High Plains Aquifer System GAM

Stakeholder Advisory
Meeting #1

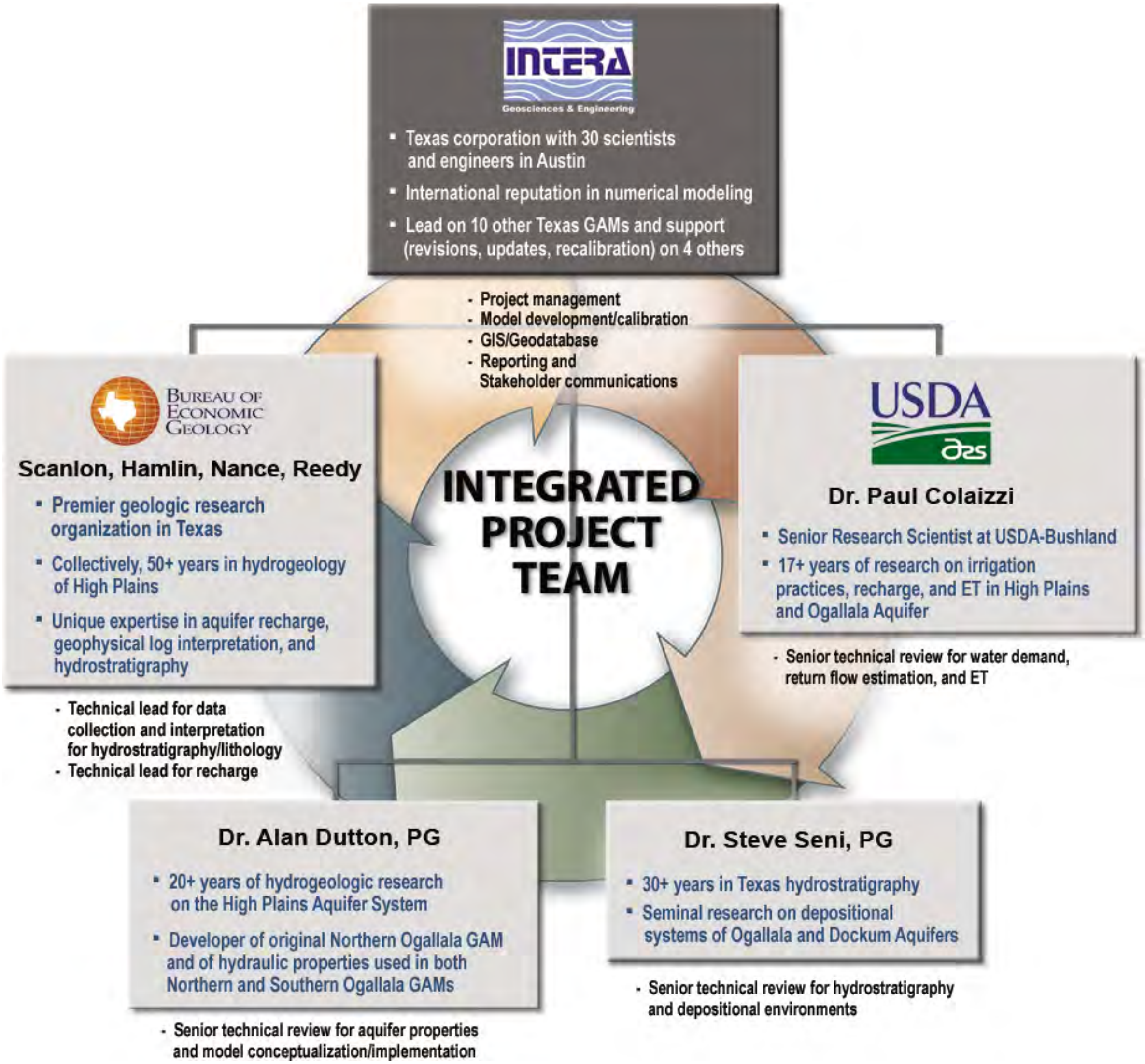
Lamesa, TX

February 11, 2013

Outline

- **Introduction**
  - The High Plains GAM team
  - Study Objectives
  - General Introduction to the GAM program
- Background
  - Basics of groundwater flow
  - Numerical groundwater modeling and the GAMs
- High Plains regional overview
- Key model improvements
- Request for Data
- GAM schedule

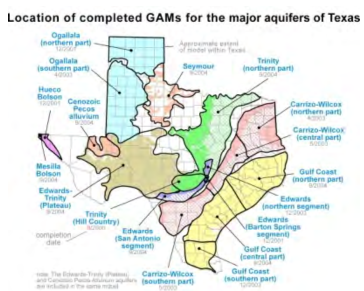
Project Team & Responsibilities

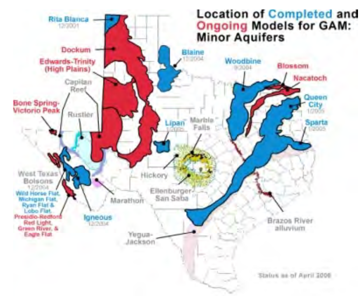


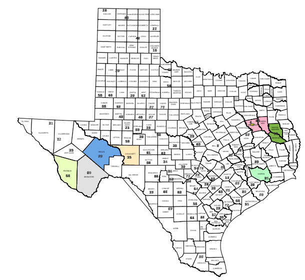
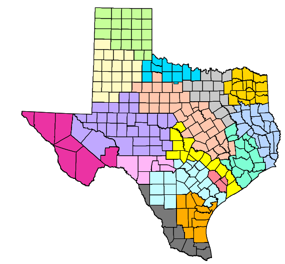
Study Objectives

- Integrate existing HPAS GAMs
  - Northern Ogallala
  - Southern Ogallala
  - Dockum
- Address key issues with the conceptual models used in the previous GAMs
- Produce tool that better captures the interrelationships between the aquifers and incorporates the most-recent data available

Groundwater Availability Modeling





Cindy Ridgeway

Contract Manager

High Plains Aquifer Groundwater Availability Model (GAM)

Texas Water Development Board

GAM Program

- Purpose: to develop tools that can be used to help GCDs, RWPGs, and others understand and manage their groundwater resources.
- Public process: you get to see how the model is put together.
- Freely available: models are standardized, thoroughly documented. Reports available over the internet.
- Living tools: periodically updated.

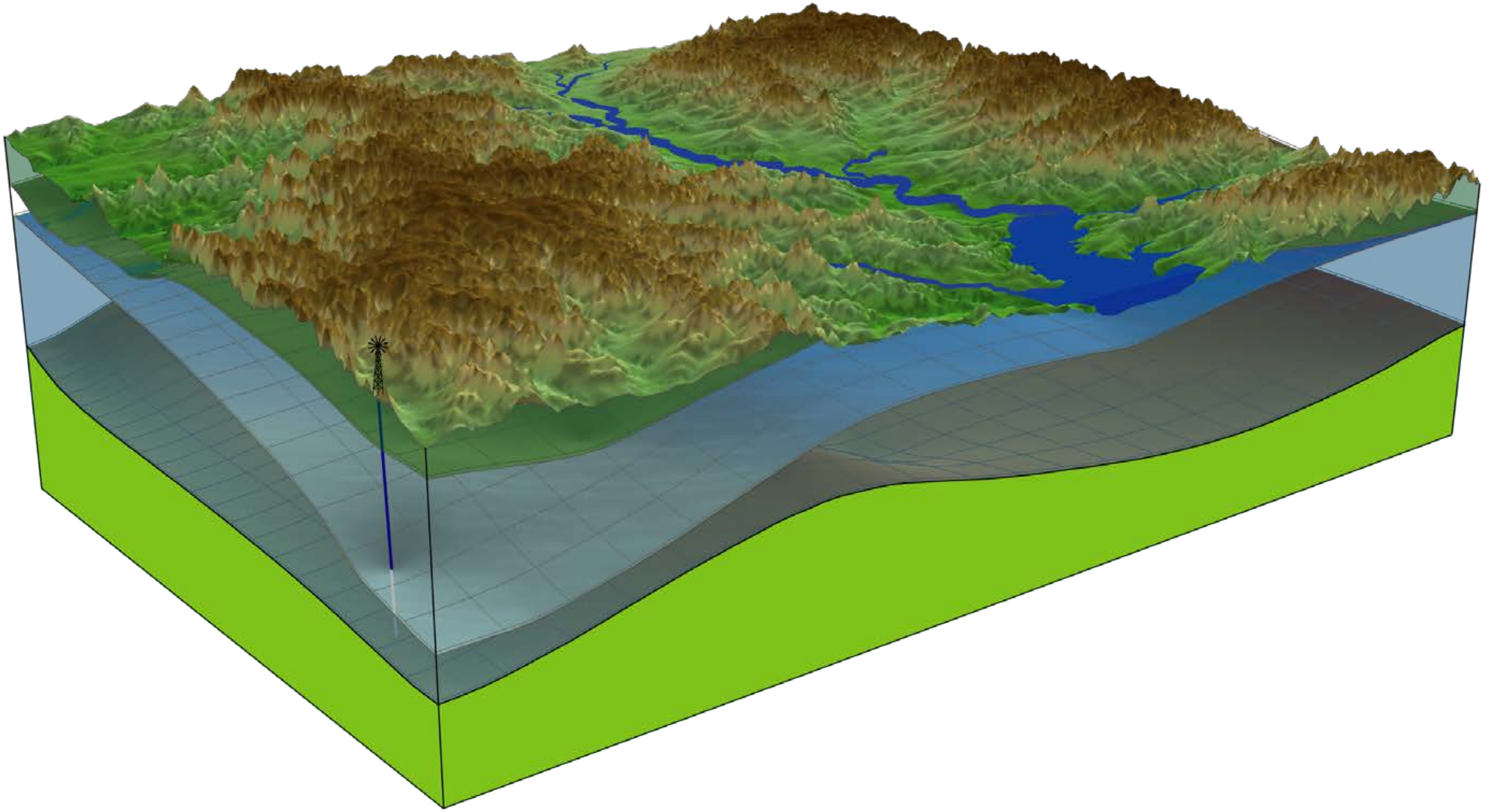
What is Groundwater Availability?

Science + Policy = Groundwater Availability

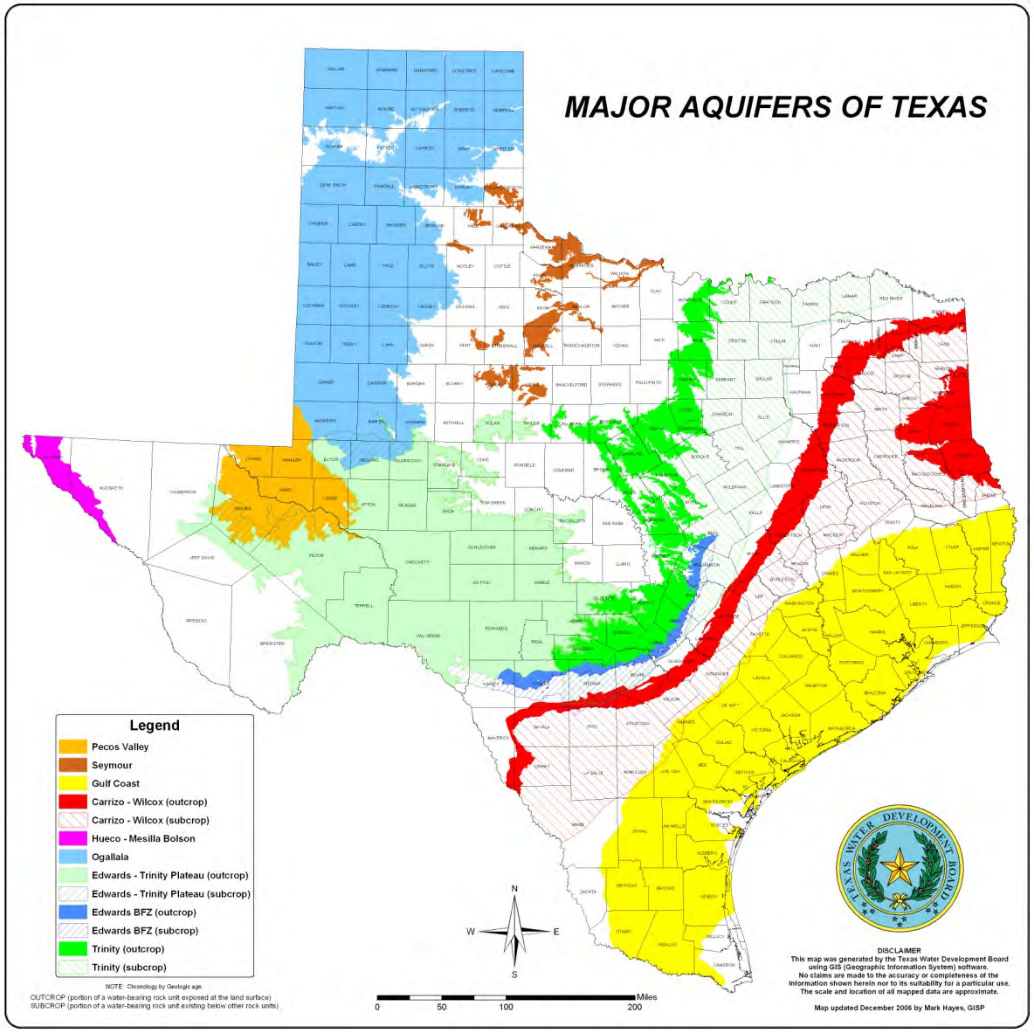
GAM or other tool + Desired Future Conditions = Managed Available Groundwater

