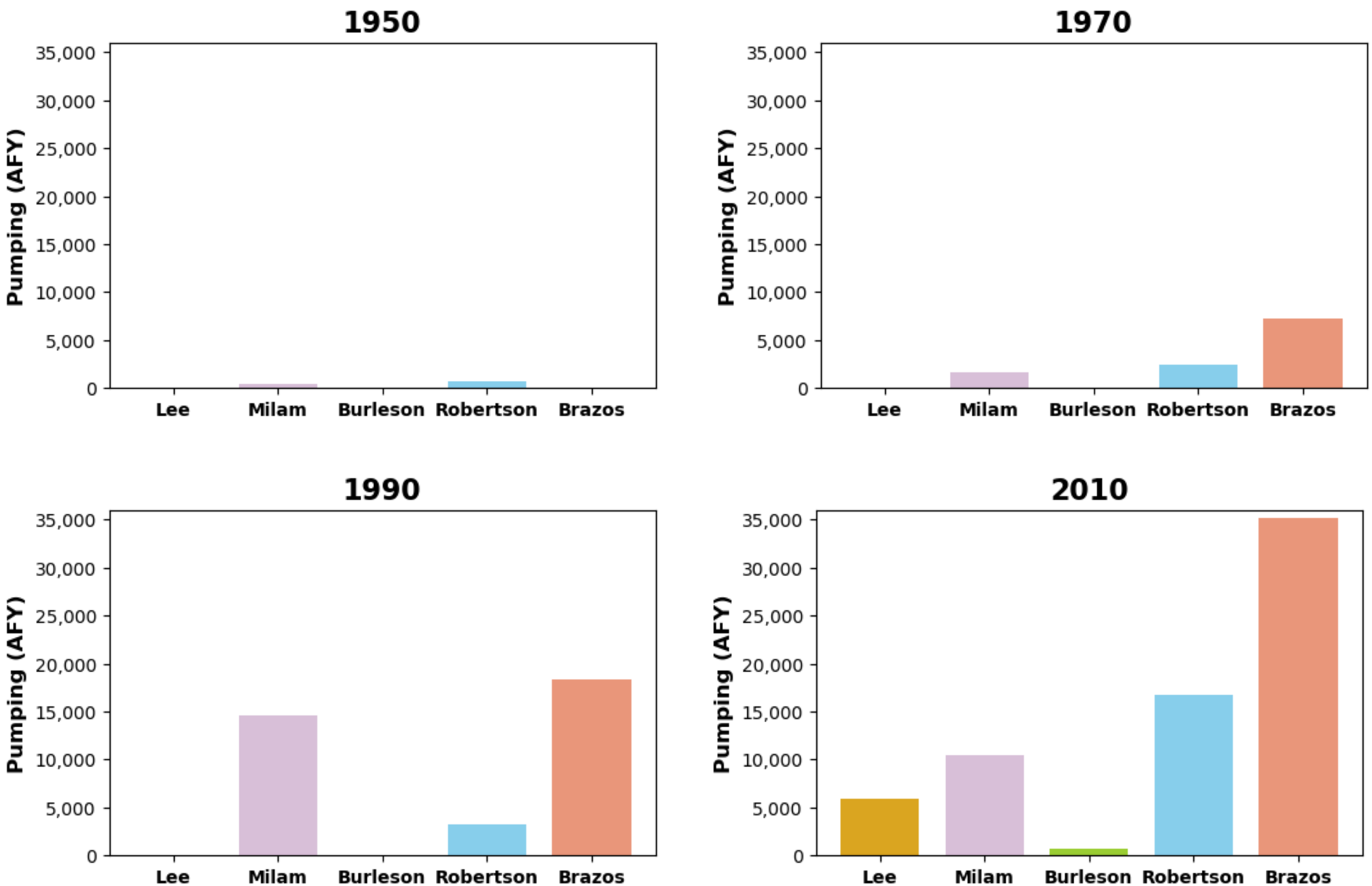
Historical Pumping from Simsboro Aquifer



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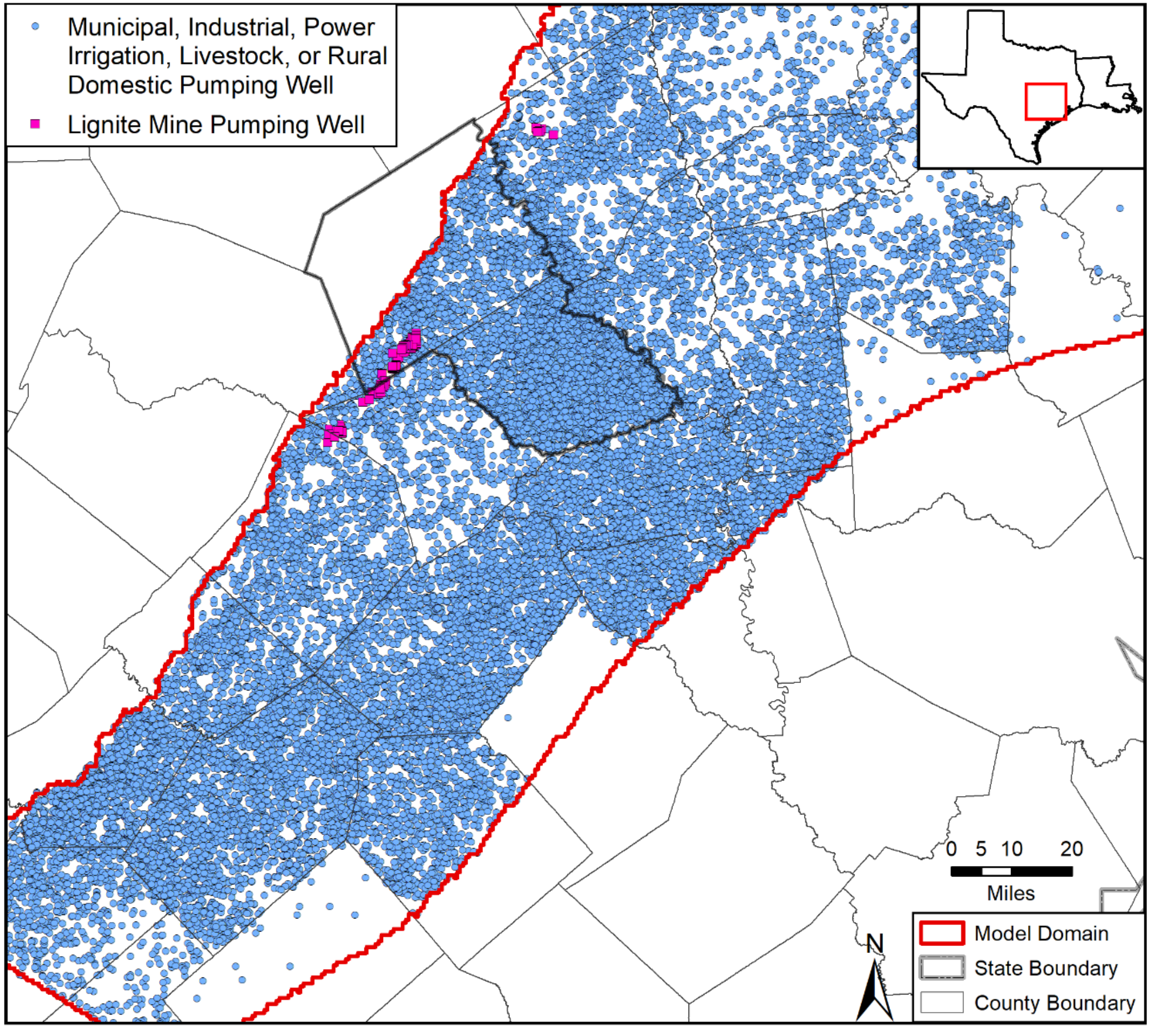
Pumping Distribution Is Based on Actual Well Locations

- Pumping is placed into the model based on well location (x,y) and the well depth
- Accurate placement of pumping is needed to test accuracy of model's prediction
- 44,000 wells located and 7,000 are in POSGCD



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Summary of Updates to Model

- Fault locations and characteristics
- Hydraulic properties
- Historical pumping
- Wells
  - Assignment to model layer
  - Assignment of pumping
- Recharge
  - How much precipitation reaches the groundwater
- Interaction between groundwater and surface water

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Development of Groundwater Availability Model (GAM) for Central Portion of Sparta, Queen City, and Carrizo-Wilcox Aquifer

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TWDB Groundwater Availability Program 1999 to Present

