Stakeholder Advisory Forum (SAF #1):

Seymour and Blaine Aquifers Groundwater Availability Model

January 22nd, 2025

TEXAS WATER DEVELOPMENT BOARD

INTERA

Meeting information

- An audio and video recording of the meeting, presentation, and the report summarizing the meeting will be made available on the project's TWDB webpage

- https://www.twdb.texas.gov/groundwater/models/gam/symr/symr.asp

Why Stakeholder Advisory Forums?

Keep stakeholders updated about progress of the modeling project

Inform how the groundwater model can, should, and should not be used

Provide stakeholders with the opportunity to provide input and data to assist with model development

Agenda

1. **Introduction**
   - **Project Objectives**
   - **Project Team**
2. Background
   - Basics of Groundwater Flow
   - Numerical Groundwater Modeling
3. GAM Specifics
   - Model Conceptualization
   - Model Development
   - Model Limitations
4. Data
   - Key Data Sources
   - Data Requests
5. Schedule
   - Project Schedule

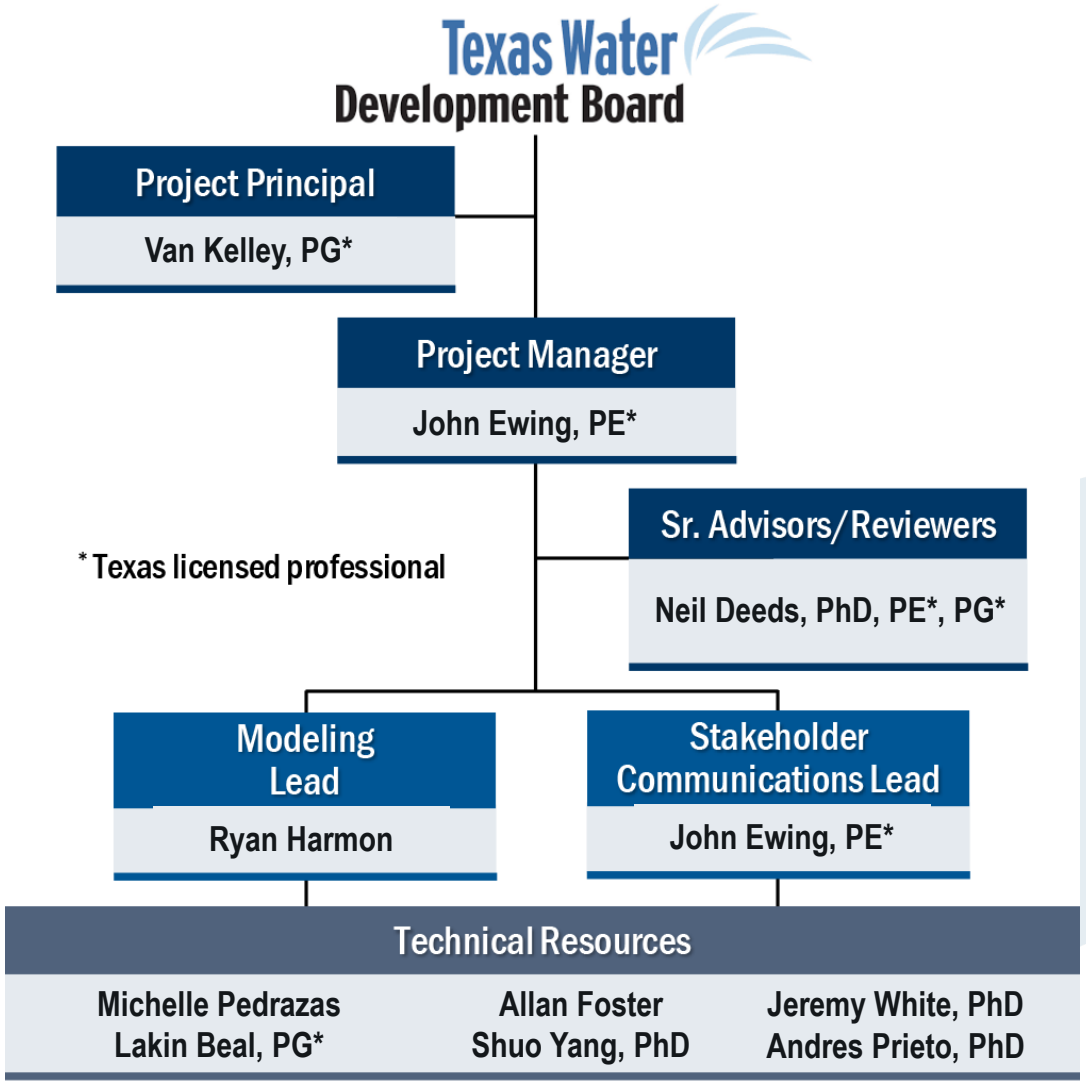
INTERA

Project Objectives

- Develop a GAM with appropriate complexity and uncertainty to represent the Seymour & Blaine aquifers
- Promote stakeholder participation which is critical to the success of the GAM program
- Provide a thoroughly documented database and model, available to the public
- Provide a tool to help GCDs, RWPGs, and other interested parties assess groundwater availability
- Provide a tool for assessing DFC of the aquifer/MAG

Acronyms:
GAM: Groundwater Availability Model
GCD: Groundwater Conservation District
RWPG: Regional Water Planning Group
DFC: Desired Future Condition
MAG: Modeled Available Groundwater

Project Team



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Groundwater Availability Modeling (GAM) Program

- Purpose: to develop tools that can be used to help Groundwater Conservation Districts, Regional Water Planning Groups, 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 are available online.
- Living tools: periodically updated.

Texas Water Development Board

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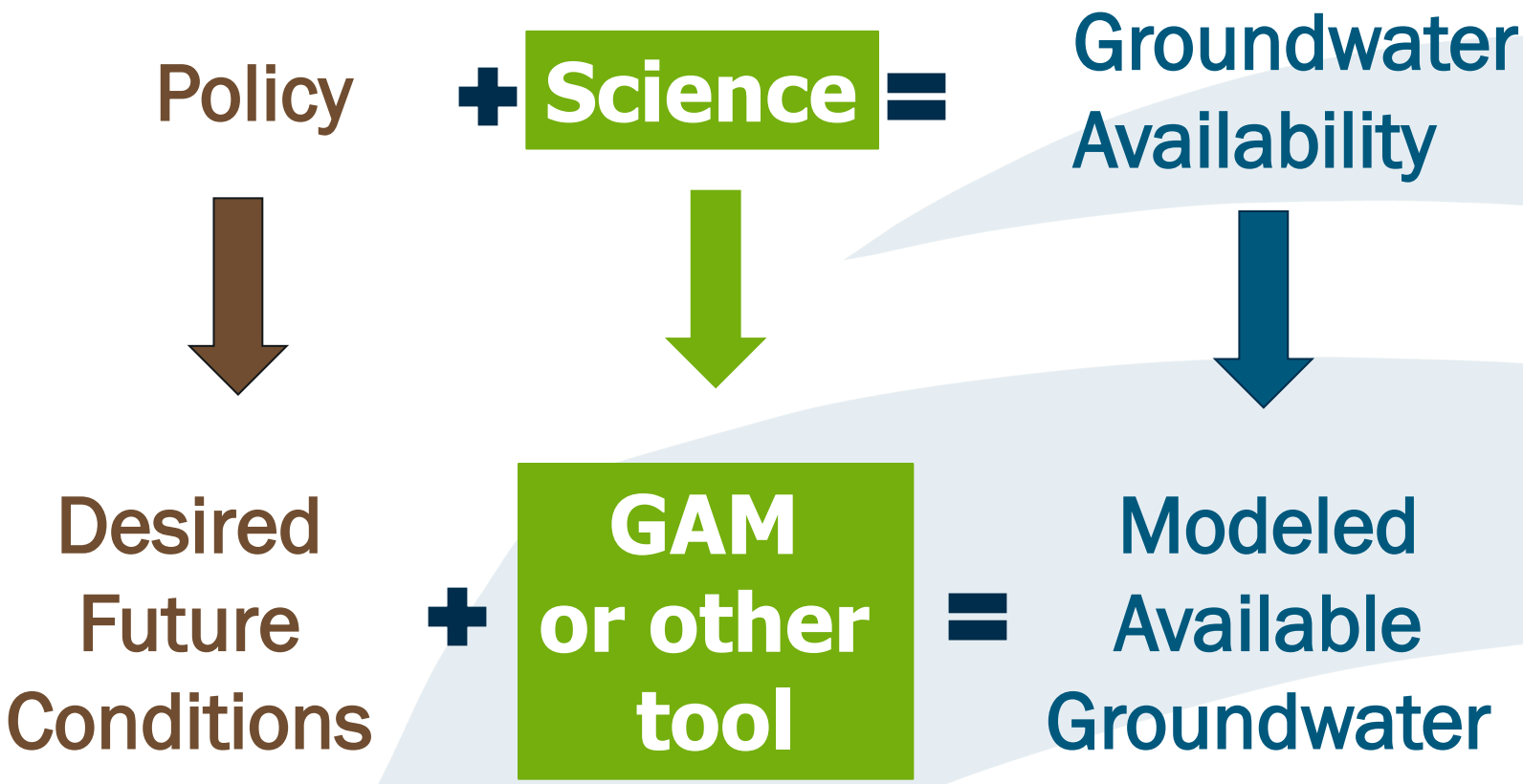
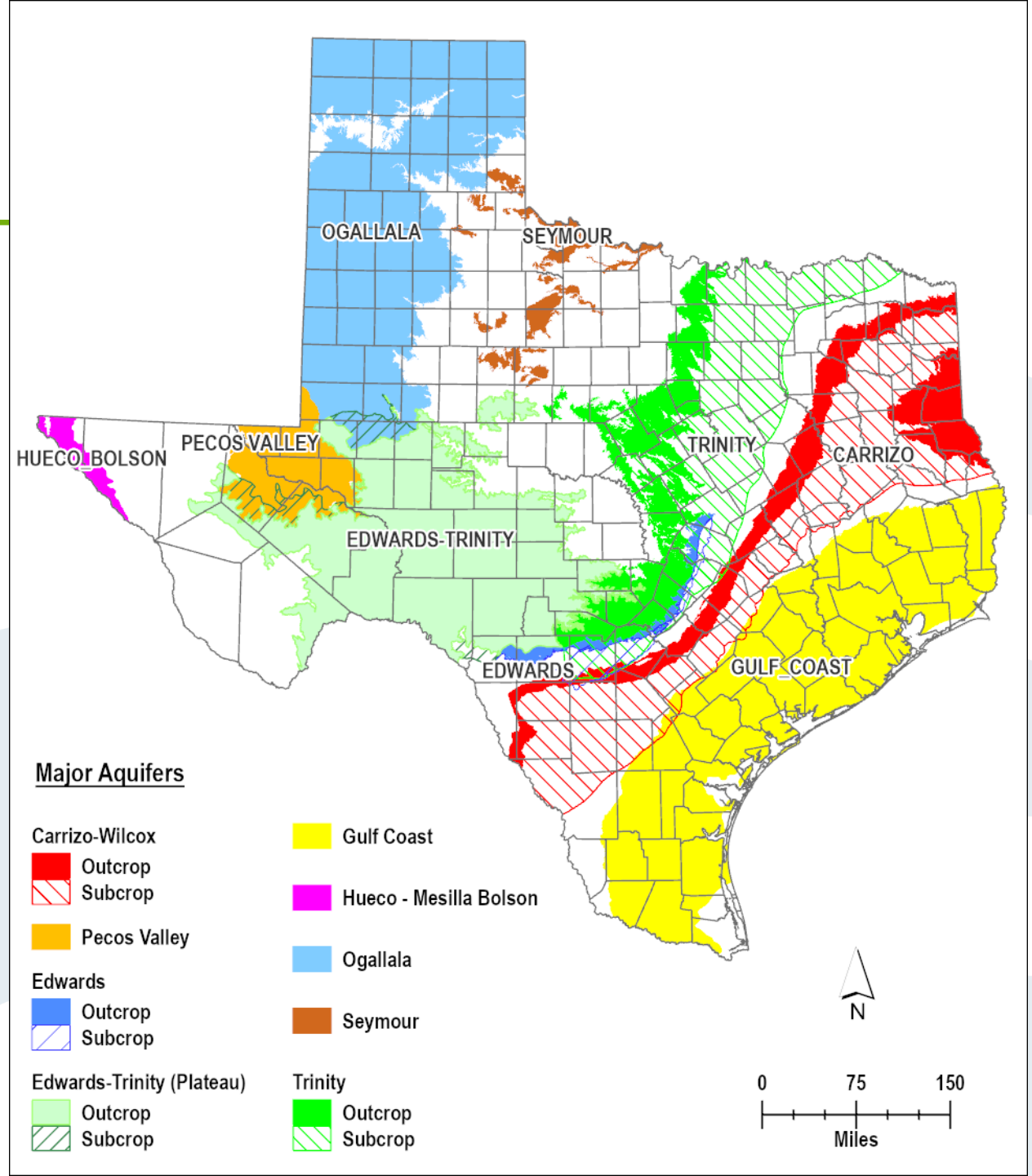
What is Groundwater Availability?