Goal: informed decision-making

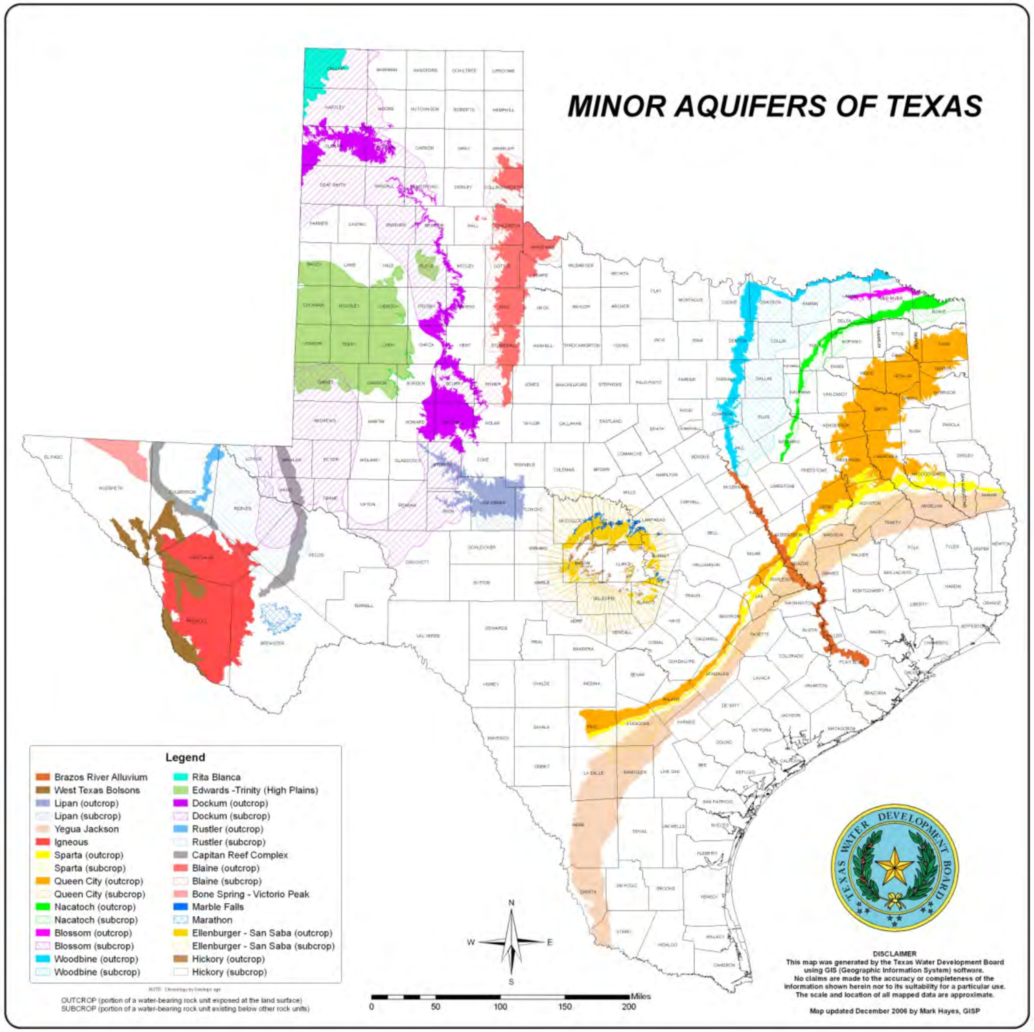
Groundwater Model



Major Aquifers



Minor Aquifers



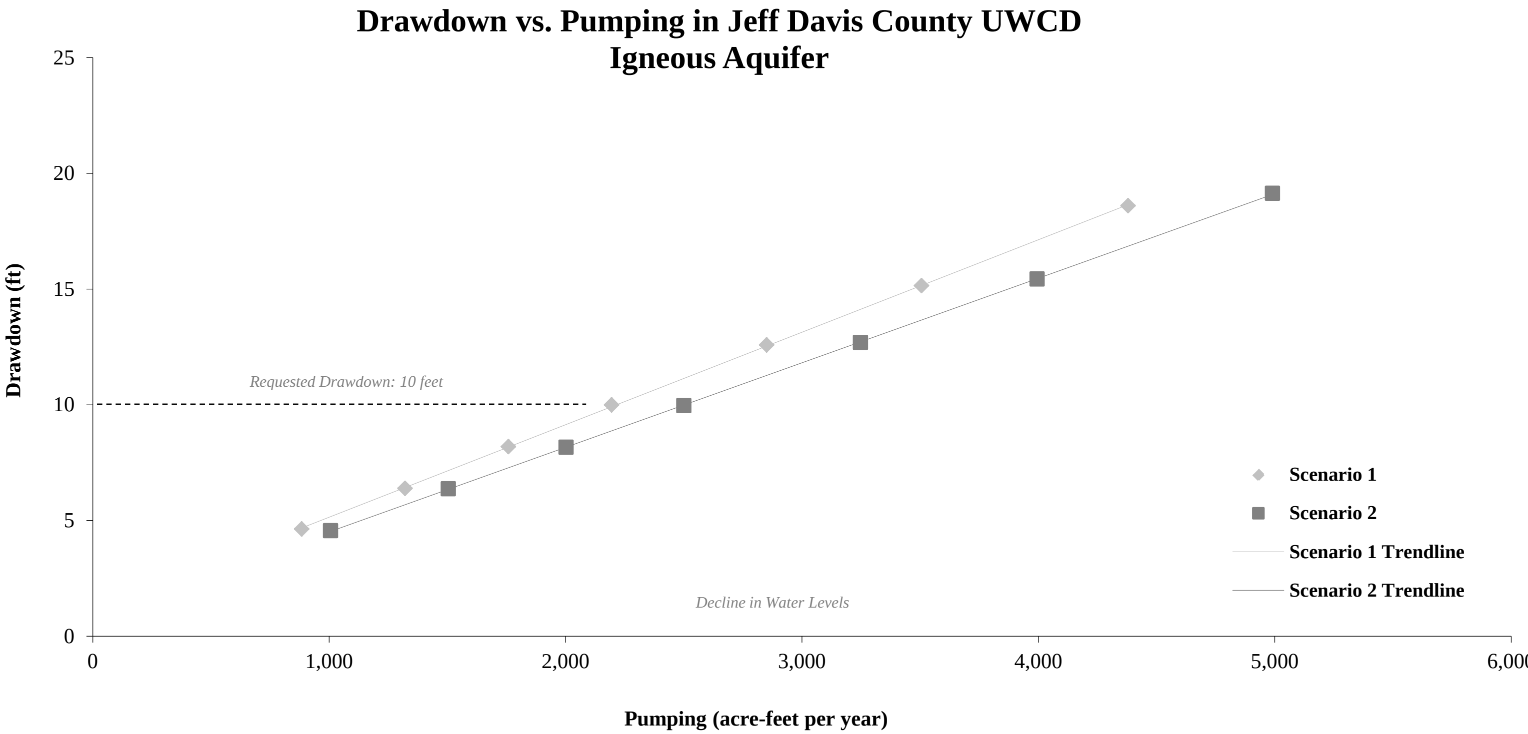
How we use Groundwater Models

- Inform groundwater districts about historical conditions in the aquifer

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

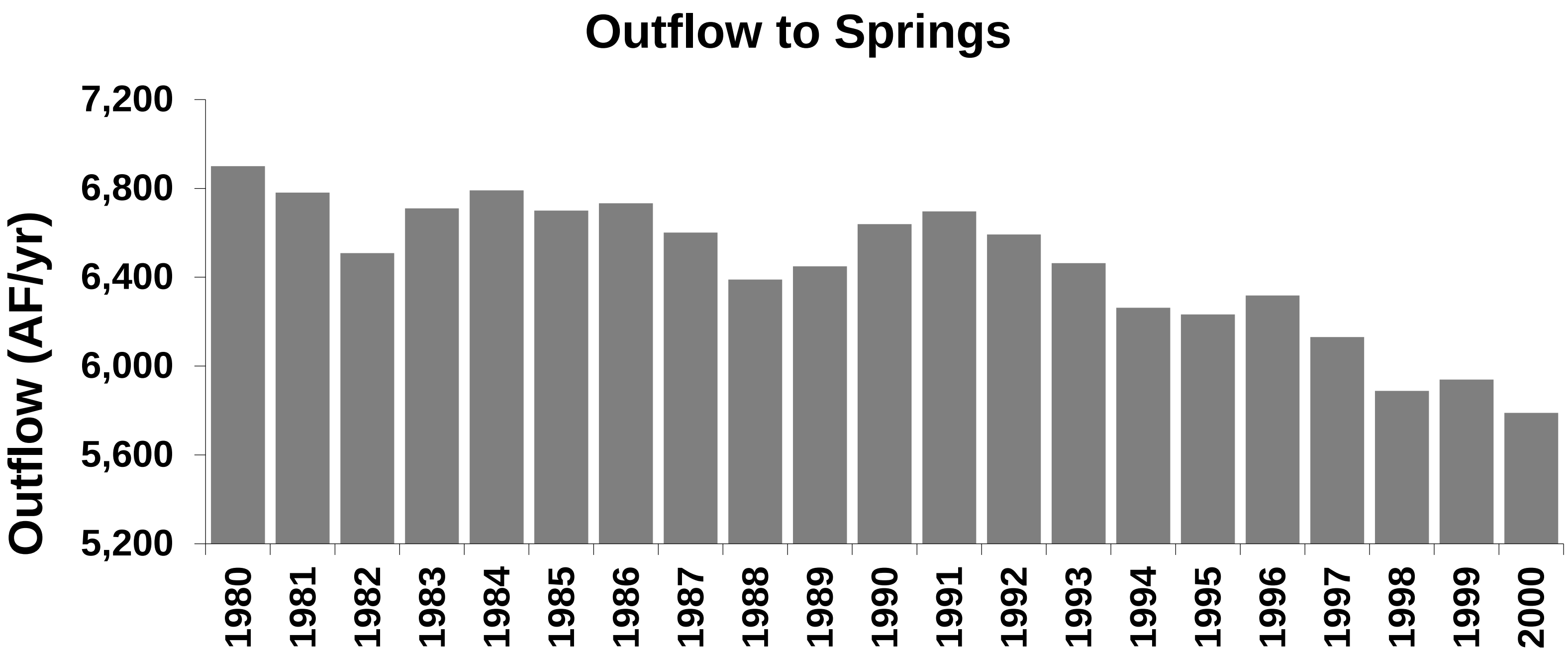
How we use Groundwater Models

- Assist districts and management areas in determining desired future conditions



How we use Groundwater Models

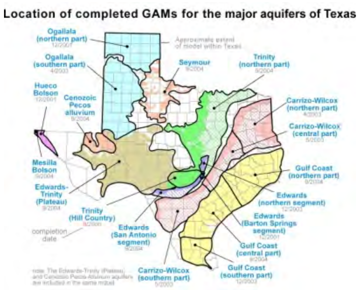
- Assist districts and management areas in determining desired future conditions

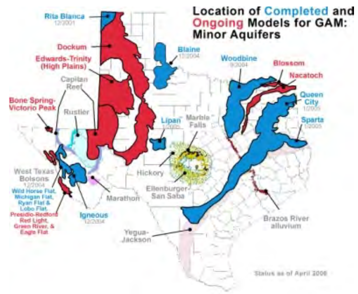


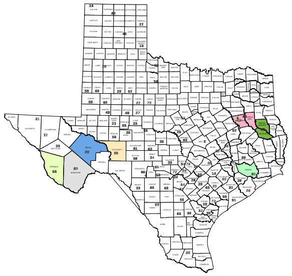
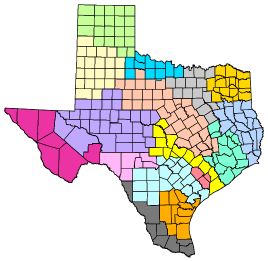
Stakeholder Advisory Forums

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

Contact Information





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Austin, Texas 78711-3231

Web information:

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

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

Outline

- Introduction
  - The High Plains GAM team
  - Study Objectives
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- High Plains regional overview
- Key model improvements
- Request for Data
- GAM schedule

Early Credits

- Thanks and credit to Robert Mace at TWDB for many of the slides in this section

What is an aquifer?

- an aquifer is geologic media that can yield economically usable amounts of water.

DIRT

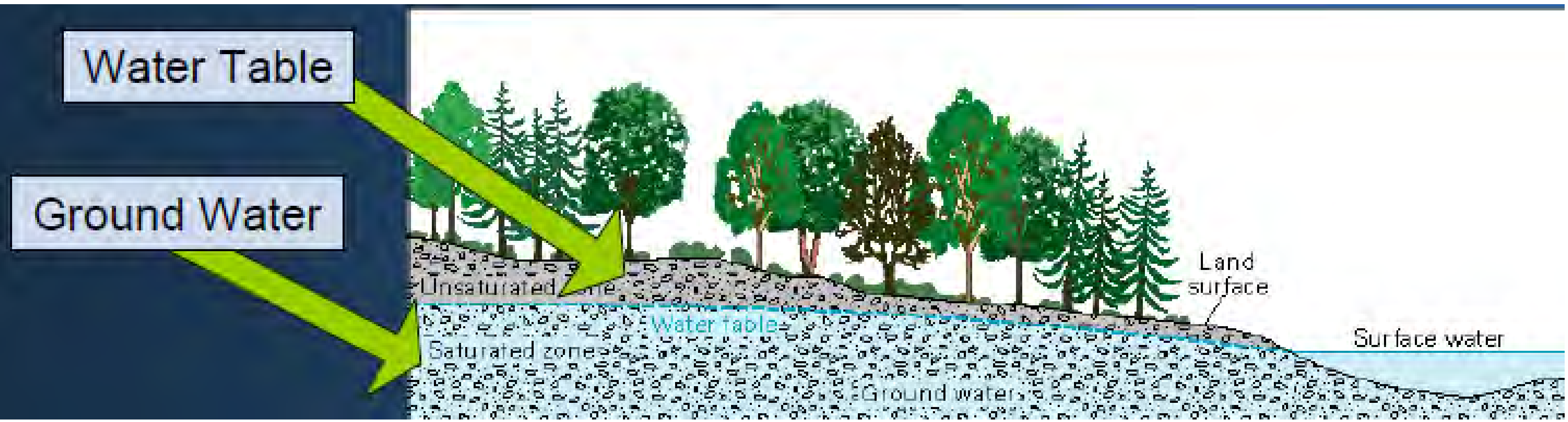
ROCK

What is an aquitard?

