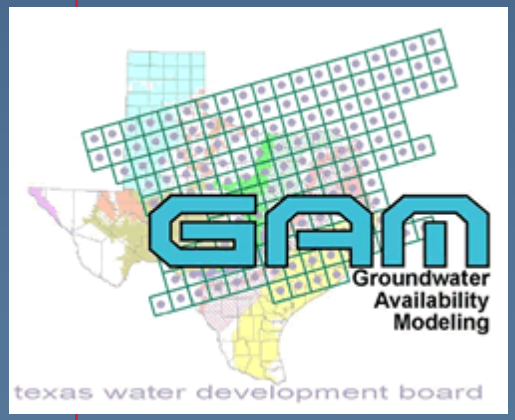
Stakeholder Advisory Forum – 6

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



San Antonio River Authority

San Antonio, Texas

August 5, 2002

INTERA

PARSONS

WATERSTONE
Environmental Hydrology and Engineering, Inc.

Presentation Outline

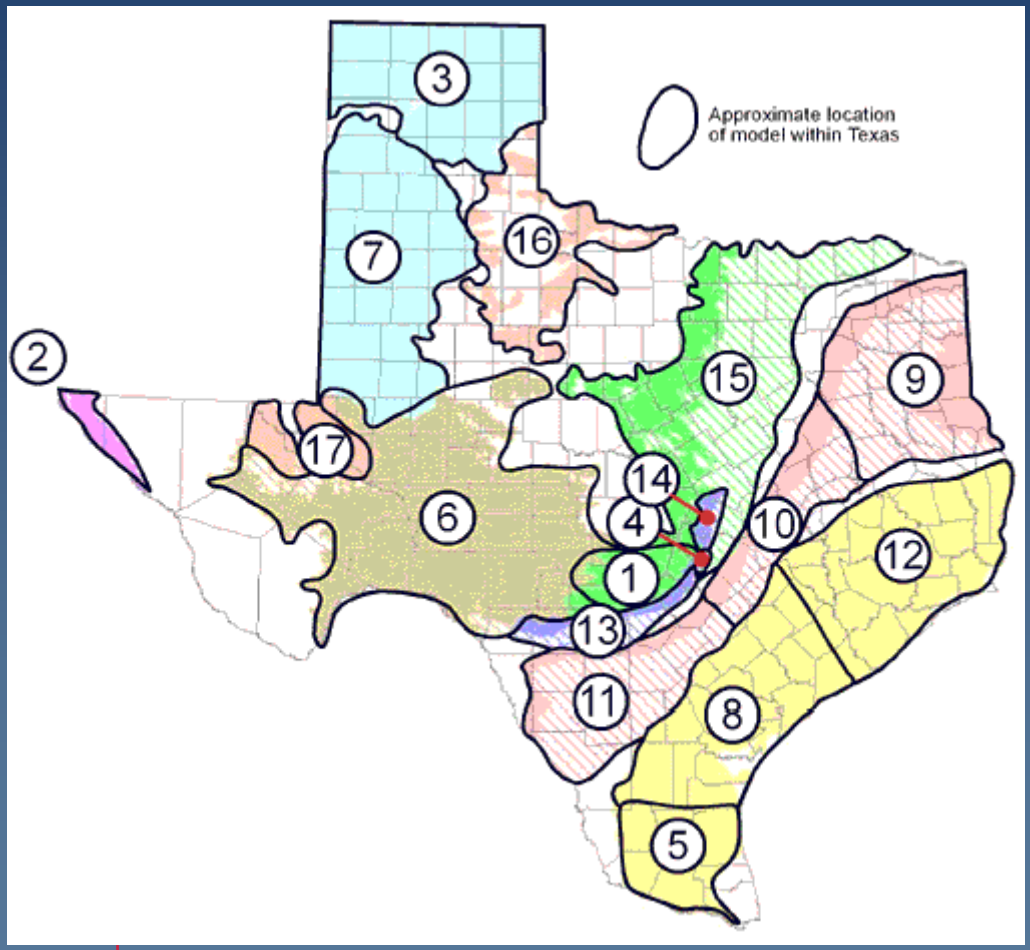
- GAM Program Review
- Conceptual Model Review
- Steady-State Model Recap
- Transient Model
- Path Forward
- Schedule and SAF-7

GAM Objectives

- Develop realistic and scientifically accurate GW flow models representing the physical characteristics of the aquifer and incorporating the relevant processes
- The models are designed as tools to help GWCD, RWPGs, and individuals assess groundwater availability
- Stakeholder participation is important to ensure that the model is accepted as a valid model of the aquifer

GAM Models

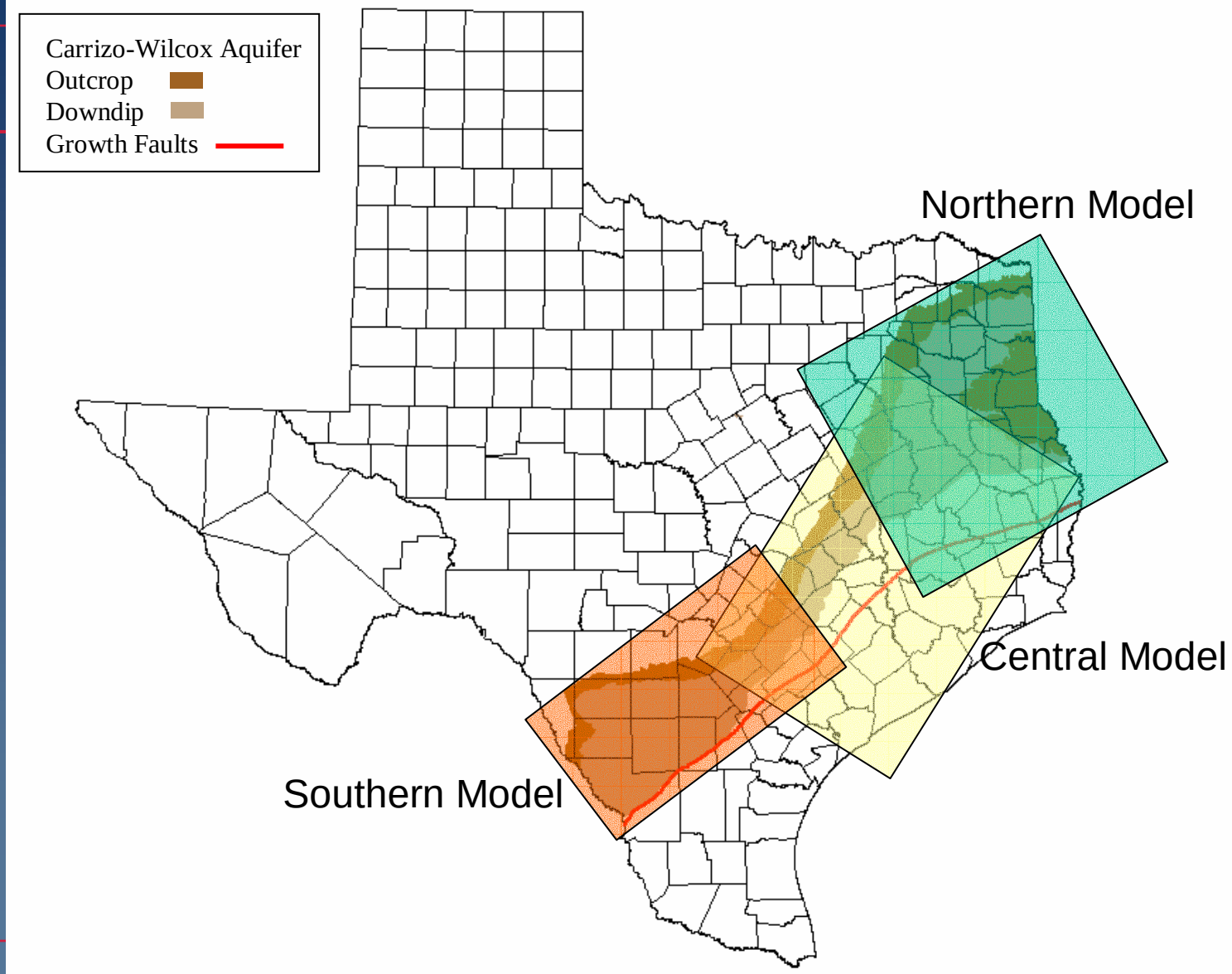
- Ongoing:
  - Carrizo-Wilcox (9-11)
  - Ogallala south (7)
  - Gulf Coast central (8)
  - Gulf Coast north (12)
  - Lower Rio Grande (5)
  - Edwards Trinity (6)
- Completed:
  - Trinity HC (1)
  - Hueco Bolson (2)
  - Ogallala north (3)
  - Edwards - BS (4)



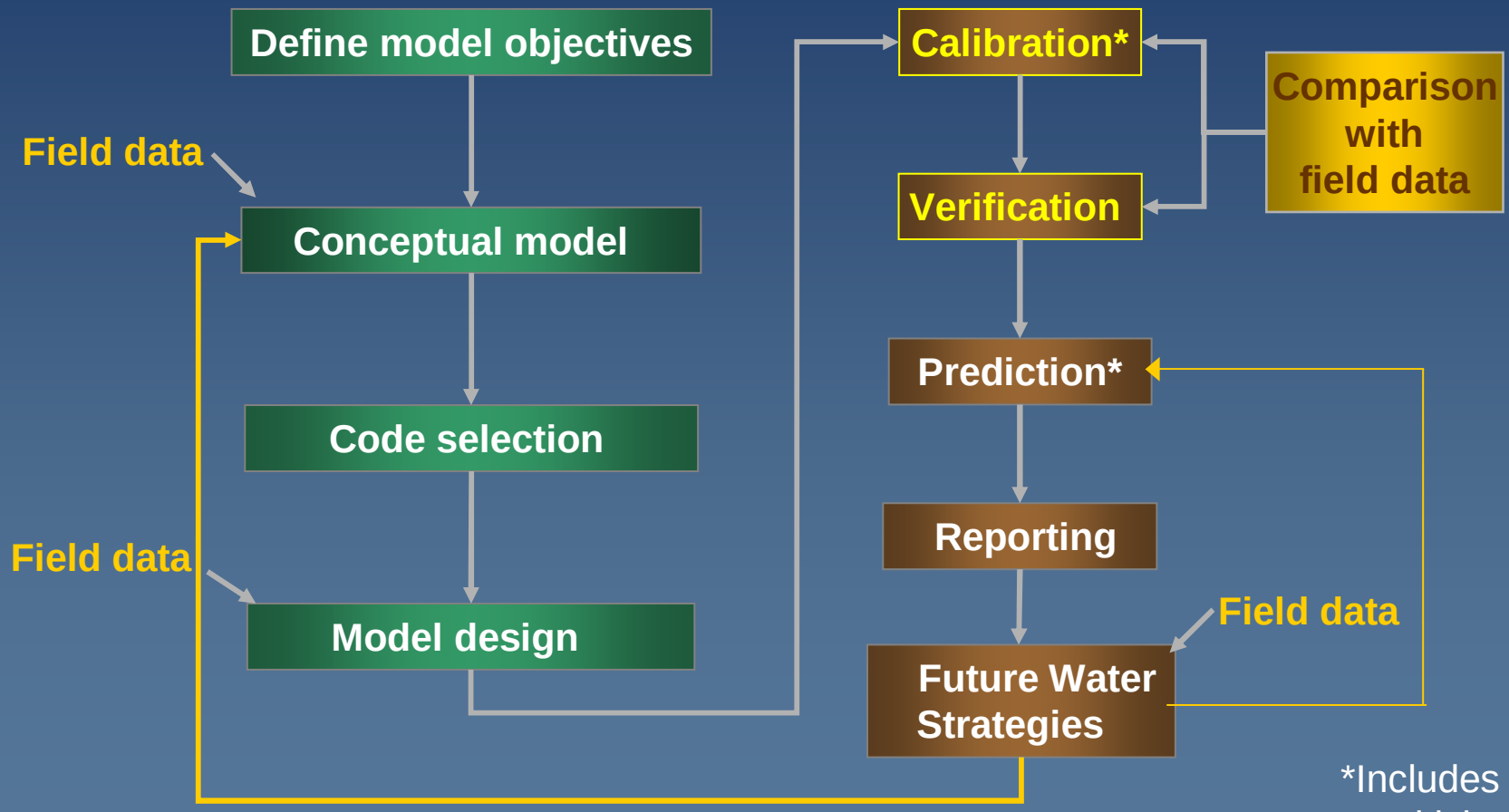
Model Specifications

- Three dimensional (MODFLOW-96)
- Regional scale (100's of mi2)
- Grid spacing of 1 square mile
- Include Groundwater/surface water interaction (Stream routing, Prudic 1988)
- Properly implement recharge
- Stress periods as small as 1 month
- Calibration to within 10% of head drop

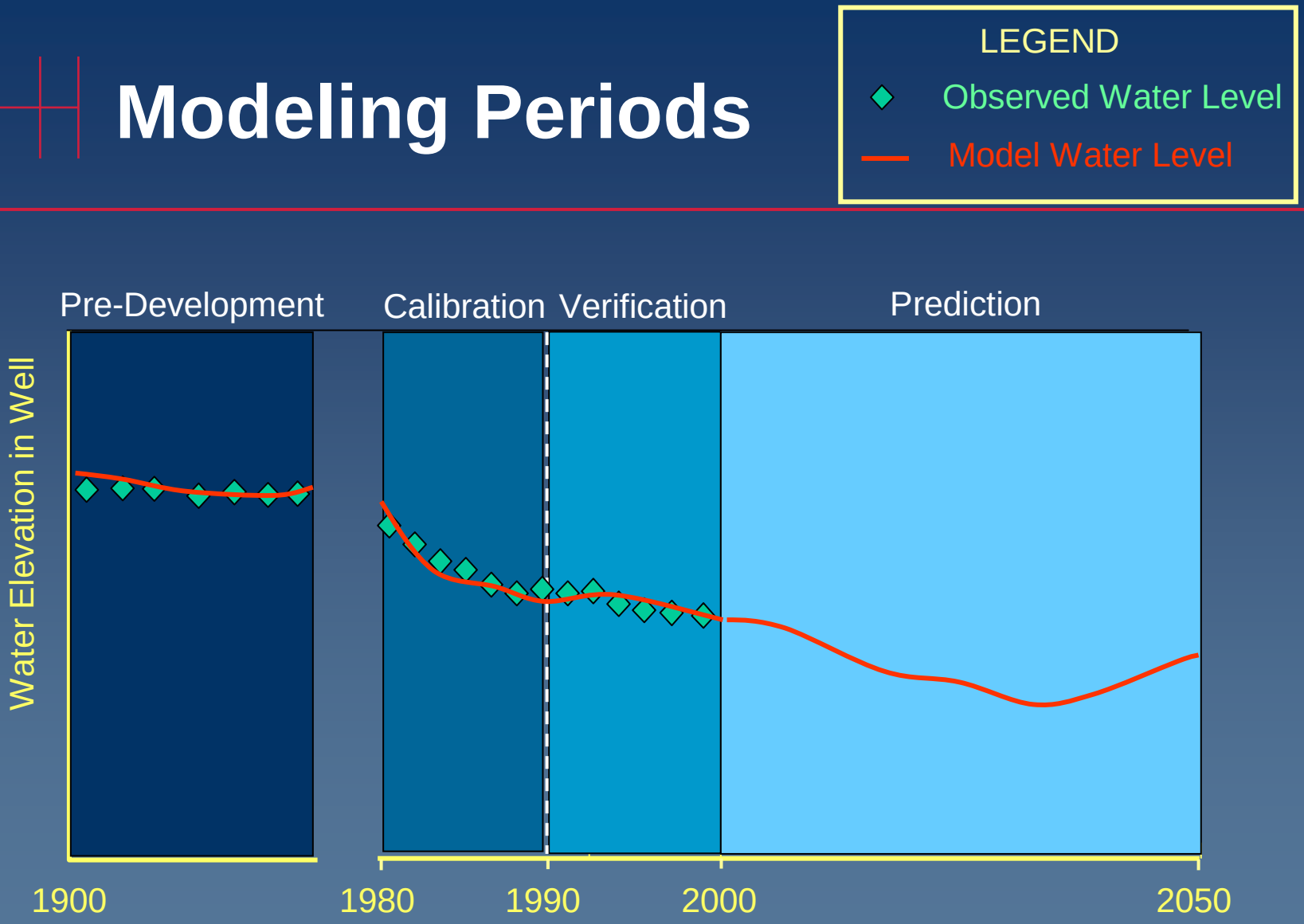
Carrizo-Wilcox GAM Model Domains



Modeling Protocol



Modeling Periods



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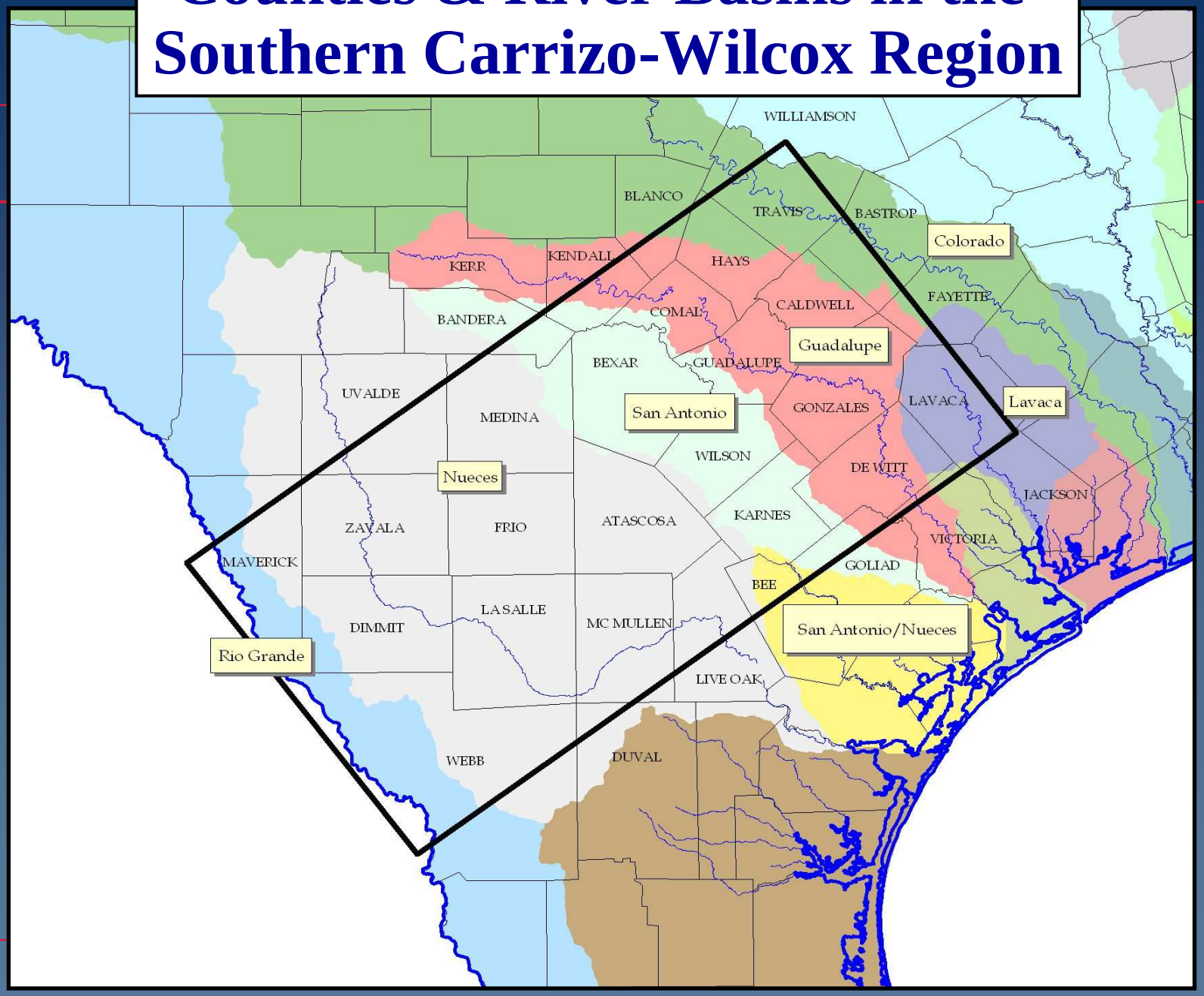
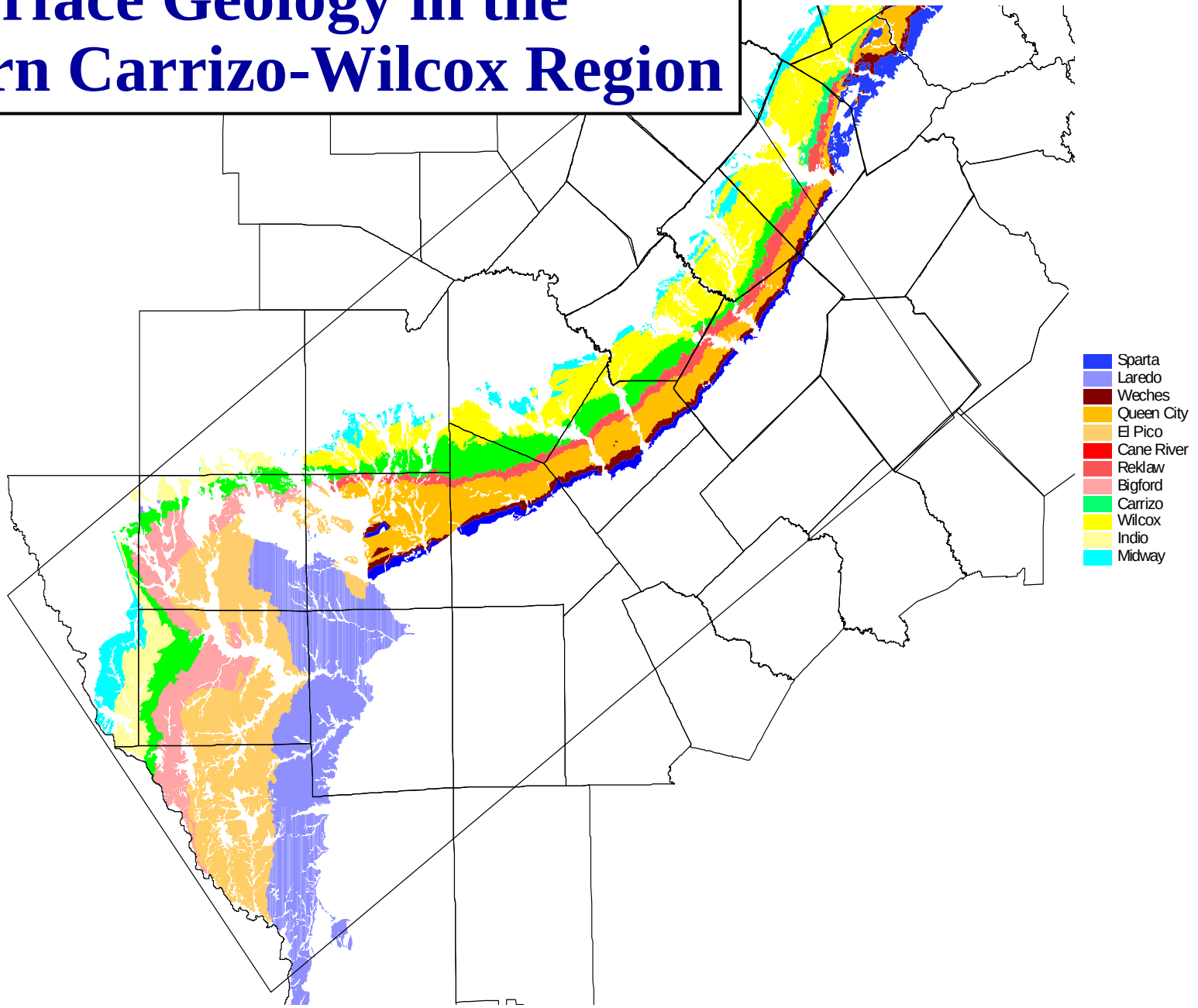
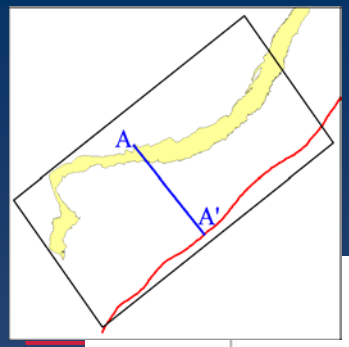
Counties & River Basins in the Southern Carrizo-Wilcox Region