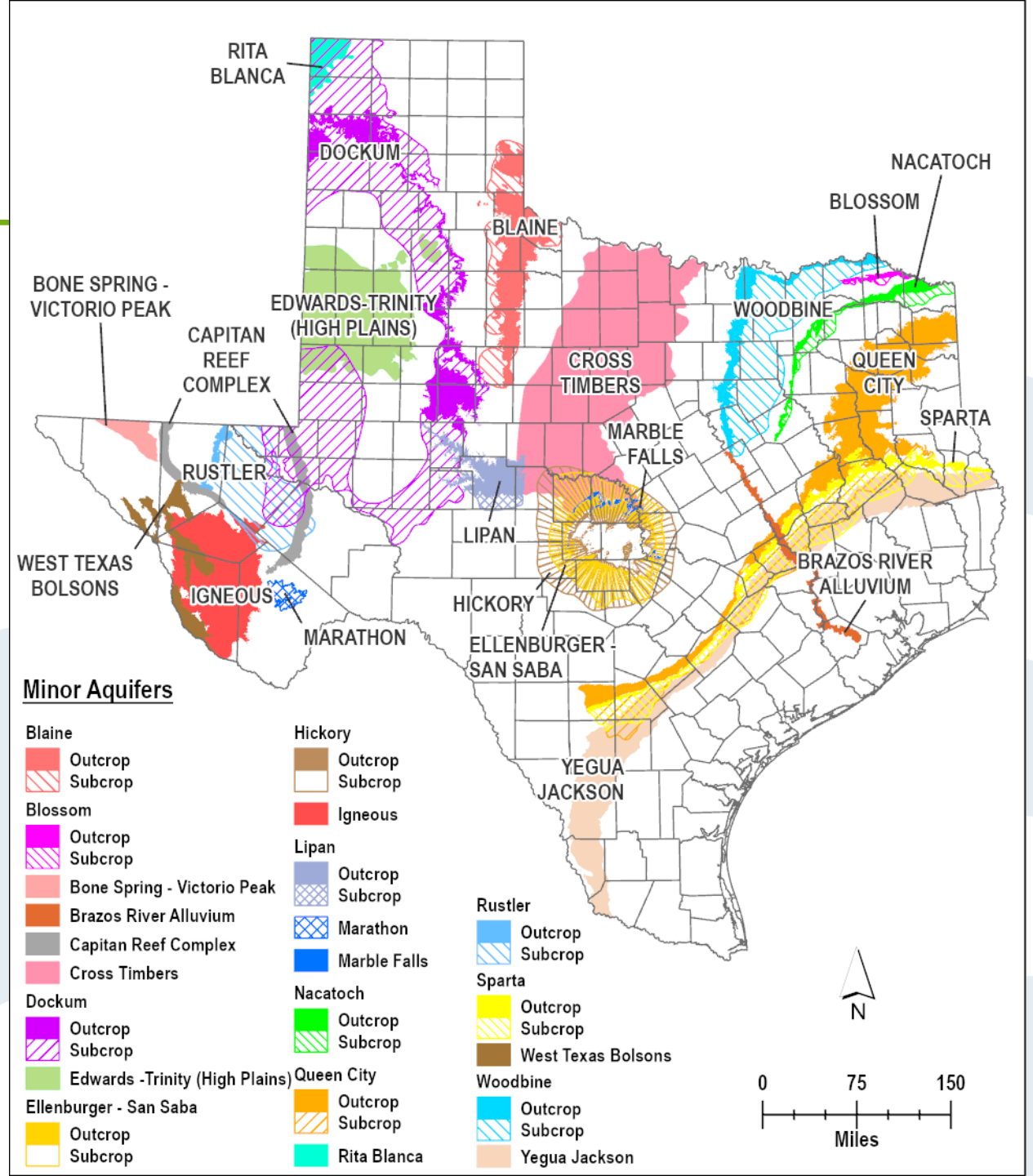


Goal: informed decision-making

Major Aquifers

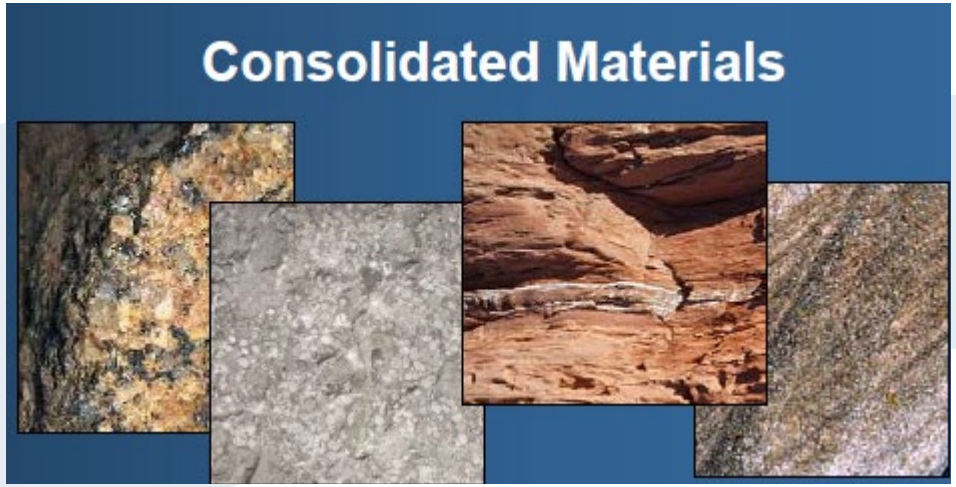


Minor Aquifers



What is an aquifer?

- An aquifer is a geologic media that can yield **economically usable amounts of water**.
- permeable rock, sand, gravel, or sediment



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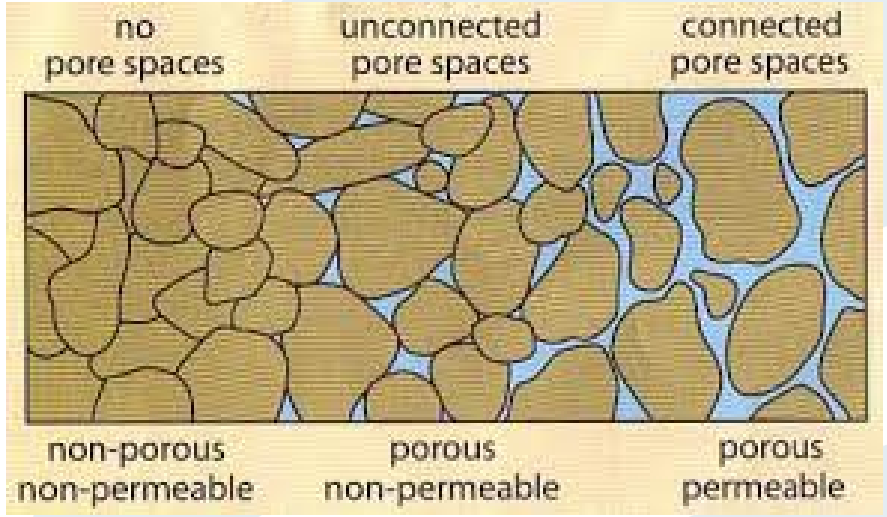
What is an aquifer?

An aquifer needs to **store** and **transmit** groundwater.

- **Porosity:** The amount of pore space in the material, determining how much water the aquifer can store.
- **Permeability:** The ability of the material to transmit water, affecting how quickly water moves through the aquifer.



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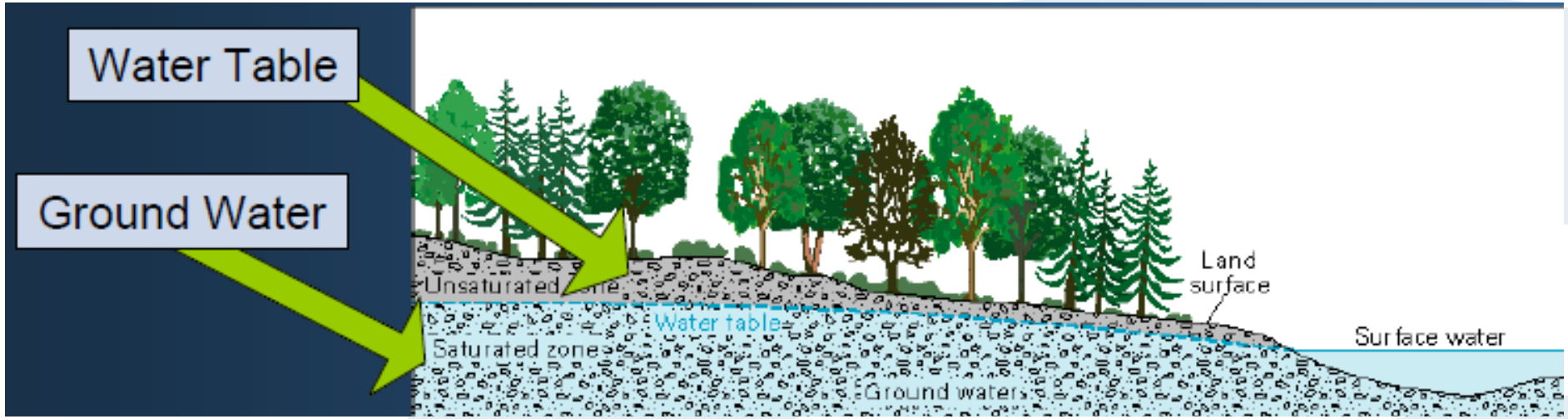
What is an aquitard?

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

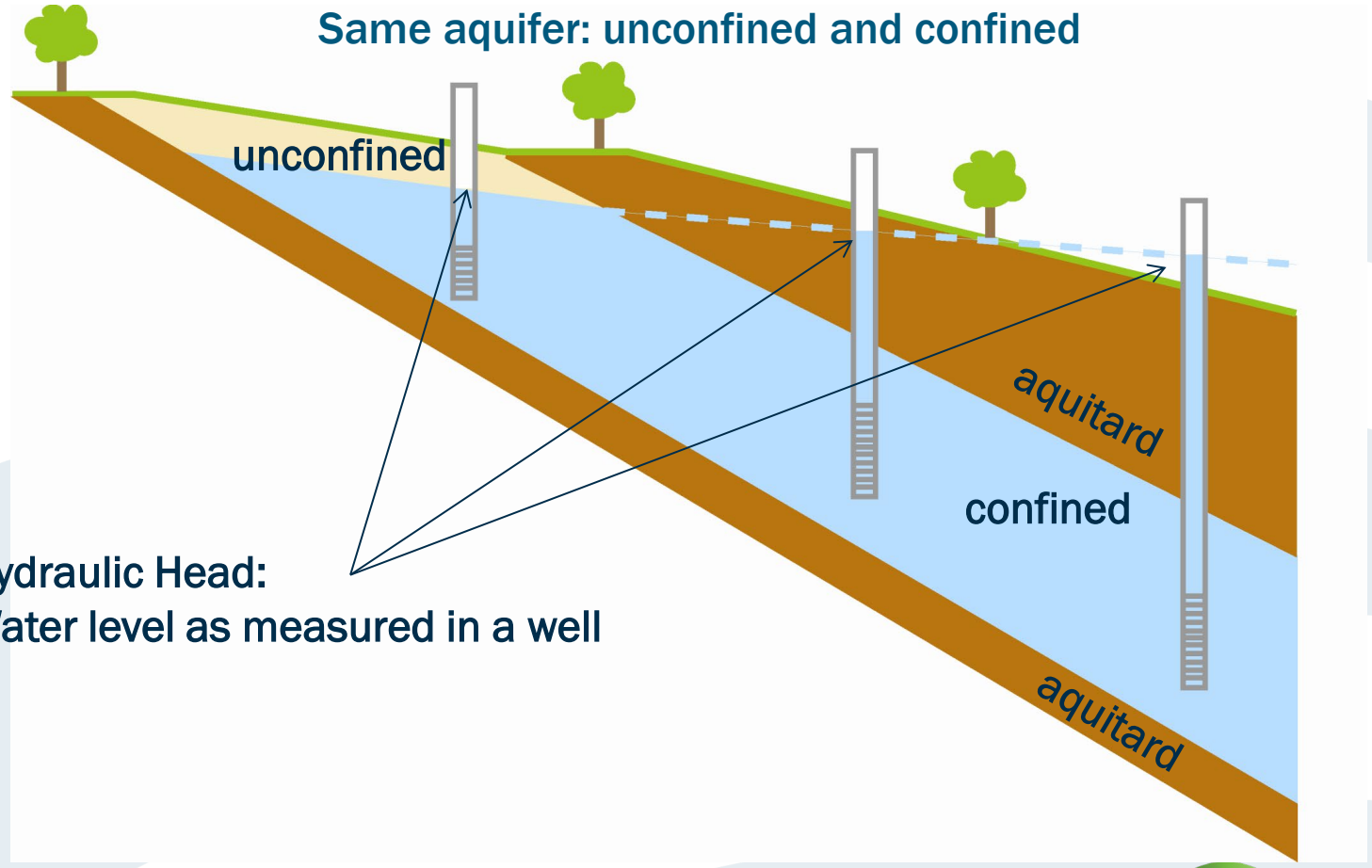
What is a water table?

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



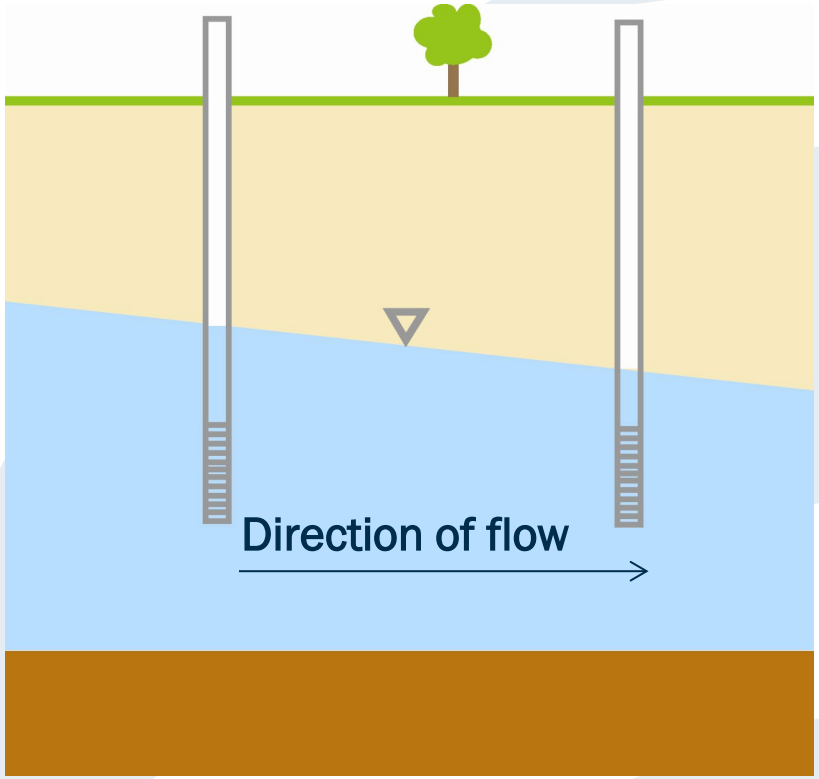
Types of Aquifer

- **Unconfined Aquifer:** The water table marks the upper boundary. Water is directly influenced by surface recharge (e.g., rainfall).
- **Confined Aquifer:** Bounded by impermeable layers (aquitards) above and below. Water is under pressure, often leading to artesian wells.



