Groundwater Availability Modeling (GAM) for the Northern Carrizo-Wilcox Aquifer

A Presentation to:

Stakeholder Advisory Forum

Stephen F. Austin State University

Nocagdoches

May 9th, 2001

Duke Engineering & Services
A Duke Energy Company

Outline

- Presentation of GAM Team
- Review of GAM Objectives and Expectations
- Introduction to Groundwater Modeling
- Overview of Northern Carrizo-Wilcox Aquifer
- GAM Schedule - SAF Meetings & Project Milestones

Northern Carrizo-Wilcox Aquifer GAM Team

- Duke Engineering & Services, Inc.
- Parsons Engineering Science
- Waterstone
- Senior Technical Experts
  - Dr. Graham Fogg (UC—Davis)
  - Dr. Steven Gorelick (Stanford)

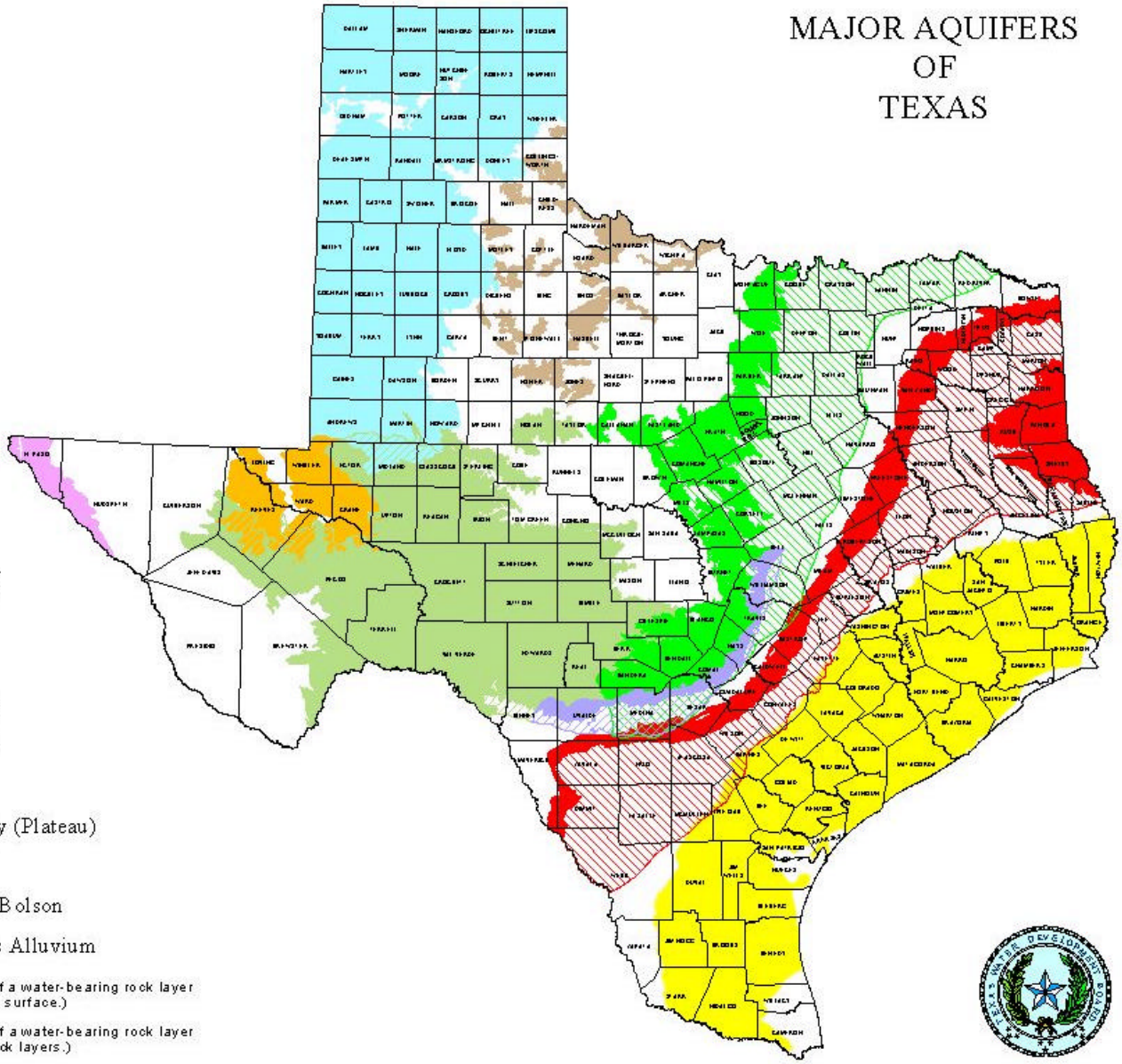
Subcontractor Support Roles

- Parsons Engineering Science
  - Geographic Information Systems (GIS)
  - Groundwater demand and pumping
  - Stakeholder communication
  - Water quality
- Waterstone
  - Modeling support

DE&S Roles

- Project Management
- Stakeholder Communication
- Data Development and Documentation
- Conceptual Model (climate, geology, hydrology, recharge, hydraulic properties, etc.)
- Model Design, Calibration, Verification, and Prediction
- Documentation and Reporting

MAJOR AQUIFERS OF TEXAS



EXPLANATION

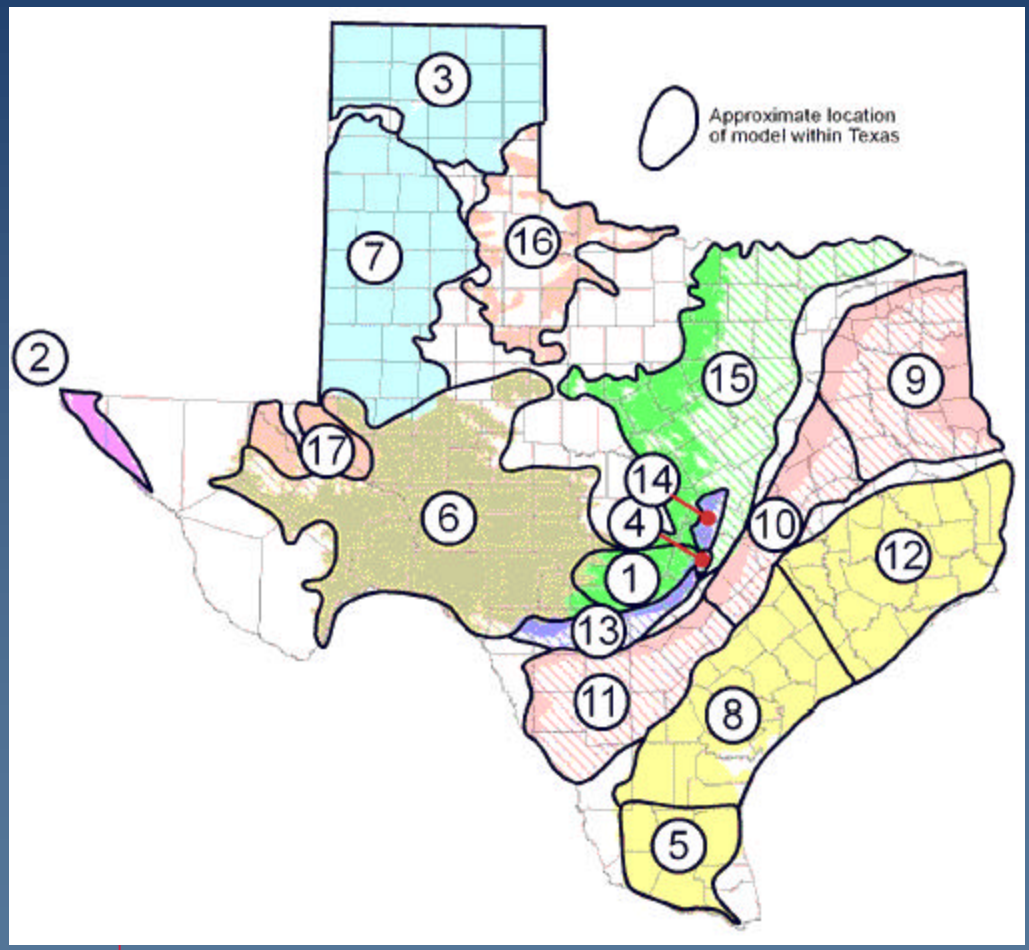
- Ogallala
- Gulf Coast
- * Edwards (BFZ)
- * Carrizo-Wilcox
- * Trinity
- * Edwards-Trinity (Plateau)
- Seymour
- Hueco-Mesilla Bolson
- Cenozoic Pecos Alluvium

OUTCROP (That part of a water-bearing rock layer which appears at the land surface.)

* DOWNDIP (That part of a water-bearing rock layer which dips below other rock layers.)

GAM Models

- Ongoing:
  - Carrizo-Wilcox (9-11)
  - Ogallala south (7)
  - Gulf Coast central (8)
  - Gulf Coast north (12)
  - Lower Rio Grande (5)
  - Edwards Trinity (6)
- Completed:
  - Trinity HC (1)
  - Hueco Bolson (2)
  - Ogallala north (3)
  - Edwards - BS (4)



GAM Objectives

- GAM is a tool that will be used to provide reliable and timely information on GW availability to ensure adequate supplies or recognize inadequate supplies through 2050
- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes

GAM Expectations

- Result in standardized, thoroughly documented, and publicly available numerical groundwater flow models and supporting data
- Include substantial stakeholder input to insure the models address the relevant water-resources issues of each aquifer
- Provide an integrated tool for the assessment of water management strategies for GCDs, RWPGs, and state planners

GAM Expectations (cont.)

- The GAM models will build and improve upon previous models
- The GAM models use established computer software and meet the GAM standards developed by TWDB and GAM TAG
- The models will be publicly available and the standardization will allow easy use and update of the model and input data ("living tools")
- Access: http://www.twdb.state.tx.us/GAM

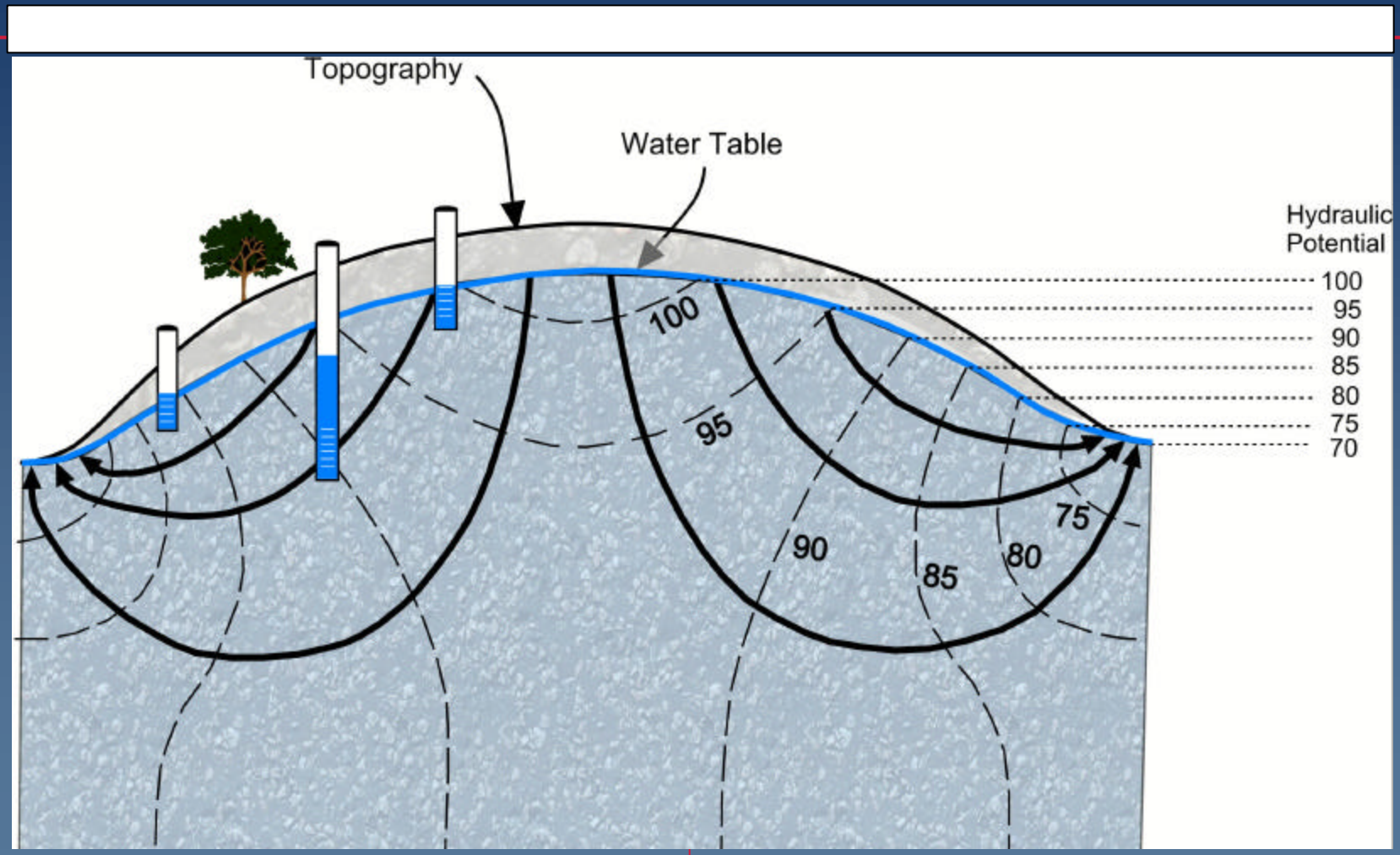
Questions?