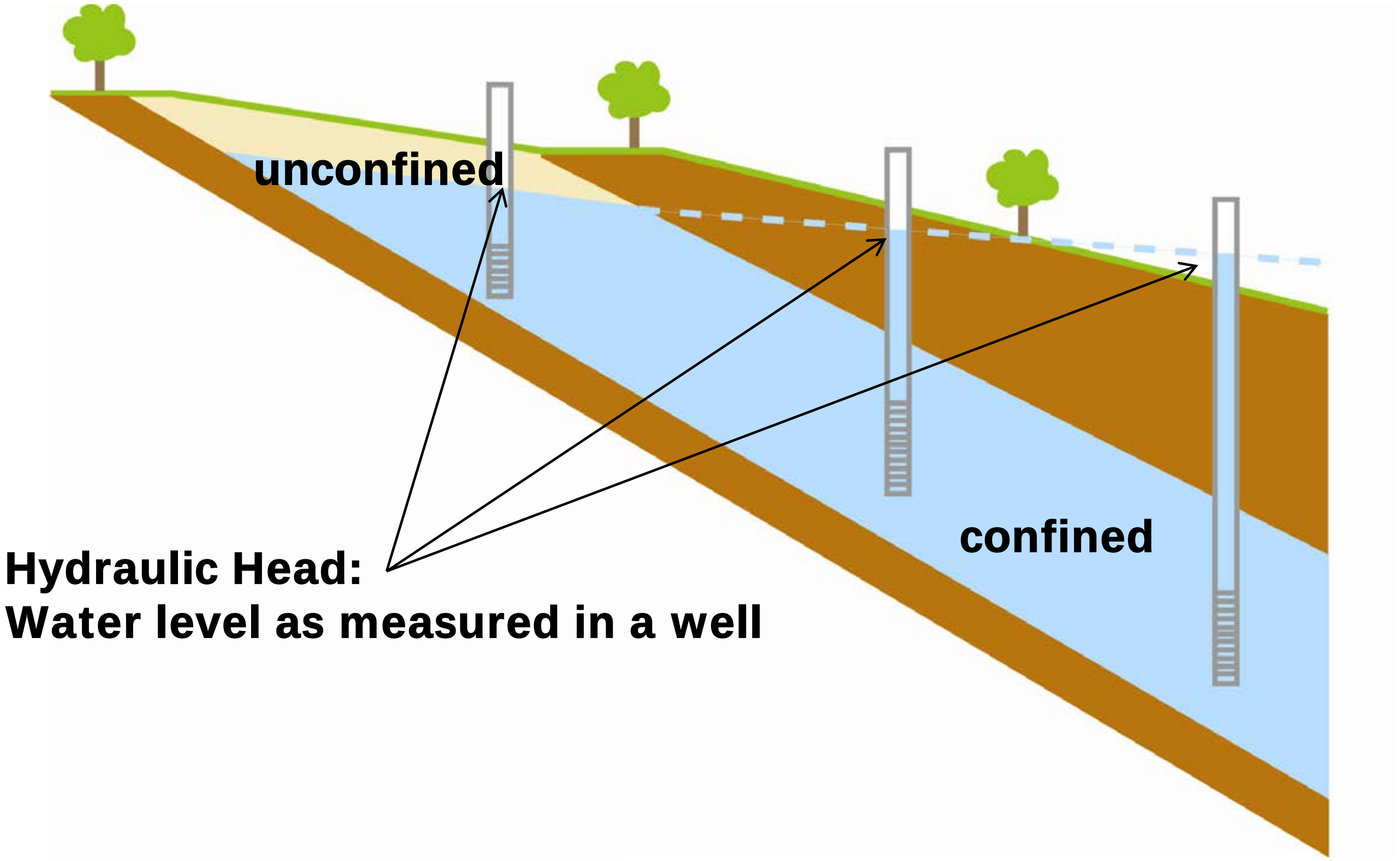
- an aquitard is geologic media that can not yield economically usable amounts of water.
- clay, shale, unfractured dense rocks
- Note: can still transmit water, but s l o w l y

What is a water table?

- A water table is where the saturated zone meets the vadose (unsaturated) zone.
- A water table occurs where the groundwater is under atmospheric pressure

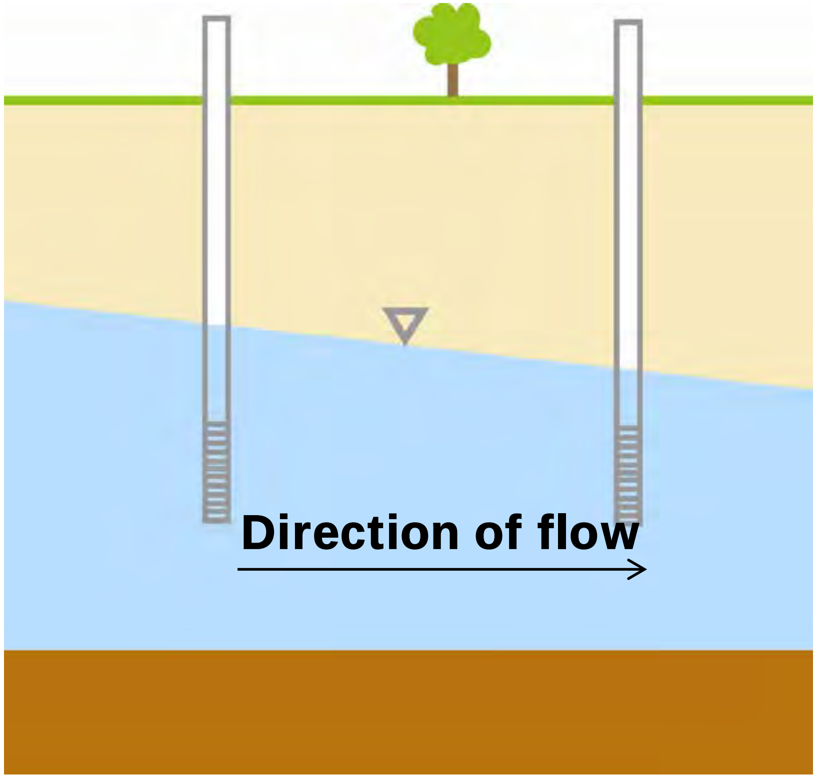


Same aquifer: unconfined and confined



Groundwater Flow

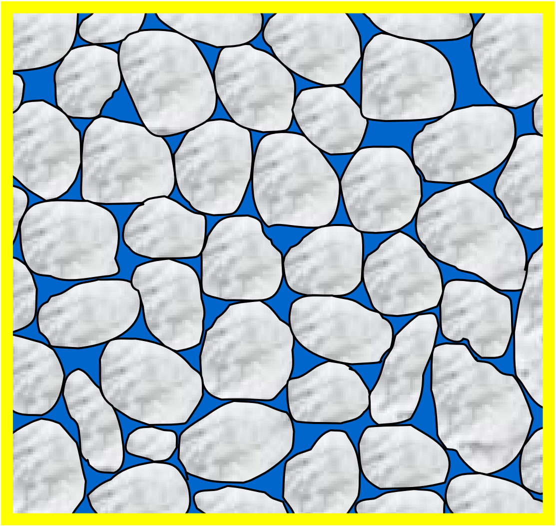
- Groundwater flows from higher potential energy (head) to lower potential energy



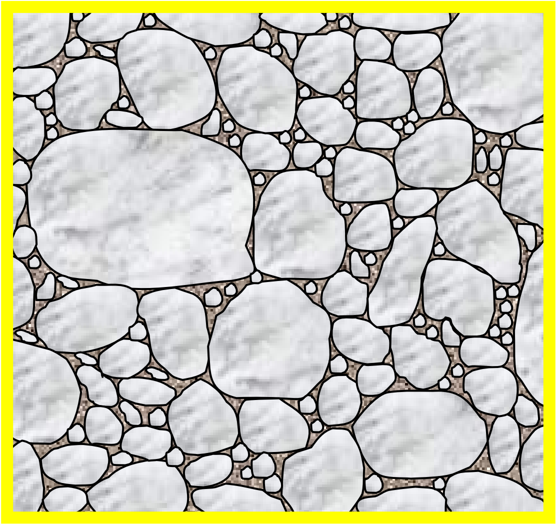
Aquifer Properties

- Hydraulic conductivity – A physical property of the geologic media representing its ability to transmit water (related to permeability and transmissivity)

Aquifer Properties



WELL SORTED
Coarse (sand-gravel)



POORLY SORTED
Coarse - Fine

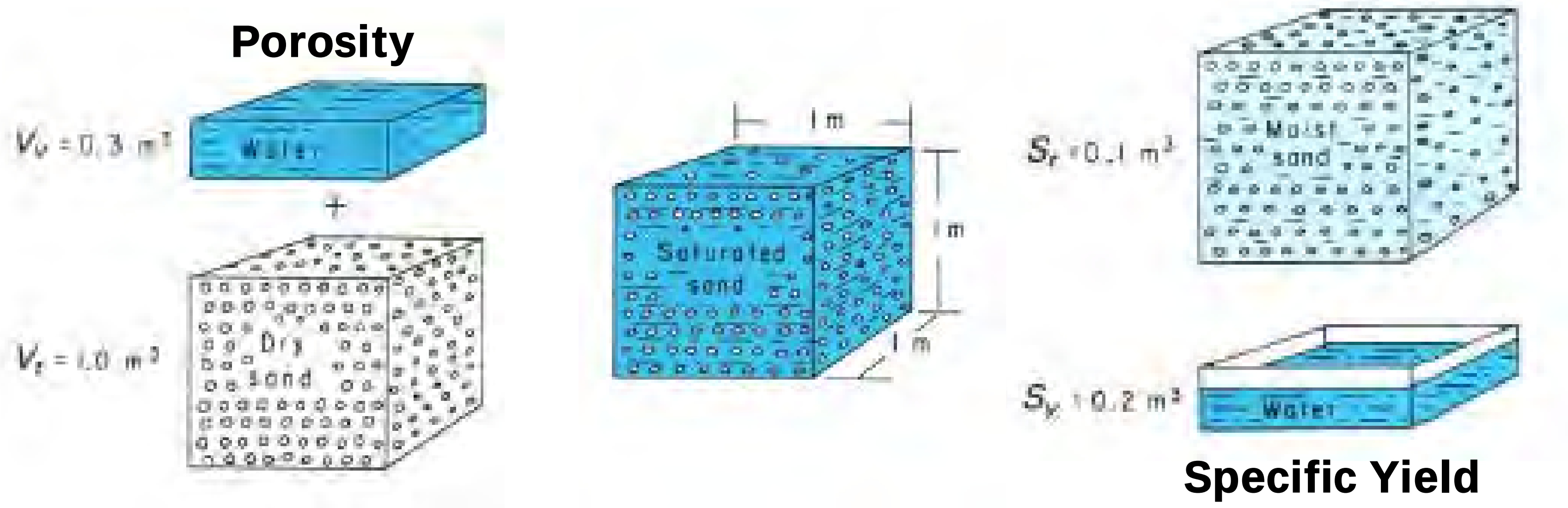
WELL SORTED
Fine (silt-clay)

Permeability and Hydraulic Conductivity

High ⟷ **Low**

Aquifer Properties

- Specific yield – The volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in water table elevation.



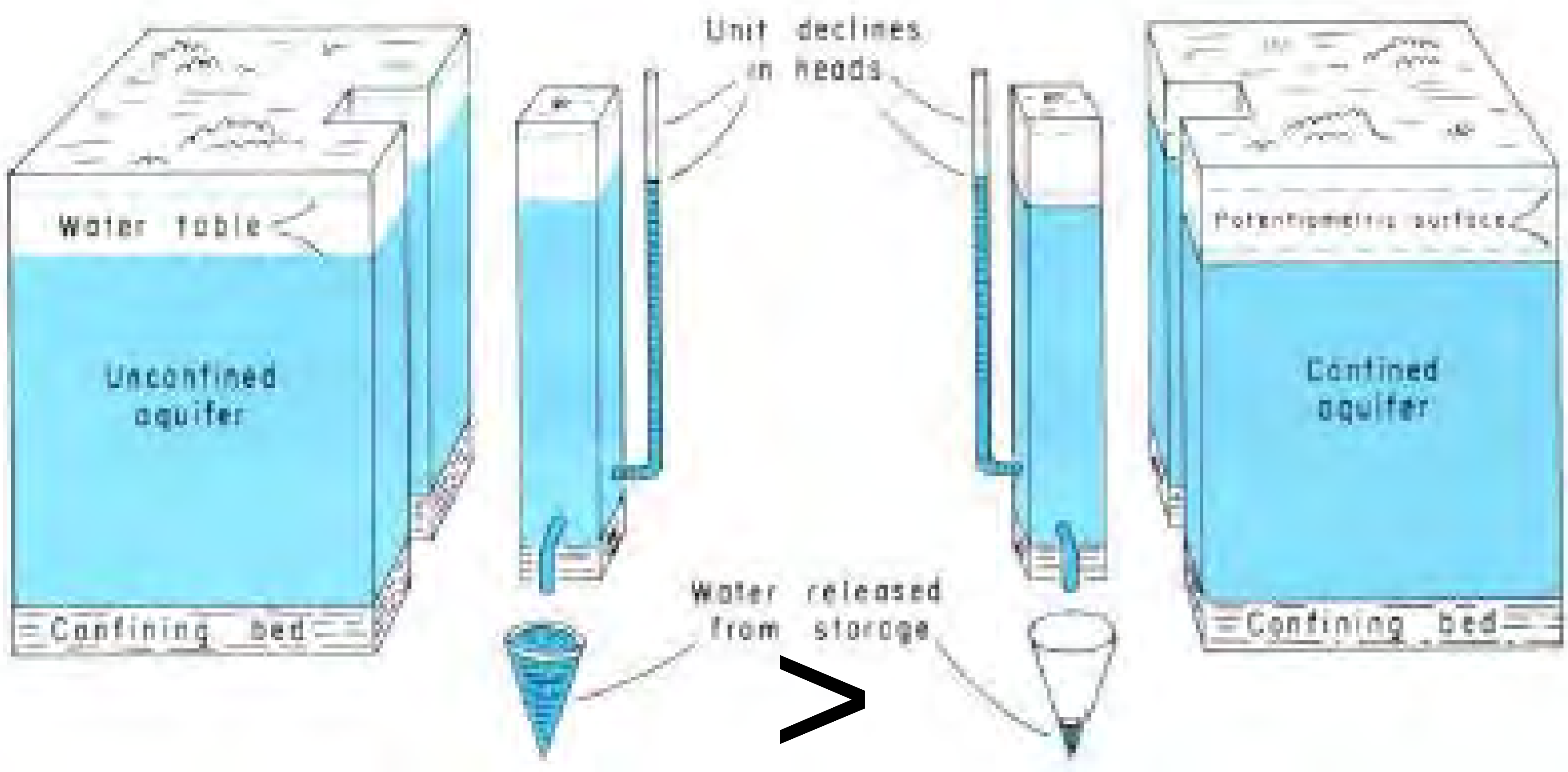
Specific Yield

From Heath (1983)