- Administered by the Texas Water Development Board (TWDB) and developed using standardized methods
- Purpose: **Use models to support development of groundwater management plans (GCD, etc..) inform development of desired future conditions, and estimate modeled available groundwater in support of managing groundwater resources in Texas**

  (modified from TWDB Sunset Self-Evaluation Report, 2009)
- TWDB has developed Groundwater Availability Models (GAMs) for 9 Major and 13 Minor Aquifers

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GAMs are "Living Tools"

- GAMs are updated periodically to incorporate new data as it becomes available
- "Living Tools" is a benefit that promotes continual data collection and analysis
- POSGCD Required to Use Four GAMs
  - Brazos River Alluvium GAM
  - Northern Trinity and Woodbine GAM
  - Yegua-Jackson GAM
  - Central Portion of Sparta, Queen City, and Carrizo-Wilcox GAM

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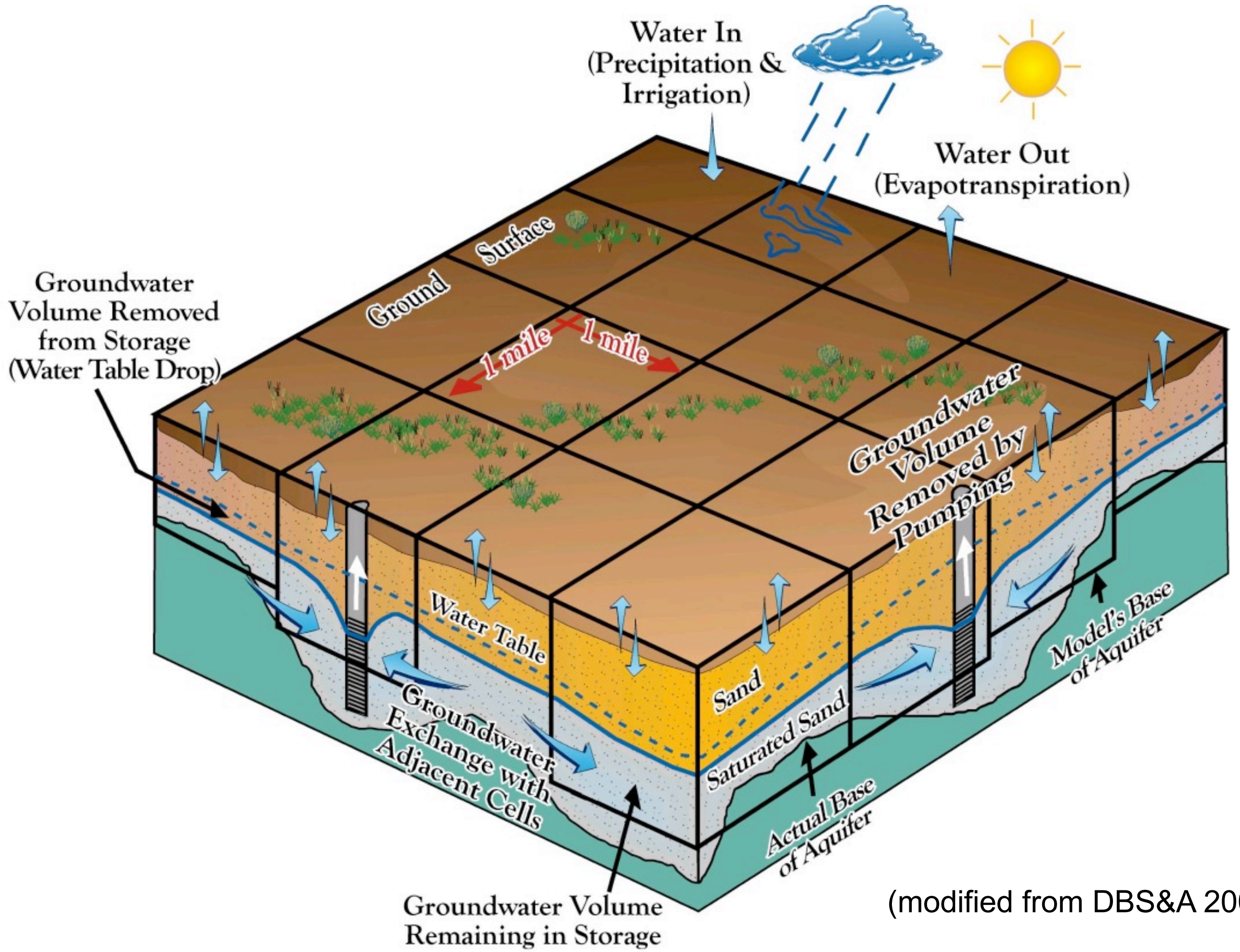
Participating Entities with Update of Central Sparta, Queen City and Carrizo-Wilcox GAM

- Texas Water Development Board
- Post Oak Savannah GCD
- Brazos Valley GCD
- Mid East Texas GCD
- Lost Pines GCD
- Lower Colorado River Authority
- Brazos River Authority
- Colorado & Lavaca Rivers and Matagorda & Lavaca Bays Basin and Bay Area Stakeholder Committee
- Environmental Stewardship

What is a Groundwater Availability Model

- Simplified Representation of Real System
- Consists of grids representing blocks of aquifer
- Flow equations link blocks together like an Excel Spreadsheet



(modified from DBS&A 2001)

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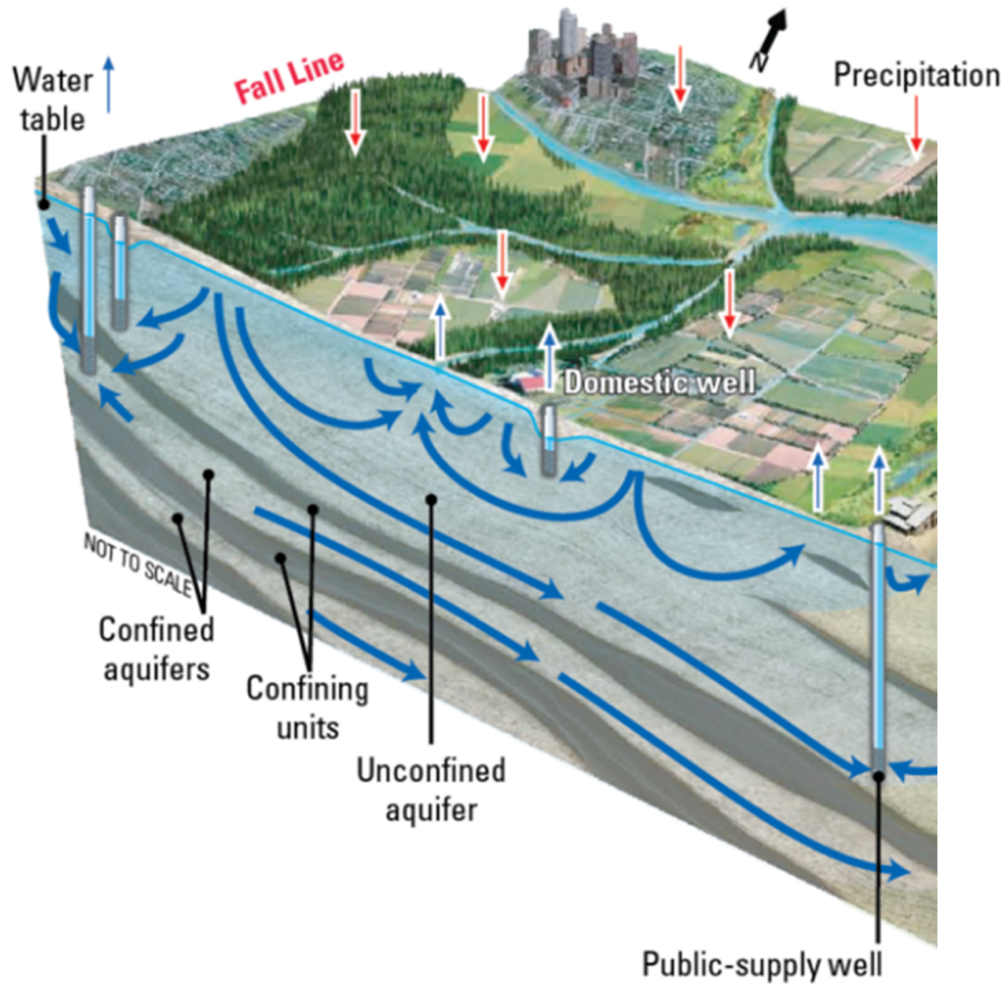
Component Required to Develop a GAM

- Conceptual Model
  - describes relationship and processes
- Data
  - aquifer properties, water level, flow rates
- Groundwater Numerical Code
  - equations that solves for flow and mass balances
- Model Construction and Calibration
  - size of aquifer blocks and methods used to fill data gaps

Schematic of Conceptual Model



Updates to Central Sparta, Queen City and Carrizo-Wilcox GAM

Component	Additional Information
Conceptual Model	Fault locations and types
	Recharge estimated from rainfall and surface geology
	Groundwater-surface water interaction
	Storage properties with depth and aquifer type
Data	Aquifer properties from pumping tests
	Historical pumping rates and locations
	Well locations
	Historical water levels
	Geophysical logs to check aquifer tops and bottoms
Groundwater Code	MODFLOW USG (2017) replaces MODFLOW96 (1996)
Model Construction and Calibration	Small grid cell sized near rivers
	Additional model layers
	Advance calibration software running on a supercomputer at TACC

→

Improved GAM Capability to Help Answer

1. How productive are the aquifers?
2. How much water is stored in the aquifers?
3. How much and how fast will pumping cause water levels to change in response to pumping?
4. How much do the aquifers interact with surface water?
5. How much do the aquifers interact with adjacent aquifers?
6. How will drought impact aquifer water levels and aquifer productivity?