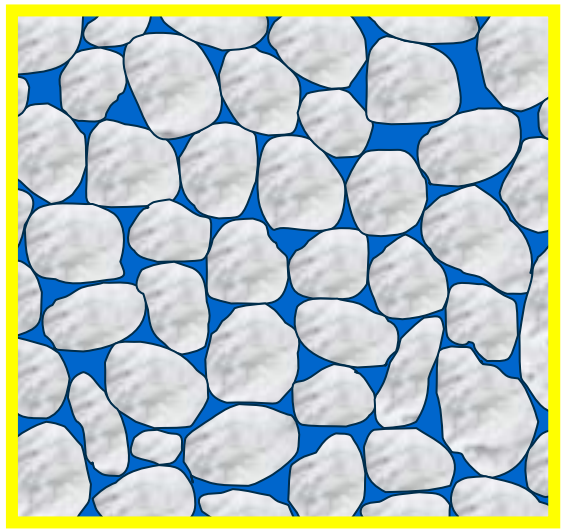
Groundwater Flow

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

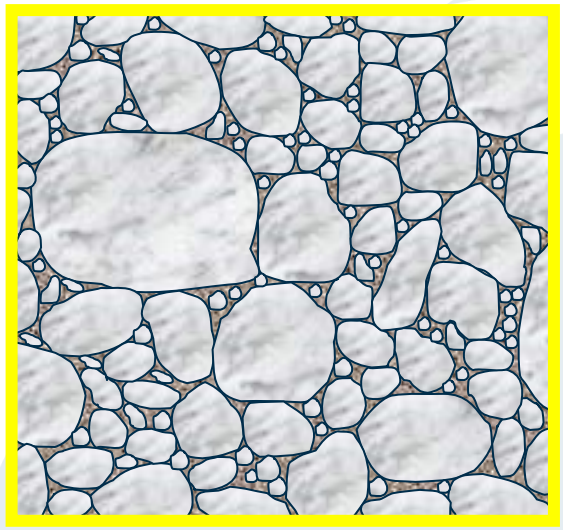


Aquifer Properties

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



WELL SORTED
Coarse (sand-gravel)



POORLY SORTED
Coarse - Fine

WELL SORTED
Fine (silt-clay)

High ⟵ Permeability and Hydraulic Conductivity ⟶ Low

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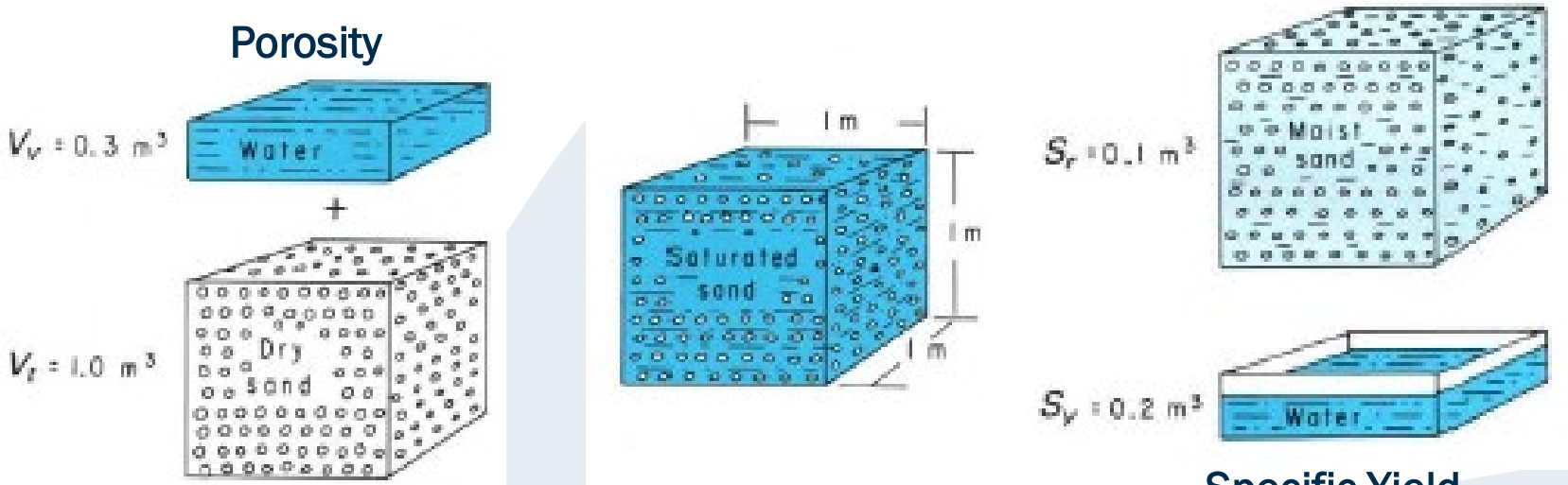
Aquifer Properties

- 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.



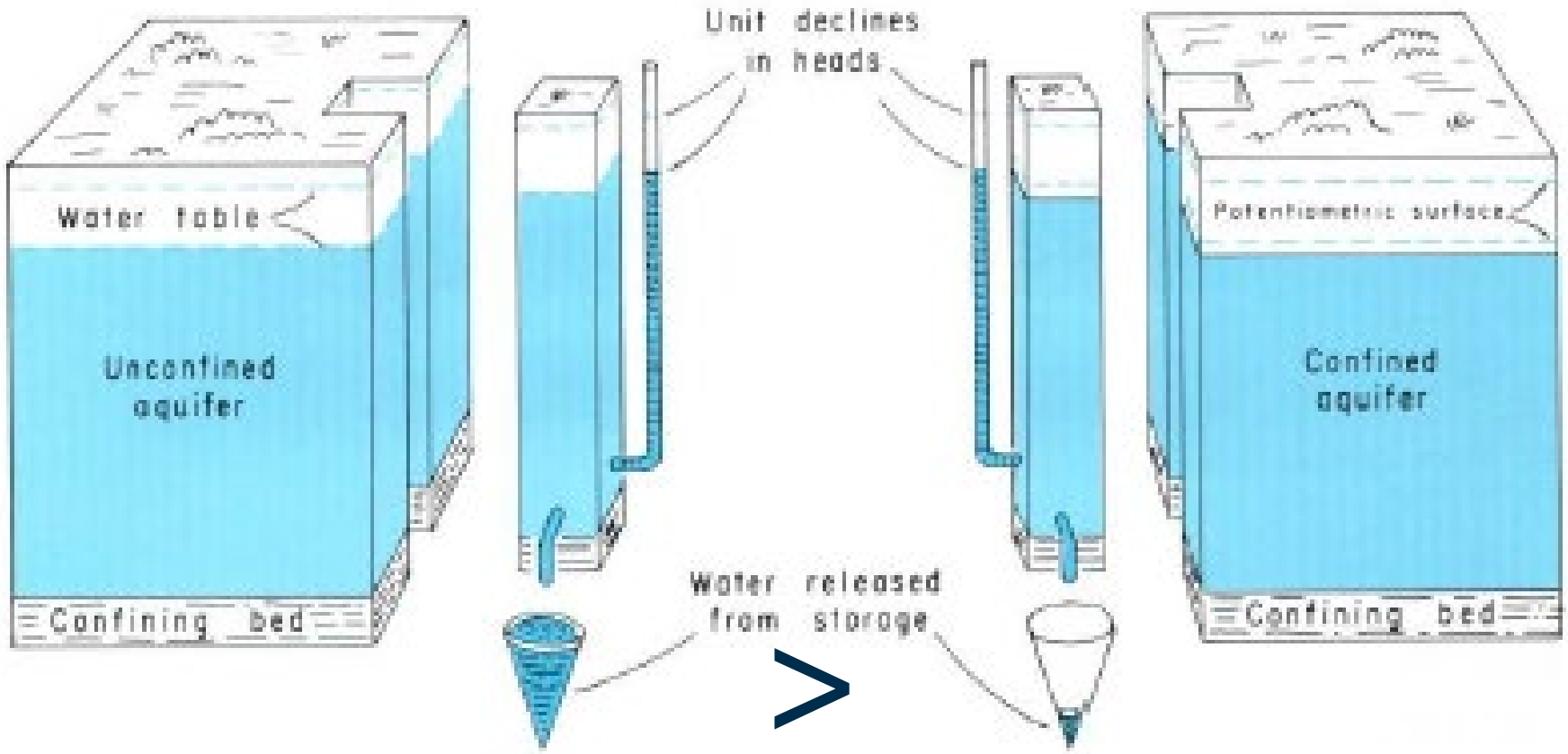
From Heath (1983)

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

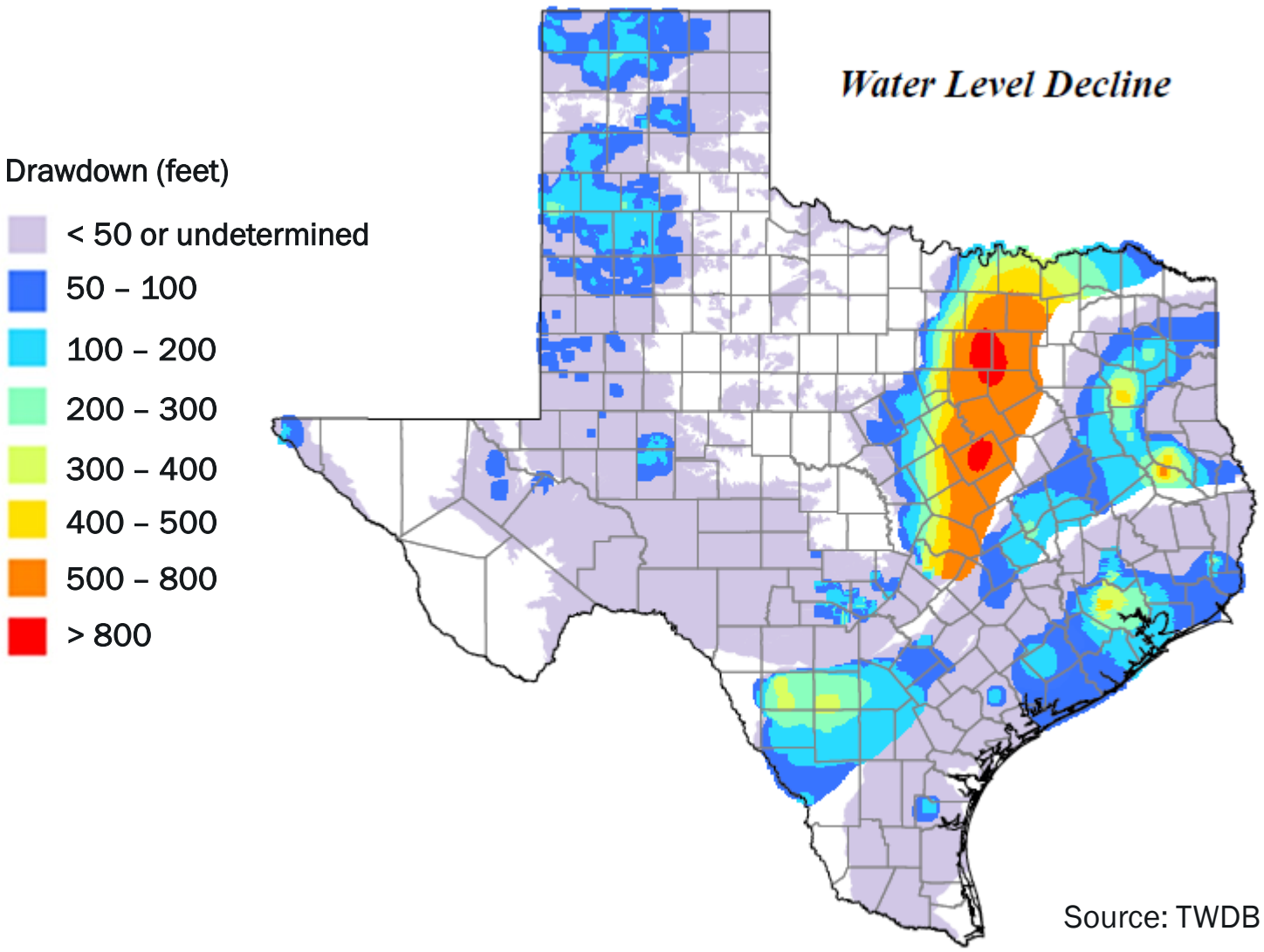
INTERA

Specific Yield vs. Storativity



From Heath (1983)

Specific Yield vs. Storativity



Source: TWDB

Historically, approximately **40x more pumping** from Ogallala Aquifer (unconfined) than from Northern Trinity Aquifer (confined)

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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.

