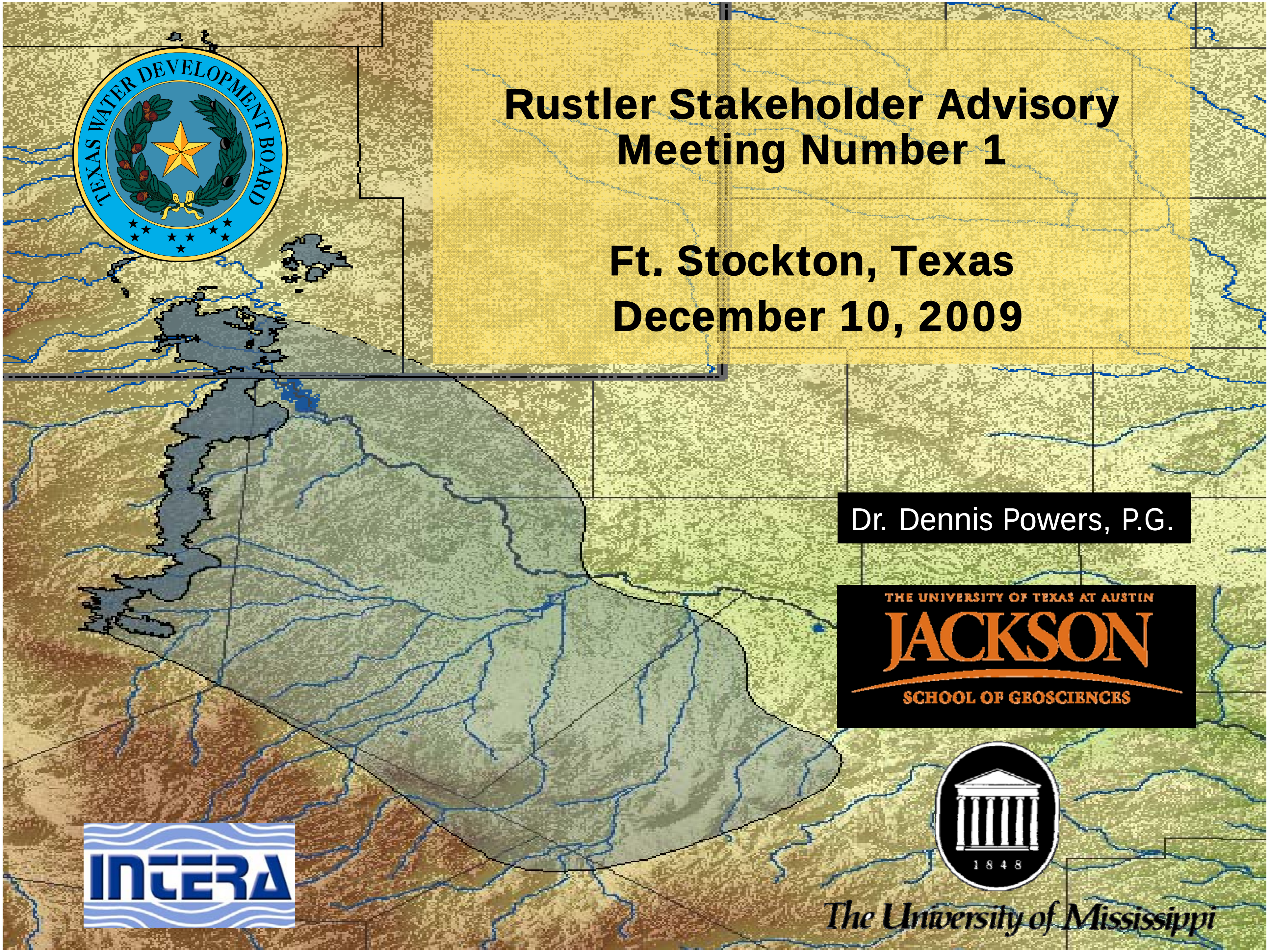
Rustler Stakeholder Advisory Meeting Number 1

Ft. Stockton, Texas
December 10, 2009

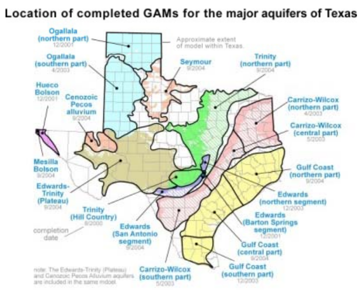
Dr. Dennis Powers, P.G.

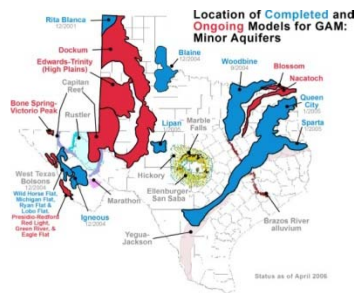


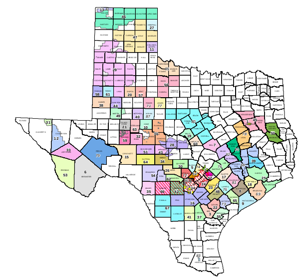
Outline

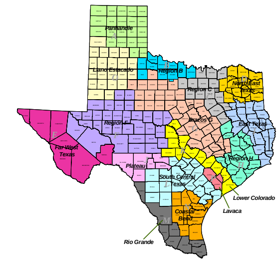
- General Introduction to the GAM program
- Introduction to the Rustler GAM team
- Rustler regional overview
- Basics of groundwater flow
- Overview of Rustler Aquifer
- Numerical groundwater modeling and the GAMs
- Data collection
- GAM schedule

Groundwater Availability Modeling









Wade Oliver

Contract Manager

Rustler Aquifer Groundwater Availability Model (GAM)

Texas Water Development Board

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.

What is Groundwater Availability?

Science + Policy = Groundwater Availability

↓ ↓ ↓

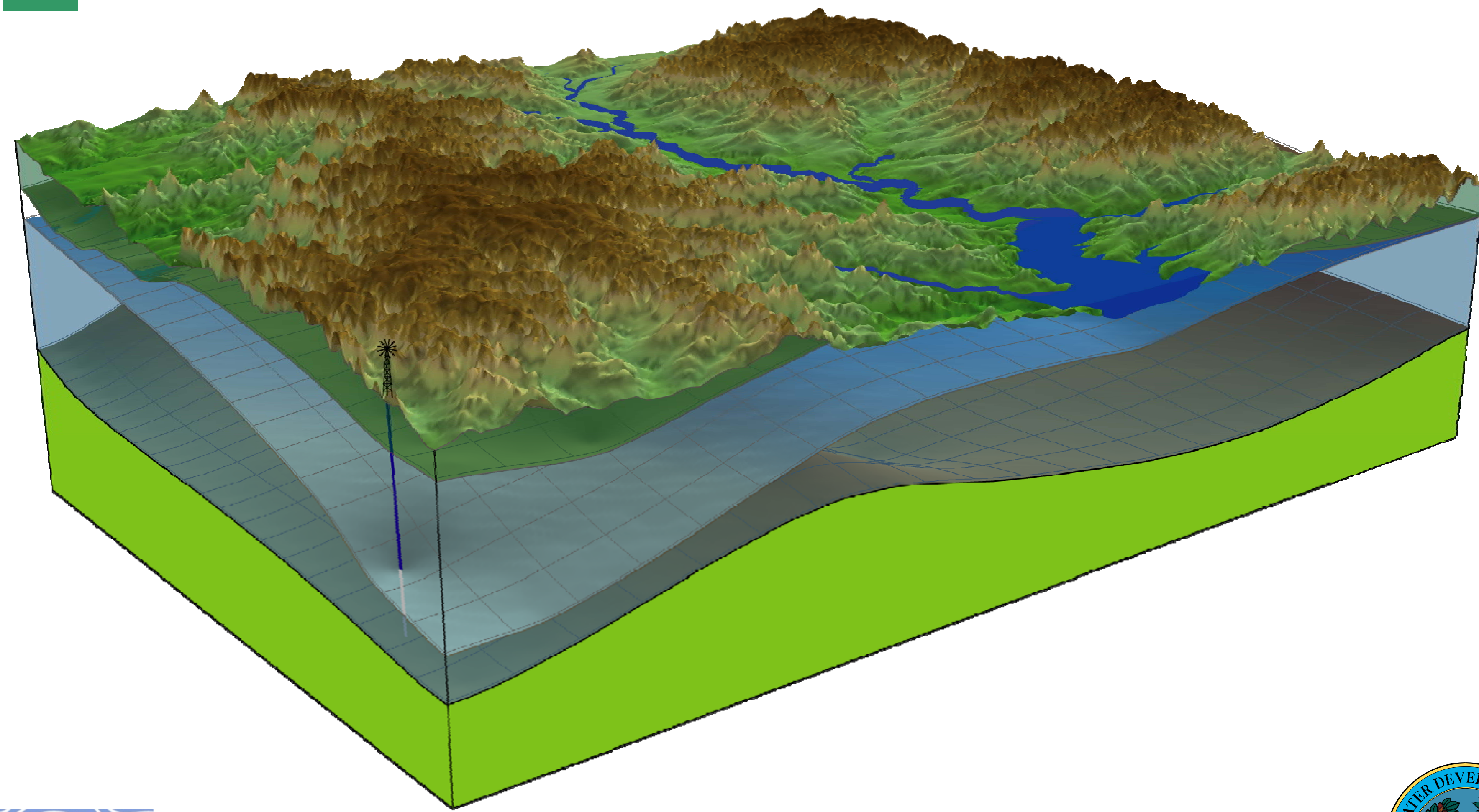
GAM or other tool + Desired Future Conditions = Managed Available Groundwater

