Conceptual Model for the High Plains Aquifer GAM

Stakeholder Advisory Forum #2
Amarillo, TX

Presented By:

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Texas Water Development Board

May 12, 2014

Todays Topics

- Introduction to the Groundwater Availability Modeling program (Cindy Ridgeway, TWDB)
- Conceptual Model for the High Plains Aquifer System
- Demonstration of the High Plains Aquifer System conceptual model viewer (in beta)

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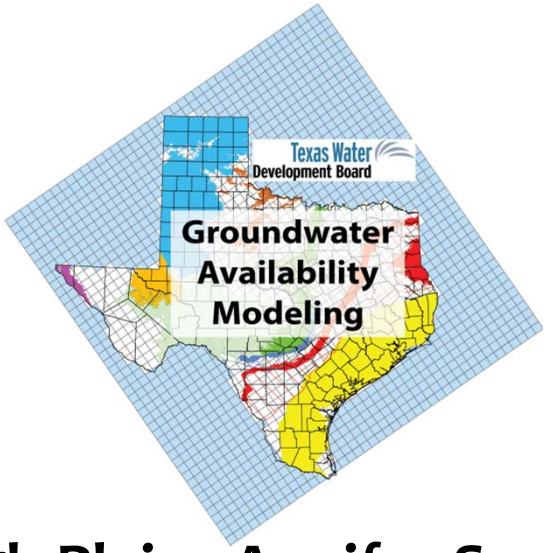
Groundwater Availability Modeling



Cindy Ridgeway

Contract Manager

High Plains Aquifer System Groundwater Availability Model (GAM)

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Disclaimer

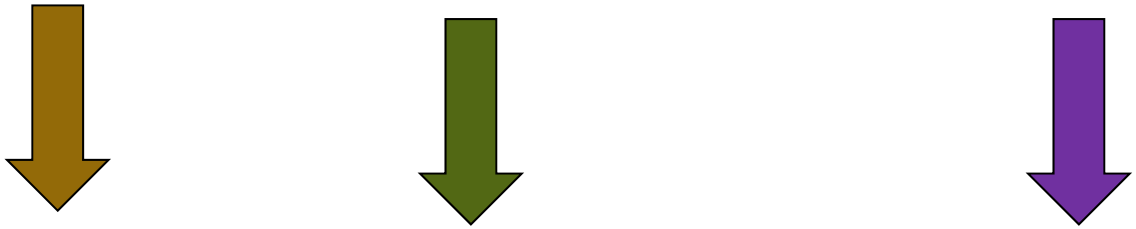
The statements contained in this presentation are my current views and opinions and are not intended to reflect the positions of, or information from, the Texas Water Development Board, nor is it an indication of any official policy position of the Board.

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?

Policy + **Science** = **Groundwater Availability**



Desired Future Conditions + **GAM or other tool** = **Modeled Available Groundwater**

Goal: informed decision-making

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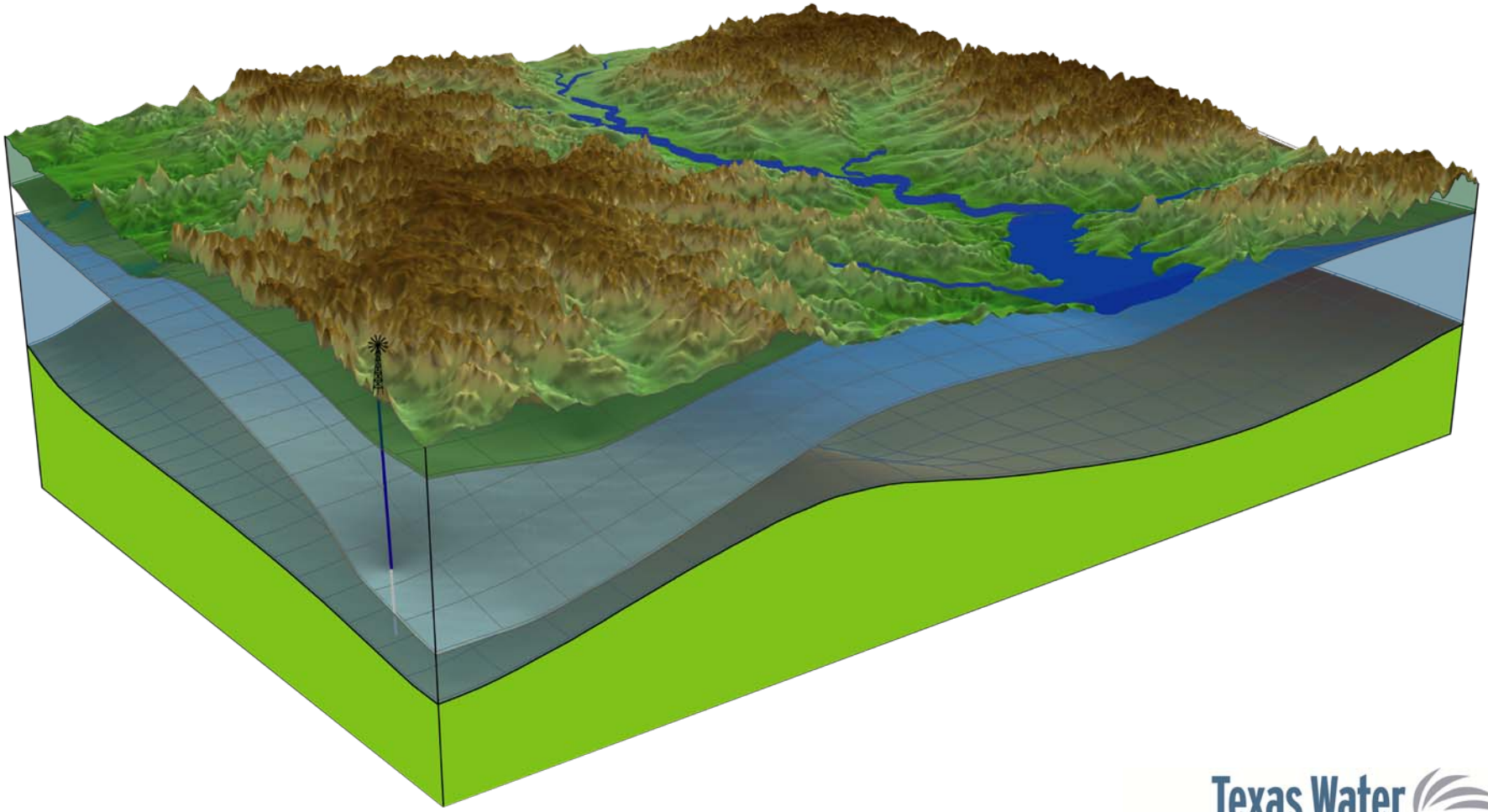
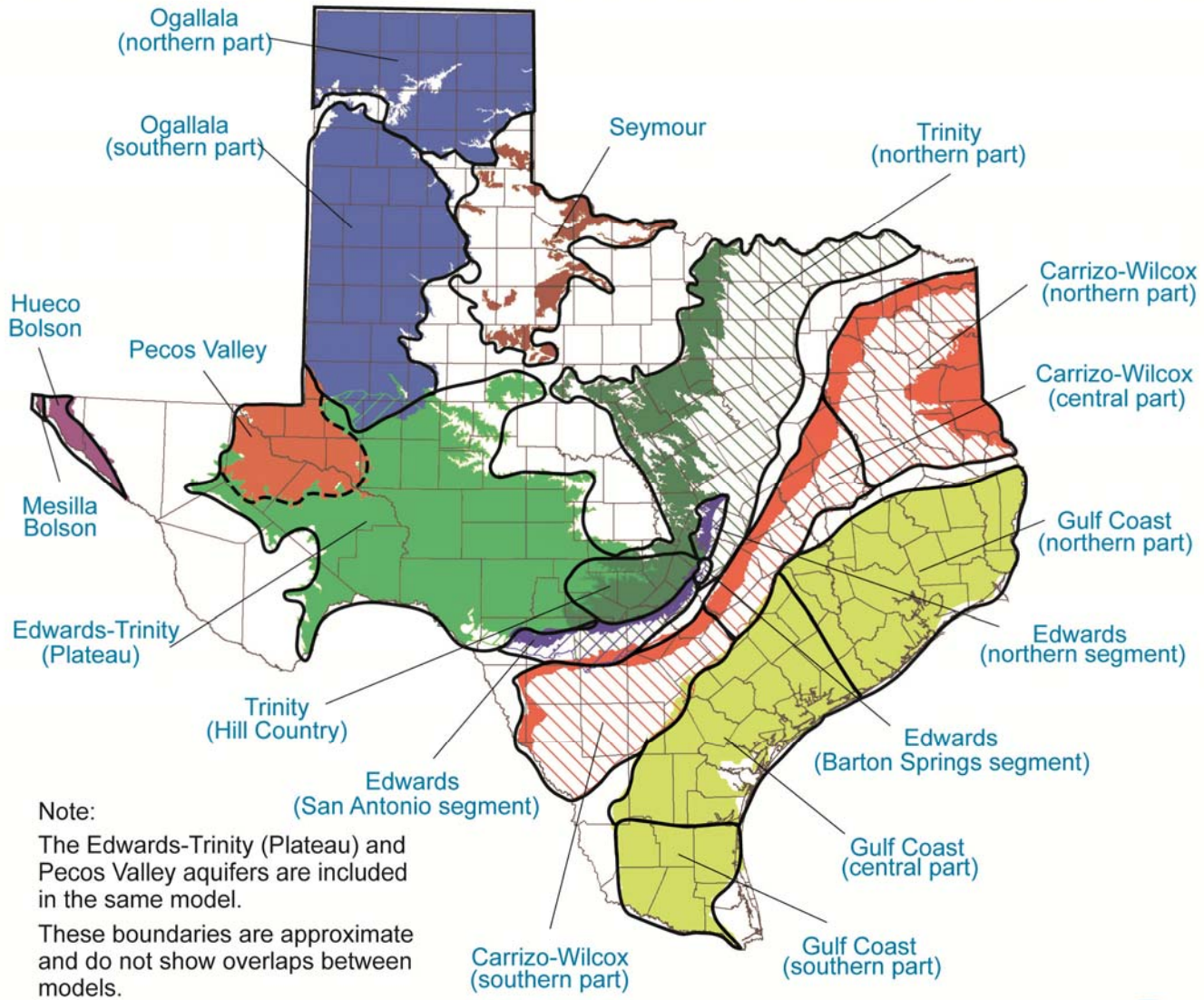
Groundwater Model



Major Aquifers



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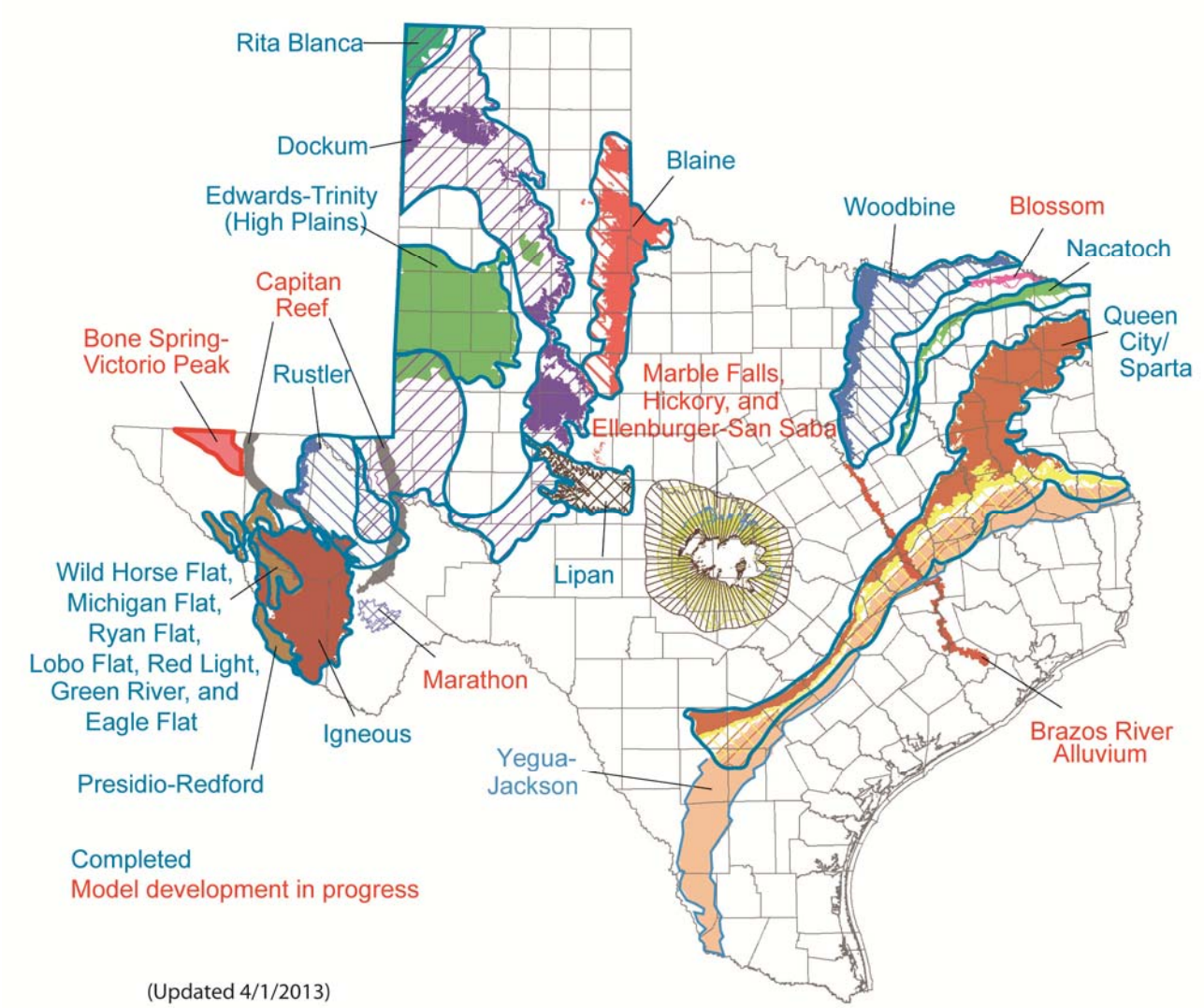
Minor Aquifers



How we use Groundwater Models

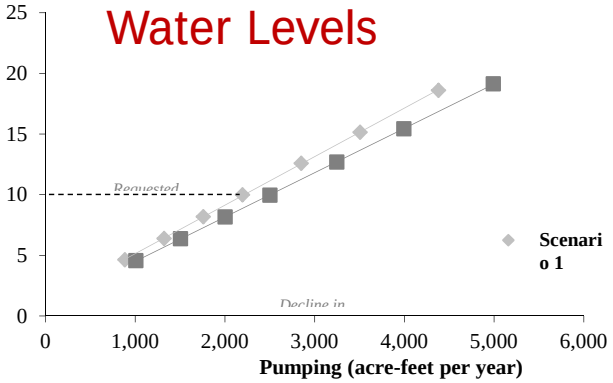
* **Texas Water Code, § 36.1071 (h)**

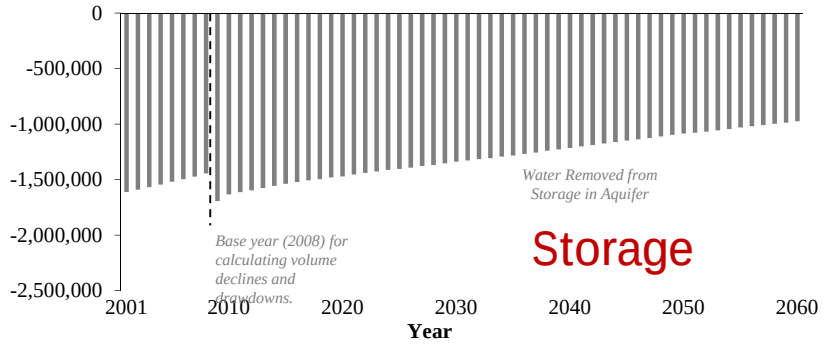
Inform groundwater districts about historical conditions in the aquifer

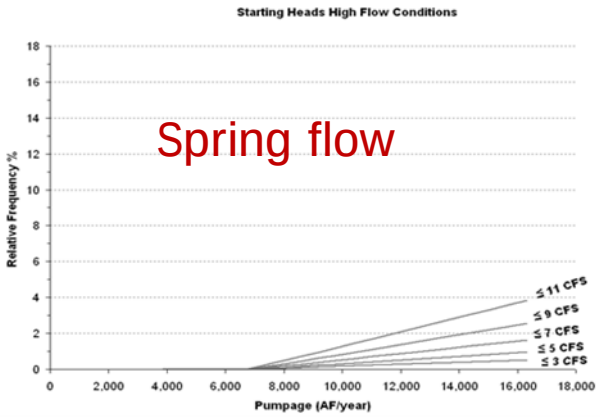
Management Plan requirement	Aquifer or confining unit	Results
Estimated annual amount of recharge from precipitation to the district	Edwards-Trinity (Plateau) Aquifer	140,509
	Pecos Valley Aquifer	14,115
	Dockum Aquifer	0
Estimated annual volume of water that discharges from the aquifer to springs and 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

* **Texas Water Code, § 36.108 (d): Assist districts and management areas in determining desired future conditions**







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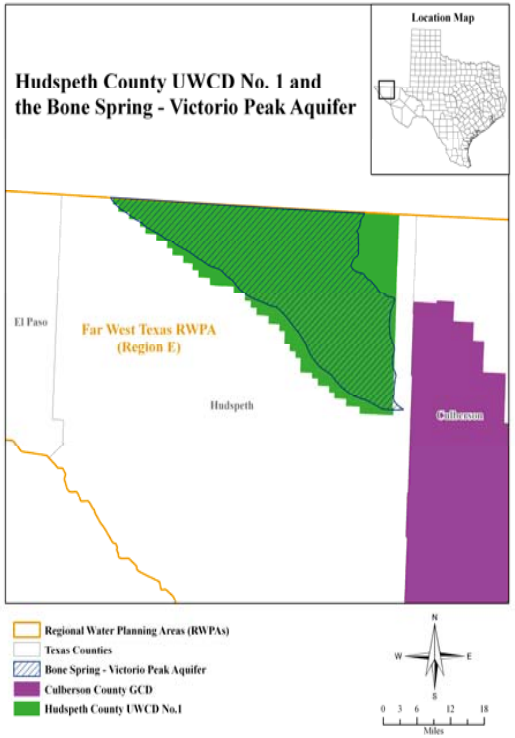
How we use Groundwater Models

* **Texas Water Code, § 36.1084 (b): Develop modeled available groundwater based on desired future conditions**

County	Regional Water Planning Area	Basin	Year					
			2010	2020	2030	2040	2050	2060
Hudspeth	E	Rio Grande	101,429	101,429	101,429	101,429	101,429	101,429



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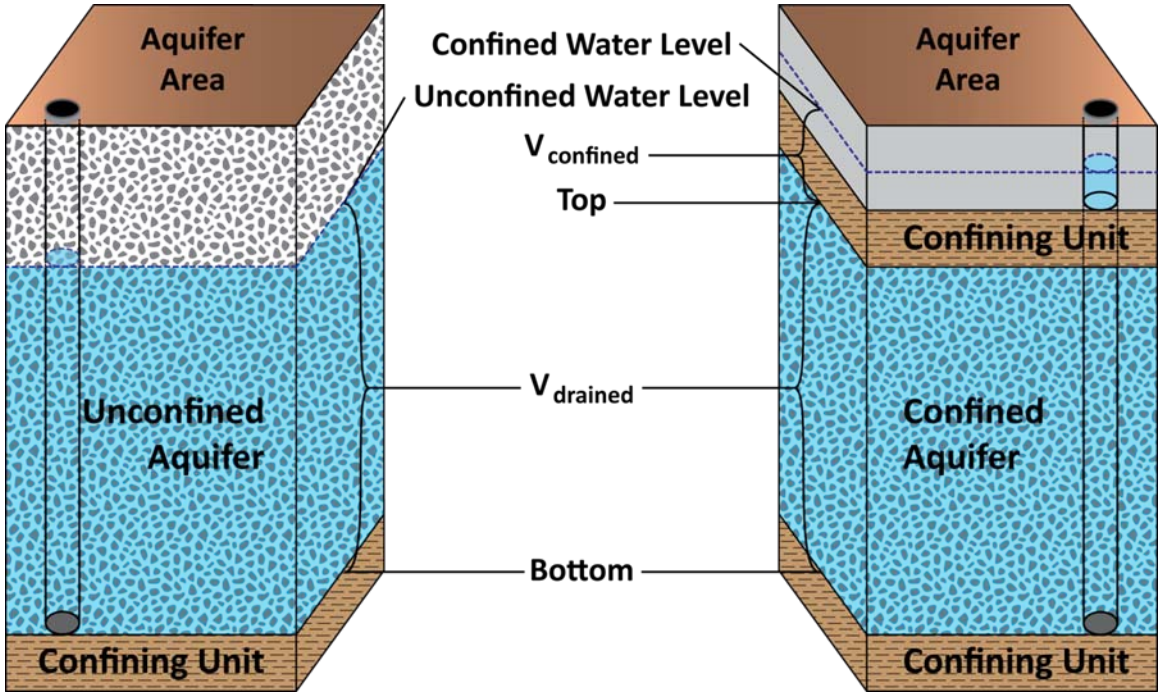
How we use Groundwater Models

* **Texas Water Code, § 36.108 (d) (3)**

Estimating total recoverable storage for explanatory reports



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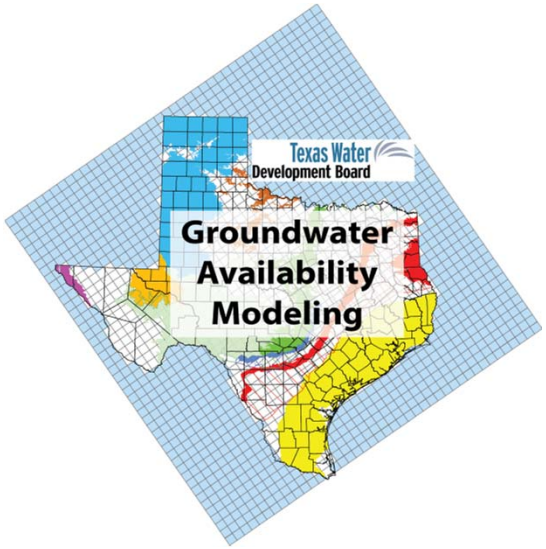
Stakeholder Advisory Forums

- **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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Austin, Texas 78711-3231

Web information:

http://www.twdb.texas.gov/groundwater/models/gam/hpas/hpas.asp#saf

http://www.twdb.texas.gov/groundwater/index.asp

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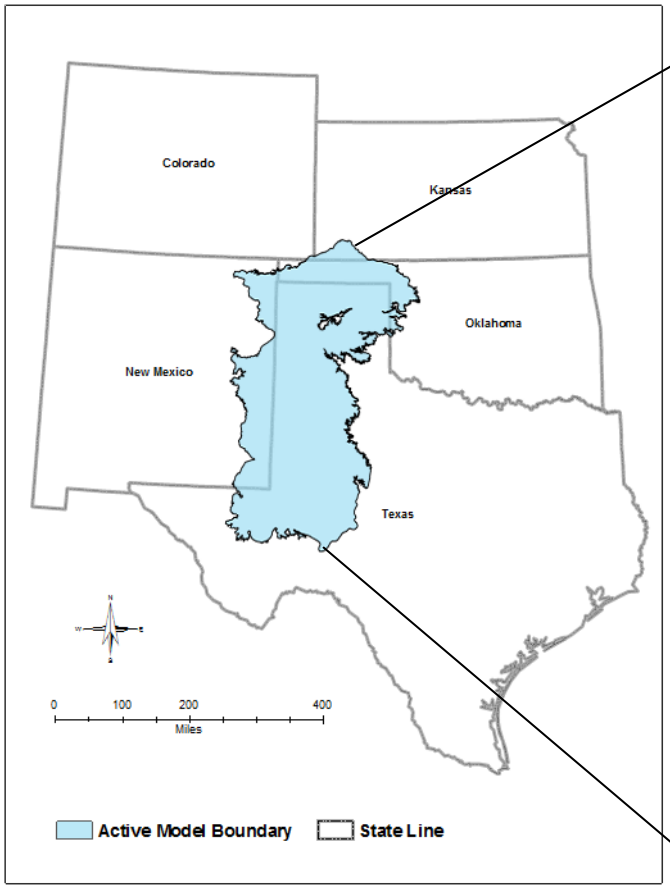
Key Aspects of Conceptualization

