Groundwater and Groundwater Modeling

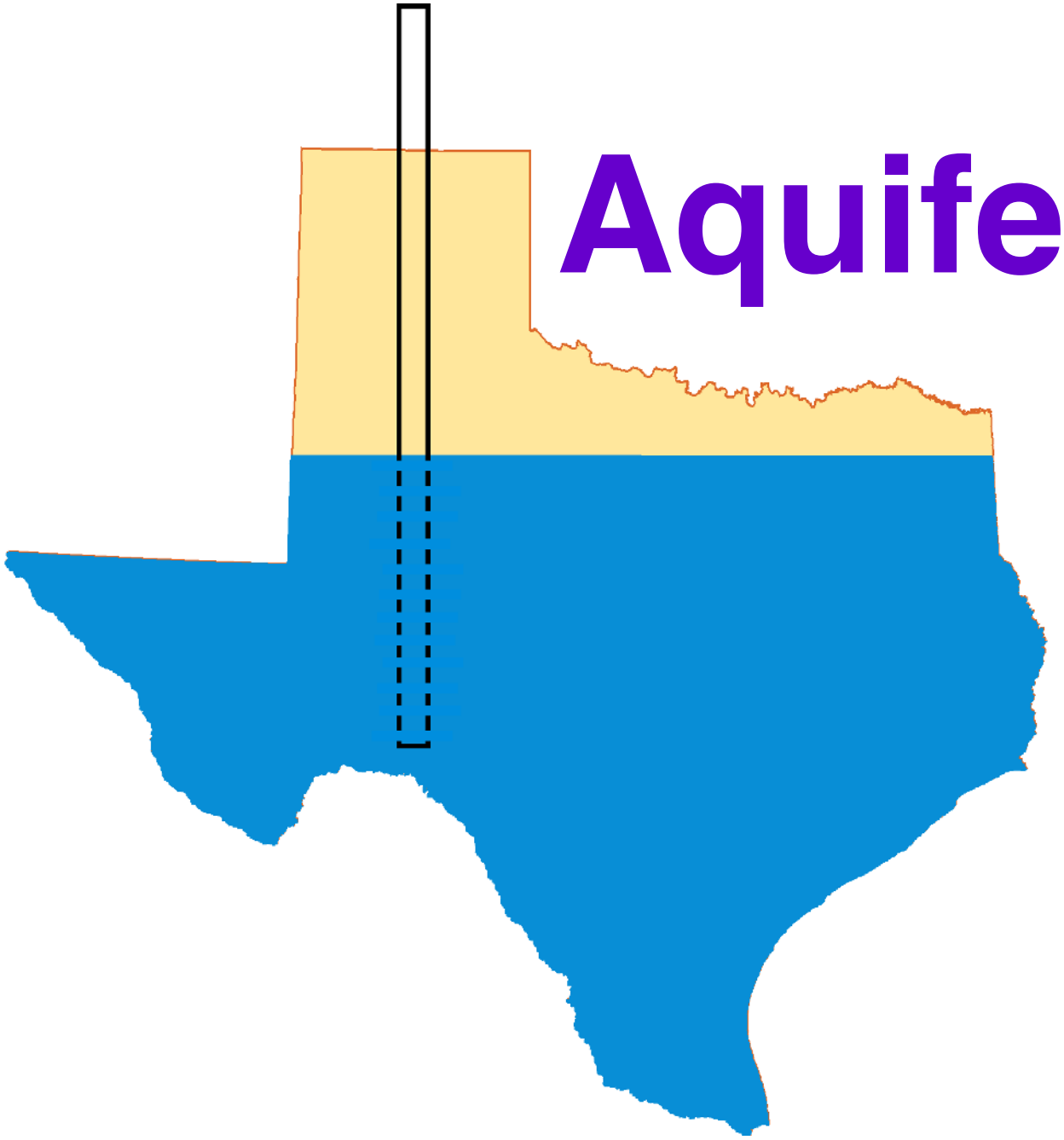
Robert E. Mace, Ph.D., P.G.
Texas Water Development Board