Aquifer Properties

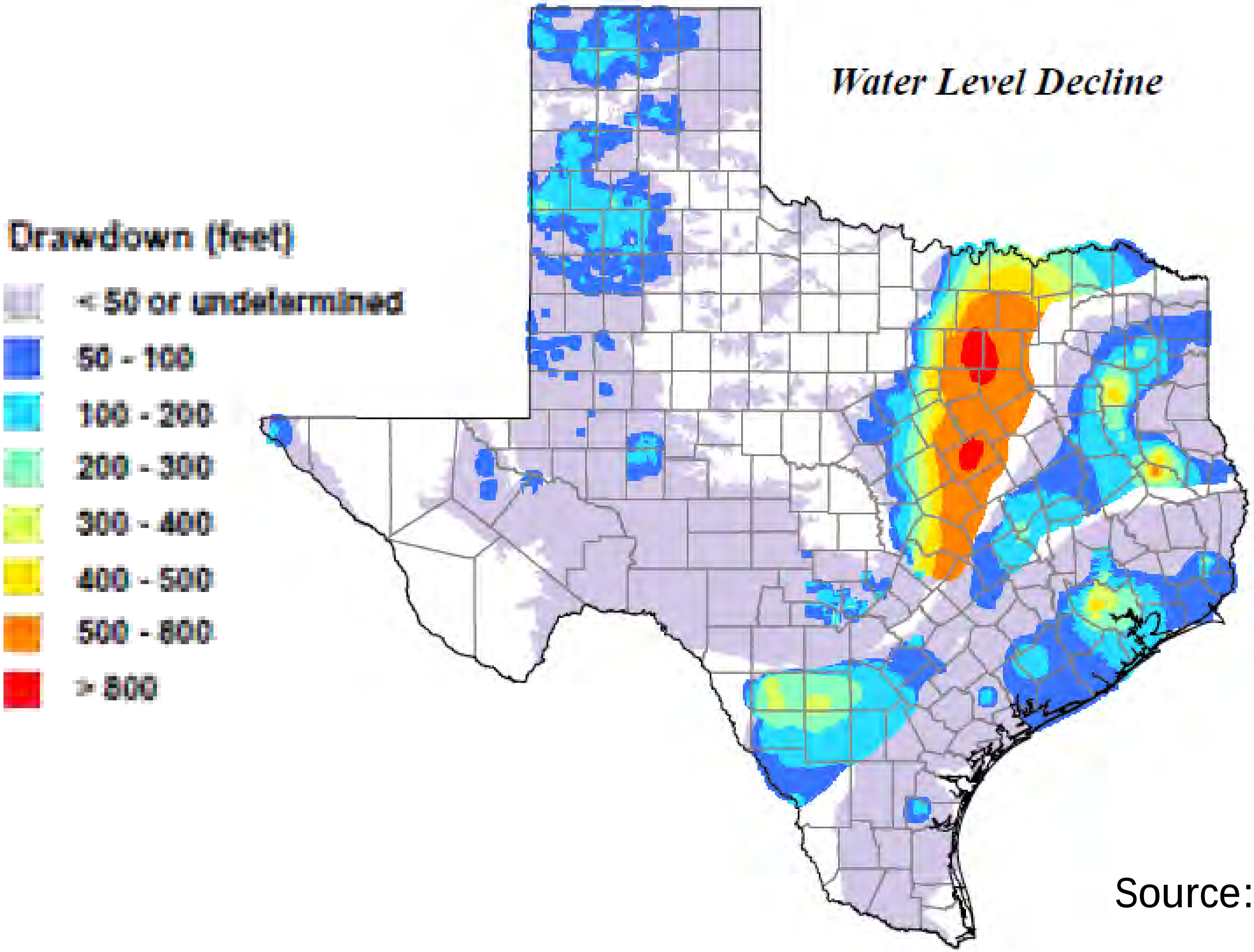
- Storativity – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head.
  - Much smaller than specific yield

Specific Yield vs. Storativity



From Heath (1983)

Specific Yield vs. Storativity



Source: TWDB

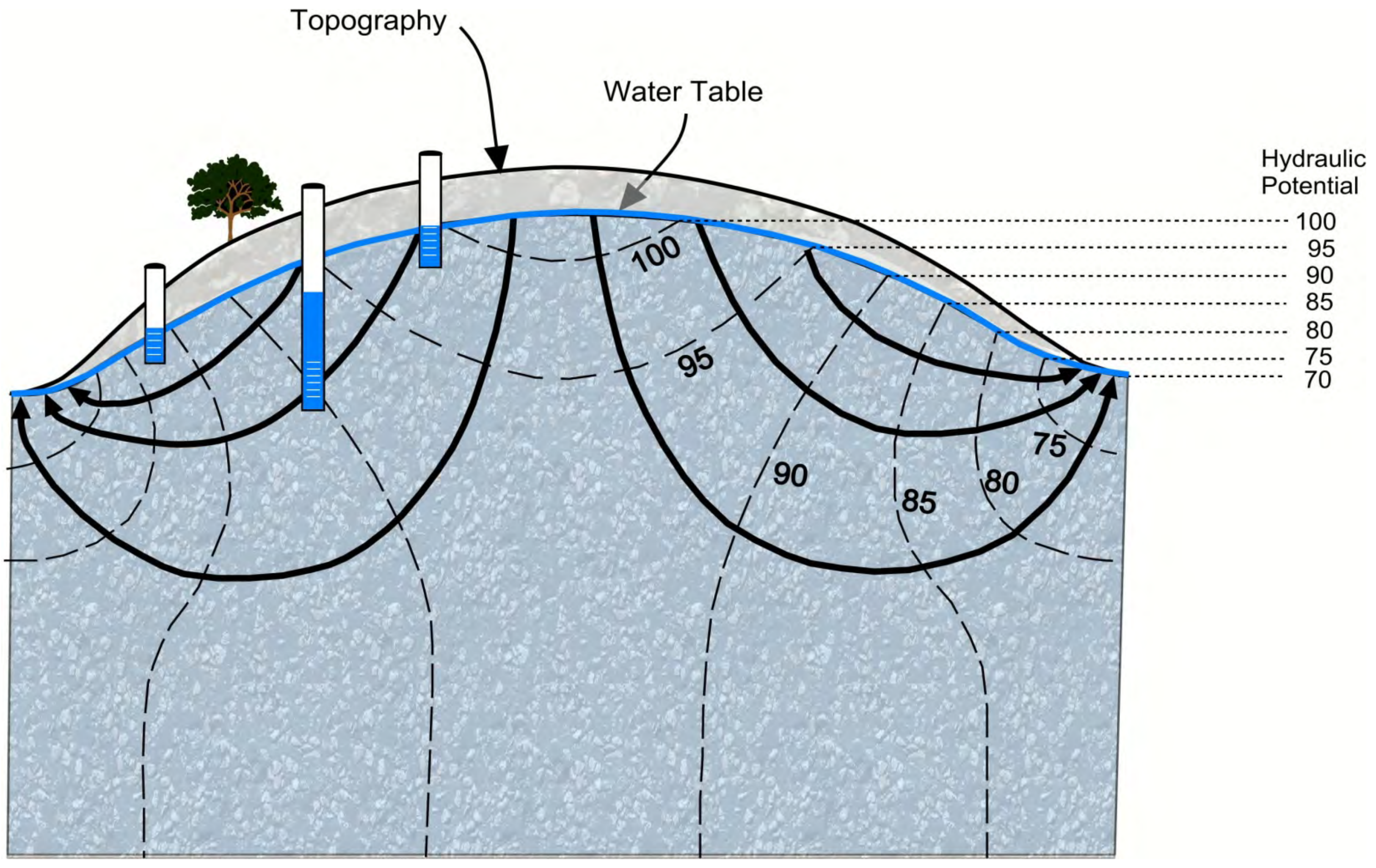
Groundwater Definitions (cont.)

- Recharge – The entry of water to the saturated zone at the water table:

  Recharge = (precipitation + stream loss) minus (runoff + evapotranspiration).

- Cross-formational flow – Groundwater flow between separate geologic formations.
- Stream losses or gains – The water that is either lost or gained through the base of the stream or river.

Schematic Cross Section of Groundwater Flow



Definition of a Model

Domenico (1972) defined a model as a representation of reality that attempts to explain the behavior of some aspect of reality and is always **less complex** than the real system it represents

Wang & Anderson (1982) defined a model as a tool designed to represent a **simplified** version of reality

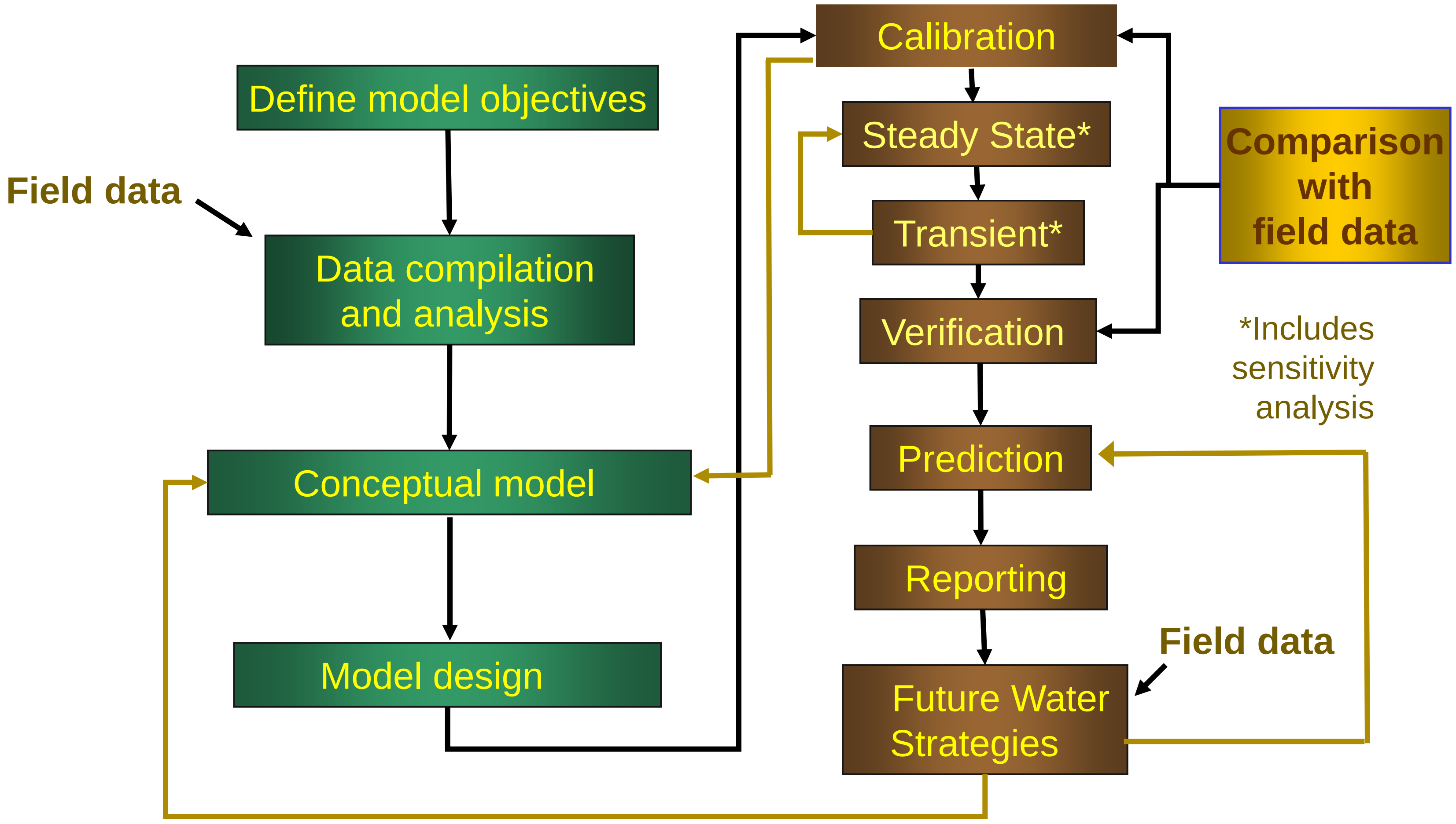
Why Groundwater Flow Models?