Goal: informed decision-making

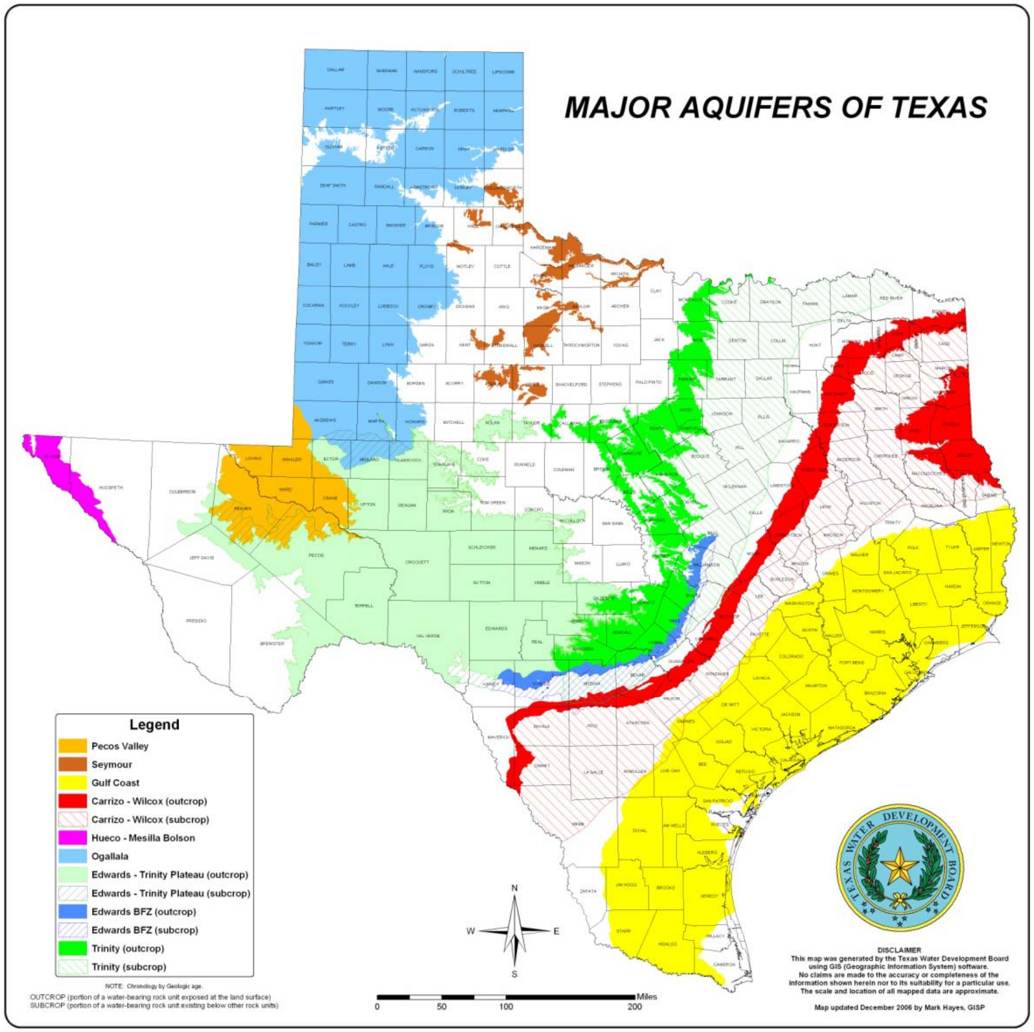
INTERA

TEXAS WATER DEVELOPMENT BOARD

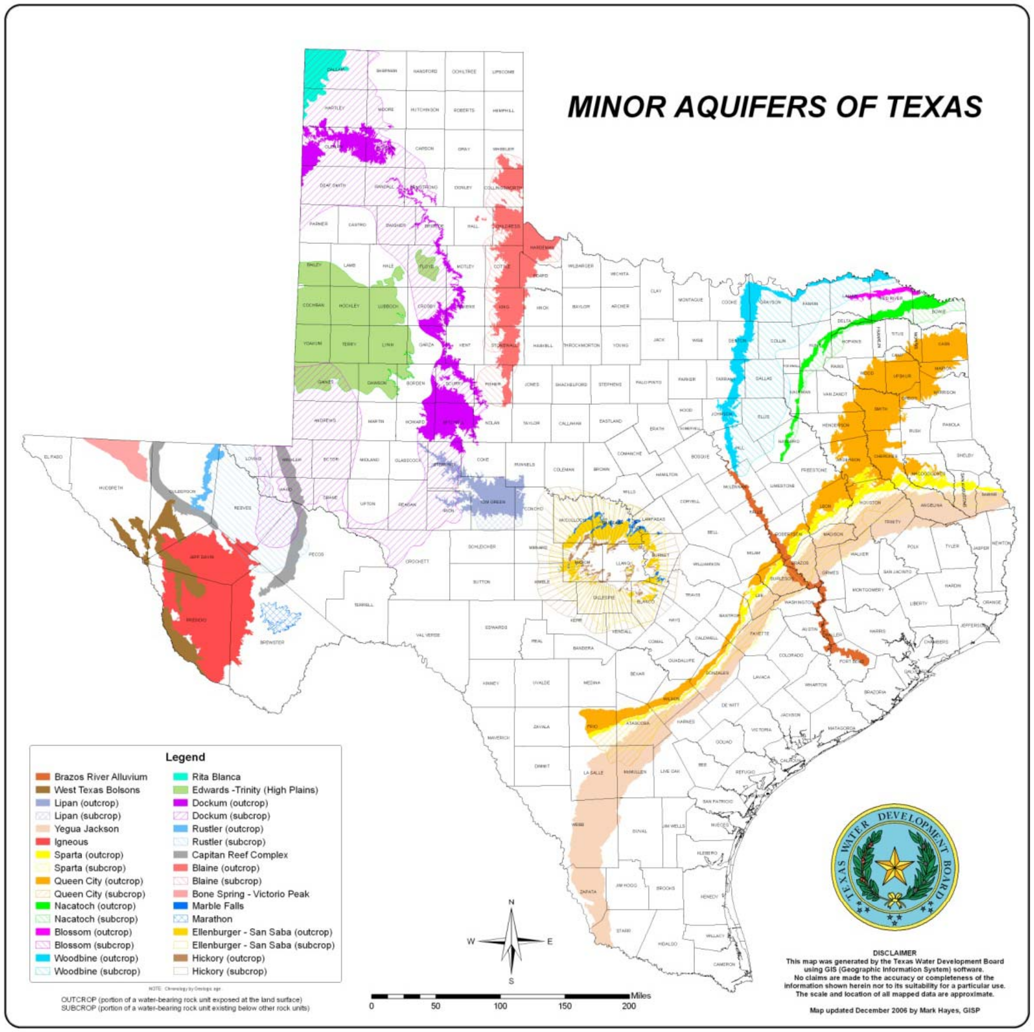
Groundwater Model



Major Aquifers



Minor Aquifers



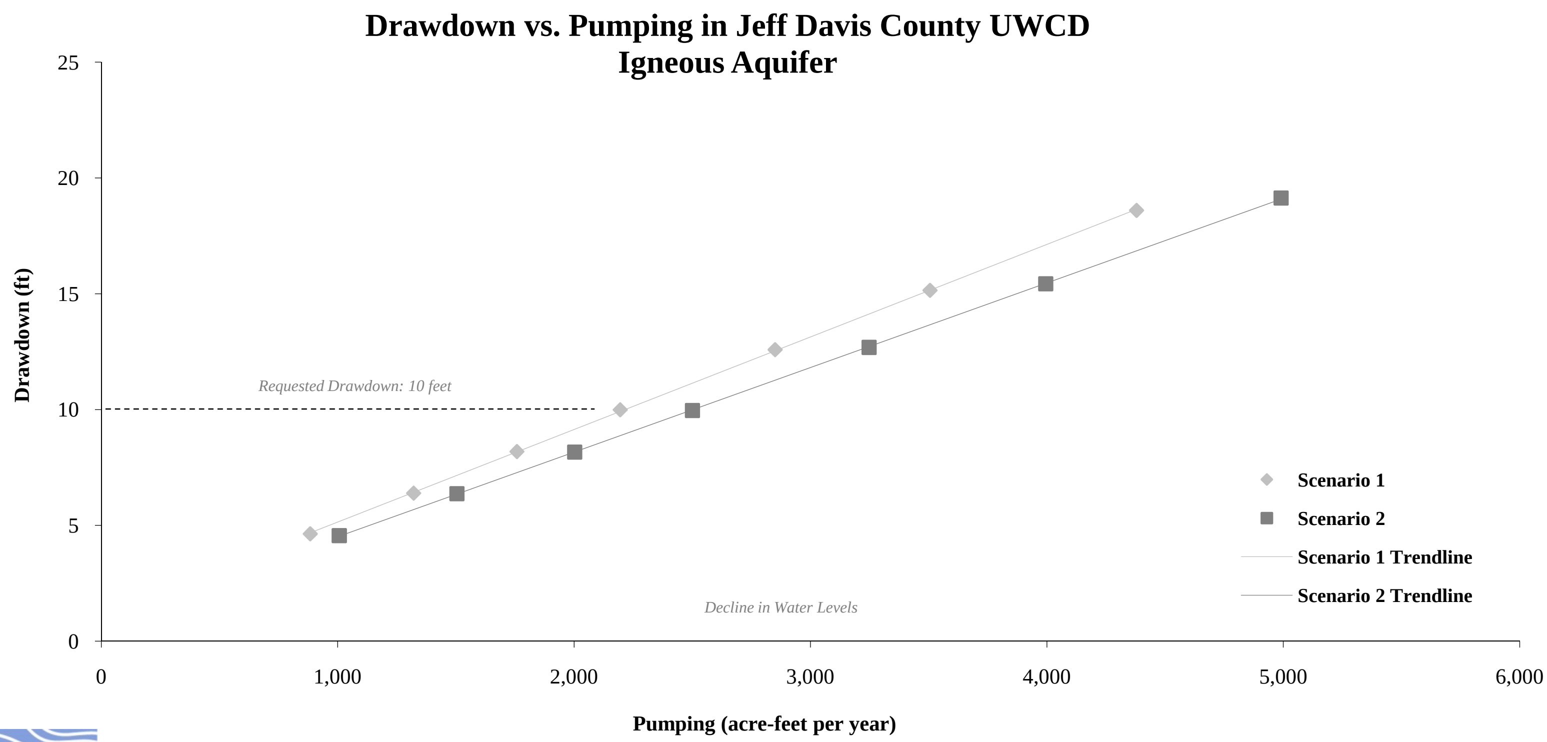
How we use Groundwater Models

- Inform groundwater districts about historical conditions in the aquifer

Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	140,509
	Pecos Valley Aquifer	14,115
	Dockum Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and any surface water body including lakes, streams, and rivers	Edwards-Trinity (Plateau) Aquifer	31,222
	Pecos Valley Aquifer	9,804
	Dockum Aquifer	0
Estimated annual volume of flow into the district within each aquifer in the district	Edwards-Trinity (Plateau) Aquifer	32,993
	Pecos Valley Aquifer	3,441
	Dockum Aquifer	554

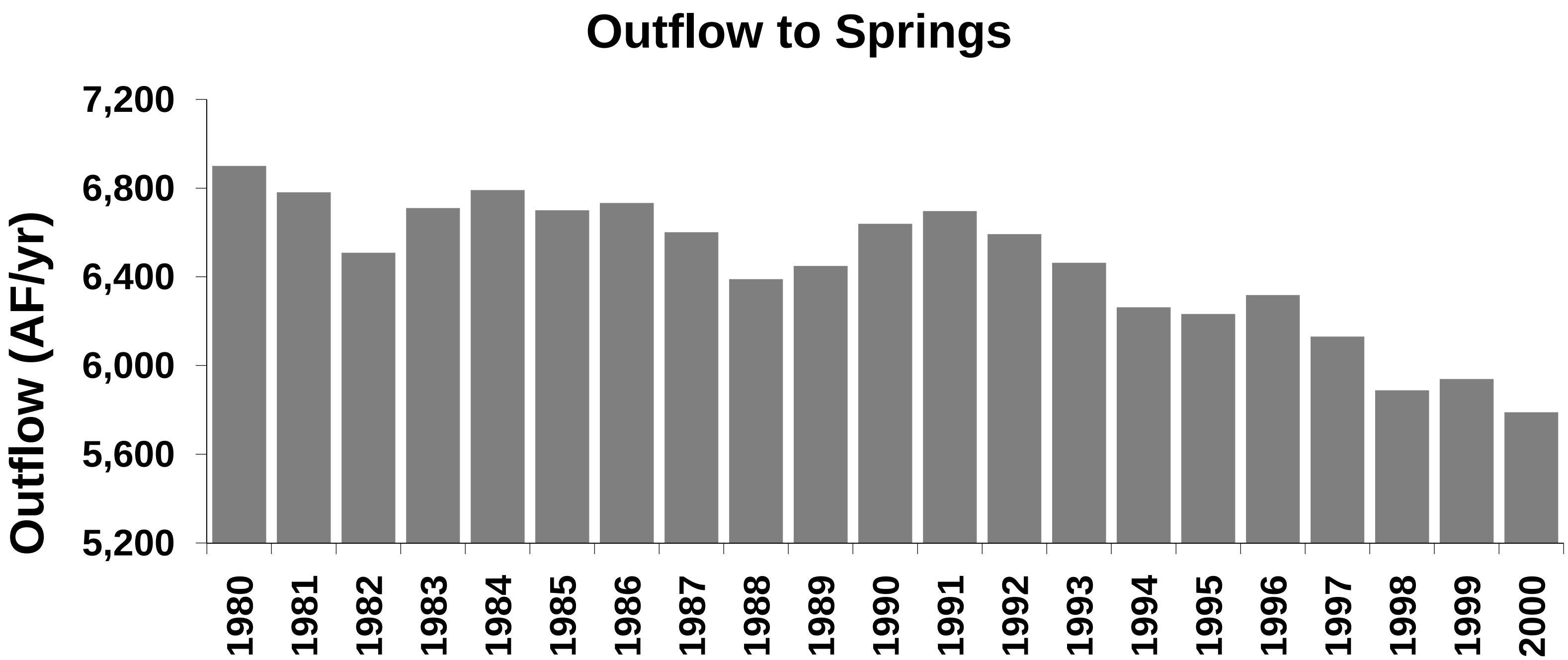
How we use Groundwater Models

- Assist districts and management areas in determining desired future conditions



How we use Groundwater Models

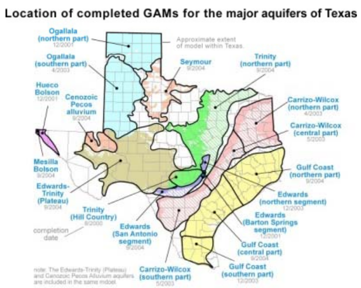
- Assist districts and management areas in determining desired future conditions

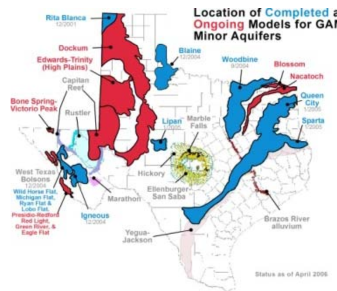


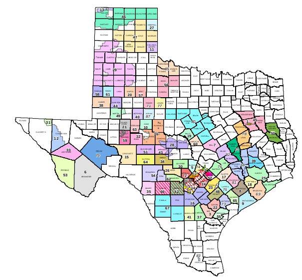
Stakeholder Advisory Forums

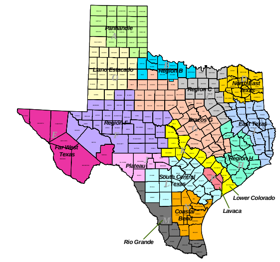
- Keep updated about progress of the model
- Understand how the groundwater model can, should, and should not be used
- Provide input and data to assist with model development

Contact Information









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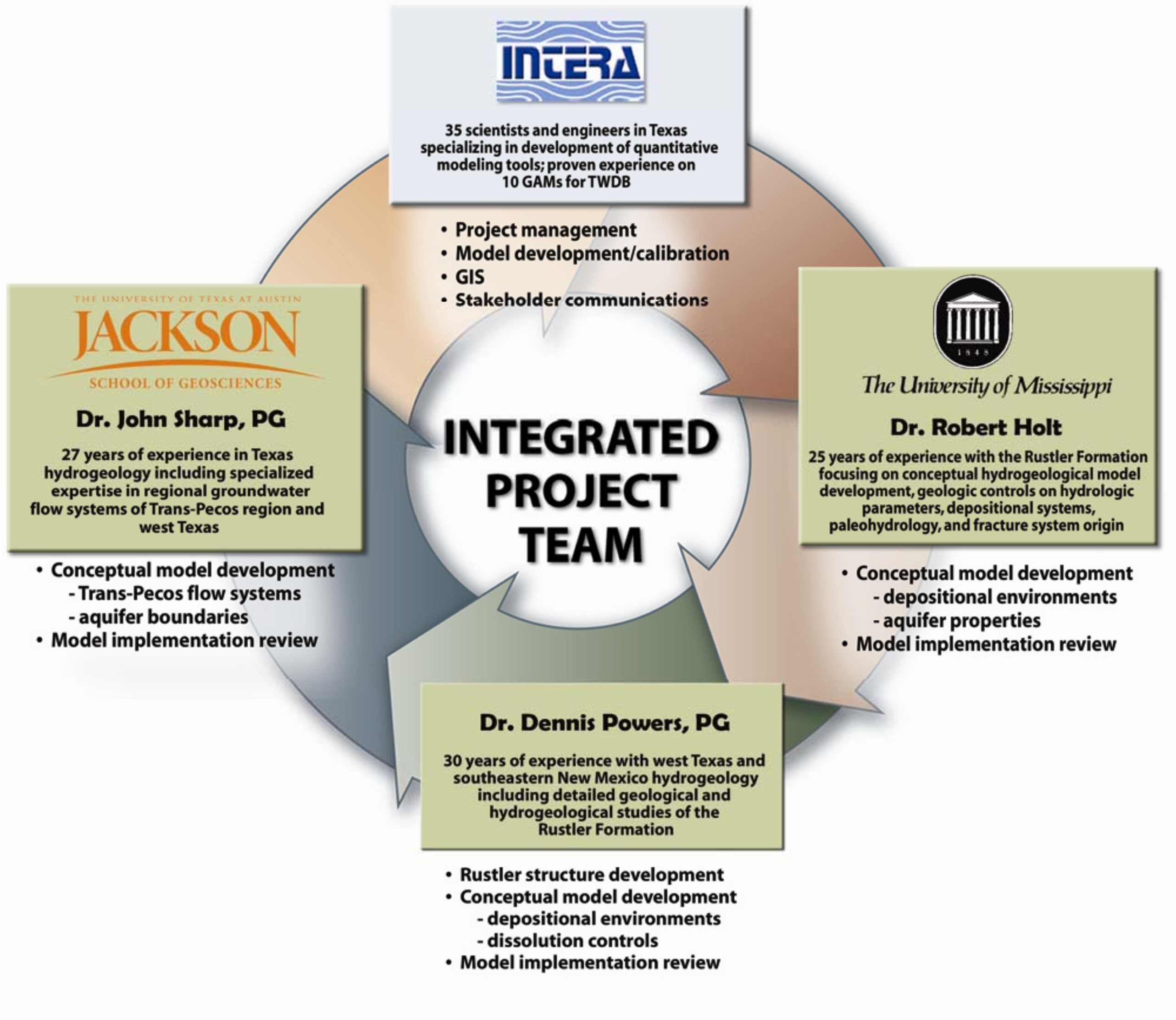
Web information:
www.twdb.state.tx.us/gam

