Groundwater Hydrology and Principles of Capture

Kip K. Allander; Supervisory Hydrologist; NV Water Science Center

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Concepts

- What is groundwater?

- Groundwater and surface water, how are these connected or related?

- Where does water come from when a well is pumped?

- What is capture and how does it work?

- What are groundwater models and why they are useful for estimating capture?

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What is groundwater?

- Liquid water in the subsurface.

- Water occupies spaces between sand, silt, and gravel in fill; or fractures and cavities in rocks.

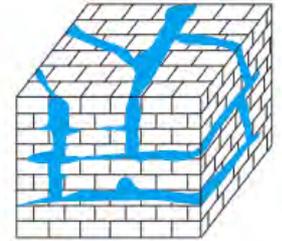- Water movement through and storage within the subsurface is governed by aquifer properties.

Permeability – ability of water to move through material.
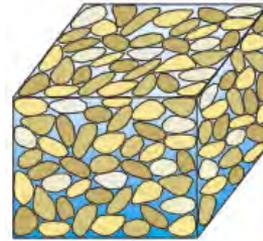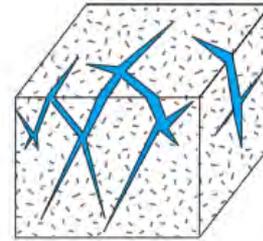
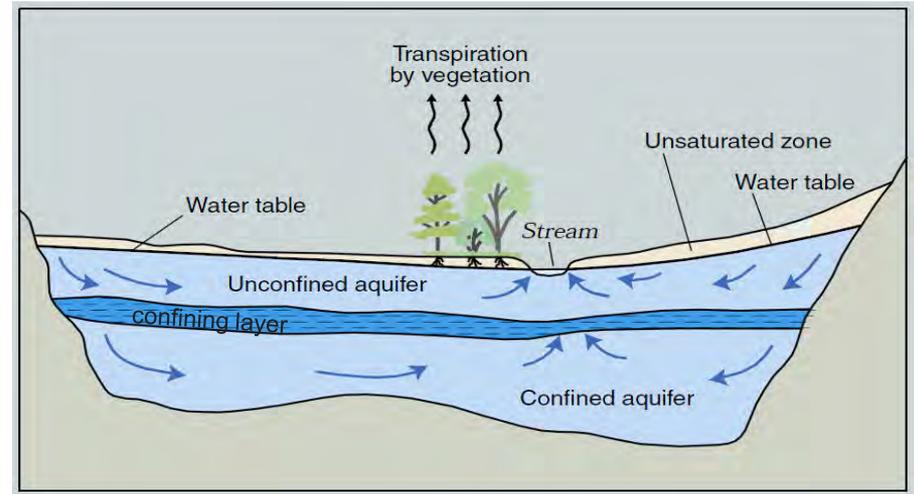A. Well-sorted sand   B. Fractures in granite   C. Caverns in limestone

Storage – amount of water that can be extracted from a given volume of aquifer.

What is groundwater?

Aquifers – exist where groundwater can be developed to provide adequate supply to wells.

- Groundwater flows from areas of recharge to areas of discharge.

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Groundwater and Surface Water are a Single Resource

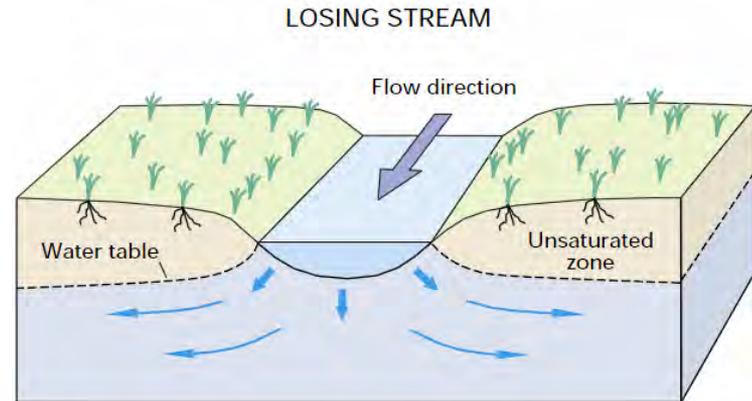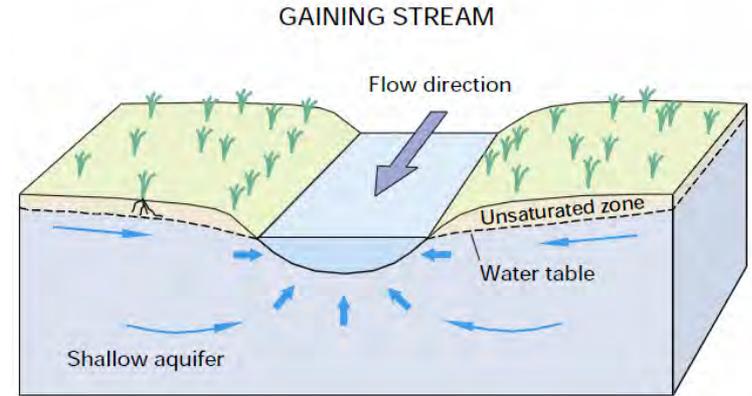Important concept for understanding how groundwater works.

