High Plains Aquifer System GAM

Stakeholder Advisory
Meeting #1

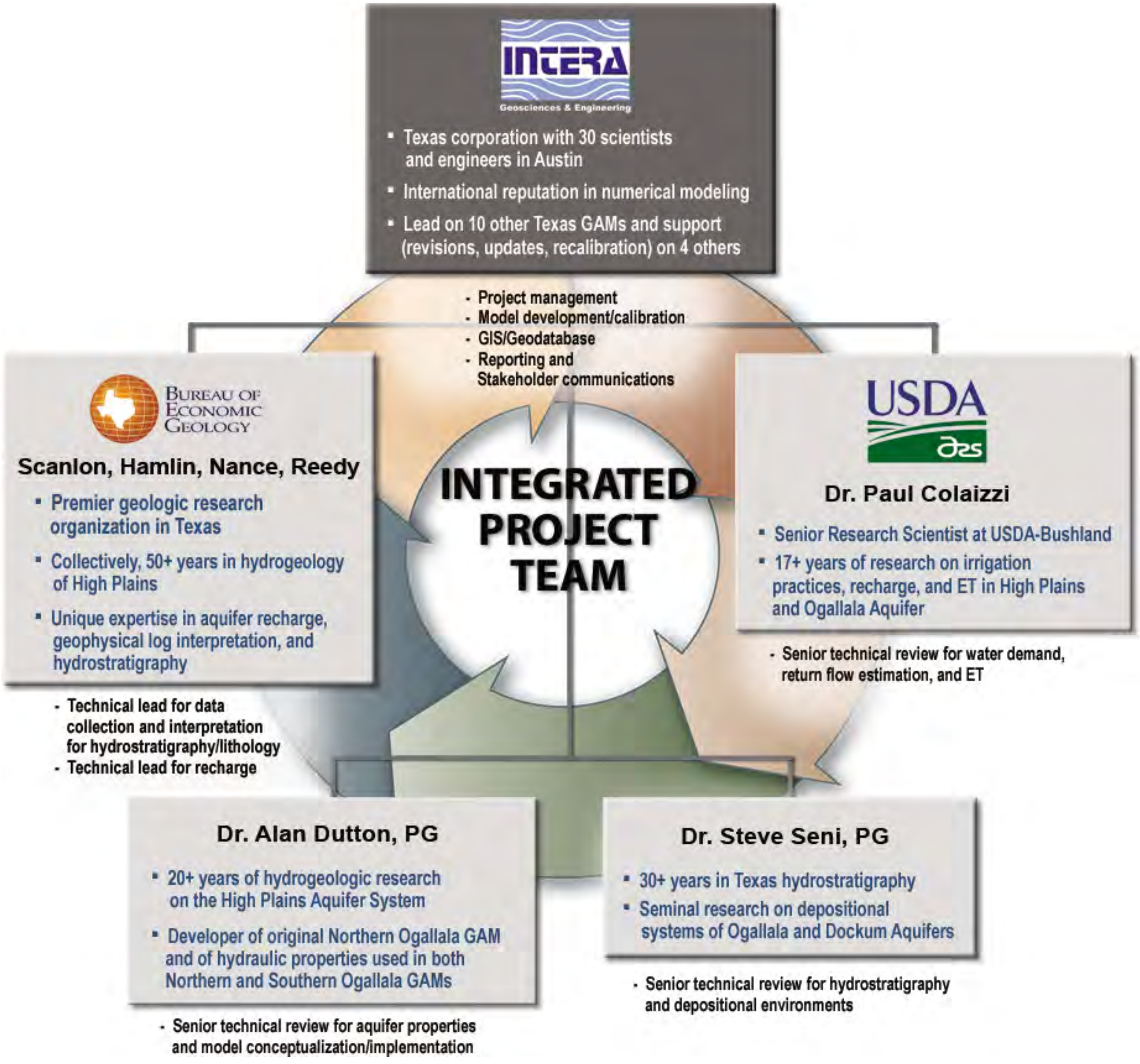
Amarillo, TX

February 28, 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

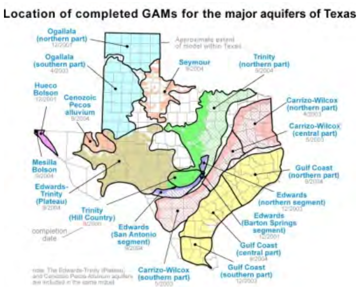
Project Team & Responsibilities

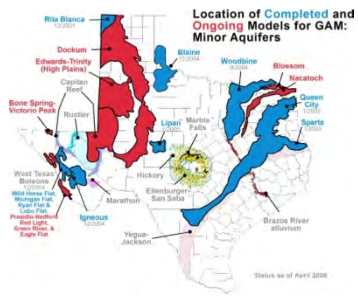


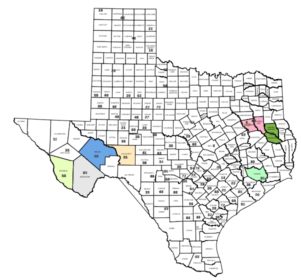
Study Objectives

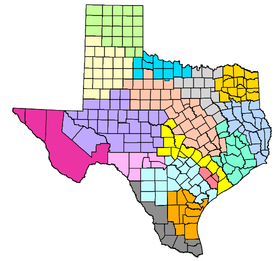
- Integrate existing HPAS GAMs
  - Northern Ogallala
  - Southern Ogallala
  - Dockum
- Address key issues with the conceptual models used in the previous GAMs
- Produce tool that better captures the interrelationships between the aquifers and incorporates the most-recent data available

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.

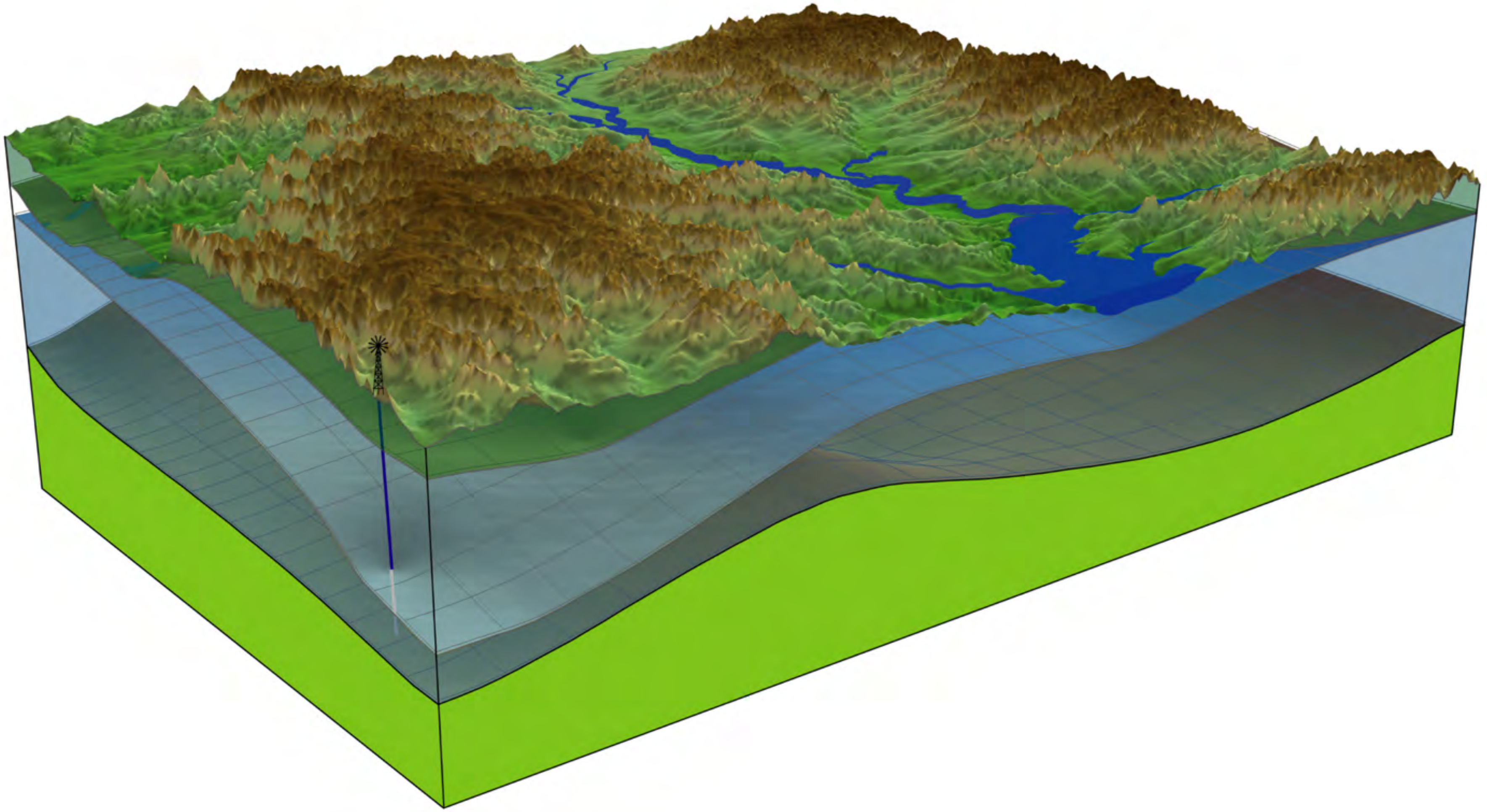
What is Groundwater Availability?

Science + Policy = Groundwater Availability

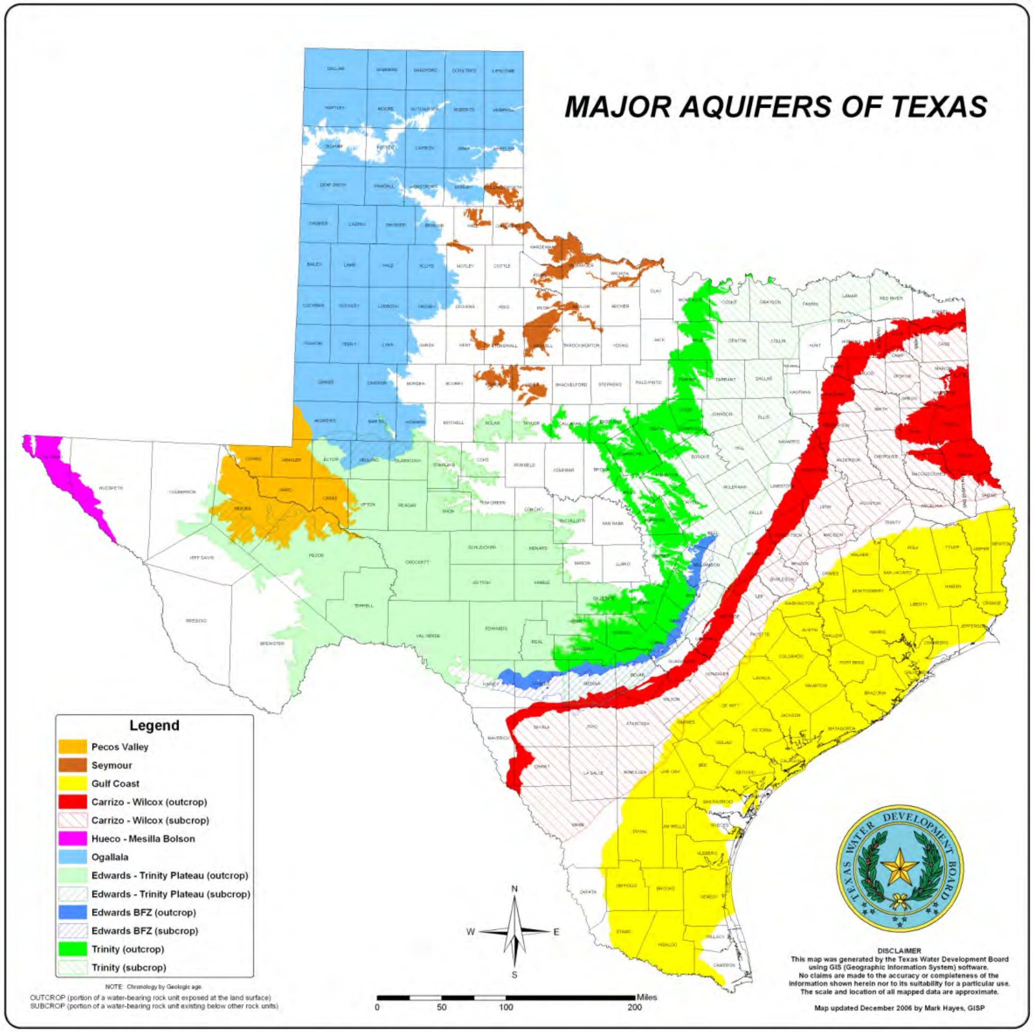
GAM or other tool + Desired Future Conditions = Managed Available Groundwater

