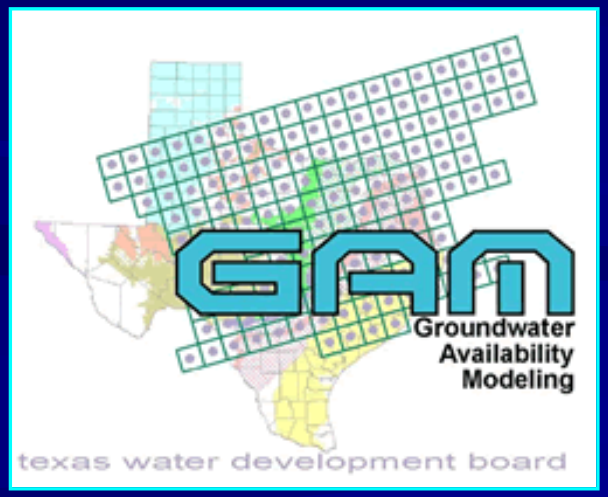
Groundwater Availability Modeling (GAM) for the Queen City and Sparta Aquifers

Stakeholder Advisory Forum (SAF#1)
The Bureau of Economic Geology
Austin, Texas
February 28th, 2003



Outline

- Queen City – Sparta GAM team
- GAM objectives
- Basics of groundwater flow
- Introduction to groundwater modeling
- GAM specifications and applicability
- Model data needs and data source review
- Identification of data needs and information request
- GAM schedule

Team Responsibilities

- INTERA – Prime role:
  - Project management
  - SAF meetings
  - Heads and calibration targets
  - Recharge
  - Pumping and discharge
  - Model calibration
  - Reporting
- BEG – Prime role:
  - Geologic structure
  - Water quality
  - Central model calibration
- BEG – Support role:
  - Recharge
  - Hydraulic properties
  - SAF meetings
  - Reporting

Team Responsibilities

- R. J. Brandes Company –
  - Support development of surface water calibration metric
- TWDB:
  - Contract Manager – Dr. Shirley Wade
- Expert Review:
  - Dr. Graham Fogg
  - Dr. Steve Gorelick
  - Dr. Bill Espey

GAM Objectives

- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes
- Promote stakeholder participation which is critical to the success of the GAM program

GAM Objectives (cont'd)

- Provide a thoroughly documented data base and model, available to the public
- The models are designed as tools to help GCDs, RWPGs, and other interested parties assess groundwater availability

SAFs

- Held on 4 month schedule
- First SAF to introduce basic information and request data for the model
- Future meetings
  - provide updates on progress
  - opportunity to obtain feedback
- SAF presentations and questions & responses from meetings will be posted at http://www.twdb.state.tx.us/gam/qc_sp/qc_sp.htm

Groundwater Flow - Definitions

- Aquifer – Water saturated permeable geologic unit that can transmit significant quantities of water
  - Unconfined – water table forms the upper boundary
  - Confined – water level usually rises above top of aquifer
- Water table – The level at which water stands in a shallow well
  - Subdued replica of topography
- Hydraulic head - The elevation that water stands in a well
  - Primary observable measure describing groundwater flow

Groundwater Flow – Definitions (cont'd)

- Hydraulic conductivity – A physical property of an aquifer representing its ability to transmit water
- Storage – A measure of the volume of water stored in pore spaces in an aquifer

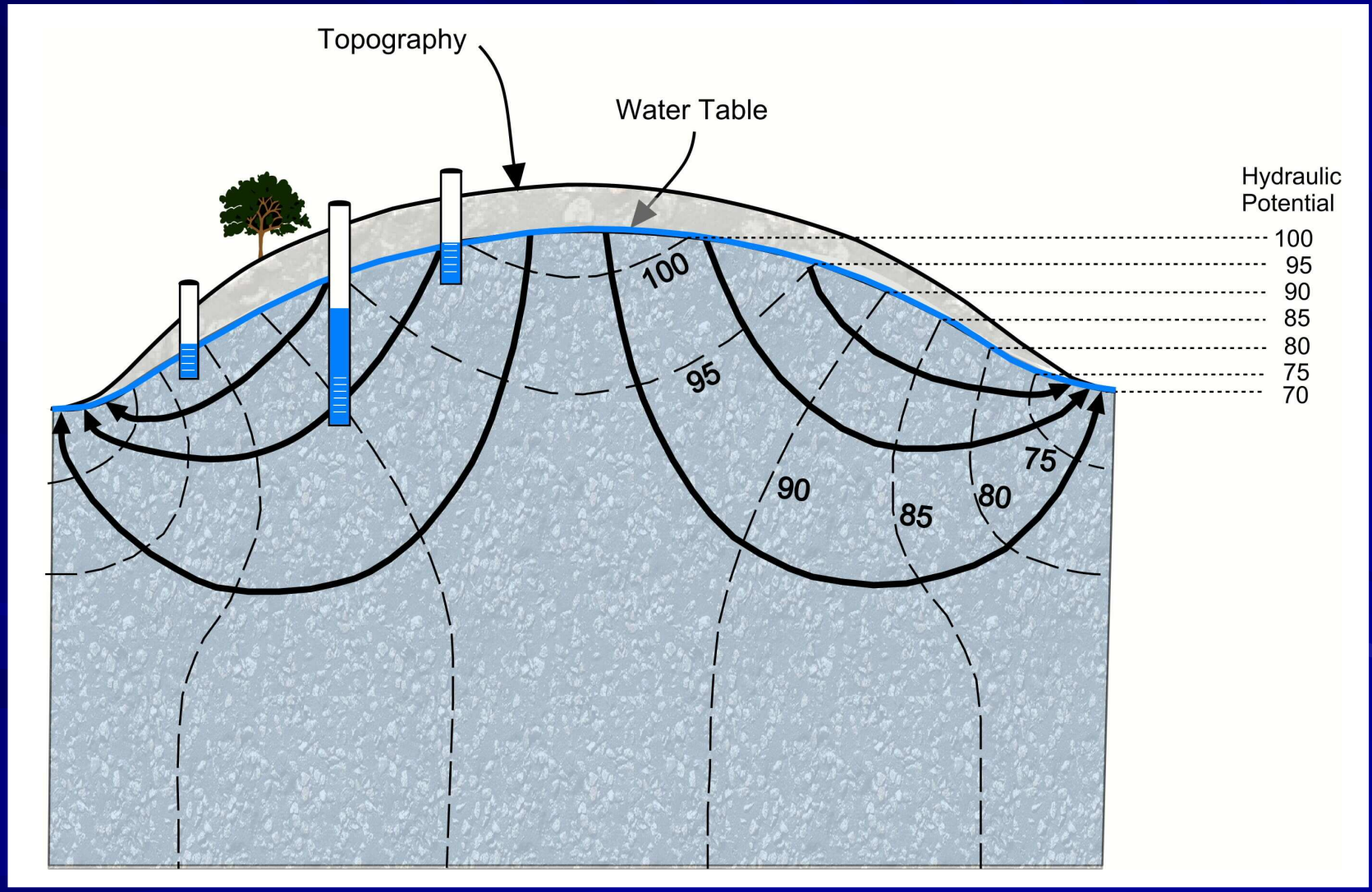
Groundwater Flow – Definitions (cont'd)

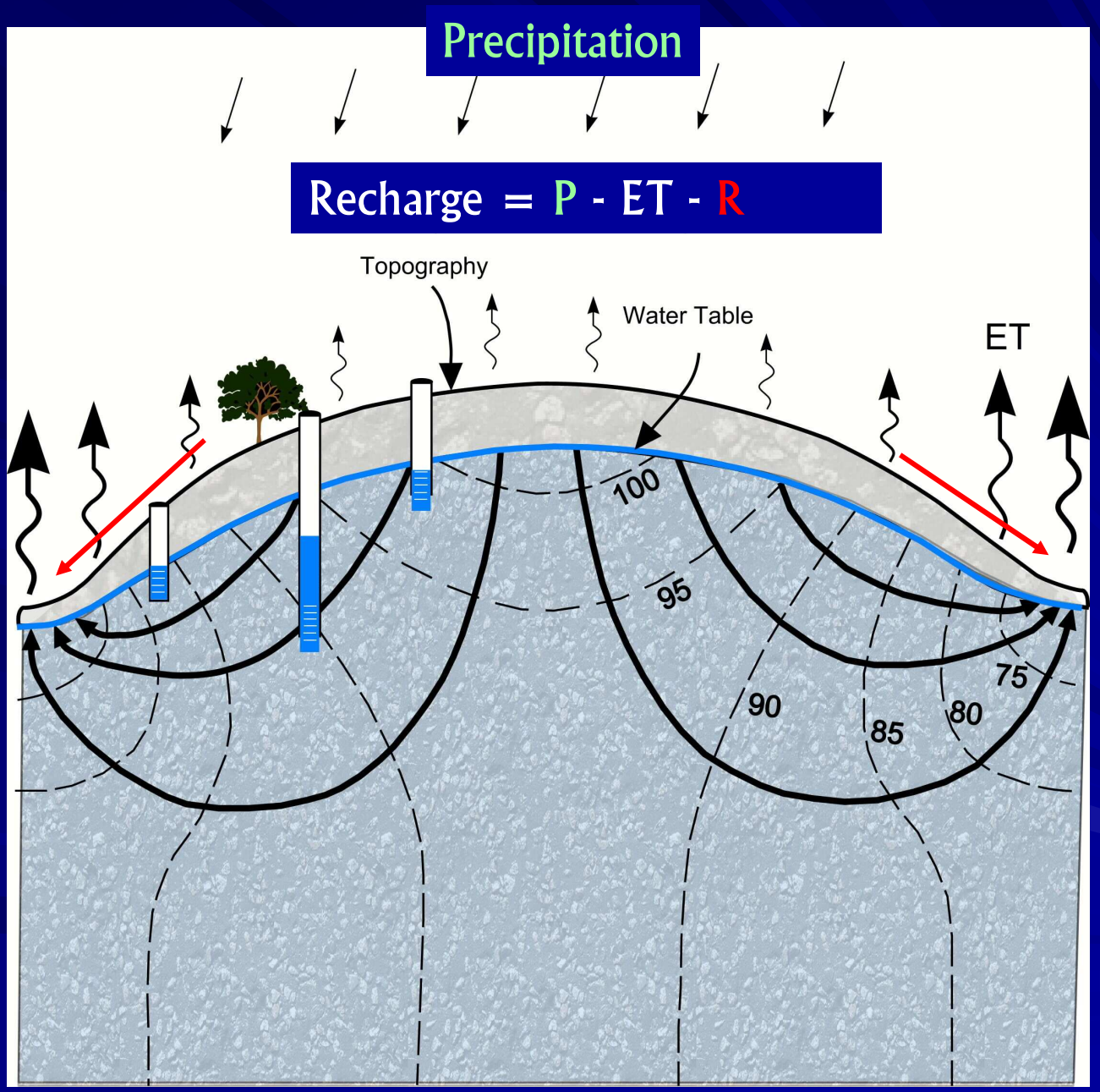
- Stream losses or gains – The water that is either lost or gained through the base of a stream
- Recharge – The addition of water to the water table. Recharge equals water inputs at ground surface (precipitation + irrigation + stream loss) minus water losses (runoff + evapotranspiration)

Basic Principles of GW Flow

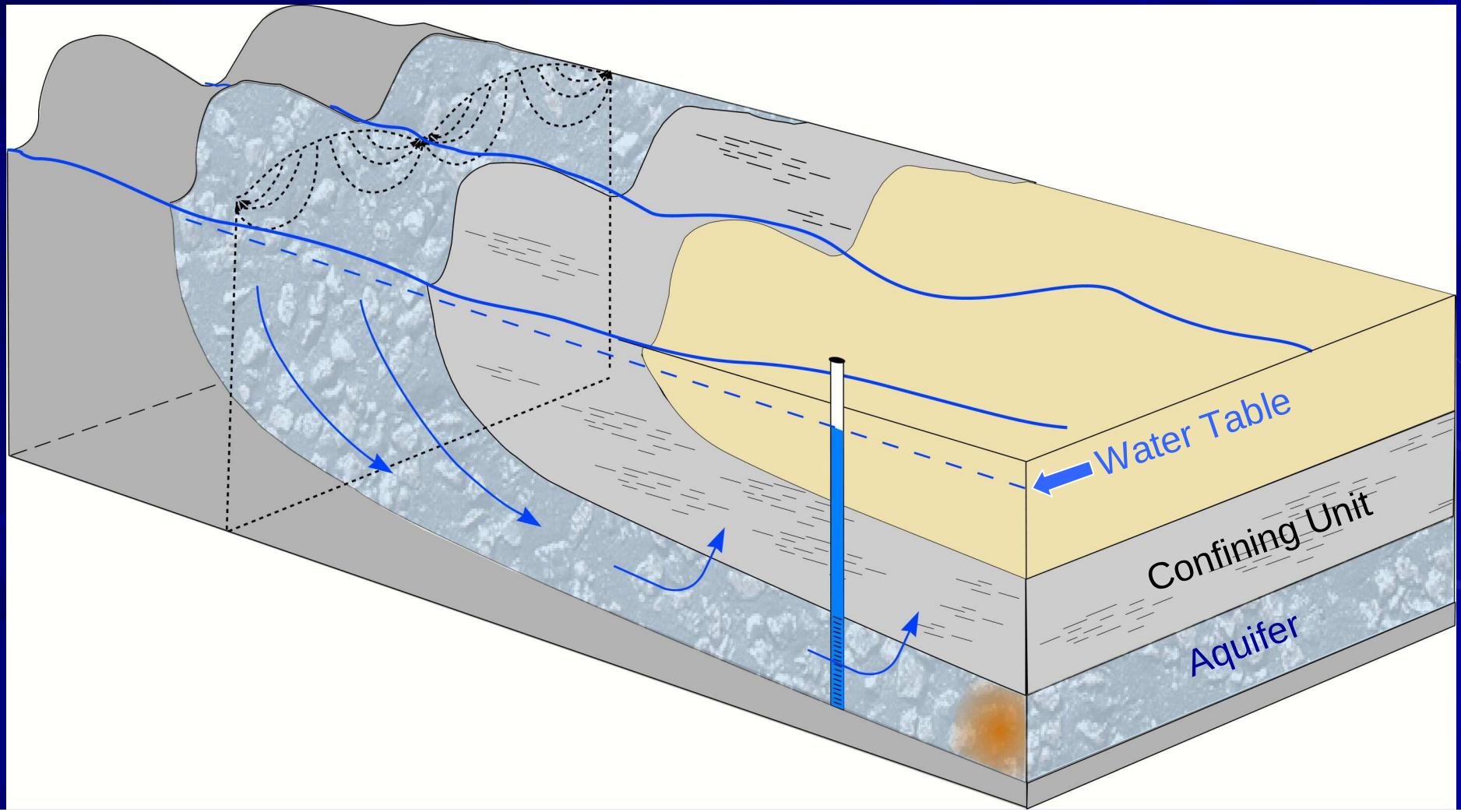
- The difference in hydraulic head between adjacent wells determines the direction of GW flow
- The thickness and hydraulic conductivity of the aquifer material determine the volume of flow in the aquifer
  - The larger the hydraulic conductivity and thickness, the greater the flow