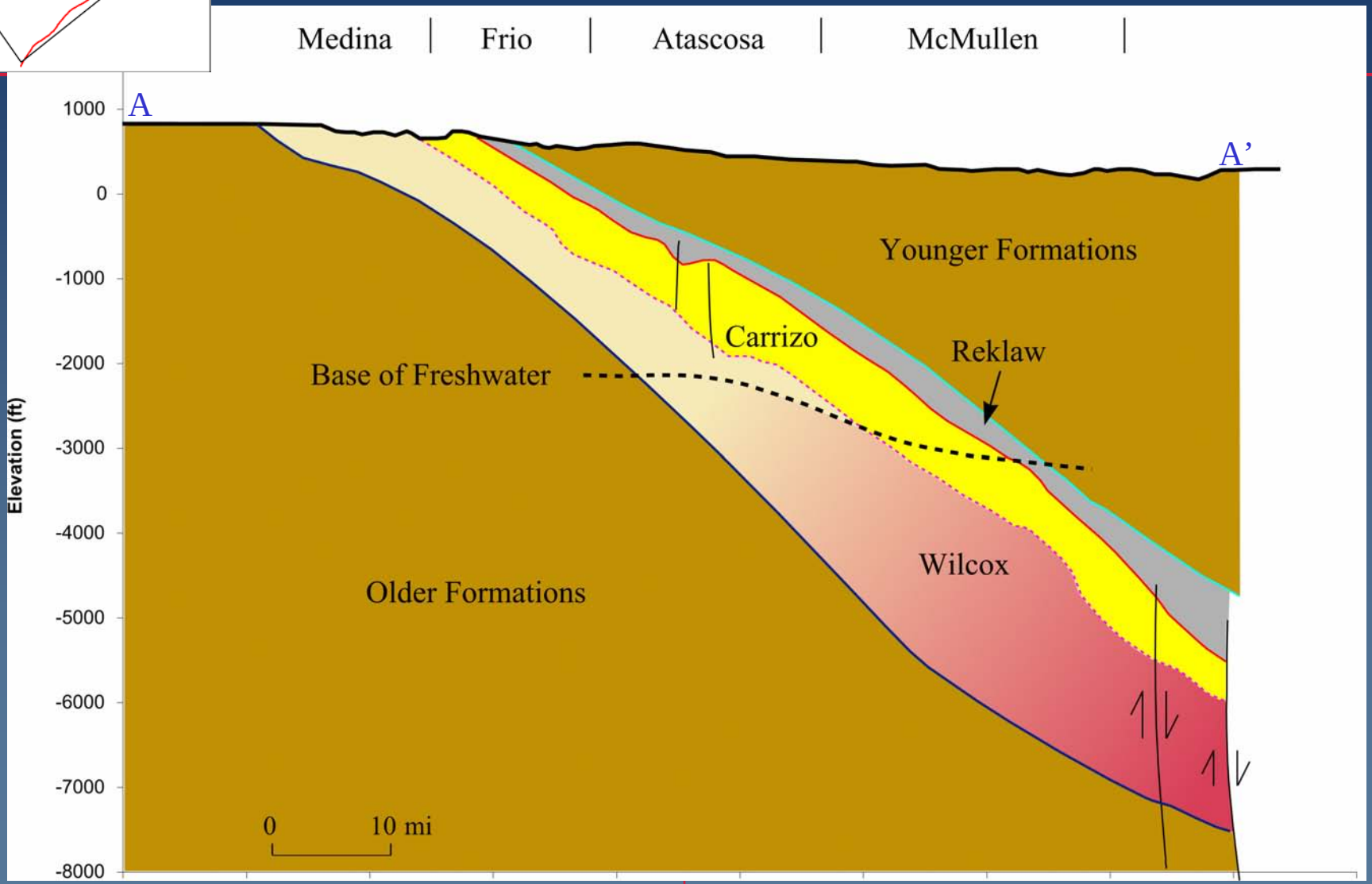


Surface Geology in the Southern Carrizo-Wilcox Region



Carrizo-Wilcox Aquifer Down-dip Boundary





Guevara & Garcia (1972)

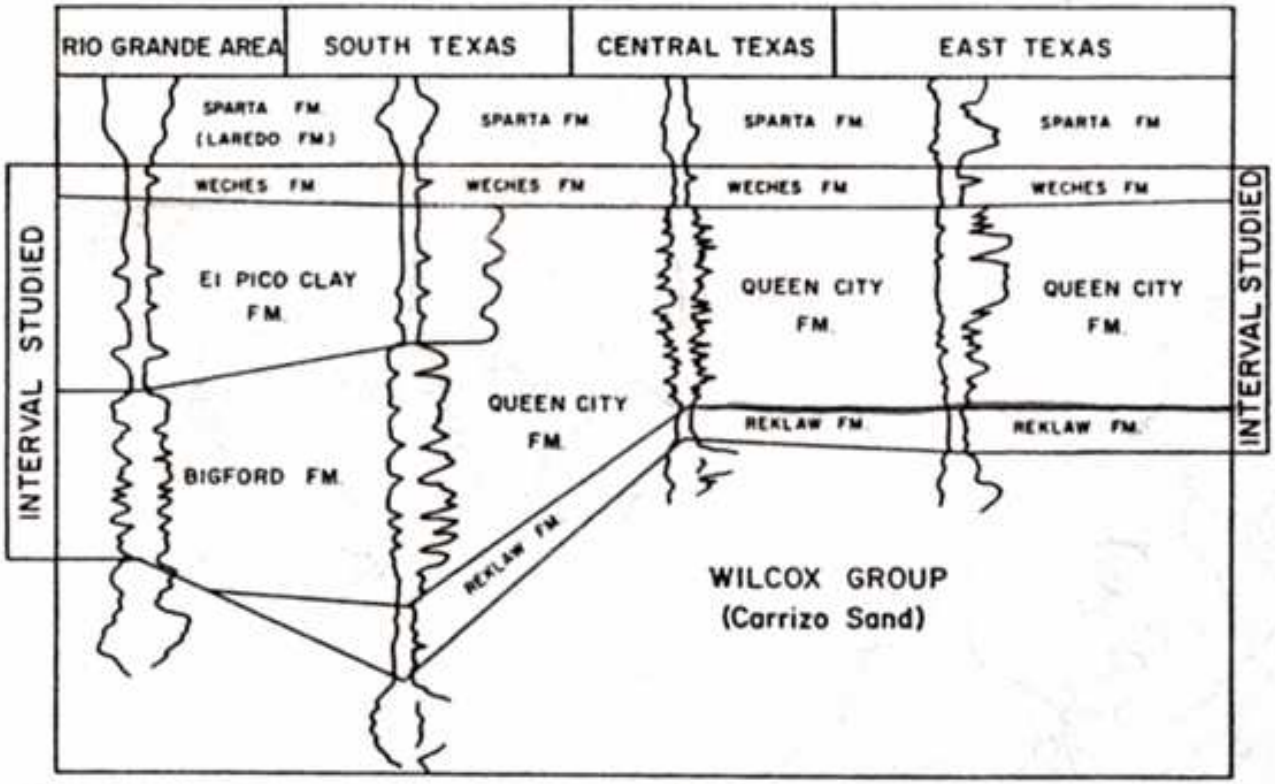
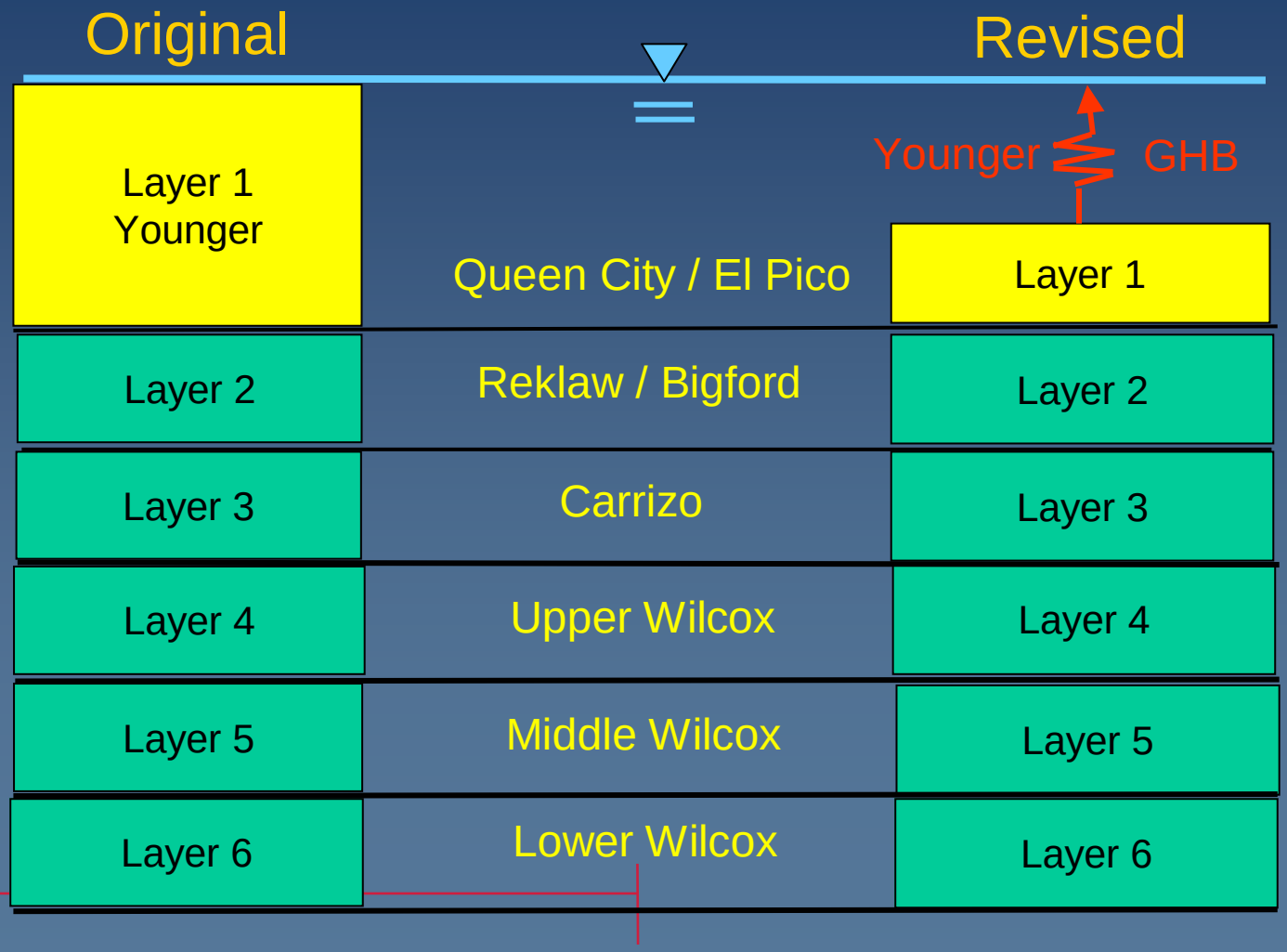


Fig. 2. Stratigraphic interval considered, Queen City and associated formations.

Model Layers



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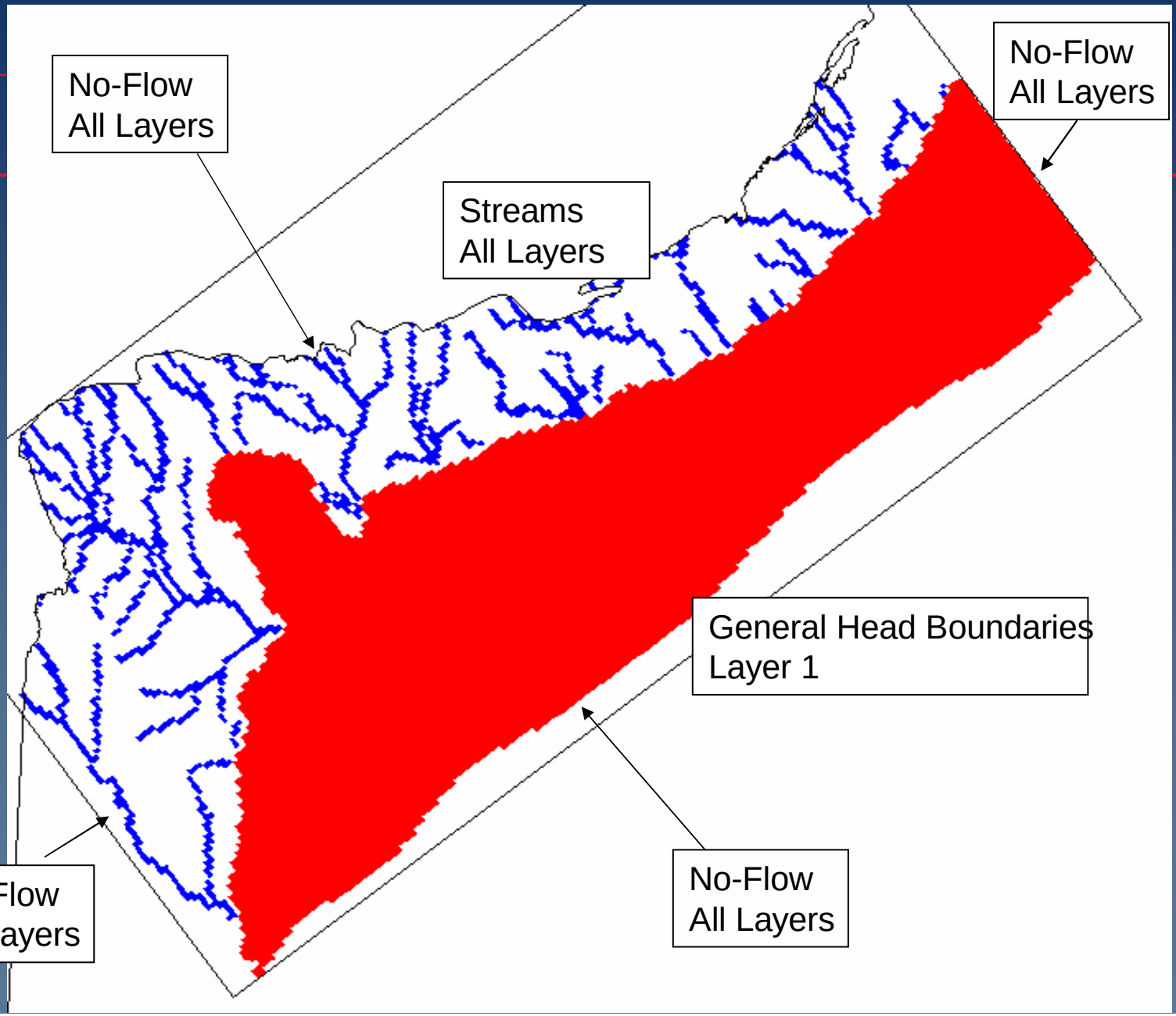
Steady-State Calibration

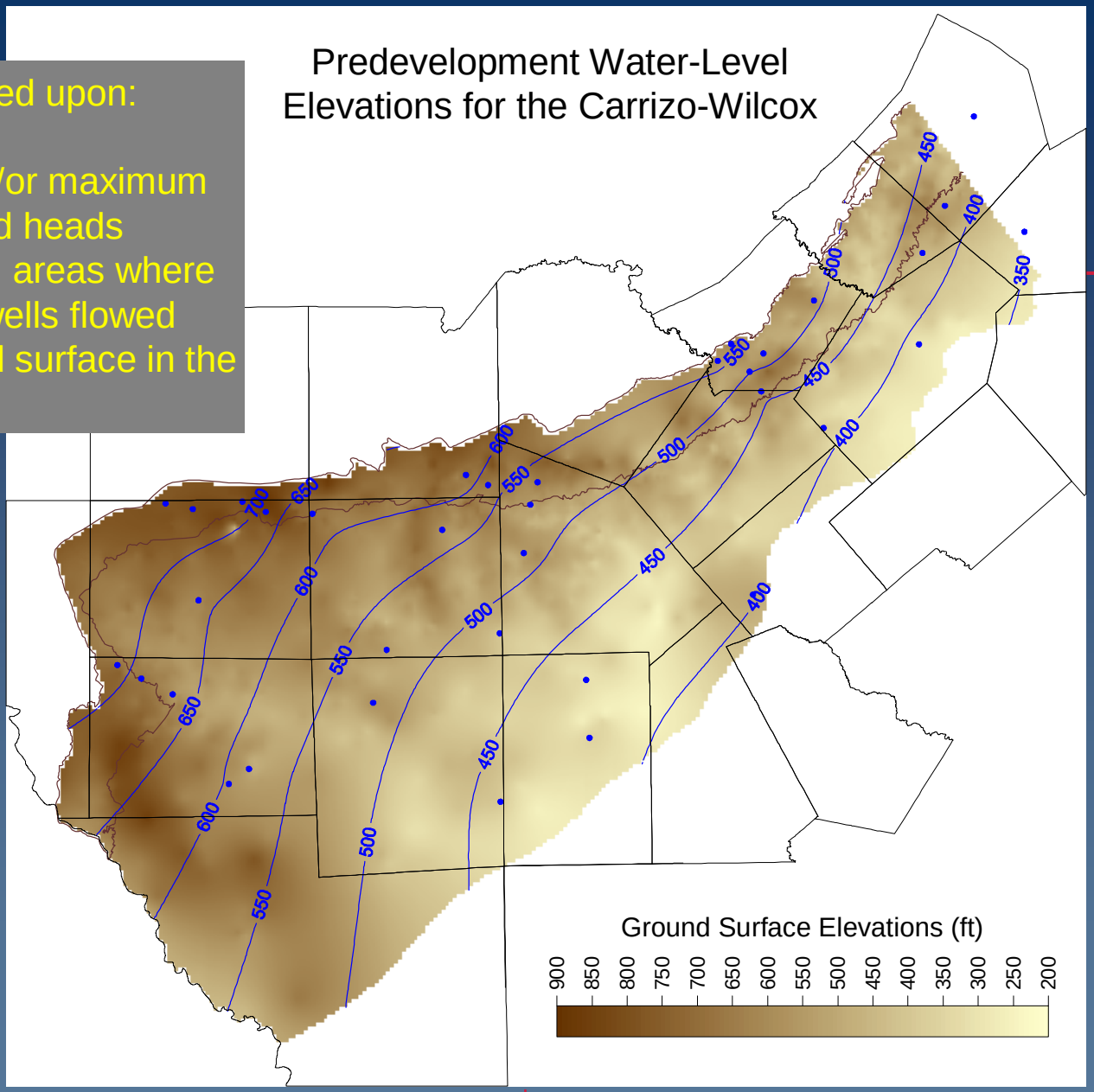
- Calibration Targets:
  - Pre-development hydraulic heads
- Parameter Variations:
  - Hydraulic conductivity
  - Recharge
- Problem:
  - Potential non-unique solution, i.e., different combination of K and R can produce similar results

Model Boundaries

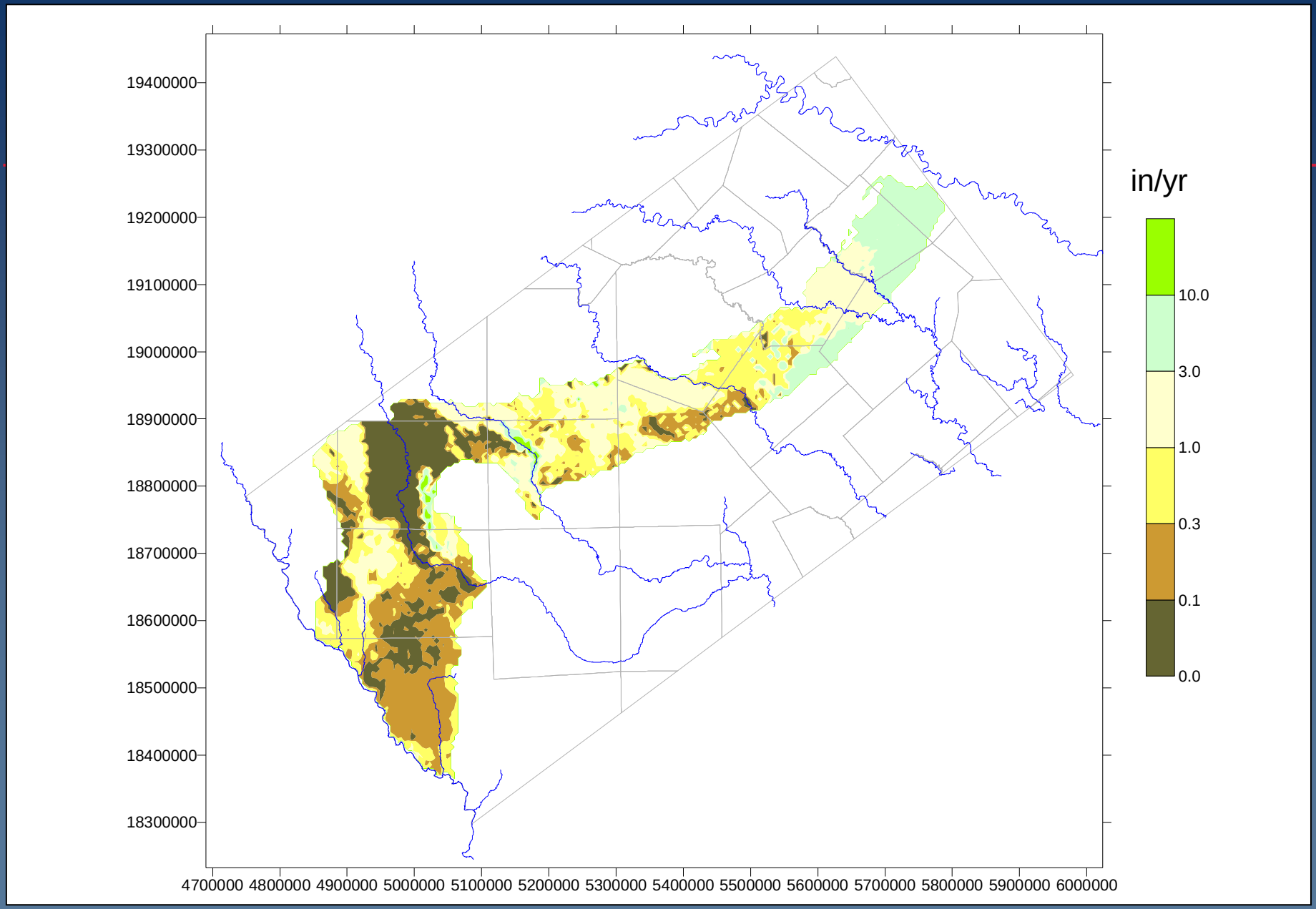


Levels based upon:

- First and/or maximum measured heads
- Reported areas where Carrizo wells flowed at ground surface in the past

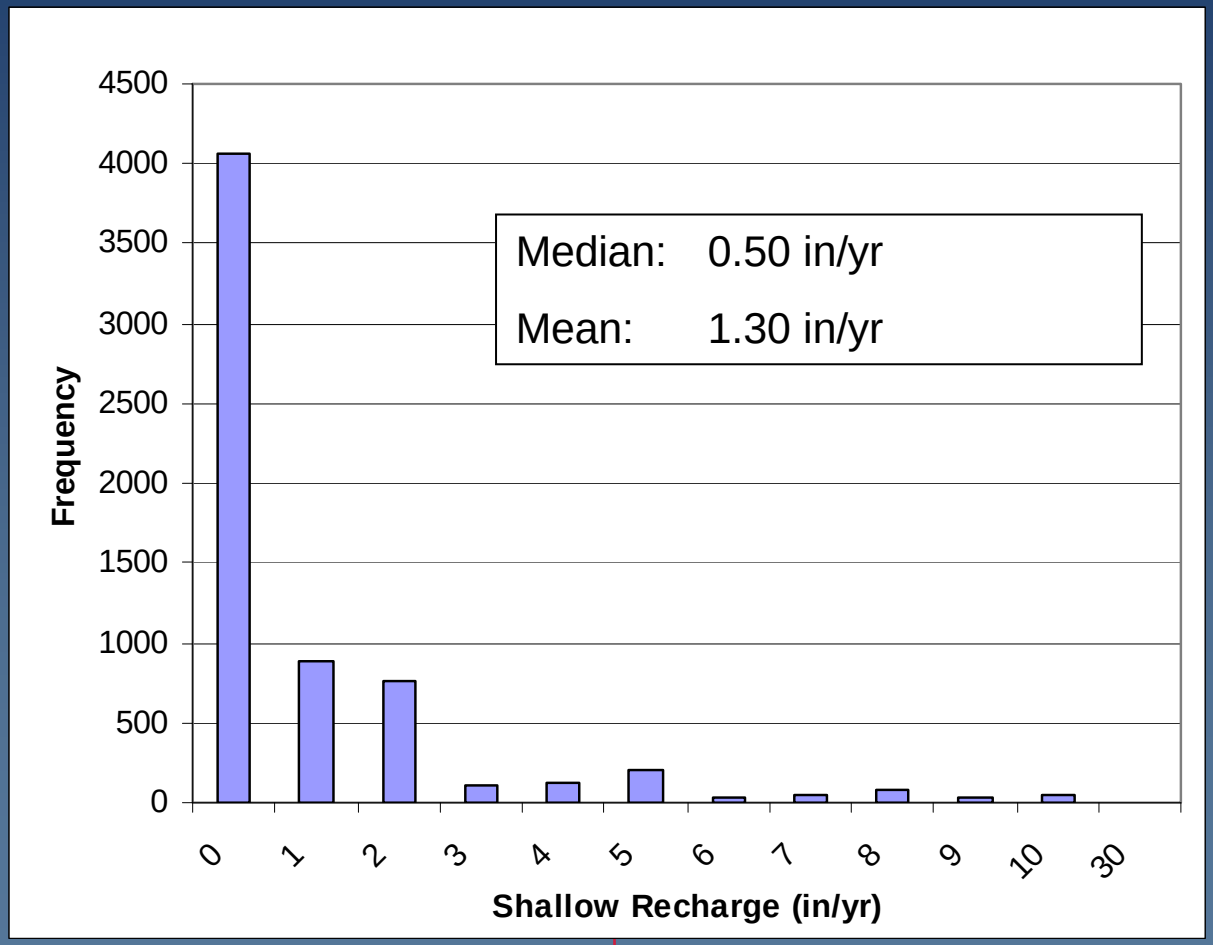


Average Recharge 1975-1999



SWAT - Example Results

25-year average annual recharge Southern C-W



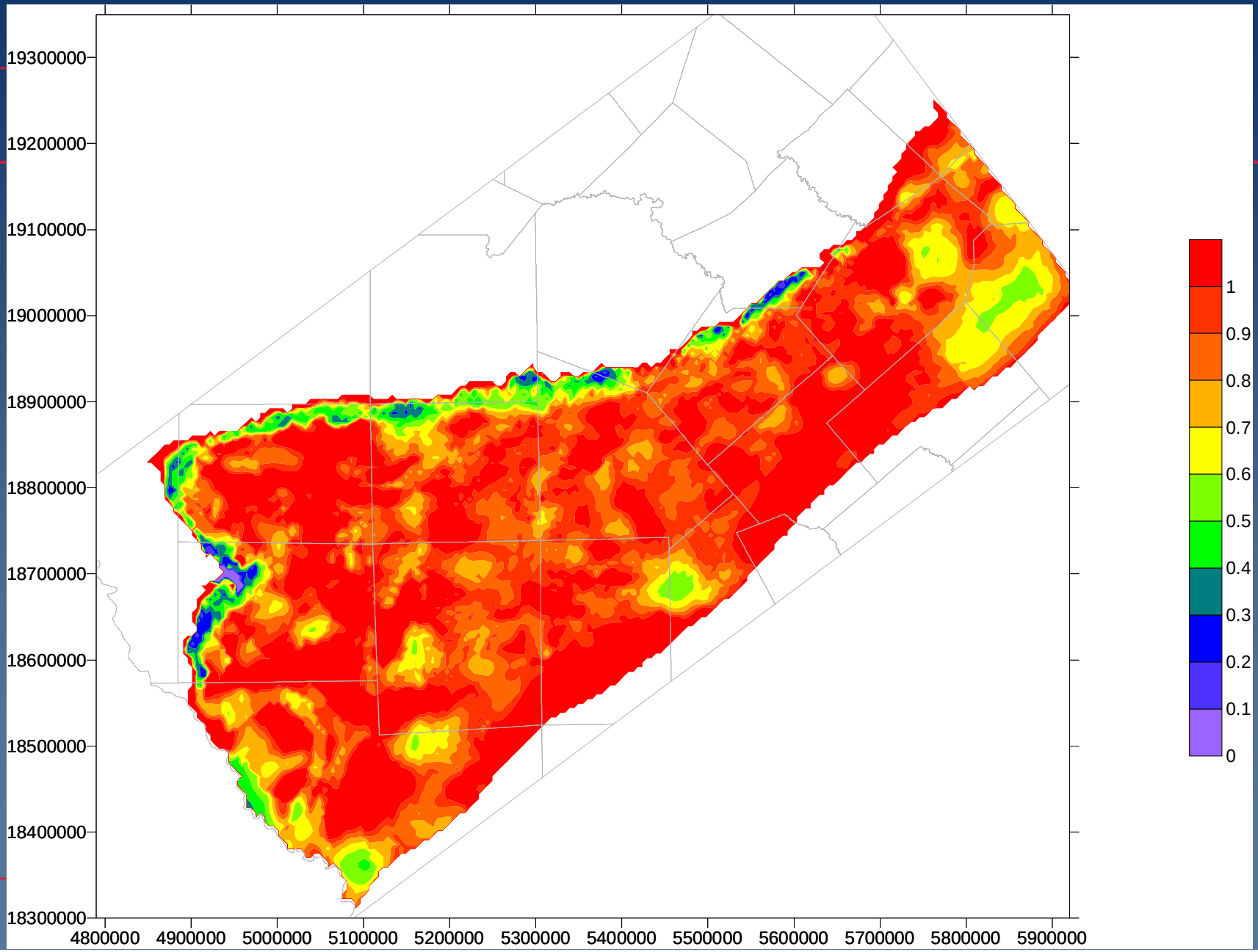
Predevelopment - Modeled Streams

- Initial stream conductance estimated from RF1 reach file parameters
- Variation in modeled conductance primarily due to stream width
- Relative bed conductivity scaled during calibration