- GAM Team
- GAM Objectives/Expectations

Why are GW Flow Models Needed?

- 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

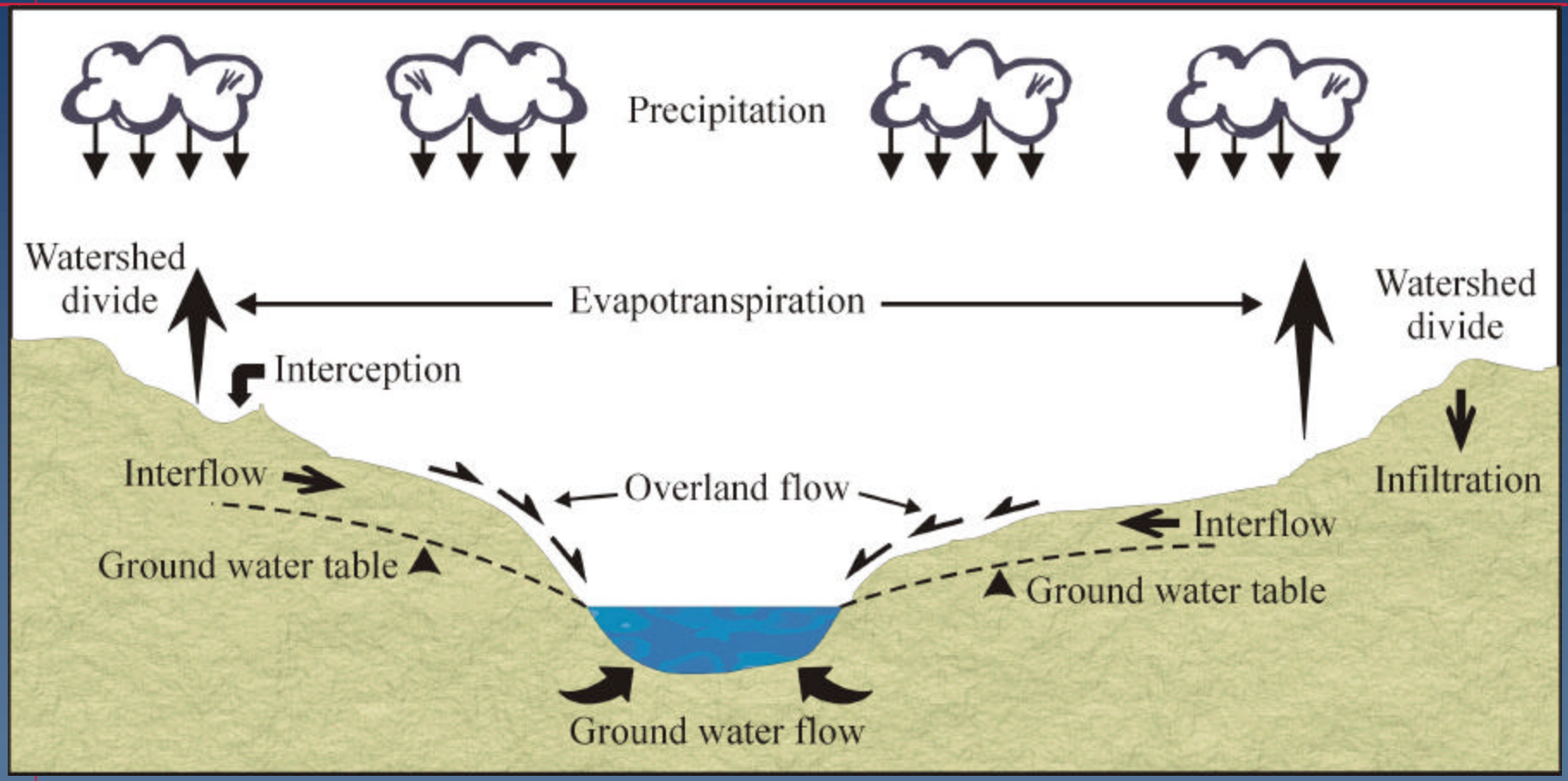
Schematic Cross Section of GW Flow

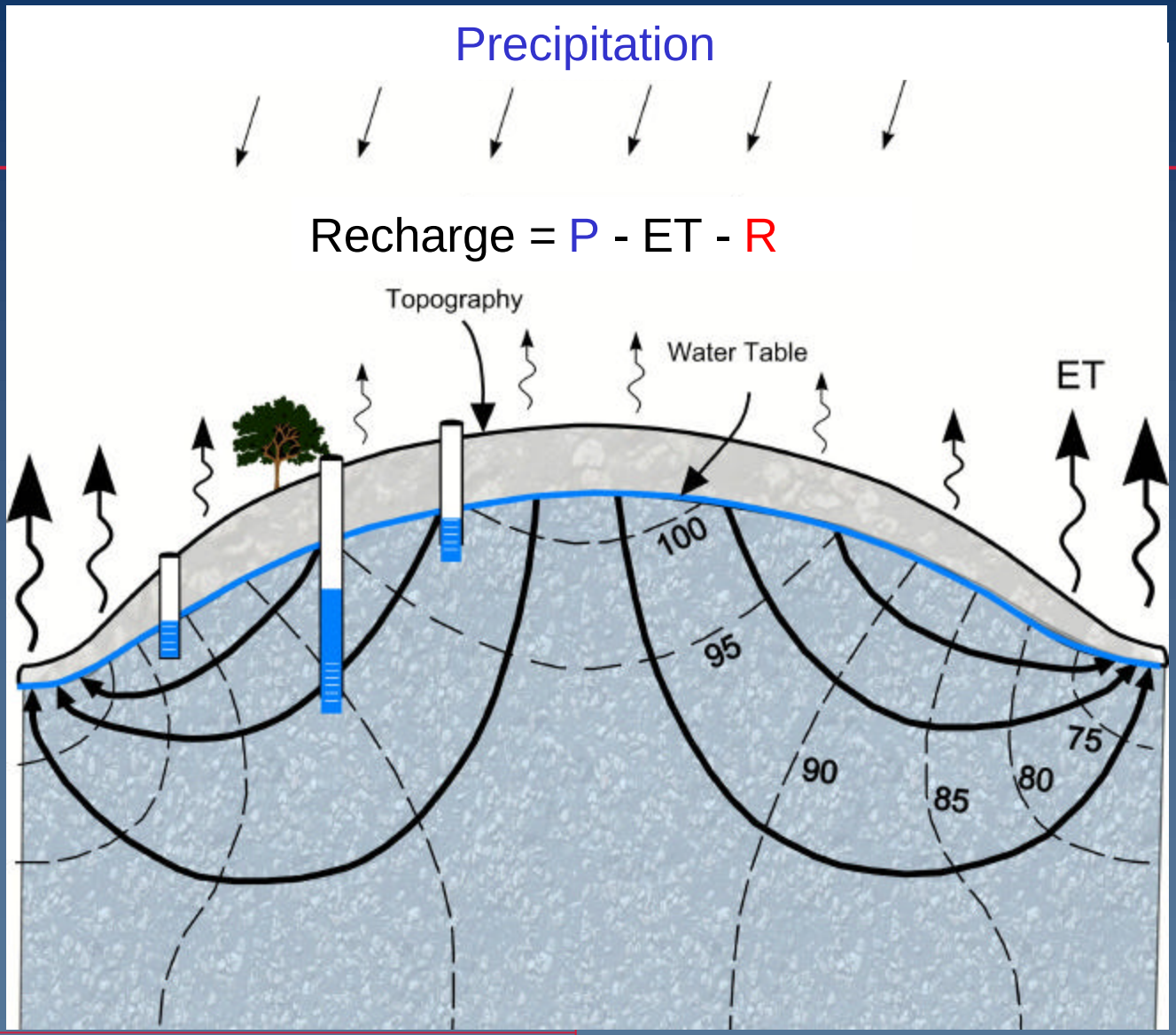


Principles of GW Flow

- 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
- GW flows from high hydraulic heads to low heads
- The water table is a subdued replica of the topography
- The difference in hydraulic head between adjacent wells describes the direction of GW flow
- The difference in hydraulic head (gradient) and the physical properties of the aquifer material define volumetric flow rates within the aquifer

Surface Water/Groundwater Hydrologic Processes

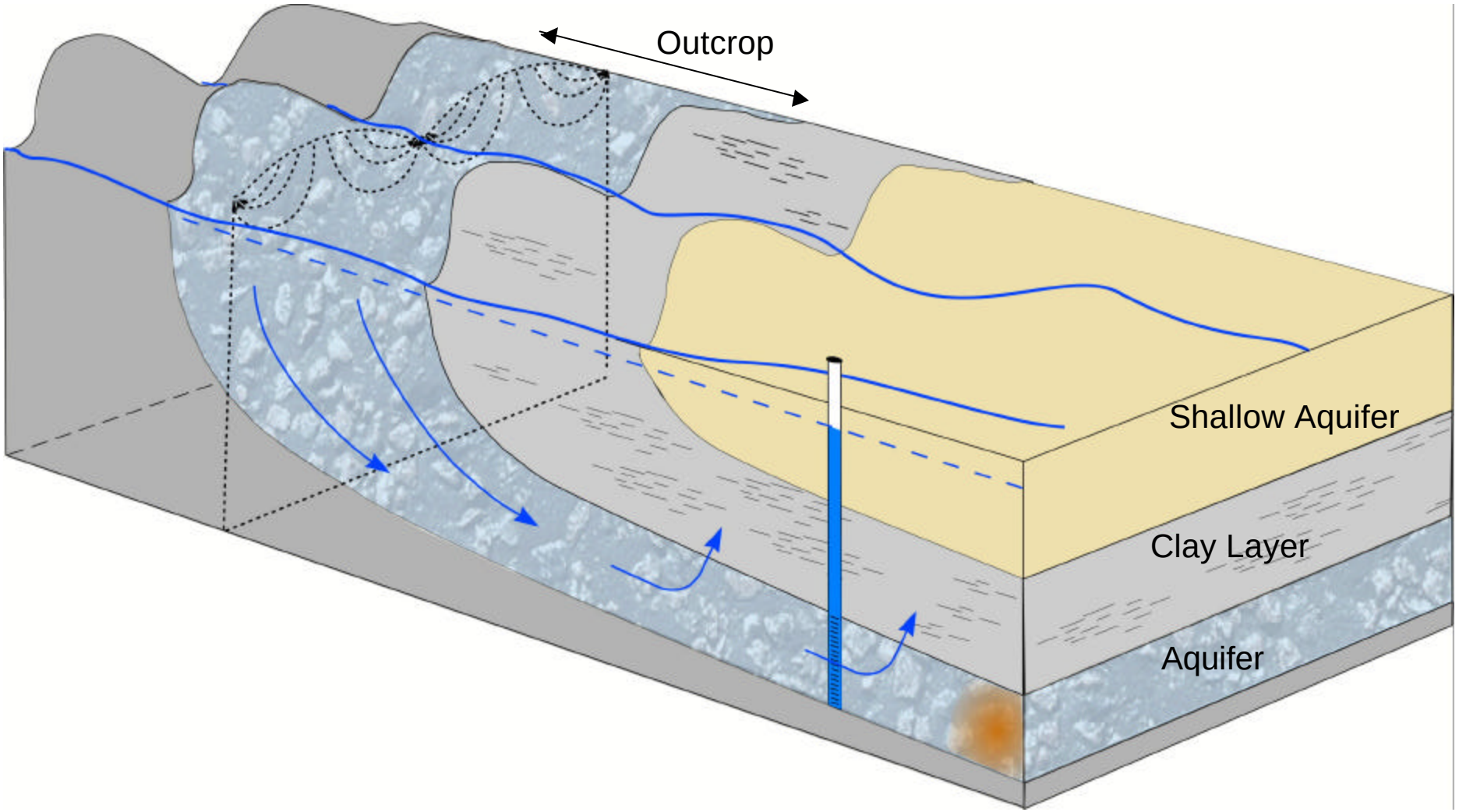



Precipitation
Recharge = P - ET - R
Topography
Water Table
ET
100
95
90
85
80
75

Principles of GW Flow (cont.)