Goal: informed decision-making

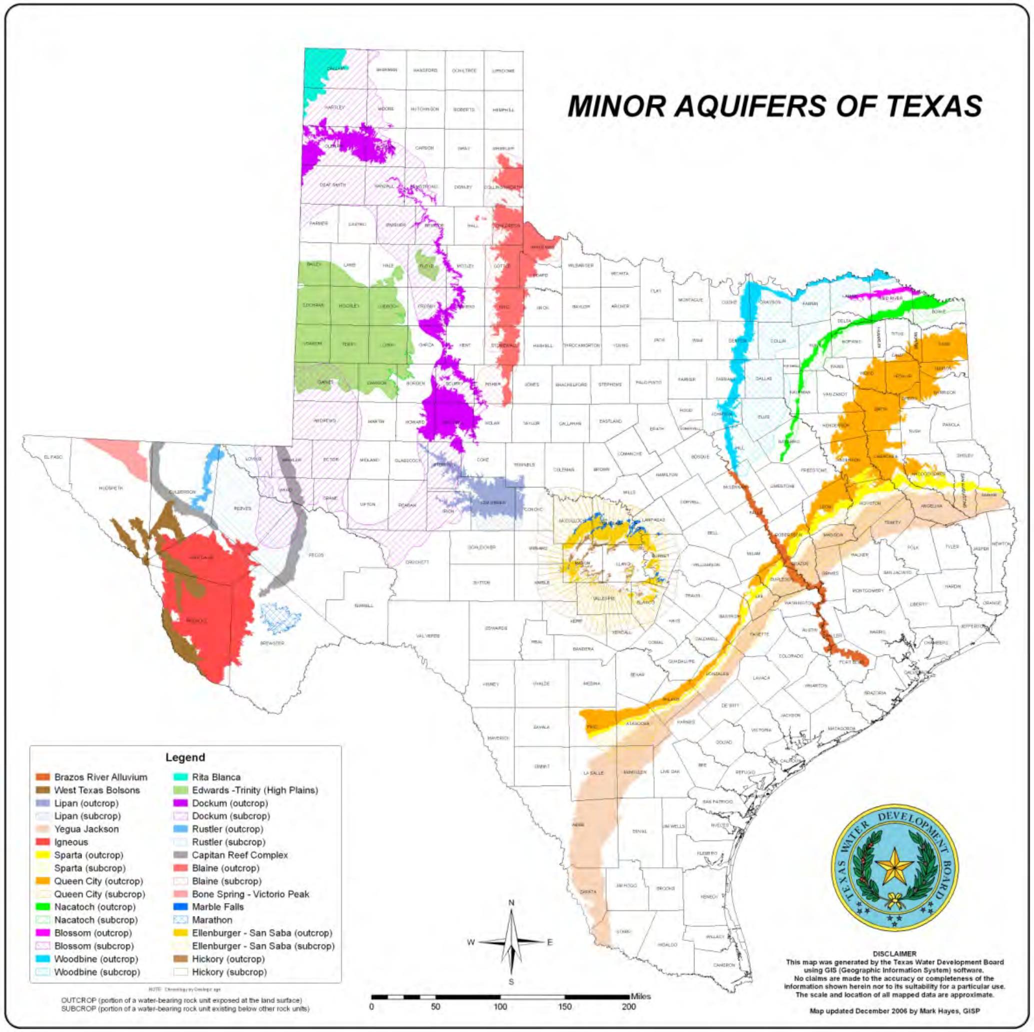
Groundwater Model



Major Aquifers



Minor Aquifers



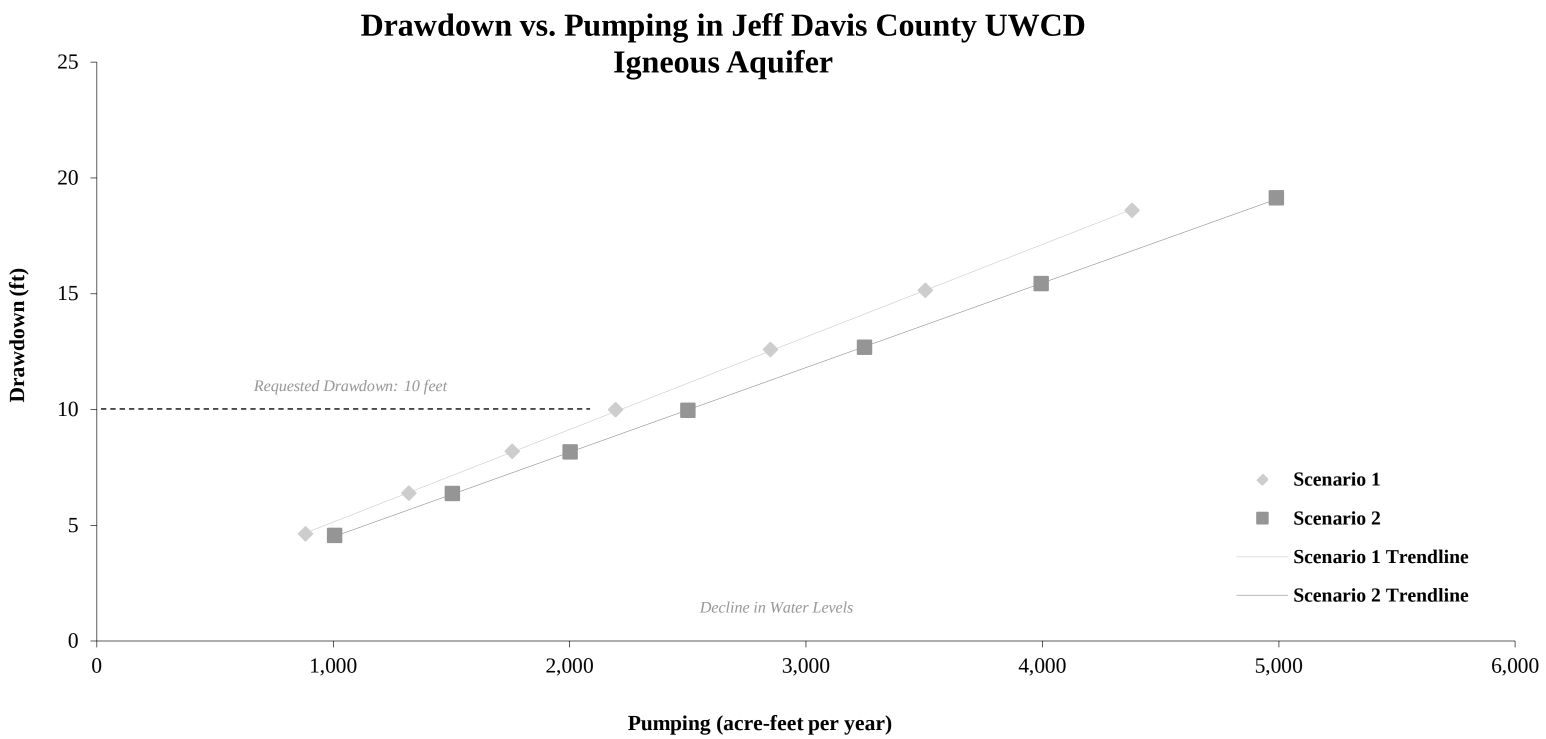
How we use Groundwater Models

- 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

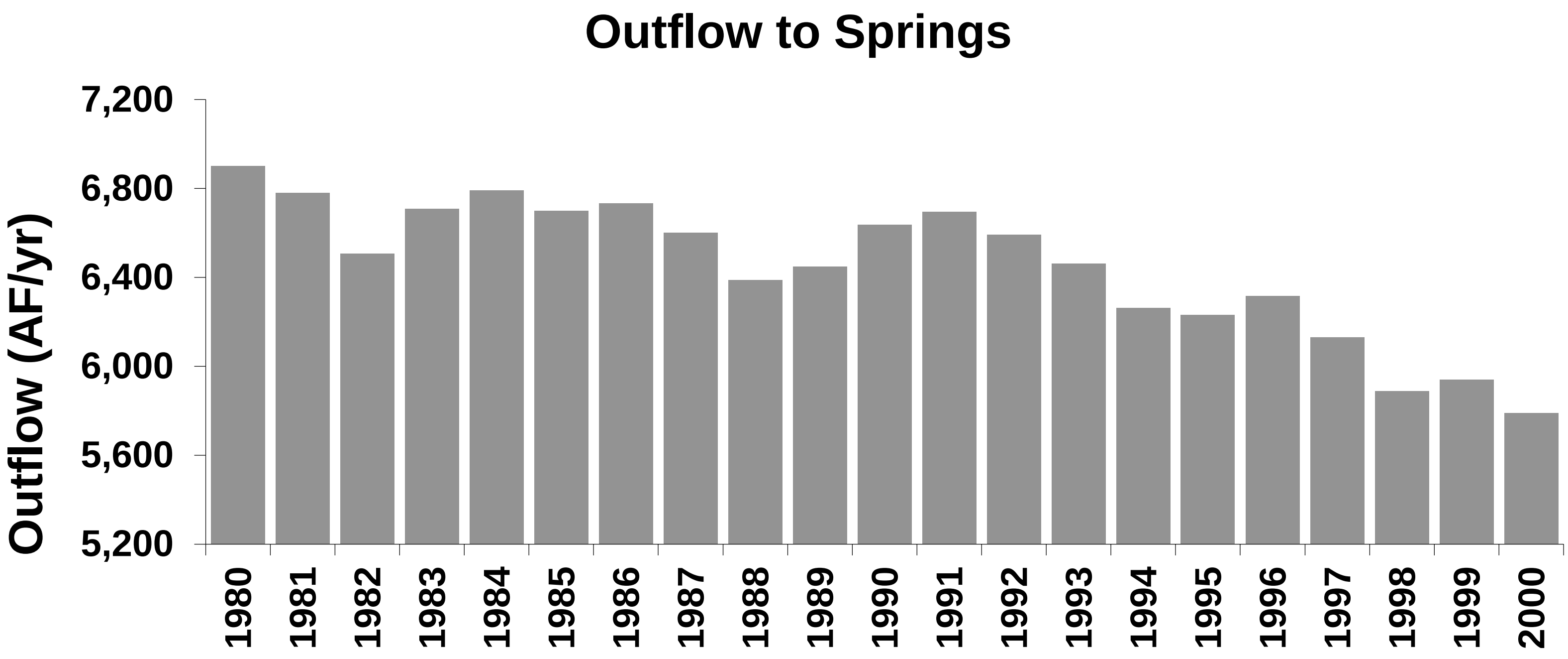
How we use Groundwater Models

- Assist districts and management areas in determining desired future conditions



How we use Groundwater Models

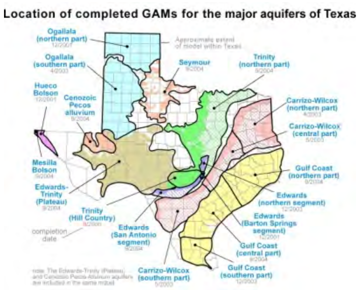
- Assist districts and management areas in determining desired future conditions

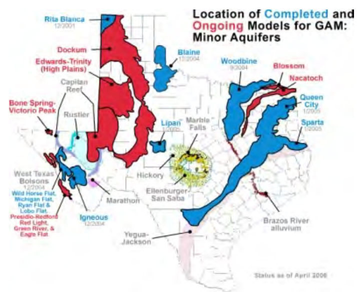


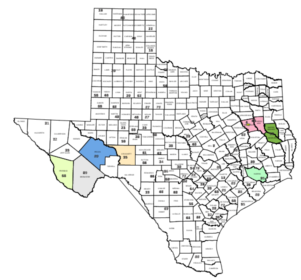
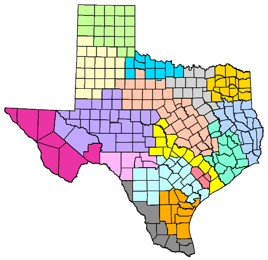
Stakeholder Advisory Forums

- 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





Cindy Ridgeway, P.G.
Cindy.Ridgeway@twdb.texas.gov
512-936-2386

Texas Water Development Board
1700 North Congress Avenue
P.O. Box 13231
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

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- Introduction
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- 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

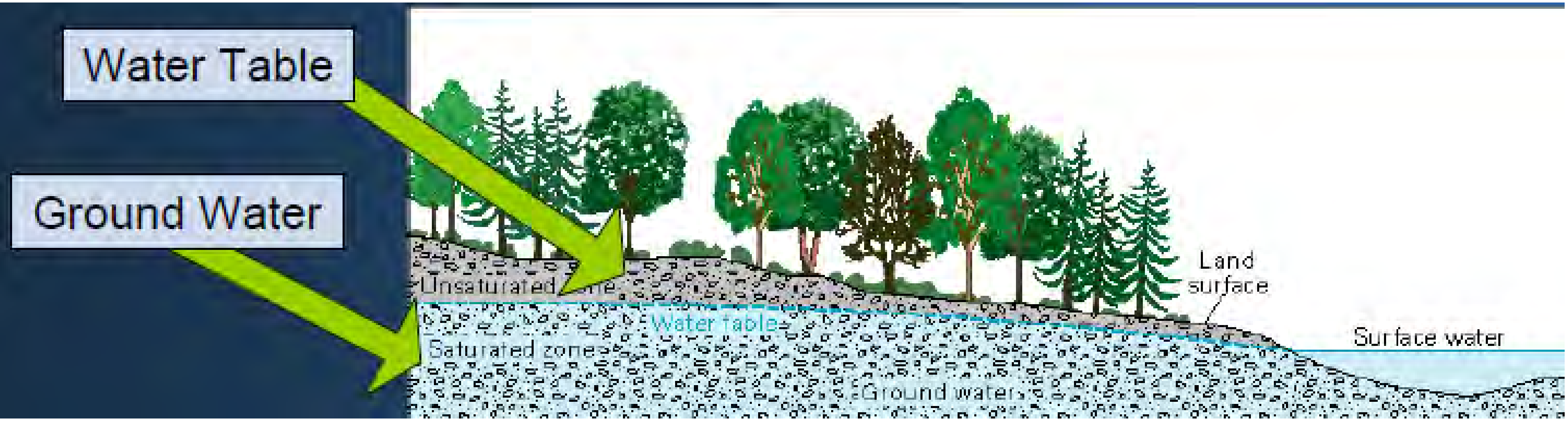
ROCK

What is an aquitard?