Schematic Cross Section of Groundwater Flow




Precipitation
Recharge = P - ET - R
Topography
Water Table
ET
100
95
90
85
80
75

Confined Aquifer



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

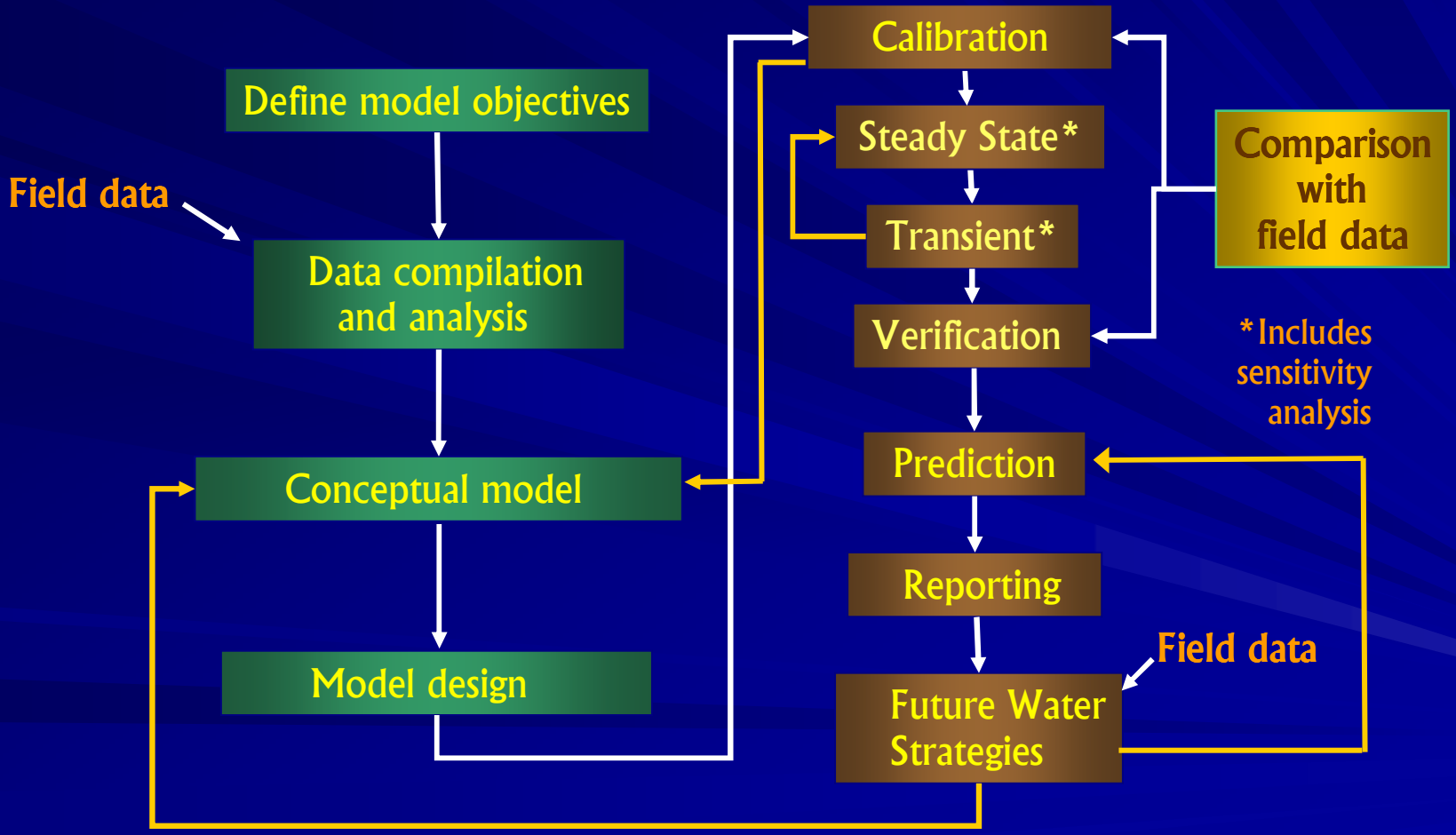
Why Groundwater Flow Models?

- 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



GAM Model Specifications

- Three dimensional (MODFLOW-96)
- Regional scale (1000's of square miles)
- Grid spacing of 1 square mile
- Implement
  - recharge
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels

Queen City-Sparta GAM Specifications

- The Queen City and Sparta aquifer GAMs will be incorporated into the current Carrizo-Wilcox GAMs
- The product will be delivered as three models
- One modeling report will be produced

Model Applicability

- The GAM is a tool capable of being used to make groundwater availability assessments on a regional scale
- The model is well suited for studying institutional water resource issues
- The model would likely require refinement to study operational issues for a specific project
- The GAM allows regional consideration of interference between resource strategies

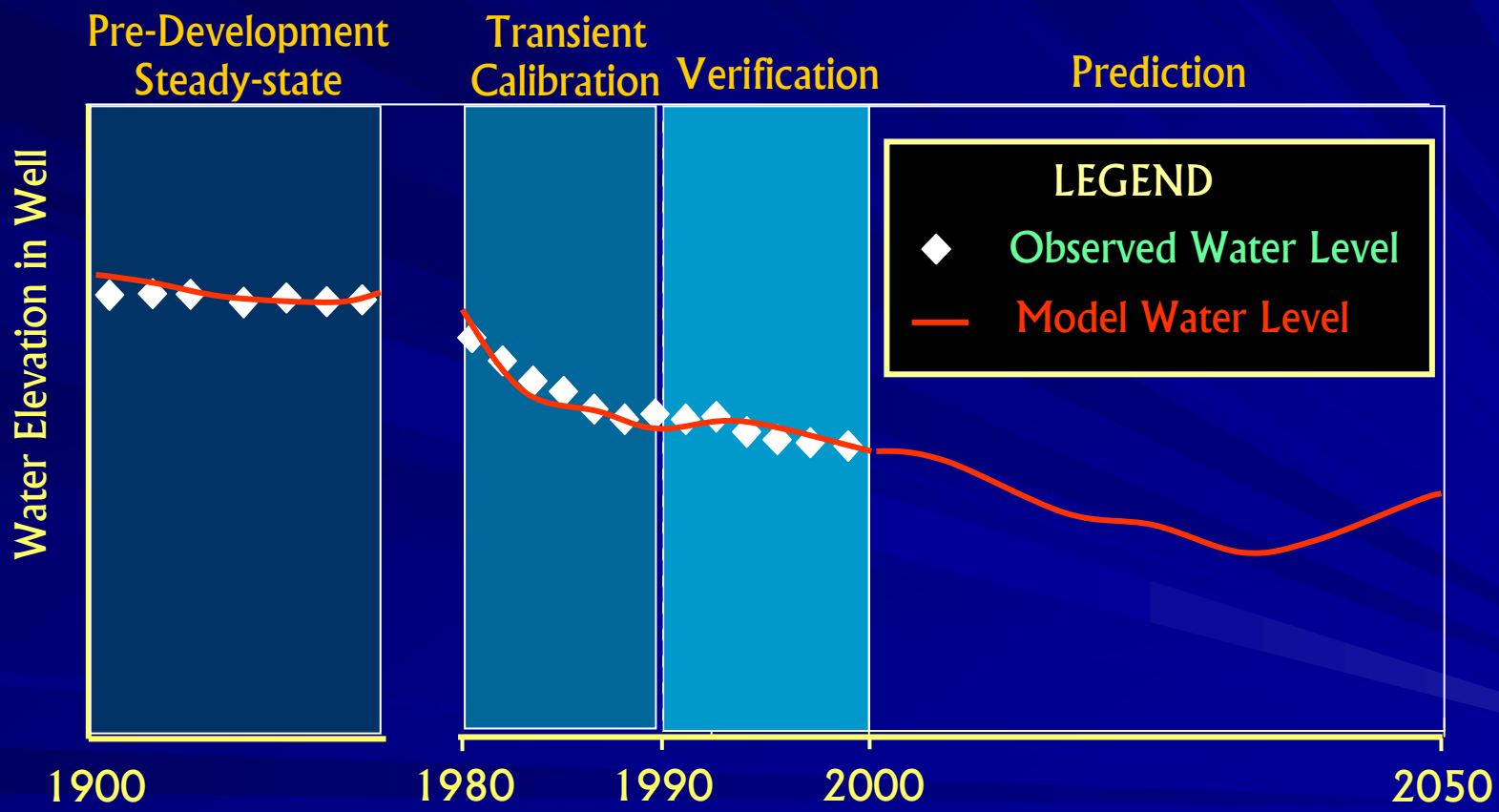
GAM Deliverables

- Calibrated groundwater model (GAM) with predictions to 2050
- Data base (data model) to support the GAM
- Final report with presentation and discussion of the data and the GAM
- All of the above will be publicly available through the TWDB at http://www.twdb.state.tx.us/gam

Data Model (Data Base) for GAM

- Provides consistent methodology for storage of the data base for each GAM
- Facilitates future improvements to or modifications of the current work
- Available to the general public as an addition to the model and final report

GAM Model Periods

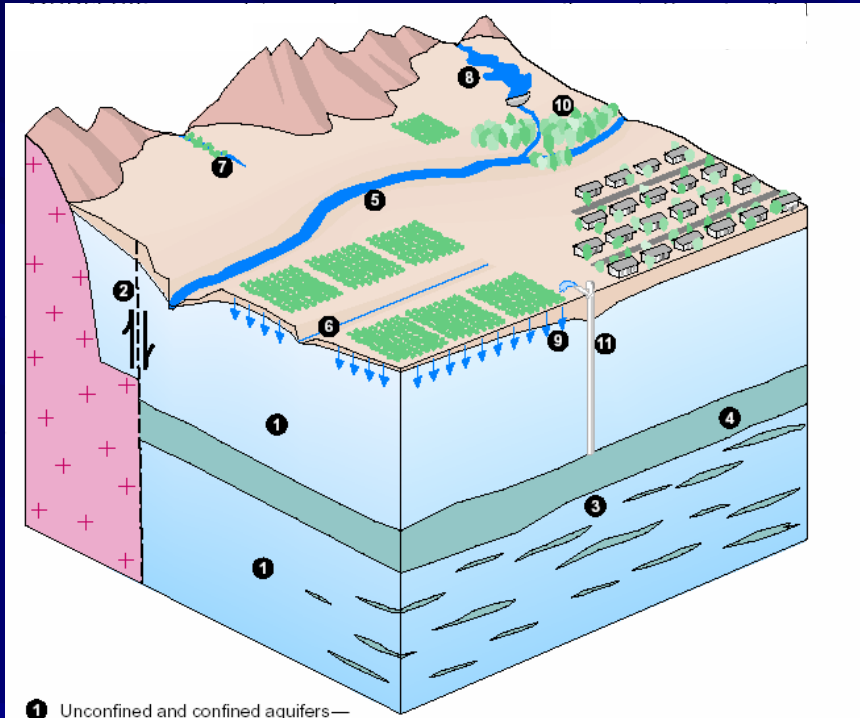


Pre-development and transient calibration periods represent different hydrologic conditions

MODFLOW

- Computer based model 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
  - PMWIN to be used in all GAMs