- Recharge is equal to precipitation minus evapotranspiration (ET) and runoff
- Recharge is a function of:
  - precipitation,
  - topography,
  - soil type,
  - soil moisture,
  - geology,
  - depth to water (water level),
  - and evapotranspiration

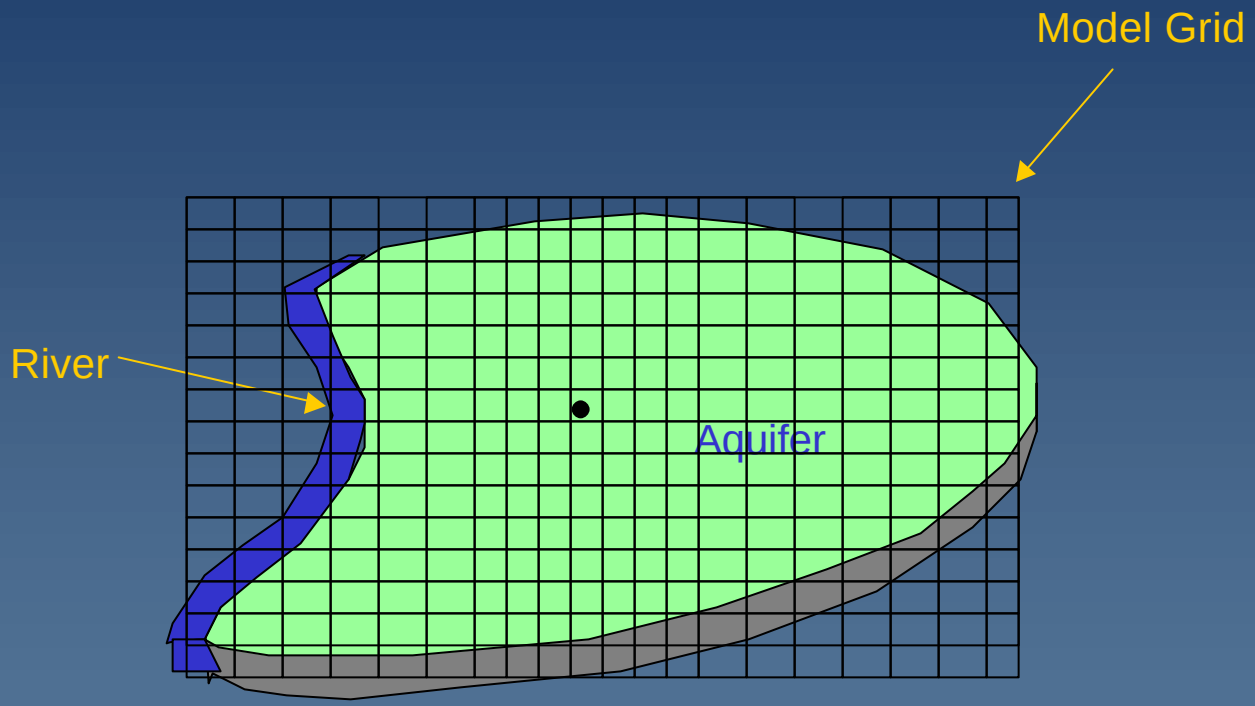
Block Diagram: confined aquifer



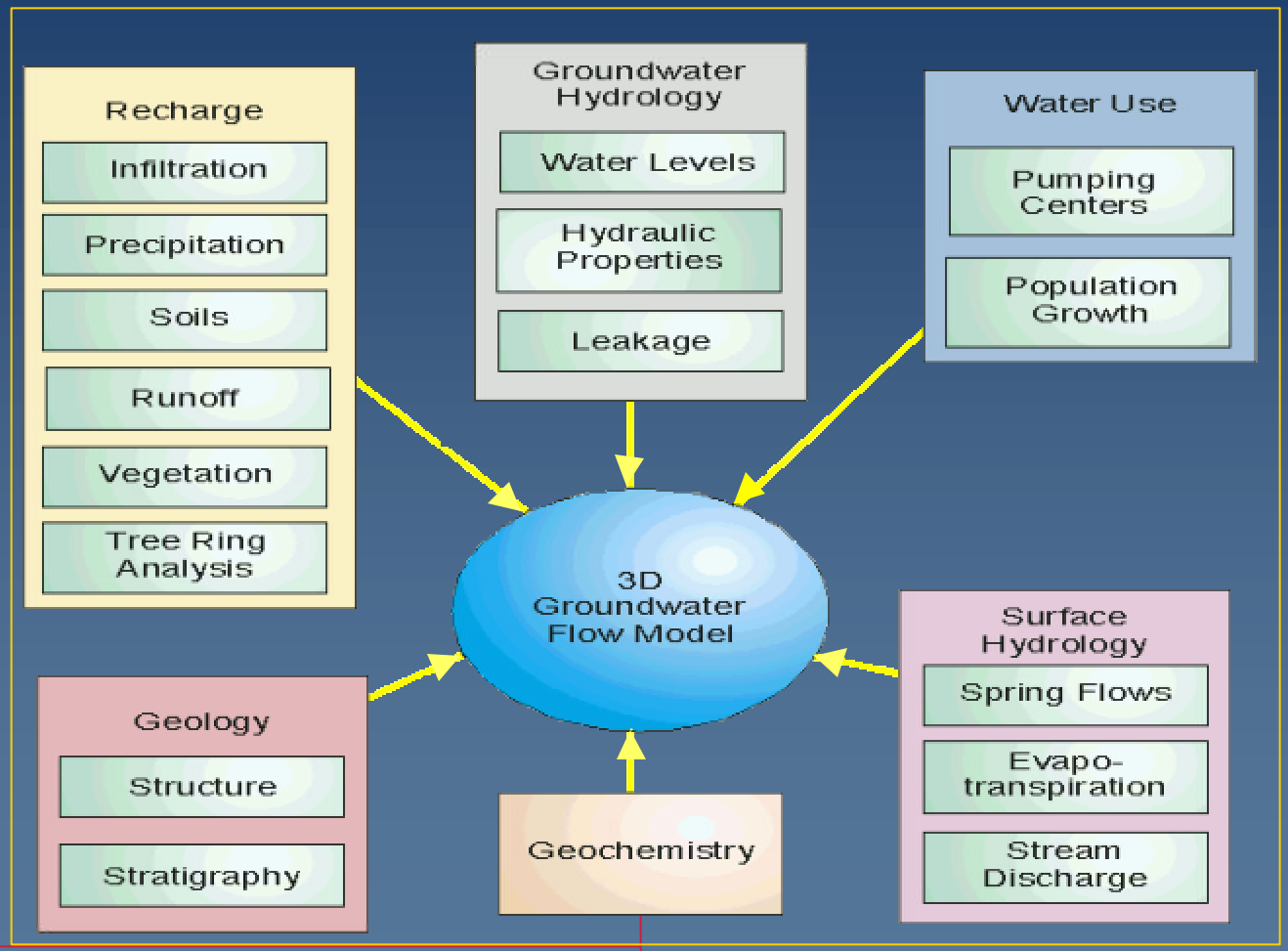
Numerical GW Flow Modeling

- 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 (grid)
- The calculated model heads can be compared to hydraulic heads measured in wells