Understanding is necessary for proper management of water resources.
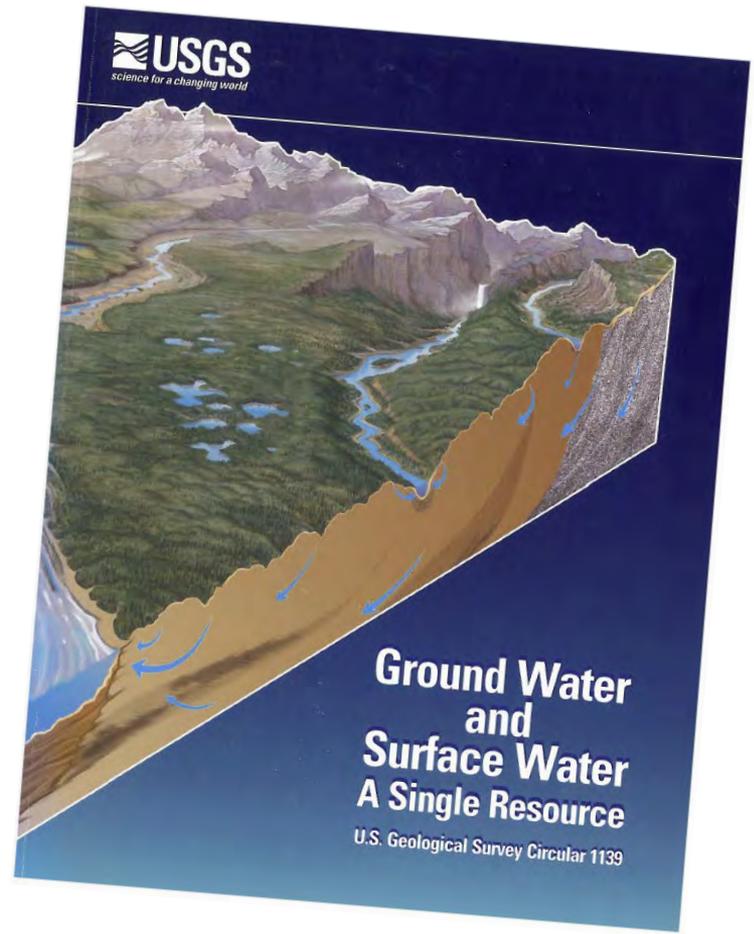
Winter, T.C., Harvey, J.W., Franke, O.L., and Alley, W.M., 1998, Ground water and surface water—A single resource: U.S. Geological Survey Circular 1139, 79 p. https://pubs.usgs.gov/circ/circ1139/

Groundwater and Surface water are a single resource

- Streams flowing year-round are connected with groundwater.

- Groundwater can:
  - Discharge to a stream (gaining stream).
  - Receive water from a stream (losing stream).

- Streams can:
  - Lose water to groundwater (losing).
 - Gain water from groundwater (gaining).

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GAINING STREAM

Flow direction

Unsaturated zone

Water table

Shallow aquifer

LOSING STREAM

Flow direction

Water table

Unsaturated zone

River Connected Groundwater Systems in Nevada

- River connected flow systems.

