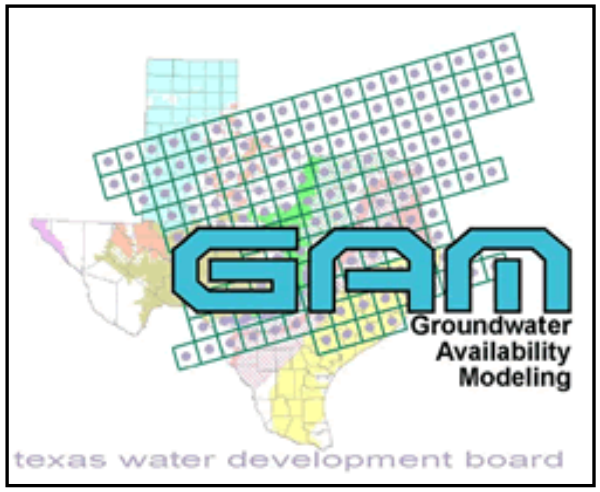
# Groundwater Availability Model (GAM) for the Yegua-Jackson Aquifer

**Stakeholder Advisory Forum (SAF#1)**
**College Station, Texas**
**June 24h, 2008**



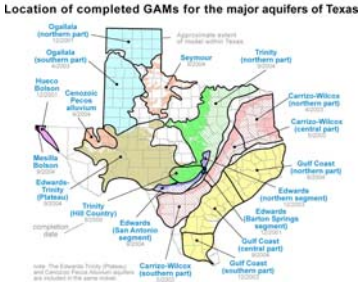

Cindy Ridgeway

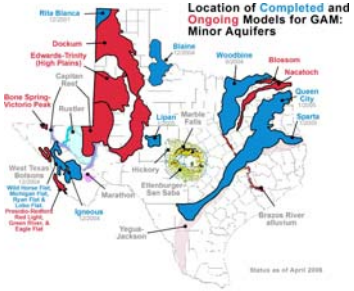

Van Kelley and Neil Deeds

# Outline

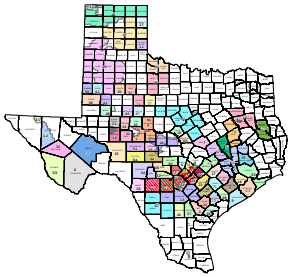
- General Introduction to the GAM program
- Introduction to the Yegua-Jackson GAM team
- Yegua-Jackson regional overview
- Basics of groundwater flow
- Overview of Yegua-Jackson Aquifer
- Numerical groundwater modeling and the GAMs
- Data collection
- GAM schedule

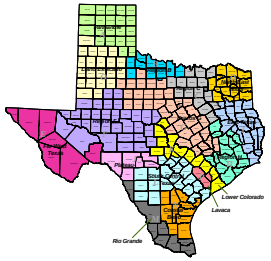
# Groundwater Availability Modeling







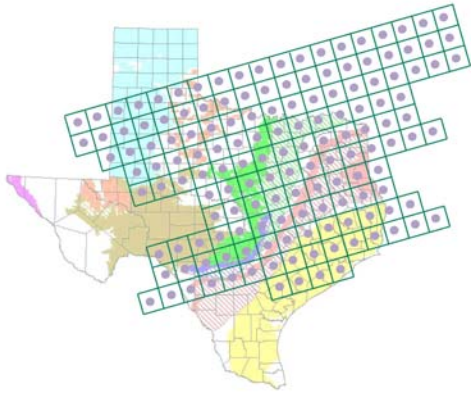


Cindy Ridgeway

Contract Manager

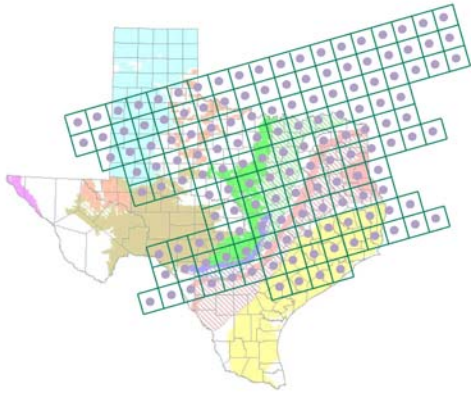
Yegua-Jackson Aquifer “GAM”

Texas Water Development Board



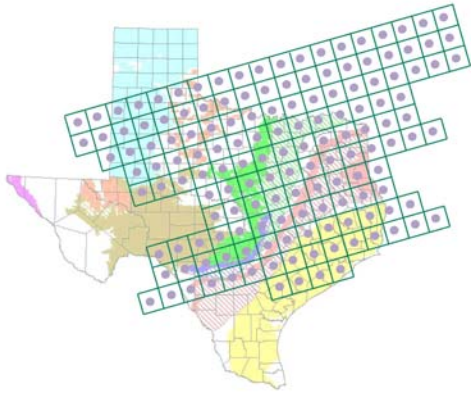
# What is the gam program?

- Purpose: to develop tools that can be used to help GCDs, RWPGs, and others understand and manage their groundwater resources.
- Public process: you get to see how the model is put together.
- Freely available: models are standardized, thoroughly documented. Reports available over the internet.
- Living tools: periodically updated.



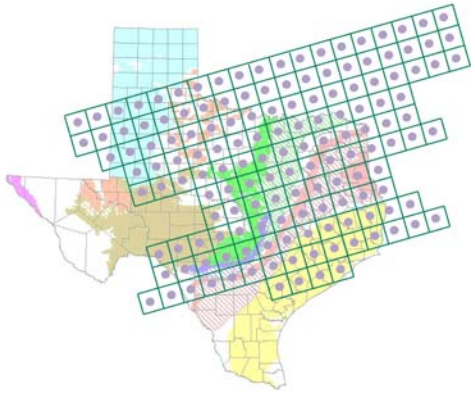
# Living tools

- GCDs, RWPGs, TWDB, and others collect new information on aquifer.
- TWDB plans to update GAMs every five years with new information.
- Please share information and ideas with TWDB on aquifers and GAMs.



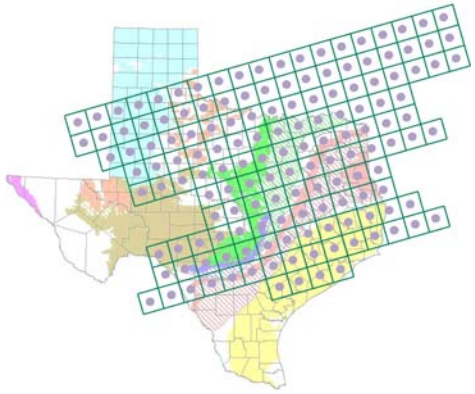
# How do we use GAM?

- The model
  - predict water levels and flows in response to pumping and drought
  - effects of well fields
- Data in the model
  - water in storage
  - recharge estimates
  - hydraulic properties
- GMAs, GCDs and RWPGs can request runs



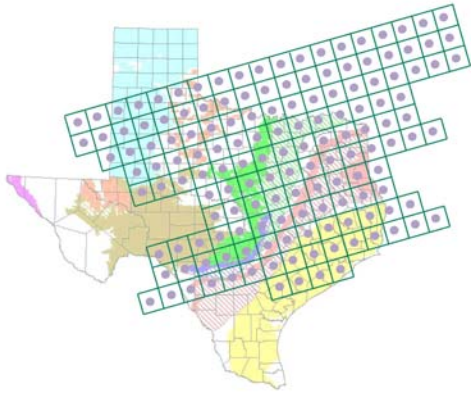
# Do we have to use GAM?

- Water Code & TWDB rules require that GCDs use GAM information, if available, for their management plans.
- TWDB rules require that RWPGs use managed available groundwater estimates, if developed in time for the planning cycle



# What is Groundwater Availability or MAG?

- Managed available groundwater (MAG)…the amount of groundwater available for use.
- The State does not directly decide how much groundwater is available for use: GCDs will through GMA process.
- A GAM is a tool that can be used to assess groundwater availability once GCDs and GMAs decide on the desired future condition of the aquifer.



# Participating in the GAM process

- Stakeholder Advisory Forums (SAF)
  - hear about progress on the model
  - comment on model assumptions
  - offer information (timing is important!)
- Report review
  - at end of project
- Contact TWDB
  - contract manager

# Comments:

**Cindy Ridgeway**
**cindy.ridgeway@twdb.state.tx.us**
**(512)936-2386**

**Texas Water Development Board**
**1700 North Congress Avenue**
**P.O. Box 13231**
**Austin, Texas 78711-3231**

**Web information:**
**www.twdb.state.tx.us/gam**

# Outline

- General Introduction to the GAM program
- **Introduction to the Yegua-Jackson GAM team**
- Yegua-Jackson regional overview
- Basics of groundwater flow
- Overview of Yegua-Jackson Aquifer
- Numerical groundwater modeling and the GAMs
- Data collection

# Yegua-Jackson GAM Team
## Primary Roles

- **INTERA**
  - Project management
  - SAF meetings
  - Heads and calibration targets
  - Recharge implementation
  - Surface water / groundwater interaction
  - Pumping data and implementation
  - Water quality
  - Model construction/calibration/SA
  - Project reporting/deliverables
- **Baer Engineering** (Paul Knox)
  - Geology/structure
- **URS** (Steve Young)
  - Aquifer Properties
- **Graham Fogg**
  - Senior Technical Review

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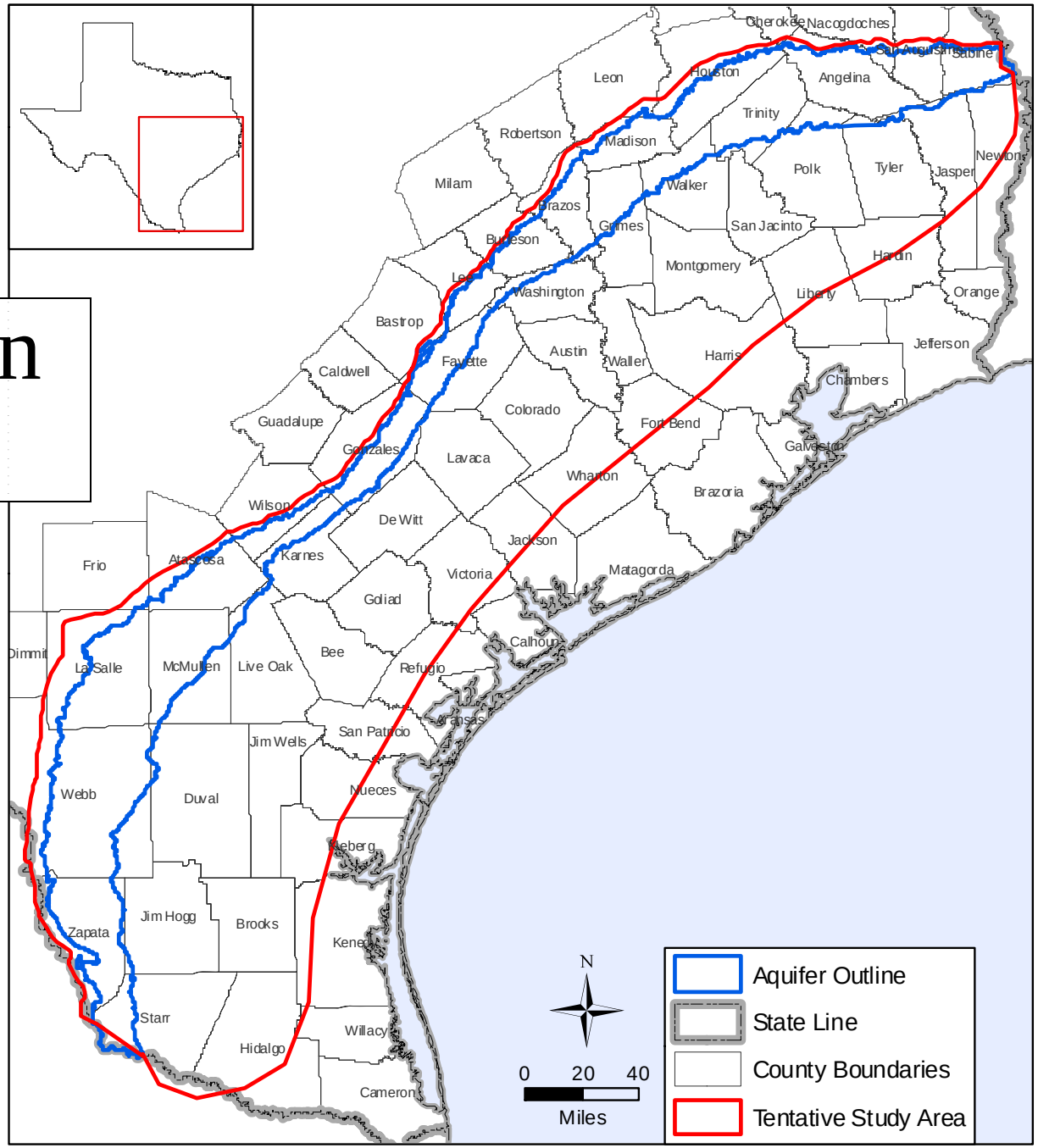
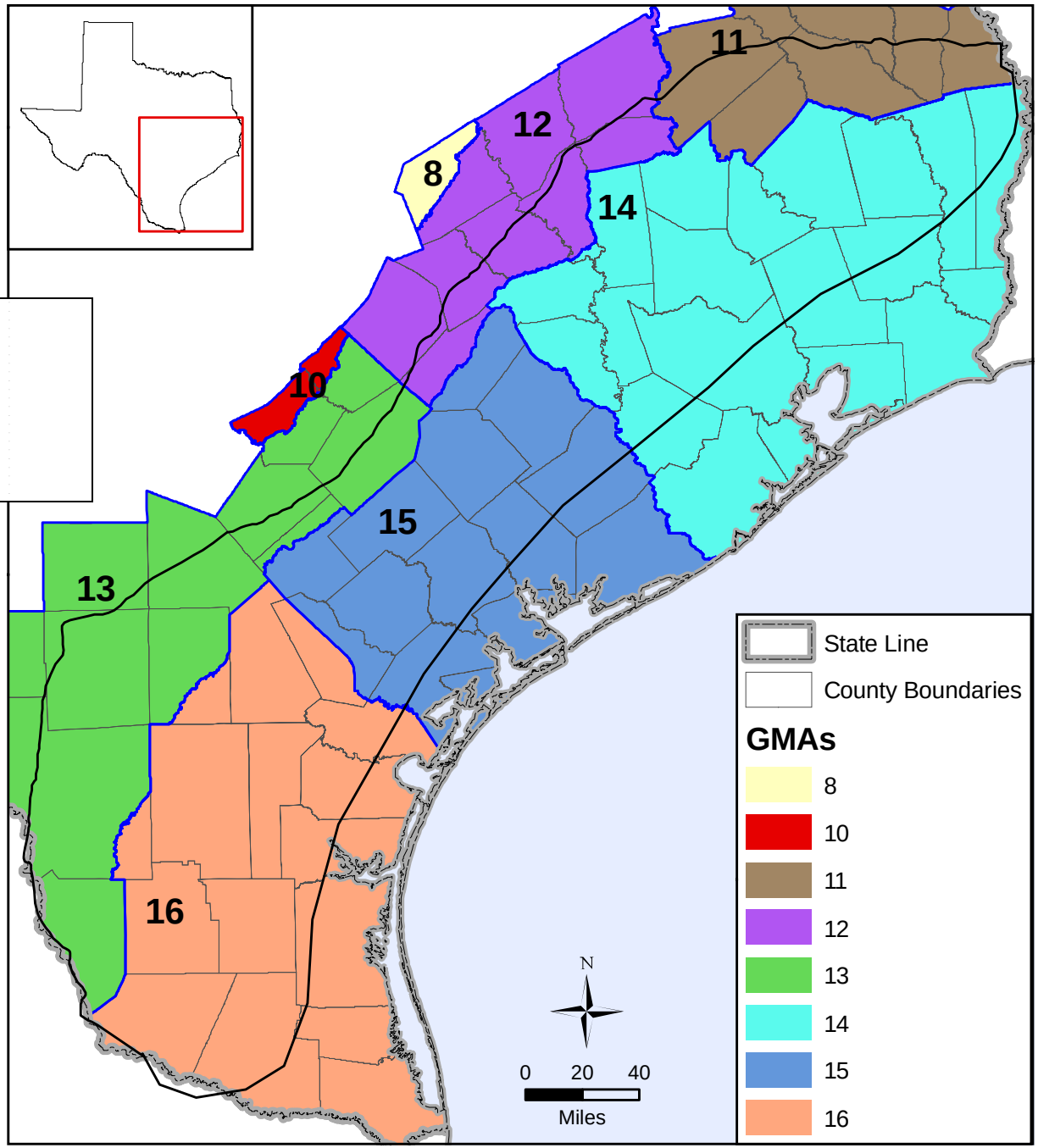
# Yegua-Jackson Aquifer