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

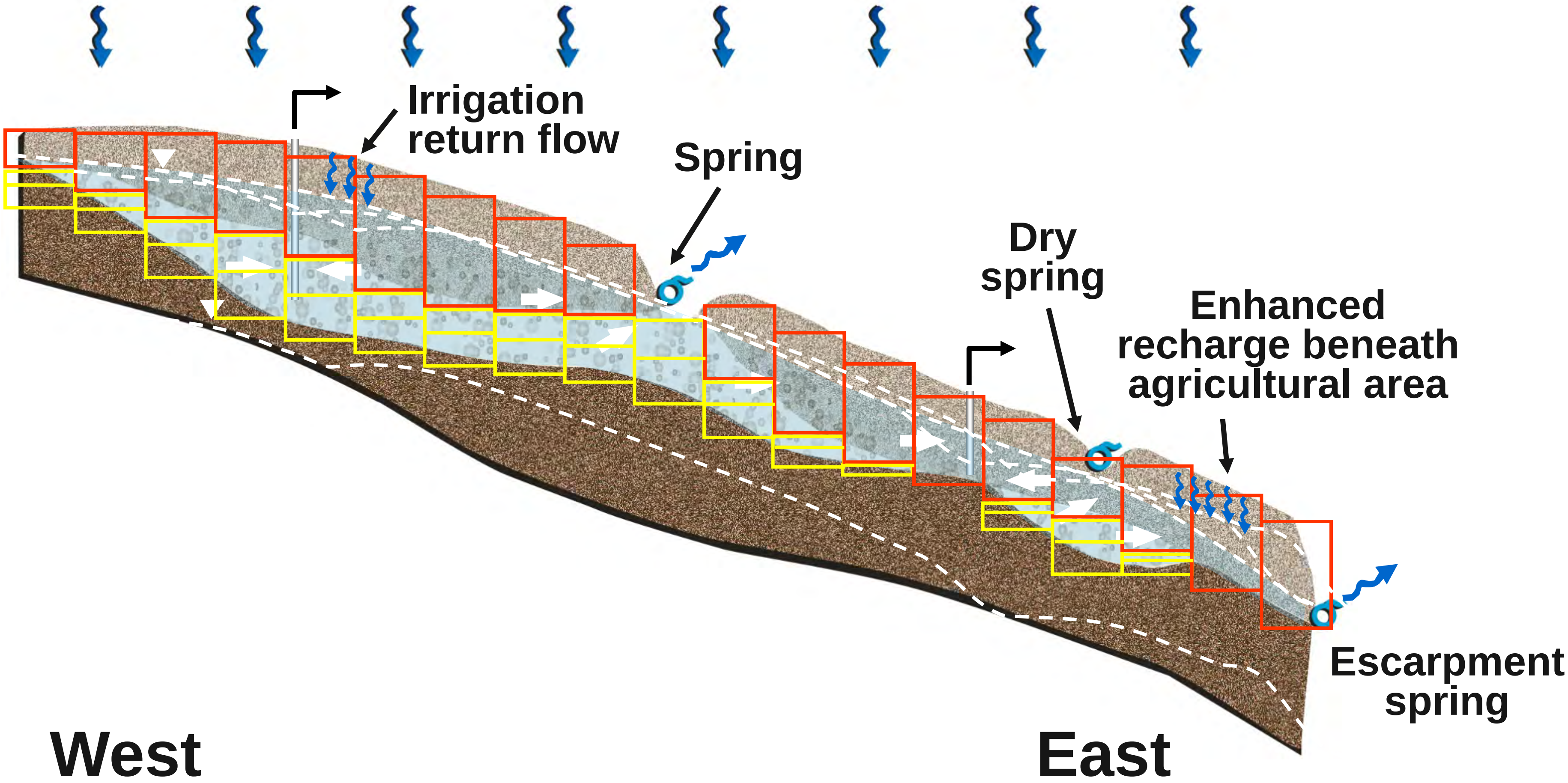
Numerical Flow Model

- A numerical groundwater flow model is the mathematical representation of an aquifer
- It uses basic laws of physics that govern groundwater flow
- In the model domain, the numerical model calculates the hydraulic head at discrete locations (determined by the grid)
- The calculated model heads can be compared to hydraulic heads measured in wells

Modeling Protocol



Start with a conceptual model
Divide it up into cells



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- **High Plains regional overview**
- Key model improvements
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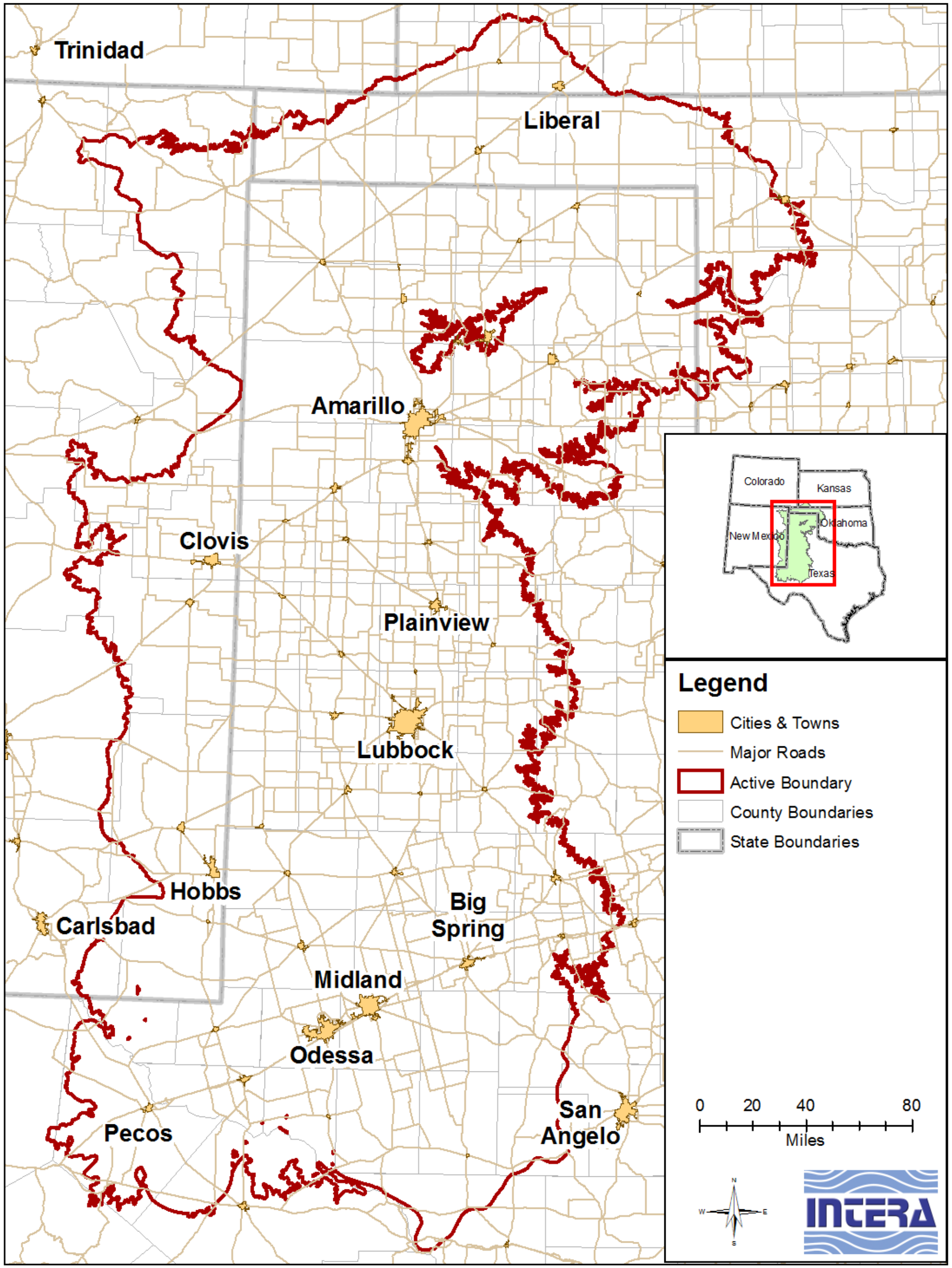
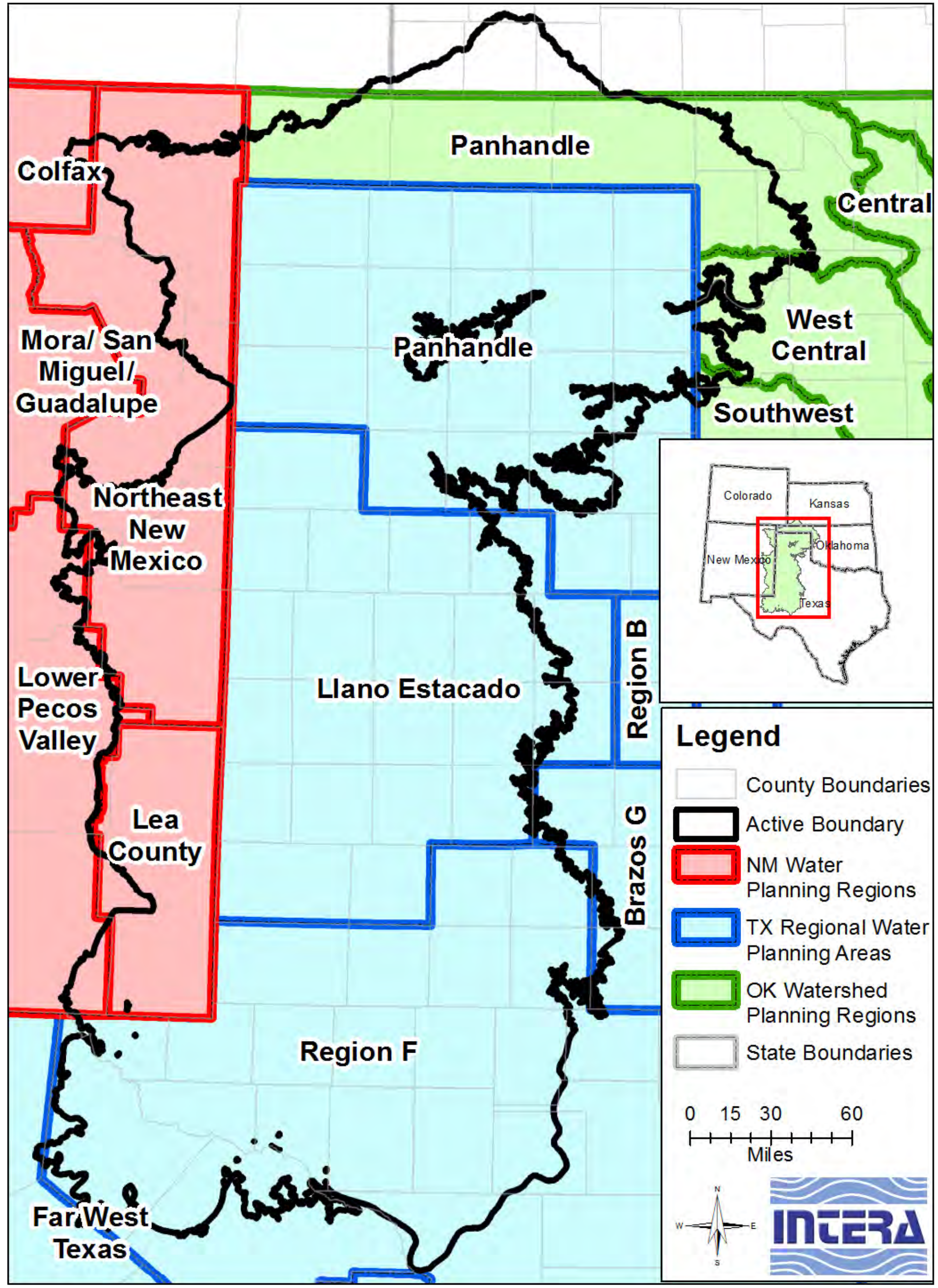
Study Area