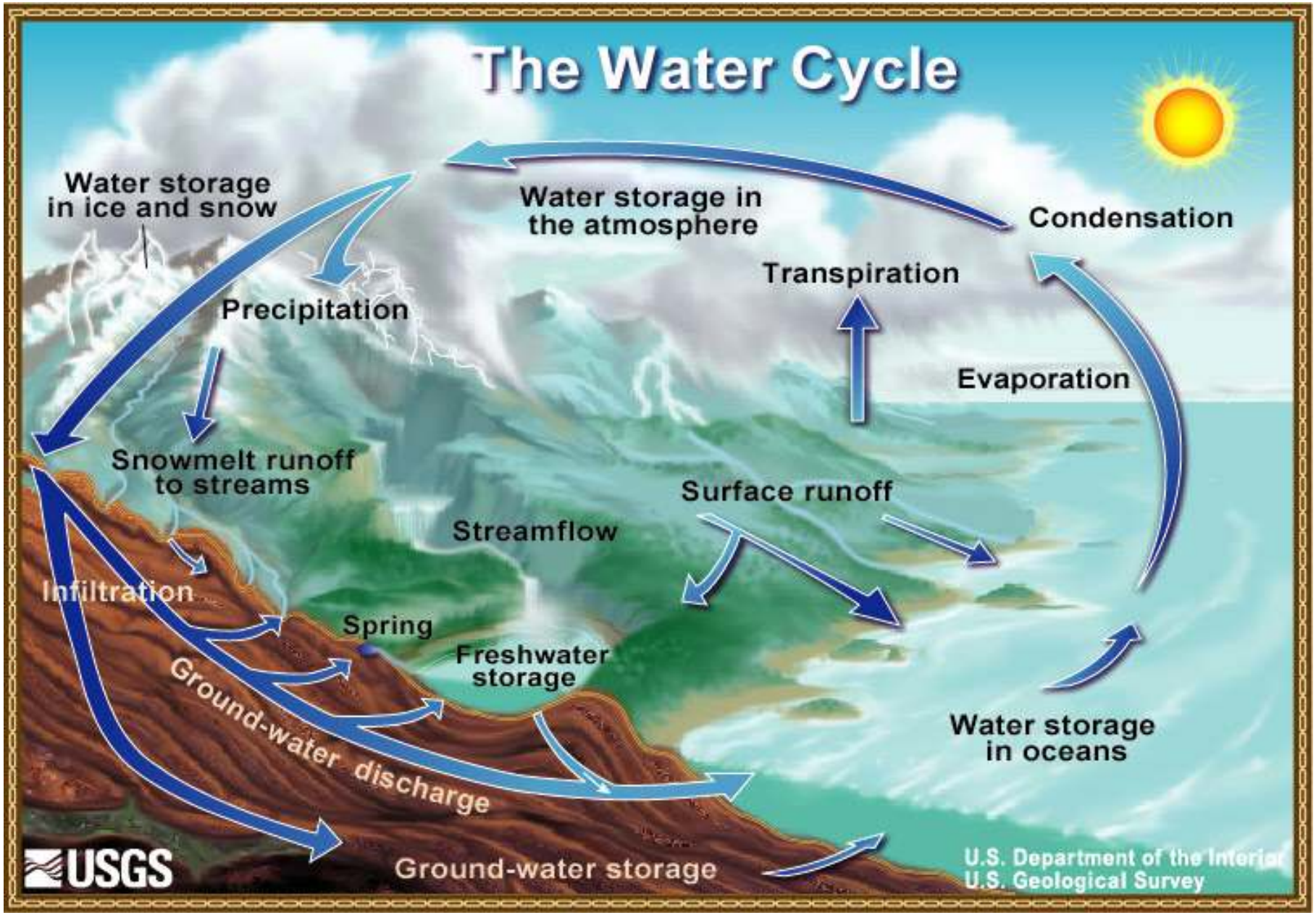
presented at

The Milam & Burleson Counties Groundwater Summit

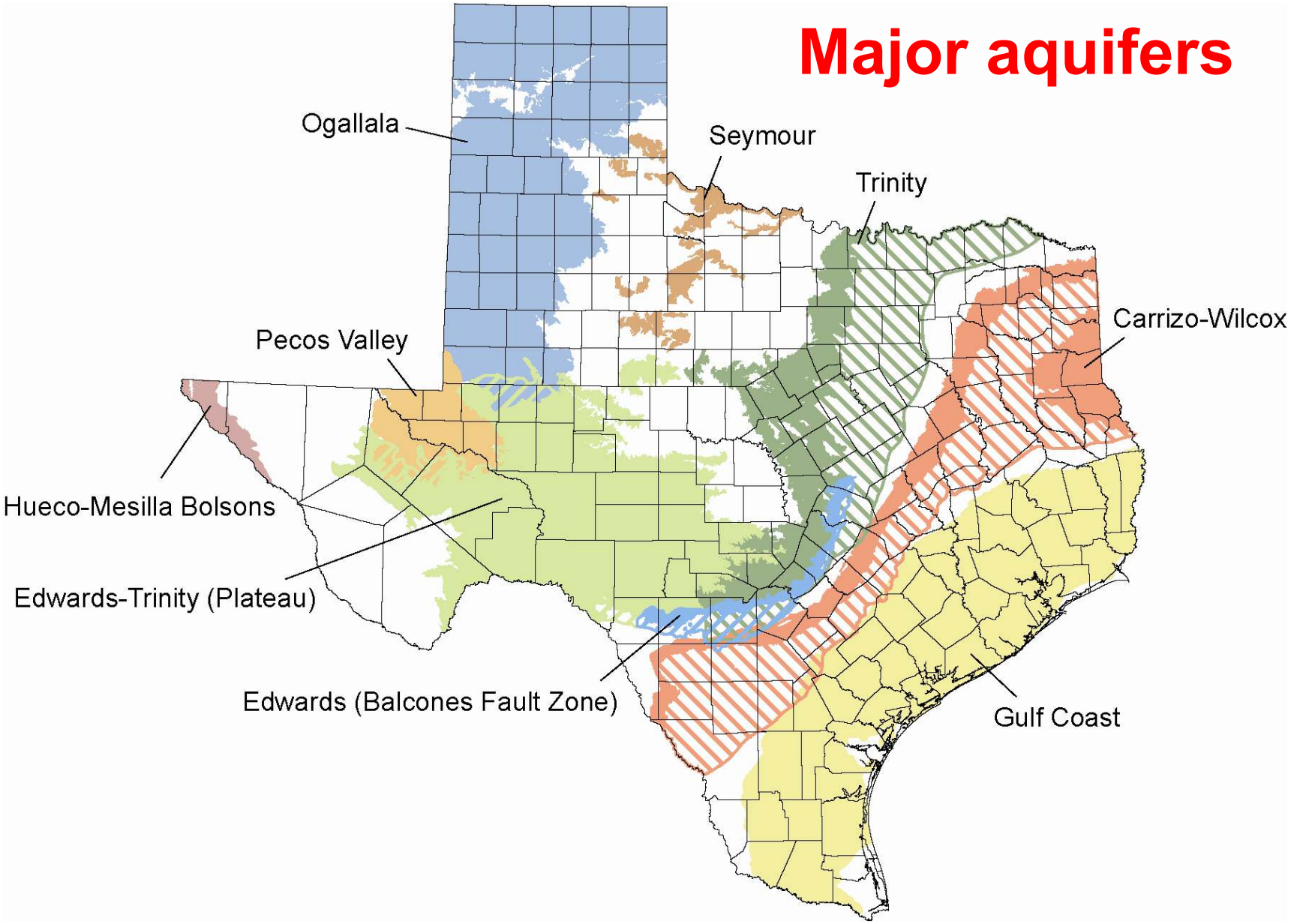
August 16, 2017; Caldwell, Texas

Aquifers 101

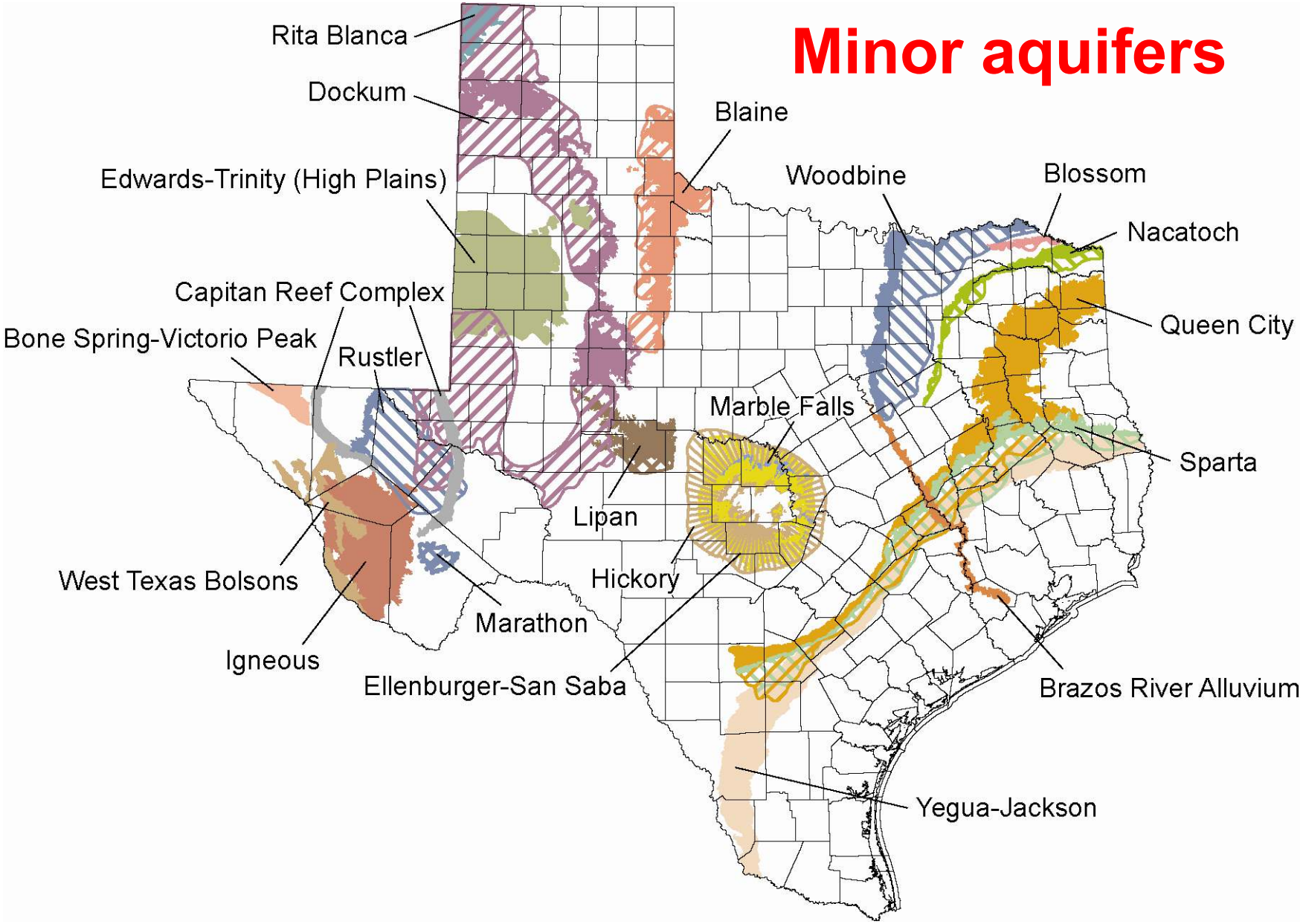



The Water Cycle
Water storage in ice and snow
Water storage in the atmosphere
Condensation
Transpiration
Precipitation
Evaporation
Snowmelt runoff to streams
Surface runoff
Streamflow
Infiltration
Spring
Freshwater storage
Water storage in oceans
Ground-water discharge
Ground-water storage
USGS
U.S. Department of the Interior
U.S. Geological Survey

Major aquifers



Minor aquifers



what is an aquifer?

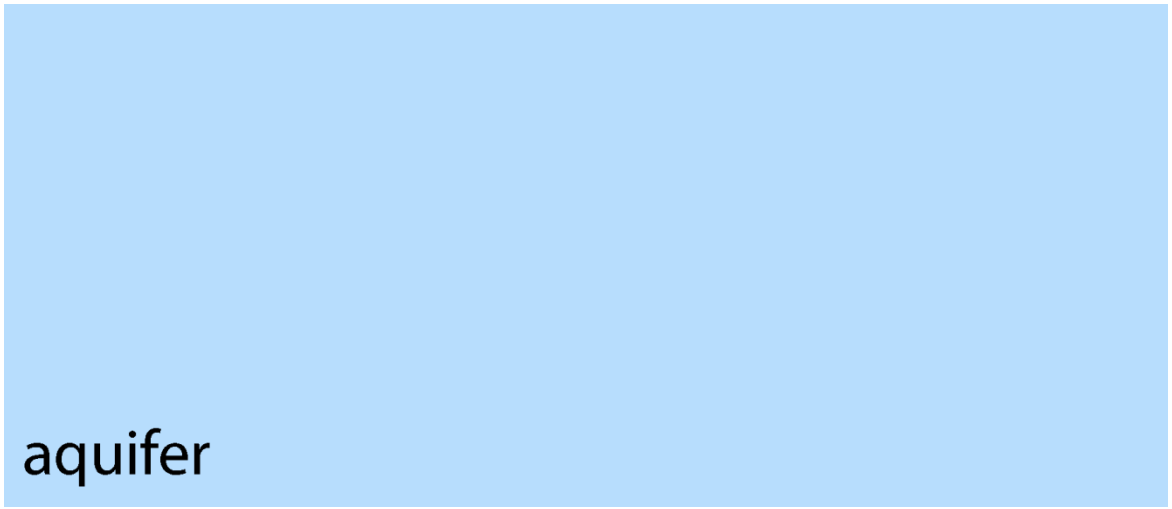
Dirt and rocks

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

Depends on who's using it

what is an aquifer?

Limestone (especially karstified), sandstone, sand, gravel, fractured rocks



what is an aquitard?

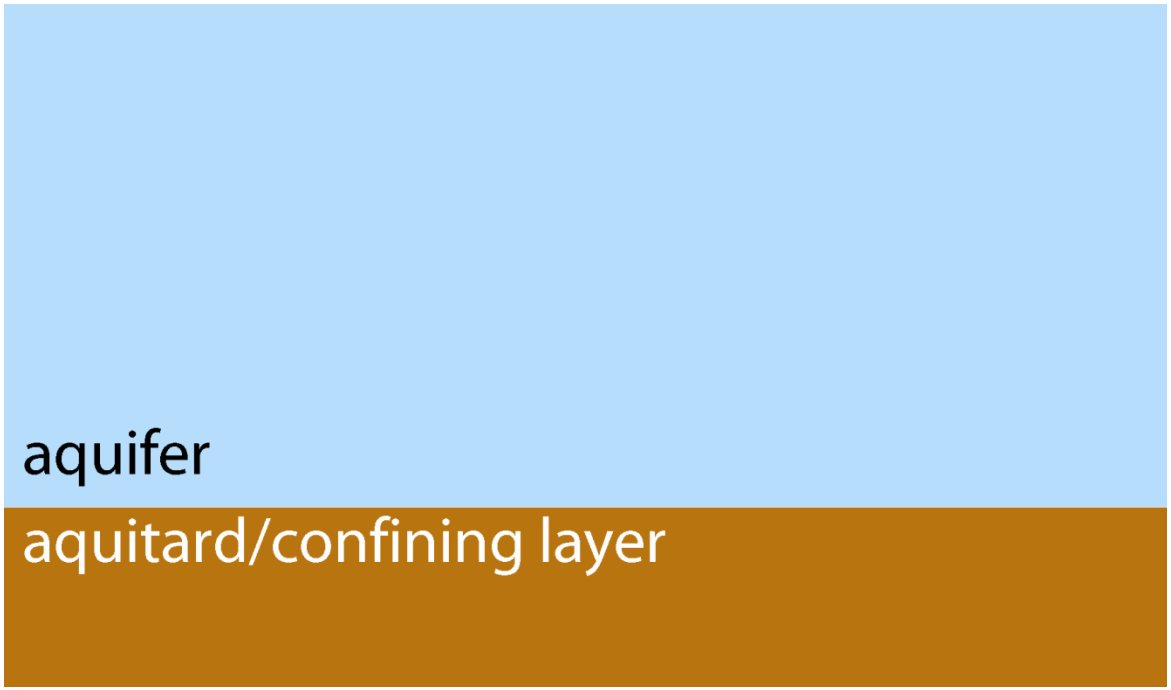
- **an aquitard is geologic media that can not yield economically usable amounts of water.**

what is an aquitard?

- **clay, shale, unfractured dense rocks**
- **Note: can still transmit water, but *s l o w l y***

what is a confining layer?

- **A confining layer is an aquitard that bounds an aquifer.**

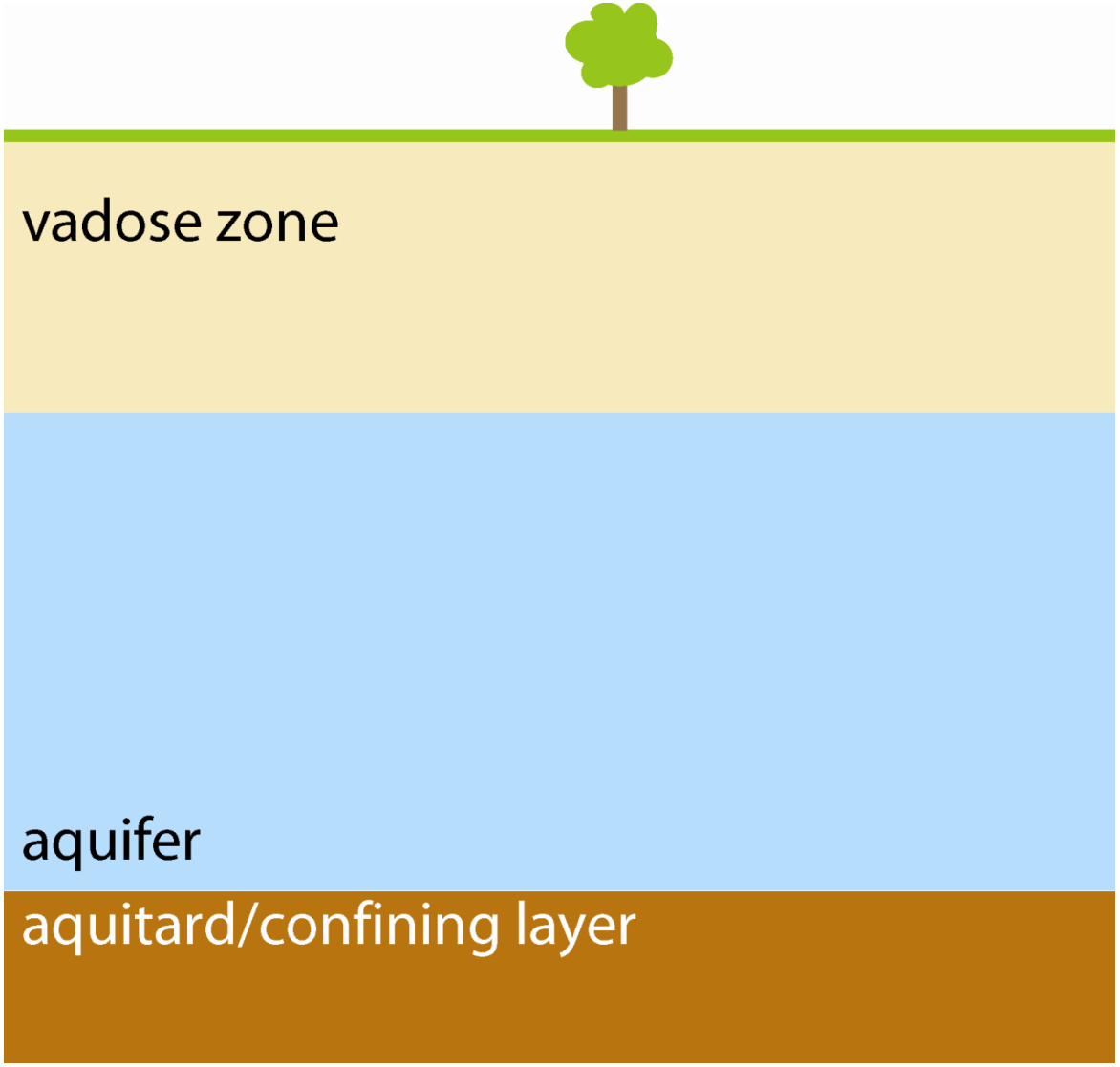


what is a vadose zone?

- **The vadose zone is the unsaturated geologic media between the water table and the land surface.**

Scientific side note: There is a saturated capillary zone between the vadose zone and the water table.

the vadose zone

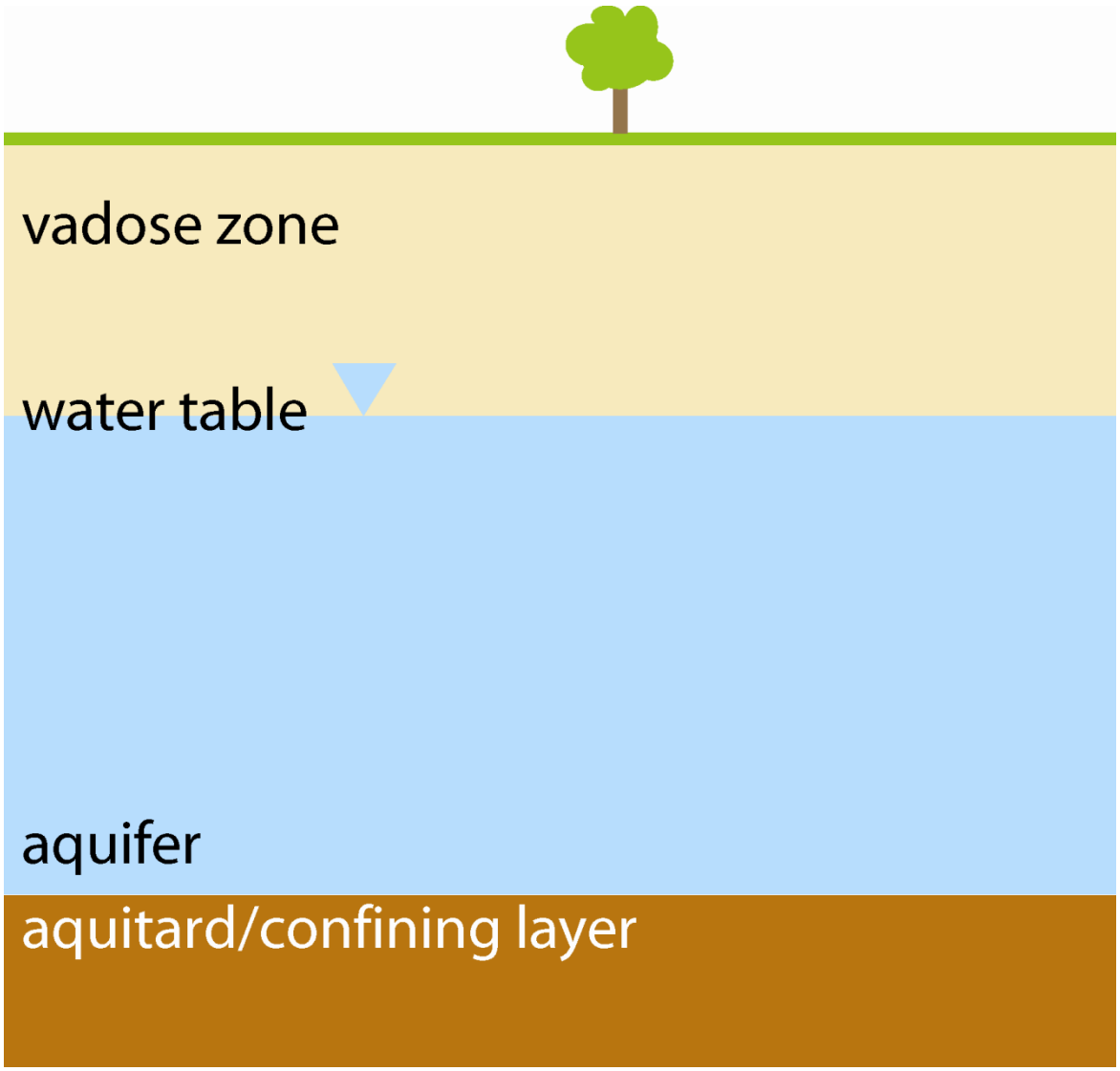


what is a water table?