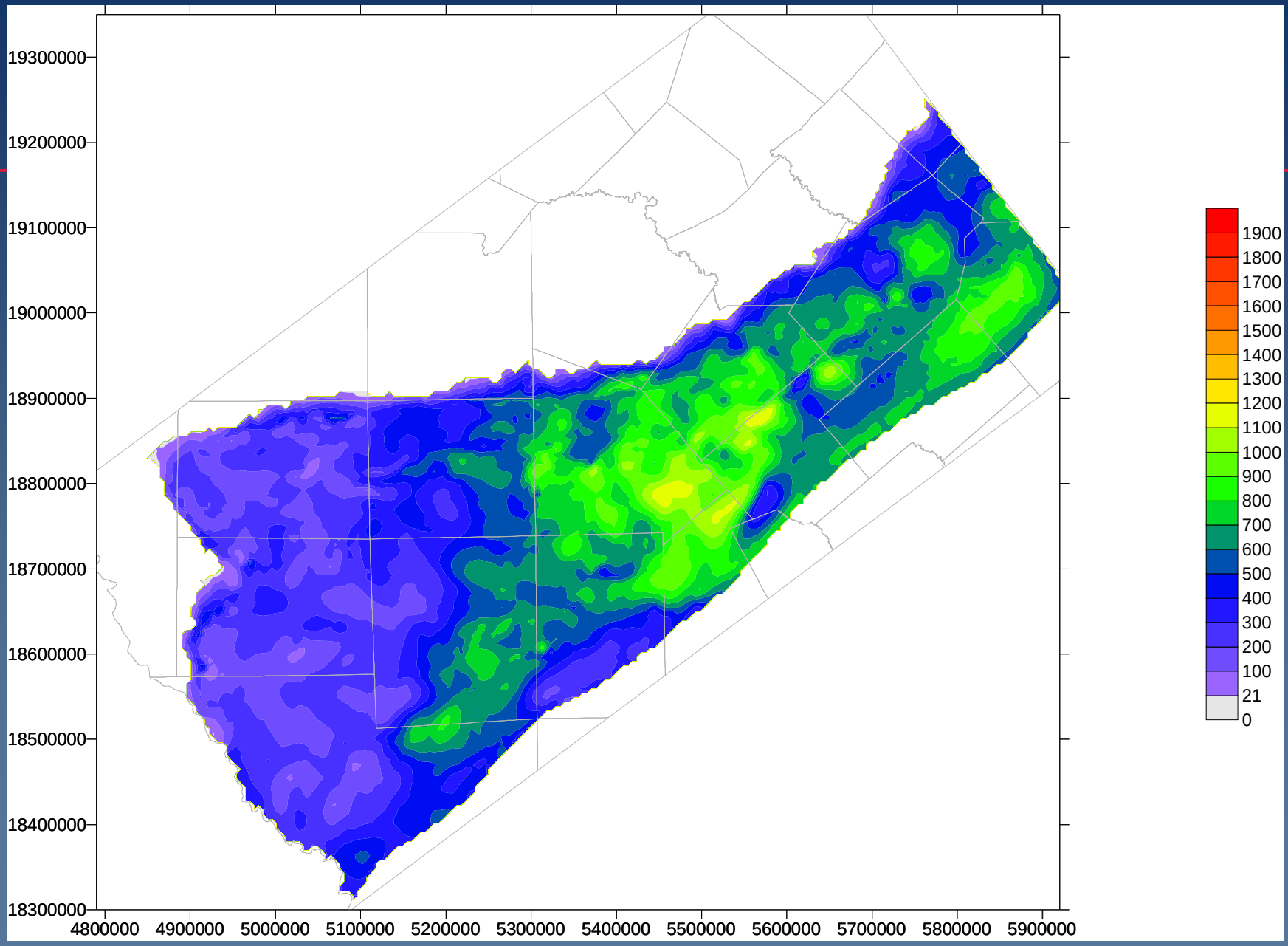
Hydraulic Conductivity

- Horizontal hydraulic conductivity point measurements are available (Mace et al, 2000)
- Poor correlation between measured values and estimated sand patterns
- Must scale K_h and K_v to regional grid scale
- Vertical hydraulic conductivity is not measurable at the grid scale.

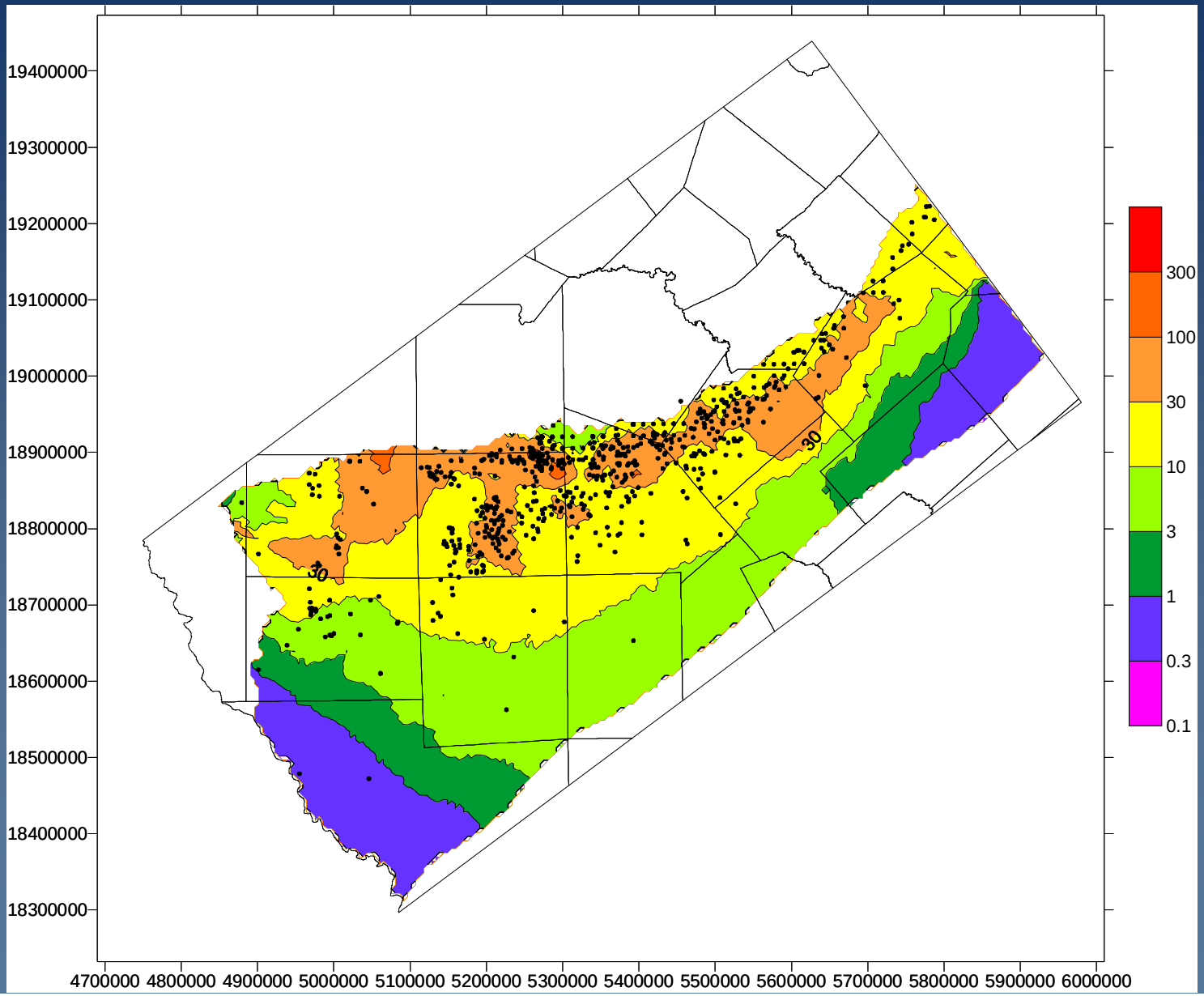
Carrizo Sand Fraction



Carrizo Thickness



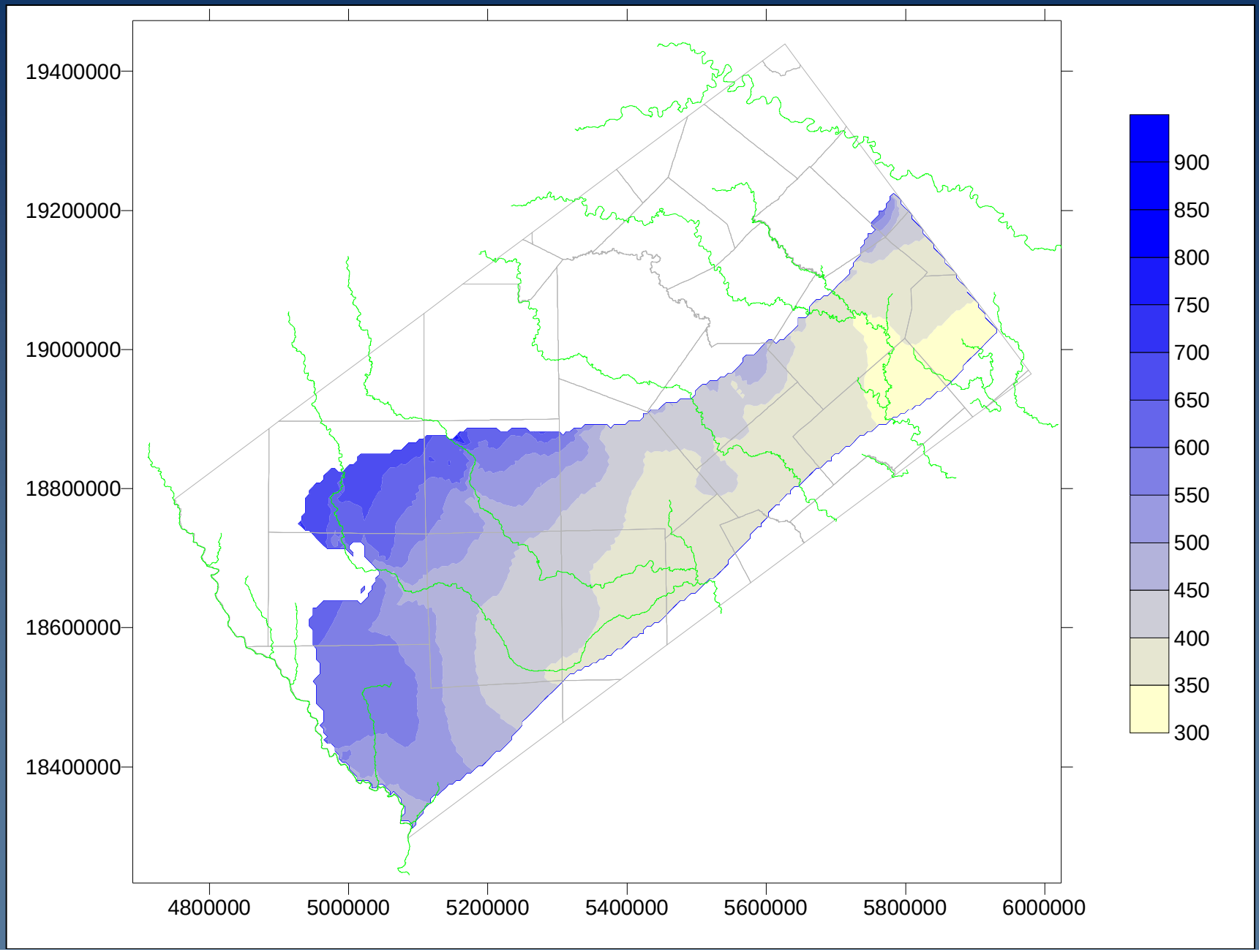
Carrizo Kh (ft/d) (Kh/Kv = 3)



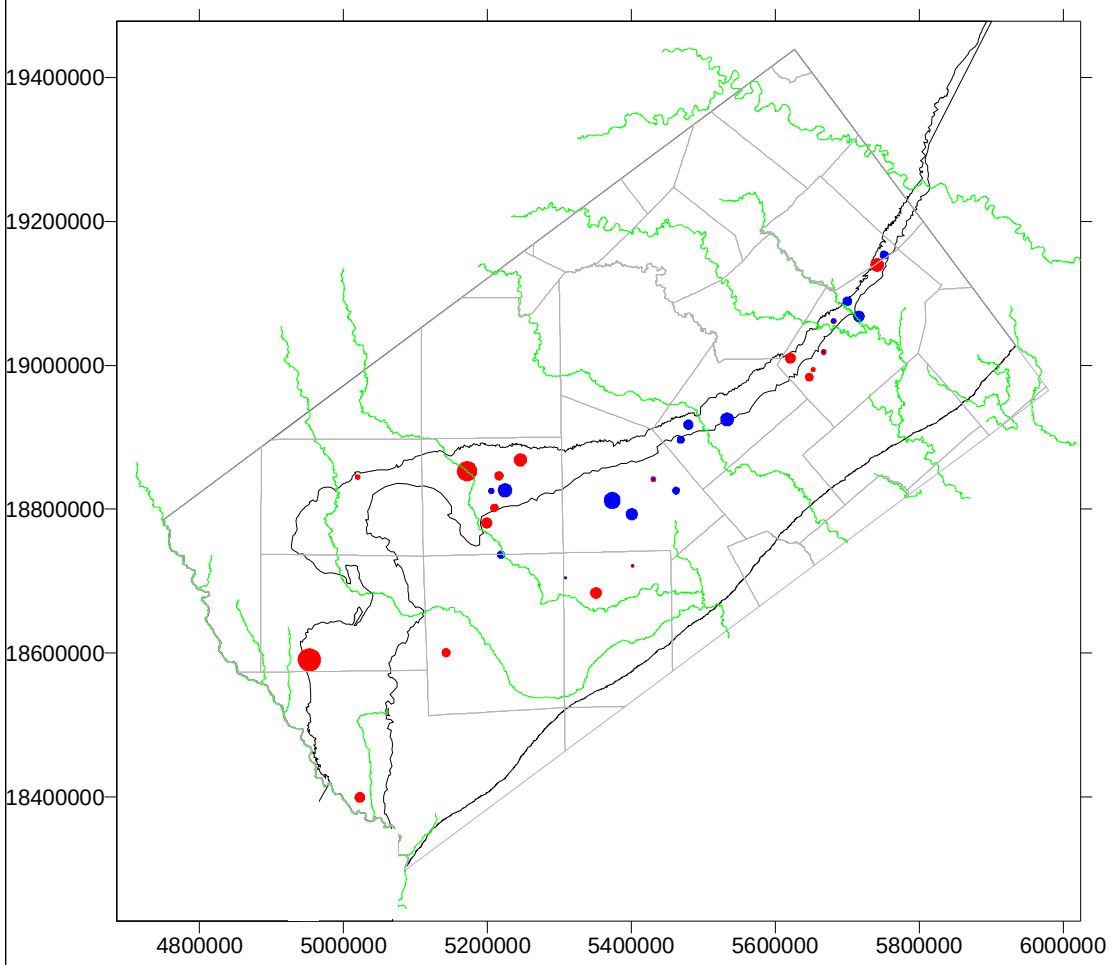
Steady State Model Hydraulic Conductivity (ft/day)

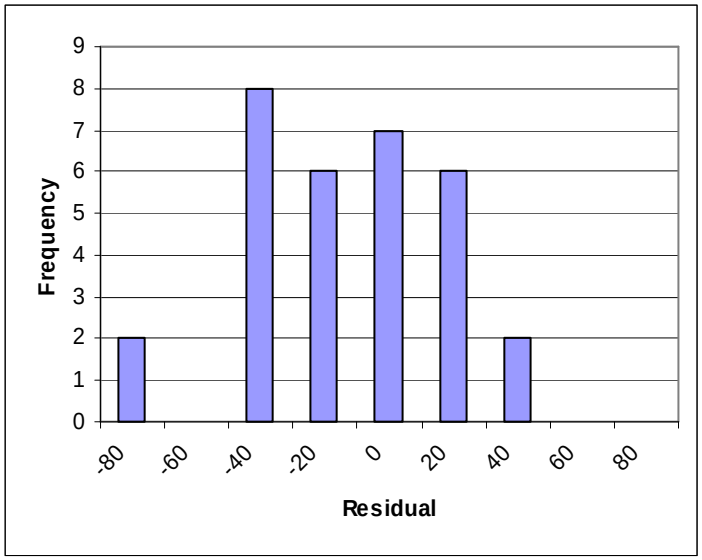
Model Layer	Horizontal	Vertical	Anisotropy Kh/Kv
Queen City / El Pico	0.3 to 30	0.0003 to 1	30 to 1000
Reklaw / Bigford	1	0.003 to 0.0003	300 to 3000
Carrizo	1 to 100	0.3 to 33	3
Upper Wilcox	0.3 to 30	0.3 to 0.003	10 to 100
Middle Wicox	0.3 to 30	0.01 to 1	30
Lower Wilcox	0.1 - 30	0.003 to 1	30

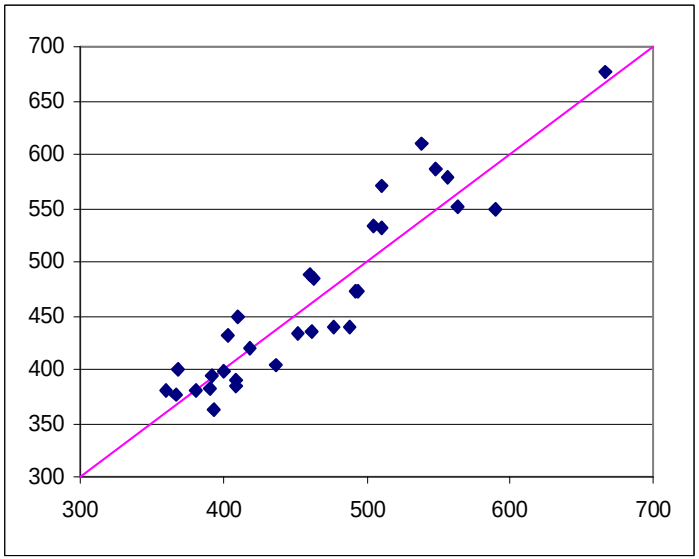
Queen City Head Results



Queen City Residuals

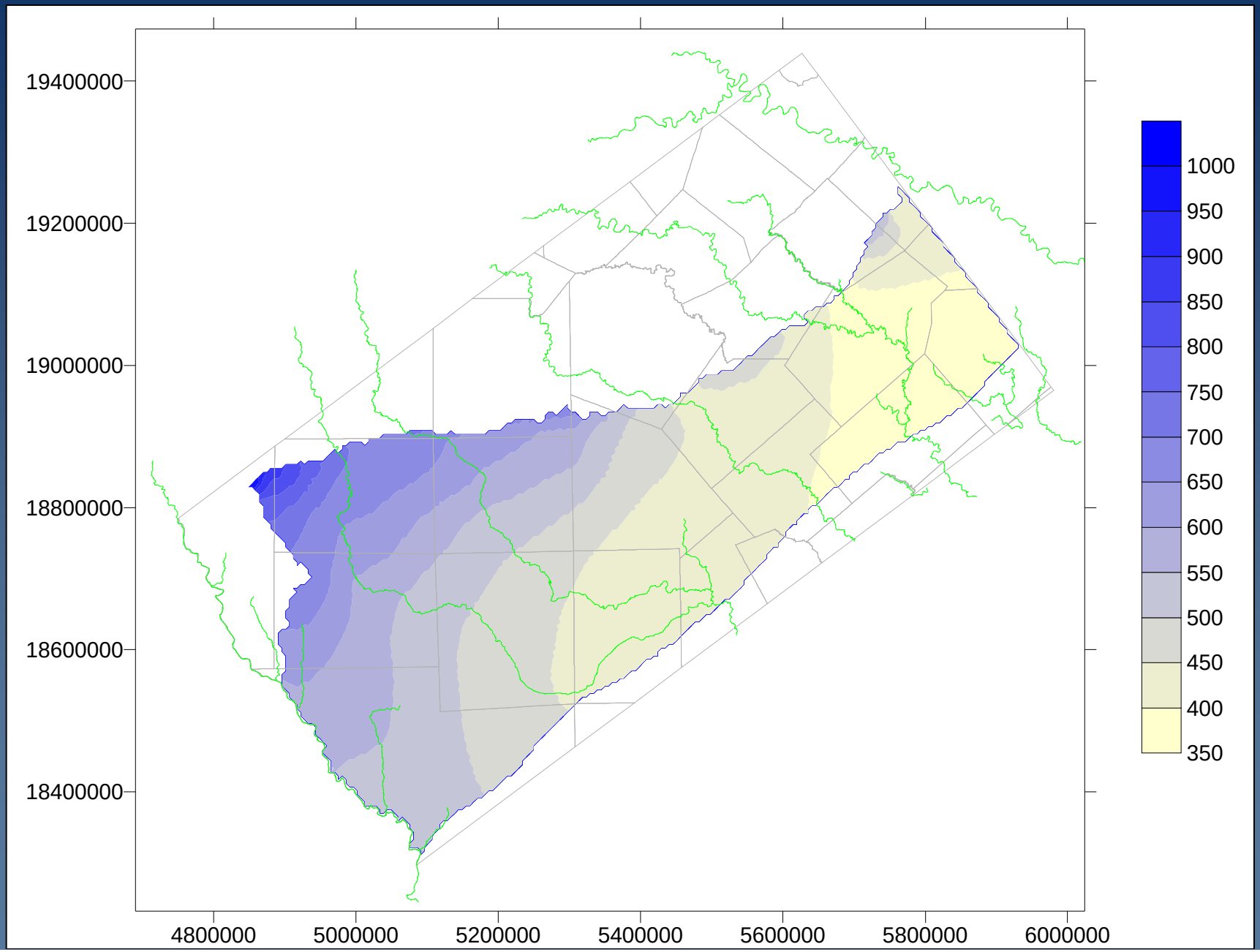




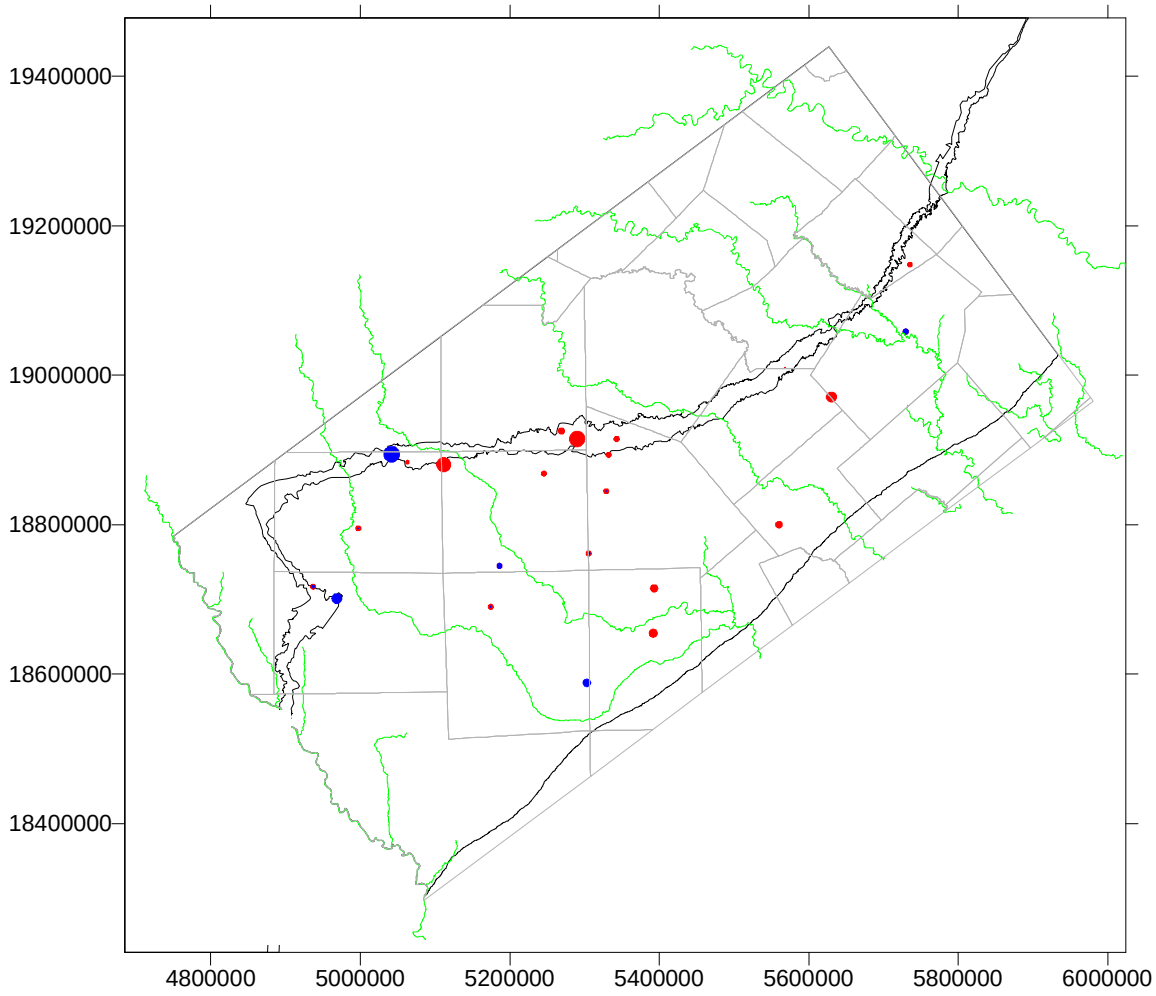


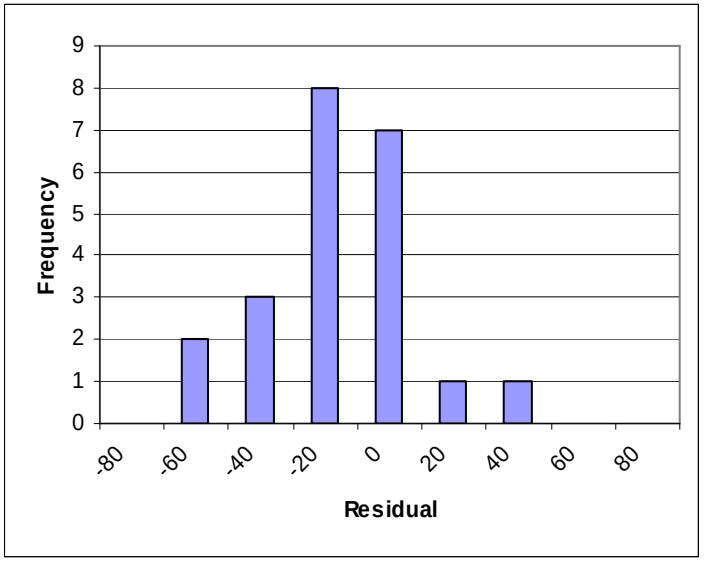
Residual Mean	-2.85
Residual Stdev	29.73
Range in Head	306.60
Stdev/Range	0.097