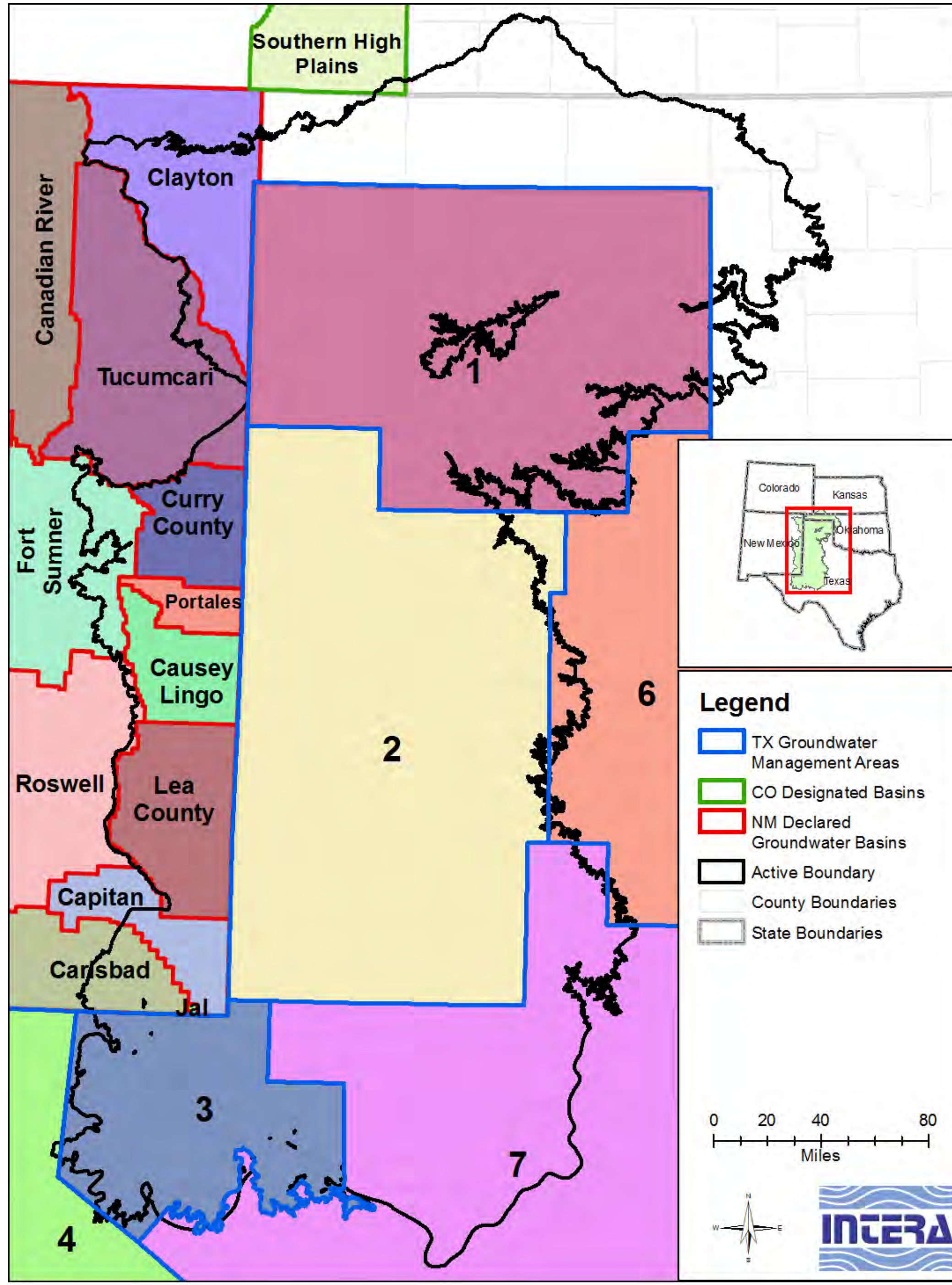


Trinidad
Liberal
Amarillo
Clovis
Plainview
Lubbock
Hobbs
Carlsbad
Big Spring
Midland
Odessa
Pecos
San Angelo
Colorado
Kansas
Oklahoma
New Mexico
Texas
Legend
Cities & Towns
Major Roads
Active Boundary
County Boundaries
State Boundaries
0
20
40
80
Miles
INTERA

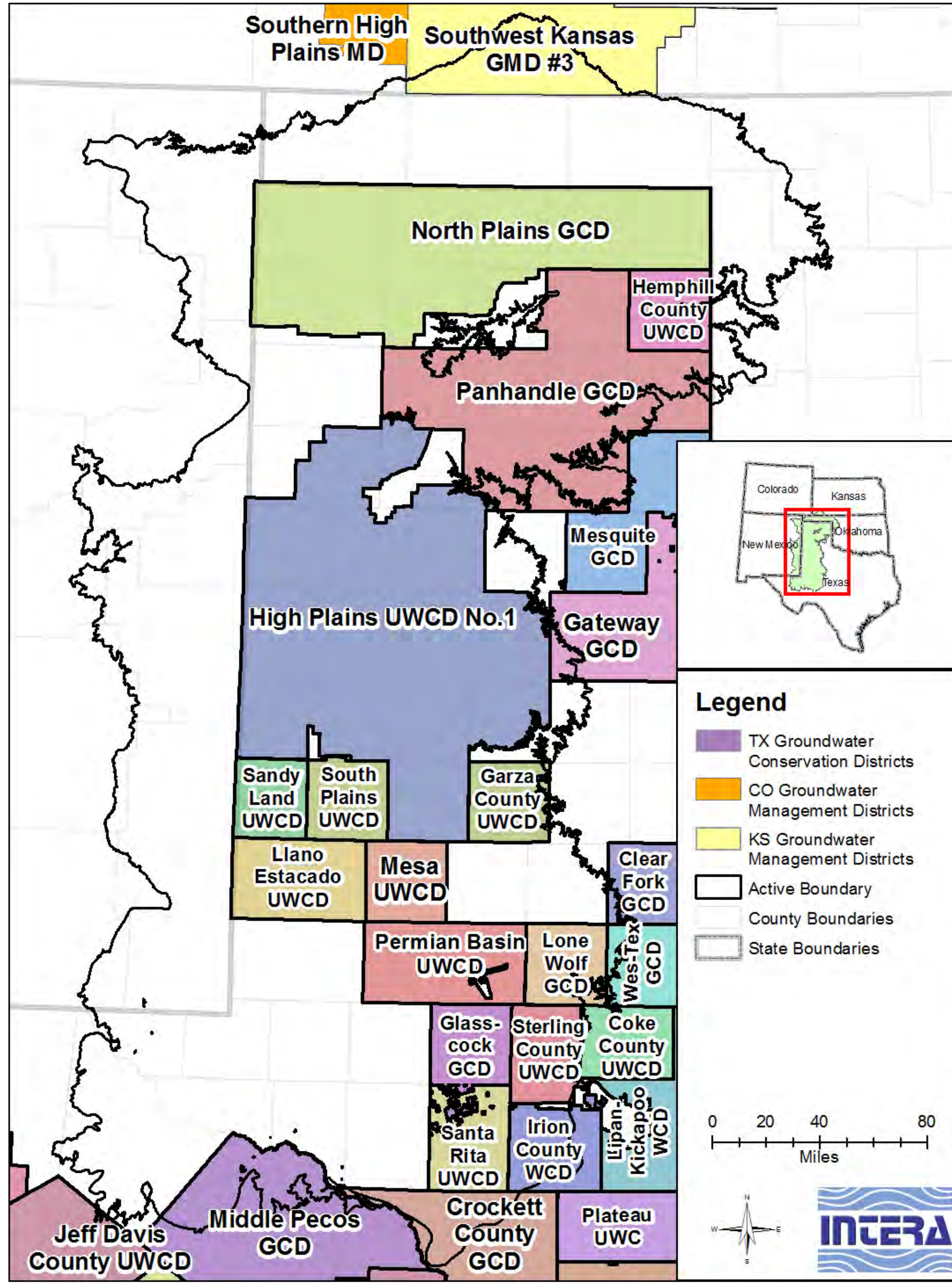
Regional Planning Groups



Groundwater Management Areas

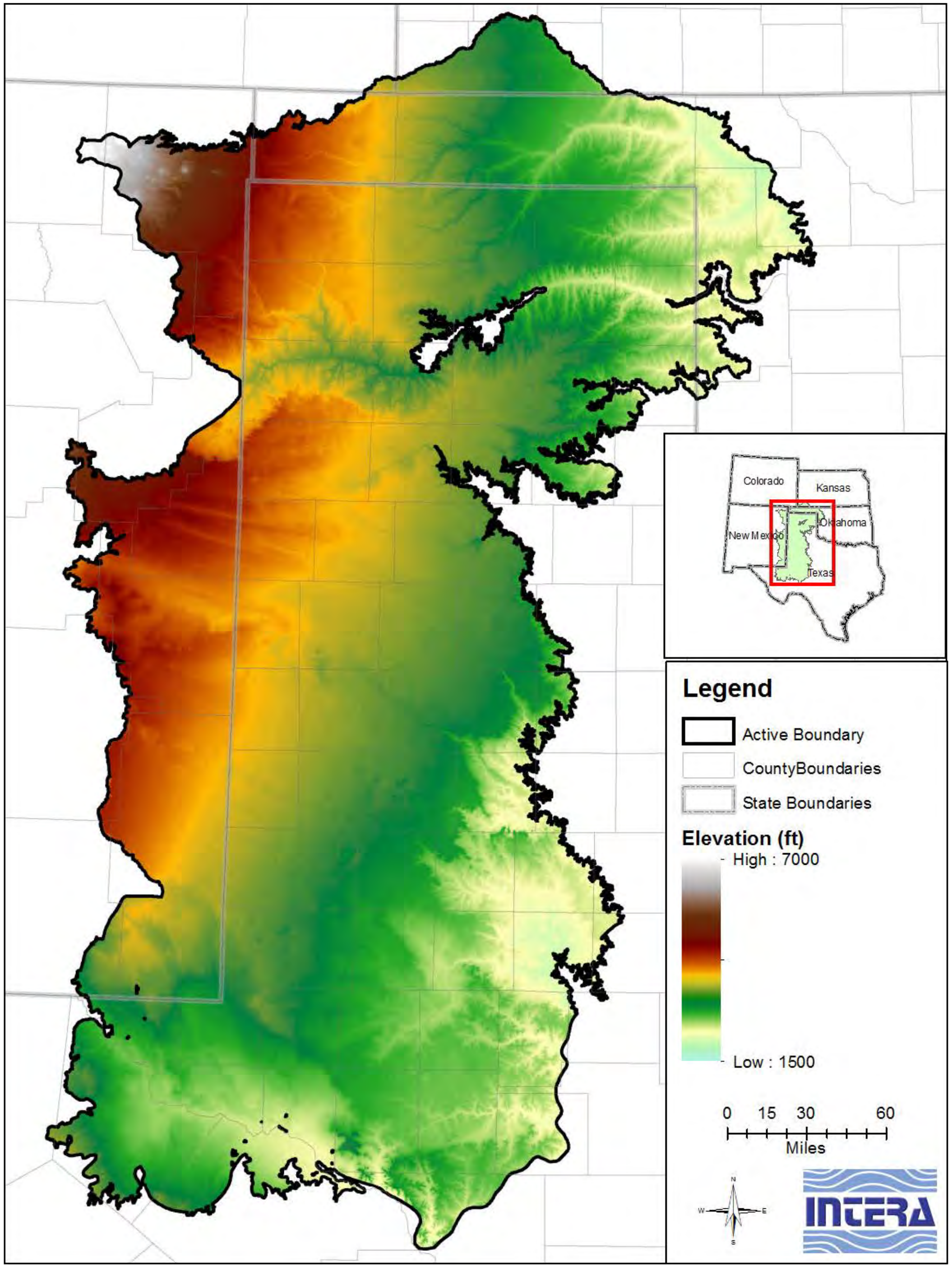


Groundwater Conservation Districts



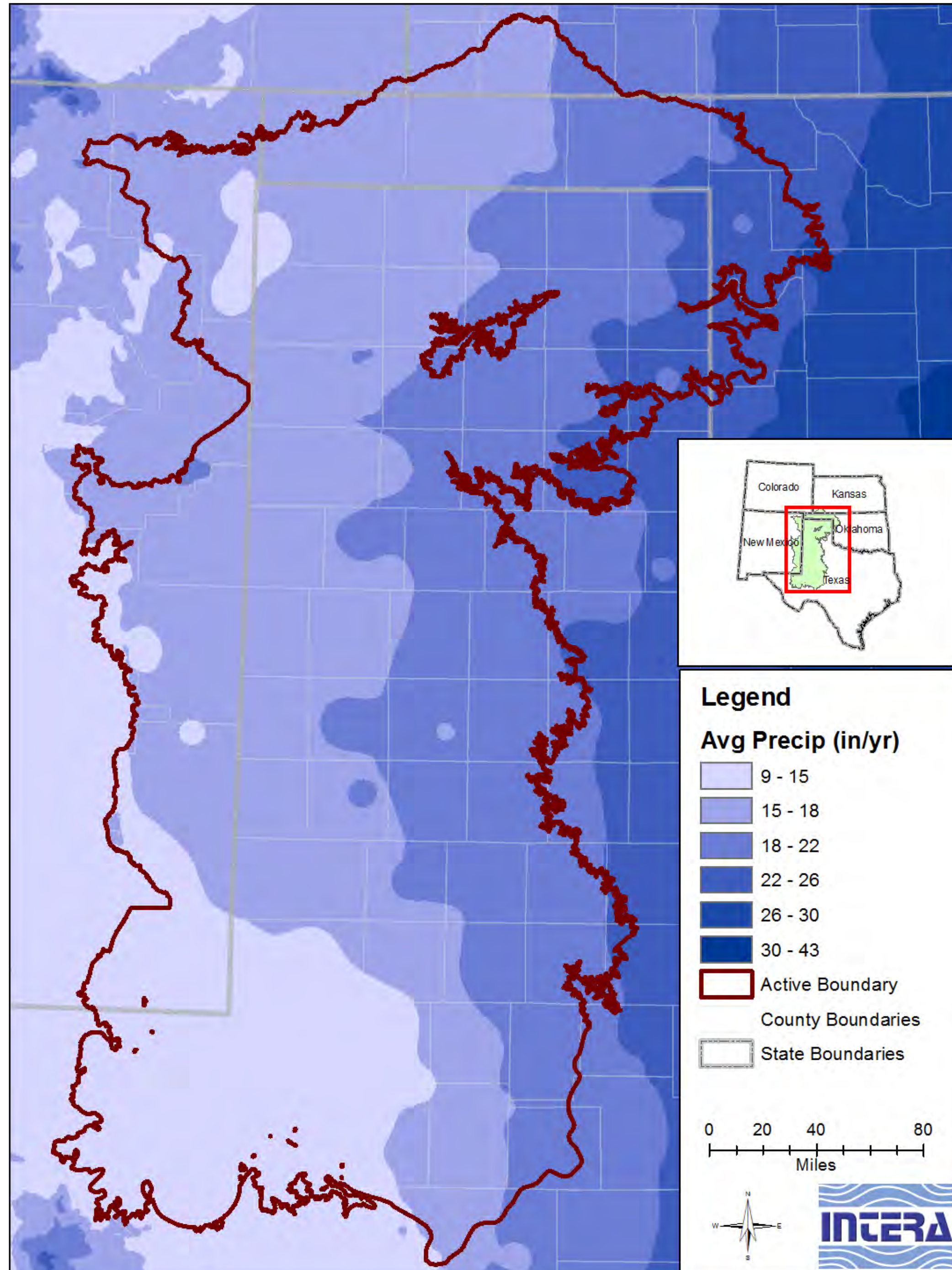
Topography (Feet above mean sea level)