Project Team & Responsibilities



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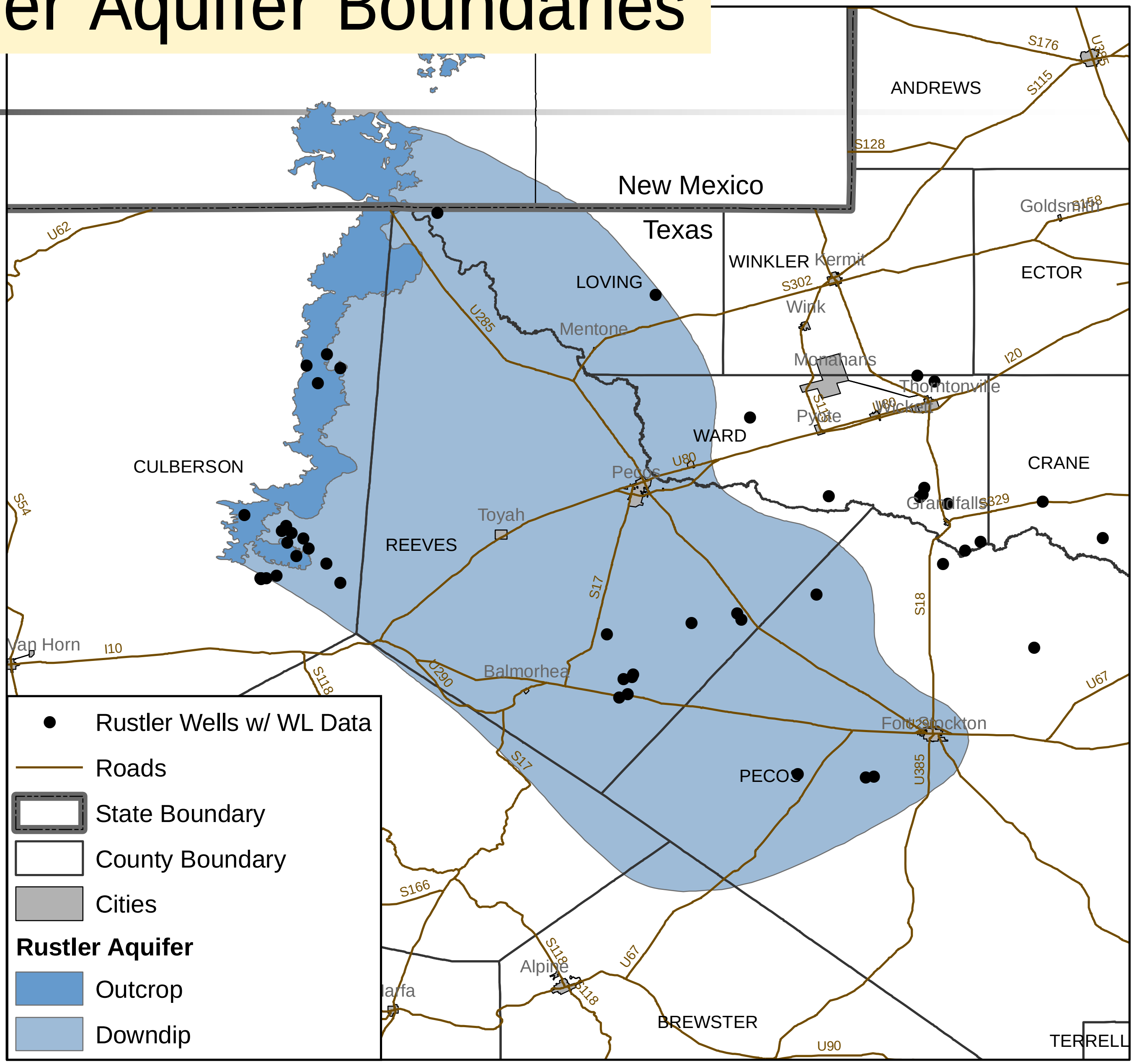
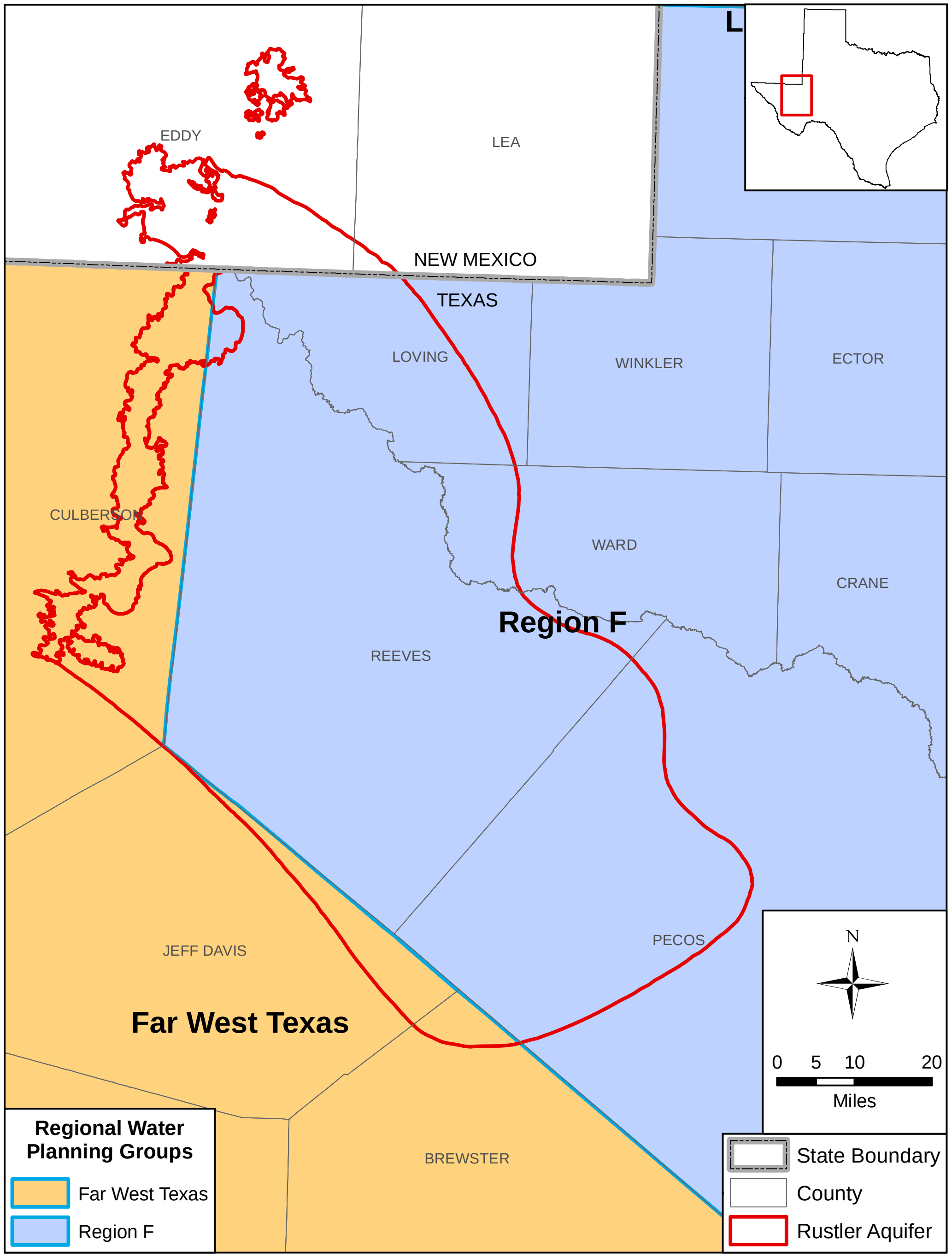
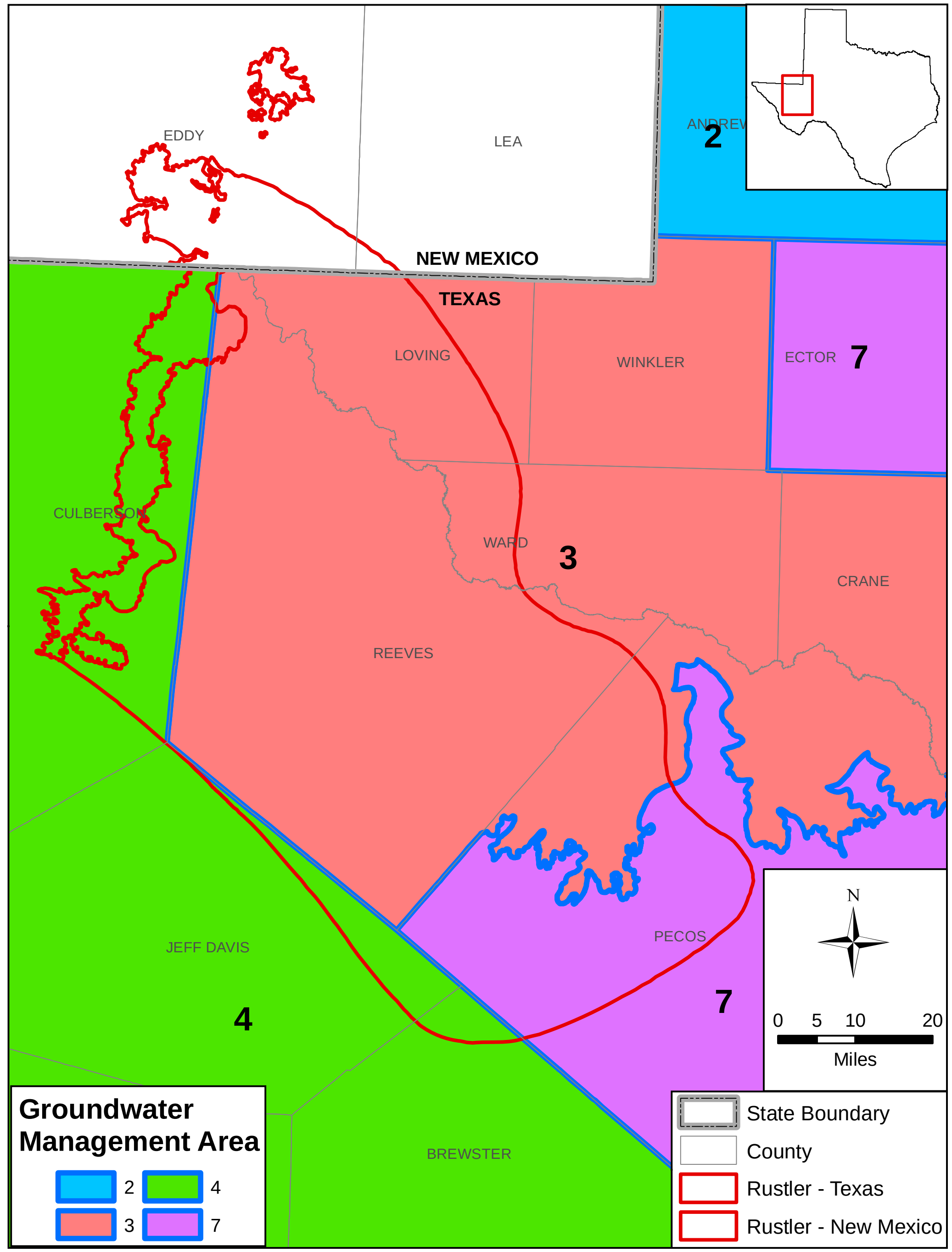
Rustler Aquifer Boundaries