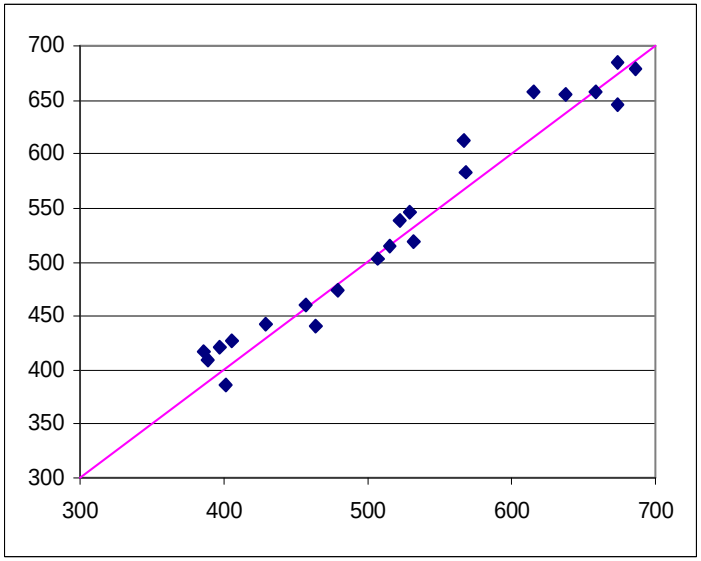
Carrizo Head Results



Carrizo Residuals

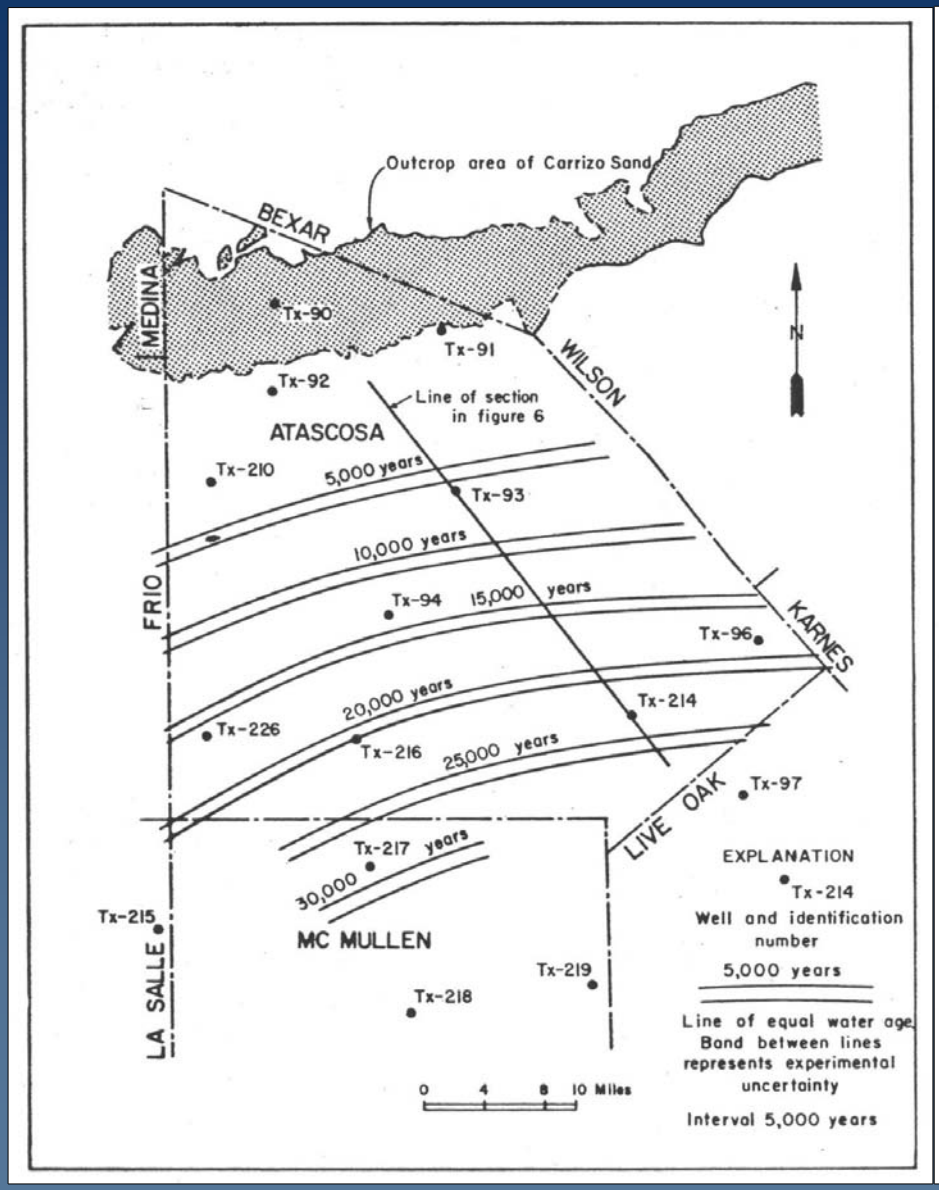


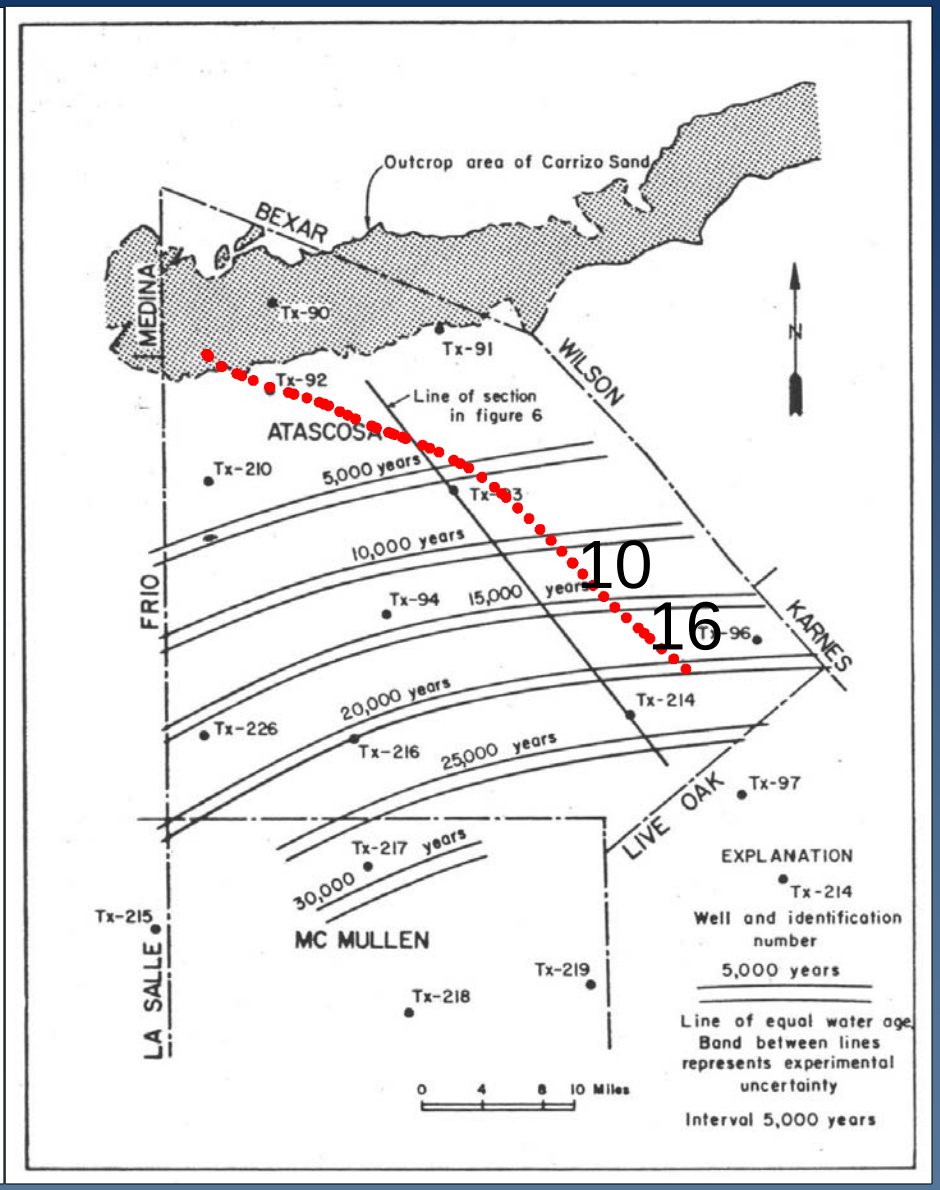




Residual Mean	-5.45
Residual Stdev	21.77
Range in Head	353.40
Stdev/Range	0.062

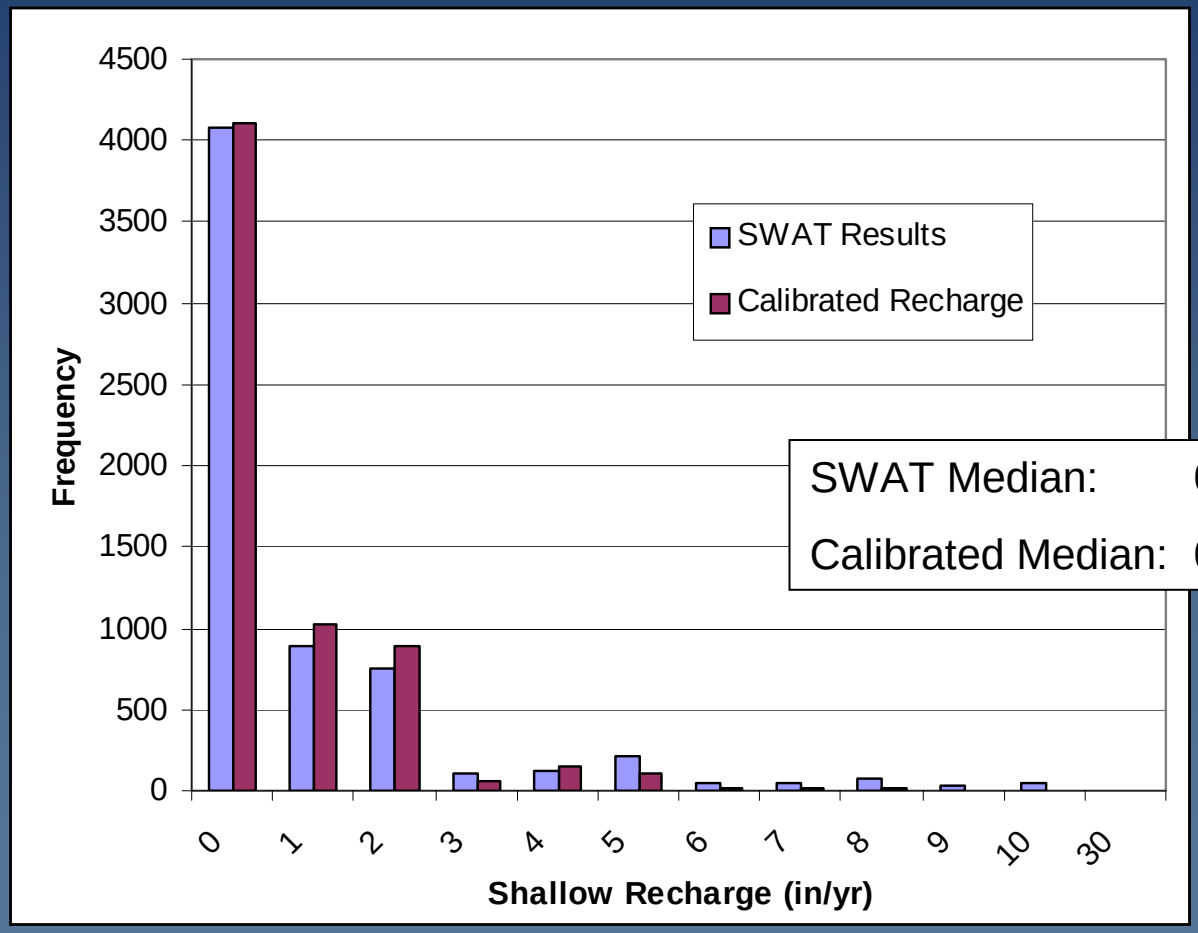
Carrizo Particle Travel Time





SWAT Results

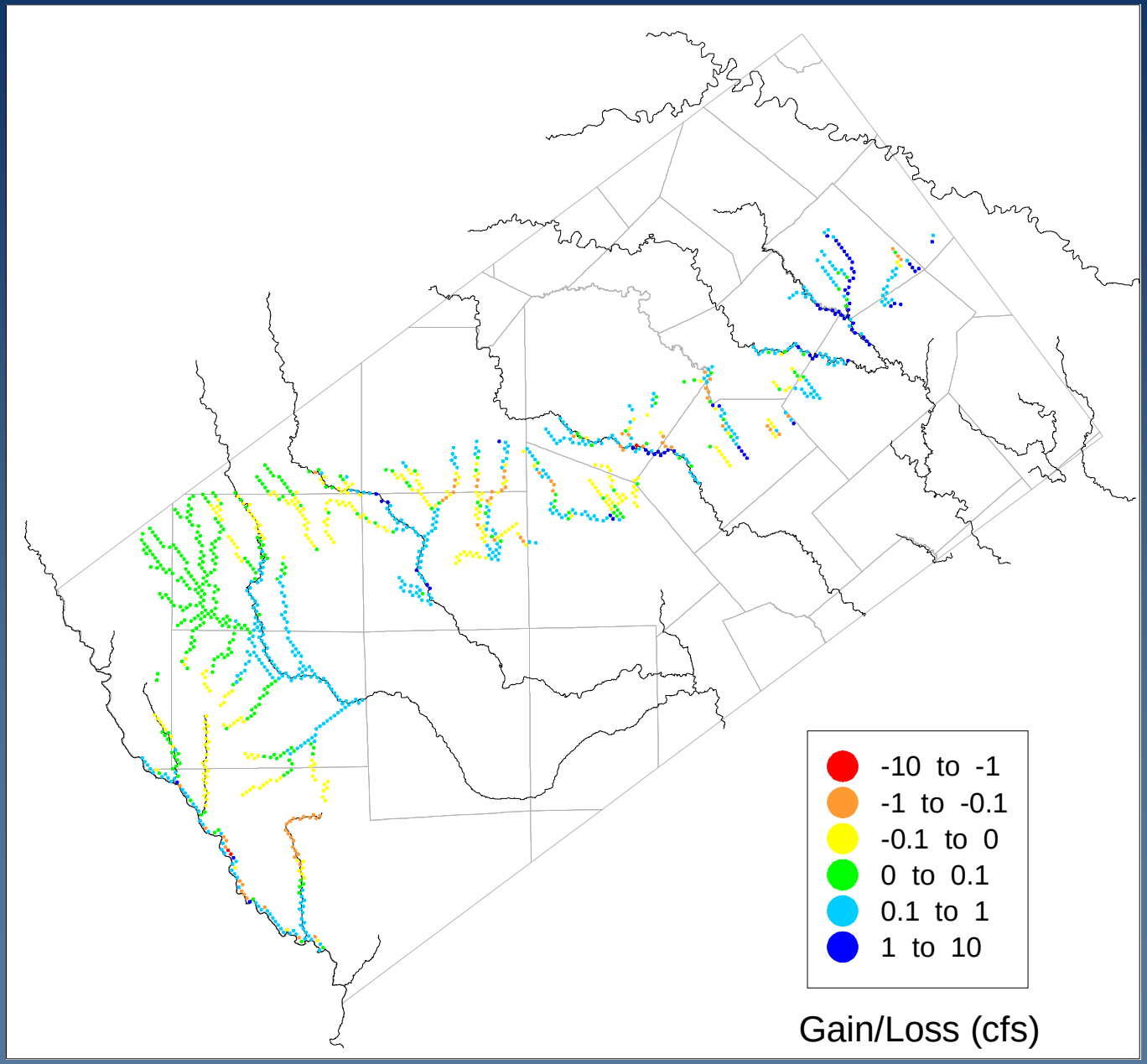
25-year average annual recharge



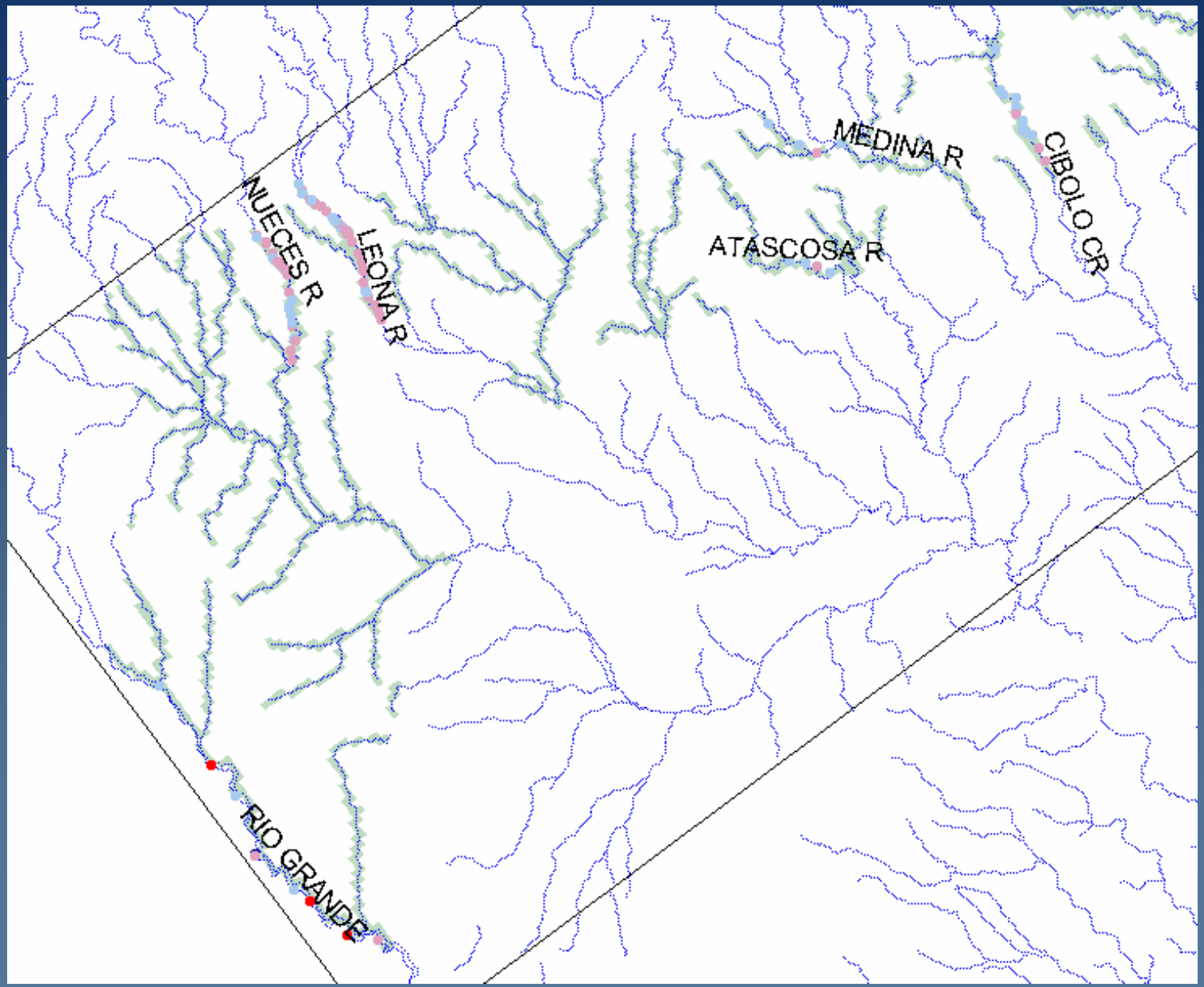
SWAT Median: 0.50 in/yr

Calibrated Median: 0.48 in/yr

Gain/Loss Results



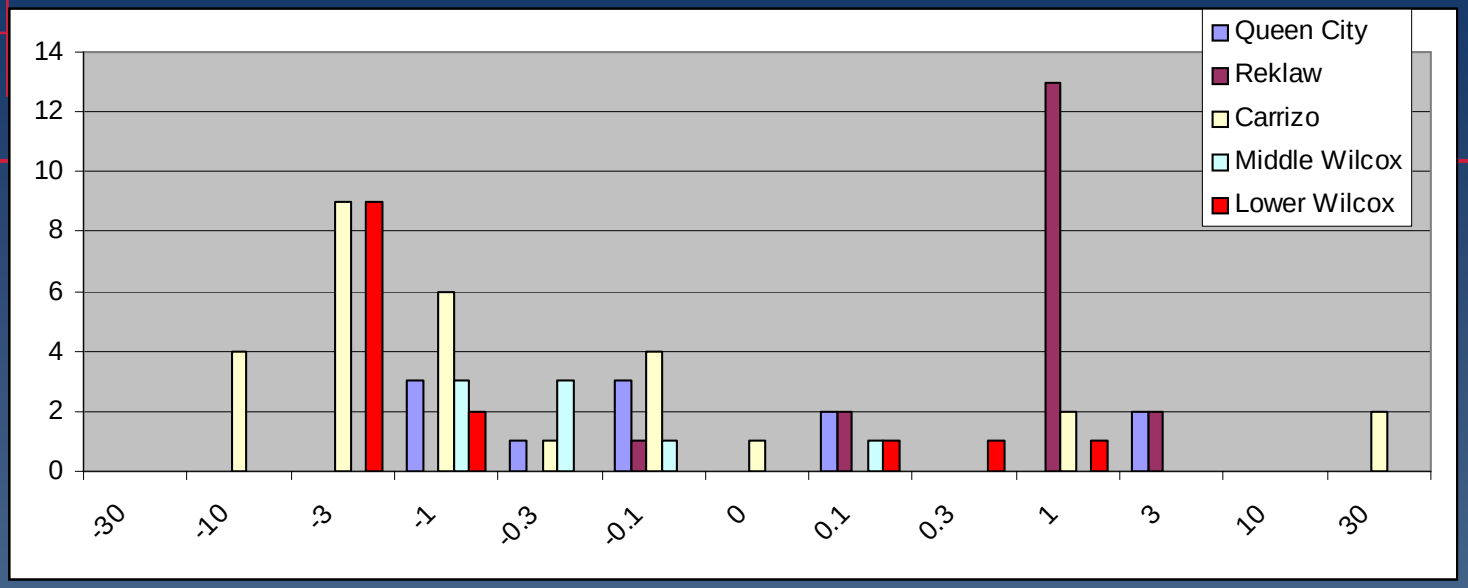
USGS Gain/Loss Studies



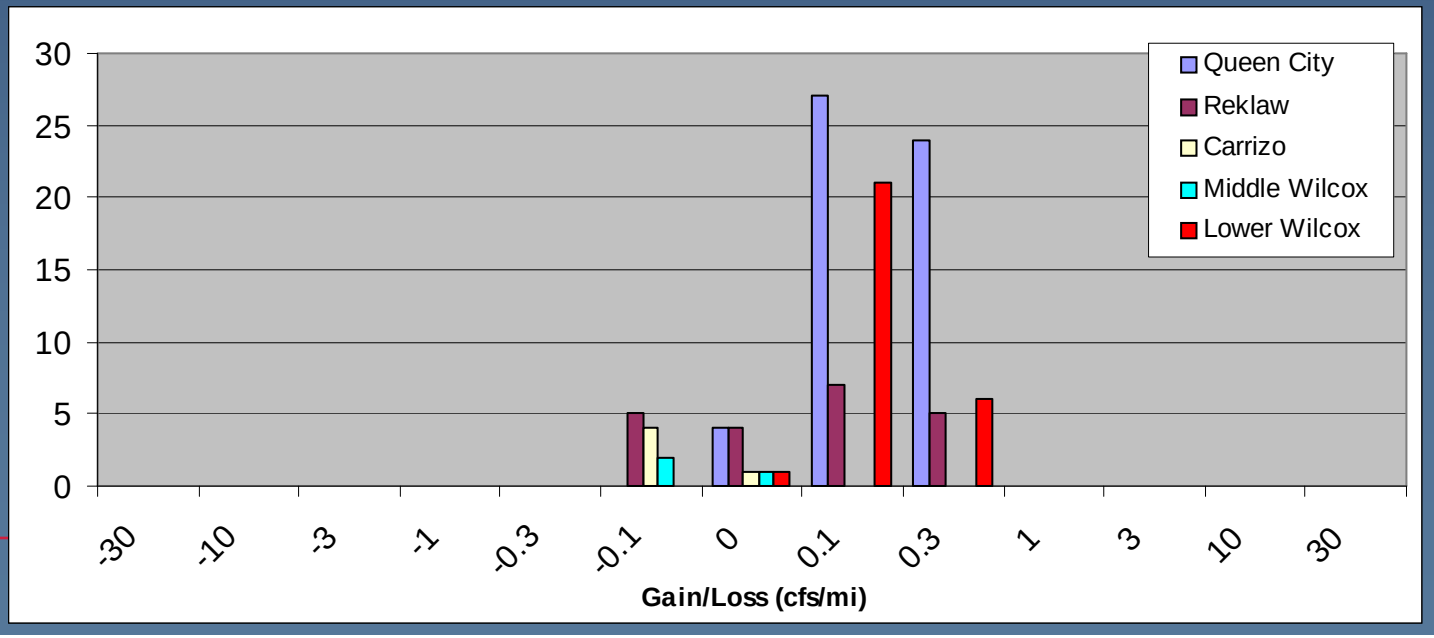
Stream Gain/Loss Results

Nueces River

Slade



Model



Model Mass Balance (%)