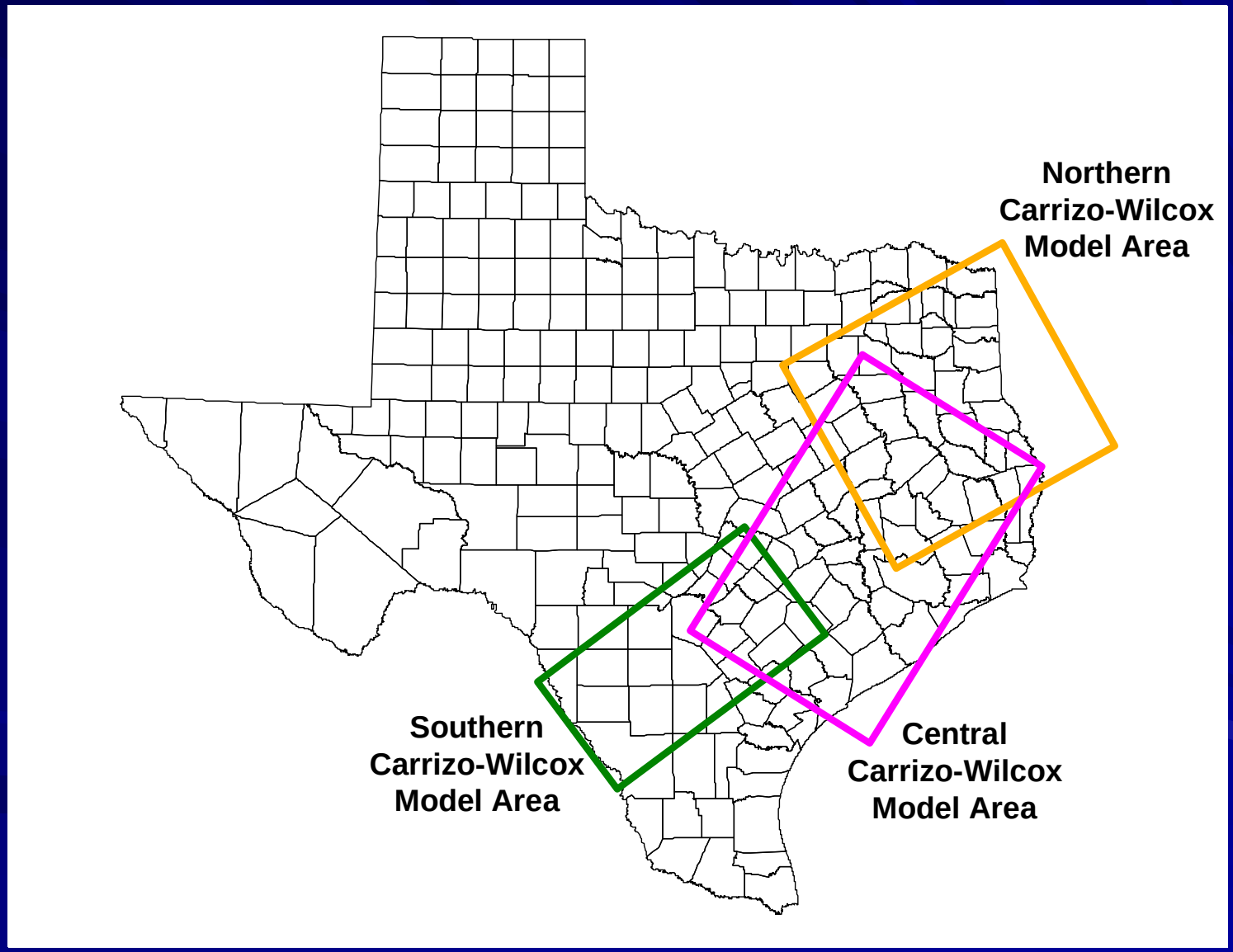
MODFLOW Processes



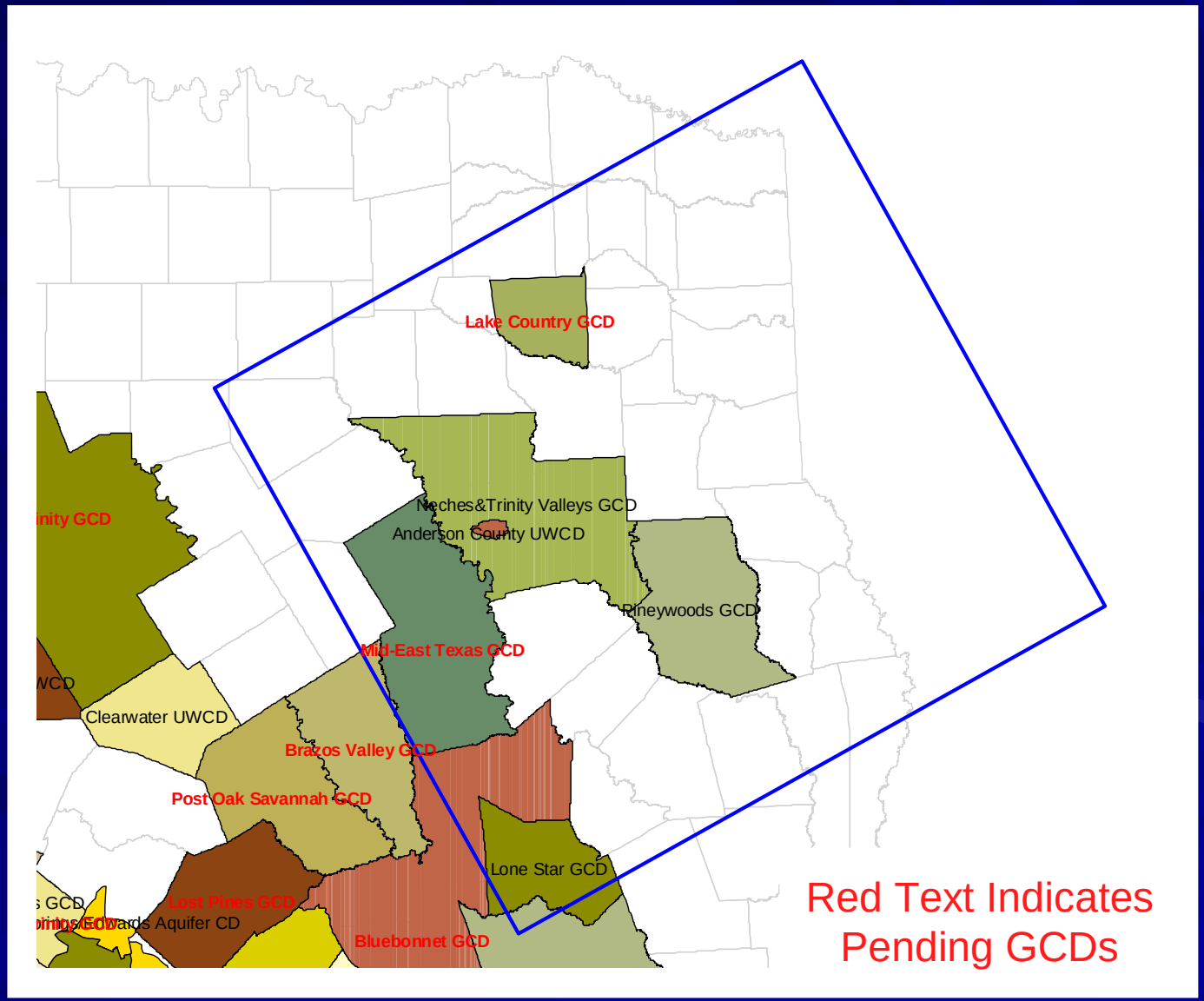
Source: USGS Fact Sheet FS-127-97

- Important for GAM
  - Confined/unconfined GW flow
  - Recharge/ET
  - Horizontal flow barriers
  - Wells
  - Streams
  - Drains (springs)
  - Reservoirs

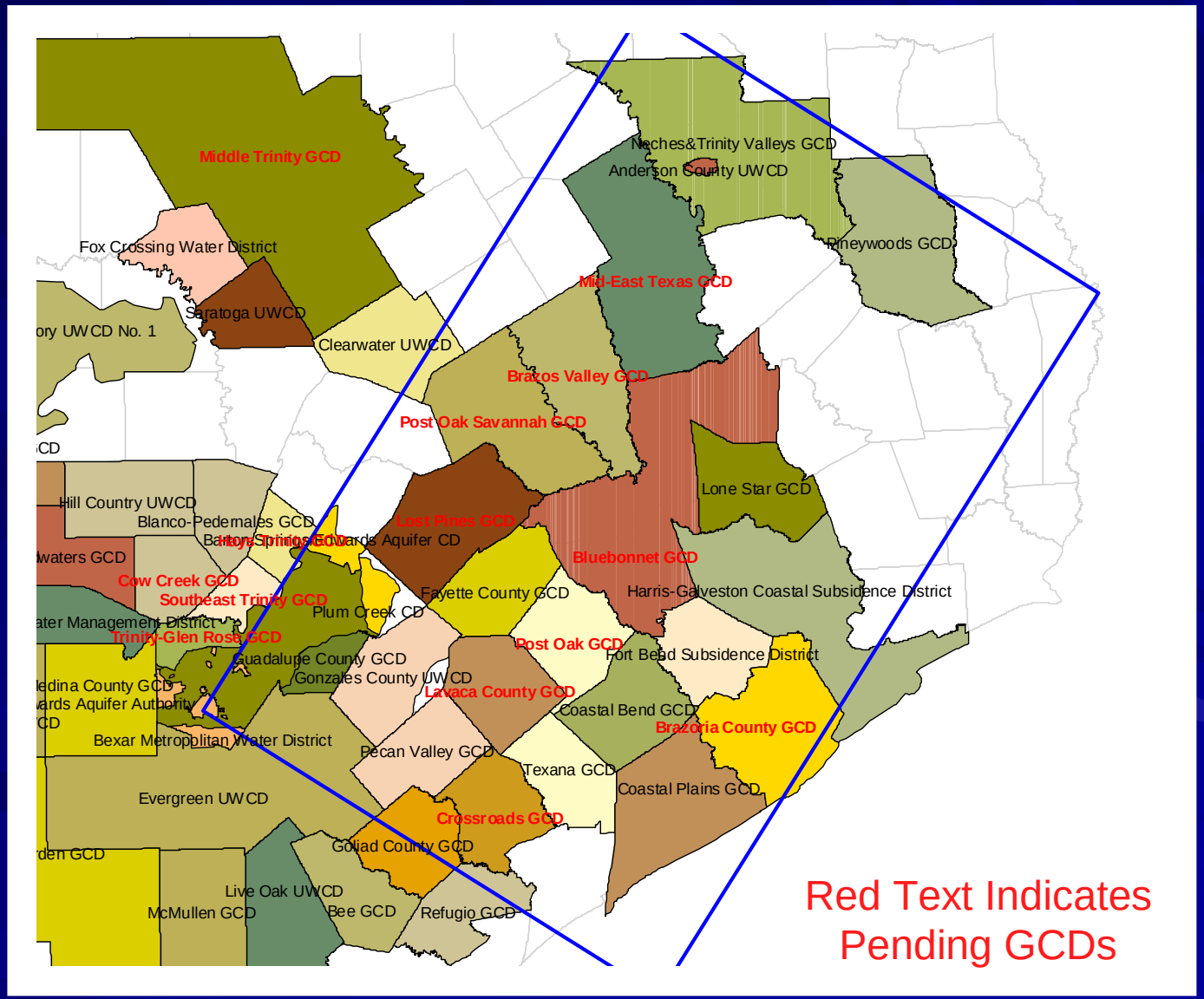
Model Domains



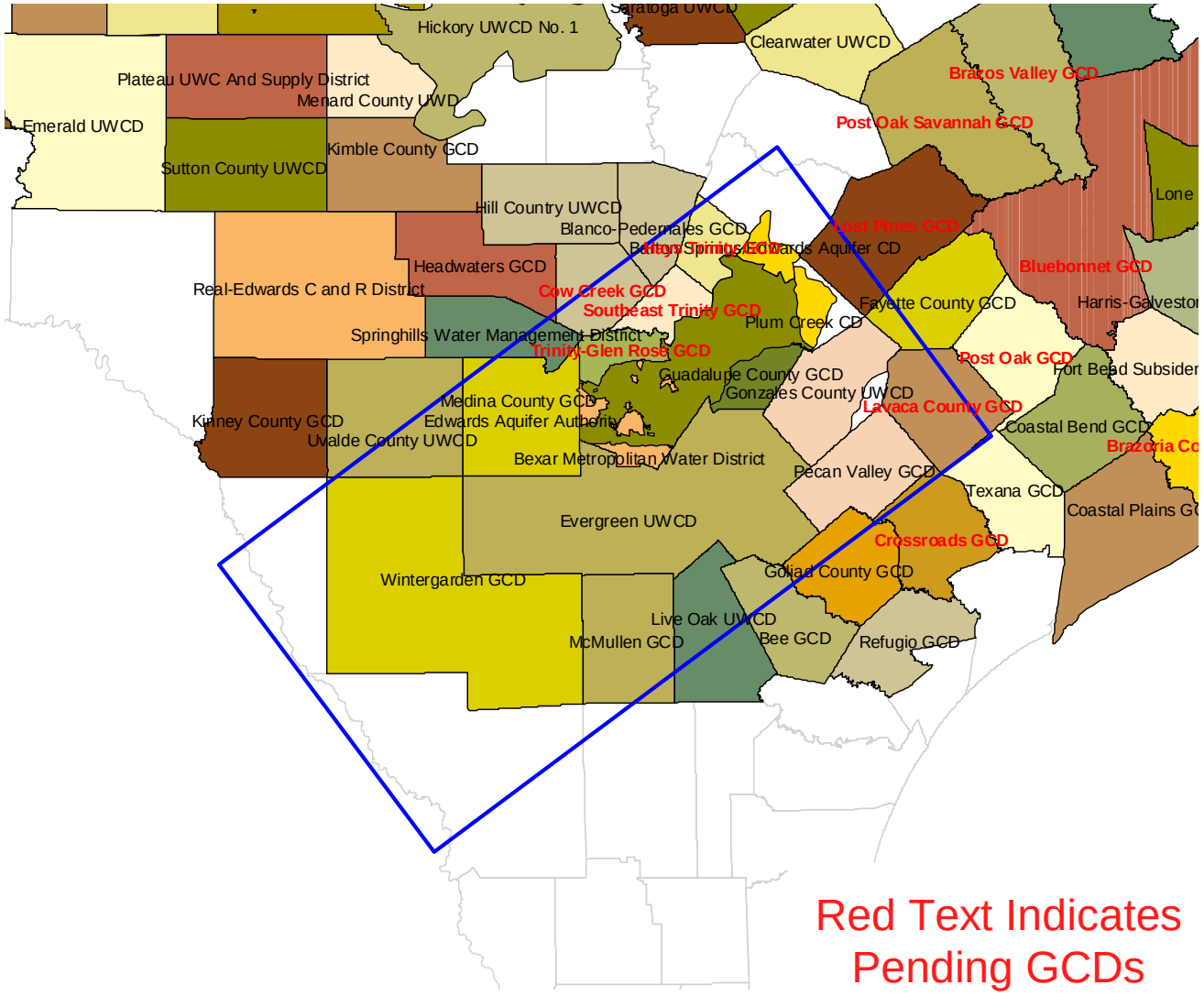
Groundwater Conservation Districts (GCDs) – Northern