Source: Online: Texas Water Development Board, March 2007

# GMAs

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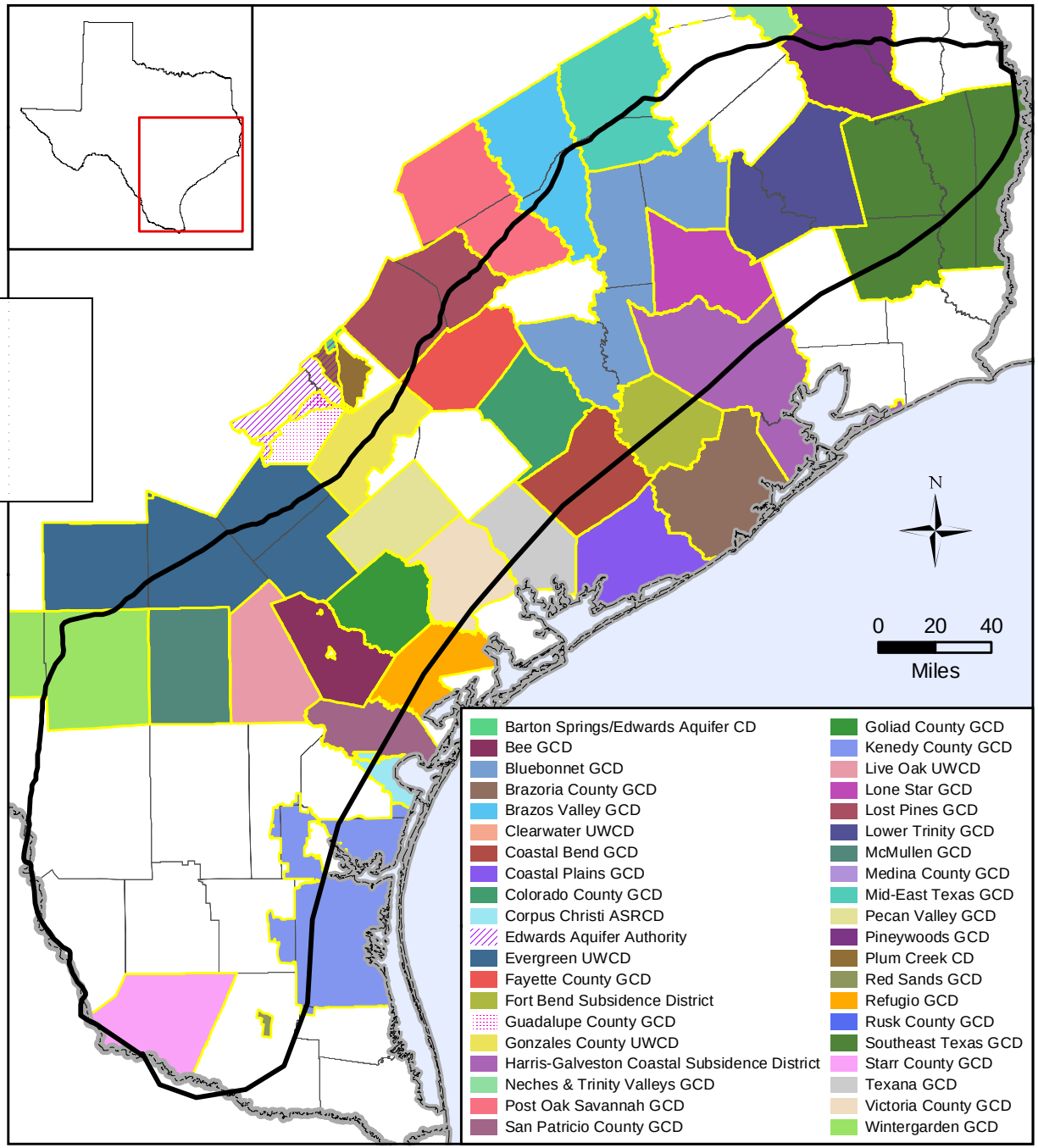
# GCDs

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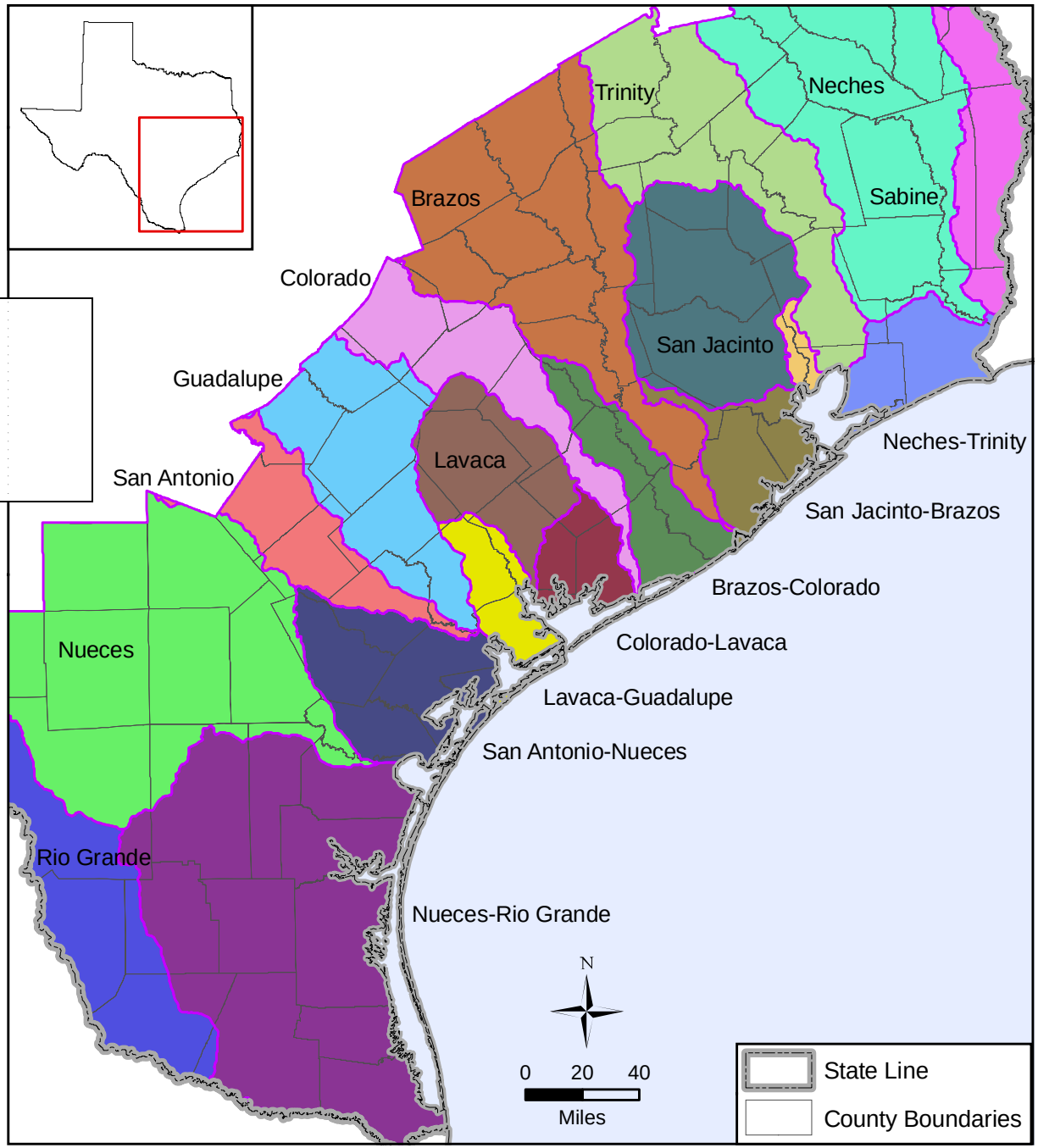
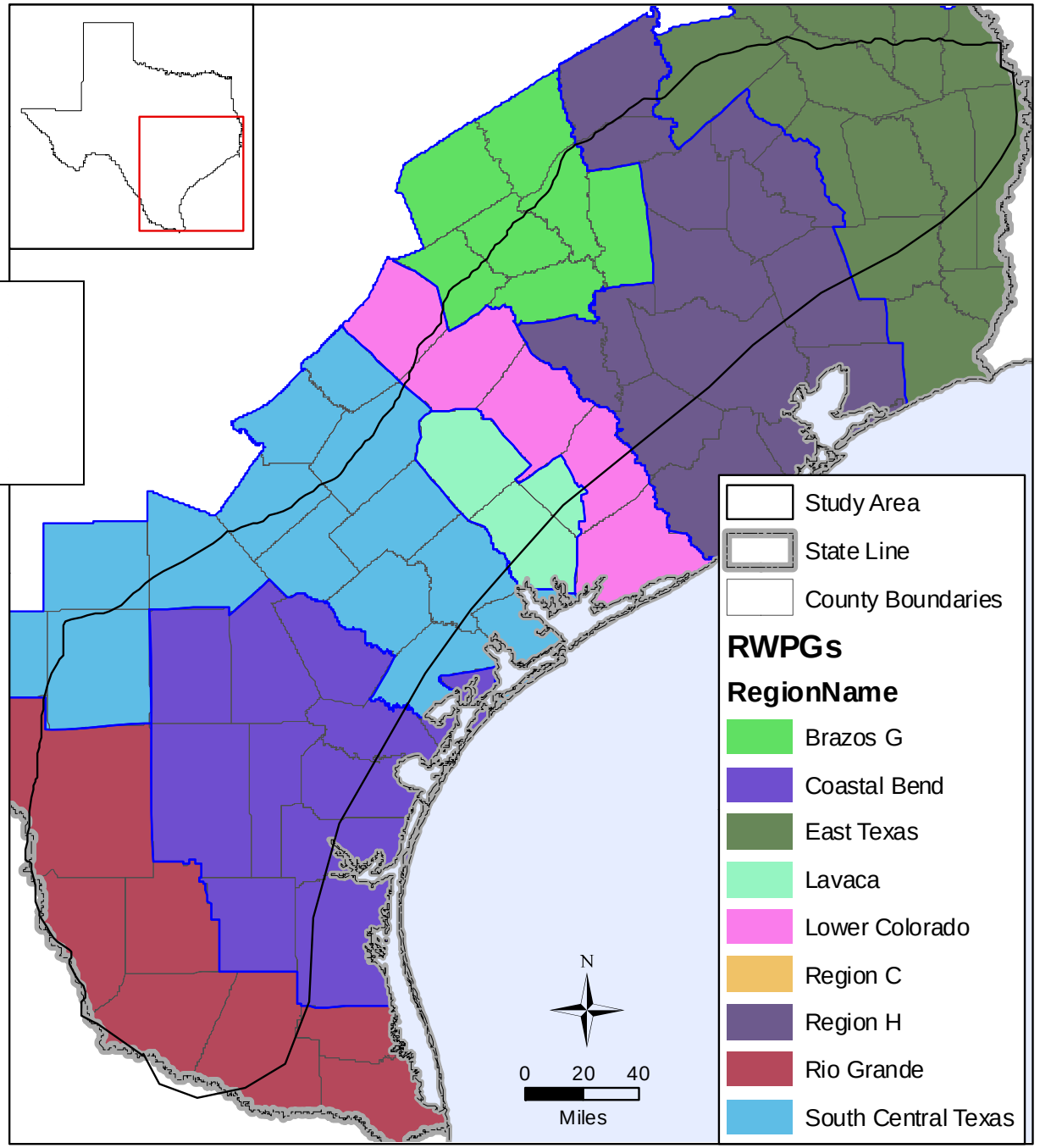
# River Basins