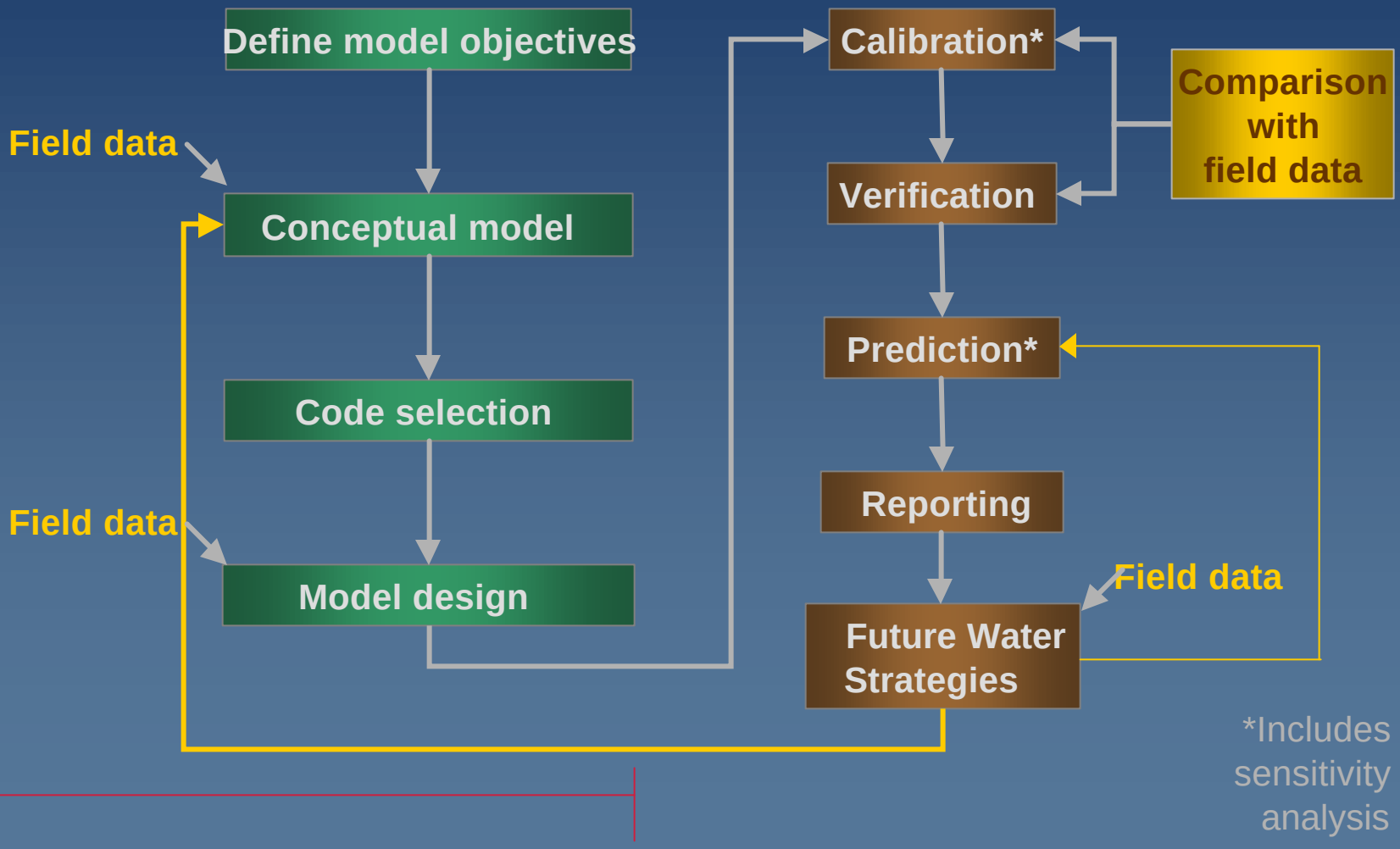
Groundwater Model Domain



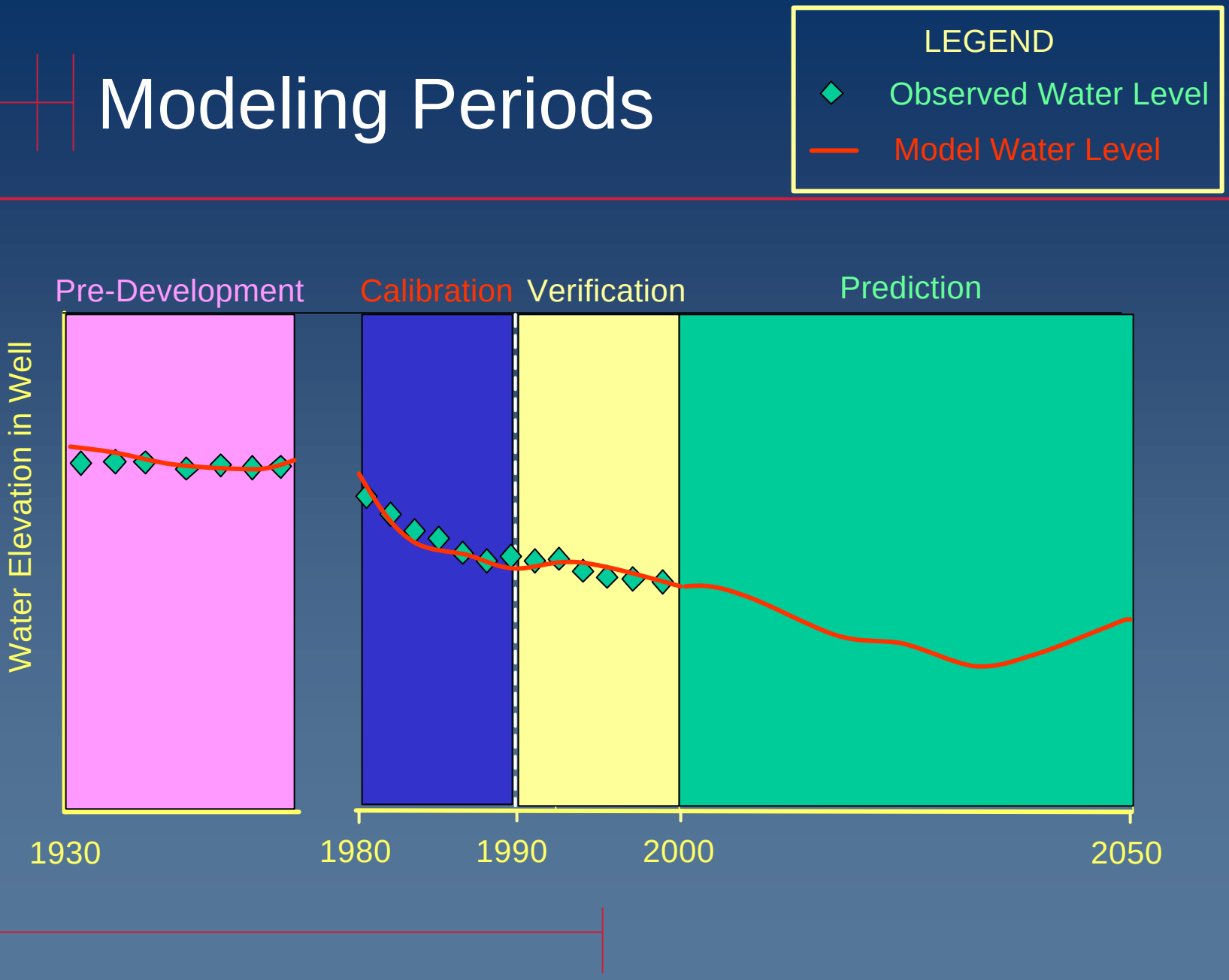
Groundwater Model Input



Modeling Protocol



Modeling Periods



Model Limitations

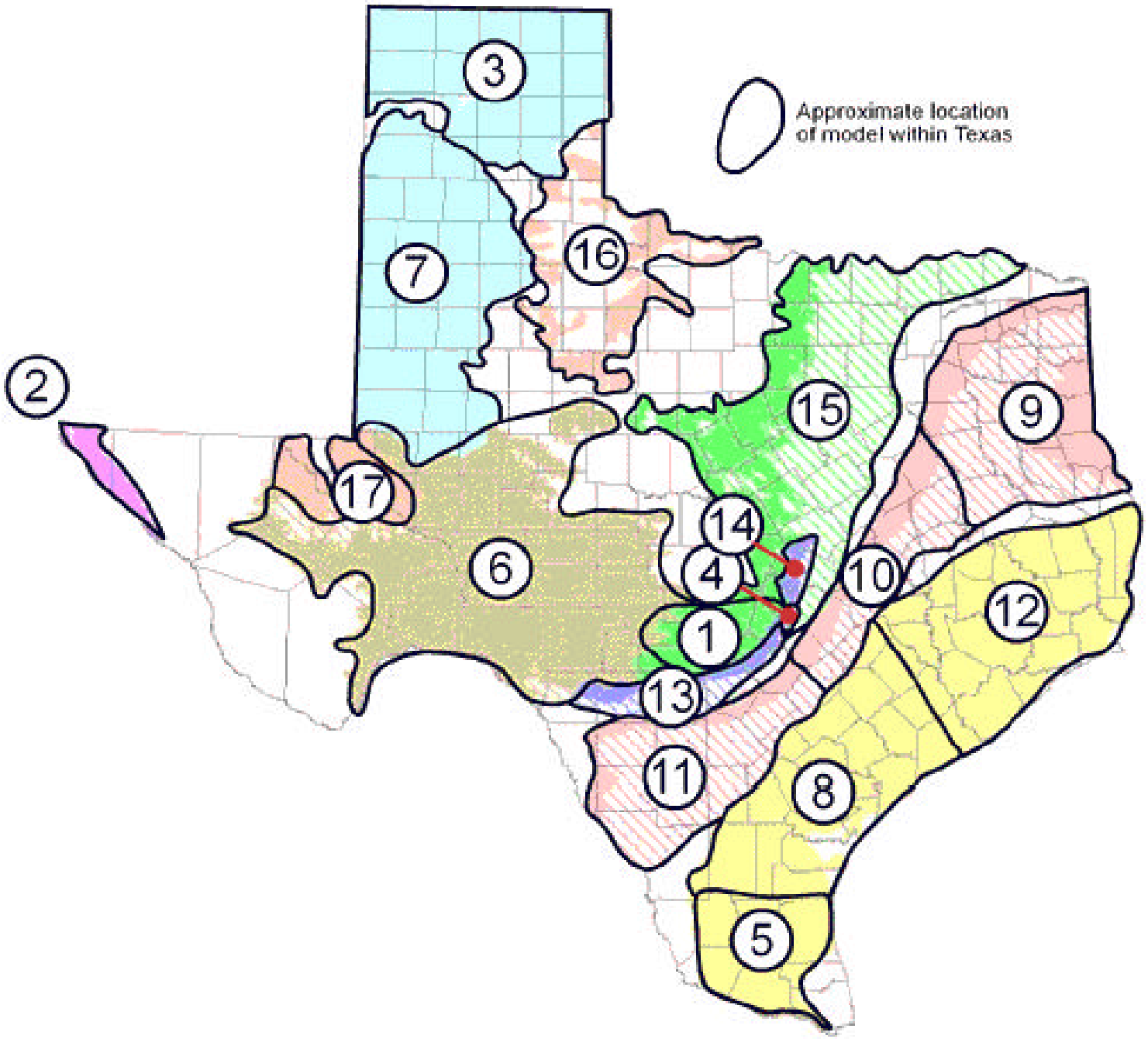
- A numerical model is an approximation of the real system
- Uncertainty in the input data (e.g., model layers, spatial distribution of hydraulic properties, incomplete water-level information in wells)
- GAM standardization limits detail that can be modeled (e.g., local drawdown, stream/spring flow variations)

Questions?

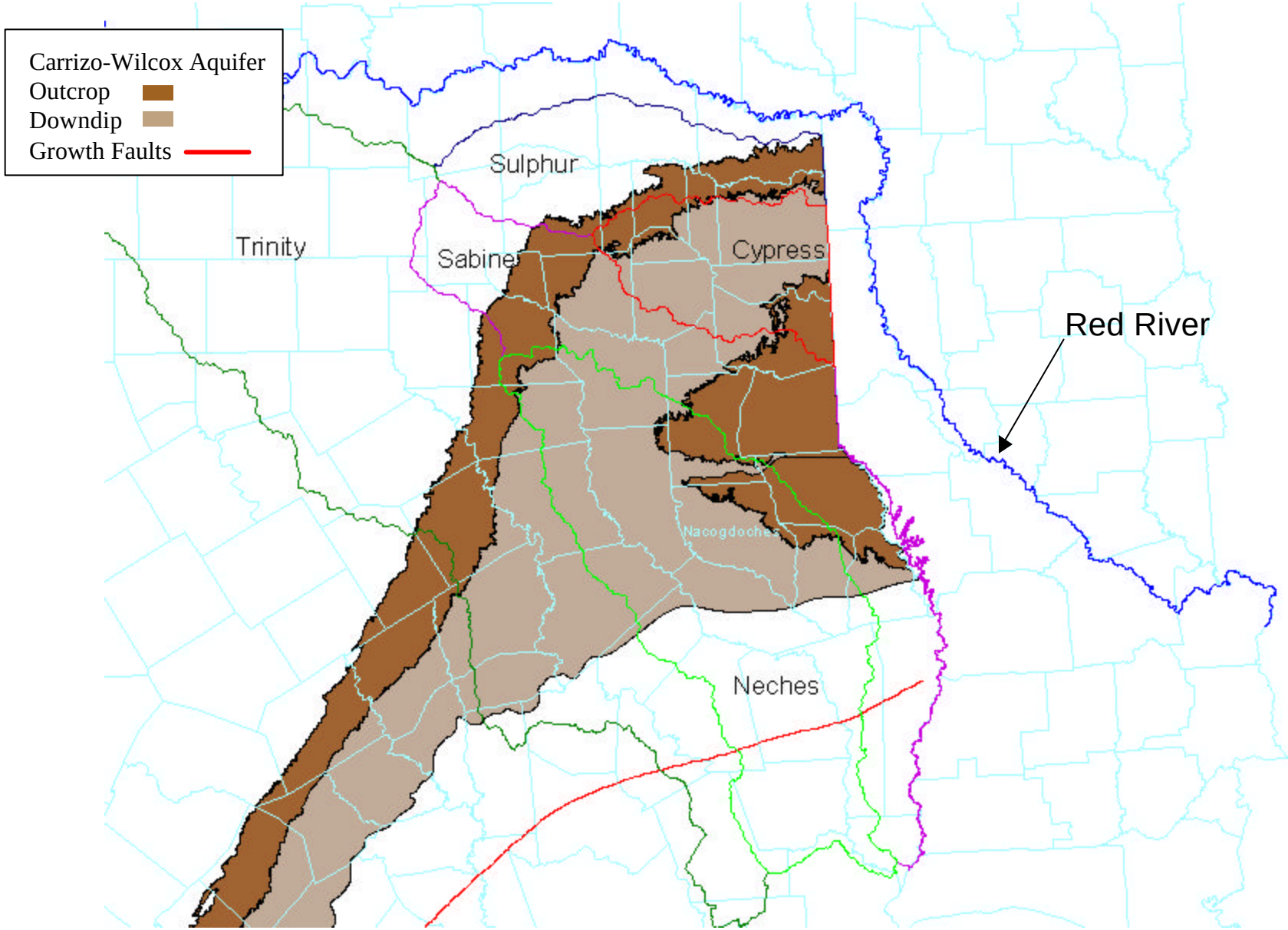
- Principals of GW Flow
- GW Flow Modeling

Northern Carrizo-Wilcox Aquifer

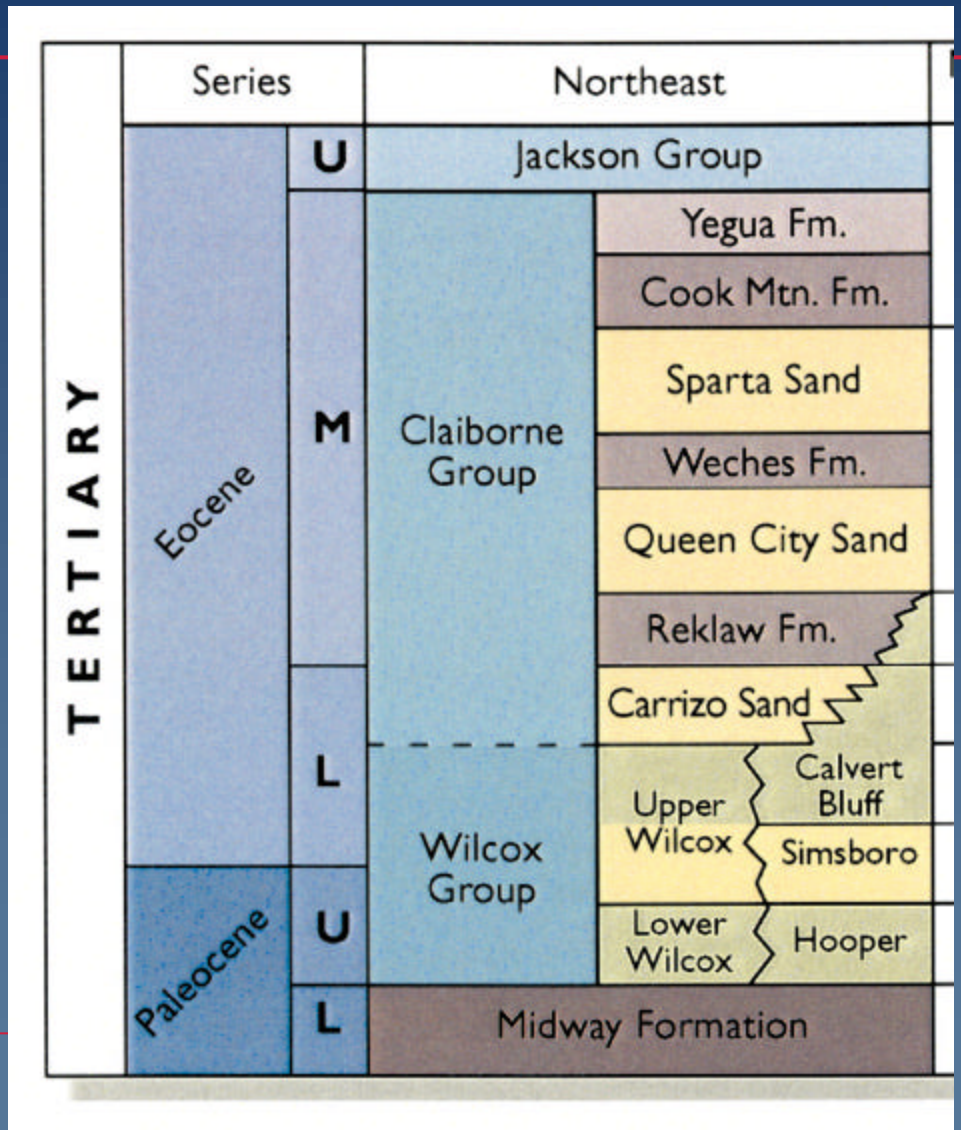
- Location and areal extent
- Coverage of major rivers
- Hydrostratigraphy
- Previous studies


