University of California, Davis
Department of Land, Air and Water Resources

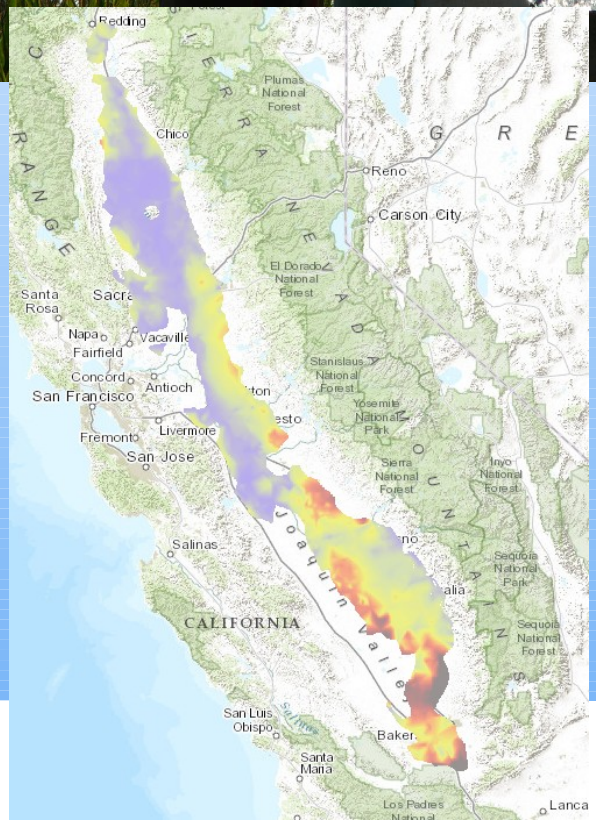
UC Cooperative Extension
Hopland Research and Extension Center

Groundwater Hydrology

Workshop: Impact of Drought on Livestock

Oct/2014

Sam Sandoval, PhD
Assistant Professor
C.E. Specialist in Water Resources



Overview

- **Hydrology and Groundwater**
  - What is Groundwater?
  - How fast does groundwater move?
  - Where does groundwater come from and where does it go?

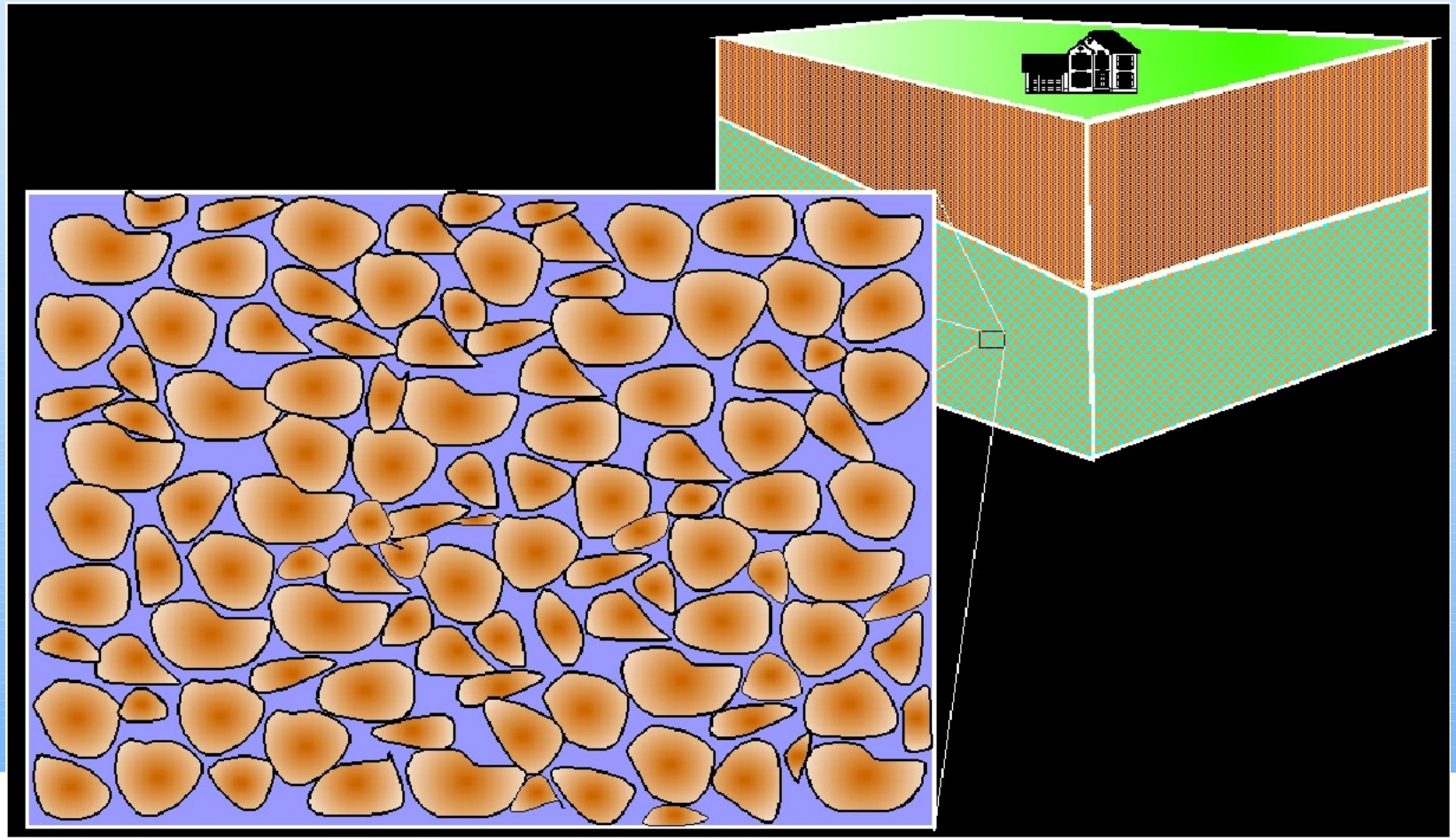
Groundwater Hydrology

What is groundwater?

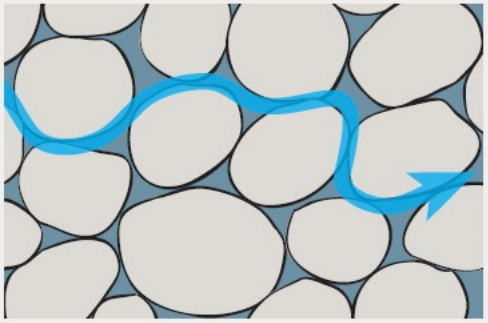
- An underground lake?
- A network of underground rivers?
- A rectangular network of pipelike water arteries?
- A giant sponge?

What is groundwater?

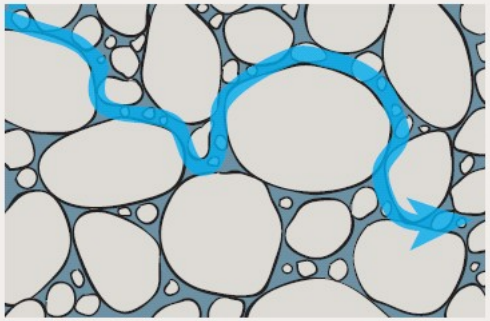
Groundwater = Water Completely filling Pores/Fractures



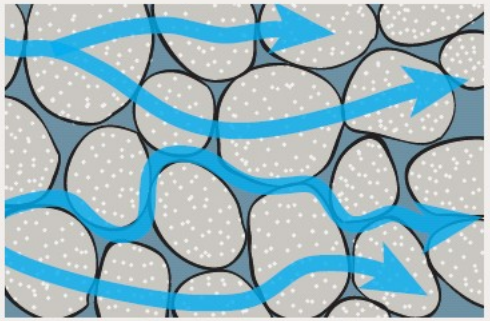
Groundwater in Different Sediments and Rocks



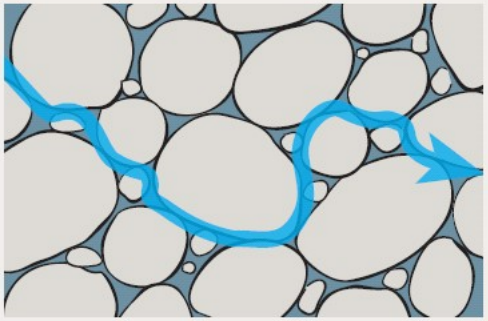
Well-sorted sediment



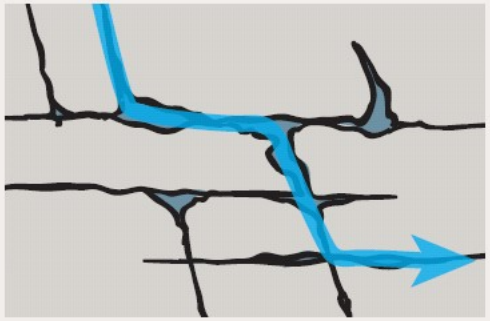
Poorly sorted sediment



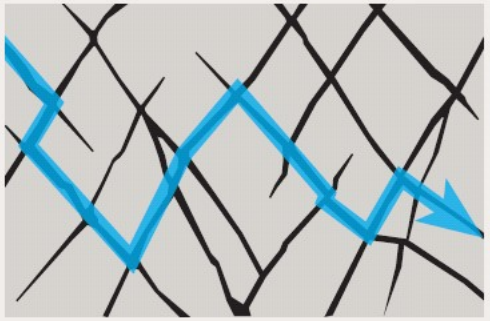
Porous sediment



Consolidated sediment

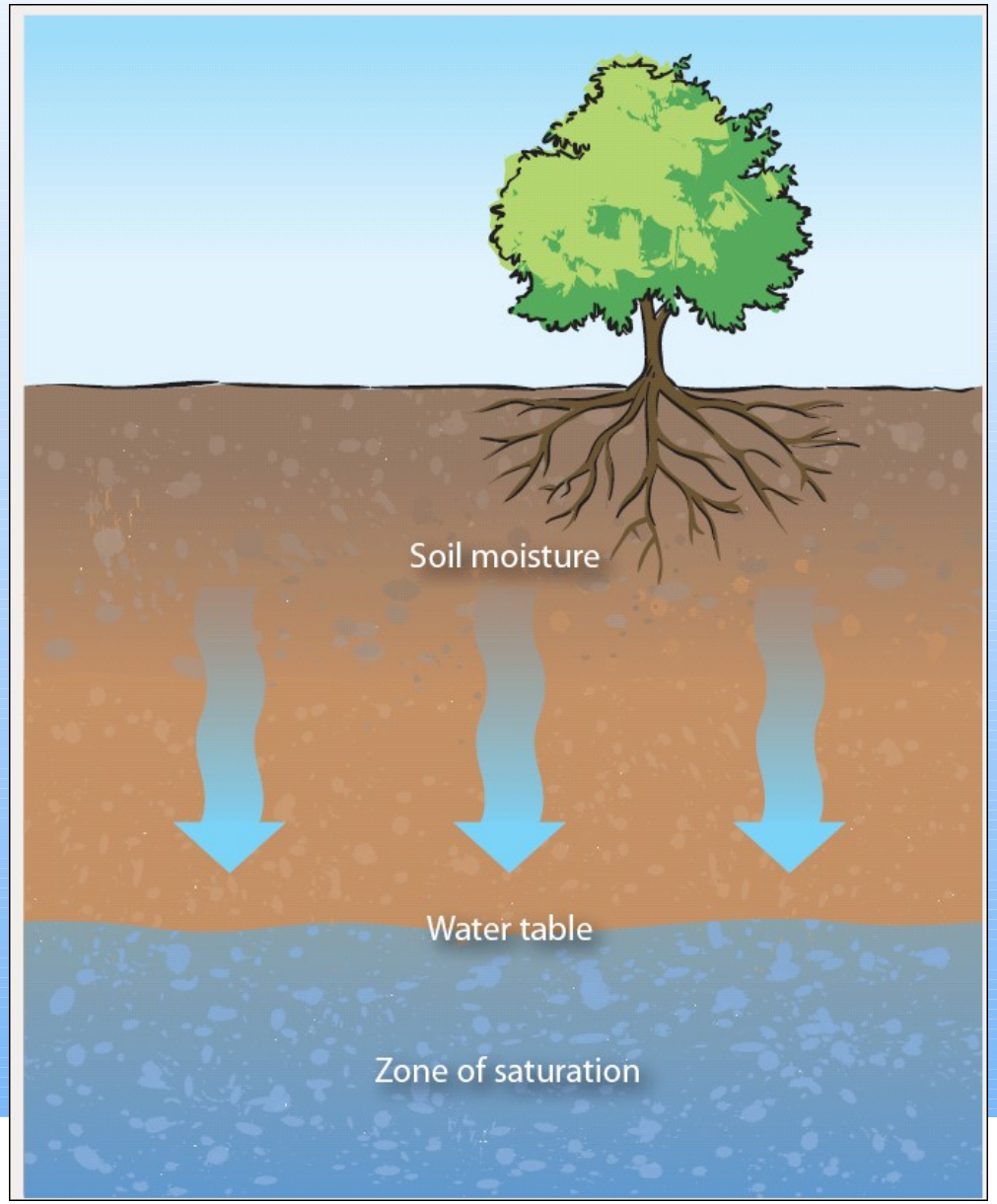


Dissolution of rock



Rock fractures

What is groundwater?



