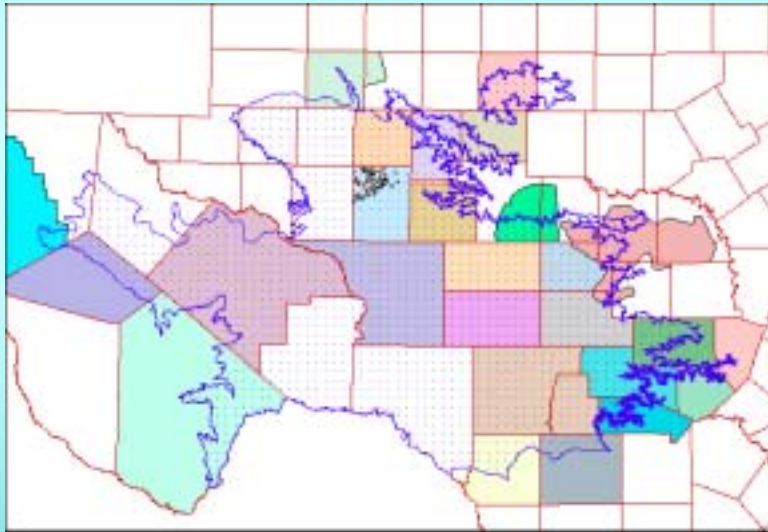




# **Welcome To The Fourth Edwards-Trinity Aquifer Model Stakeholders Advisory Forum**



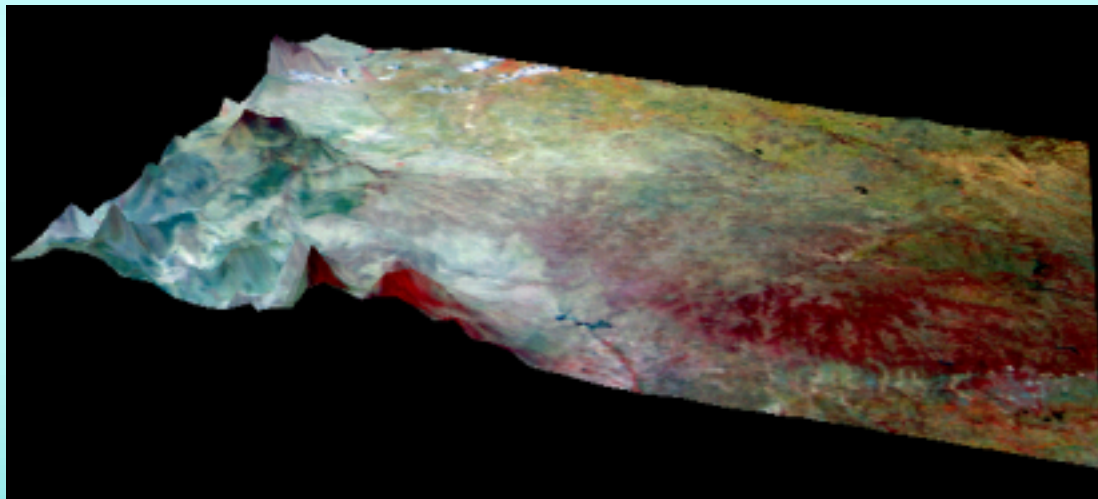
**ET SAF 4**

**June 25, 2002**

**Texas Water Development Board  
Groundwater Availability Modeling**



# A Groundwater Flow Model for the Edwards-Trinity Aquifer of West-Central, Texas



**Roberto Anaya**

**Texas Water Development Board**

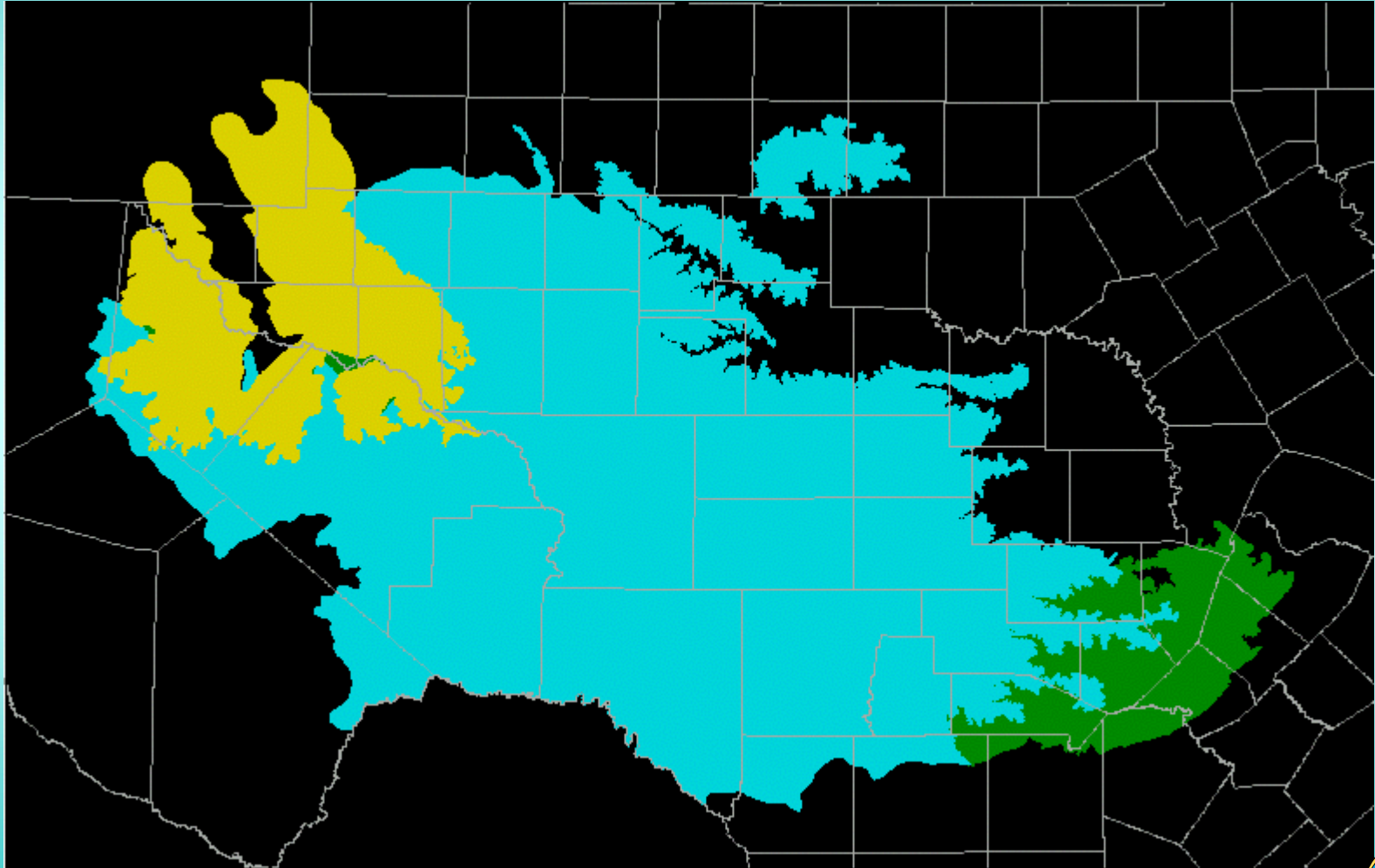


# Edwards-Trinity Stakeholders Advisory Forum Objectives

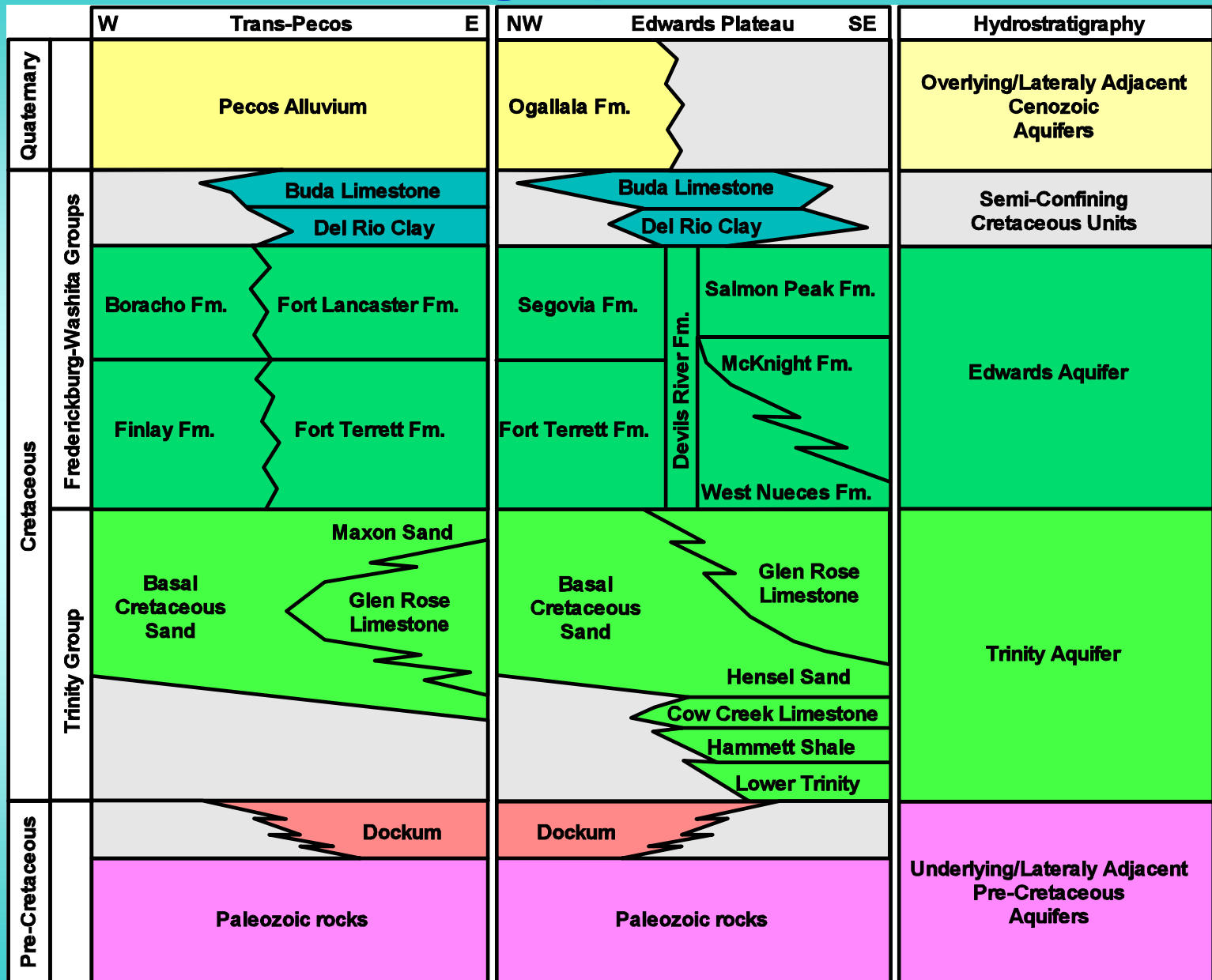
- Provide Public Awareness of GAM
- Update Interested Participants
- Solicit Data and Information
- Encourage Comments and Criticism



# Spatial Extent Of The Edwards-Trinity Model



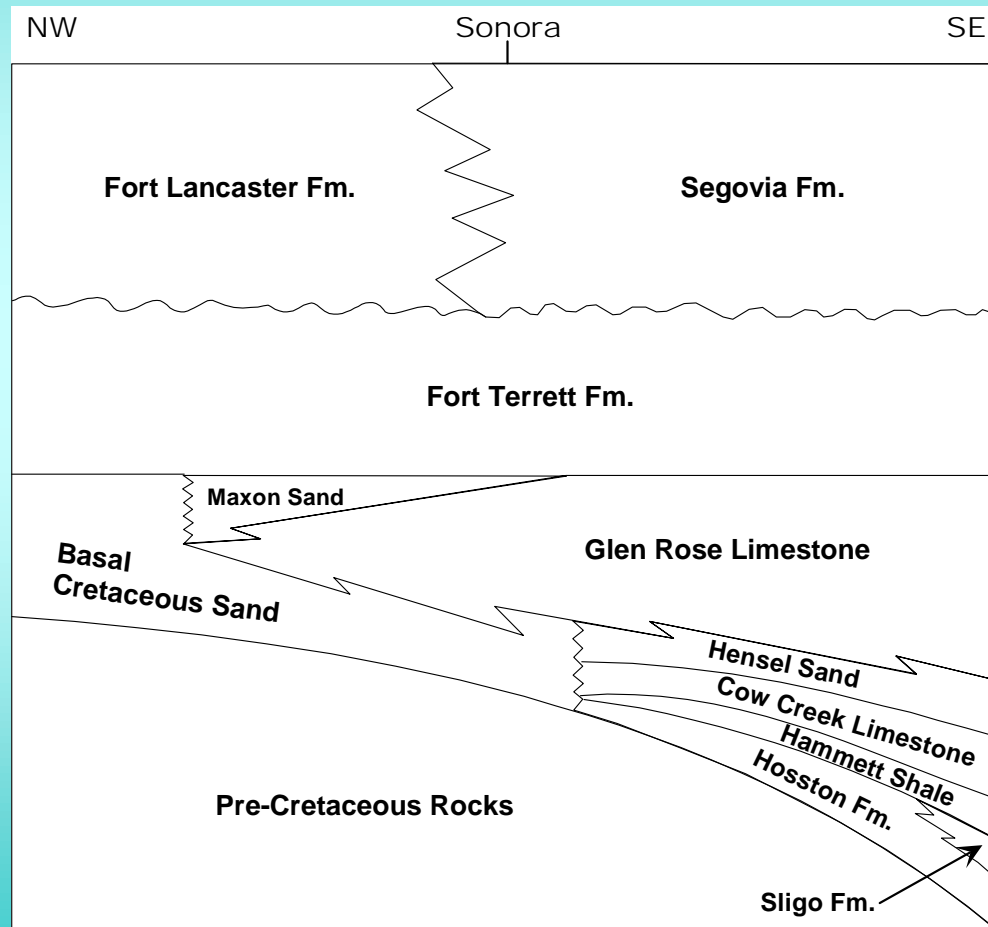
# Stratigraphic Units



Modified From Barker and Ardis, 1996



# Vertical Profile Of The Edwards-Trinity Aquifer Sediments



Modified From Barker and Ardis, 1996



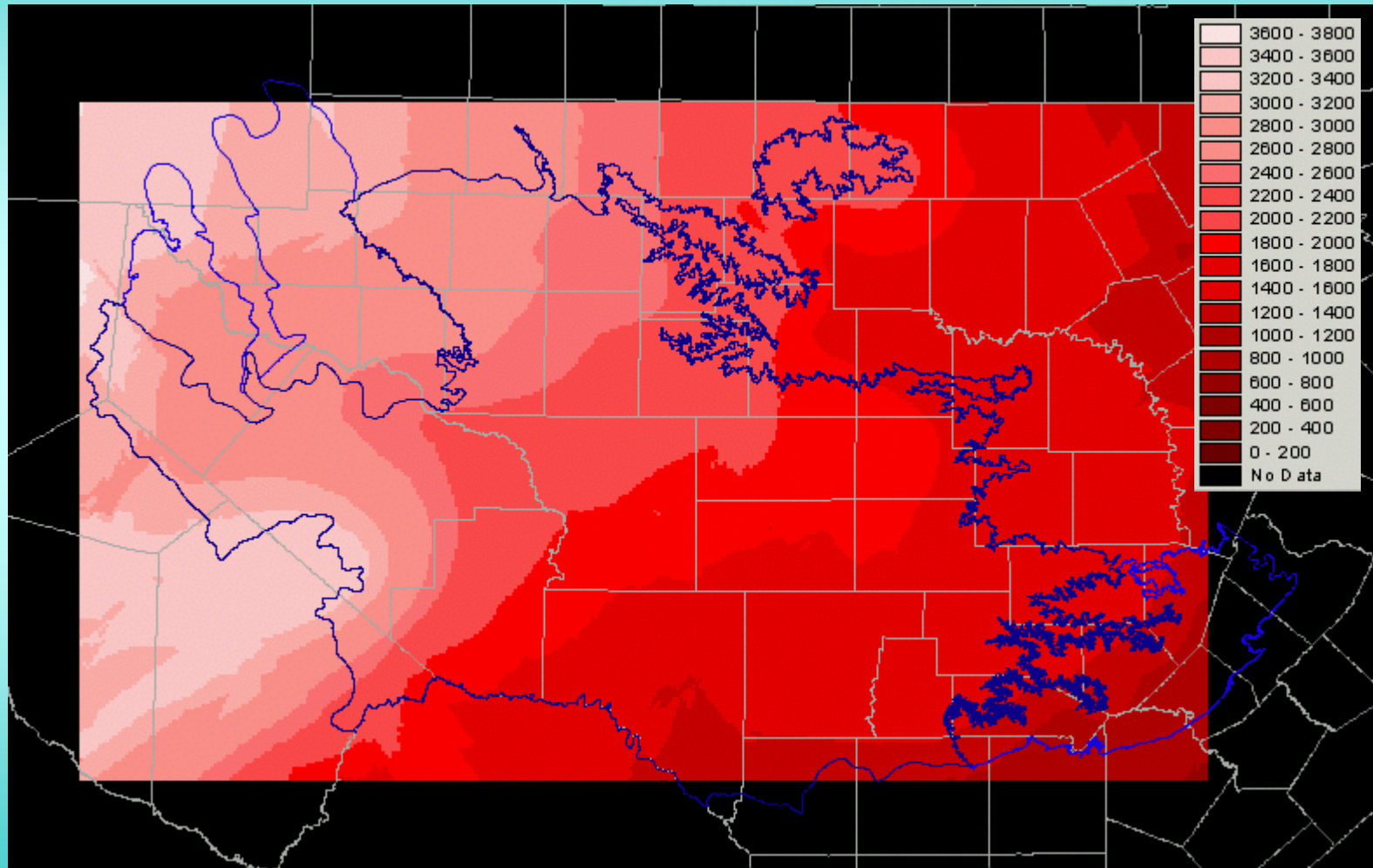
# Pre-Development Groundwater Conditions

- First winter measurement for each well site in TWDB database excluding 50s drought
- Water level measurements selected from pre-1980
- Trinity potentiometric surface
- Fredericksburg/Edwards potentiometric surface
- Composite Edwards-Trinity potentiometric surface





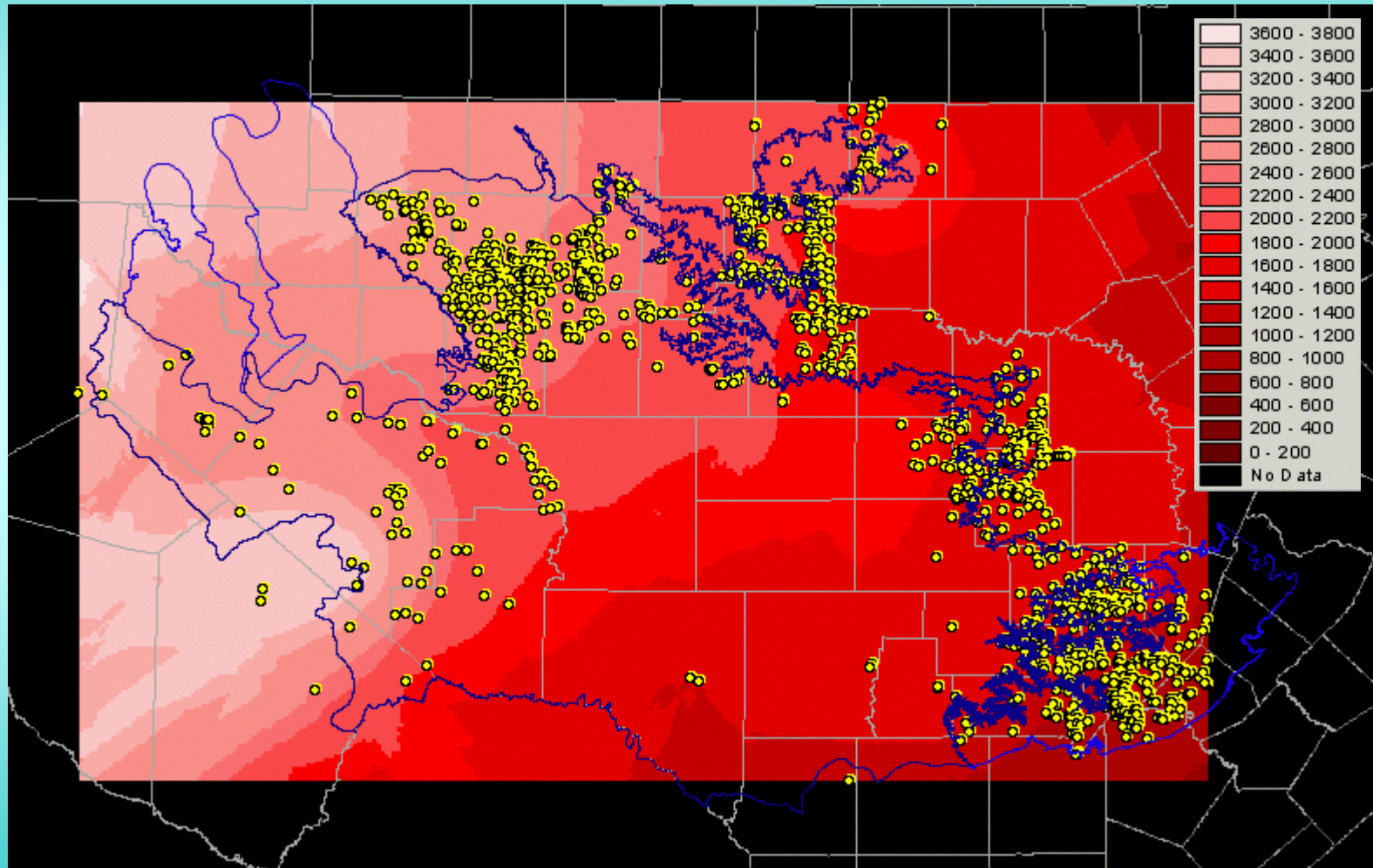
# Trinity Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought



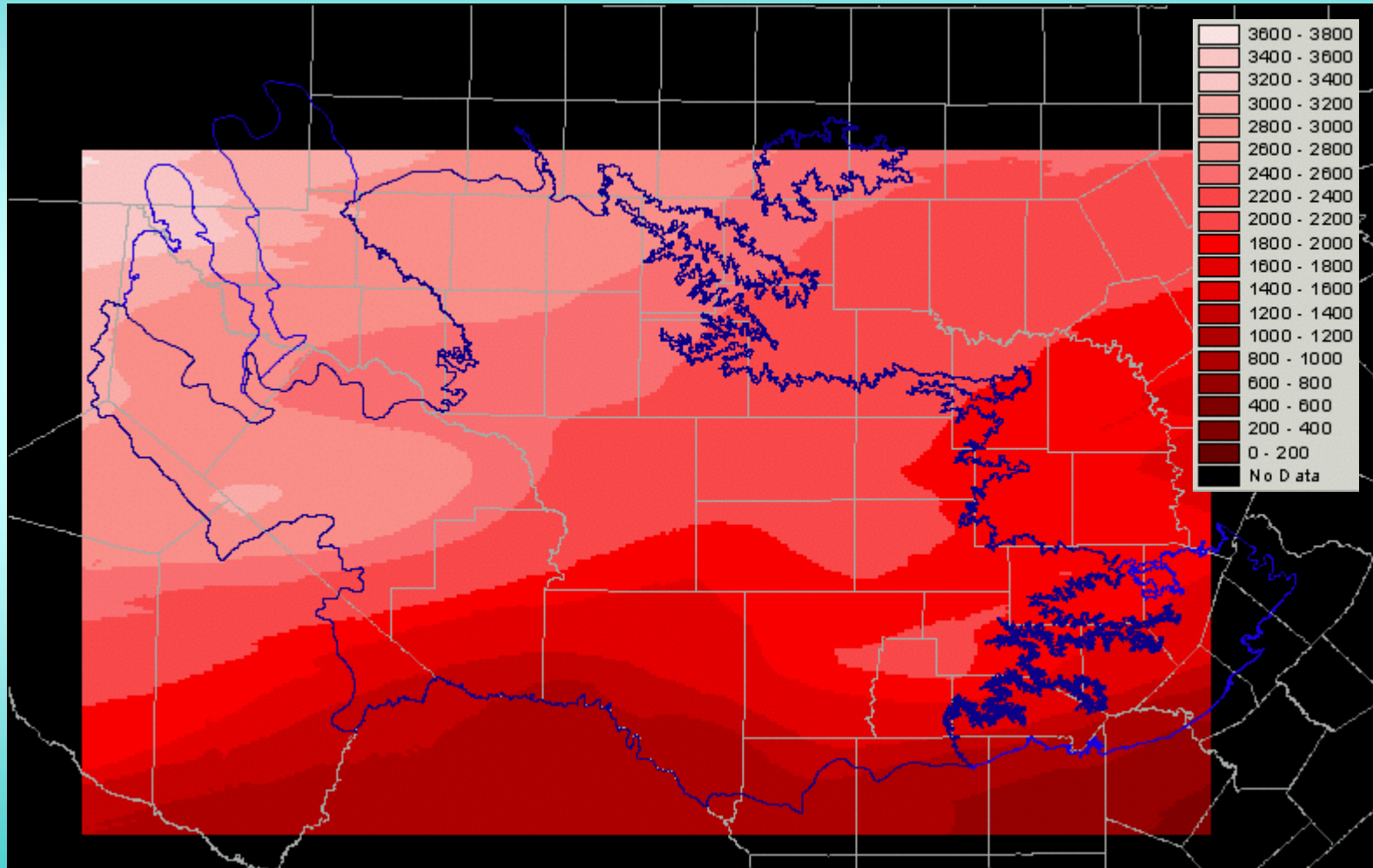
# Trinity Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought



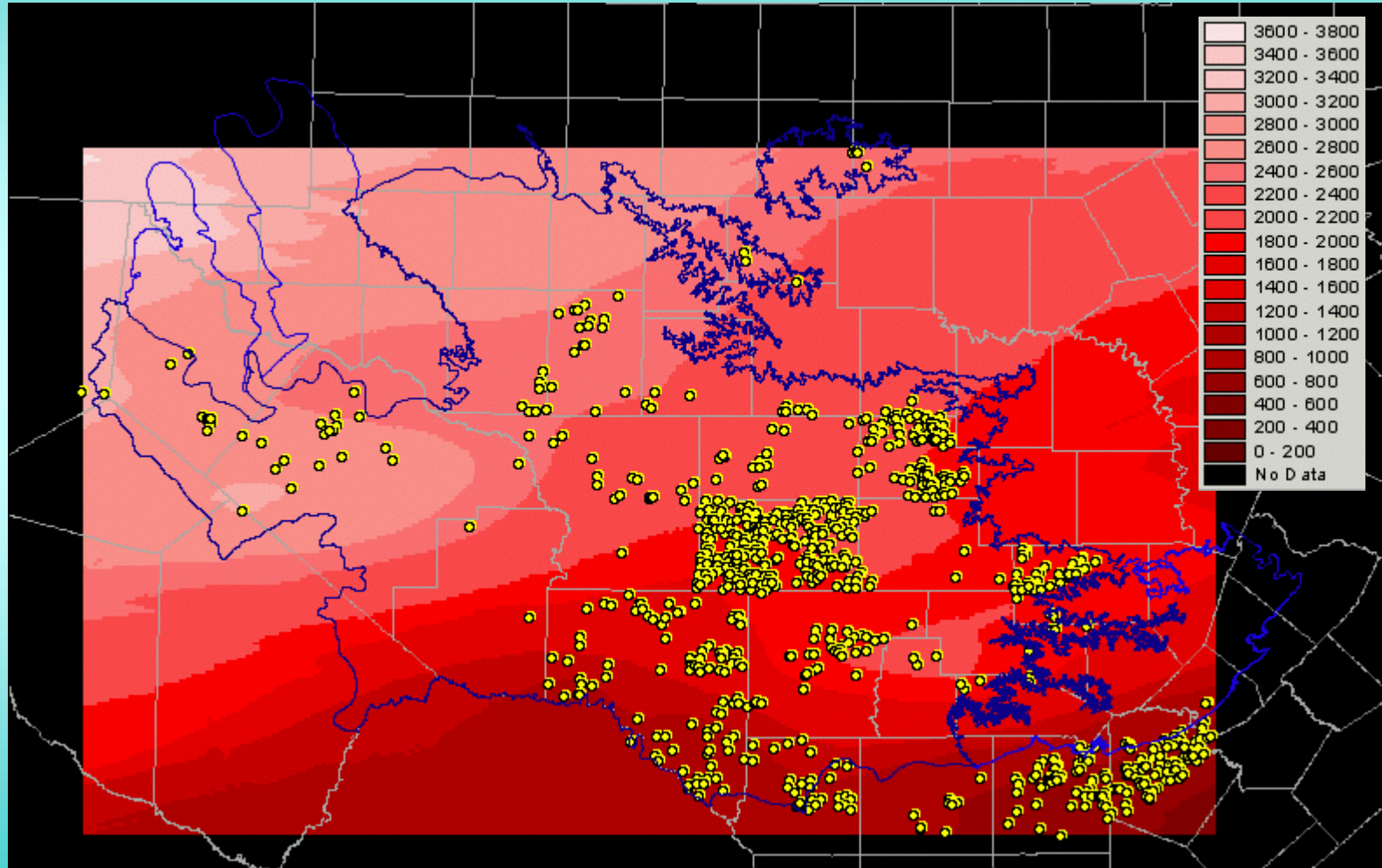
# Edwards Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought



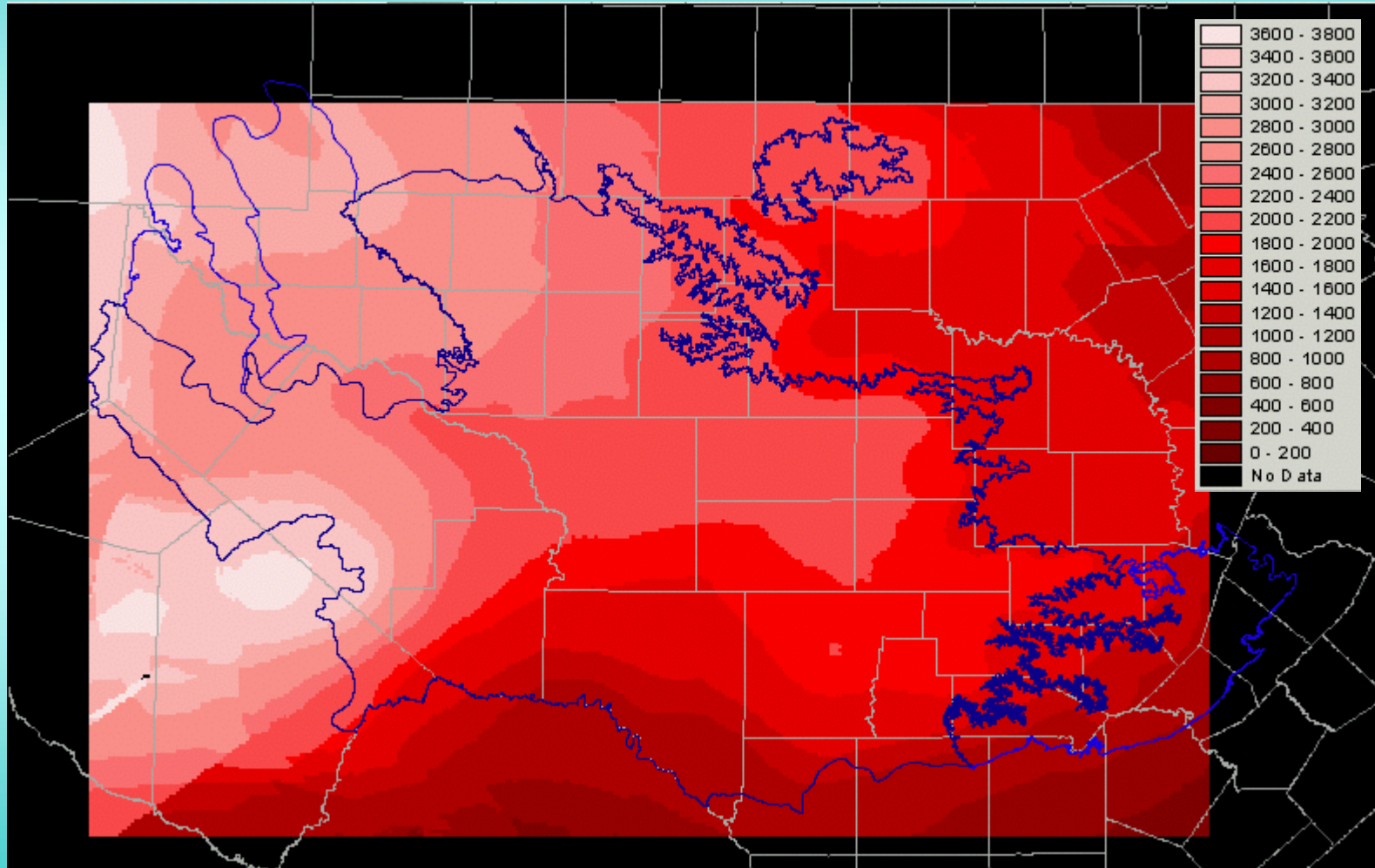
# Edwards Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought



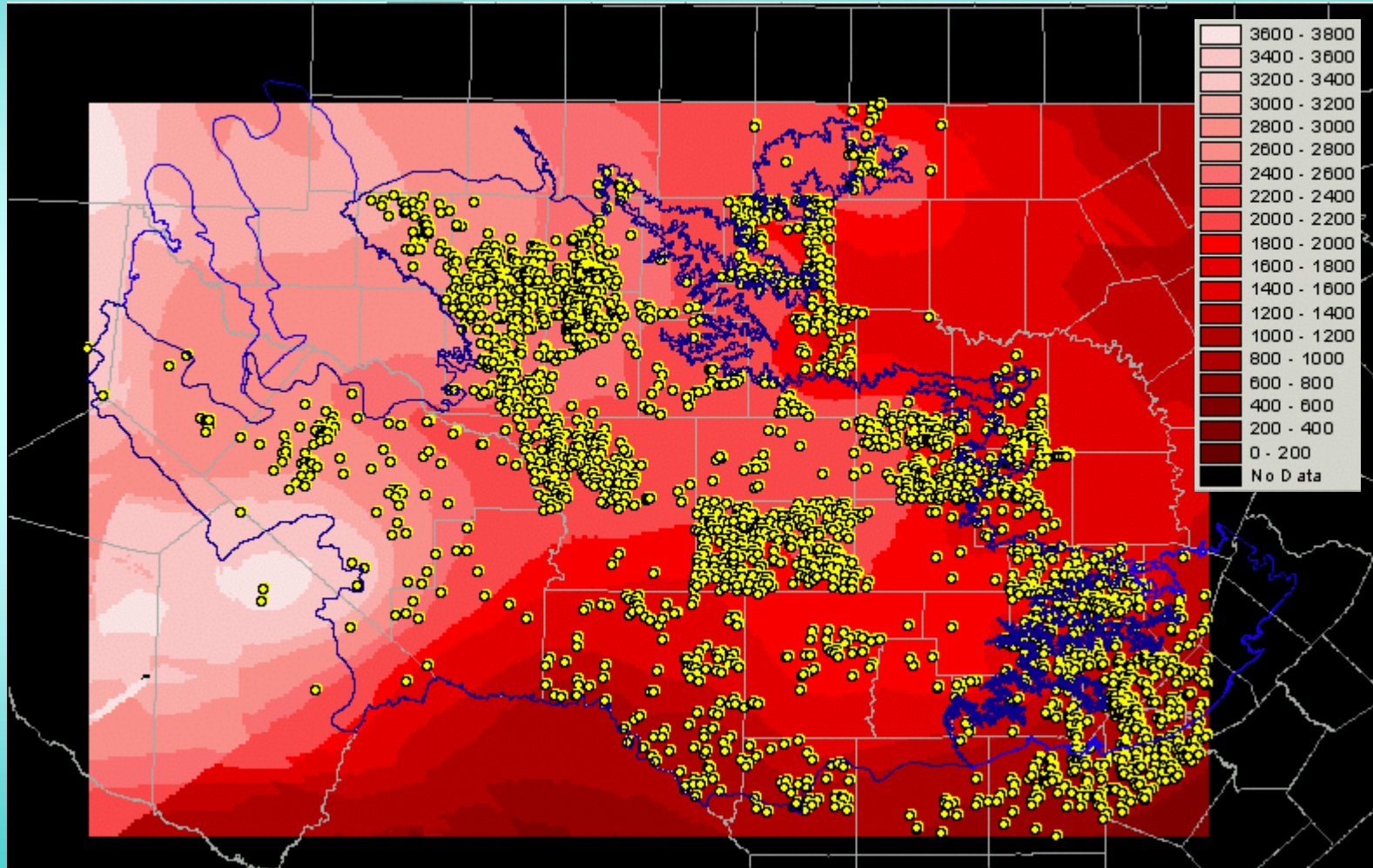
# Edwards-Trinity Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought



# Edwards-Trinity Predevelopment Water Levels (Prior to 1980)



Earliest Winter Measurements Excluding 50' Drought

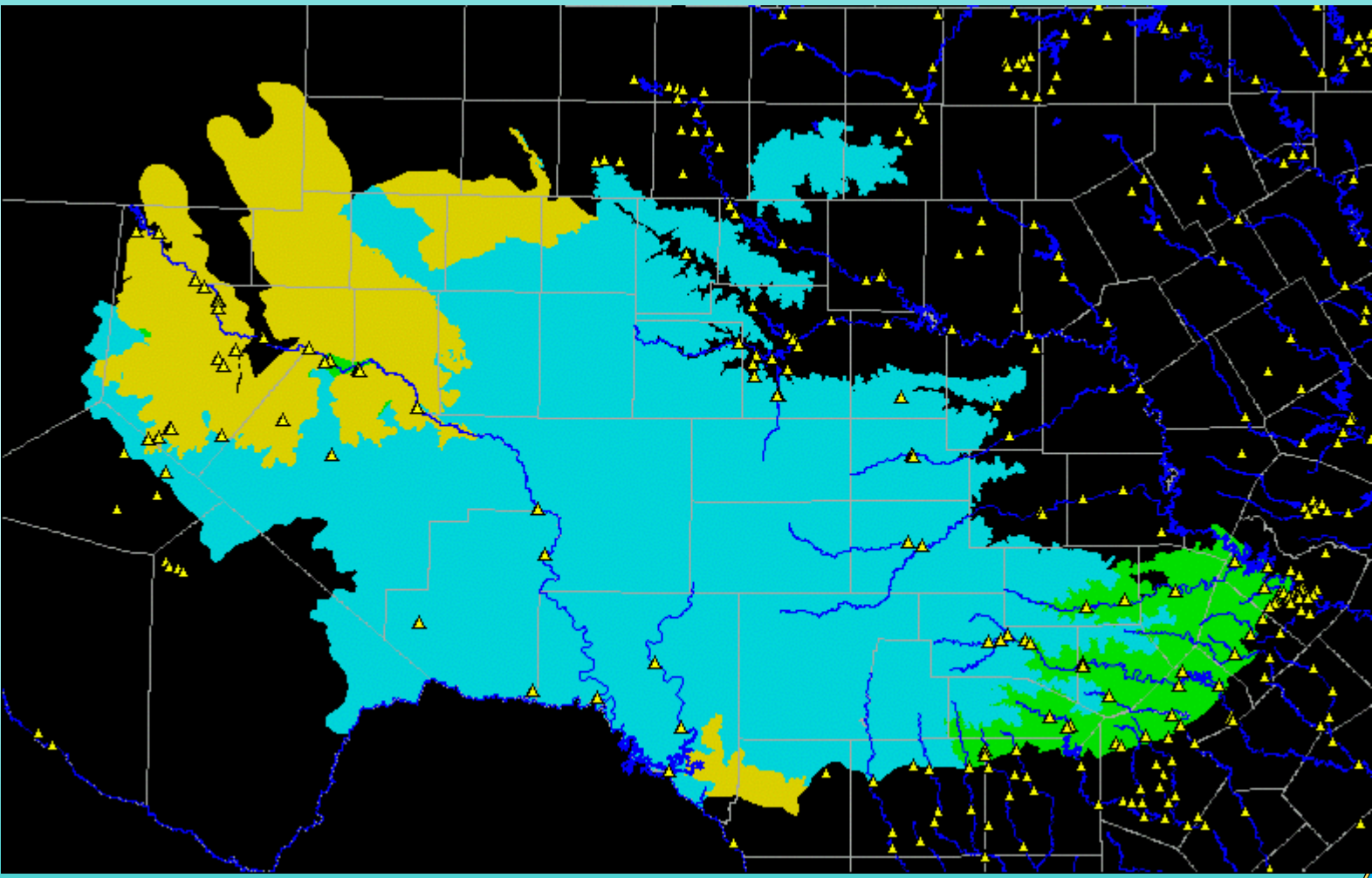


# Surface Hydrology

- MODFLOW drain package will be used to model major springs
- MODFLOW stream-routing package will be used to model major rivers
- MODFLOW reservoir package will be used to model reservoirs

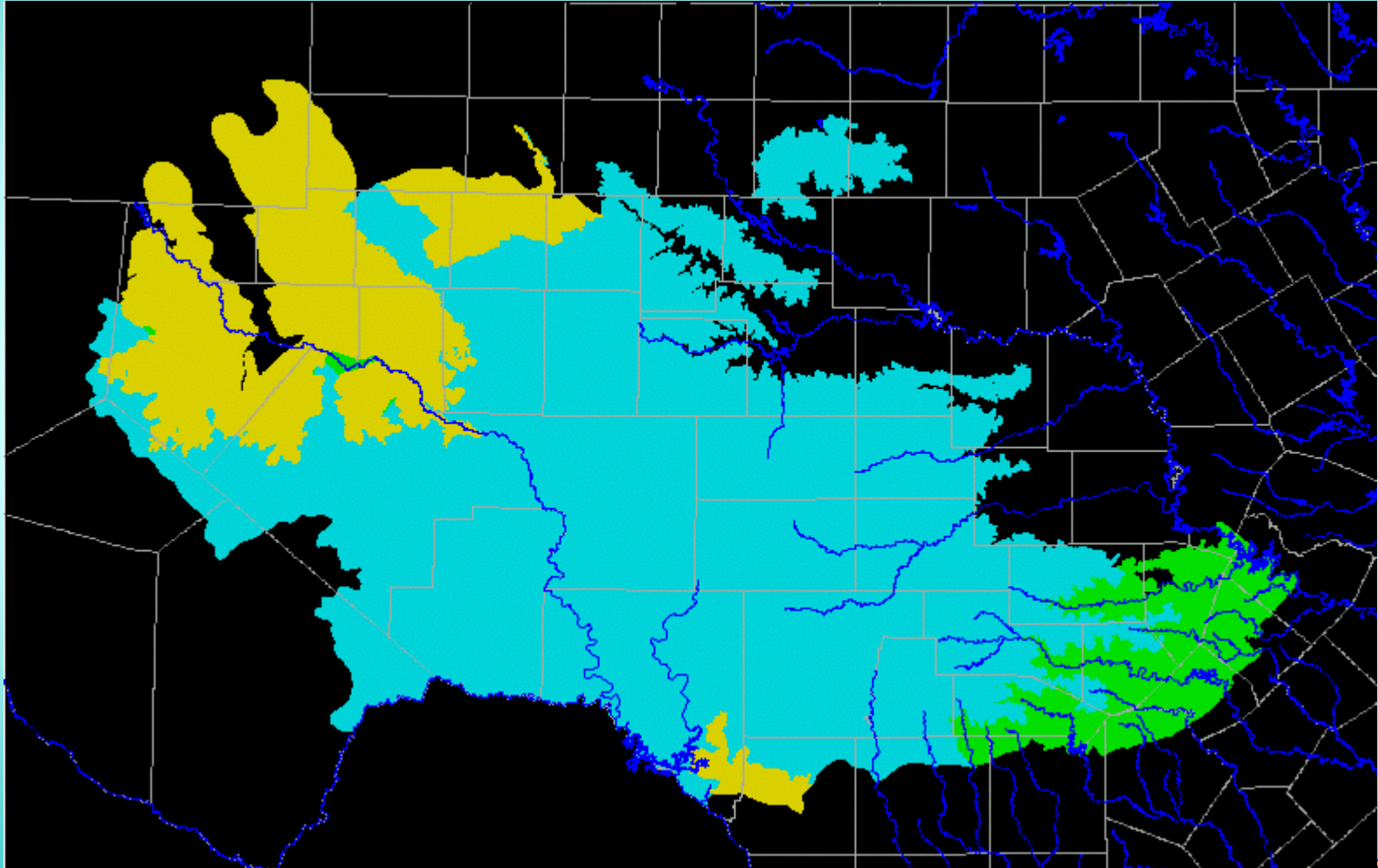


# USGS Surface Water Gage Sites

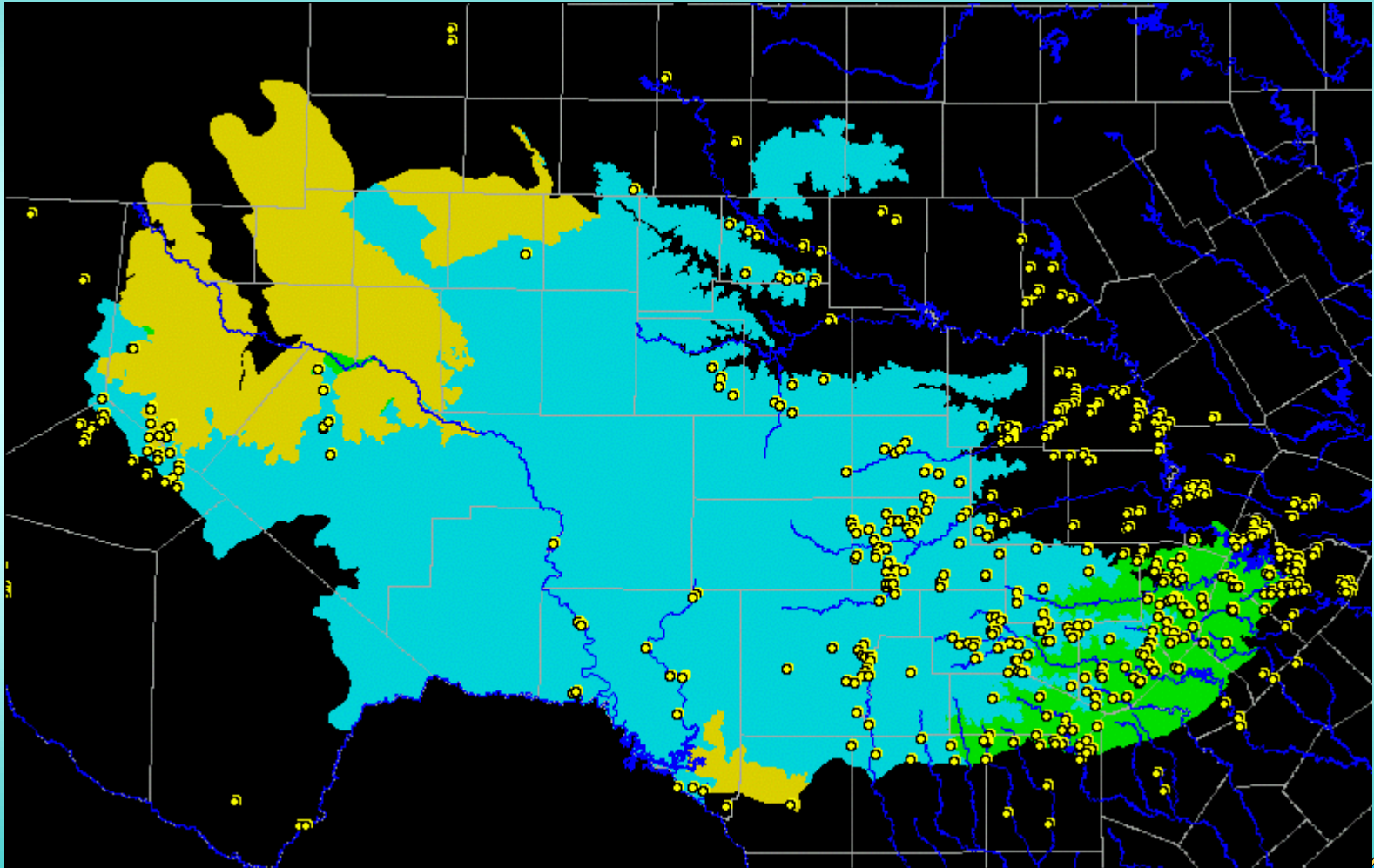




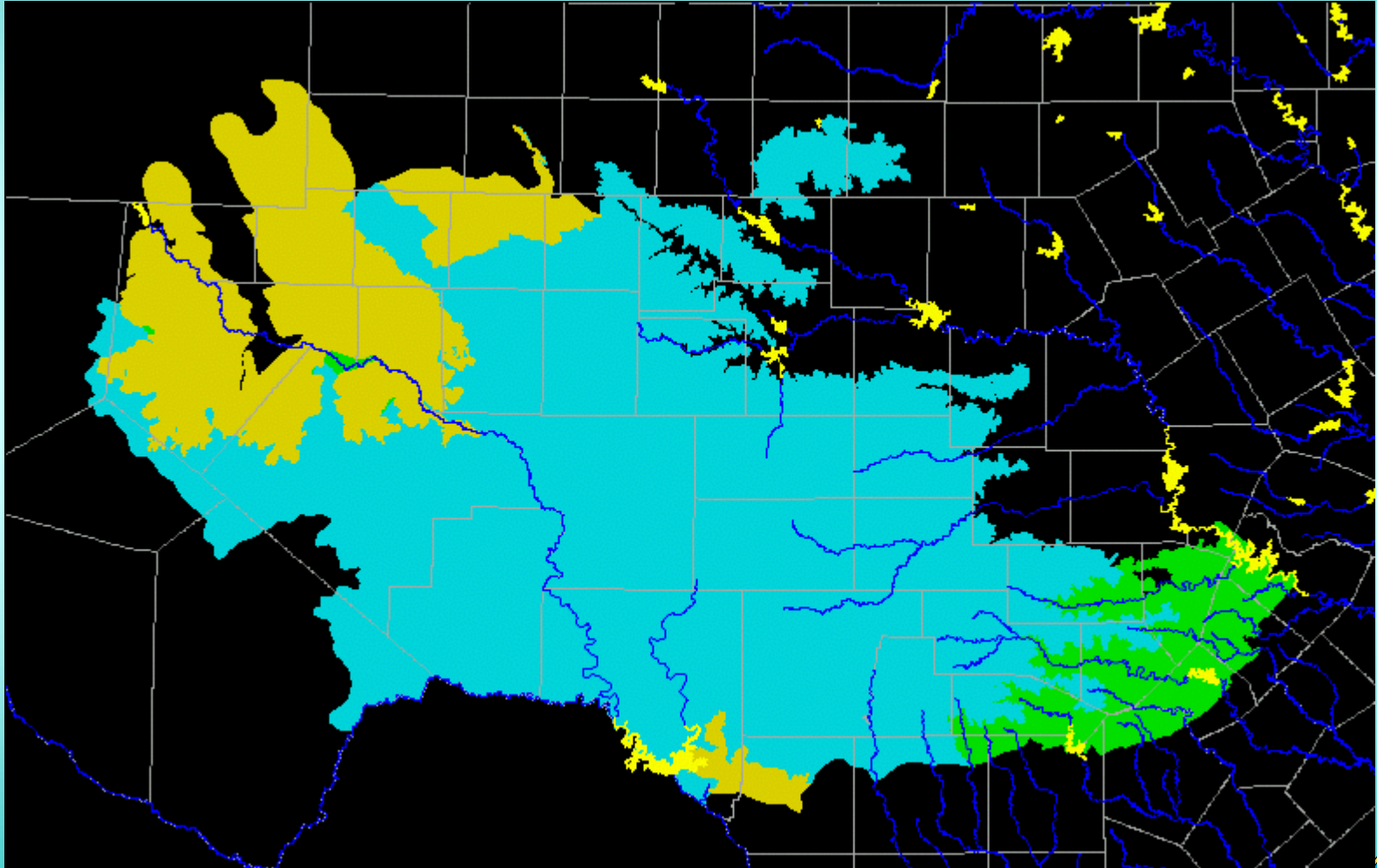
# Major Rivers



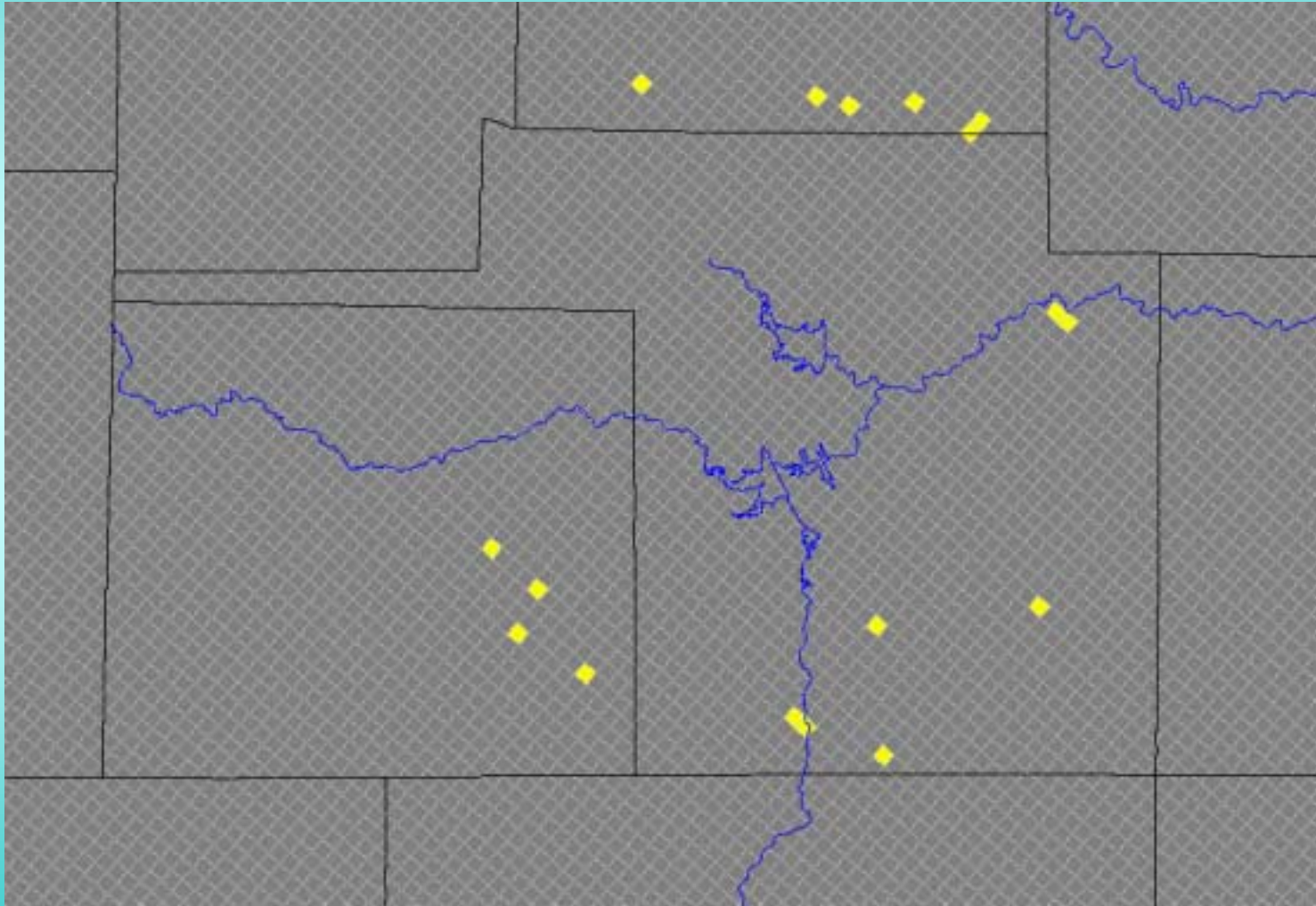
# TWDB Database Spring Locations



# Major Reservoirs



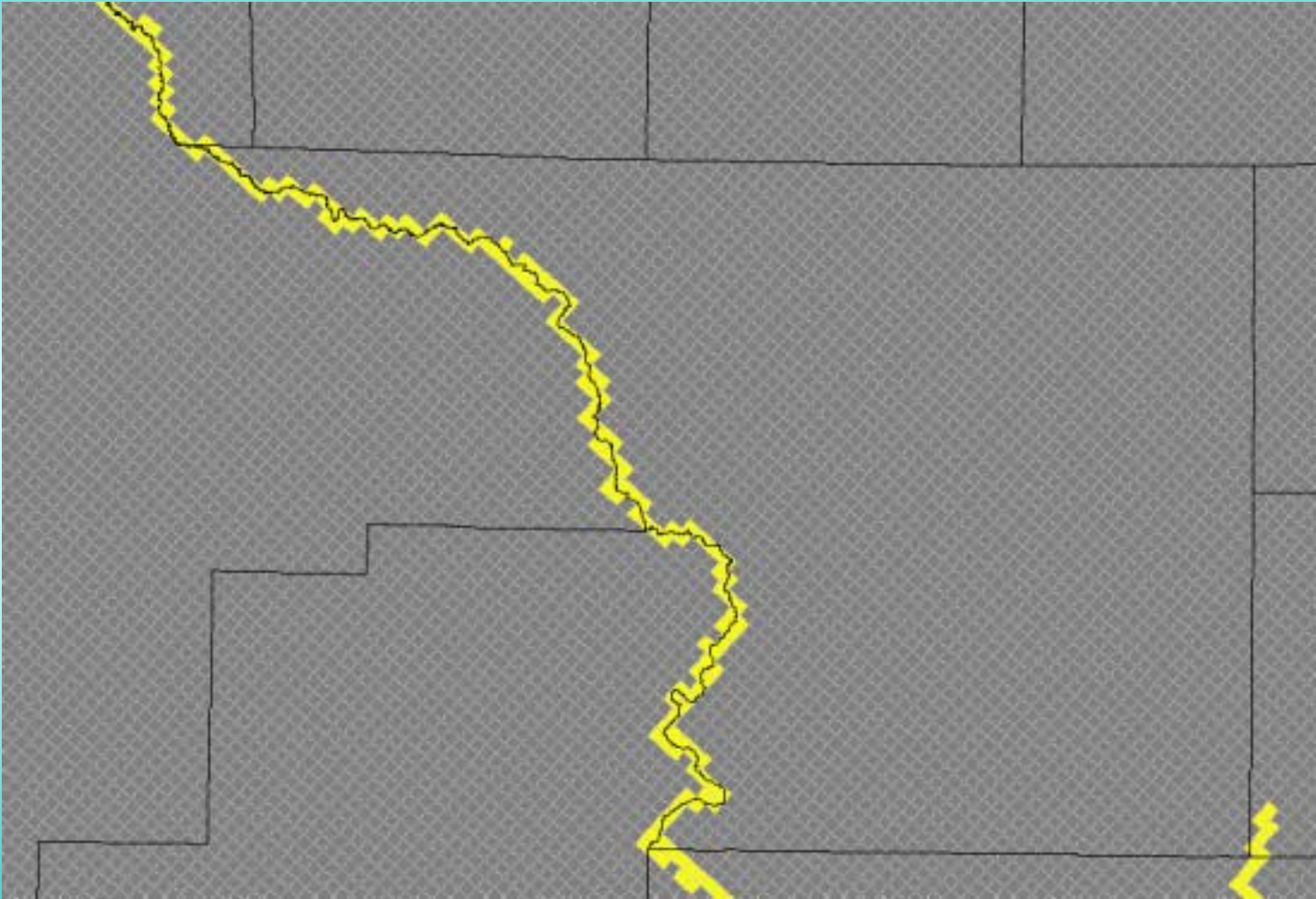
# Drain Cells - Irion and Tom Green Counties



Springs in Concho River Basin



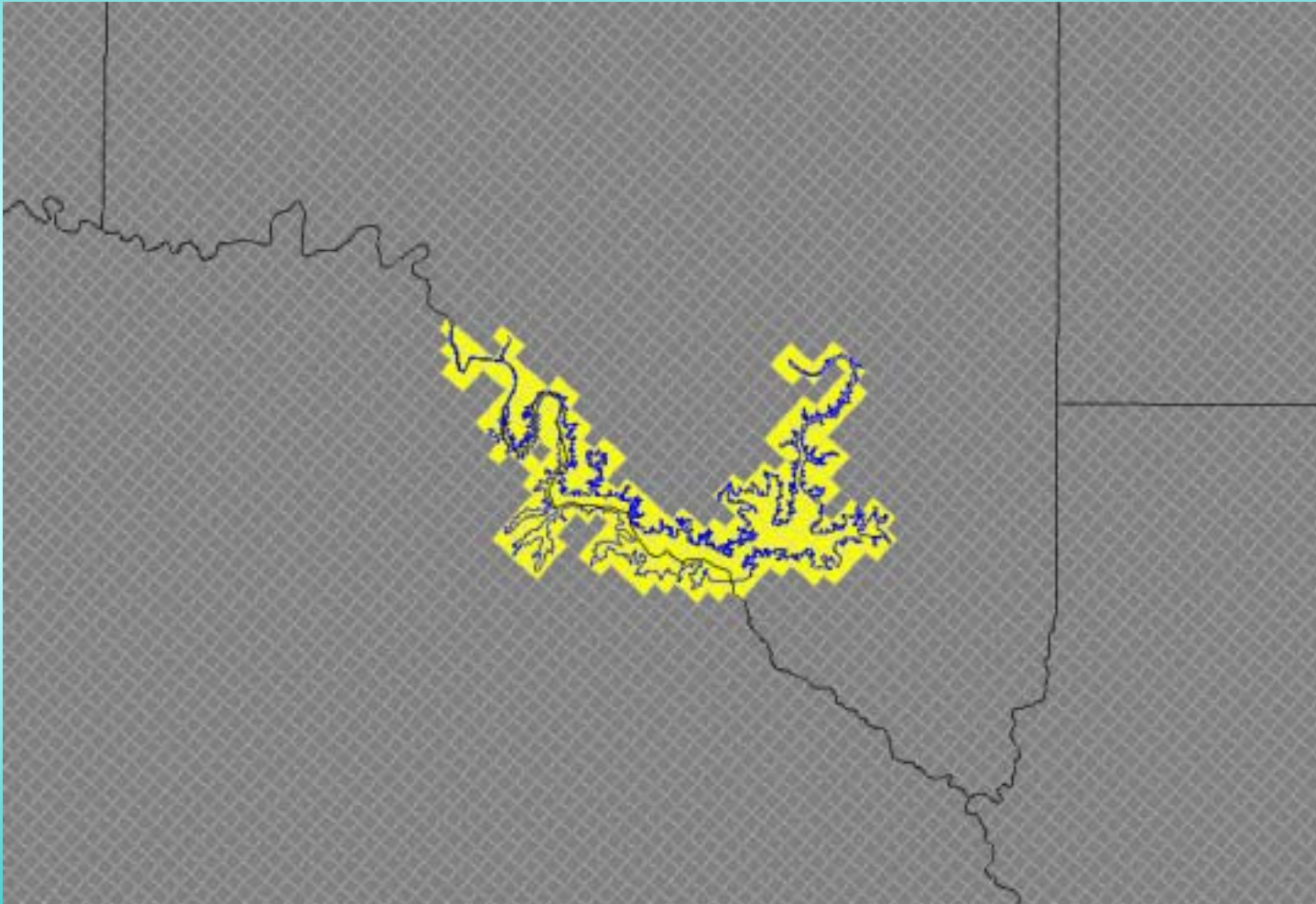
# Stream Cells - Crockett, Pecos, and Terrell Counties



Pecos River



# Reservoir Cells - Val Verde County



Amistad Reservoir



# Lunch Time!

## 90 Minute Break

We will reconvene to finish the discussion of the Edwards-Trinity Aquifer Model

FOR MORE INFO VISIT...