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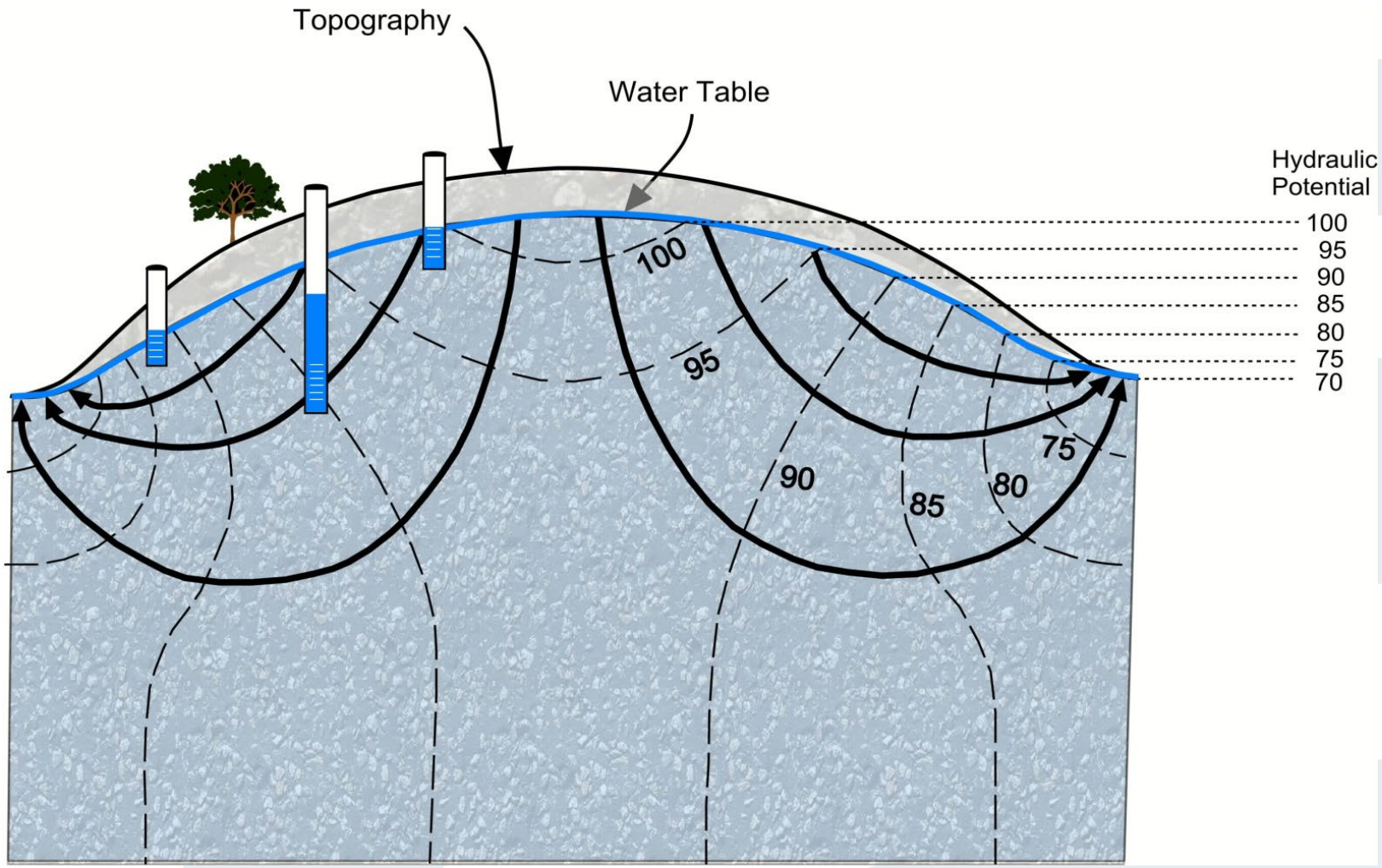
Schematic Cross Section of Groundwater Flow

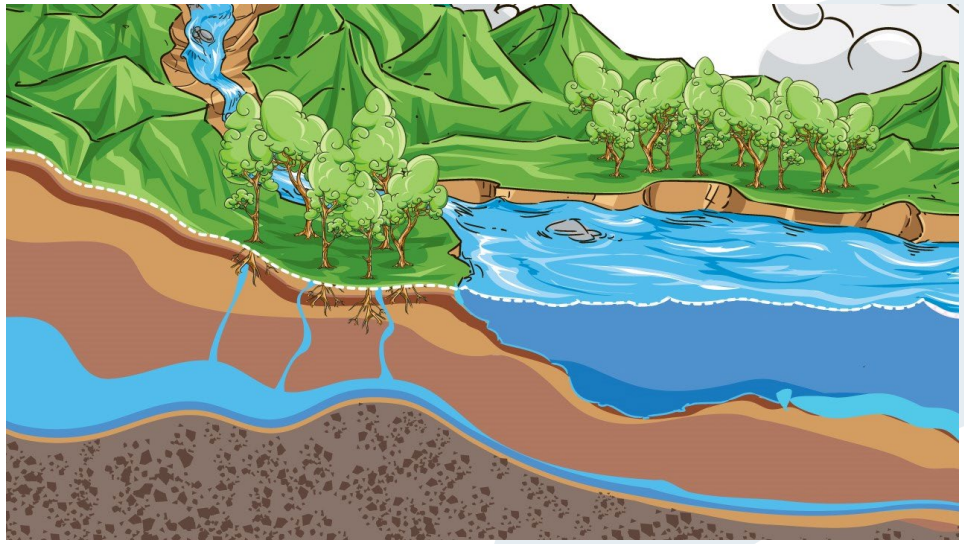
— flow lines

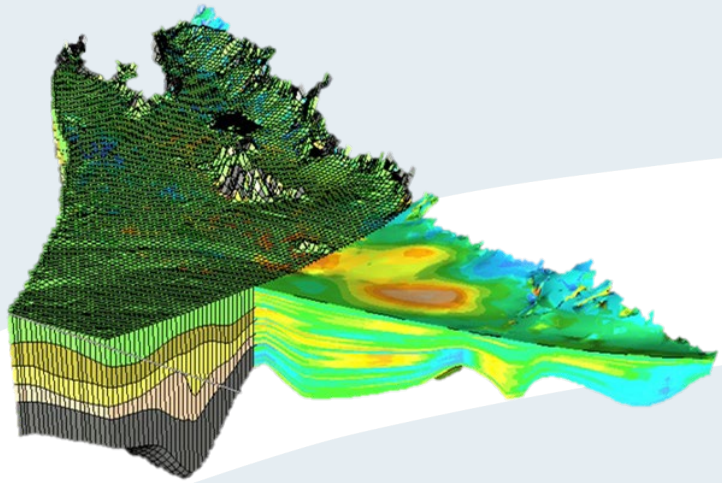
– - equipotential lines



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





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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

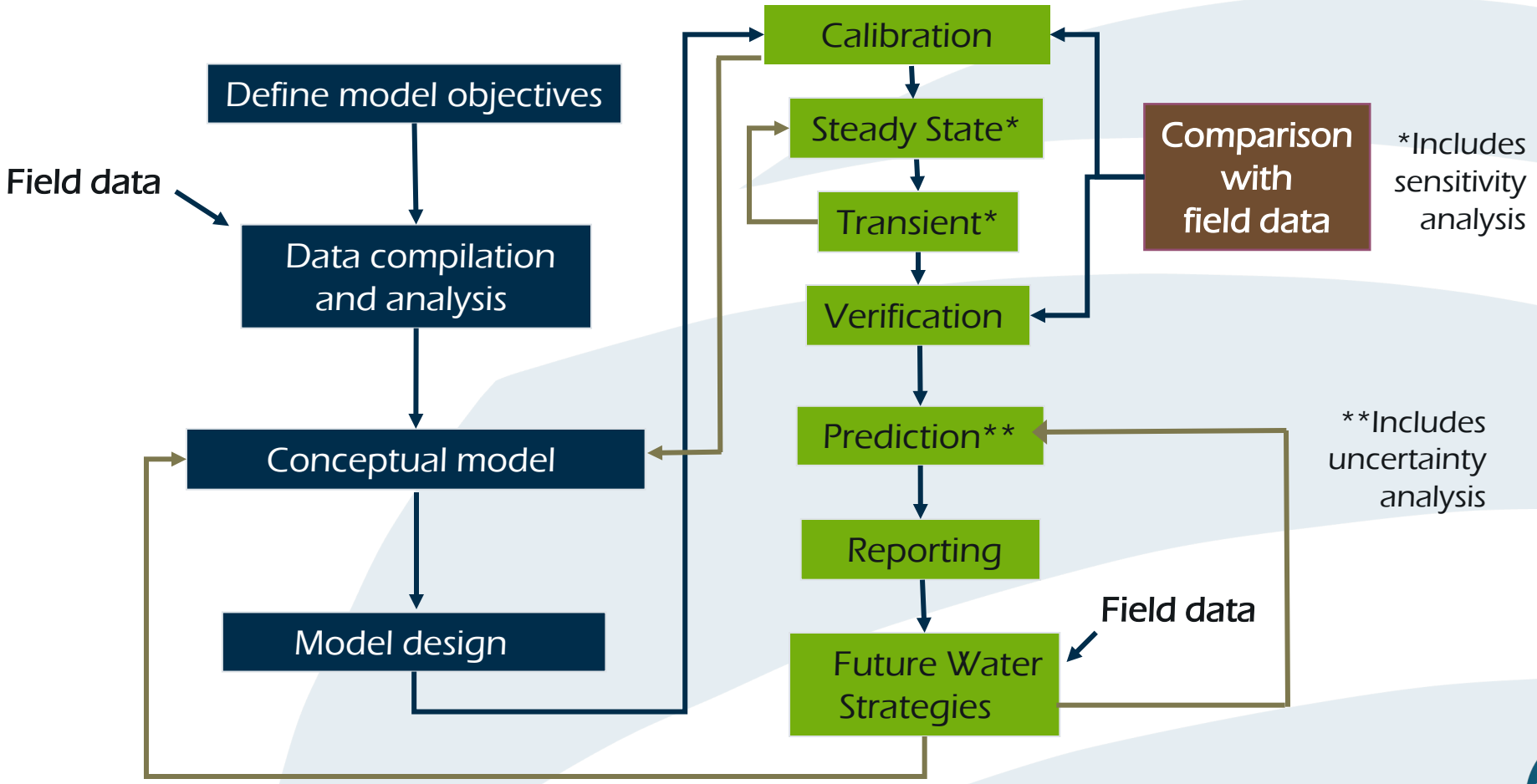
INTERA

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

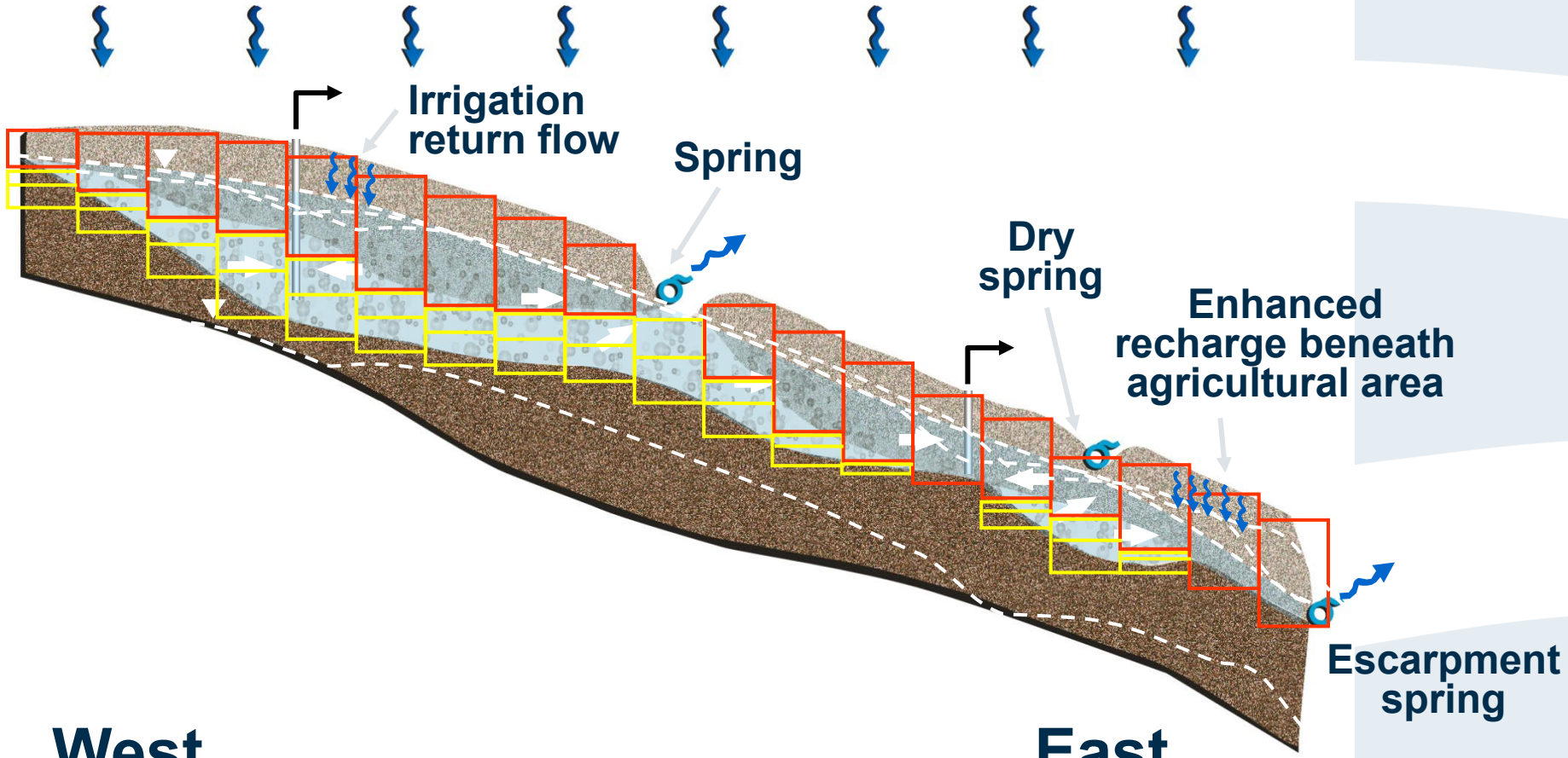
INTERA

Modeling Protocol



Start with a conceptual model

Divide it up into cells



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   - Data Source Review
   - Database Development
   - Data Request & Data Needs
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INTERA