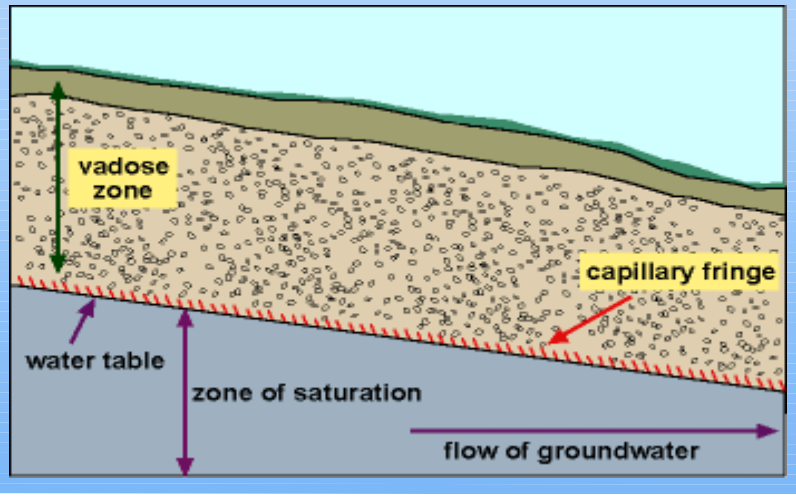
Unsaturated Zone

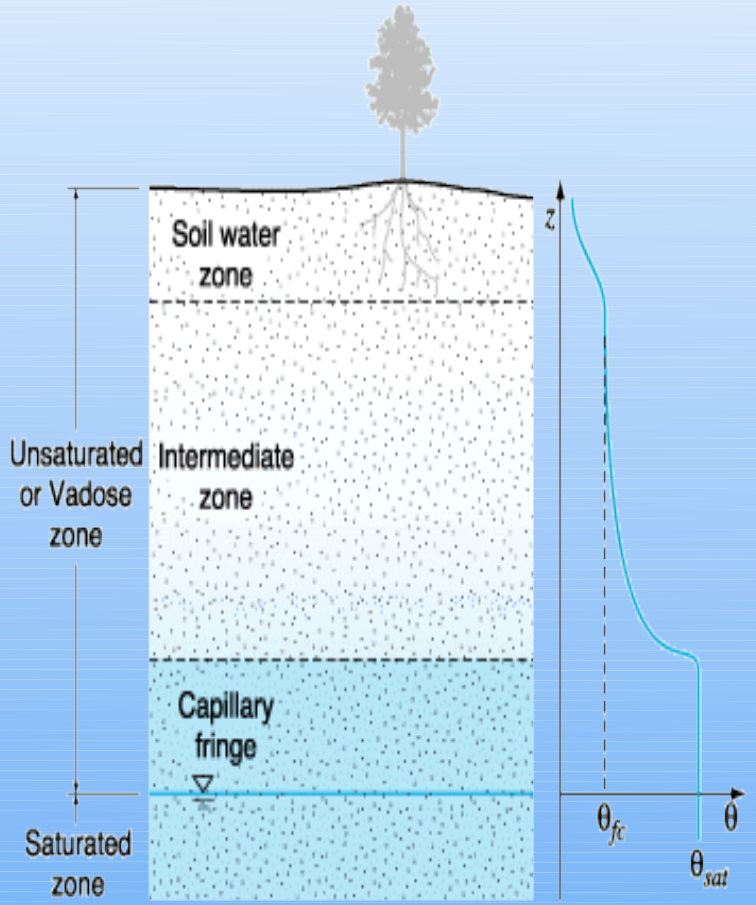
Saturated Zone

Unsaturated Zone

AKA Vadose zone

- (“Zone of aeration”)
- above the water table
- soil pores contain either air or water

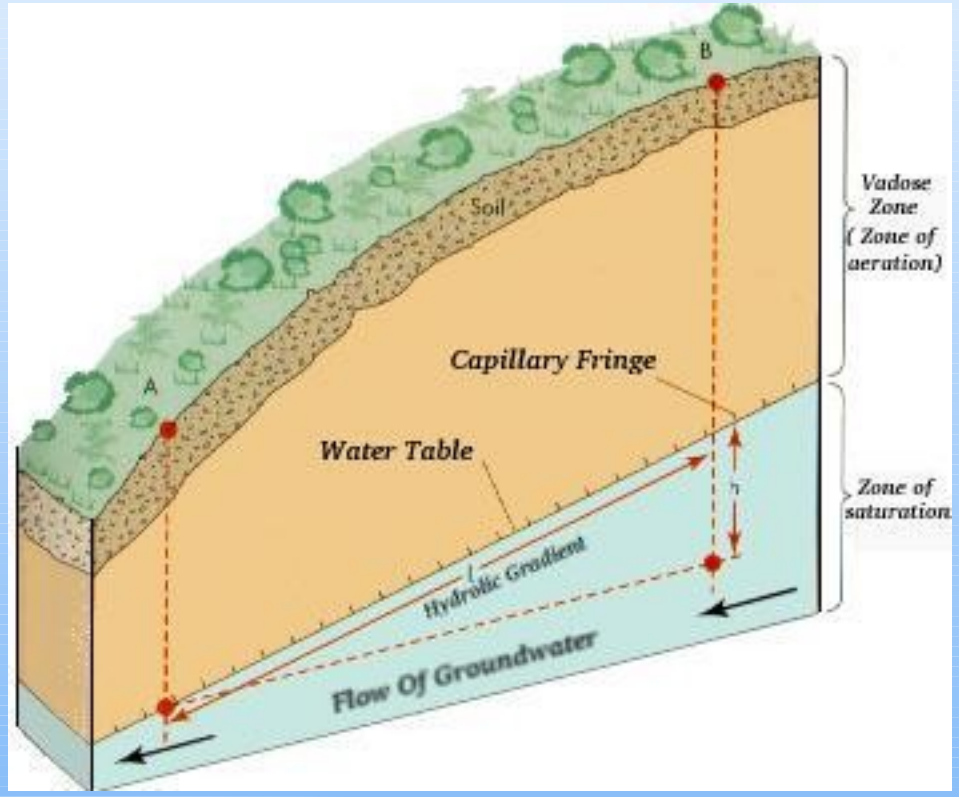




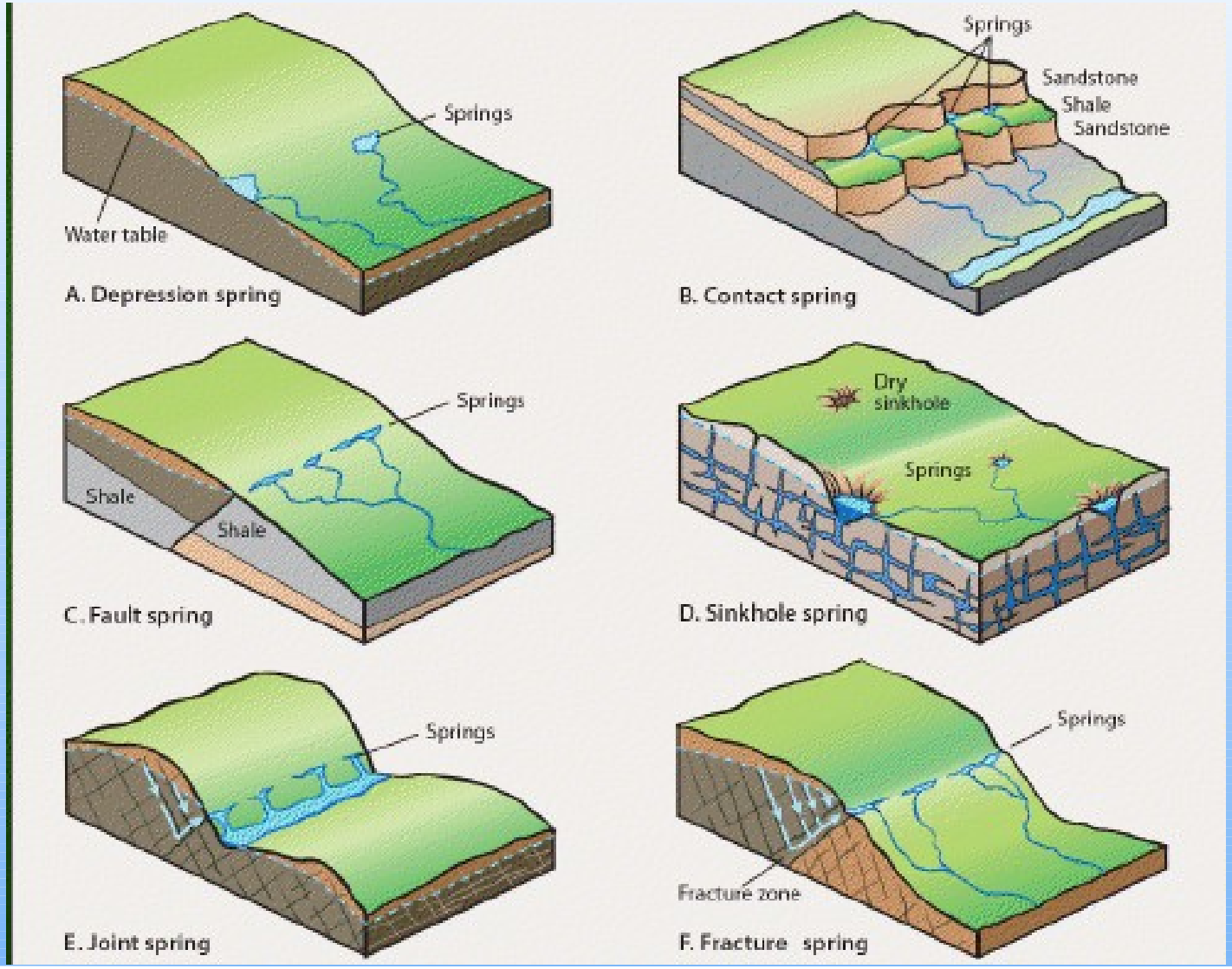
saturated Zone

Aquifers: Water bearing properties; this is the “saturated zone”

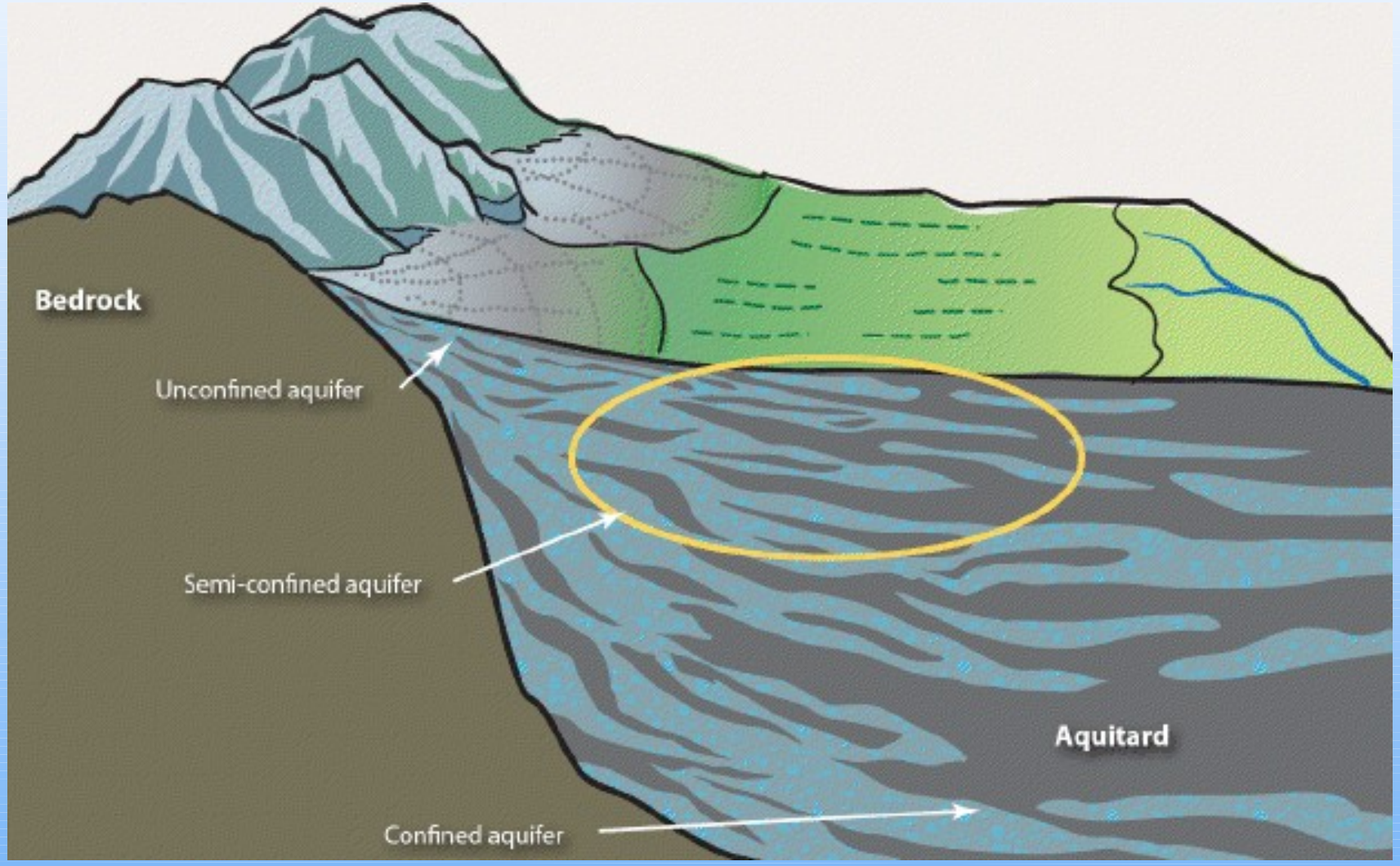
- ***Confined***: Soil or rock below the land surface that is saturated with water. There are layers of impermeable material both above



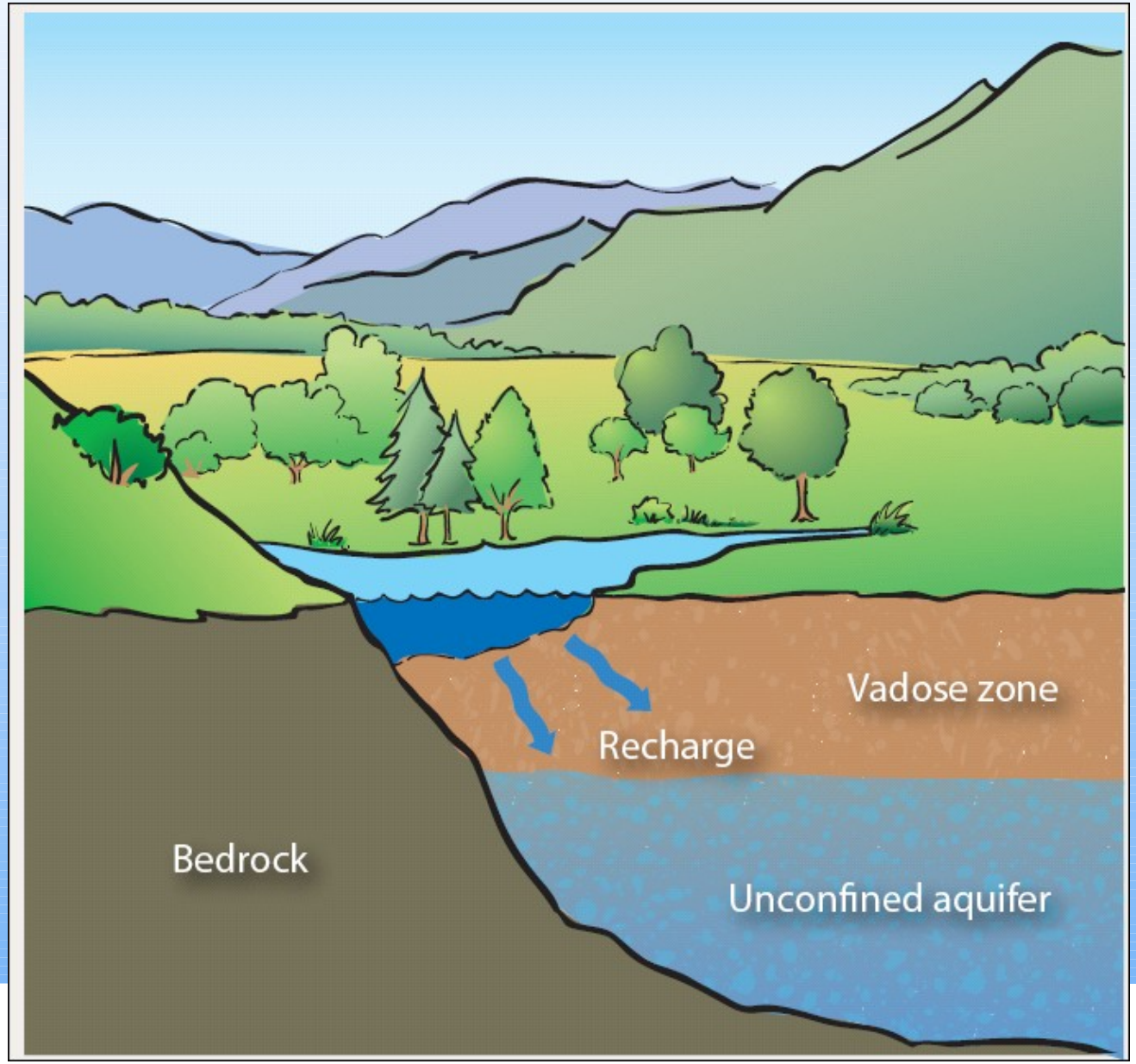
Springs


Springs
Water table
A. Depression spring
Springs
Sandstone
Shale
Sandstone
B. Contact spring
Springs
Shale
Shale
C. Fault spring
Dry
sinkhole
Springs
D. Sinkhole spring
Springs
E. Joint spring
Springs
Fracture zone
F. Fracture spring