- **A water table is where the aquifer meets the vadose (unsaturated) zone.**

Scientific definition: surface on which the fluid pressure in the pores of a porous medium is exactly atmospheric.

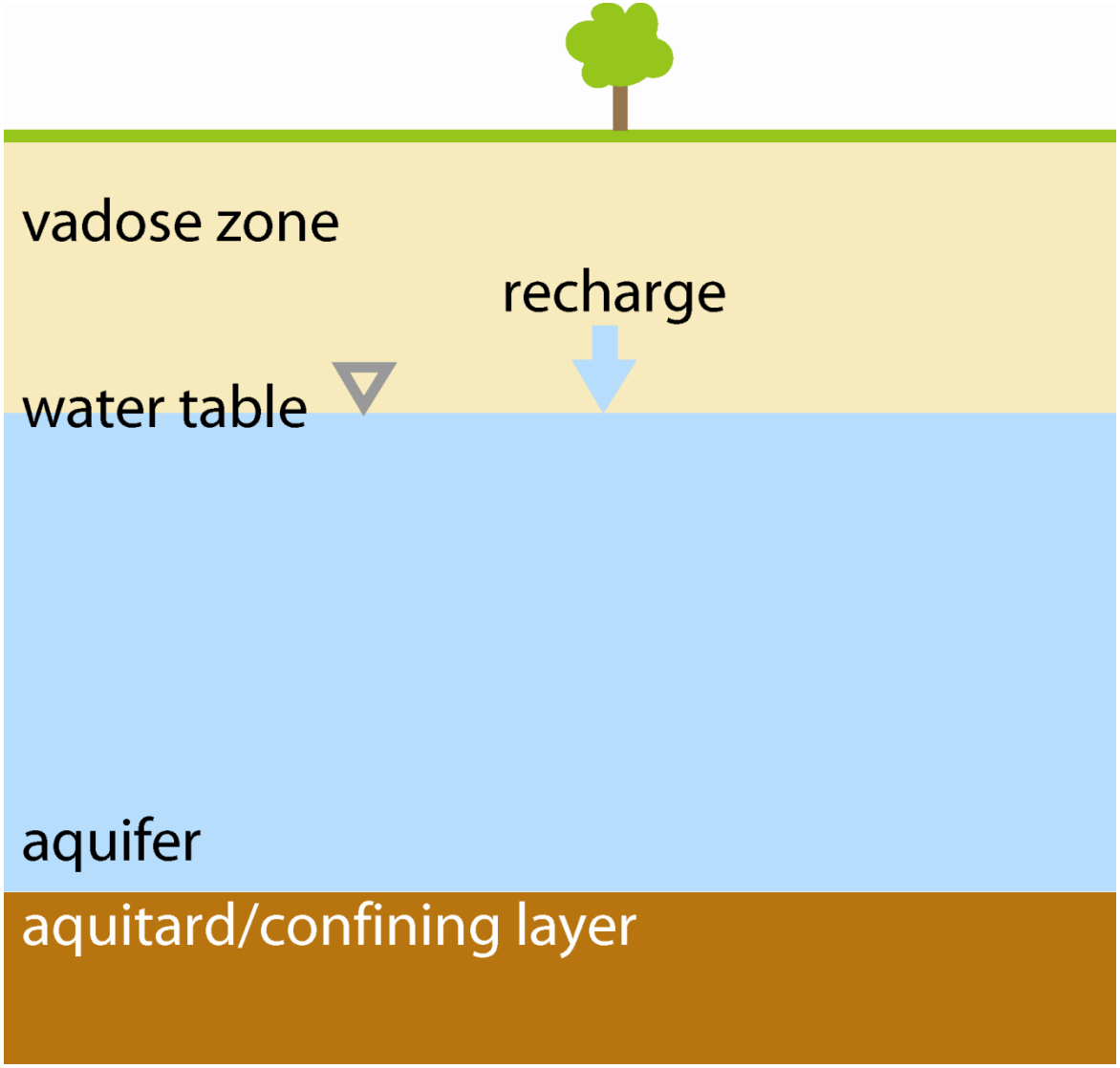
the water table



what is recharge?

- **Recharge is water that infiltrates to the water table of an aquifer.**

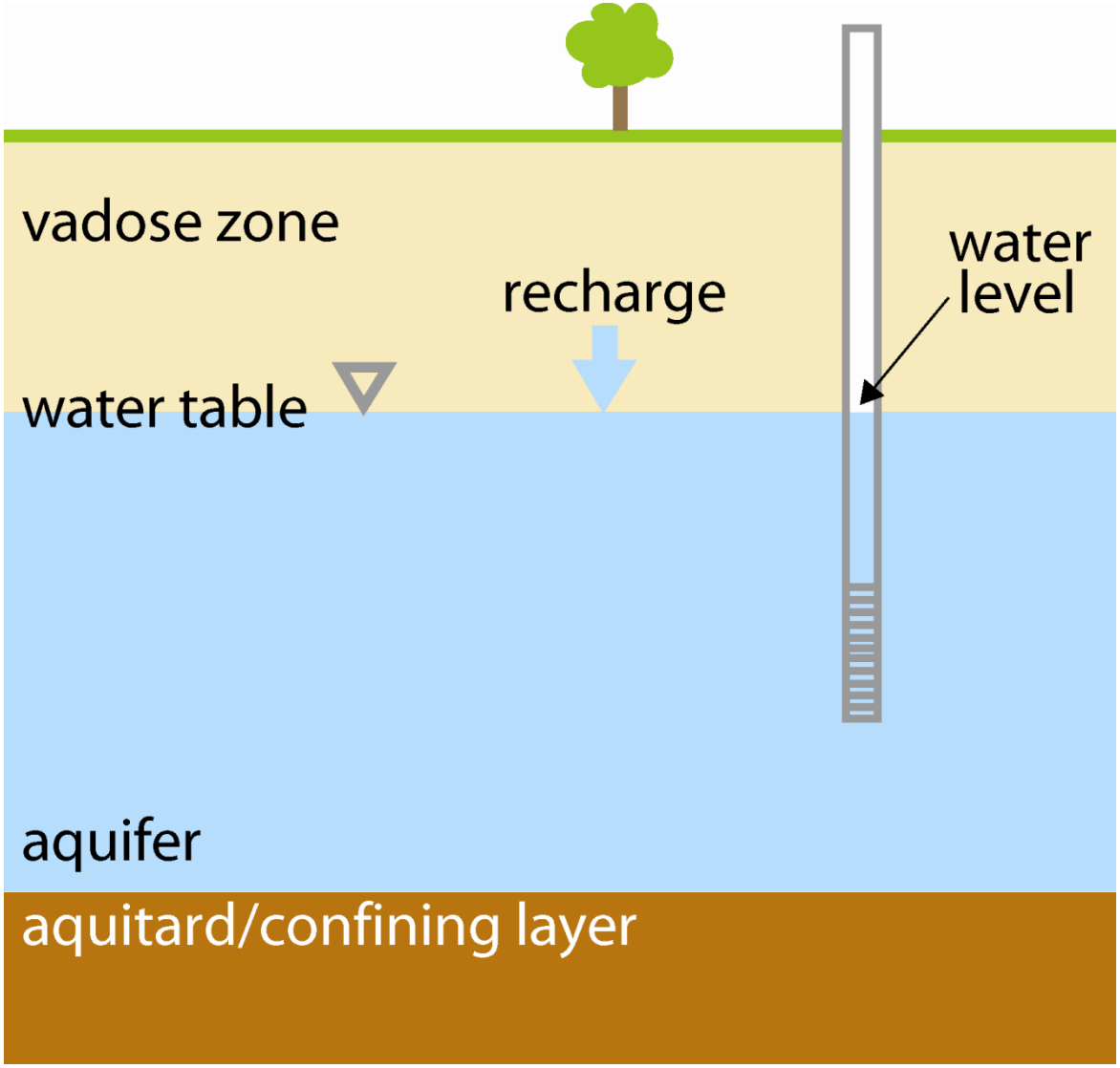
recharge


vadose zone
recharge
water table
aquifer
aquitard/confining layer

what is a water level?