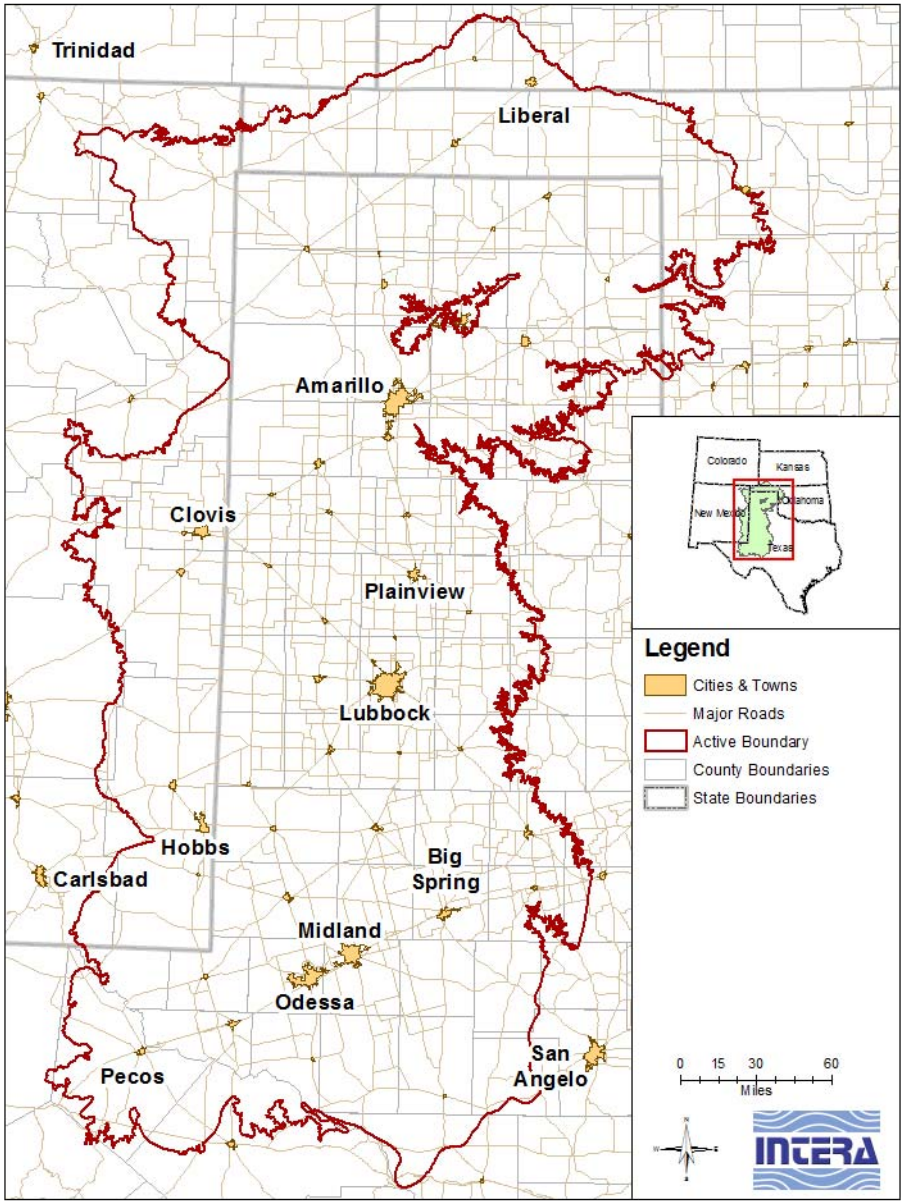
The **Conceptual Model** is a simplified description of the various hydrogeologic and structural components of an aquifer system and their interactions.

- Extent and hydrostratigraphy
- Structure*
- Hydraulic/storage properties
- Recharge/discharge*
- Groundwater production*
- Cross-formational flow
- Water quality

*Additional financial support from NPGCD, PGCD, and HPWD allowed increased analyses in these areas of the conceptual model, in addition to enhanced data visualization and additional stakeholder meetings

Study Area

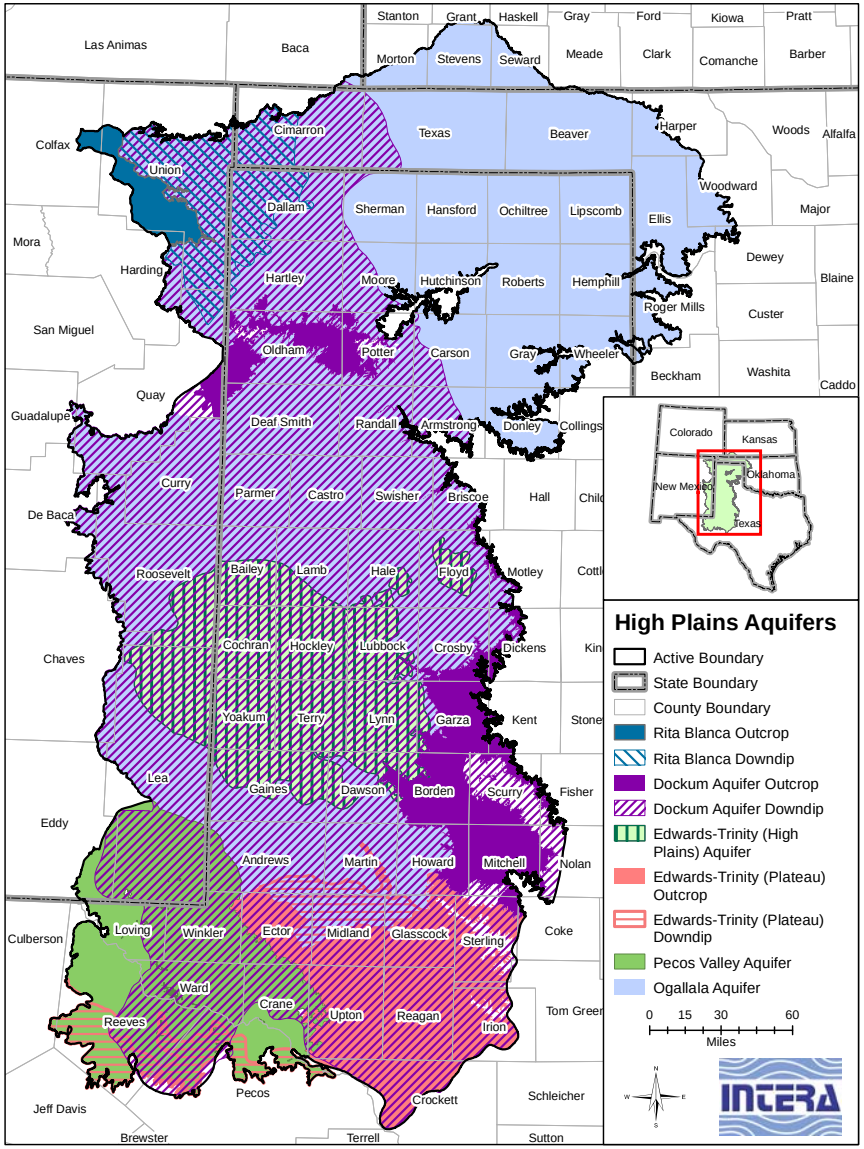

Colorado
Kansas
Oklahoma
New Mexico
Texas
0
100
200
400
Miles
Active Model Boundary
State Line


Trinidad
Liberal
Amarillo
Clovis
Plainview
Lubbock
Hobbs
Carlsbad
Big Spring
Midland
Odessa
Pecos
San Angelo
Legend
Cities & Towns
Major Roads
Active Boundary
County Boundaries
State Boundaries
0
15
30
60
Miles
INTERA

Extent and Hydrostratigraphy

System	Formation		Aquifer	Model Layer		
				North	Central	South
Quaternary	Pecos Valley Alluvium		Pecos Valley			1
Tertiary	Ogallala		Ogallala	1	1	
Cretaceous	Duck Creek‖	Boracho‡	Edwards -Trinity		2‖	2‡
	Kiamichi‖	Finlay‡				
	Edwards‖					
	Comanche Peak‖					
	Walnut‖					
	Antlers					
Jurassic	Morrison		Rita Blanca	2		
	Exeter					
Triassic	Cooper Canyon		Upper Dockum		3	3
	Trujillo					
	Tecovas		Lower Dockum	4	4	4
	Santa Rosa					
Permian	Dewey Lake			No Flow		
	Rustler		Rustler			

‖ Edwards-Trinity (High Plains) Aquifer represented by layer 2 in the central portion of the domain.
‡ Edwards-Trinity (Plateau) Aquifer represented by layer 2 in the southern portion of the domain.



Structure

- Correlation based on 2,050 geophysical logs retrieved from:

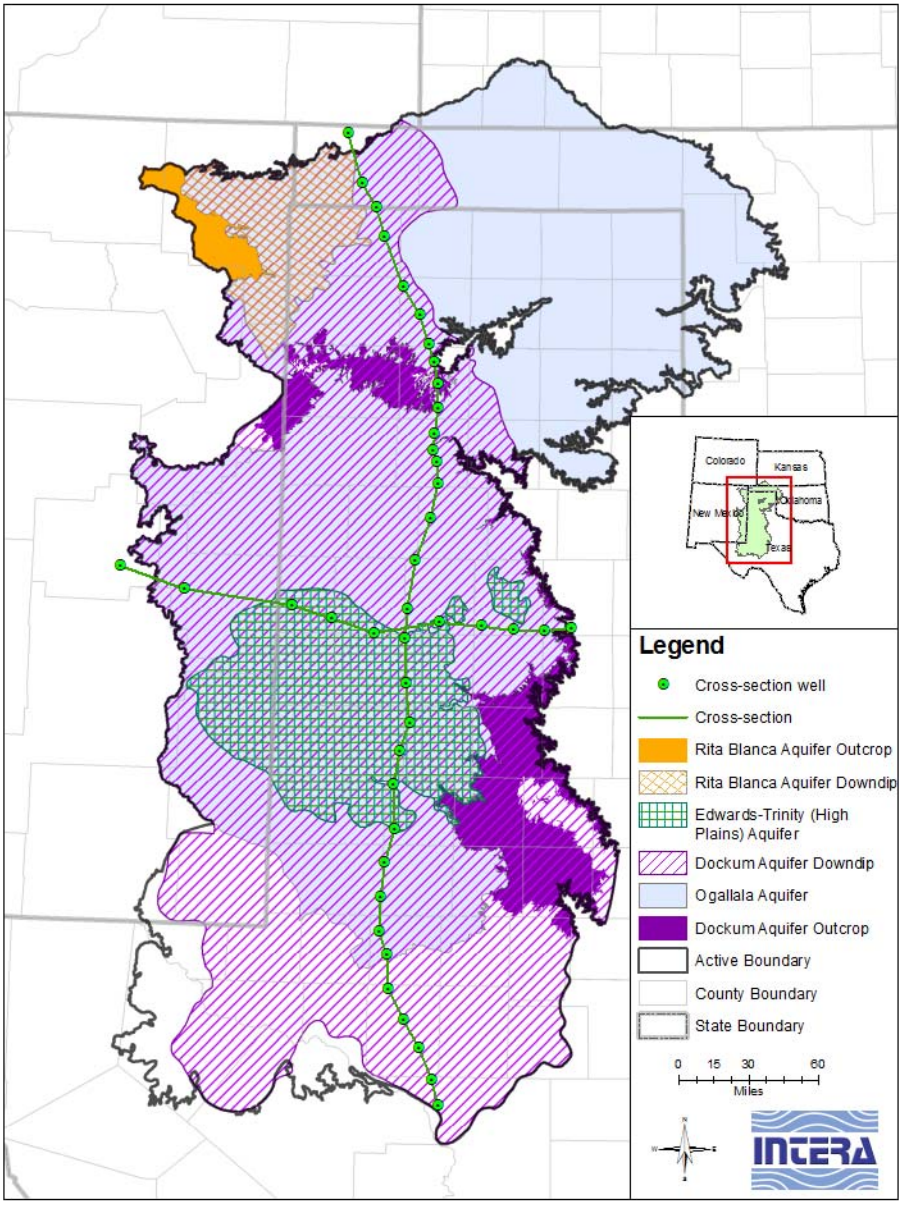
BRACS database	BEG Geophysical Log Facility
commercial suppliers	Railroad Commission
UT Lands Office	NM Oil Conservation Division
City of Amarillo	City of Canyon

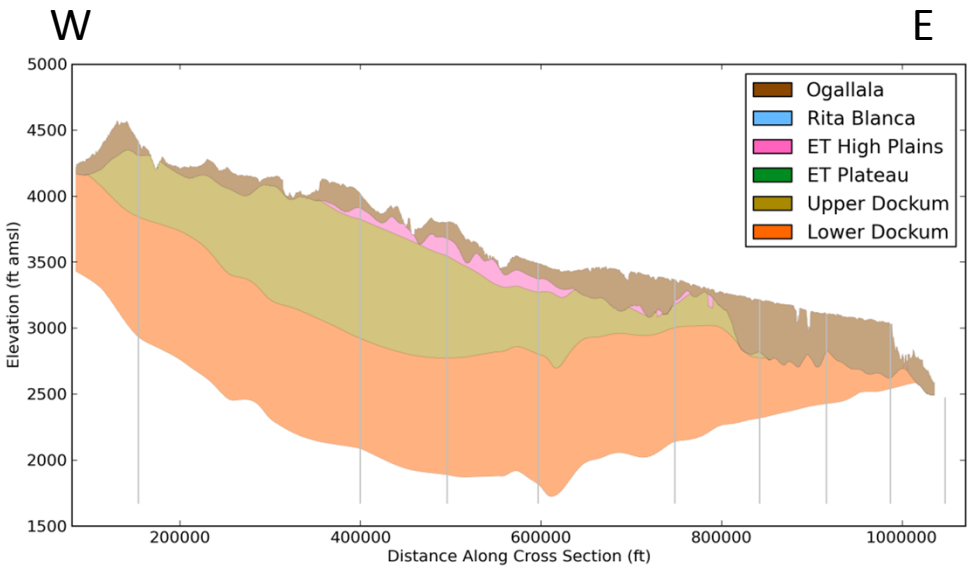
- Secondary information from driller's logs, cores, and previous studies
  - Use for "infilling"
  - Added detail in inter-geophysical log areas

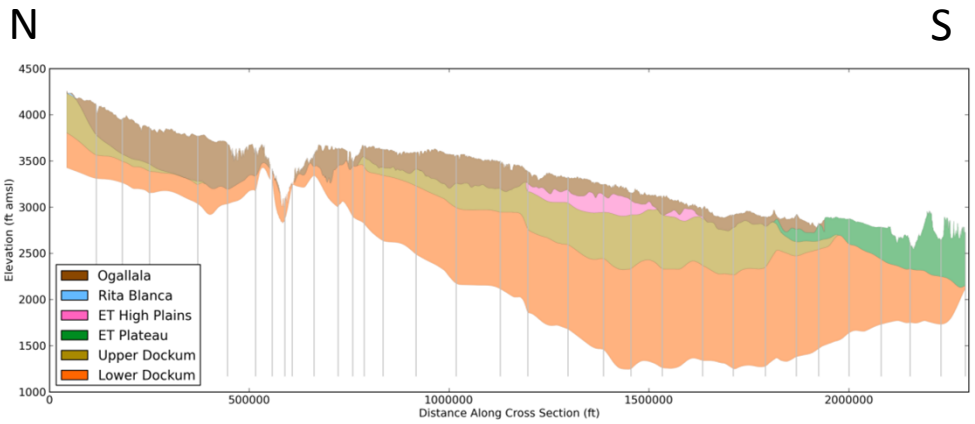
- Lithology based on calibrated gamma ray logs.

- Additional District funding allowed significant increase in geophysical log resolution and improved detail in surface creation.

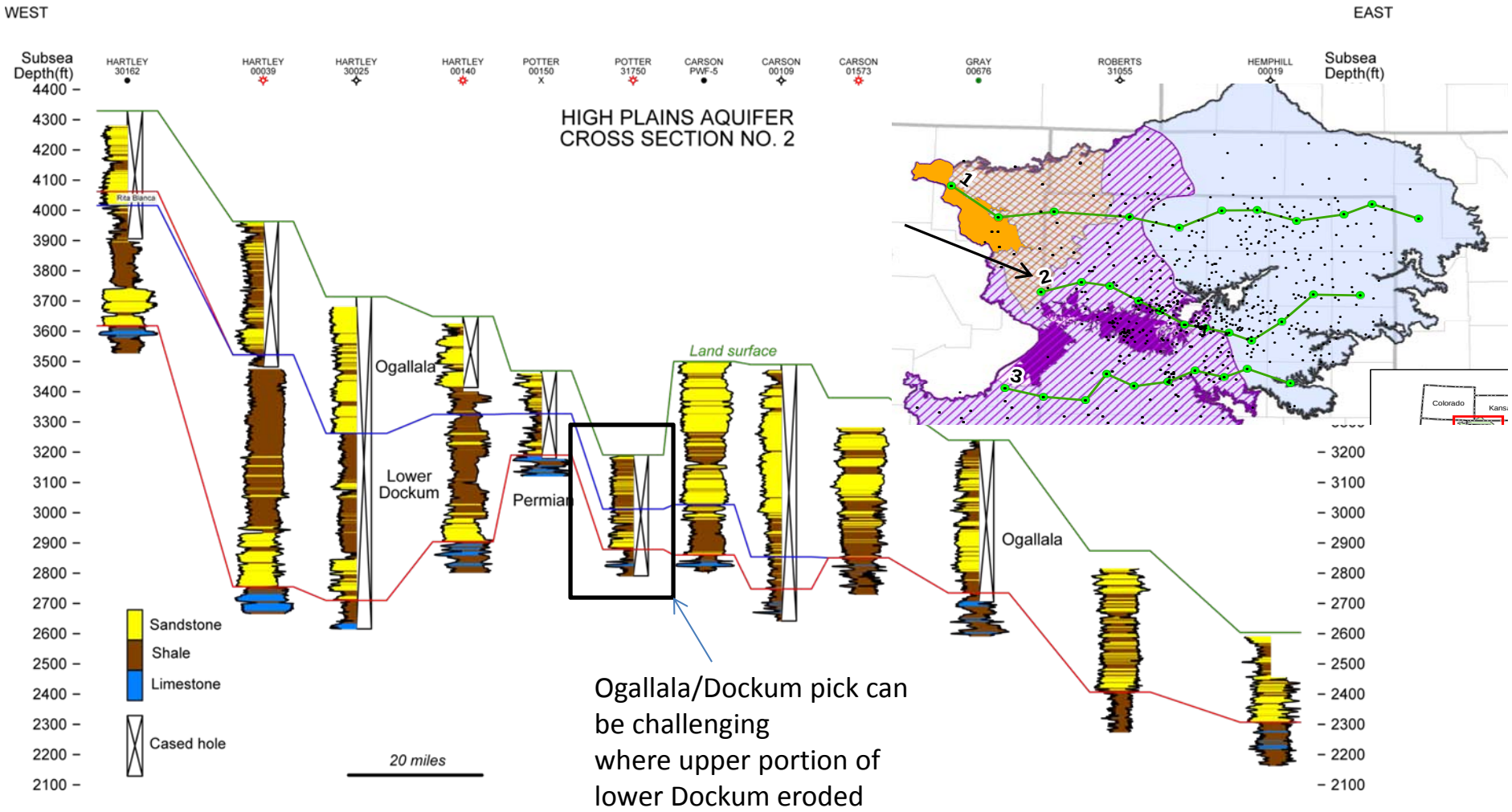
Structural Correlations





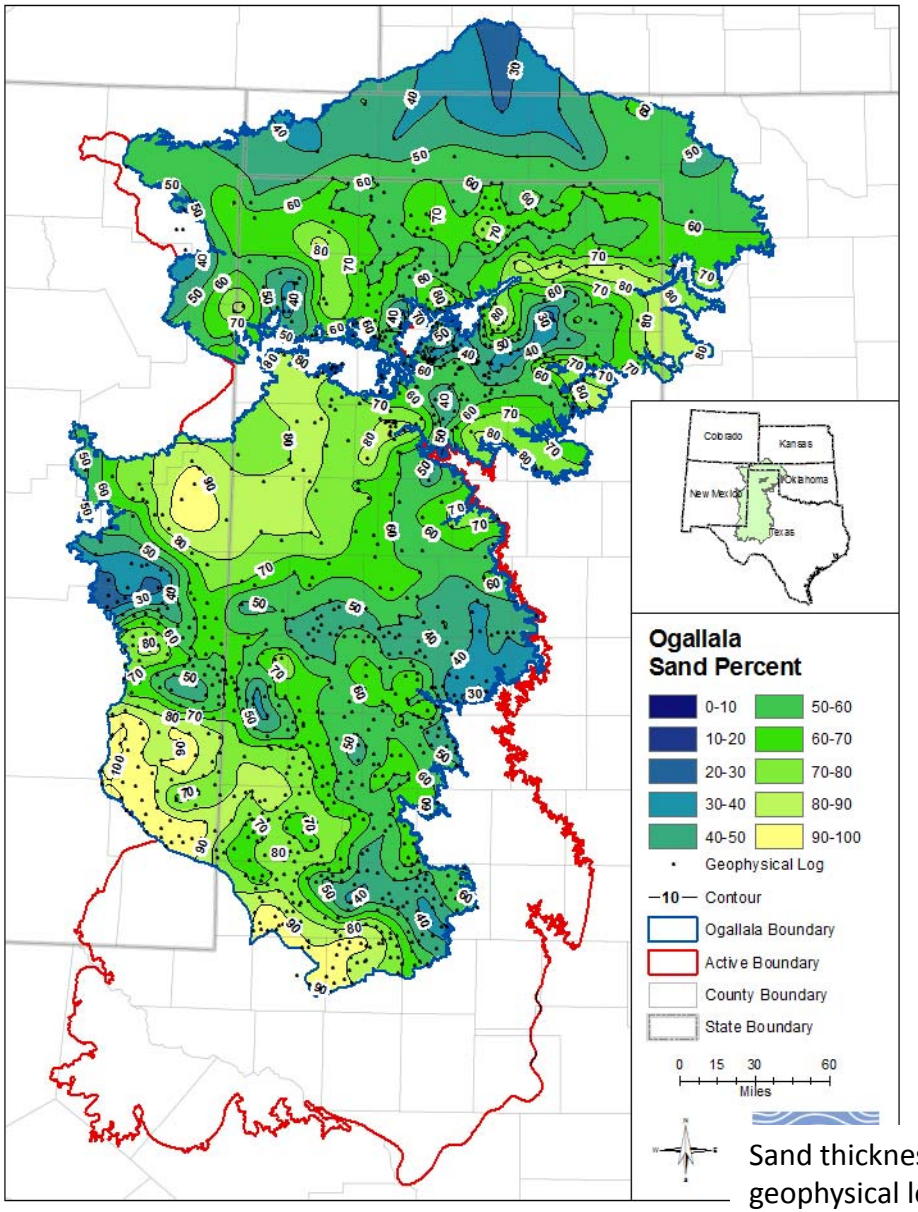


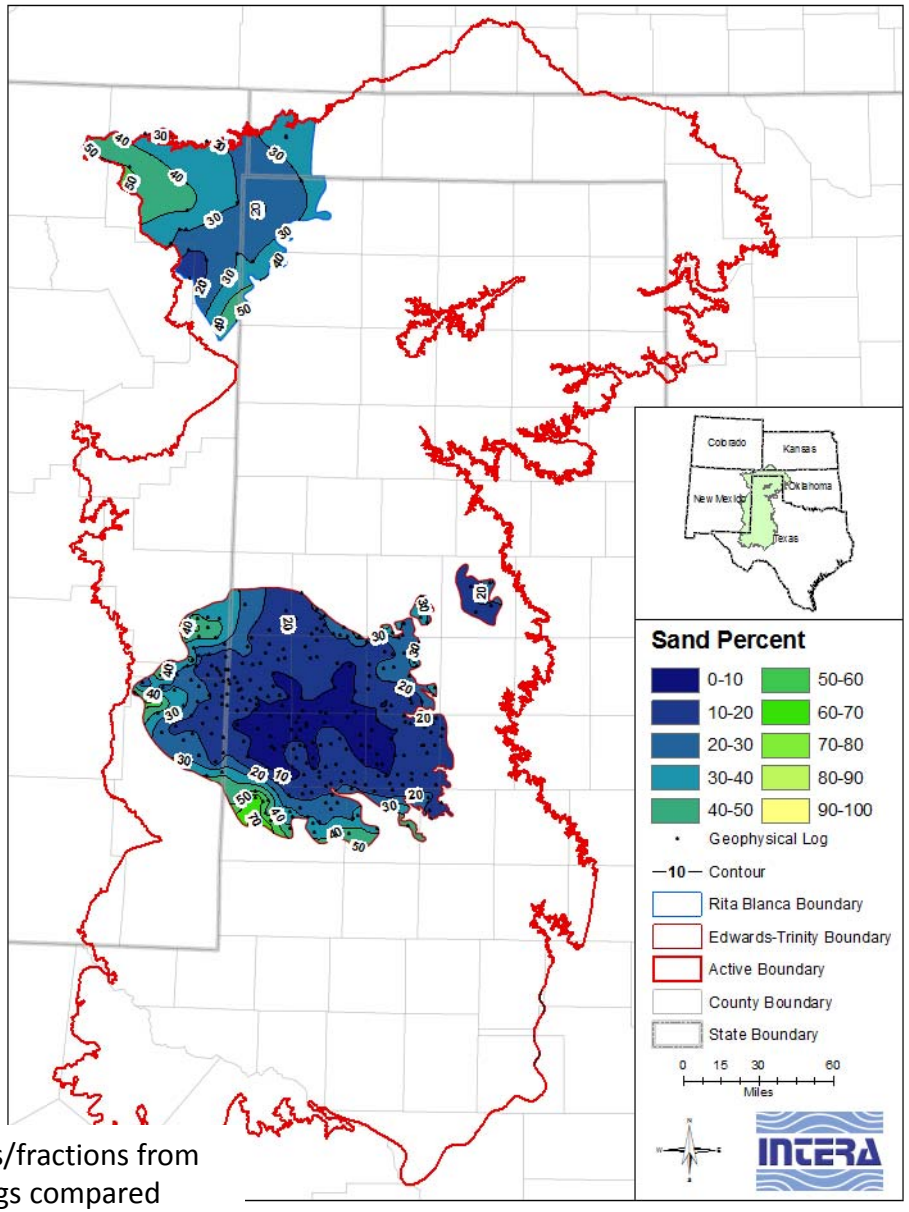
Lithologic Cross Section



Ogallala/Dockum pick can be challenging where upper portion of lower Dockum eroded