Approximate location
of model within Texas
3
7
16
2
17
15
9
14
4
6
10
12
1
13
11
8
5

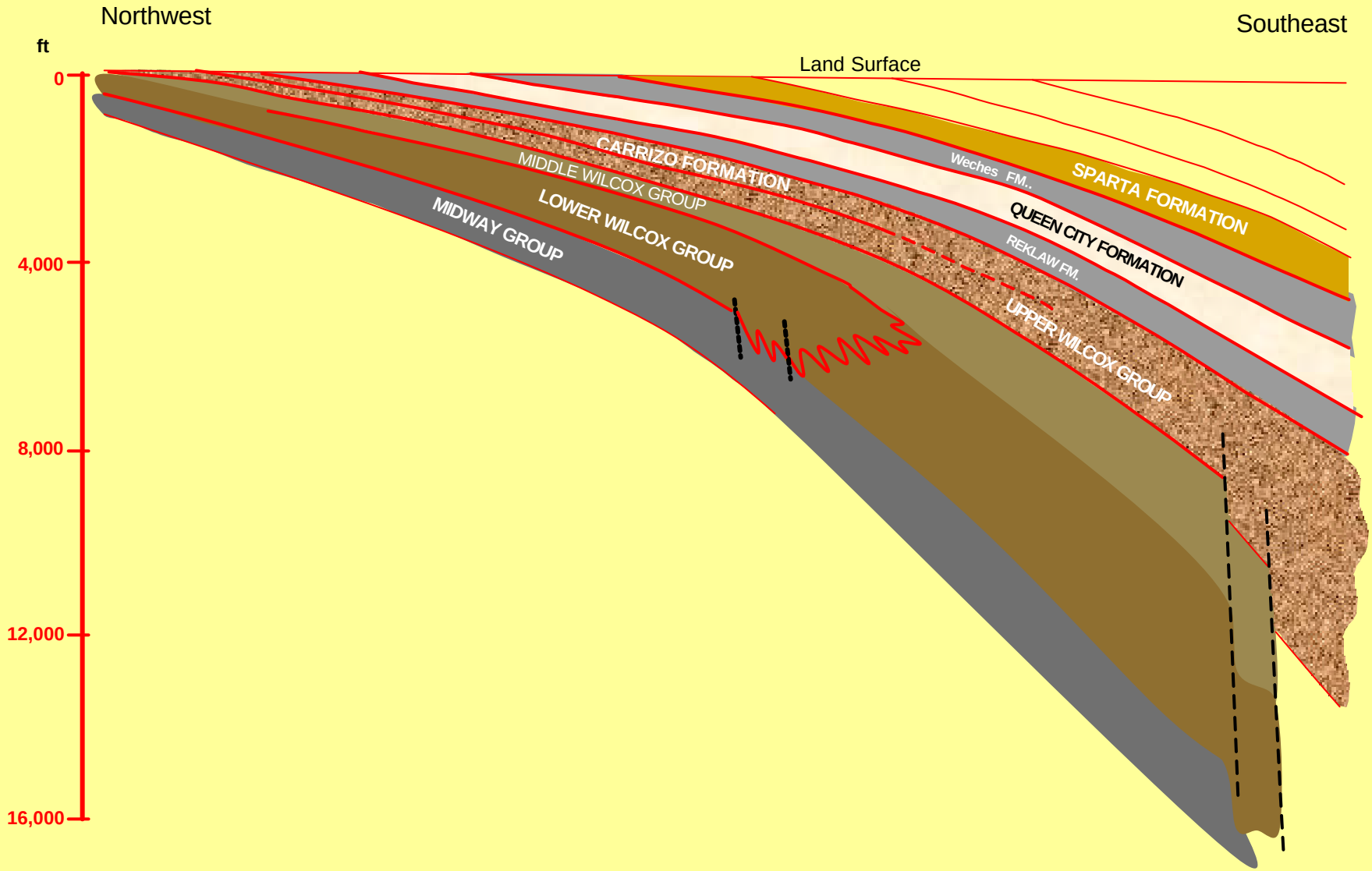
Northern Carrizo-Wilcox - River Basins



Stratigraphy



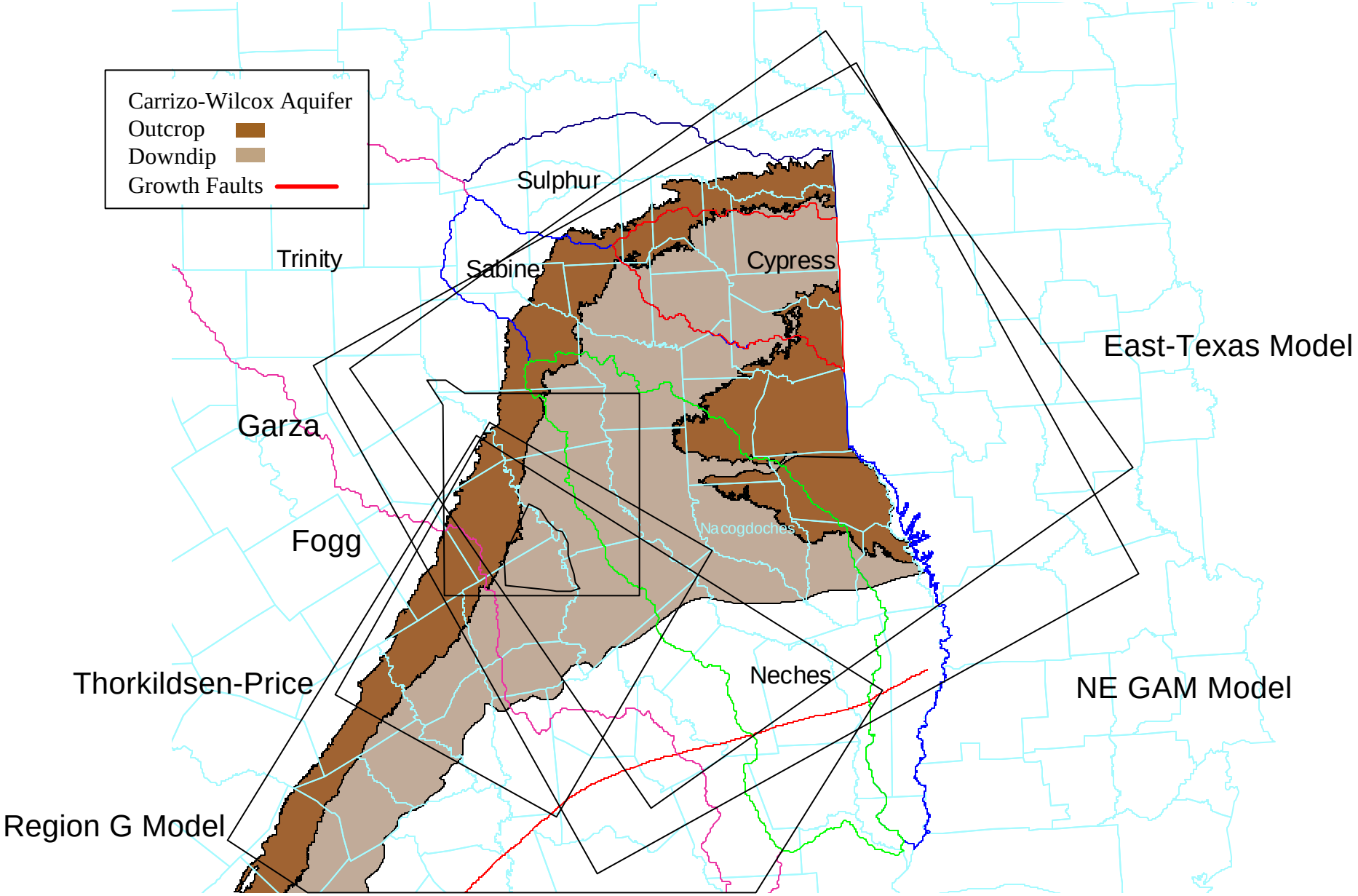
Schematic Cross-Section



Northern Carrizo-Wilcox Aquifer

- Previous Model Studies:
  - Garza (1975)
  - Fogg et al. (1983)
  - Thorkildsen (1991)
  - Harden & Assoc. (2000) Region-G
  - TWDB (unpublished)