Regional Planning Groups

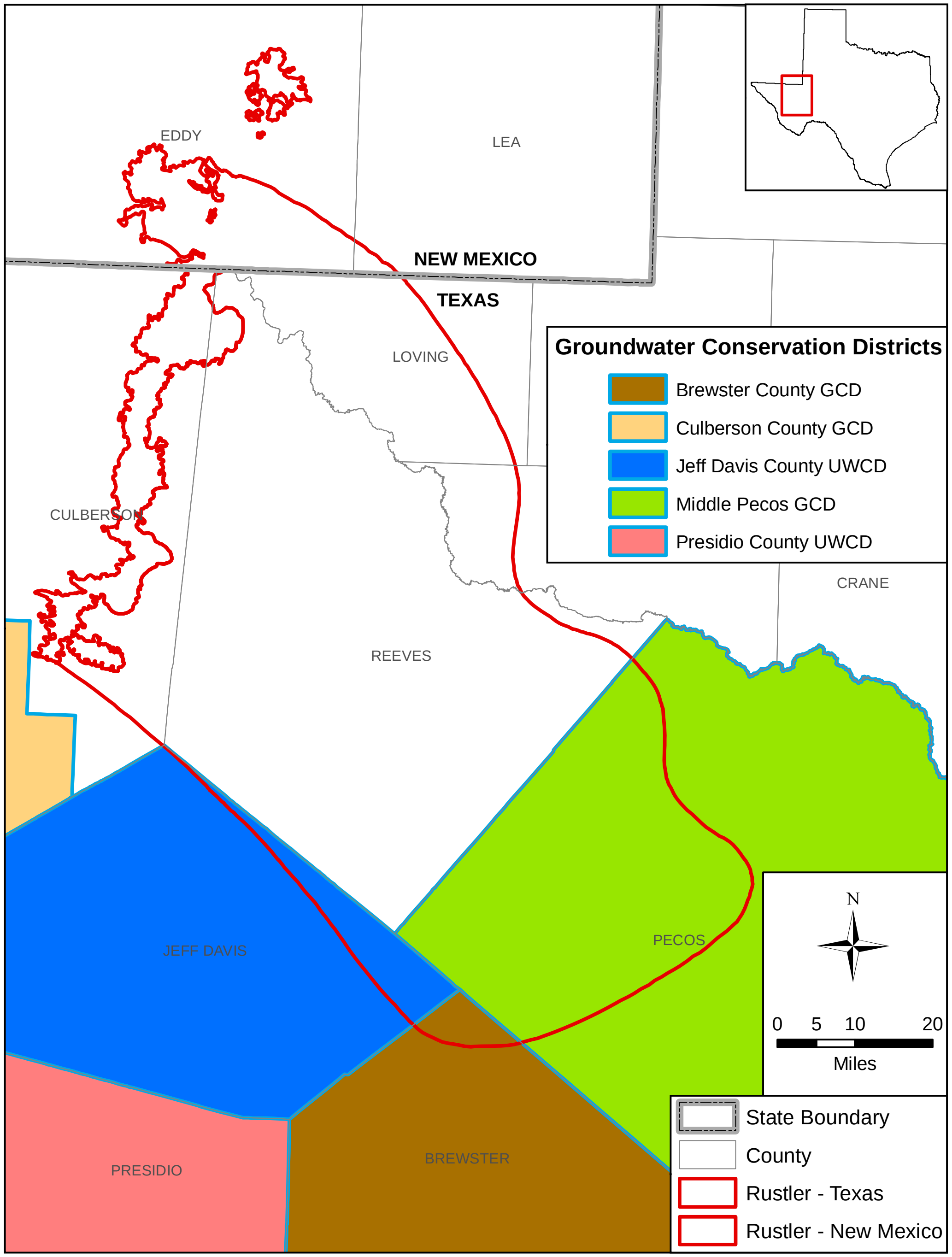


Groundwater Management Areas



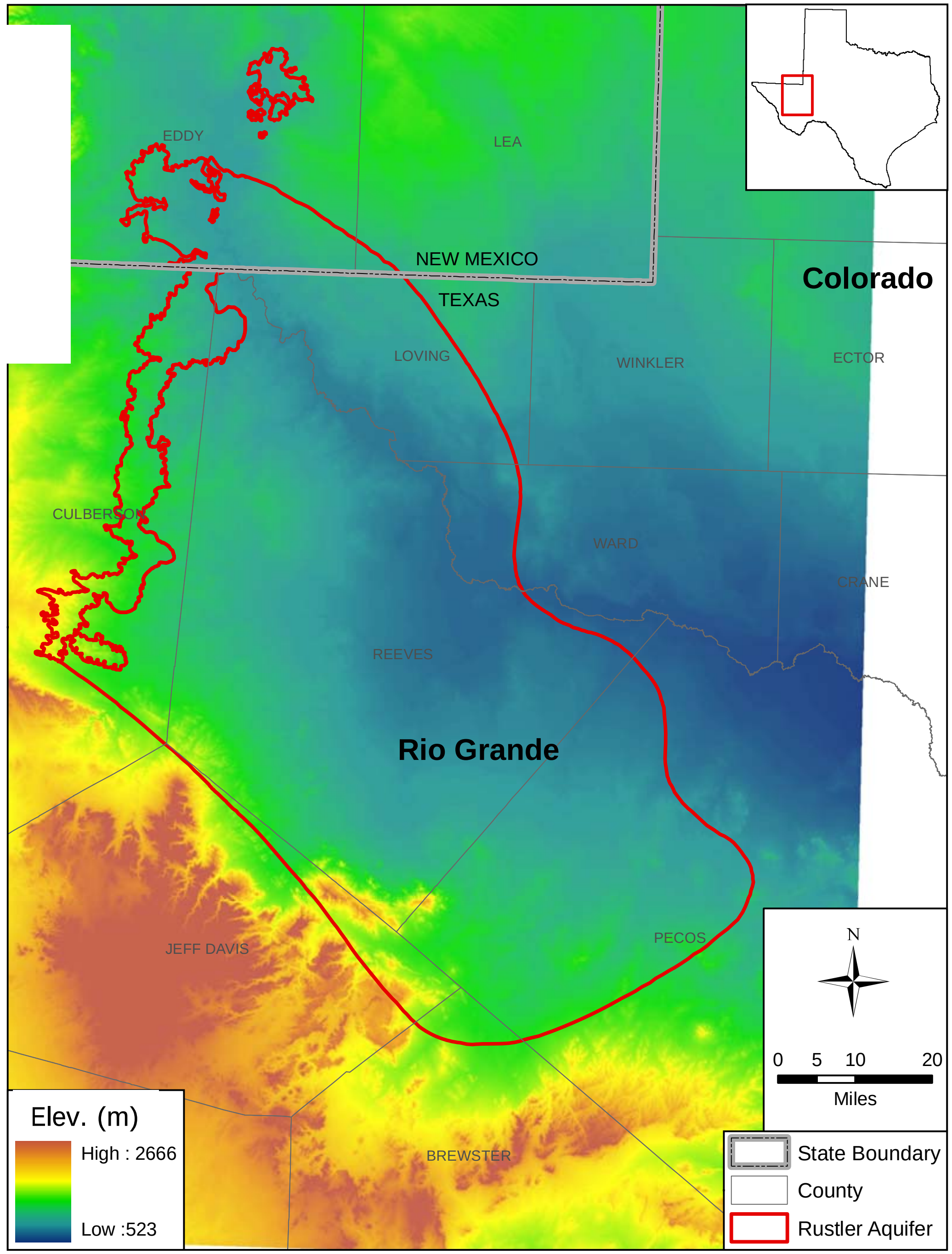
INTERA

Groundwater Conservation Districts

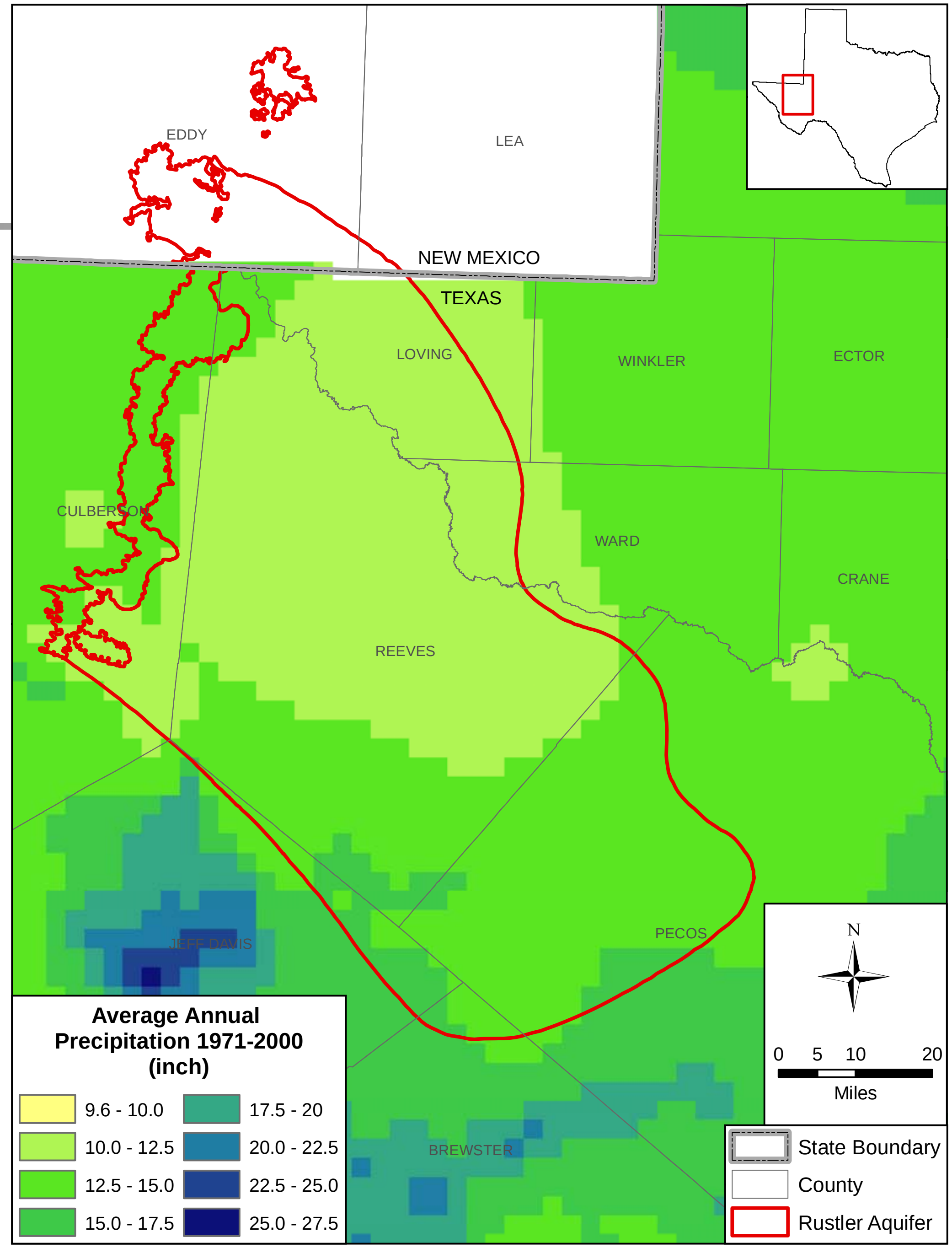


INTERA

Topography (meter above mean seal level)

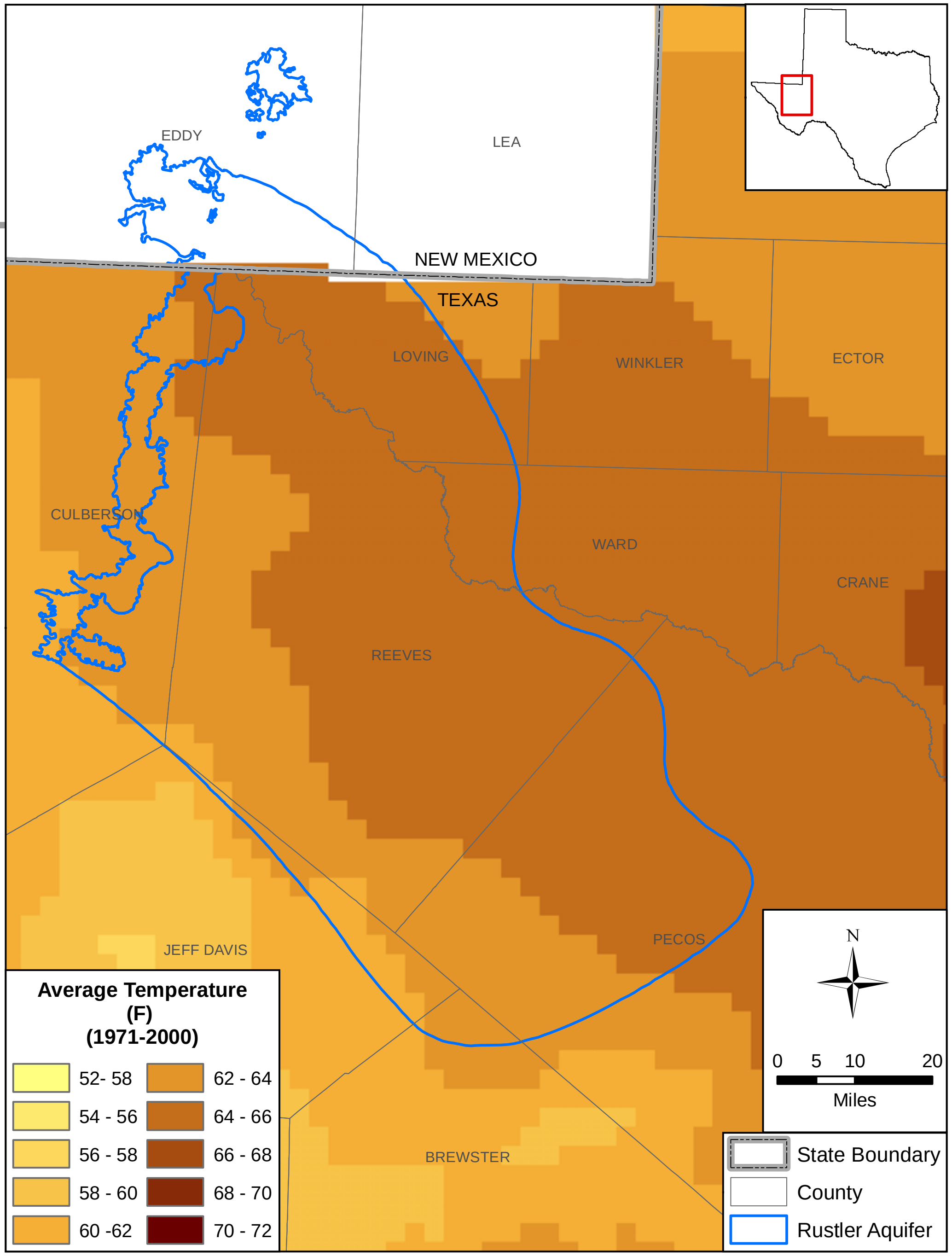


Annual Average Precipitation 1971- 2000



INTERA

Annual Average Temperature 1971- 2000



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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.

INTERA

Groundwater Flow – Definitions (continued)

- 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.

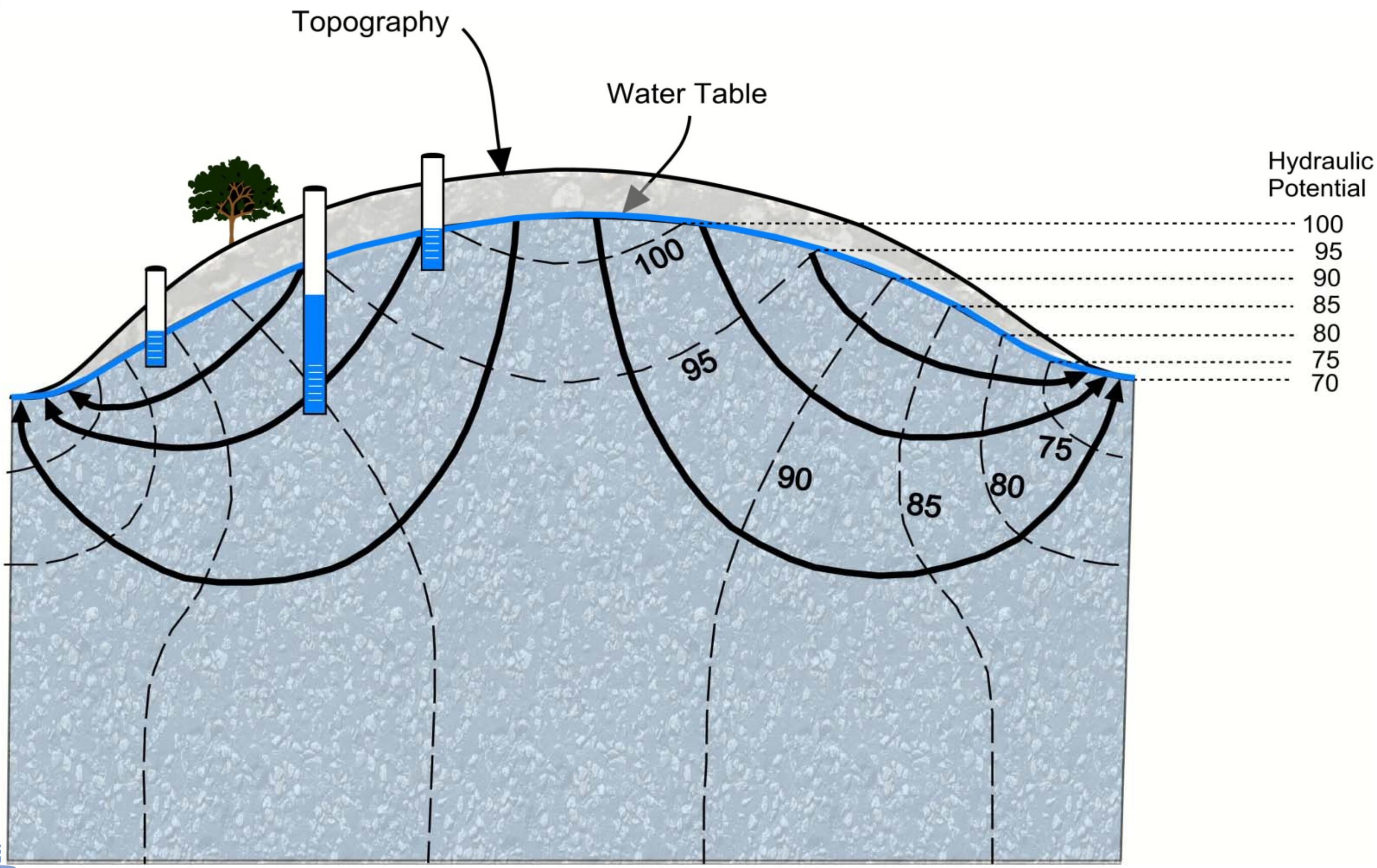
Basic Principles of GW Flow

- 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.