  - Much of groundwater movement between groundwater basins is by streamflow.

  - 25 percent of the Nevada's groundwater systems.

  - Substantial potential for conflict between groundwater and surface water users due to shared nature of resource.

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Where does water come from when pumping a well?

- Storage change – water from aquifer near well.

- Streamflow capture – diversion from stream.

- Evapotranspiration capture – water intercepted from plant use and evaporation.
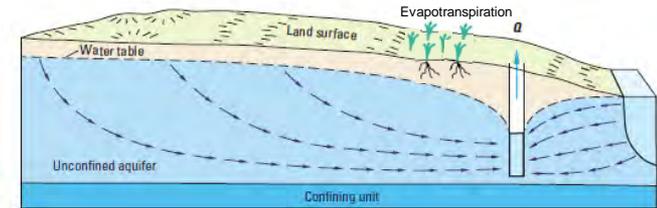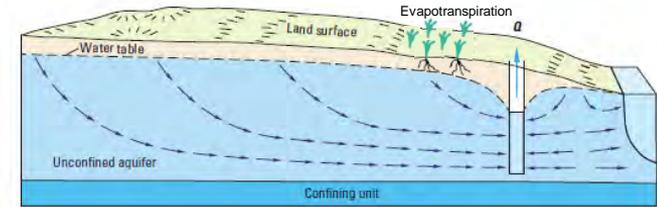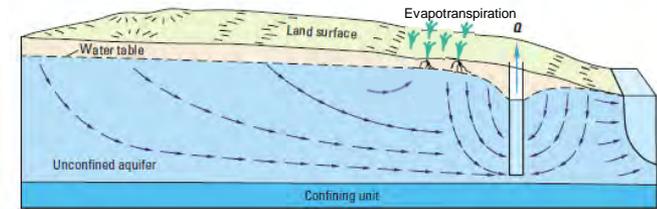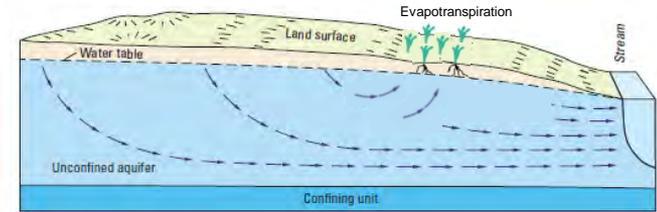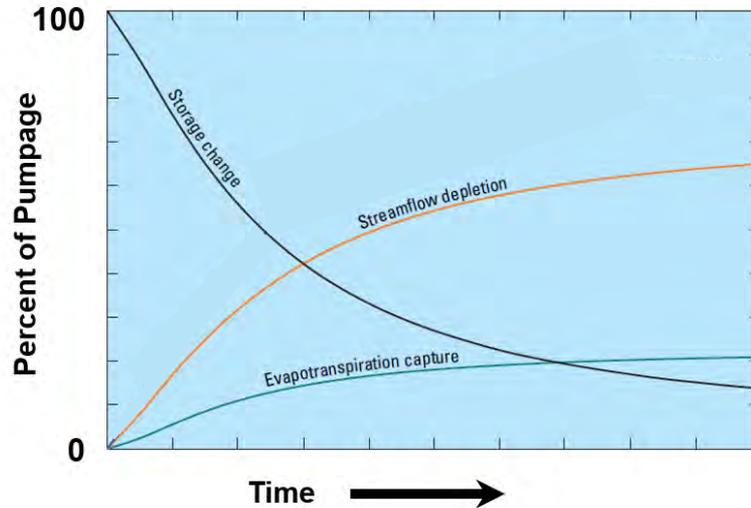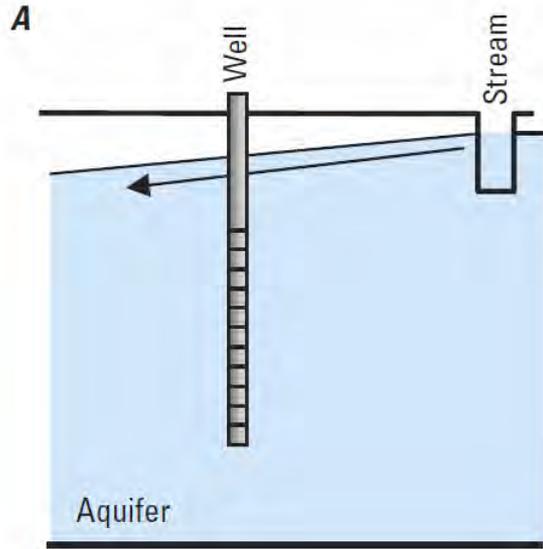
What is capture?