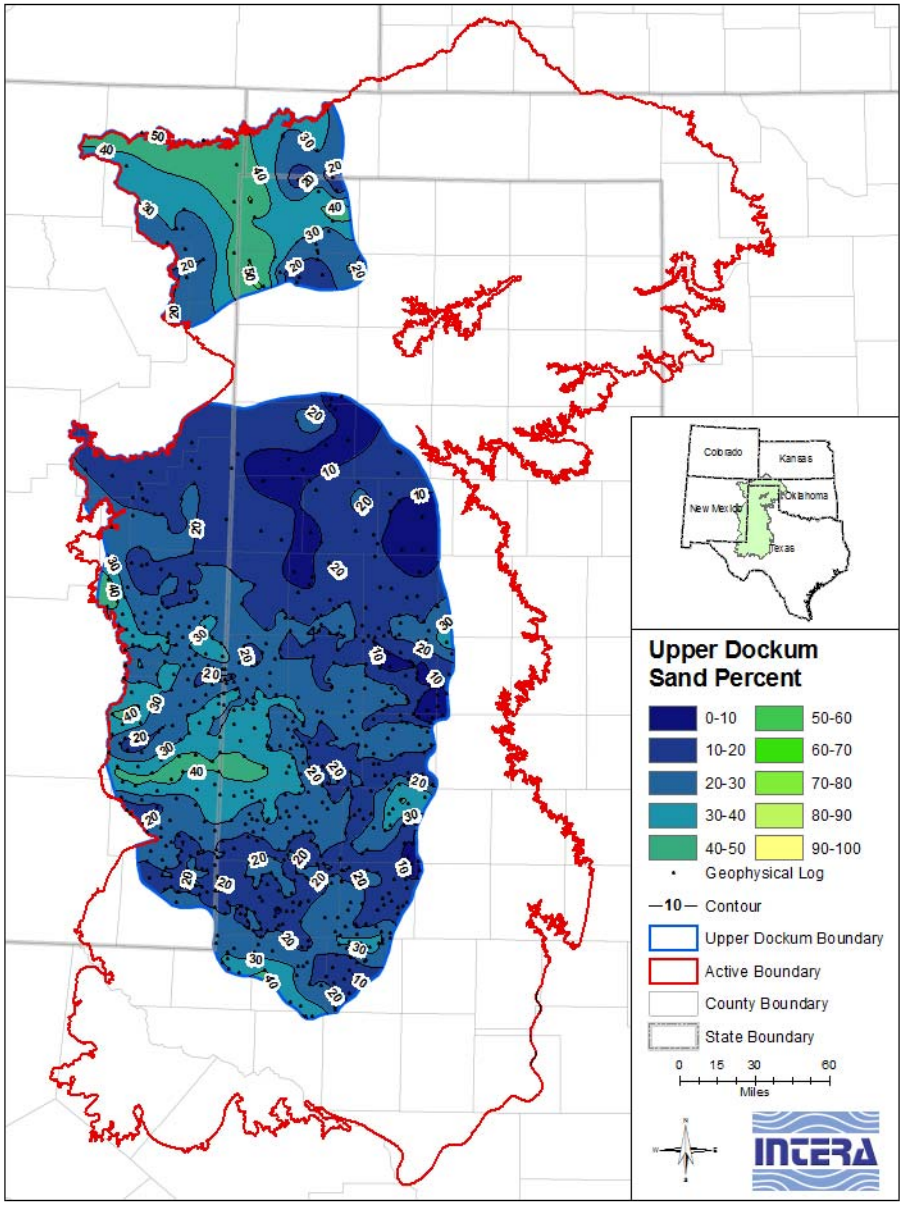
Lithology Estimates

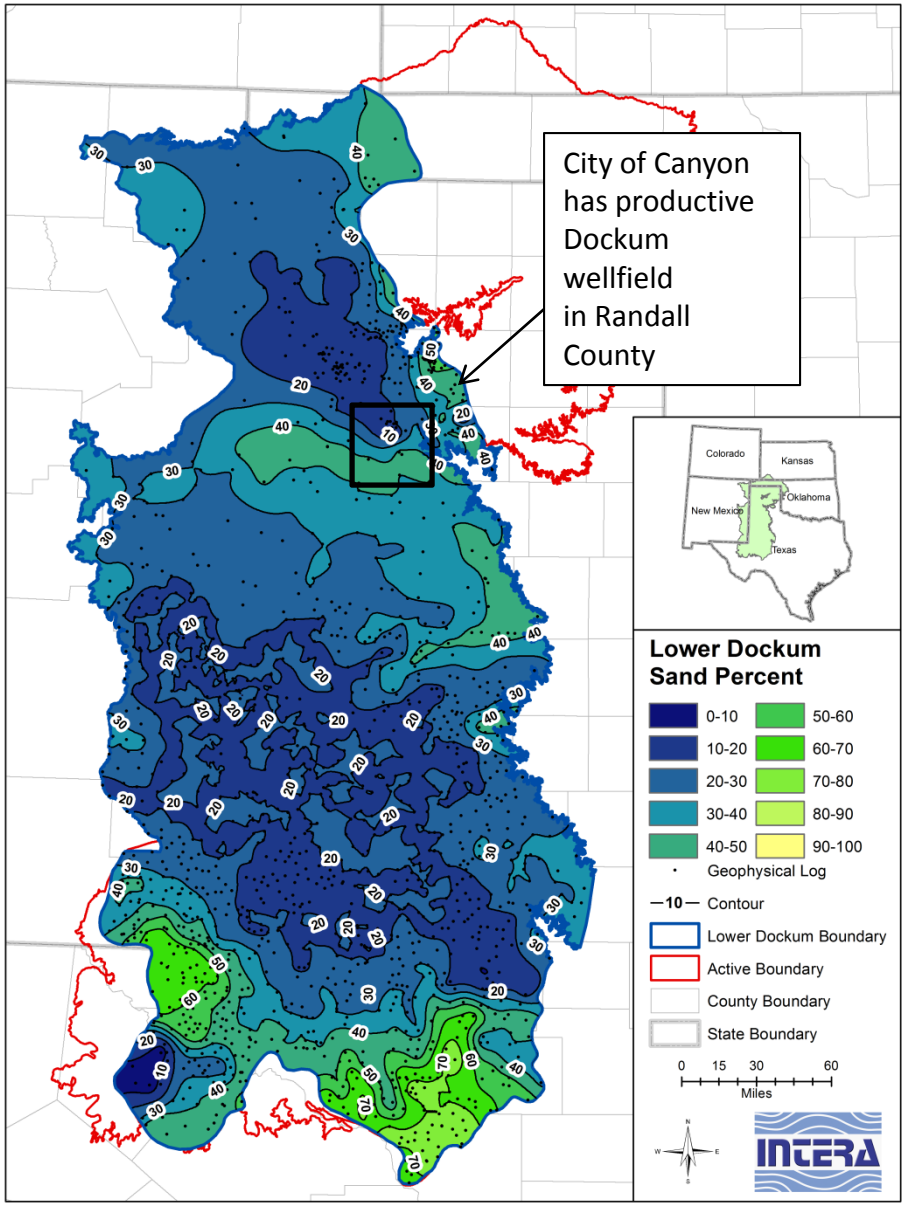




Sand thickness/fractions from geophysical logs compared favorably to previous studies

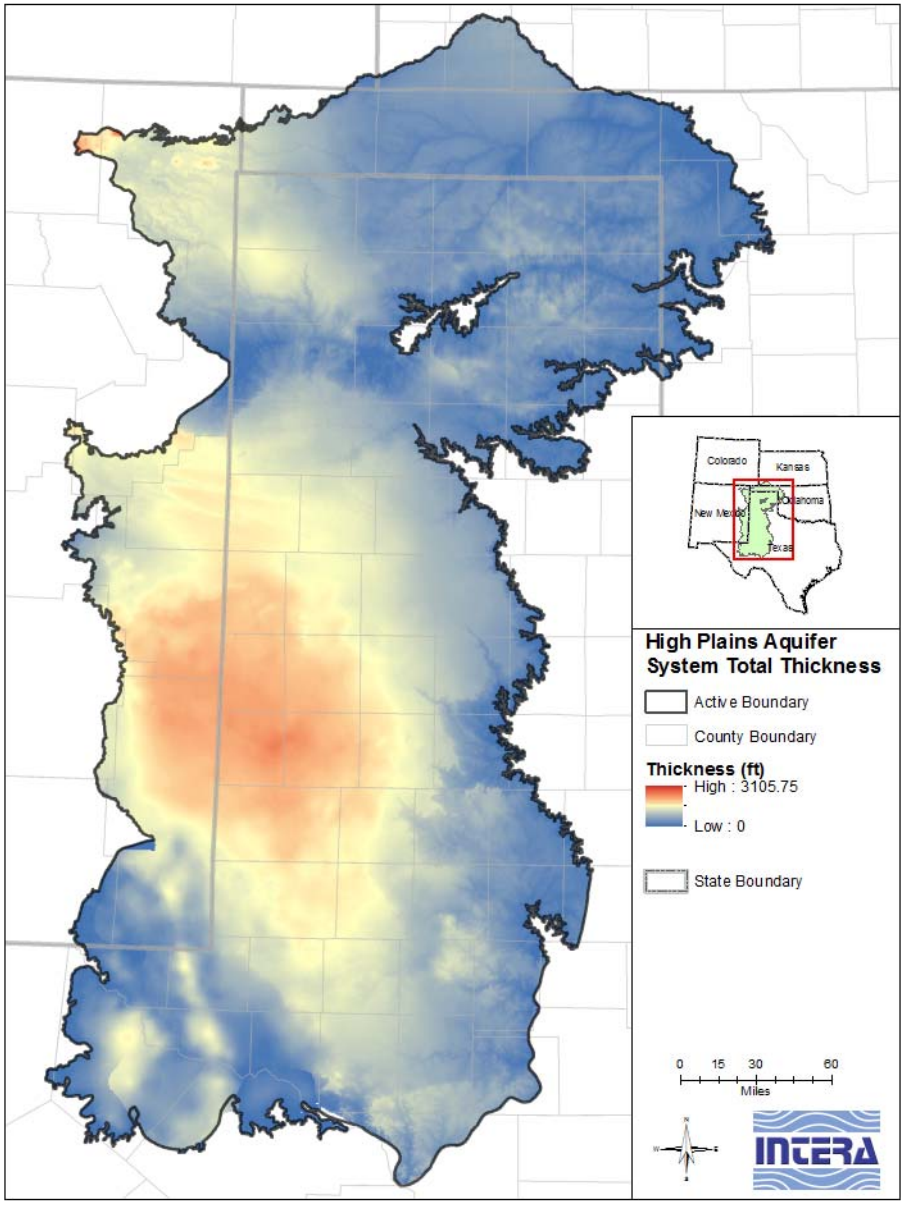
Lithology Estimates





Total HPAS Thickness

- Highest where the Dockum is thickest in the South
- Generally corresponds with area of poor water quality in the Dockum

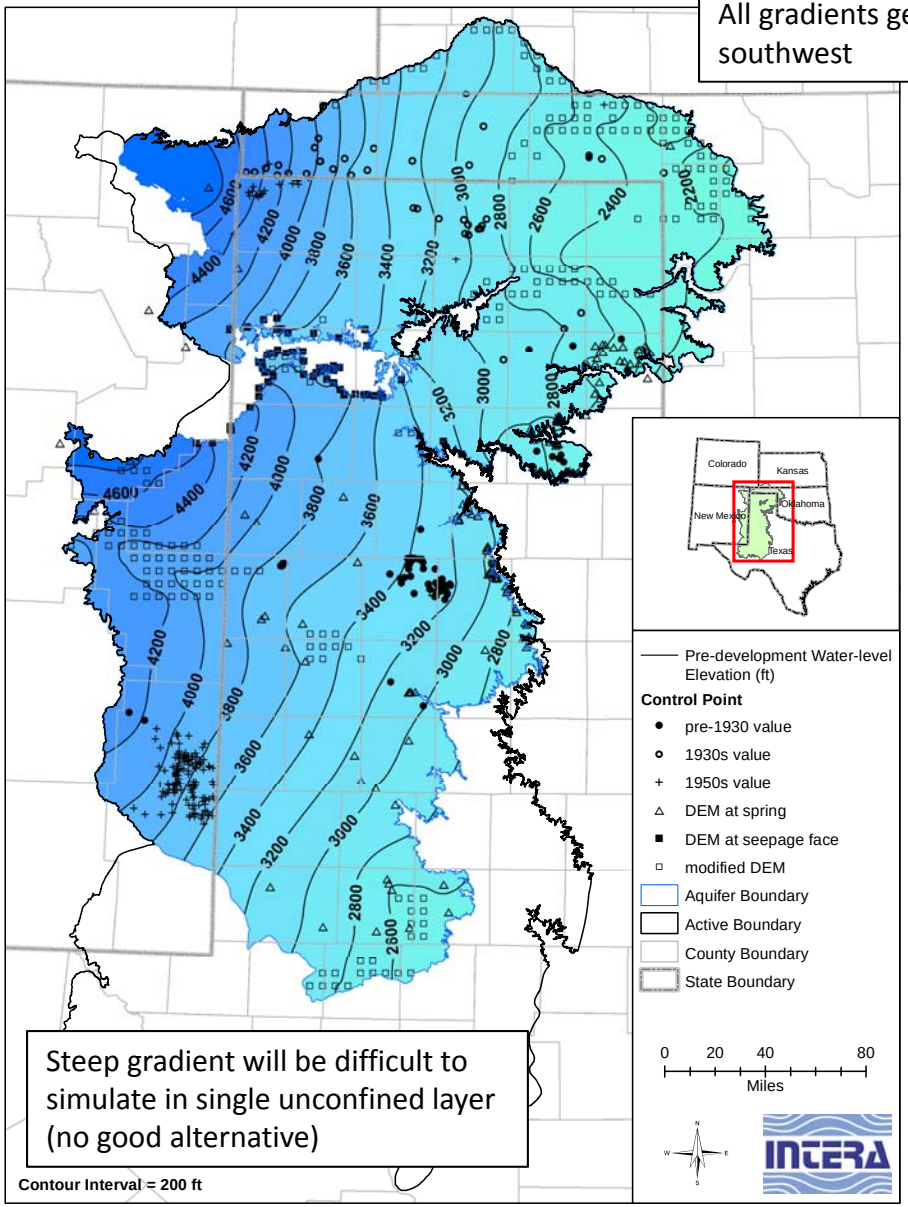


Water Levels

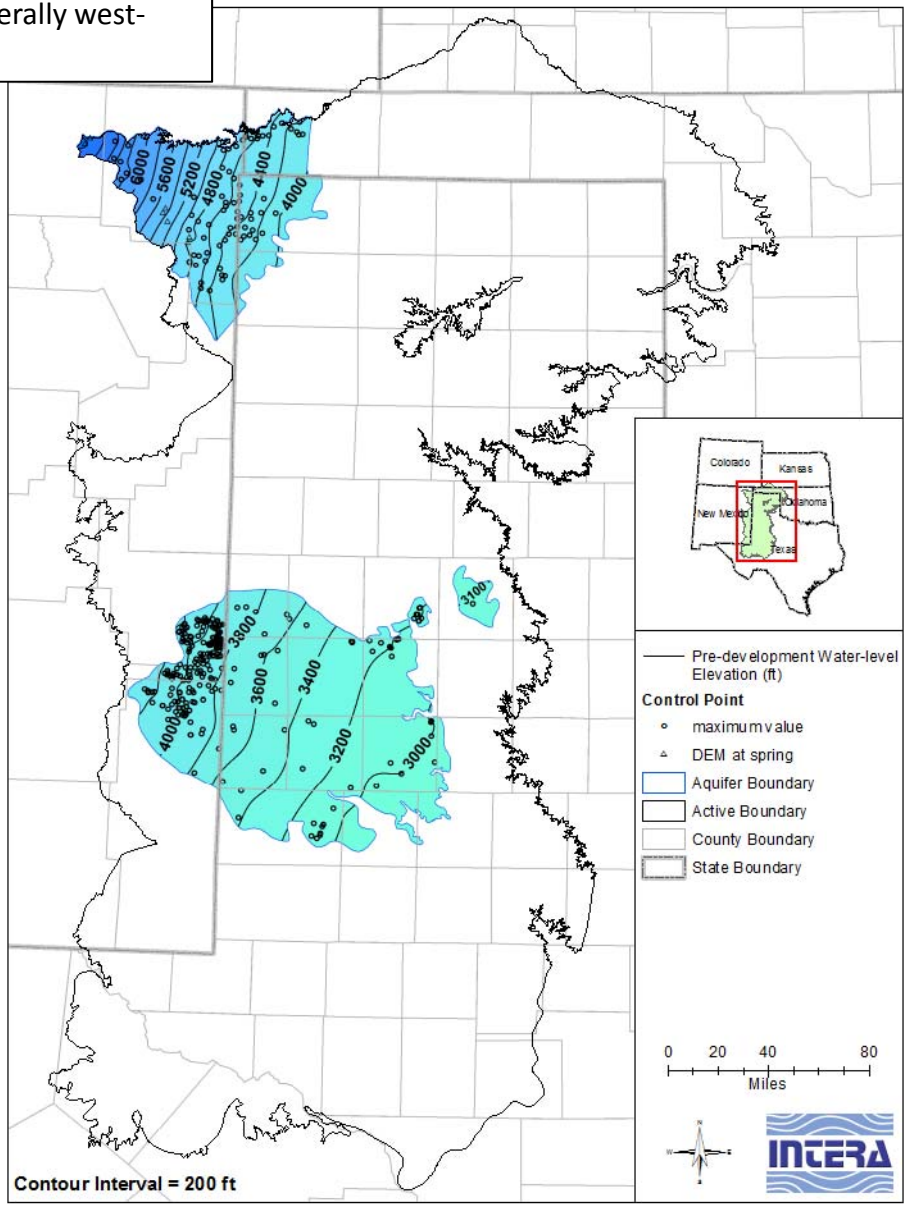
- Water-level data from 21,645 wells were retrieved from
  - TWDB groundwater database
  - Groundwater Conservation Districts
  - USGS groundwater database
- Wells were assigned to aquifers based on the current study's new structural surfaces
- When no well screen information was known, total depth and professional judgment was used (e.g. other information, such as water level trends, nearby well completions)
- Predevelopment estimates utilized known spring and other surface discharge locations to infill areas with lack of data