Groundwater Conservation Districts (GCDs) – Central

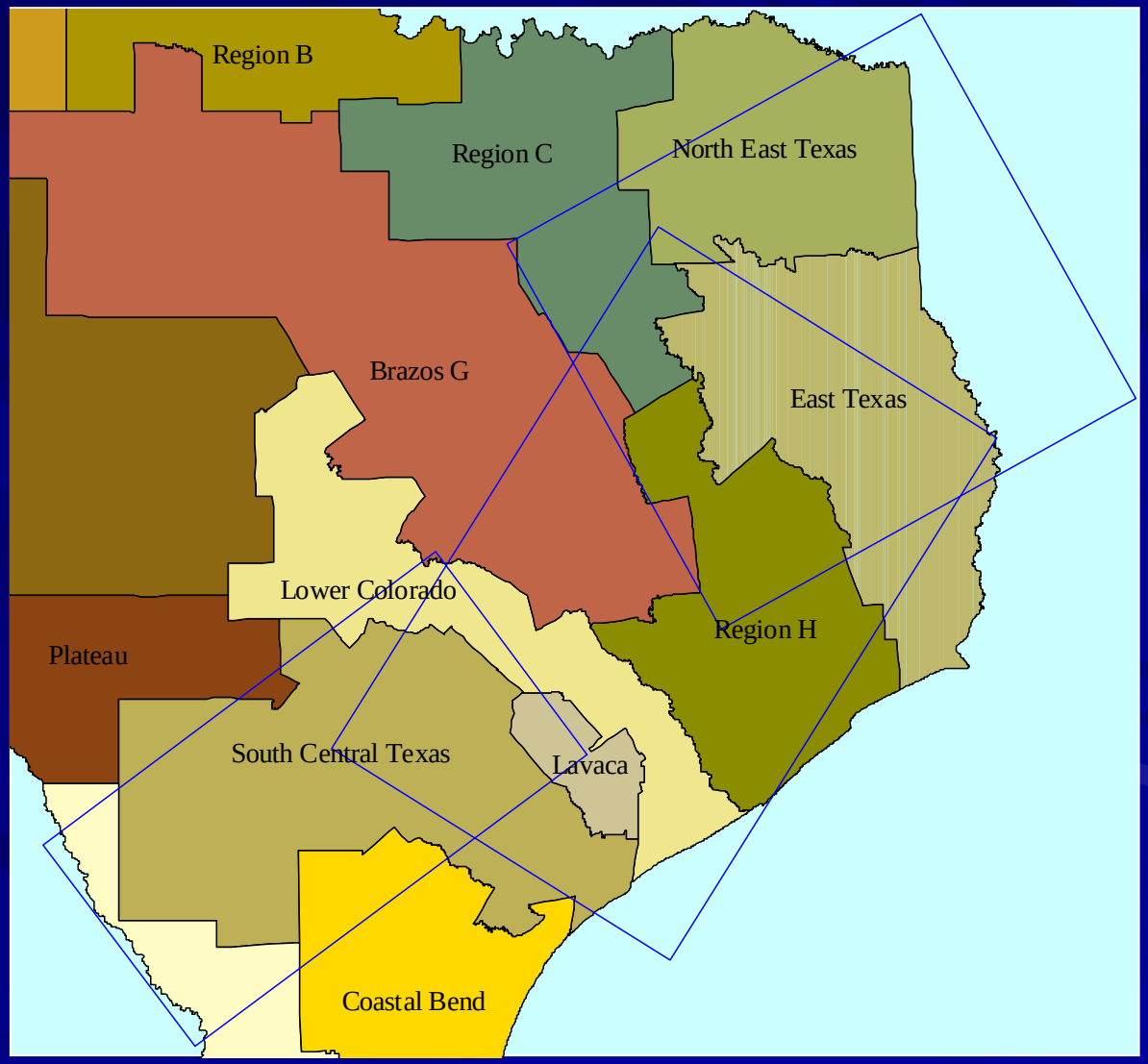


Groundwater Conservation Districts (GCDs) – Southern



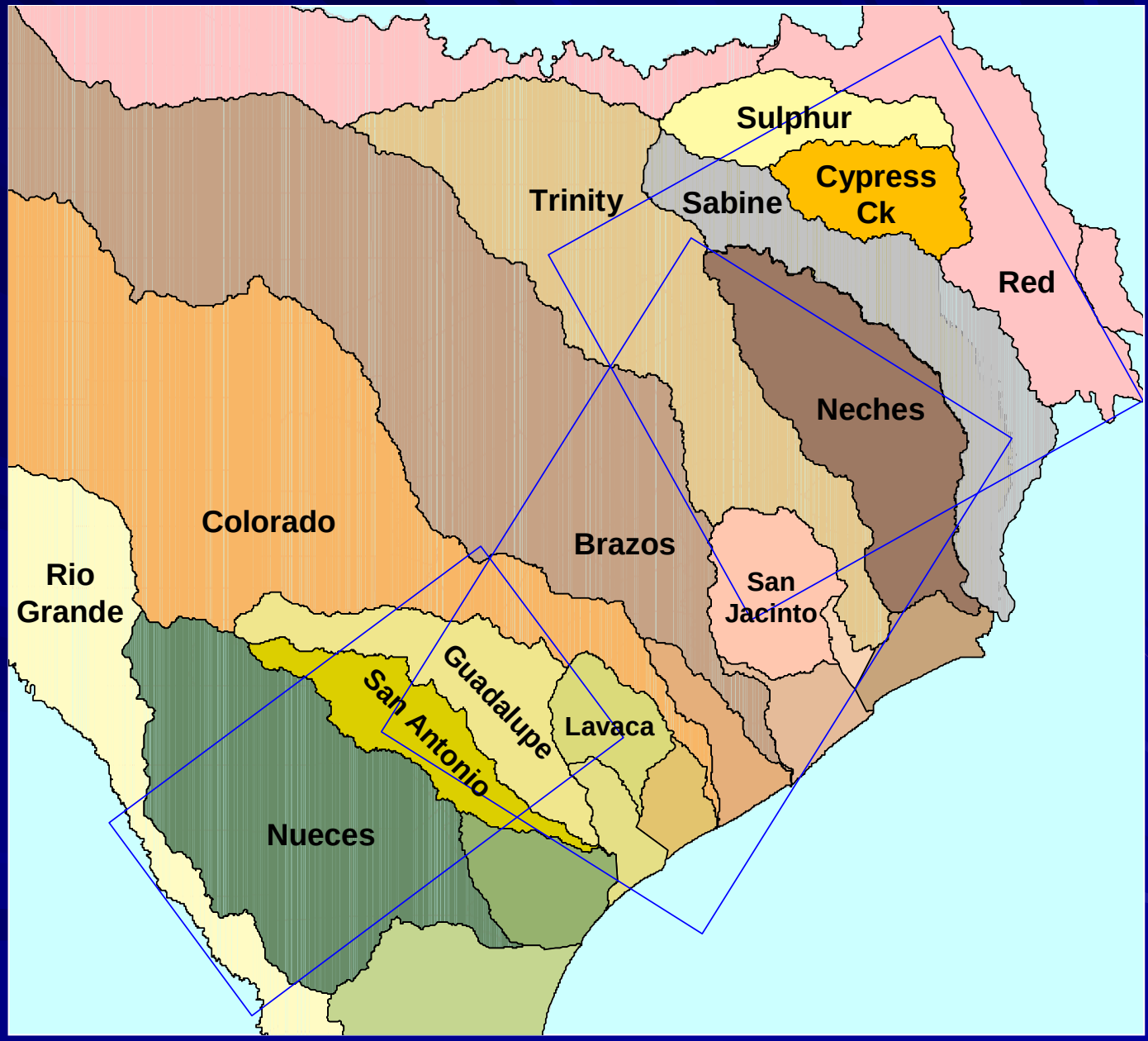
Regional Water Planning Groups (RWPGs)

Ten of the Sixteen RWPGs represented In the three GAM region

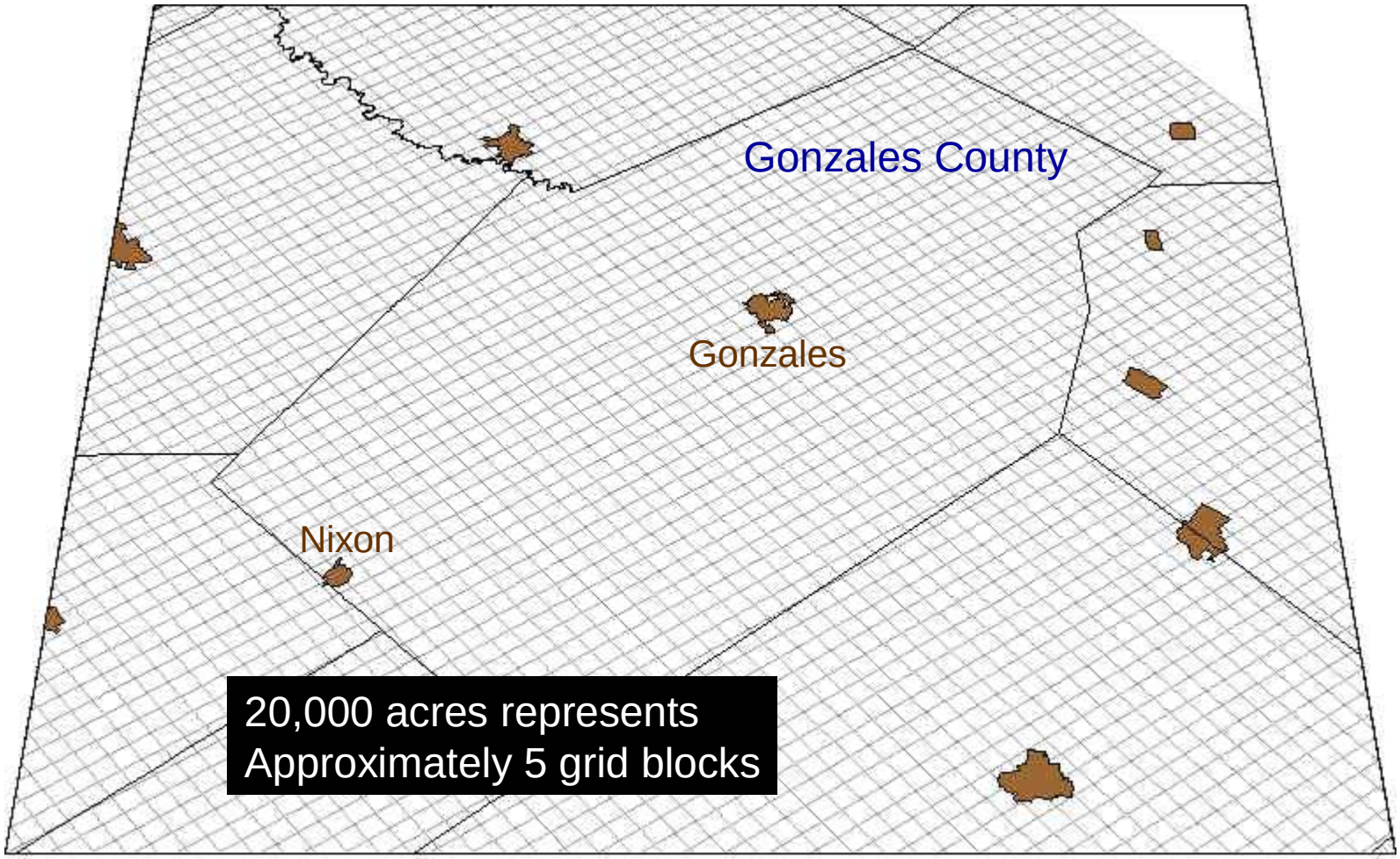


River Basins

Every major river basin is represented in the three GAM model areas



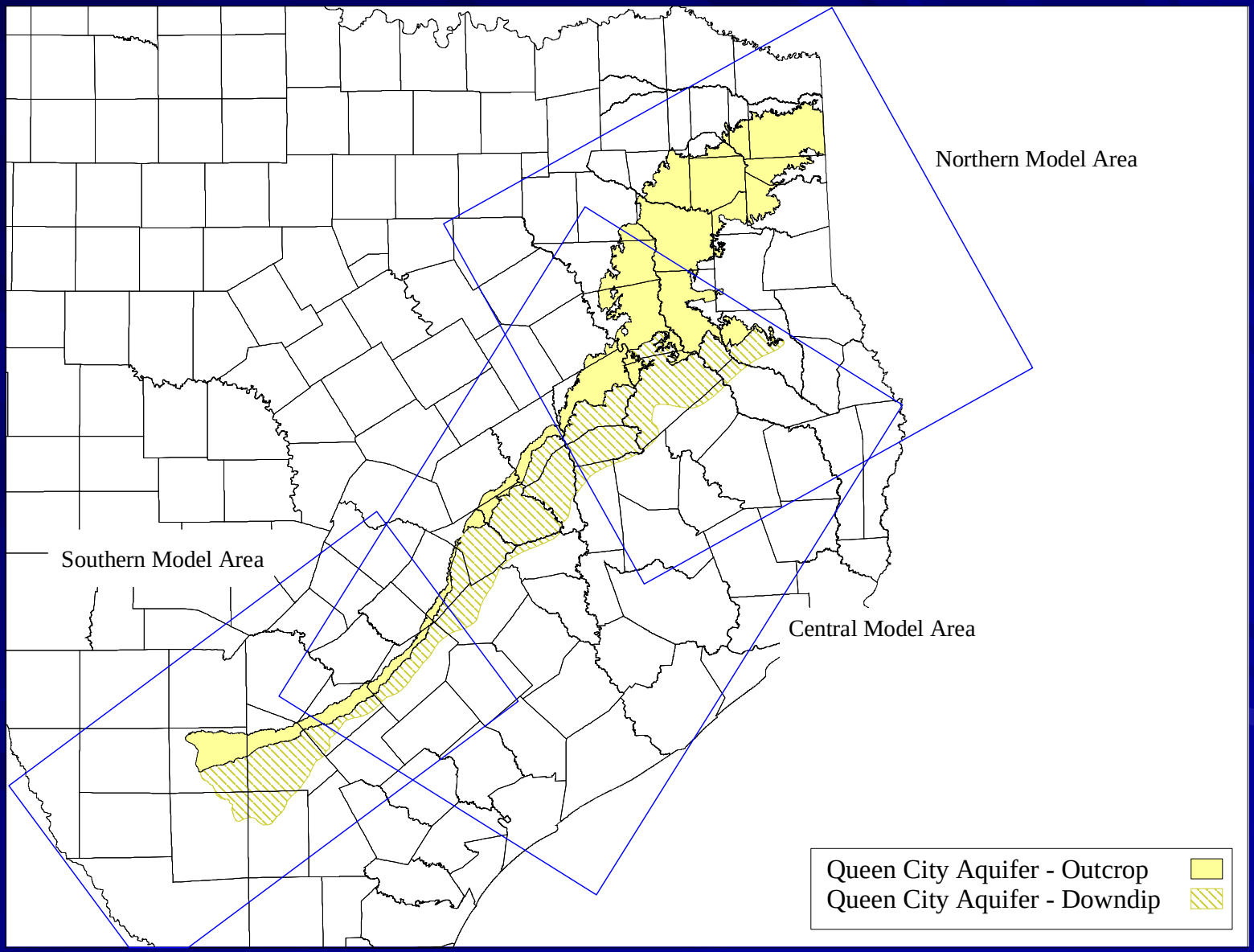
Model Grid Scale



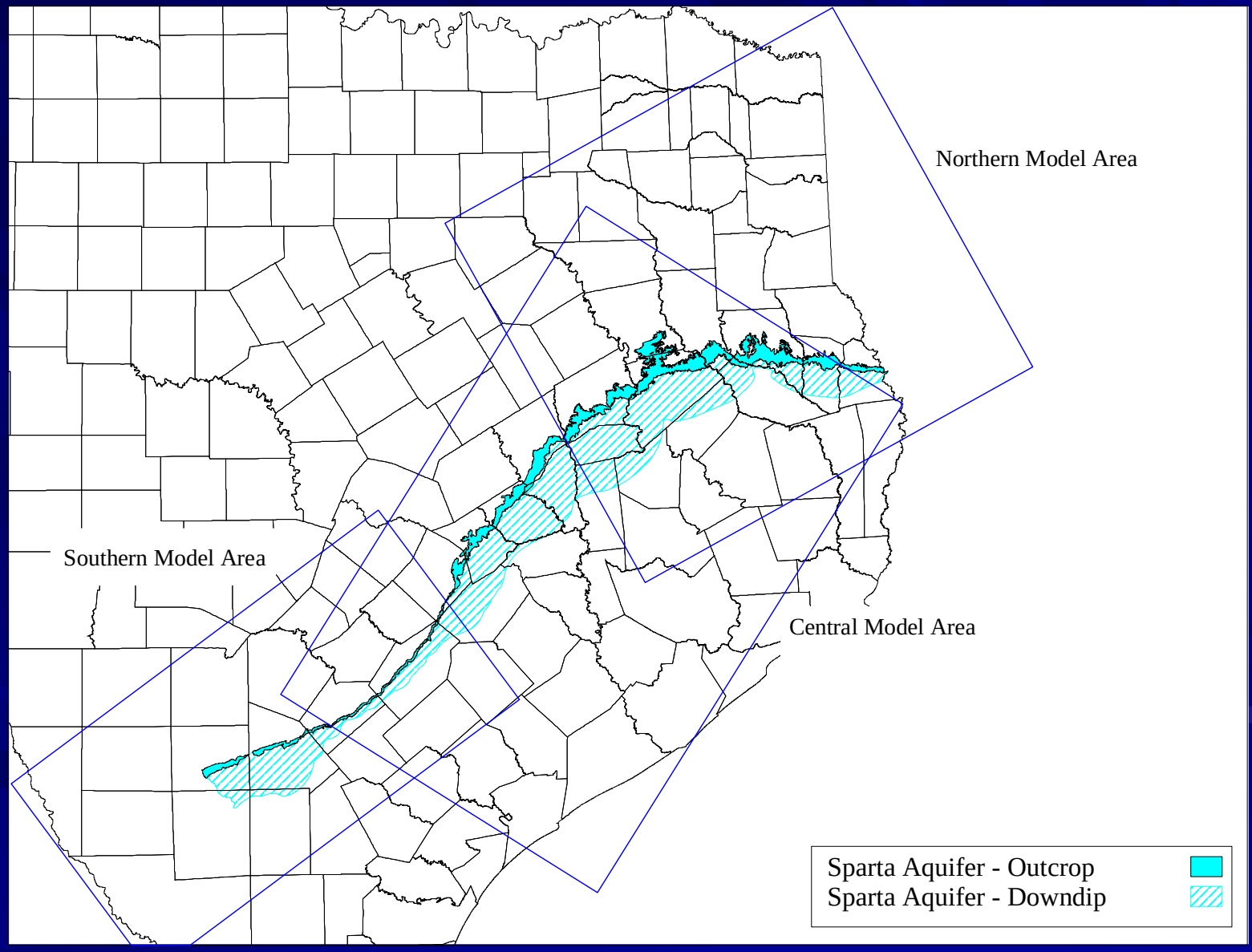
Queen City & Sparta Aquifers

- The Queen City and Sparta Aquifers extend from South Texas northeastward through East Texas into Ark. & La.
  - Sediments of the Tertiary Claiborne Group
  - Queen City aquifer consists of sand, loosely-cemented sands, and interbedded clays
  - Sparta Aquifer consists of sand and interbedded clays with massive basal sands which gently dip to the Gulf Coast (max thickness of 300 ft.)
  - Aquifers are separated by the Weches Formation which is a marine confining unit