Confined – Unconfined Aquifers

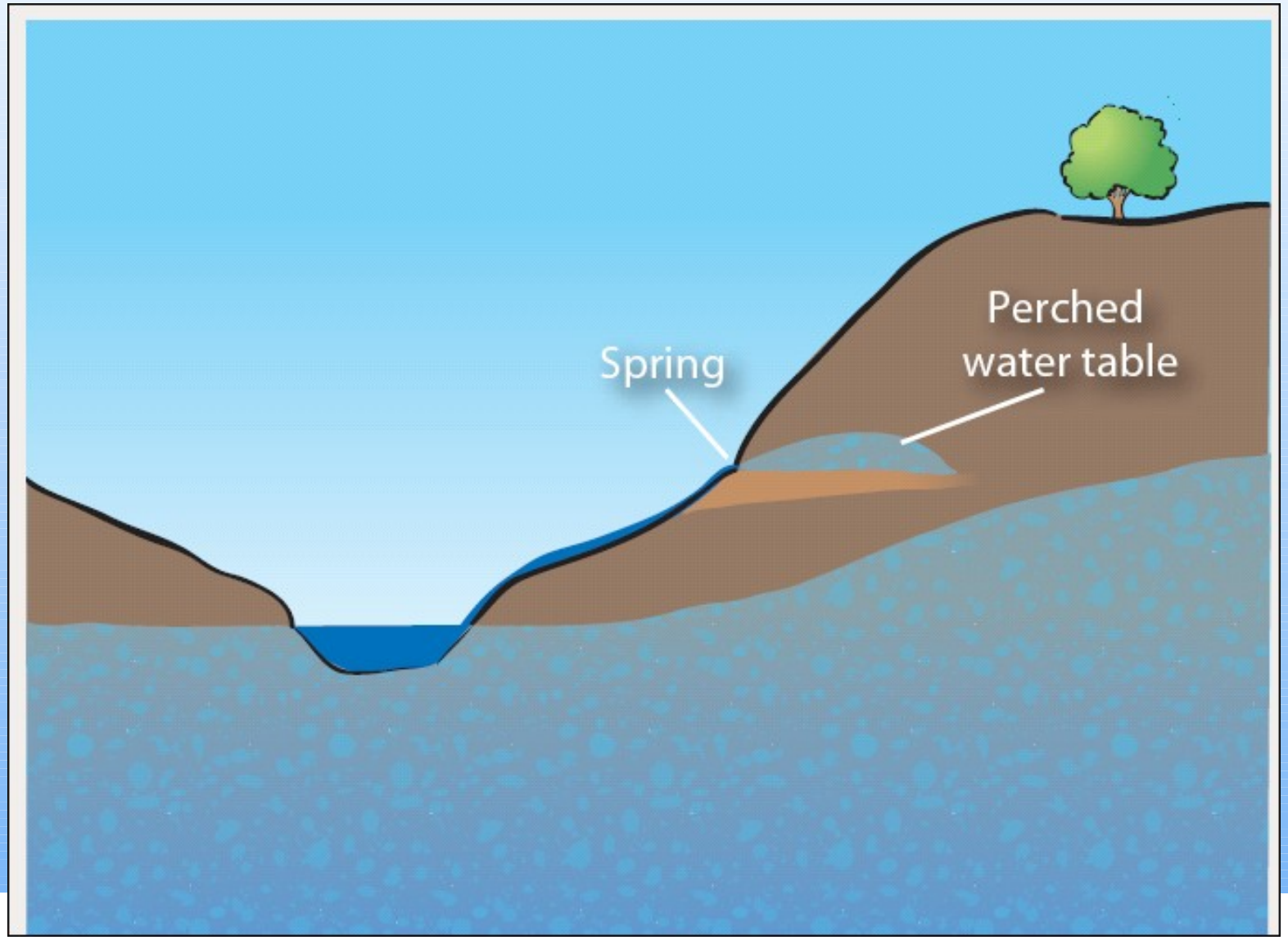


Unconfined Aquifer



Losing stream

Unconfined Aquifer



Gaining stream

Other Types of Aquifers

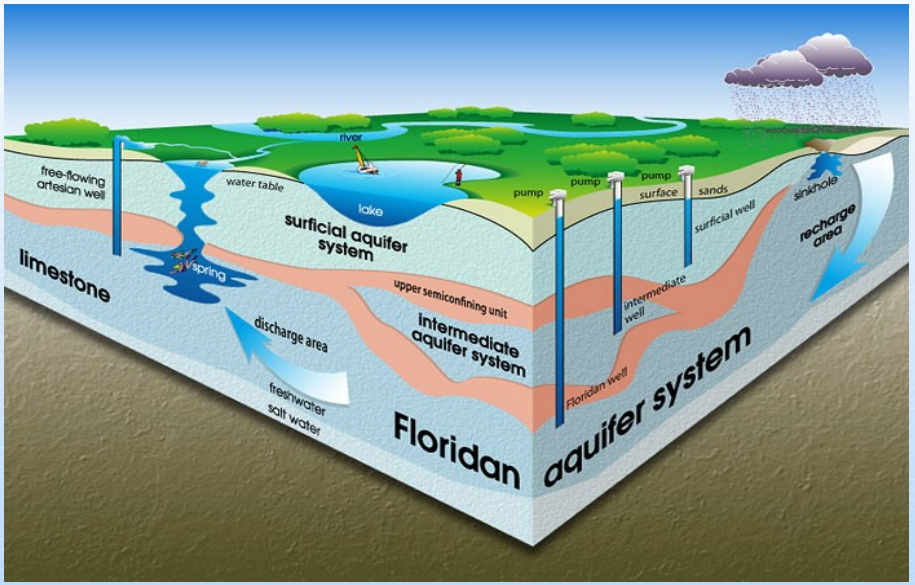
- **Aquiclude**: contains water but cannot transmit it rapidly enough to furnish a significant supply to a well or spring.
- **Aquitard ("confining unit")**: low-permeability zone that retards, but does not prevent, the flow of water. It does not readily yield water for beneficial uses but can serve as a ground water storage unit.
- **Aquifuge**: Contains no geologic openings and cannot hold, transport water

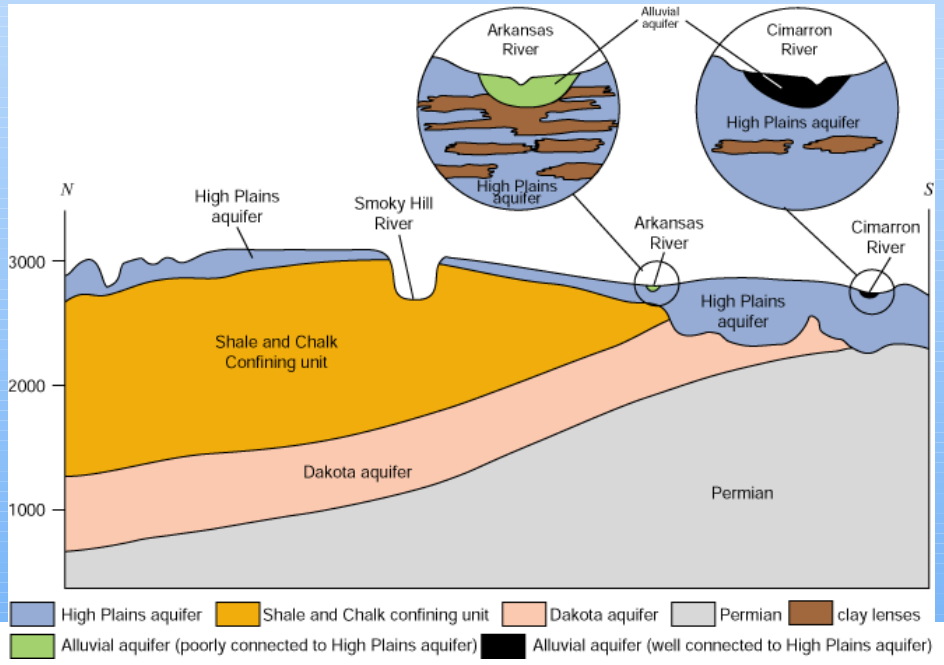
Aquifers Comes in All Shapes and Sizes

To be a good aquifer…

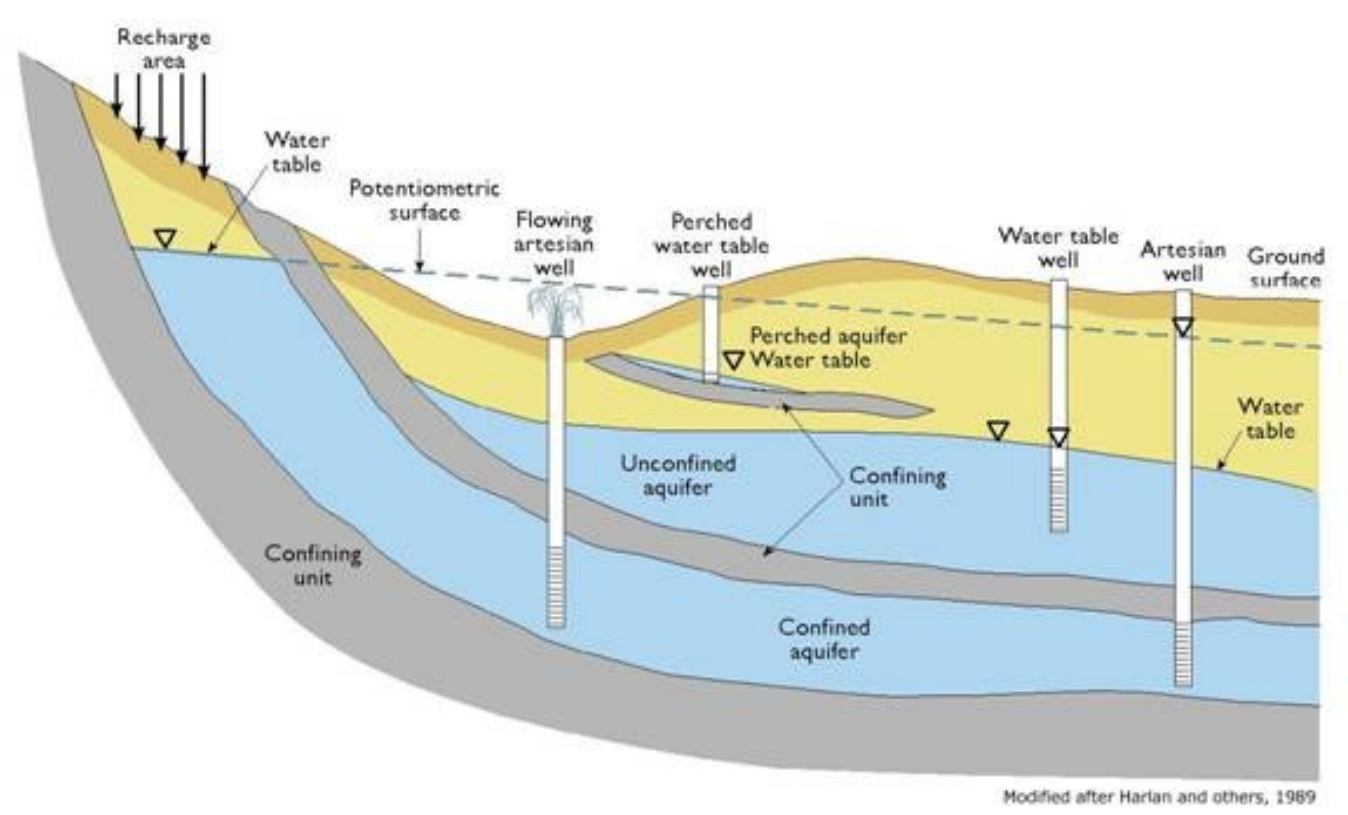
1 - good porosity (space between grains)