Pre-development Water Levels

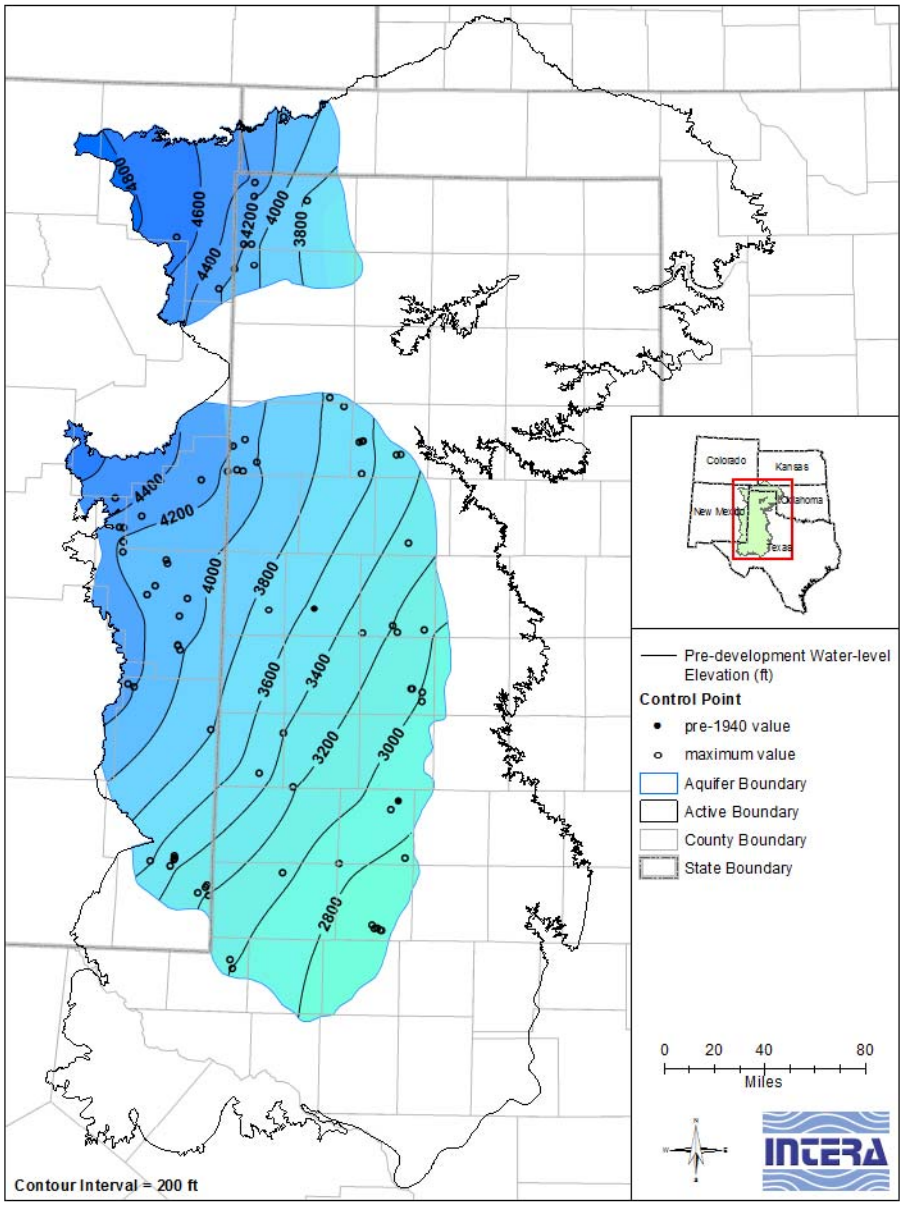
All gradients generally west-southwest

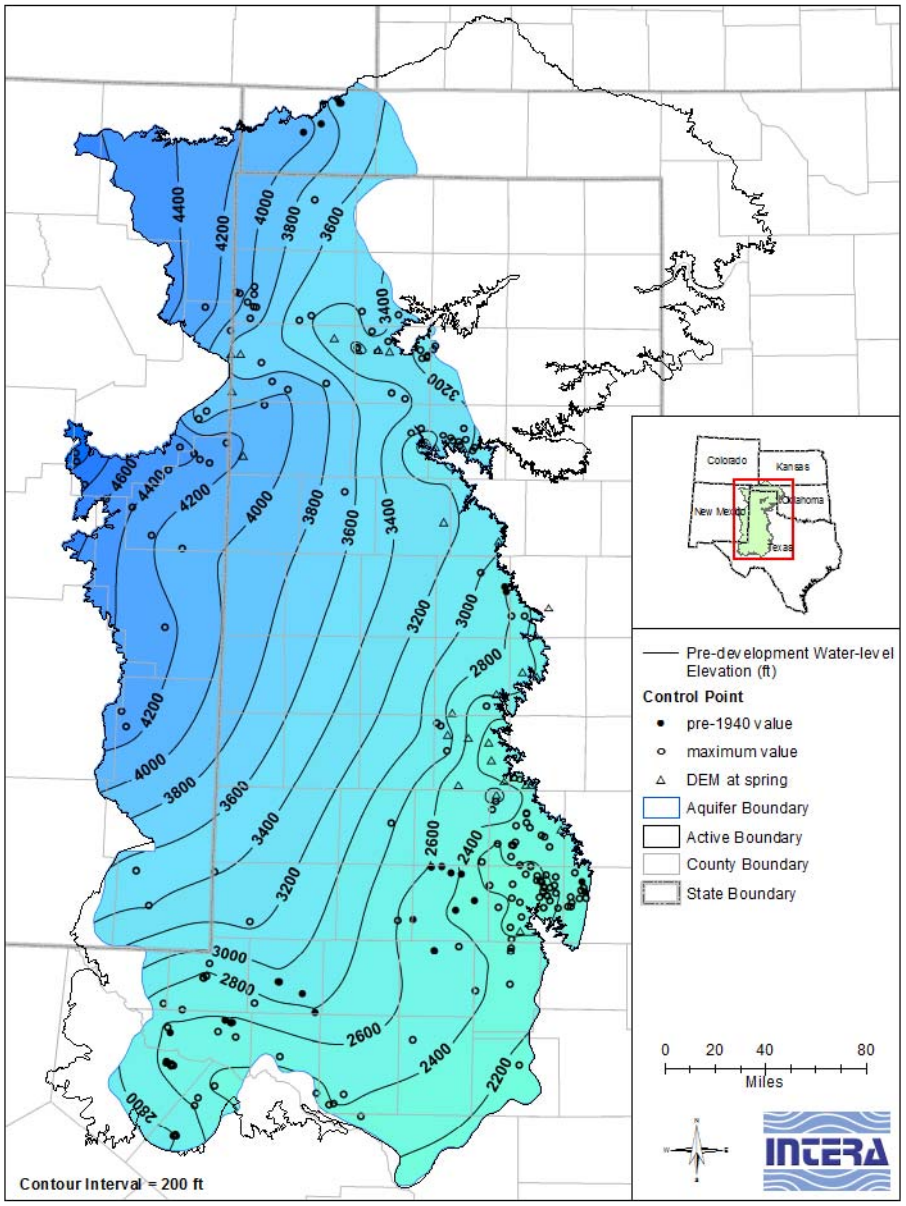


Steep gradient will be difficult to simulate in single unconfined layer (no good alternative)



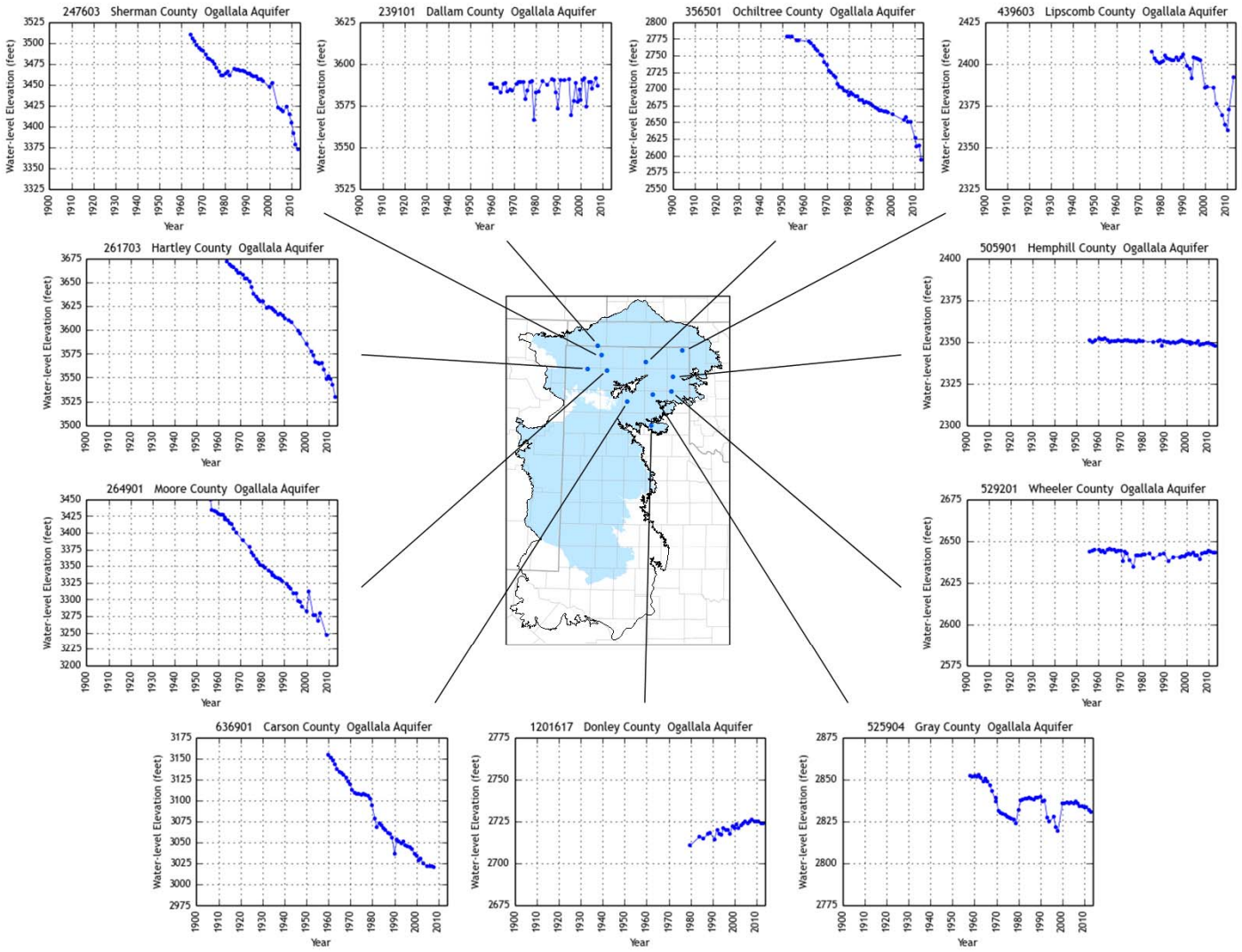
Pre-development Water Levels





Transient Water Levels

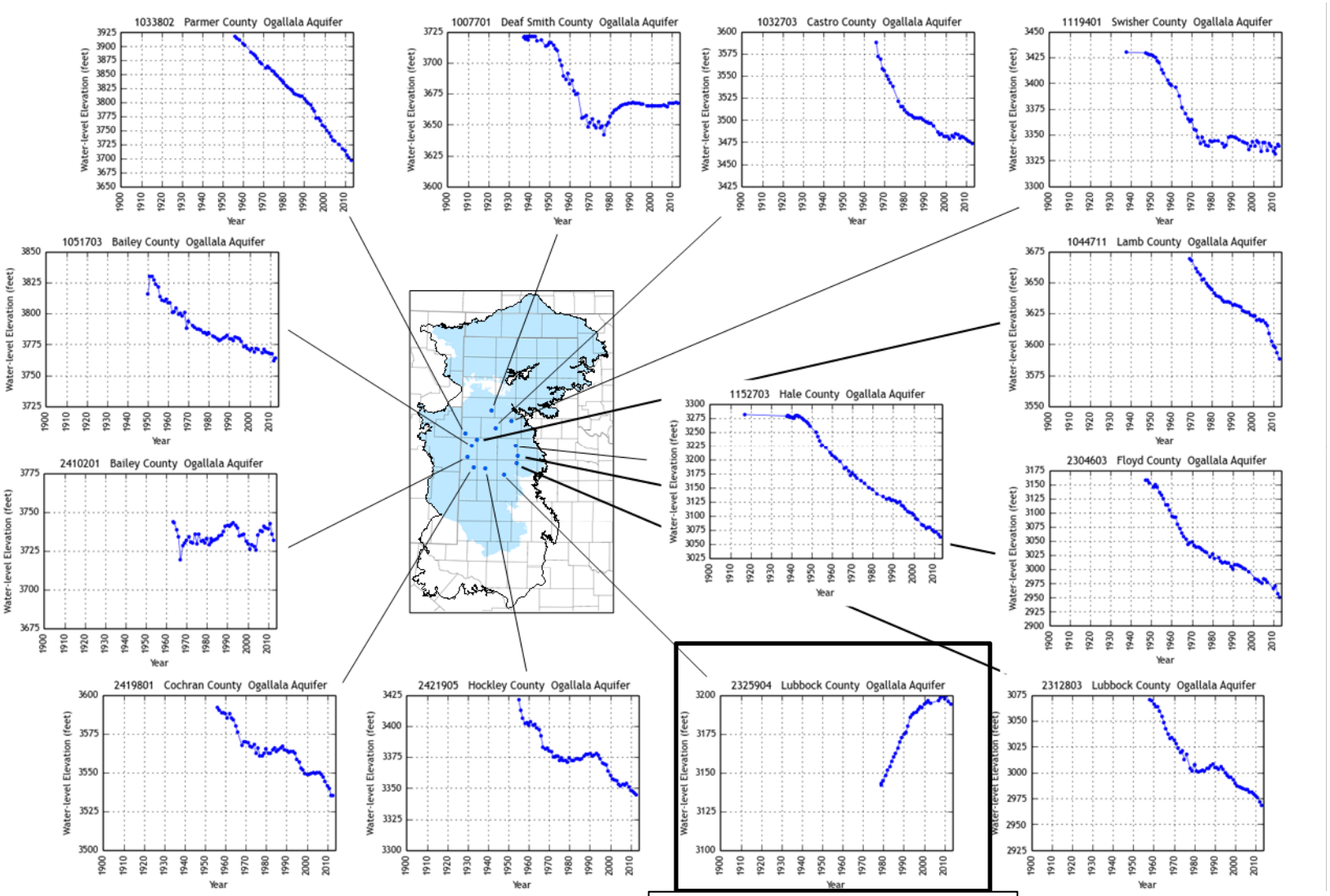
N. Ogallala: **1288** hydrographs



Areas with small initial saturated thickness or unsuitable topography (for ag) show steadier levels