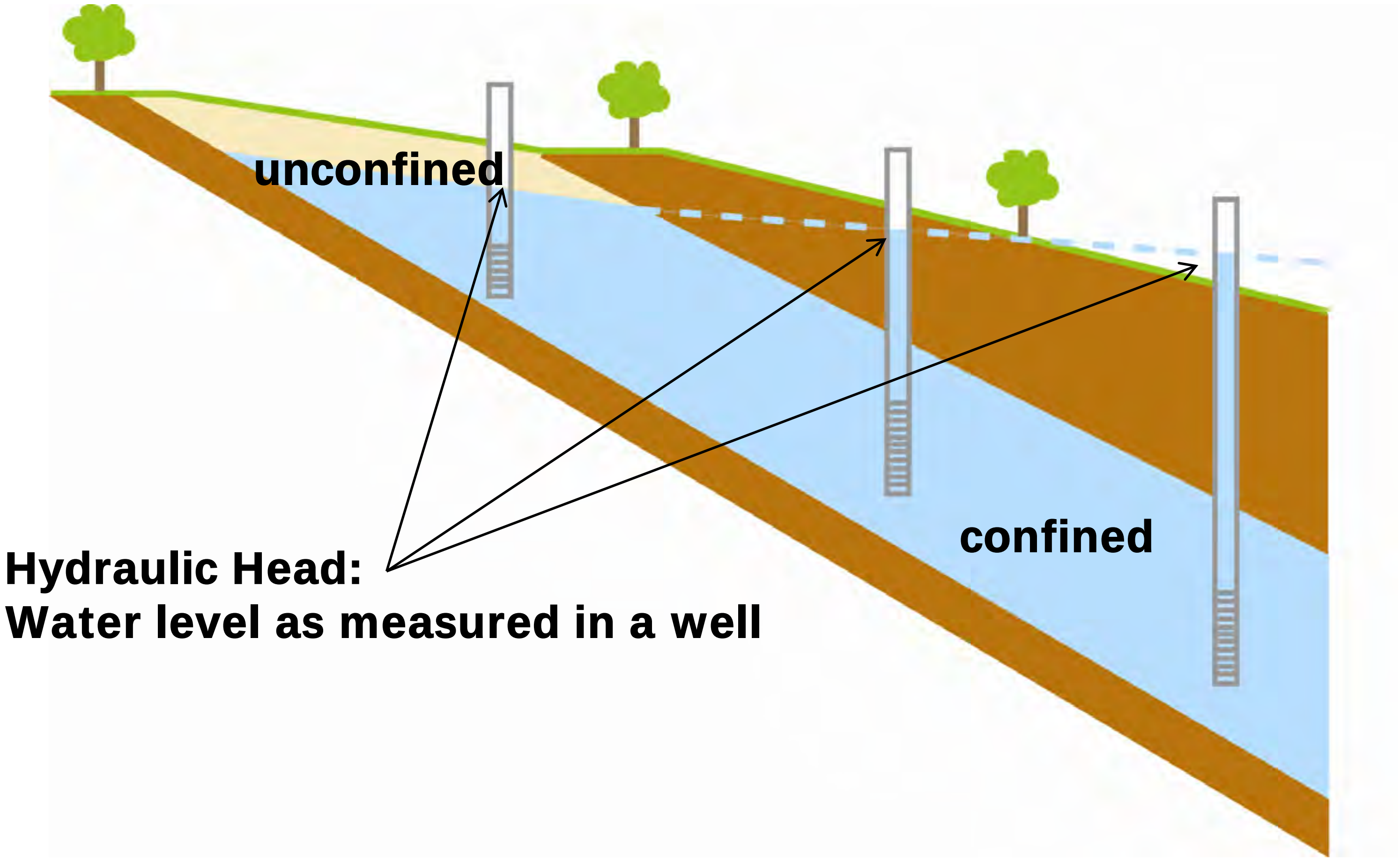
- an aquitard is geologic media that can not yield economically usable amounts of water.
- clay, shale, unfractured dense rocks
- Note: can still transmit water, but s l o w l y

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

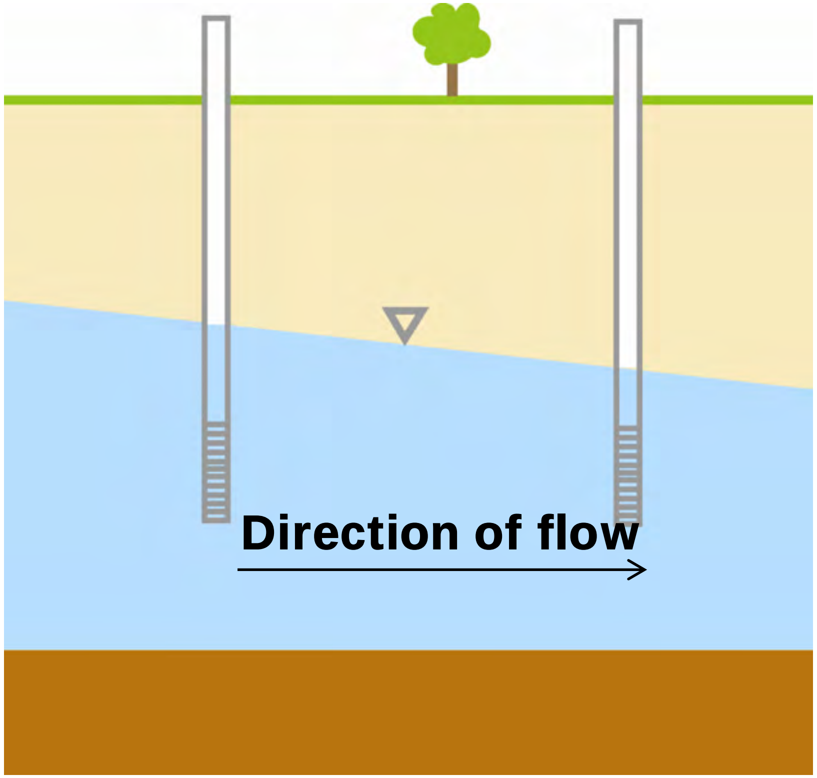


Same aquifer: unconfined and confined



Groundwater Flow

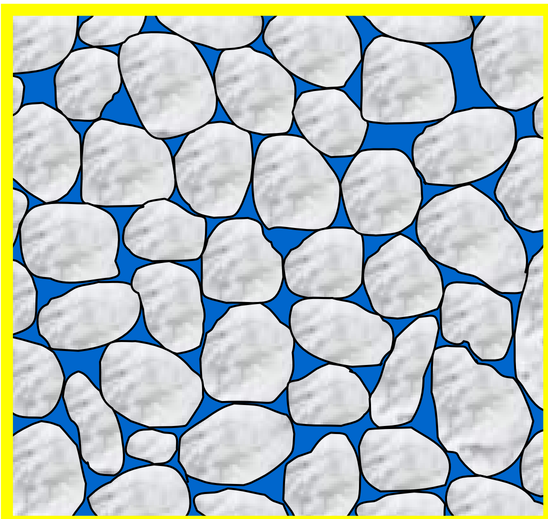
- Groundwater flows from higher potential energy (head) to lower potential energy



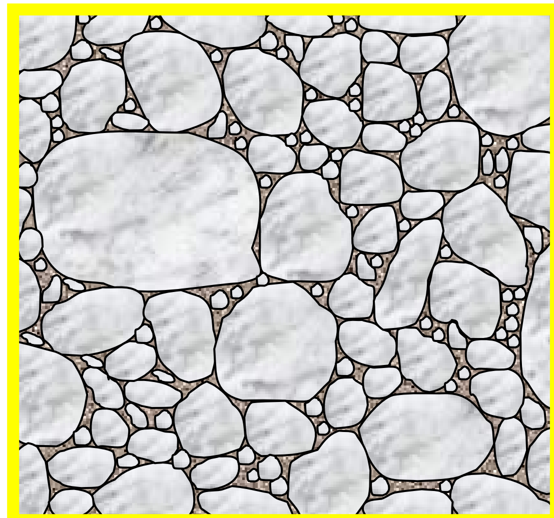
Aquifer Properties

- 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

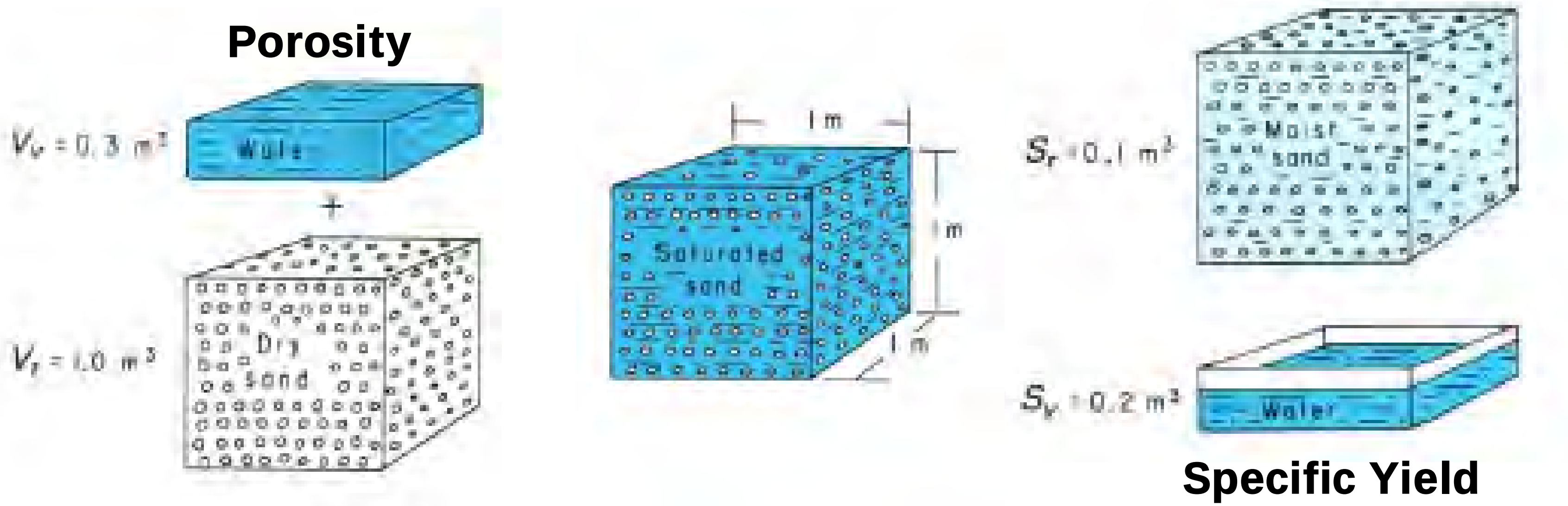
WELL SORTED
Fine (silt-clay)

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.