- Stream capture = streamflow depletion.

- Is reduction in streamflow to supply pumping.

- Equivalent to stream diversion.

- ET Capture = ET Salvage
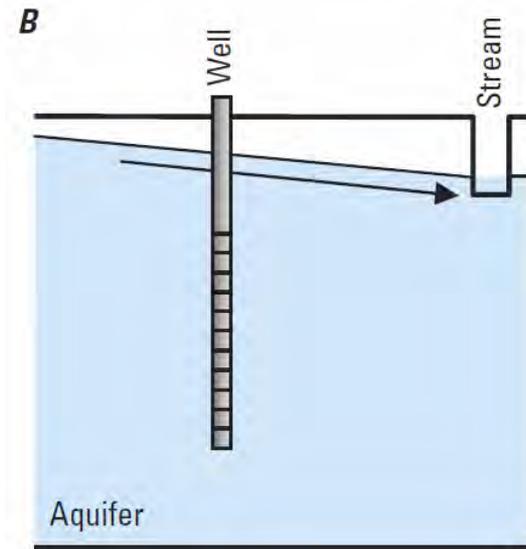
- Water intercepted from plant use and evaporation.

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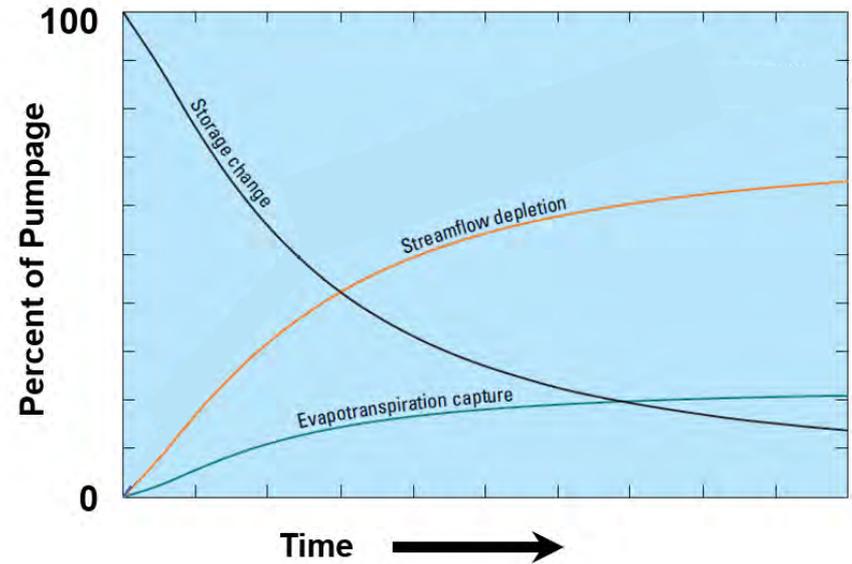
Stream capture occurs whether streams are gaining or losing
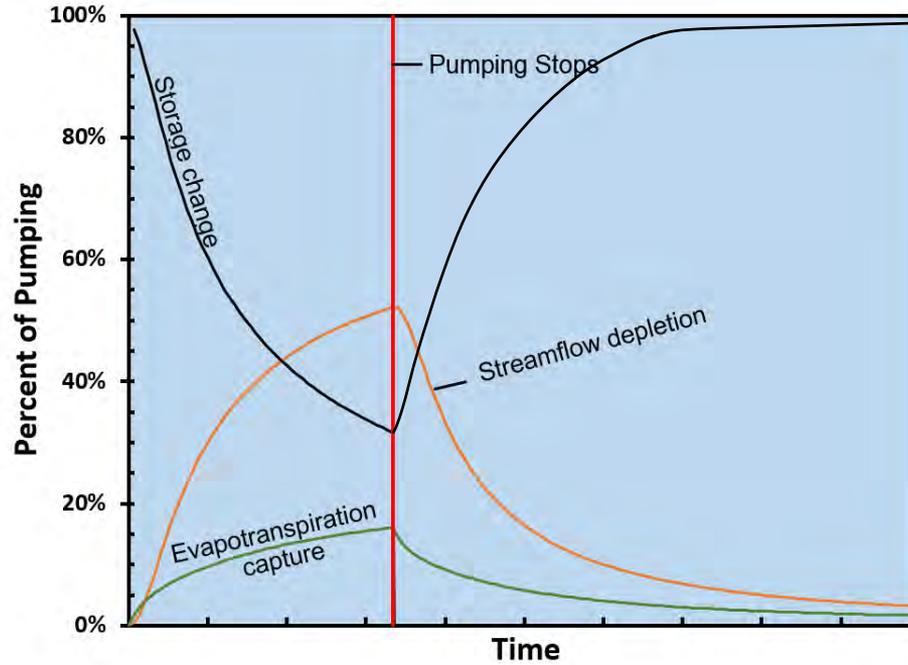
A) Increased loss from stream.
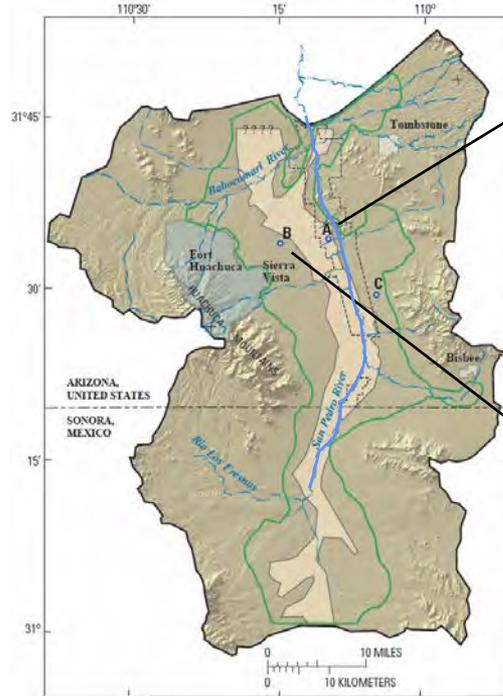
B) Decreased gain of stream.