Source: USGS



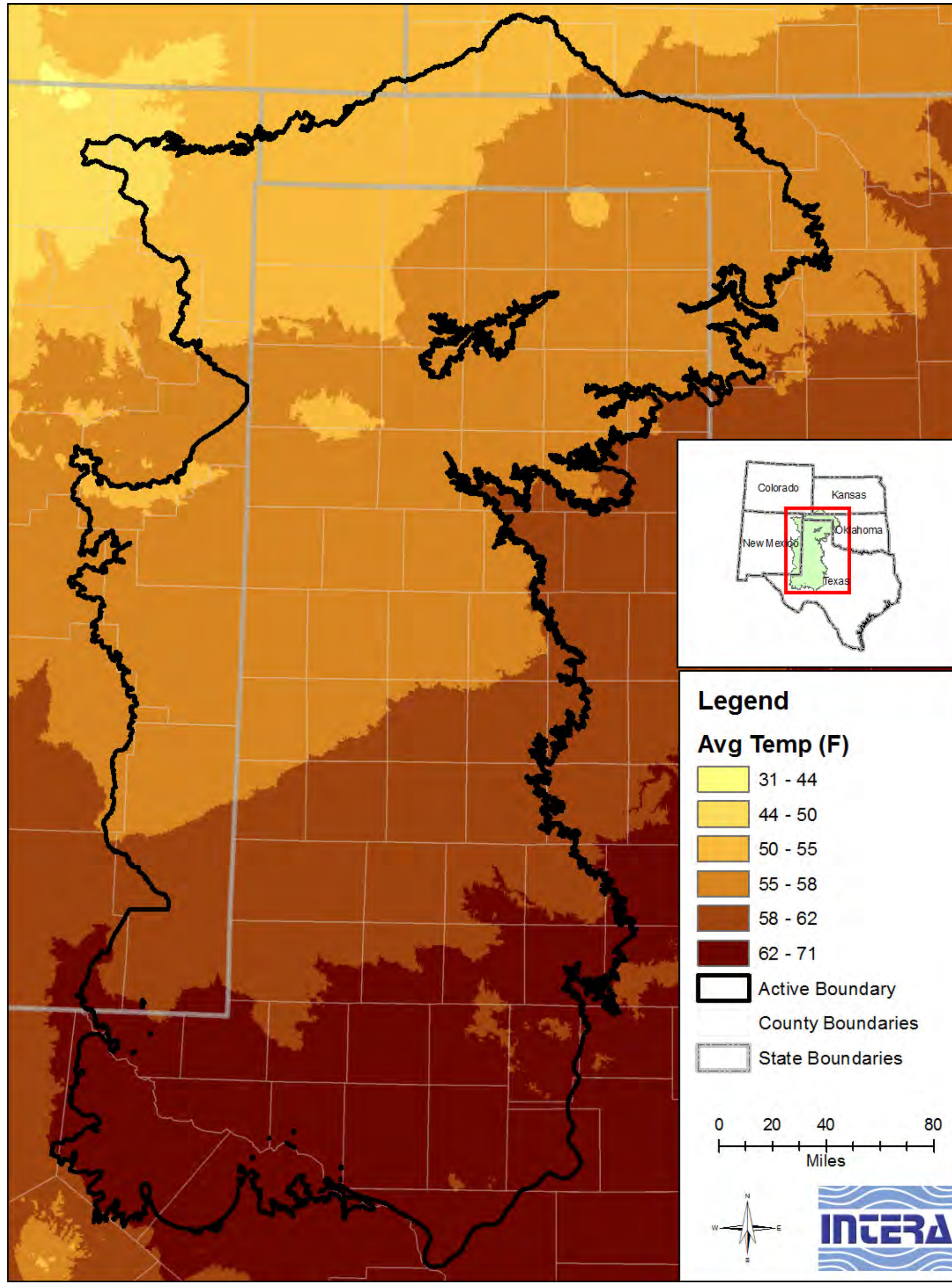
Annual Average Precipitation 1971- 2000

Source: Oregon State University PRISM Climate Data Group

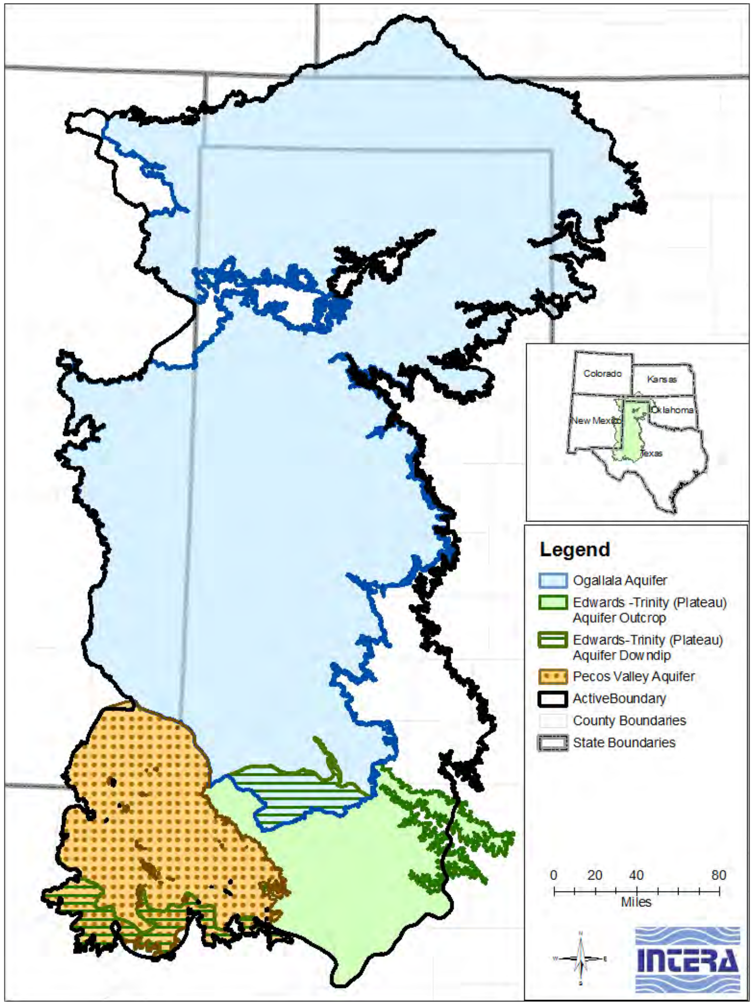


Annual Average Temperature 1971- 2000

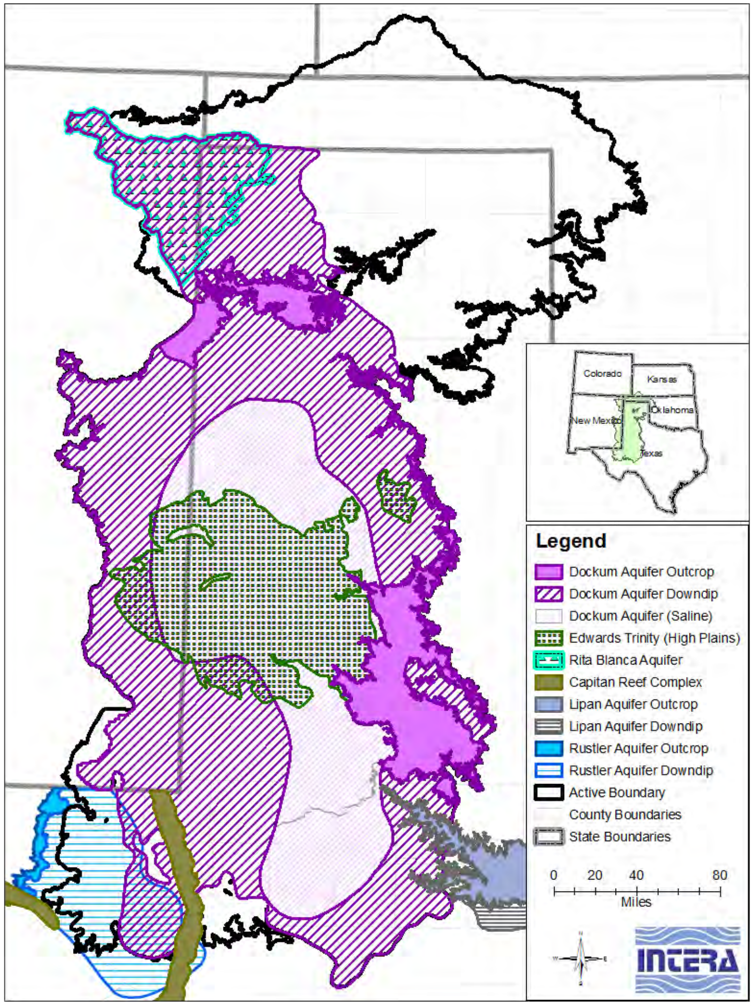
Source: Oregon State University PRISM Climate Data Group



High Plains Aquifer Boundaries



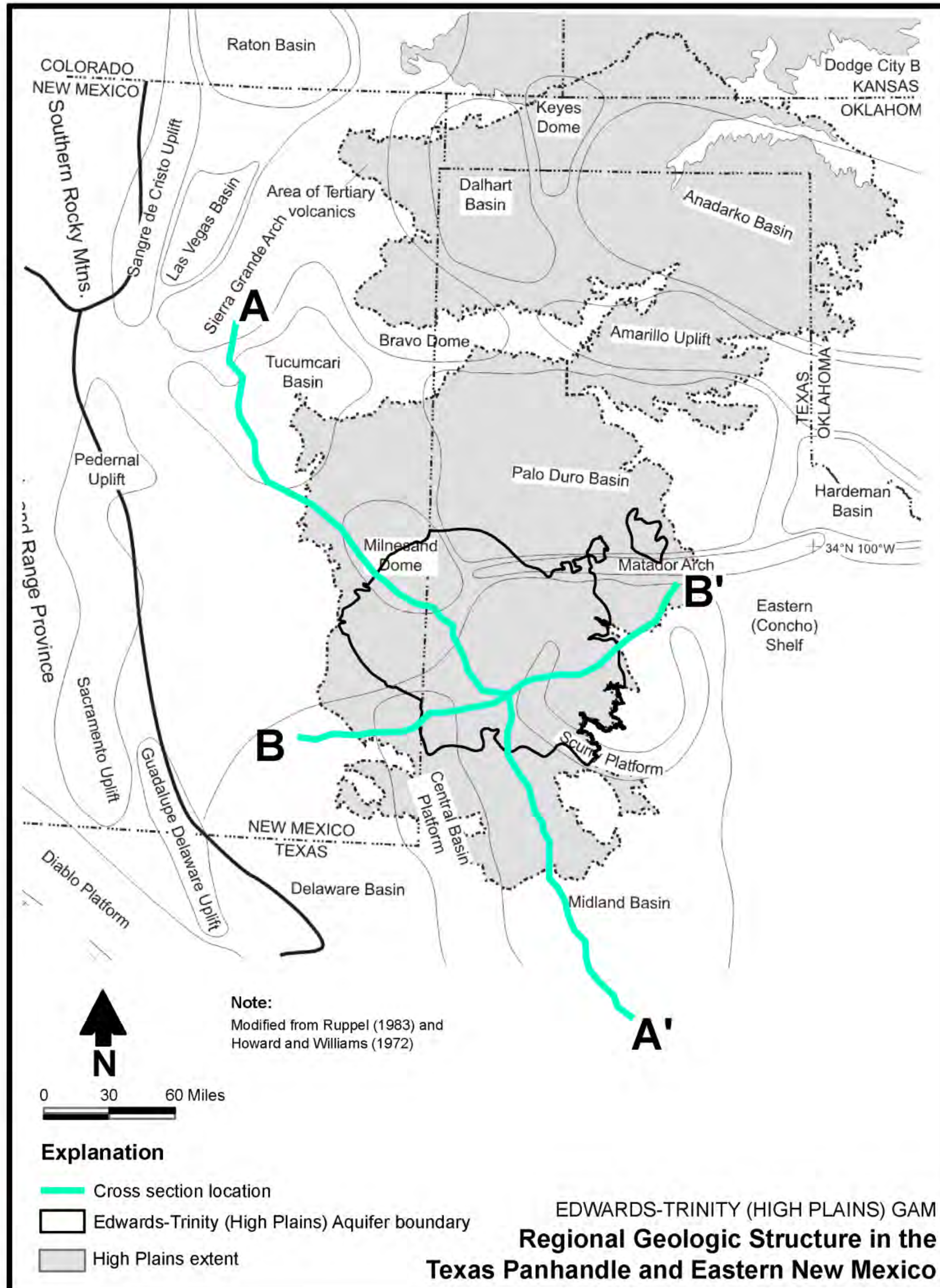
Major Aquifers



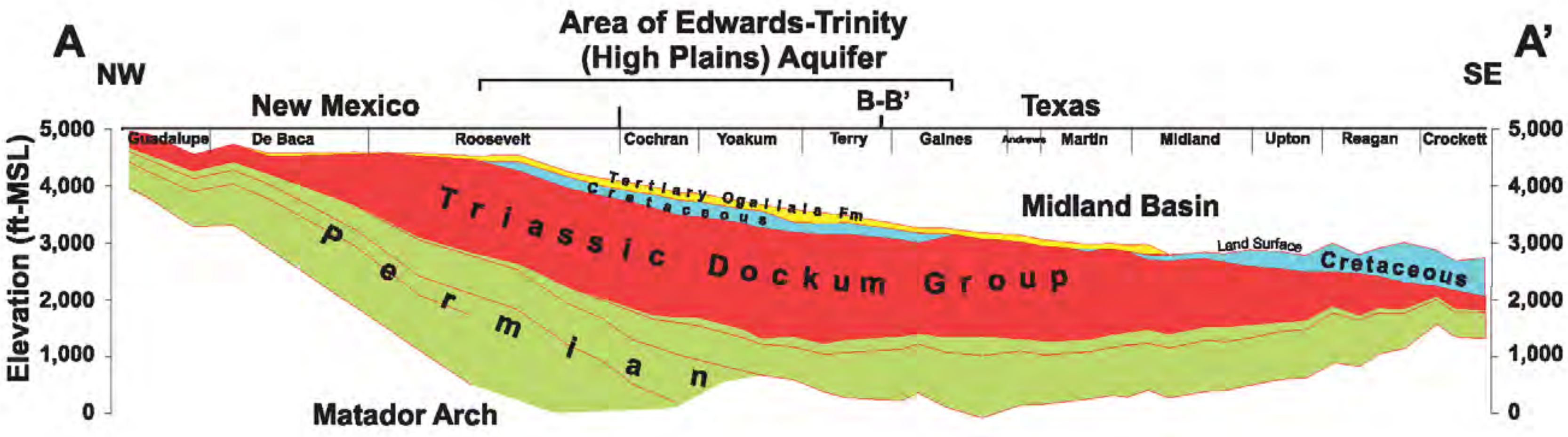
Minor Aquifers

Cross-Section

Source: Blandford and others (2008)



Cross-Section



Source: Blandford and others (2008)

Model Layering

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.