[www.twdb.state.tx.us/gam](http://www.twdb.state.tx.us/gam)



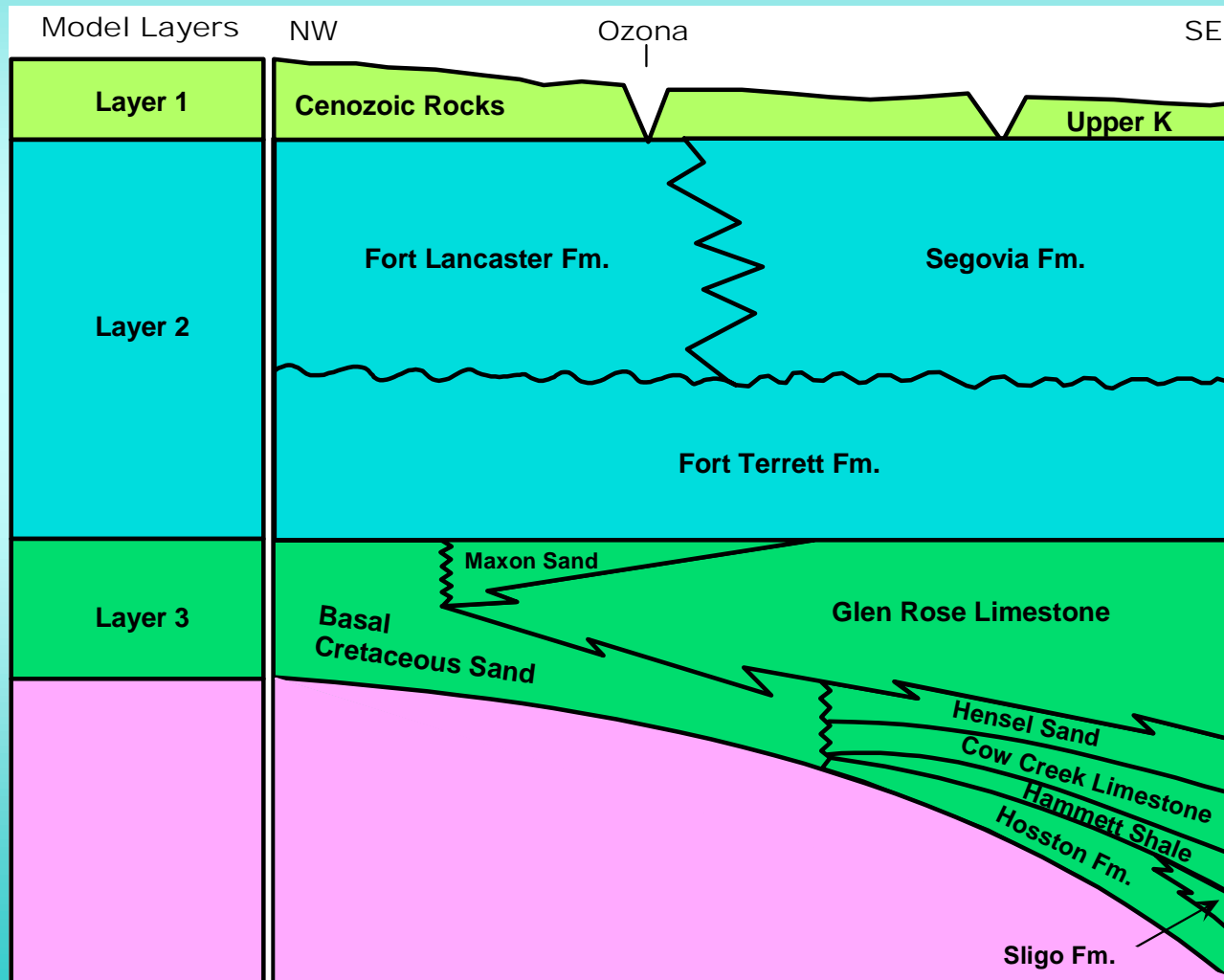
# Conceptual Model and Boundary Conditions

- 3 layers proposed for the model
- Top layer number 1 will be used to model Edwards-Trinity cap rocks
- Emphasis will be placed on bottom 2 layers
- General-head boundary will be used for layer 3 cells to represent the hydraulic connection with underlying and lateral aquifers

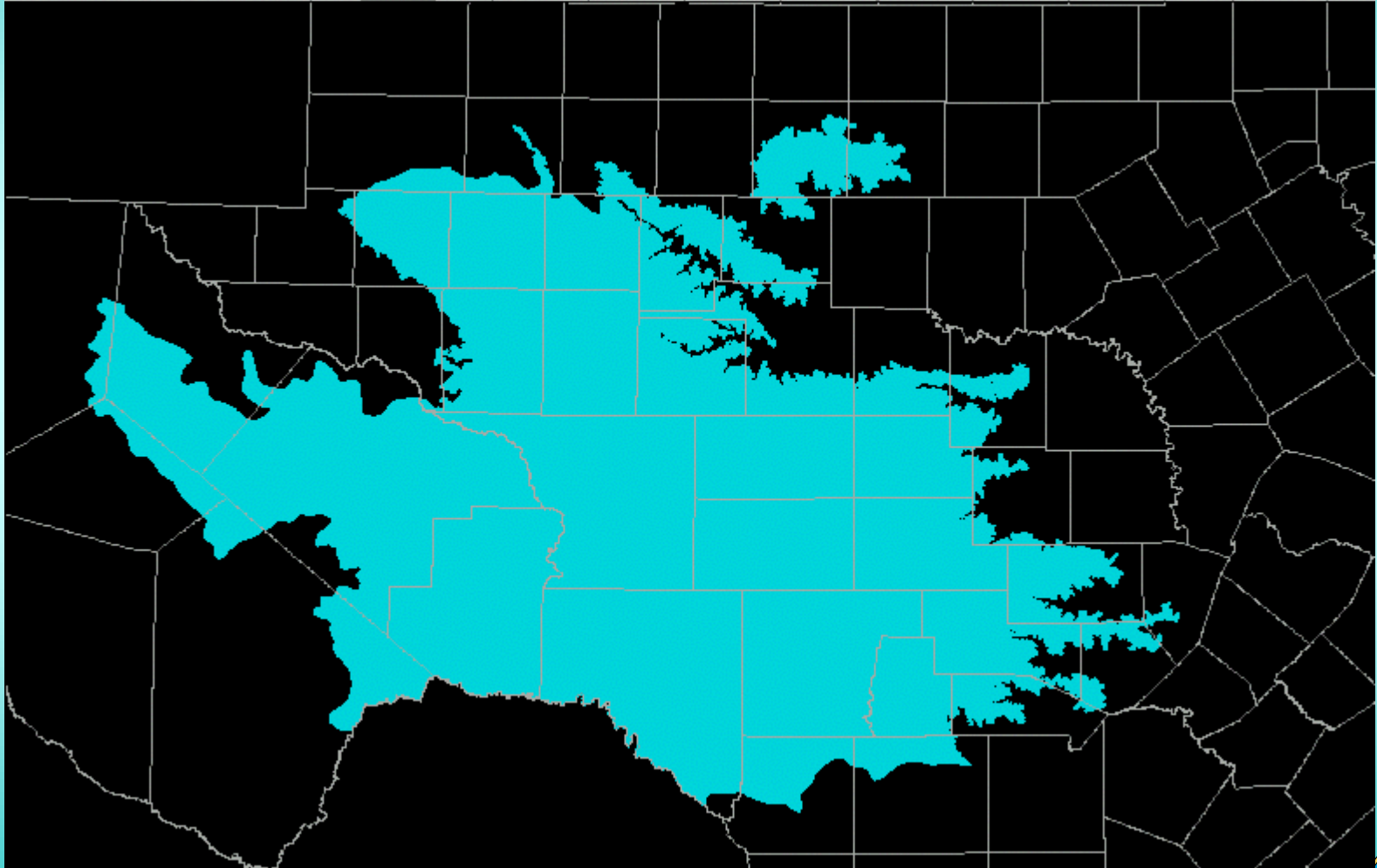




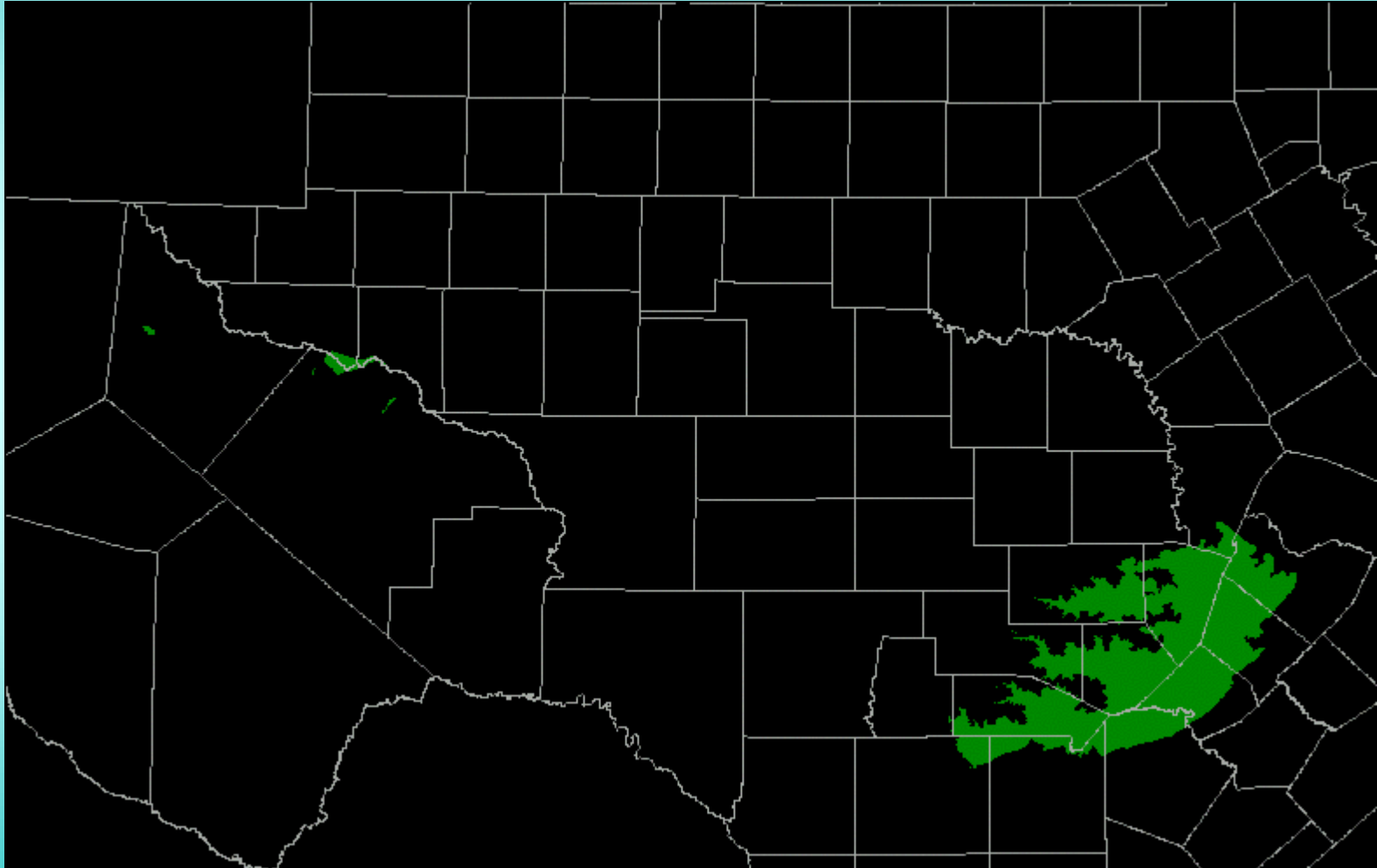
# Proposed Model Layers for the Edwards-Trinity Aquifer Model



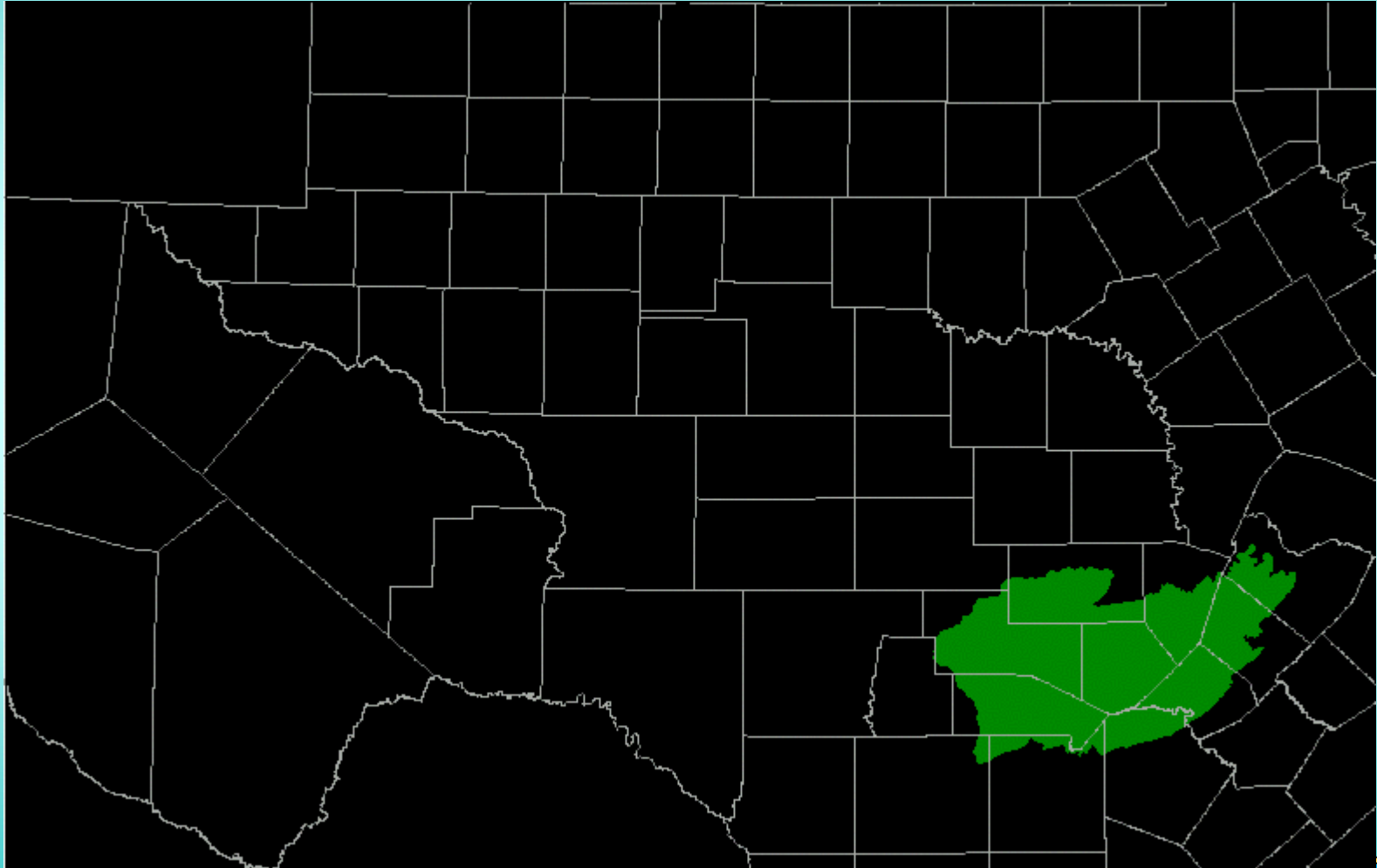
# Spatial Extent of the Edwards-Trinity Sediments



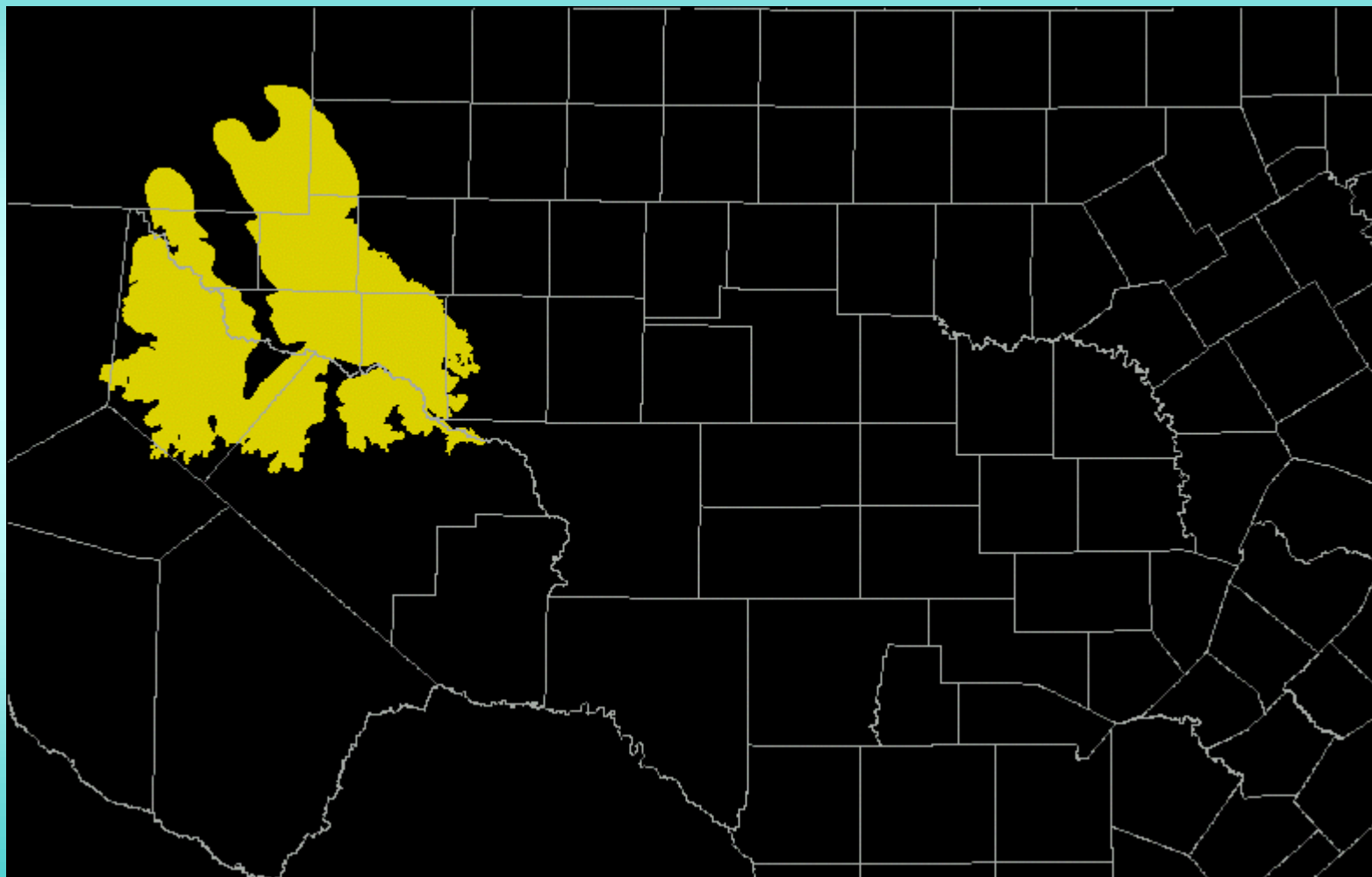
# Spatial Extent of the Trinity-Hill Country Sediments



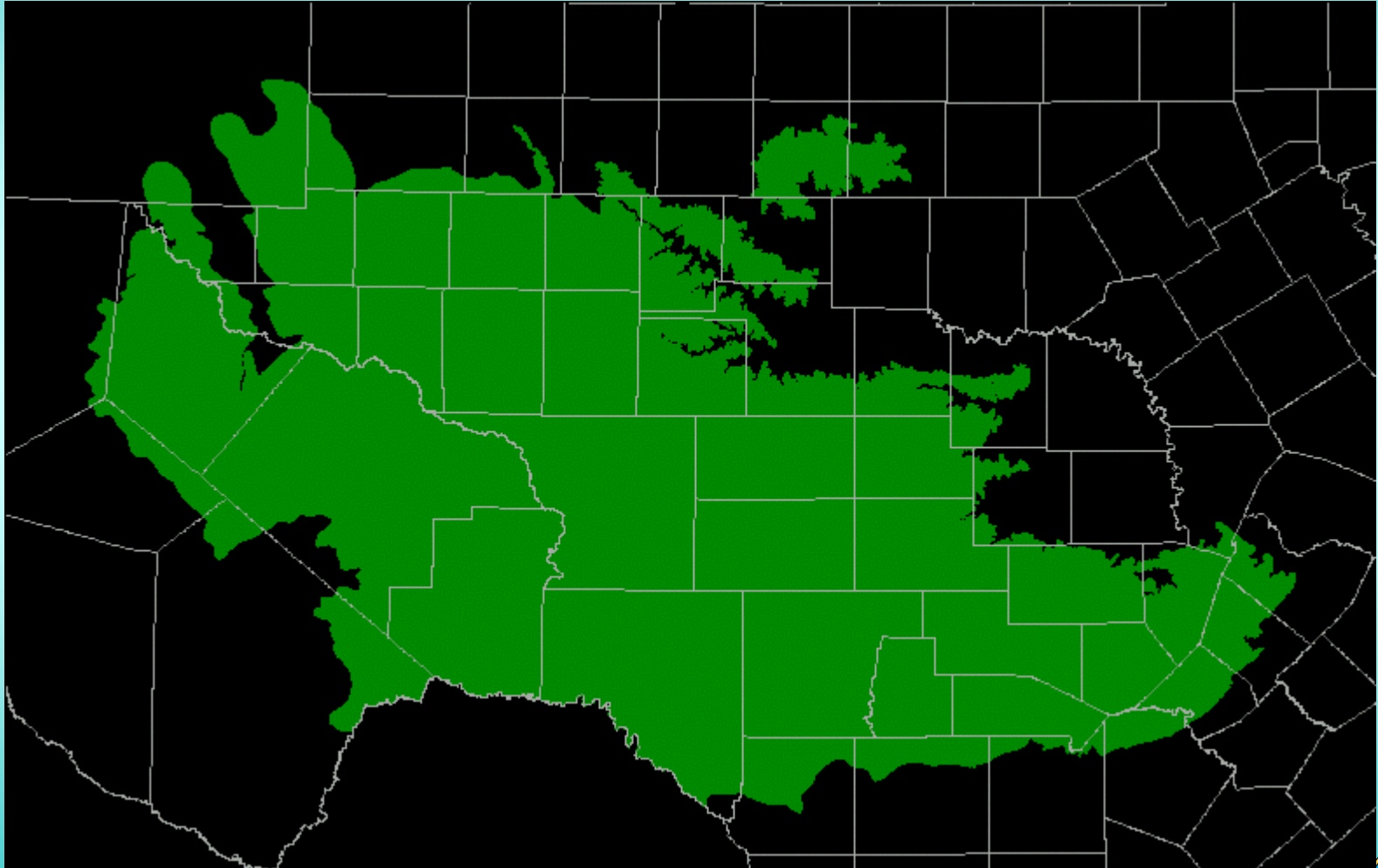
# Spatial Extent of the Trinity-Hill Country Model



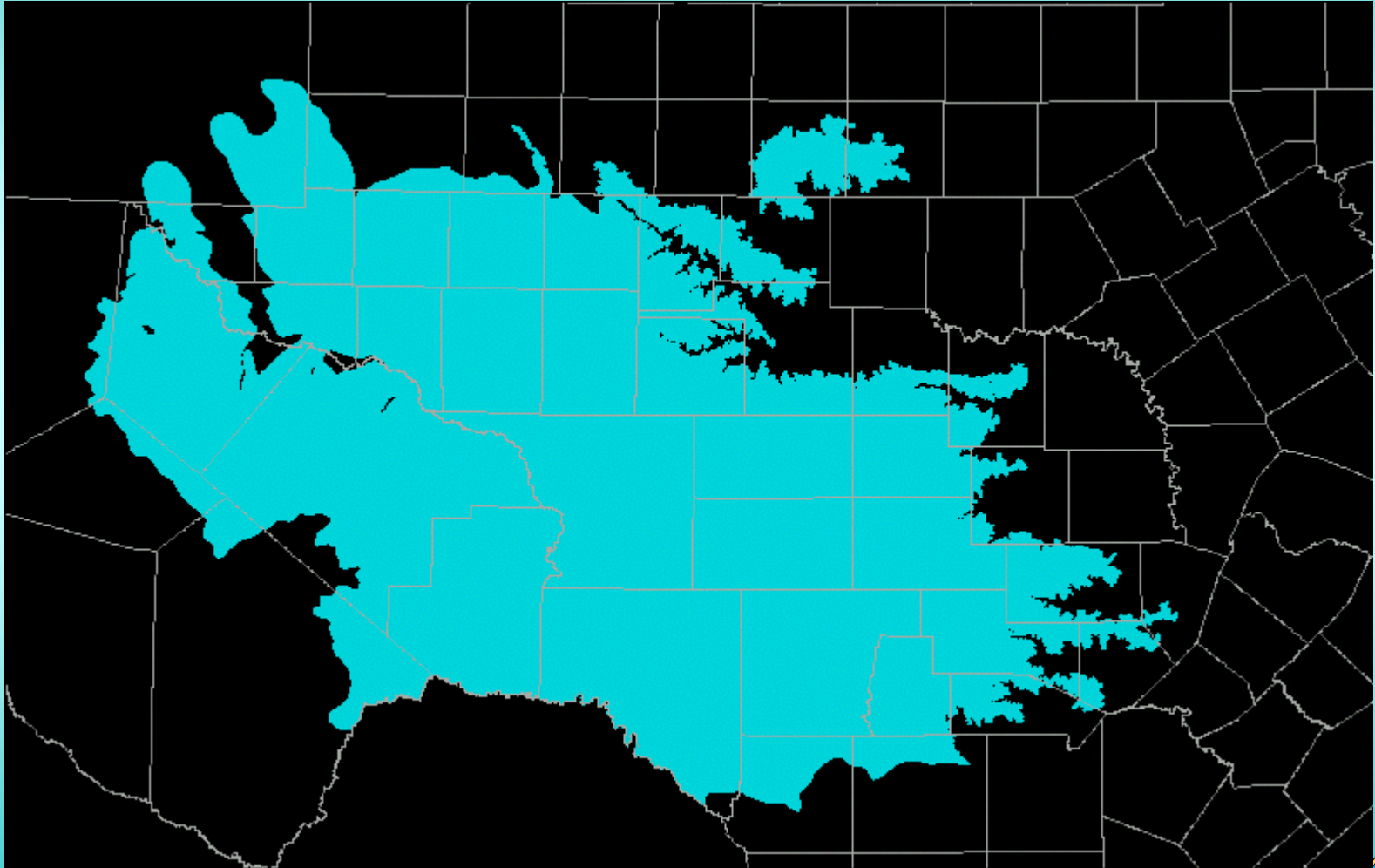
# Spatial Extent of the Pecos Alluvium Sediments