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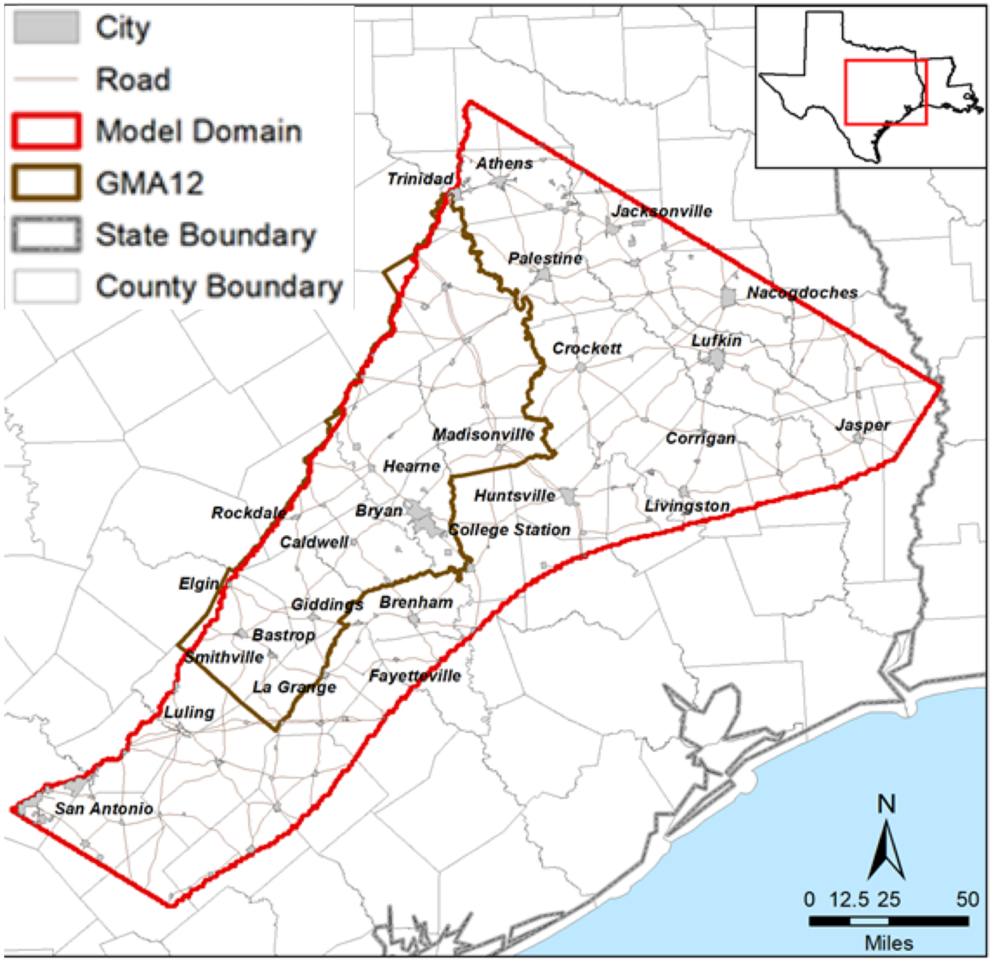
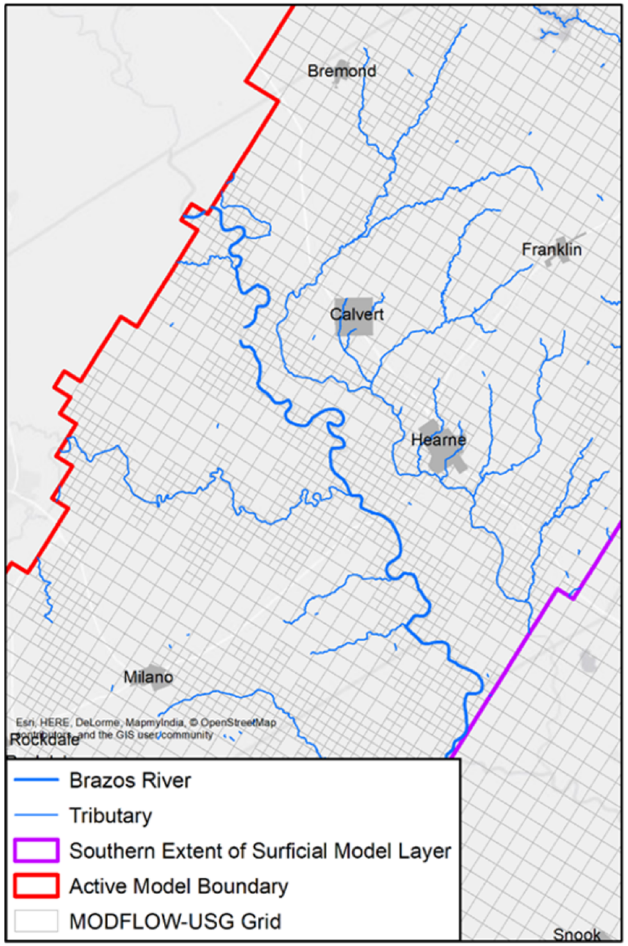
Model Construction