MODFLOW

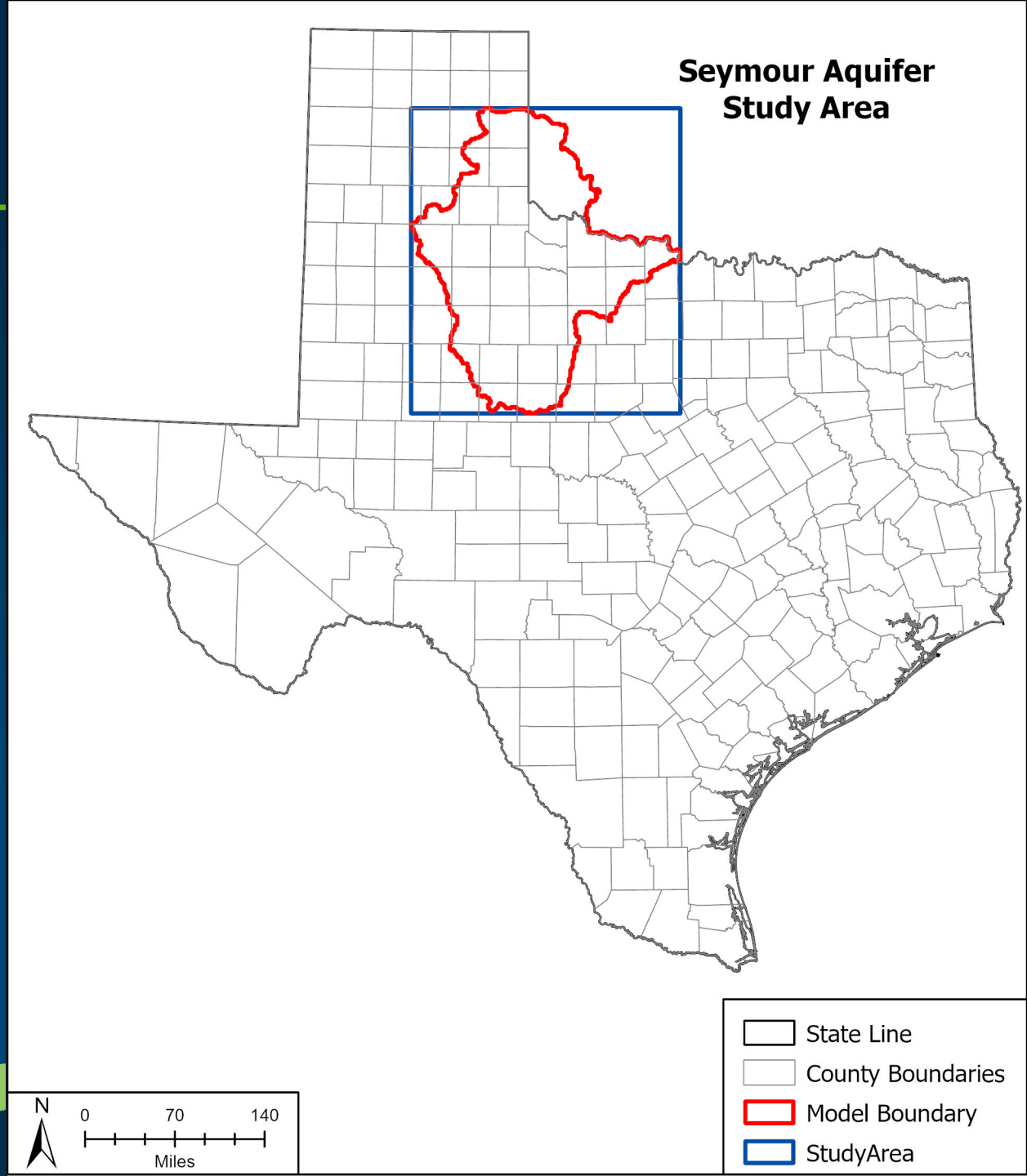
- Code developed by the U.S. Geological Survey
- Selected by TWDB for all GAMs
- Handles the relevant processes
- Comprehensive documentation
- Public domain – non-proprietary
- Most widely used groundwater modeling code
- Supporting interface programs available
- Using MODFLOW-6 – most recent standard version

Previous Studies

- Ewing and others (2004) – Original GAM of Seymour and Blaine aquifers 1980-2000
- Scanlon and others (2005) – ET study that includes recommendations for the Seymour
- Jones and others (2012) – Conceptual Model of Seymour pod in Haskell, Knox and Baylor counties
- Jigmond and others (2014) – Refined GAM of Seymour pod in Haskell, Knox and Baylor counties
- Finch and others (2016) – BRACs study of Blaine Aquifer and Whitehorse Formation including structure, water quality and lateral extension of Blaine Aquifer

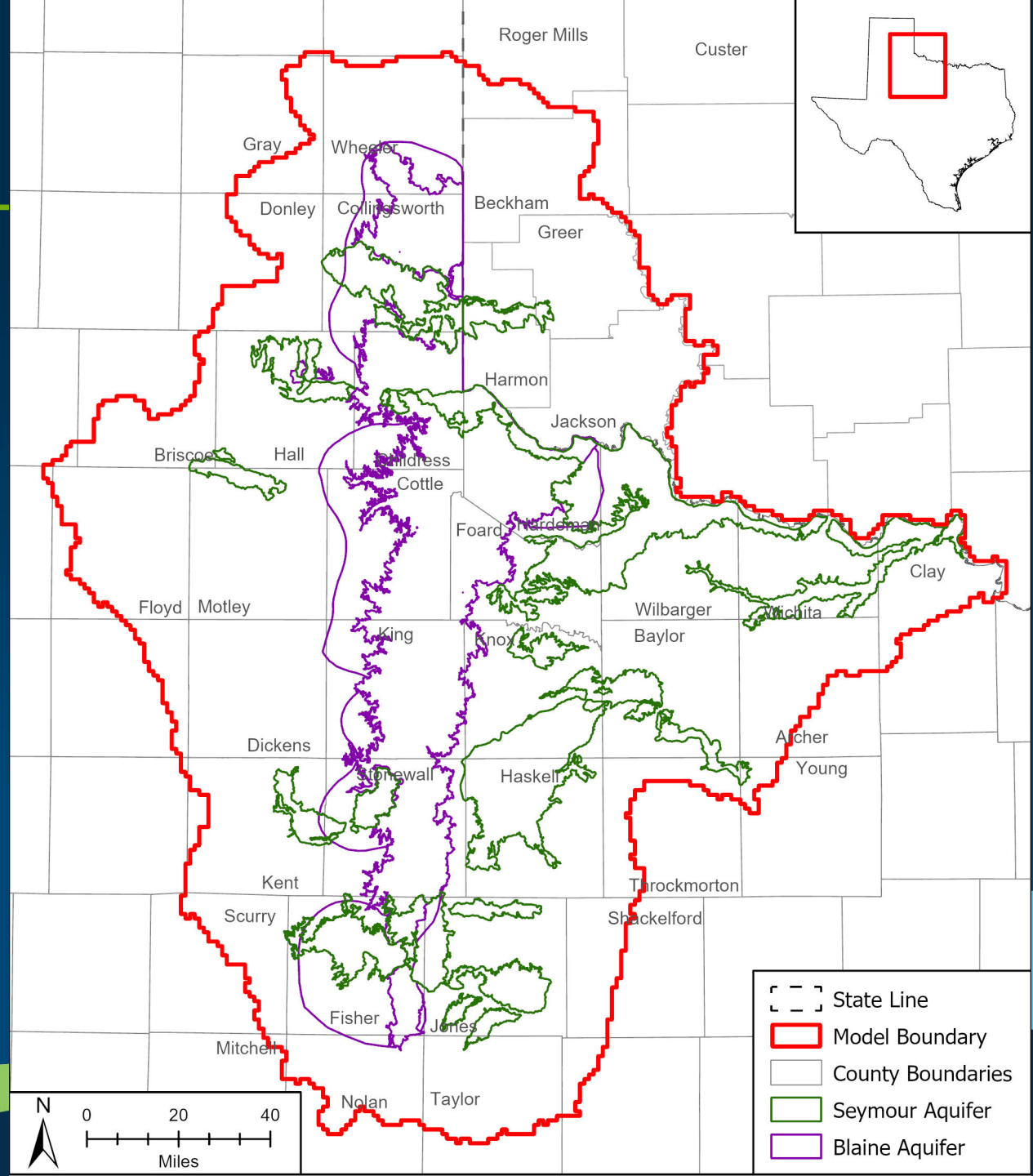
INTERA

Study Area

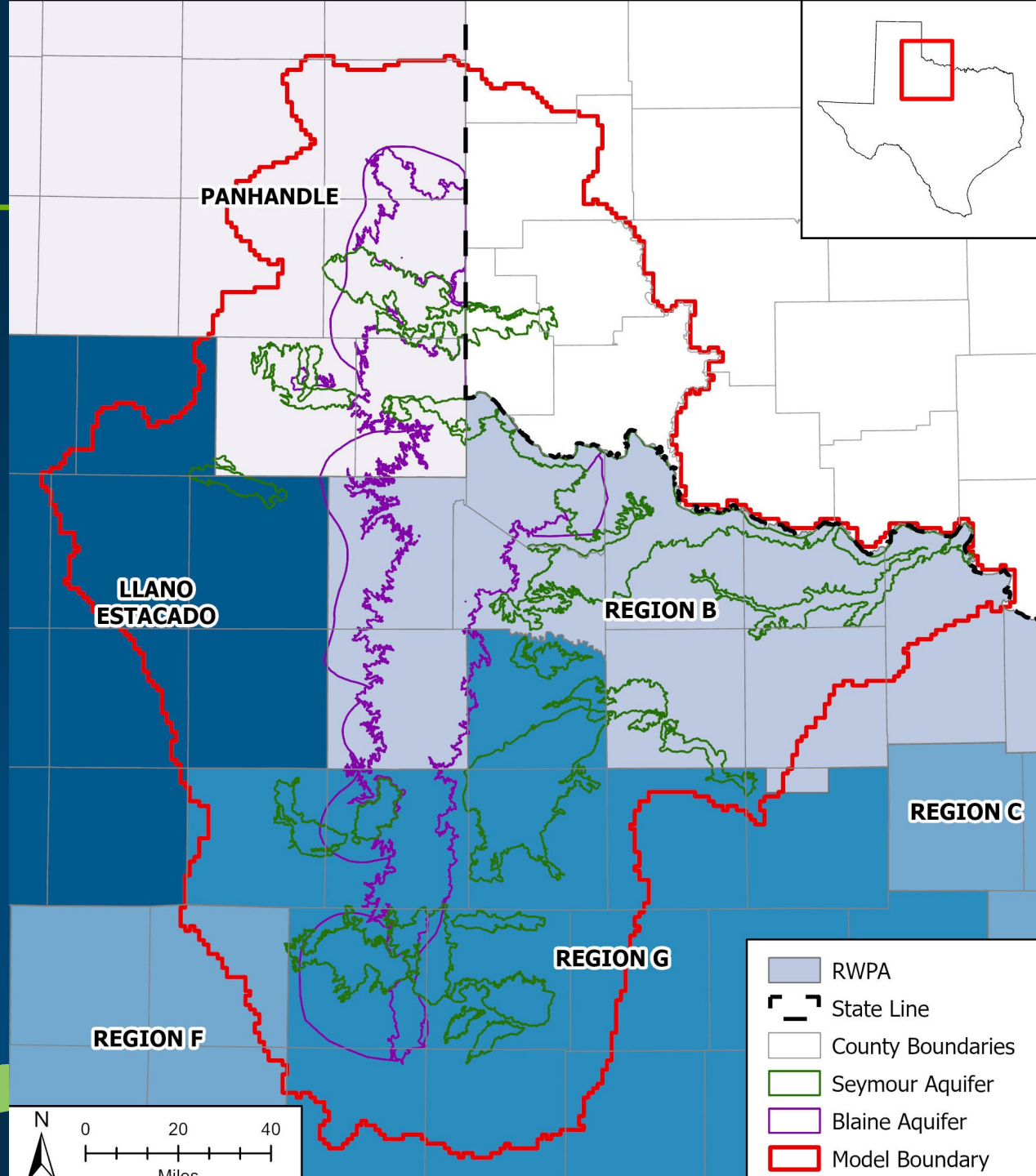

Seymour Aquifer
Study Area
N
0
70
140
Miles
State Line
County Boundaries
Model Boundary
StudyArea

Pods

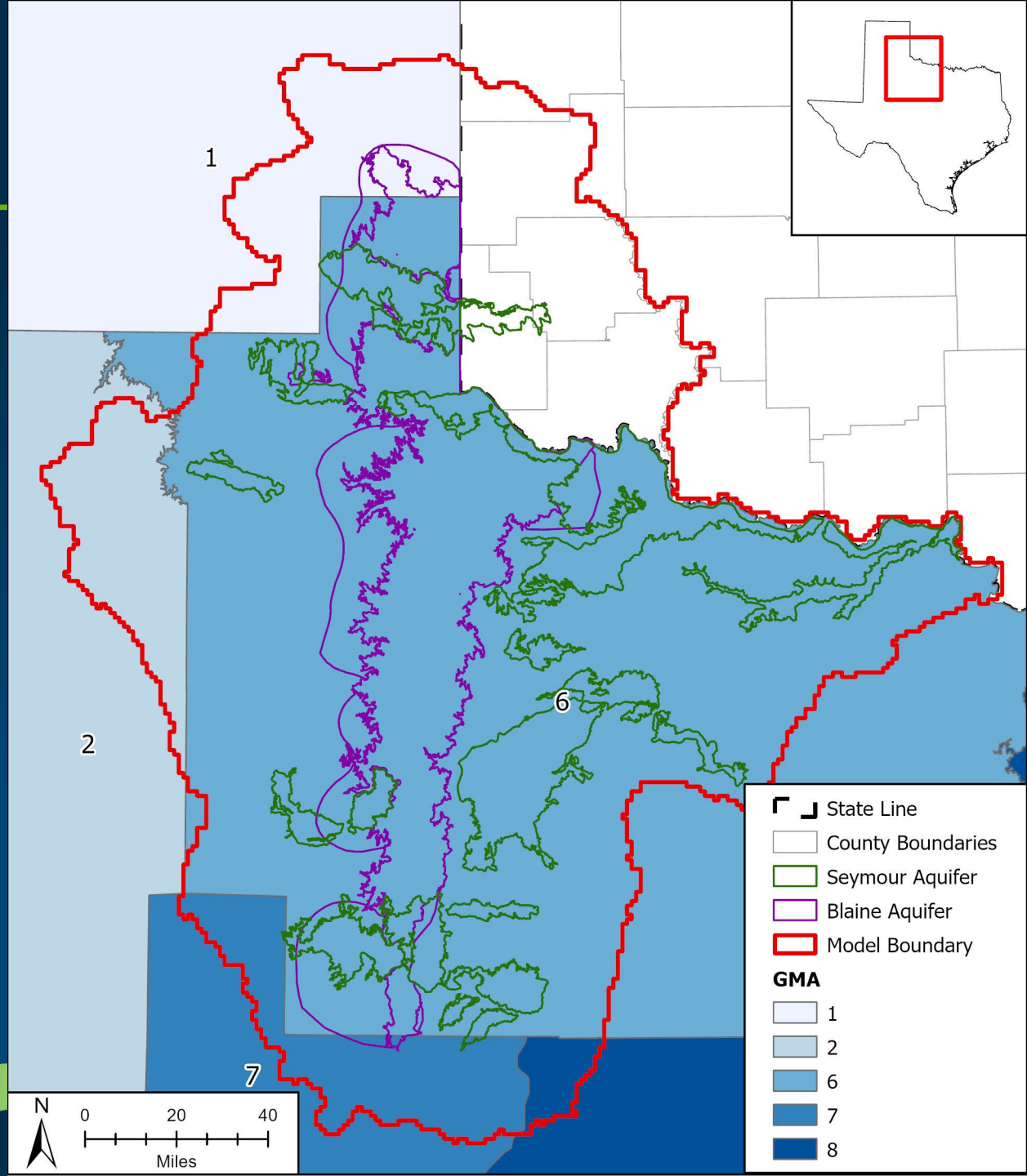
- Seymour Aquifer extent
- Blaine Aquifer extent