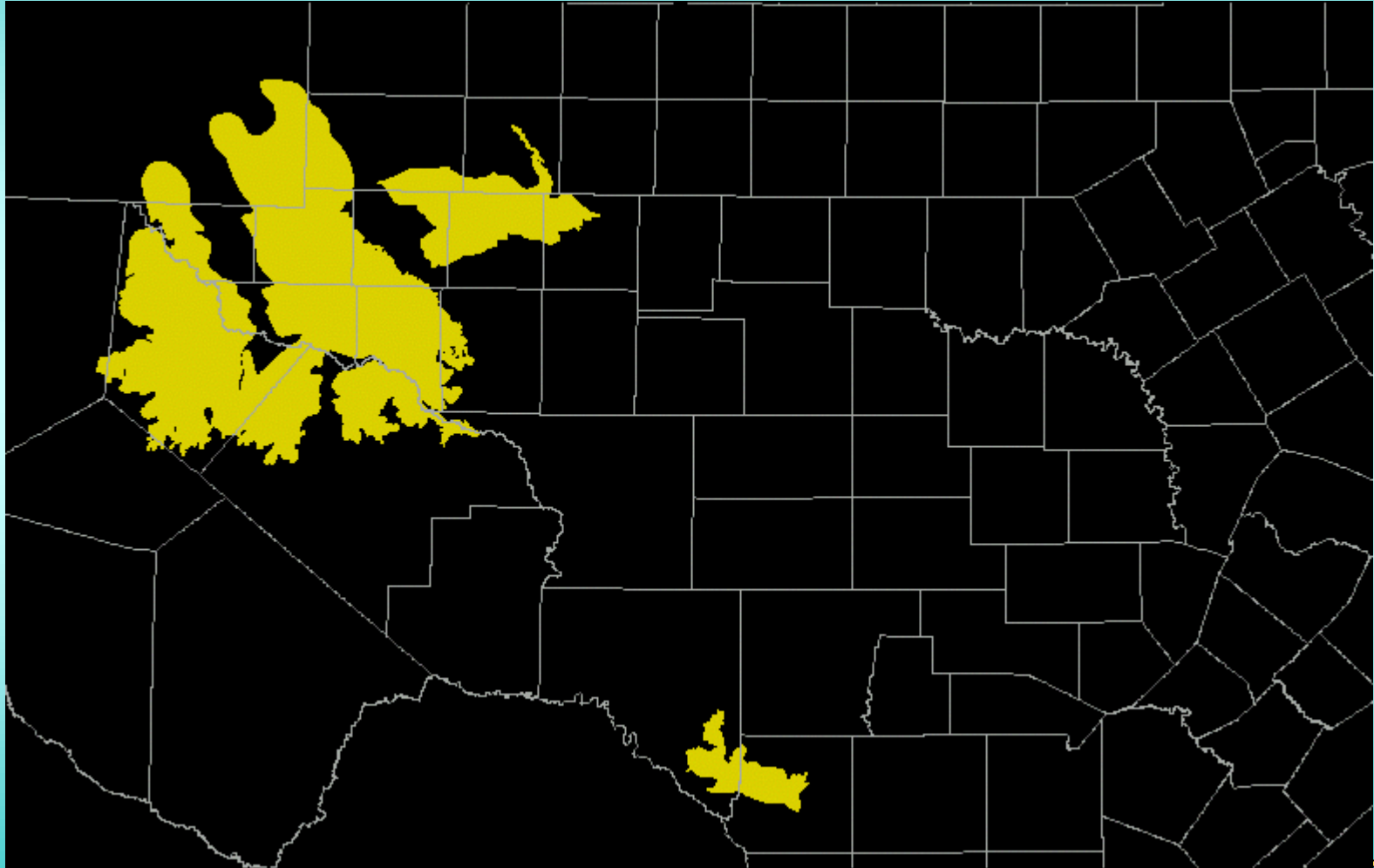
# Extent of Model Layer 3



# Extent of Model Layer 2

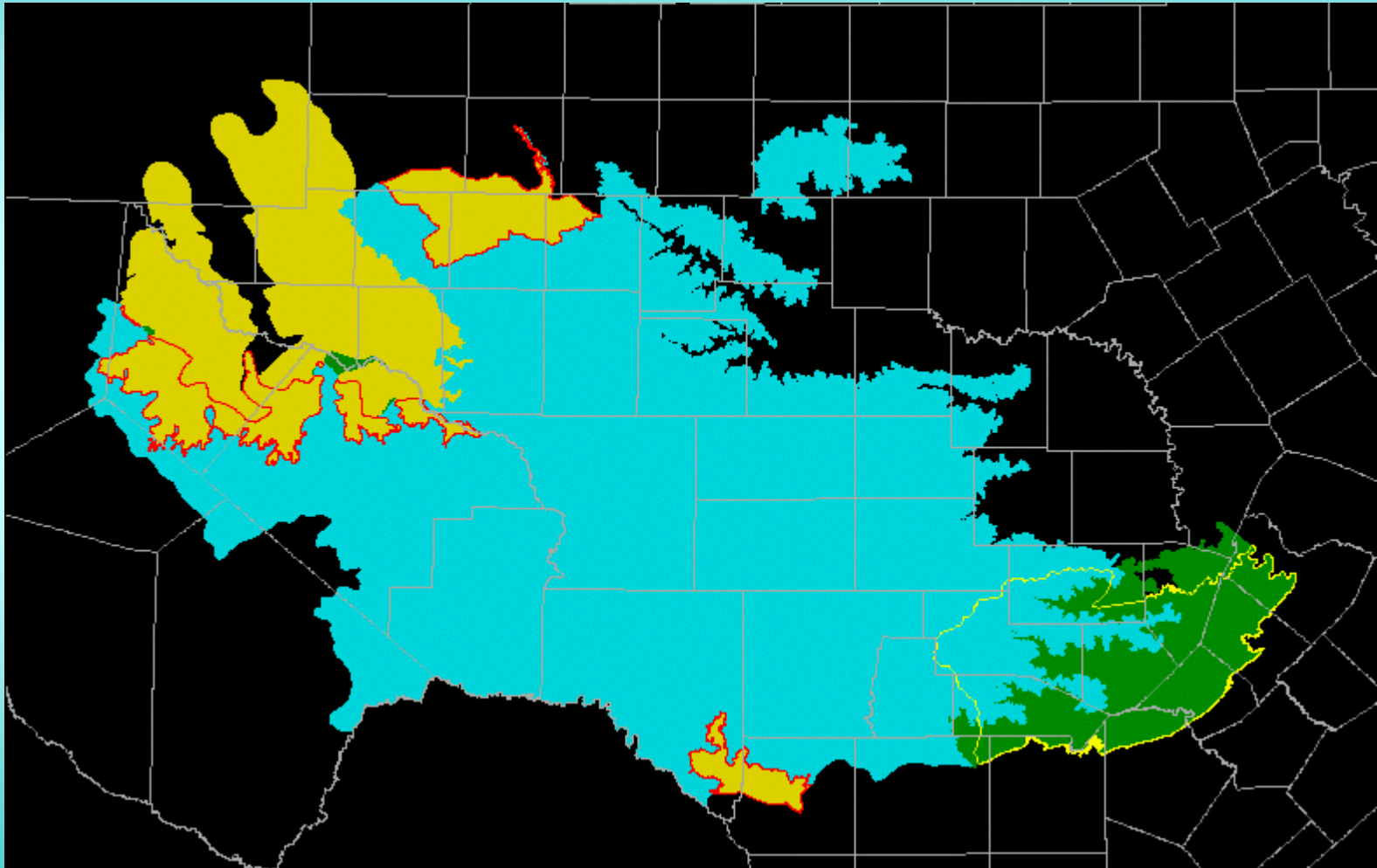


# Extent of Model Layer 1

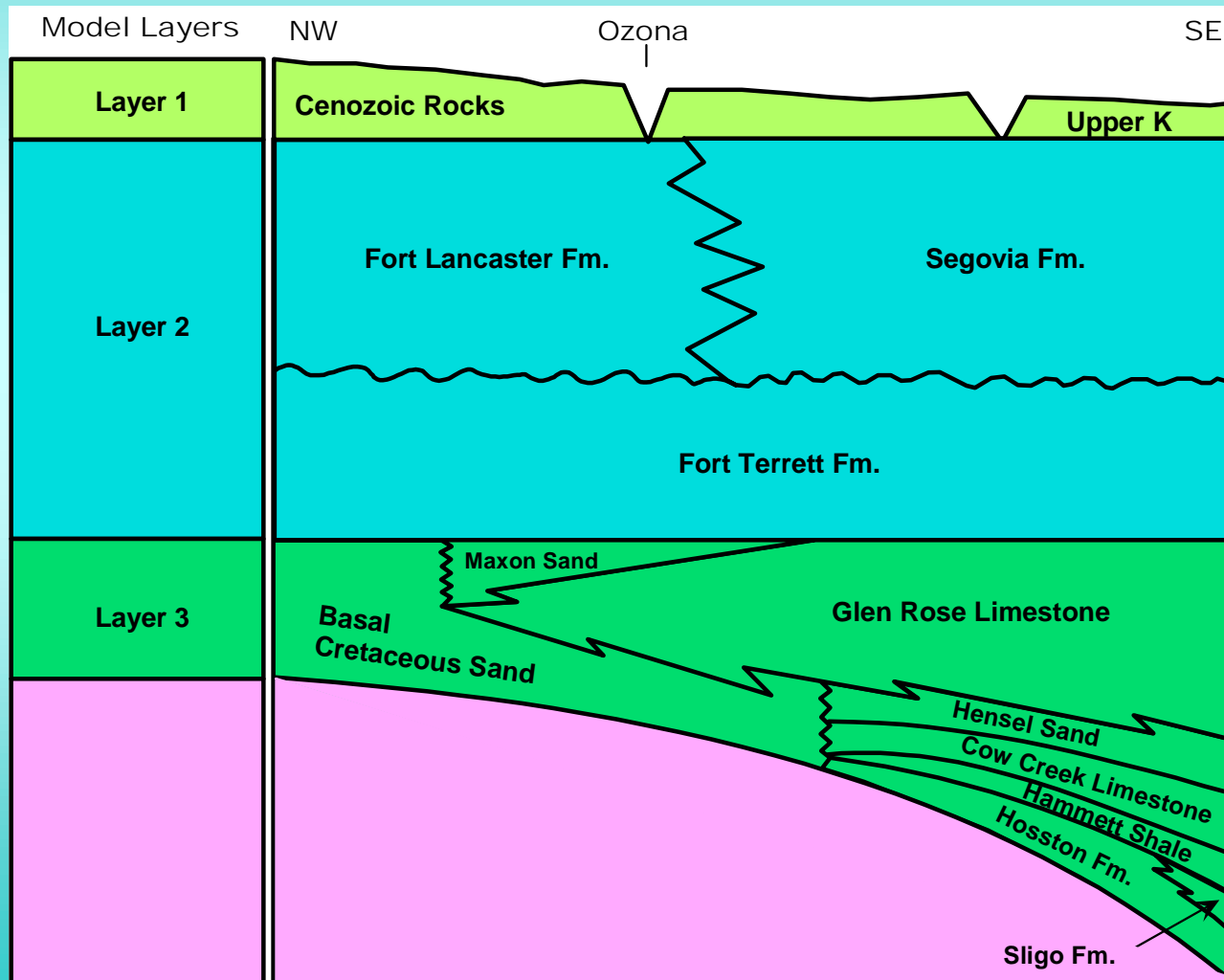




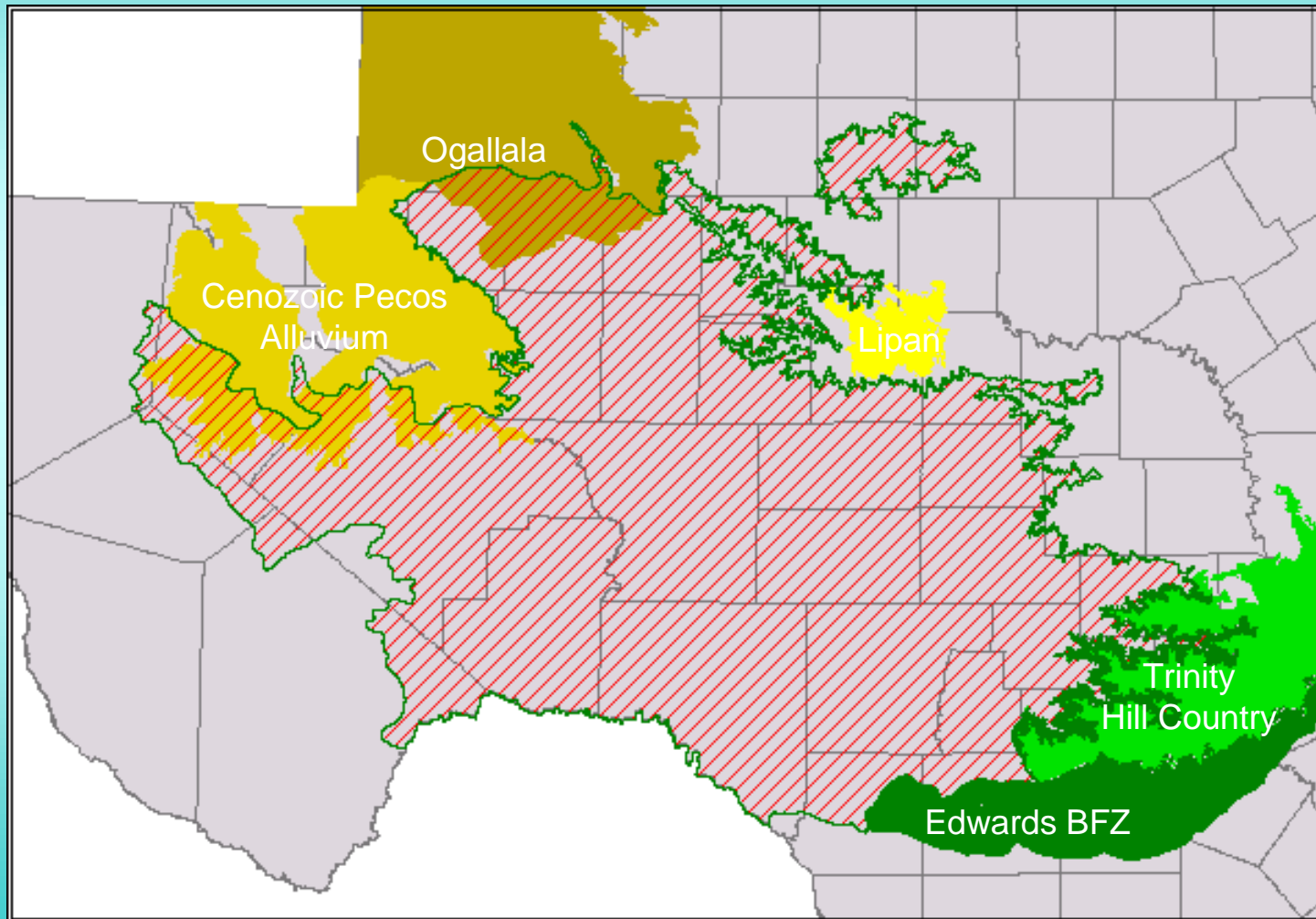
# Extent of Model Layers 1, 2, & 3



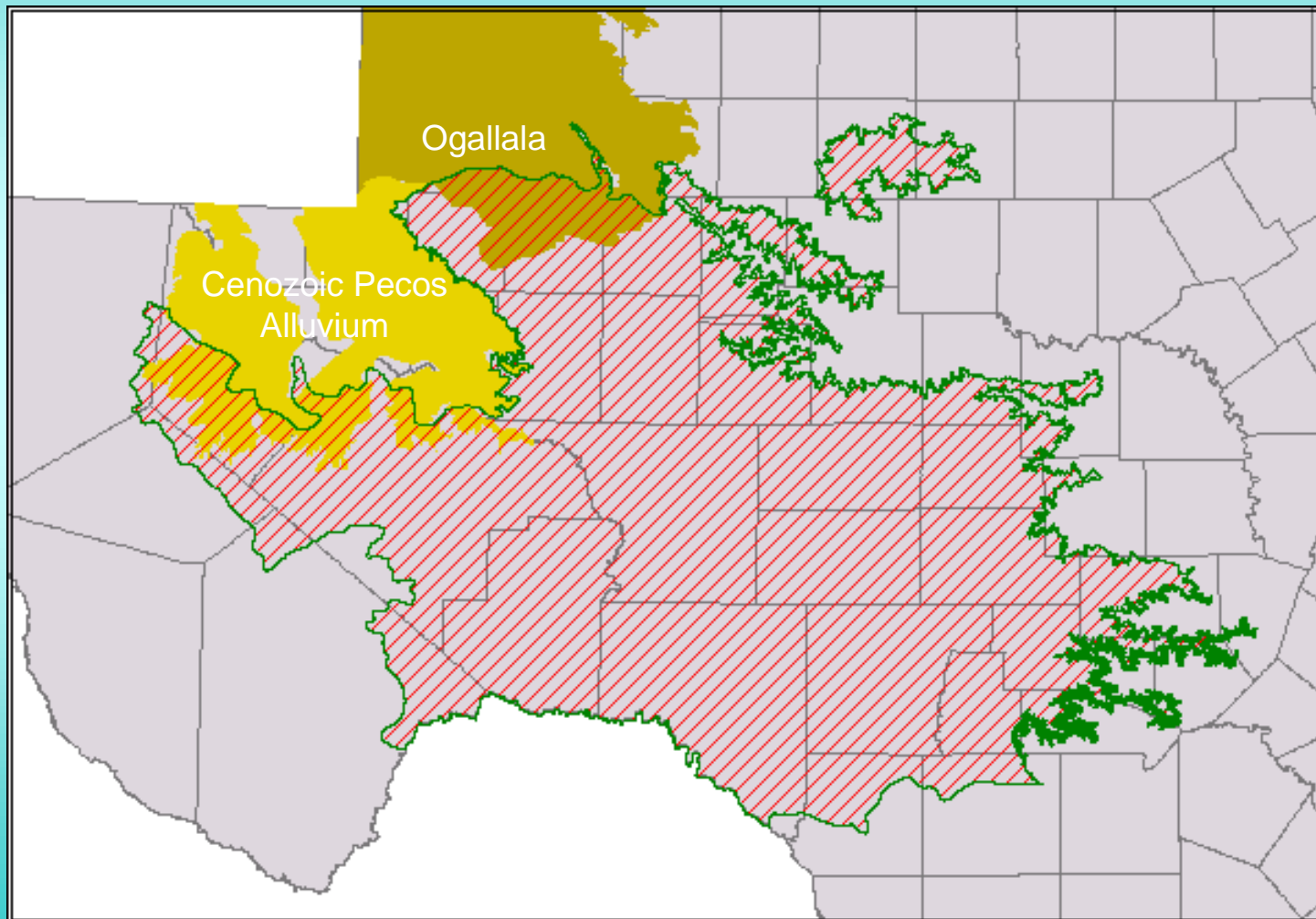
# Proposed Model Layers for the Edwards-Trinity Aquifer Model



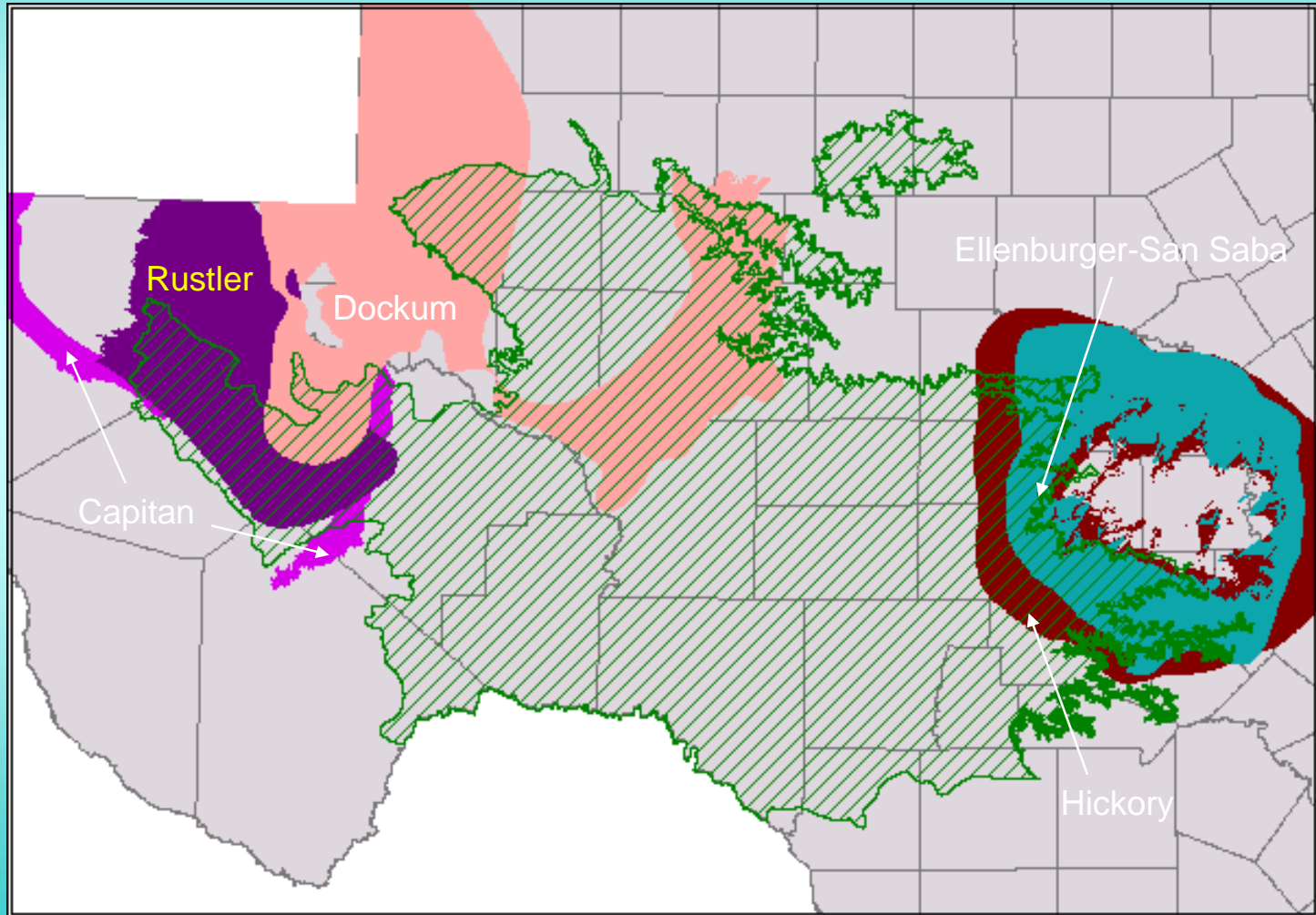
# Lateral Geology at Edges of Edwards-Trinity



# Overlying Geology of Edwards-Trinity Aquifer



# Underlying Geology at Base of Edwards-Trinity Aquifer

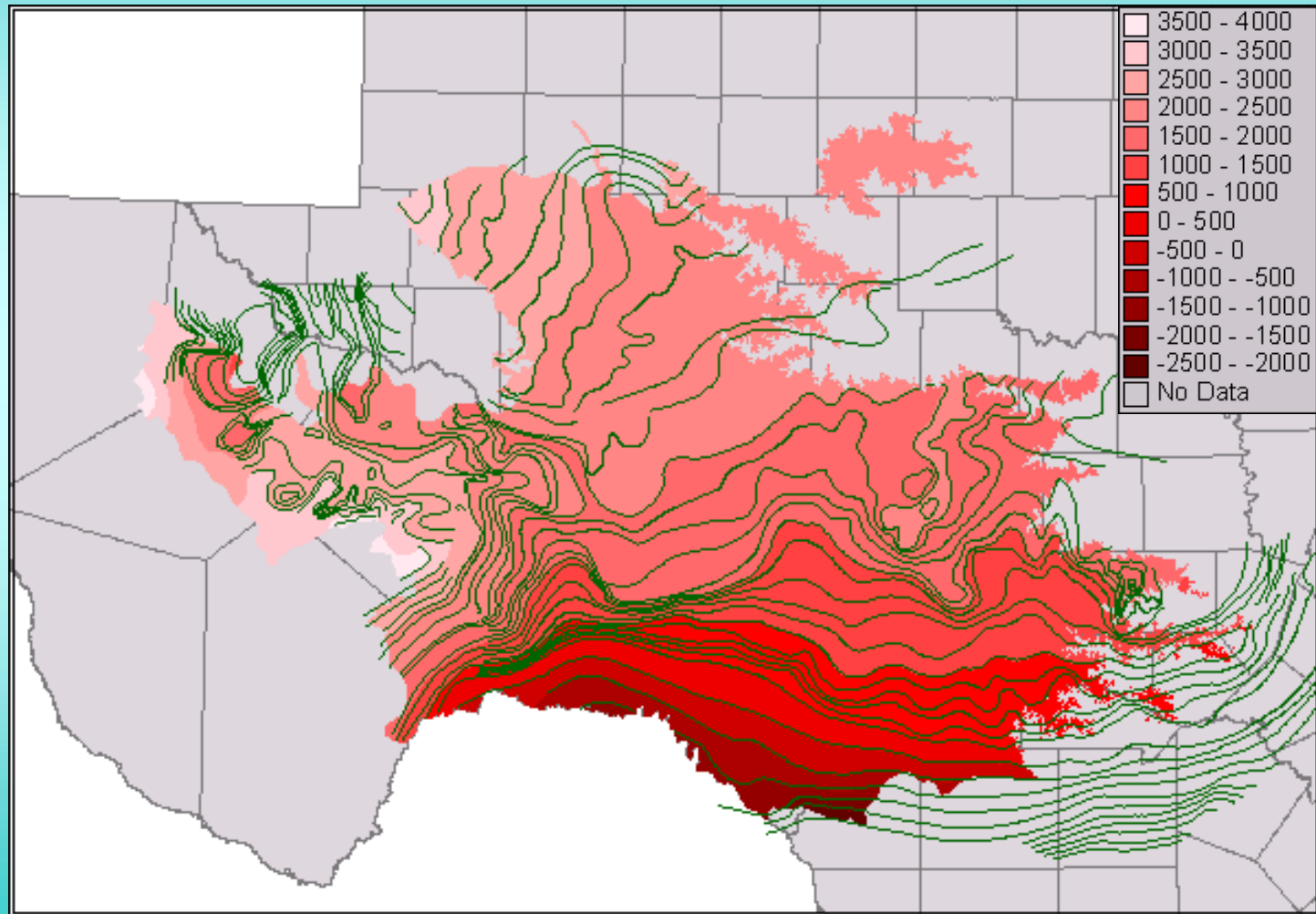


# Current Structural Geometry of the Edwards-Trinity Model

- Data sources included USGS, BEG GAT sheets, report cross-sections, and a few well logs
- All data was compiled into point locations
- All data was then checked for outlier significance
- A trial and error technique was used to interpolate structural surfaces with advance geostatistical methods

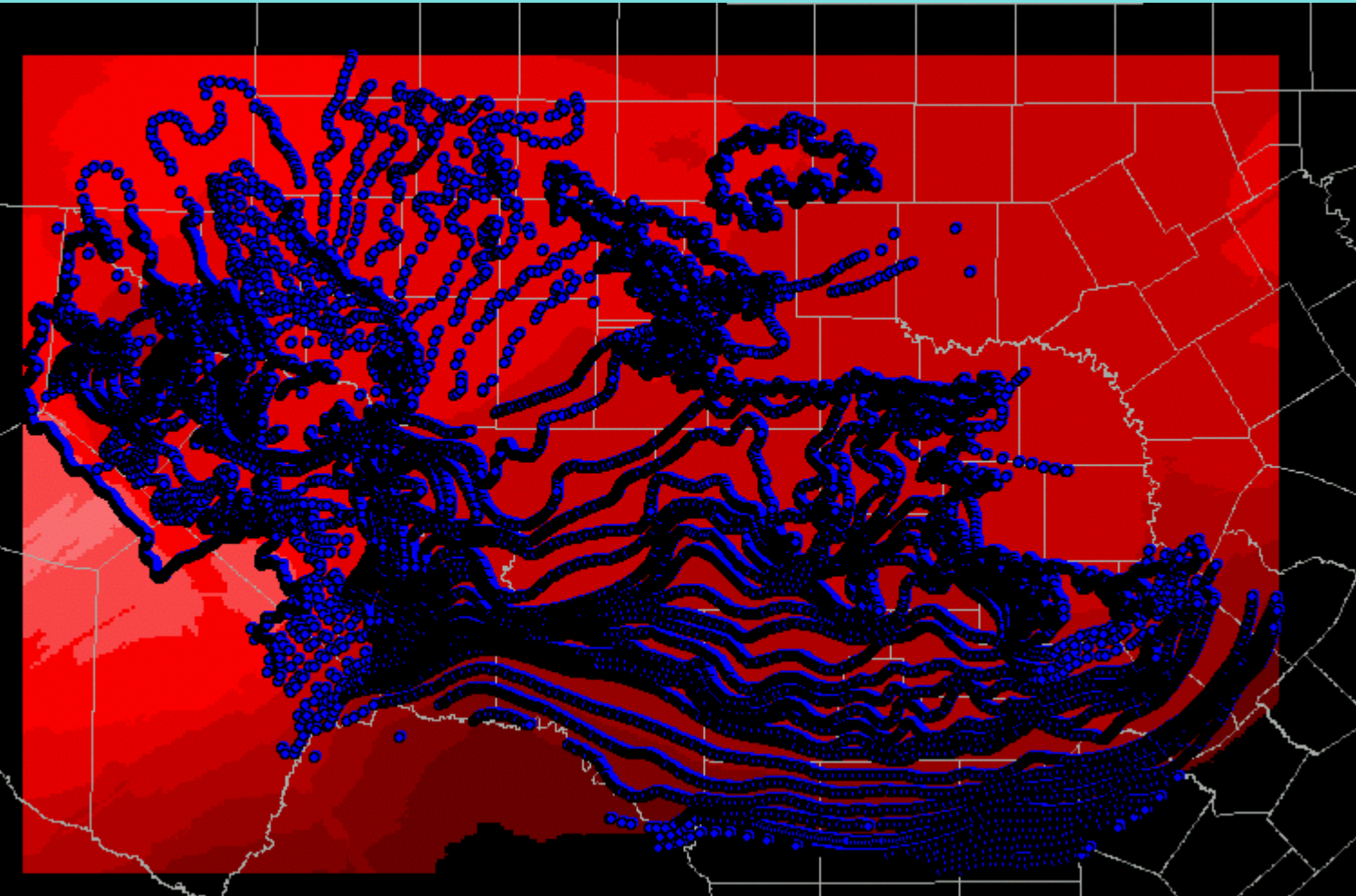
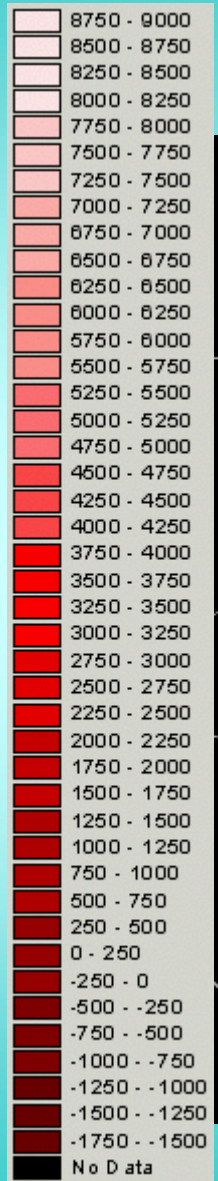