2 - good permeability (connection btwn



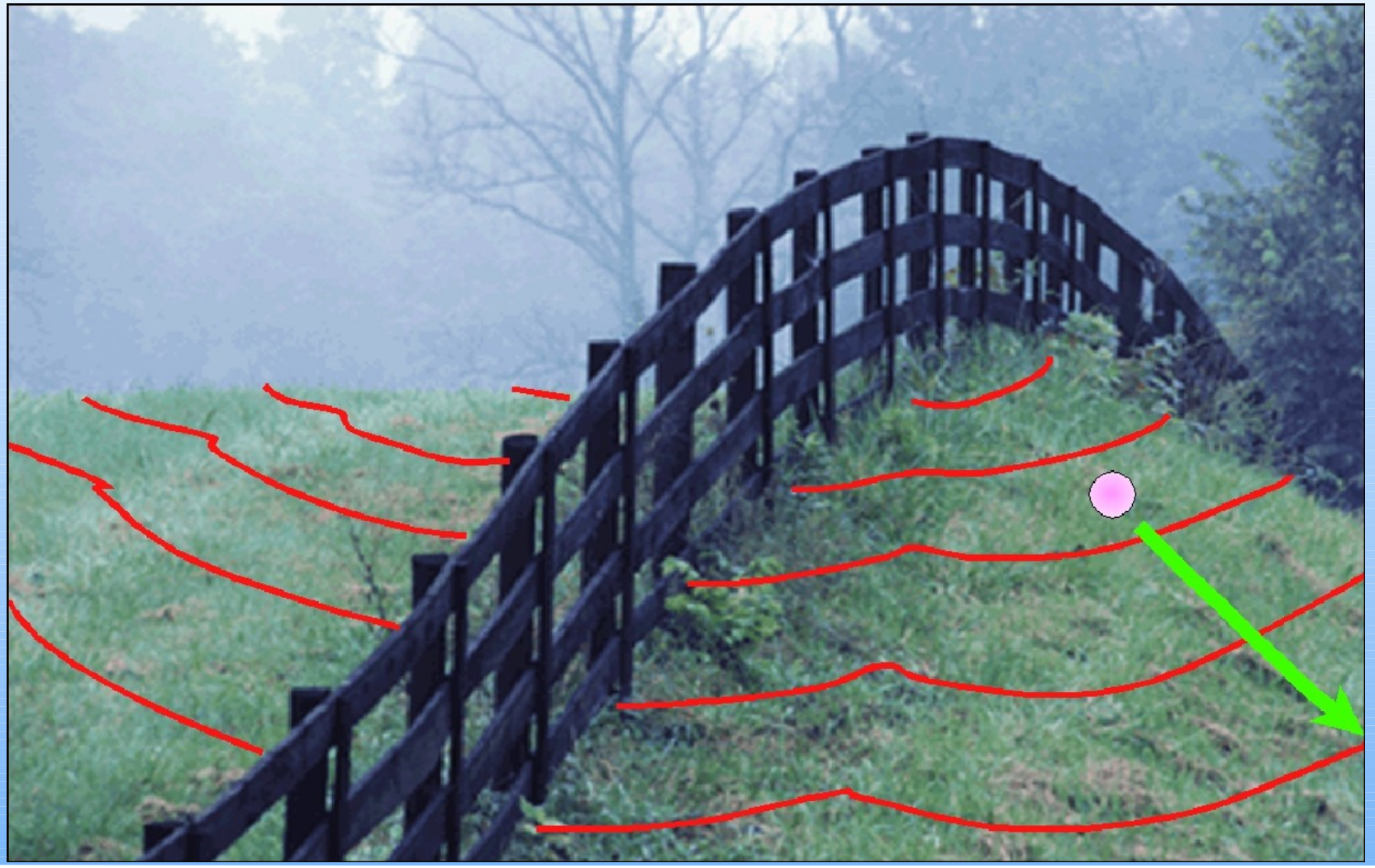


Aquifers are interconnected too

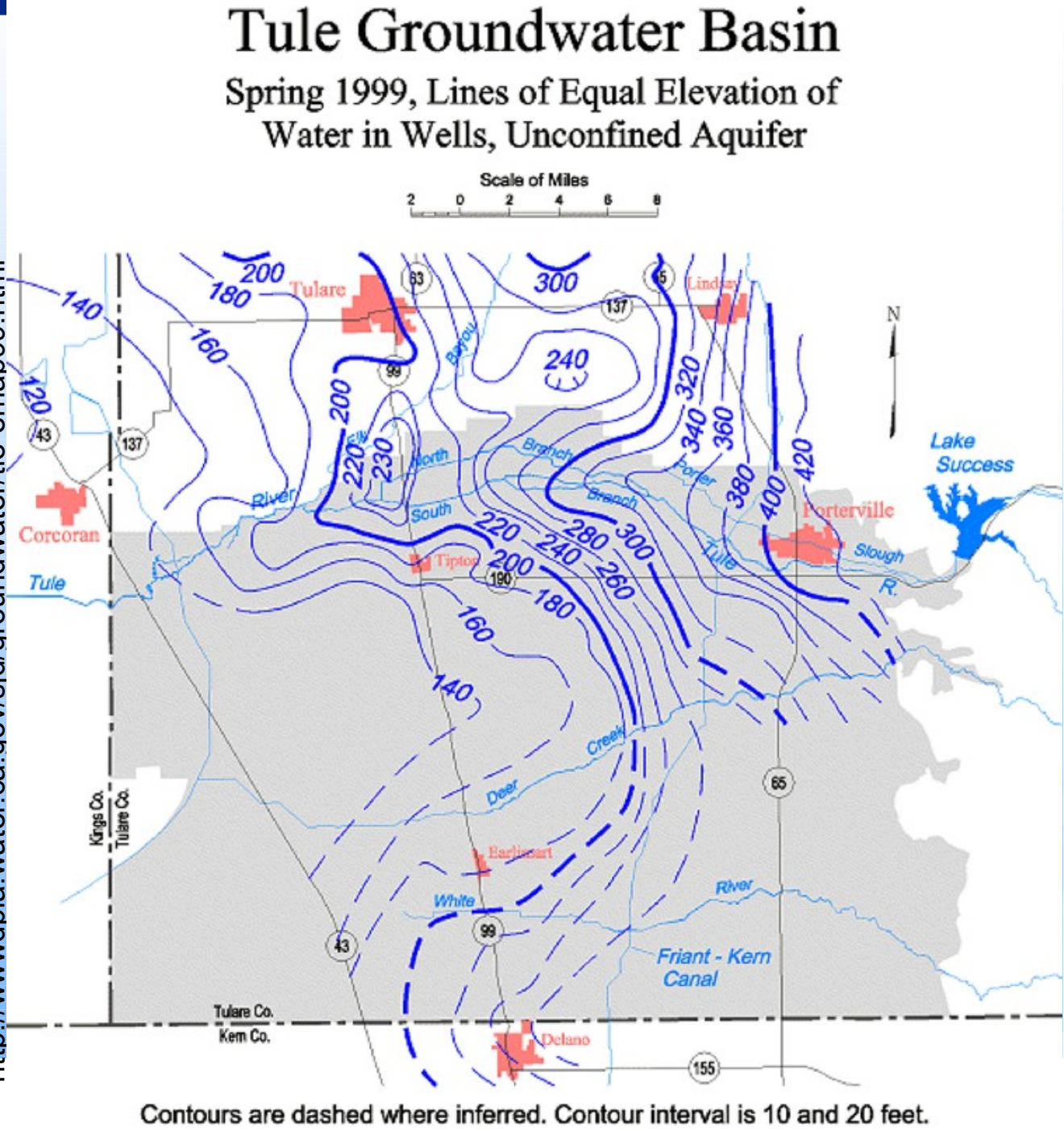


- Cross contamination concerns
- Subsurface contaminant transport

Direction of Groundwater Flow?

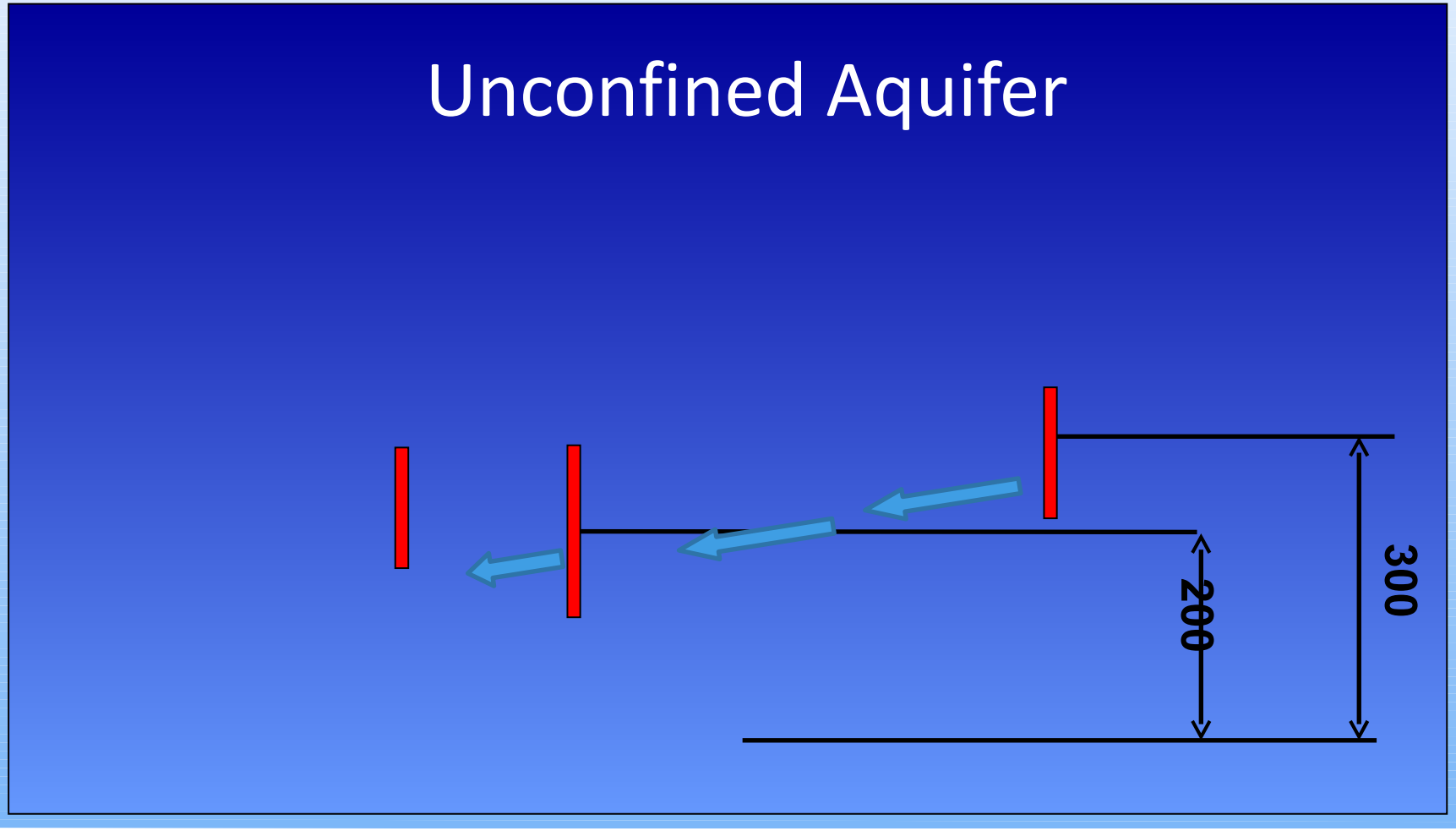


Direction of Regional GW Flow

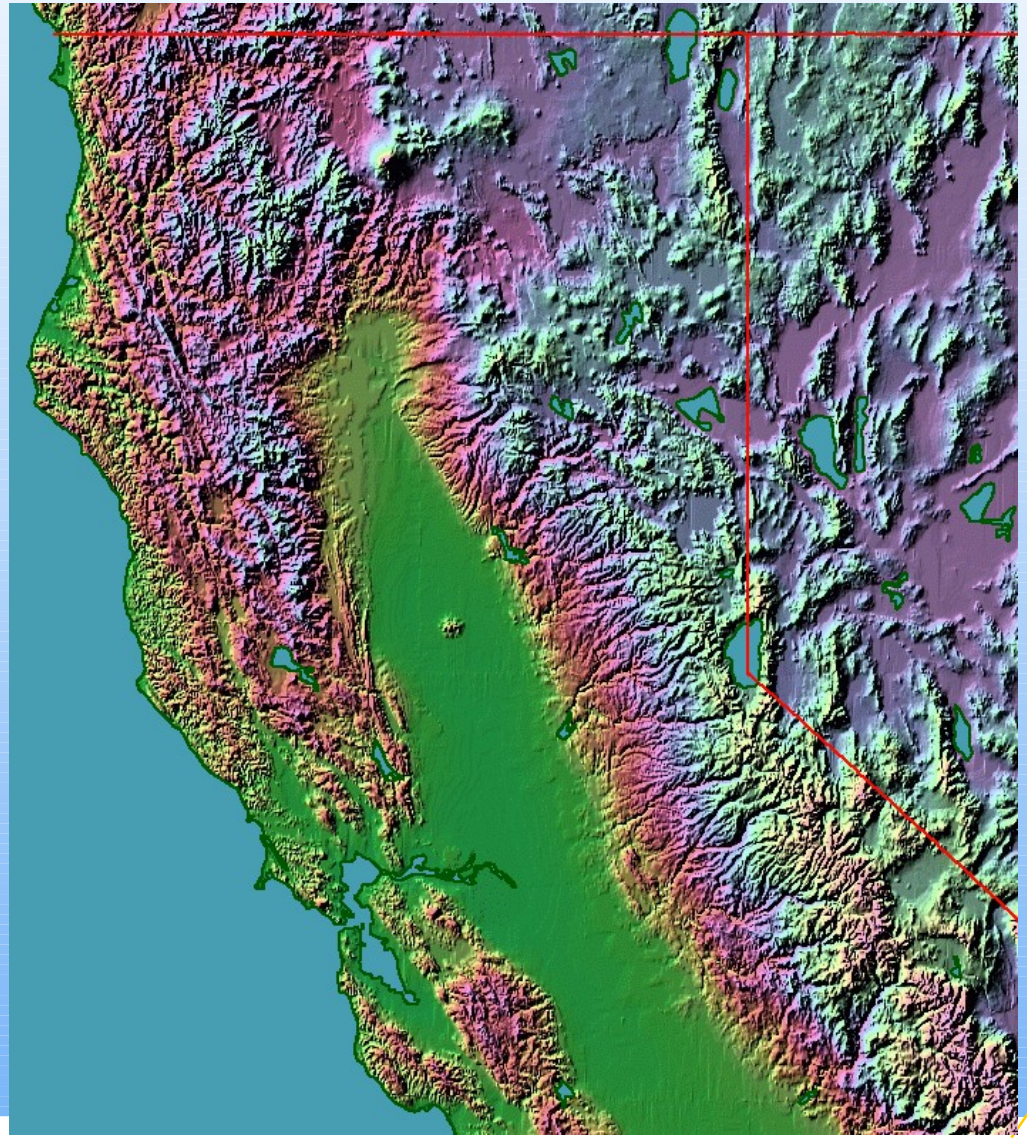


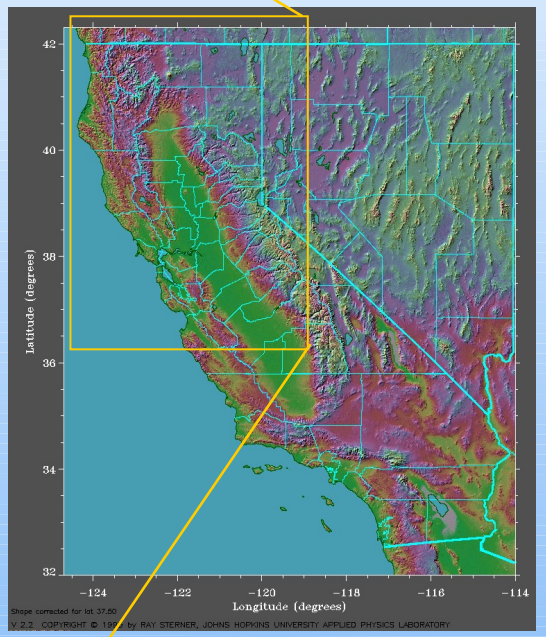
Map from: http://www.dpla.water.ca.gov/sid/groundwater/tle-emap99.html

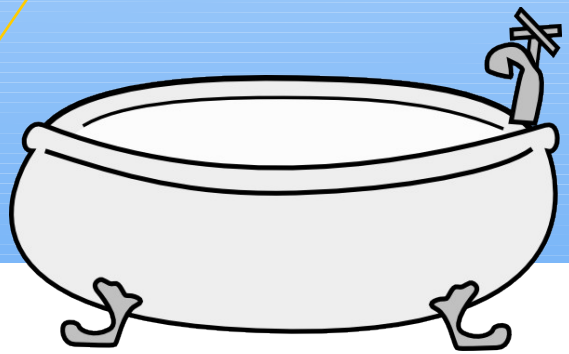
Direction of Groundwater Flow?