Northern Carrizo-Wilcox GAM Previous Model Domains

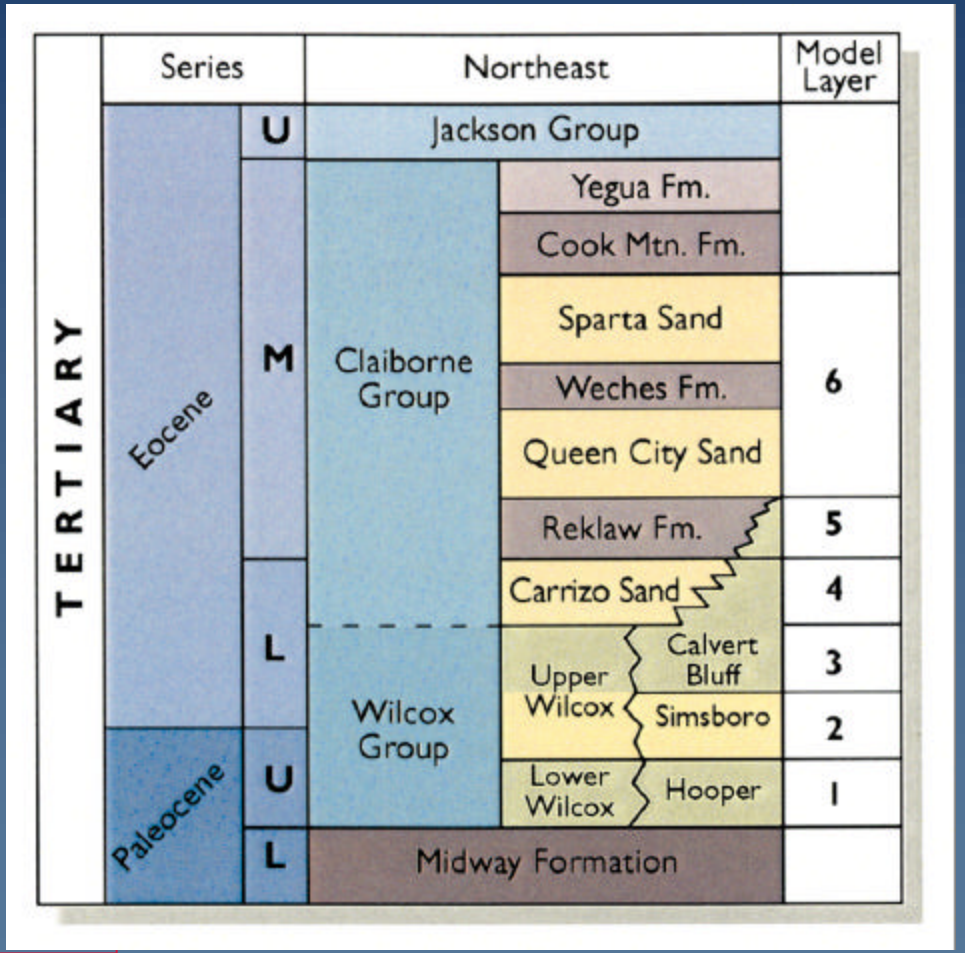


Modeling Approach

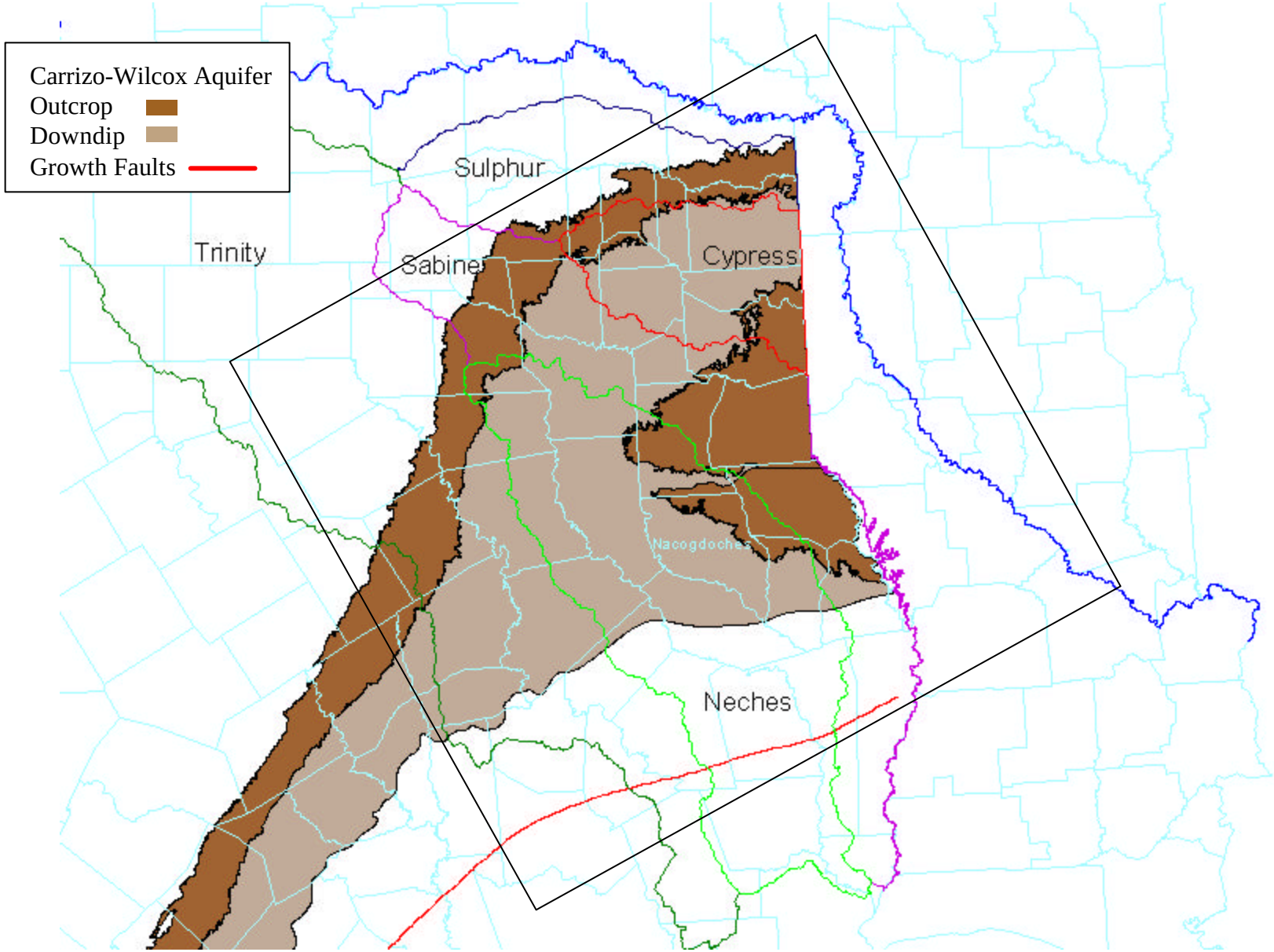
- Hydrostratigraphic layers
- Lateral boundaries
- Overlap and cooperation with adjacent GAM model
- Recharge, Surface/GW Interaction

Model Layers

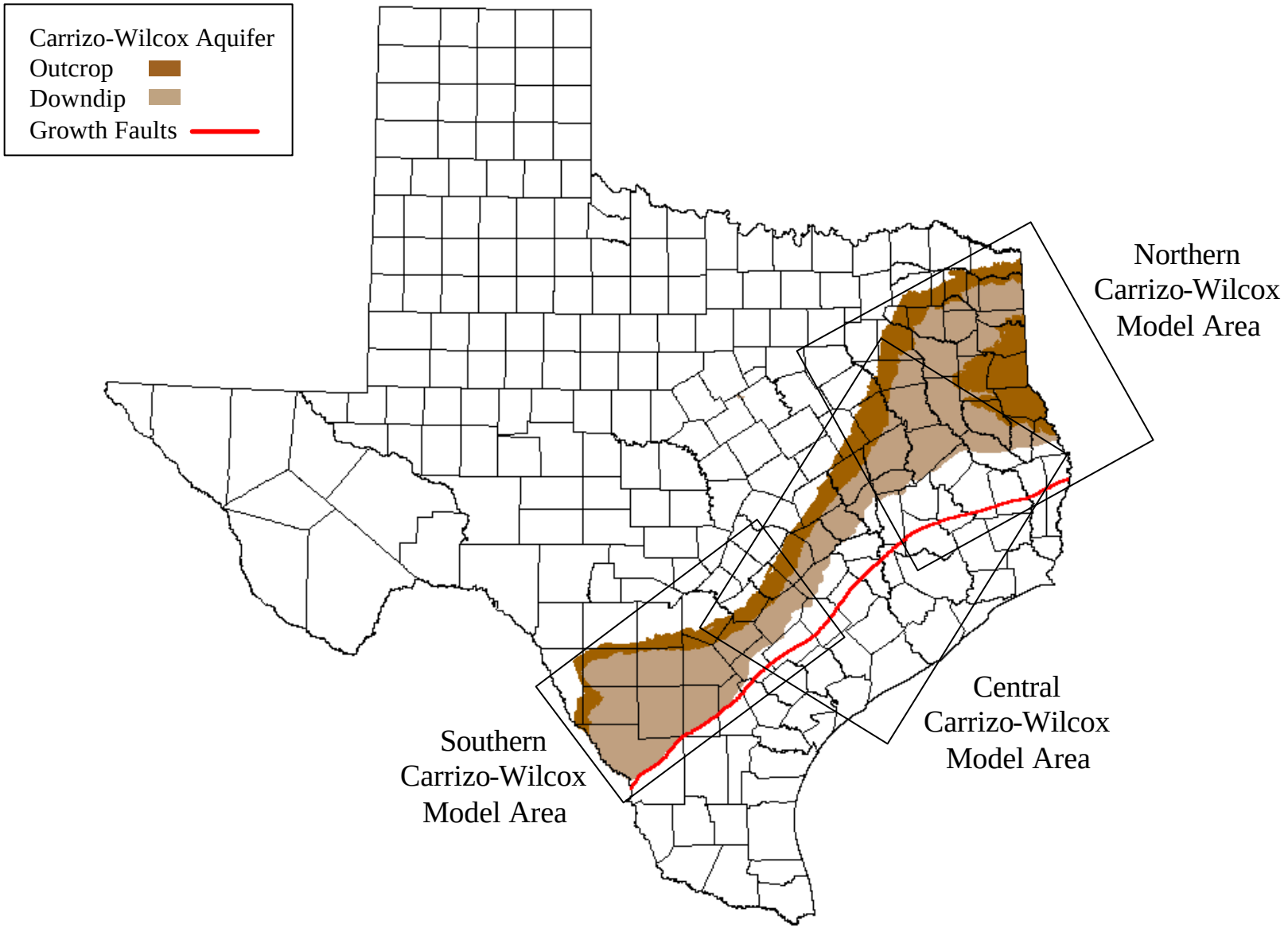
- Total of six layers
  - Lower Wilcox (Hooper)
  - Middle Wilcox (Simsboro)
  - Upper Wilcox (Calvert Bluff)
  - Carrizo Sand
  - Reklaw Fm
  - Shallow aquifers
    - (QC, W, S)



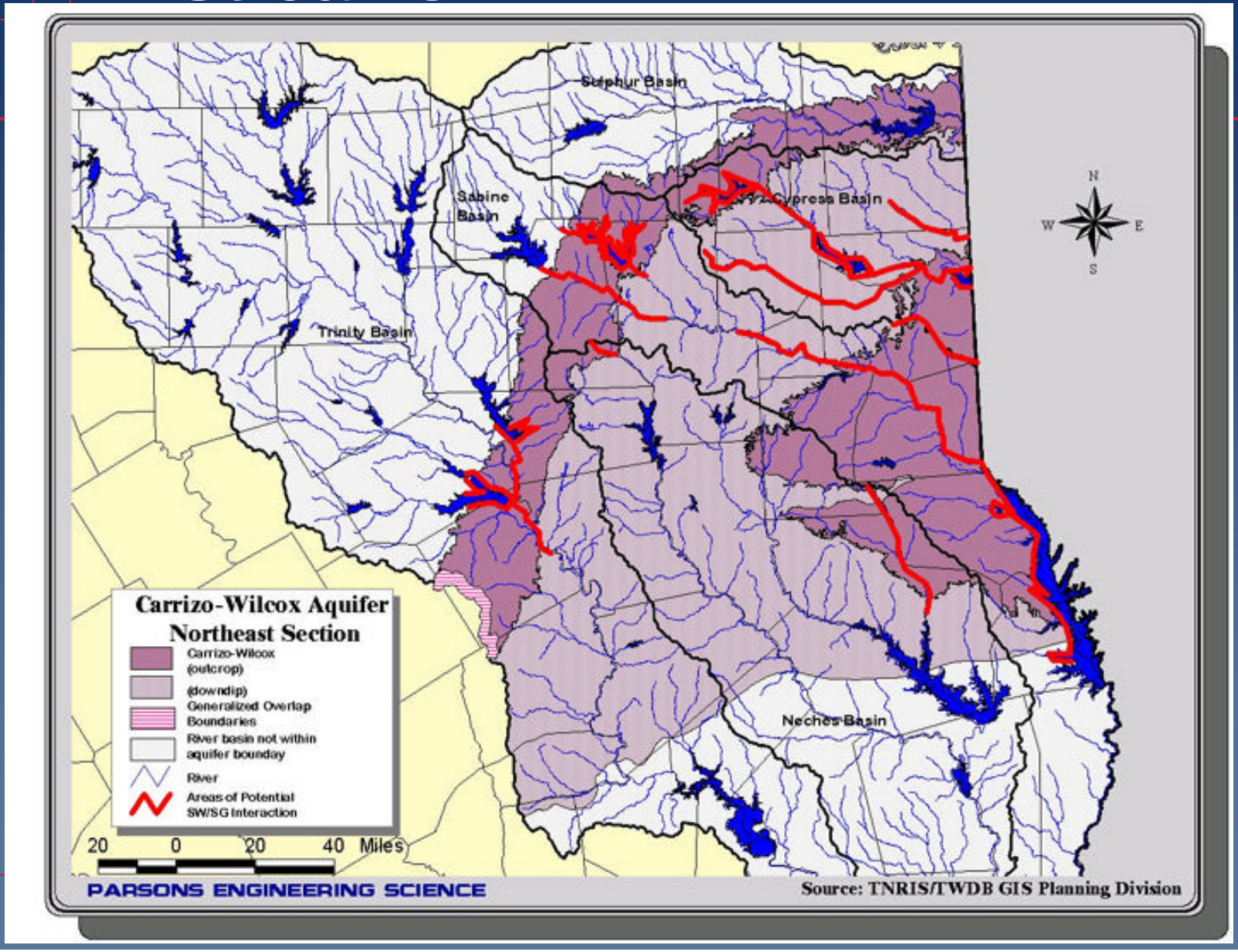
Northeast Carrizo-Wilcox GAM Model Domain