# Structural Base of Edwards-Trinity Sediments



From - USGS unpublished data, 2001

# Structural Base of Trinity

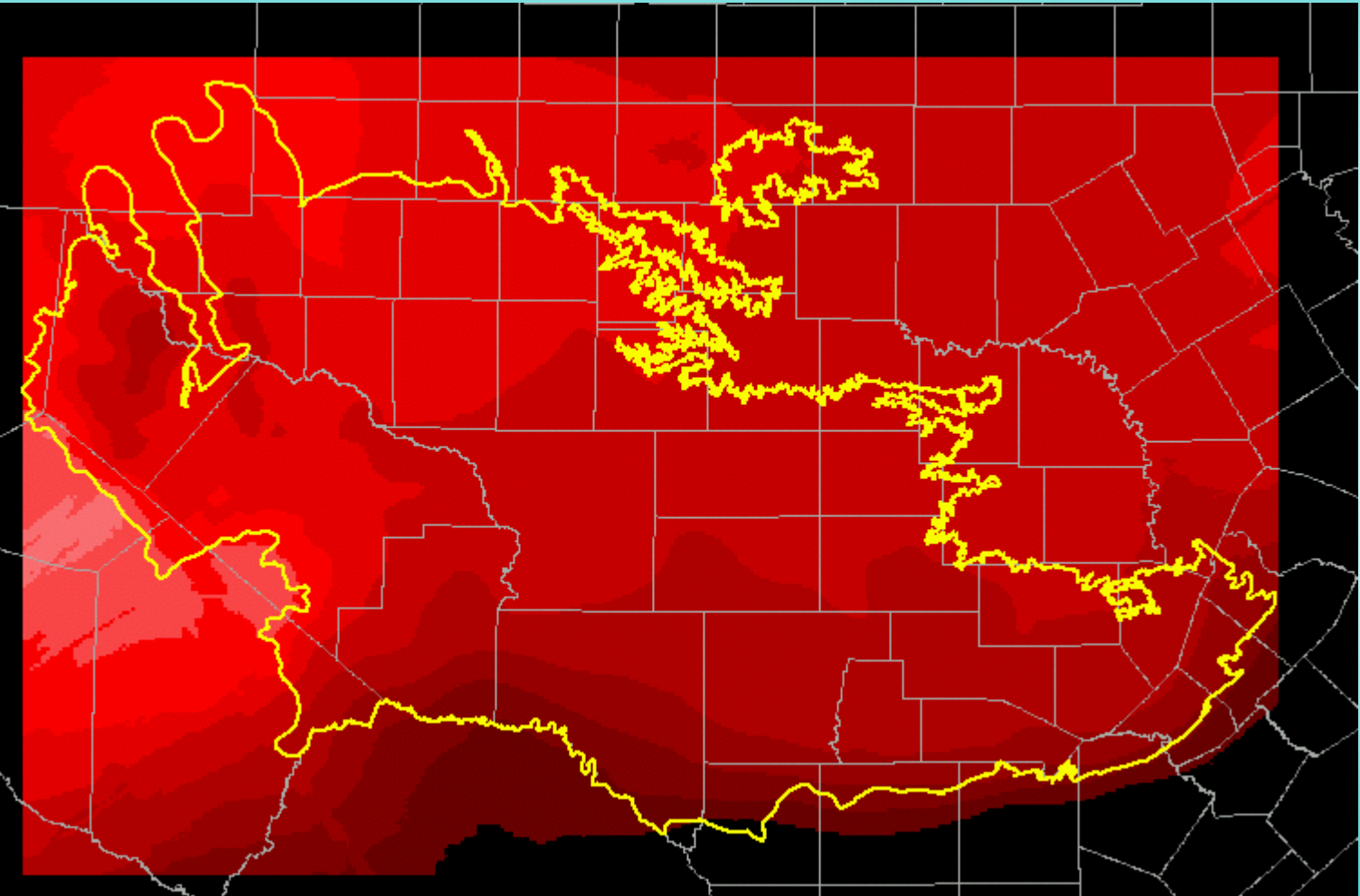
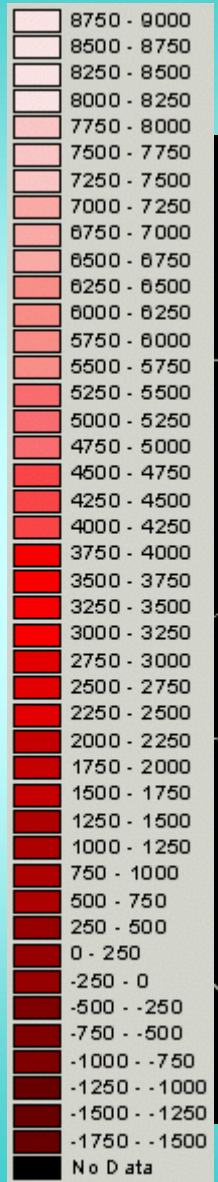


Bottom of Layer 3 Control Data





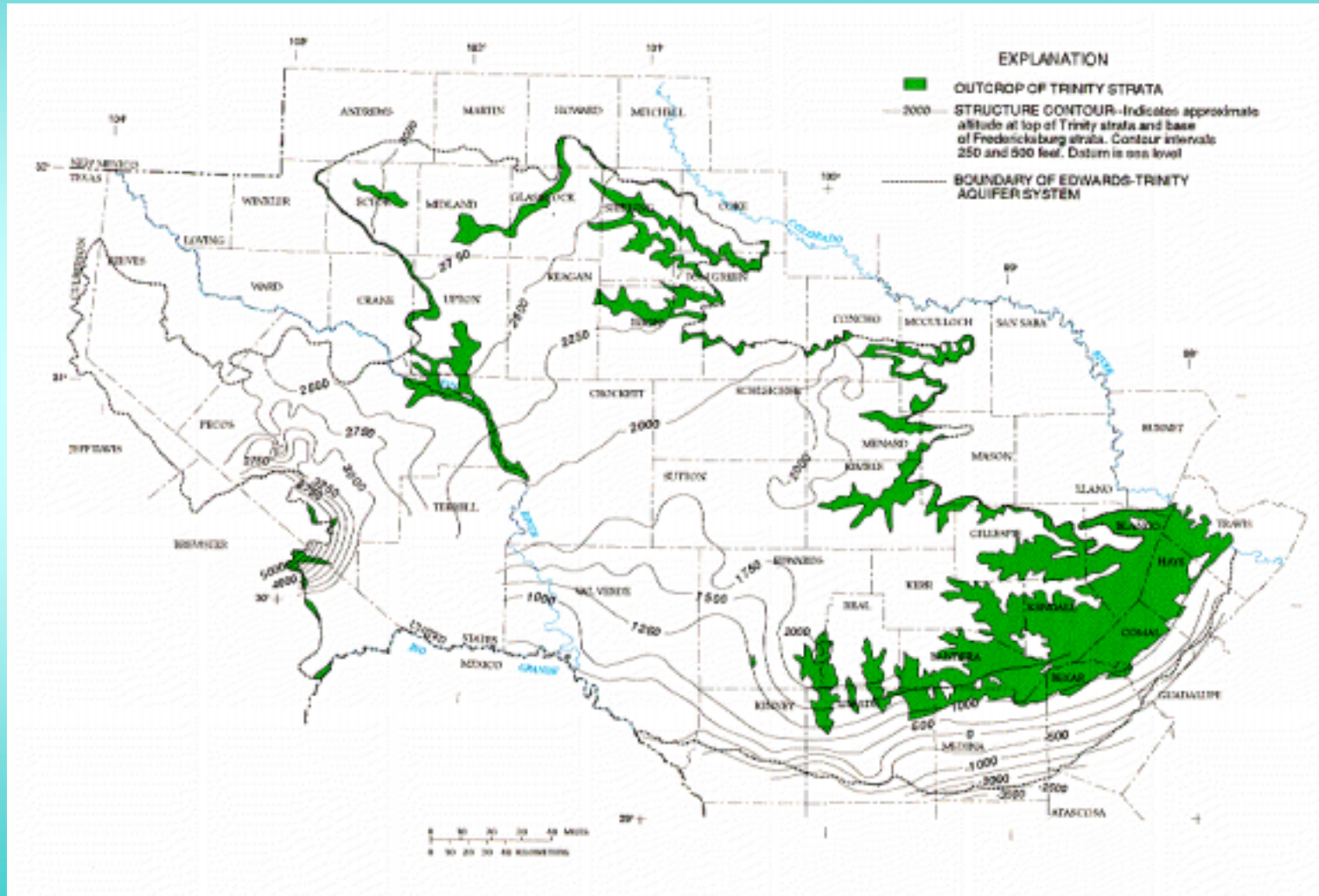
# Structural Base of Trinity



Bottom of Layer 3



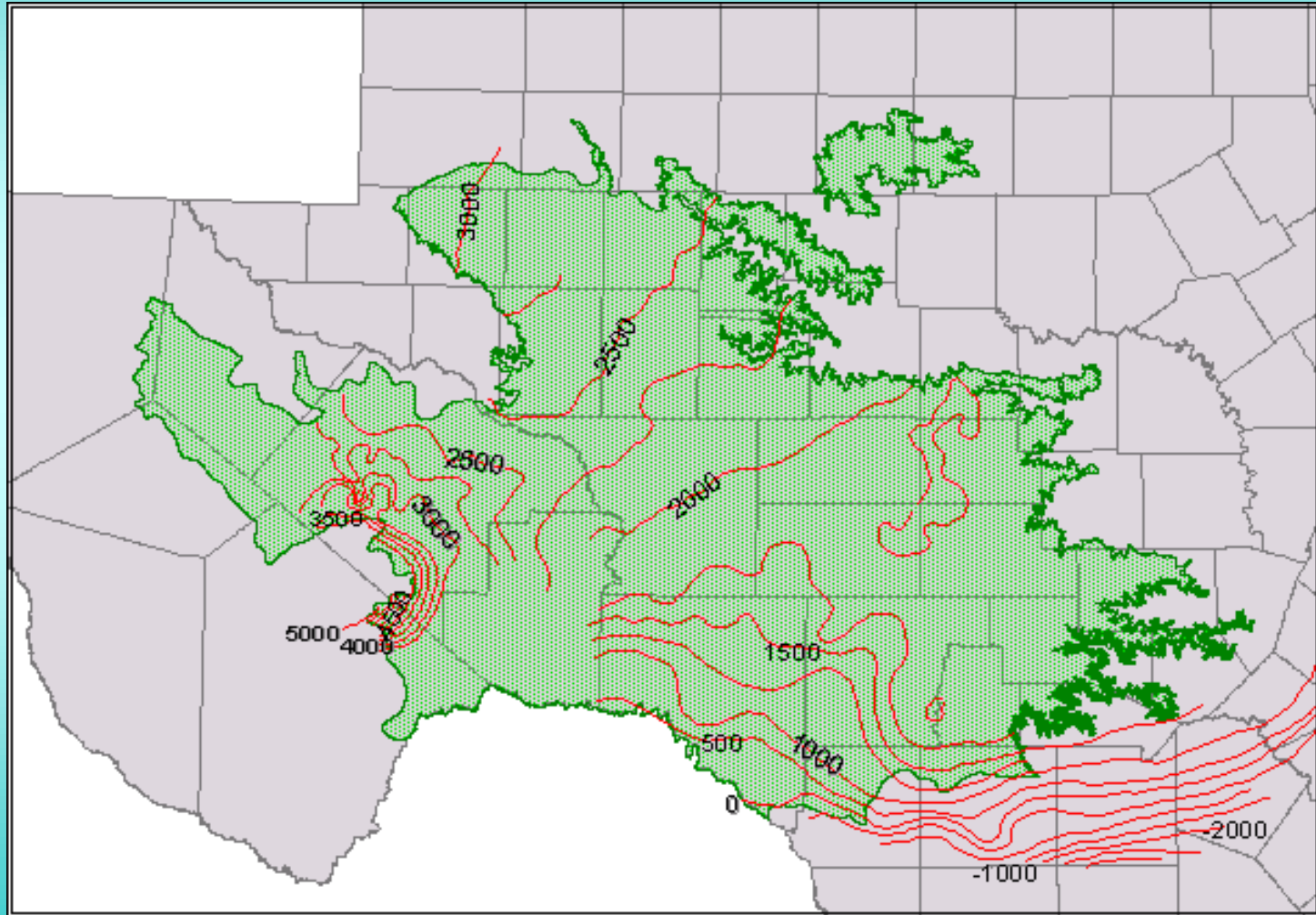
# Structural Base For Edwards Group



From Barker and Ardis, 1996

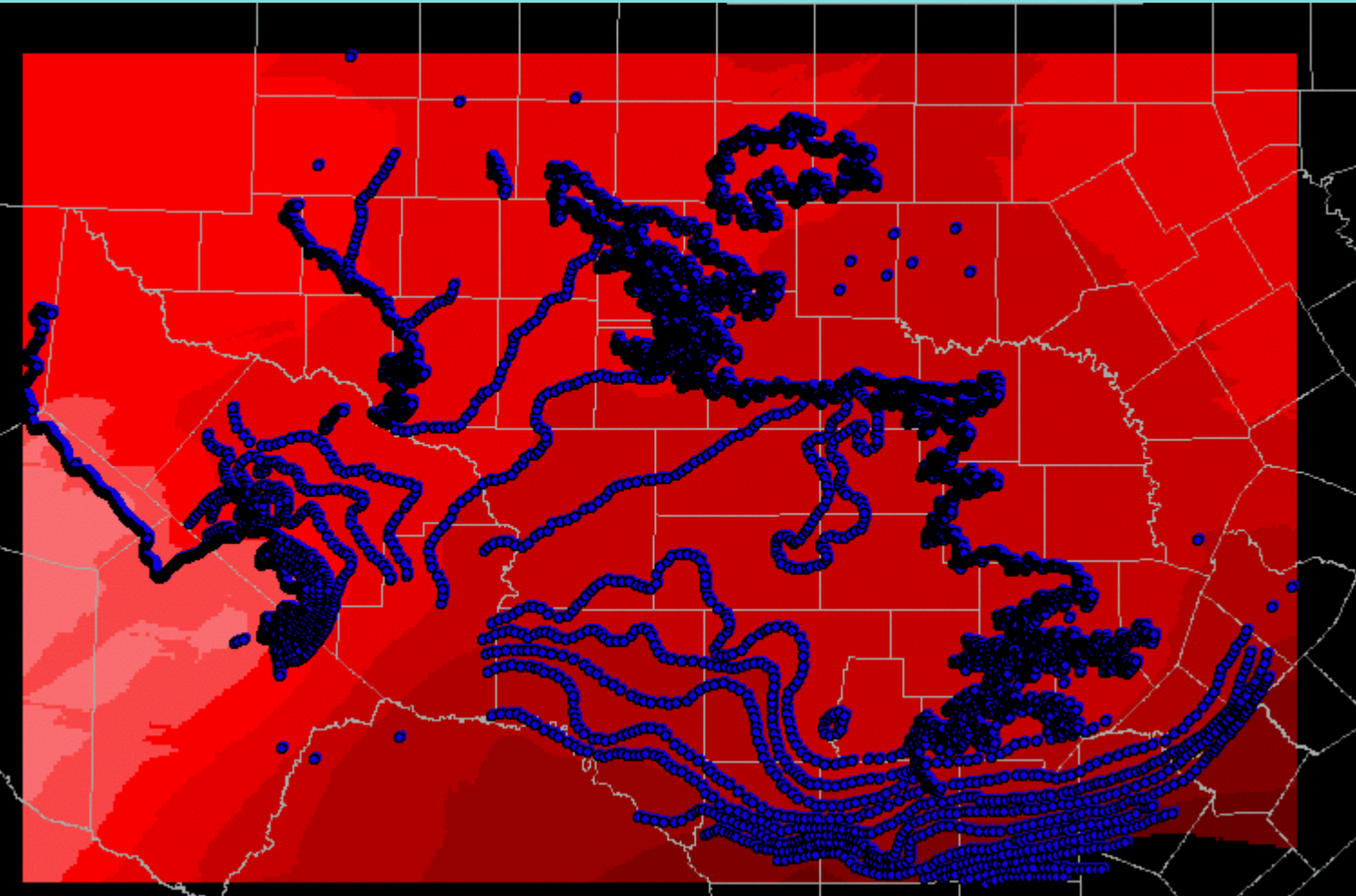
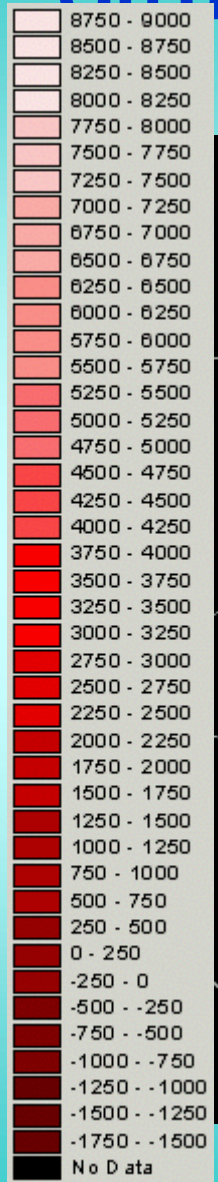


# Structural Base of Edwards Sediments



Adapted From - Barker and Ardis, 1996

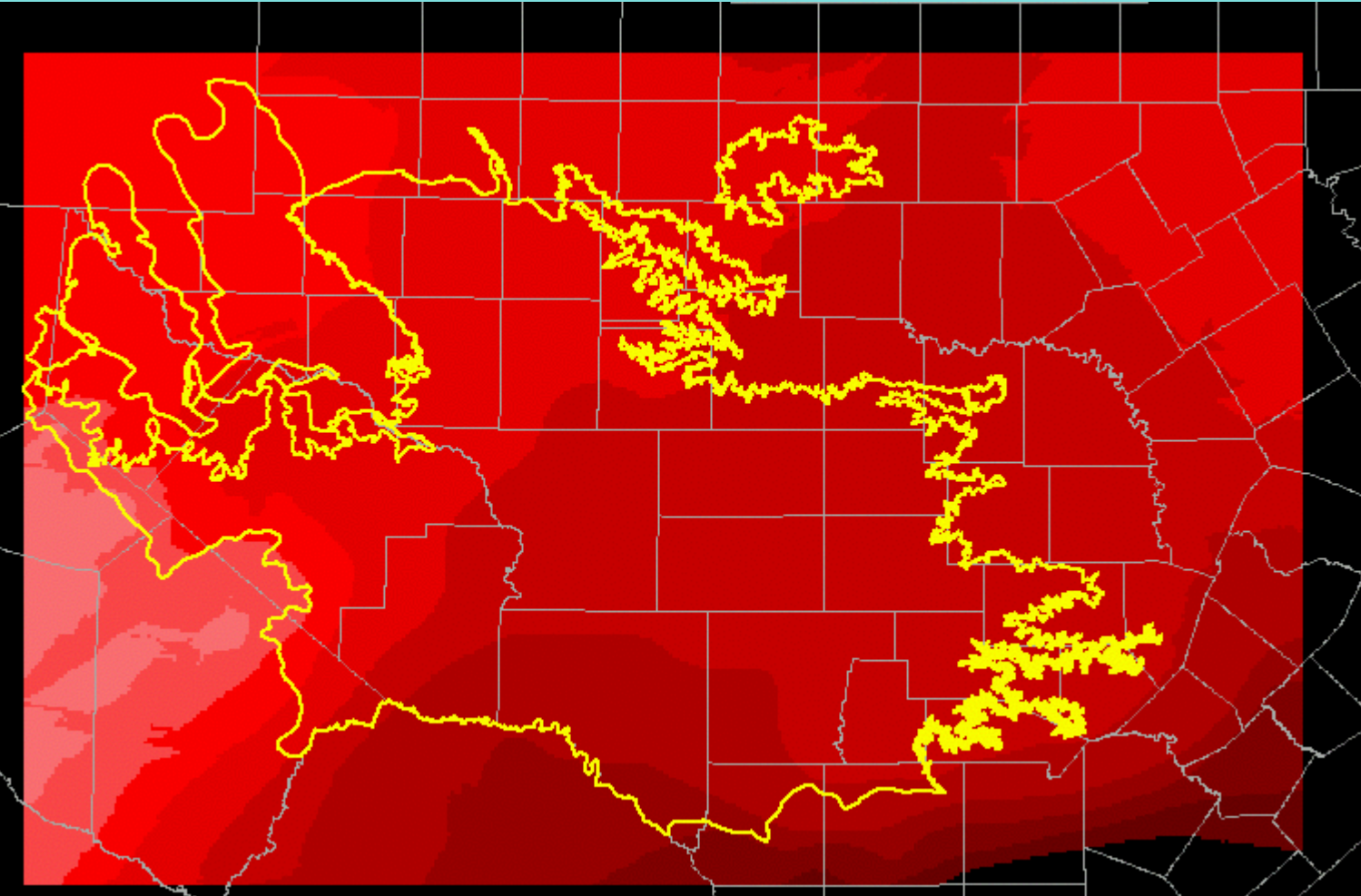
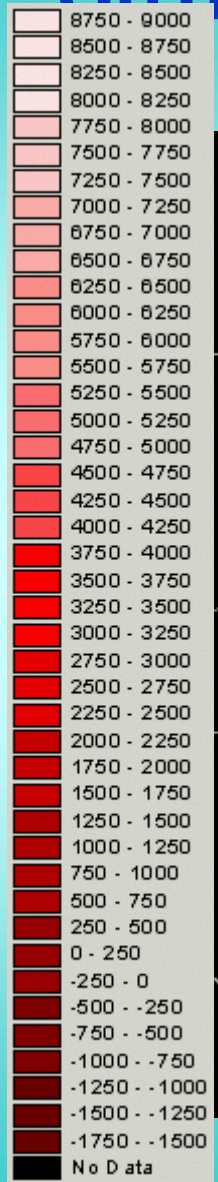
# Structural Base of Fredericksburg/Edwards



Bottom of Layer 2 Control Data



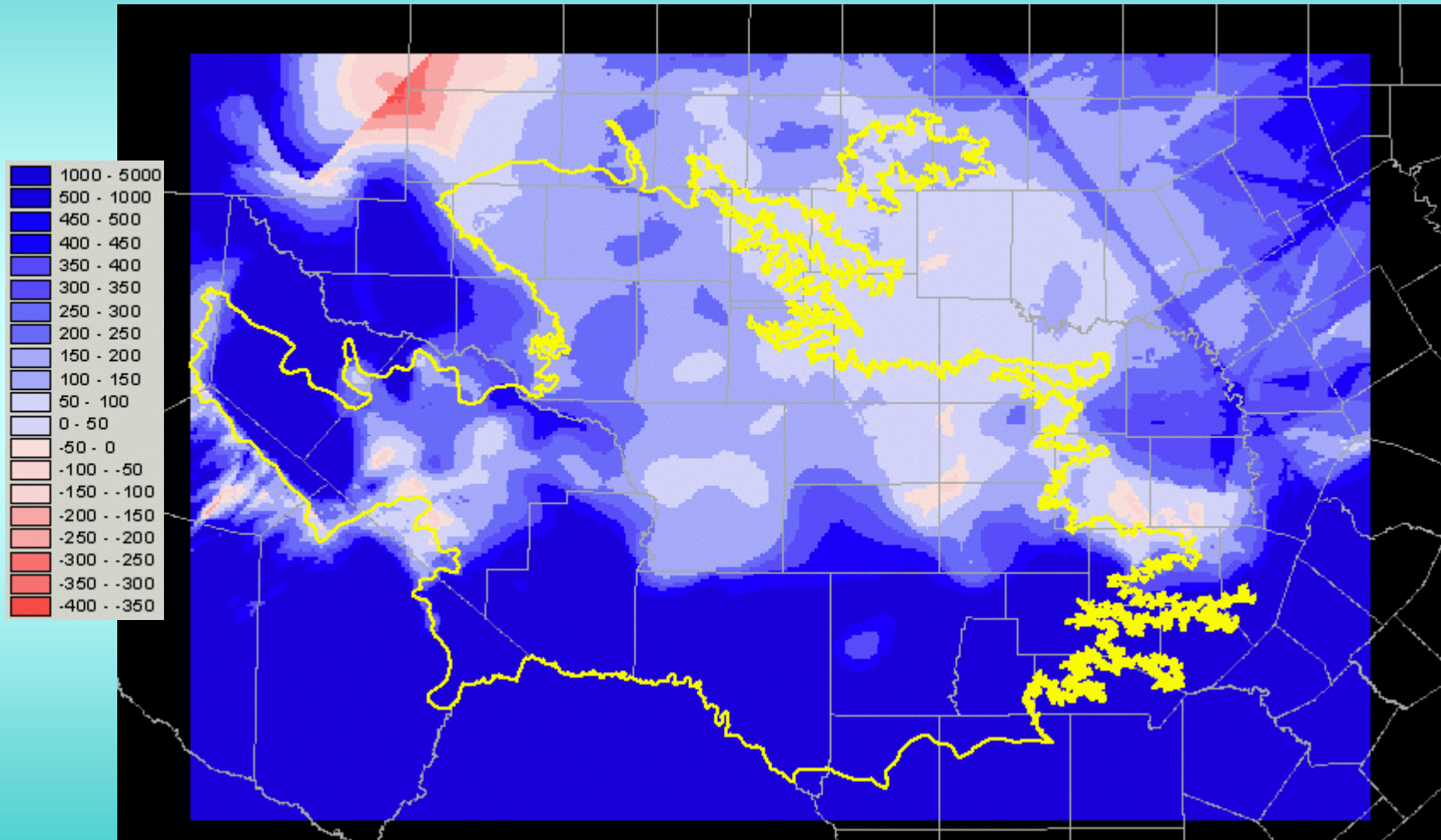
# Structural Base of Fredericksburg/Edwards



Bottom of Layer 2



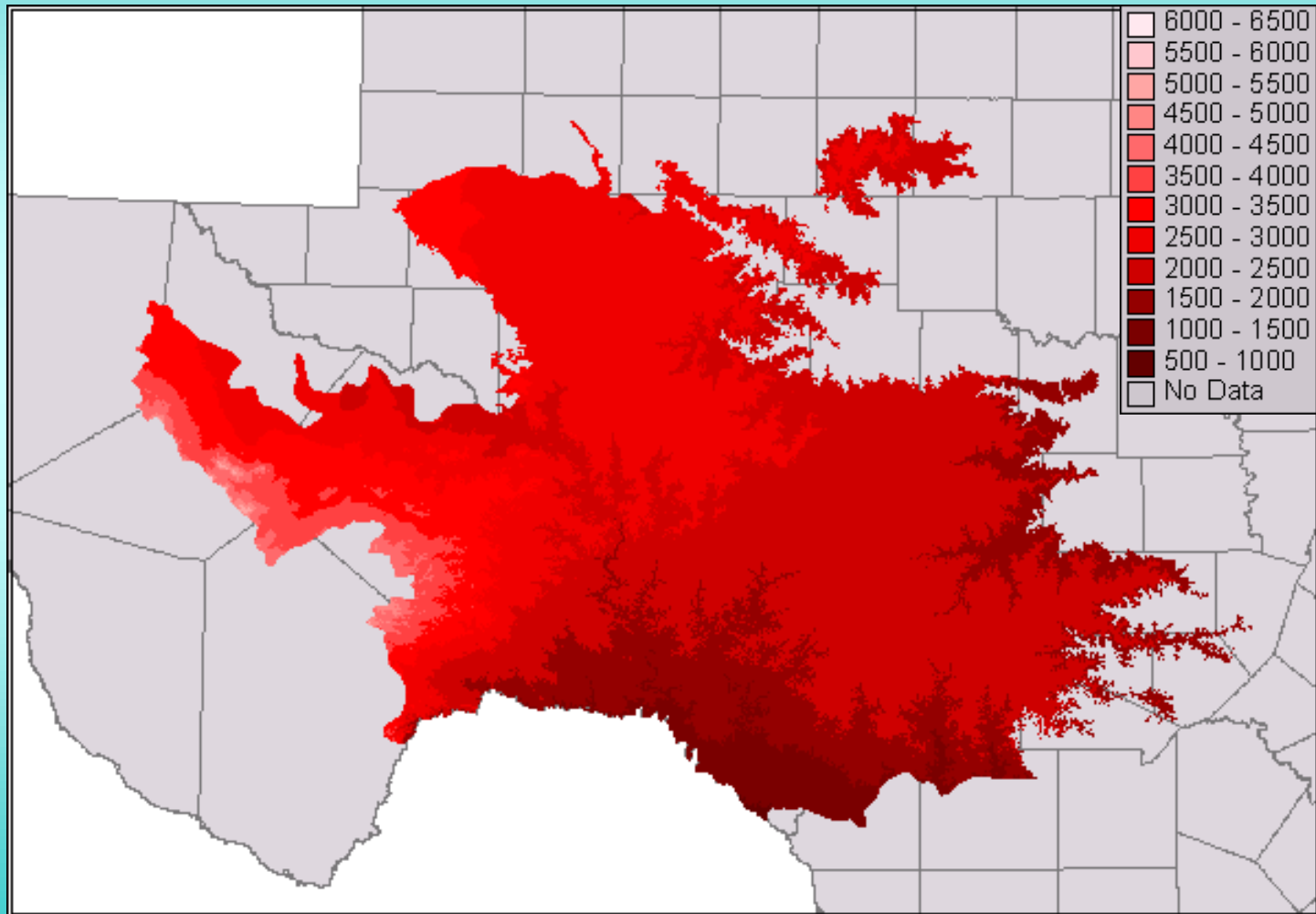
# Difference Between Layer 2 and Layer 3



Layer 2 - Layer 3

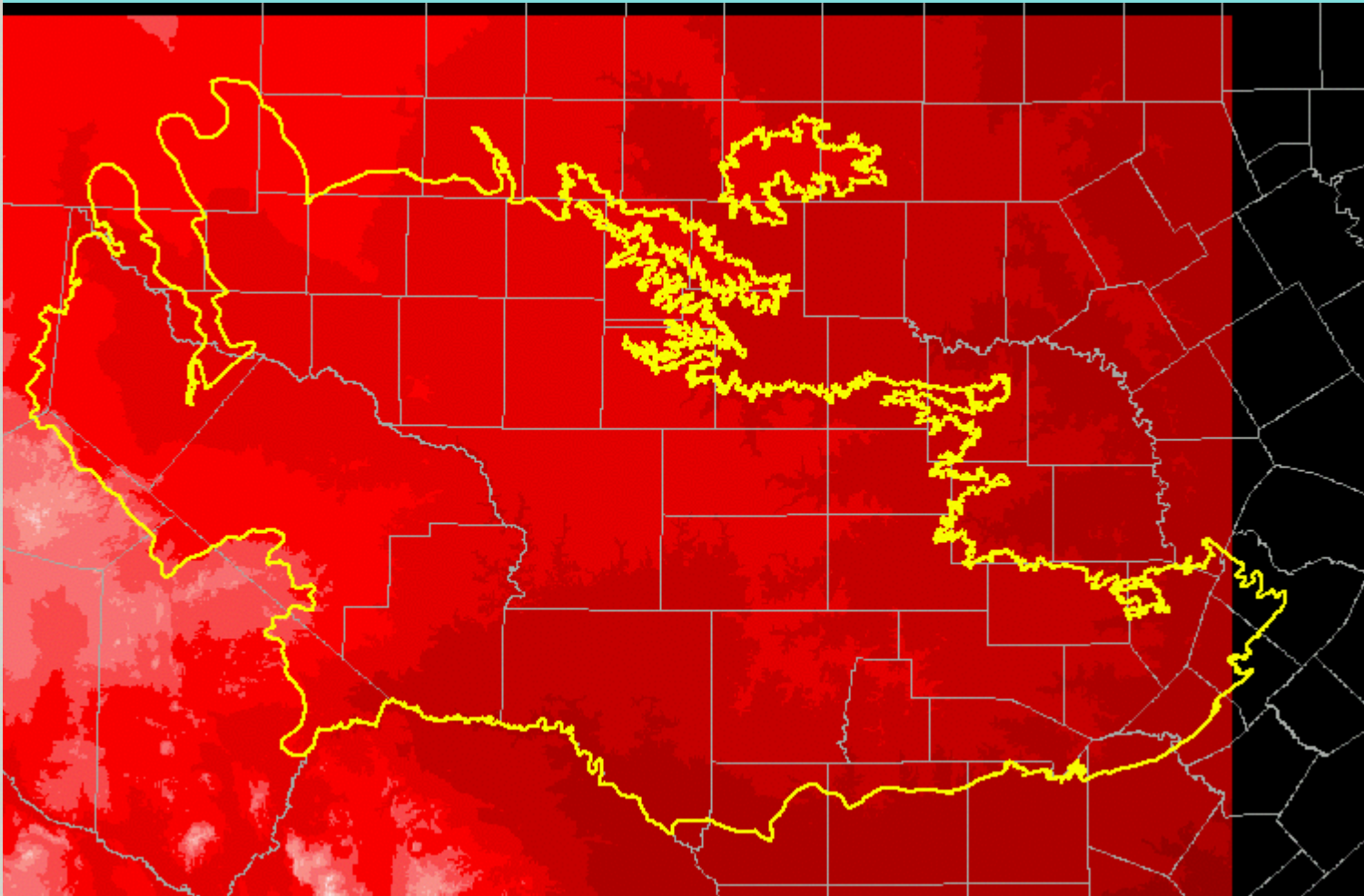
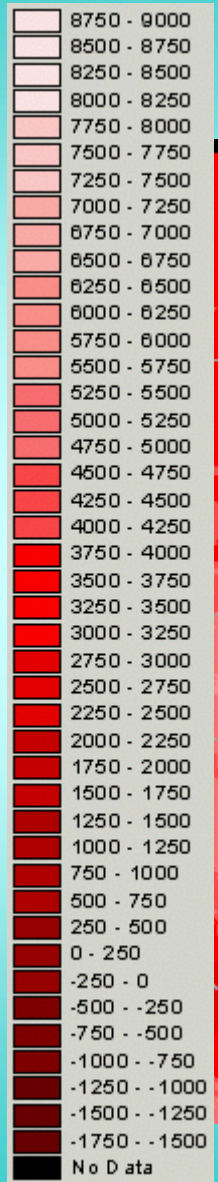


# Structural Top of Edwards-Trinity Sediments



From - USGS unpublished data, 2001

# Topographic Surface



3 Arc Second DEM





# Questions or Comments?

## 15 Minute Break!

We will reconvene for a few more minutes to finish discussion on model grid and pumping test status

FOR MORE INFO VISIT...