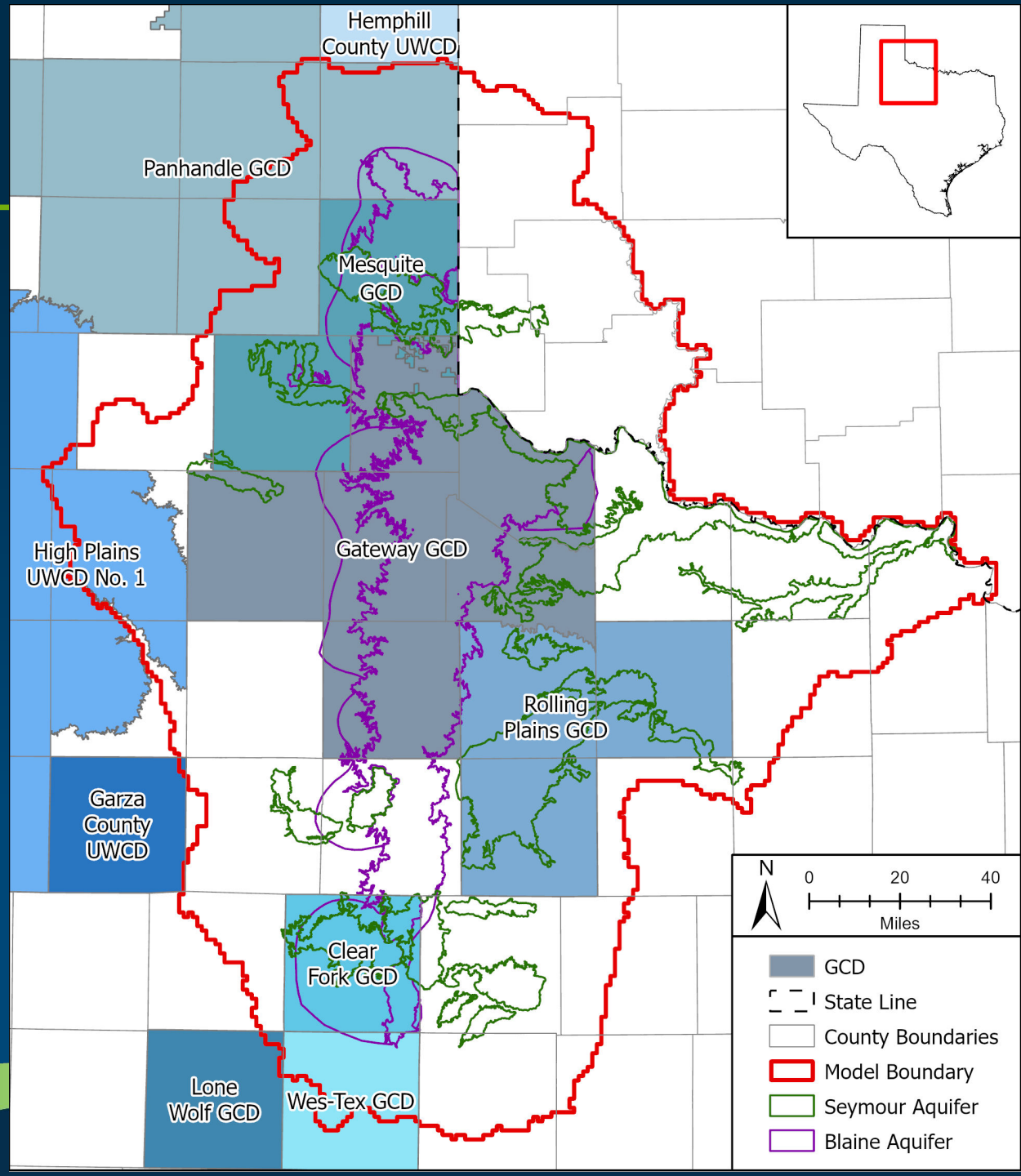
Regional Water Planning Groups



Groundwater Management Areas

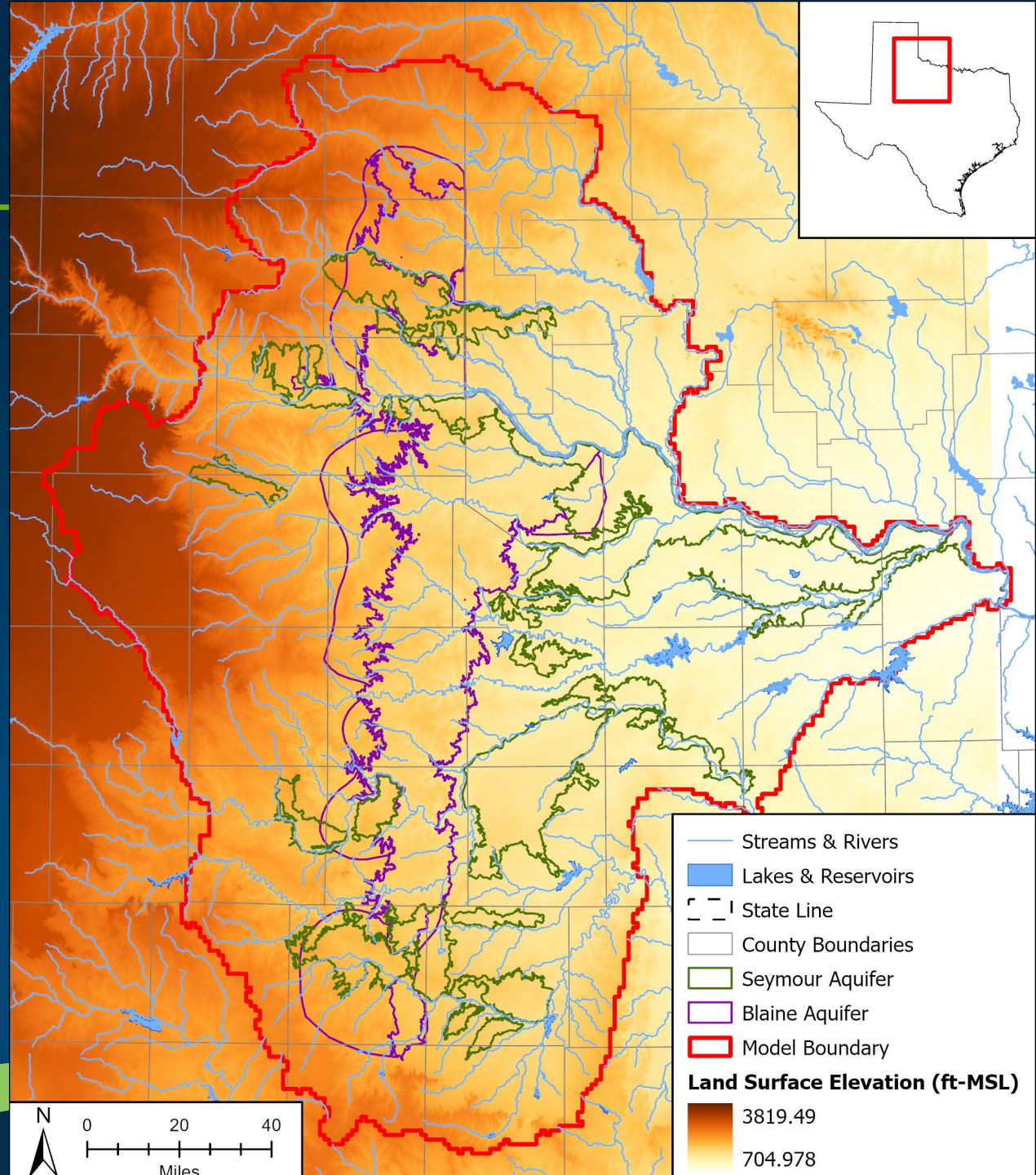


Groundwater Conservation Districts



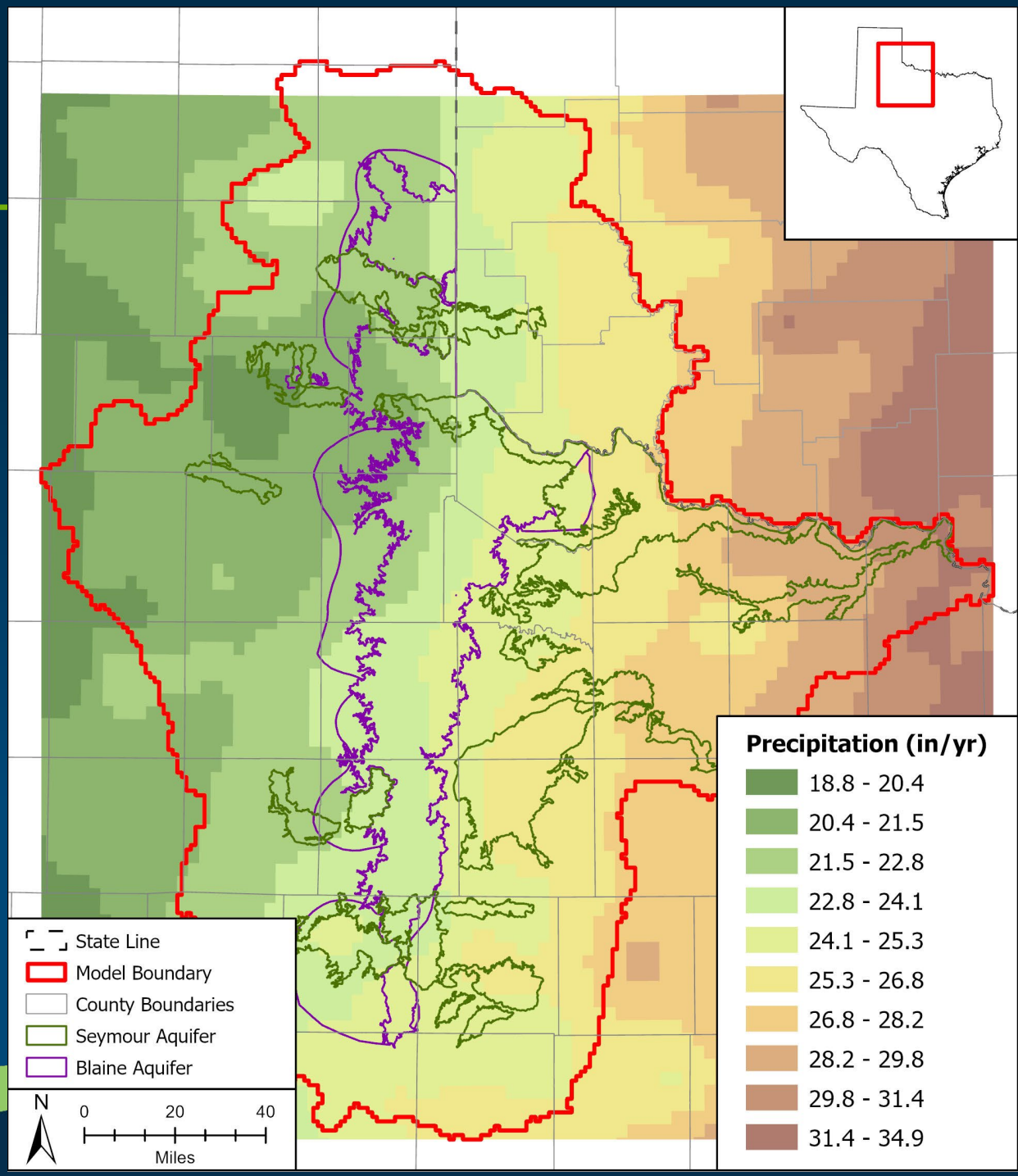
Topography

- Feet above mean sea level
- Source: USGS

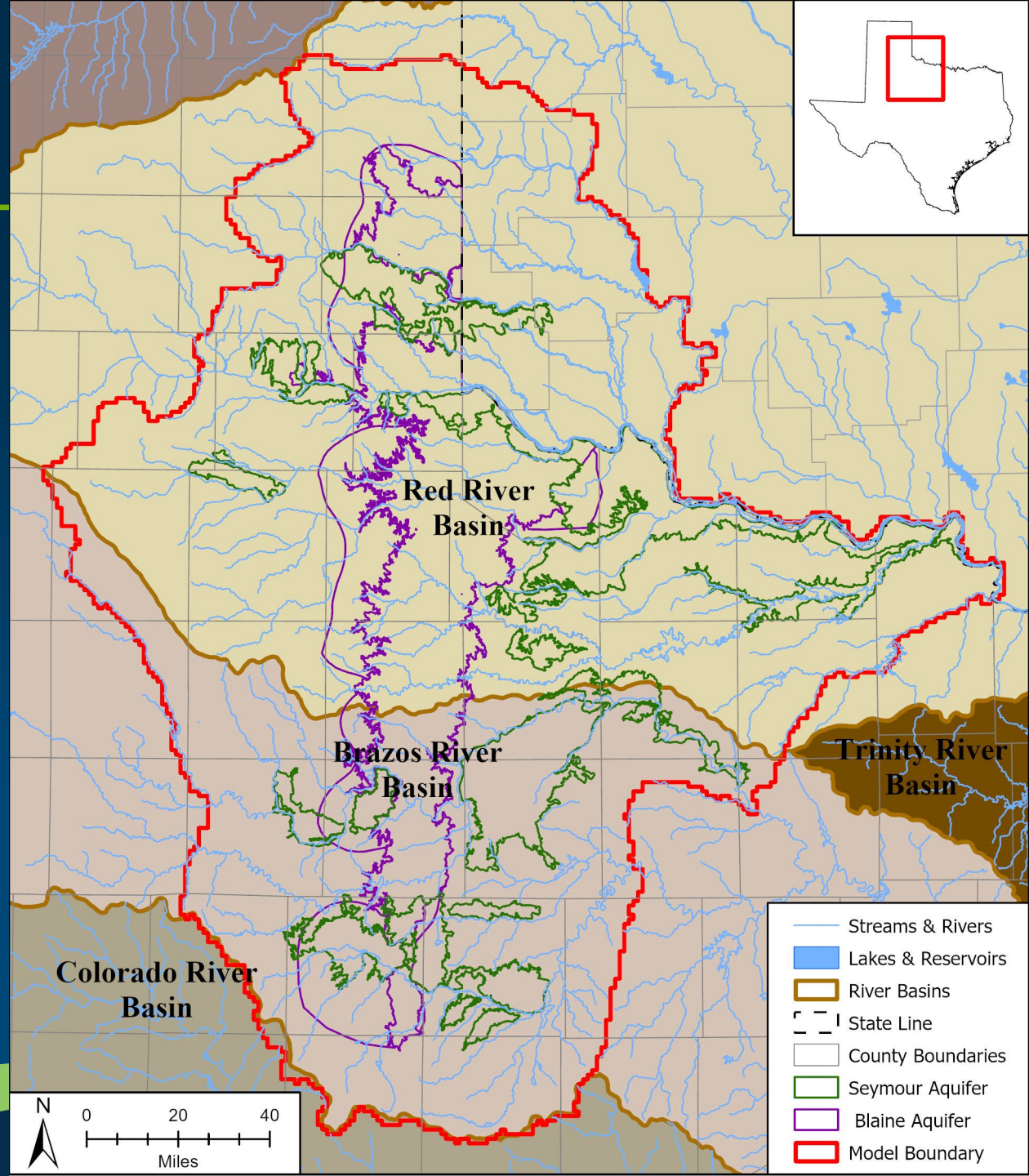


Annual Average Precipitation

- Source: Oregon State University Spatial Climate Analysis Service

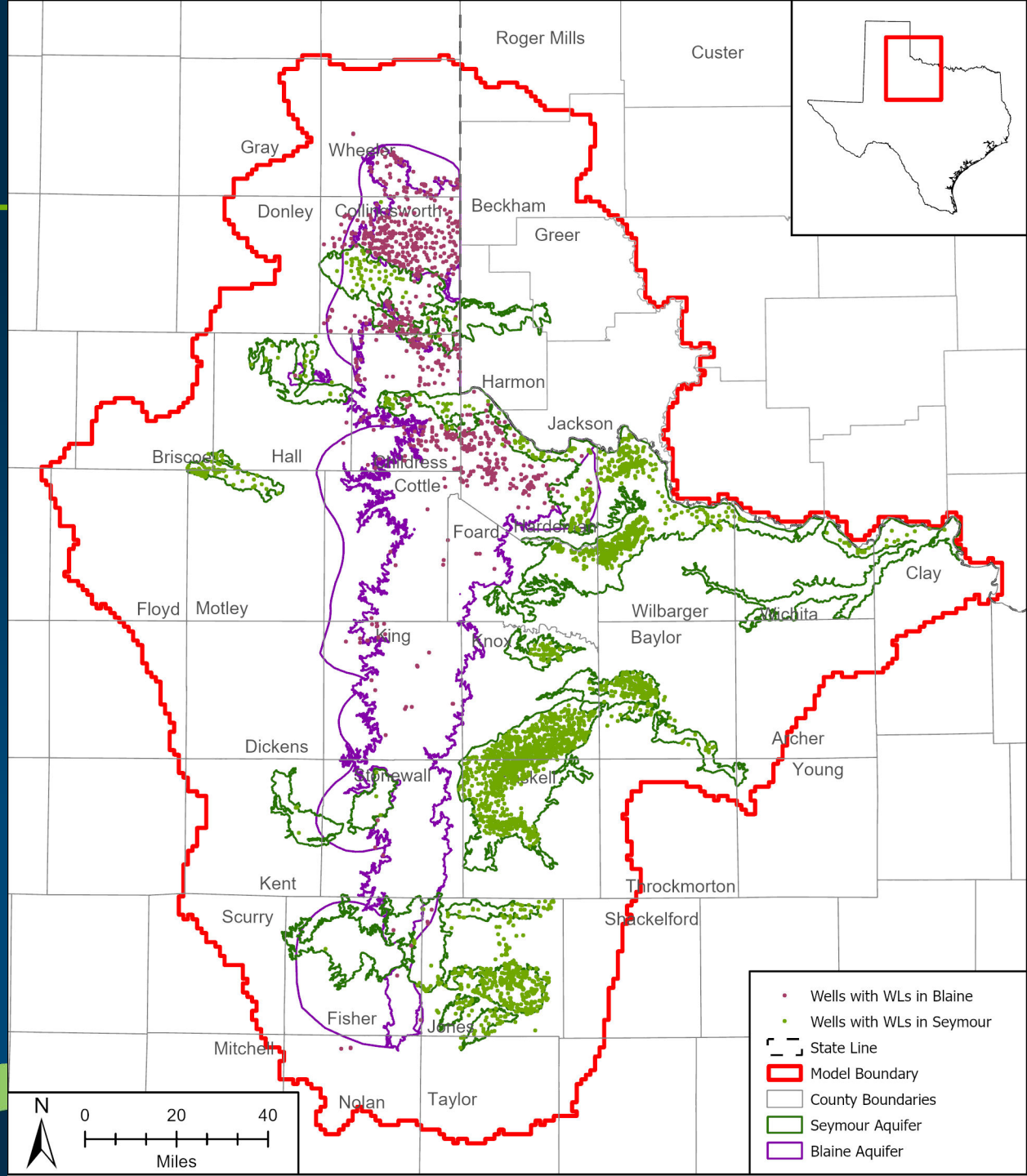


River Basins



Water Levels

- Wells with water levels from TWDB

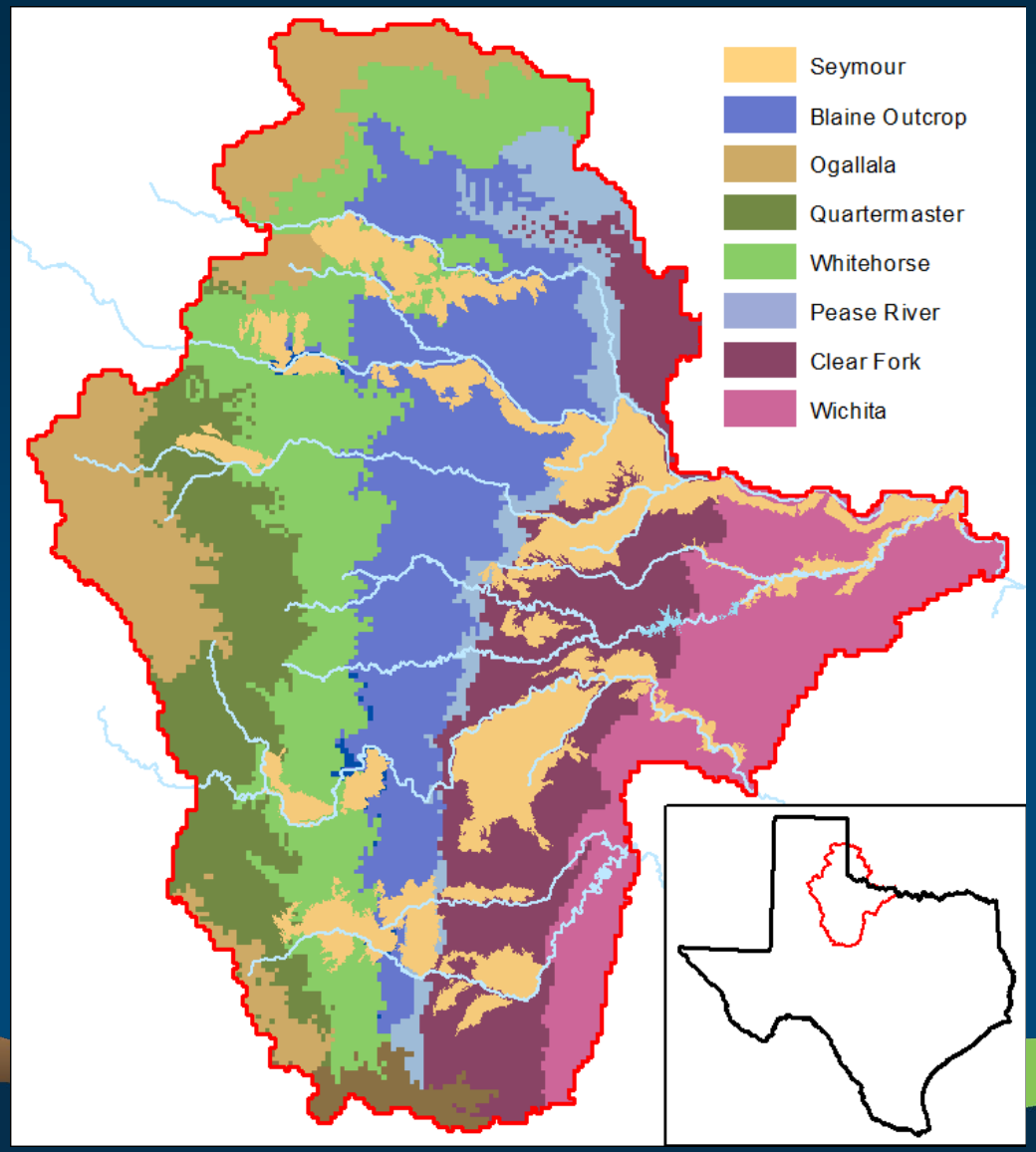


Model Inputs

- Structure: Top & bottom elevation surfaces for each layer