Queen City Aquifer



Sparta Aquifer



Model Data Needs

- Top & bottom elevation surfaces for each layer
- Aquifer Properties:
  - Thickness
  - Hydraulic Conductivity (K)
  - Storativity or specific yield (transient)
- Initial water table elevations
- Recharge estimates
- Stream characteristics
- Pumping

Key Data Sources

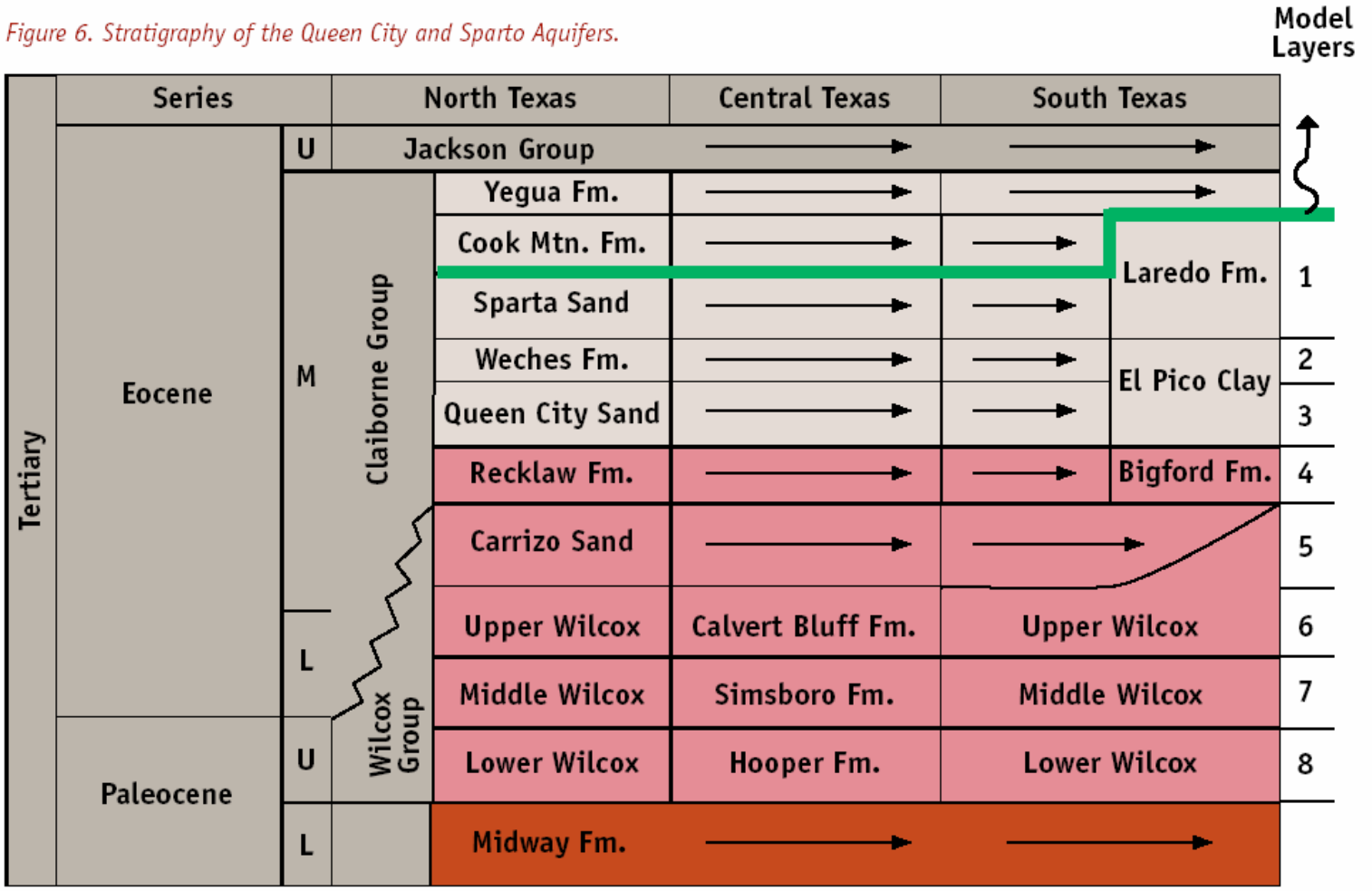
- TWDB data at their website: http://www.twdb.state.tx.us/data/data.htm
  - Queen City (1053 wells)
  - Sparta (587 wells)
- County reports by TWDB & predecessors
- U.S. Geological Survey reports
- UT Bureau of Economic Geology reports
- Louisiana state publications
- TCEQ drillers logs
- Brune (1975) spring locations & flows

Key Data Sources (cont'd)

- Websites:
  - U.S. Geological Survey
    - topography
    - stream flows
    - stream gain/loss studies
  - U.S. EPA
    - stream characteristics
    - land use / land cover
    - soil type
  - National Climatic Data Center - precipitation

Proposed Model Stratigraphy

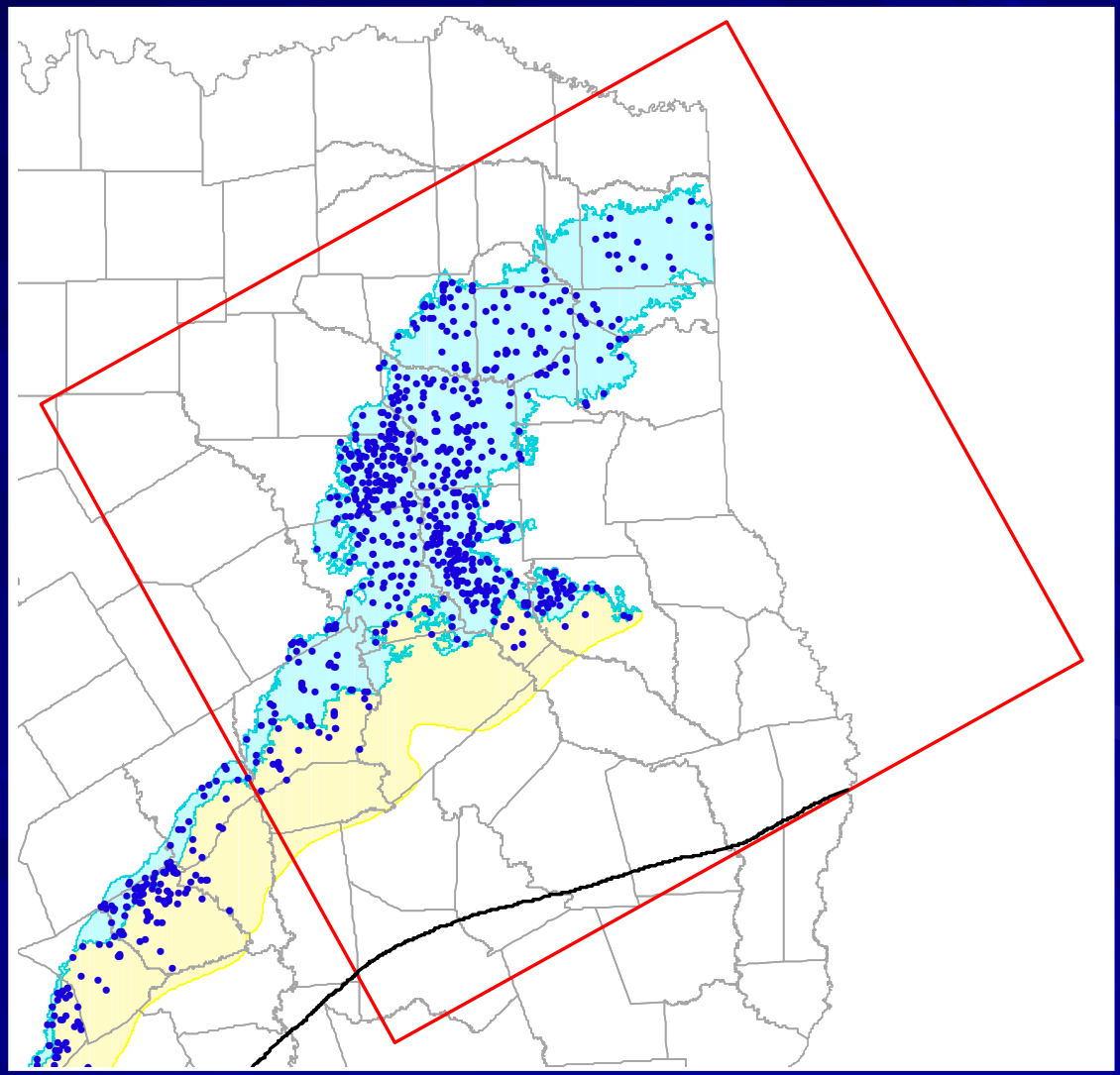
Figure 6. Stratigraphy of the Queen City and Sparto Aquifers.



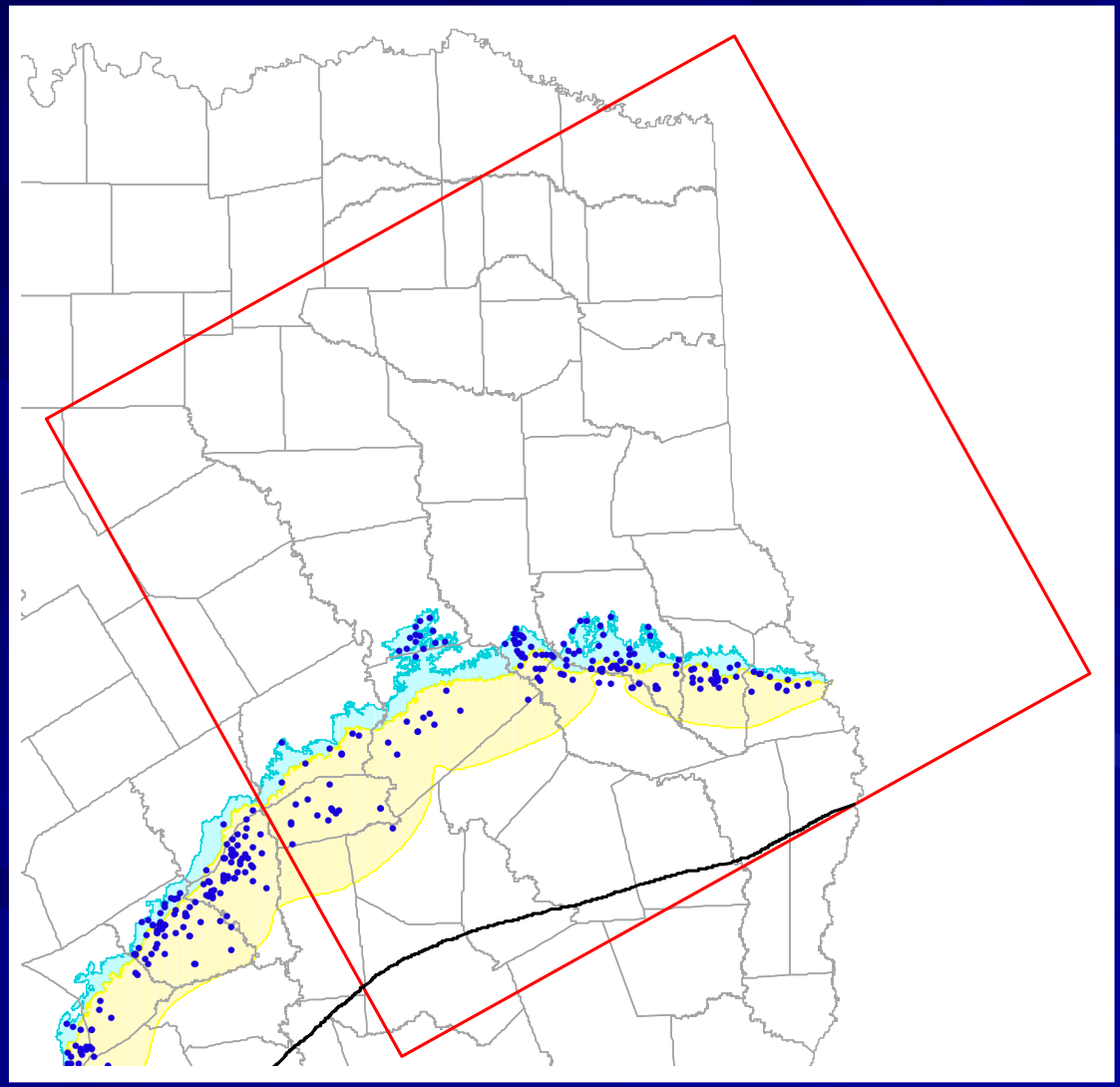
Geologic Structure Data Sources

- Structure – Refers to the elevation of the tops of the Queen City, the Weches, and the Sparta formations
- TCEQ well log database Guevara & Garcia (1972)
  - 700 Logs available across the 3 model areas.
- The TWDB East Texas Model
  - Available data north of the Brazos River
- Sand thickness maps:
  - Queen City – Guevara & Garcia (1972)
  - Sparta – Payne (1968)

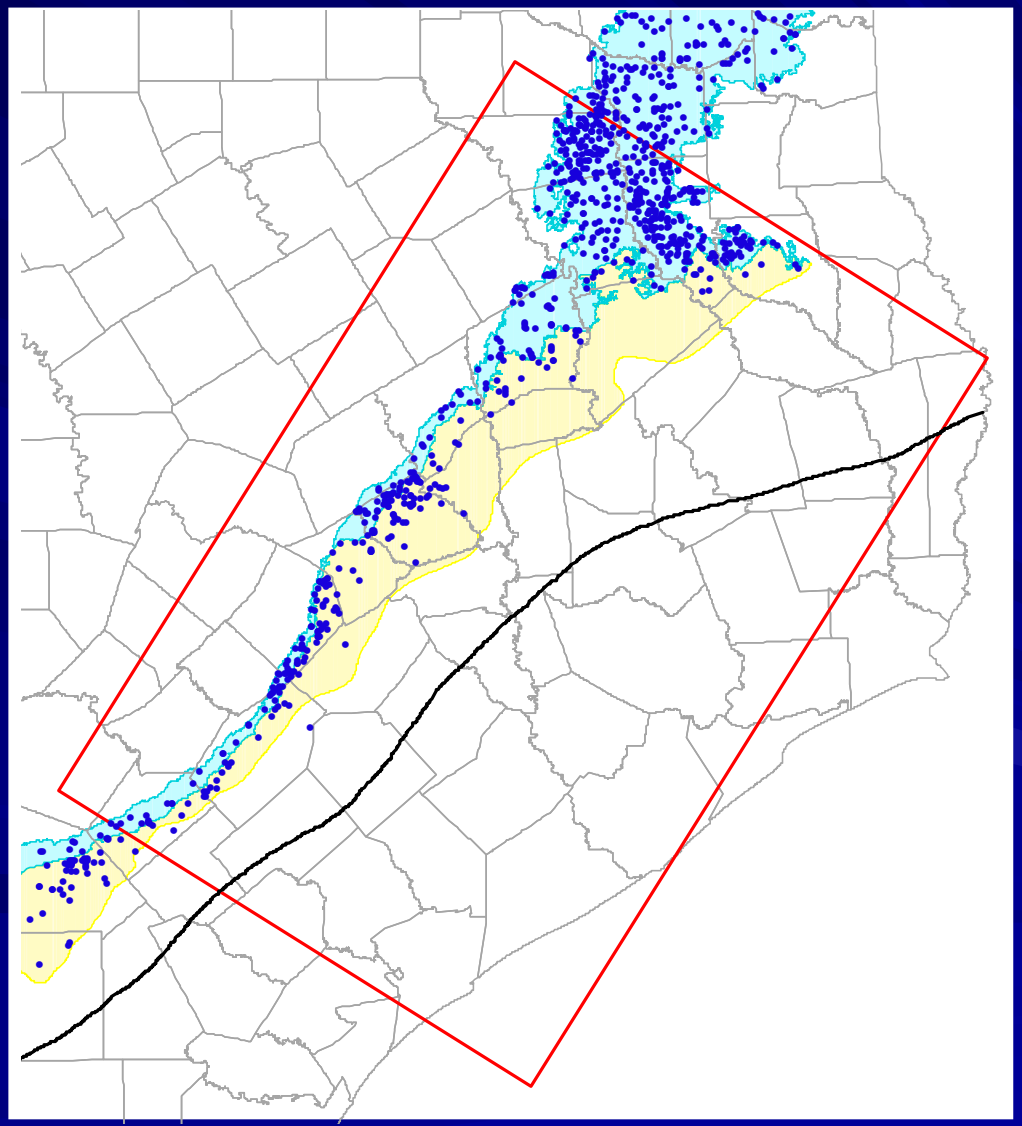
North Model Queen City – Water-Level Locations