Areal Extent – no change

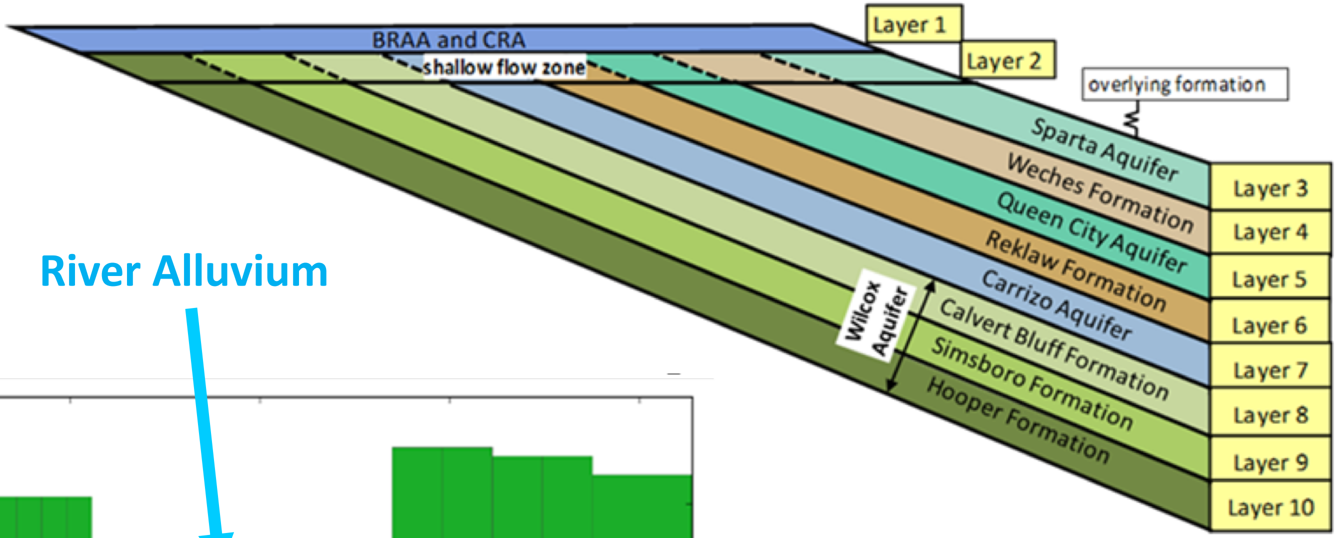


Grid cell Sizes – Smaller and refined around rivers



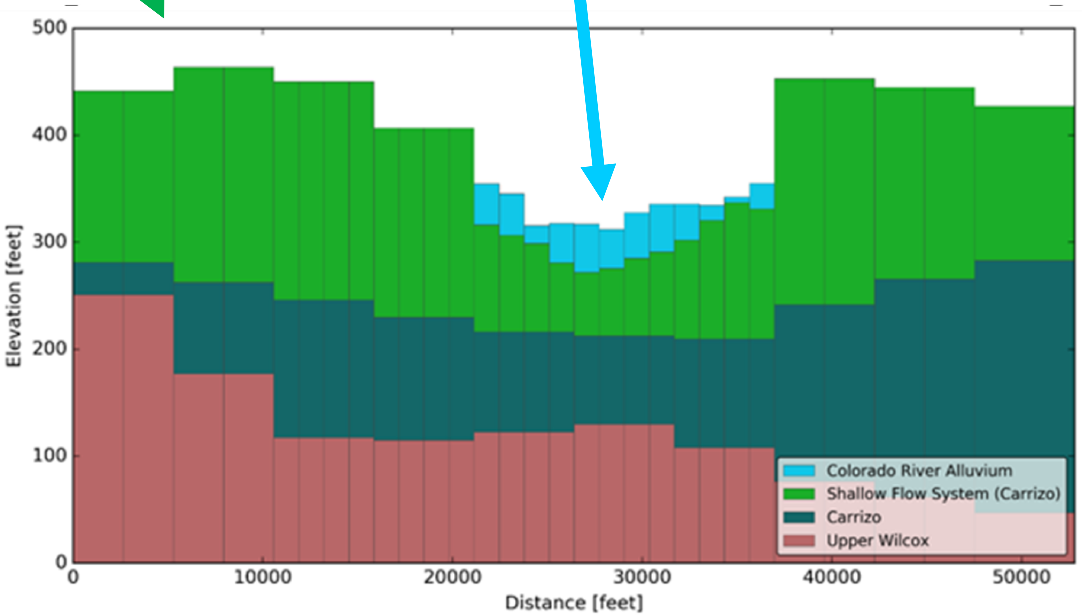
Model Construction (con't)

Vertical Layering– added two layers – river alluvium and a shallow groundwater flow zone



Shallow Flow Zone

River Alluvium



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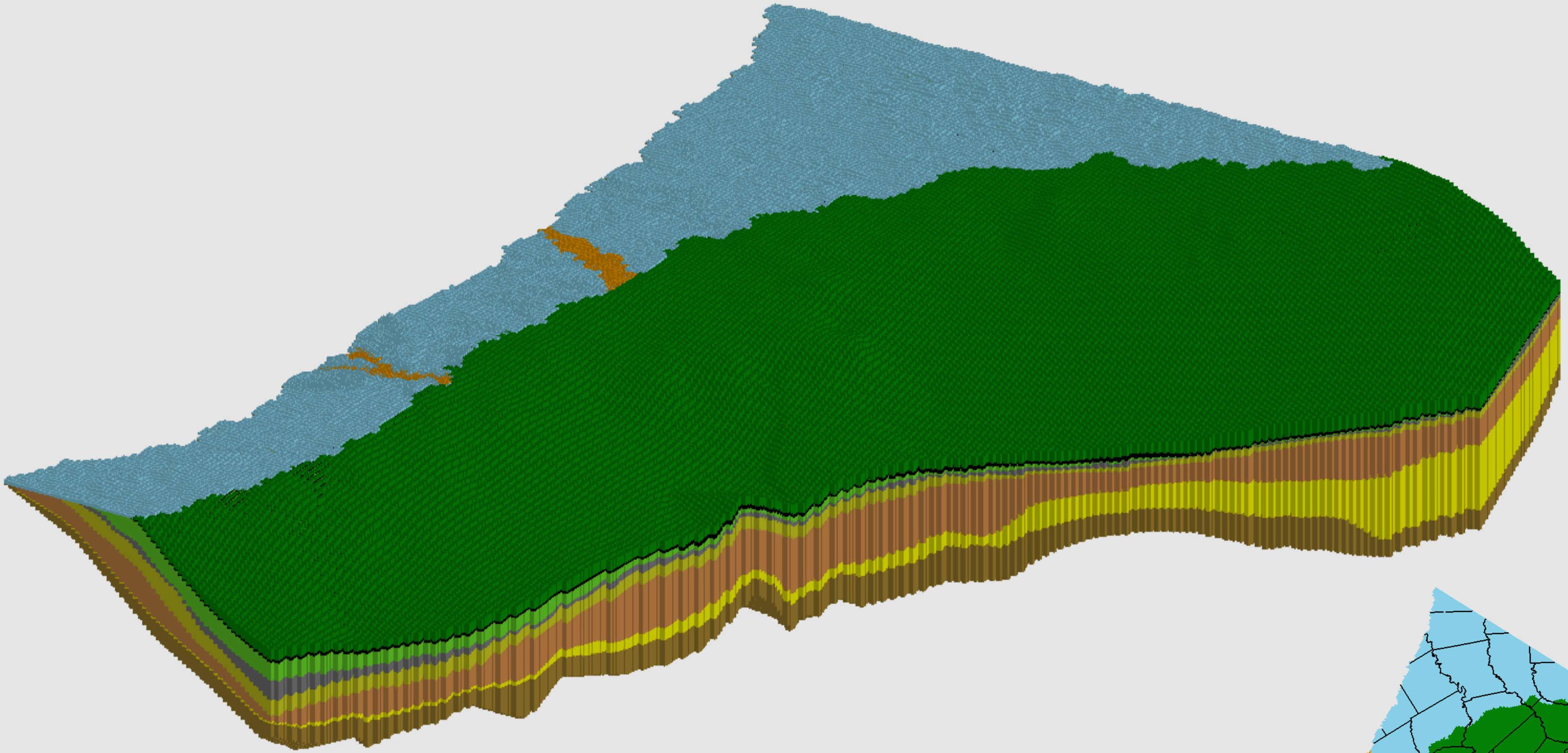
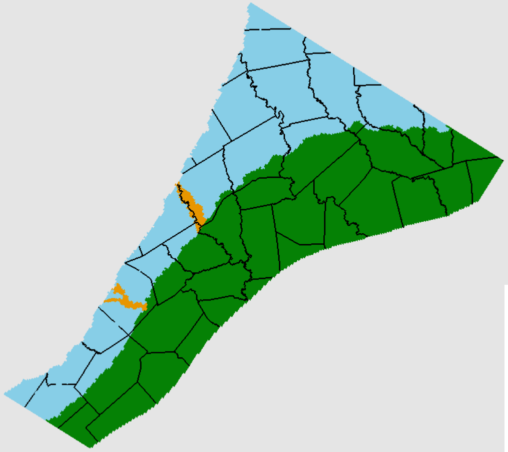
Three-Dimensional View





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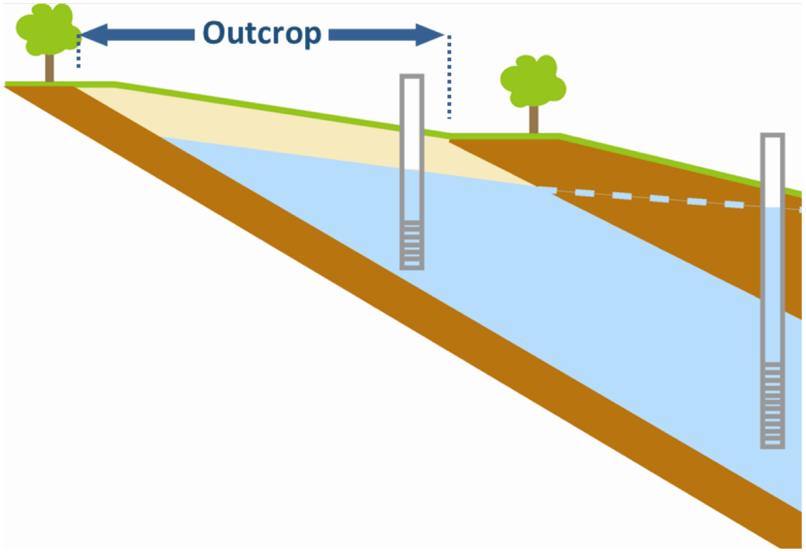
Changes to Recharge & Shallow Groundwater Flow