- **A water level is the level at which water rests (or would rest) in a well.**

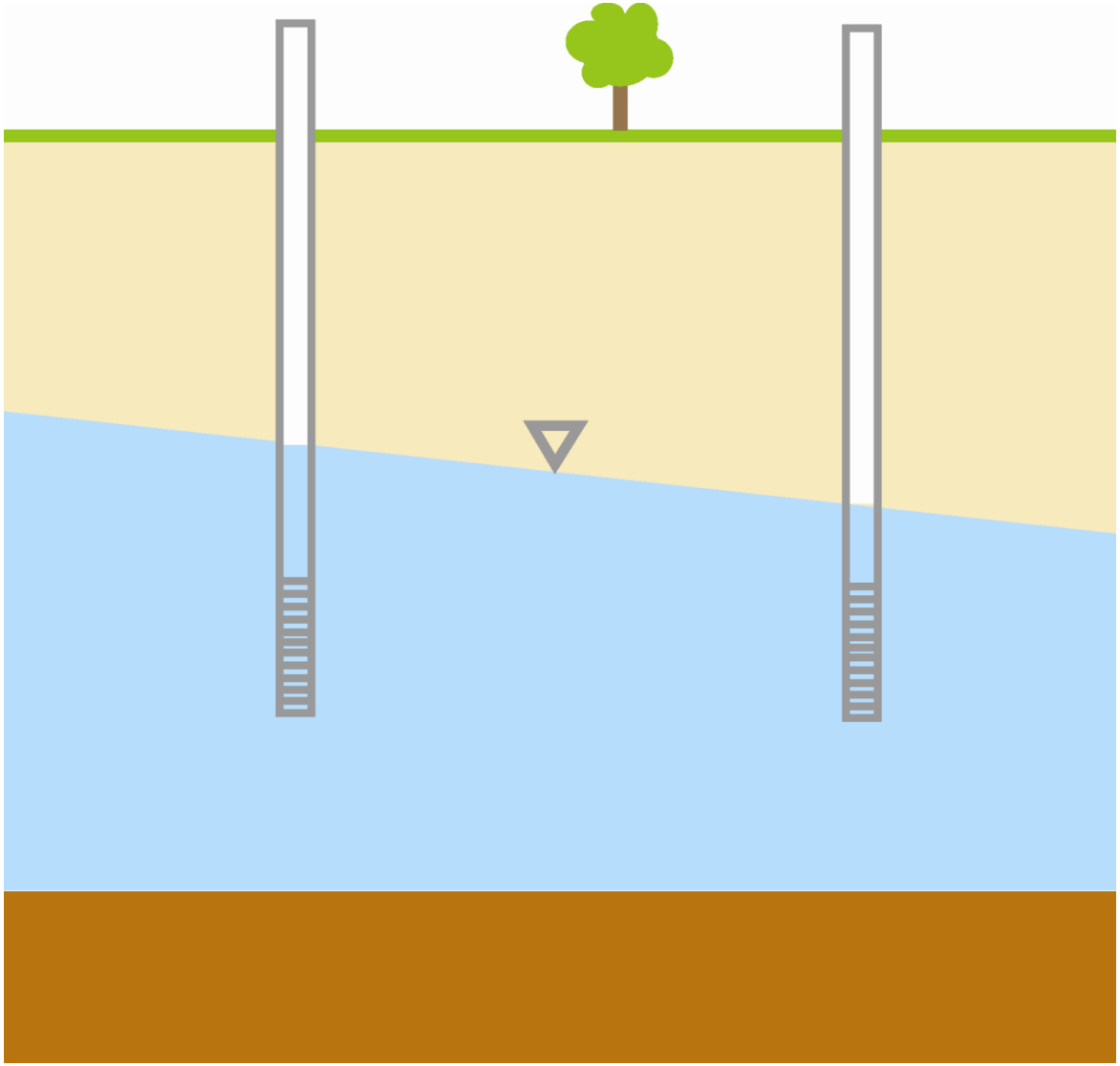
the water level



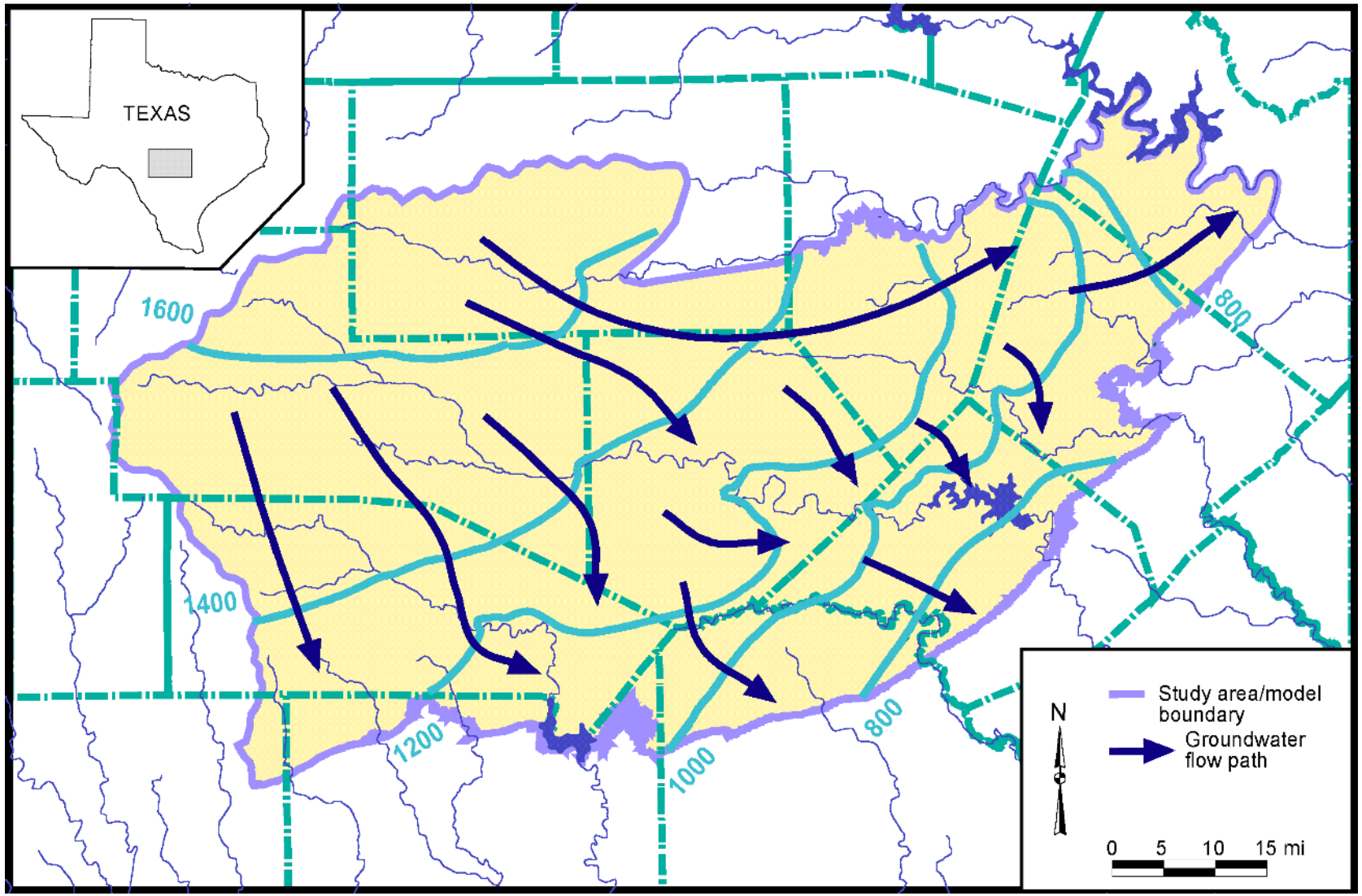
2 rules of groundwater flow

- **water flows downhill (to lower potential energy)**
- **water flows uphill to money**

water flows downhill (to lower potential energy)



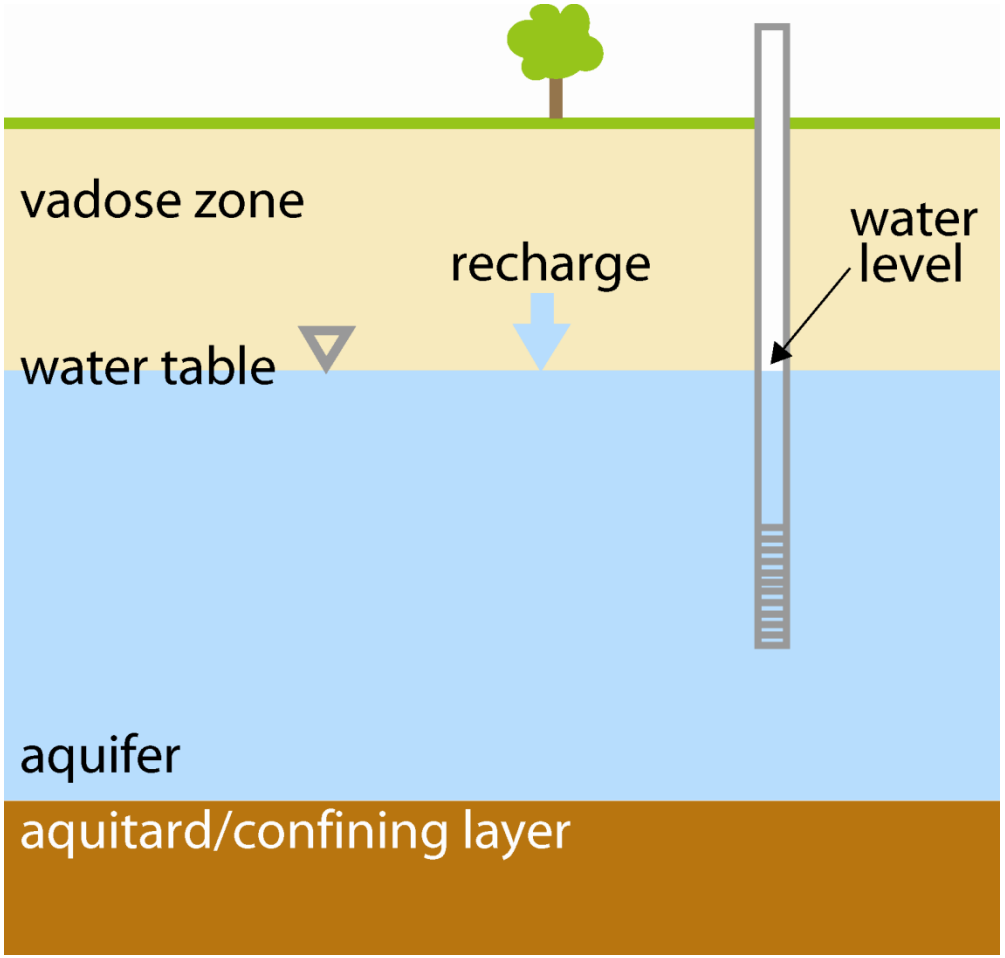
Groundwater Flowpaths



what is an unconfined aquifer?

- **An unconfined aquifer is an aquifer that is bounded by a confining layer at its bottom but not at its top.**

an unconfined aquifer

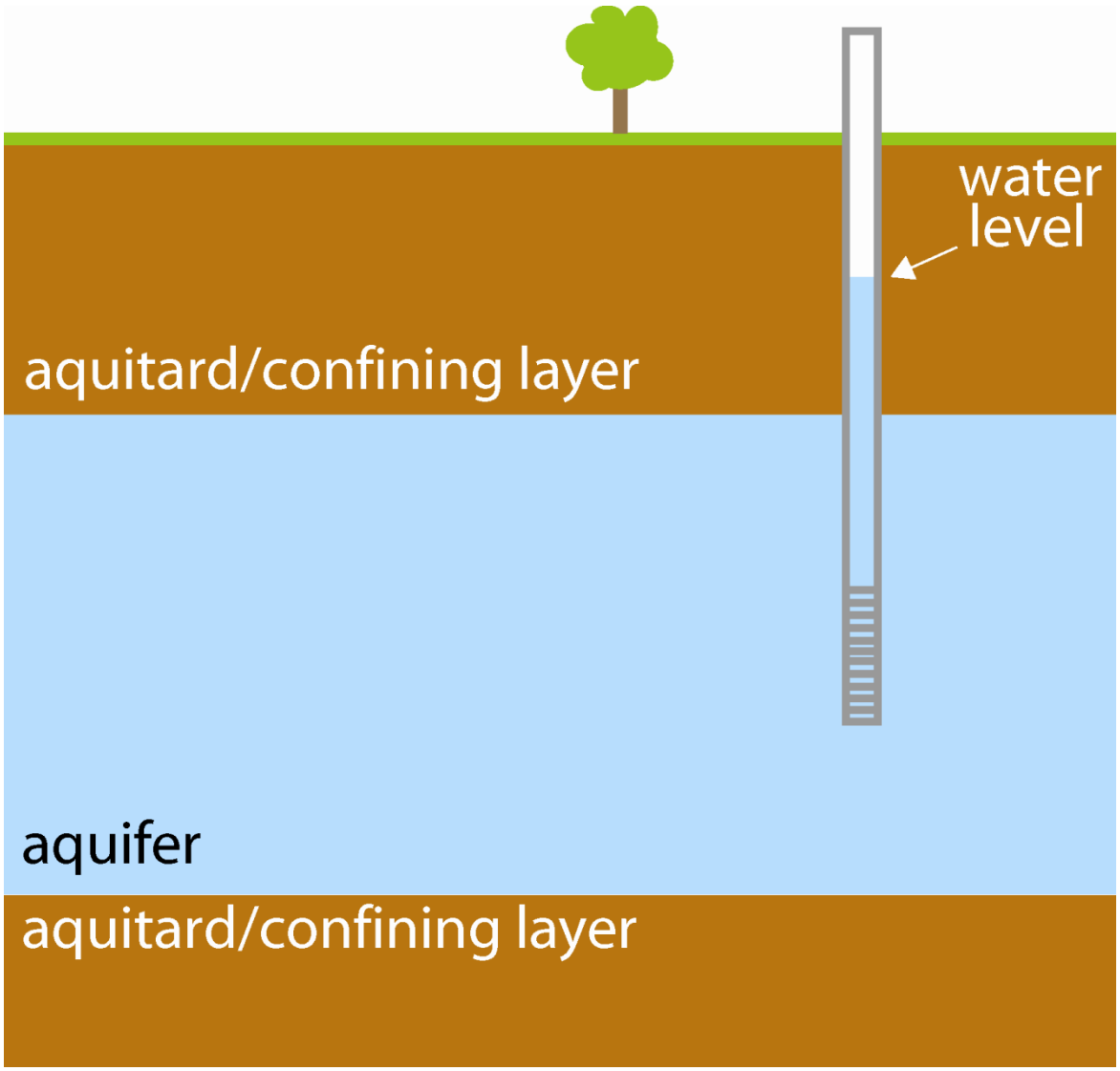


what is a confined aquifer?

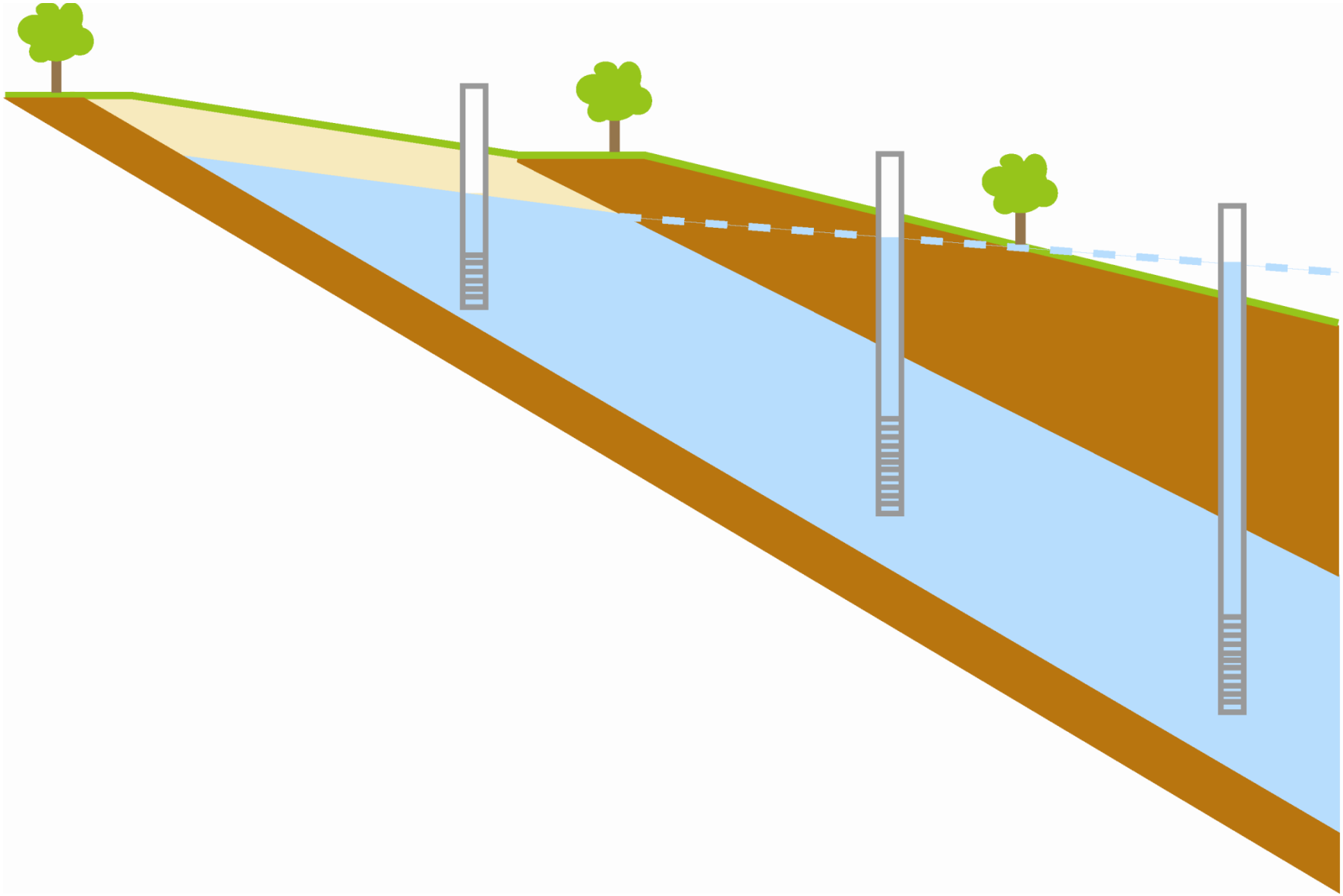
- **A confined aquifer is an aquifer that is bounded by confining layers at its bottom and top and where the water level rises above the top of the aquifer.**

Scientific side note: This is also an artesian aquifer. "Artesian" does not require water to flow at land surface.