[www.twdb.state.tx.us/gam](http://www.twdb.state.tx.us/gam)

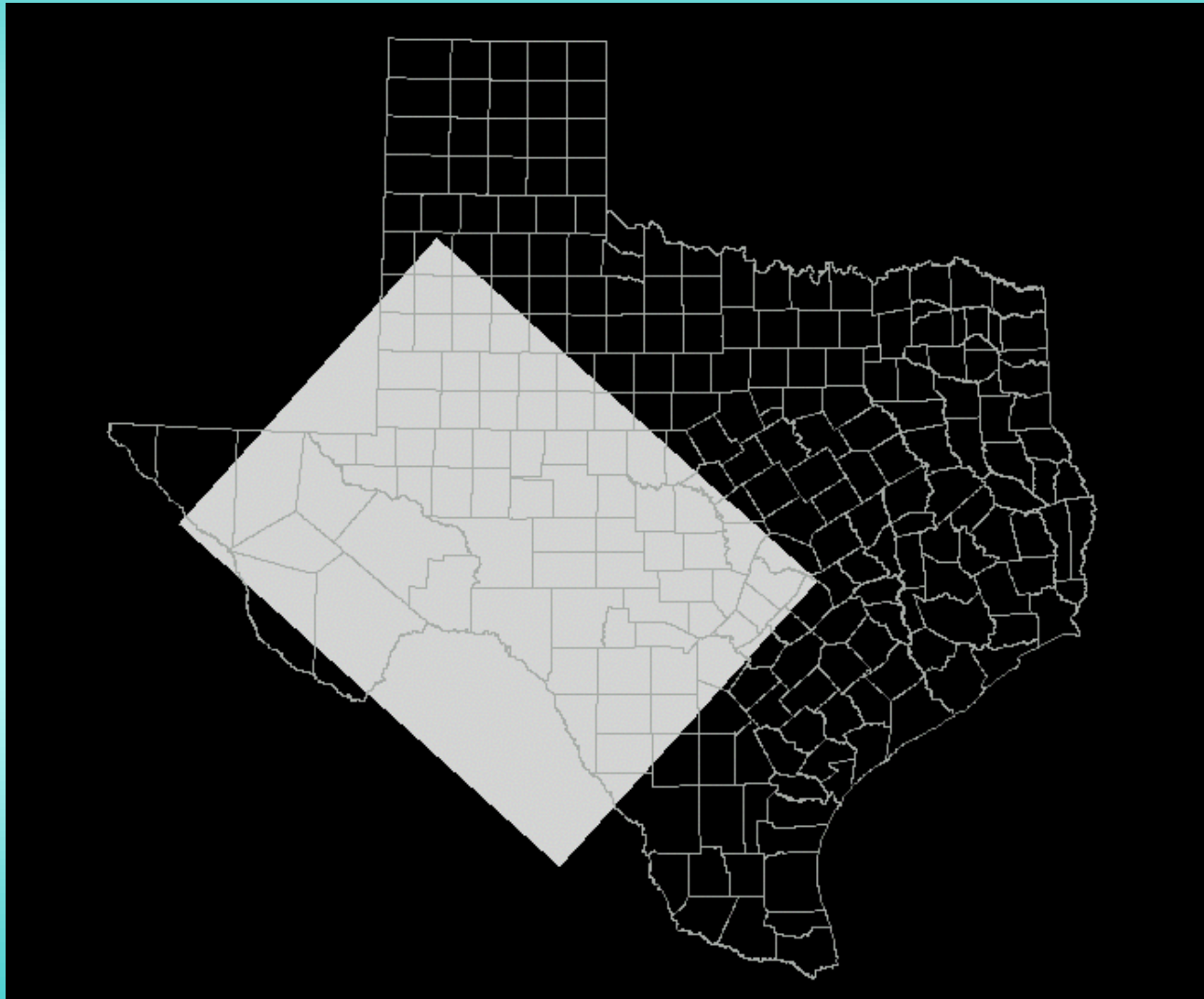


# Development of Model Grid for Edwards-Trinity Model

- 300 X 400 cell grid
- Rotated 42 degrees east of north (clockwise)
- 1 mile X 1mile cells
- 120,000 square miles
- Largest of all the GAM grids



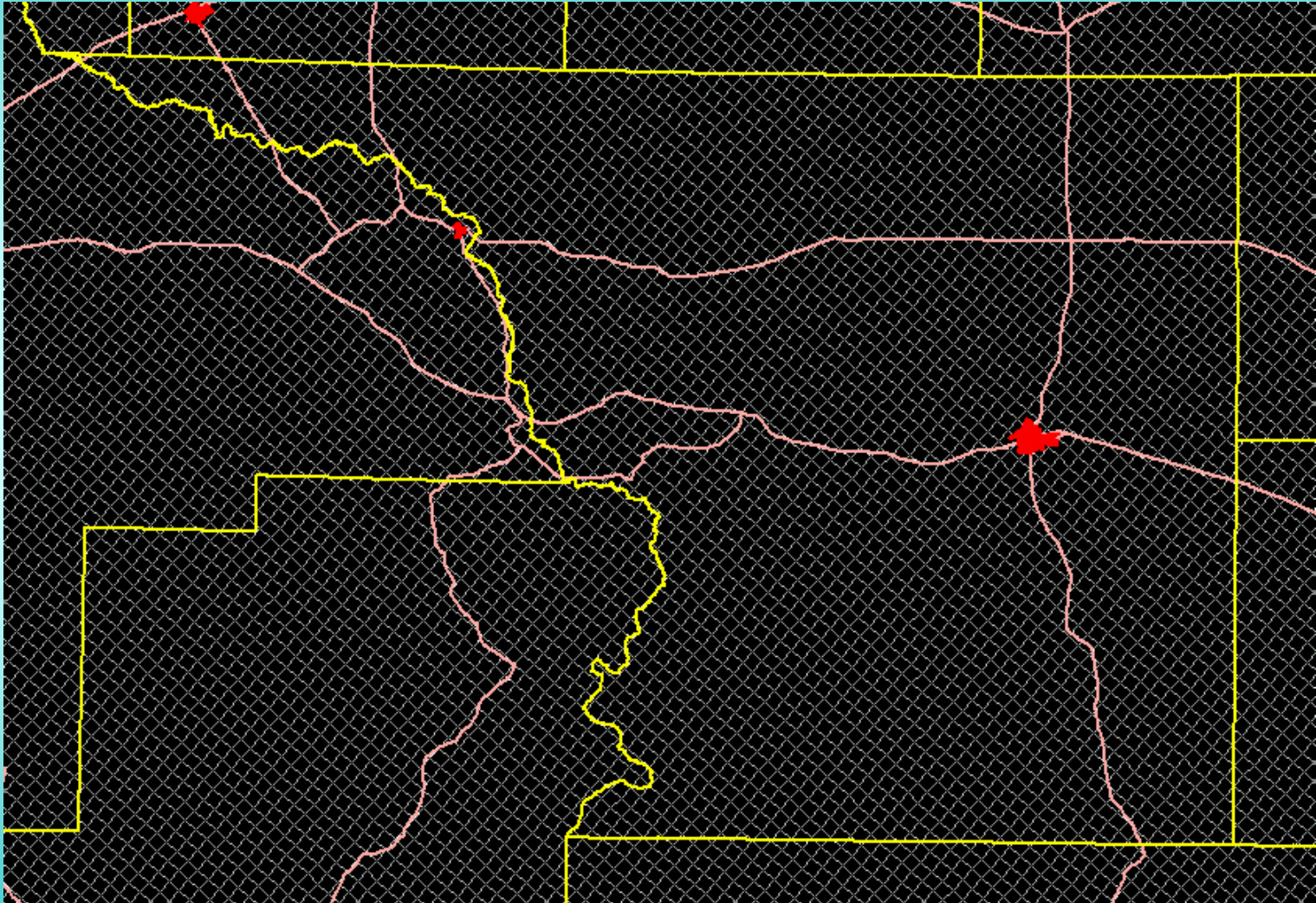
# Edwards-Trinity 300X400 Model Grid



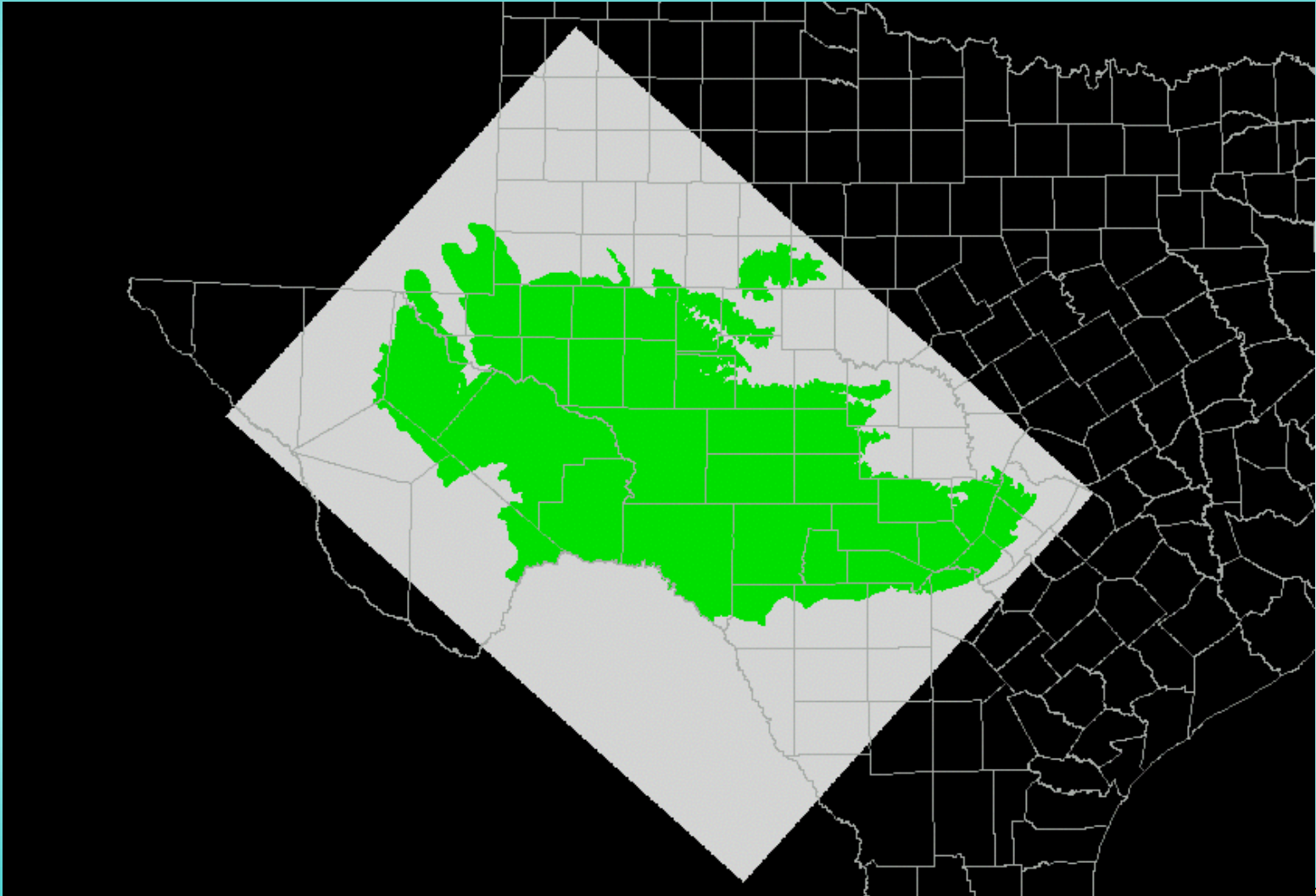
120,000 Square miles



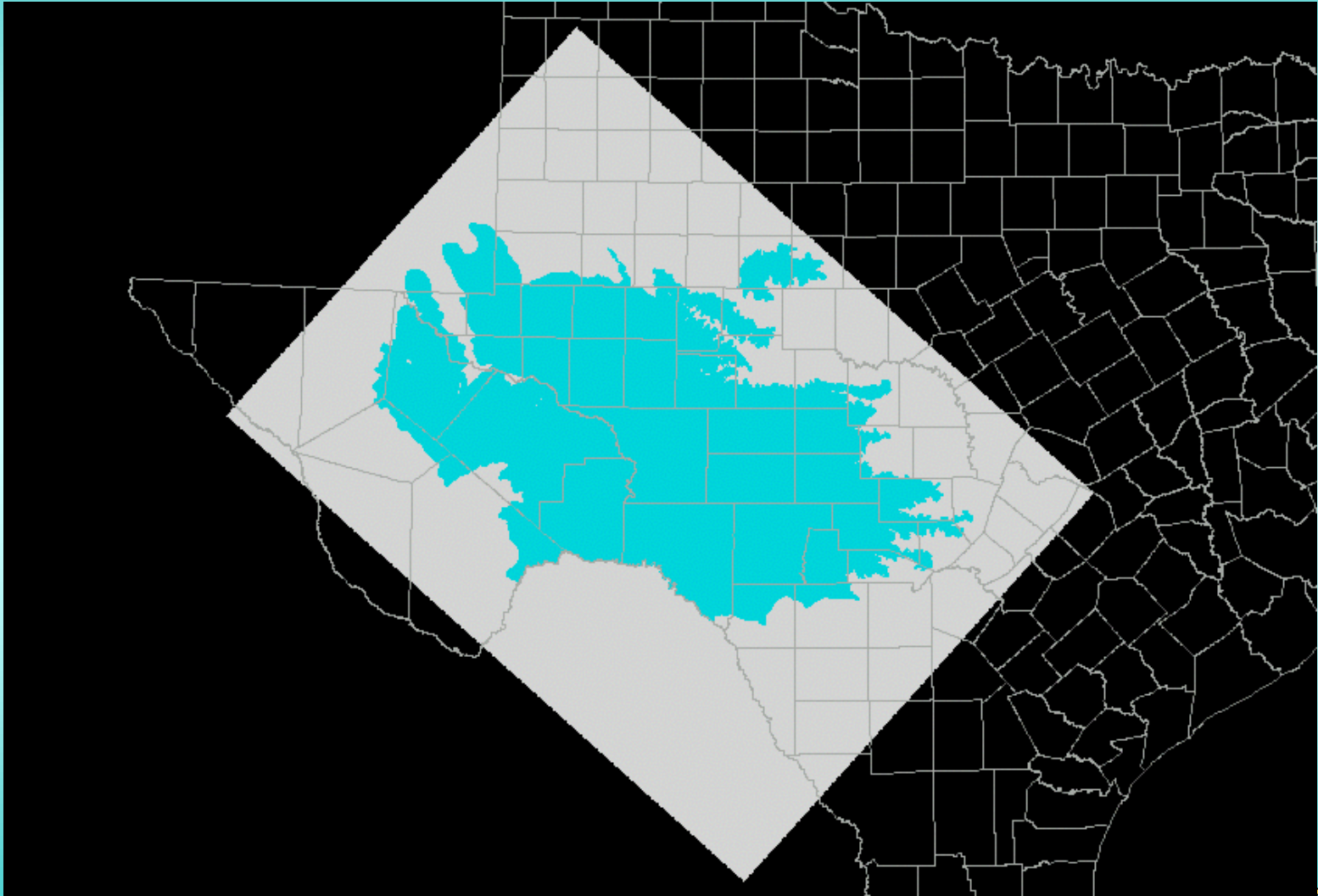
# Model Grid Relative to Crockett County



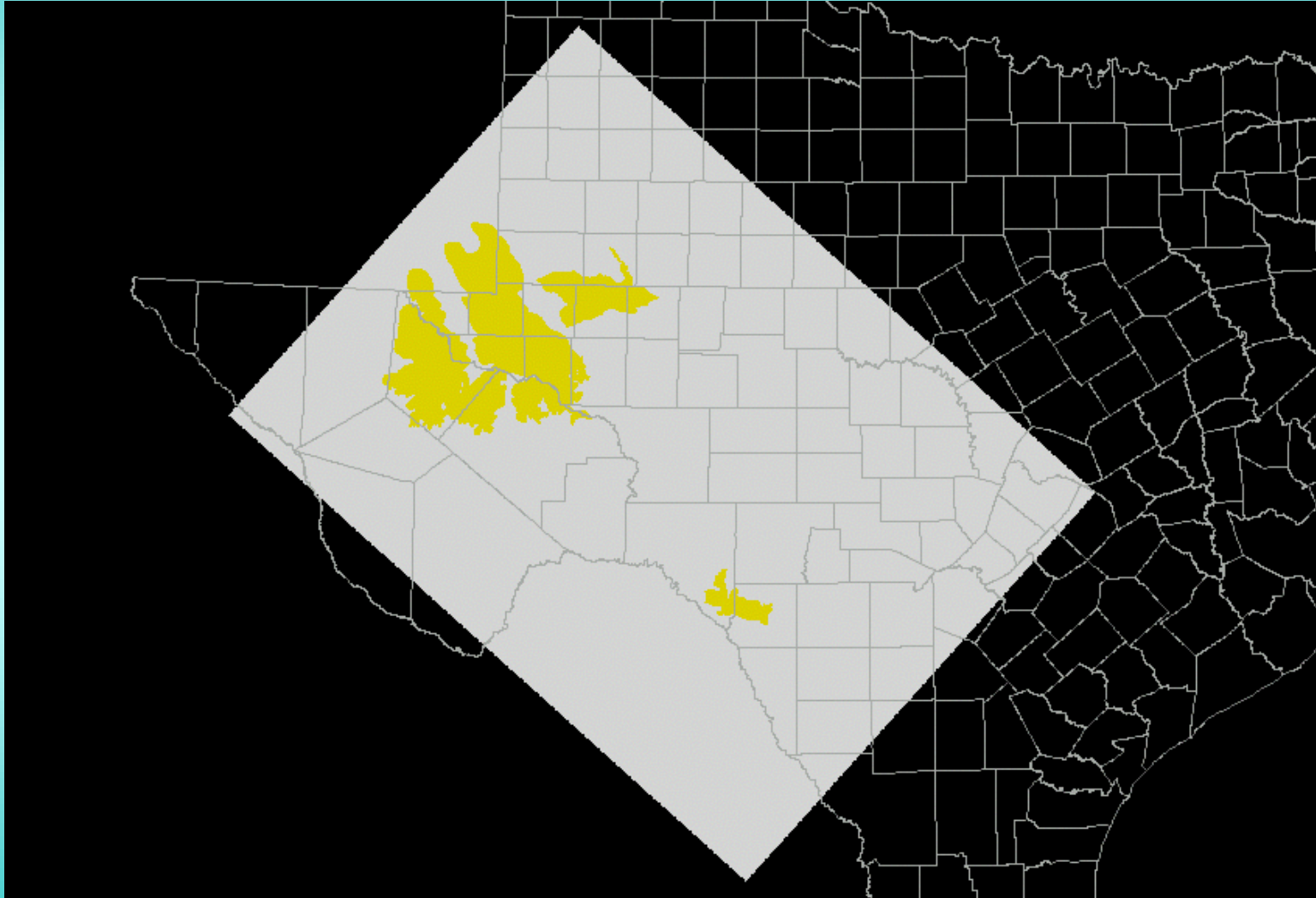
# Layer 3 Foot Print



# Layer 2 Foot Print



# Layer 1 Foot Print



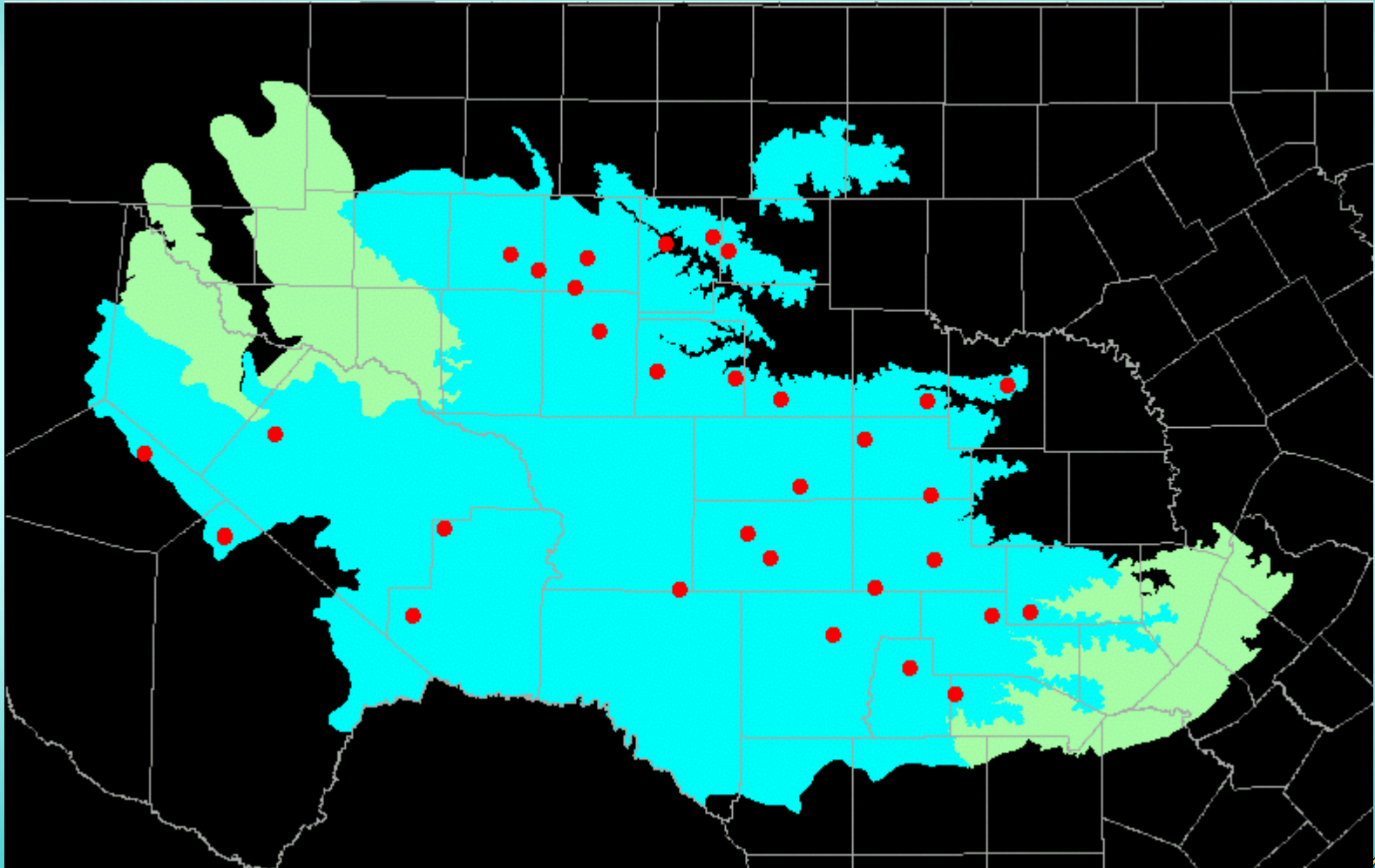
# Status of Pumping Tests and Hydraulic Properties

- TWDB goal of 39 new pumping tests will be met as part of the Edwards-Trinity GAM initiative
- TWDB groundwater database searched for specific capacity tests
- TNRCC specific capacity tests acquired
- Additional pumping tests were selected from literature review