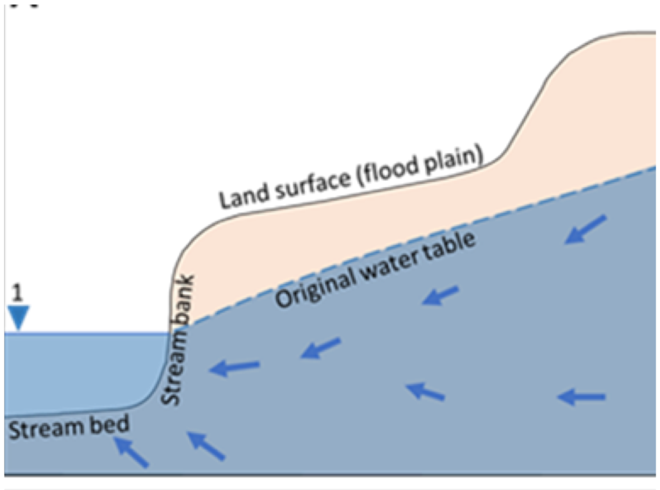
Recharge Rate about Doubled

- Recharge only occurs on outcrops
- Recharge Rate Increases with:
  - increased annual precipitation
  - decreased annual ET
  - Increased permeability (or percent sand) of formation



Groundwater Flux to Streams About Tripled

- When aquifer is full, primary outlet for groundwater discharge is surface water
- Addition of Shallow Model Layers Allows two Flow Zones to Coexist:
  - Shallow groundwater flow is controlled by topography
  - Deep groundwater flow is controlled location of large pumping wells



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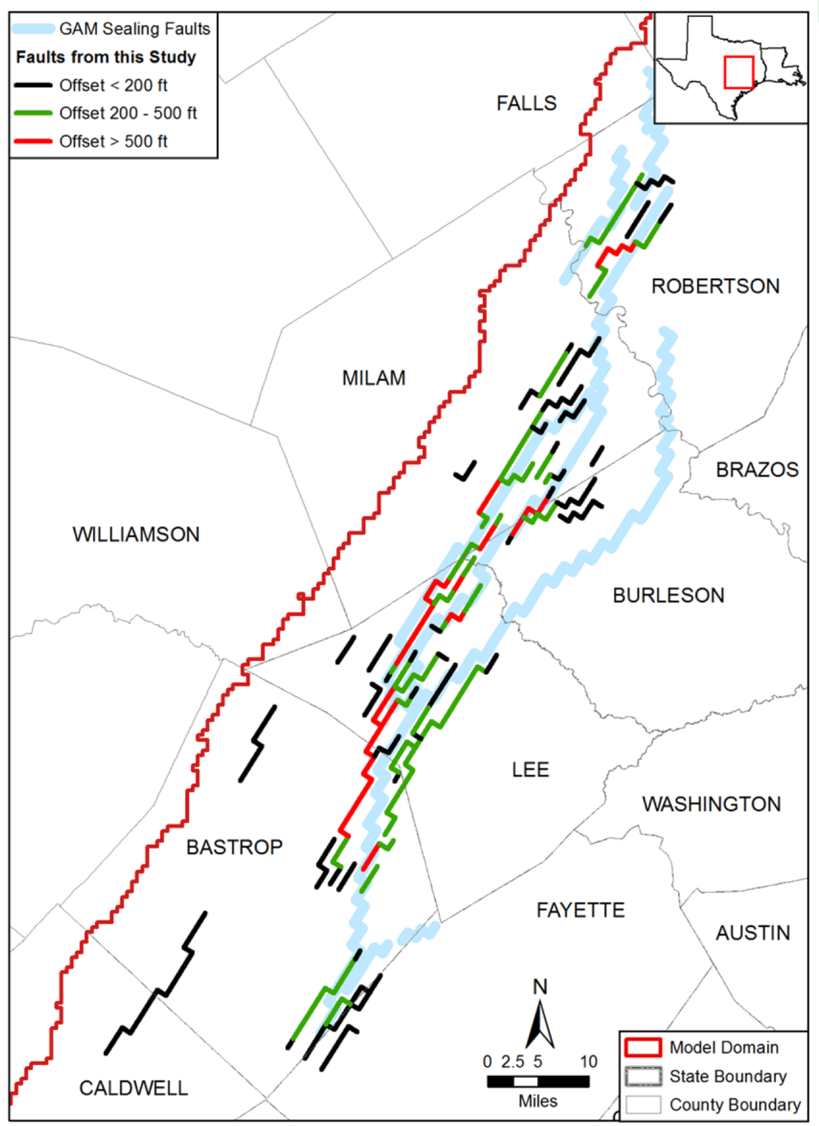
Updated Fault Representation: Smaller Footprint and Faults with Varying Properties

- Aquifer Pumping Test Data
- Historical Water Levels in Wells
- Historical Pumping Rates
- Geophysical Logs



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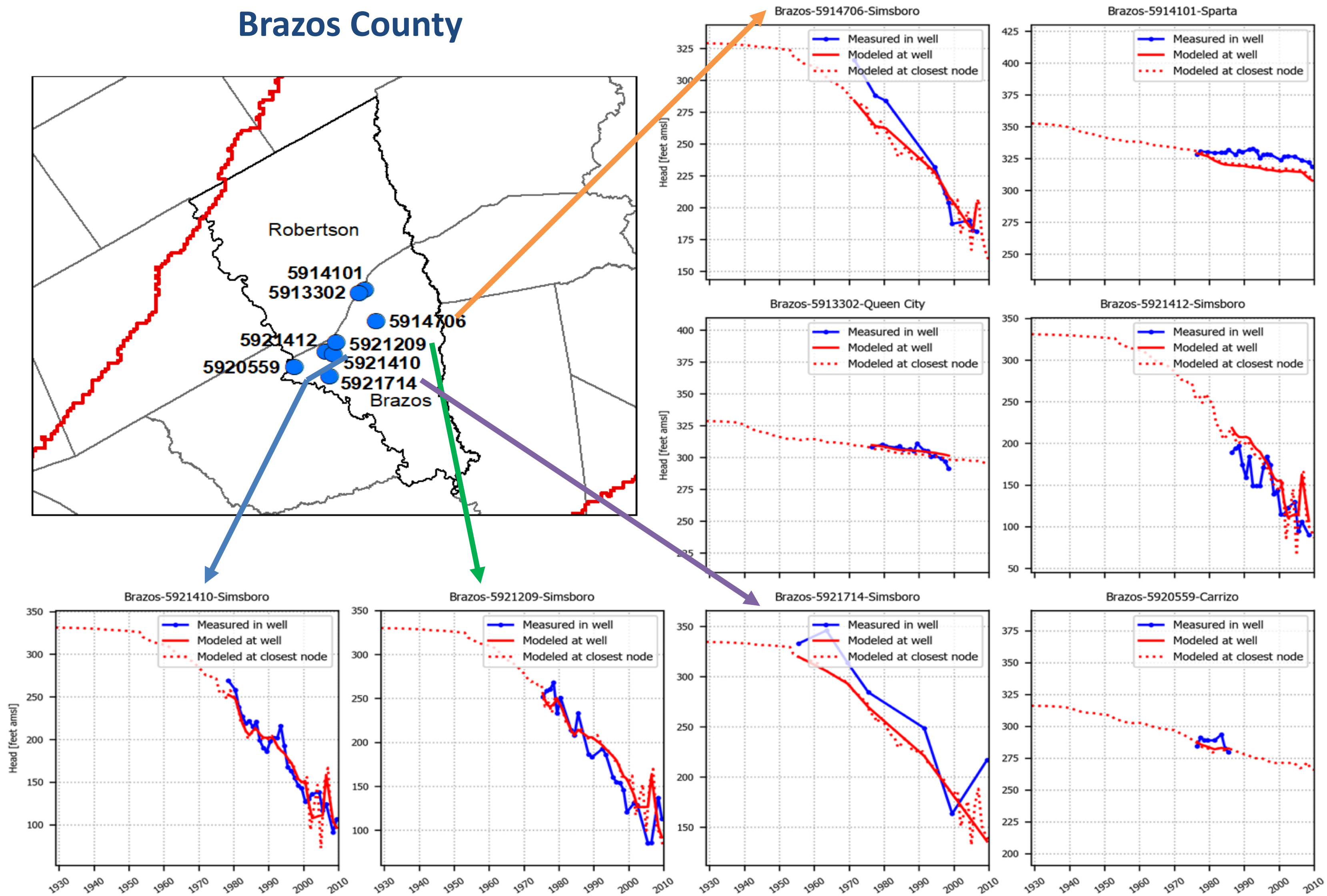
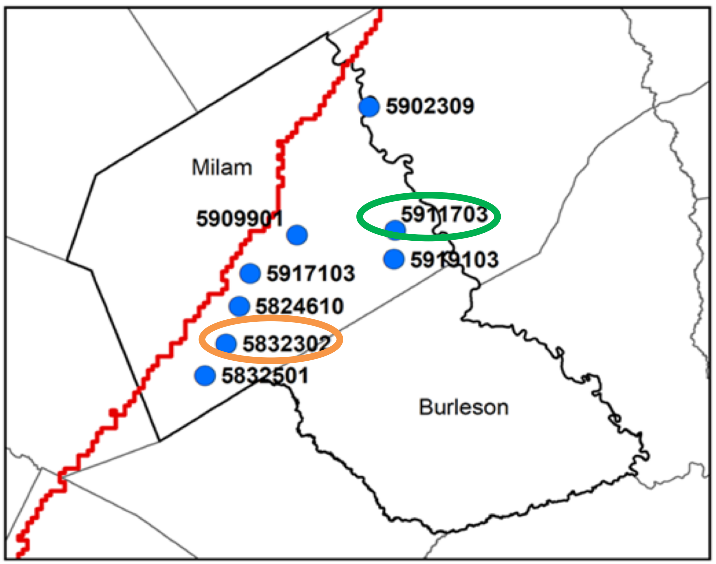
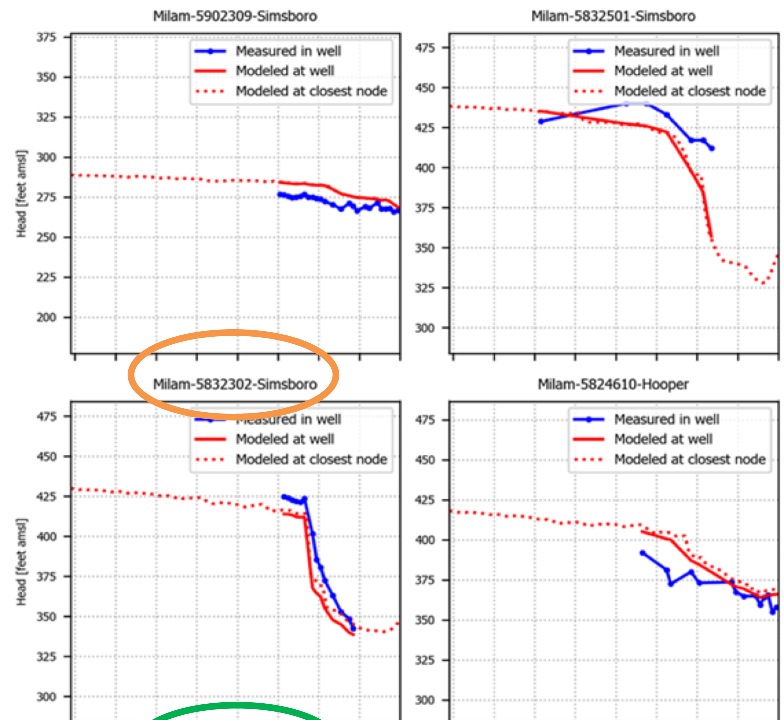
Updated GAM Provides Good Matches to Historical Water Levels in Regions of High Pumping in Simsboro Aquifer