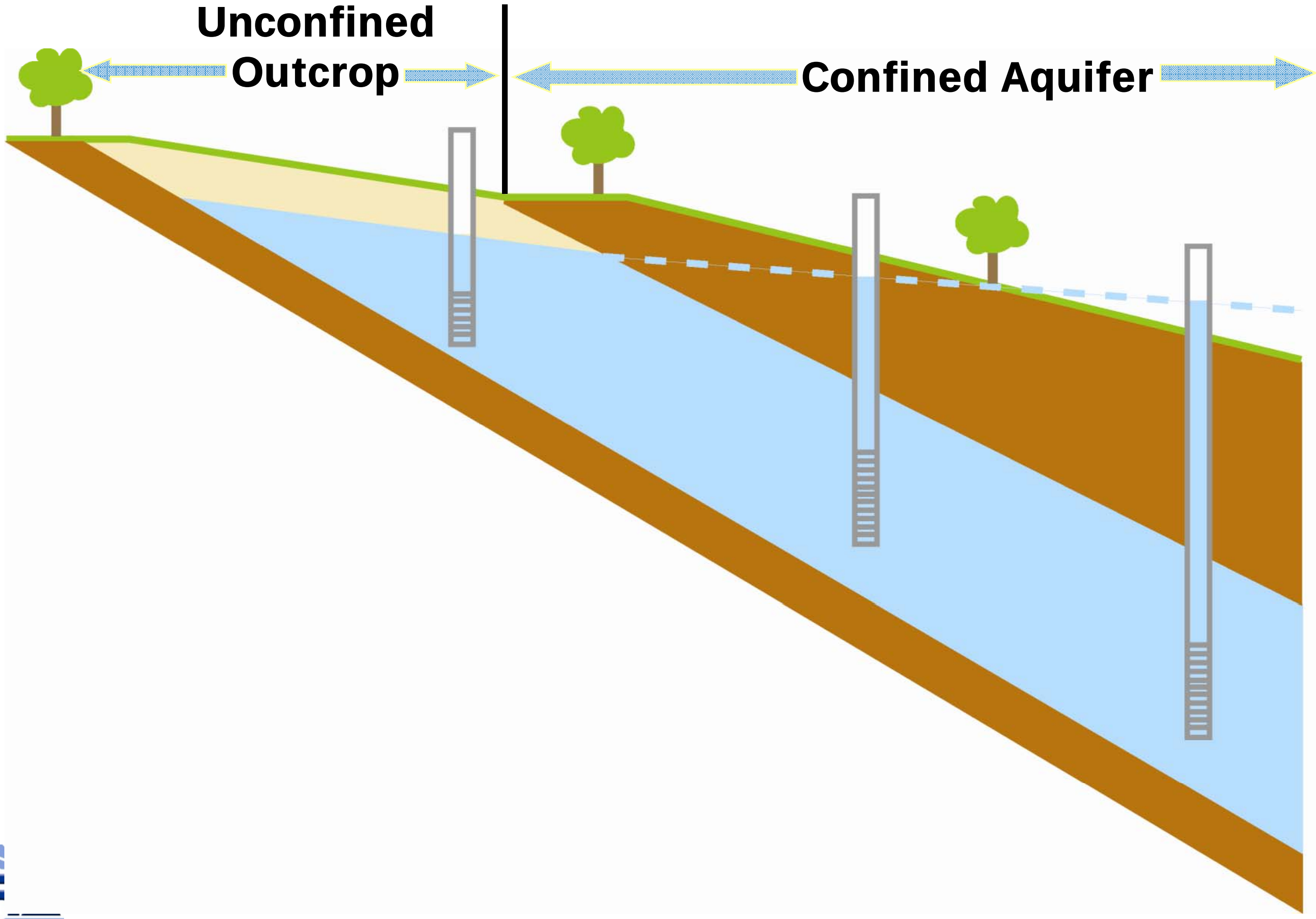
Basic Principles of GW Flow

- 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/Unconfined Aquifer



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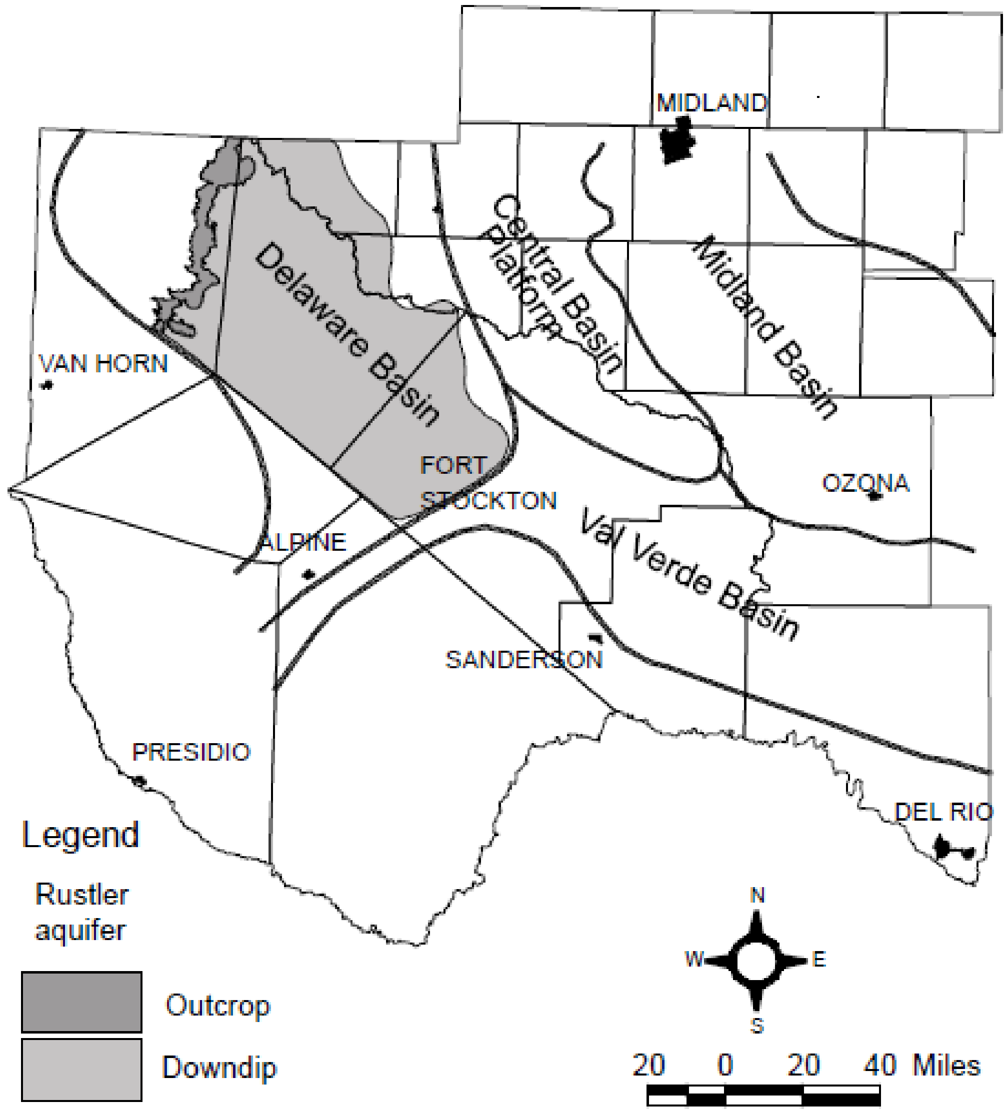
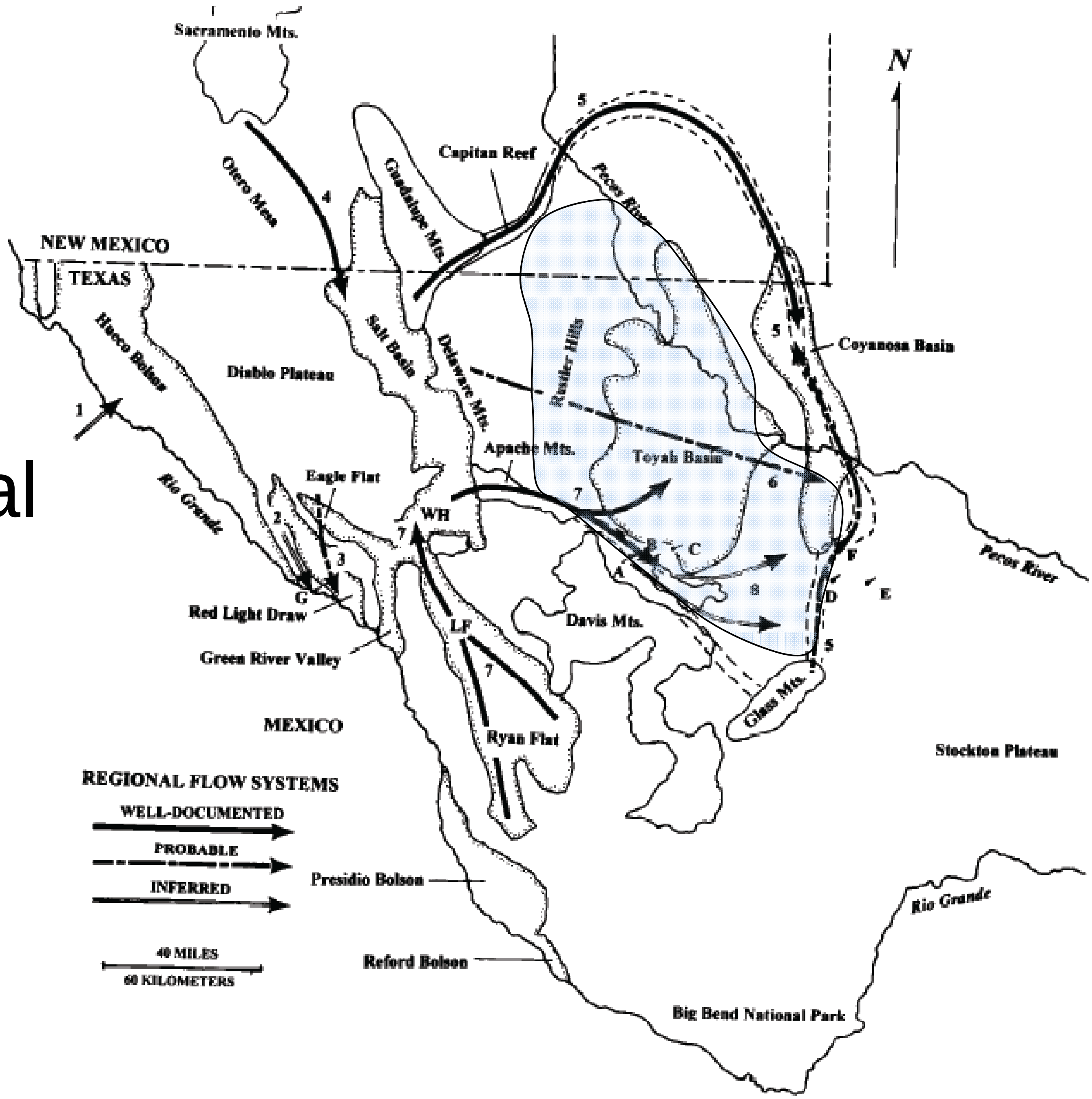
INTERA

Structural Setting



Conceptual Flow Systems

after Sharp (2001)

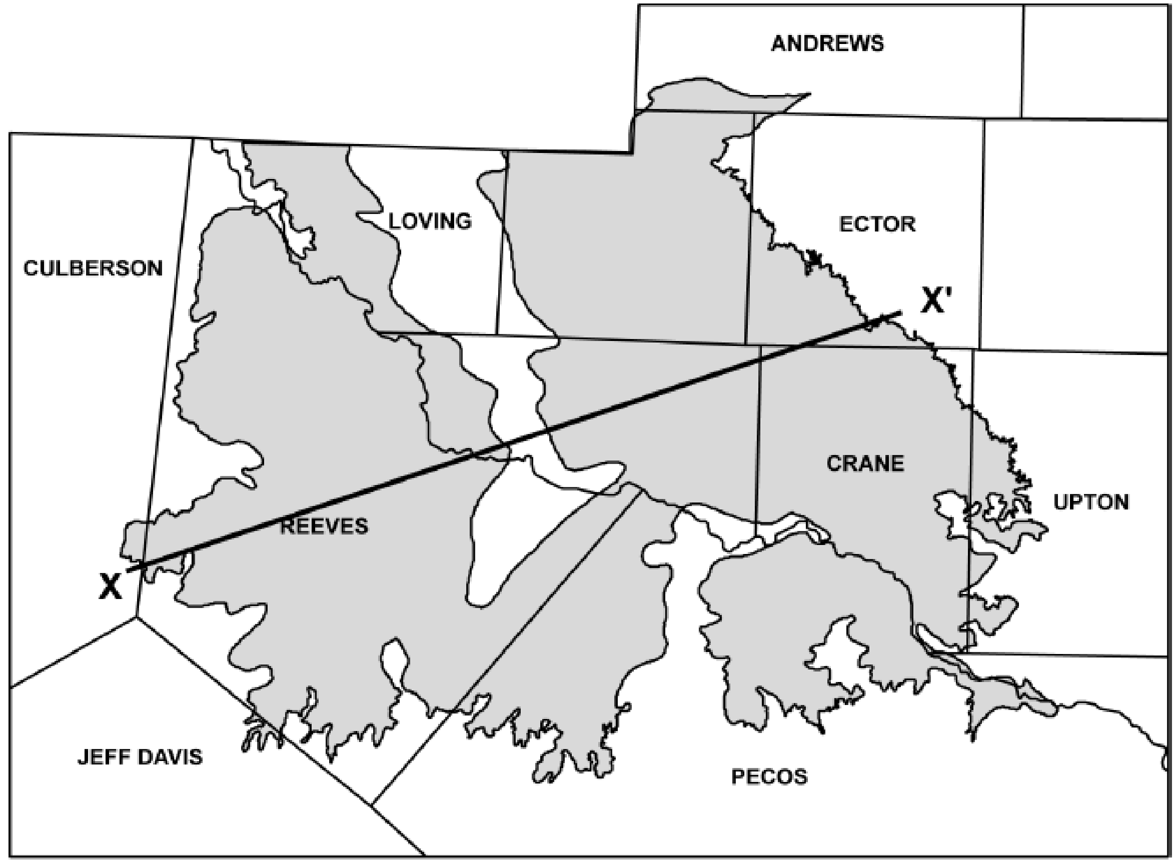


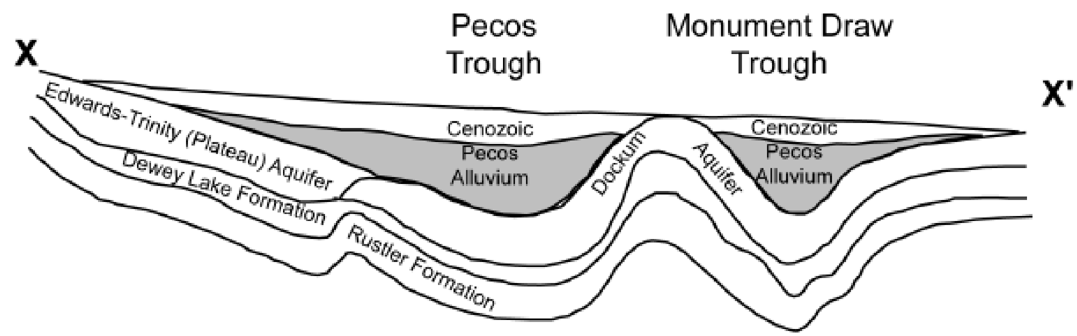
INTERA

Generalized Stratigraphy

System	Culberson and Reeves Counties, TX	Pecos County, TX/ Glass Mountains	Central Basin Platform
Quaternary/ Tertiary	Pecos Alluvium	Alluvium Volcanics	Alluvium
Cretaceous		Edwards-Trinity	Edwards-Trinity
Triassic	Dockum	Dockum	Dockum
Permian	Dewey Lake	Dewey Lake	Dewey Lake
	Rustler: Forty-Niner Magenta Dolomite Tamarisk Culebra Dolomite Lower Gypsum & Mud Siltstone	Rustler: Upper Member Middle Member Lower Member Tessey Limestone	Rustler: Upper Member Basal Member
	Salado	Salado	Salado

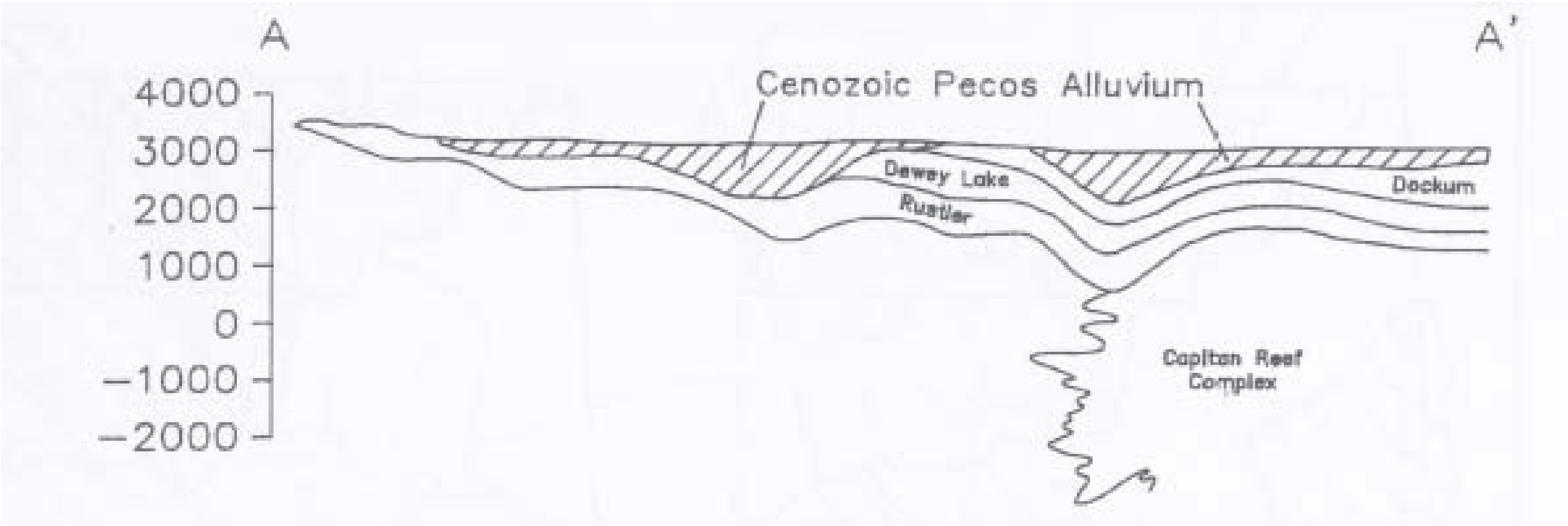
Structural Cross-Section

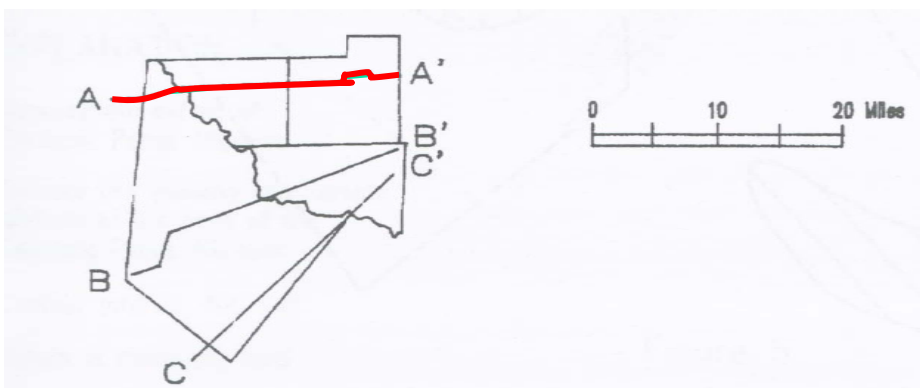




From Jones (2001)

Structural Cross-Section



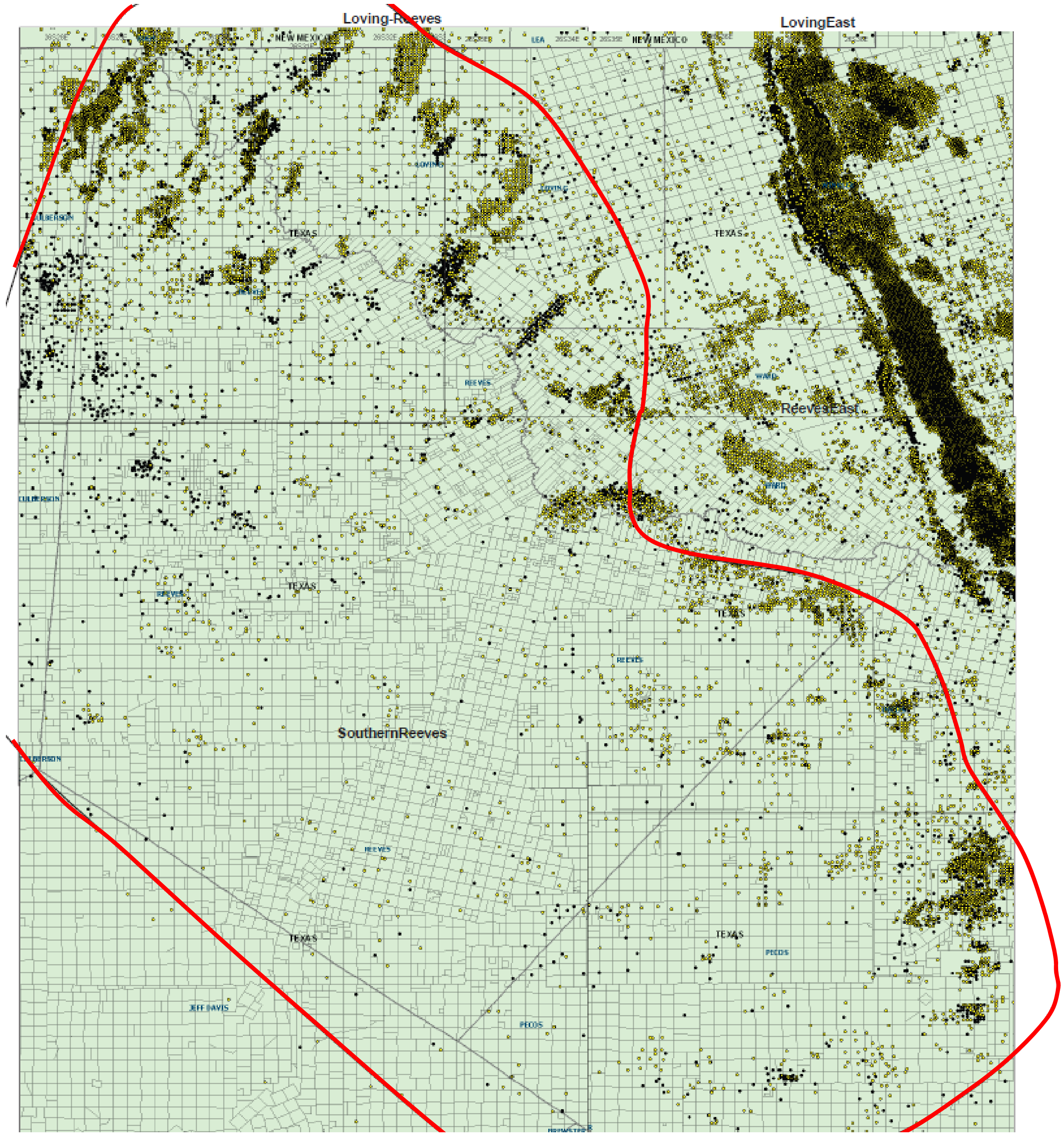


From Ashworth (1990)