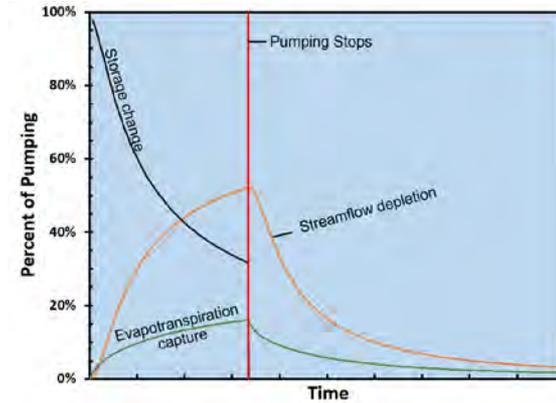# Capture continues after pumping stops

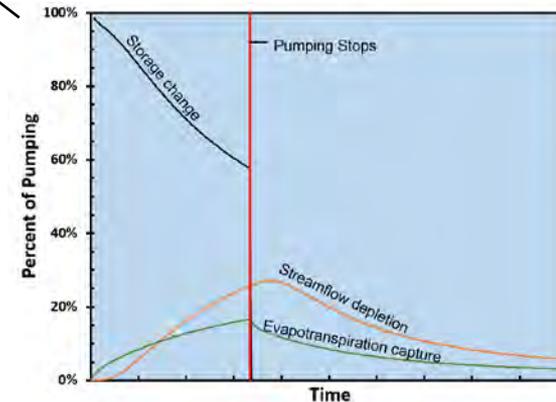# Degree of capture depends on location and system properties.

- The closer the well (Well A), induces greater capture sooner.