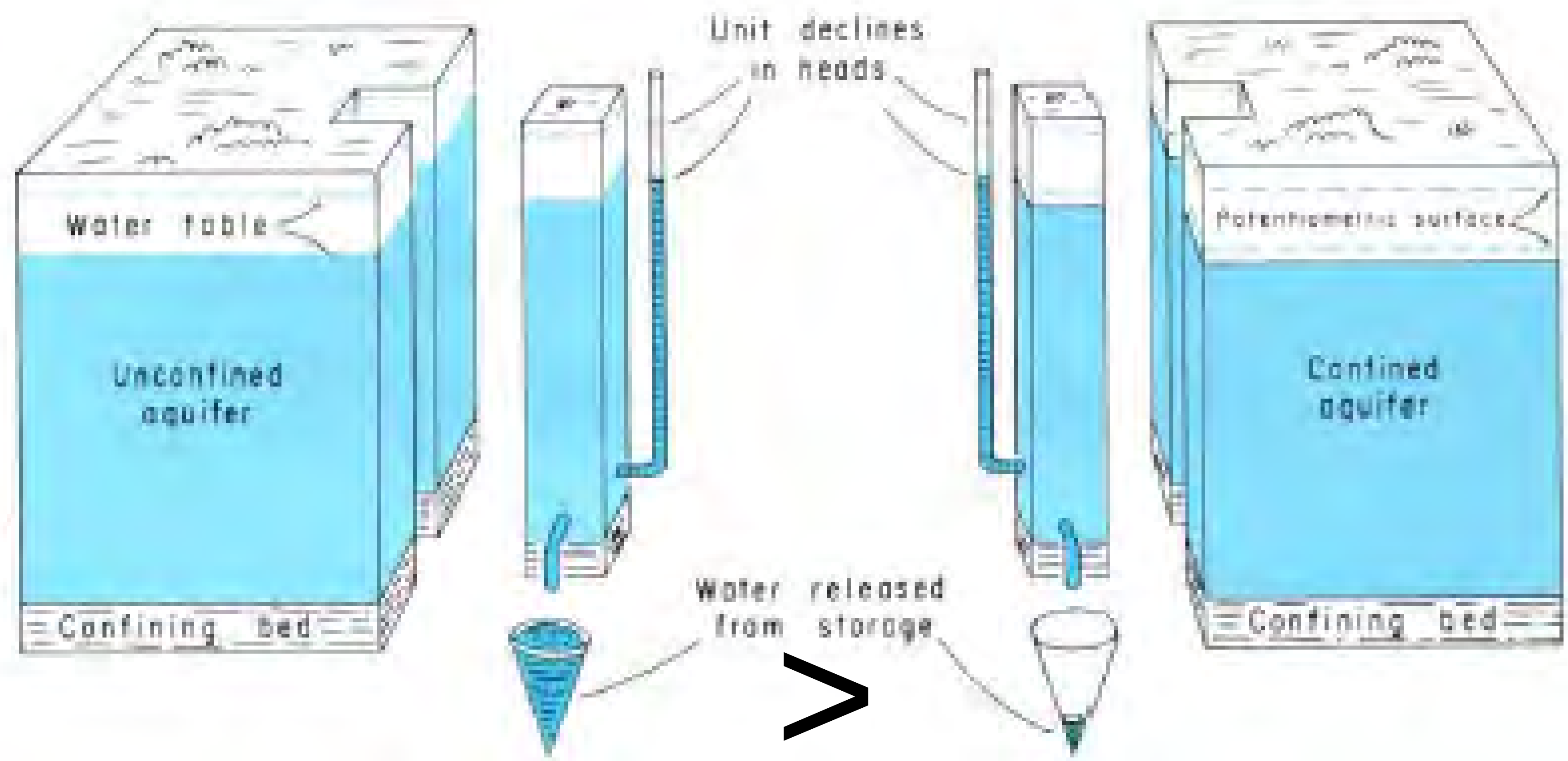


From Heath (1983)

Aquifer Properties

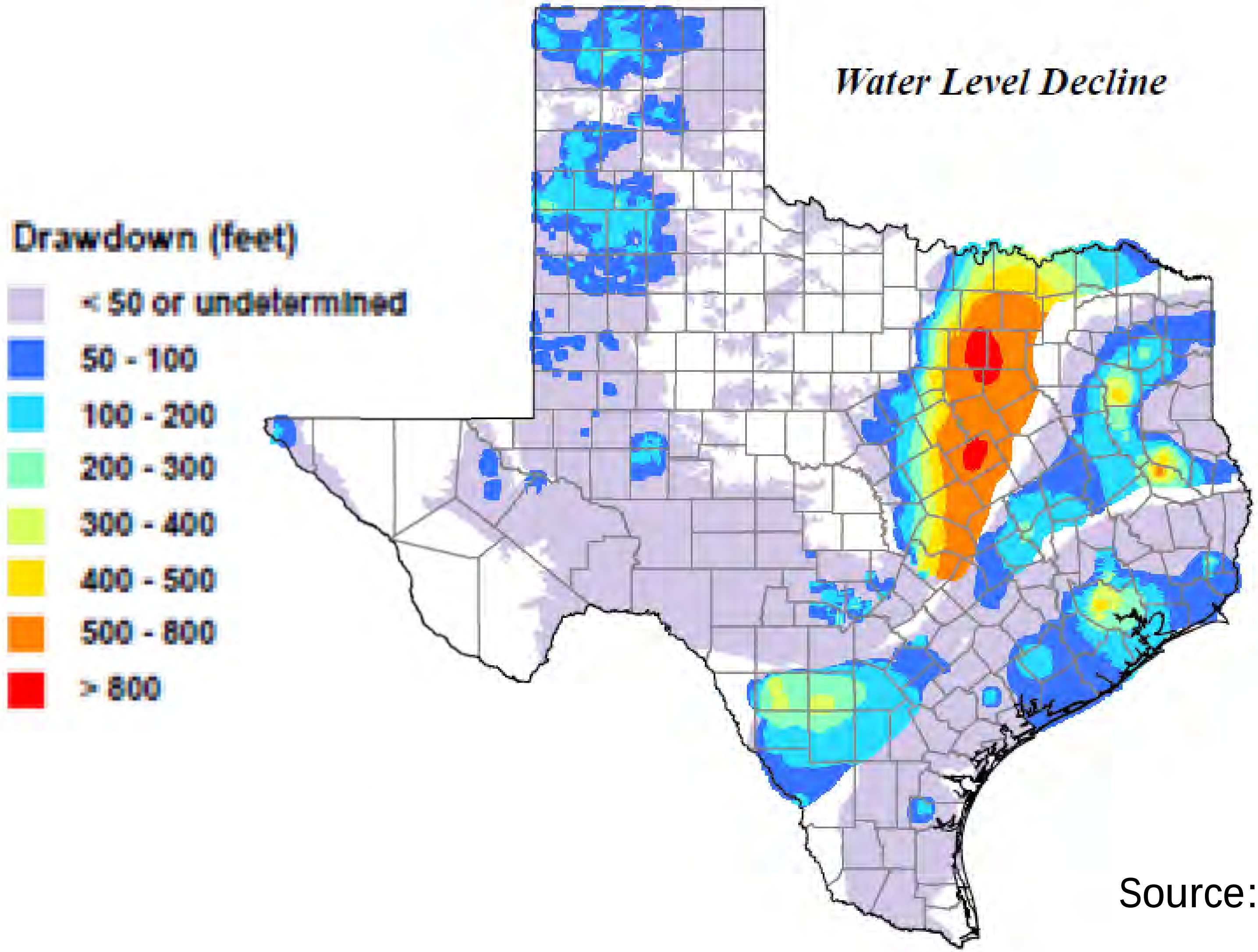
- Storativity – The volume of water that a confined aquifer releases from storage per unit surface area of aquifer per unit decline in head.
  - Much smaller than specific yield

Specific Yield vs. Storativity



From Heath (1983)

Specific Yield vs. Storativity



Source: TWDB

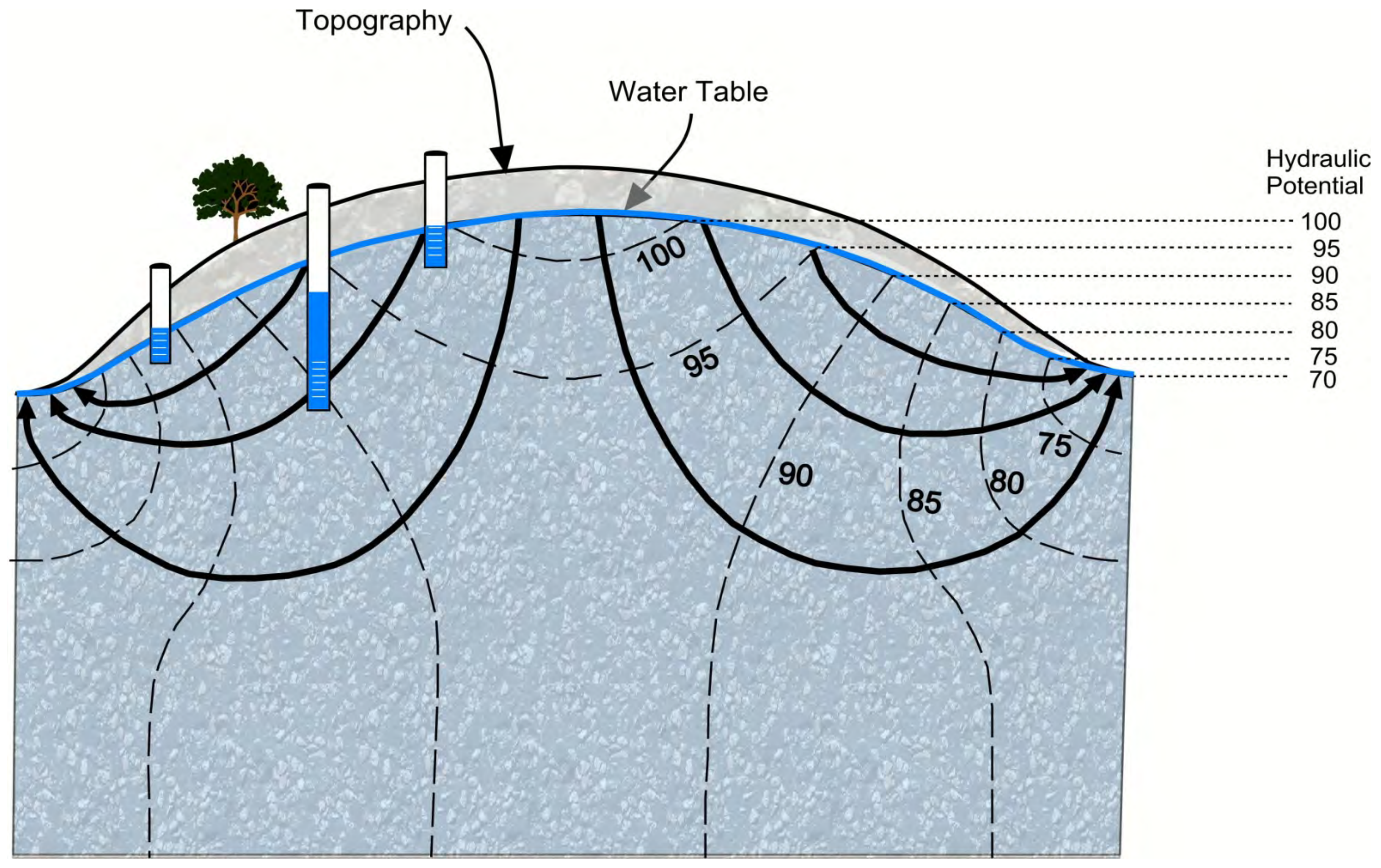
Groundwater Definitions (cont.)