Transient Water Levels

S. Ogallala: **1721** hydrographs

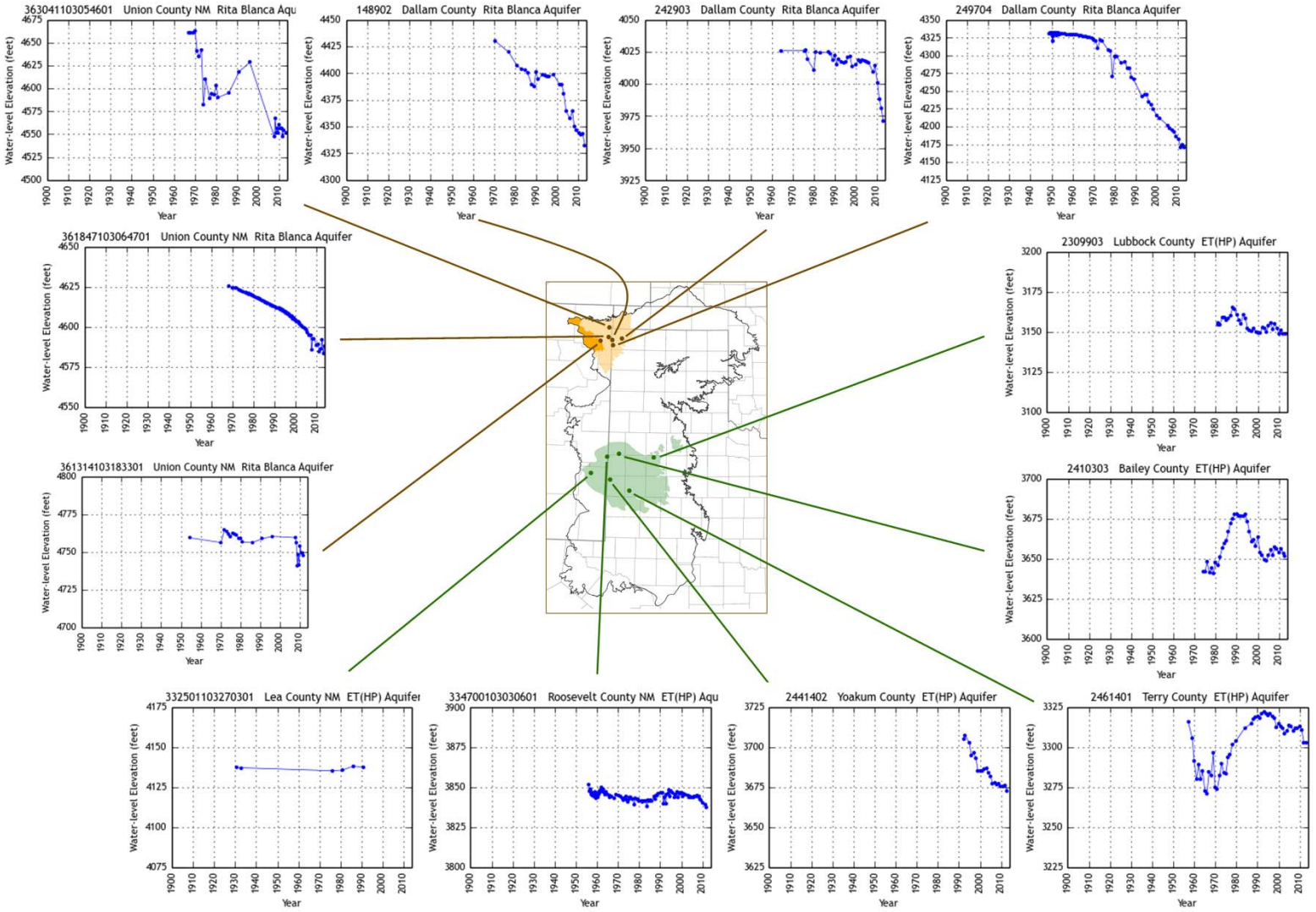


Believed to be due to urban runoff to playas

Transient Water Levels

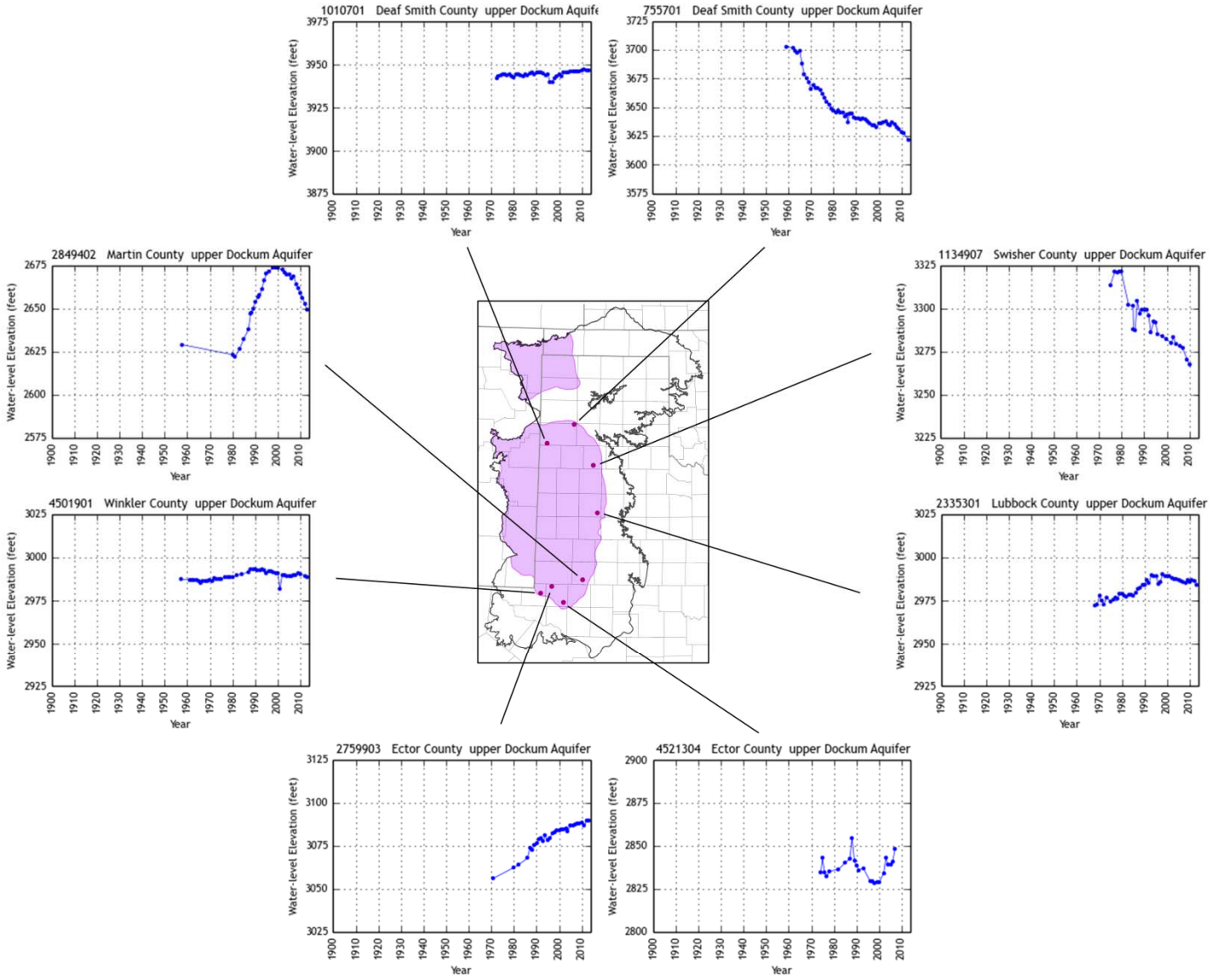
Rita Blanca: **19** hydrographs

Edwards-Trinity (High Plains) : **10** hydrographs



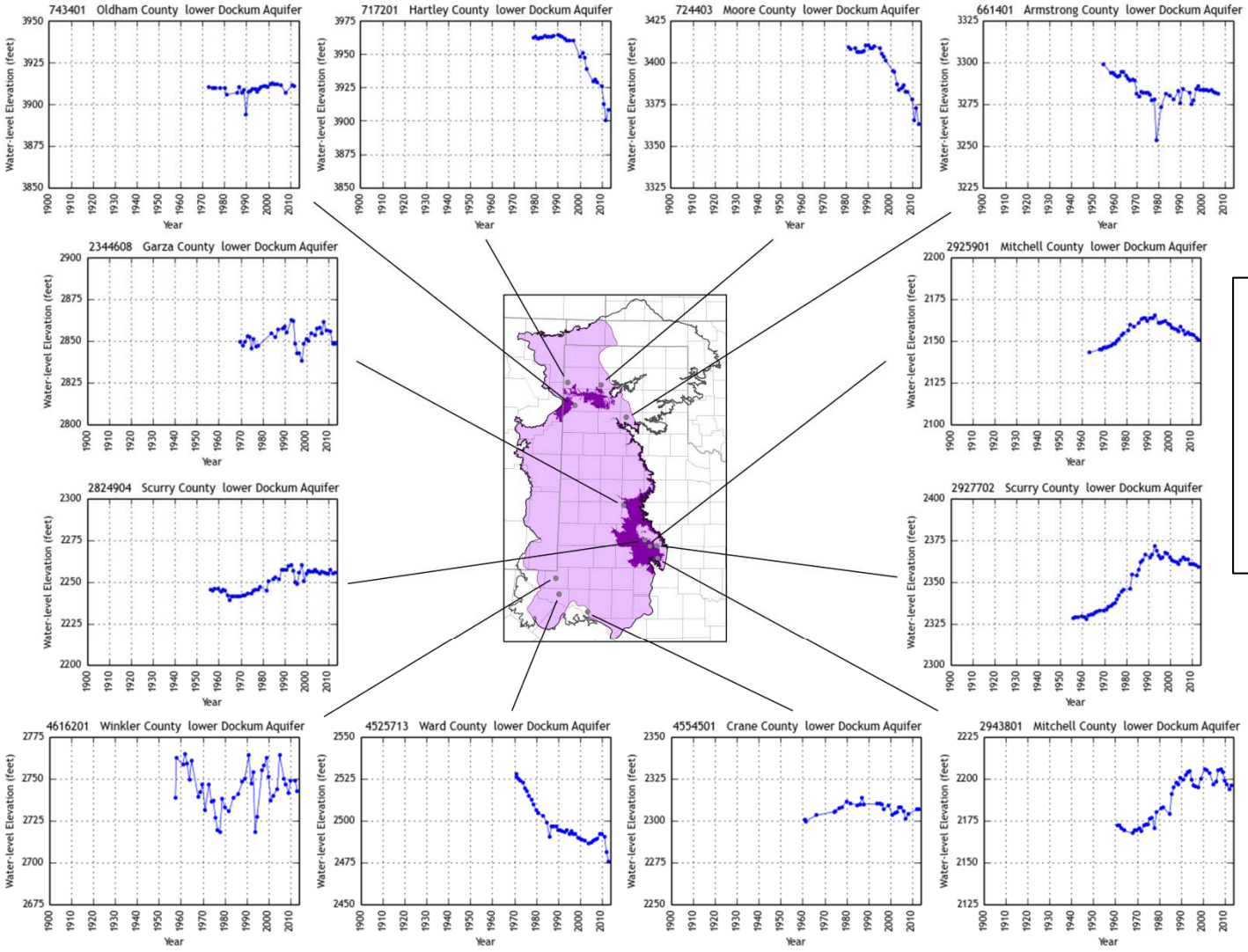
Transient Water Levels

Upper Dockum: **26** hydrographs



Transient Water Levels

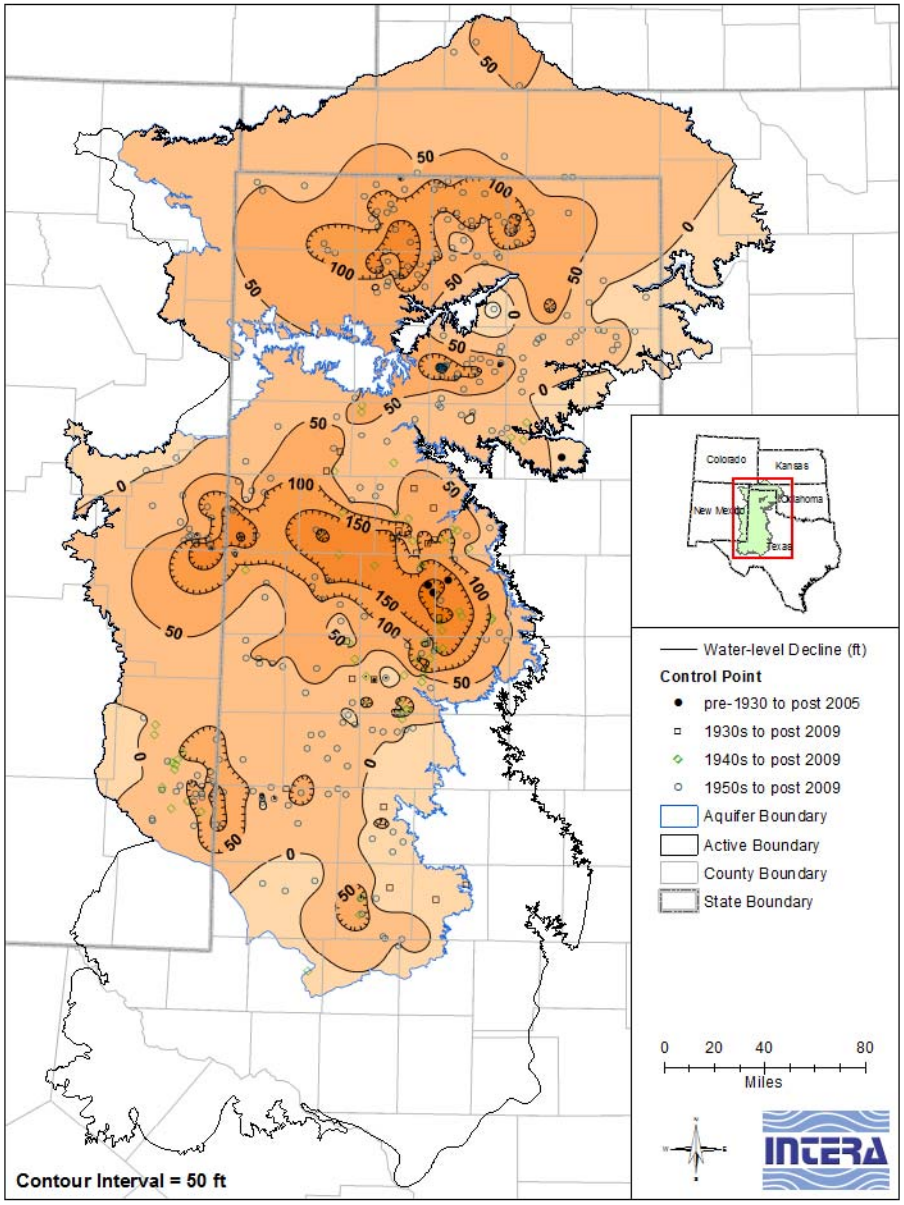
Lower Dockum: **165** hydrographs

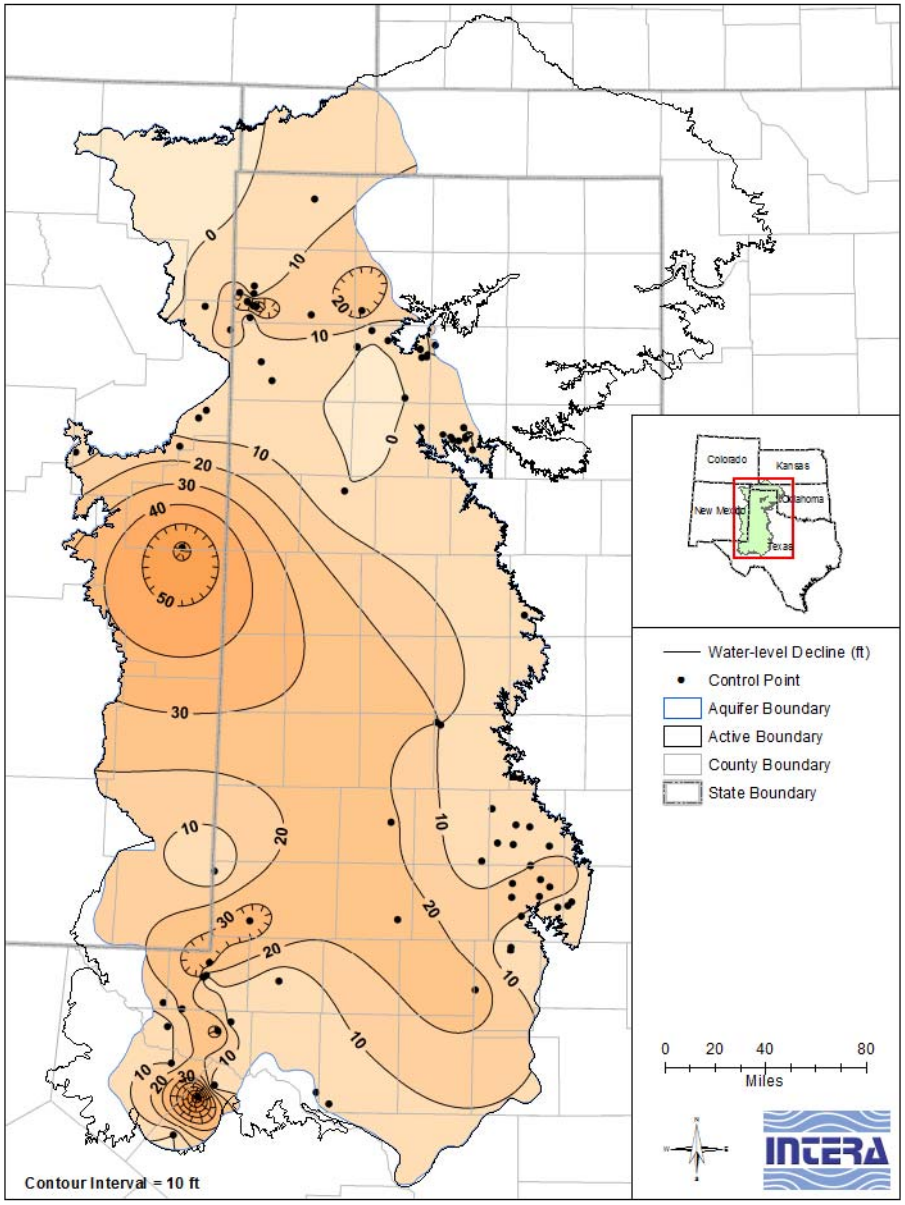


Most hydrographs in areas near outcrop where water quality is best

Currently lack hydrographs showing potential effects of O&G water use on Santa Rosa water levels

Water Level Decline

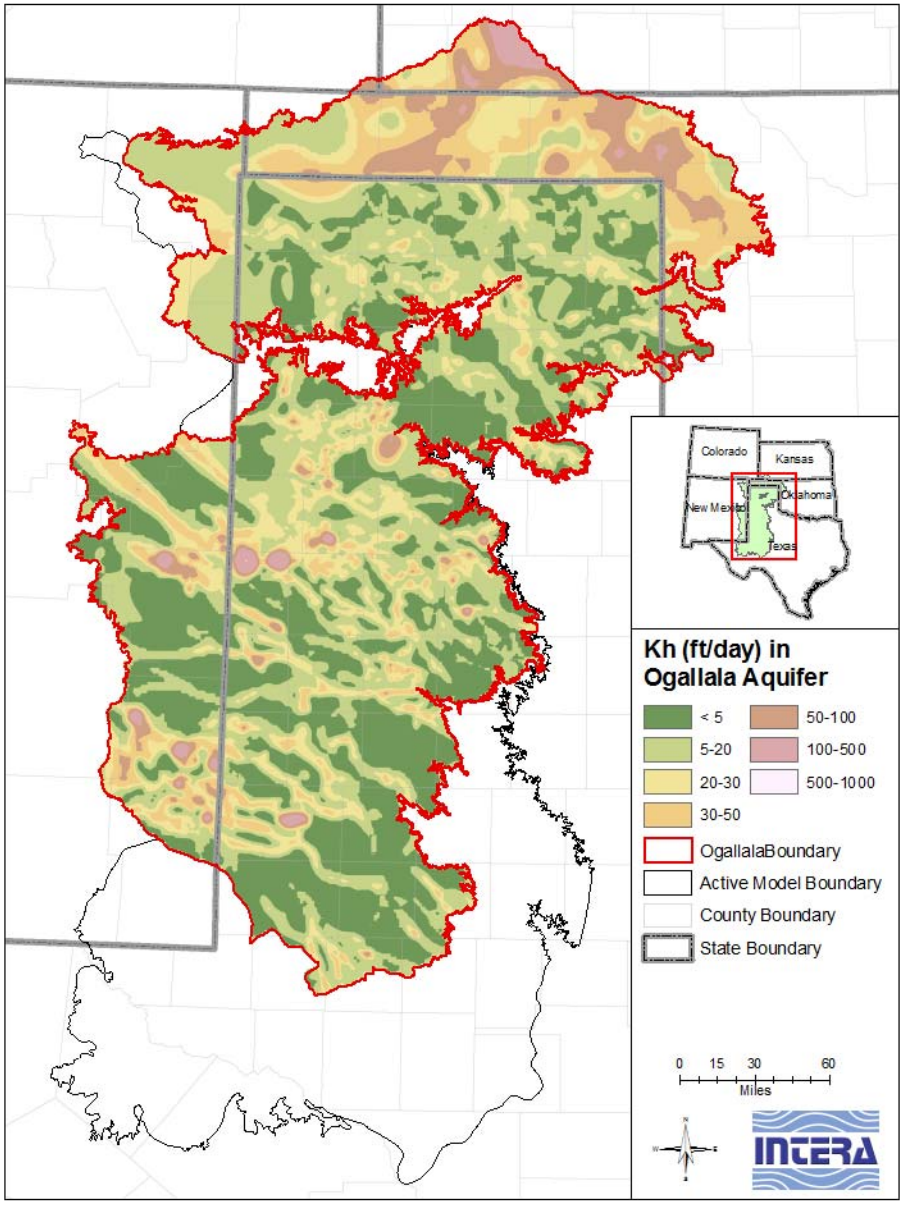


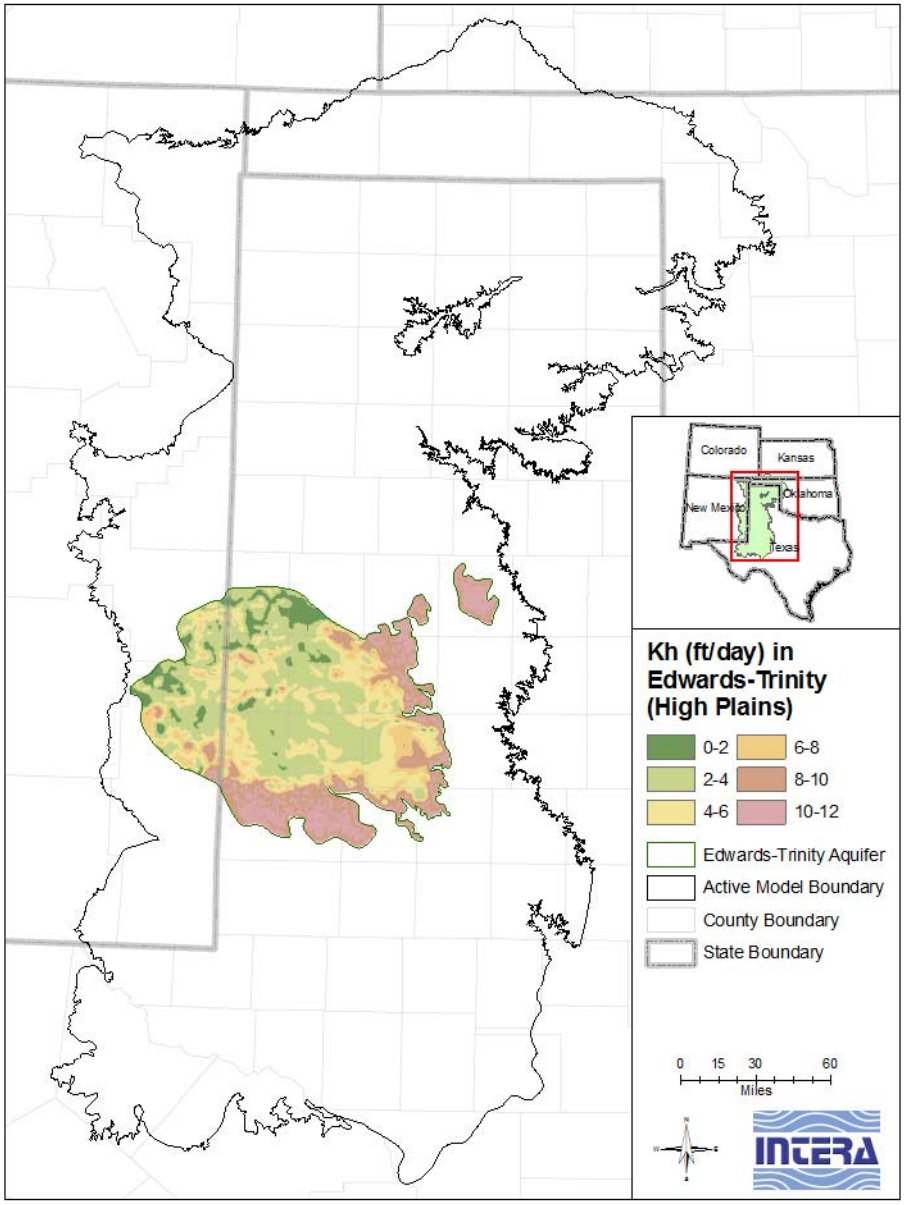


Hydraulic Parameters

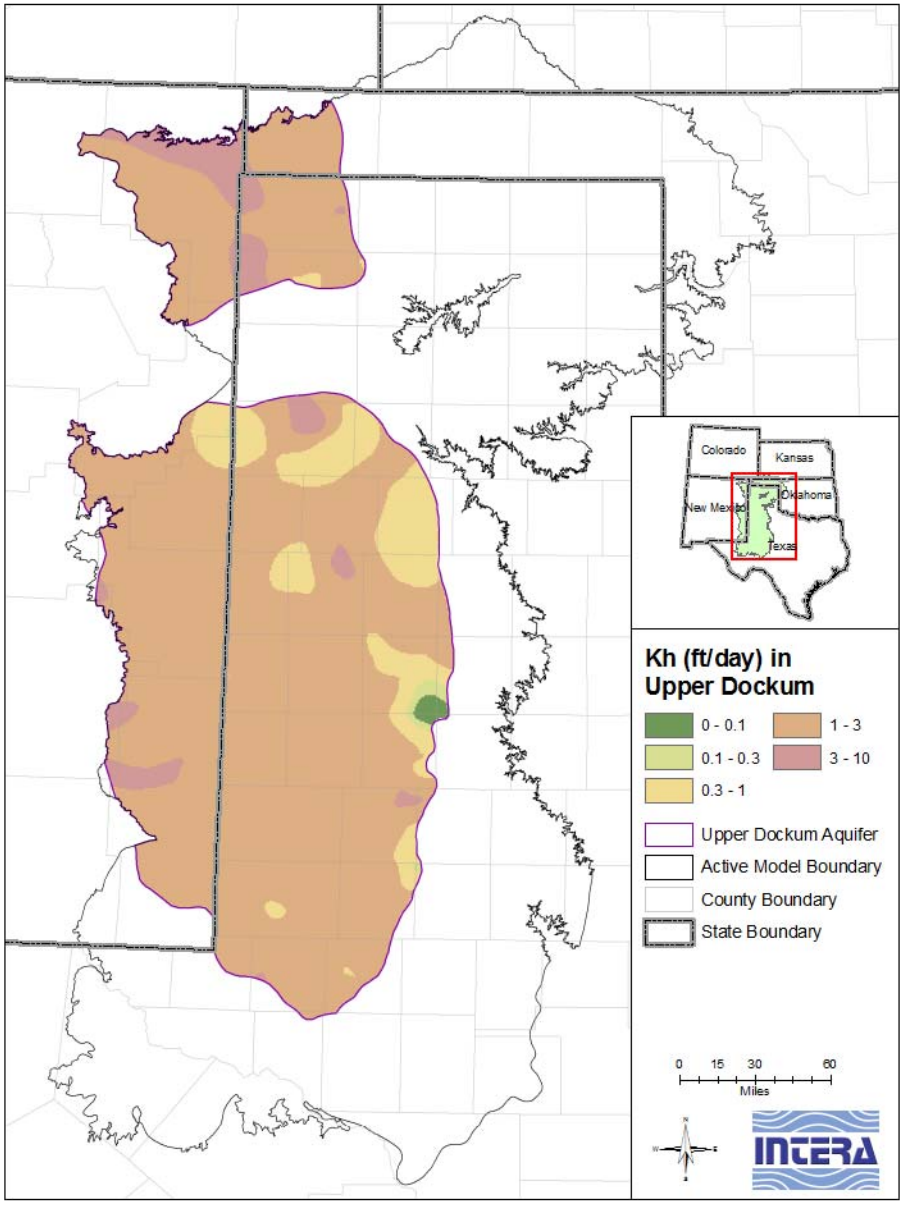
Initial values	OGALLALA	ETHP	DOCKUM
K (horizontal)	Naing (2002) + Dutton and others (2001) + additional point data from cities/GCDs	Effective K values derived from values given in Blandford and others (2008)	Sand K values in Ewing and others (2008) multiplied by current study's sand fractions
K (vertical)	Blandford and others (2008)	Blandford and others (2008)	Senger and others (1987) + Ewing and others (2008)
Storage	Sy: Blandford and others (2003) + Dutton and others (2001) + McGuire (2012)	Sy : 0.05 for limestone, 0.15 for sand, 0.1 for shale	Ss and Sy : Ewing and others (2008)