Model Structure

- Challenges:
  - Develop a base Rustler
  - Develop internal Rustler stratigraphy
- Use Hiss (1976) as a starting point for the Top of Rustler
- Develop the Rustler lithology at select locations to develop an understanding of stratigraphy
- Younger units structure will be based upon GAMs, Literature, and interpretation (as needed)

- TGS Log Library (private)
- We will also look into RRC, BEG..
- Sandia
- Sulpher Mining
- Models:
  - Sandia
  - Davies
  - Boghici



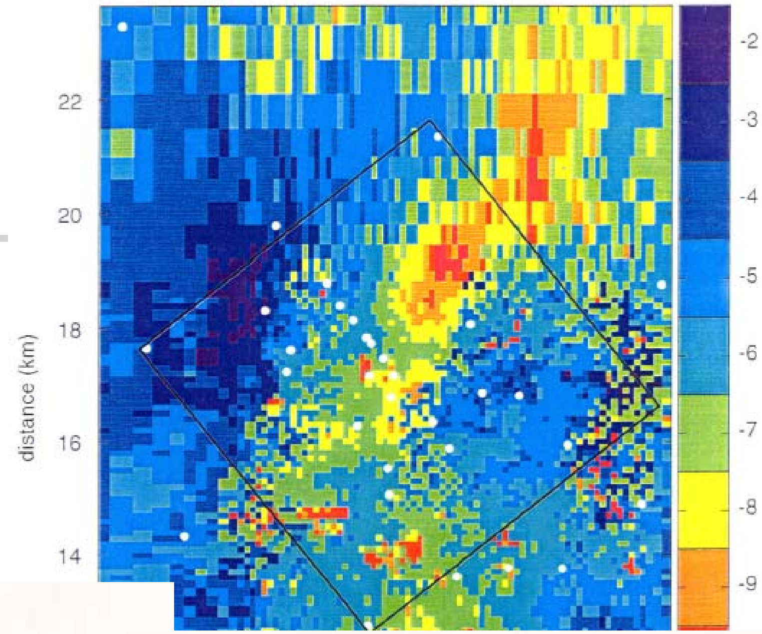
Sandia Model

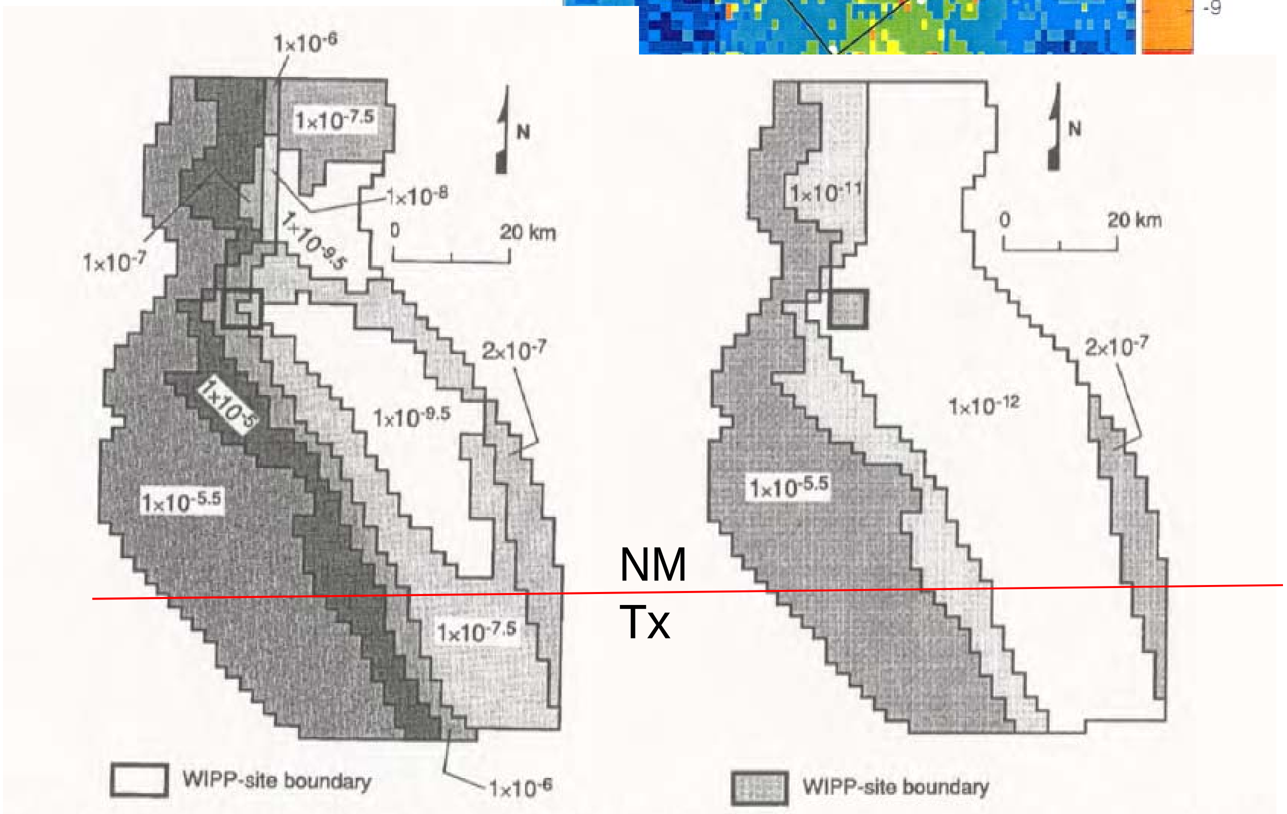
- Dr. Holt interpreted Rustler structure and stratigraphy into Texas
- We will attempt to access these original logs

Corbet, T.F., 2000. A Groundwater-Basin Approach to Conceptualize and Simulate Post-Pleistocene Subsurface Flow in a Semi-Arid Region, Southeastern New Mexico and Western Texas, USA., Hydrogeology Journal, Vol, 8, p. 310-327.

Properties

- General lack of data
- High range in measured values in NM

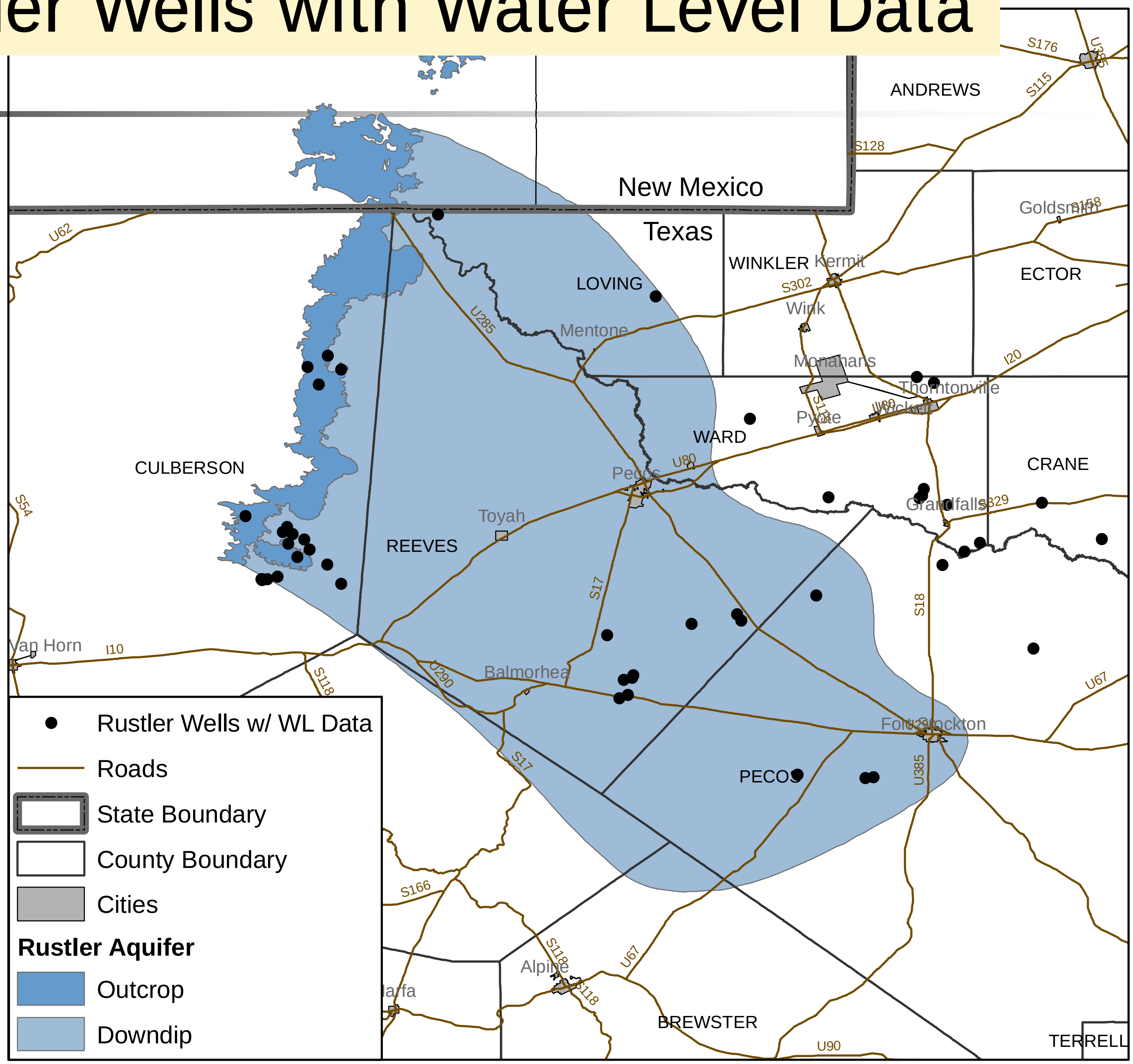




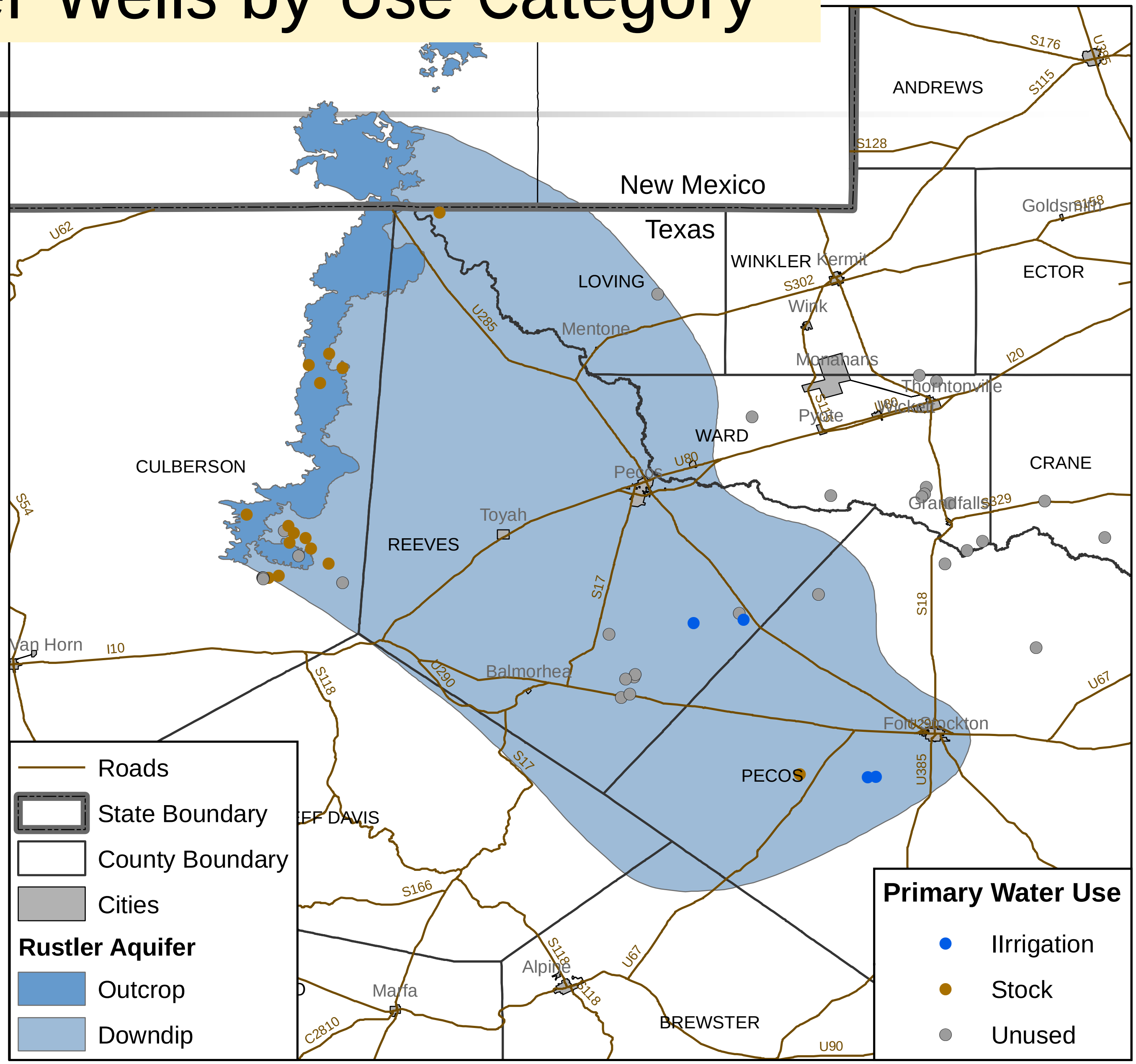
Properties

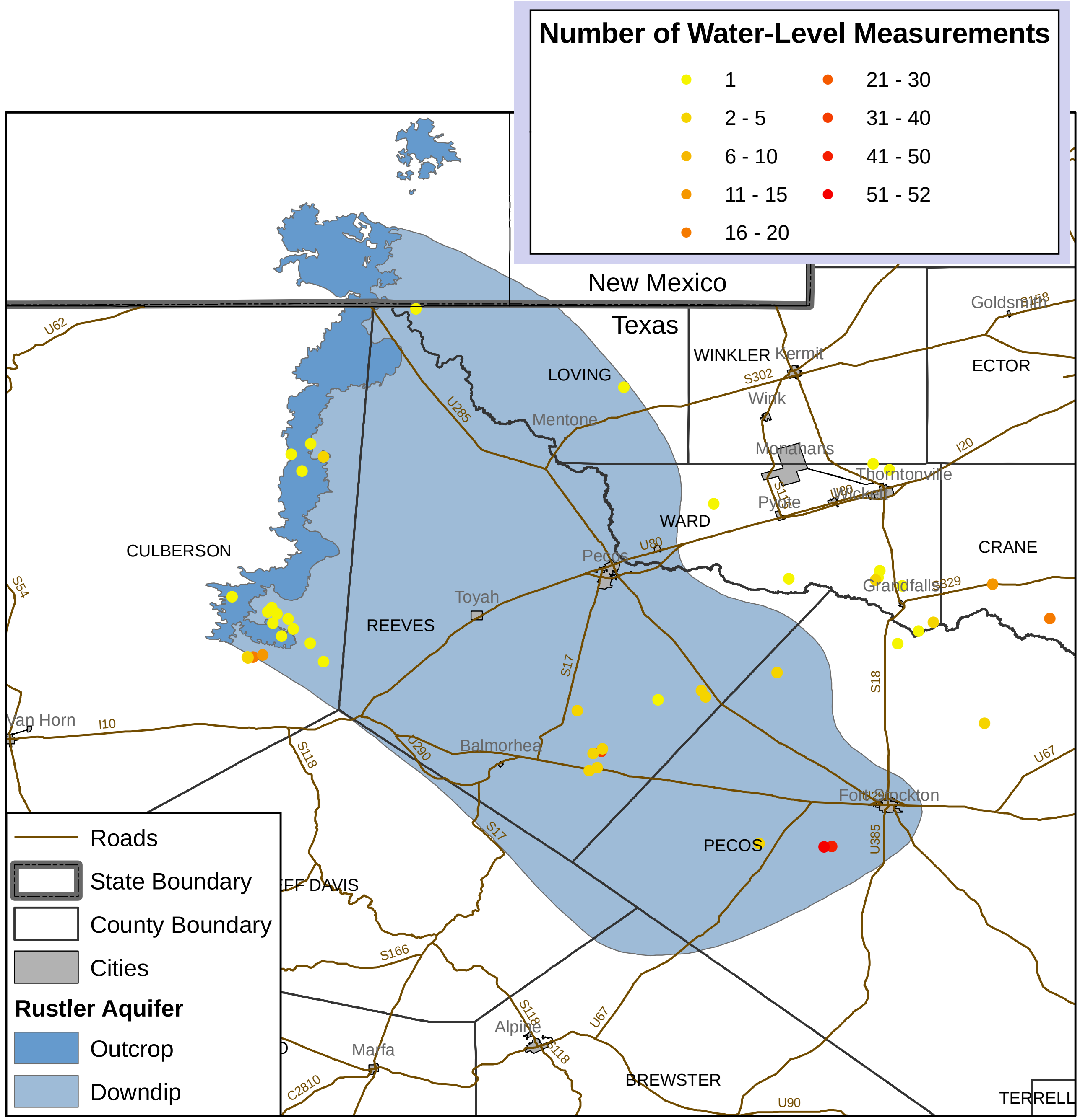
- Properties of the Rustler members have been correlated to:
  - Depositional facies (halite presence)
  - Secondary porosity
  - Depth of burial
- We will attempt to use soft data in addition to measurements to upscale properties