Inflow					
	Recharge	Stream	GHBs	Top	Bottom
Queen City	43	2	3	0	52
Reklaw	15	3	0	17	63
Carrizo	23	1	0	24	50
Upper Wilcox	2	0	0	51	47
Middle Wilcox	29	2	0	20	39
Lower Wilcox	22	1	0	46	0
Model	92	6	2		
Outflow					
	Recharge	Stream	GHBs	Top	Bottom
Queen City	0	38	47	0	15
Reklaw	0	14	0	60	27
Carrizo	0	10	0	57	34
Upper Wilcox	0	1	0	75	24
Middle Wilcox	0	35	0	39	25
Lower Wilcox	0	27	0	73	0
Model	0	67	33		

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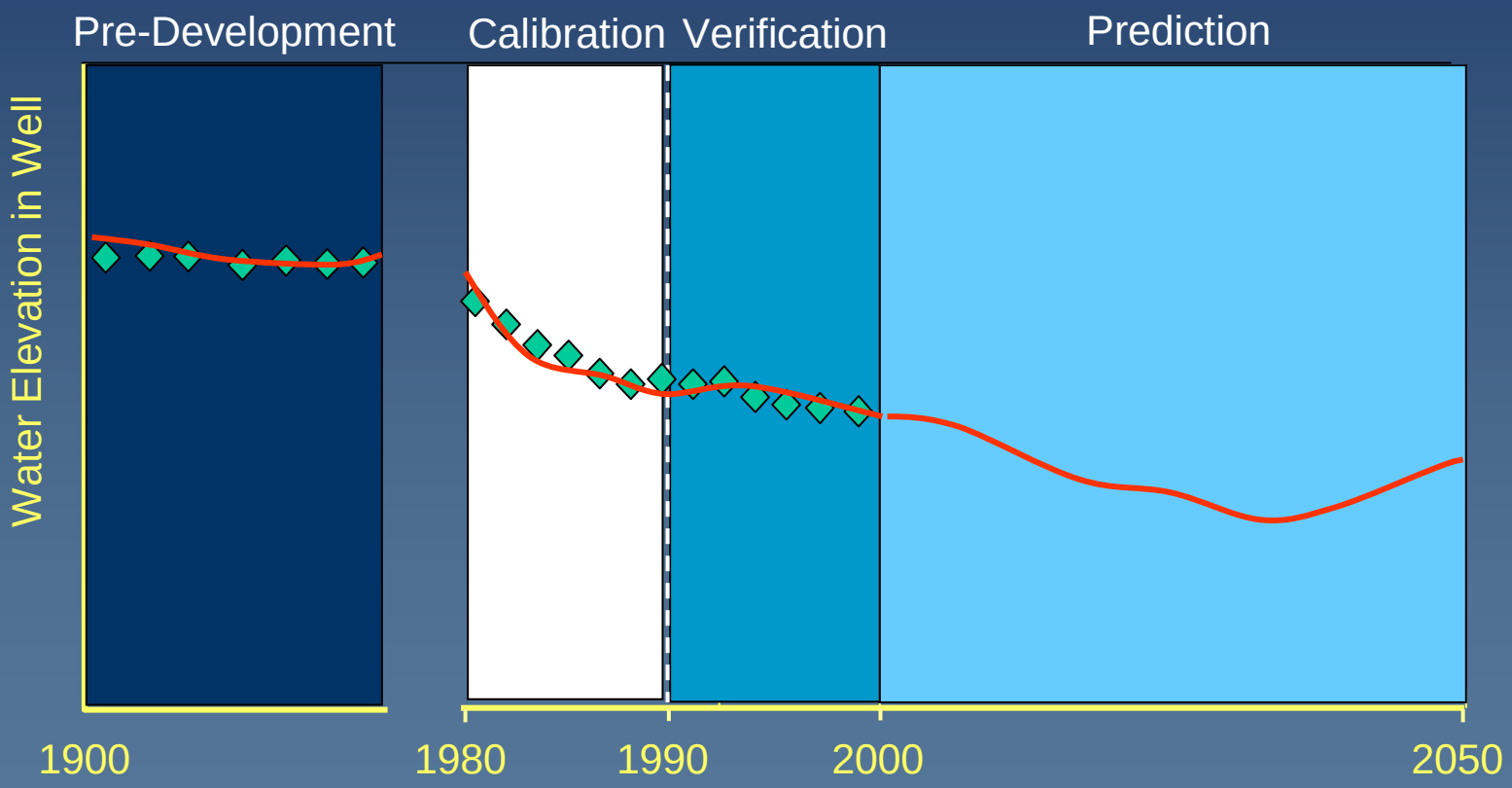
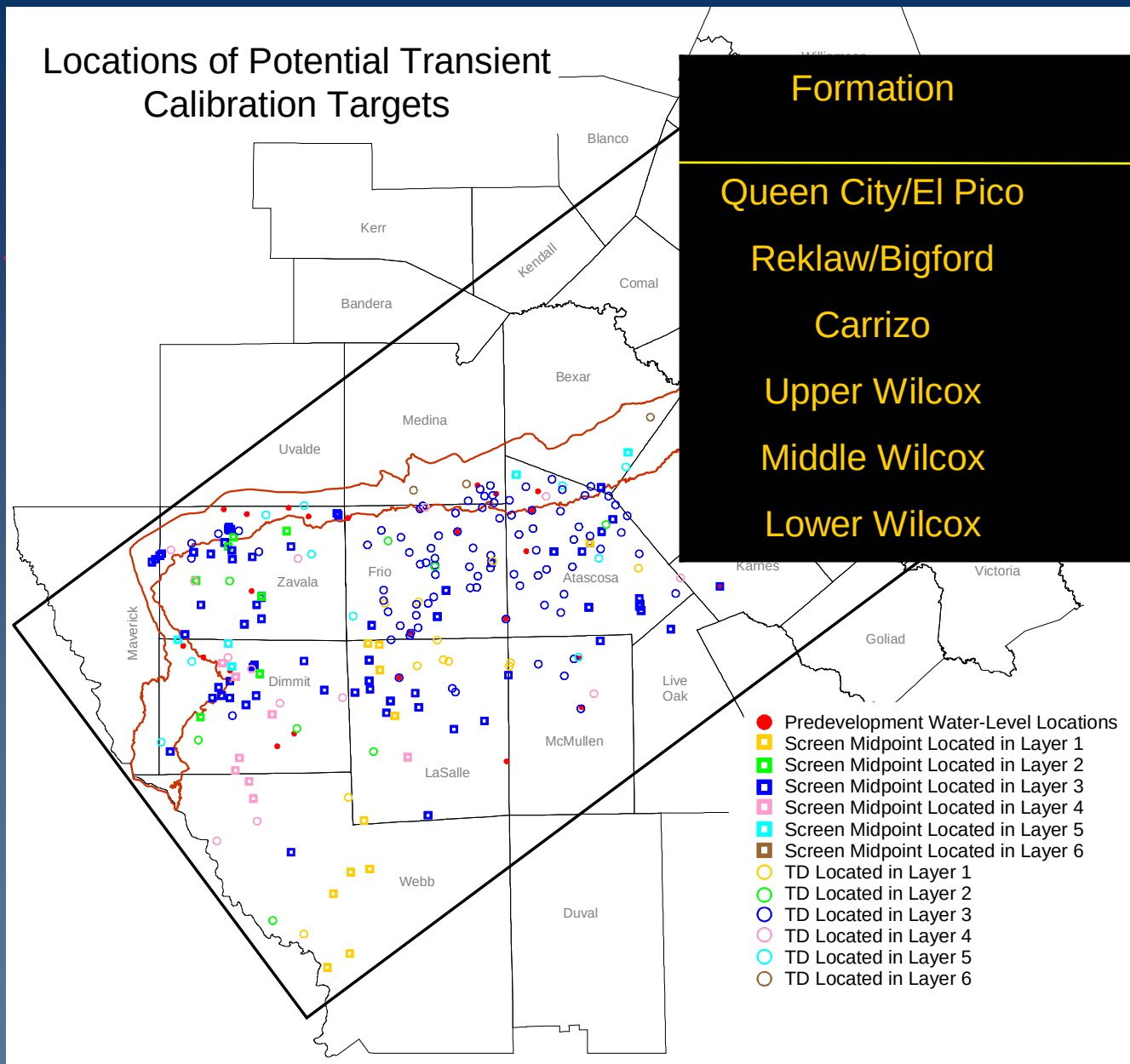
Modeling Periods



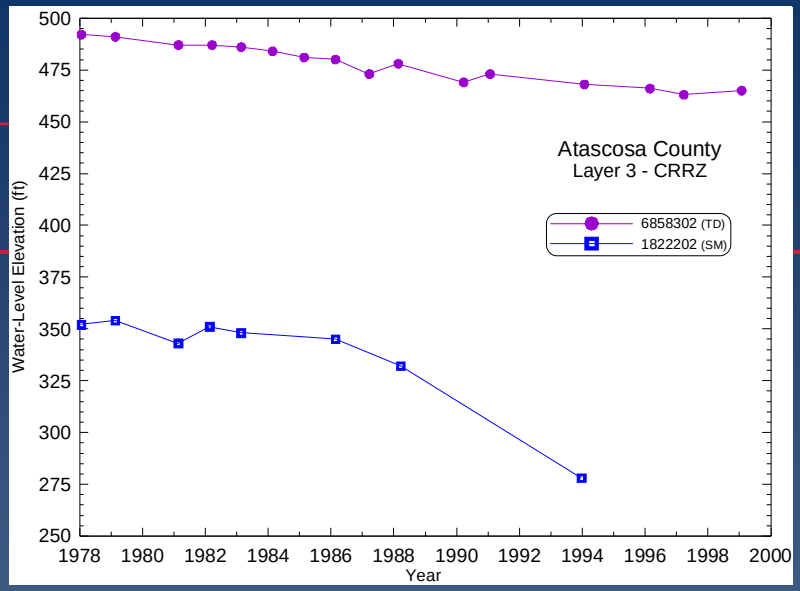
Transient Calibration

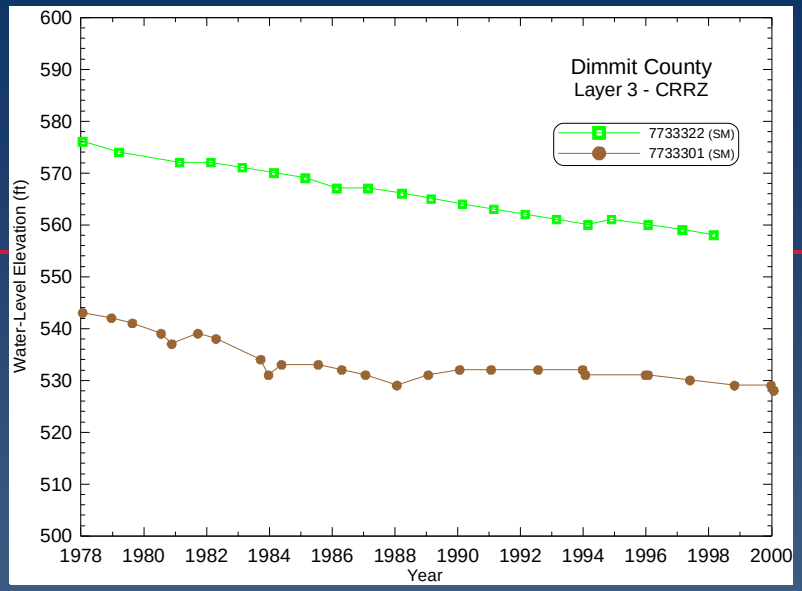
- Calibration Targets (1980-1990):
  - Hydraulic heads
  - Stream/Aquifer interaction (flow rates)
- Model Parameters:
  - Hydraulic conductivity
  - Storativity
  - Recharge (monthly variation)
  - Pumpage (monthly variation)
  - Stream headwater flowrates
- Verification (1991-2000):
  - Hydraulic heads
  - Stream/Aquifer interaction (flow rates)

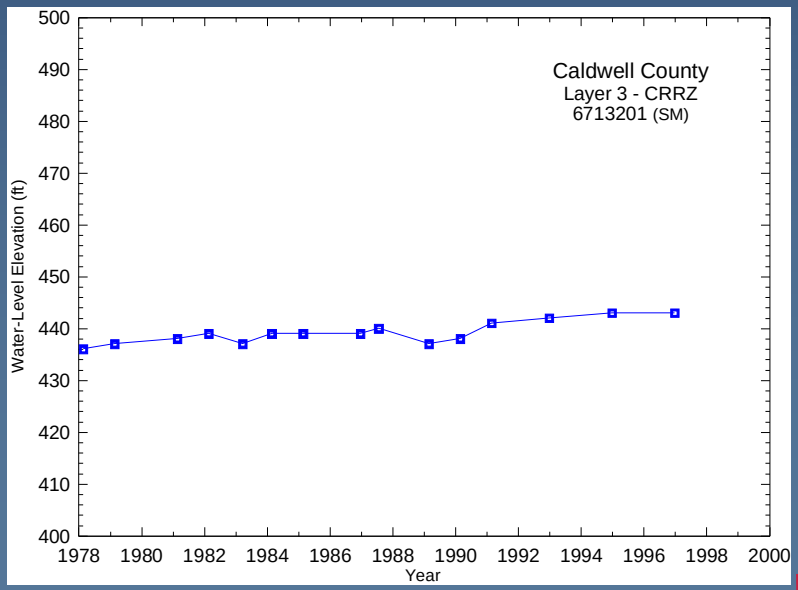
Locations of Potential Transient Calibration Targets

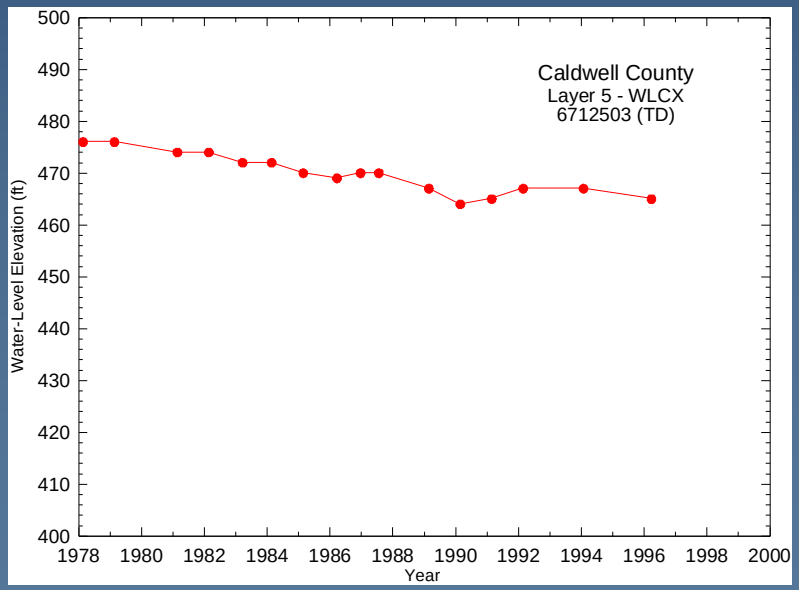


Formation	Number of Hydrographs
Queen City/El Pico	26
Reklaw/Bigford	15
Carrizo	195
Upper Wilcox	20
Middle Wilcox	25
Lower Wilcox	10

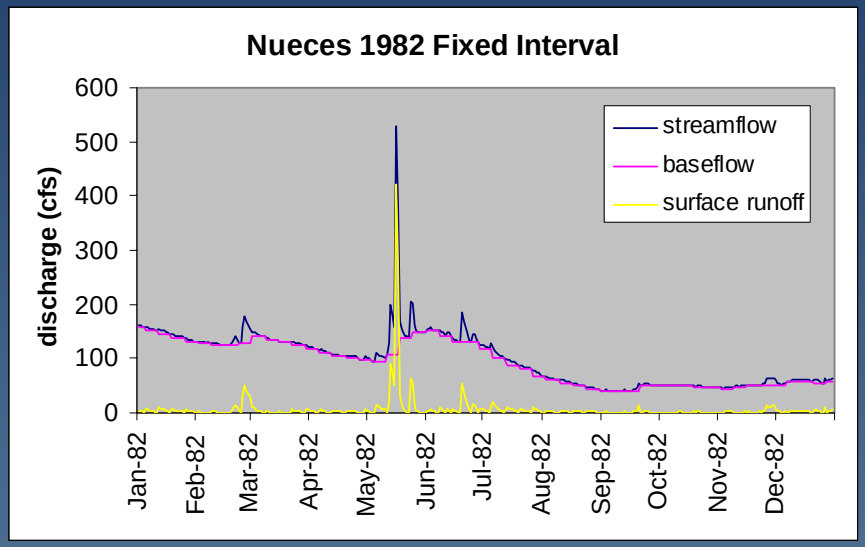

Atascosa County
Layer 3 - CRRZ
6858302 (TD)
1822202 (SM)
Water-Level Elevation (ft)
Year


Dimmit County
Layer 3 - CRRZ
7733322 (SM)
7733301 (SM)
Water-Level Elevation (ft)
Year


Caldwell County
Layer 3 - CRRZ
6713201 (SM)
Water-Level Elevation (ft)
Year

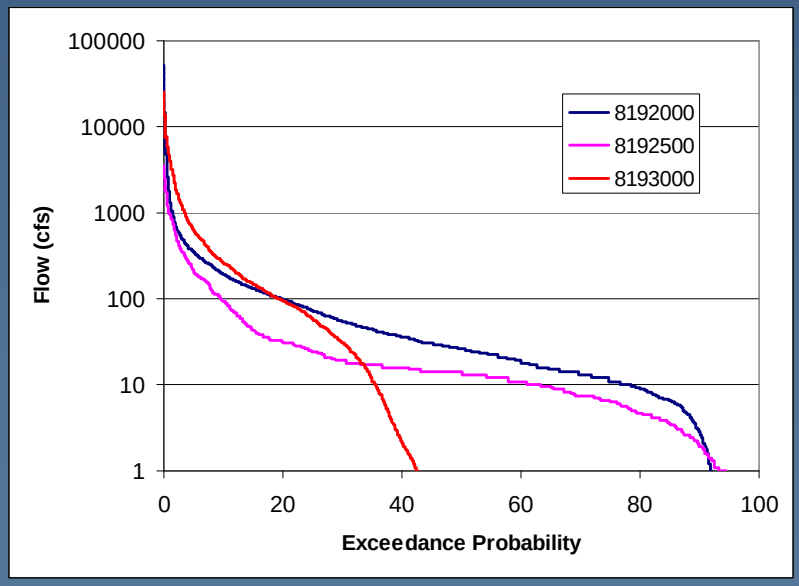

Caldwell County
Layer 5 - WLCX
6712503 (TD)
Water-Level Elevation (ft)
Year

Surface Water Calibration Targets

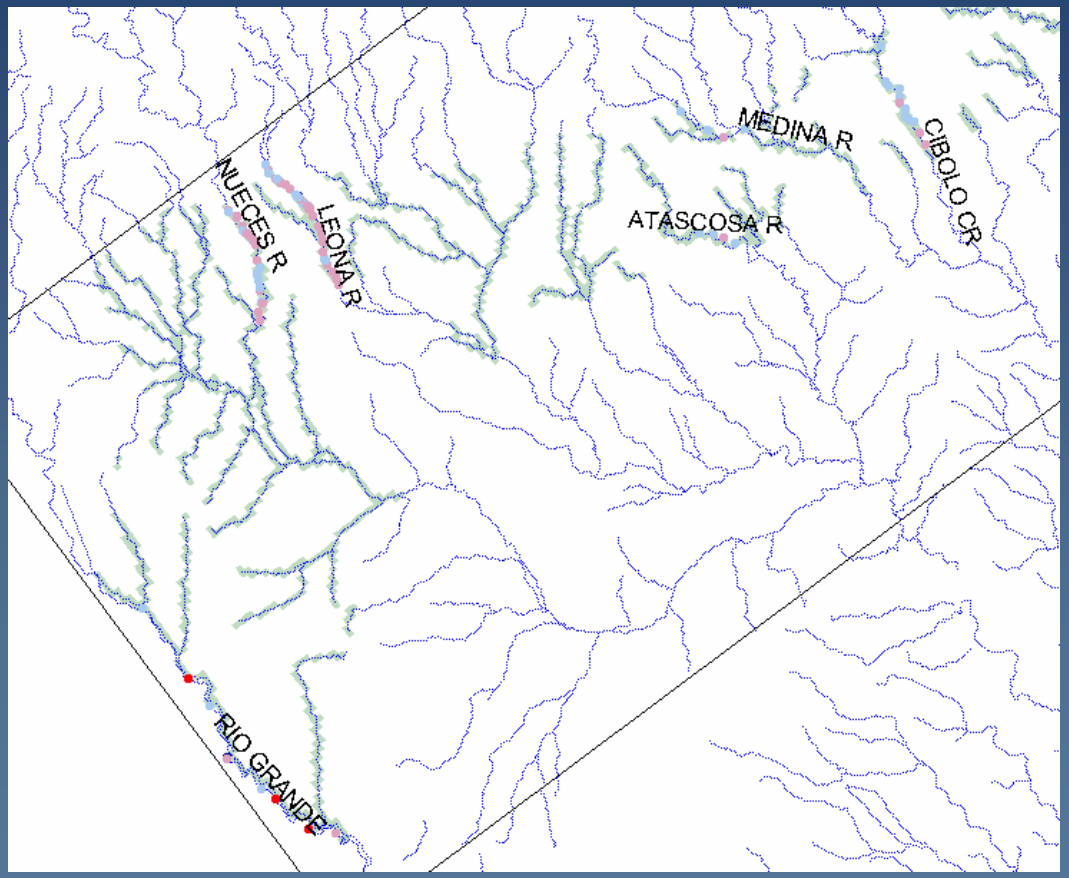


Base Flow Estimates

Flow Duration Curves

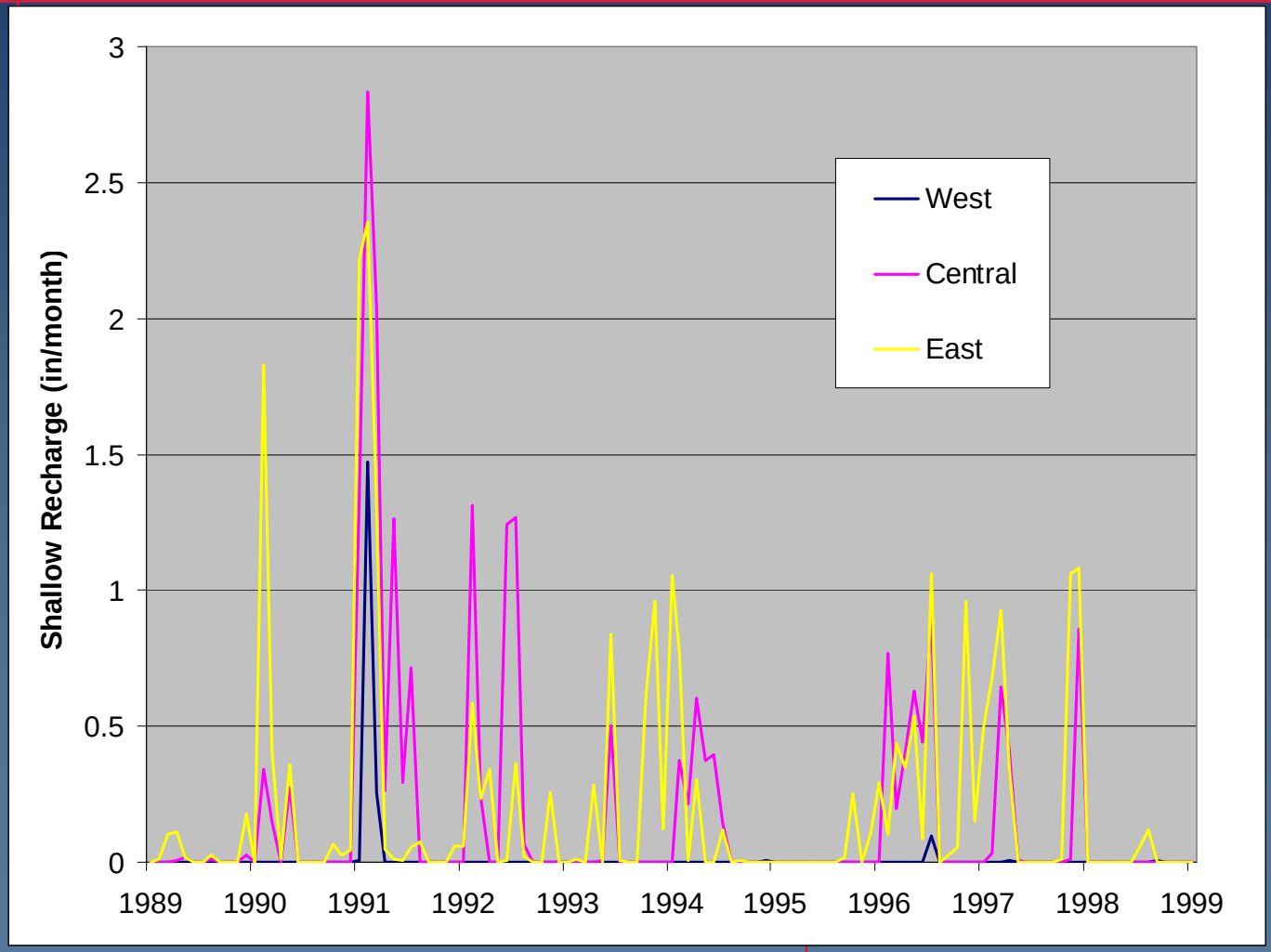


Surface Water Calibration Targets



USGS Gain Loss Study
Results of Slade (2002)