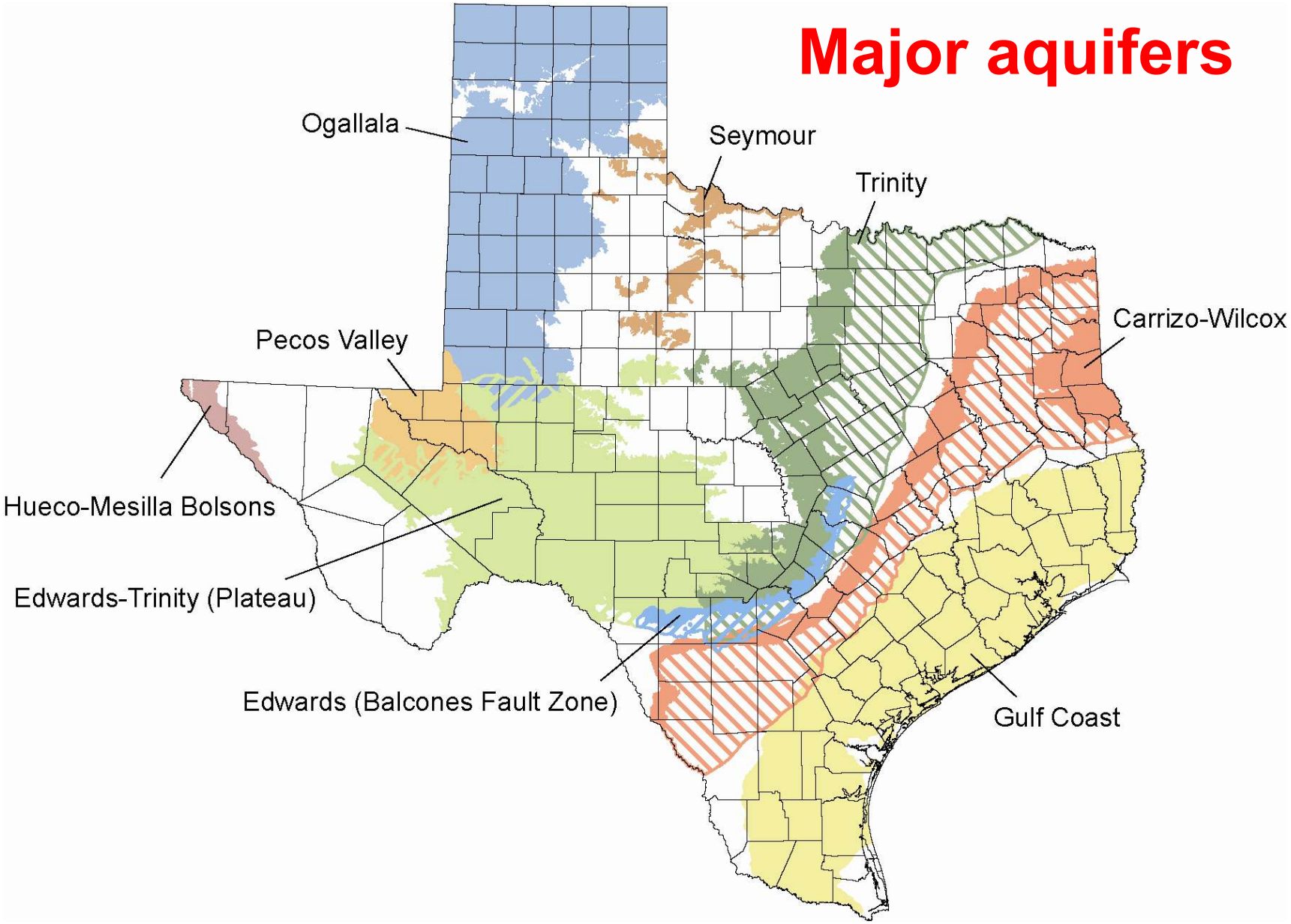
a confined aquifer



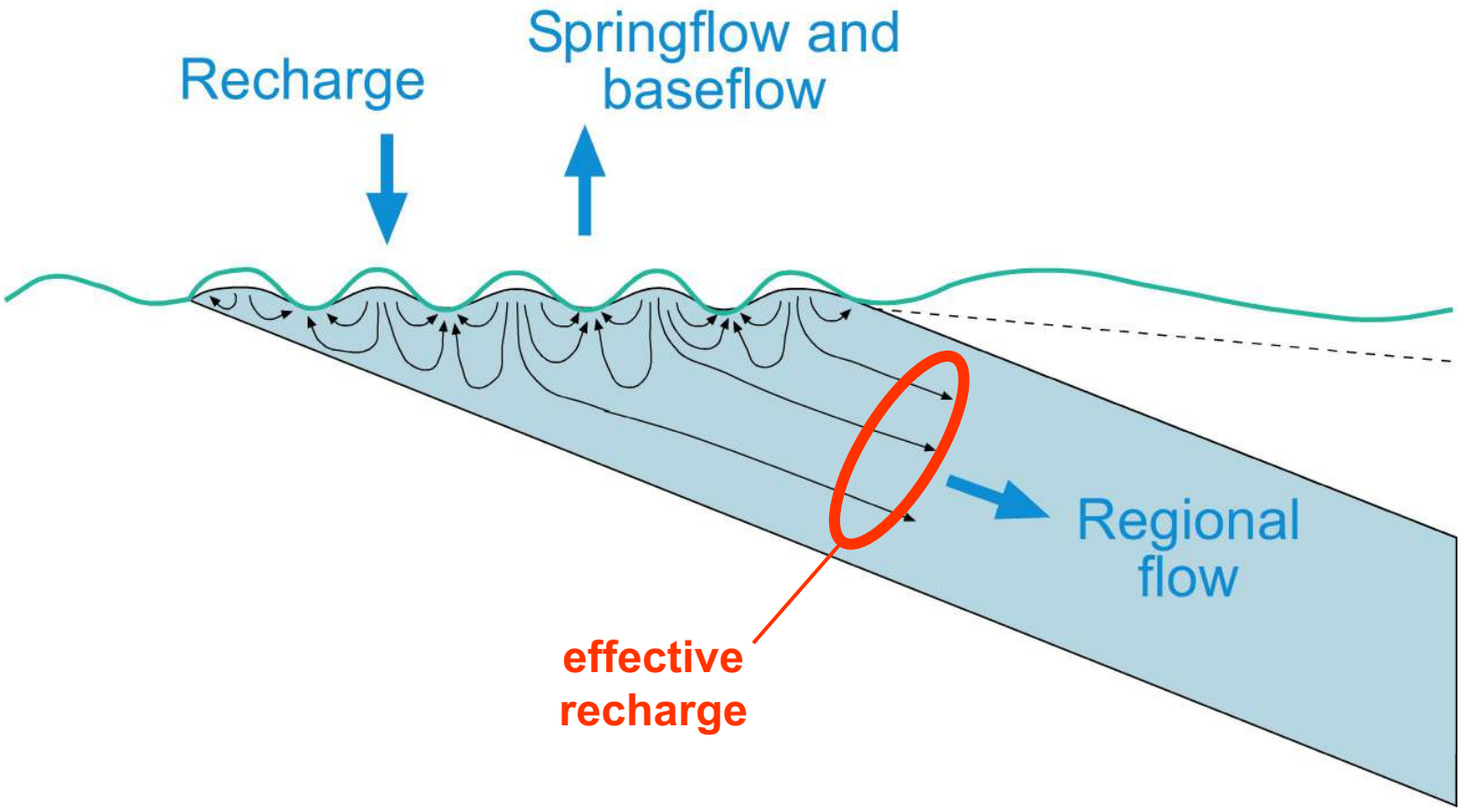
same aquifer: unconfined and confined



Major aquifers



recharge & “effective” recharge



what is permeability ?
hydraulic conductivity ?
transmissivity ?

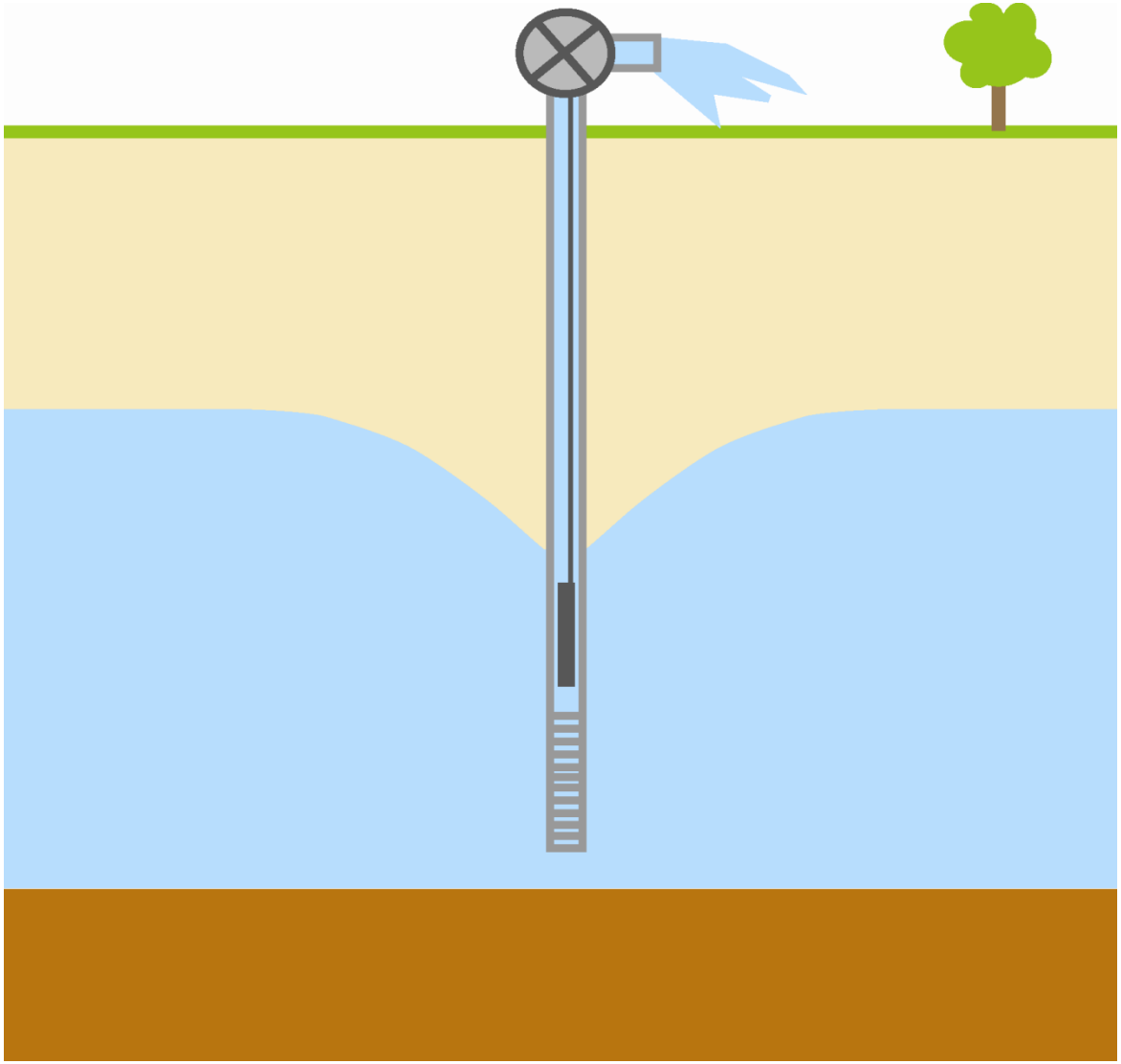
- **Terms that describe the ease with which water flows through geologic media.**

Scientific side note: permeability is independent of fluid type; hydraulic conductivity is specific to water and relative to a unit area; and transmissivity is specific to water and relative to the thickness of the aquifer and a unit width.