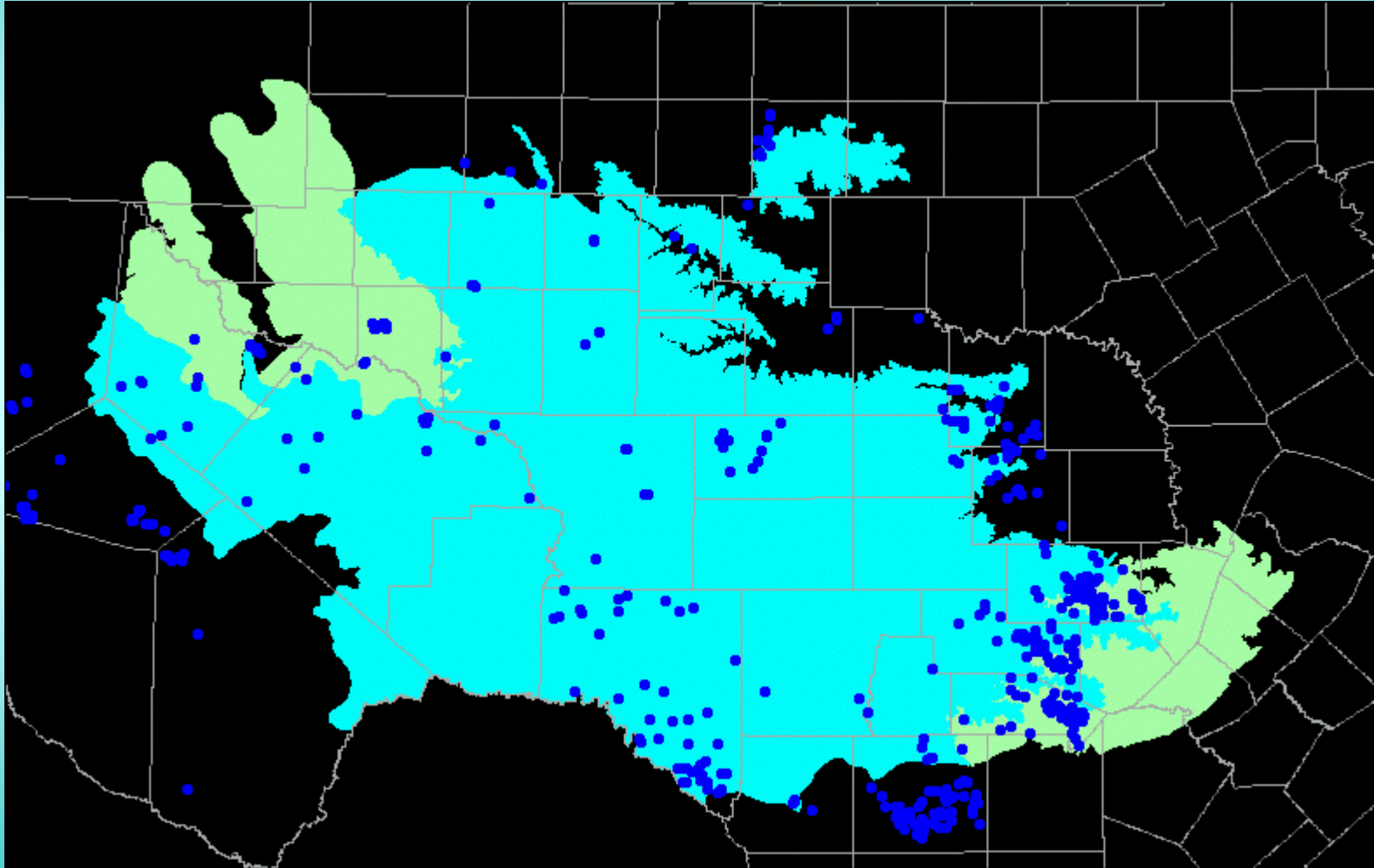
# Pumping Tests from Current TWDB GAM



35 Tests Completed with 4 More Currently Underway



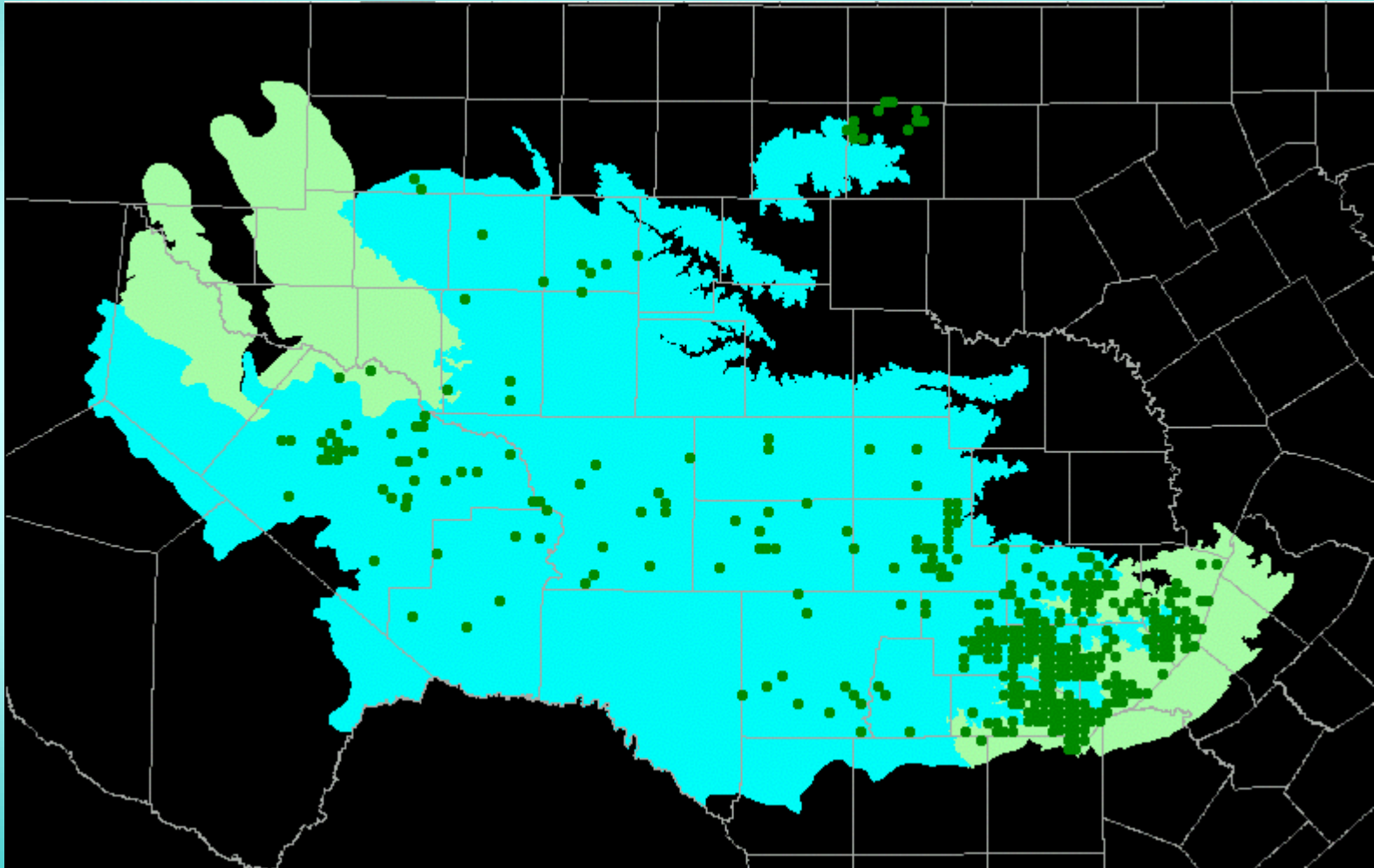
# Specific Capacity Tests from TWDB Database



About 369 Tests Found



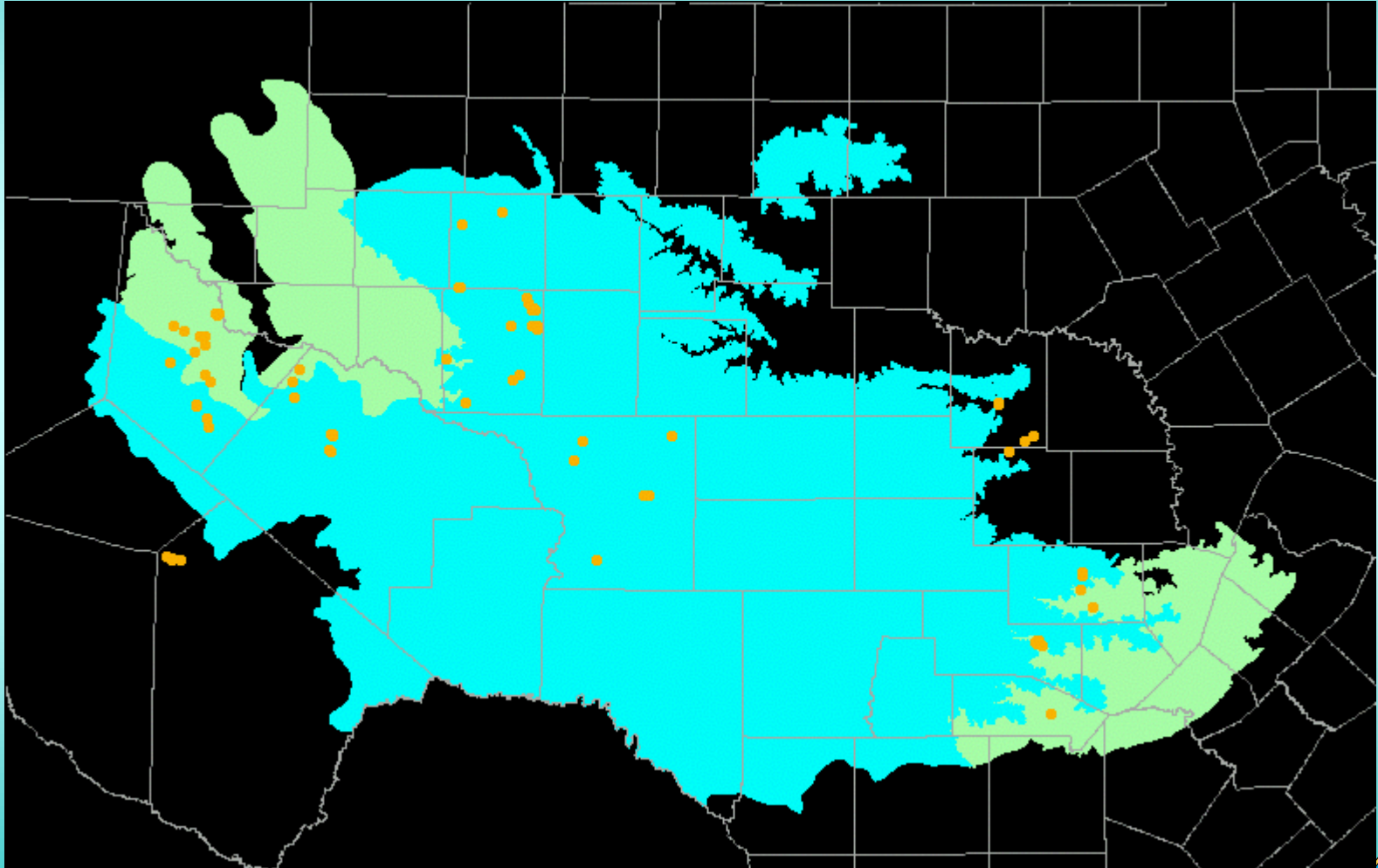
# Specific Capacity Tests from TNRCC



About 879 Tests Found



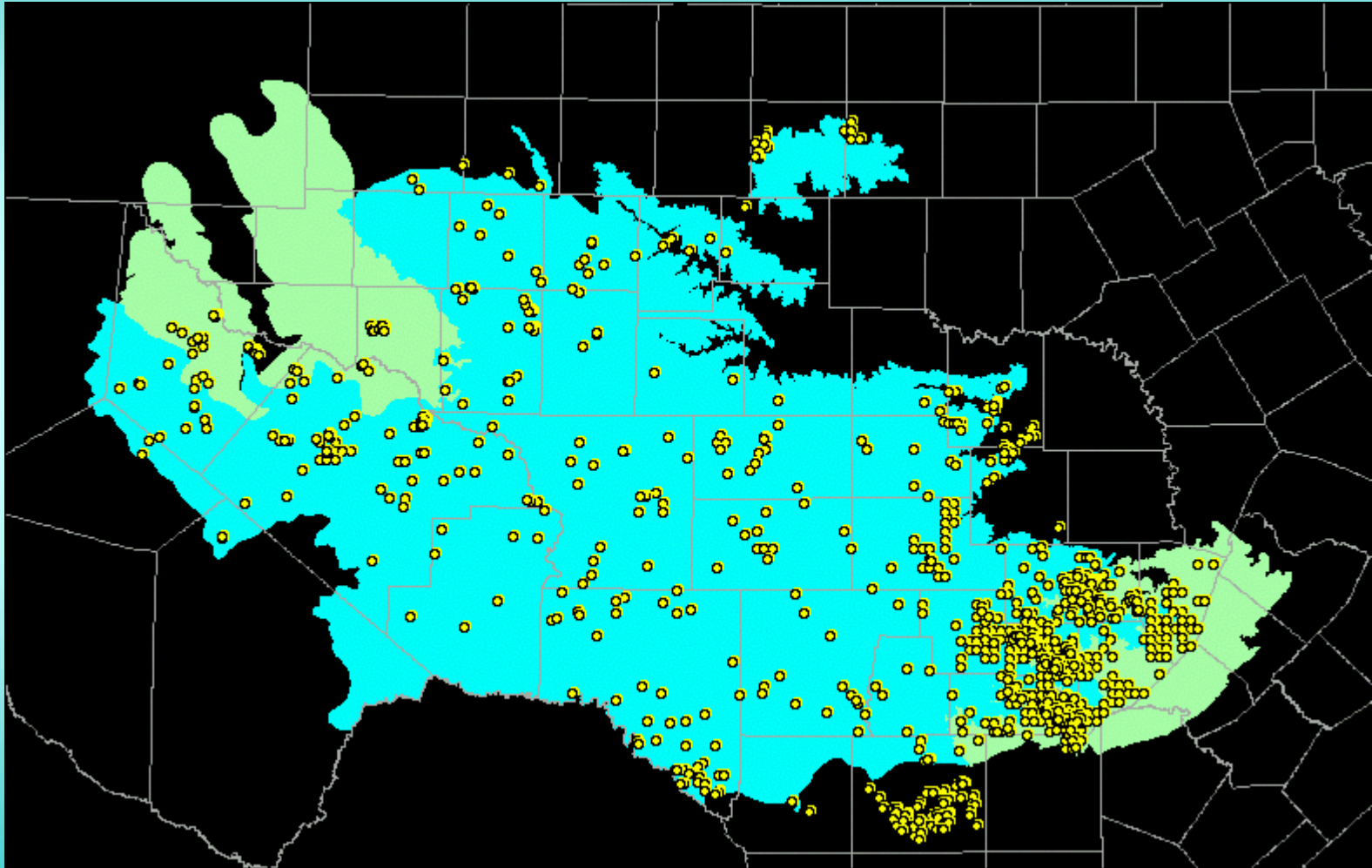
# Pumping Tests from Literature Review



About 87 Tests Found



# Data Density for Hydraulic Properties



Over 1350 Data Points Expected



# Current Project Status

- Completed Literature Review
- Finalization of Conceptual Model
- Finalization of Structure Geometry
- Completed 36 of 39 New Pumping Tests
- Finalization of ALL Data Collection
- Steady-State Water Levels Analysis
- Continued Data Processing and Analysis



# Potential Topics For ET SAF 5

- Final Structural Geometry
- Final Hydraulic Property Distributions
- Introduce Pumpage Distributions
- Introduce Methods for Recharge and Evapotranspiration Estimates
- Steady-State Calibrations Methods



# Primary Literature Sources

- R. A. Barker and A. F. Ardis, *Hydrogeologic Framework of the Edwards-Trinity Aquifer System, West-Central Texas*, USGS Professional Paper 1421-B, 1996.
- L. E. Walker, *Occurrence, Availability, and Chemical Quality of Groundwater In The Edwards Plateau Region of Texas*, Texas Department of Water Resources Report 235, 1979.
- R. Rees and A. W. Buckner, *Occurrence and Quality of Groundwater In The Edwards-Trinity (Plateau) Aquifer in the Trans-Pecos Region of Texas*, Texas Department of Water Resources Report 255, 1980.
- E. L. Kuniansky and K. Q. Holligan, *Simulation of Flow in the Edwards-Trinity Aquifer System and Contiguous Hydraulically Connected Units, West-Central Texas*, USGS Water-Resources Investigation Report 93-4039, 1994.

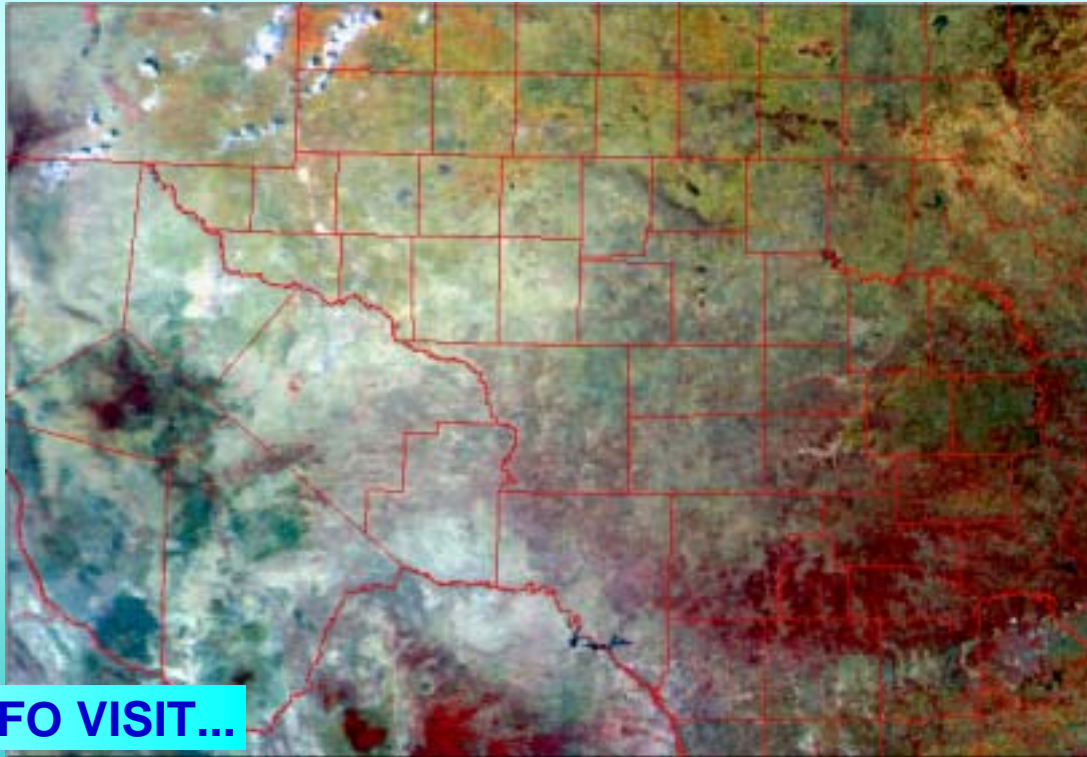




# Questions or Comments?

**End of ET SAF 4!**

Have a safe drive home ...



**FOR MORE INFO VISIT...**

**[www.twdb.state.tx.us/gam](http://www.twdb.state.tx.us/gam)**



**A U.S.-Mexico  
Borderlands View  
of the Edwards-Trinity  
Aquifer**

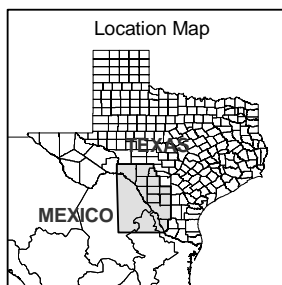
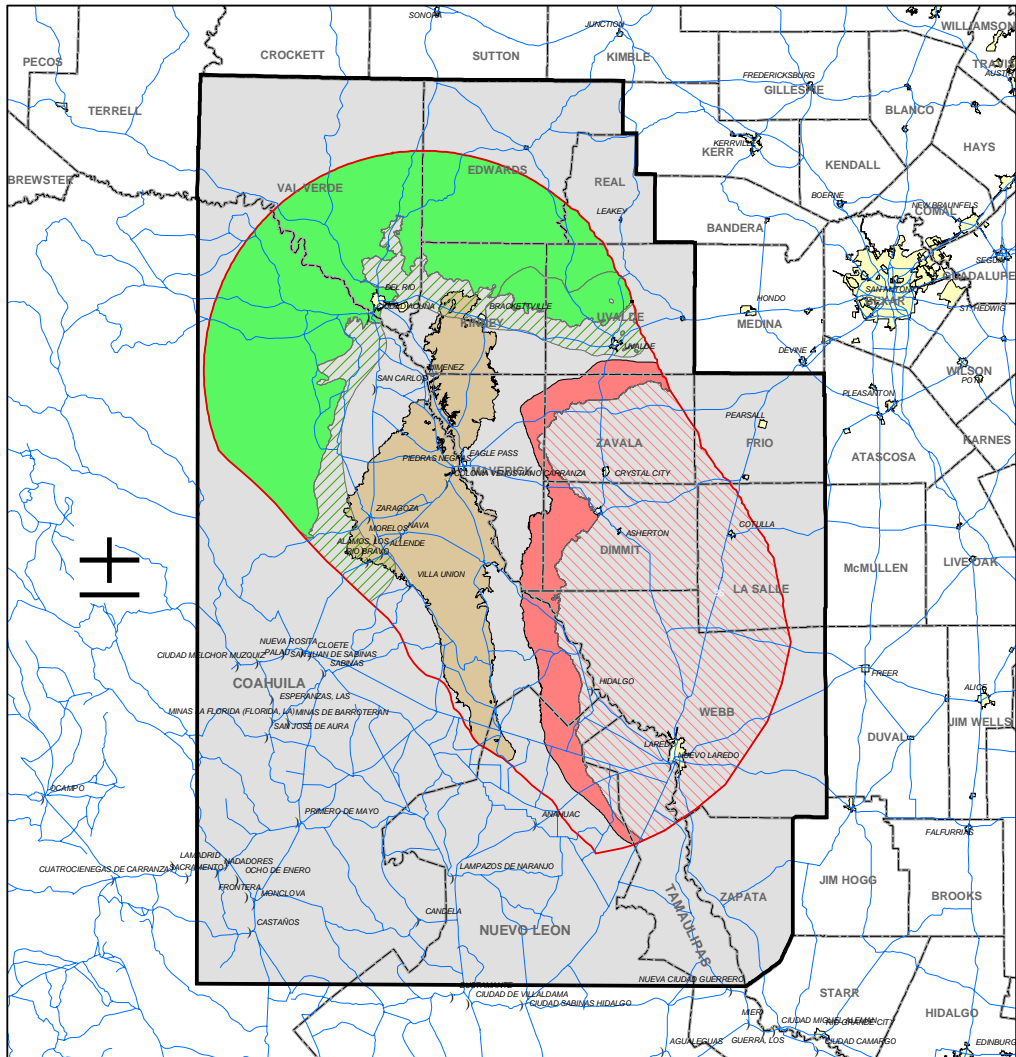
By

Radu Boghici

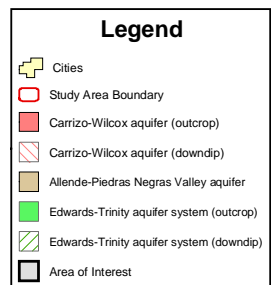
Texas Water

Development Board

# AQUIFERS WITHIN STUDY AREA



Map prepared by Mark Hayes  
Texas Water Development Board  
April 30, 2002





# Correlation Diagram

ERATHEM	SYSTEM	SERIES	GROUP	UNITED STATES		MEXICO	
				DEVILS RIVER TREND	MAVERICK BASIN		
CENOZOIC	Quaternary			Alluvium			
	Tertiary			Uvalde Gravel	Sabinas Conglomerate		
MESOZOIC	CRETACEOUS	GULFIAN		Anacacho Limestone	Taylor & Navarro Groups		
					Austin Group		
					Eagle Ford Group		
					Buda Limestone		
					Del Rio Clay		
		COMANCHEAN	Washita Group	Devils River Formation	Salmon Peak Formation		
			Fredericksburg Group	Devils River Formation	McKnight Formation		
					West Nueces Formation		
		Trinity Group	Maxon Sand	Glen Rose Limestone			
			Basal Cretaceous		Pearsall Fm.	La Pena Formation	
	Sand		Sligo Fm.	Cupido Formation			
			Hosston Formation				
PALEOZOIC	PERMIAN			Undivided			
	Cambrian through Pennsylvanian			Rocks of Ouachita Structural Belt			

## EXPLANATION

- Allende - Piedras Negras Valley aquifer
- Cretaceous rocks not part of Edwards-Trinity aquifer system because they are discontinuous, unsaturated, or have low permeability
- Edwards-Trinity aquifer system

Modified from Barker et al., 1994, table 1

# Geologic Province Areas

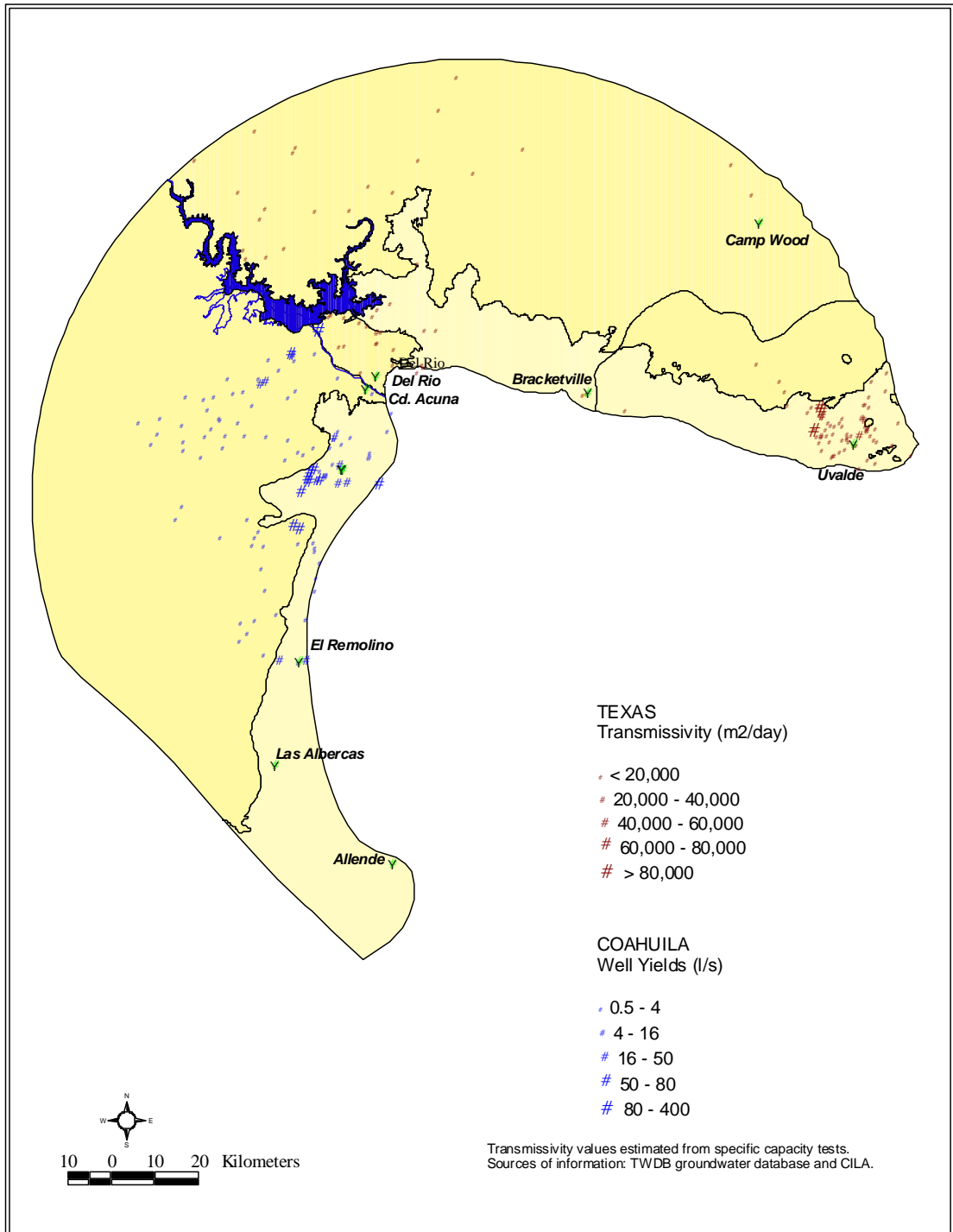


Map modified from Lozo and Smith (1964) and Smith (1970).

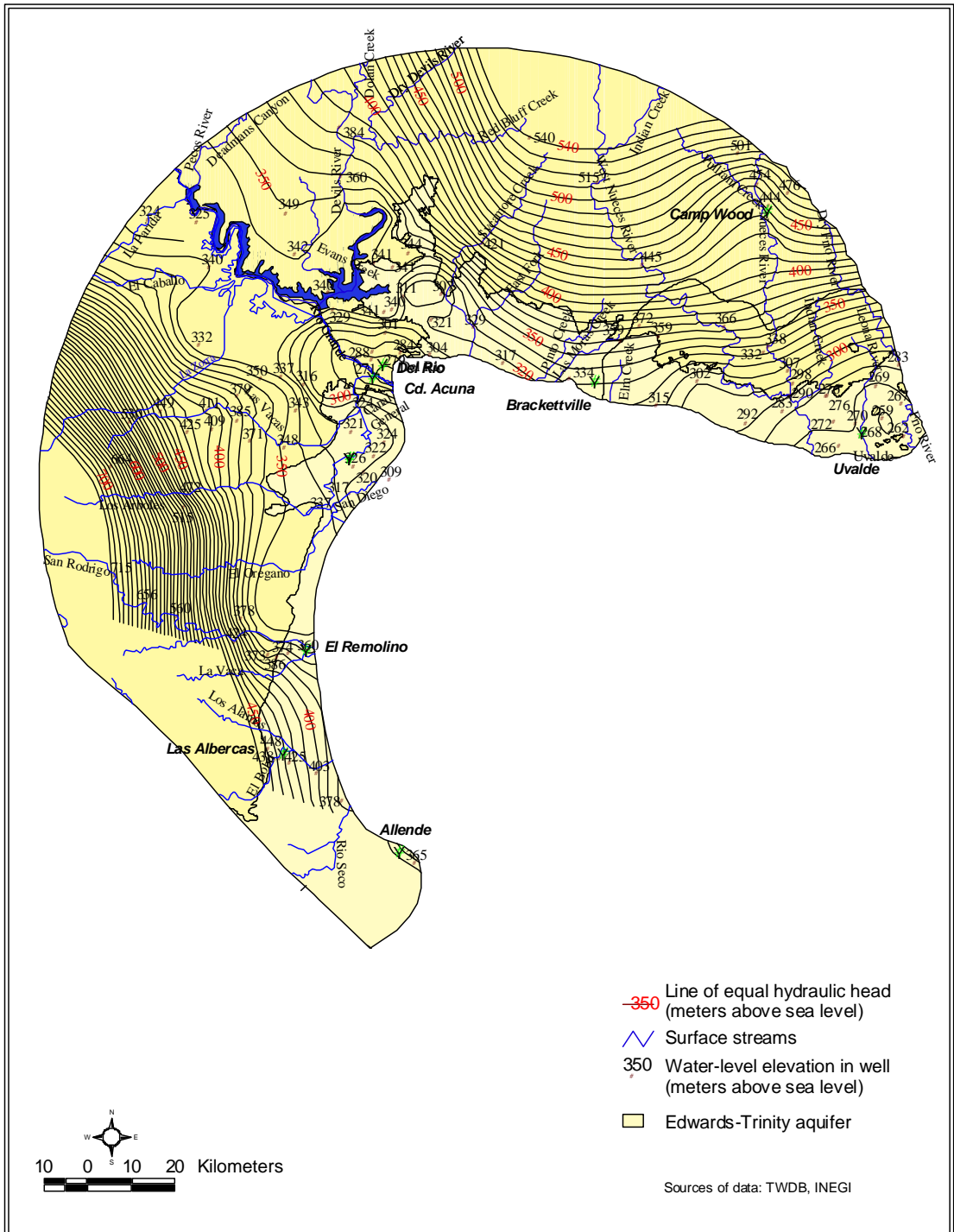
NORTHERN AREA		CENTRAL AREA	SOUTHERN AREA
Coahuila	Texas		
Buda Limestone	Buda Limestone	Buda Limestone	
Del Rio Clay	Del Rio Clay	Del Rio Clay	
WASHITA GROUP	mudstone	Fort Lancaster Formation	Salmon Peak Formation
			Devils River Formation
FREDERICKSBURG GROUP	Aurora	Fort Terrett Formation	McKnight Formation
			West Nueces Formation
Rocks of		Trinitian	Age

Modified from Smith (1970), figure 15.