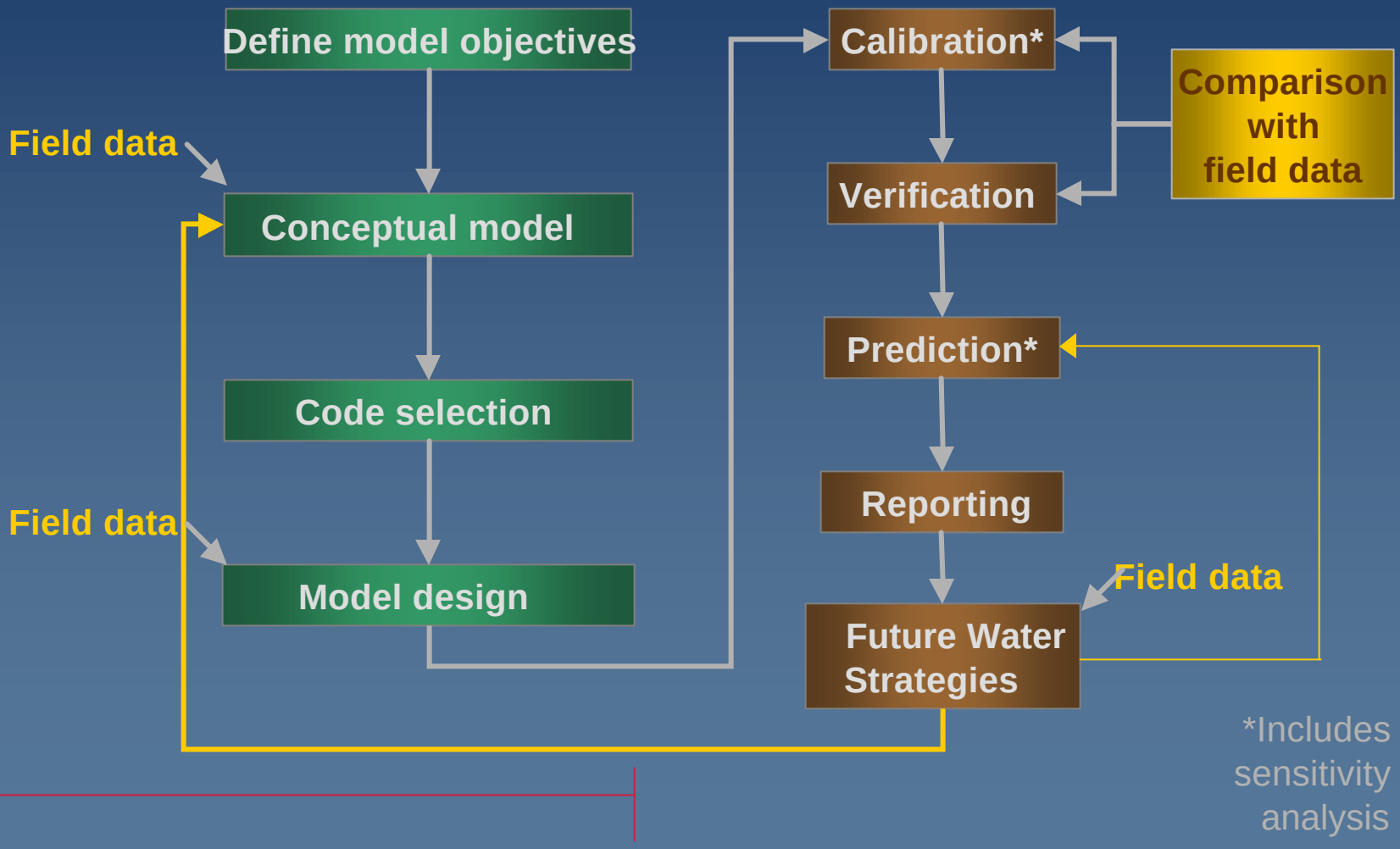
Carrizo-Wilcox GAM Model Domains



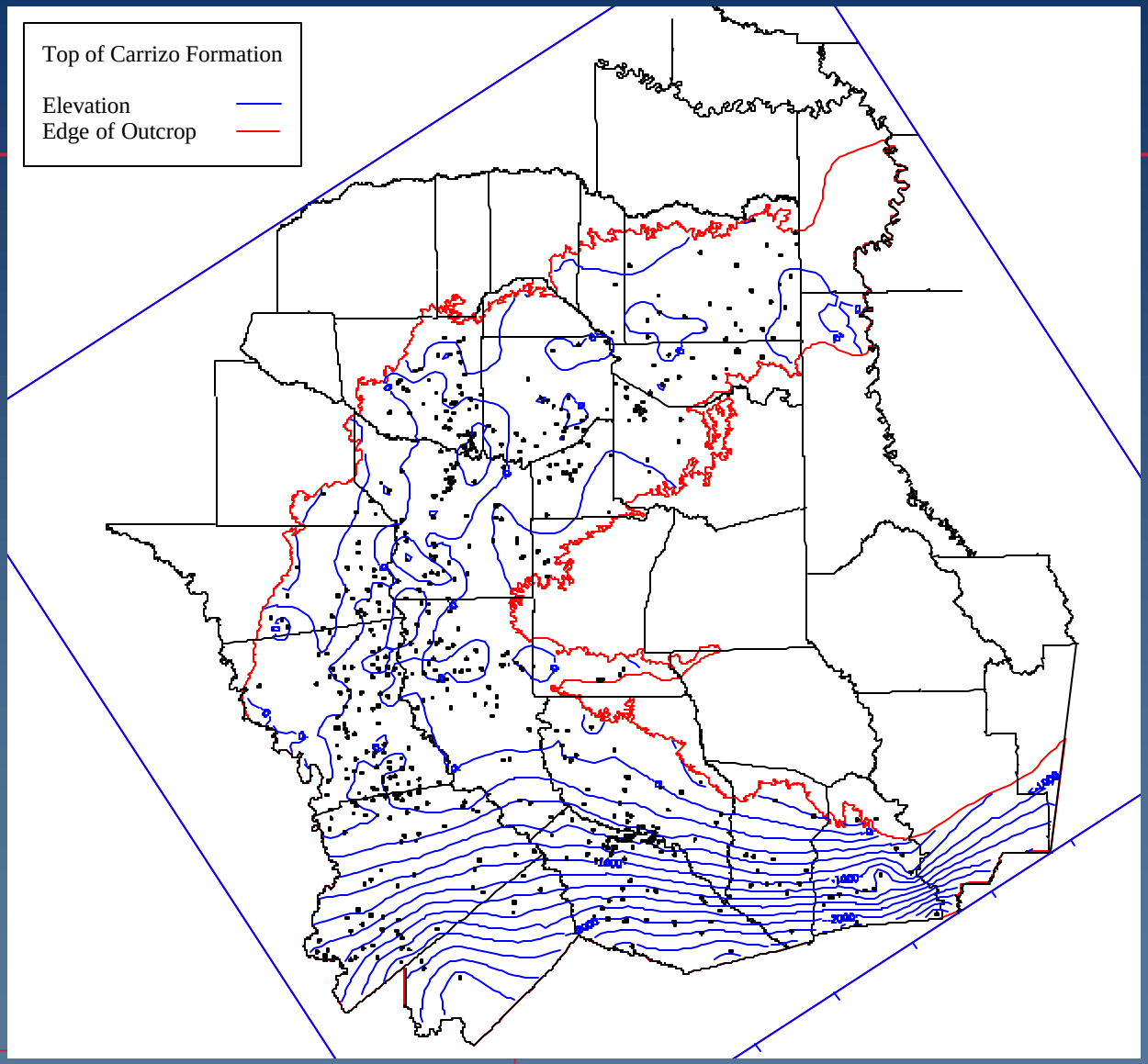
Recharge: Infiltration, Streams



Modeling Protocol

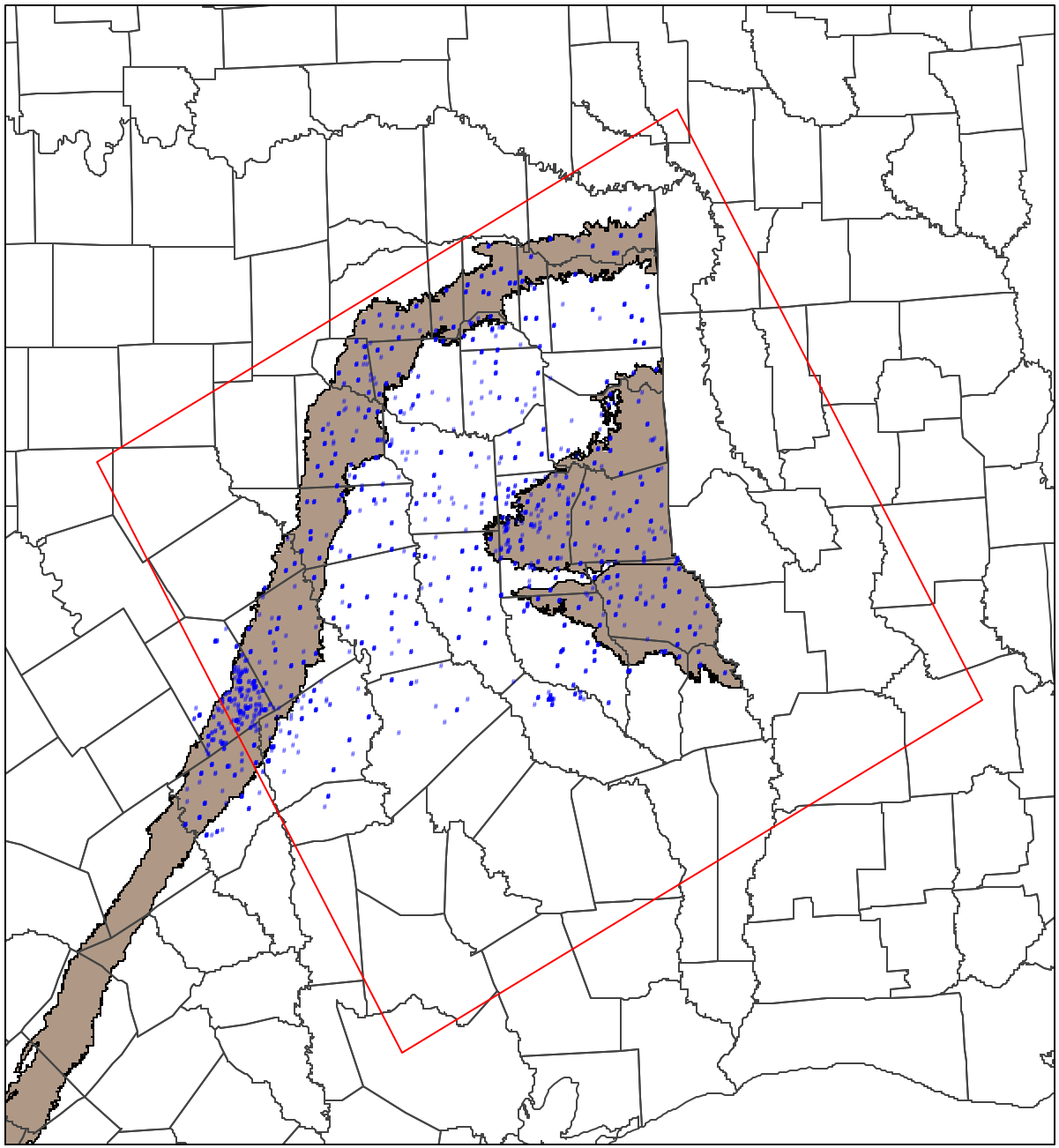


Geologic Input Data (Top Carrizo)