- 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

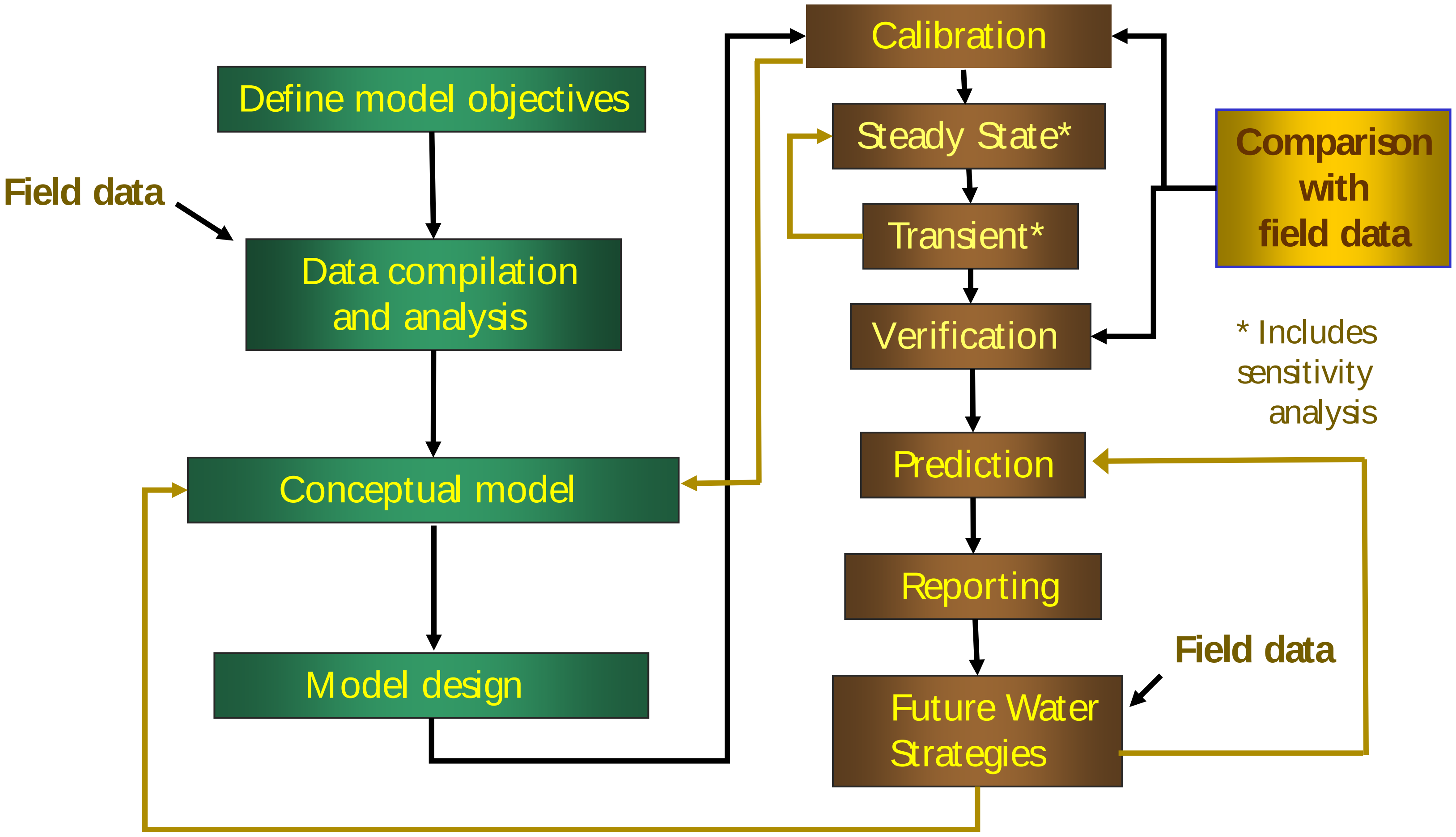
Why Groundwater Flow Models?

- 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

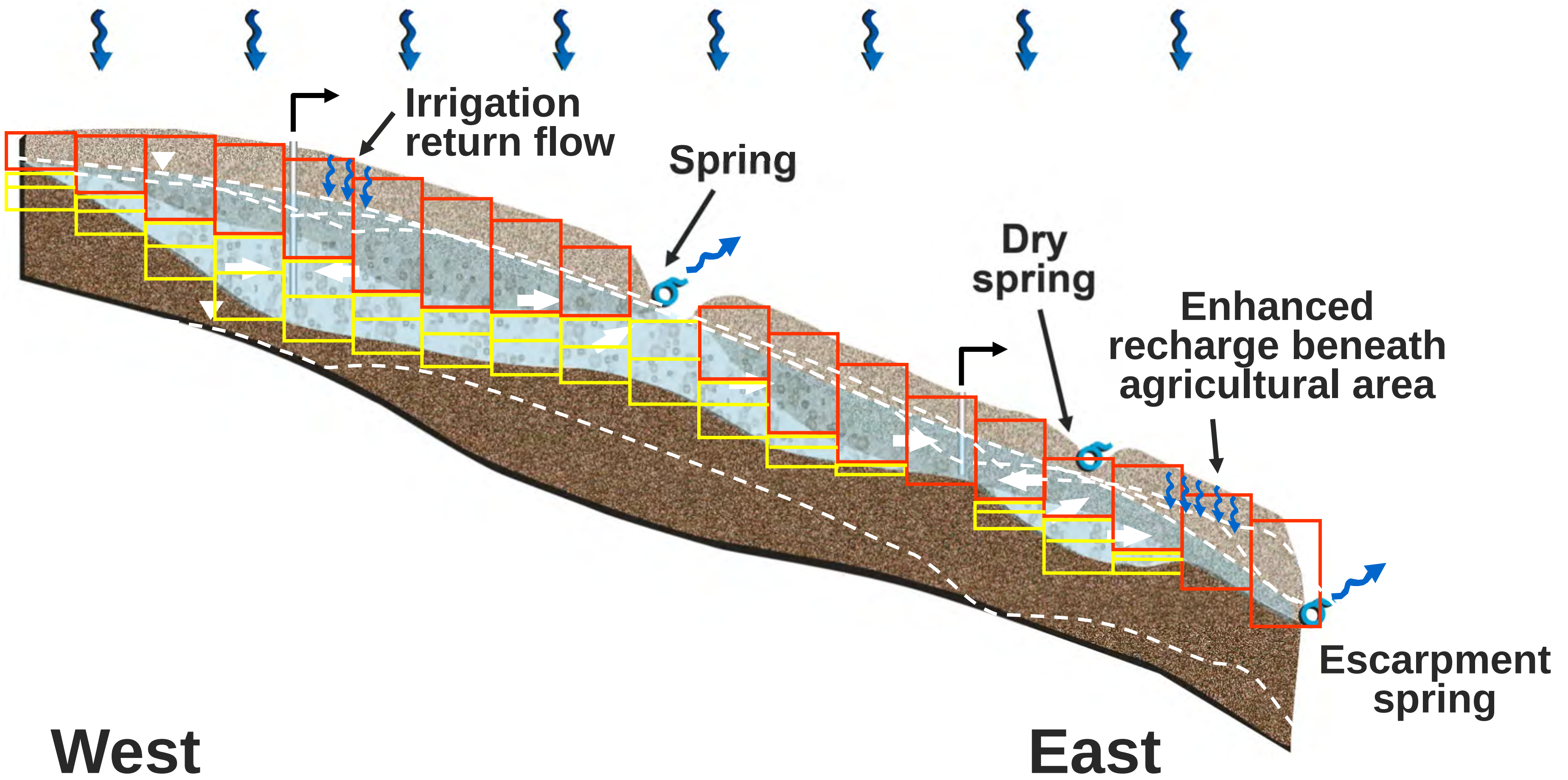
Numerical Flow Model

- 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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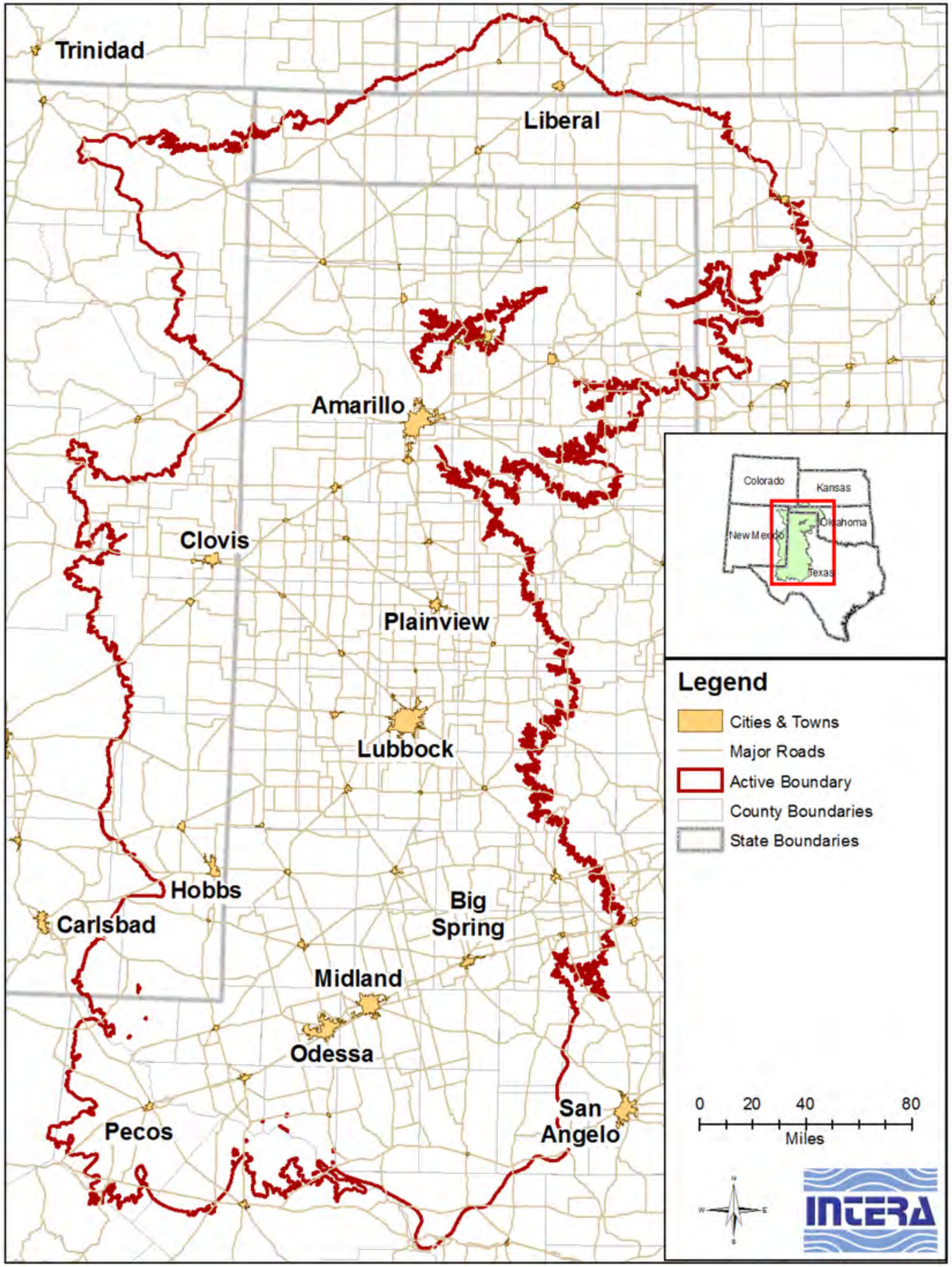
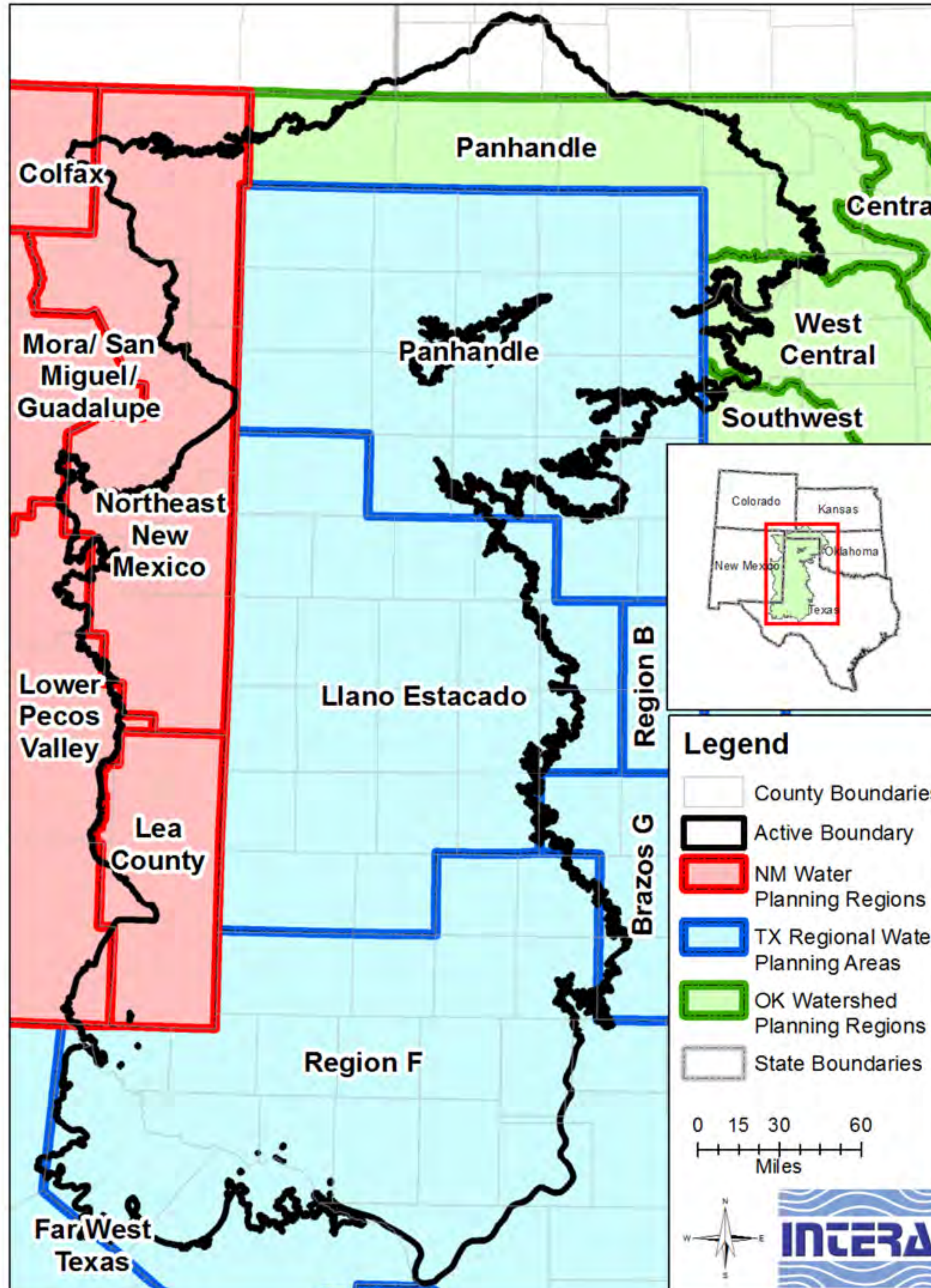
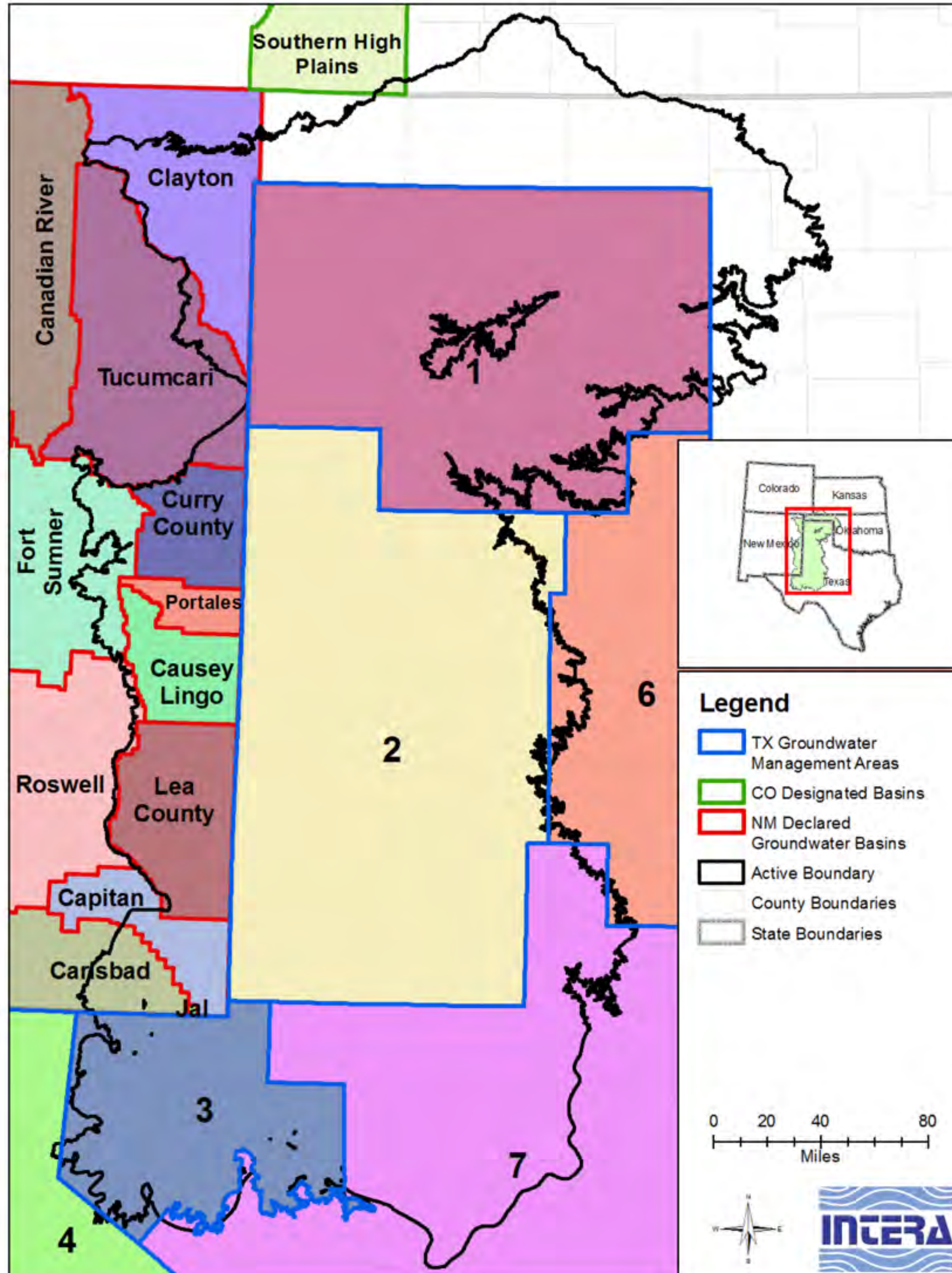
Study Area