- Aquifer Properties
  - Hydraulic Conductivity (K_h and K_v)
  - Storativity or Specific Yield (transient)
- Initial water table elevations
- Recharge
- Stream characteristics
- Springs
- Pumping

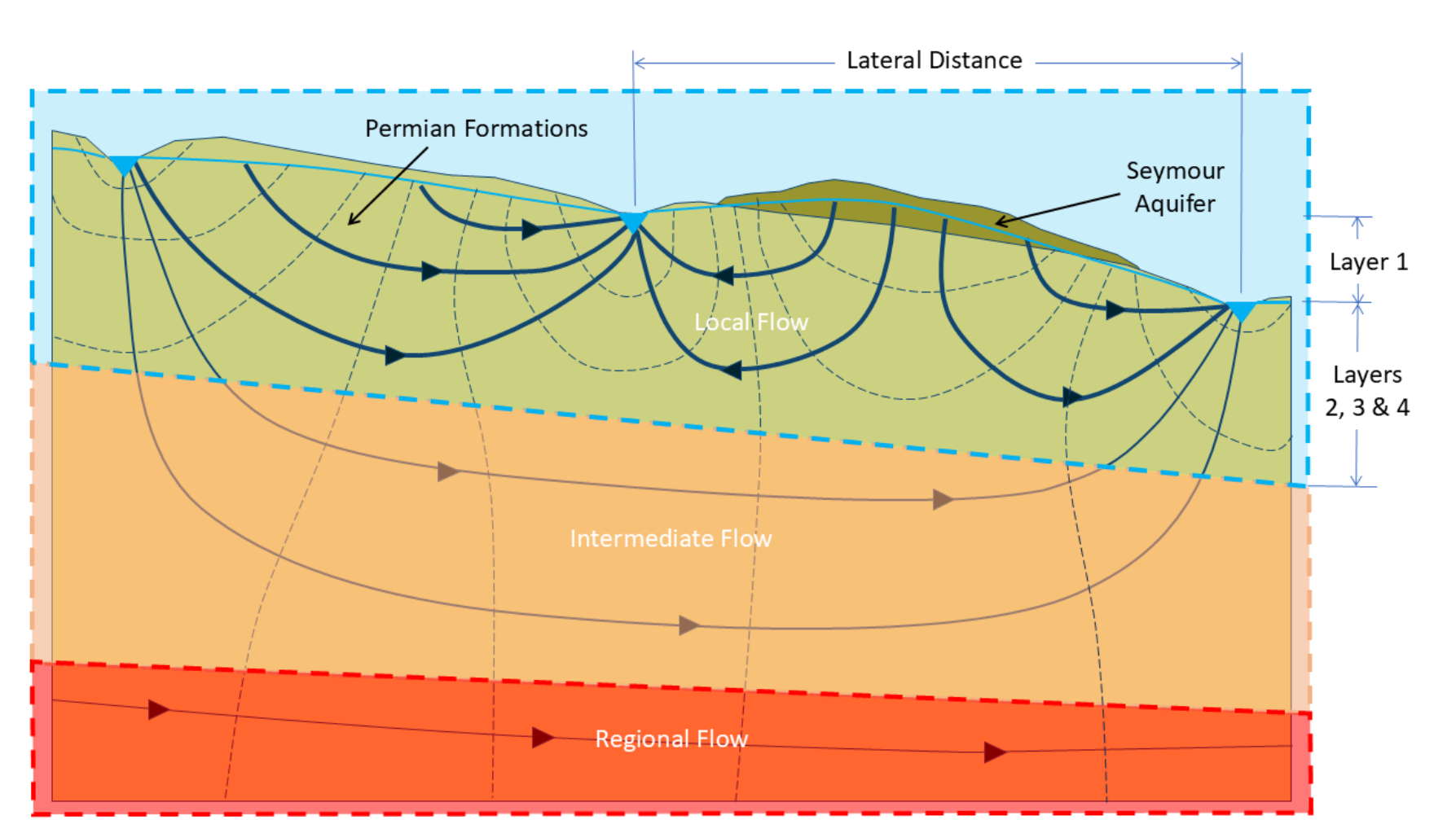
INTERA

Surface Geology and Stratigraphy



System	Series	Group	Formation	Layer
Quaternary	Recent to Pleistocene		Alluvium	1
			Seymour	
Tertiary	Missing			
Cretaceous				
Jurassic				
Triassic				
Permian	Ochoa		Quartermaster	2
	Guadalupe	Whitehorse		
		Pease River	Dog Creek Shale	
			Blaine Gypsum	3
			Flowerpot Shale	4
			San Angelo	
	Leonard	Clear Fork	Choza	
			Vale	
			Arroyo	
		Wichita (upper portion)	Lueders	
			Clyde	