Transient Recharge Functions

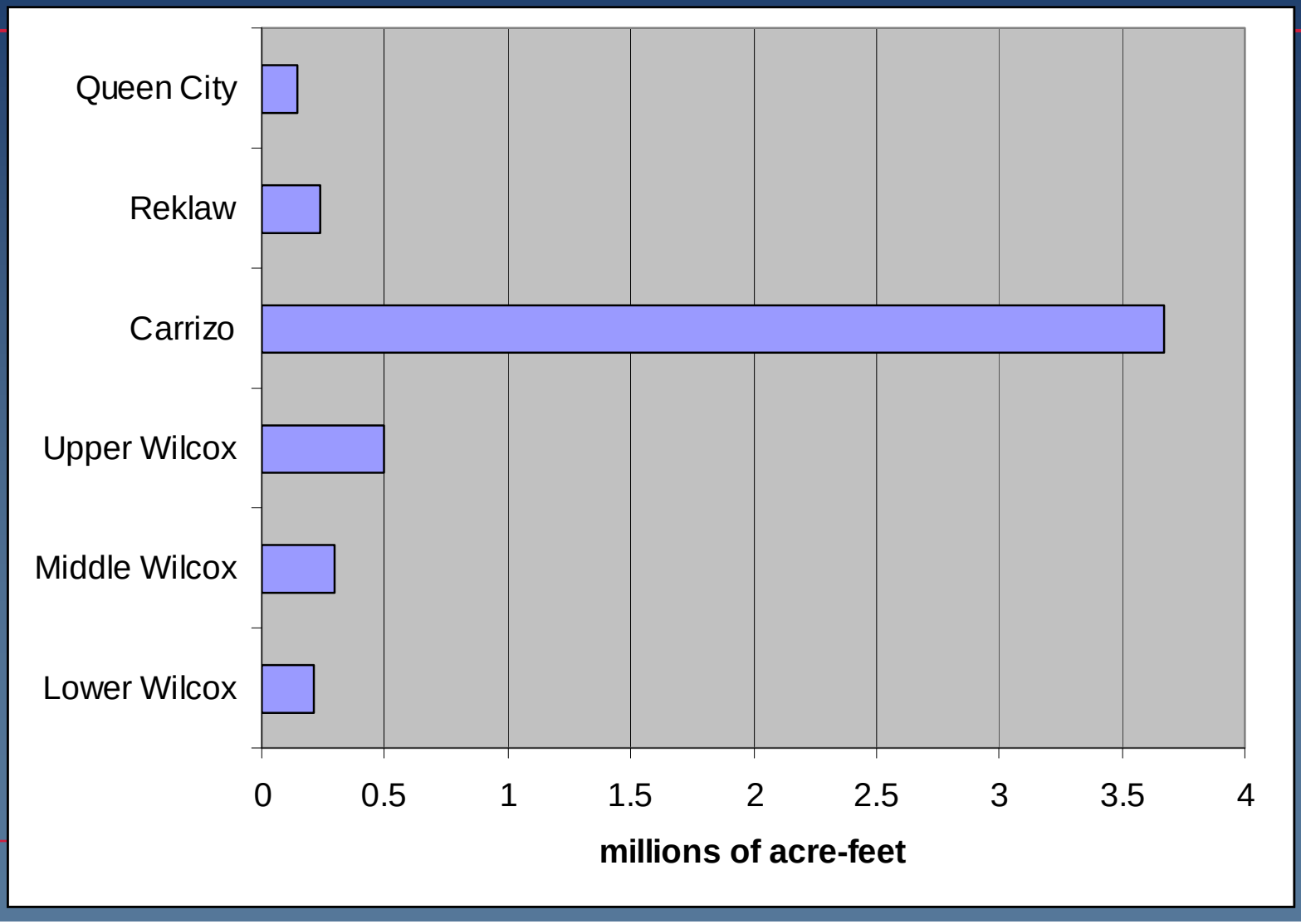


Shallow Recharge

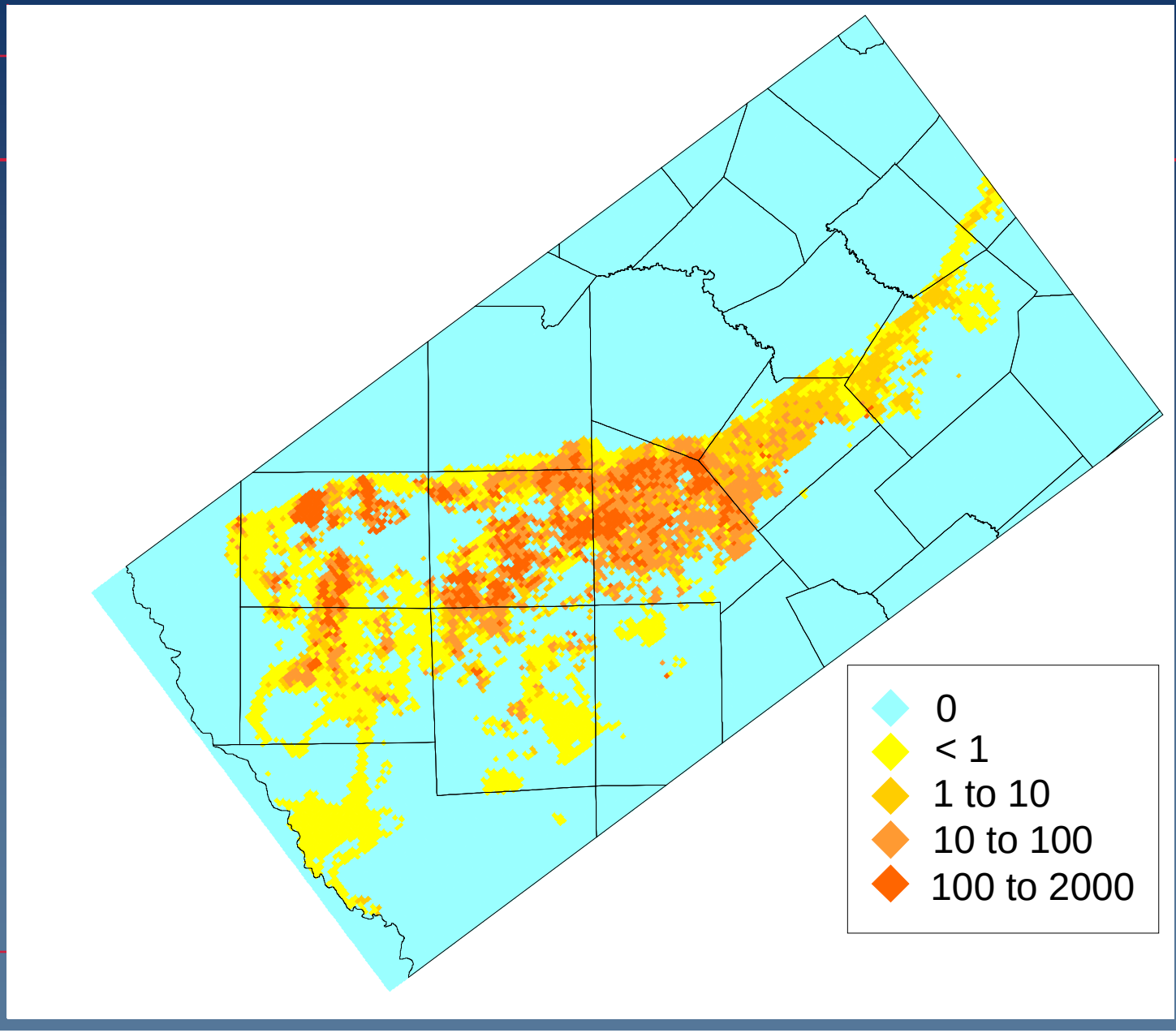
Representative
5 square mile areas

Preliminary Results
Not Final

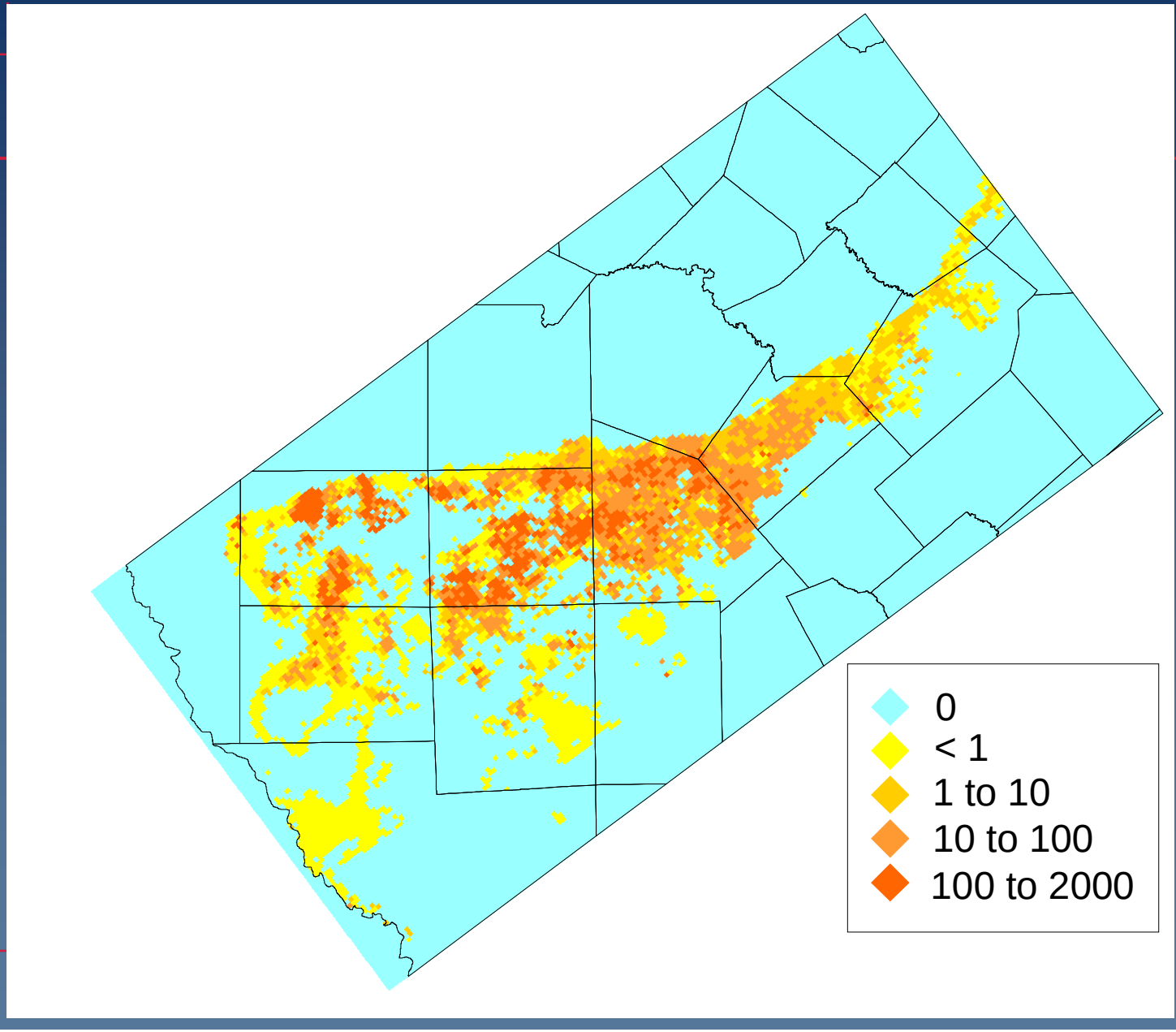
Cumulative Pumping – 1980 to 1999



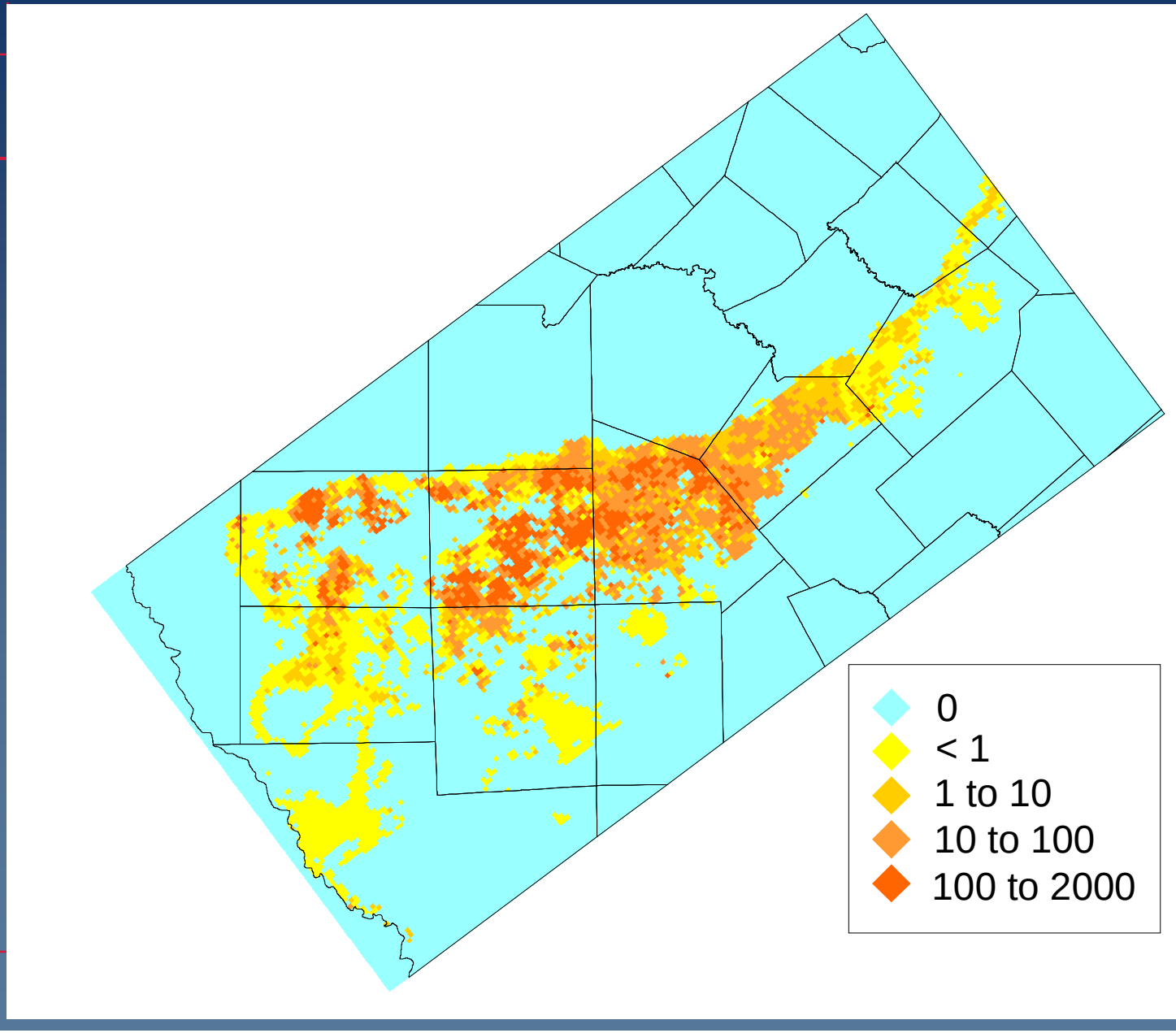
Pumping – 1980 (acre-ft/yr)



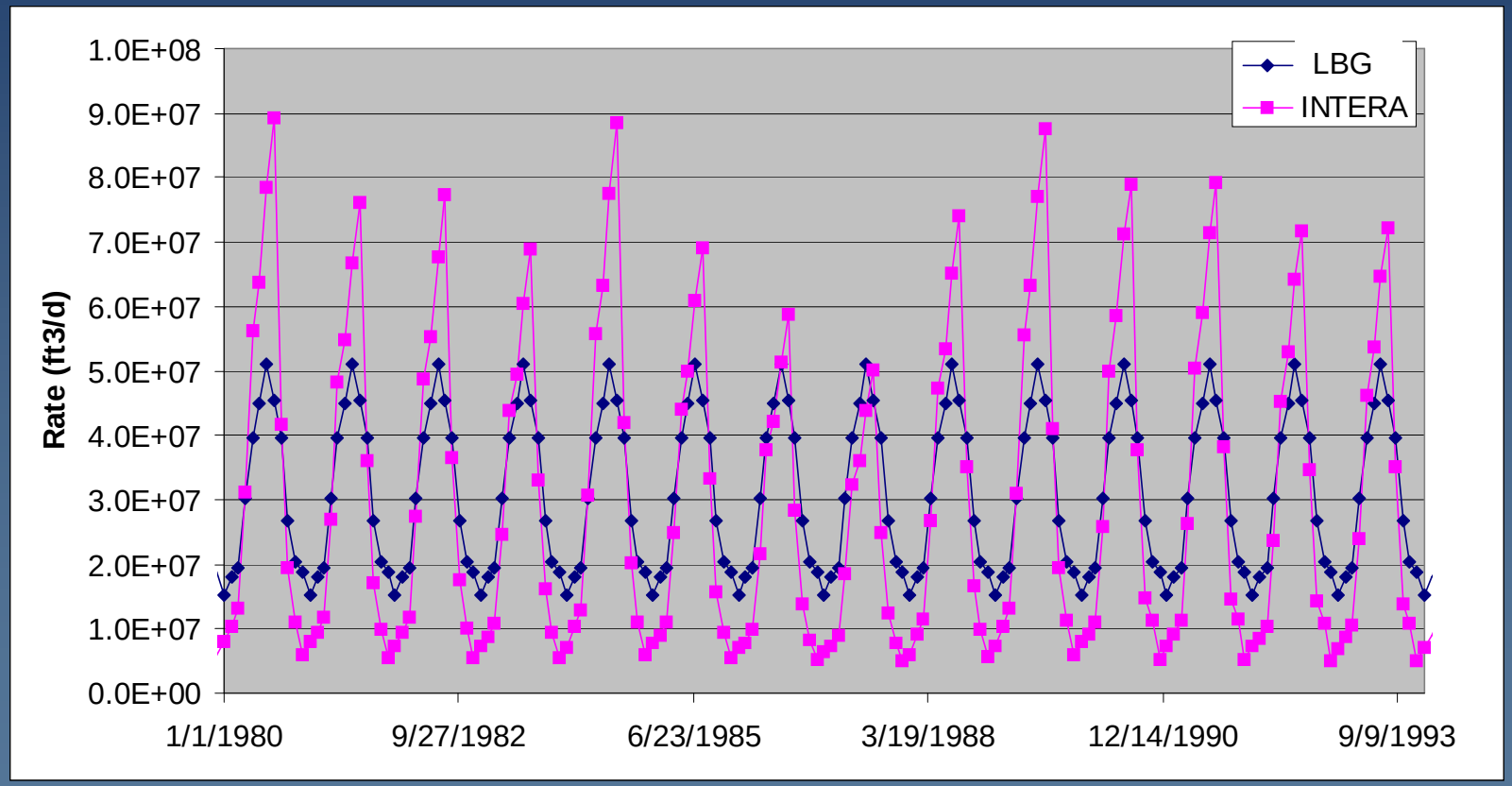
Pumping – 1990 (acre-ft/yr)



Pumping – 1999 (acre-ft/yr)



Model pumping rate comparison

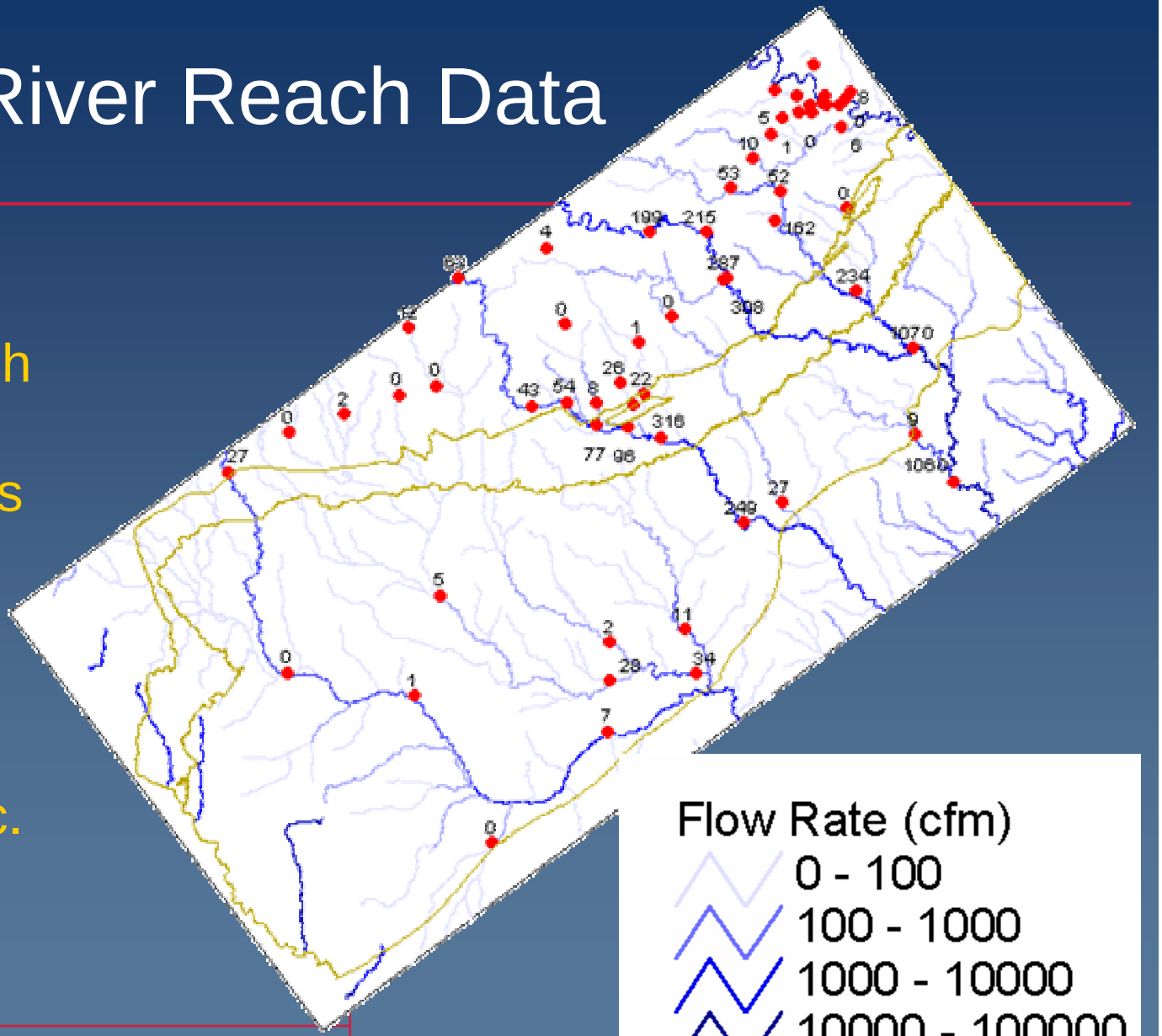


Stream Routing

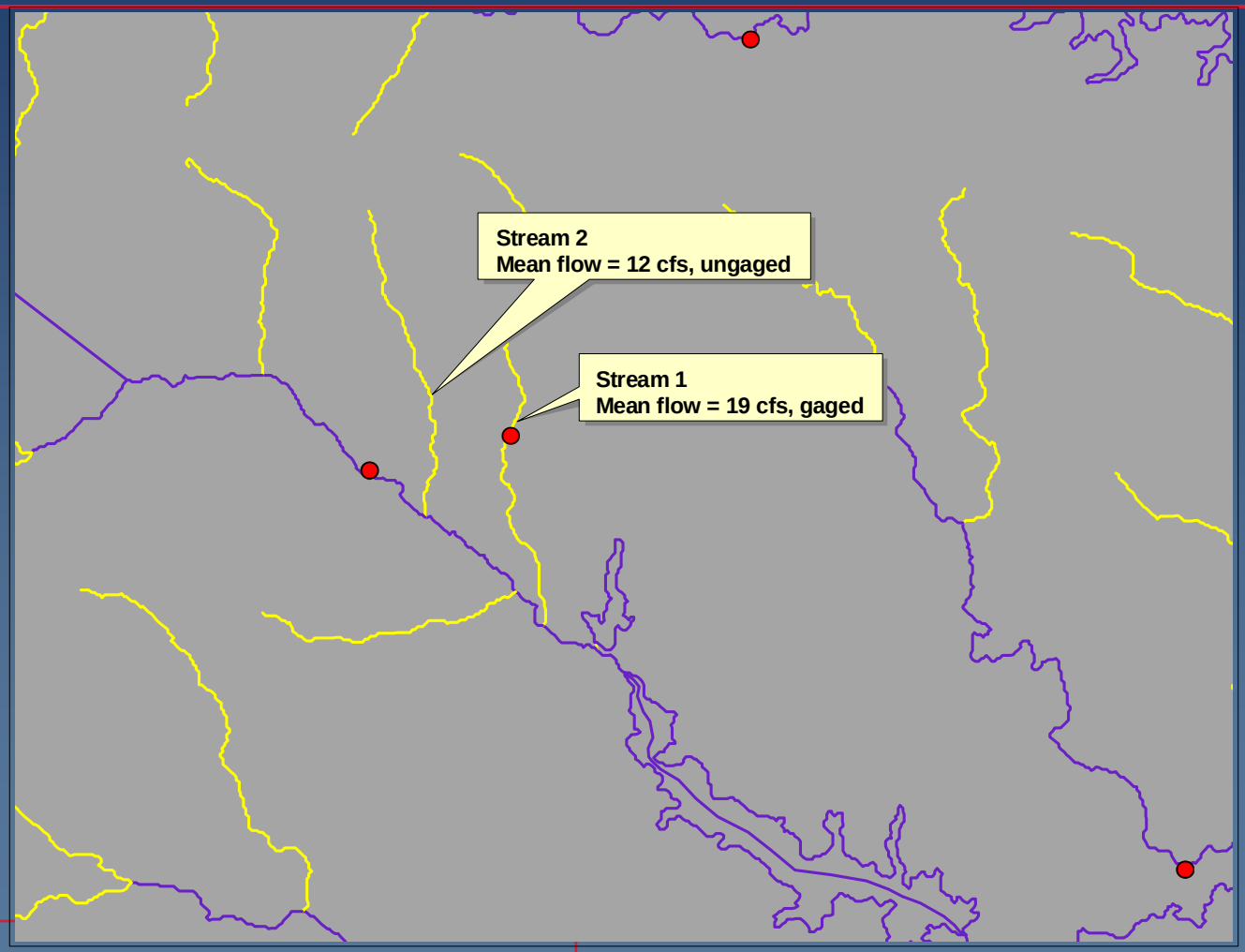
- Use MODFLOW Stream Routing Package (Prudic, 1988)
- Stream stages are calculated using Manning's equation
- Stream-routing package routes surface water and calculates stream/aquifer interaction (gaining/losing)

EPA River Reach Data

EPA river reach data include many attributes needed in MODFLOW: width, depth, stage, roughness, etc.