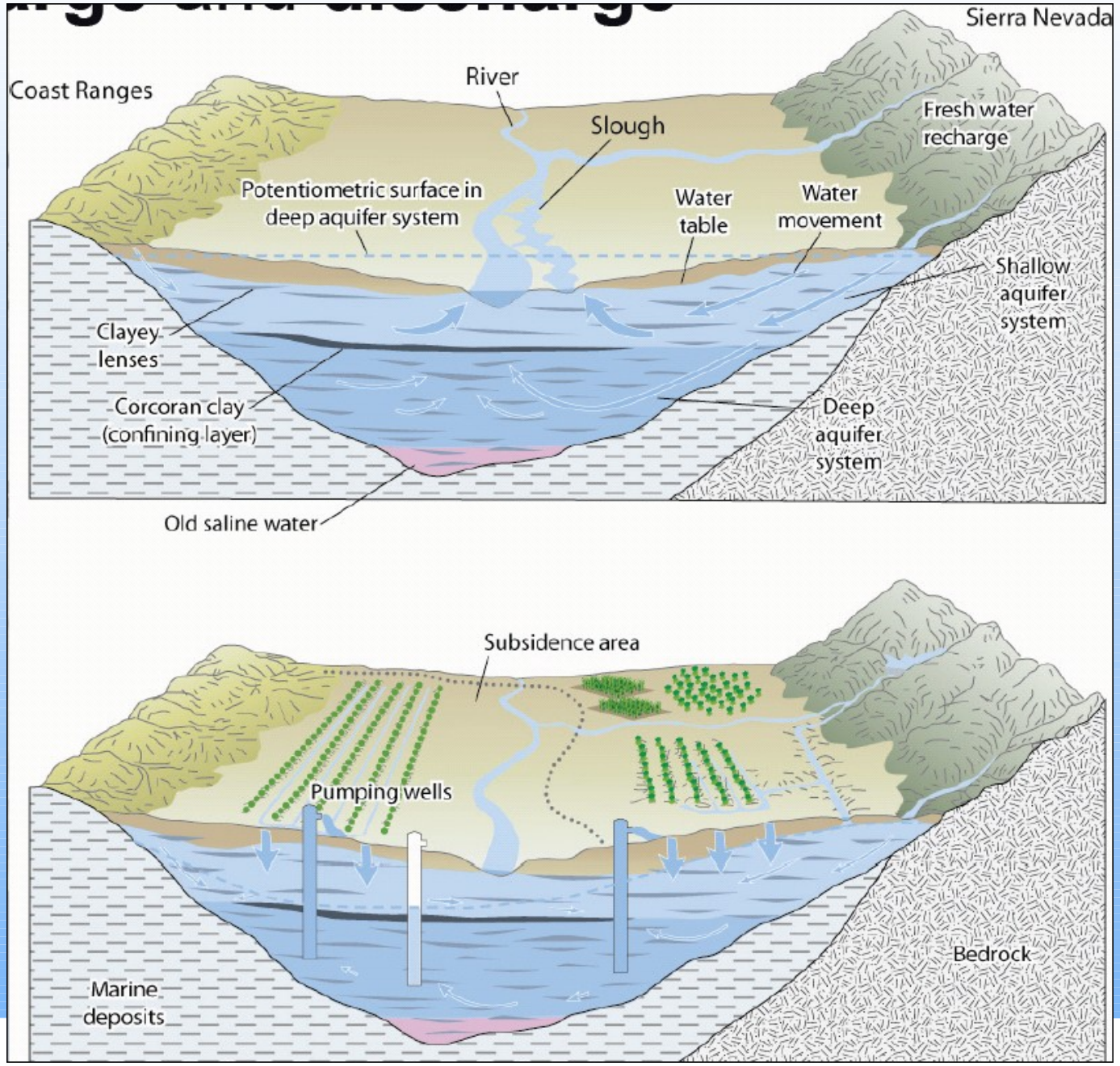


California groundwater







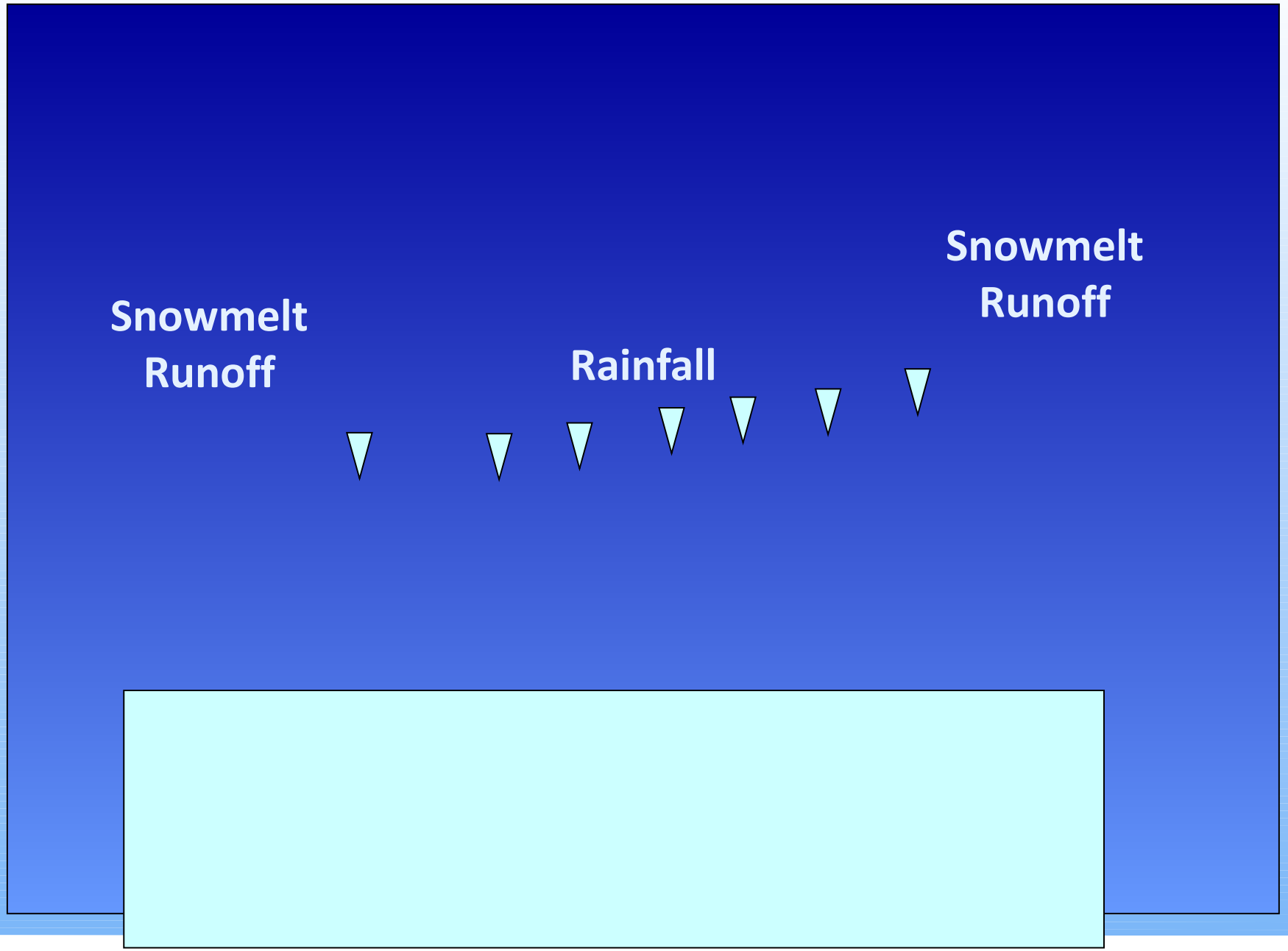


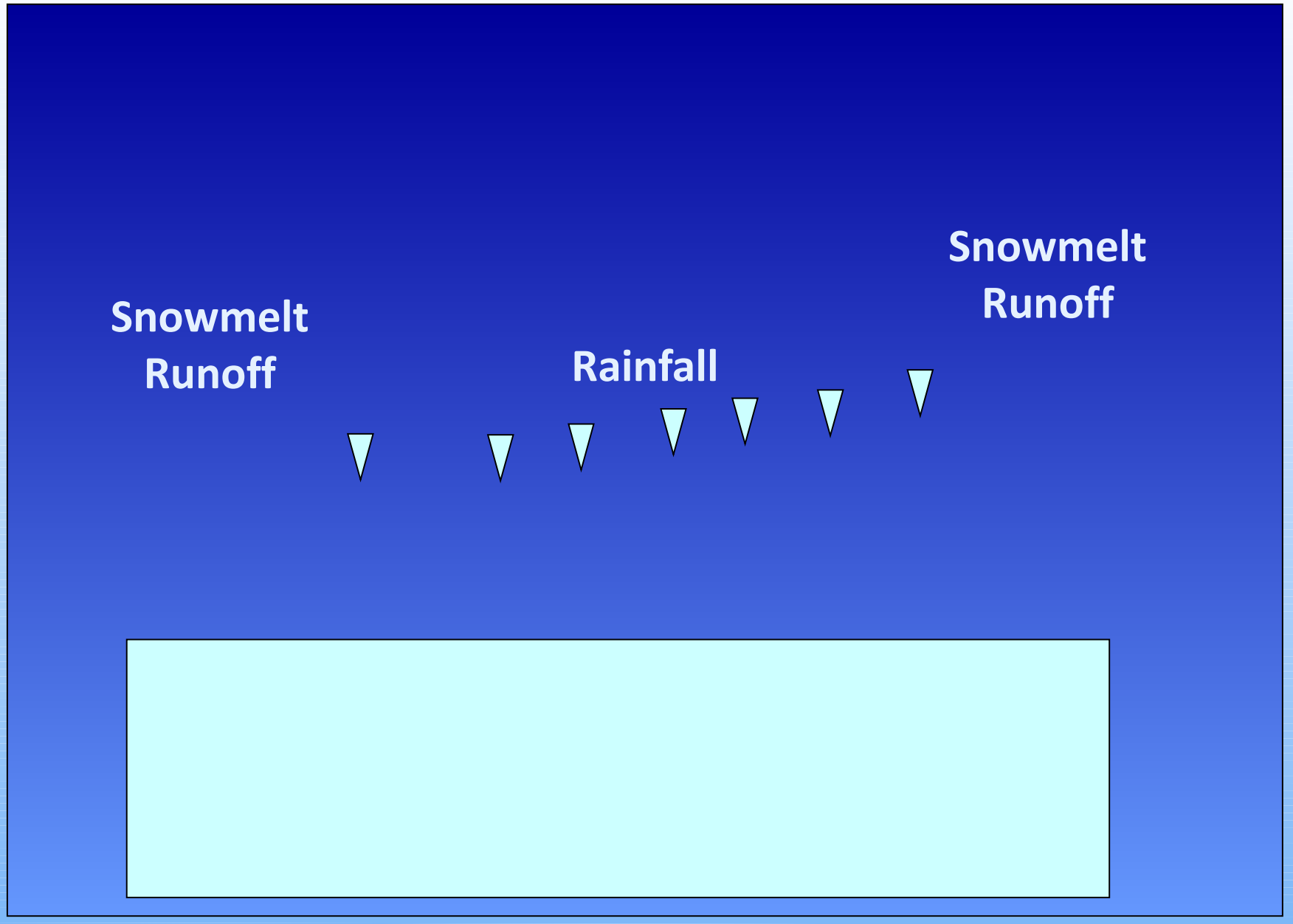
Courtesy, Claudia Fawn, USGS, 2008

Sediments

=> result of erosion, water, wind, lake deposition, ocean bay deposition

fractured bedrock of California's mountain ranges


Snowmelt
Runoff
Rainfall