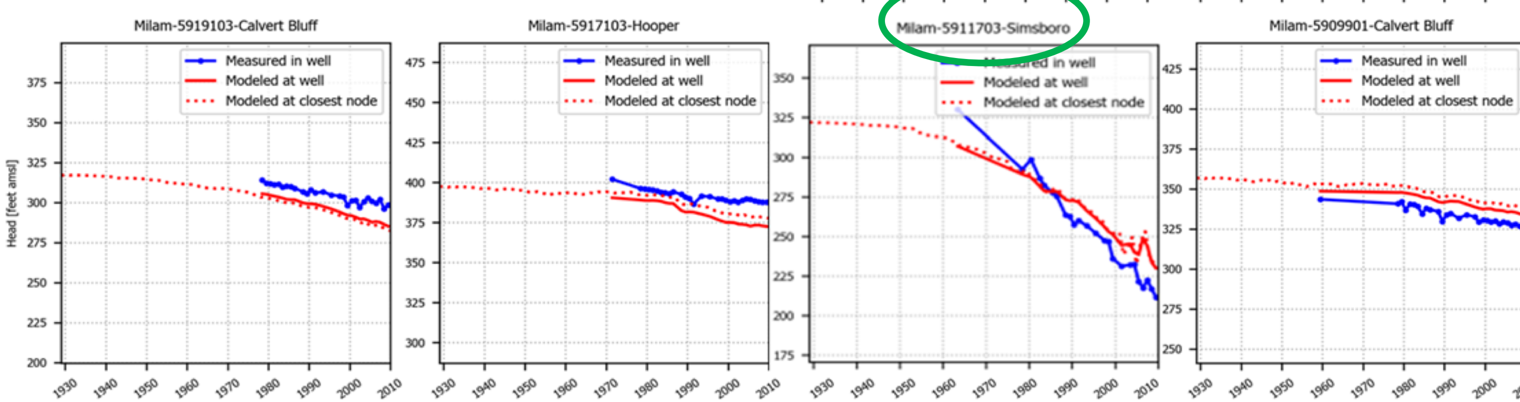


Updated GAM Provides Good Matches to Historical Water Levels in Simsboro Affected by “Alcoa” and “Bryan” Pumping