Rustler Wells with Water Level Data



Rustler Wells by Use Category

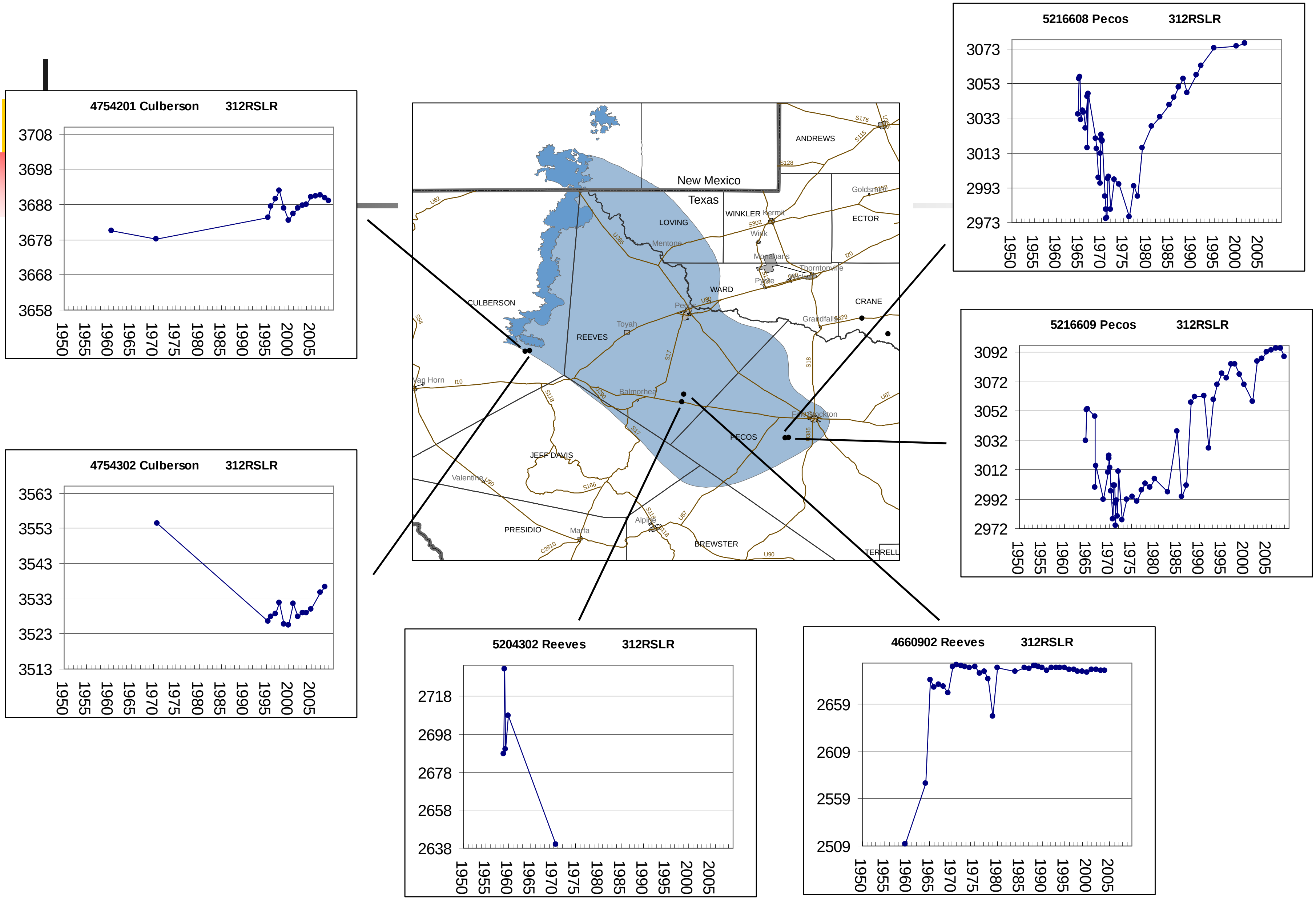



Number of Water-Level Measurements
1
2 - 5
6 - 10
11 - 15
16 - 20
21 - 30
31 - 40
41 - 50
51 - 52
New Mexico
Texas
LOVING
WINKLER
ECTOR
CULBERSON
REEVES
WARD
CRANE
PECOS
JEFF DAVIS
BREWSTER
TERRELL
Kermit
Wink
Mentone
Monahans
Thorntonville
Wickett
Pyote
Pecos
Toyah
Grandfalls
Goldsmith
Van Horn
Balmorhea
Fort Stockton
Alpine
Marfa
U62
U285
S302
I20
U80
S54
S17
I10
S118
U290
S18
S329
U67
U385
S166
C2810
U90
S158
Roads
State Boundary
County Boundary
Cities
Rustler Aquifer
Outcrop
Downdip

Rustler Wells with Water-Level Measurements
Year of First and Last Measurement and Total Number of Measurements

State Well Number	County	Year of First Water-Level Measurement	Year of Last Water-Level Measurement	Number of Water-Level Measurements	Primary Use
4535901	Crane	1954	1969	13	unused
4544601	Crane	1974	1993	19	unused
4723501	Culberson	1988	1988	1	Stock
4723601	Culberson	1988	1988	1	Stock
4723602	Culberson	1986	1988	2	Stock
4723801	Culberson	1988	1988	1	Stock
4746101	Culberson	1960	1960	1	Stock
4746602	Culberson	1970	1970	1	unused
4747401	Culberson	1970	1970	1	Stock
4747402	Culberson	1970	1970	1	Stock
4747403	Culberson	1970	1970	1	Stock
4747404	Culberson	1970	1970	1	Stock
4747701	Culberson	1970	1970	1	unused
4747801	Culberson	1970	1970	1	Stock
4747902	Culberson	1970	1970	1	Stock
4754201	Culberson	1960	2009	17	Stock
4754202	Culberson	1970	1970	1	unused
4754203	Culberson	1995	1995	1	unused
4754206	Culberson	1977	2002	2	unused
4754207	Culberson	1977	1995	2	unused
4754302	Culberson	1970	2008	14	Stock
4755304	Culberson	1970	1970	1	unused
4601202	Loving	1974	1974	1	Stock
4613402	Loving	1981	1981	1	unused

State Well Number	County	Year of First Water-Level Measurement	Year of Last Water-Level Measurement	Number of Water-Level Measurements	Primary Use
4542703	Pecos	1963	1963	1	unused
4559501	Pecos	1950	1957	2	unused
4655604	Pecos	1956	1958	2	unused
5215502	Pecos	1957	1987	2	Stock
5216608	Pecos	1964	2002	45	Irrigation
5216609	Pecos	1964	2008	52	Irrigation
4653903	Reeves	1988	1988	1	Irrigation
4654802	Reeves	1988	1989	2	unused
4654901	Reeves	1988	1989	2	Irrigation
4660202	Reeves	1959	1987	3	unused
4660902	Reeves	1959	2004	39	unused
4660903	Reeves	1959	1960	2	unused
4660904	Reeves	1959	1960	2	unused
5204211	Reeves	1988	1989	2	unused
5204302	Reeves	1958	1970	5	unused
4517910	Ward	1959	1959	1	unused
4533906	Ward	1967	1967	1	unused
4533910	Ward	1967	1967	1	unused
4533912	Ward	1958	1967	2	unused
4534703	Ward	1957	1957	1	unused
4542603	Ward	1940	1967	2	unused
4542802	Ward	1967	1967	1	unused
4630601	Ward	1967	1967	1	unused
4640705	Ward	1967	1967	1	unused
4517802	Winkler	1967	1967	1	unused



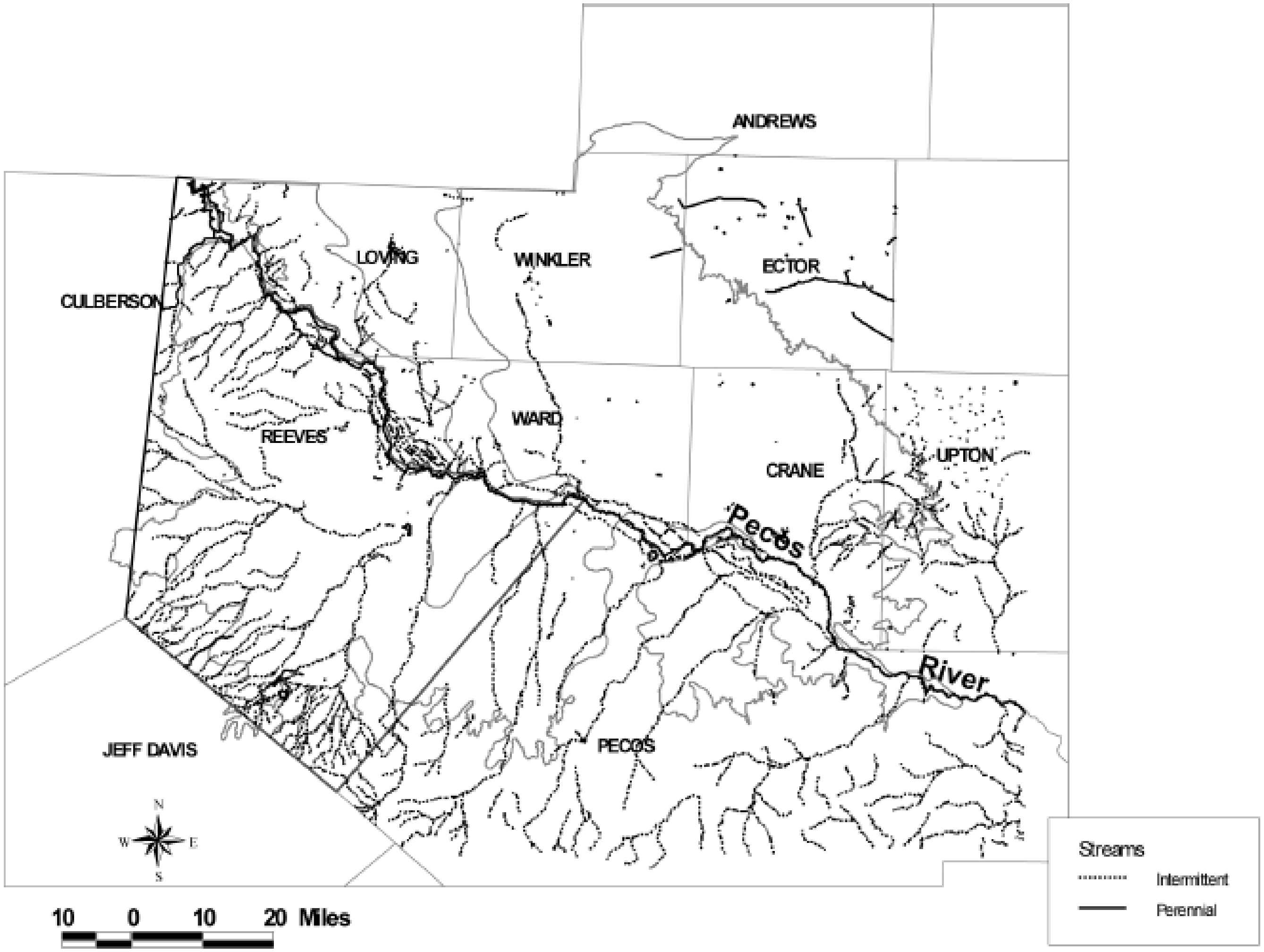
Pumping will be estimated from PreD


countries.
Recharge Zone
C22

Recharge-Discharge

- Develop conceptual water balance as part of conceptual model development
  - Outcrop water balance
  - Boundary flows and spring flows will be an important part of conceptualization and implementation
  - Water chemistry – flow paths

Stream-Aquifer Interaction



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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?

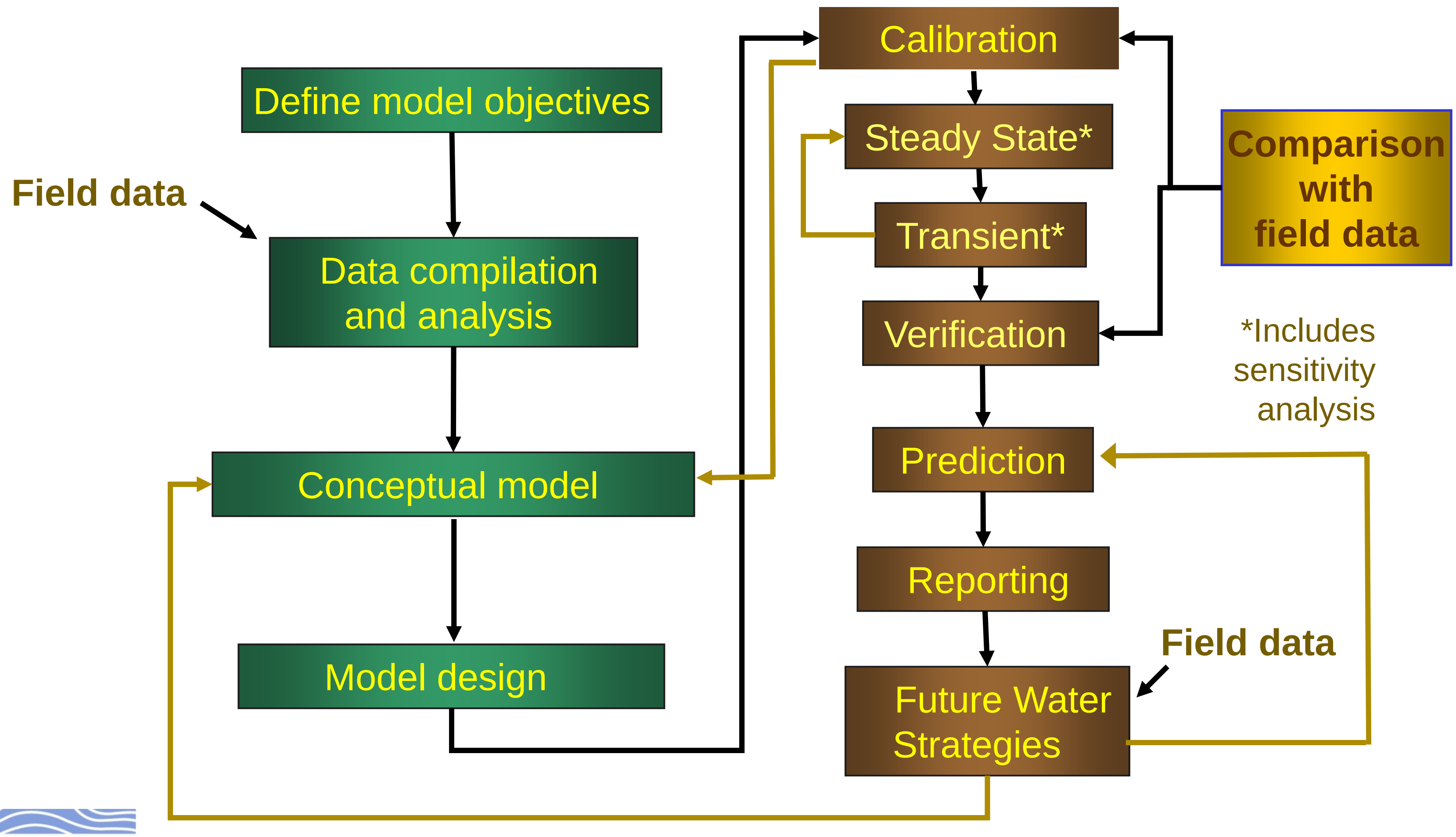
- In contrast to surface water, groundwater flow is difficult to observe
- Aquifers are typically complex in terms of spatial extent and hydrogeological characteristics
- A groundwater model provides the only means for integrating available data for the prediction of groundwater flow at the scale of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