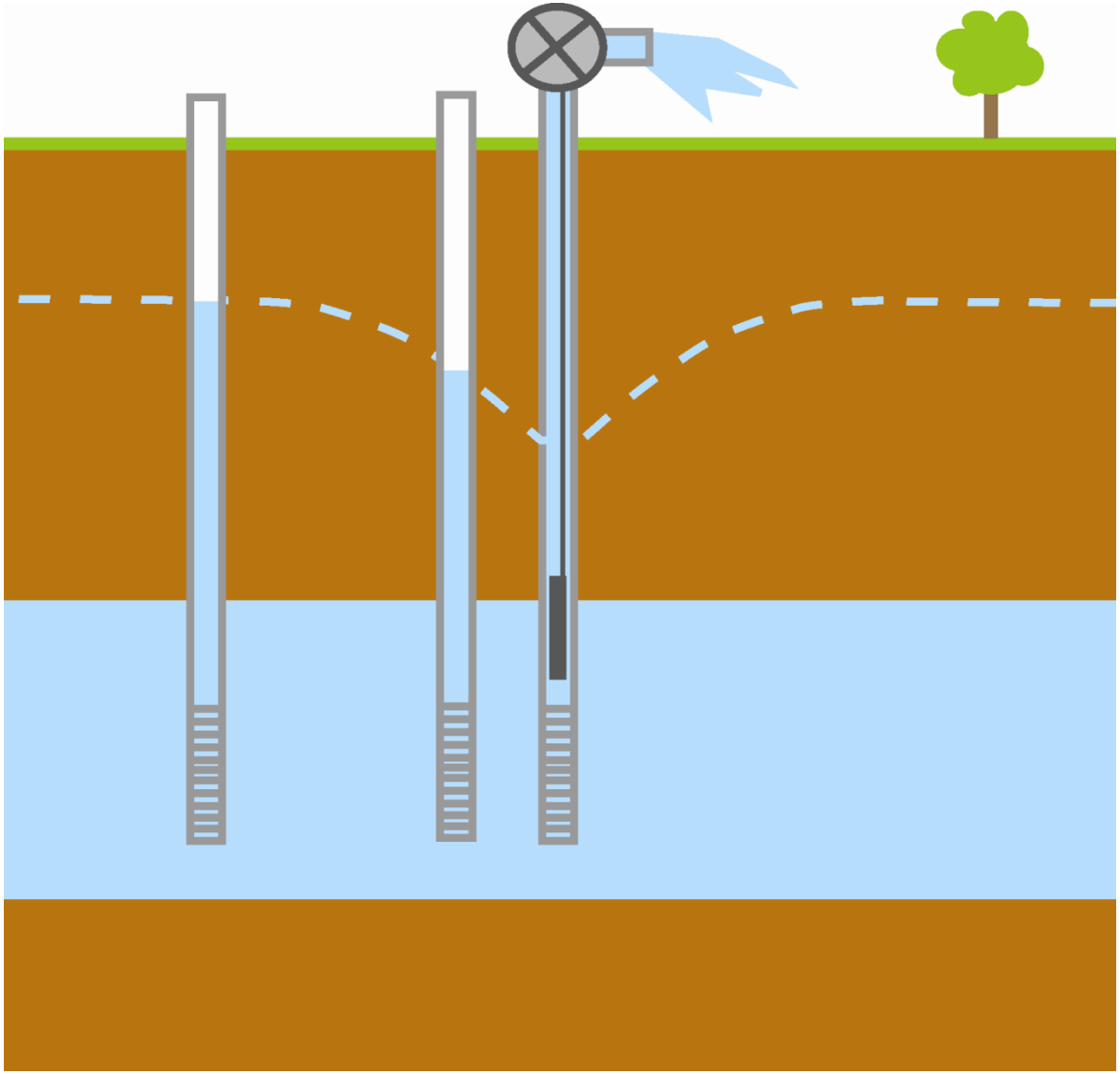
2 rules of groundwater flow

- **water flows downhill (to lower potential energy)**
- **water flows uphill to money**

pumping a well: unconfined



pumping a well: confined



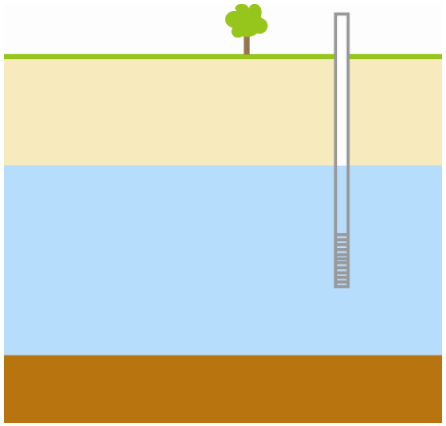
what is storativity?

- **Storativity describes the amount of water released from an aquifer for a decrease in water level.**

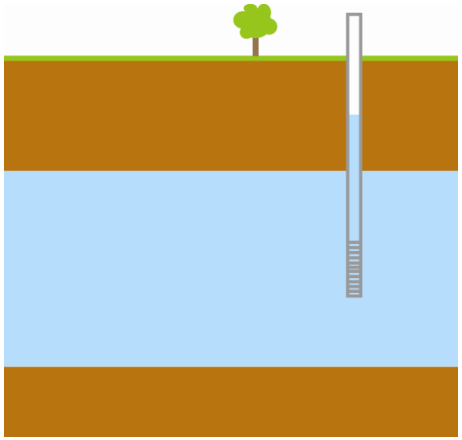
Scientific side note: Storativity is called “specific yield” in an unconfined aquifer.

storativity

- **Unconfined aquifers**
  0.01 to 0.3

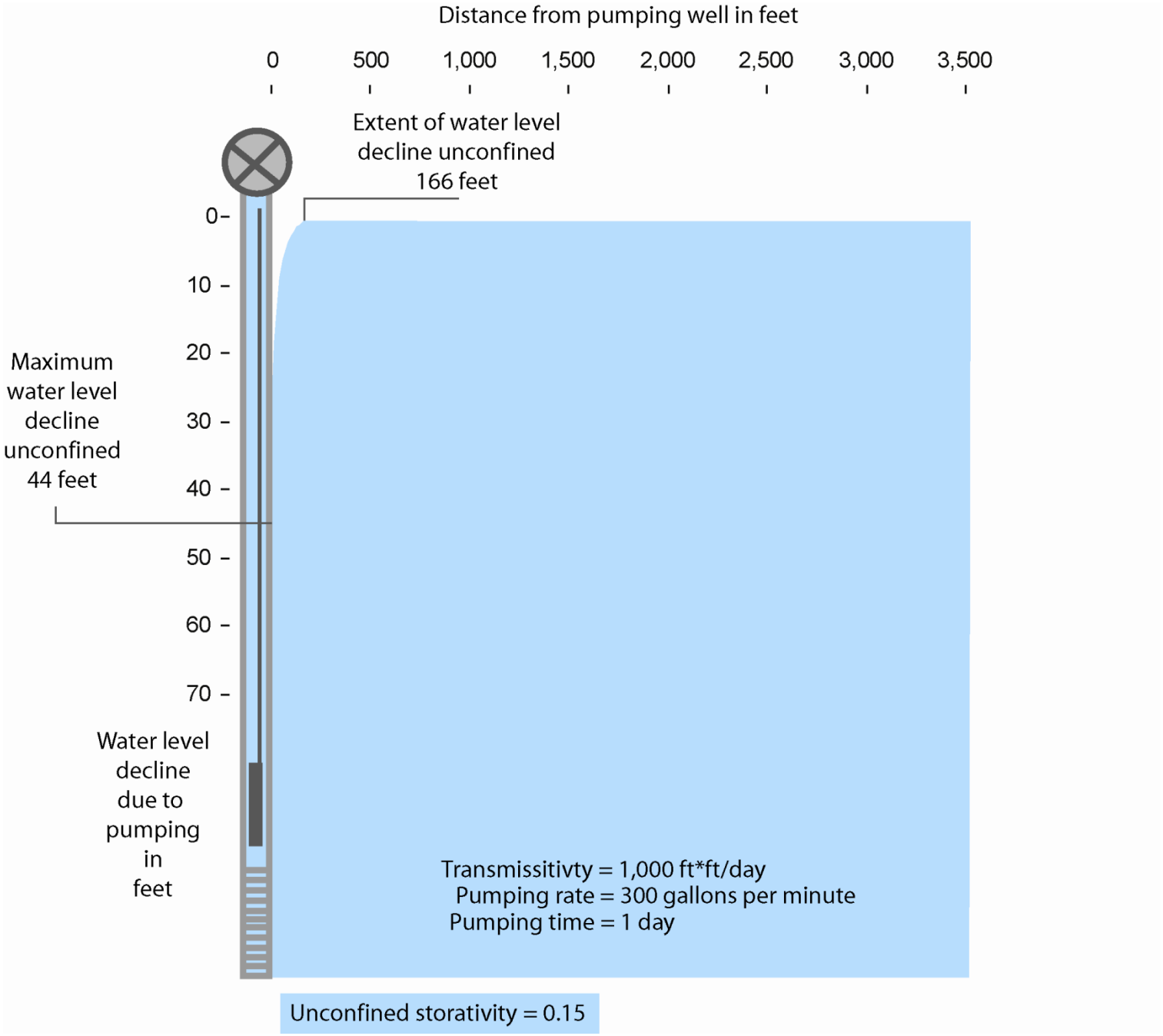


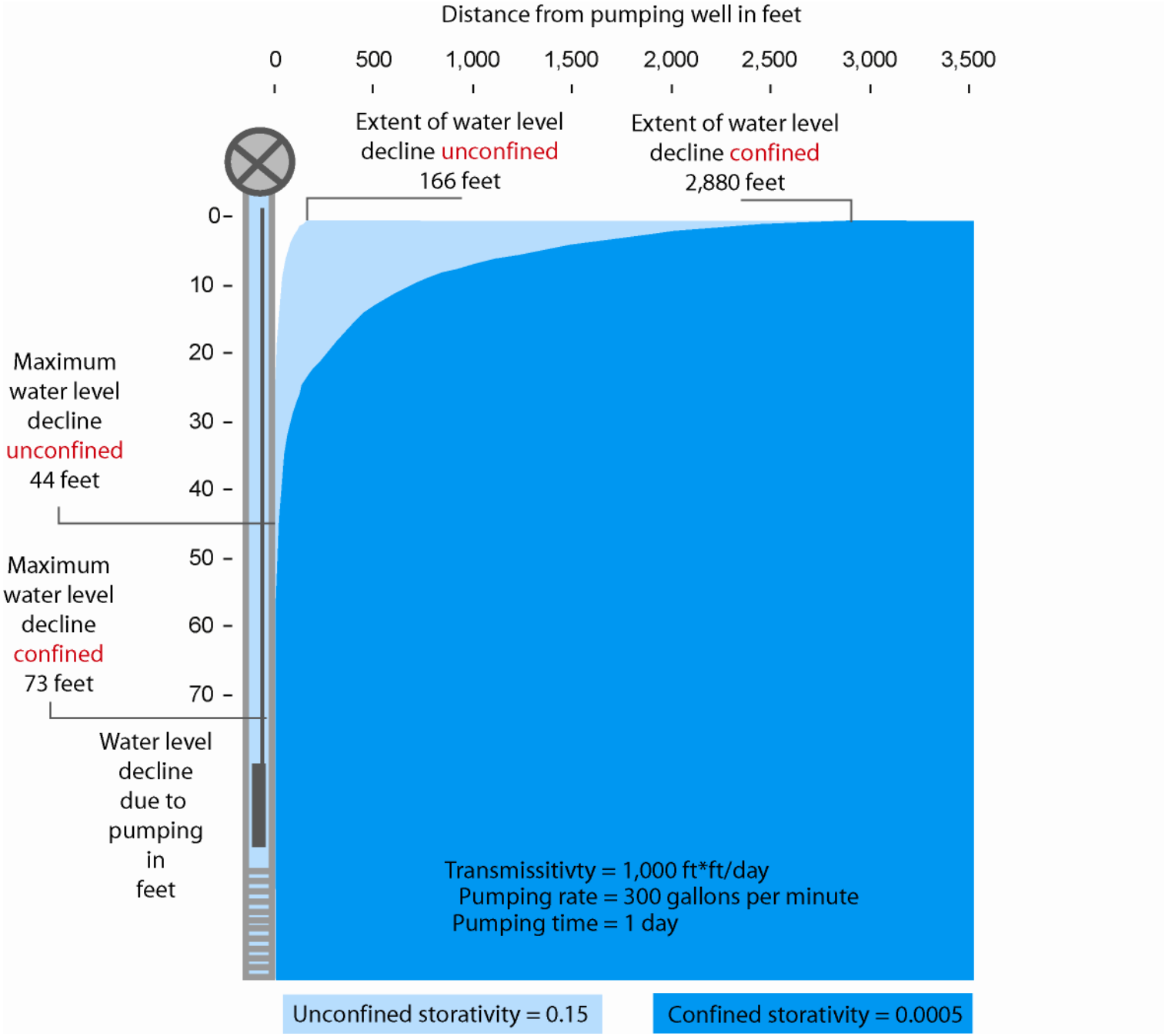
- **Confined aquifers**
  0.005 to 0.00005



Unconfined aquifer: checking the oil in the engine

Confined aquifer: checking the pressure in the tire


Distance from pumping well in feet
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Extent of water level decline unconfined 166 feet
0
10
20
30
40
50
60
70
Maximum water level decline unconfined 44 feet
Water level decline due to pumping in feet
Transmissitivty = 1,000 ft*ft/day
Pumping rate = 300 gallons per minute
Pumping time = 1 day
Unconfined storativity = 0.15