Milam County

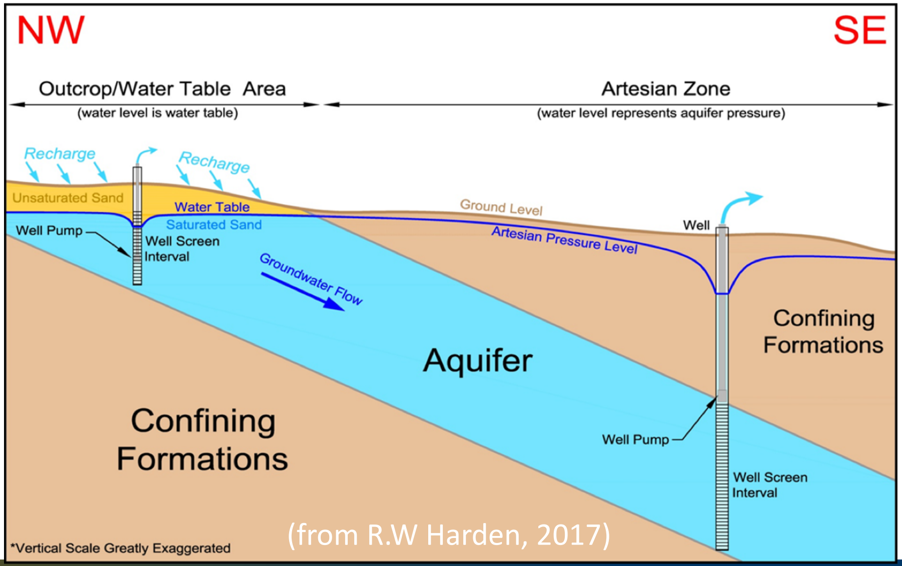






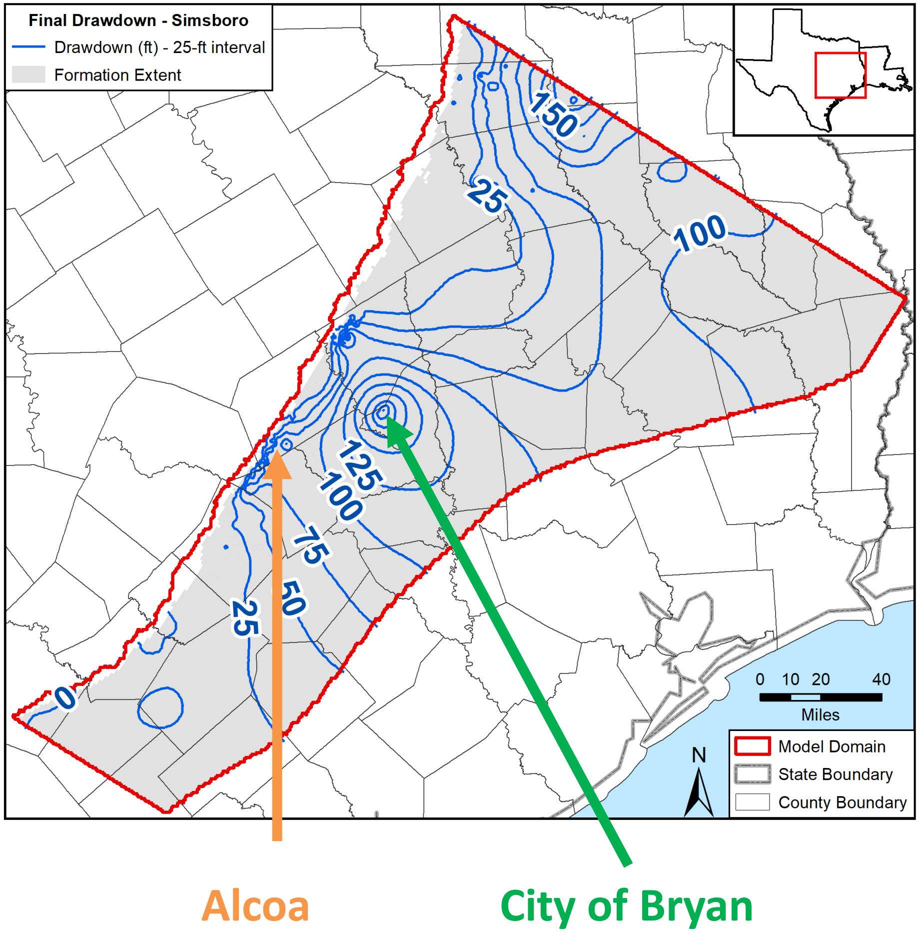
Simulation of Historical Pumping from "Alcoa" and "Bryan" Provides Valuable Info Understanding Simsboro Aquifer

- Simsboro Pumping
  - Alcoa pumping ~25,000 AFY for 15 years
  - Pumping 15,000 AFY to 30,000 AFY in vicinity of City of Bryan for about 30 years
- Lesson Learned
  - Outcrop/Shallow Groundwater Zone is resistant to drawdown
  - Drawdown spread far in confined zone



(from R.W Harden, 2017)

Drawdown Simsboro Aquifer from 1930 to 2010



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Groundwater Model: Uses

- Simulate and Predict Pumping Effects
  - Water Level Changes
  - Groundwater Flow Rates and Directions
  - Water Balances (track water from source to discharge)
- Applications
  - Joint Planning among GCDs (GMA 12)
  - Evaluation of Production in Aquifers
  - Interpretation of Water Level Data
  - Water Management Strategies

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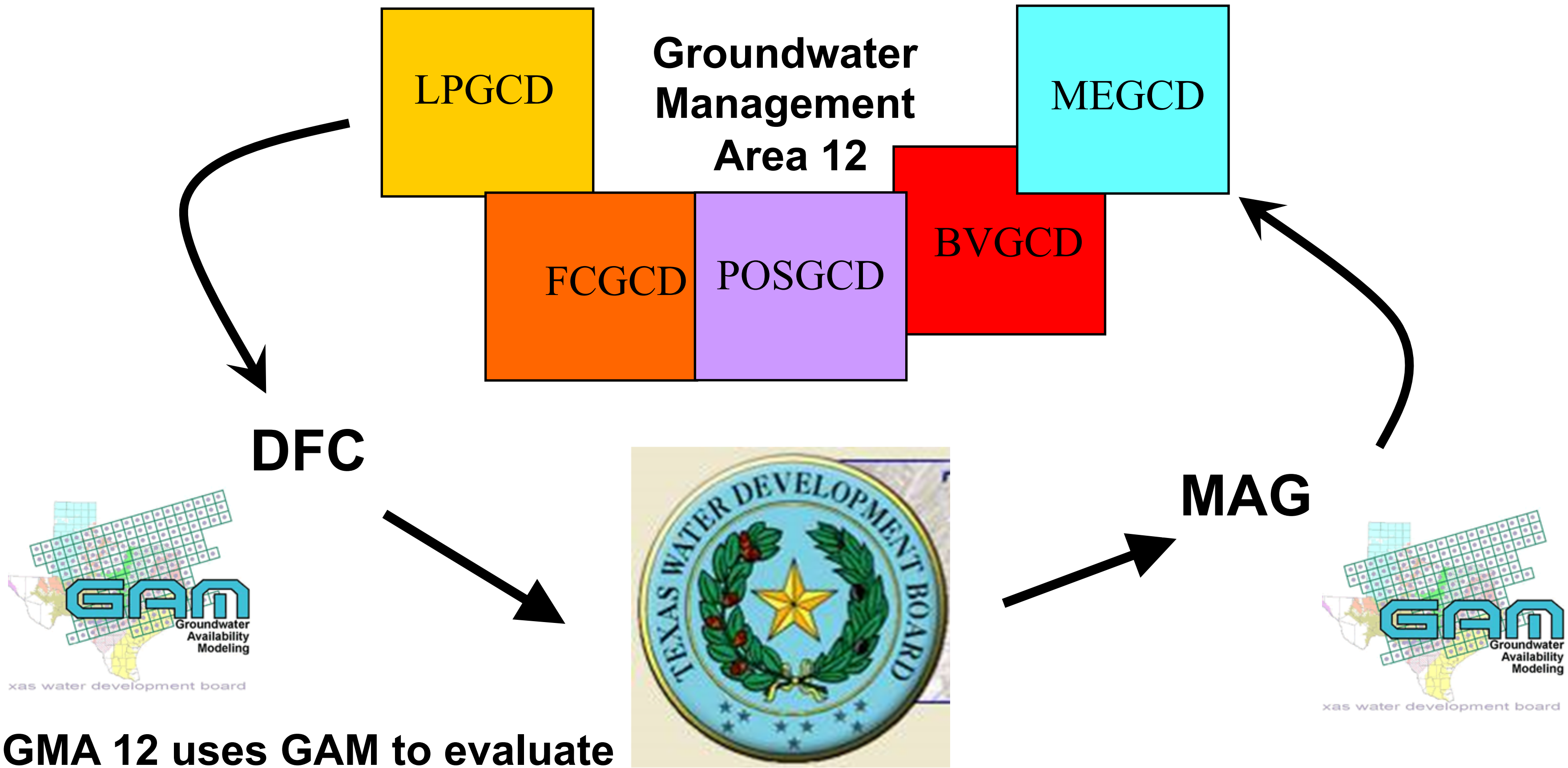
Application: GAMs are Used by GMAs and TWDB in Joint Planning Process



GMA 12 uses GAM to evaluate various water management strategies, Desired Future Conditions (DFCs), and the future pumping scenarios

TWDB uses GAM to help determine Modeled Available Groundwater (MAG) from the DFCs

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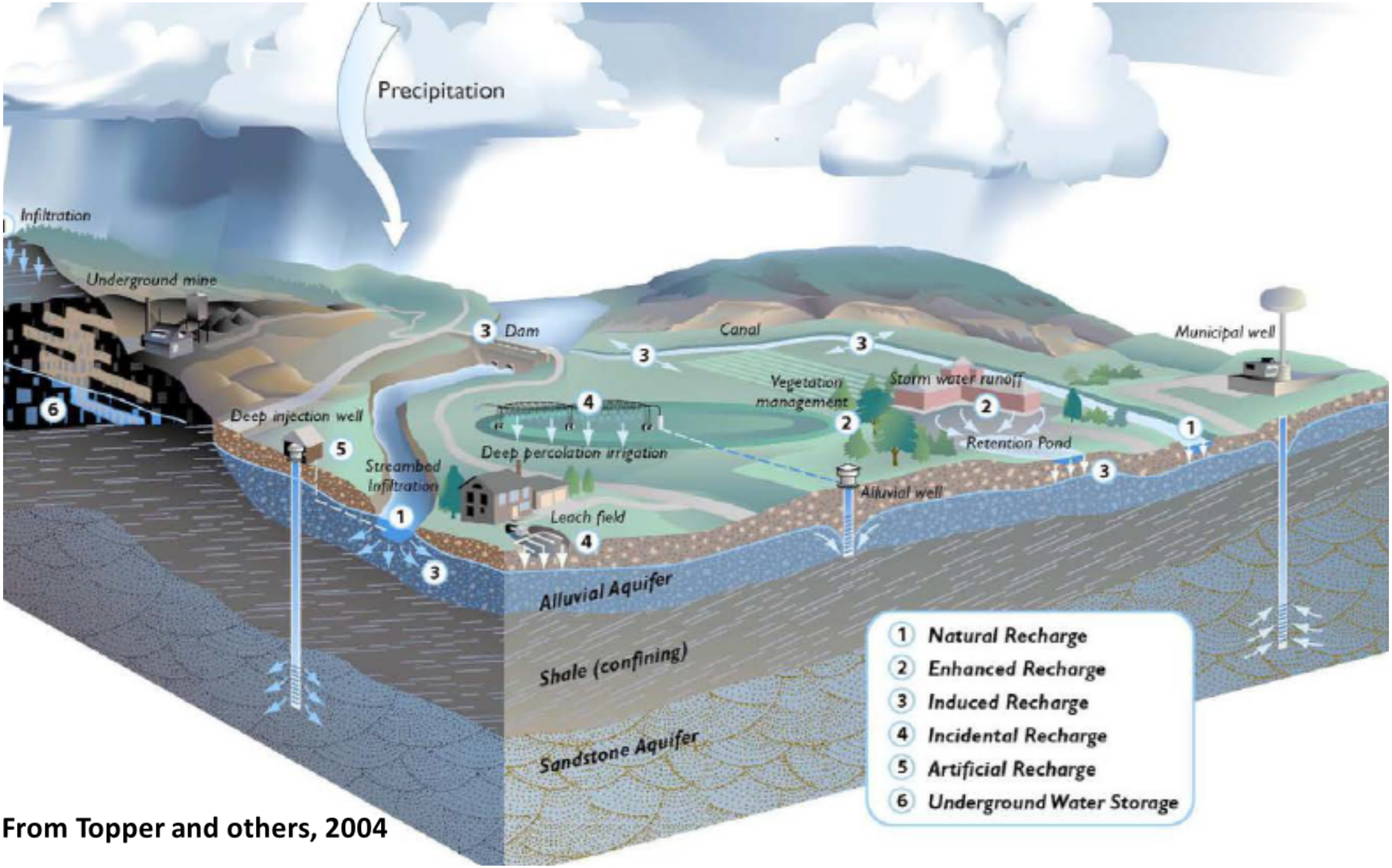
Application: Evaluate Alternative Water Management Strategies – Example Enhanced Recharge and Aquifer Storage and Recovery