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

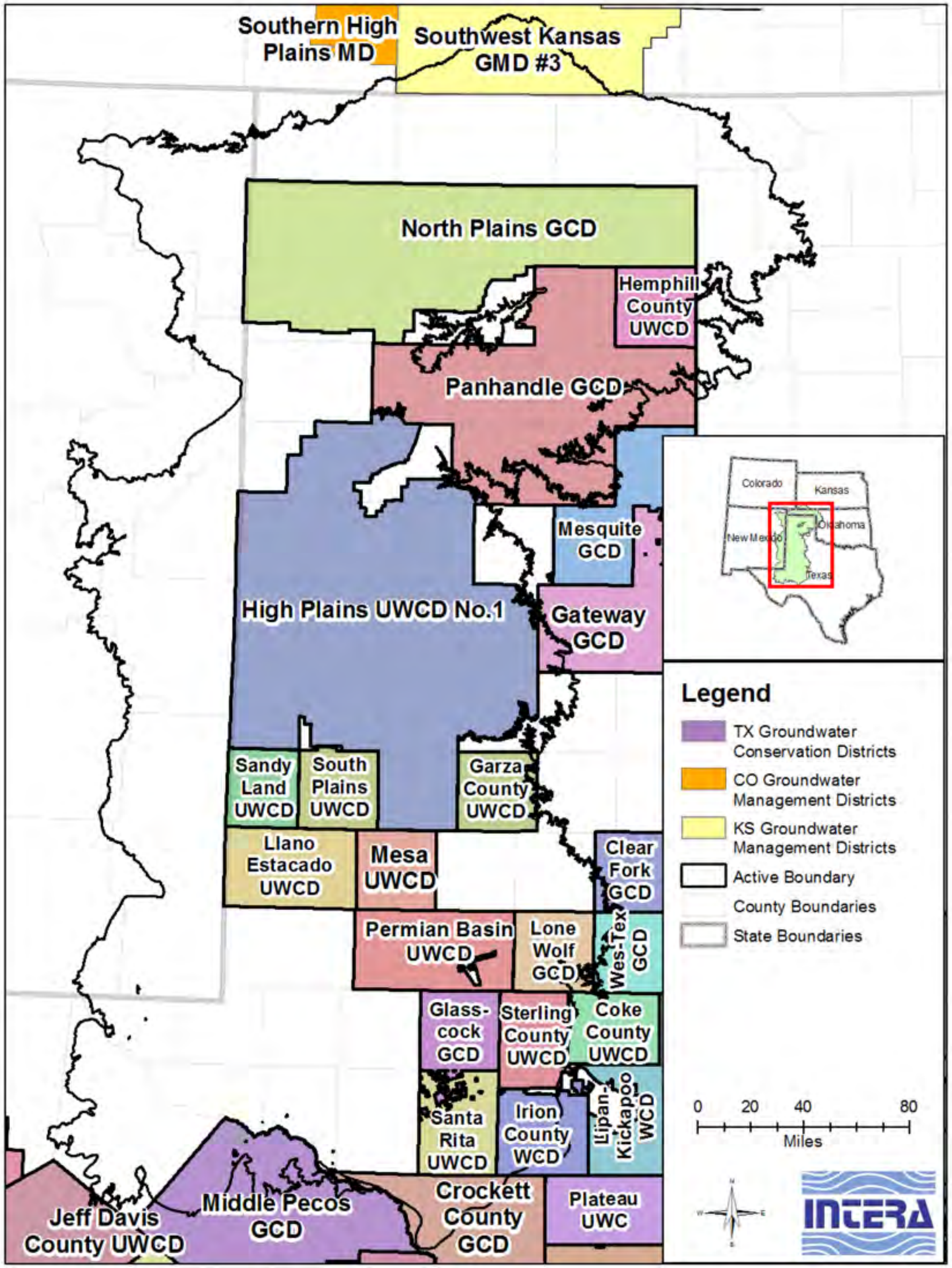
Regional Planning Groups



Groundwater Management Areas

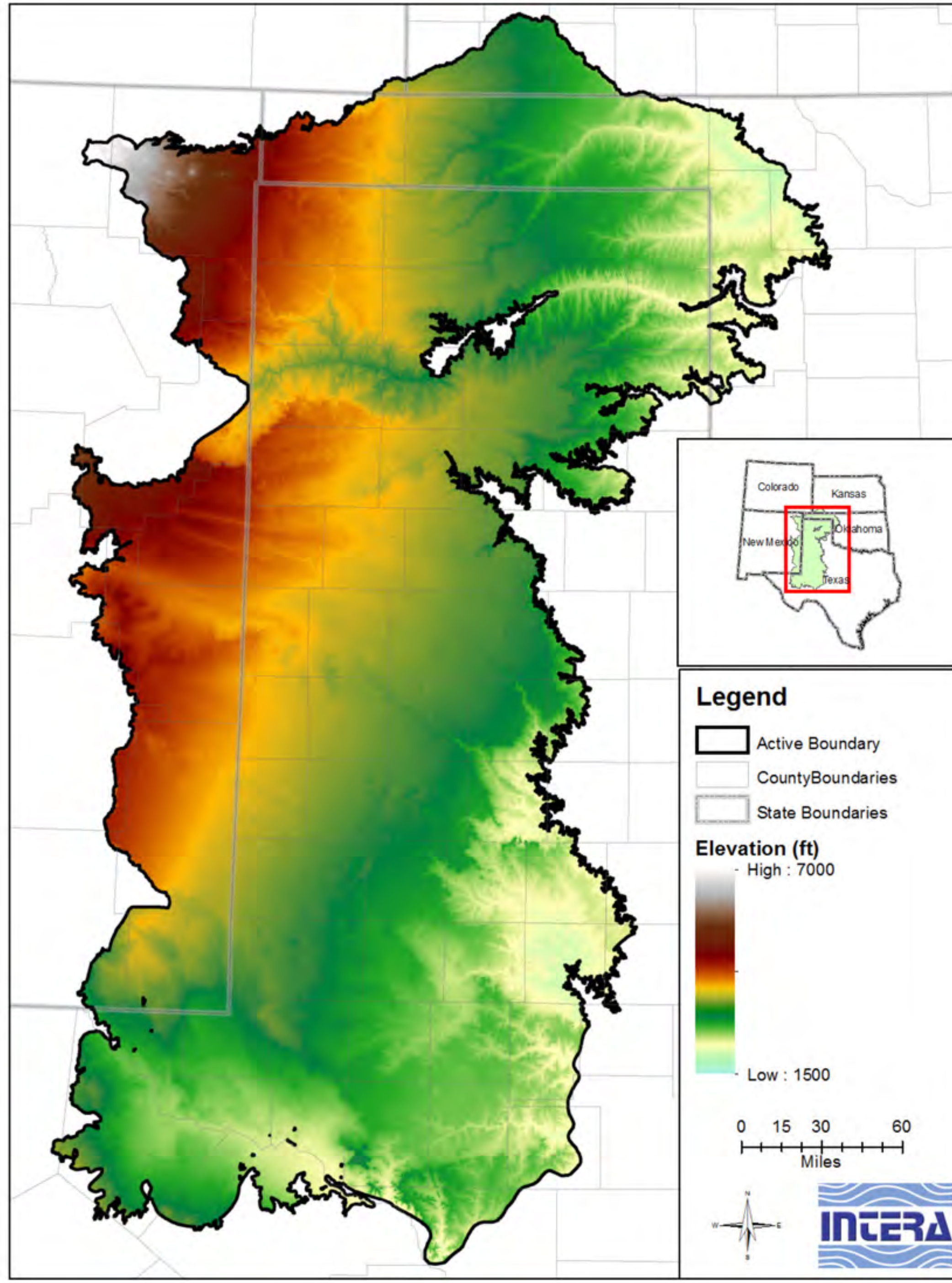


Groundwater Conservation Districts



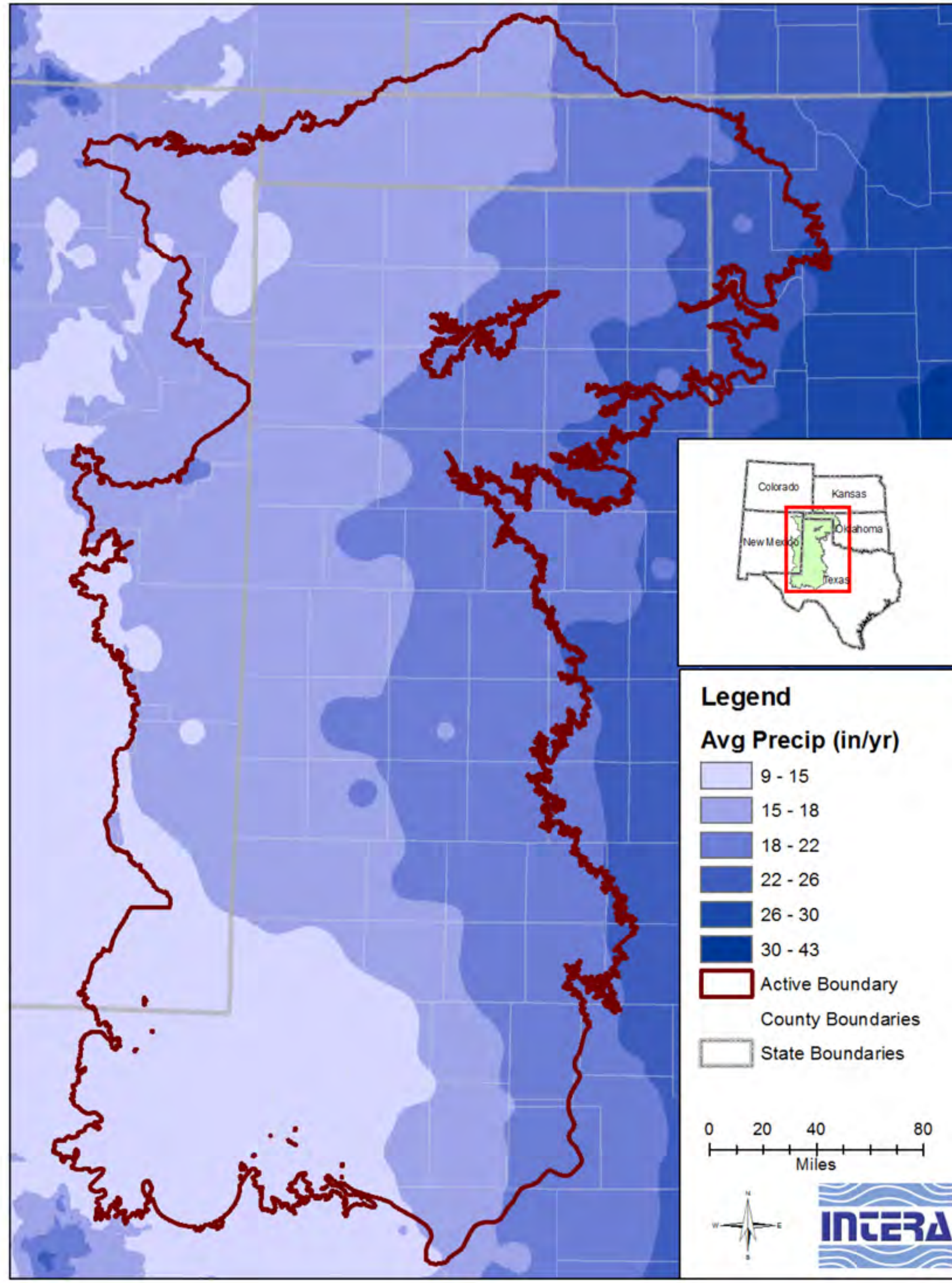
Topography (Feet above mean sea level)

Source: USGS