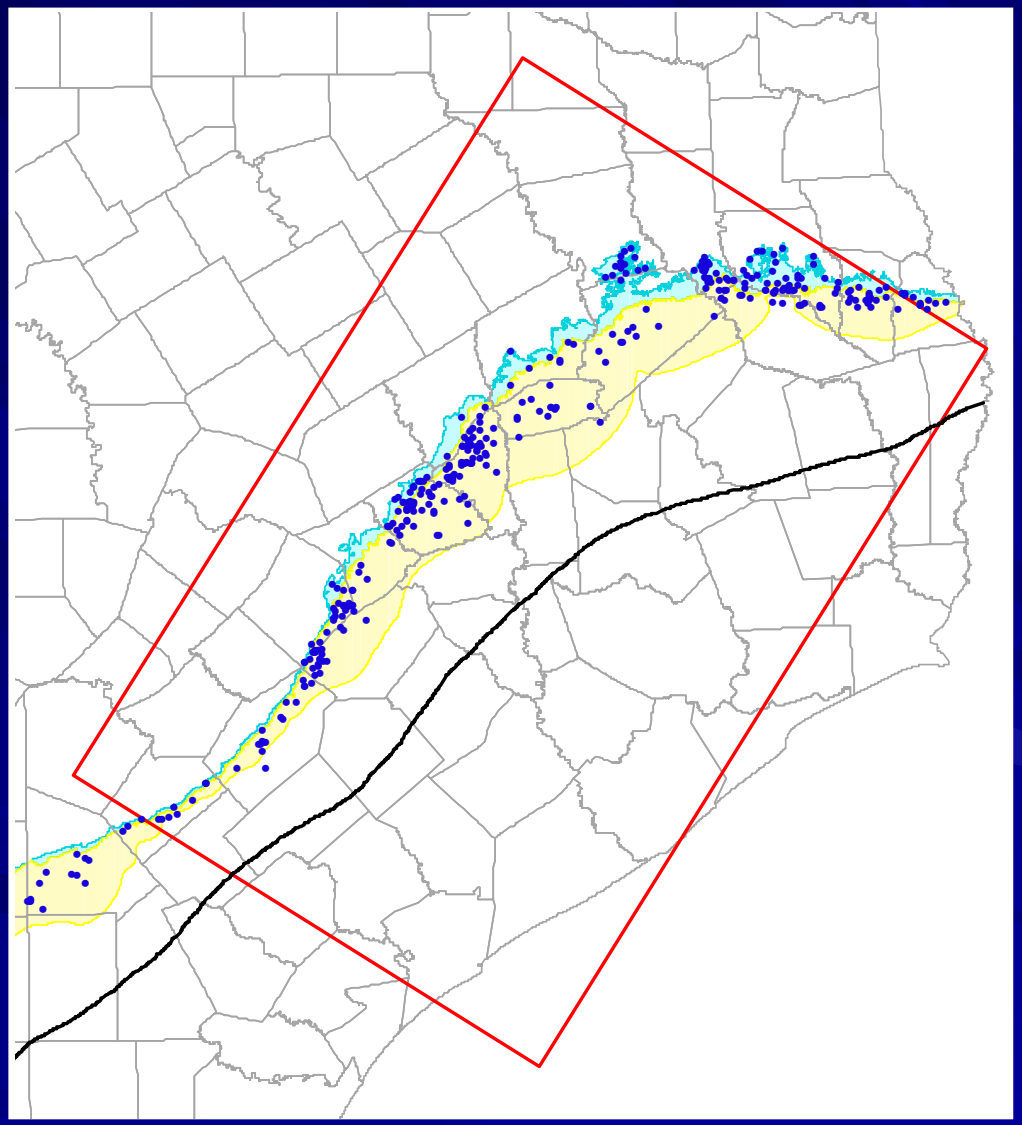
North Model Sparta – Water-Level Locations



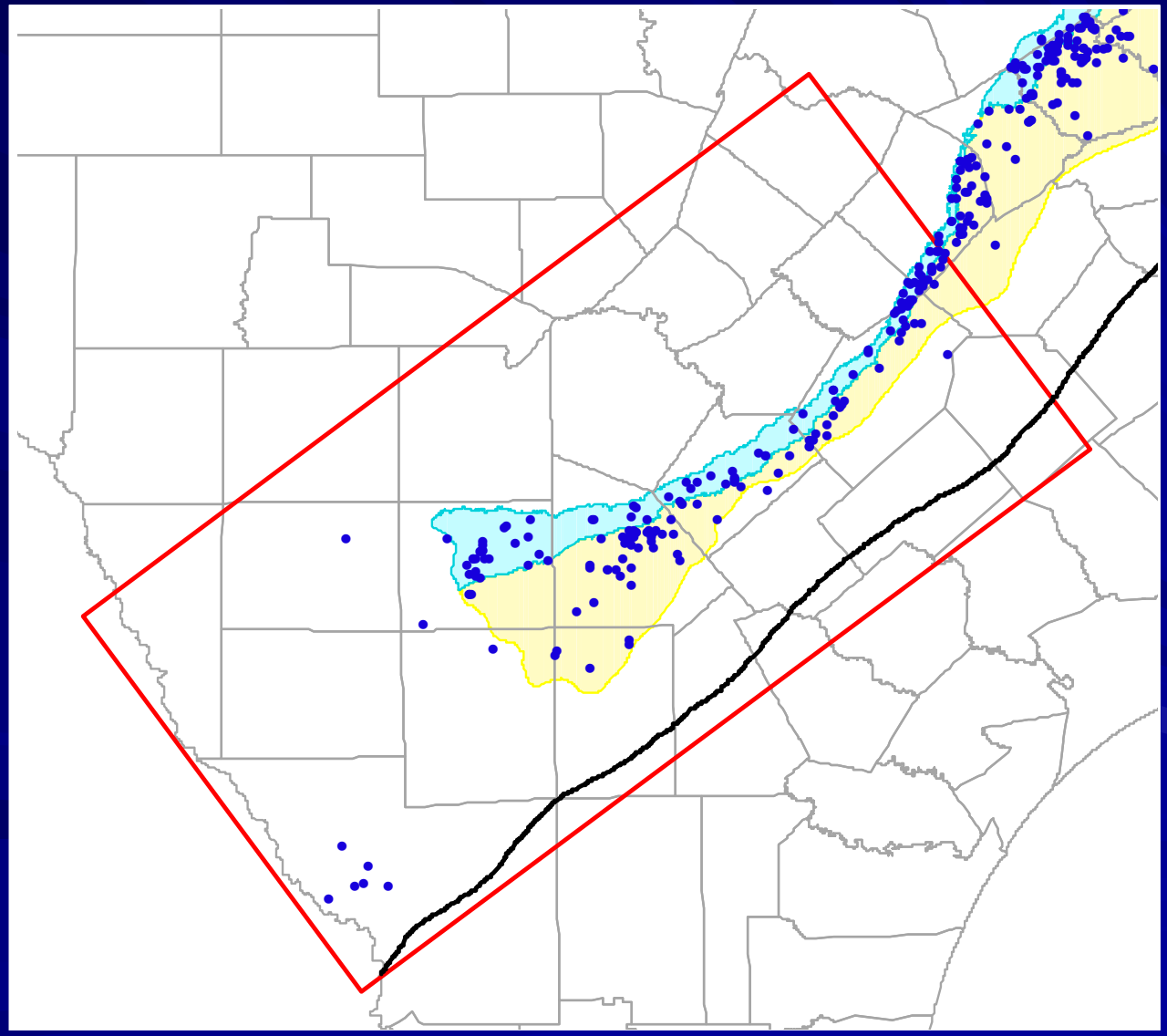
Central Model Queen City – Water-Level Locations



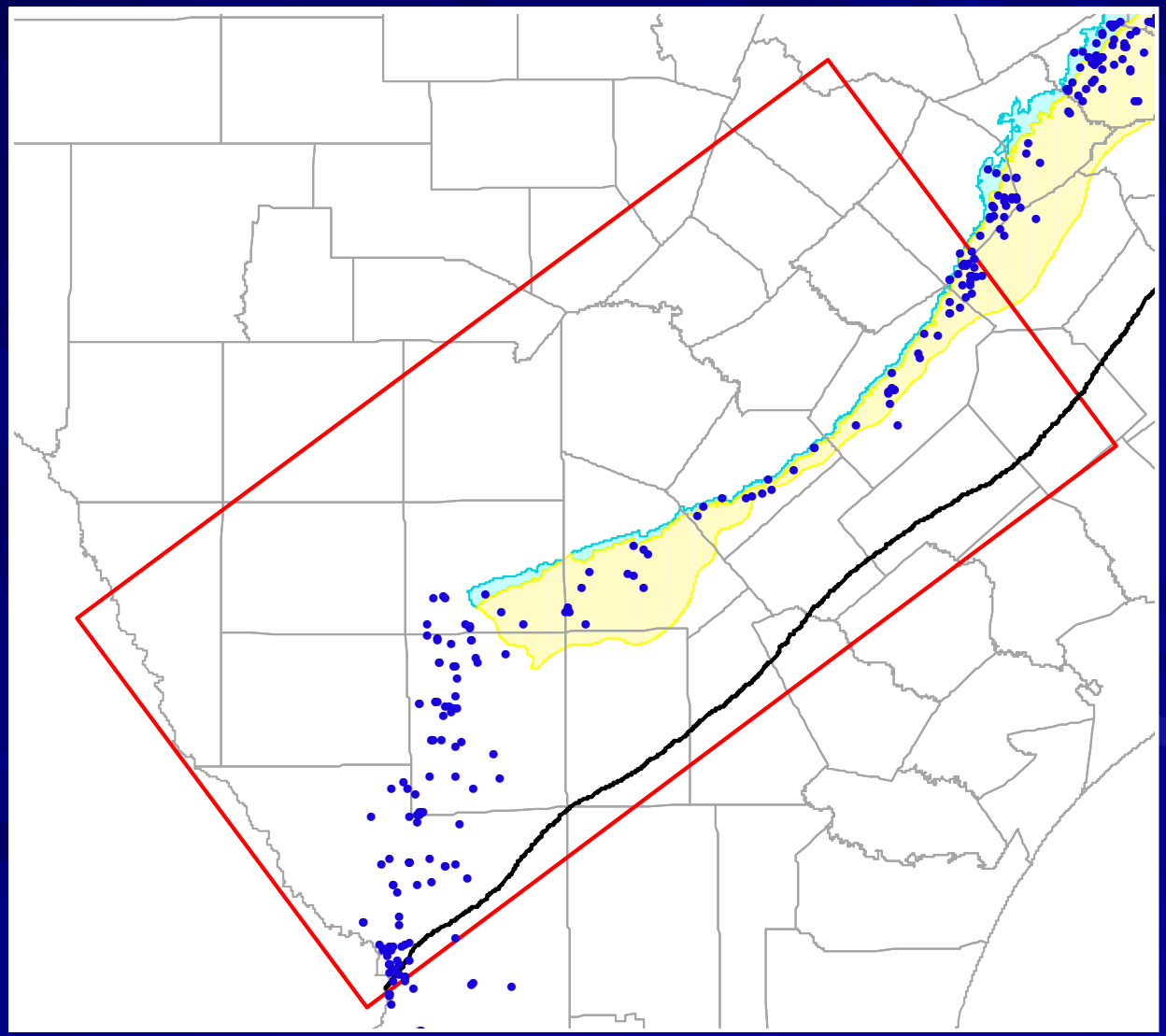
Central Model Sparta – Water-Level Locations



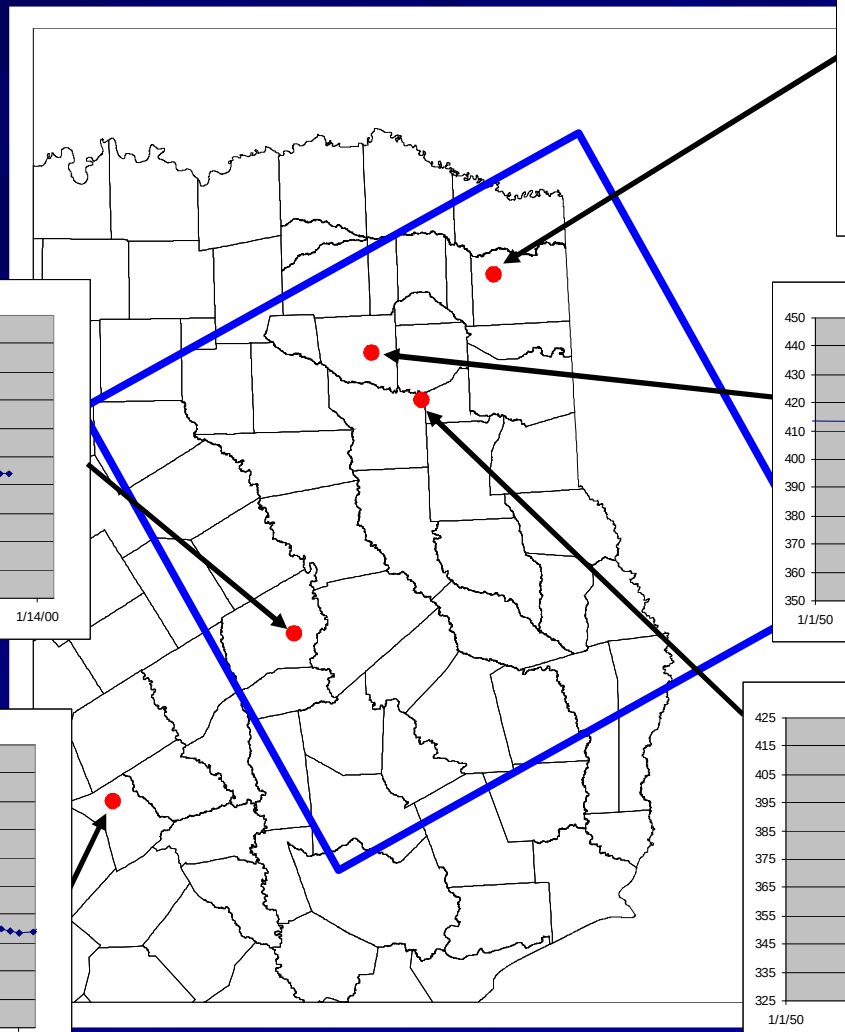
South Model Queen City / El Pico –Water-Level Locations