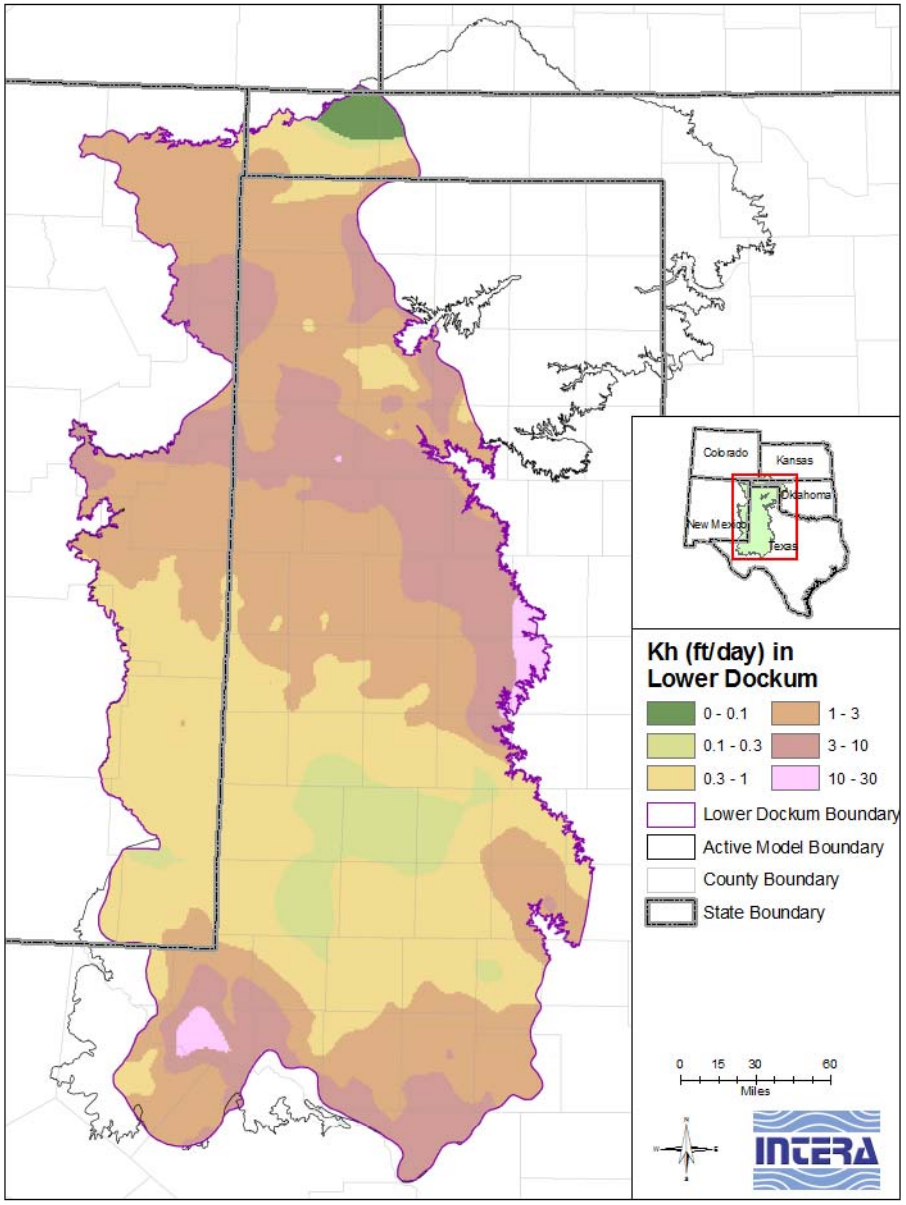
Hydraulic Parameters





Hydraulic Parameters



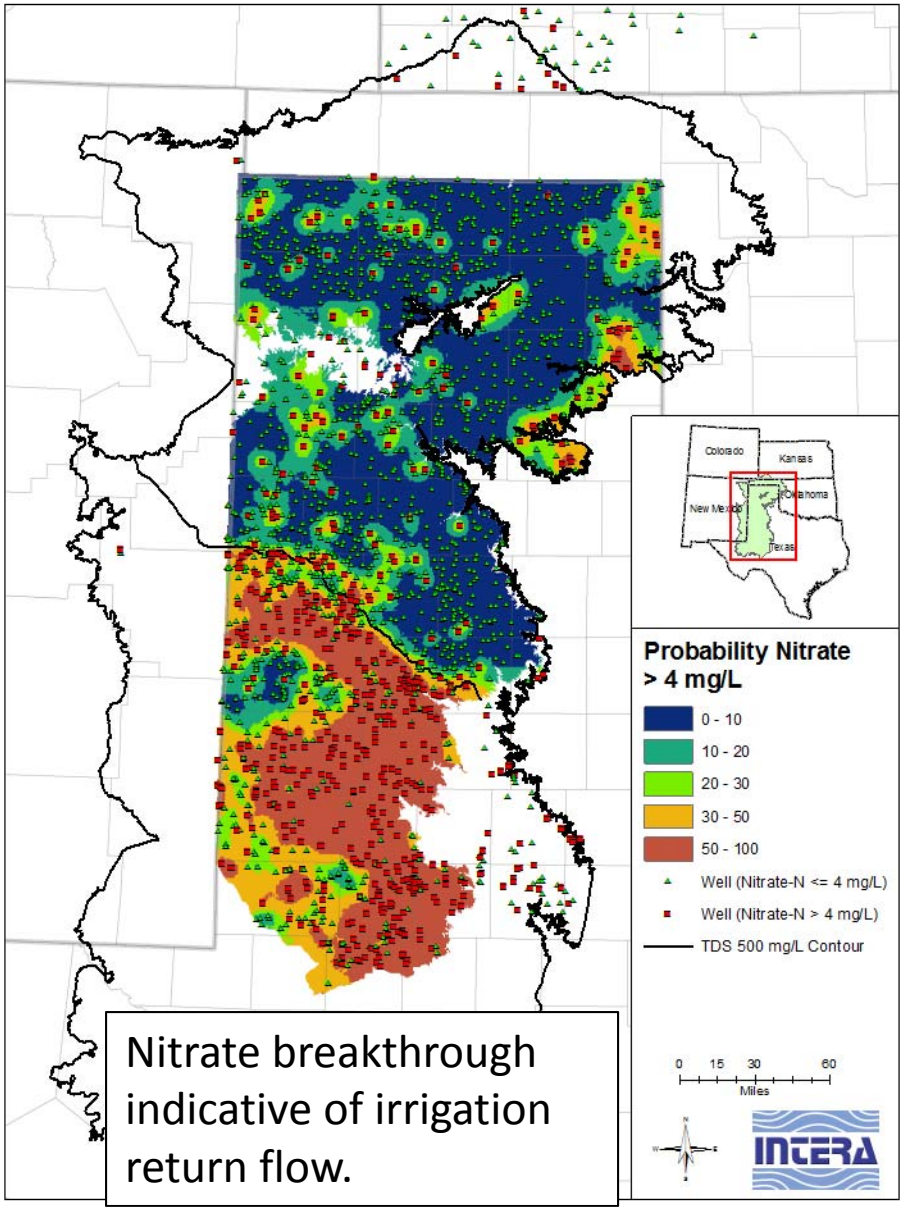


Recharge

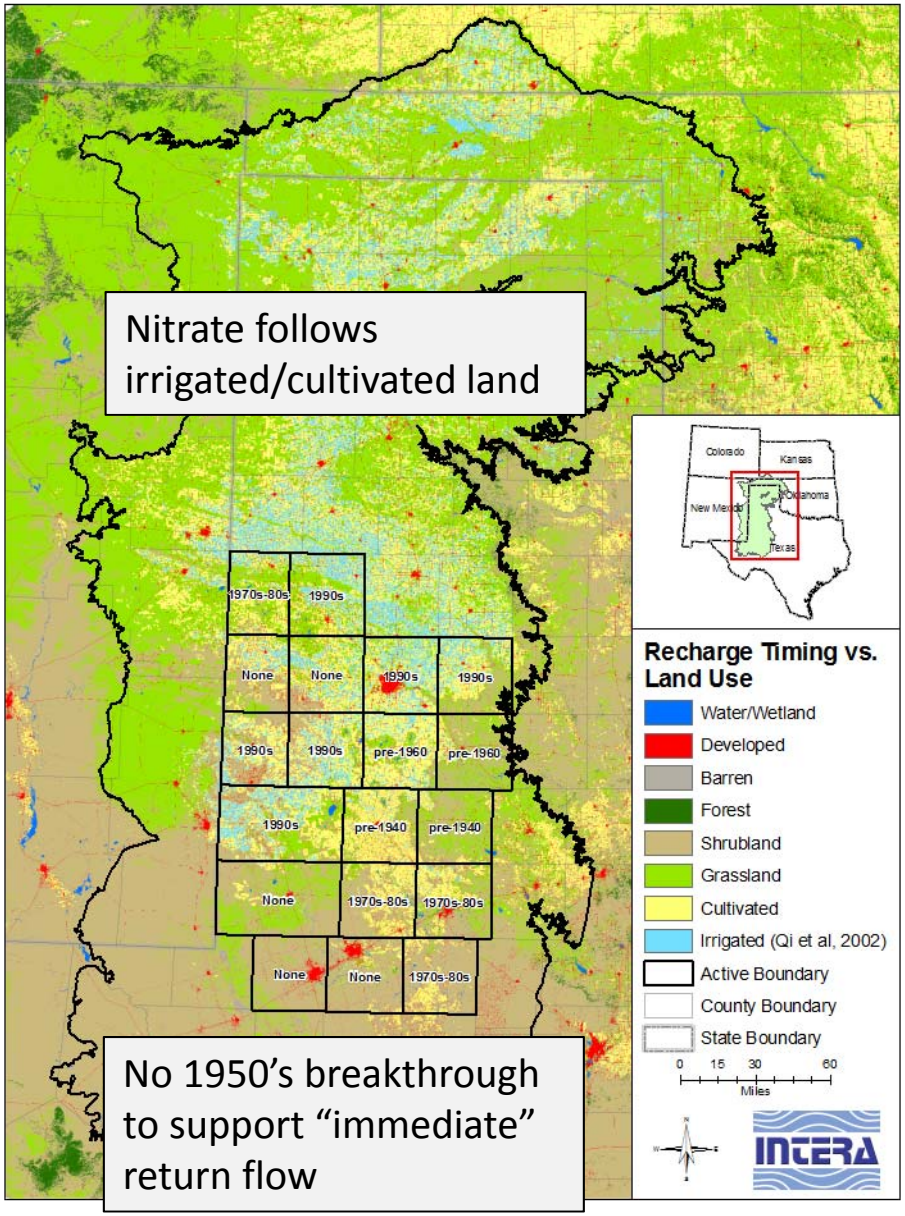
	N. OGALLALA	S. OGALLALA	DOCKUM
Pre-development	Based on chloride mass balance + soil type	Based on playa density	From previous GAM (Ewing and others, 2008)
Post-development	Unchanged from pre-development	Based on land use distribution	From previous GAM (Ewing and others, 2008)

Additional district funding allowed new analyses from the Scanlon and Reedy at the BEG, especially in the area of irrigation return flow.

Recharge



Nitrate breakthrough indicative of irrigation return flow.

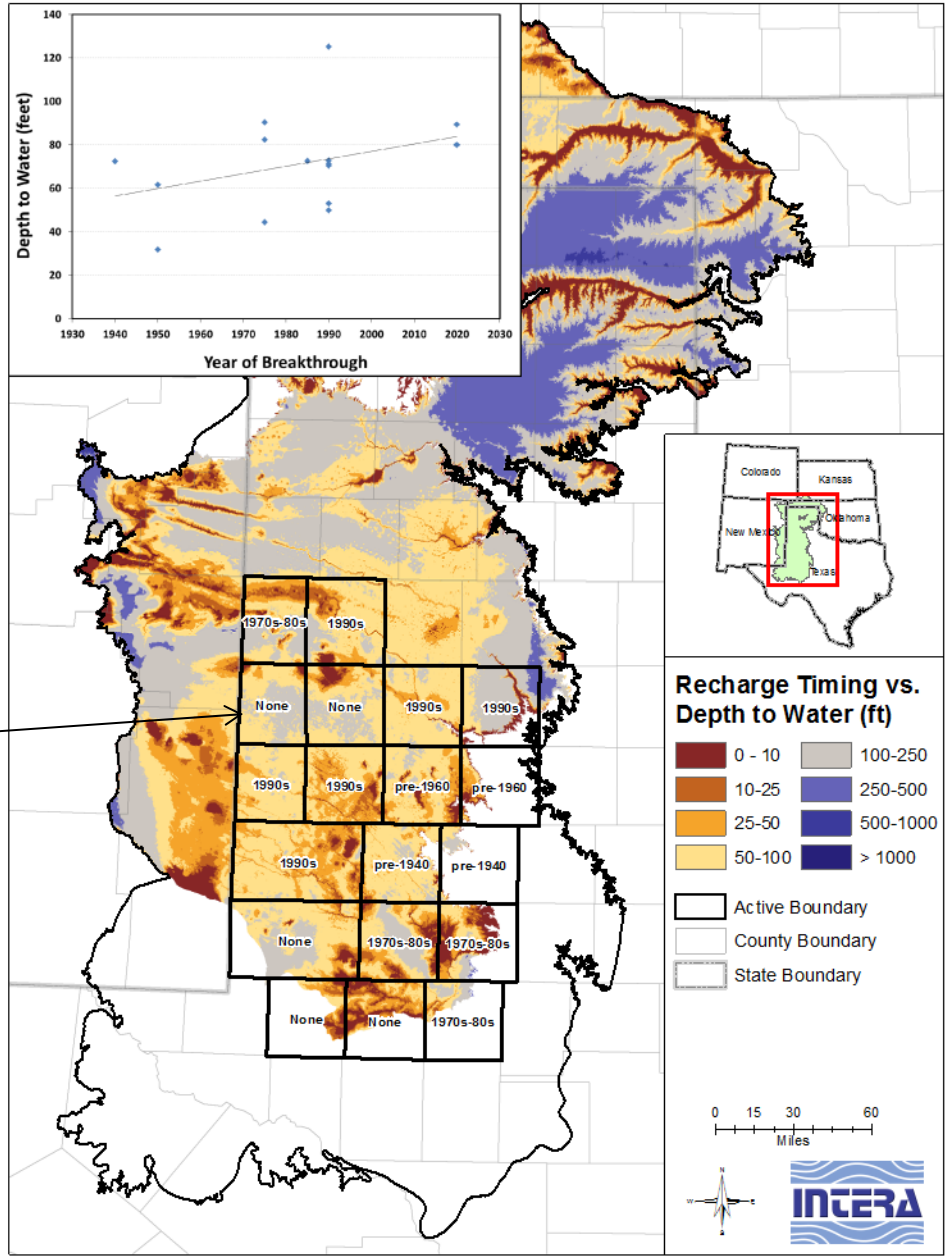


Nitrate follows irrigated/cultivated land

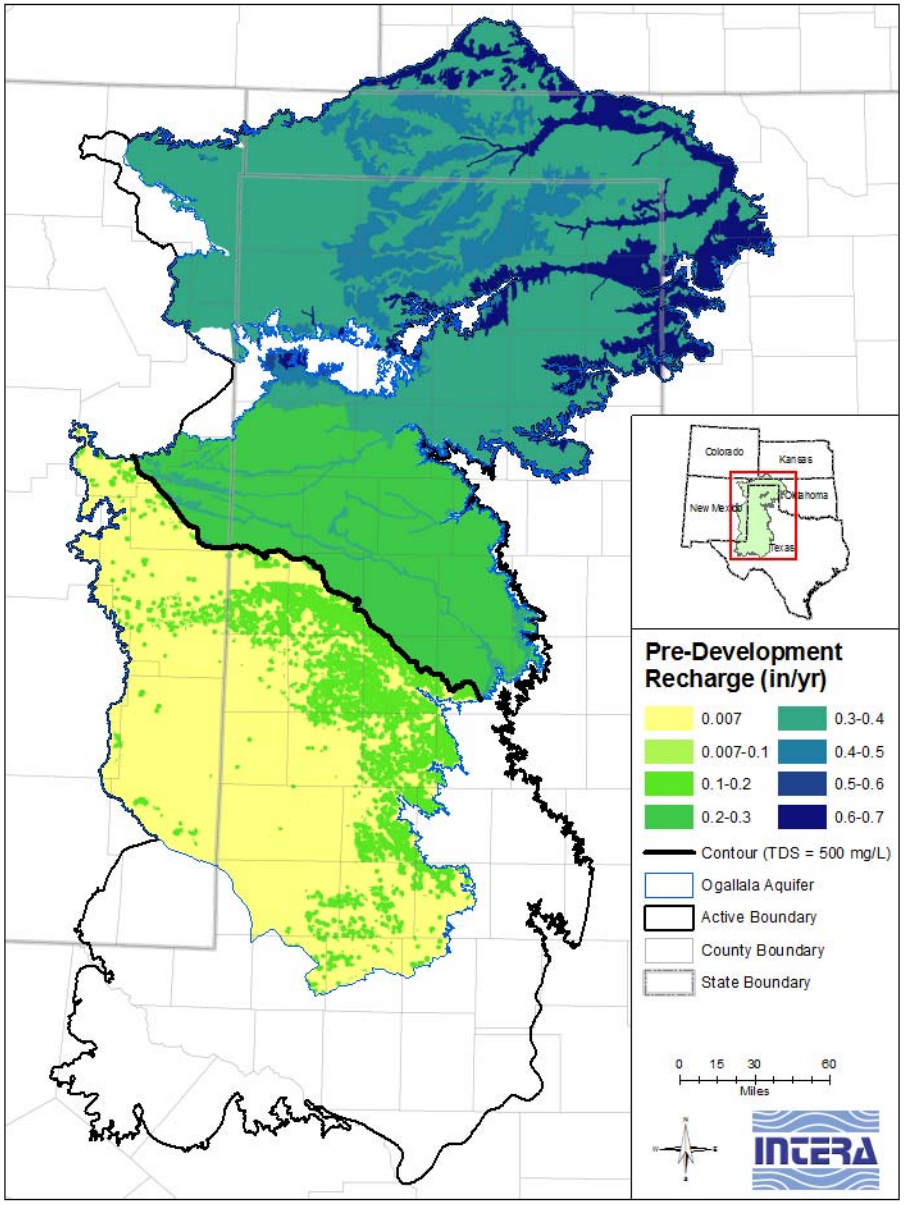
No 1950's breakthrough to support "immediate" return flow