INTERA

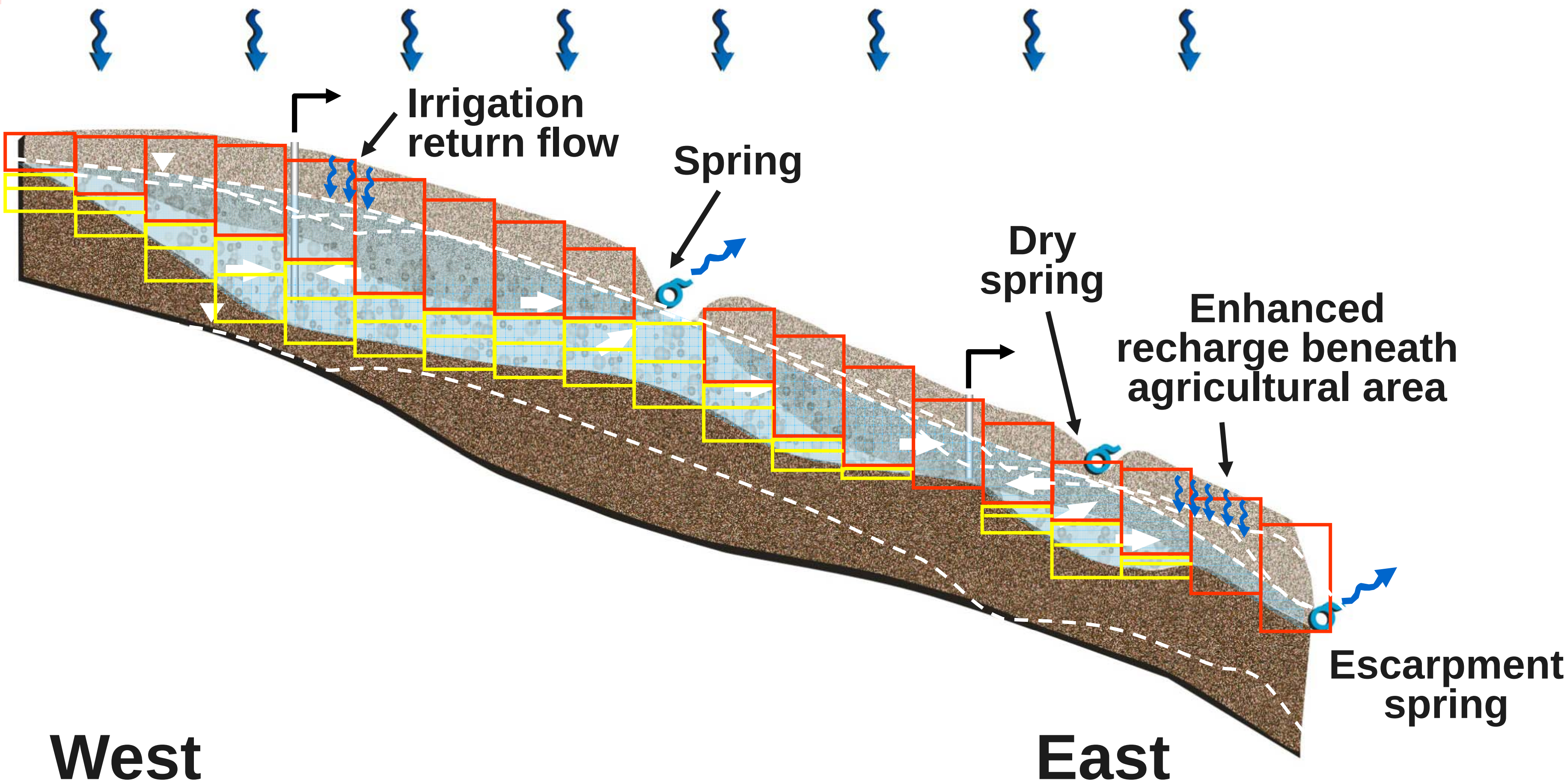
Numerical Flow Model

- 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

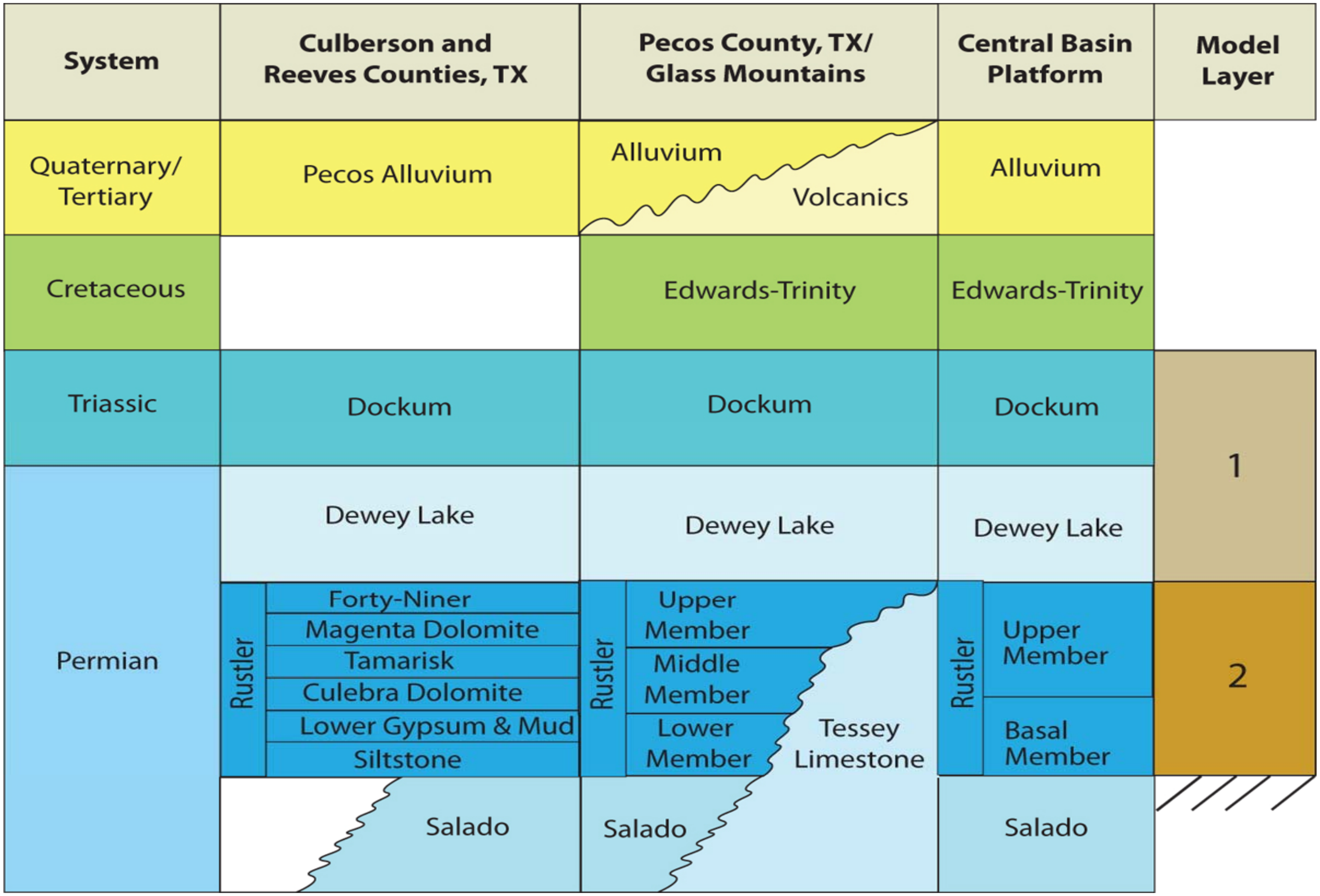
Modeling Protocol



Start with a conceptual model
Divide it up into cells



Model Layering



GAM Model Specifications

- Three dimensional (MODFLOW-2000)
- Regional scale (1000's of square miles)
- Grid spacing
  - Uniform grid – ¼ miles proposed
- 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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- Rustler regional overview
- Basics of groundwater flow
- Overview of Rustler Aquifer
- Numerical groundwater modeling and the GAMs
- Data collection
- GAM schedule

Data Collection

- Heads, Discharge & Water Quality Data
  - County Reports (predevelopment)
    - Evidence of artesian wells
    - Evidence of flowing springs
  - TWDB groundwater database
  - GCDs
  - Thesis work
  - Other literature

Data Collection

- Hydraulic Properties
  - County reports
  - Meyers
  - TCEQ Surface Casing Database
    - Typically specific capacity tests
  - GCD
  - Literature/Thesis
  - Stakeholders

Outline

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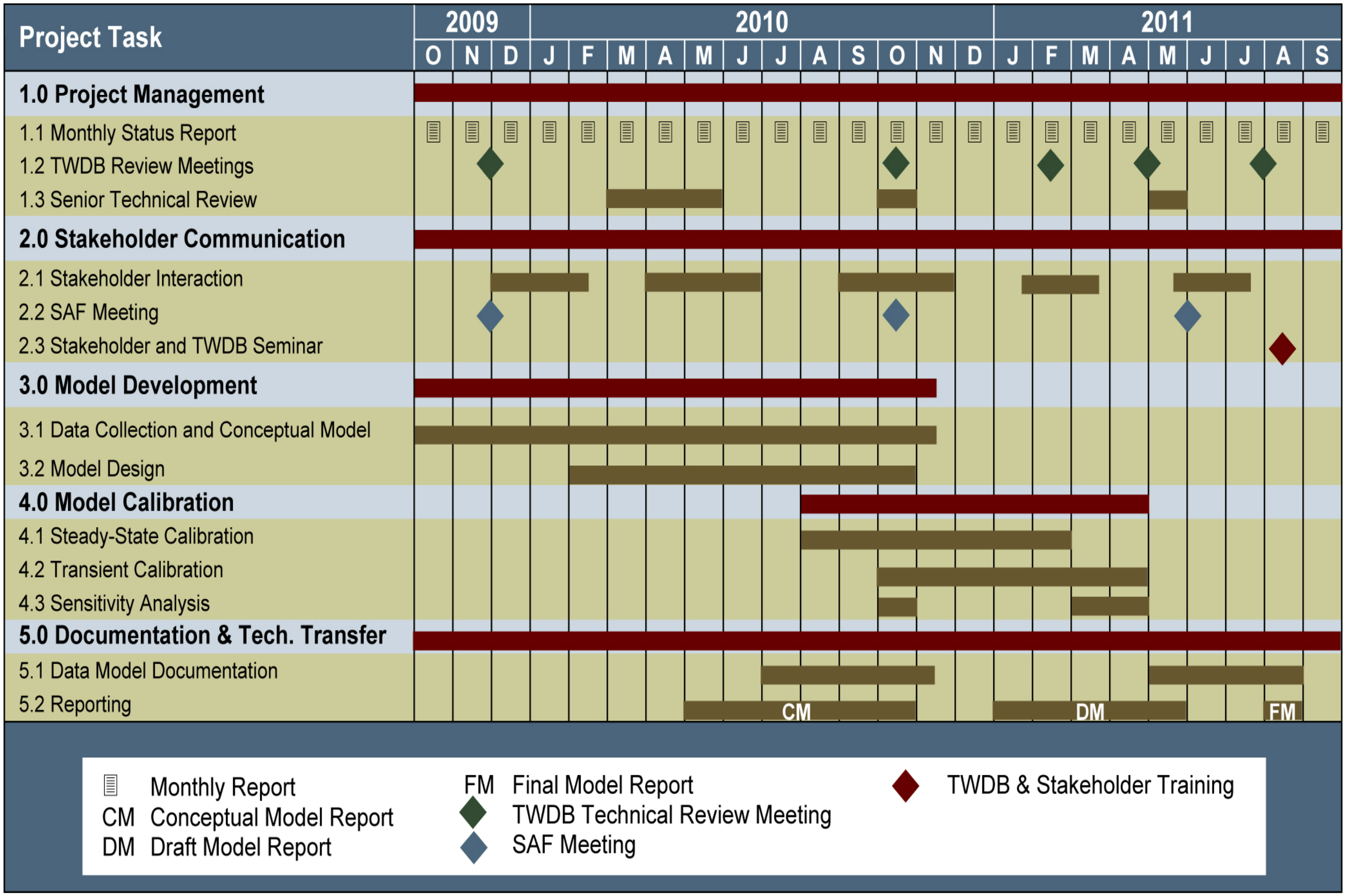
- GAM schedule

Project Tasks and Proposed Schedule



Data Request

- Request:
  - Any un-published data to support the model
    - Heads
    - Properties
    - Structural picks
  - Date request by March 15, 2010


Thank You
Questions?
Van Kelley
512-425-2047
vkelley@intera.com

Meeting Minutes for the

First Rustler Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

December 10th, 2009

Pecos County Courthouse, Ft. Stockton, Texas

The first Stakeholder Advisory Forum (SAF) Meeting for the Rustler Groundwater Availability Model (GAM) was held on Thursday, December 10th, 2009 at 9:00 AM at the Pecos County Courthouse located at 103 West Callaghan in Ft Stockton, 79735. A list of meeting participants is provided at the end of these meeting notes.

The primary purpose of the first SAF meeting is to provide an introduction to the Rustler GAM Team and the 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: Wade Oliver, TWDB

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

SAF Presentation: Van Kelley, INTERA Inc

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

1. Introduction to the Rustler GAM Team
2. Rustler Regional Overview
3. Basics of Groundwater Flow
4. Overview of the Rustler 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/rslr/rslr.htm

Questions and Answers: Wade Oliver (TWDB) Presentation:

Q: Does the TWDB publish any error bounds with their model predictions or are the GAMs always used purely deterministically?

A: *Currently we do not calculate nor publish error bounds. This is a very difficult process given the model complexity. Ideally one would consider model error and how this translates to monitoring and the compliance with Desired Future Conditions.*

Q: I ask the question because I have to wonder when mean error from portions of the Edwards-Trinity model is reduced from 256 ft to 80 ft. It seems there should be an error bound on the model predictions.

A: While your comment is true, complete and rigorous error analysis on these models is very involved and in the end the model error may be small in some cases relative to the assumptions in future resource use.

The following are a series of Stakeholder Comments in open discussion:

C: With the Cenozoic-Pecos Alluvium aquifer GAM a sensitivity analysis was run which gives one a good idea of the important parameters and which are unknown and those of those of us experienced in modeling already understand the uncertainties.

C: But the general public does not and they are the decision makers at the GMA.

A: *Formal one-off sensitivity analyses are performed for all GAMs.*

Questions and Answers: Van Kelley (INTERA) Presentation:

Q Will your study extend into the regions of the Rustler which have TDS concentrations in excess of 5,000 ppm?

A: *Yes, the study will go out past 5000 ppm to establish natural boundaries for the aquifer system. The TWDB defines the Rustler Aquifer to be that portion with TDS less than or equal to 5000 ppm.*

Rustler Aquifer GAM Stakeholder Advisory Forum 1
December 10, 2009

Attendance

Name	Affiliation
Alyson McDonald	Texas AgriLife Extension
Gary Bryant	Texas AgriLife Extension
Paul Weatherby	General Mngr. - Middle Pecos GCD
Jim Duke	Representing: Williams Family
Wade Oliver	TWDB
Van Kelley	INTERA