Snowmelt
Runoff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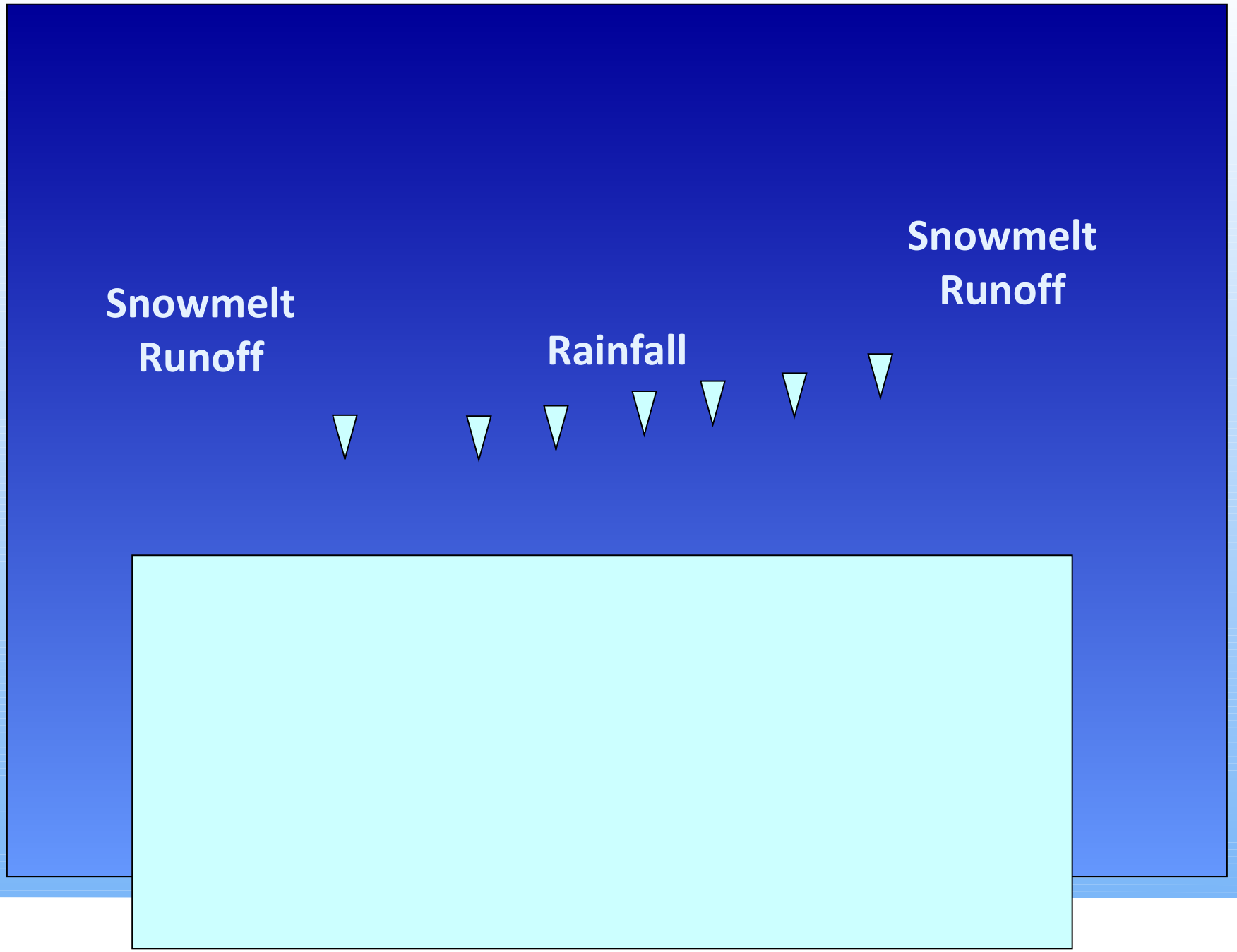
Runoff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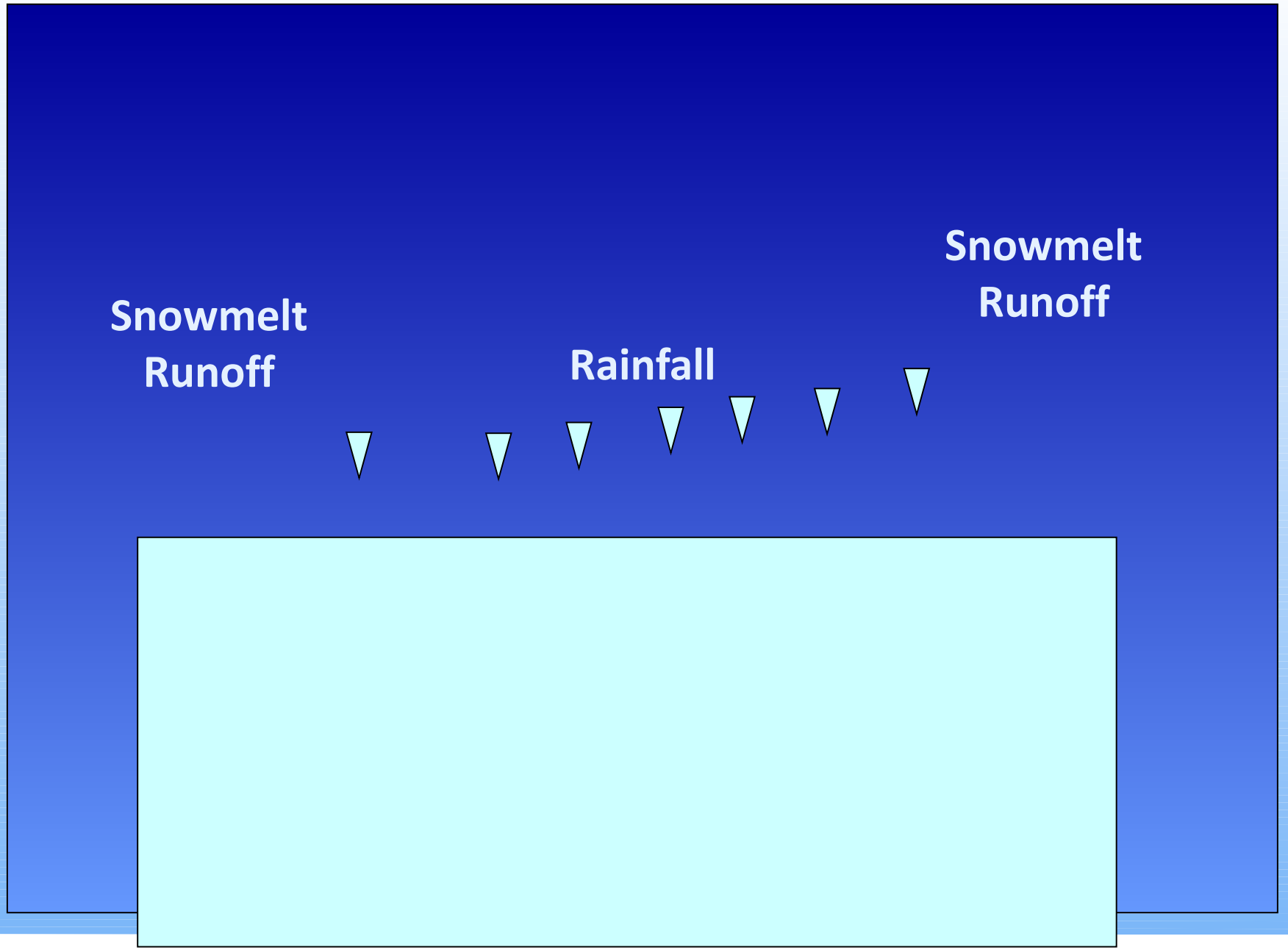
Snowmelt
Runoff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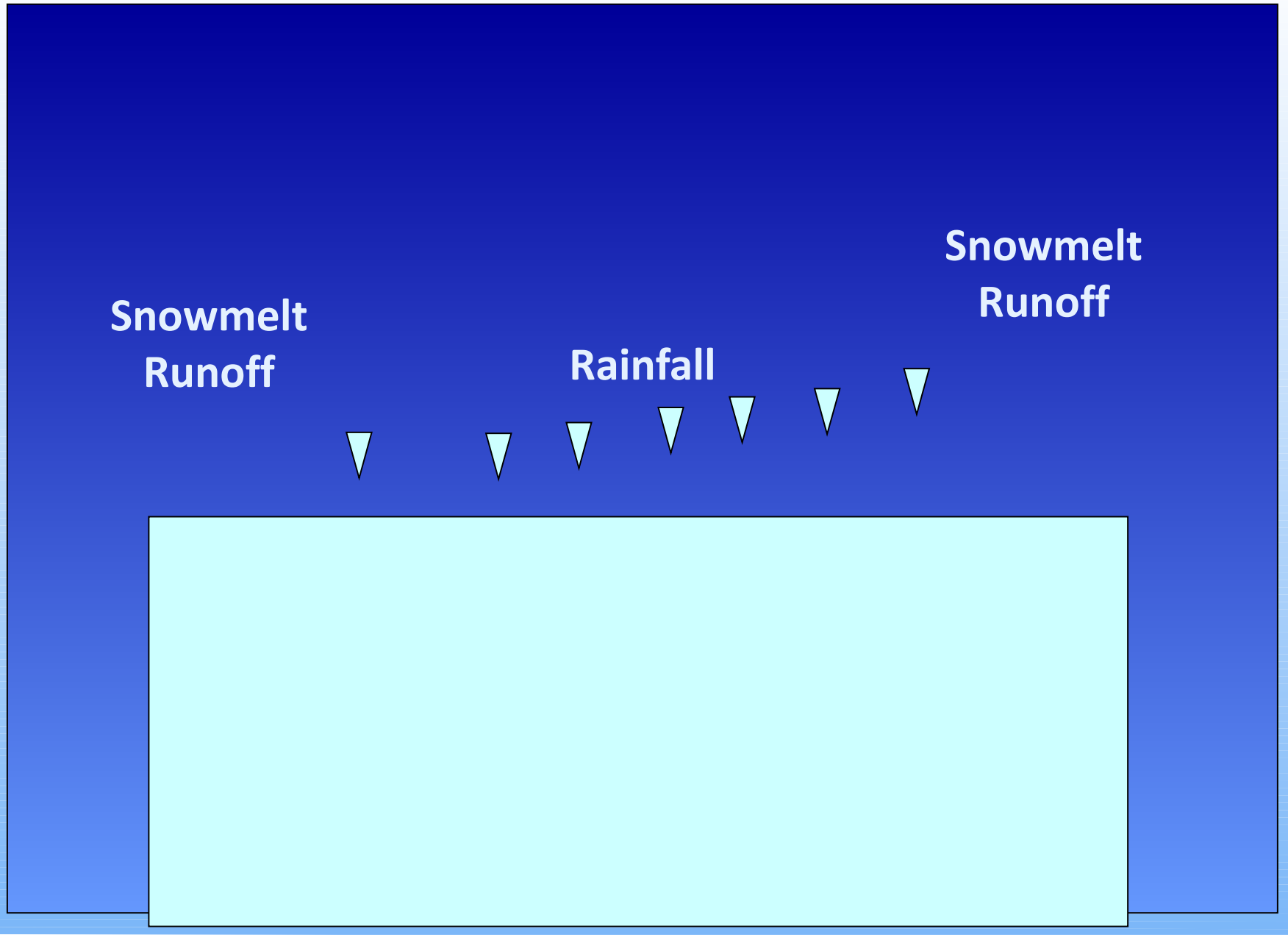
Snowmelt