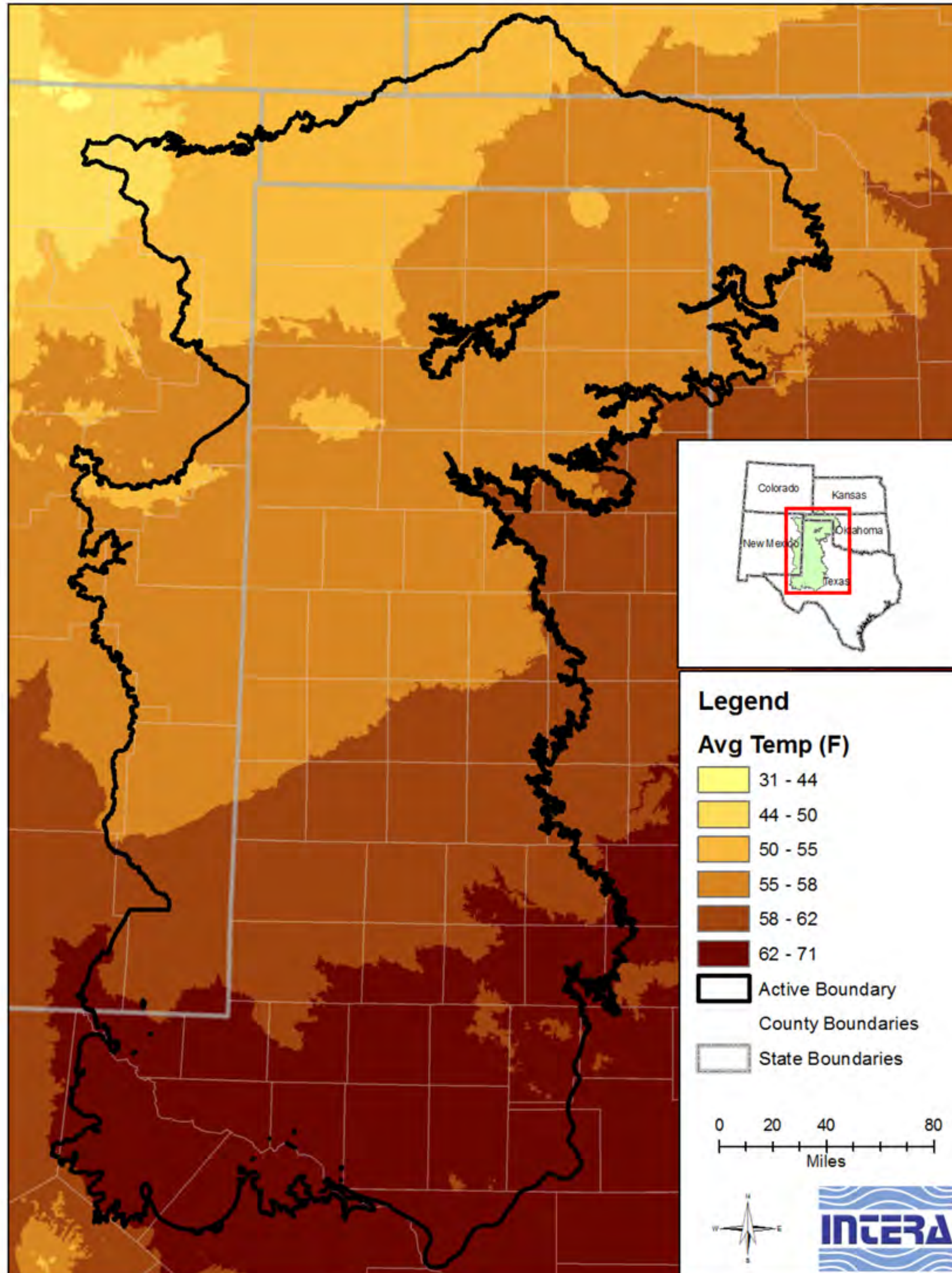
Annual Average Precipitation 1971- 2000

Source: Oregon State University PRISM Climate Data Group

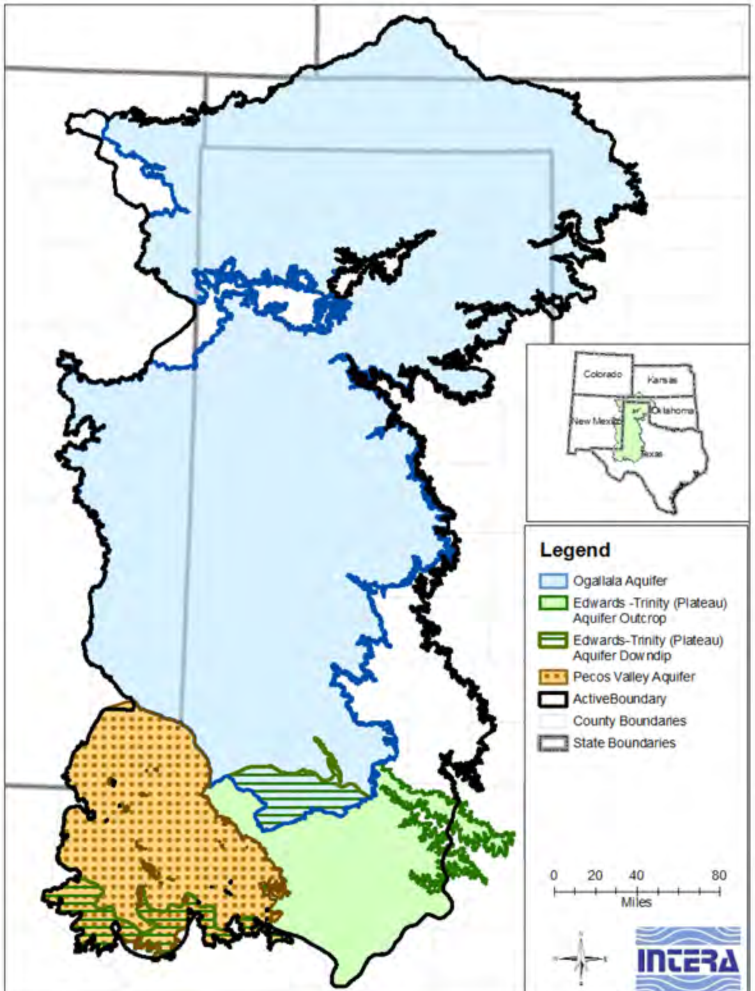


Annual Average Temperature 1971- 2000

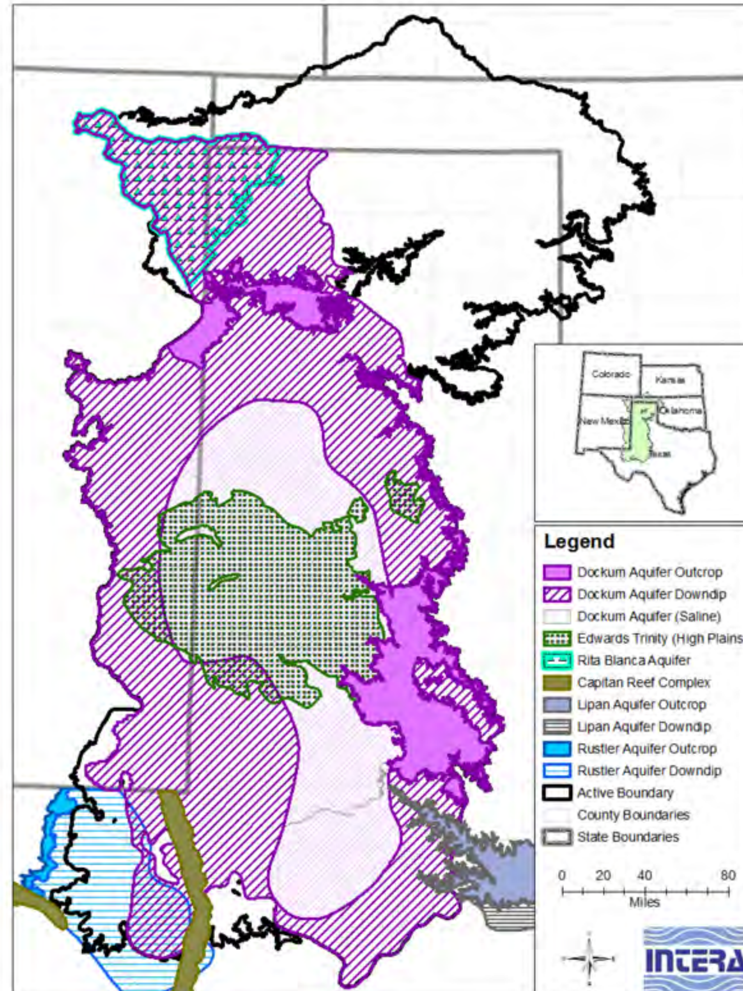
Source: Oregon State University PRISM Climate Data Group