Layer Thickness



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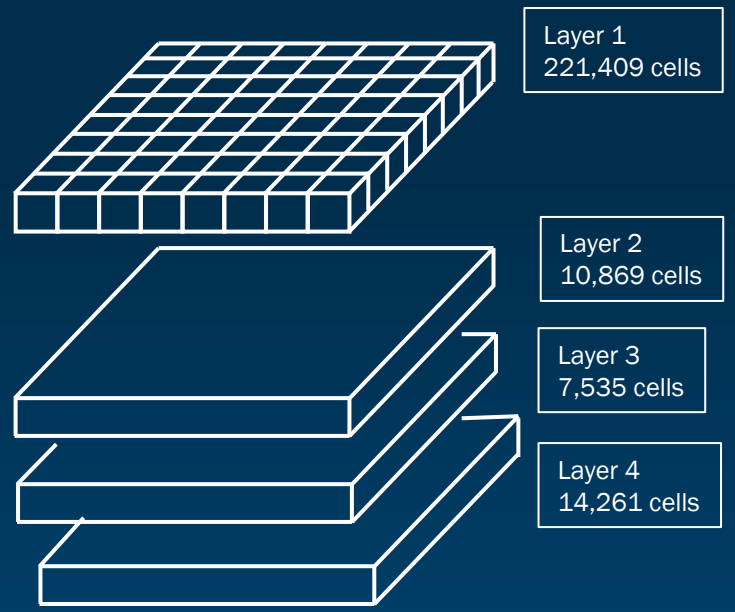
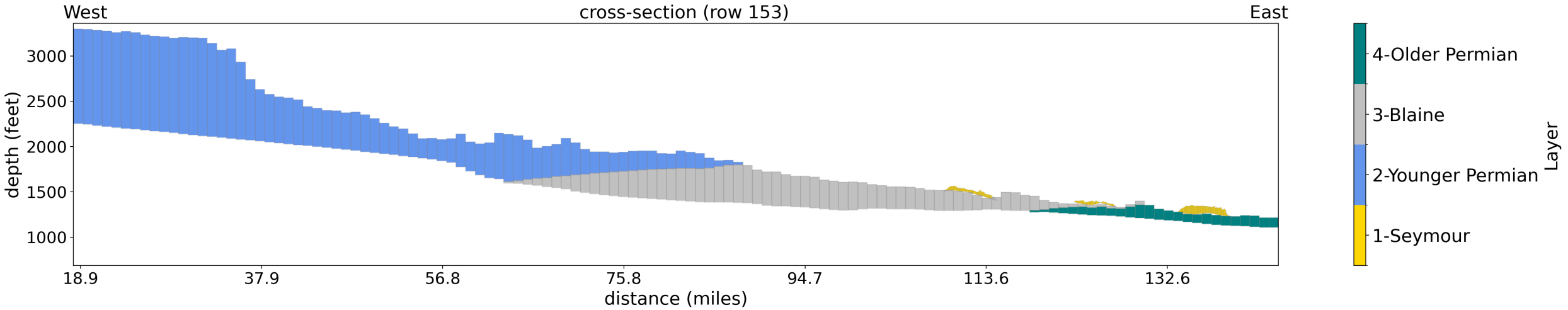
Model Grid and Layering

- Layer 1: Seymour Aquifer discretized to a 1/8-mile square grid
- Layer 2: Younger Permian Layer discretized to 1-mile square grid
- Layer 3: Blaine Aquifer discretized to 1-mile square grid
- Layer 4: Older Permian Layer discretized to 1-mile square grid





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Boundary Conditions

Recharge

- Primary source of natural recharge comes from precipitation
- Will follow the conceptual model of Ewing and others (2004) and Jones and others (2012)
- Will be spatially divided into three land use categories that vary over the historical period
  - Natural conditions
  - Rainfed agriculture
  - Irrigated agriculture
- Will vary temporally with precipitation

Natural Aquifer Discharge

- The Seymour Aquifer discharges to springs and seeps, local creeks and major streams throughout the study area
- A significant portion of discharge from the aquifer is to the underlying Permian formations which are, in turn, connected to streams and creeks

Pumping

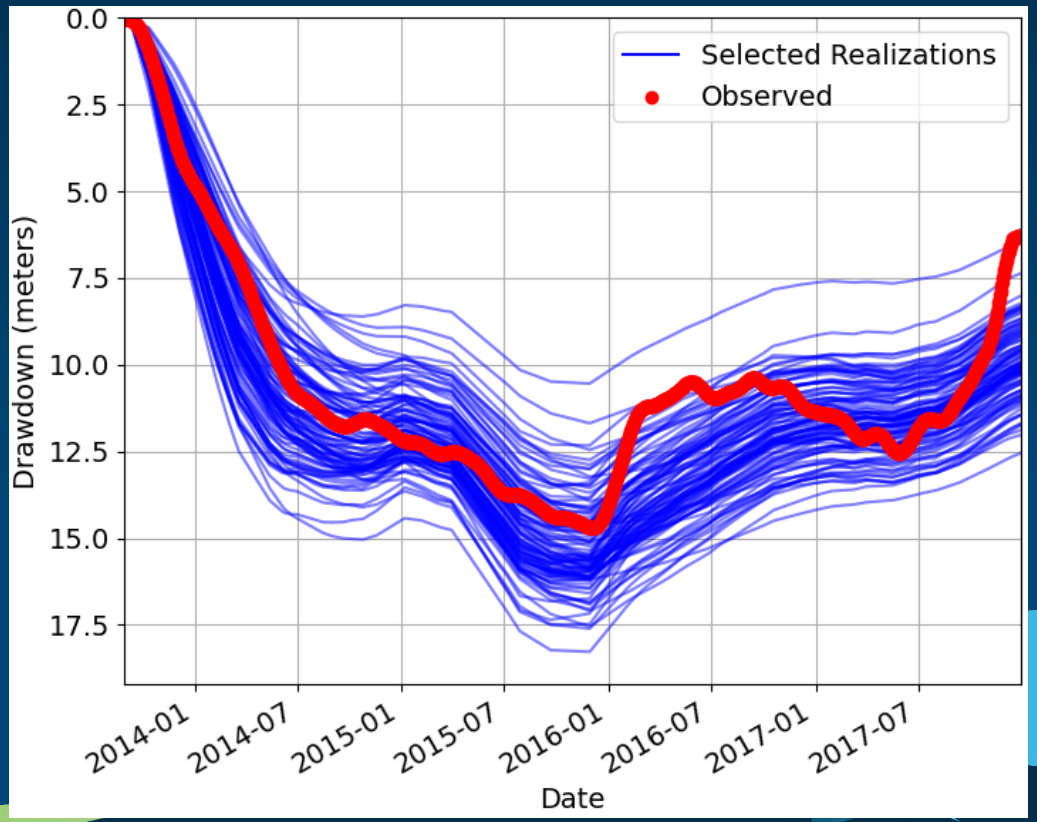
- Based on the recent study for TWDB documenting pumping from 1984 through 2020

INTERA

History Matching

- Adjust model inputs consistent with conceptual model until the simulation results adequately reproduce historic observations

- To be effective and robust
  - Embrace a realistic number of “unknowns”
  - Embrace data quality and the expectation of the model to reproduce historic observations
  - Augmented with expert knowledge
  - Designed to minimize uncertainty in forecasts
  - Objective, transparent and efficient
- Iterative ensemble smoother
  - Highly efficient for automated history matching
  - Uncertainty for free



47
INTERA

Model Limitations

- The Seymour aquifer is heterogeneous vertically (sand, gravel, silt, clay), but is represented as one layer with average properties.
- Data available (e.g., geology, wells, pumping) is limited in some regions.
- The GAM is a tool for making groundwater availability assessments on a regional basis only.
- The GAM is not capable of predicting aquifer responses at small scales (e.g., individual wells).

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Key Data Sources

- TWDB data at their website: http://www.twdb.state.tx.us/data/data.htm
  - Seymour Aquifer (approx. 5000 wells)
  - Blaine Aquifer (approx. 1300 wells)
- County reports by TWDB & predecessors
- U.S. Geological Survey reports
- UT Bureau of Economic Geology reports
- Oklahoma WR Board & GS reports
- TCEQ drillers logs
- Brune (1975) spring locations & flows

INTERA

Key Data Sources

- Websites:
  - U.S. Geological Survey
    - topography
    - stream flows
    - stream gain/loss studies
  - U.S. EPA
    - stream characteristics
    - land use / land cover
    - soil type
  - National Climatic Data Center - precipitation

Data Requests

- Seymour & Blaine data for areas with sparse information
  - Geologic logs
  - Water levels (elevations)
  - Pump tests
  - Aquifer properties
- Relevant data **not** in the TWDB database. Data provided must be documented and publicly available.
- Data needed by 3/1/25.

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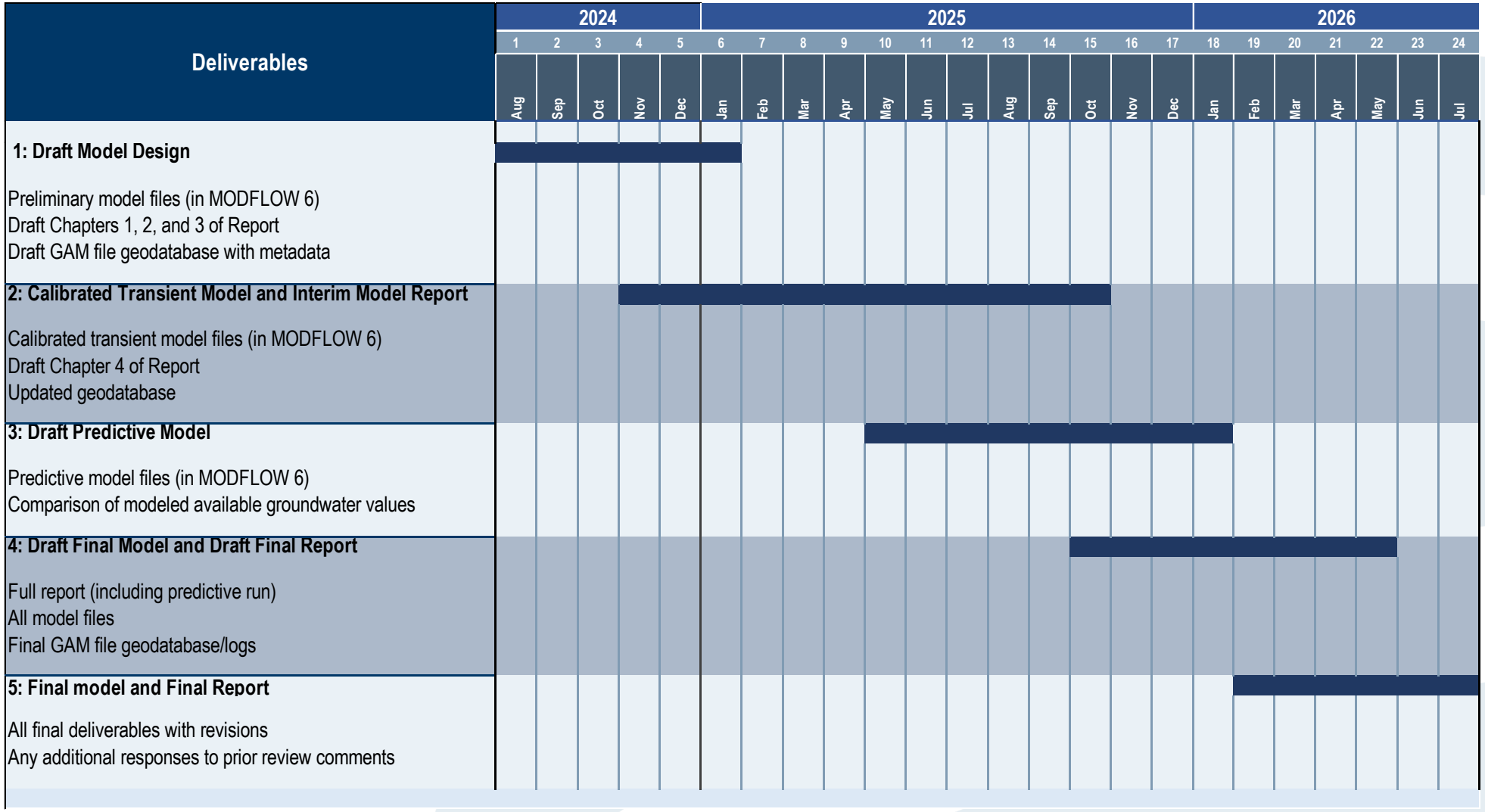
Project Schedule



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Web information:

https://www.twdb.texas.gov/groundwater/models/gam/symr/symr.asp

Discussion

Thank you for your attention, thoughts and feedback!

Questions?