# Distribution of Transmissivity and Well Yields

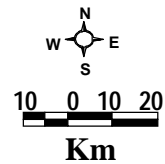
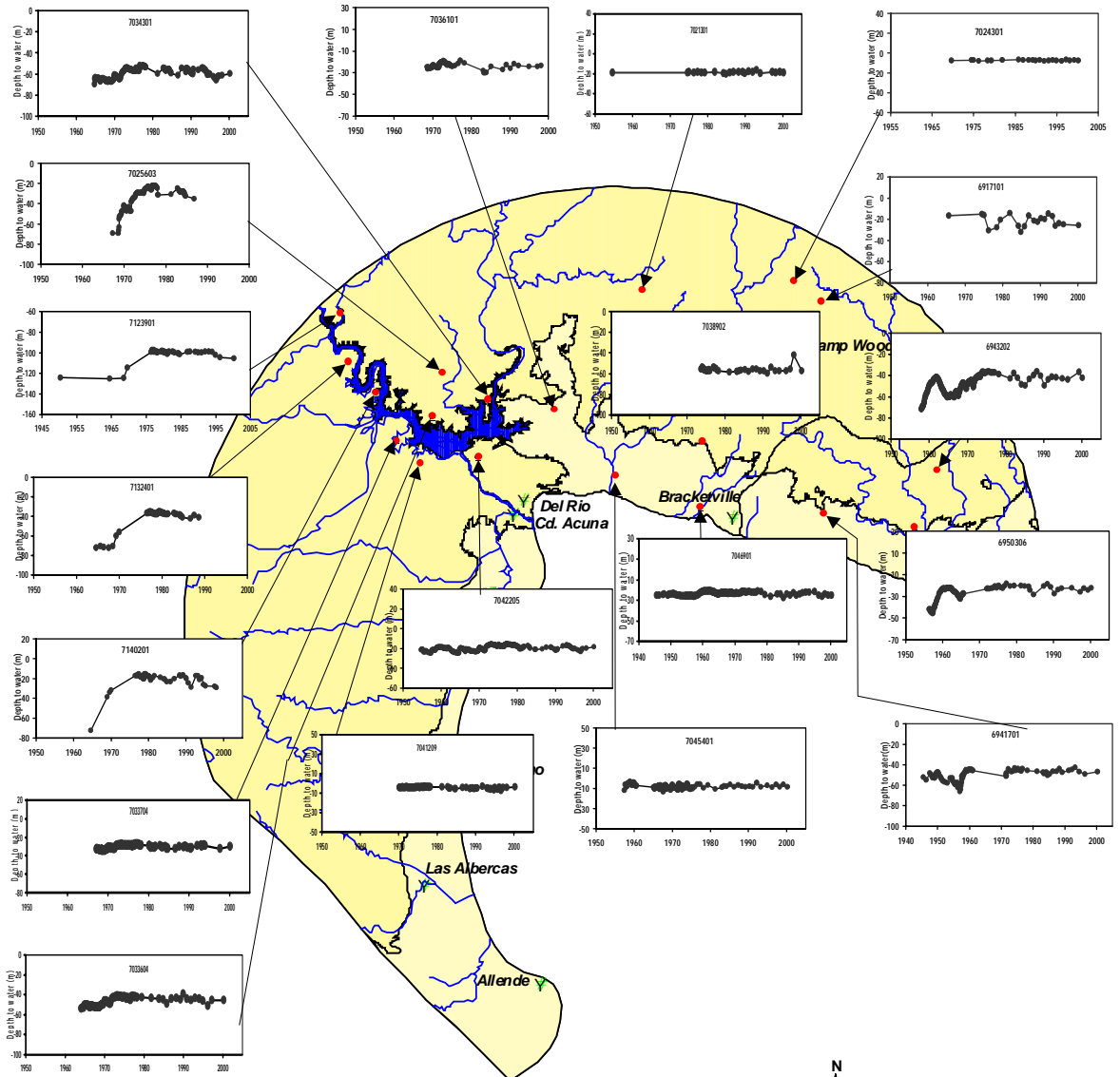


# Potentiometric Surface Map

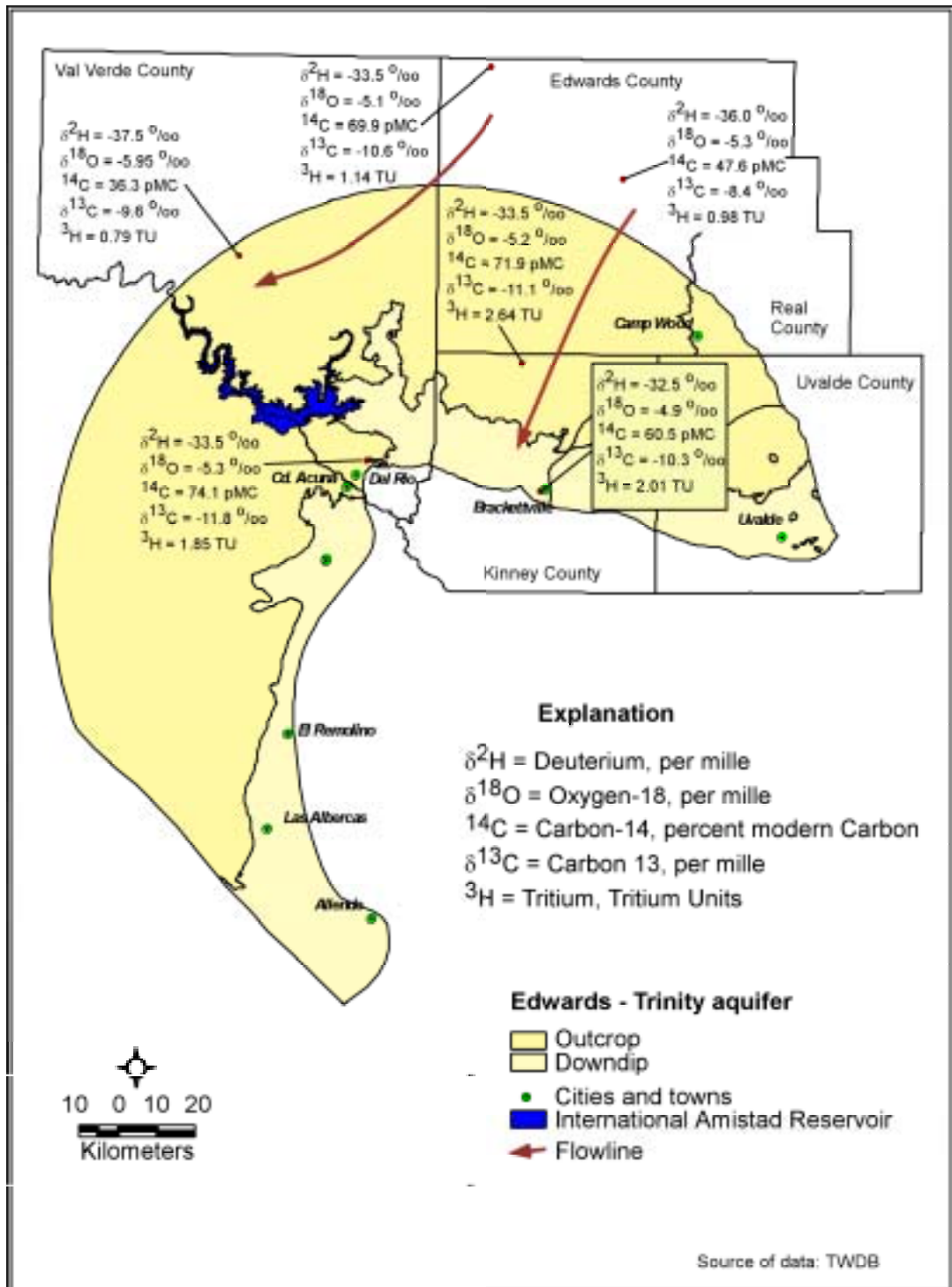




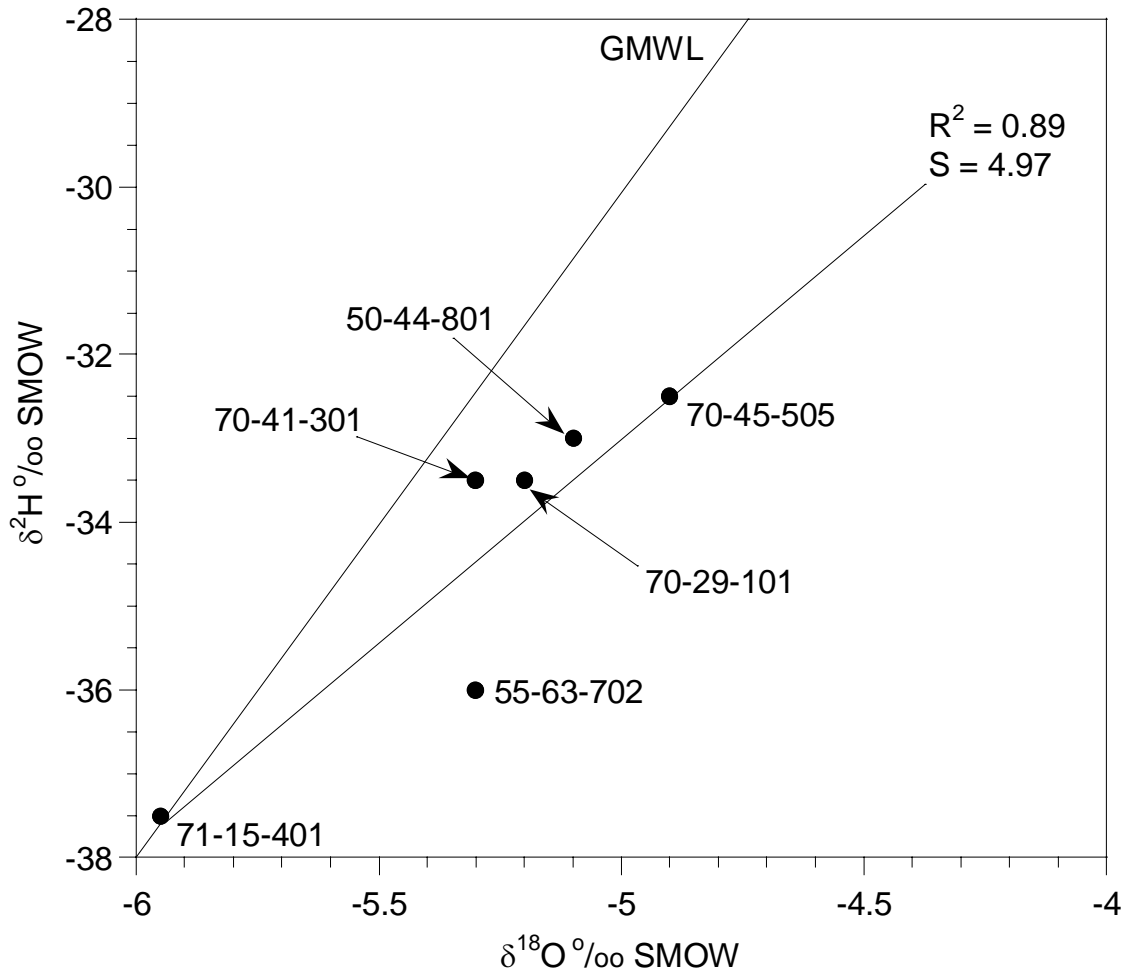
# Well Hydrographs



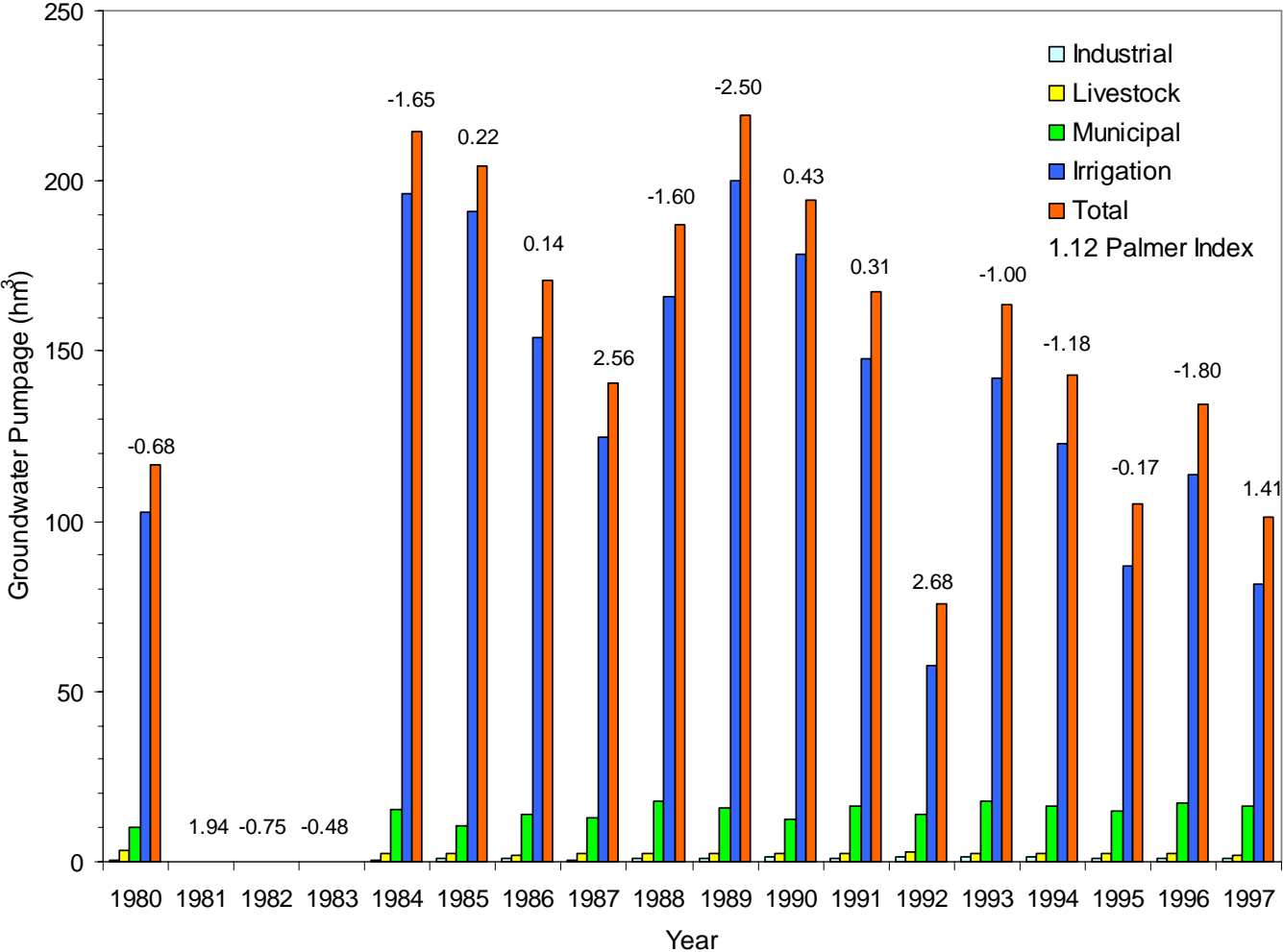
# Distribution of $\delta^2\text{H}$ , $\delta^{18}\text{O}$ , $^{14}\text{C}$ , $\delta^{13}\text{C}$ , and $^3\text{H}$



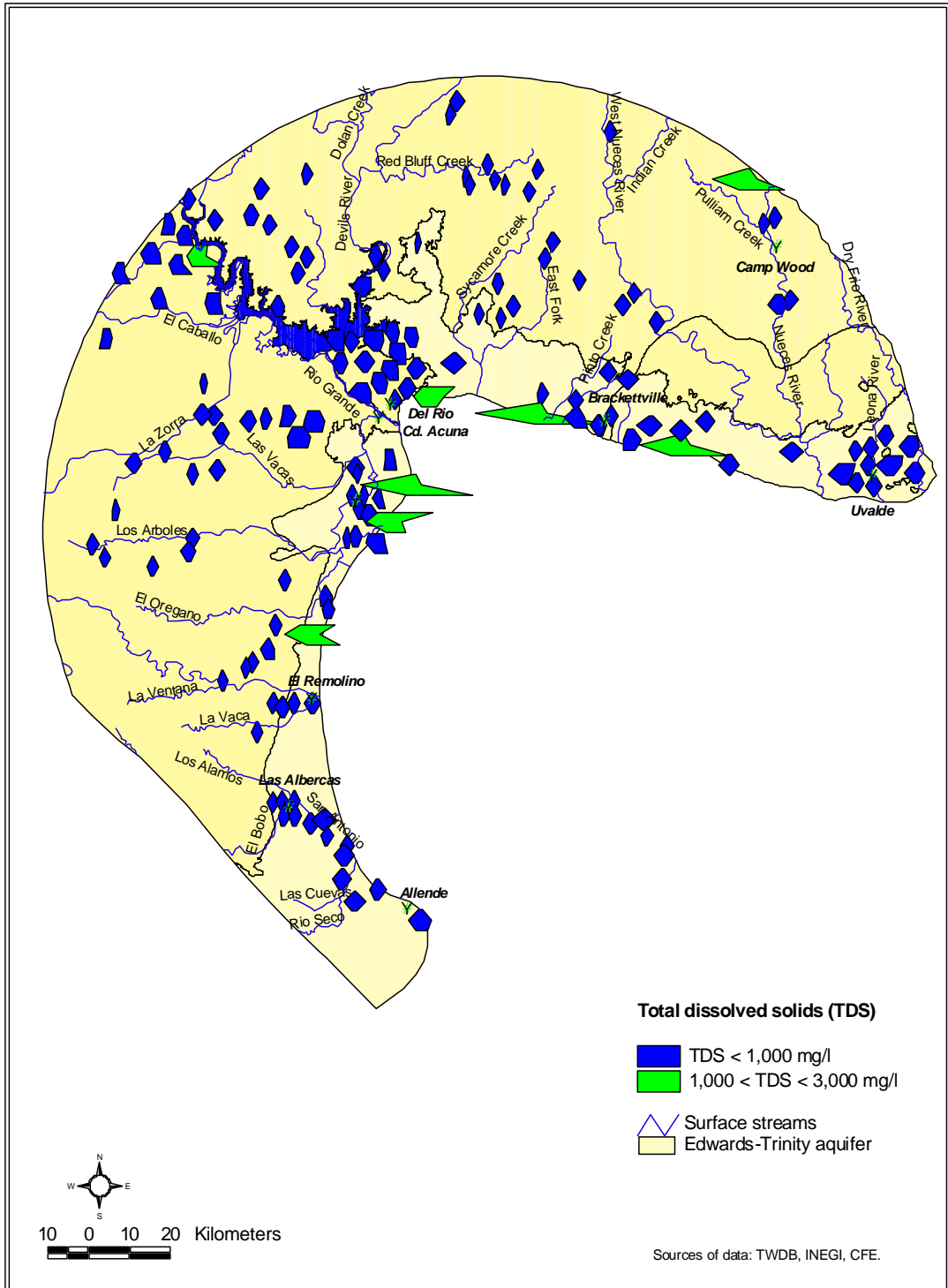
# Plot of $\delta^2\text{H}$ versus $\delta^{18}\text{O}$ For Edwards-Trinity Samples



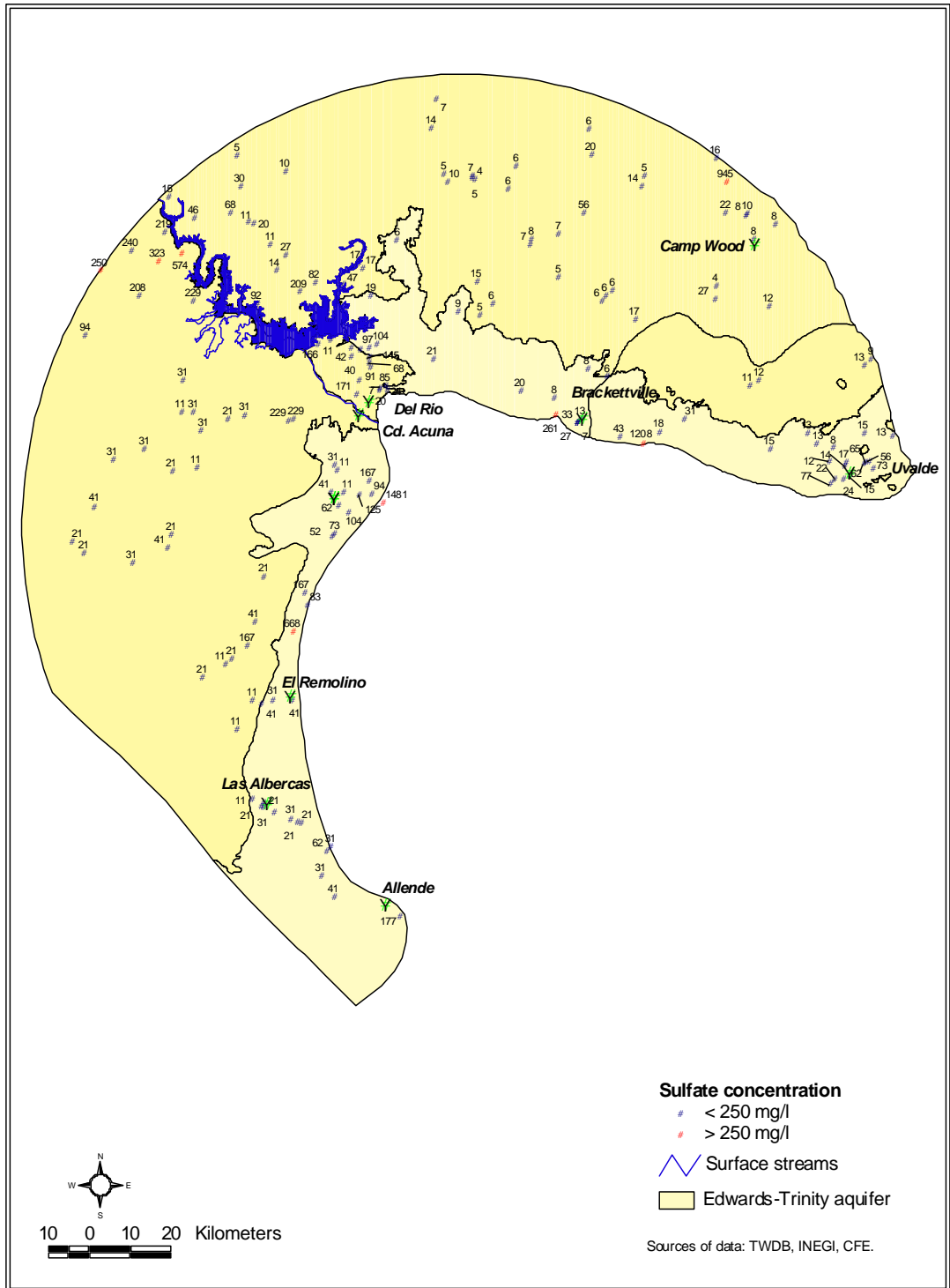
# Groundwater Pumpage From the Edwards-Trinity Aquifer, 1980-1997



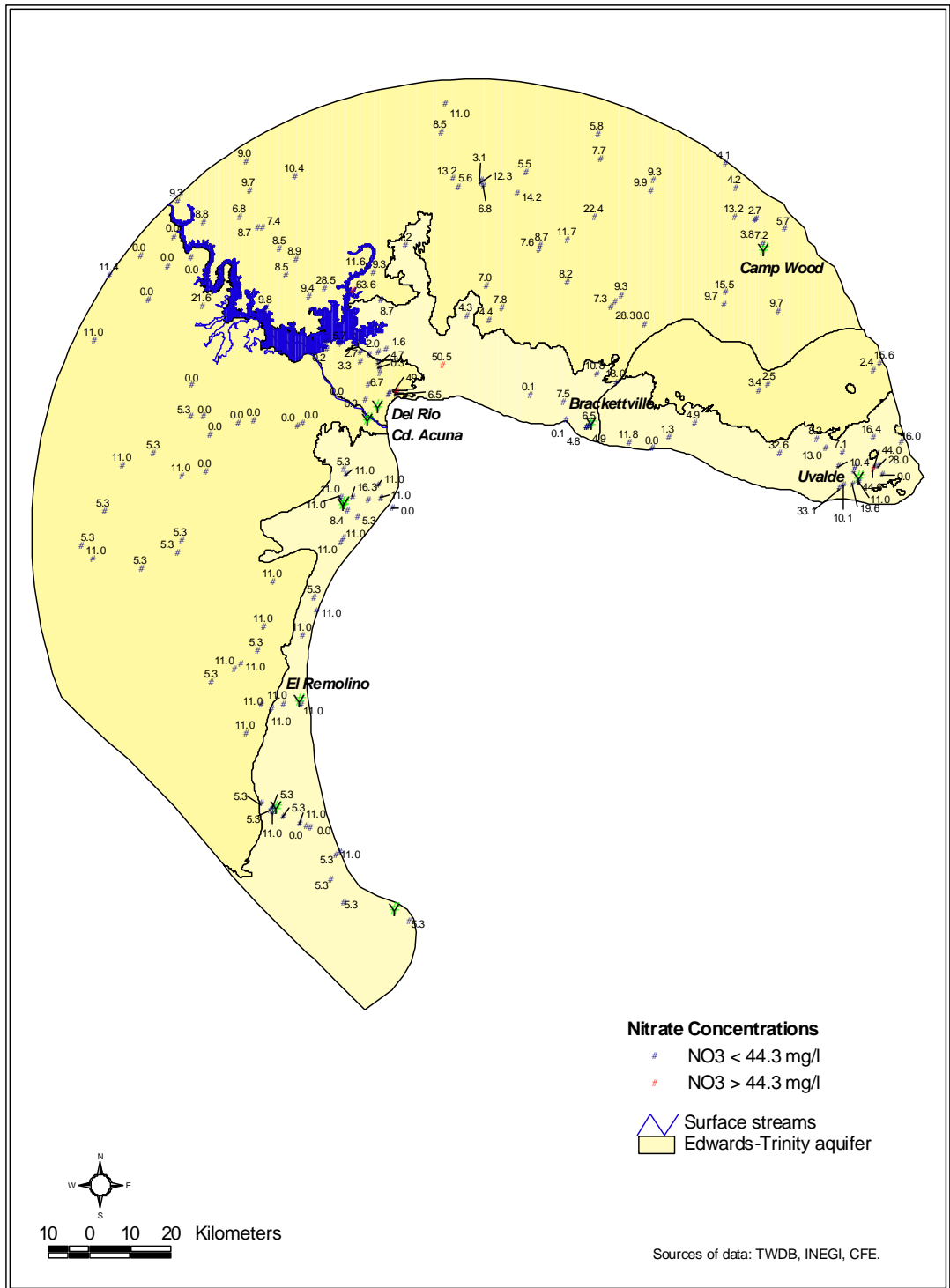
# Hydrochemical Facies of the Edwards-Trinity Aquifer



# Sulfate Distribution Map



# Nitrate Distribution Map



**Edwards-Trinity GAM Stakeholders Advisory Forum 4**  
**June 25, 2002 – Ozona, Texas**  
**List of Attendees**

<b>Name</b>	<b>Affiliation</b>
Wendell Moody	Private Citizen
Scott Holland	Sterling County UWCD / Irion County Water Conservation District
Grant Snyder	URS Corporation
Alyson McDonald	Texas Coop. Extension
Stan Reinhard	Hickory UWCD NO. 1
Johnny Jones	Crockett County
Janet Adams	Jeff Davis County UWCD
Roy Walston	Crockett County
Will Wilde	City of San Angelo
Cindy Cawley	Plateau UWCD
Allan Lange	Lipan-Kickapoo Water Conservation District
Dennis Clark	Emerald UWCD
Joe David Ross	Private Citizen
Larry Hoffmann	Private Citizen
Roberto Anaya	Texas Water Development Board
Radu Boghici	Texas Water Development Board
Rick Harston	Glasscock County UWCD
Cindy Weatherby	Santa Rita UWCD
Cameron Cornett	Headwaters UWCD



**Edwards-Trinity GAM Stakeholders Advisory Forum 4**  
**June 25, 2002 – Ozona, Texas**  
**Meeting Summary**

About 19 people attended the fourth Edwards-Trinity Aquifer Groundwater Availability Modeling Stakeholders Advisory Forum, held in Ozona, Texas. The stakeholders present were representing 9 local groundwater conservation districts, 2 consulting firms, and local landowners.

As a guest speaker, Radu Boghici of the Texas Water Development Board presented his findings on his recently completed US-Mexico Borderlands study. He discussed the hydrogeologic relationship between Edwards-Trinity aquifer units on both sides of the US-Mexico border. Roberto Anaya presented an update on the pre-development groundwater level conditions and the characterization of surface water features to be used in the Edwards-Trinity model. Roberto Anaya also discussed how and why the revised conceptual model of the Edwards-Trinity aquifer model will include the Hill Country portion of the Trinity aquifer in addition to the Pecos Alluvium aquifer in order to facilitate boundary condition issues. An update was also presented on the current structural geometry of the model layers and the size and orientation of the model grid to be used. The session ended with an update on the pumping tests and hydraulic properties for the Edwards-Trinity. The stakeholders were notified that the modeling project is still slightly behind schedule and that additional staff is assigned and working hard to bring the project back on schedule.

The next SAF meeting was tentatively scheduled for the third Thursday in October 2002 in Big Lake, Texas. Potential topics for the next forum include 1) final structure and 3-D model grid with associated boundary conditions; 2) final distribution of hydraulic properties; and 3) status and methodology for distributing pumpage, recharge, and evapotranspiration; 4) a discussion on methods to be used for steady-state model calibration.

Primary Stakeholder Issues Follow:

1) A stakeholder suggested that spring information could be used to improve pre-development water level surfaces.

**ANSWER:** The suggestion was well taken and will be investigated and implemented where possible.

2) A stakeholder suggested contacting the TNRCC for surface water data that they collect for special projects.

**ANSWER:** The suggestion was well taken and the TNRCC will be contacted and solicited for any available surface water data within the Edwards-Trinity study area.

3) A stakeholder asked how the down-dip boundary would be handled in the confined portions of the aquifer in Kinney and Val Verde counties.

ANSWER: The down-dip boundary will be treated in the same way as the method being used by the Edwards BFZ model. USGS will be contacted to see if the 3,000 mg/L or 10,000 mg/L TDS boundary is being used.

4) A stakeholder is concerned that the model will be used to misrepresent the “availability” of groundwater. He states that just because the water levels show that there is water in the aquifer it does not mean that that water can be readily produced.

ANSWER: The model will be well documented with assumptions and limitations on both the development of the model and the use of the model.

5) A stakeholder still has concerns that the model does not include faults that he has been informed of by local oil patch workers near his property in Sutton County.

ANSWER: It was explained that significant faults may exist within the older Paleozoic rocks beneath the Cretaceous Edwards-Trinity aquifer sediments but that these faults do not propagate up into the younger Cretaceous rocks. The difference between faults and fractures was also explained and though small faults may exist within the Edwards-Trinity rocks, they are too small to show up in the model’s structural geometry.

6) A stakeholder believes that not enough money and effort is being spent to “accurately” determine recharge rates to the aquifer and asked what method is best to determine recharge because all the experts seem to come up with a different rate.

ANSWER: Agreeably and unfortunately recharge rates are not an easy parameter to estimate. Recharge rates are dependent upon many factors and vary over both time and space. Current technology and data do not allow for “accurate” measurement of recharge. The Edwards-Trinity model will produce the best available estimates of recharge rates once the model has been calibrated.

7) A stakeholder asked why the model grid was extended so far to the south-west.

ANSWER: The model grid was extended to incorporate portions of the Edwards-Trinity on the Mexico side of the Rio Grande at some point in the future when more data is available. It also allows for a portion of the Edwards-Trinity within the eastern Big Bend region of Brewster County where the geology is too complex to be modeled in the current project. At some point in the future when better knowledge and data of that area becomes available it may be added to the model.

-Roberto Anaya, 06/27/02