High Plains Aquifer Boundaries

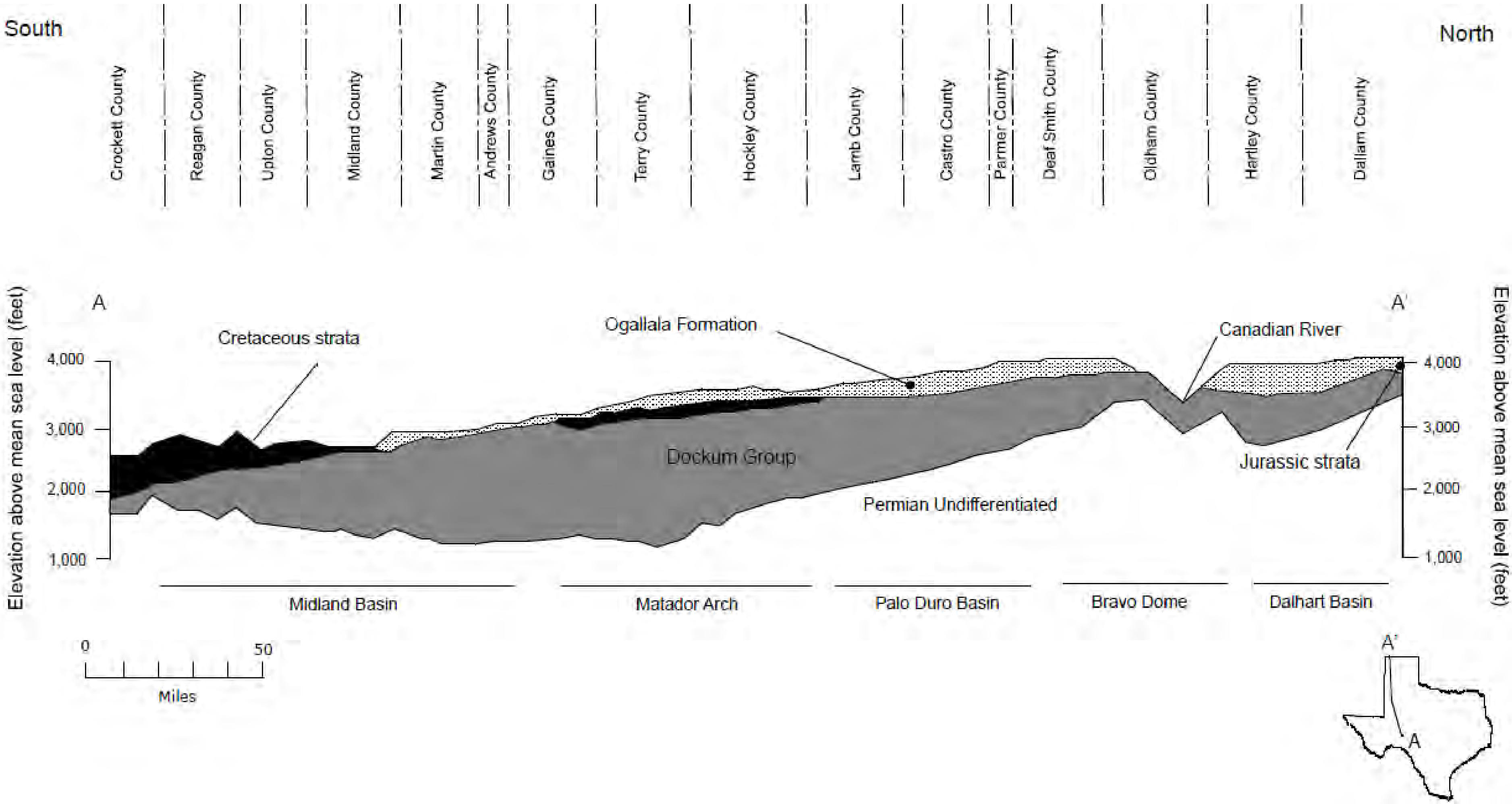


Major Aquifers



Minor Aquifers

Cross-Section



Source: Bradley and Kalaswad (2003)

Model Layering

System	Formation		Aquifer	Model Layer North	Model Layer Central	Model Layer South
Quaternary	Pecos Valley Alluvium		Pecos Valley			1
Tertiary	Ogallala		Ogallala	1	1	
Cretaceous	Duck Creek[ǁ]	Boracho[‡]	Edwards -Trinity		2[ǁ]	2[‡]
	Kiamichi[ǁ]	Finlay[‡]				
	Edwards[ǁ]					
	Comanche Peak[ǁ]					
	Walnut[ǁ]					
	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			

ǁ 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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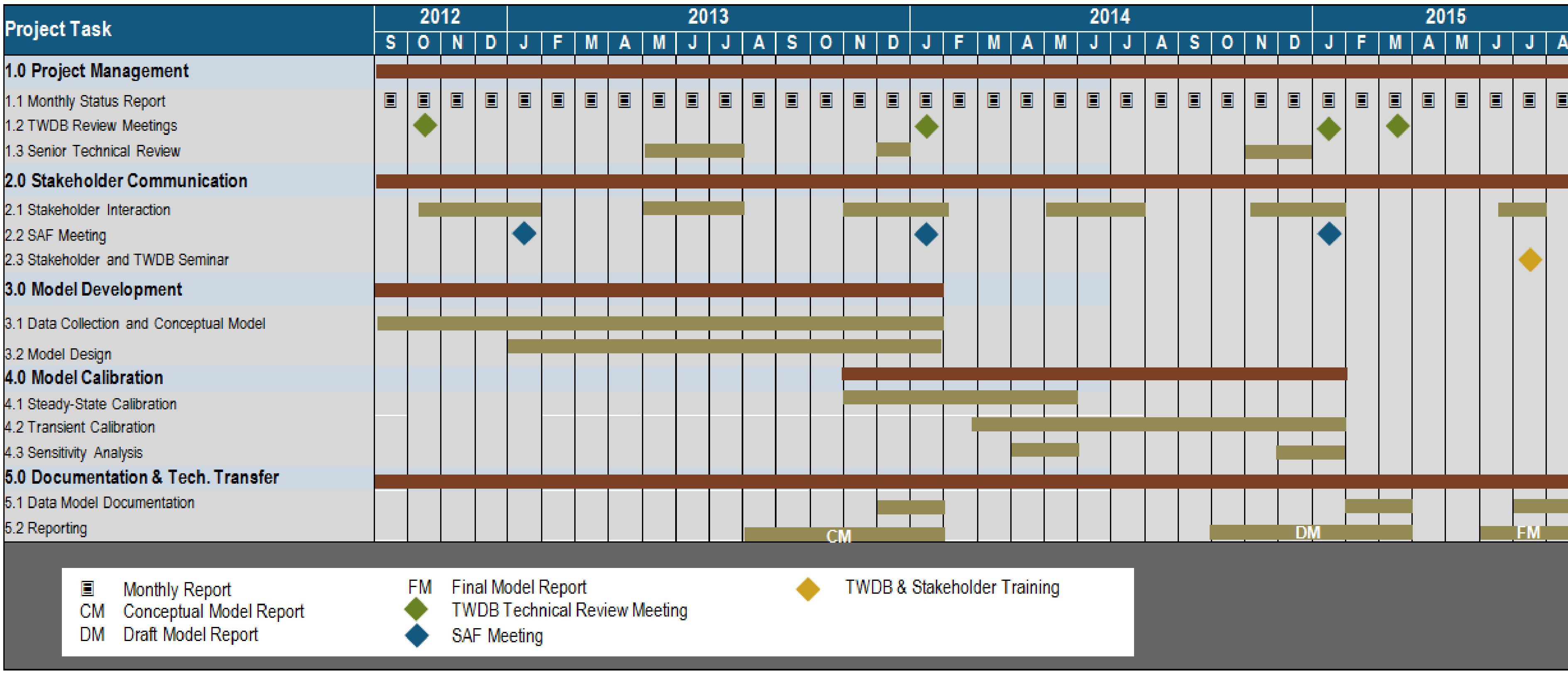
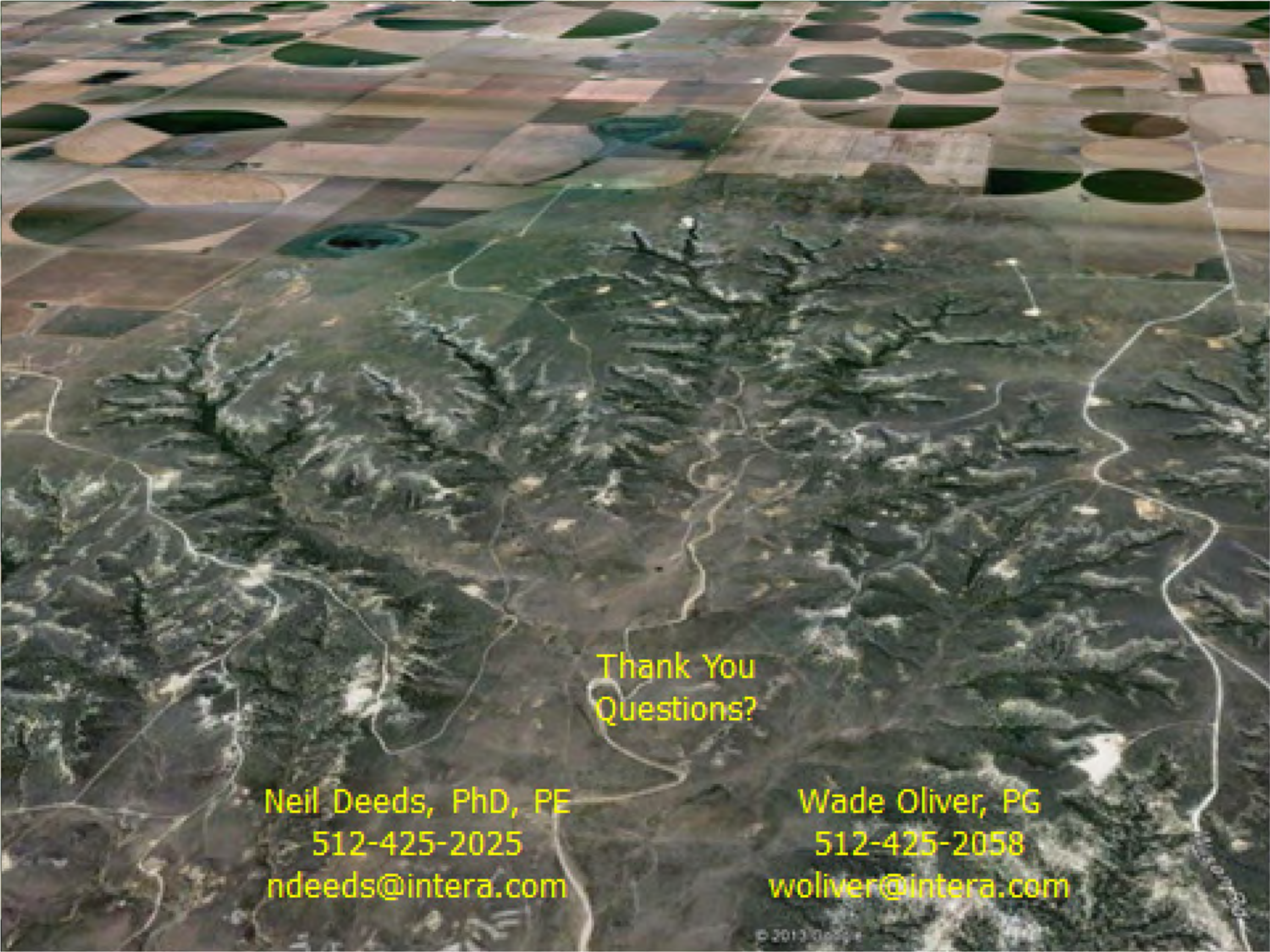
Data Request

- Any un-published data to support the model
  - Geophysical logs
  - Pump tests
  - Water levels
  - Interpreted properties
  - Structural picks
  - Production information
- Data request by March 31, 2013

Tasks and Proposed Schedule




Thank You
Questions?
Neil Deeds, PhD, PE
512-425-2025
ndeeds@intera.com
Wade Oliver, PG
512-425-2058
woliver@intera.com
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