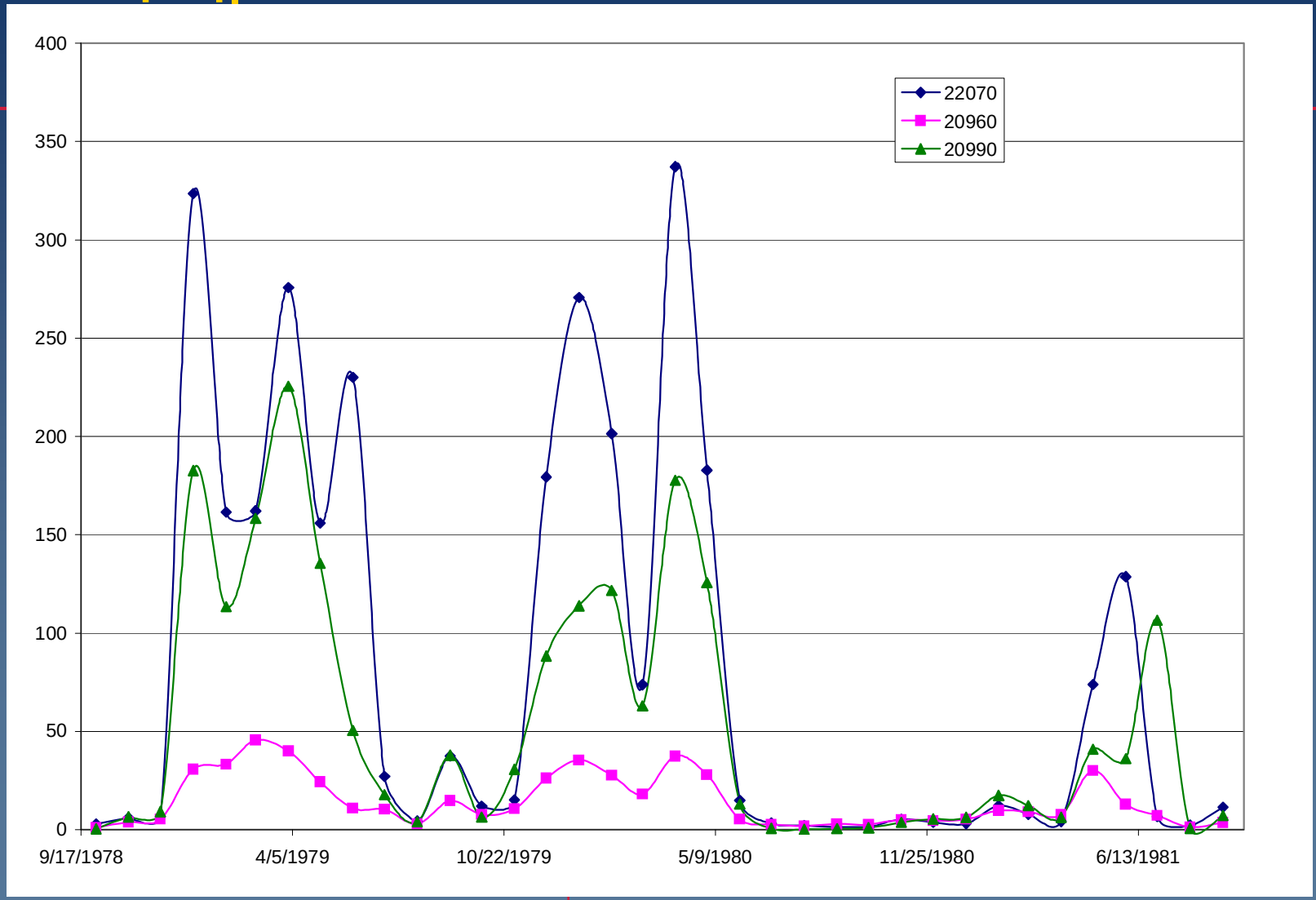
Estimating Stream Flows at Headwaters



Estimating Stream Flows at Headwater Assumptions

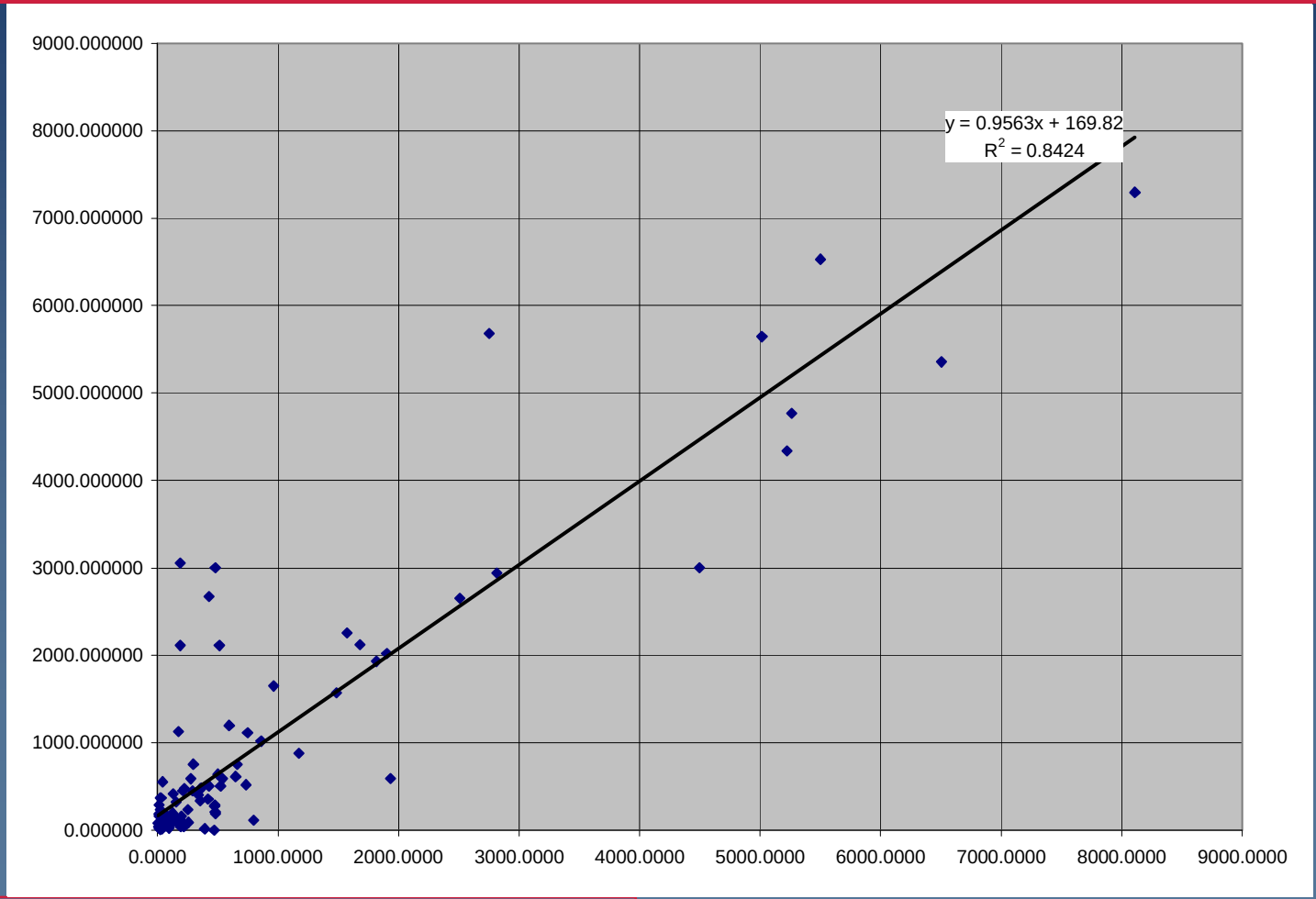
- Daily stream flows are logarithmically distributed
- Average stream flows from RF1 dataset are accurate
- Proximal streams react similarly. Stream 2 reacts similarly to Stream 1
- $\text{Stdev}(\text{Log}(Q_2)) = \text{Stdev}(\text{Log}(Q_1))$

- Response of nearby streams is

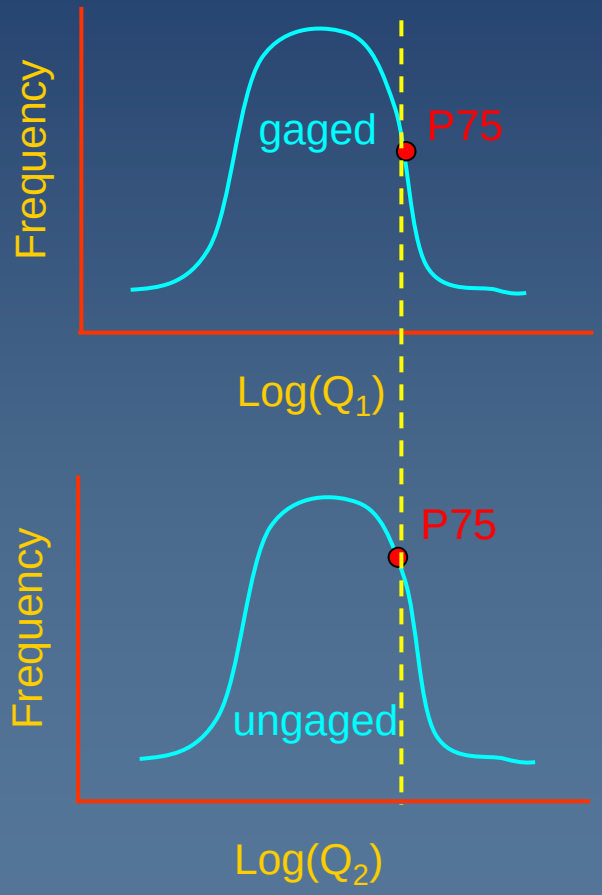


Estimating Ungaged Stream Flows at Headwaters

- Plot below shows period-of-record means from USGS gage data versus mean flows from RF1 data



Estimating Stream Flows at Headwater Process



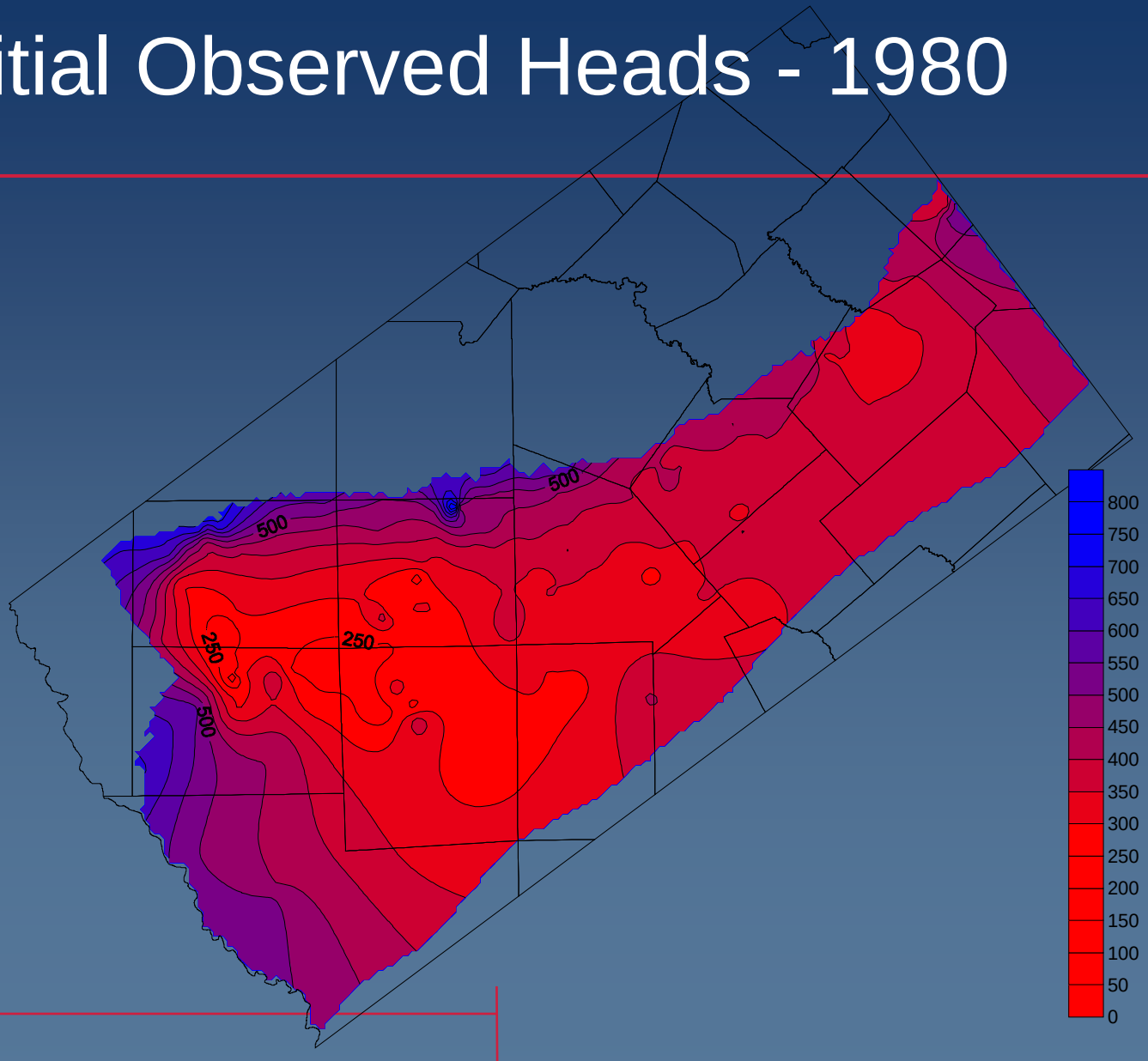
In month X we have a measured monthly average flow rate equal to the 75th percentile (P75).

Knowing the mean monthly flow rate and the standard deviation, we can then calculate the 75th percentile flow rate for the ungaged stream.