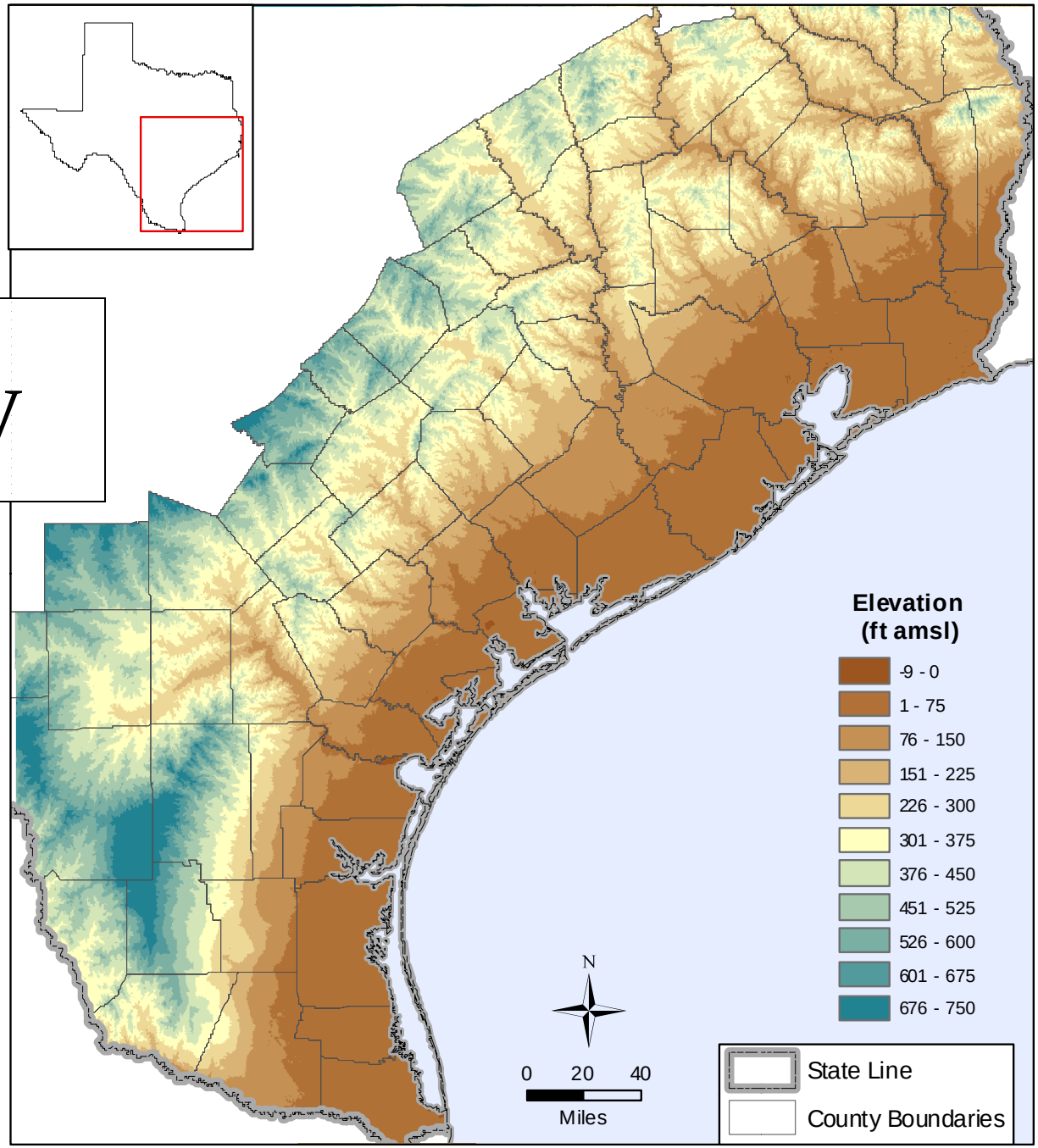

Source: Online: Texas Water Development Board, March 2007

# RWPGs



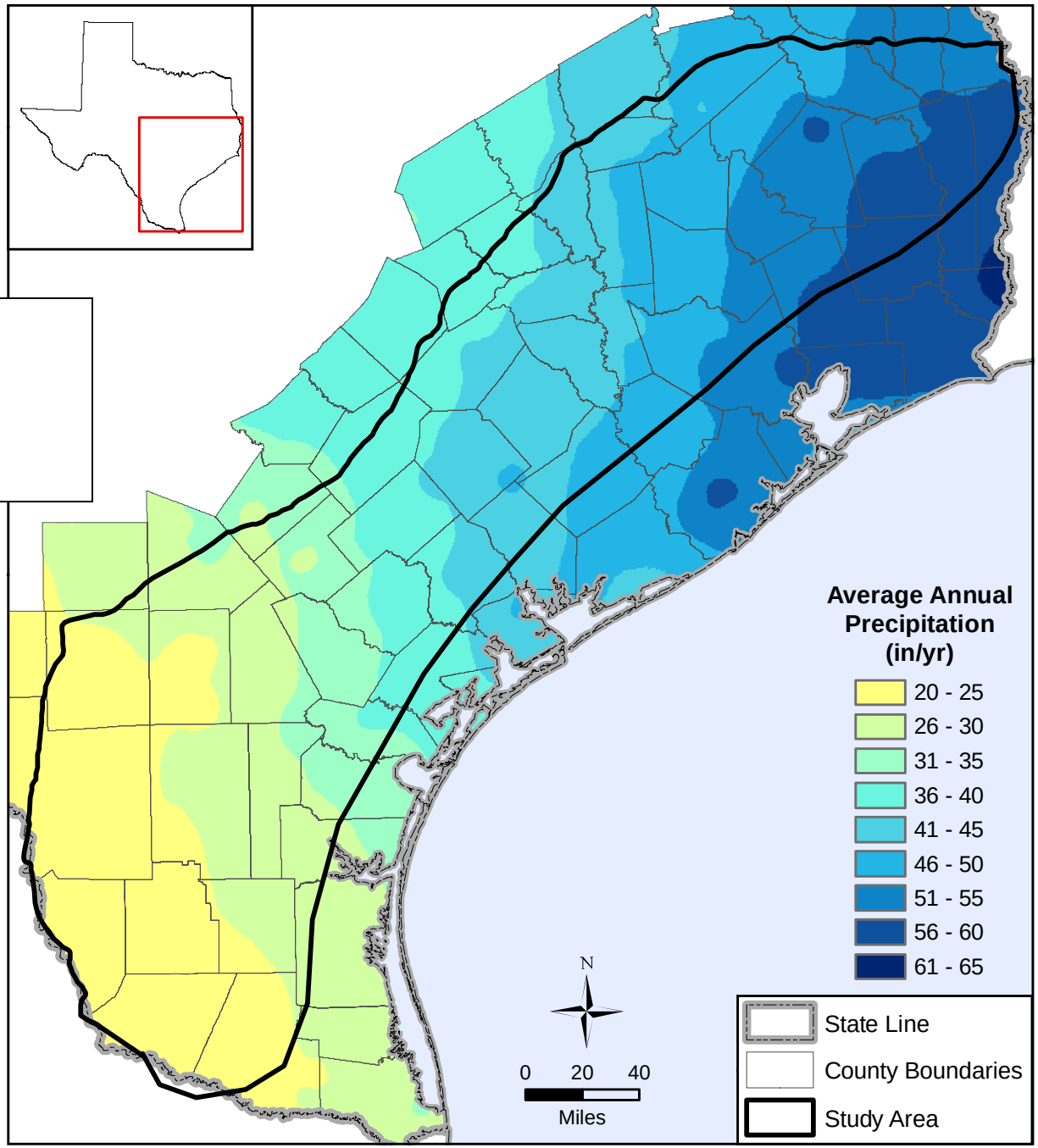

Source: Online: Texas Water Development Board, March 2007

# Topography



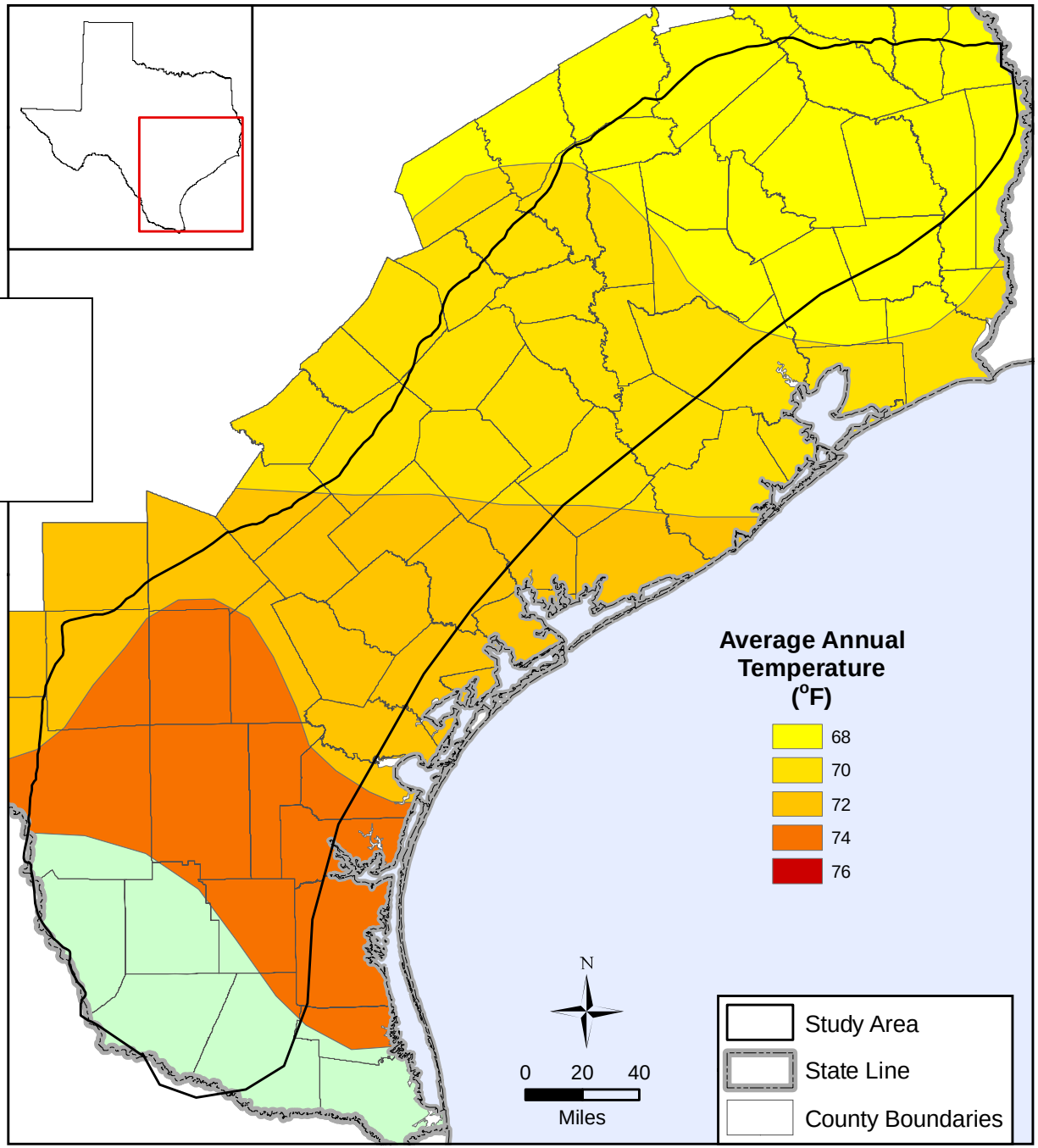

Source: Online: Texas Water Development Board, March 2007

# Average Precipitation




Source: Online: Texas Water Development Board, March 2007

# Average Temperature

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# Groundwater Flow - Definitions

- Aquifer – Water saturated permeable geologic unit that can transmit significant quantities of water (e.g., sands & gravels).
  - Unconfined – water table forms the upper boundary
  - Confined – has overlying/underlying lower permeabilty layers
- Water table – The top of the saturated zone.
- Hydraulic head – The water level in a well expressed as an elevation.