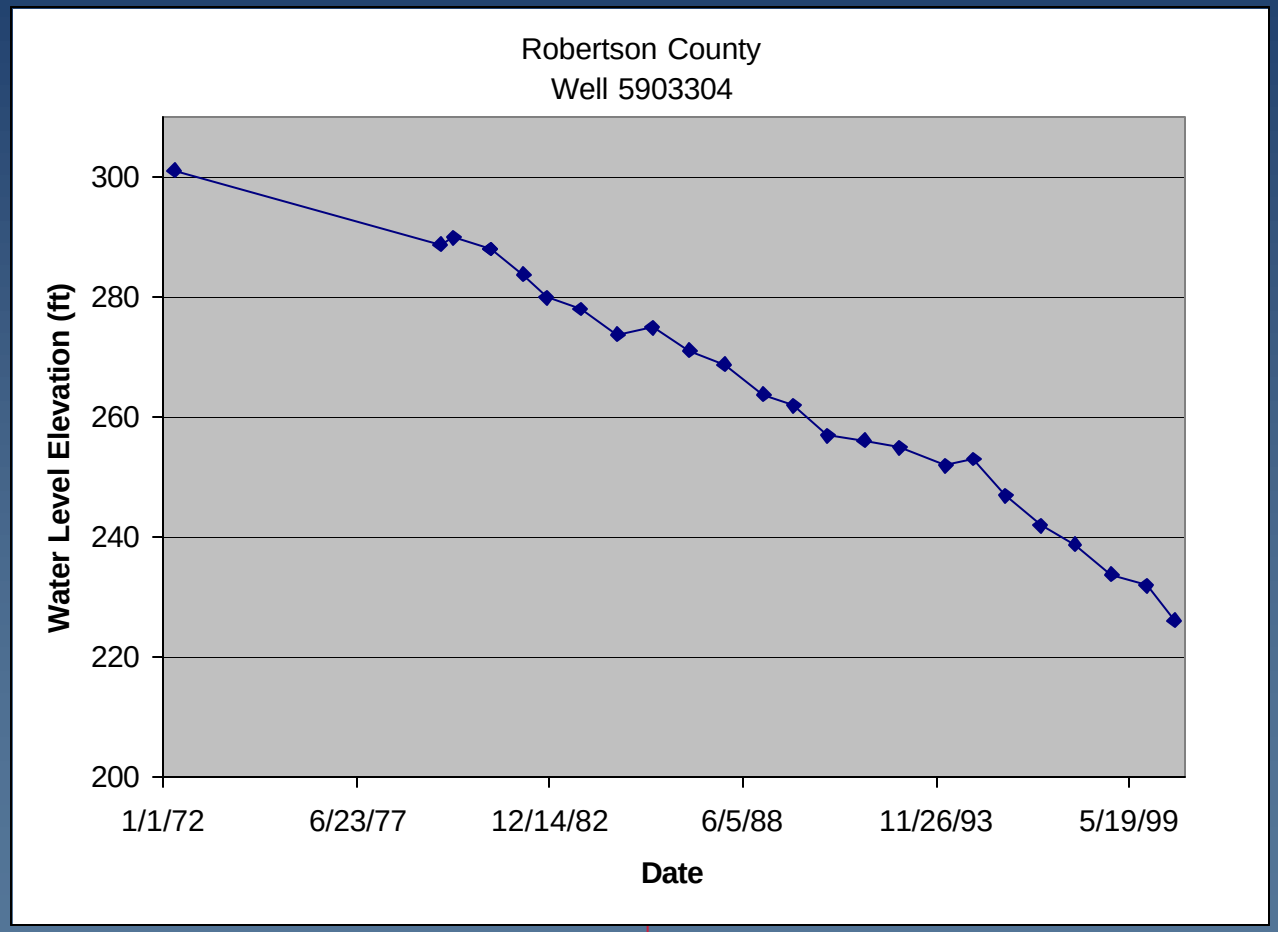


Water Level Measurements

Model Domain
Water Levels
1980 - 1984
Counties
Carrizo-Wilcox Outcrop



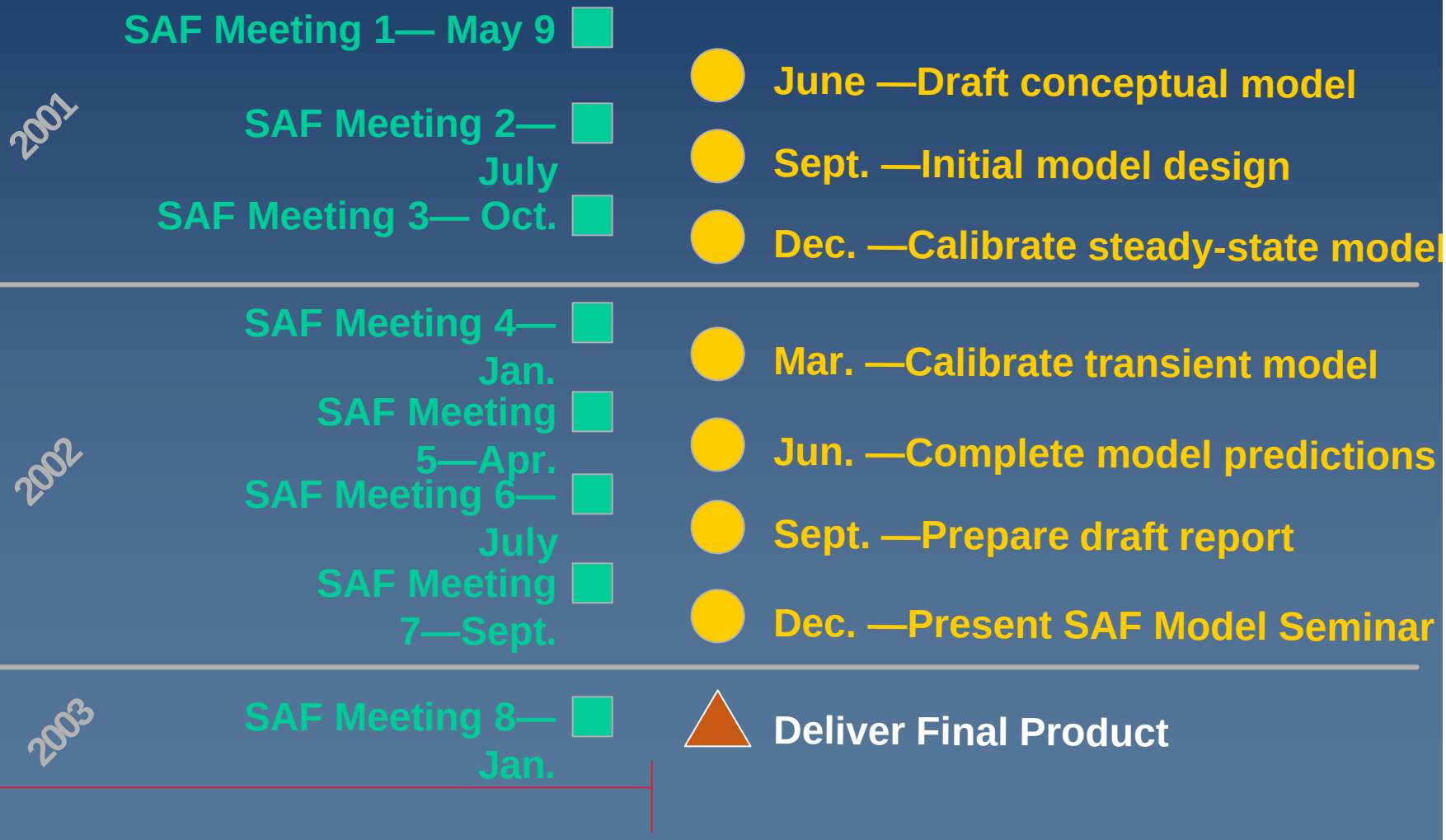
Well Hydrographs



Questions?

- Carrizo-Wilcox Aquifer
- Modeling Approach

Schedule


2001
SAF Meeting 1— May 9
SAF Meeting 2— July
SAF Meeting 3— Oct.
June —Draft conceptual model
Sept. —Initial model design
Dec. —Calibrate steady-state model
2002
SAF Meeting 4— Jan.
SAF Meeting 5—Apr.
SAF Meeting 6— July
SAF Meeting 7—Sept.
Mar. —Calibrate transient model
Jun. —Complete model predictions
Sept. —Prepare draft report
Dec. —Present SAF Model Seminar
2003
SAF Meeting 8— Jan.
Deliver Final Product

LIST OF ATTENDEES

Northern Carrizo-Wilcox Aquifer
Groundwater Availability Modeling
Stakeholder Advisory Forum
May 9, 2001
Nacogdoches, Texas

Buzz Patrick	Temple-Inland FPC
Mary Ambrose	Texas Natural Resource Conservation Commission
Art Whallon	Parsons Corporation
Sanjeev Kalaswad	Texas Water Development Board
John Pickens	Consultant
Kevin Spencer	R.W. Harden & Associates
Allen Davis	TXU Mining
James Beach	LBG-Guyton Associates
Arnold Pierce	Schaumburg & Polk, Inc.
Reeves Hayter	Hayter Engineering
Leon Young	Stephen F. Austin State University
Kelley Holcomb	Angelina-Neches River Authority
Robert Mace	Texas Water Development Board
Rainer Senger	Duke Engineering & Services, Inc.

Stakeholder Advisory Forum No. 1
Northern Carrizo-Wilcox GAM
held
May 9, 2001
Stephen F. Austin State University, Nacogdoches

Introduction

The first Stakeholder Advisory Forum (SAF) for the Northern Carrizo-Wilcox Groundwater Availability Model (GAM) was held on May 9th at Stephen F. Austin State University in Nacogdoches. The purpose of the forum was to introduce interested stakeholders to the GAM program, the basics of groundwater flow and groundwater flow modeling, and the proposed methodology to be used in modeling the Northern Carrizo-Wilcox aquifer. The presentation material is available at the TWDB GAM website (www.twdb.state.tx.us/gam).

Meeting Questions & Responses: (not necessarily listed in the order in which they were asked)

1. Will the Queen City and Sparta aquifers be modeled for this project?

Response: The emphasis of the Northern Carrizo-Wilcox GAM is on the Carrizo and Wilcox geologic units. The Queen City and Sparta are minor aquifers that will not be modeled as individual discrete hydrostratigrahic units for this project. Shallow geologic units above the Recklaw Formation will be modeled as a single model layer.

2. Will water quality be an issue in the model? What water quality parameters are being considered in the model?

Response: Water quality will not be directly modeled in this GAM project. However, total dissolved solids (TDS) data derived from the TWDB database will be used as an indication of water quality and will be plotted as maps and included in the Final Report that will be posted on the TWDB website (http://www.twdb.state.tx.us).

3. Can the aquifer be restored if it is physically damaged from the drawdowns from pumping?

Response: Land subsidence or consolidation of clay layers as a result of pumping is not considered to be an important process in the Northern Carrizo-Wilcox GAM region. Therefore, the aquifer should recover provided sufficient recharge is available.

4. How will poor data quality affect the model? How will it be handled?

Response: There are possibly some errors or inconsistencies in the database, which we will attempt to remove. In addition, there are uncertainties in the data. The quality of the data will be assessed.

5. Is any input from the WAM models currently being completed being considered for use in the GAM?

Response: An example of data from WAM that can be useful to GAM is average streamflows. It is desirable for the WAM and GAM models to be compatible. A module to MODFLOW that would allow this capability is not currently available and such modeling is not included in the scope of work for this project.

6. Will any water well data from Louisiana be used in the model and where are we getting this data?

Response: The model will include Louisiana data west of the Red River. Data sources include published reports from the Regional Aquifer Systems Analysis Program of United States Geological Survey, and County and Parish water resources reports.

7. Is there a goal on how much input data that will be needed?

Response: There is no specific goal. One needs more data to define areas that are more heterogeneous.

8. Where are we getting the input data?

Response: The data for supporting the GAM is being obtained from the TWDB website, County water resources reports, United States Geological Survey reports, RWPGs, GCDs, and any other relevant published documents.

9. Is there a process to continuously verify, clarify, and modify the model, as new data becomes available?

Response: At the completion of the 2-yr project to develop the GAM for the Northern Carrizo Wilcox, the model, final report, and all supporting data (with source documentation) will be posted on the TWDB website. They will be available to interested persons or agencies as "living" tools that can be modified and used to include new data and information.

10. What is the downdip boundary condition for the model?

Response: The downdip boundary has been located in line with the approximate updip location of growth faults which is further south than the downdip limit of the potable water region in the Carrizo-Wilcox aquifer. The goal is to have the model boundary at a sufficient distance that hydraulic stresses from past pumping and future estimated pumping would not yield unrepresentative interactions at the model boundary.

11. Will measured steamflow data be used for calibration?

Response: Yes. The streamflow-routing package of MODFLOW will be used and groundwater-surface water interaction will be modeled.

12. Are we going to look at smaller subregions in finer detail?

Response: The GAM lateral grid spacing is 1mile by 1mile. Parameters must be averaged and assigned to each grid cell. Smaller scale features cannot be addressed with this model. The completed model could be used as a starting point for refinement to address smaller subregions.

13. Will there be notifications sent out when new information is posted on the TWDB website?

Response: Additional data and information is posted regularly on the website. Interested users are encouraged to periodically check for new information.

14. How will County other or rural pumpage be handled in Regions D and I?

Response: County water use will be areally distributed based on population distribution and/or land-use distribution. It was discussed at the meeting that animal farms (e.g., chicken farms) might be a problem, since they are not necessarily covered by land-use distributions. It was suggested that it might be possible to obtain information on their location from TNRCC based on water-quality monitoring of wells from these farms.