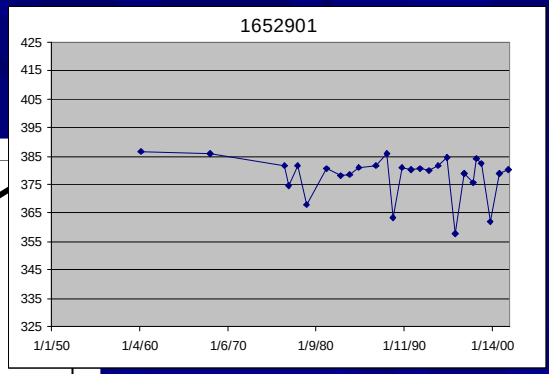


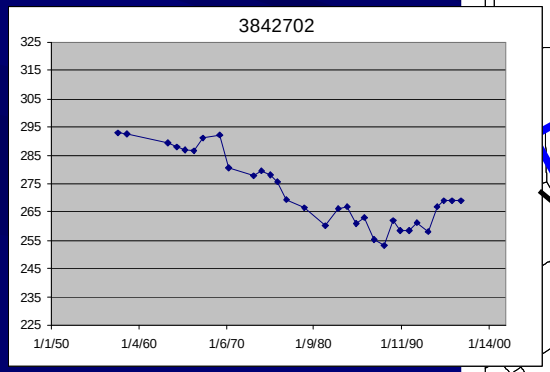
South Model Sparta / Laredo – Water-Level Locations