# Groundwater Flow – Definitions (cont'd)

- Hydraulic conductivity (permeability) – A physical property of the geologic media representing its ability to transmit water.
- Specific yield – The volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in water table elevation.
- Storativity – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head.

# Groundwater Flow – Definitions (cont'd)

- Recharge – The entry of water to the saturated zone at the water table:

  Recharge = (precipitation + stream loss) minus (runoff + evapotranspiration).

- Cross-formational flow – Groundwater flow between separate geologic formations.
- Stream losses or gains – The water that is either lost or gained through the base of the stream or river.

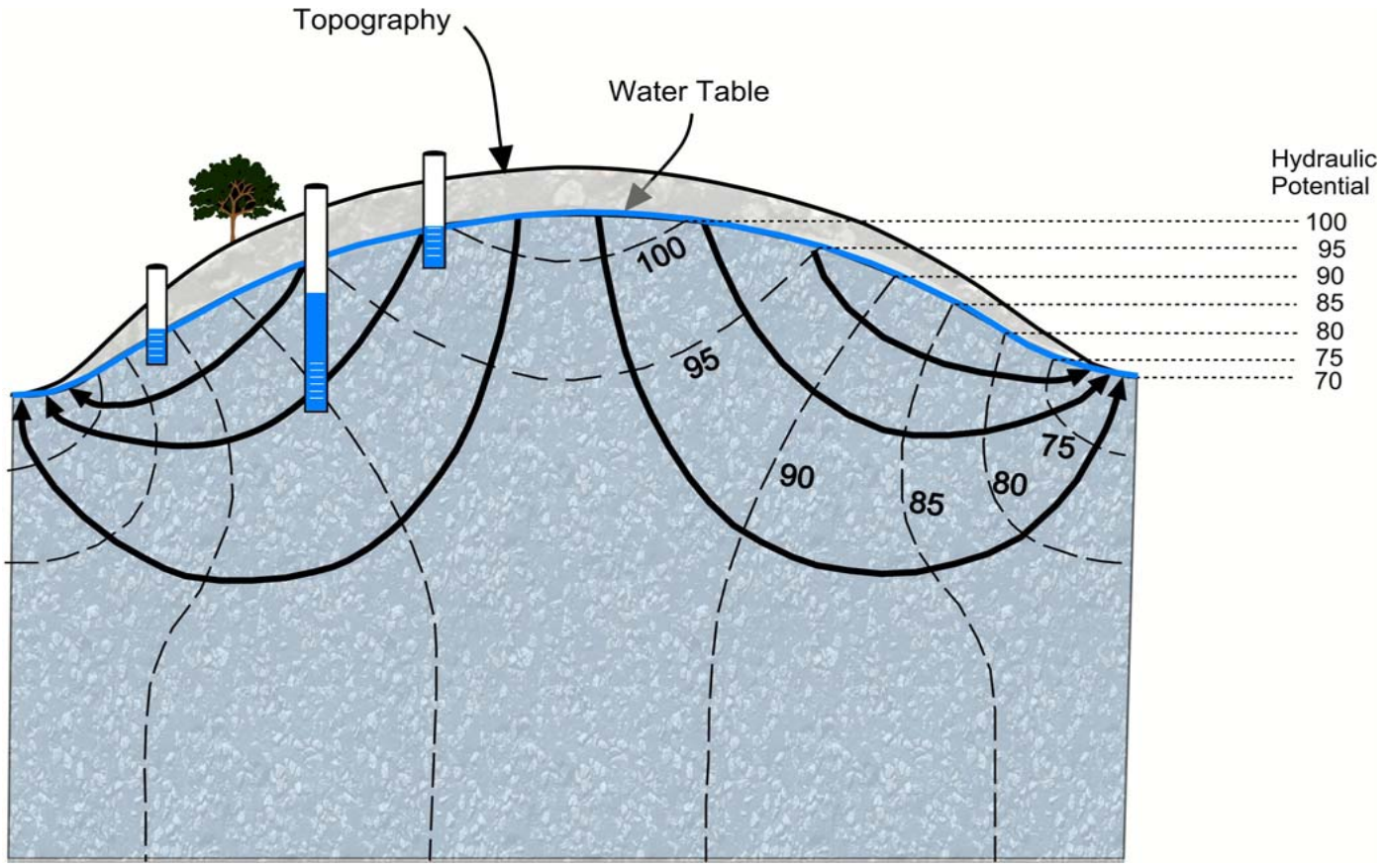
# Basic Principles of GW Flow

- The primary observable quantity describing groundwater flow is the water level as measured in a well.
- The water level expressed as elevation is termed the hydraulic head.
- The difference in hydraulic head between adjacent wells determines the direction of GW flow (from higher heads towards lower heads).
- The water table is typically a subdued replica of the topography.

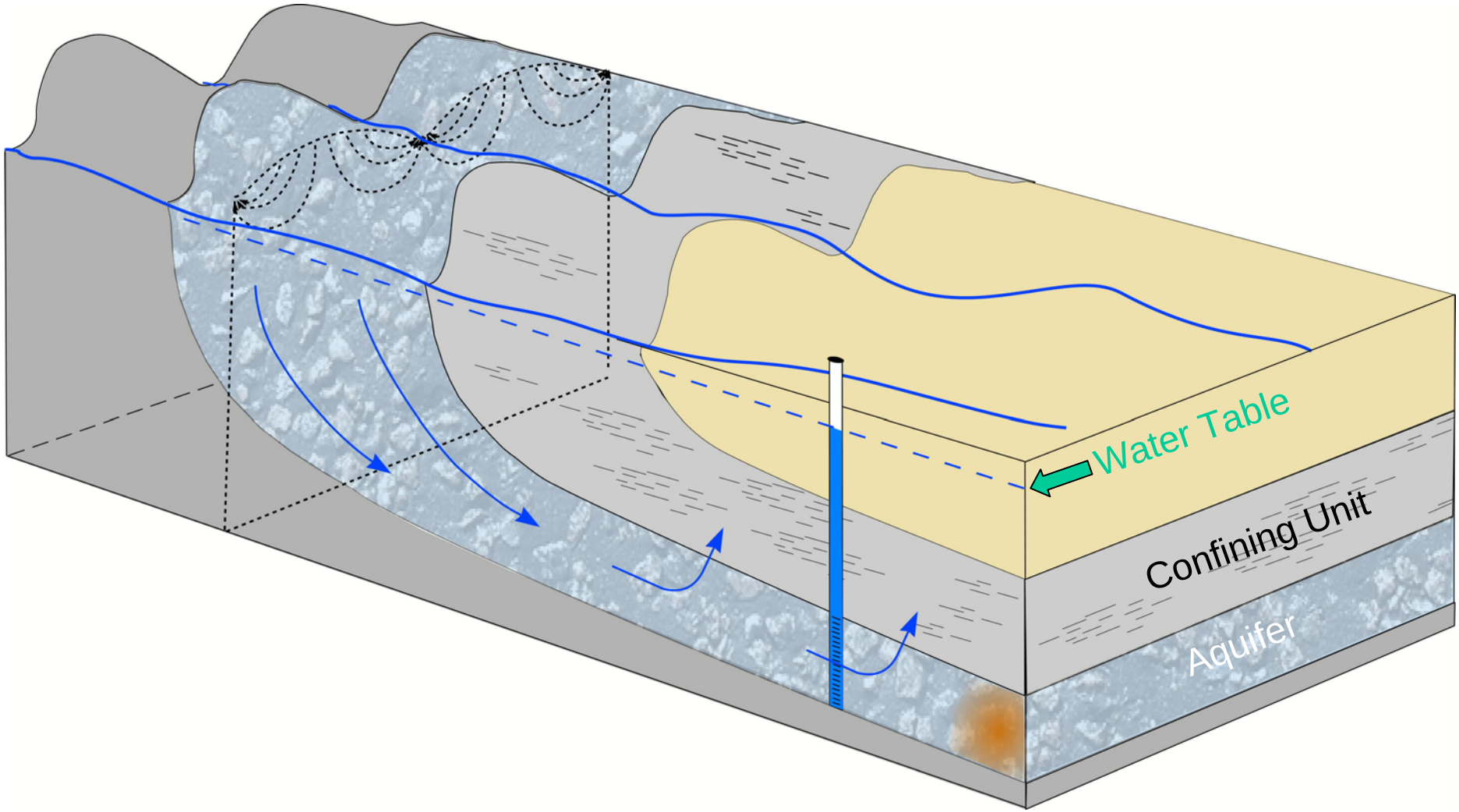
# Basic Principles of GW Flow (cont'd)

- The thickness and hydraulic conductivity of the aquifer material define volumetric flow rates (e.g., for pumping)
  - The larger the hydraulic conductivity and thickness, the greater the flow.

# Schematic Cross Section of Groundwater Flow



# Confined Aquifer



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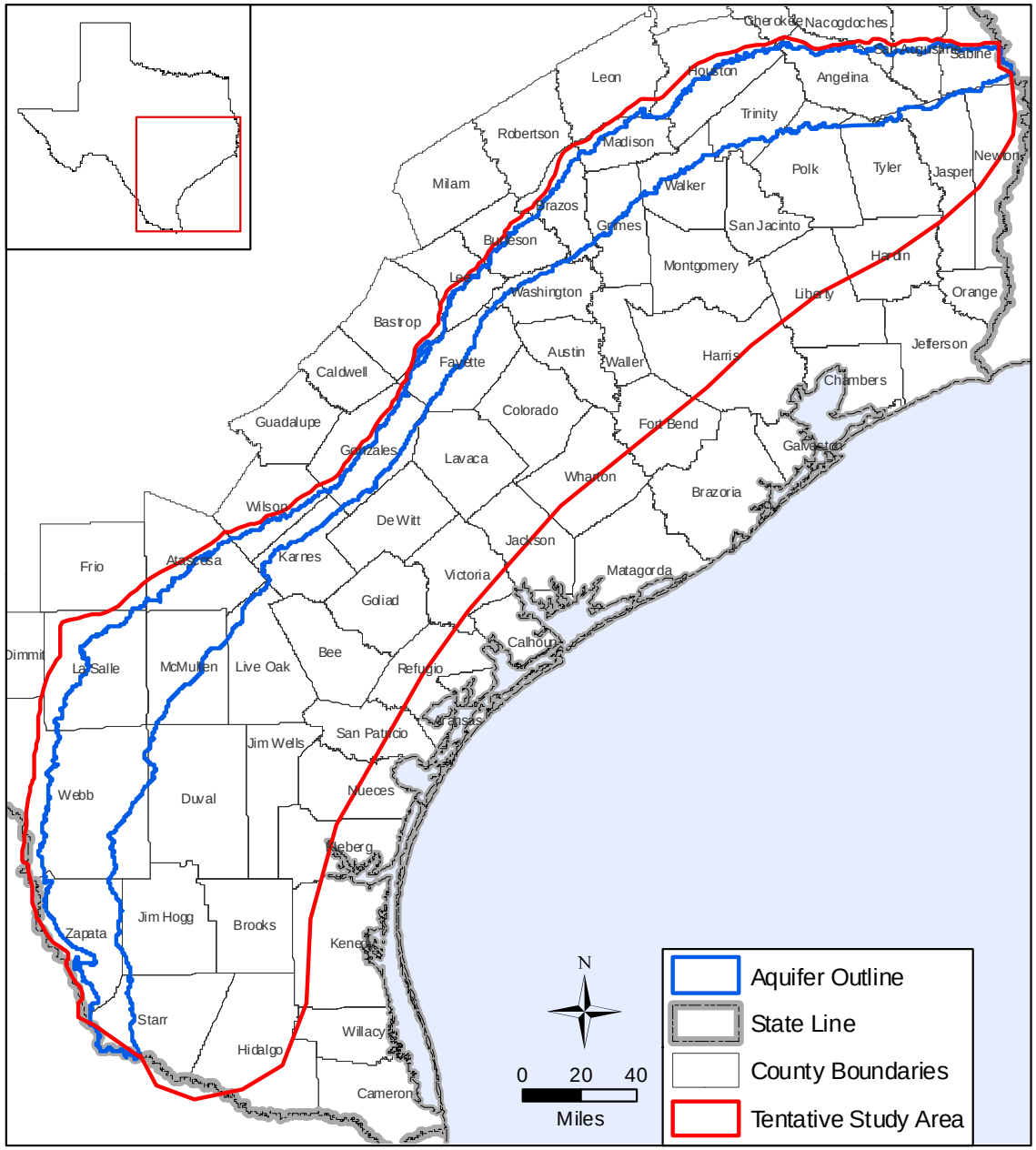
# Yegua-Jackson Aquifer