Runoff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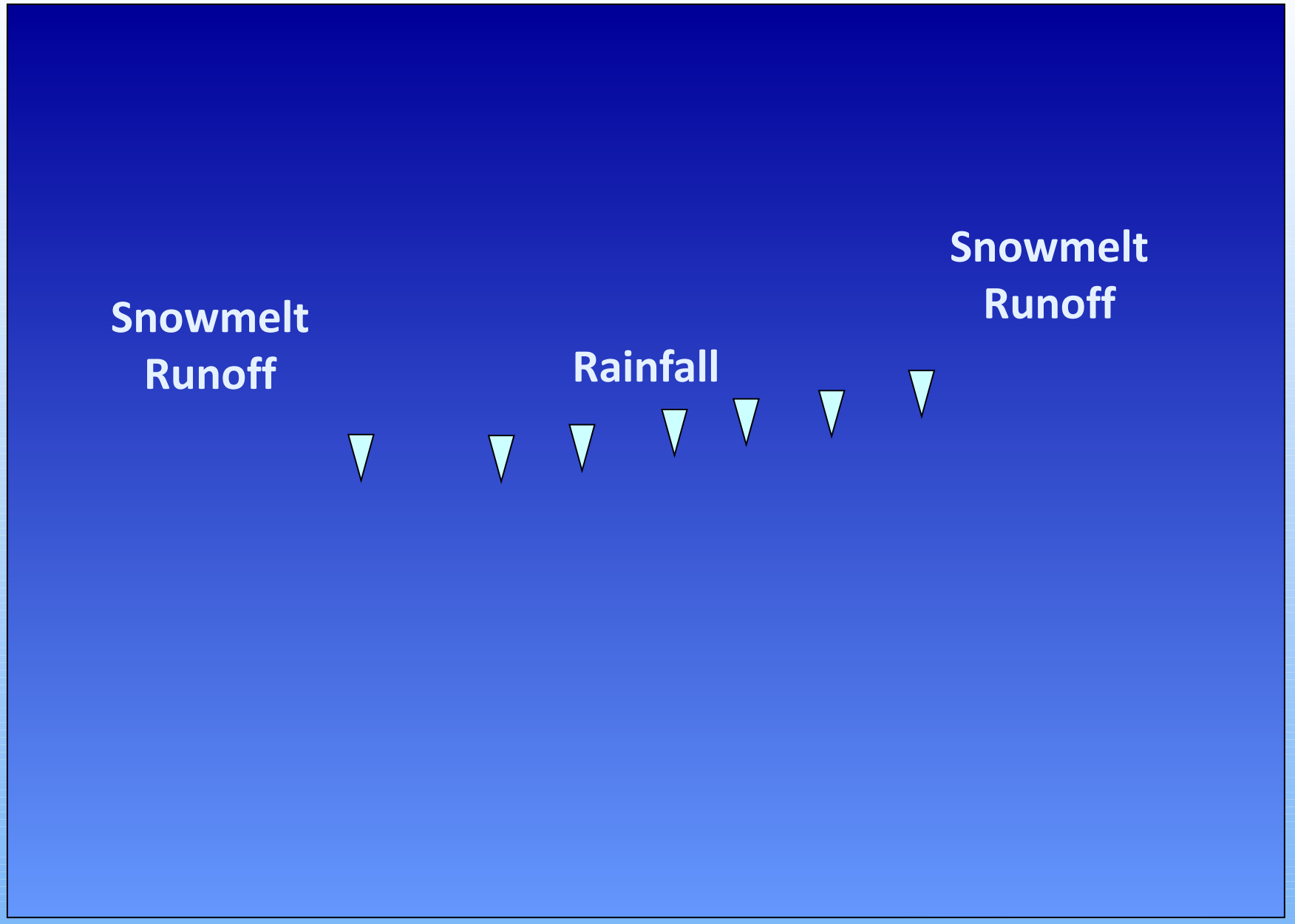
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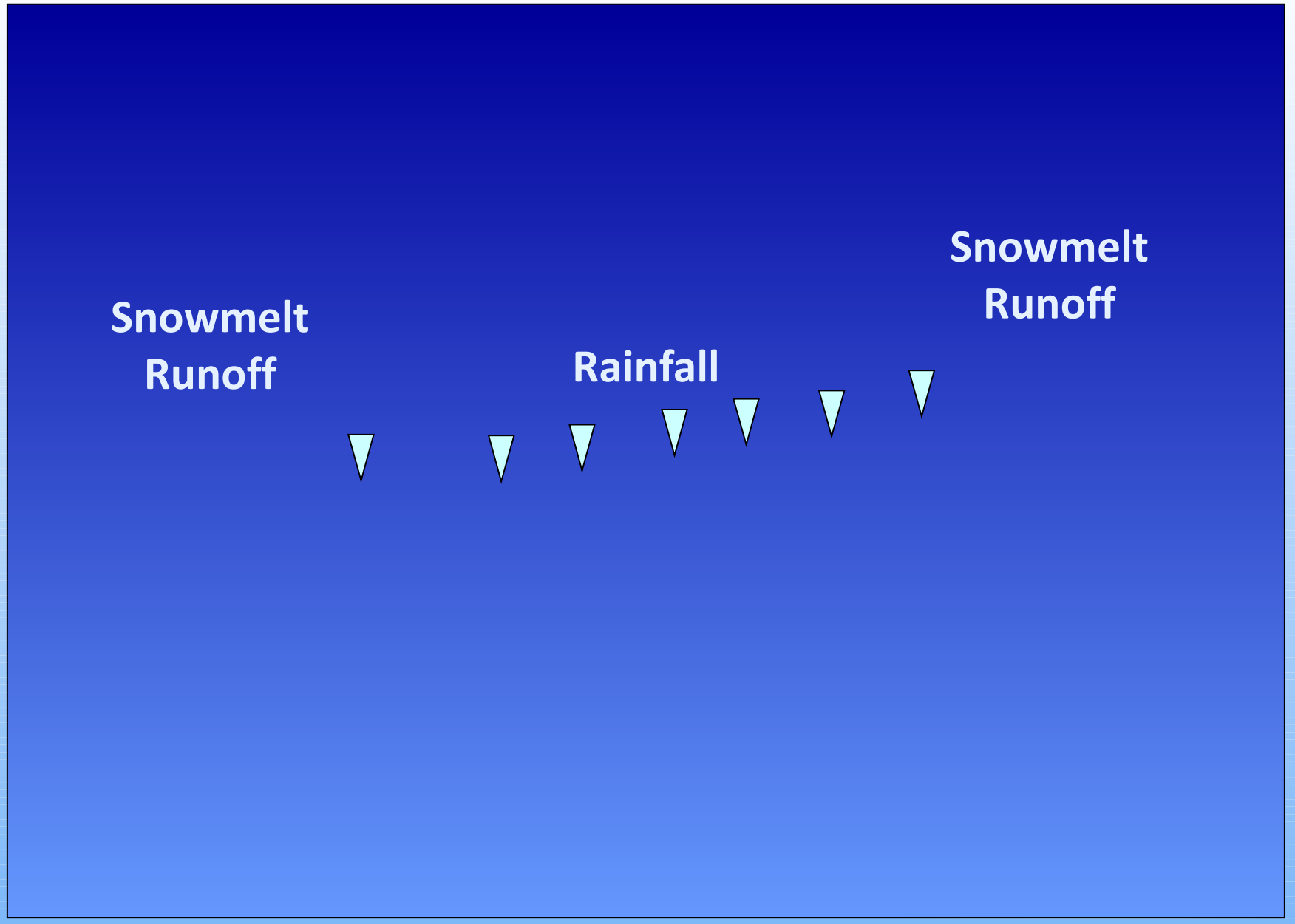
Snowmelt
Runoff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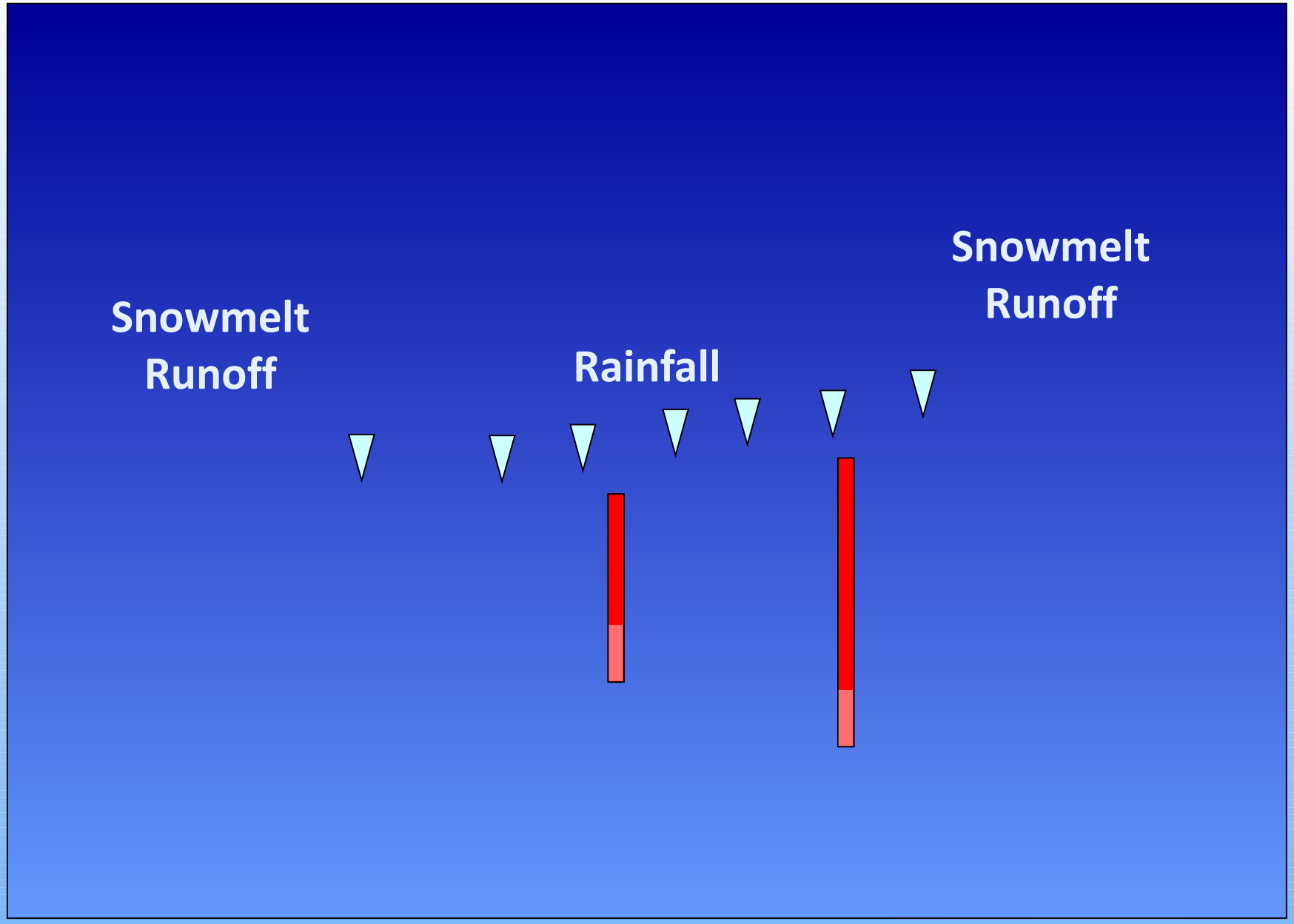
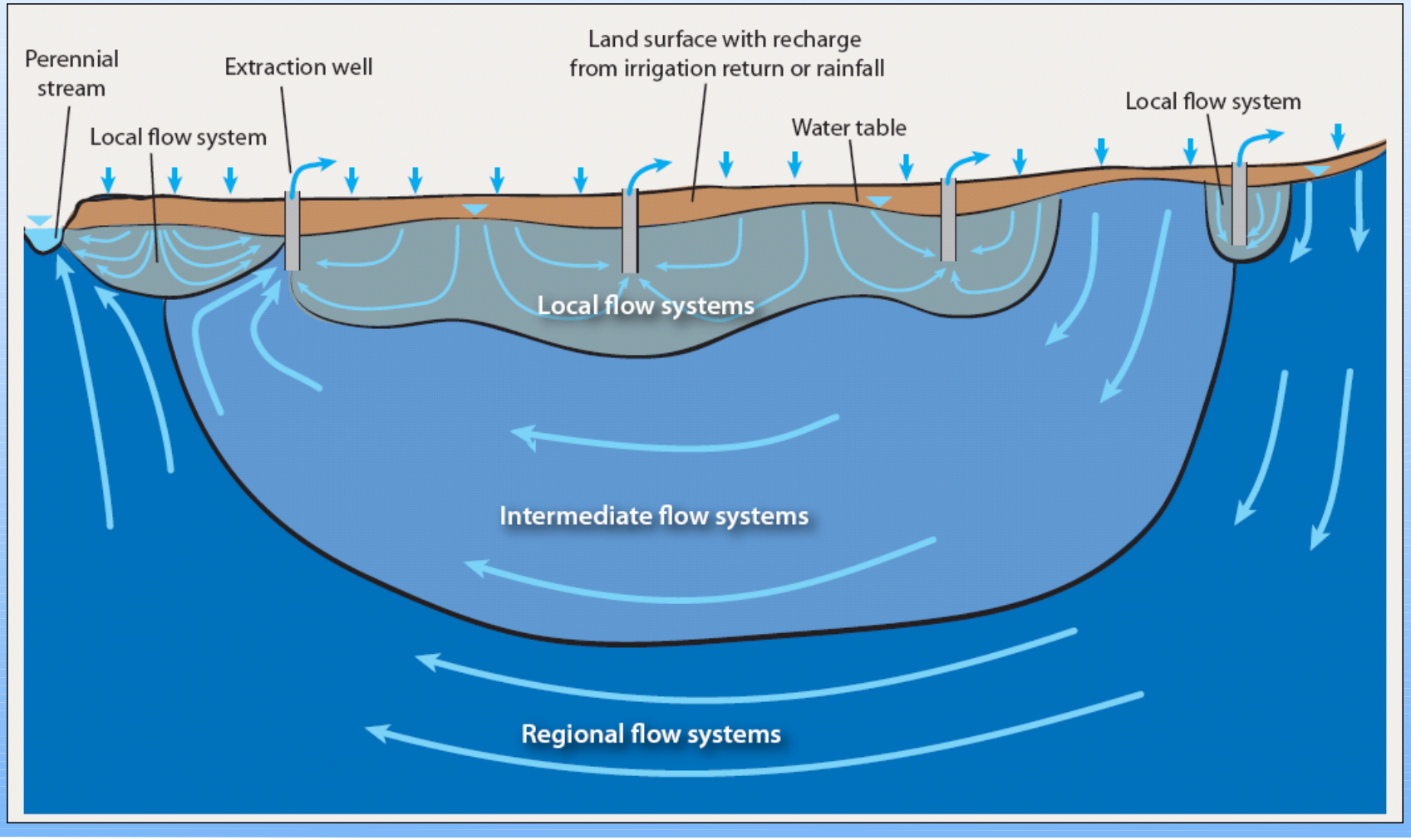
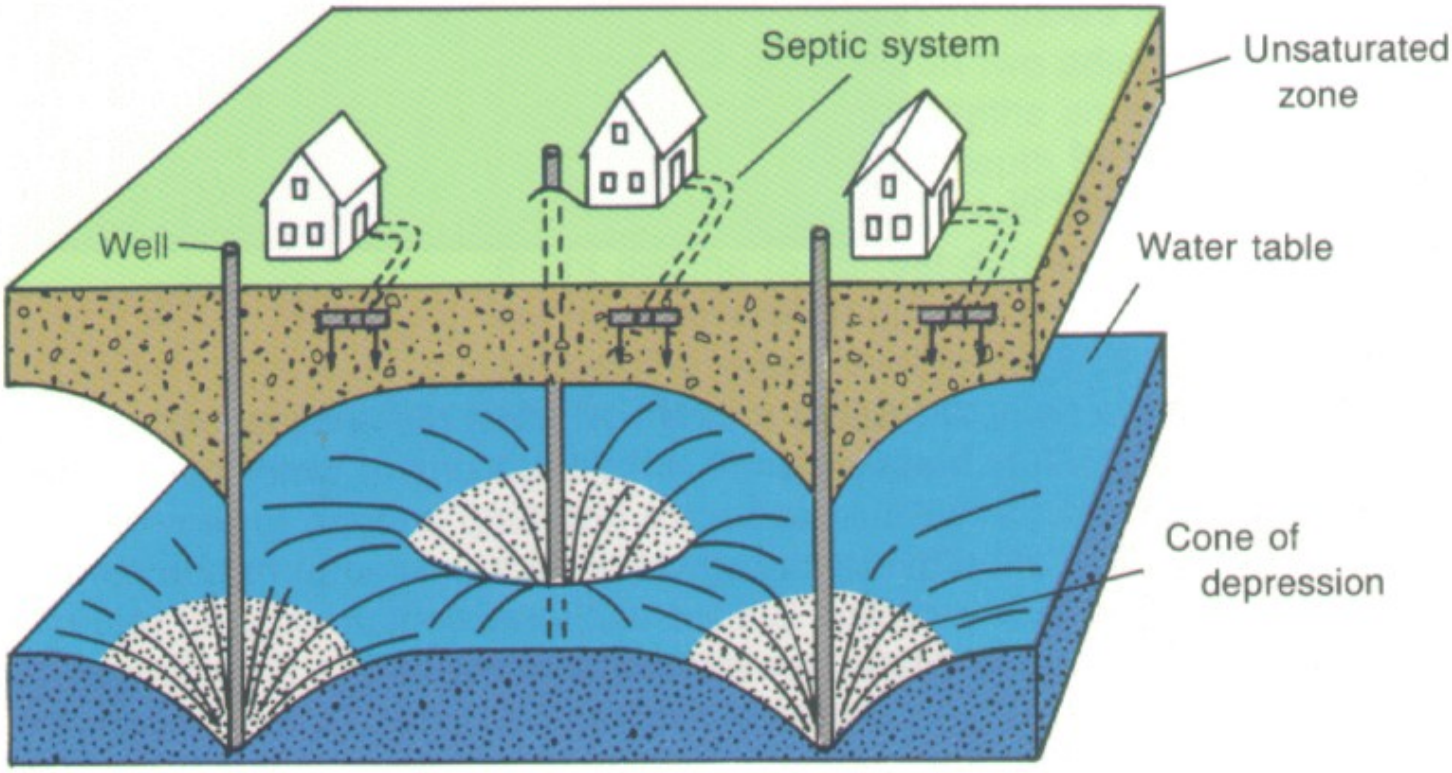