Preliminary Transient Model Results

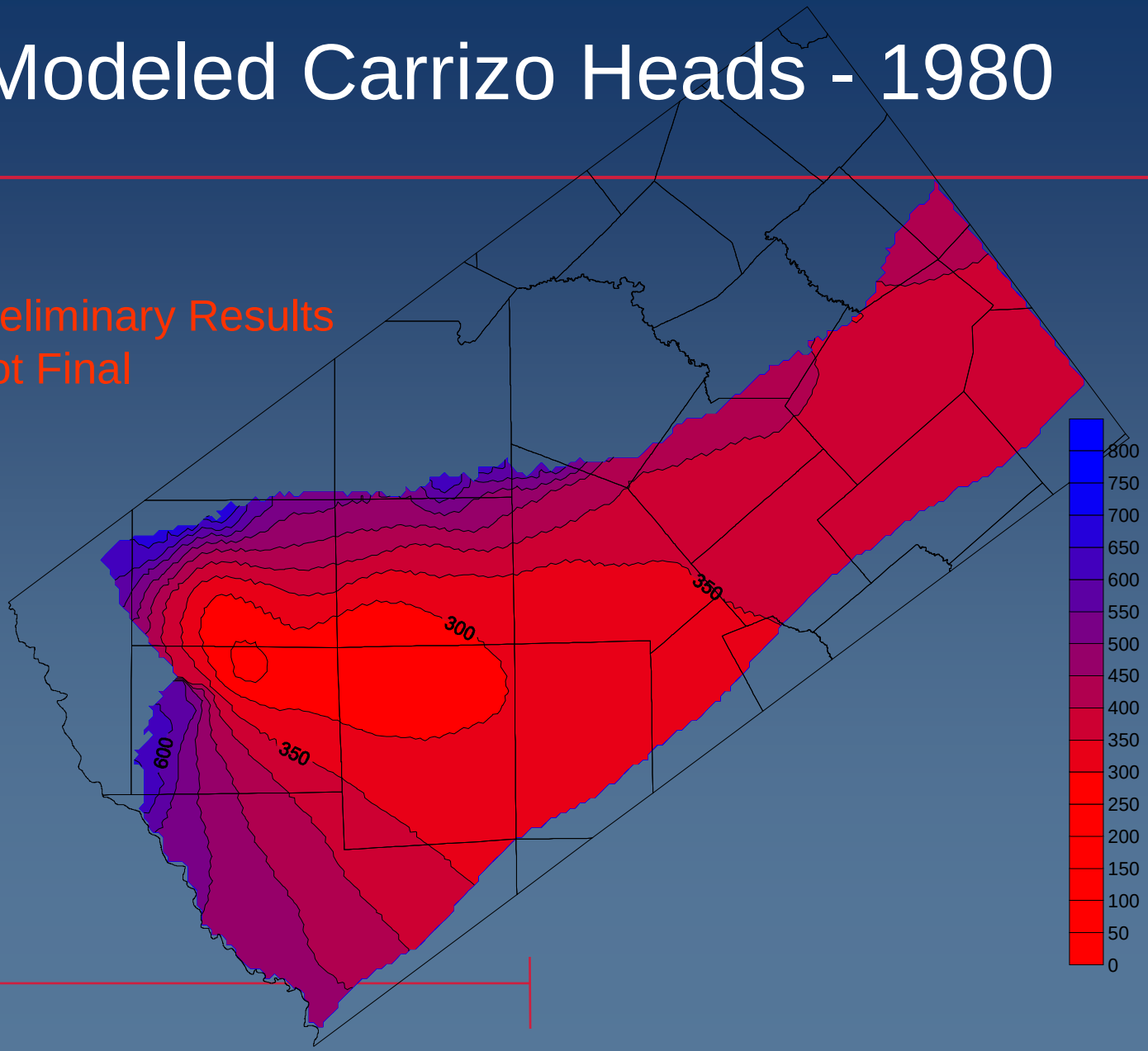
Not Final

Initial Observed Heads - 1980



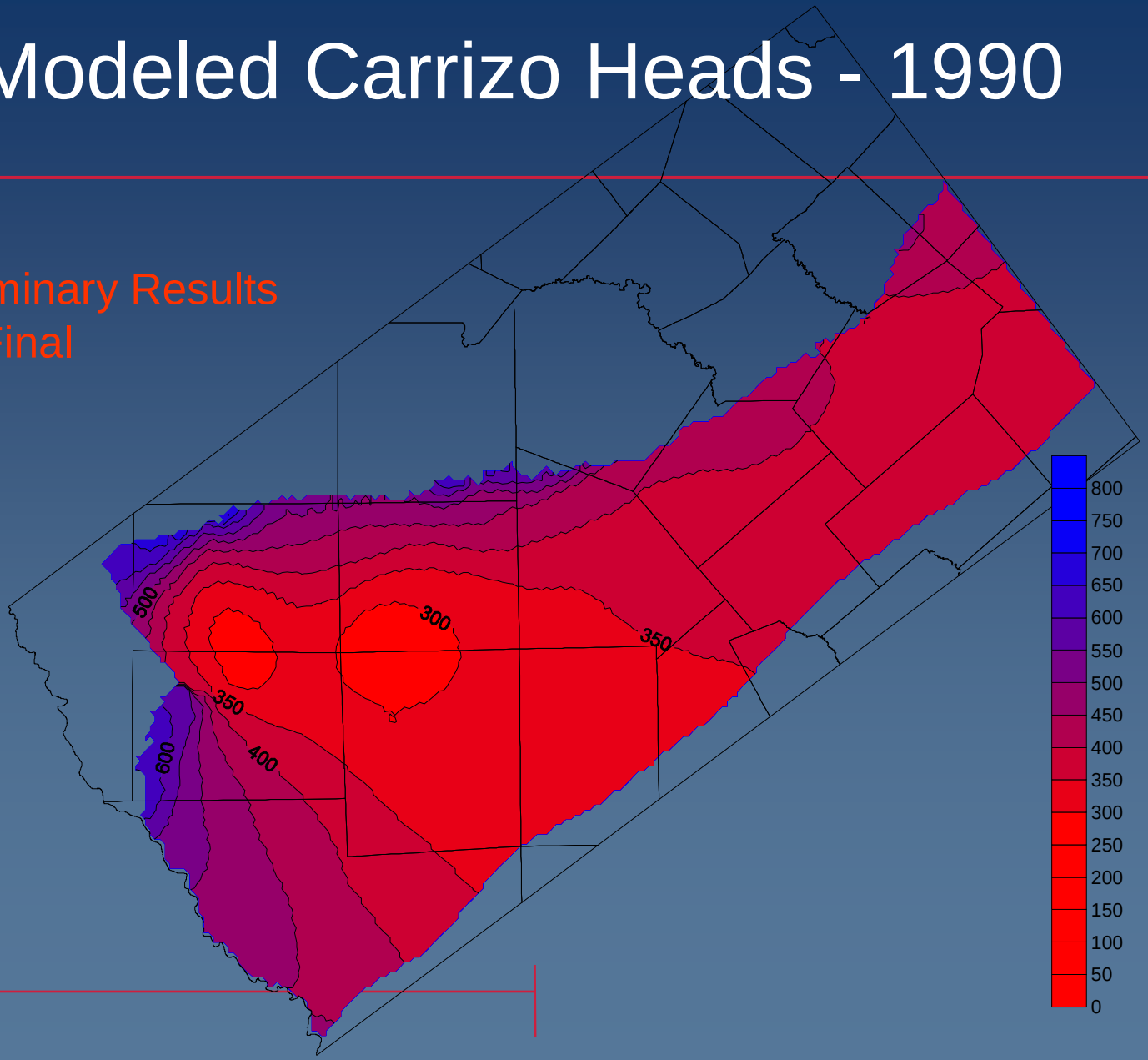
Modeled Carrizo Heads - 1980

Preliminary Results
Not Final



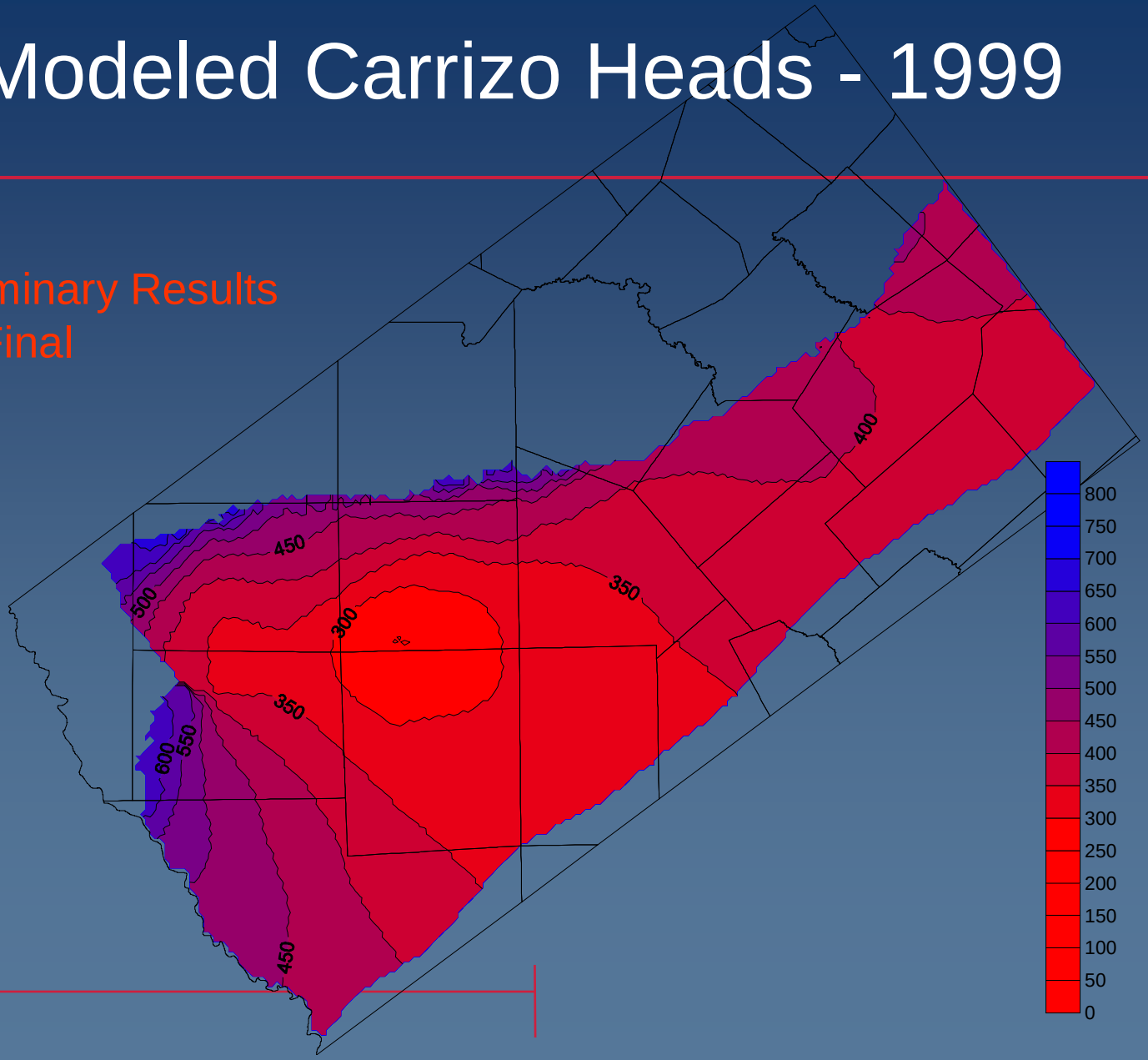
Modeled Carrizo Heads - 1990

Preliminary Results
Not Final



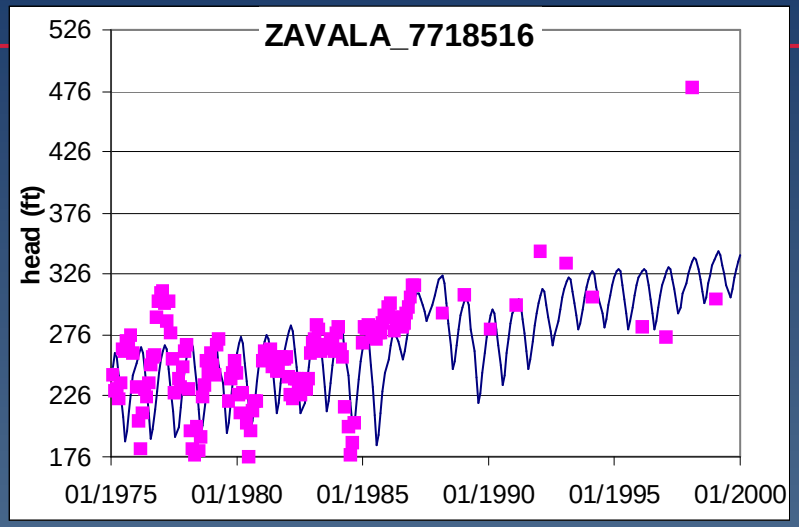
Modeled Carrizo Heads - 1999

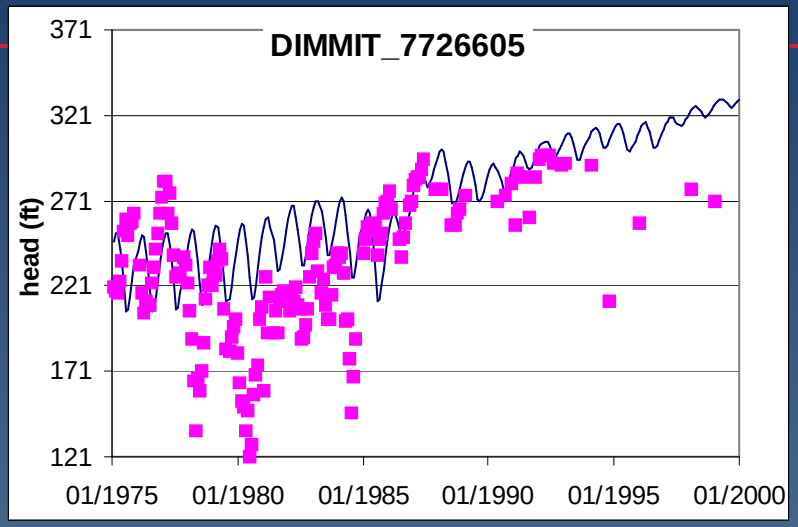
Preliminary Results
Not Final

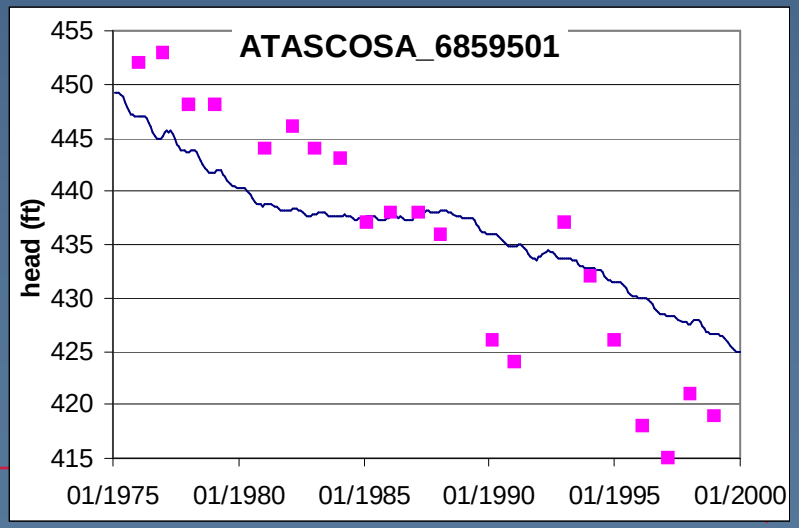


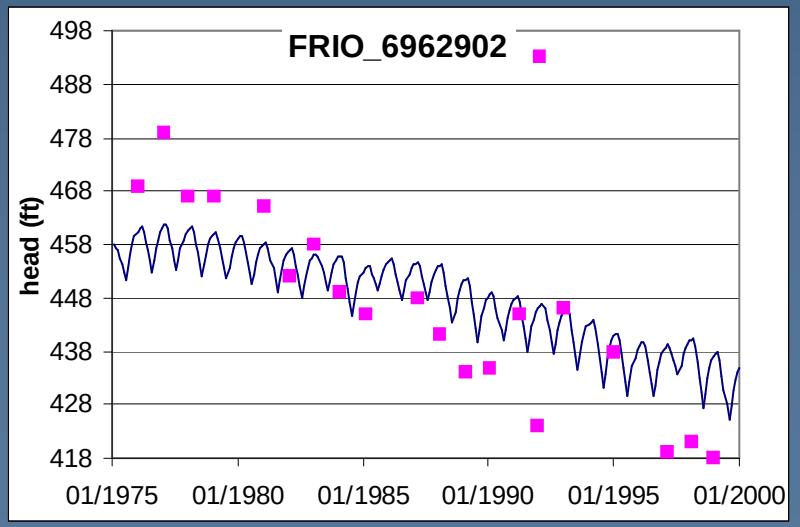
Select Hydrographs Simulated versus Observed

Preliminary Results
Not Final



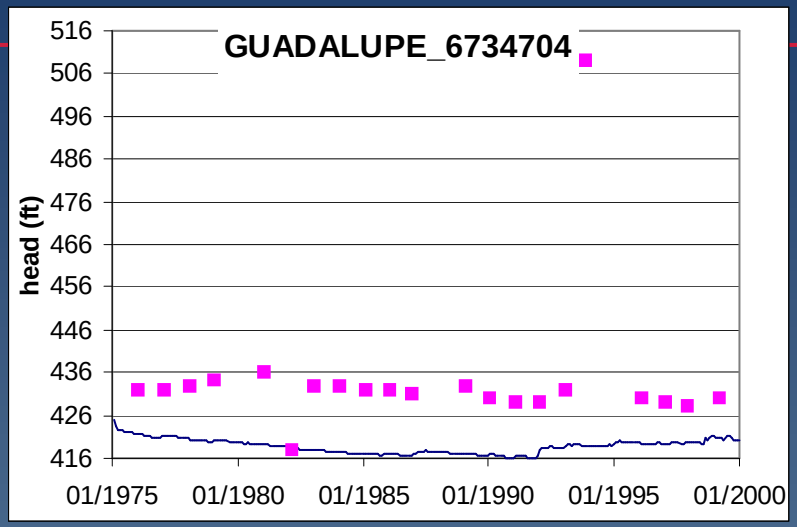


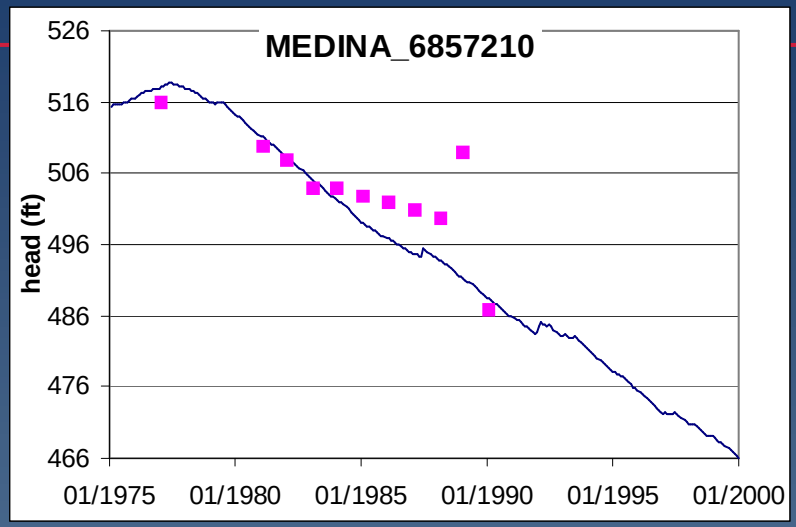


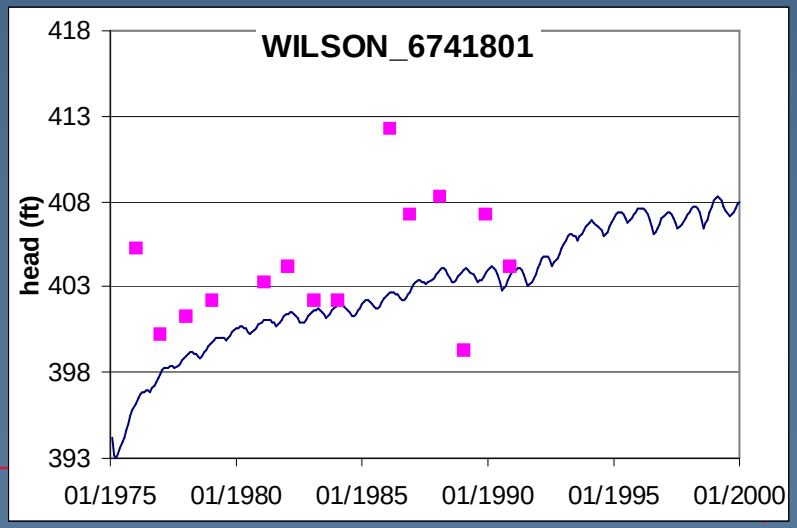


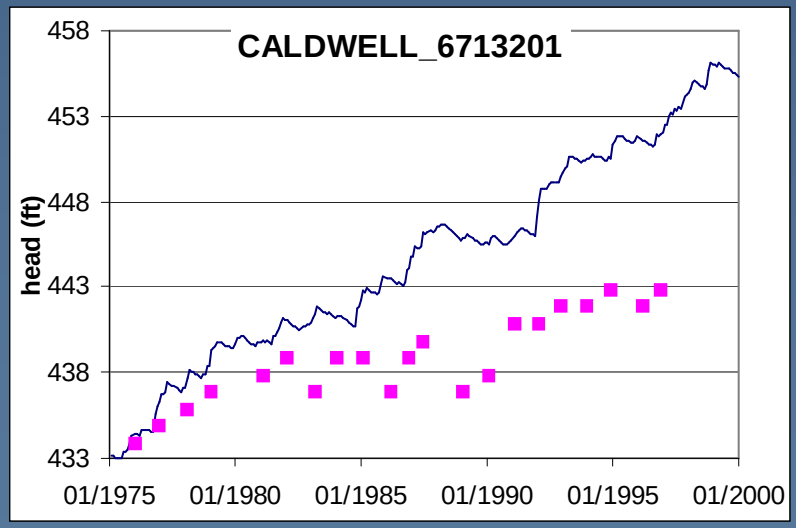
Select Hydrographs Simulated versus Observed

Preliminary Results
Not Final



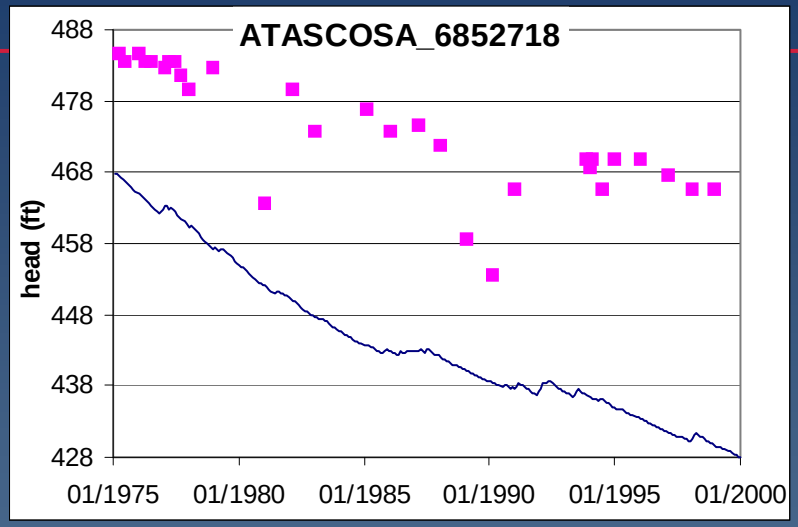


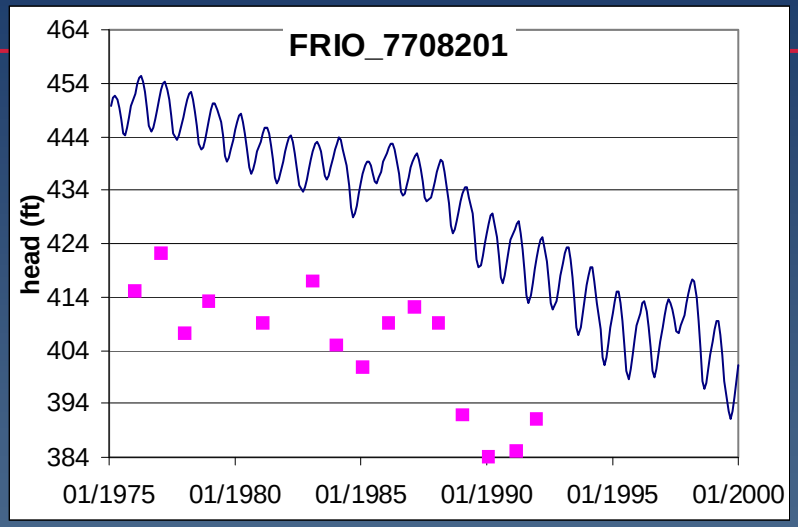


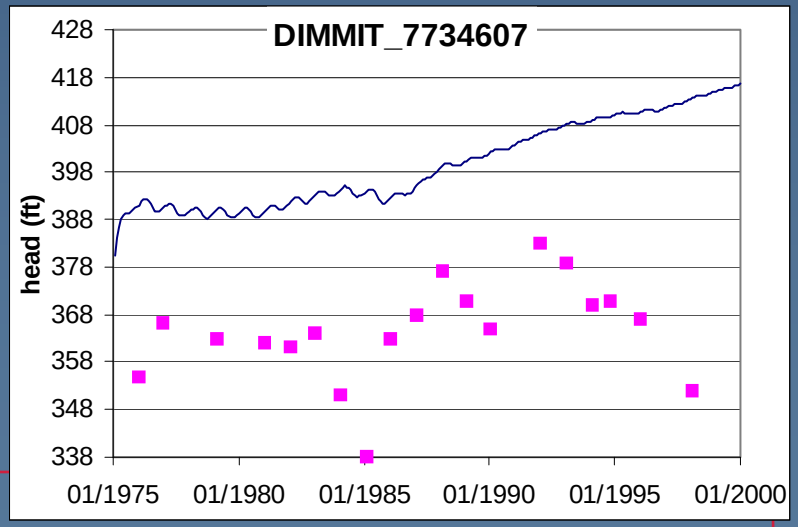


Select Hydrographs Simulated versus Observed

Preliminary Results
Not Final





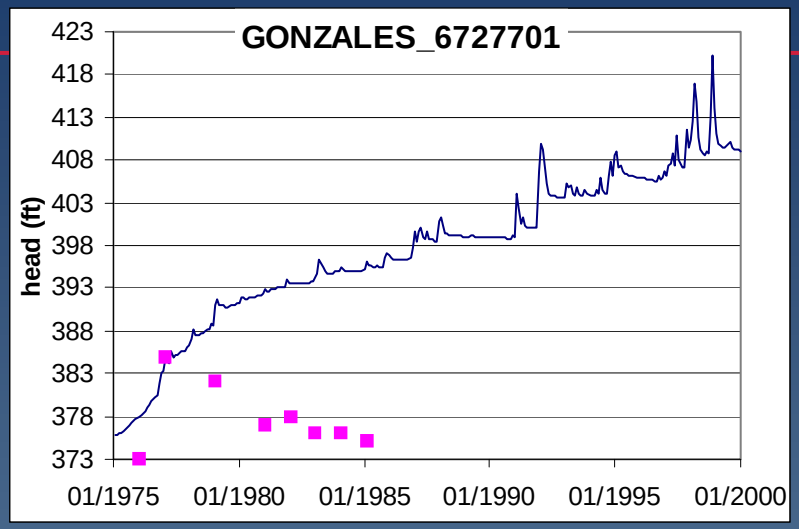


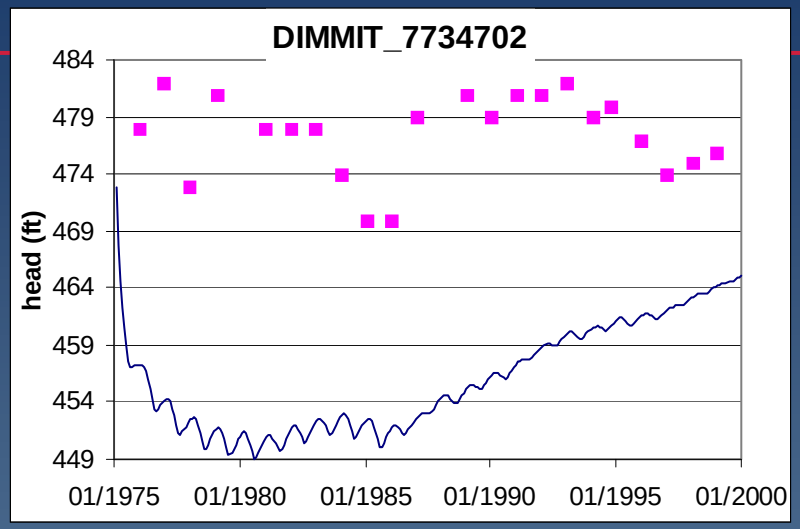
Magnitude in error..
Trends not bad

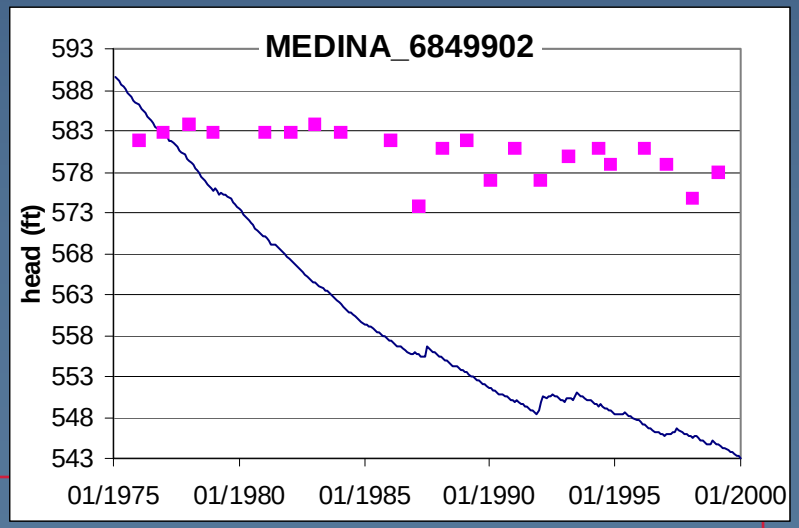
Generally initialization Issue

Select Hydrographs
Simulated versus Observed

Preliminary Results
Not Final







Magnitude in error..
Trends in error

Parameterization Issue

Presentation Outline

- GAM Program Review
- Conceptual Model Review
- Steady-State Model Recap
- Transient Model
- Path Forward
- Schedule and SAF-7

Path Forward

- Currently are looking at initialization (heads) problem areas of the model
- Parameterization will be adjusted to better match trends in problem areas of the model
- Calibration focus from groundwater to surface water as groundwater calibration improves

Presentation Outline

- GAM Program Review
- Conceptual Model Review
- Steady-State Model Recap
- Transient Model
- Path Forward
- Schedule and SAF-7

Southern GAM Schedule

2001

- SAF 1 — Apr 24
- SAF 2 — Aug 7
- SAF 3 — Nov 27

- Mar 13 — Kickoff Meeting
- Aug 13 — Conceptual Model
- Dec. —Initial model design

2002

- SAF 4 — Mar. 1
- SAF 5 — May 30
- SAF 6 — Aug 5
- SAF 7 — Oct 18
- Model Review Oct 11 – Nov 8

- May 7 — Steady-state model review
- August 20 — Transient model review
- Sept 13 — Predictions review
- Oct 14 — Draft report review
- Dec — Present SAF Model Seminar

2003

- SAF 8 — Jan

Deliver Final Product

Expected SAF-7 Discussion

- Transient model calibration
- Model sensitivity analysis
- Model prediction results
- Supporting database

Thank You

- www.twdb.state.tx.us/GAM

Meeting Minutes for the

Sixt Southern Carrizo-Wilcox Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

August 5, 2002

San Antonio River Authority

San Antonio, Texas

The sixth Stakeholder Advisory Forum (SAF) Meeting for the Southern Carrizo-Wilcox Groundwater Availability Model (GAM) was held on August 5th from 1:30 until 3:00 PM at the San Antonio River Authority Board Room in San Antonio, Texas. Attachment A of these meeting minutes provides a list of all participants who signed up as attending the meeting.

The purpose of the sixth SAF meeting was to present a review of the preliminary transient model calibration results. The presentation also reviewed the GAM objectives and expectations as is done in all SAF presentations.

SAF Presentation: Van Kelley, INTERA

Van Kelley, Project Manager for the INTERA Southern Carrizo-Wilcox Team presented a prepared presentation. The presentation was structured according to the following outline:

1. Review of the GAM Project, Objectives, and Expectations
2. Model Design: Conceptual Model Review
3. Model Calibration: Steady-State Model Review
4. Model Calibration: Preliminary Transient Model Calibration
5. Path Forward & GAM Schedule: SAF Meetings and Project Milestones

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

Questions and Answers: Open Forum:

Q. What is the conversion of of pumpage shown in ft^3/day to acre-ft/day?

A: One acre-ft is 43,560 ft^3.

Q: To what degree will the southern Carrizo-Wilcox GAM correspond to the central Carrizo-Wilcox GAM in the overlap region?

A: The GAM contracts require a certain degree of consistency between the models particularly in the area of structure. The southern team has worked with and met with the central team to attempt to ensure that the two models to use the same data in the overlap area. However, there will be some

different interpretation associated with parameterization and recharge, and potential effects associated with extrapolation of data.

Q: What percentage of grid cells are out of calibration?

A: This is difficult to quantify at this time. However, if I had to estimate I would say that the current model calibration indicates that approximately 15 to 20% of the hydrographs used for transient calibration were off. Currently, it is difficult to assess what areal coverage and corresponding grid block distribution that would represent.

Q: The hydrograph from Wilson County indicates rising water levels between 1980 and 1999; most of the wells in Wilson County however, show declining water levels?

A: We will check the specific wells from Wilson County, that are being used for transient calibration to make sure, we are using a representative wells and representative areal distribution to properly simulate the water-level response in the aquifer. Wilson County has wells that are experiencing both upward and downward water level trends in calibration and verification periods.

ATTACHMENT A: SIGN-UP SHEET

Name	Affiliation	Contact Information (including email address, if available)
Barry Miller	GCUWCD	GCUWCD@GUEC.NET
Steve Raabe	SARA	
Cliff Lowe	Evergreen UWCD	
Joe Peters	TNRCC	jpeters@tnrcc.state.tx.us
Ronnie Hernandez	SARA	ronnieh@sara-tx.org
Carl Lambeck	City of Stockdale	
Bob Johnson	SAWS	bkjohnson@saws.org
Kevin Morrison	SAWS	kmorrison@saws.org
Vic Hilderbran	Uvalde UWCD	
Diane Savage	WCWAP	
Gaylon Click	WCWAP	
Grant Snyder	URS Corp.	