- Considered a minor aquifer in Texas as of the 2002 State Water Plan
- Exists primarily in the outcrop and near-outcrop regions of the Yegua Formation and Jackson Group




Source: Online: Texas Water Development Board, March 2007

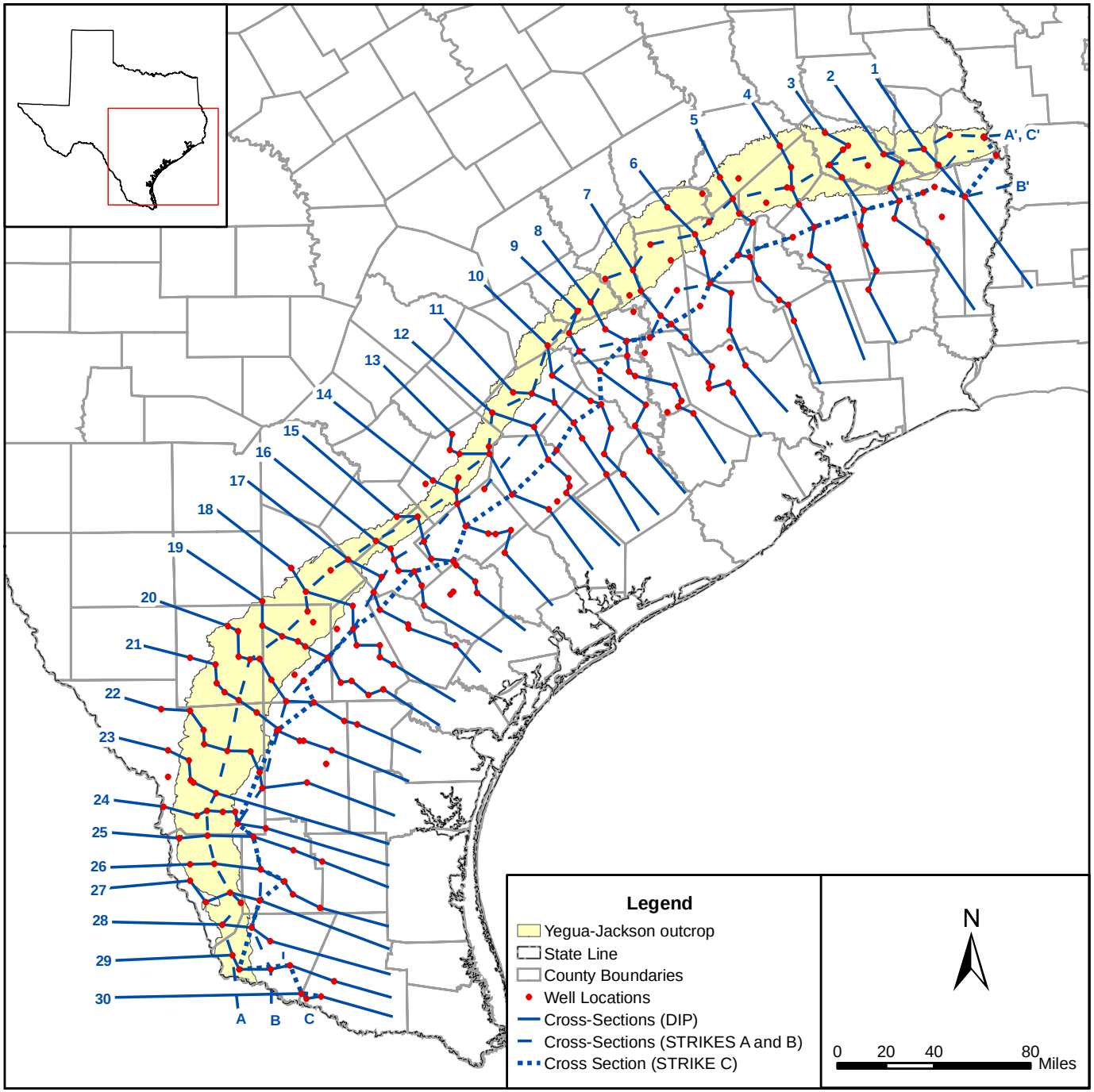
# Stratigraphic Column

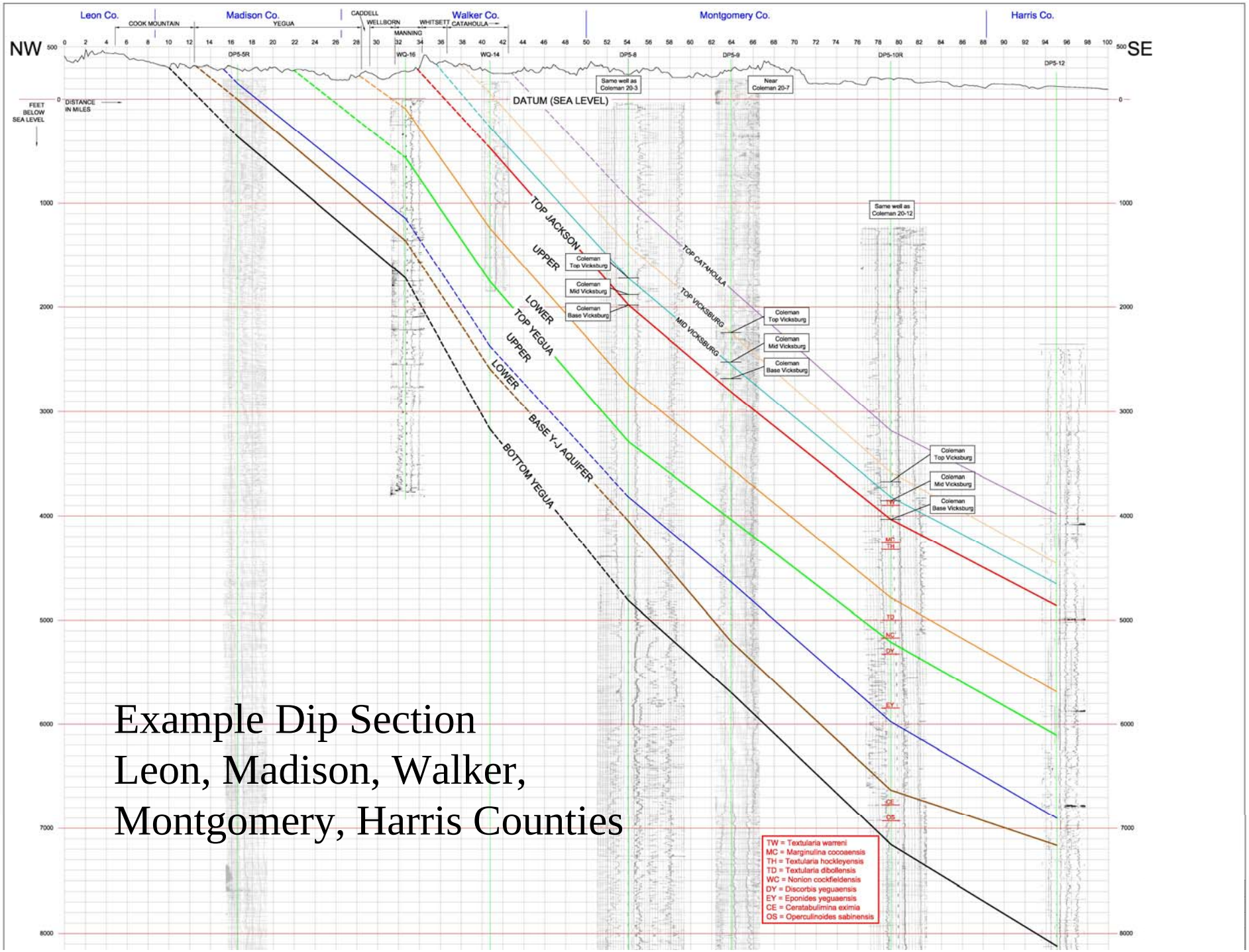
| Series | | | Group | Formation |
|---|---|---|---|---|
| Tertiary | Oligocene | | | Catahoula |
| | Eocene-Oligocine | | Jackson | Whitsett |
| | Eocene | Upper | | Manning |
| | | | | Wellborn |
| | | | | Caddell |
| | | Middle | Upper Claiborne | Yegua |
| | | | | Cook Mountain |

# Yegua-Jackson Structure

- Structure completed for the TWDB by INTERA and Baer Engineering in 2007
- Divided into four units
  - Upper Jackson
  - Lower Jackson
  - Upper Yegua
  - Lower Yegua
- Also mapped
  - Net sand
  - Depositional Environments
  - Faults