Distance from pumping well in feet
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Extent of water level decline unconfined 166 feet
Extent of water level decline confined 2,880 feet
0
10
20
30
40
50
60
70
Maximum water level decline unconfined 44 feet
Maximum water level decline confined 73 feet
Water level decline due to pumping in feet
Transmissitivty = 1,000 ft*ft/day
Pumping rate = 300 gallons per minute
Pumping time = 1 day
Unconfined storativity = 0.15
Confined storativity = 0.0005

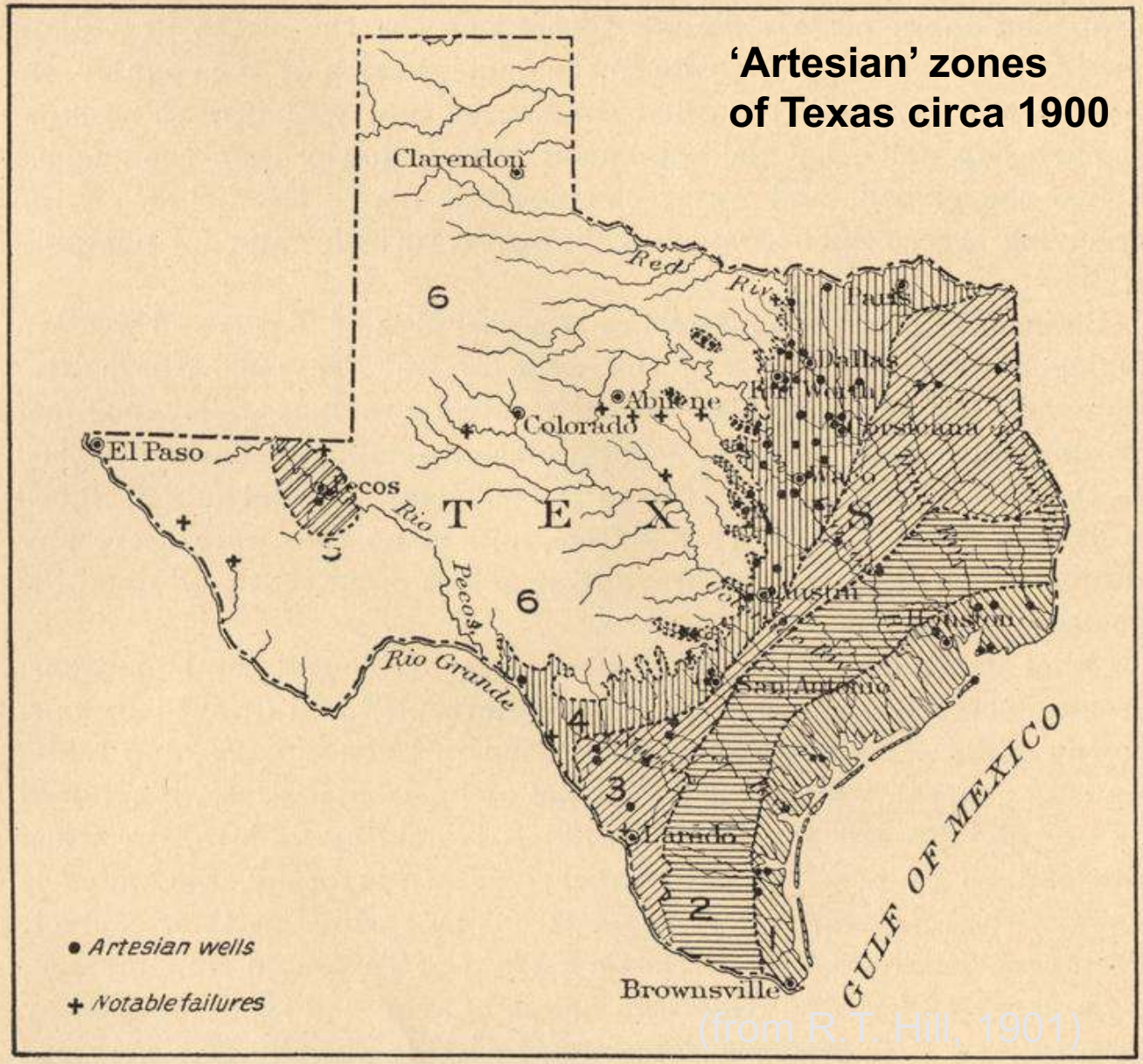
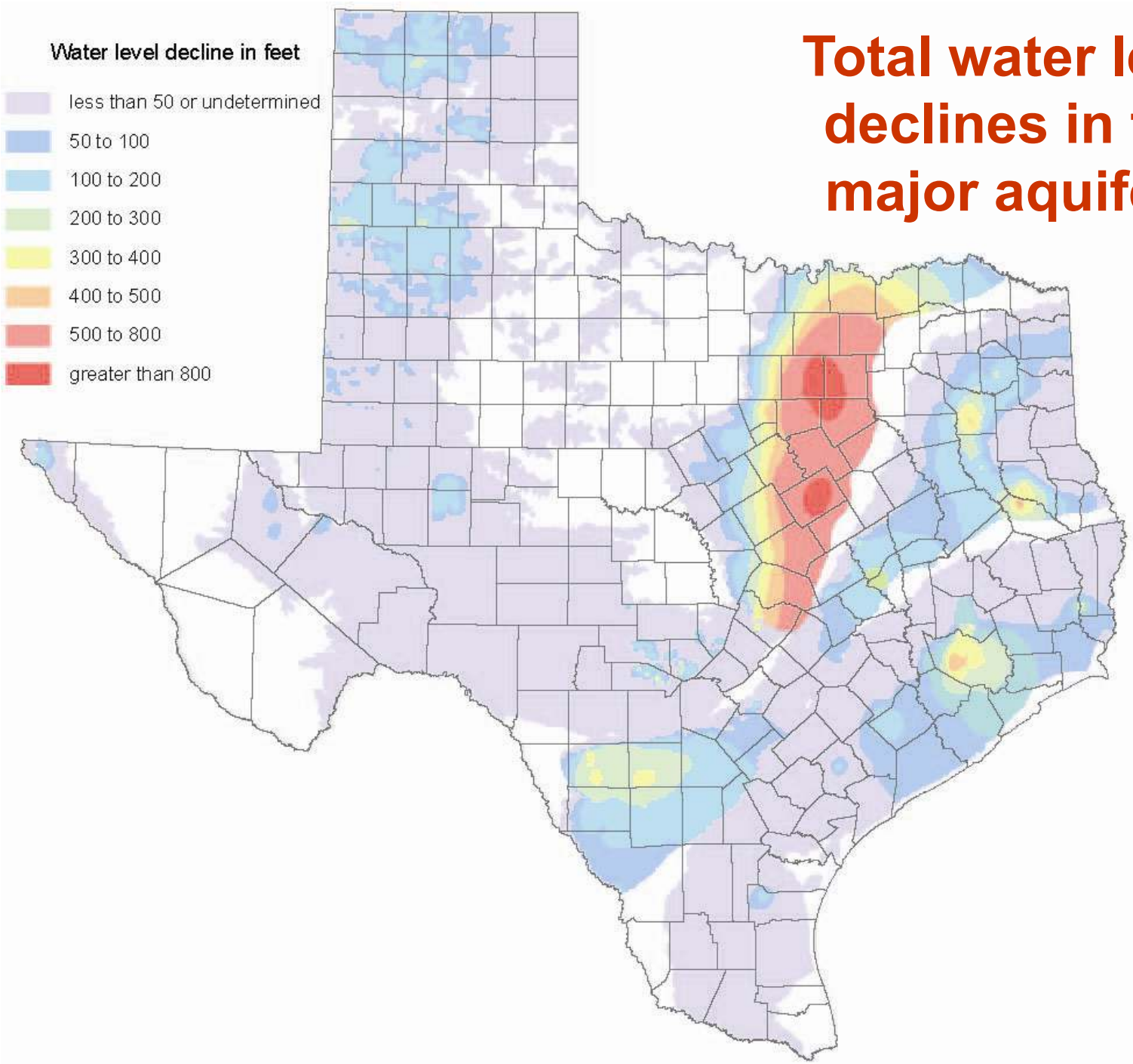


FIG. 44.—Map showing artesian districts of Texas.

1, Coast Prairie system; 2, Hallettsville system; 3, Carrizo system; 4, Black and Grand prairies system; 5, Trans-Pecos Basin system; 6, Stevens County and Jack County systems.

Total water level declines in the major aquifers



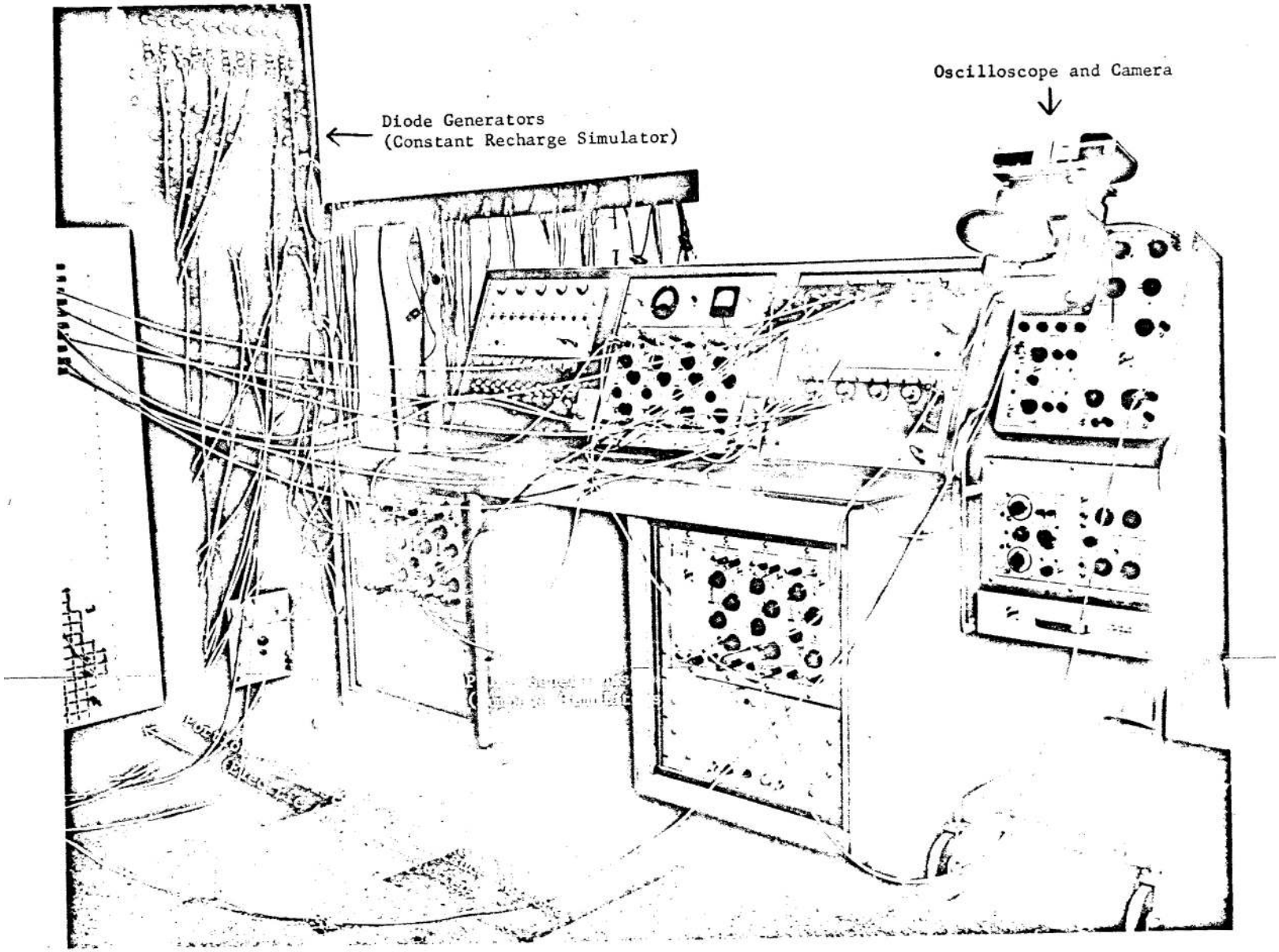
Questions?

Revenge of the Synth(etic aquifers)

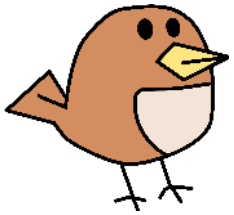
starring: [redacted] Robert Mace [redacted]

What is a Numerical Groundwater Flow Model?