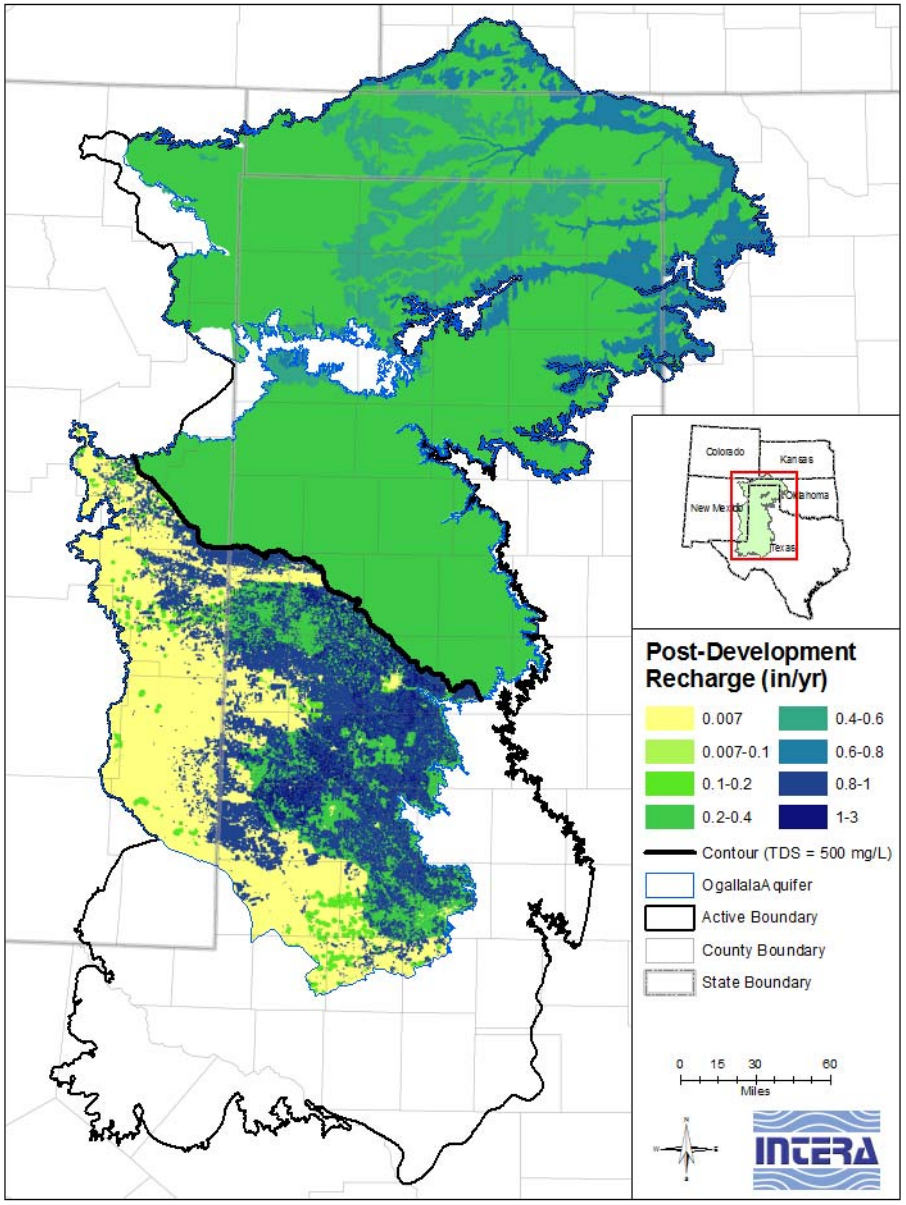
Recharge

No breakthrough with deep water table, less cultivated land

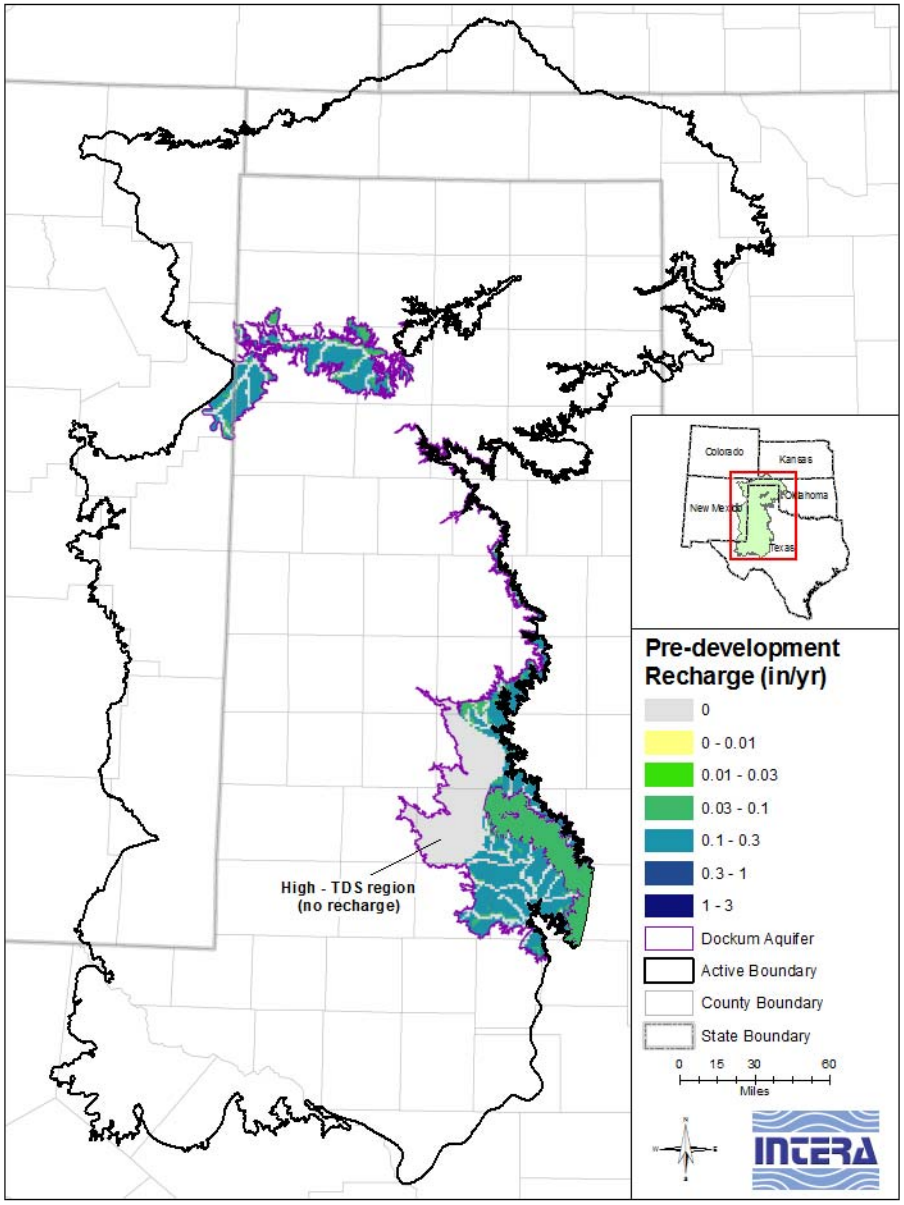


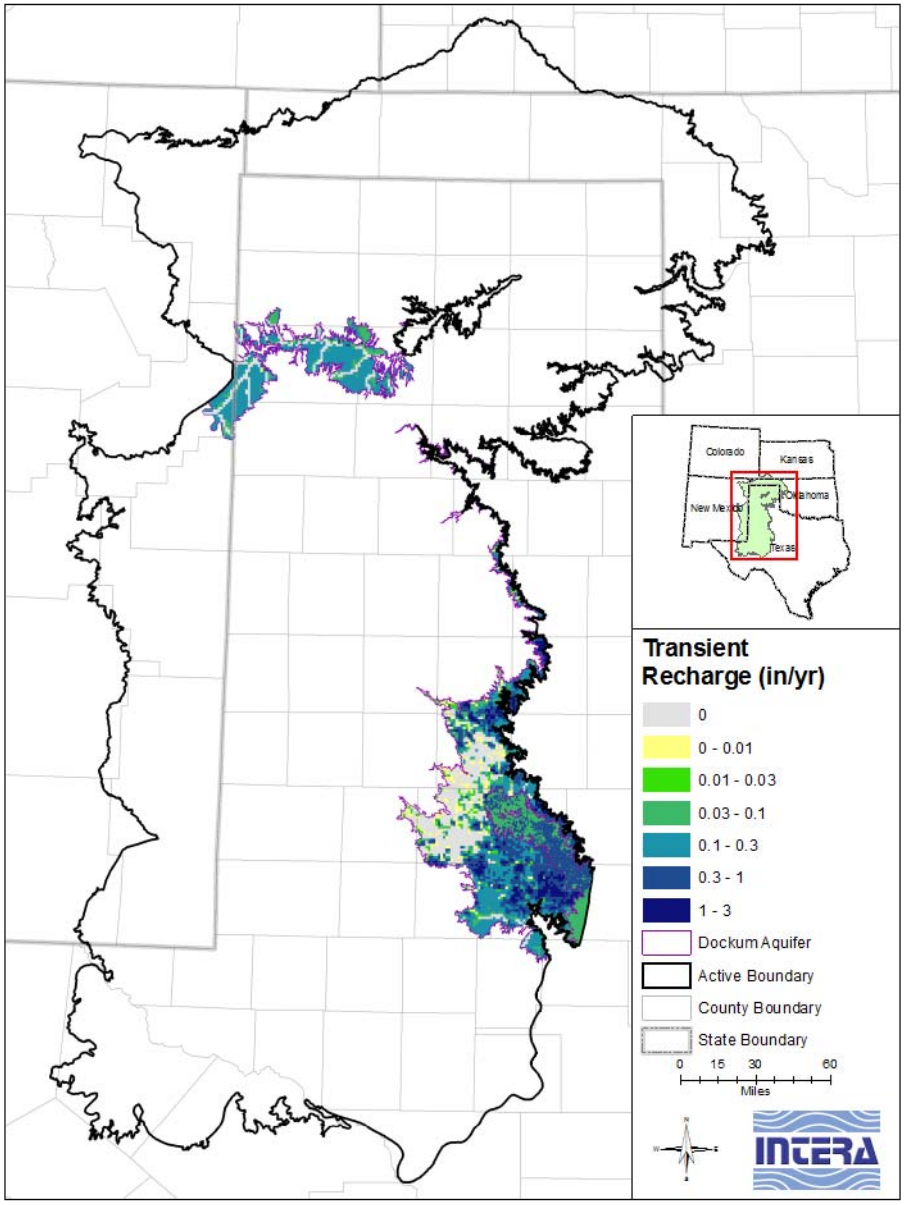
Recharge Estimate: Ogallala





Recharge Estimates: Dockum

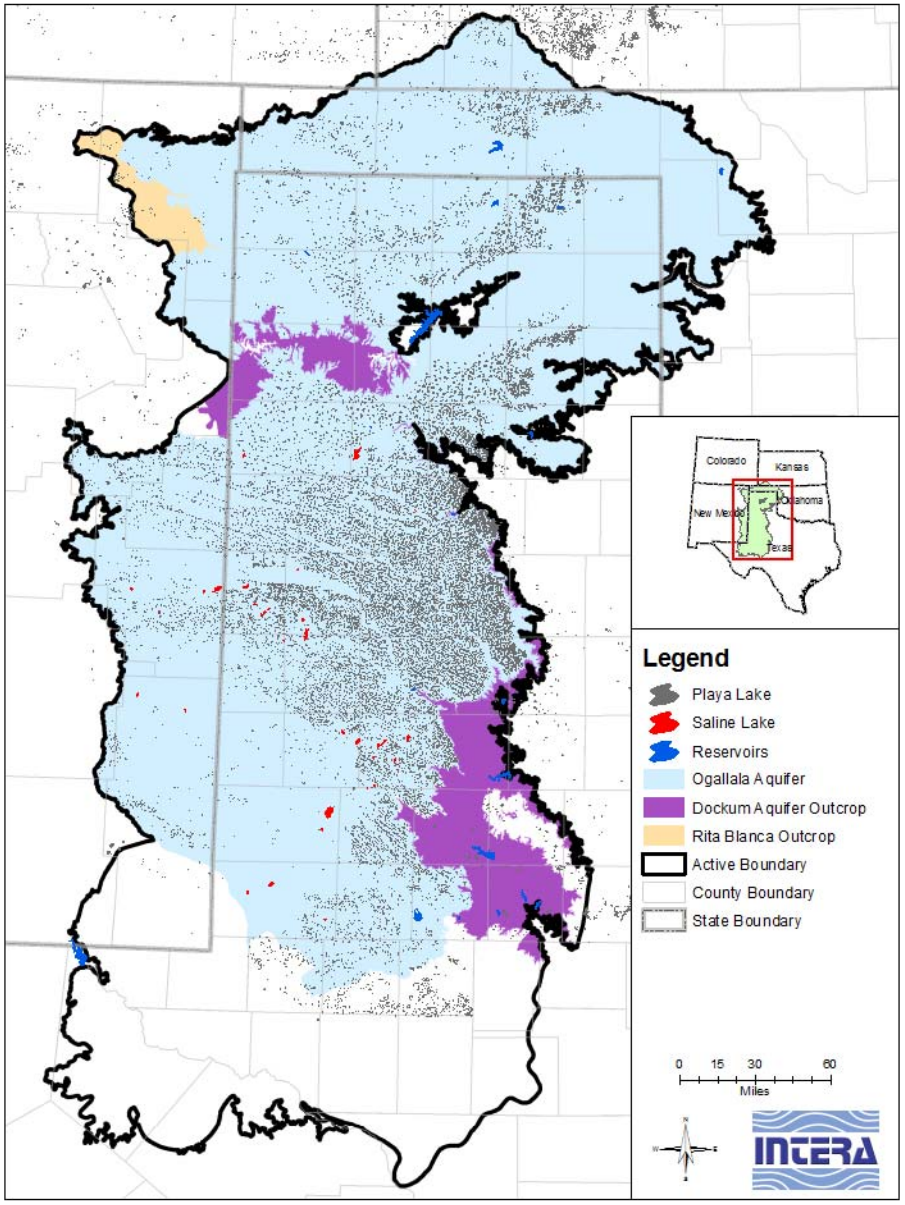


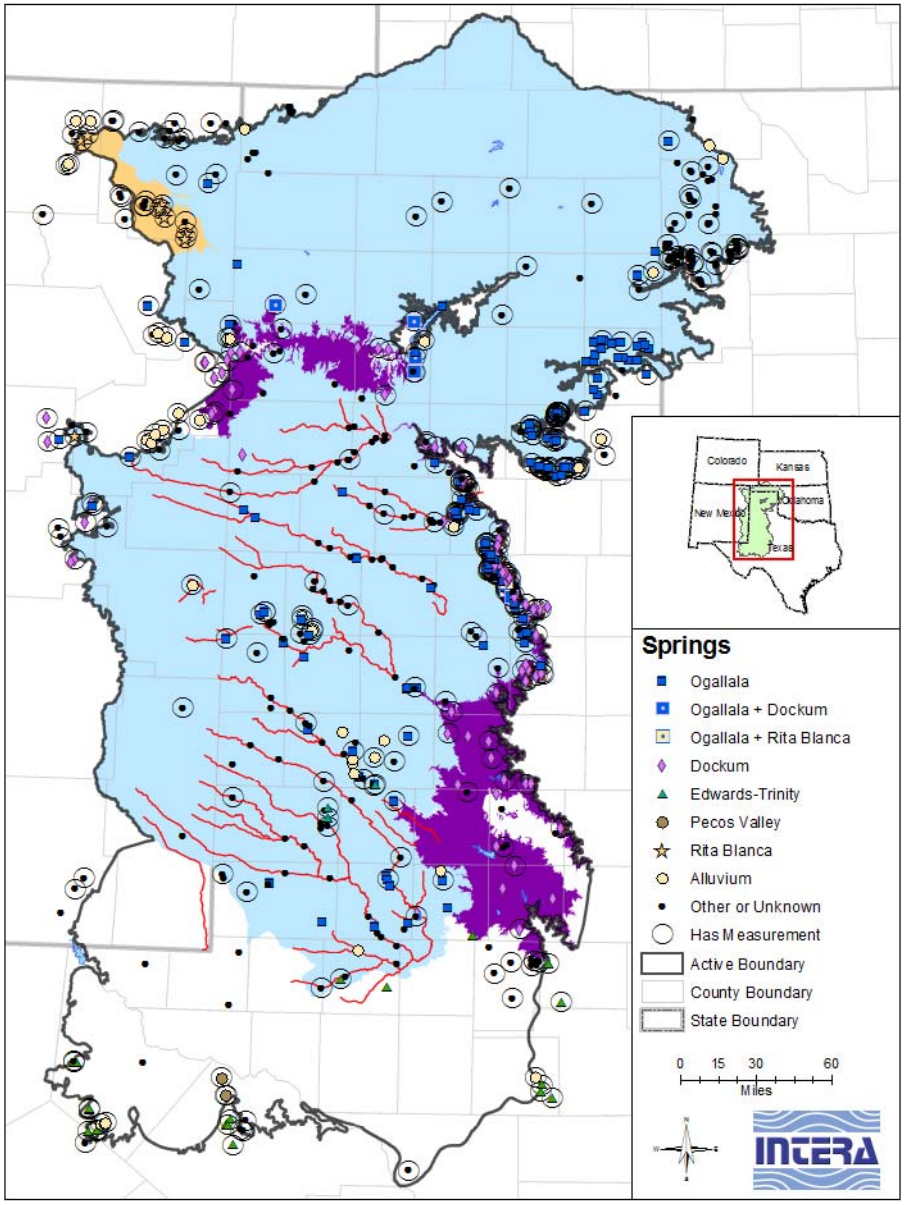


Natural Discharge

- Discharge to surface water from Ogallala not a large portion of post-development water balance
- Used spring locations to tie water levels to surface in Predevelopment
- Saline lakes typically denote areas of former or current discharge.

Natural Discharge: Springs and Saline Lakes





Groundwater Production

- Pumping is the dominant discharge mechanism.

- Pumping data taken from:

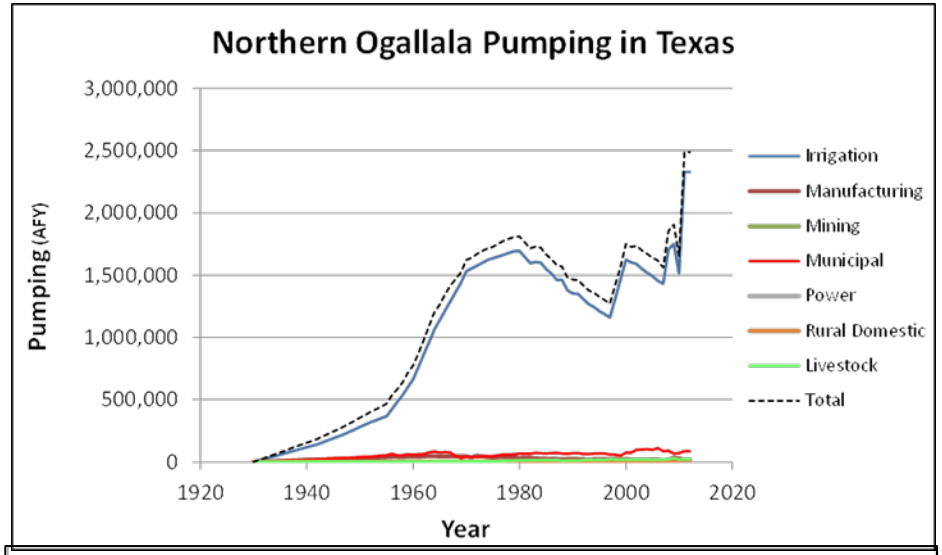
  TWDB Water Use Survey
  Amosson and others (2003)
  INTERA, Inc. & Dutton (2010)
  Blandford et al. (2003)

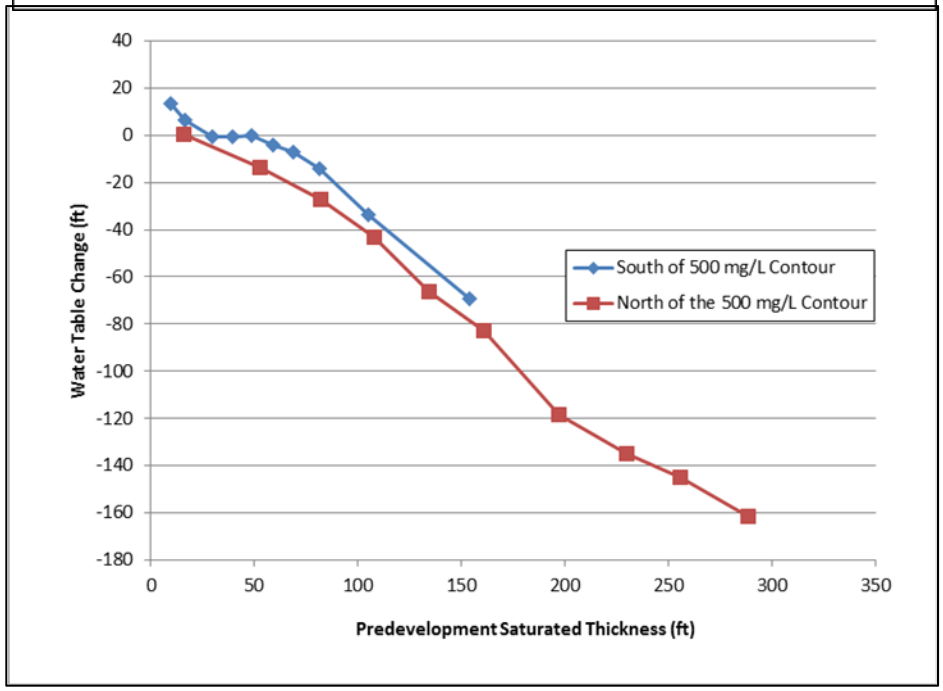
  TWDB Irrigation Survey
  North Plains GCD
  Ewing et al. (2008)
  Blandford et al. (2008)

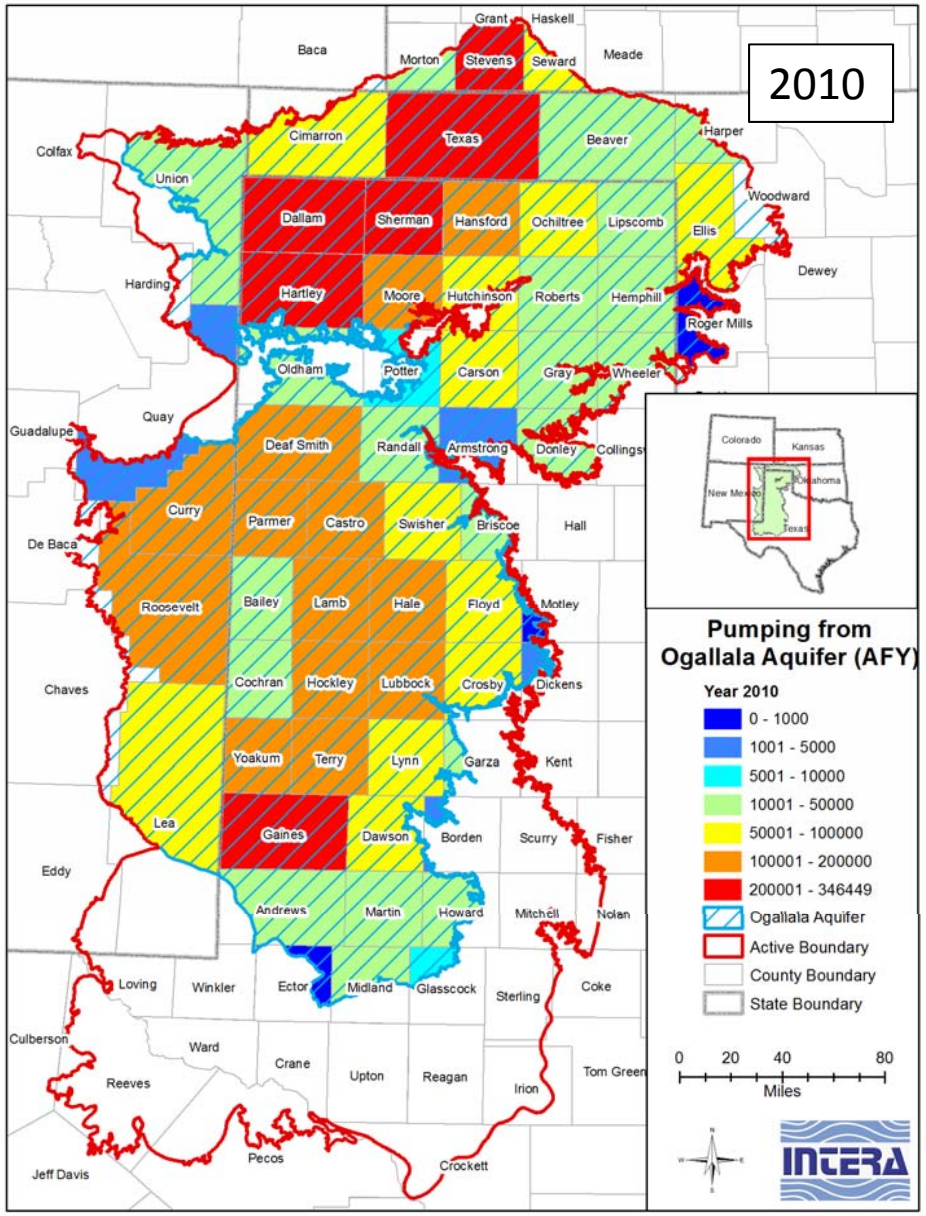
- Demand-based pumping estimates prior to 1980 (from irrigation survey) will likely be revised where they are significantly different from storage changes calculated from water levels

Additional district funding allowed development of a GIS-based tool for efficiently calculating storage change.

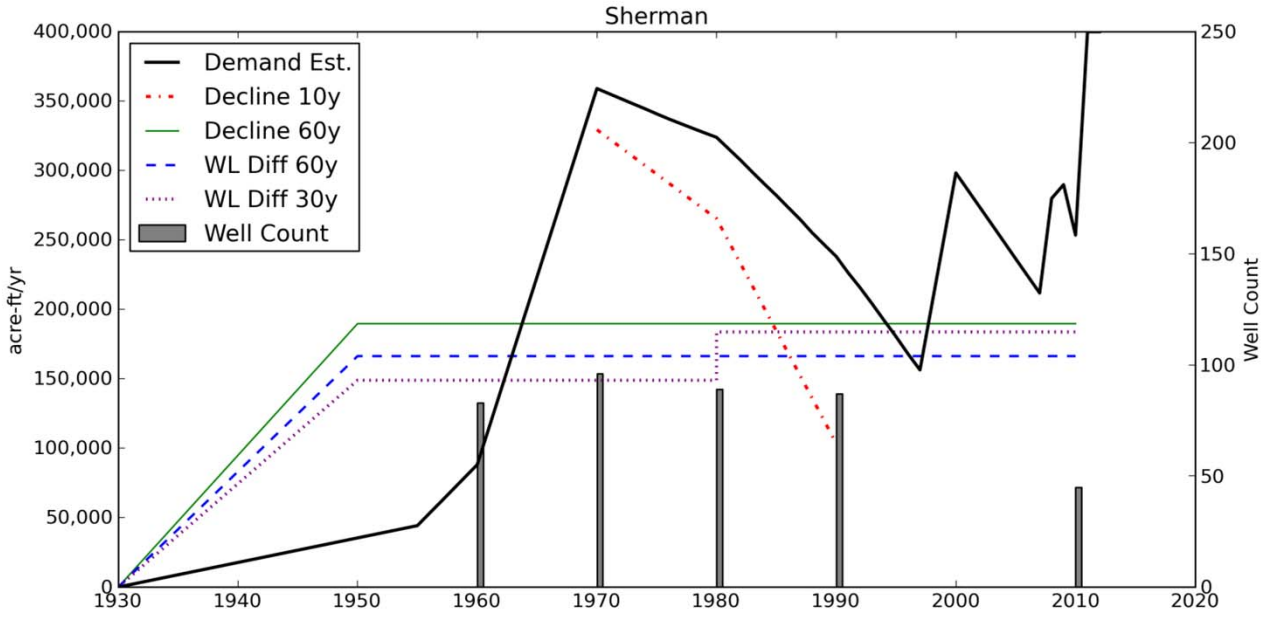
Groundwater Production





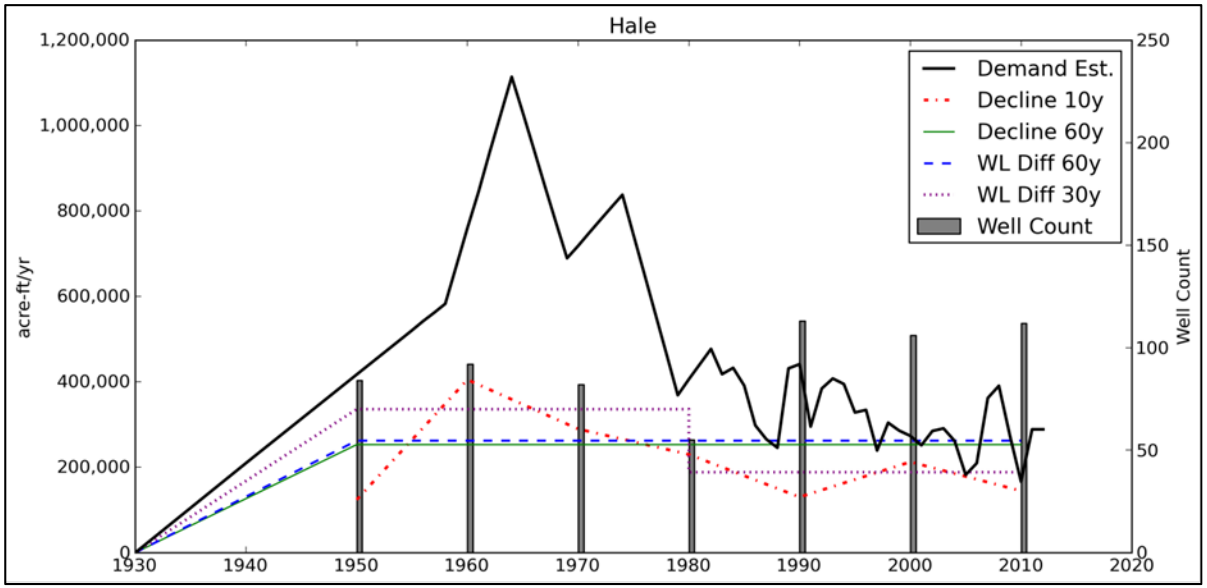


Groundwater Production: Using Storage Change



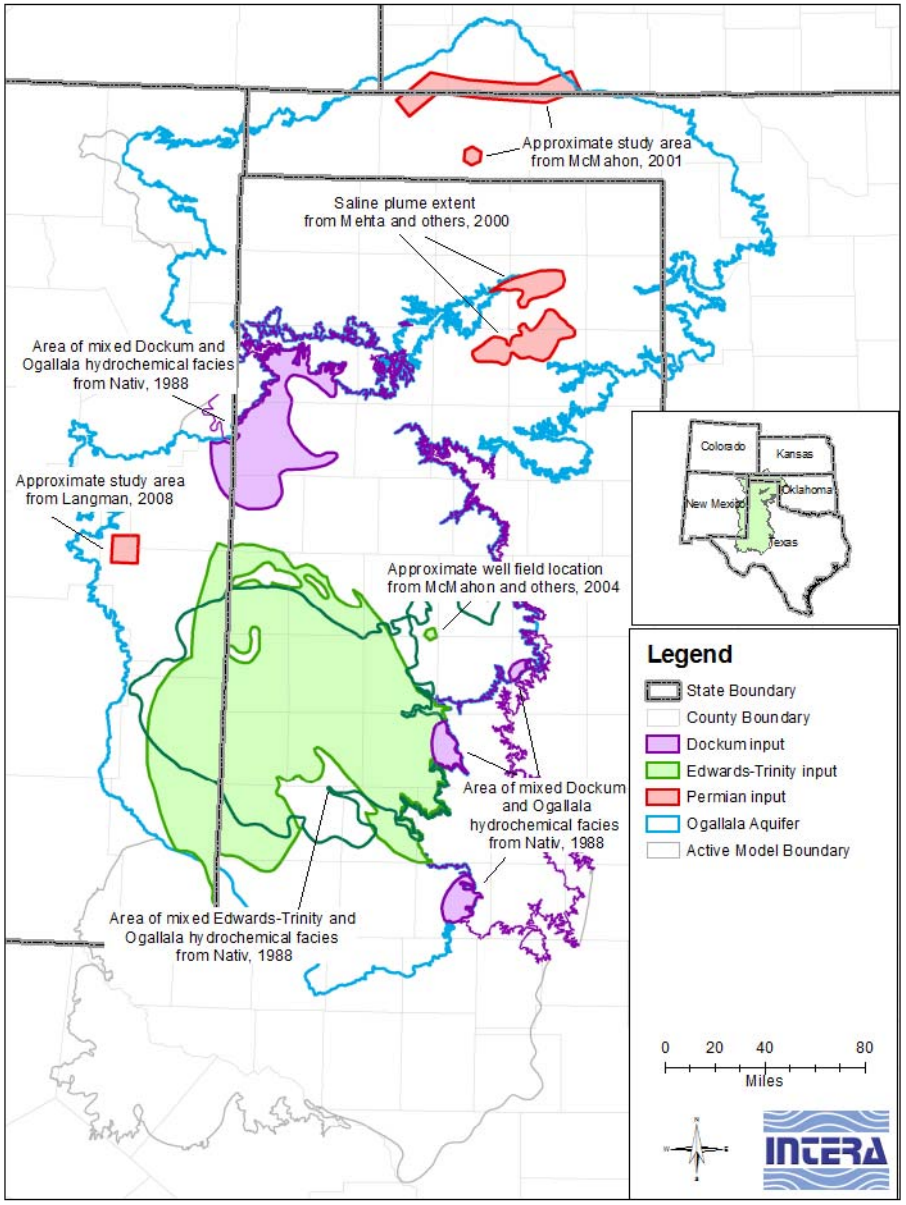
Technique requires high density monitoring network, and high production, otherwise storage change estimate is swamped by "noise" in data.

For some counties, clear differences exist between storage change estimates and demand-based estimates.