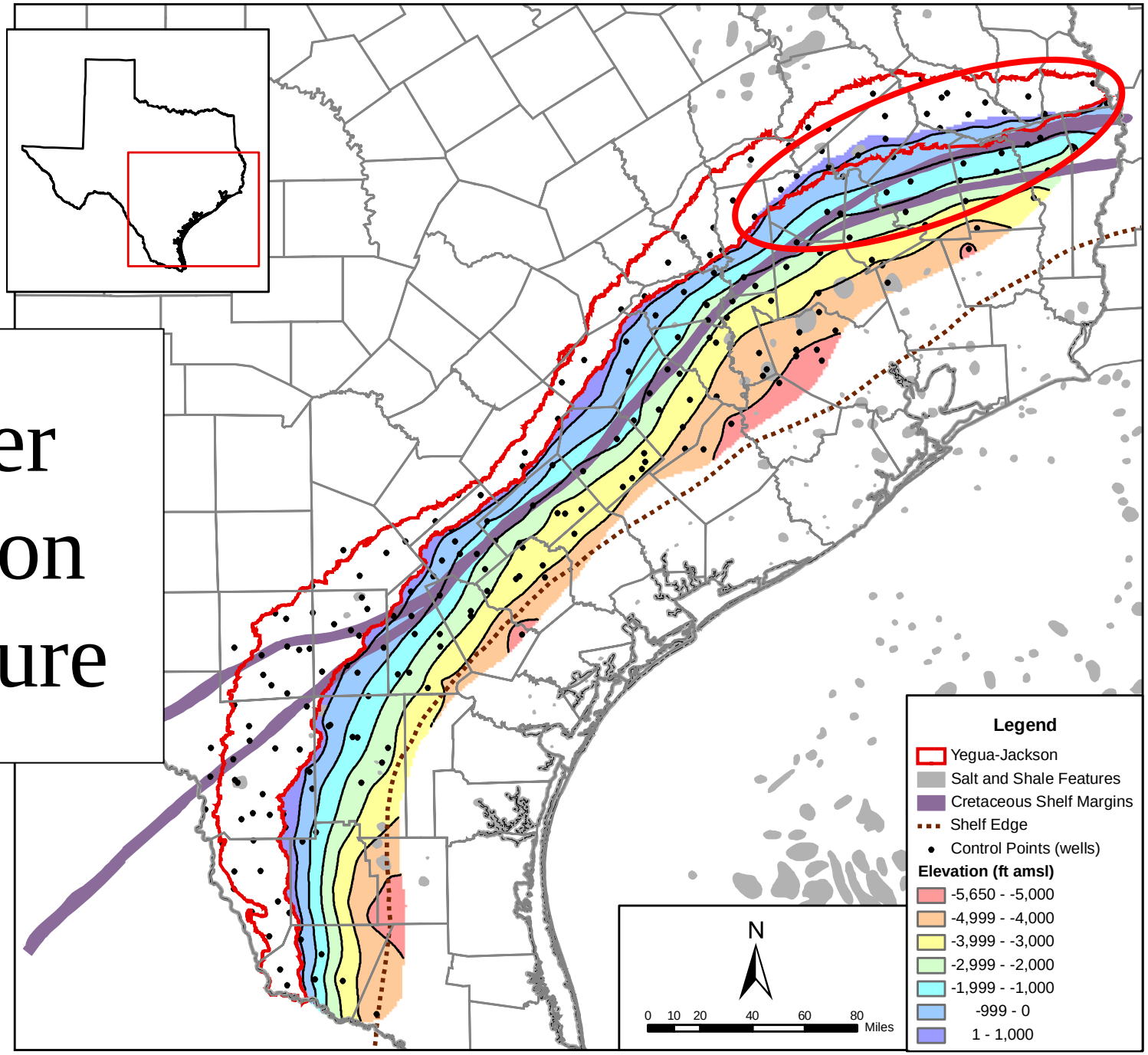
# Cross-Section Base Map



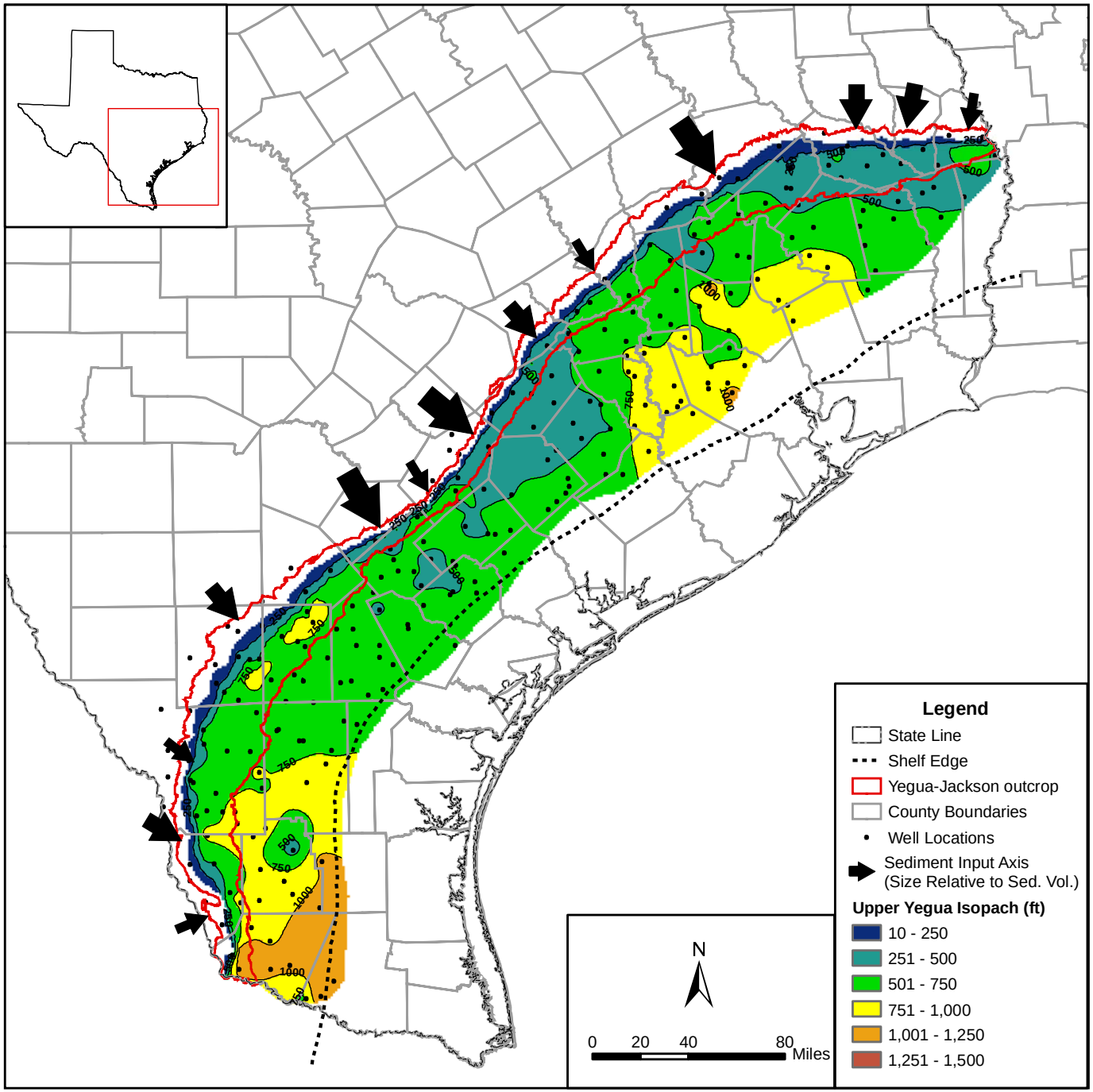



Example Dip Section
Leon, Madison, Walker,
Montgomery, Harris Counties

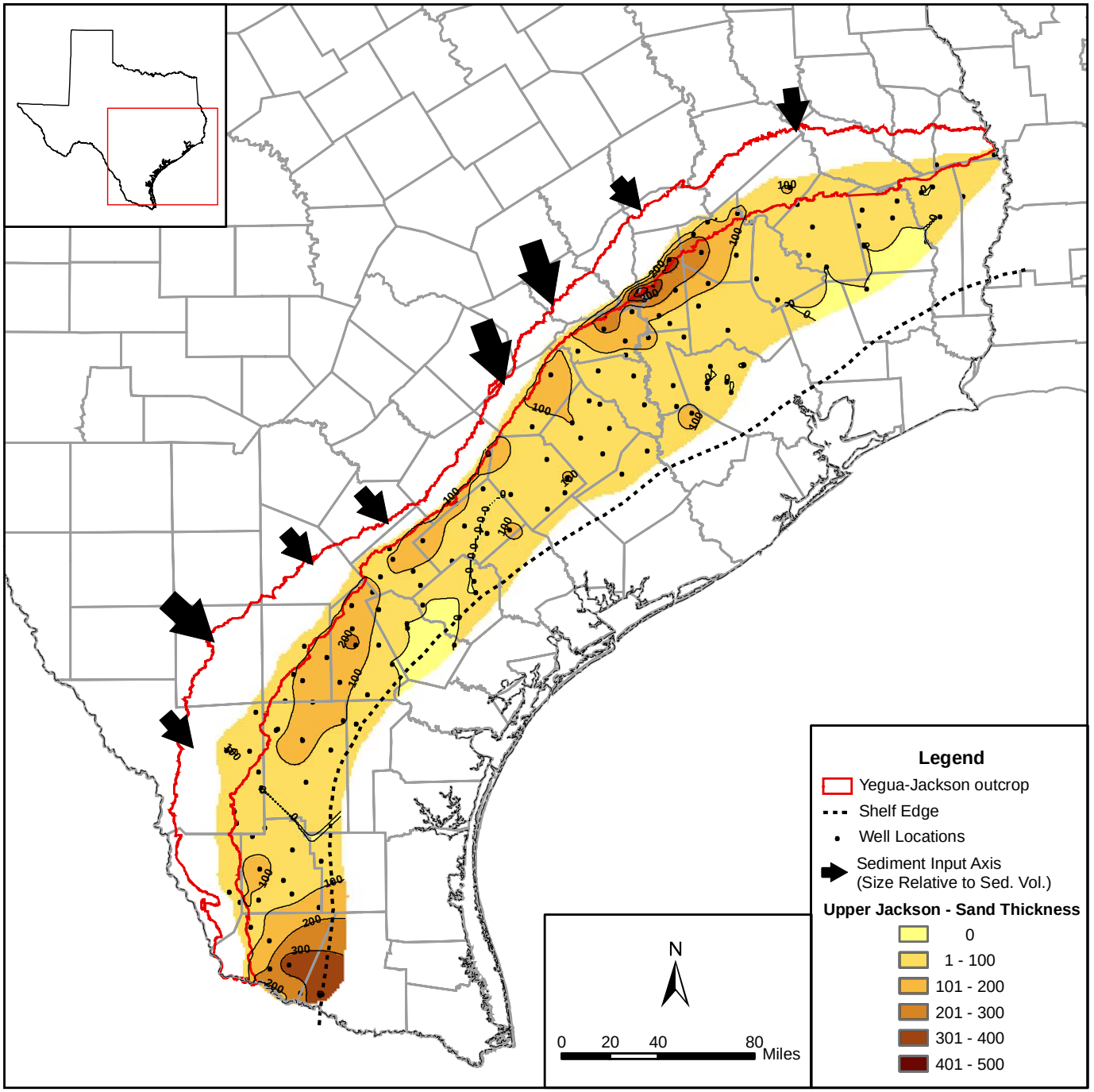
# Upper Jackson Structure



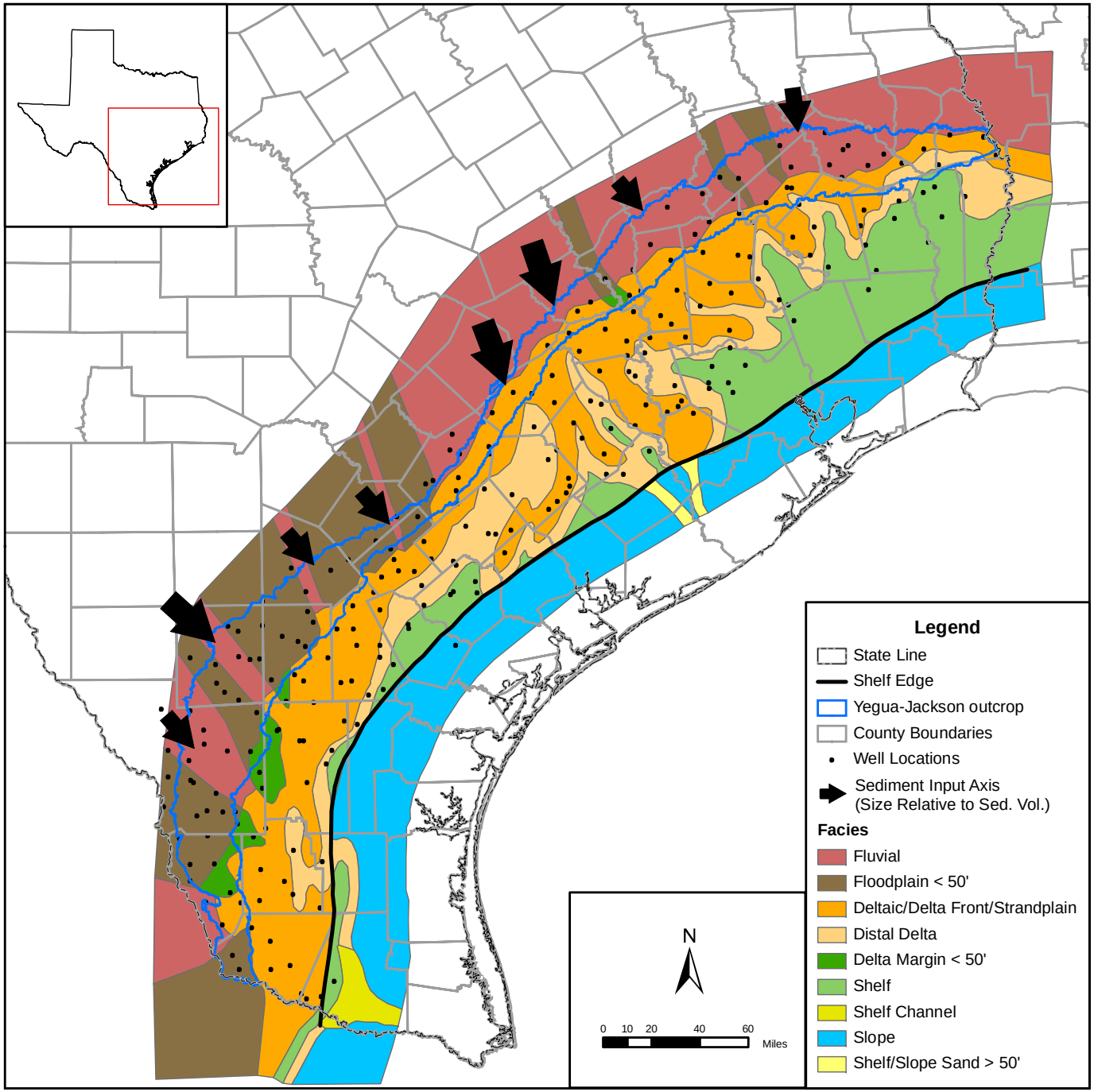
# Upper Yegua Isopach



# Upper Yegua Net Sand



# Upper Yegua Facies



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- **Numerical groundwater modeling and the GAMs**
- Data collection
- Identification of data needs
- GAM schedule

# Definition of a Model

**Domenico (1972)** defined a model as a representation of reality that attempts to explain the behavior of some aspect of reality and is always **less complex** than the real system it represents