- The further well (Well B), induces less capture, but for longer duration.
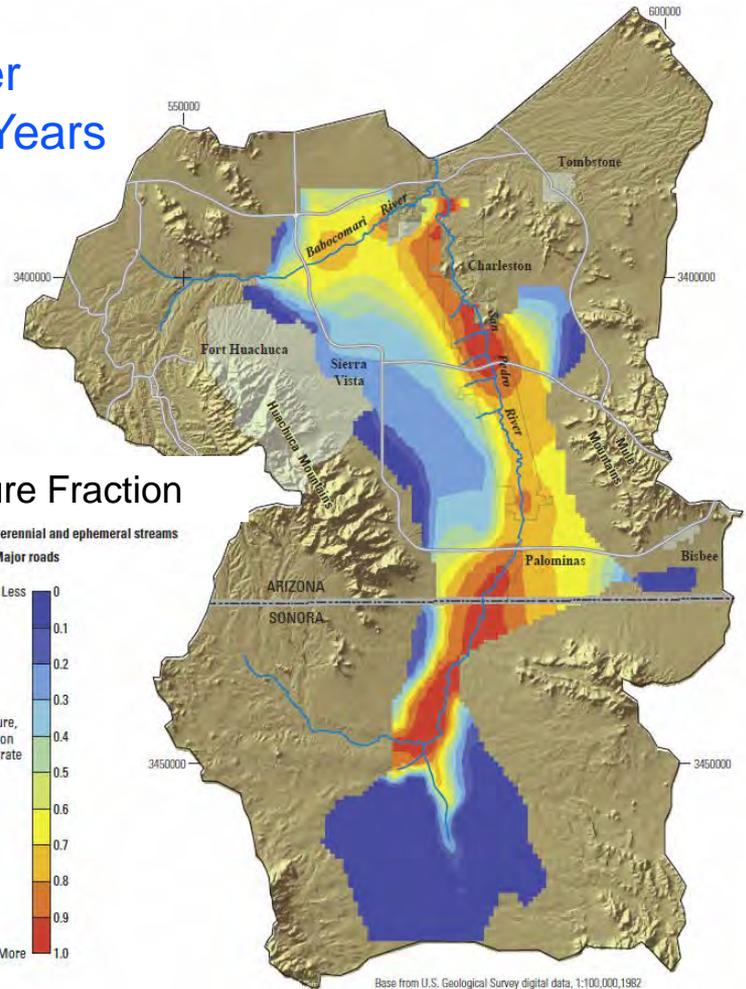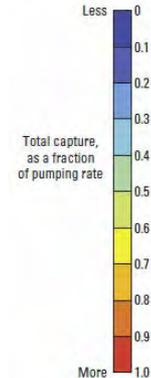

Well A

Well B

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Capture maps

- Estimates of capture based on location and properties of system.

- For defined durations of pumping.

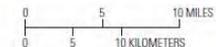- Developed from 'calibrated' groundwater flow models.

After 50 Years

Capture Fraction

Perennial and ephemeral streams
Major roads

Total capture, as a fraction of pumping rate

Less 0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
More 1.0

Base from U.S. Geological Survey digital data, 1:100,000, 1982
Universal Transverse Mercator projection, Zone 12, NAD83
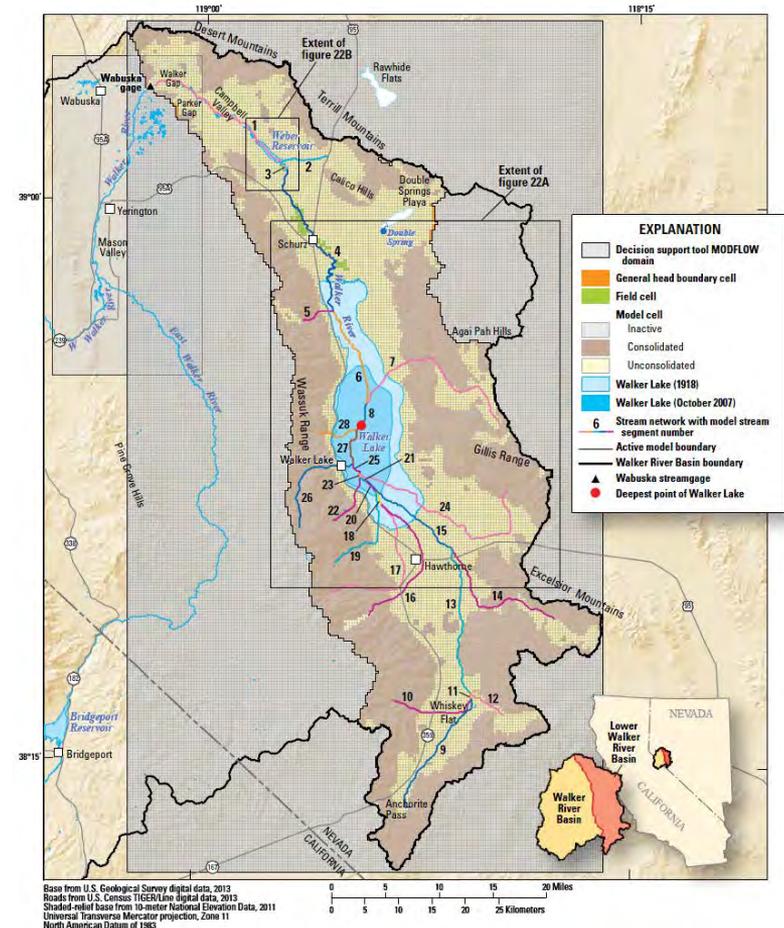
Barlow and Leake (2012)