- **'The aquifer in a computer!'**

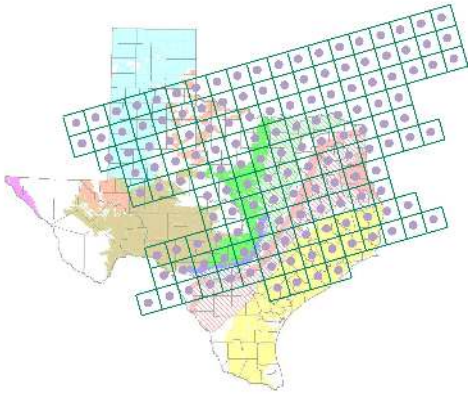


Equipment Used in Electric-Analog Model
Study of Aquifers in Houston District



The birds and the bees of groundwater models

- **Conceptual model**
- **Model architecture**
- **Calibrate the model**
- **Sensitivity analysis**
- **Predictions**
- **Documentation**
- **Updating**

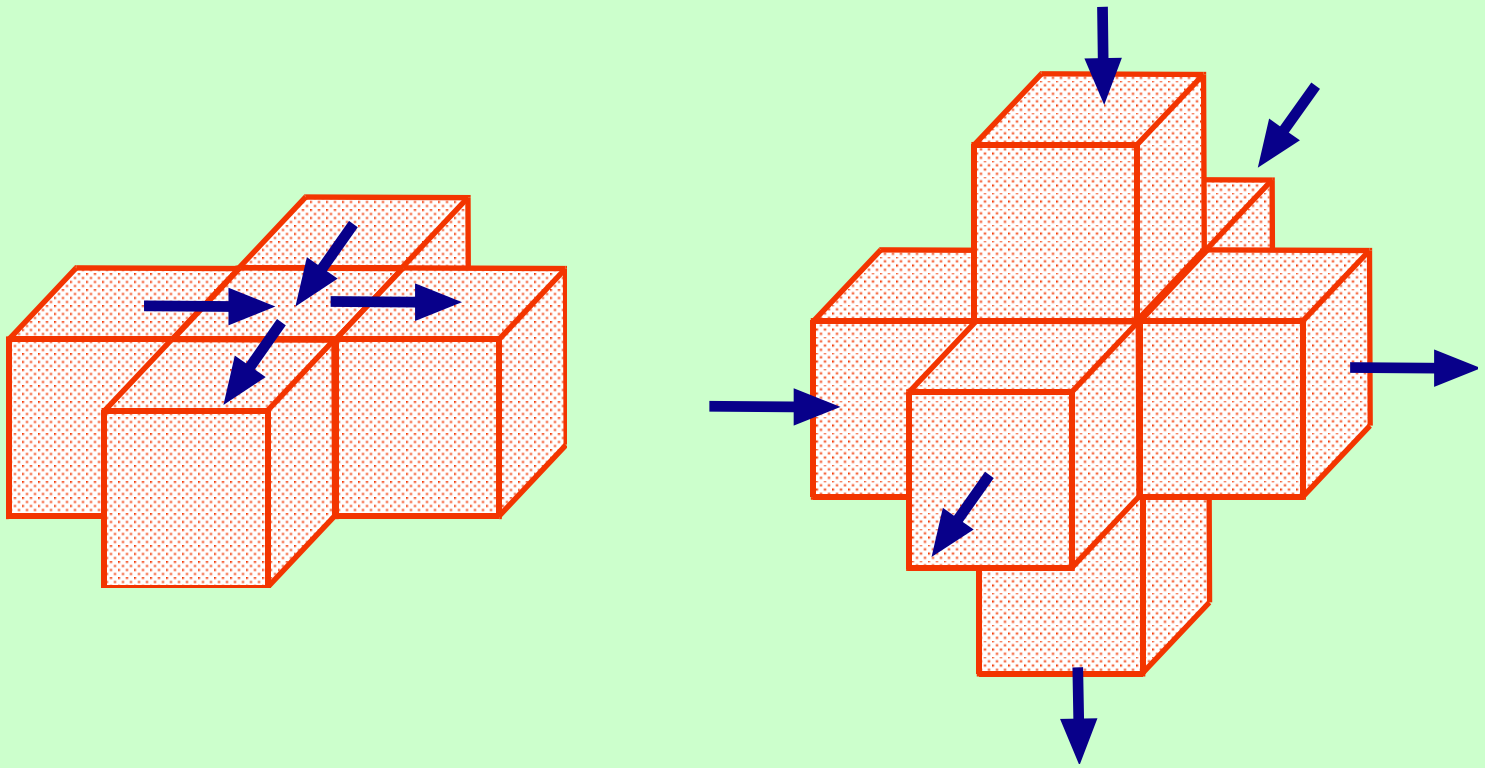


Groundwater models are data hungry:

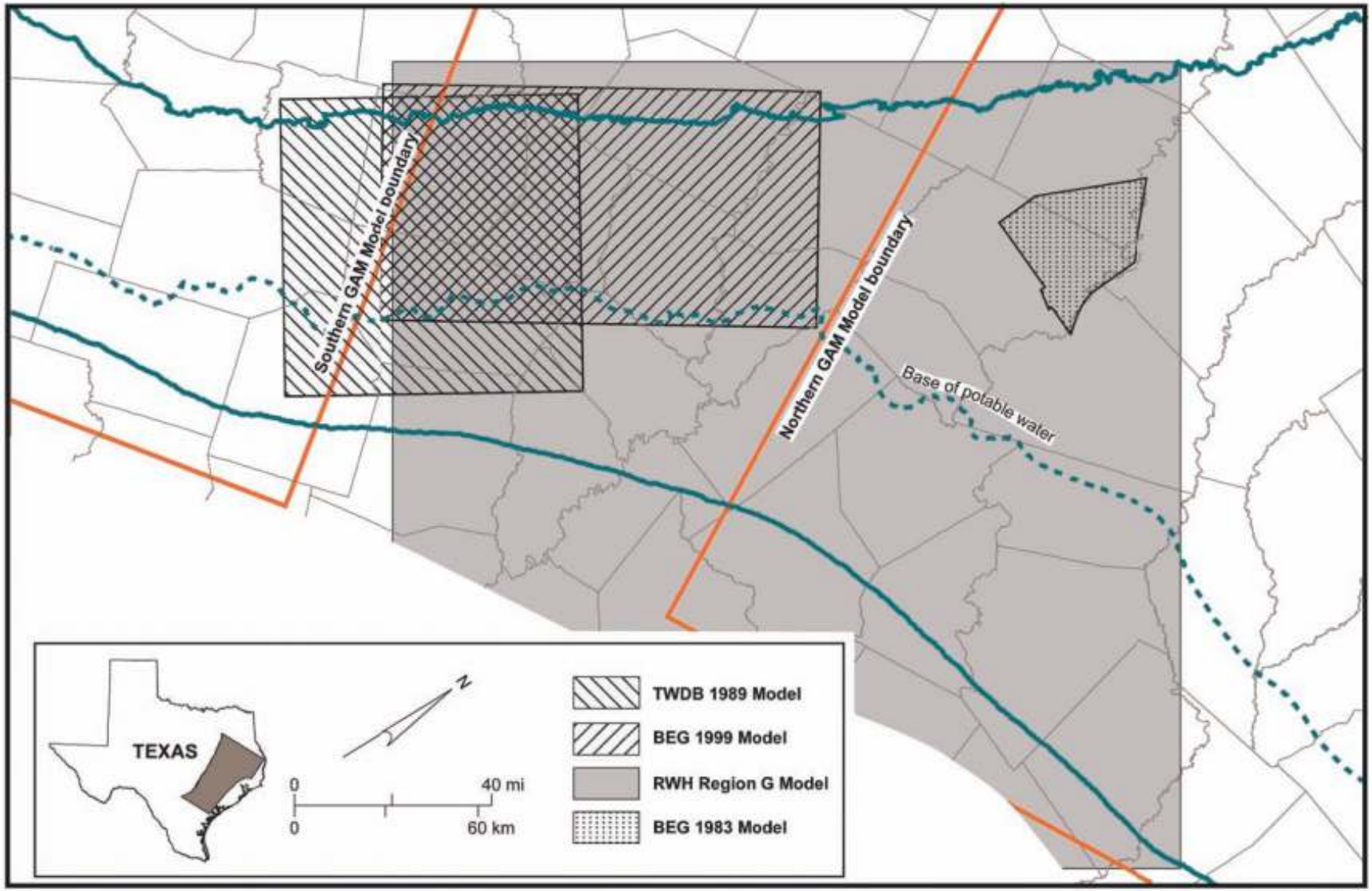
- geology
- structure
- digital elevation models
- water levels
- water-level variations
- soil maps
- precipitation
- water quality

- stream flows
- spring flows
- lake levels
- hydraulic properties
- pumping
- cultural references
- satellite imagery
- geophysical mapping
- well information

model architecture



Models of the Carrizo-Wilcox



from Dutton and others (2003)

Groundwater Availability Modeling Program

- **Aim**: Produce groundwater flow models for the major and minor aquifers of Texas.
- **Purpose**: Develop various tools that can be used to aid in groundwater resources management by stakeholders.
- **Public process**: Stakeholder involvement during model development process and during associated aquifer related projects-as applicable.
- **Models**: Freely available, standardized, thoroughly documented. Reports available over the internet.
- **Living tools**: Periodically updated.

How we use Groundwater Models?

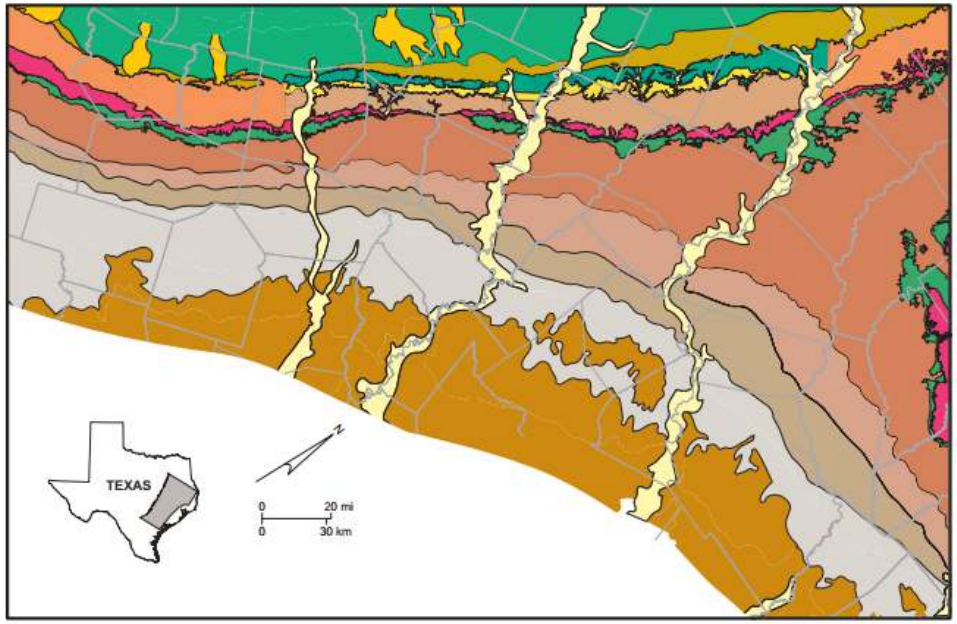
Per Statute:

- TWDB provides groundwater conservation districts with water budget data for their management plans.
- Groundwater management areas can use to assist in determining desired future conditions.
- TWDB uses when calculating estimated Modeled Available Groundwater.
- TWDB uses when calculating Total Estimated Recoverable Storage.

FINAL TECHNICAL REPORT

GROUNDWATER AVAILABILITY MODEL FOR THE CENTRAL PART OF THE CARRIZO-WILCOX AQUIFER IN TEXAS

2003



Prepared for
Texas Water Development Board

By Alan R. Dutton, Bob Harden[1], Jean-Philippe Nicot, and David O'Rourke[2]

Bureau of Economic Geology
Scott W. Tinker, Director
John A. and Katherine G. Jackson School of Geosciences
The University of Texas at Austin
Austin, Texas 78713-8924

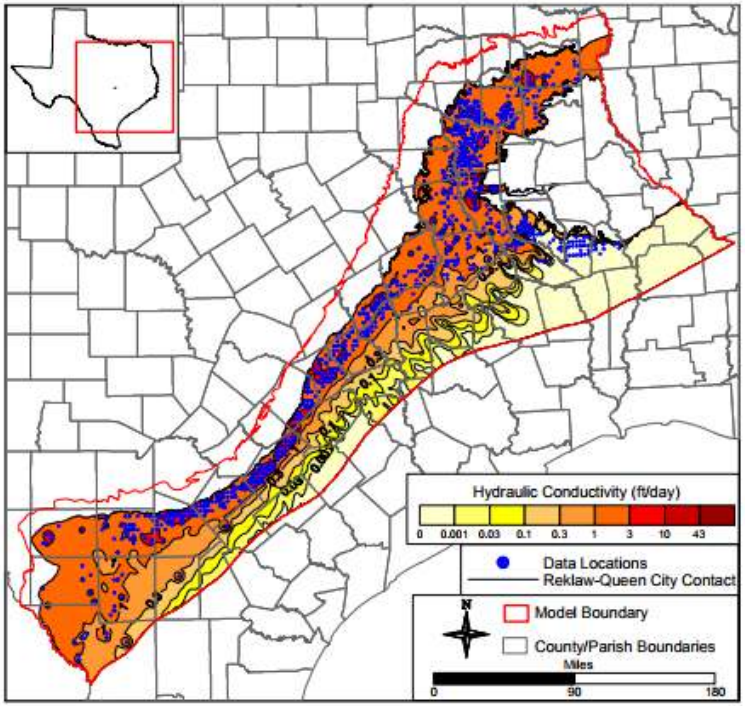
[1] R. W. Harden and Associates, Inc.
[2] HDR Engineering Services, Inc.

FEBRUARY 2003

FINAL REPORT

2004

Groundwater Availability Models for the Queen City and Sparta Aquifers



Prepared for the:

Texas Water Development Board

Prepared by:

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[2] R.J. Brandes Company

October, 2004

Effect of Faults on Groundwater Flow in the Carrizo-Wilcox Aquifer in Central Texas: Update the Central GAM for Sparta, Queen City, Carrizo-Wilcox Aquifers

Stakeholder Meeting #2
April 27, 2017

Post Oak Savannah GCD Office
Milano, TX

Presented by:
Steve Young, INTERA

Questions?

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