**Wang & Anderson (1982)** defined a model as a tool designed to represent a **simplified** version of reality

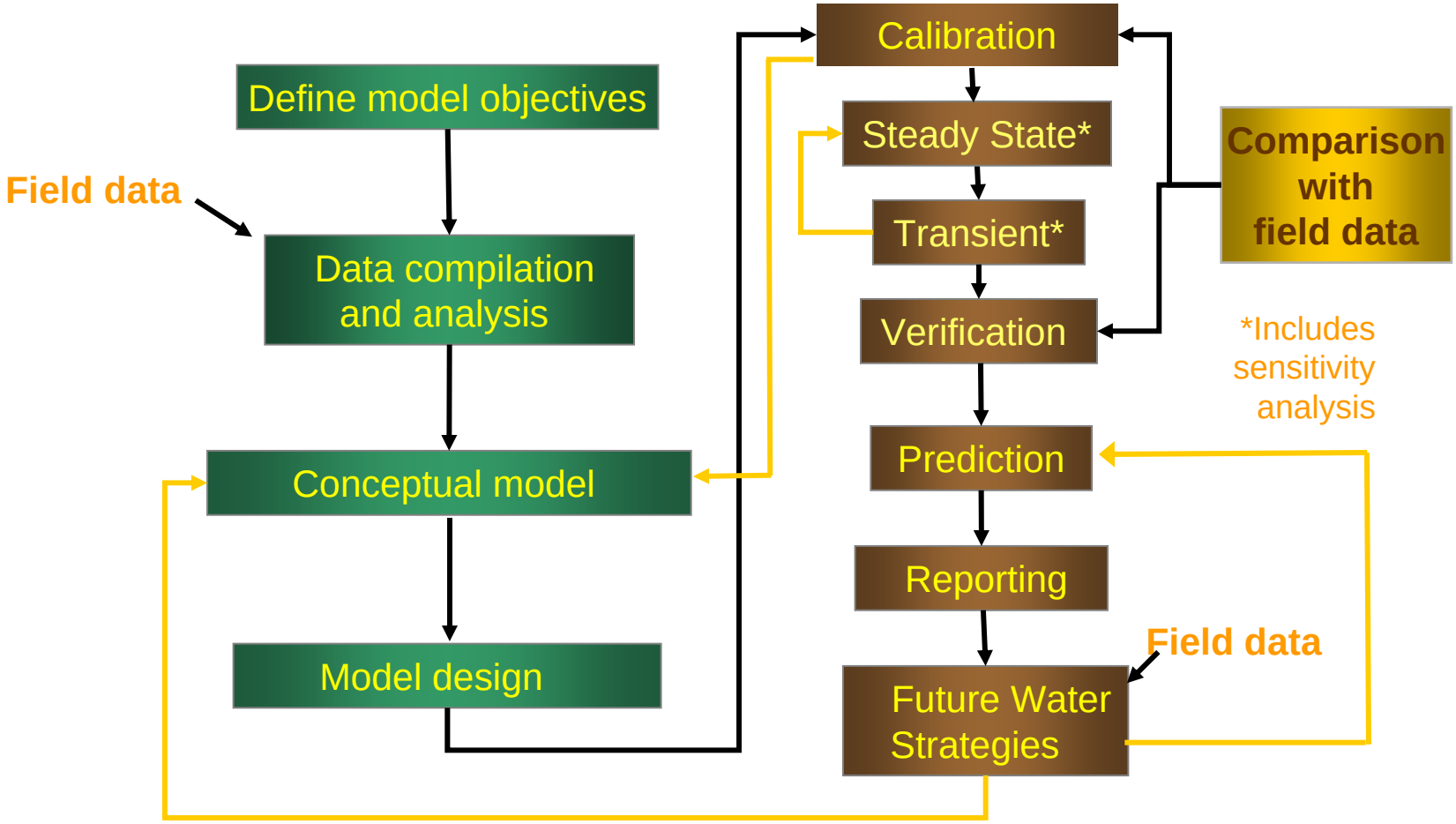
# Why Groundwater Flow Models?

- In contrast to surface water, groundwater flow is difficult to observe
- Aquifers are typically complex in terms of spatial extent and hydrogeological characteristics
- A groundwater model provides the only means for integrating available data for the prediction of groundwater flow at the scale of interest

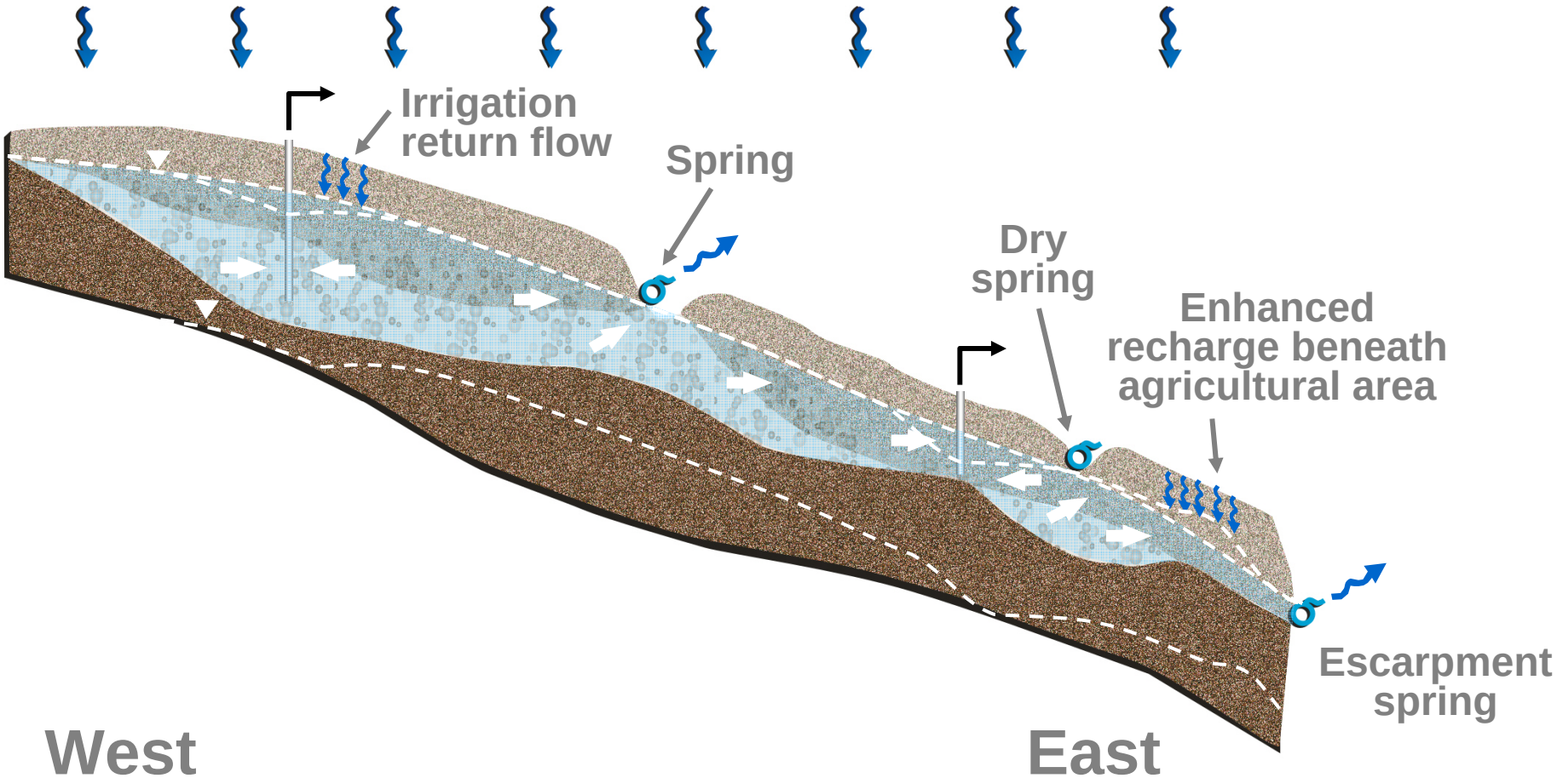
# Numerical Flow Model

- A numerical groundwater flow model is the mathematical representation of an aquifer
- It uses basic laws of physics that govern groundwater flow
- In the model domain, the numerical model calculates the hydraulic head at discrete locations (determined by the grid)
- The calculated model heads can be compared to hydraulic heads measured in wells