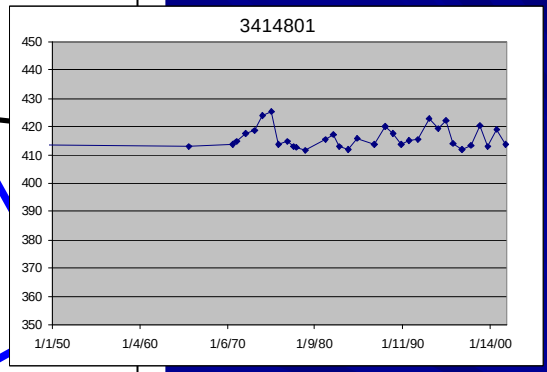


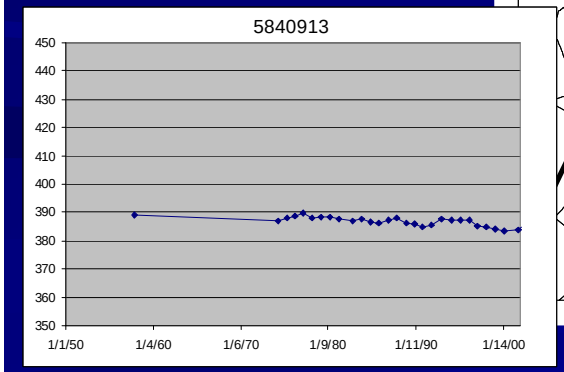
Select Queen City Hydrographs North

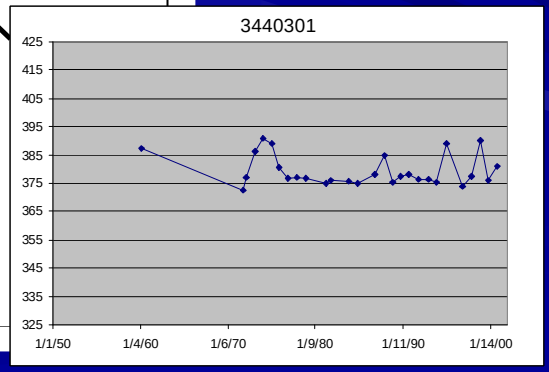




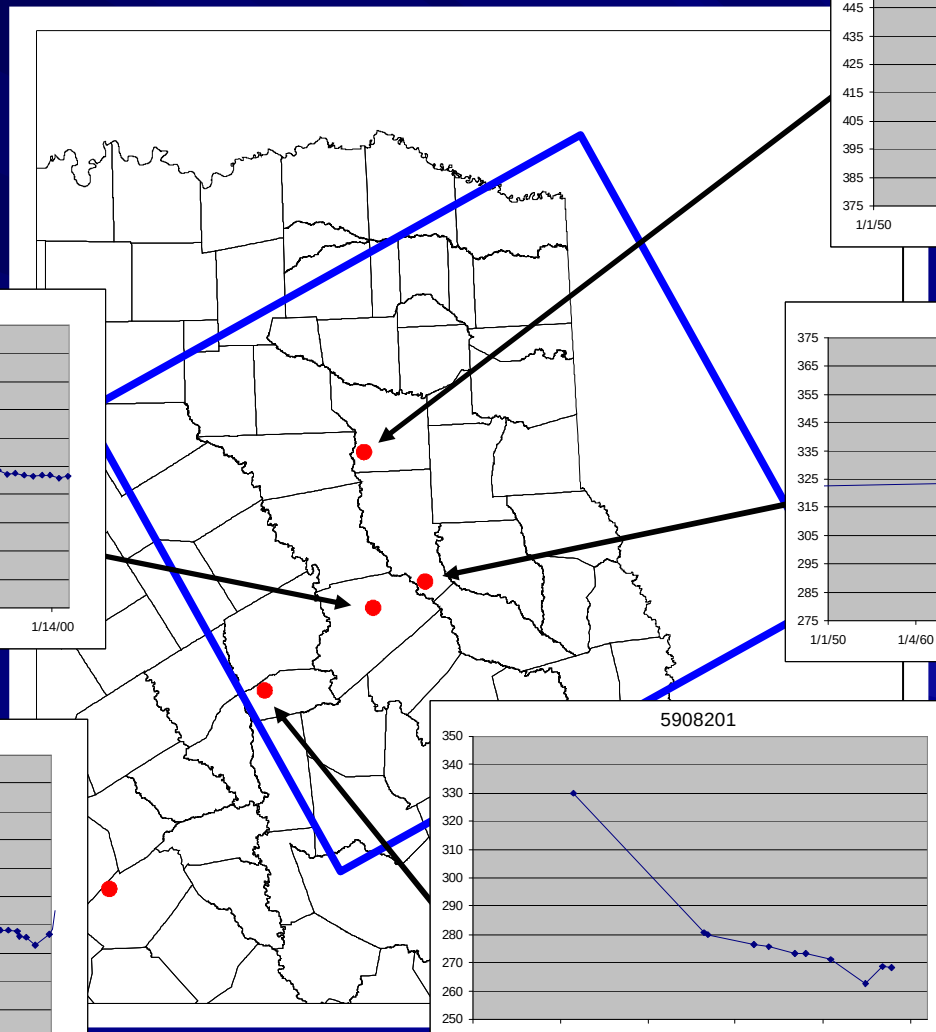


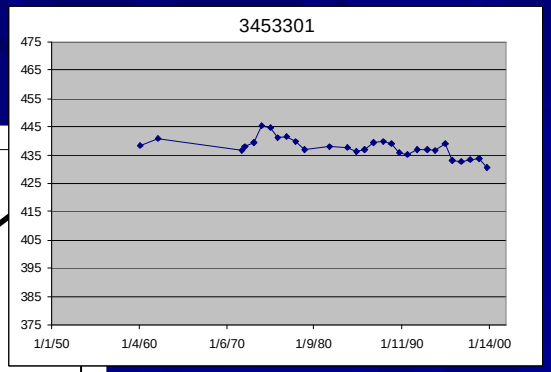


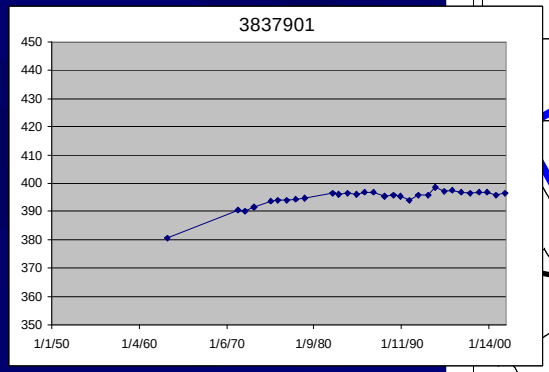


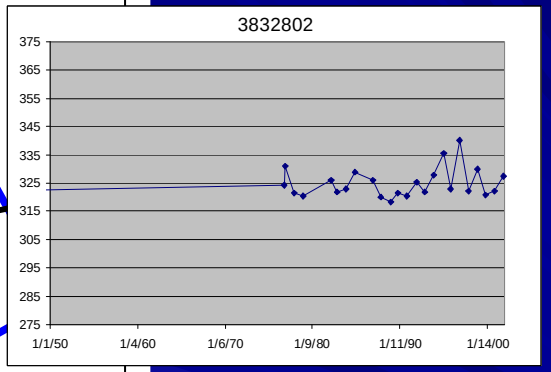


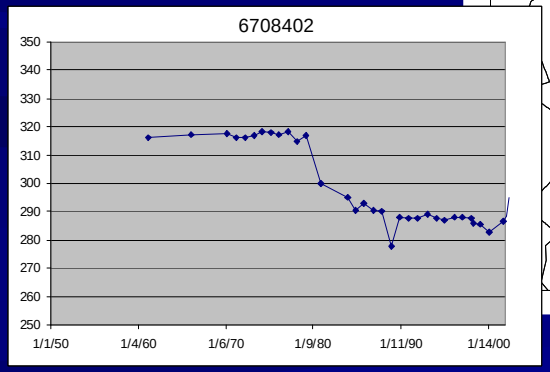
Select Sparta Hydrographs North



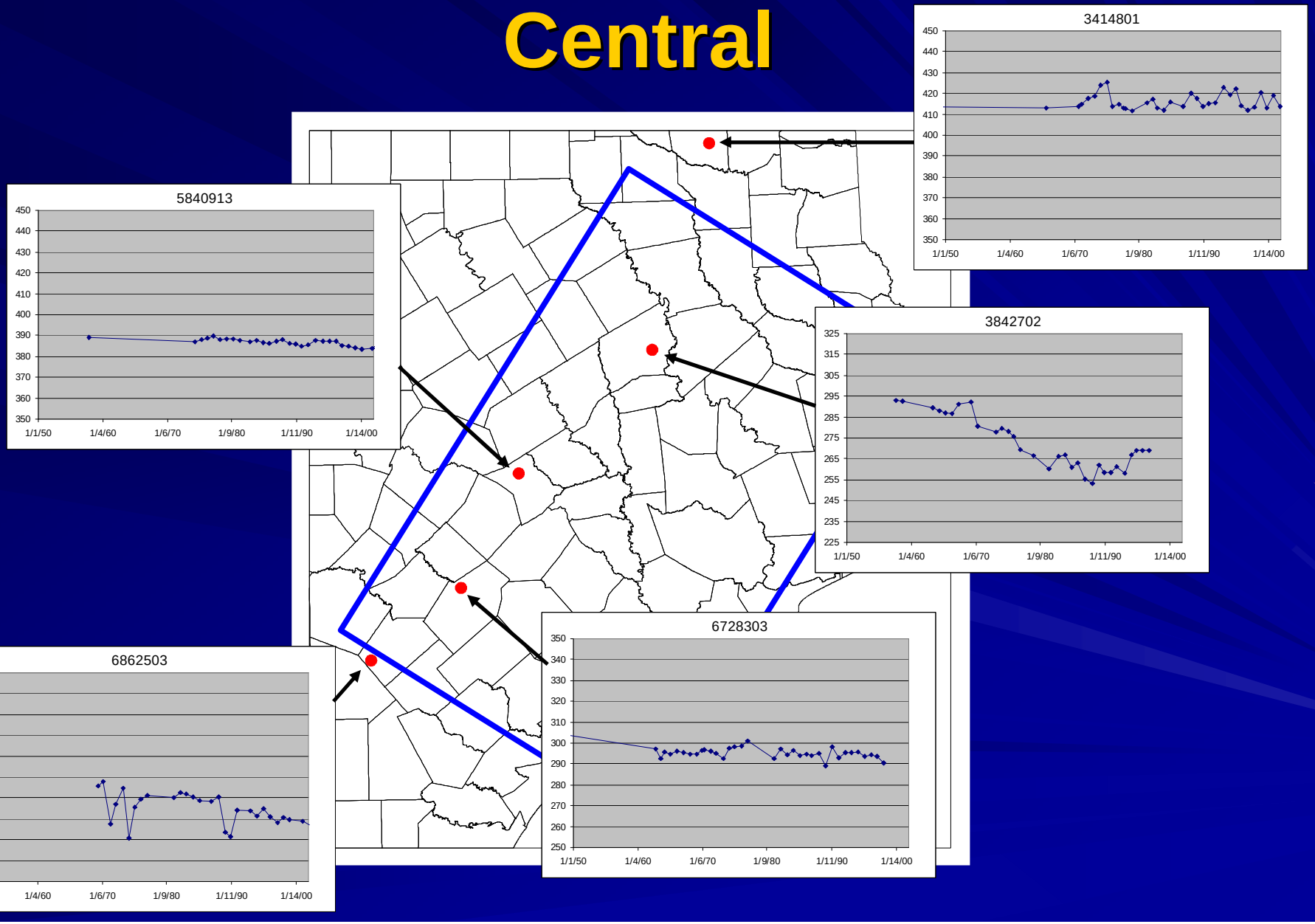




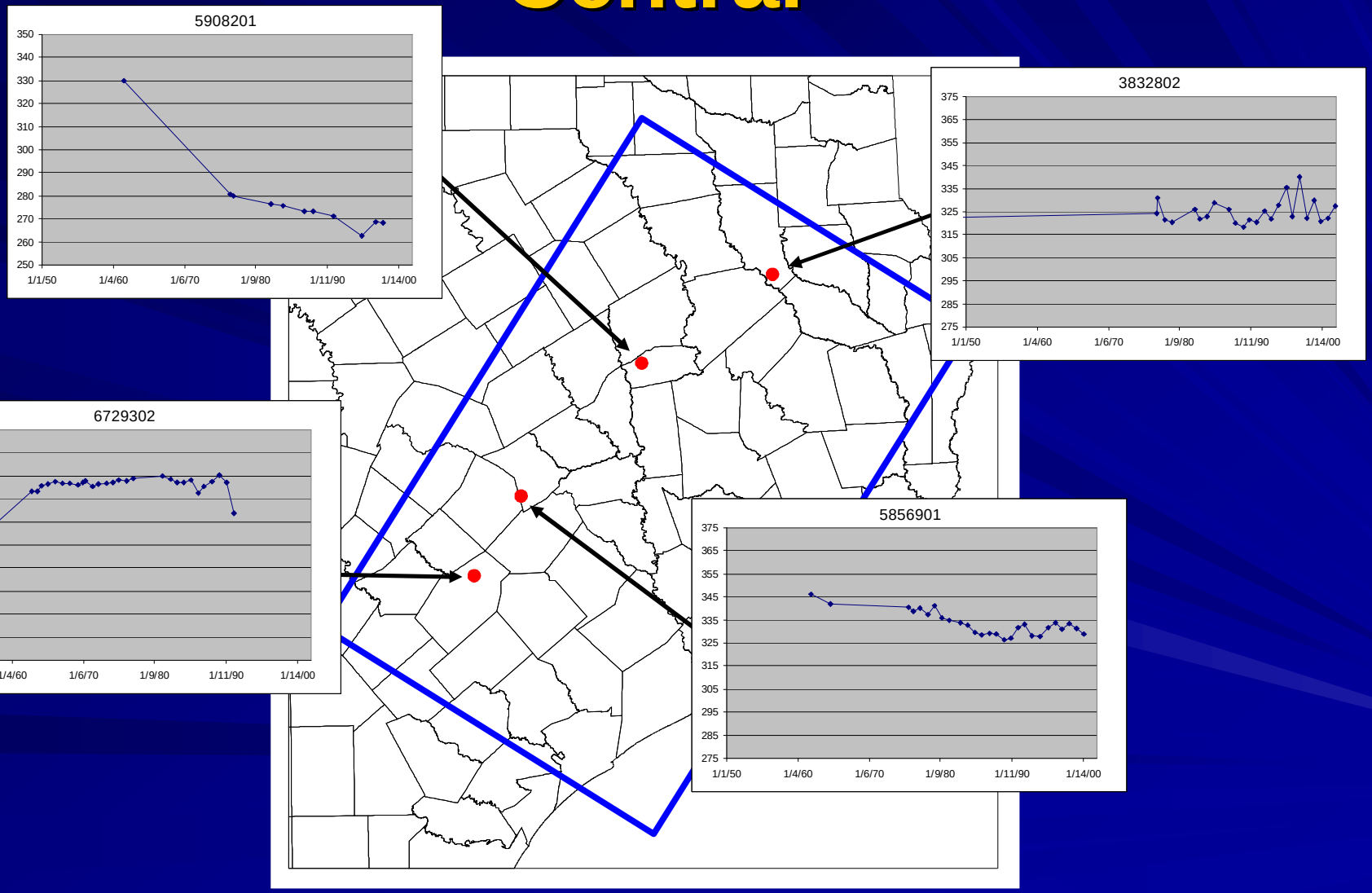




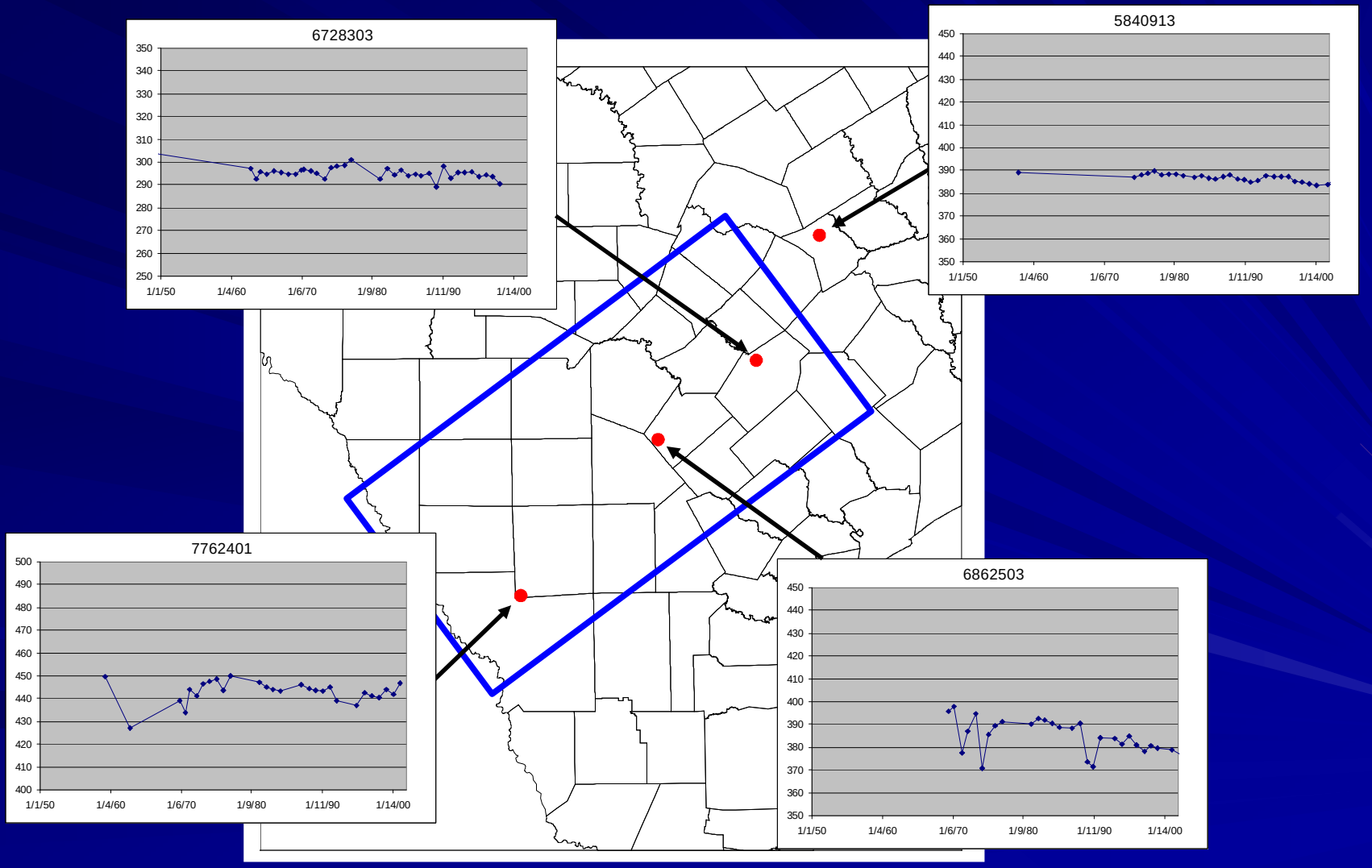
Select Queen City Hydrographs Central



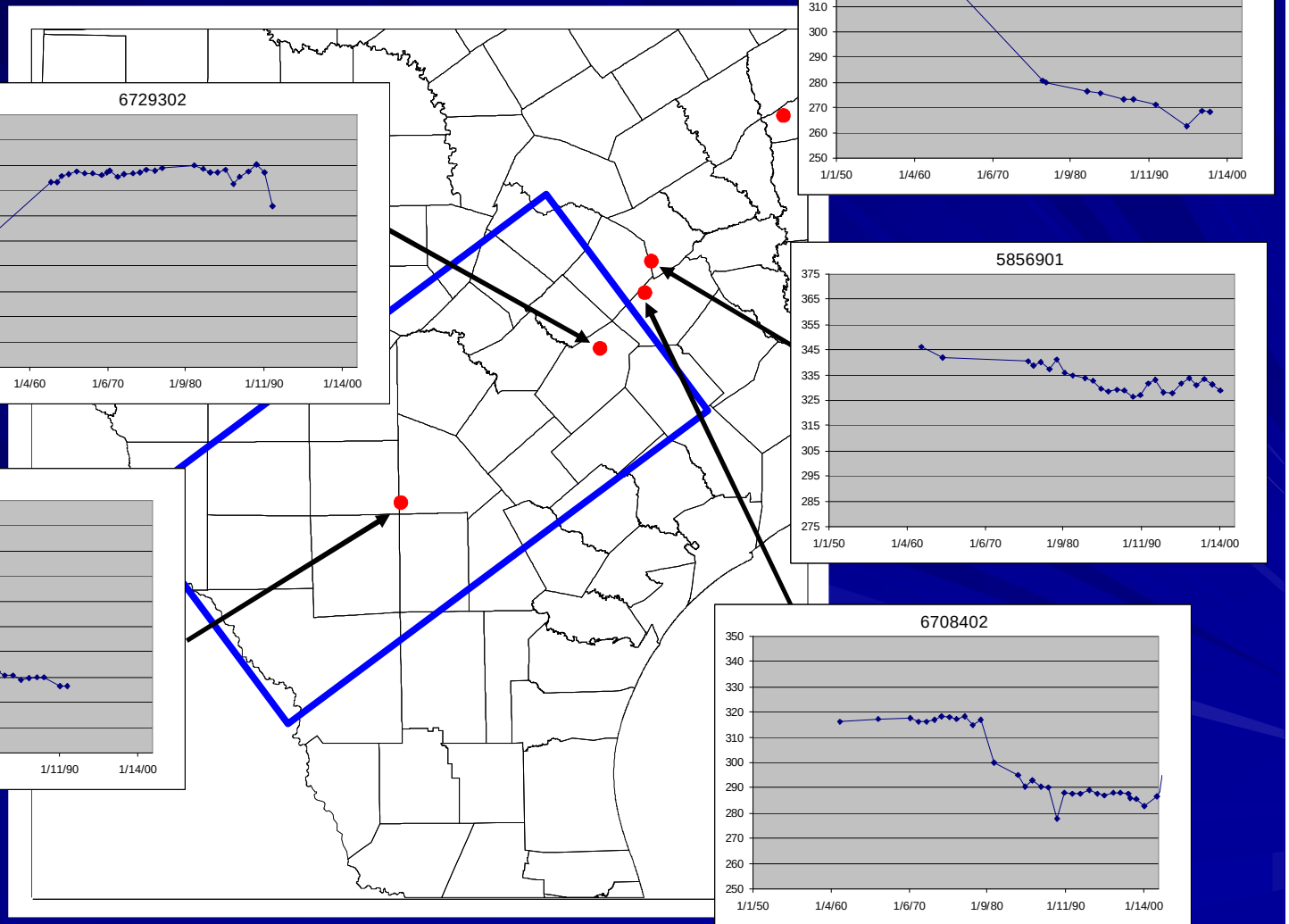
Select Sparta Hydrographs Central



Select Queen City Hydrographs South



Select Sparta Hydrographs South



Hydraulic Properties

- Published Reports:
  - USGS
    - Payne (1968)
    - Hays et al (1998)
    - RASA – Prudic (1991)
  - BEG
    - Guevara & Garcia (1972)
  - TWDB
    - Myers (1969)
    - County Reports
- TCEQ file search of the drillers logs
  - Estimates of specific capacity will be used to augment published values
- Stakeholder provided data

Current Data Needs

- Queen City & Sparta data:
  - Geologic logs
  - Water levels (elevations)
  - Aquifer properties
- Data provided will be made publicly available
- Data needed by April 30, 2003

Current Data Needs (cont'd) – Who to Contact?

- Van Kelley
  INTERA Inc.
  9111A Research Blvd
  Austin, TX 78758
  (512) 425-2047
  vkelley@intera.com
- Dr. Shirley Wade
  Texas Water Development Board
  P.O. Box 13231
  Austin, TX 78711
  (512) 936-0883
  shirley.wade@twdb.state.tx.us

GAM Schedule

2003

SAF 1 — Feb 28

Stakeholder - Apr 31 Data

SAF 2 — May

SAF 3 — Oct

Jan 23 — Kickoff Meeting
- Complete database
- Evaluate data
- Preliminary model design

July 31 — Draft Conceptual Model Report

Nov — Steady-state model review

2004

Jan — Transient model review

SAF 6 — Feb

Feb — Predictions review

Stakeholder Comments

Mar 1 — Draft report review

SAF 5 — June
Training Seminar

June — Final Report & Model

Meeting Wrap-Up

- Next meeting – May
  - Database review
  - Preliminary conceptual model
  - Preliminary approach to model implementation
- Discussion / comments / questions

ATTACHMENT B: SIGN-UP SHEET
QUEEN CITY/SPARTA AQUIFER SAF1 MEETING
FEBRUARY 28, 2003

NAME	AFFILATION
Larry Akers	Evergreen UWCD
Robert Mace	TWDB
Heather Forrest	TWDB
Shirley Wade	TWDB
John Lich	TCEQ
Nathan Ausley	Post Oak Savannah GCD
Alan Dutton	BEG
Katie Kier	BEG
Jean-Philippe Nicot	BEG
James Sloan	TCEQ

Meeting Minutes for the

First Queen City/Sparta Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

February 28, 2003

Bureau of Economic Geology

Austin, Texas

The first Stakeholder Advisory Forum (SAF) Meeting for the Queen City/Sparta Groundwater Availability Model (GAM) was held on February 28th from 1:30 until 3:30 PM at the Bureau of Economic Geology in Austin, Texas. Attachment A of these meeting minutes provides a list of all participants who signed up as attending the meeting.

The purpose of the first SAF meeting was to introduce stakeholders to the purpose of the GAM Program, the basics of groundwater flow and groundwater flow modeling, the proposed methodology to be used in modeling the Queen City and Sparta Aquifers, a summary of data to be reviewed, and an identification of data needs.

Meeting Introduction: Dr. Shirley Wade, TWDB

The meeting was initiated by Dr. Shirley Wade of the Texas Water Development Board (TWDB). She gave a brief introduction to the GAMs and discussed the current status of the GAM program. She then discussed groundwater availability and use of the GAMs, followed by a look at the future of the GAMs and opportunities for public involvement in GAM development.

SAF Presentation: Van Kelley, INTERA

Van Kelley, Project Manager for the INTERA Queen City/Sparta Team presented a prepared presentation. The presentation was structured according to the following outline:

1. Queen City – Sparta GAM team
2. GAM objectives
3. Basics of groundwater flow
4. Introduction to groundwater modeling
5. GAM specifications and applicability
6. Model data needs and data source review
7. Identification of data needs and information request
8. GAM schedule

The presentation is available on the GAM website (*www.twdb.state.tx.us/gam)*.

Questions and Answers: Open Forum:

Q. Where does the aquifer end? Will we get more accurate boundaries of where the Queen City and Sparta aquifers end?

A: The downdip limit of an aquifer has been defined by the TWDB as the line where total dissolved solids exceed 3000 ppm. Defining the extent of usable water is not the primary purpose of the GAMs, but some information on aquifer extent may be obtained from the water quality work that is part of the GAM scope. Water quality information for areas that are downdip of most water wells may be obtained from oil and gas wells if budget allows. Resistivity logs may also be used to estimate water quality.

Q: Are bad water lines well defined?

A: The extent of usable water is not well known in some areas, but better defined in others. If this study produces new data, the downdip aquifer boundaries as defined by the TWDB could conceivably change.

Q: Will the boundary be moved further downdip if the water quality standard is lowered?

A: The current aquifer boundary is set at 3000 ppm total dissolved solids, a value that already exceeds the limit for potable water.

Q: Will the 50-year prediction window for the GAM models roll forward on the 5-year updates planned for the GAMs?

A: The time windows for calibration, validation, and 50-year prediction will move forward for future updates. The RWPGs will provide the predicted water use numbers for the updated GAMs.