Cross-formational Flow

- Some evidence of cross-formational flow found in literature review based on lithology, heads and hydrochemistry



Water Quality

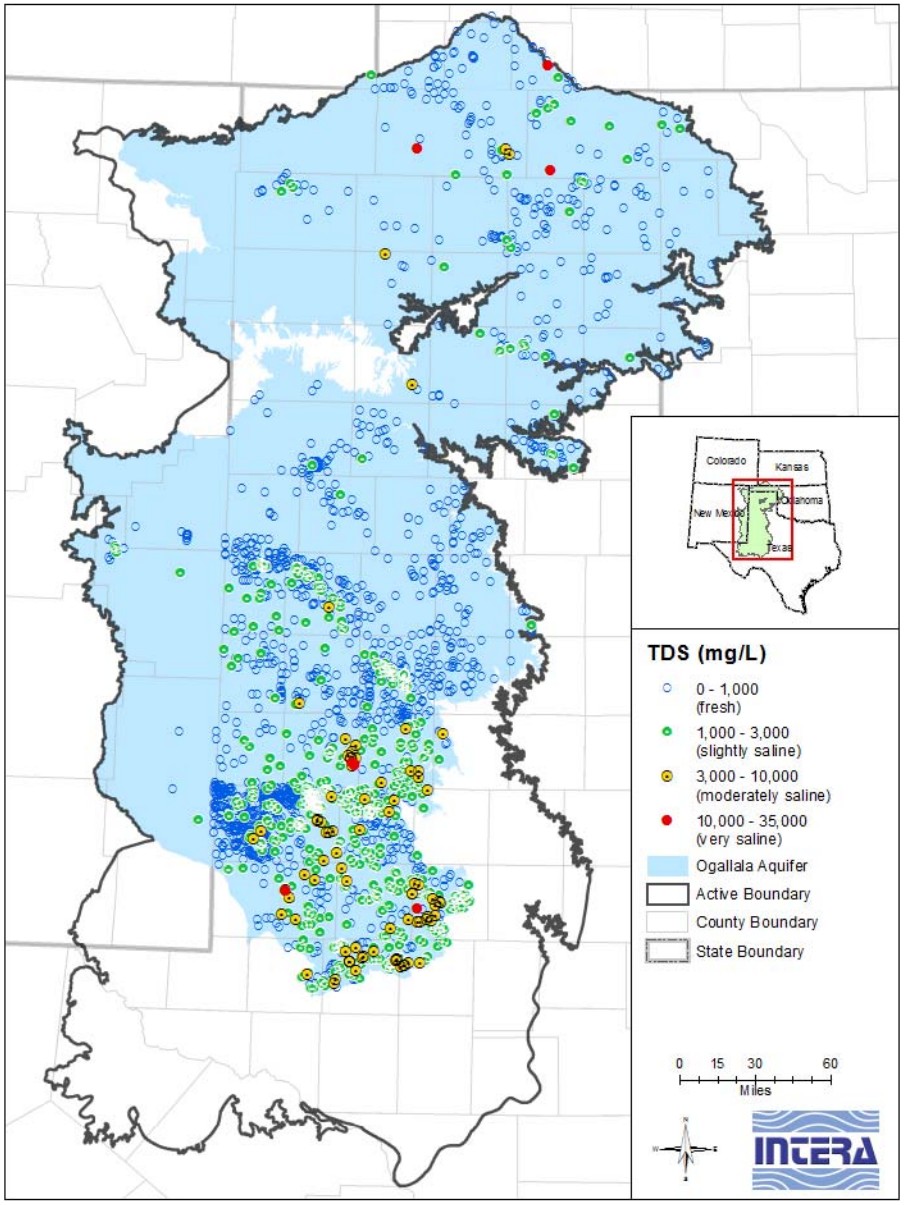
- Groundwater water quality analysis included 5,897 wells retrieved from

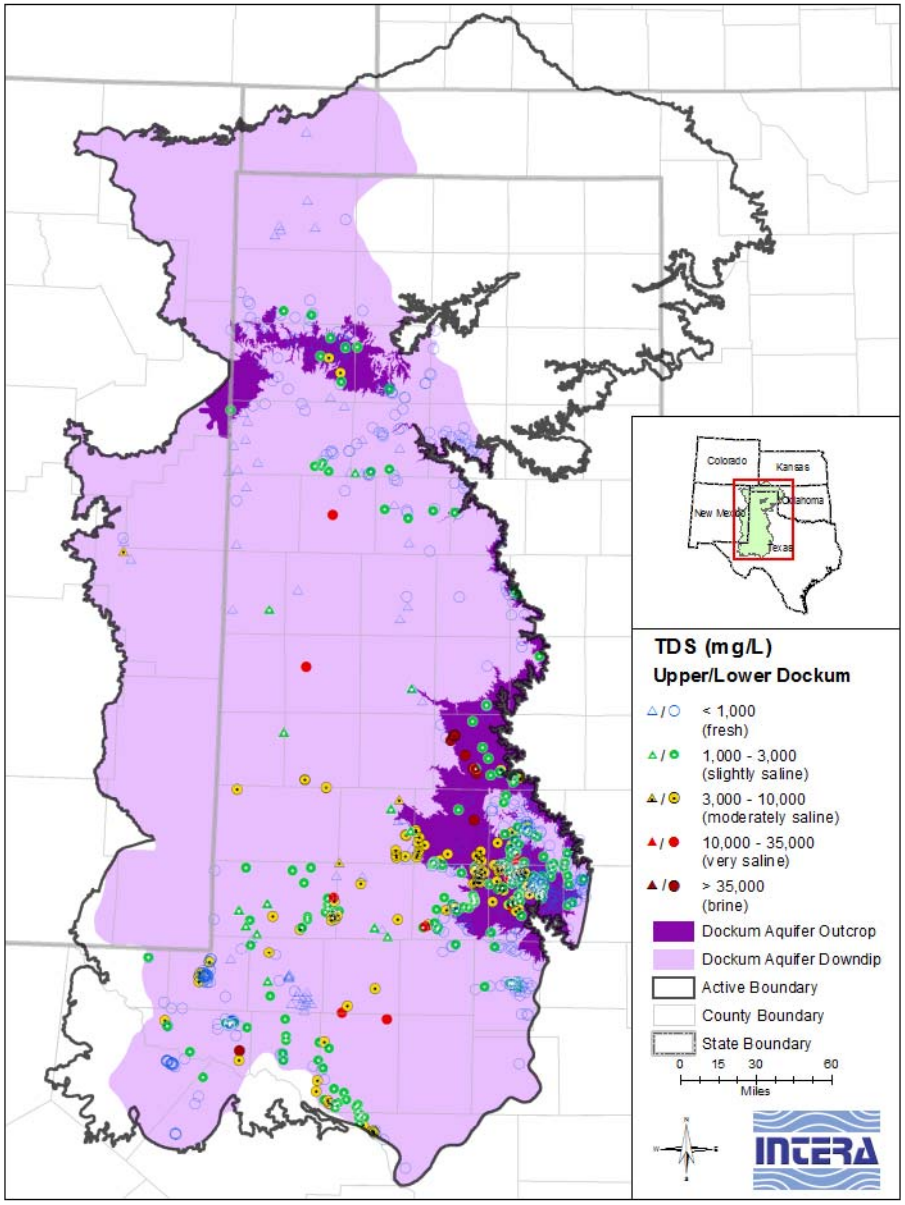
  TWDB Groundwater Database (TX)
  USGS NWIS Database (non-TX)

- Wells were assigned to aquifers based on the current study's new structural surfaces.

- Only the most recent sampling event for a given parameter was chosen from each well.

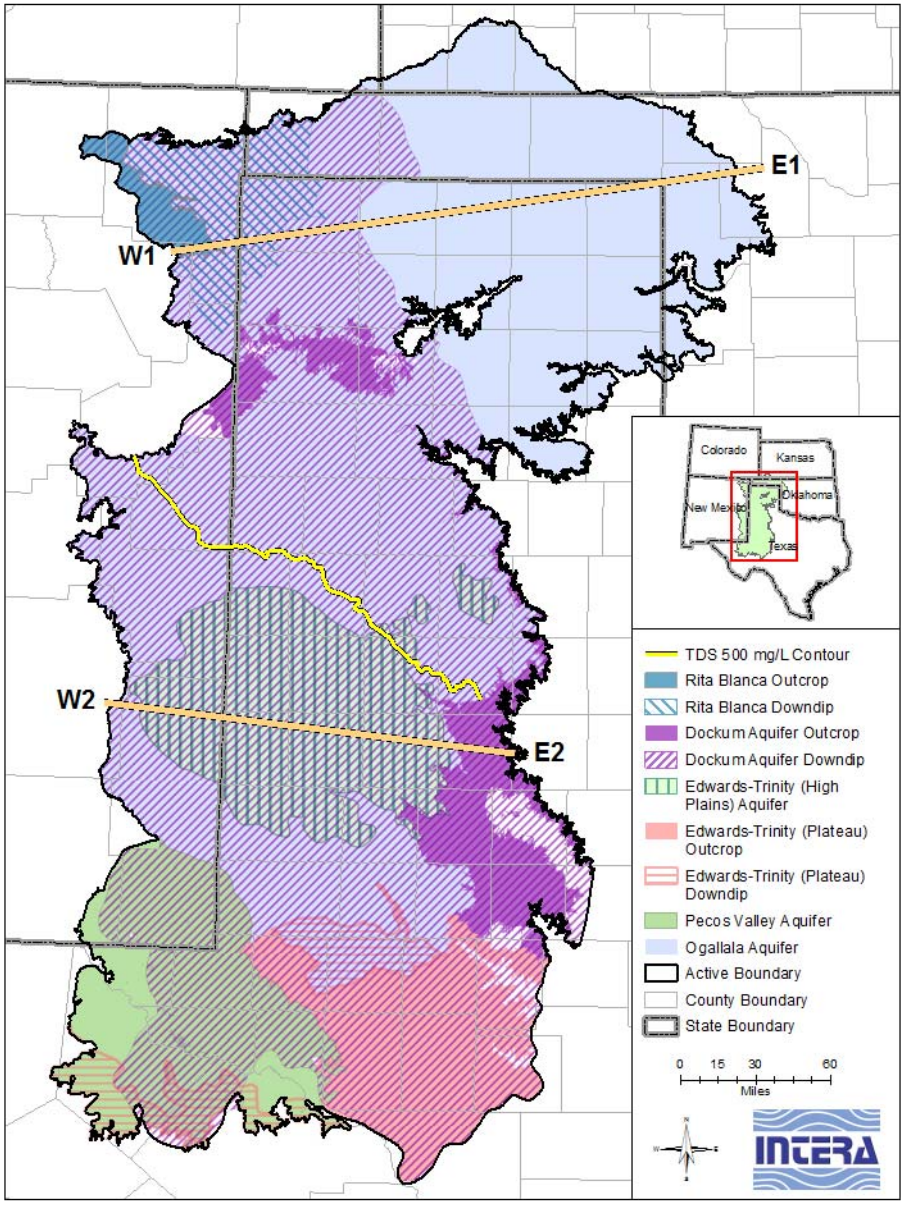
Water Quality



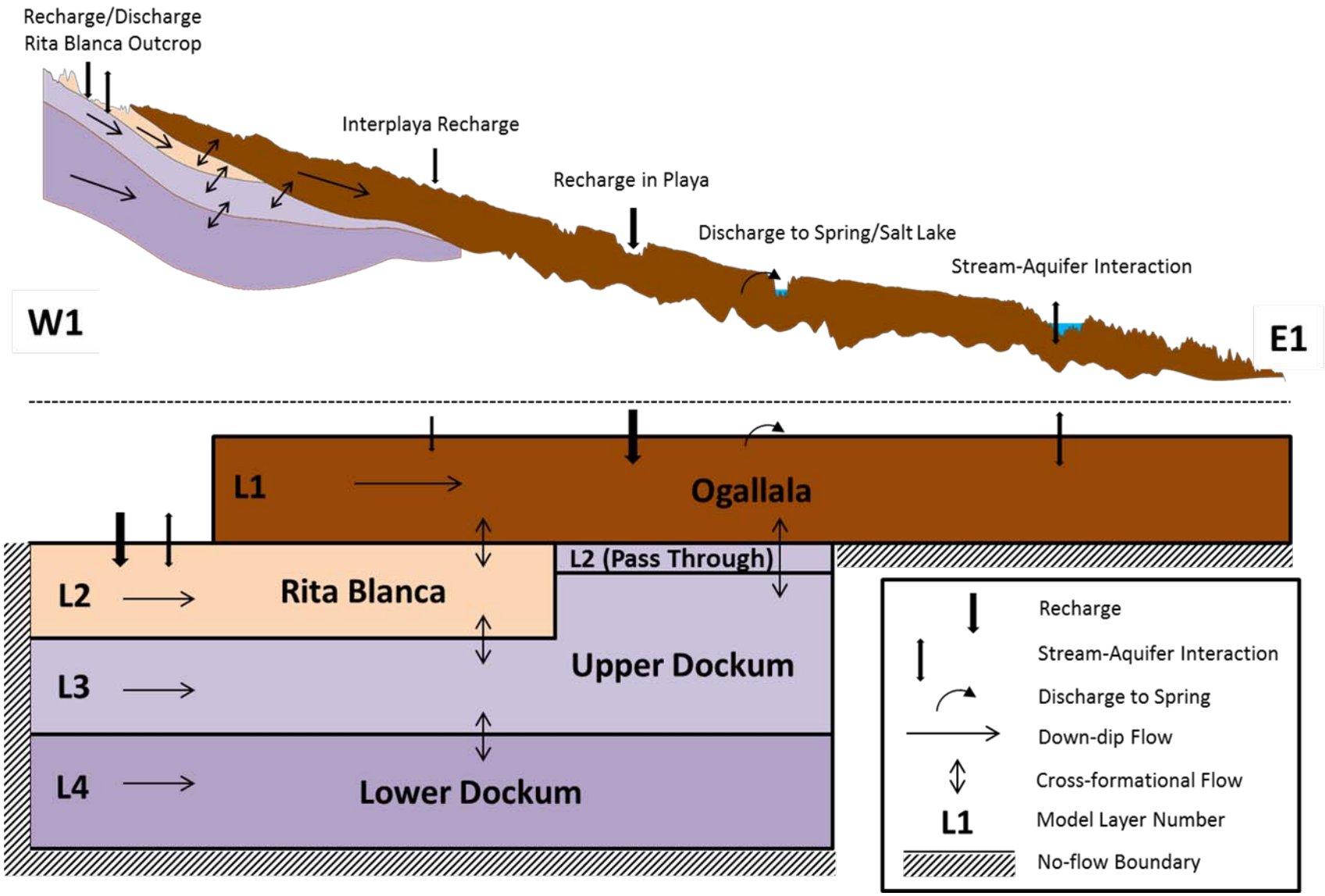


Conceptual Model

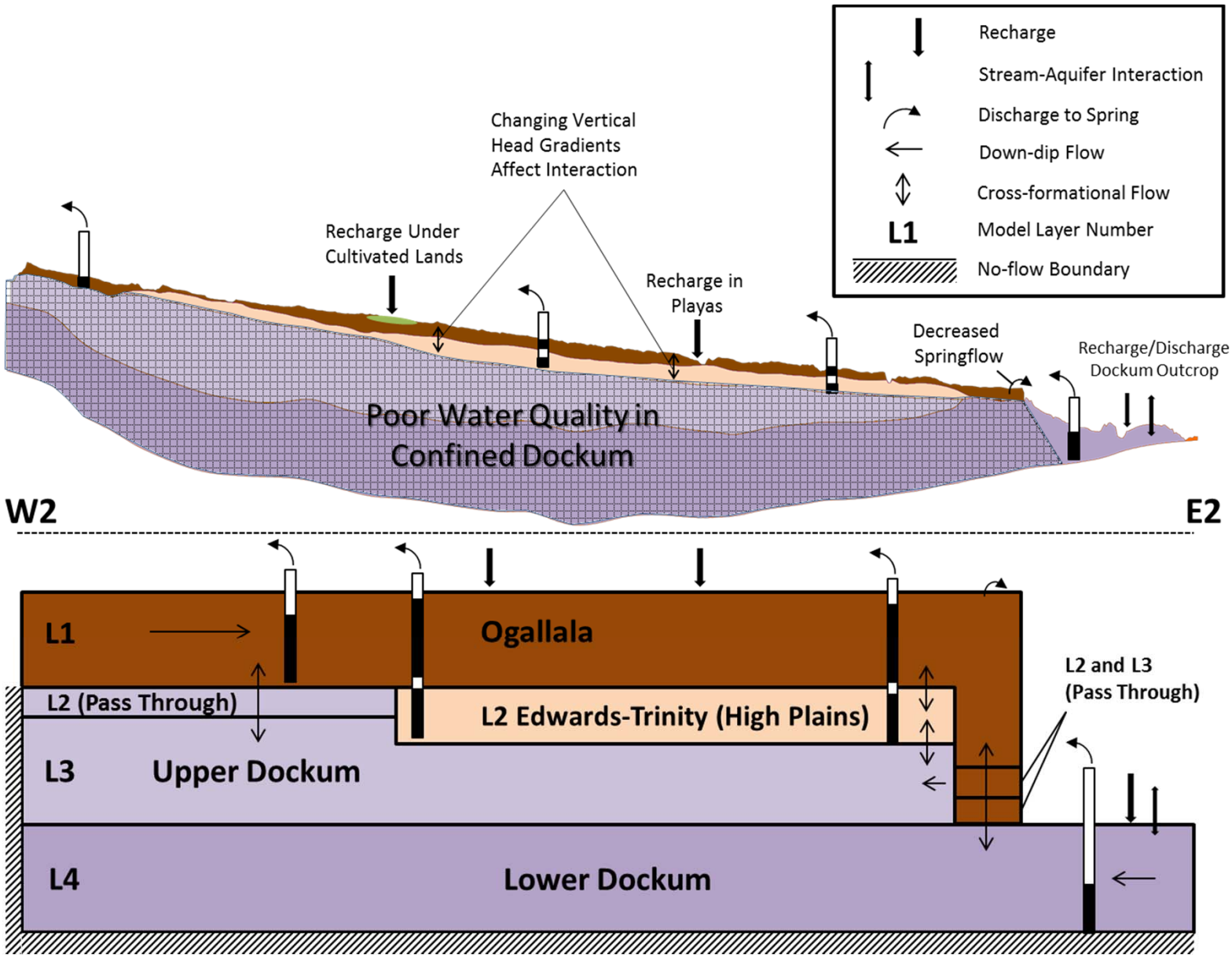
- During Pre-development: recharge balances discharge, no net change in groundwater storage
- During Post-development: Increased discharge from pumping, locally increased recharge from irrigation, overall reduction in natural discharge and GW storage
- Northern and Southern sections have different hydrostratigraphy and recharge patterns.



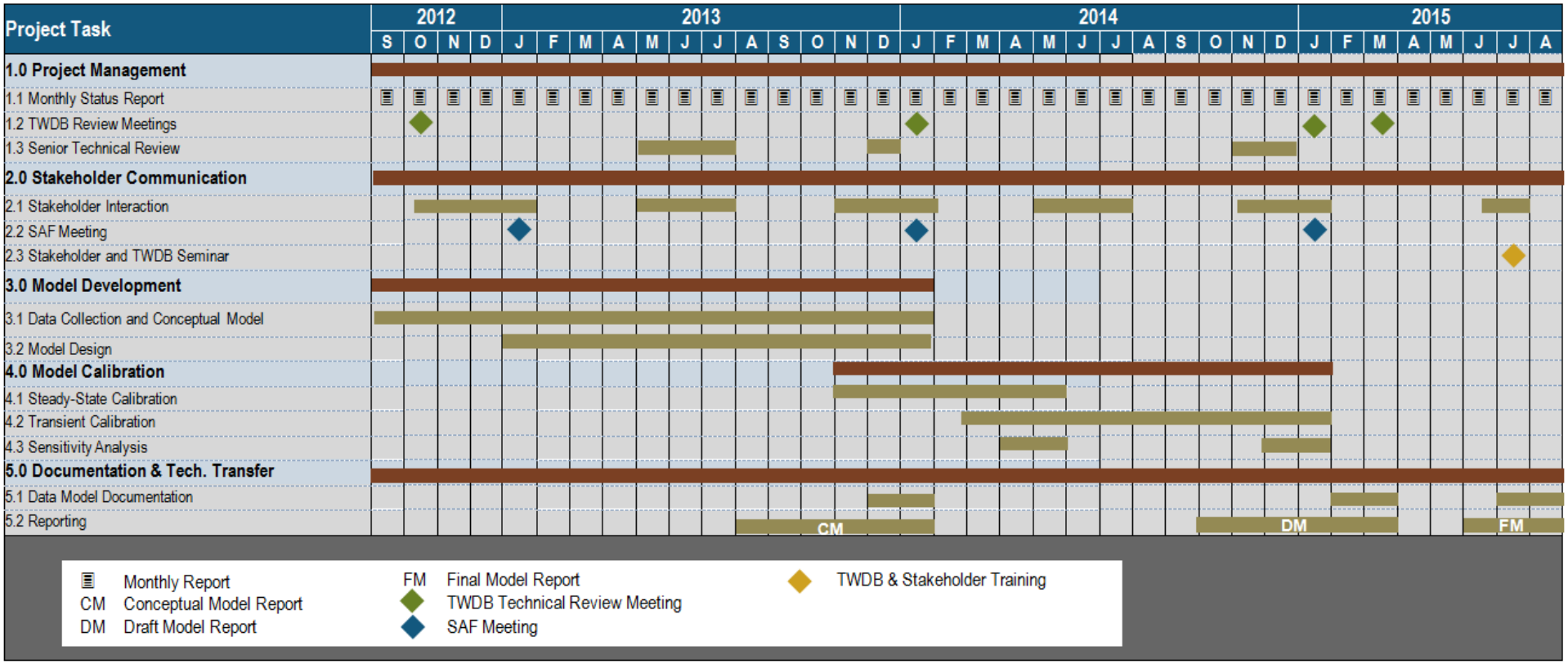
Conceptual Model



Conceptual Model



Schedule


Project Task
2012
2013
2014
2015
S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1.0 Project Management
1.1 Monthly Status Report
1.2 TWDB Review Meetings
1.3 Senior Technical Review
2.0 Stakeholder Communication
2.1 Stakeholder Interaction
2.2 SAF Meeting
2.3 Stakeholder and TWDB Seminar
3.0 Model Development
3.1 Data Collection and Conceptual Model
3.2 Model Design
4.0 Model Calibration
4.1 Steady-State Calibration
4.2 Transient Calibration
4.3 Sensitivity Analysis
5.0 Documentation & Tech. Transfer
5.1 Data Model Documentation
5.2 Reporting
CM
DM
FM
Monthly Report
CM Conceptual Model Report
DM Draft Model Report
FM Final Model Report
TWDB Technical Review Meeting
SAF Meeting
TWDB & Stakeholder Training

High Plains Aquifer System Conceptual Model Viewer

- Link: hpasgam.intera.com
- Web-based, works through browser
- Road and satellite basemaps
- Address finder
- Layer selector
- Aquifer Boundaries
- Surfaces
- Surface query tool
- Water level monitoring wells
  - Marker clustering (“drill down” to individual wells)
  - Time series water level plots
  - Time series saturated thickness (Ogallala only)

The application is in beta, and we need your feedback to make it better.

High Plains Aquifer System Groundwater Availability Model

Stakeholder Meeting #2, Amarillo, May 12, 2014

1. Q: What TDS concentration is used for the Dockum Aquifer boundary
   A: 5,000 mg/L. 3,000 mg/L typically defines other aquifers in Texas
2. Q: What there are restriction to the types of geophysical logs that were used? CRMWA has logs that do not appear to have been considered in this study
   A: INTERA will follow up with CRMWA.
3. Q: In the conceptual model report, "downdip" appears to be used interchangeably with "confined" or "subcrop". Suggest using "downdip" to describe direction following the actual dip.
   A: Nomenclature will be reviewed for consistency in the structure section.
4. Q: Is there recharge along the Canadian River in the Dockum? The Canadian is thought to be source of discharge.
   A: We do conceptualize recharge as occurring in the Dockum outcrop in that area, although some of that recharge likely discharges locally to the Canadian
5. Q: How many geophysical logs were used to define the Rita Blanca?
   A: Looking at the slide, it appears to be 15-20.
6. Q: Did the pump test data from the CRMWA wells affect the estimate of hydraulic conductivity in Roberts County?
   A: It does affect the estimate locally, but the values were not significantly outside the range that had estimated in previous studies.
7. Q: Follow up. It appears that several of the more recent pump tests were not considered in the conceptual model.
   A: INTERA will follow up with CRMWA.
8. Q: Will the data from the CRMWA wellfield be used to estimate specific yield?
   A: Single well pump tests cannot be used to estimate specific yield
9. General discussion of recharge in Lynn County. Pumping in the 1950s drew down water levels, wells ran dry. Some of those wells have since recovered.
10. Please adjust pre-development and post-development legends so that the bins are the same color.
11. Comment on springs: In Dallam County, Buffalo Springs may eminate from the Rita Blanca instead of Ogallala/Dockum.
12. Q: Pumping in Roberts County appears low for 2010. CRMWA has meter data for their wellfield use for the past several years.
    A: INTERA will follow up with CRMWA.
13. Comment: Demand based pumping estimates are often 10-20% higher than metered (or reported) data
14. Q: What is the source of recharge in the Dockum that creates east-southeast gradient in the northwest portion of the model (there is no outcrop evident there).

A: Either lateral flow from outcrop areas in New Mexico, or crossformational flow from overlying units (Rita Blanca or Ogallala).

15. Comment: Instead of “playa recharge” it may be more accurate to say “recharge around playas” since studies have shown that the clay fill in the playas does not allow significant infiltration.
16. Q: When will 2010 water-in-storage numbers be available for the new model?
    A: They could be available early in 2015, when the transient model is completed in draft form.
17. Q: Does the conceptual model viewer show all wells with water level measurements?
    A: No, the wells that are shown are from the TWDB groundwater database, and contain at least five historical measurements.
18. Q: Will the model be able to estimate impacts of water level change on springs?
    A: We can calibrate to springs, only when they consist of a discrete feature and have good historical measurements. Otherwise they are treated more as potential sources for discharge, but are not a focus of calibration. So in most cases, the answer is no.
19. Q: Can this model be used at a local scale for particular well fields? Will the size of the model make it difficult to run?
20. A: The model will be too coarse for simulating day-to-day wellfield operations. That would require either a submodel, or a refined version of the model. We don’t anticipate excessively long run times for the regional model, but the ability to run it will be dependent on the experience of the user.

NAME	AFFILIATION
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Steve Shumate	Panhandle Groundwater Conservation District
Ray Brady	Hemphill County Underground Water Conservation District
C. E. Williams	Panhandle Groundwater Conservation District
Dale Hallmark	North Plains Groundwater Conservation District
Steve Walthour	North Plains Groundwater Conservation District
Bob Harden	R. W. Harden & Associates
Janet Guthrie	Hemphill County Underground Water Conservation District
Ben Weinheimer	Texas Cattle Feeders Association
Cindy Cockerham	Sen. Seliger
Cindy Ridgeway	Texas Water Development Board
John Williams	Canadian River Municipal Water Authority/ Region A