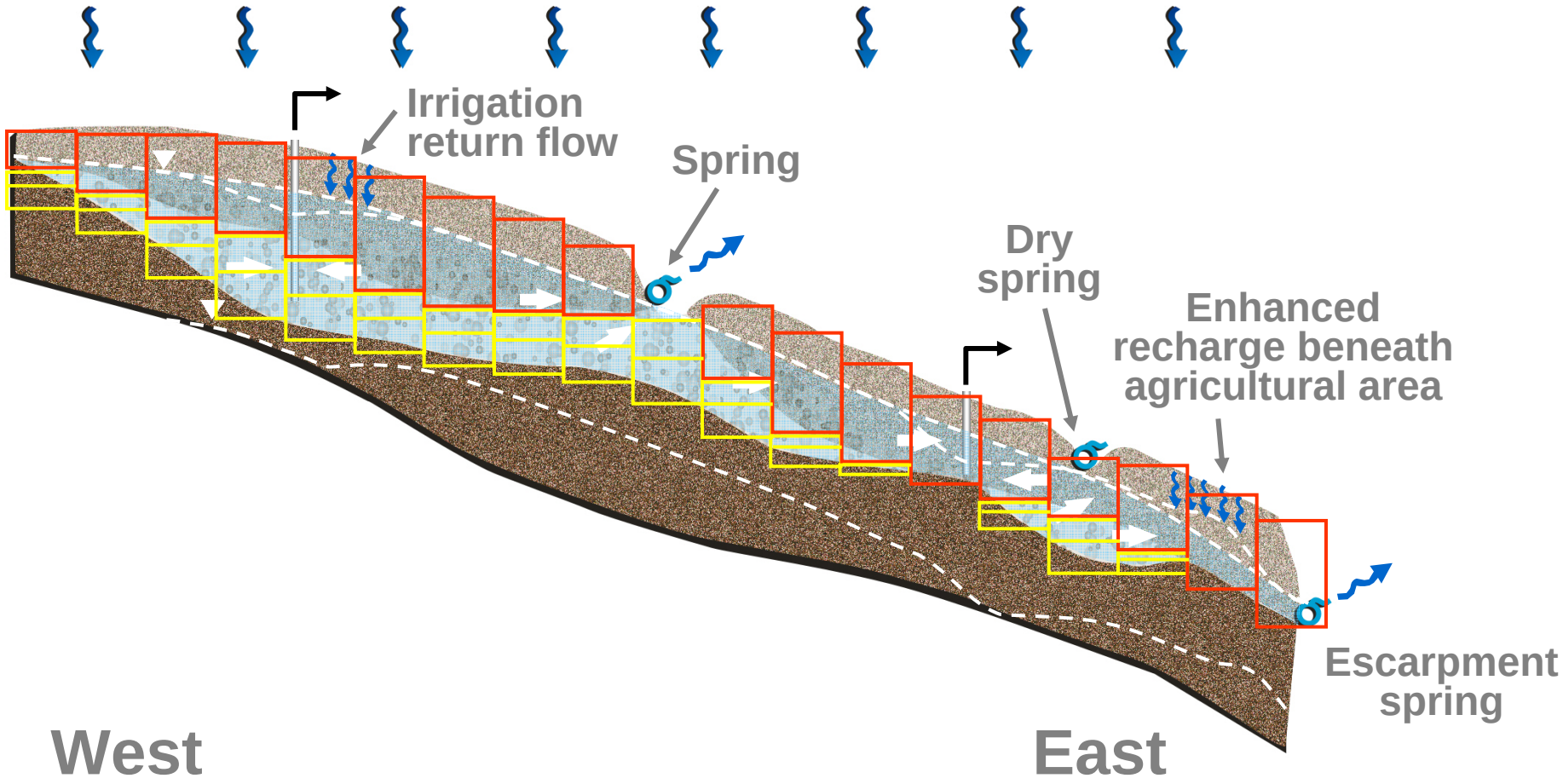
# Modeling Protocol



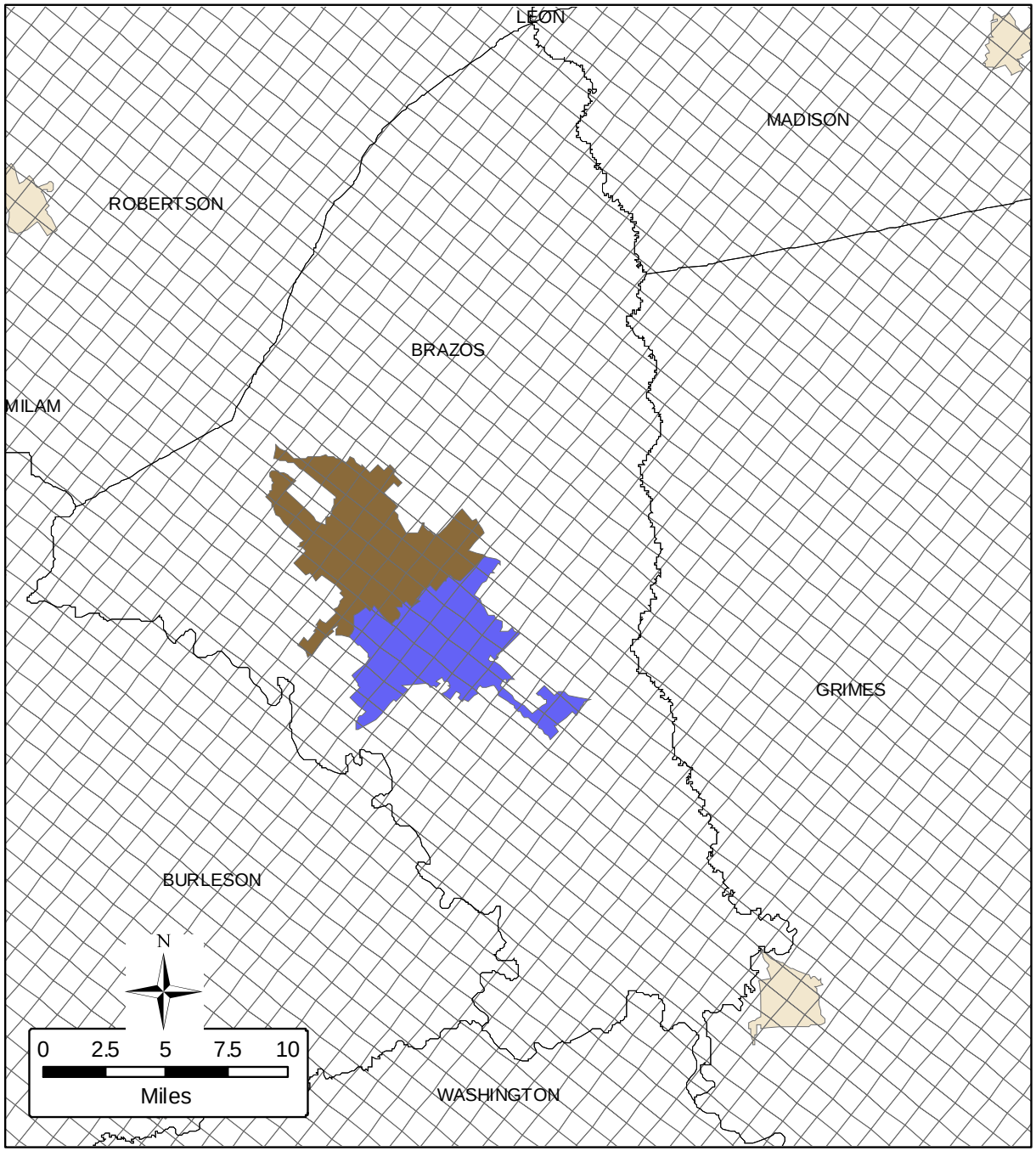
# Start with a conceptual model



# Divide it up into cells



# Model Grid Scale




Source: N/A

# Model Layering

| Series | | | Group | Formation | Model Layer |
|---|---|---|---|---|---|
| Tertiary | Oligocene | | | Catahoula | 1* |
| | Eocene-Oligocine | | Jackson | Whitsett | 2 |
| | Eocene | Upper | | Manning | |
| | | | | Wellborn | 3 |
| | | | | Caddell | |
| | | Middle | Upper Claiborne | Yegua | 4 |
| | | | | | 5 |
| | | | | Cook Mountain | |

*in the outcrop, Layer 1 simulates the surficial aquifer

# GAM Model Specifications

- Three dimensional (MODFLOW-2000)
- Regional scale (1000's of square miles)
- Grid spacing
  - Uniform grid of 1 square mile or less
  - Yegua Jackson will be 1 square mile
- Implement
  - recharge
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels/fluxes

# MODFLOW

- Code developed by the U.S. Geological Survey
- Selected by TWDB for all GAMs
- Handles the relevant processes
- Comprehensive documentation
- Public domain – non-proprietary
- Most widely used groundwater model
  - USGS had 12,261 downloads of MODFLOW computer code in 2000
- Supporting interface programs available
  - Groundwater Vistas to be used in all GAMs

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# Data Collection

## Key Data Sources

- Heads
  - County Reports (predevelopment)
    - Evidence of artesian wells
    - Evidence of flowing springs
  - TWDB groundwater database
  - GCDs?
- Water quality
  - TWDB groundwater database

# Data Collection

## Key Data Sources

- Fluxes
  - Baseflow
    - Slade et al. (2002) gain-loss studies
    - Hydrograph separation analysis
    - San Antonio River Authority, Evergreen Underground WCD, and Goliad GCD sponsoring groundwater-surface water interaction study on the Lower San Antonio River with the USGS.
  - Springs
    - Brune (1981)
    - TWDB database

# Data Collection

## Key Data Sources

- Hydraulic Properties
  - County reports
  - Meyer
  - PWS Database
  - TCEQ Surface Casing Database
    - Typically specific capacity tests
  - GCDs
  - Stakeholders

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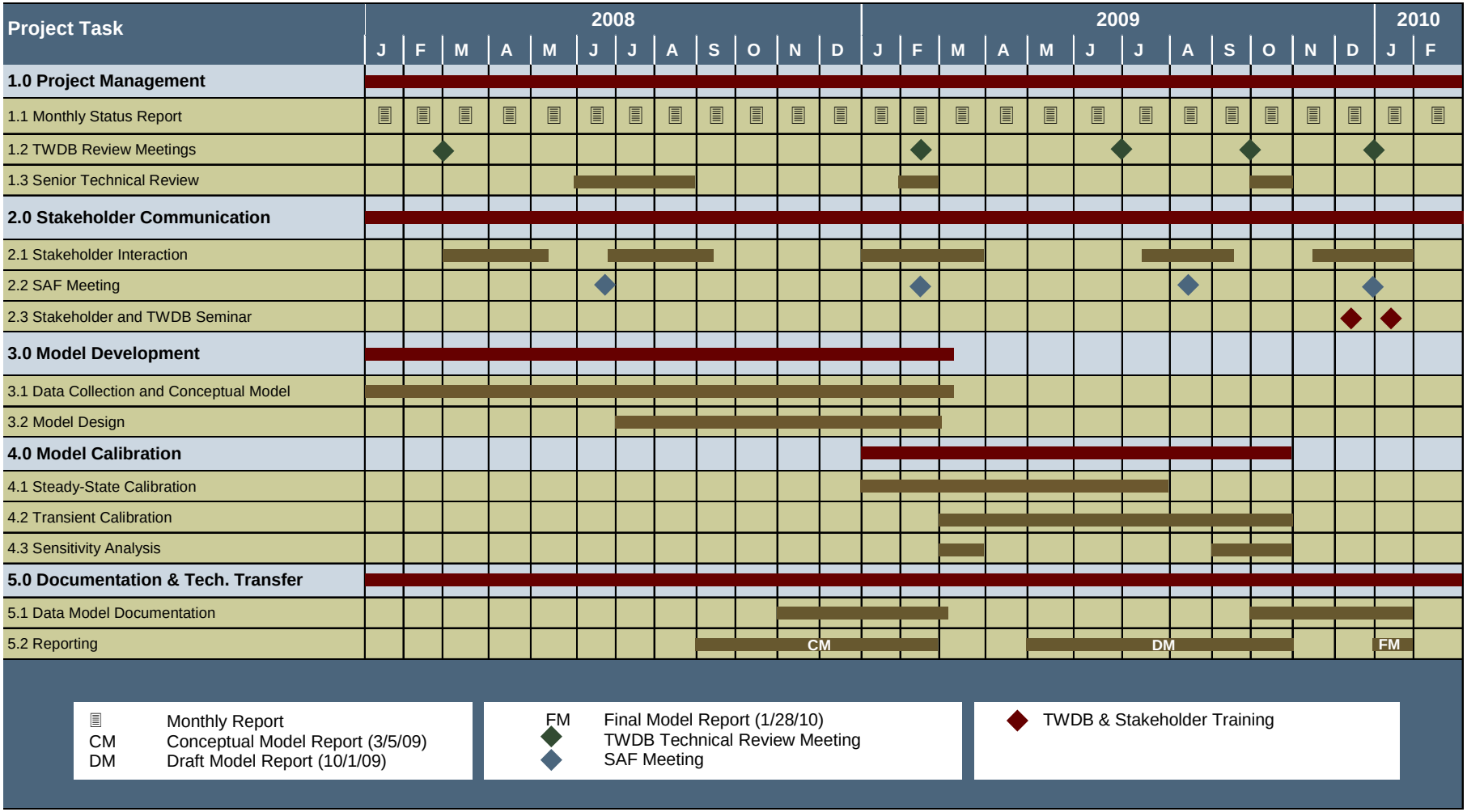
# Schedule


Project Task
2008
2009
2010
J F M A M J J A S O N D J F M A M J J A S O N D J F
1.0 Project Management
1.1 Monthly Status Report
1.2 TWDB Review Meetings
1.3 Senior Technical Review
2.0 Stakeholder Communication
2.1 Stakeholder Interaction
2.2 SAF Meeting
2.3 Stakeholder and TWDB Seminar
3.0 Model Development
3.1 Data Collection and Conceptual Model
3.2 Model Design
4.0 Model Calibration
4.1 Steady-State Calibration
4.2 Transient Calibration
4.3 Sensitivity Analysis
5.0 Documentation & Tech. Transfer
5.1 Data Model Documentation
5.2 Reporting
CM
DM
FM
Monthly Report
CM Conceptual Model Report (3/5/09)
DM Draft Model Report (10/1/09)
FM Final Model Report (1/28/10)
TWDB Technical Review Meeting
SAF Meeting
TWDB & Stakeholder Training

# Thank You – Questions?

# Meeting Minutes for the

# First Yegua-Jackson Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

## June 24, 2008

## Vegetable and Fruit Improvement Center, Suite 120, Bldg A

## College Station, Texas

The first Stakeholder Advisory Forum (SAF) Meeting for the Yegua-Jackson Groundwater Availability Model (GAM) was held on Tuesday, June 24th, 2008 at 1:00 PM at the Texas A&M Vegetable and Fruit Improvement Center located at 1500 Research Parkway in College Station. A list of meeting participants is provided at the end of these meeting notes.

The primary purpose of the first SAF meeting was to provide an introduction to the Yegua-Jackson GAM Team and their proposed approach to developing the model and to solicit input from stakeholders including any available data that could be made public. The meeting also provided a forum for discussing the project schedule and provided an opportunity for feedback from stakeholders.

**Meeting Introduction: Cindy Ridgeway, TWDB**

The meeting was initiated by Ms. Cindy Ridgeway of the Texas Water Development Board (TWDB). She gave a brief introduction to the GAM Program and discussed how GAMs are used in Texas water resources planning. She then discussed GAMs and how they relate to Managed Available Groundwater as well as the importance of the stakeholder process.

**SAF Presentation: Neil Deeds and Van Kelley, INTERA Inc**

Neil Deeds and Van Kelley (INTERA) presented a prepared presentation structured according to the following outline:

1. Introduction To Yegua-Jackson Team
2. Yegua-Jackson Regional Overview
3. Basics of Groundwater Flow
4. Overview of Yegua-Jackson Aquifer
5. Numerical Groundwater Modeling and the GAMs
6. Data Collection/Data Needs
7. GAM Schedule

The presentation is available on the GAM website:

*(http://www.twdb.state.tx.us/gam/ygjk/ygjk.htm)*

**Questions and Answers: Cindy Ridgeway (TWDB) Presentation:**

Q: Does the TWDB send GCDs updates automatically when the revise or update a GAM?

A: *Yes, modifications to GAMs are communicated to GCDs through email with major updates also being mailed to the GCD with the model files and documentation.*

Q: What is the status of the Gulf Coast GAM?

A: *Cindy gave a description of the new approach to determining the Gulf Coast structure statewide, and indicated that this new structure would be used when the Gulf Coast GAMS were updated.*

Q: Can GCDs perform their own GAM simulations to support planning or the GMA process thereby bypassing a request of the TWDB to perform the simulations?

A: *Yes, a GCD can perform their own simulations. However, if the simulations are going to be used to support a Desired Future Condition, they have to document the simulation very well for the TWDB and they have to provide the model input and output files to the TWDB for their review. The only drawback is that the GCD will have to bear the cost of performing the simulations if they do not use the TWDB.*

Q: When can a GCD expect to receive the GAM water balance from the TWDB to be used to support their Management Plan?

A: *A GCD should receive the water balance information for their GCD to support the Management Plan at least 3 to 6 months prior to the due date for the plan to be submitted to the TWDB.*

**Questions and Answers: Van Kelley and Neil Deeds (INTERA) Presentation:**

Q During the presentation of the aquifer study area it was asked if the aquifer actually extended below the Gulf Coast Aquifer? And if so, do we need to be worried about Gulf Coast Aquifer injection wells?

A: *The formations which are equivalent to those that comprise the Yegua-Jackson Aquifer do extend below the Gulf Coast Aquifer but at depths much greater than the extent of freshwater or even brackish water in the aquifer. Because of faulting and the lower energy depositional nature (finer-grained) of gulf coast formations as they extend gulfward (i.e., deeper), they are very poorly connected to the freshwater portions of the aquifers. The bulk of the potable Yegua-Jackson Aquifer is constrained to the outcrop.*

Q: There are potable confined wells producing in Grimes County and in Lafayette Counties.

A: *The modeling team would like to know where these wells are so we can make sure that the GAM appropriately captures the confined portions of the aquifer as being*

*well connected to the outcrop. In developing the Yegua-Jackson structure, it was noted that there were portions of the aquifer where potable groundwater existed in confined portions of the aquifer. For each control well, we made estimates of fresh groundwater versus brackish and saline groundwater. We could map a depth to freshwater surface.*

It was requested that INTERA develop a depth to poor groundwater quality for the upper and lower Yegua and Jackson aquifer units and post it on the TWDB website.

## Yegua-Jackson Aquifer GAM Stakeholder Advisory Forum 1
## June 24, 2008

## Attendance

| Name | Affiliation |
|---|---|
| Kip Brunner | Fayette Water Supply |
| David A. Van Dresar | Fayette County GCD |
| Lloyd A. Behm | Bluebonnet GCD |
| Marius Jigmond | TWDB |
| Wade Oliver | TWDB |
| Van Kelley | INTERA |
| Neil Deeds | INTERA |
| Cindy Ridgeway | TWDB |