What are Groundwater Models?

- Mathematical representations of complex hydrologic systems.

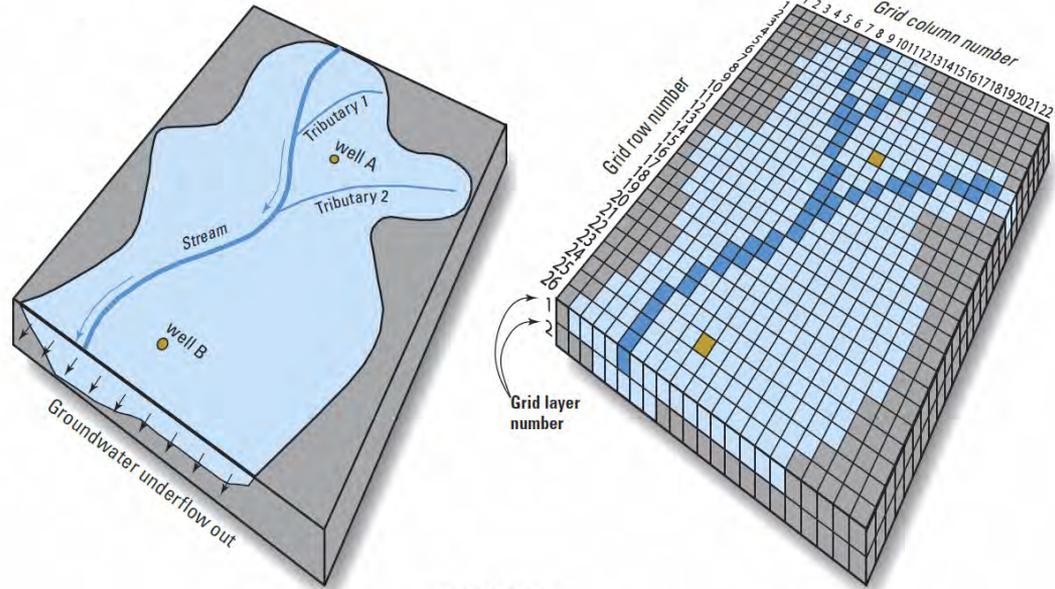- Simulate hydrologic systems based on principles, aquifer properties, and boundary conditions.

Groundwater flow equation:

$$\frac{\partial}{\partial x}\left[K_{xx}\frac{\partial h}{\partial x}\right] + \frac{\partial}{\partial y}\left[K_{yy}\frac{\partial h}{\partial y}\right] + \frac{\partial}{\partial z}\left[K_{zz}\frac{\partial h}{\partial z}\right] + W = S_s\frac{\partial h}{\partial t}$$
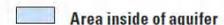

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Why are Groundwater Models often needed to estimate capture?

- Irregular geometries.
  - Aquifer boundaries.
  - Streams.

- Spatially varying properties.

- Complex pumping schedules.

EXPLANATION

Area inside of aquifer	Finite-difference grid
Area outside of aquifer	Model cell containing portion of stream
	Model cell containing well

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Questions?

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