GAM Model Specifications

- Three dimensional (MODFLOW-NWT)
- Regional scale (1000's of square miles)
- Grid spacing
  - Uniform grid – ½ mile proposed
- Implement
  - recharge
  - groundwater/surface water interaction
  - pumping
- Calibration to observed water levels/fluxes

MODFLOW

- Code developed by the U.S. Geological Survey
- Selected by TWDB for all GAMs
- Handles the relevant processes
- Comprehensive documentation
- Public domain – non-proprietary
- Most widely used groundwater model
  - USGS had 12,261 downloads of MODFLOW computer code in 2000
- Supporting interface programs available
  - Groundwater Vistas to be used in all GAMs
- Using MODFLOW-NWT – most recent version

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Key Model Improvements

- Integrate existing HPAS GAMs
  - Northern Ogallala (including Rita Blanca)
  - Southern Ogallala (including Edwards-Trinity)
  - Dockum
  - Cross-formational flow important to DFC process

Key Model Improvements

- Address some key conceptual issues, including
  - Improved/consistent hydrostratigraphy (utilize BRACS)
  - Historical pumping estimates (potentially base on volumetric balance)
  - Treatment of recharge, return flow
- HPWD, PGCD, NPGCD provided additional resources for these tasks and more, e.g.
  - Increased density of structural picks
  - Streamlined tools for estimating historical production
  - More comprehensive treatment of recharge
  - **More stakeholder involvement (more direct meetings) – it is critical that we get all useful data and information from all the districts and other stakeholders**

Hydrostratigraphy

- BEG (Hamlin/Nance) will lead development of structure, with review by Seni
- Primary control through new geophysical log analyses
- Secondary information from driller's logs, cores, previous studies
- Products
  - Structural picks
  - Lithology and potentially porosity estimates
  - Water quality estimates, when possible (more applicable to Dockum)

Hydraulic Properties

- Lack of pump test data in region, relative to total number of wells. Possible additional sources:
  - TCEQ water supply records
  - GCD records, Ag research stations
- Other inputs/considerations
  - Specific capacity from driller’s logs
  - Lithology and sand percent from geophysical logs
  - DBSA lithologic analyses of driller’s logs
  - Depositional environment
  - Specific yield

Recharge

- Effort led by Bridget Scanlon at BEG
- Primary Ogallala issues
  - Differences between Northern and Southern implementations
  - Where does areal recharge occur outside playas
  - Rate of infiltration versus water table decline
  - Irrigation return flow
  - Significant recharge in the southernmost counties
- Dockum recharge will likely be similar to previous model
- Developing new spatial and temporal recharge model consistent across the region

Natural Discharge

- Discharge to surface water from Ogallala a small portion of post-development water balance
- Some exceptions (e.g. Hemphill County)
- Records of past springs may be helpful for steady-state calibration
- Some springs have a perched source that may not be implementable in this model

Groundwater Production

- Dominant discharge mechanism for Ogallala
- Increasing in Dockum
- Some meter data now available
  - North Plains (all)
  - Panhandle (in management areas)
  - High Plains (starting)
- Historical demand estimates available
- Change in storage calculations can provide alternative estimation method

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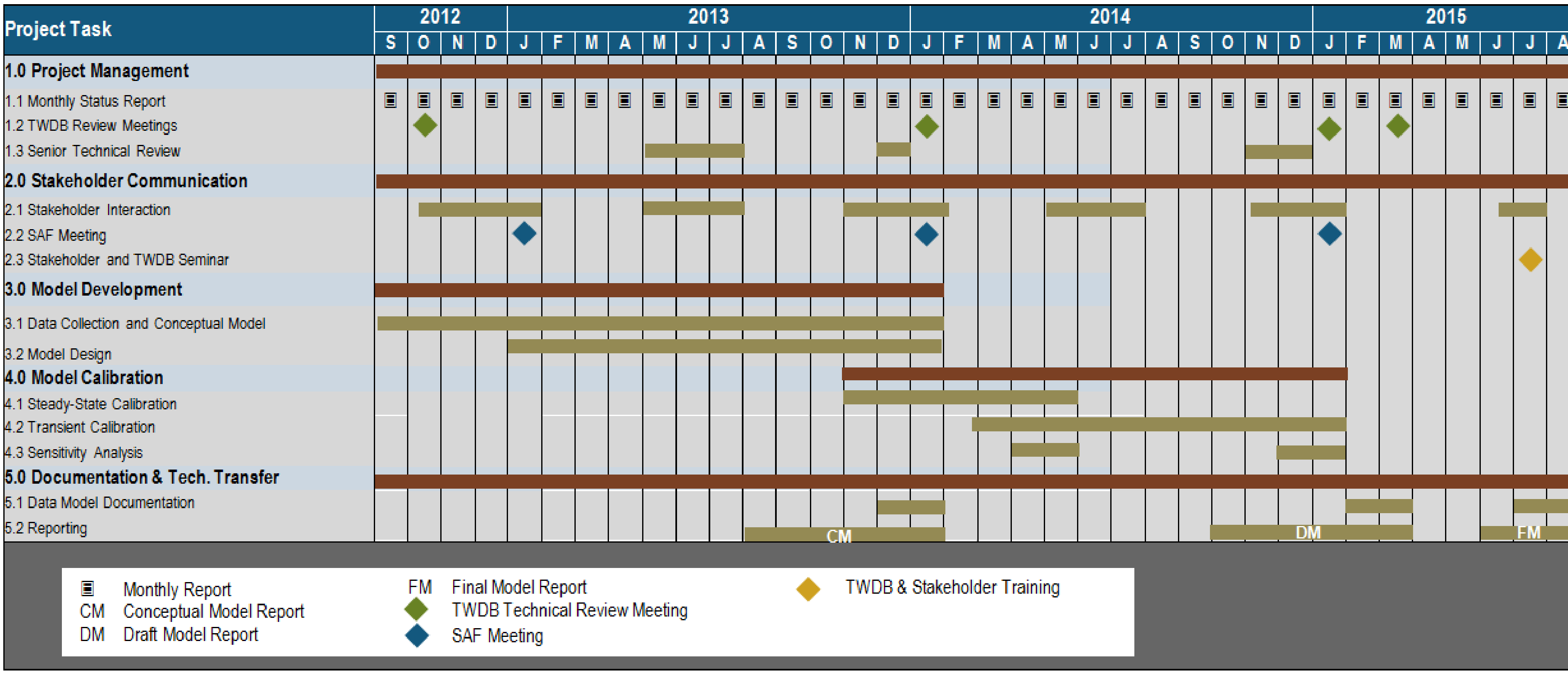
Data Request

- Any un-published data to support the model
  - Geophysical logs
  - Pump tests
  - Water levels
  - Interpreted properties
  - Structural picks
  - Production information
- Data request by March 15, 2013

Tasks and Proposed Schedule



Thank You
Questions?

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Meeting Minutes for the First High Plains Aquifer System Groundwater Availability Model (GAM) Stakeholder Advisory Forum (SAF) Meeting

February 11, 2013

Mesa UWCD Offices, Lamesa, Texas

The first Stakeholder Advisory Forum (SAF) Meeting for the High Plains Aquifer System Groundwater Availability Model (GAM) was held on Monday, February 11, 2013 at 1:00 PM at the offices of Mesa Underground Water Conservation District located at 212 North Ave. G in Lamesa, Texas. A list of meeting participants is provided at the end of this meeting note.

The purpose of the first SAF meeting was to provide an introduction to the High Plains Aquifer System, the modeling team, and to solicit input from stakeholders including any available data that could be made public in support of this modeling project. The meeting also provided a forum for discussing the project schedule and provided an opportunity for feedback from stakeholders.

Meeting Introduction: Cindy Ridgeway, TWDB

The meeting was initiated by Ms. Cindy Ridgeway of the Texas Water Development Board (TWDB). She gave a brief introduction to the GAM Program and discussed how GAMs are used in Texas water resources planning. She then discussed GAMs and how they related to modeled available groundwater (MAG) as well as the importance of the stakeholder process. She closed by introducing the High Plains Aquifer System GAM Team and introduced the project manager Dr. Neil Deeds of INTERA, Inc.

SAF Presentation: Neil Deeds, Ph.D., P.E., INTERA, Inc.

Dr. Deeds presented a prepared presentation structured according to the following outline:

1. The basics of groundwater flow in the aquifers;
2. The concept of numerical groundwater flow modeling;
3. The concept of numerical groundwater flow modeling;
4. Experience from previous models of the aquifers;
5. The planned approach to modeling the aquifers;
6. A request for relevant data to support the model; and
7. The proposed schedule for the project.

Questions and Answers:

Q: Senate Bill 660 last legislative session required that desired future conditions provide a balance between the "highest practicable level of groundwater production and the conservation, preservation" etc. of groundwater. Will the TWDB use the GAM to provide the districts with an estimate of the "highest practicable level of groundwater production" to consider when developing DFCs?

A: No. Texas Water Code 36.108 (d) and 36.108 (d-2) direct the districts in a groundwater management area to propose desired future conditions that provide a "balance between the highest practicable level of groundwater production and the conservation, preservation, protection, recharging, and prevention of waste of groundwater and control of subsidence." TWDB uses the GAMs to provide the best available information about the aquifers such as extracting historical water budgets to see how the aquifer(s) responded in the past or to develop modeled available groundwater based on from DFC policy decisions by management entities. What is considered "practicable" inherently contains policy decisions made at a local level regarding the extent to which groundwater could feasibly be developed. Statute directs that this determination is to be made by the local groundwater districts in the management areas.

Q: When will the model be complete?

A: A draft of the transient model is scheduled to be finished in January 2015.

Q: How did additional GCD funding come to happen?

A: TWDB selected the contractor under the original scope. Participating districts identified several scope areas that could be improved with additional funding. Participating districts then coordinated with TWDB to provide additional funding under an expanded scope.

Q: How does the funding for this GAM ($600K original + $300K additional from the Districts) compare to previous Texas GAMs?

A: It is one of the higher levels of funding for a GAM.

Q: When does TWDB give a green light to use the model for the DFC process?

A: The final report will be completed in August 2015. The model will be reviewed by TWDB and, if found to meet GAM standards, will be available after that (approximately 1-2 months after delivery). The districts may choose to use the draft model prior to review by TWDB, but this carries some risk if TWDB determines that some changes need to be made.

Q: Can we request an extension for adopting DFCs, i.e. wait for the model to come out officially?

A: TWDB rules regarding the timing of the adoption of DFCs (Texas Administrative Code §356.31(a)), which is consistent with Texas Water Code §36.108, require that new DFCs are adopted not later than five years after the date the GMA last adopted a DFC. The statute does not provide for flexibility in this requirement.

Q: How much of this is reinventing the wheel from previous models?

A: In nearly all aspects of the model, the goal is to enhance existing work. We are not going to be reanalyzing accepted analysis/data, but rather improving and extending the model, where possible, with new data.

Q: What was the time period of the previous model [Southern portion of the Ogallala Aquifer including the Edwards-Trinity (High Plains) GAM]?

A: The focus of the model calibration was between 1980 and 2000.

Q: How can [or should] the districts that did not provide additional funding contribute to the project?

A: GCD data input is critical to this process. The districts in this region have been around for a long time and have collected lots of valuable data. Resources for updating the model will be amplified if the districts can help in providing all this data [including more recent data].

Q: Will the data that the districts provided for the previous GAM(s) be incorporated into the model?

A: Yes.

Q: It would be nice to simulate years 2010 and 2011 in the model update, since these represent very wet and very dry years.

A: We have proposed that the transient calibration run through 2011. The changes to the aquifers during this time period will therefore be included in the model.

February 11, 2013

Attendance

Name	Affiliation
Cindy Ridgeway	TWDB
Leatrice Adams	Permian Basin UWCD
Donna Springer	Permian Basin UWCD
Gerald Crenwelge	High Plains WD
HP Brown	Region O
Ray Brady	RMBT
Stefan Schuster	DBSA
Bill Mullican	HPWD
Ken Rainwater	TTUWRC
Darrell Peckham	Water Quest
Deanya Williams	Mesa UWCD
Lori Barnes	Llano Estacado UWCD
Harvey Everheart	Mesa UWCD
Ben Weinheimer	TX Cattle Feeder's Assocation
Jim Conkwright	HPWD
Jason Coleman	SPUWCD
Wade Oliver	INTERA
Neil Deeds	INTERA