From Topper and others, 2004

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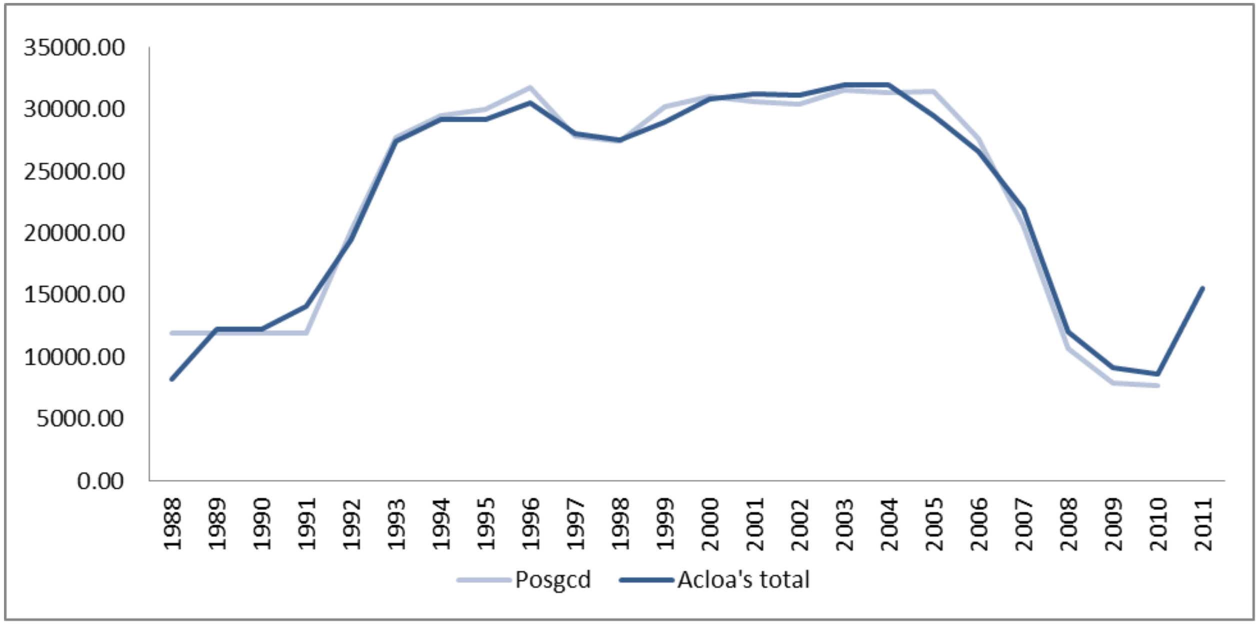
Questions ?

POSGCD Data Collection from Texas RRC

Data	Number of Wells
Pumping Test Data	32 Wells
Annual Pumpage Data	130 total Wells, 1988-2011
Pumping Wells with Construction data (Screen depths etc.)	116 Wells
Pumping Wells with no Construction data (Screen depths etc.)	17 Wells
Water Levels in Monitoring Program	~5,000 Water Levels



Groundwater Balance: Predevelopment around 1930

Milam County

	Acre-ft/year
In-flow	
Recharge	55,500
Regional Flow	900
Out-flow	
Stream	-47,500
Springs & Seeps	-7,900
Evaportranspiration	-1,000

Burleson County

	Acre-ft/year
In-flow	
Recharge	17,300
Regional Flow	2,700
Out-flow	
Stream	-19,300
Springs & Seeps	-200
Vertical Flow to Yegua-Jackson	-500

- Prior to pumping– the aquifers are full
- Very little vertical groundwater flow downward
- 98% of recharge is discharged to rivers

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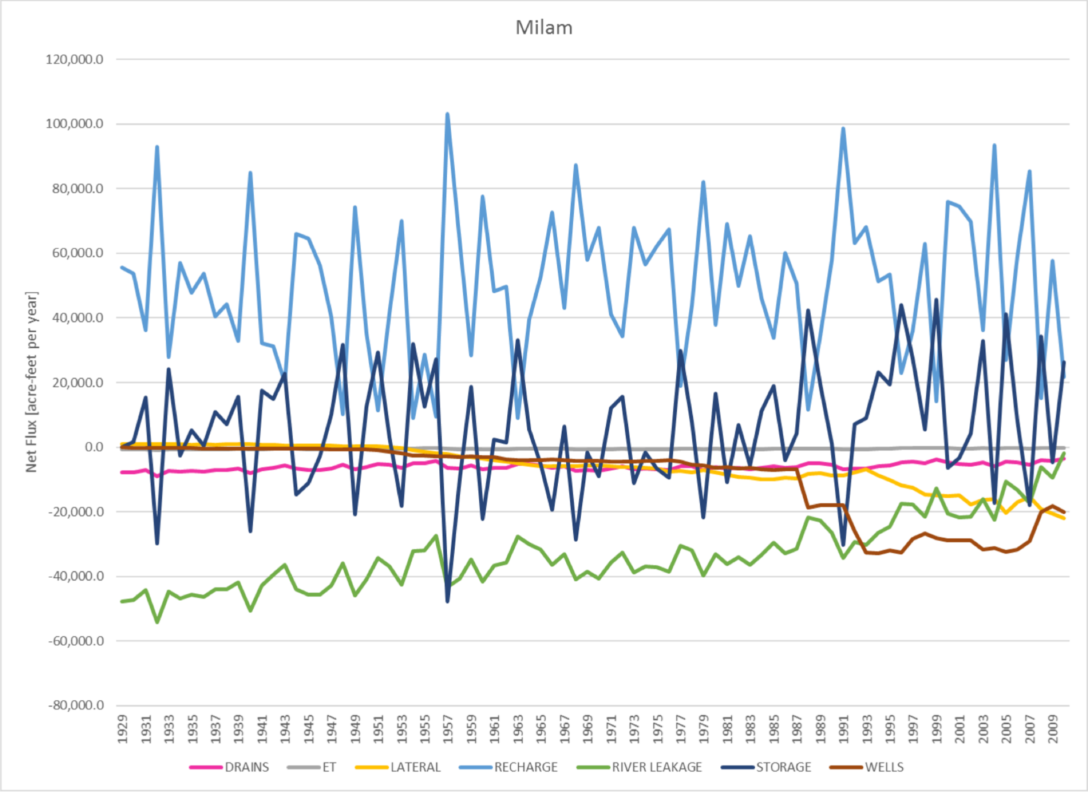
Water Budget From 1930 to 2010: Milam County

- Recharge rate values between 40,000 AFY to 100,000 AFY
- Decrease in groundwater flow to streams is shown by green line
- Evidence that pumping in Milam and Brazos is affecting water balance is provided by yellow and brown lines



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Schematic of Dipping Aquifer