Snowmelt
Runoff
Rainfall
Snowmelt
Runoff

Local & regional Groundwater Flow

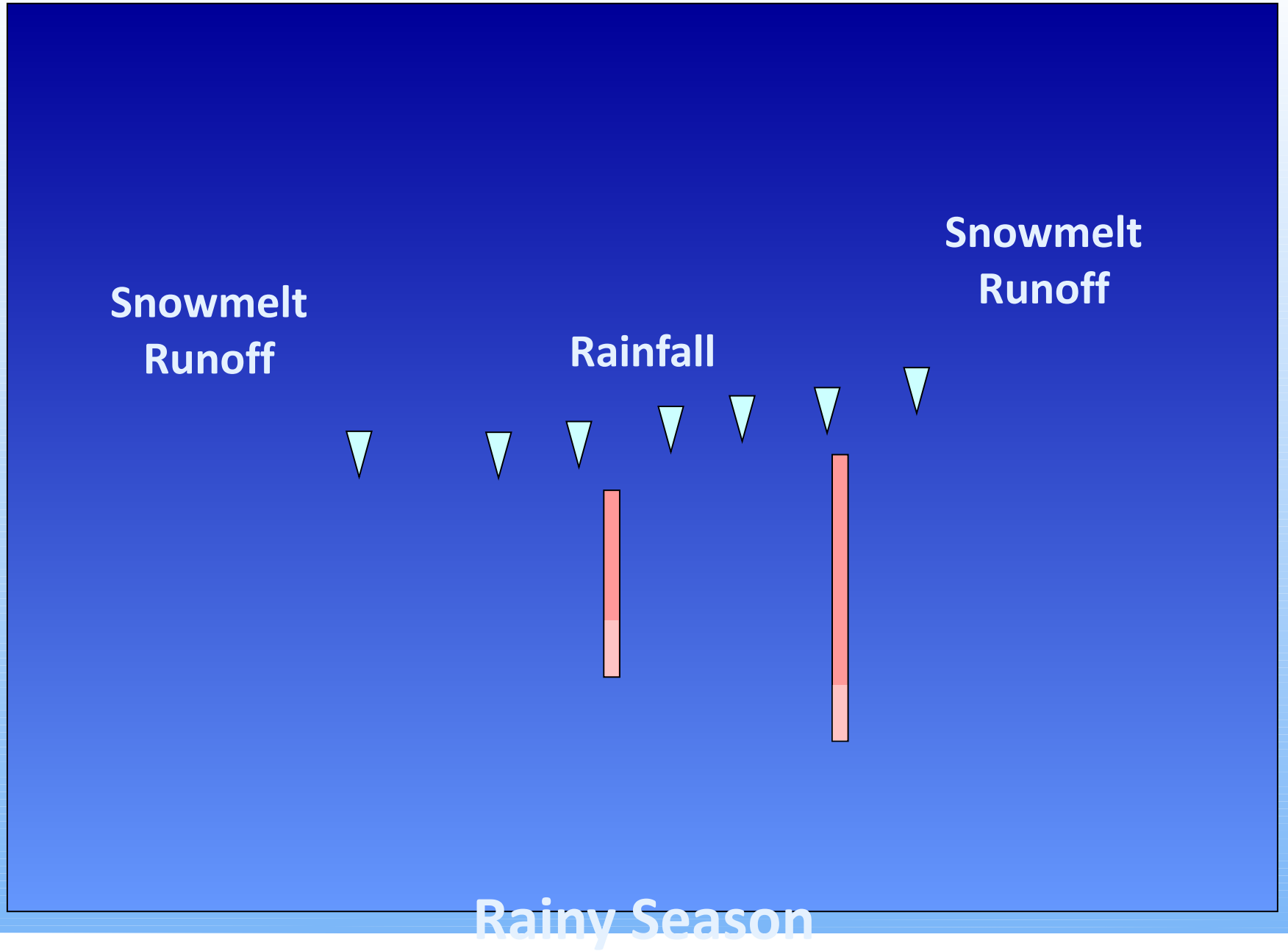


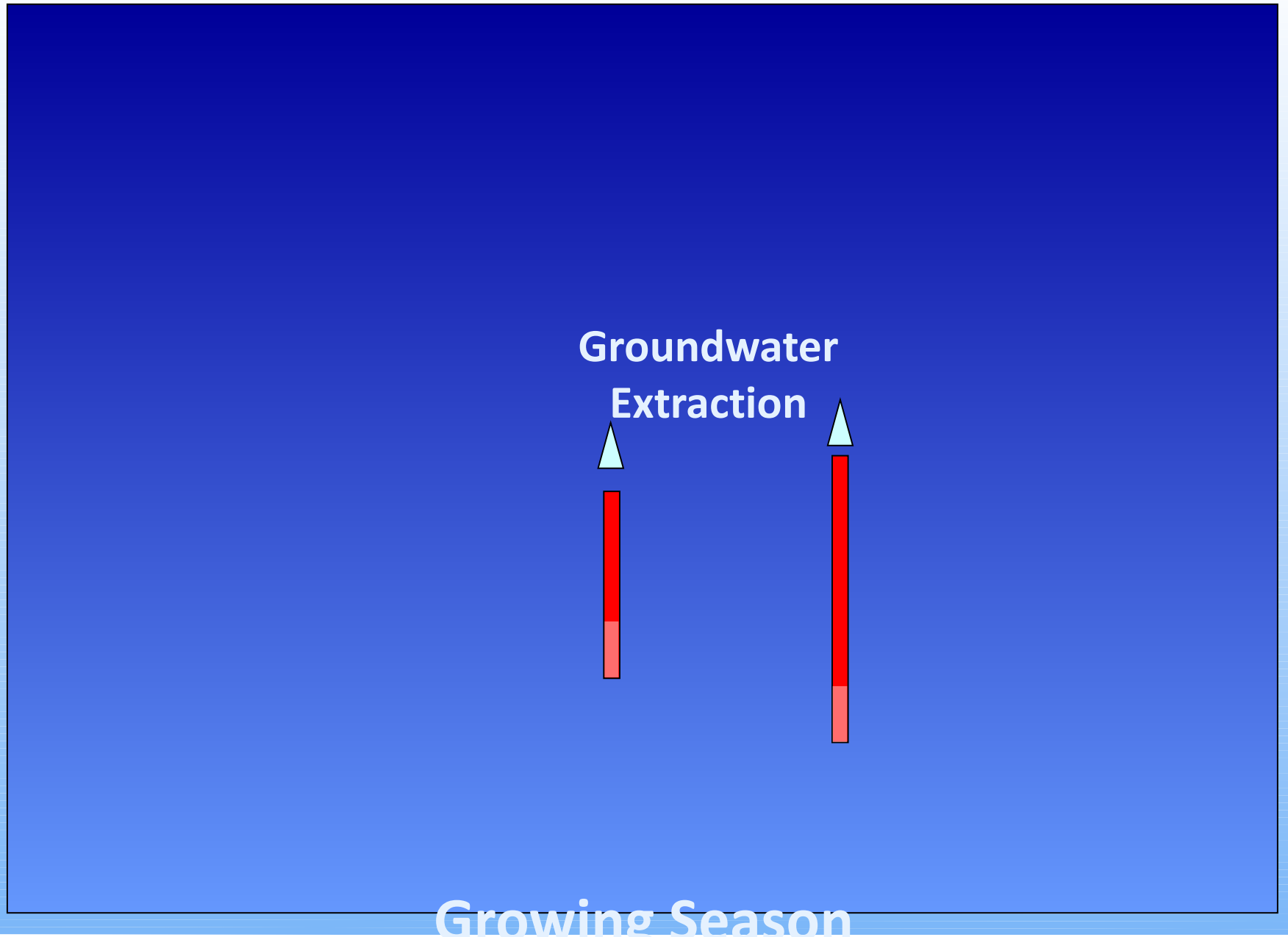
Cone of Depression near a well

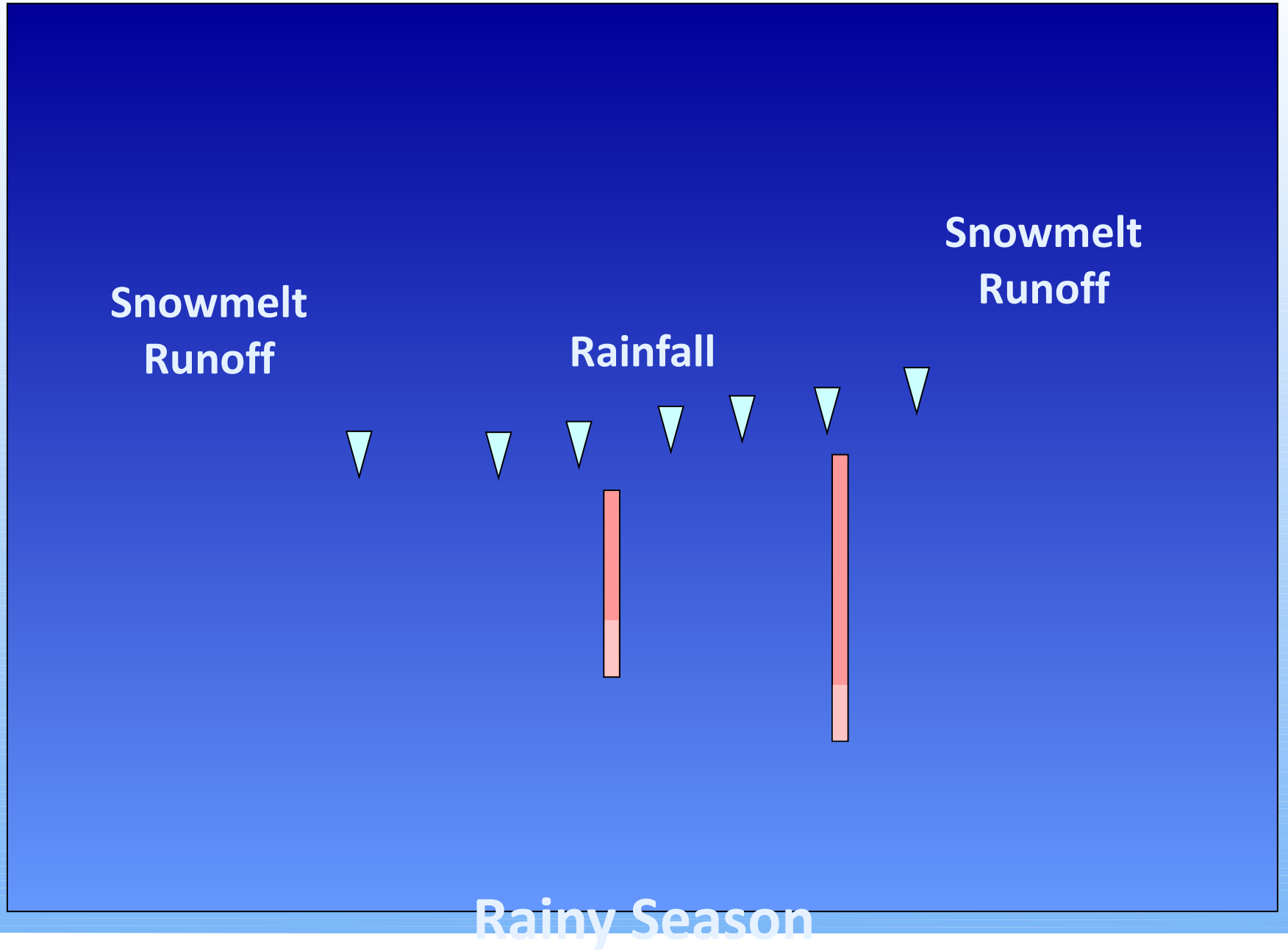


Effect of concentrated housing on ground-water level.

from: U.S. Geological Survey, 'Ground Water and the Rural Homeowner'


Snowmelt
Runoff
Rainfall
Snowmelt
Runoff
Rainy Season


Groundwater
Extraction
Growing Season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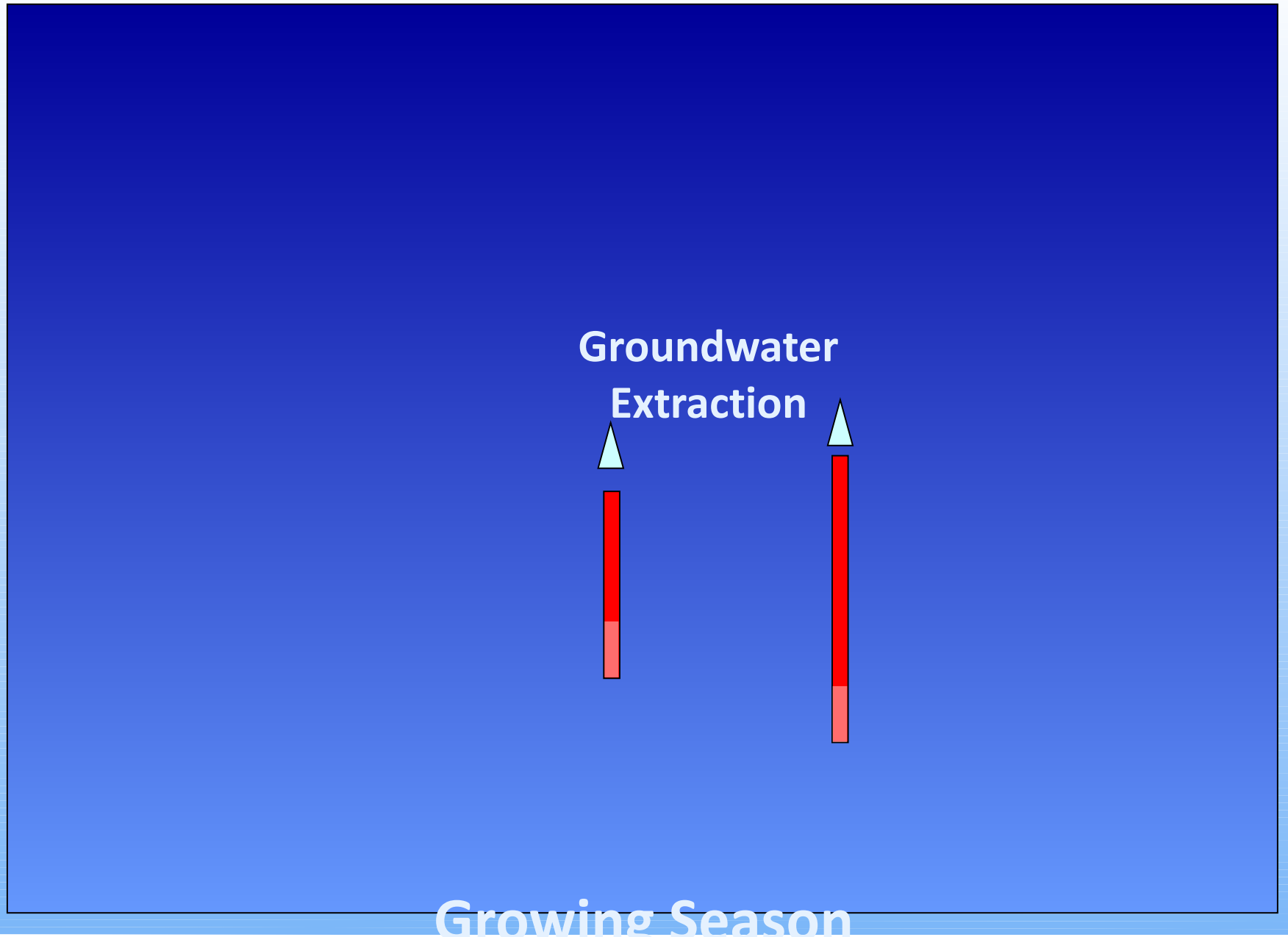
Runoff
Rainy Season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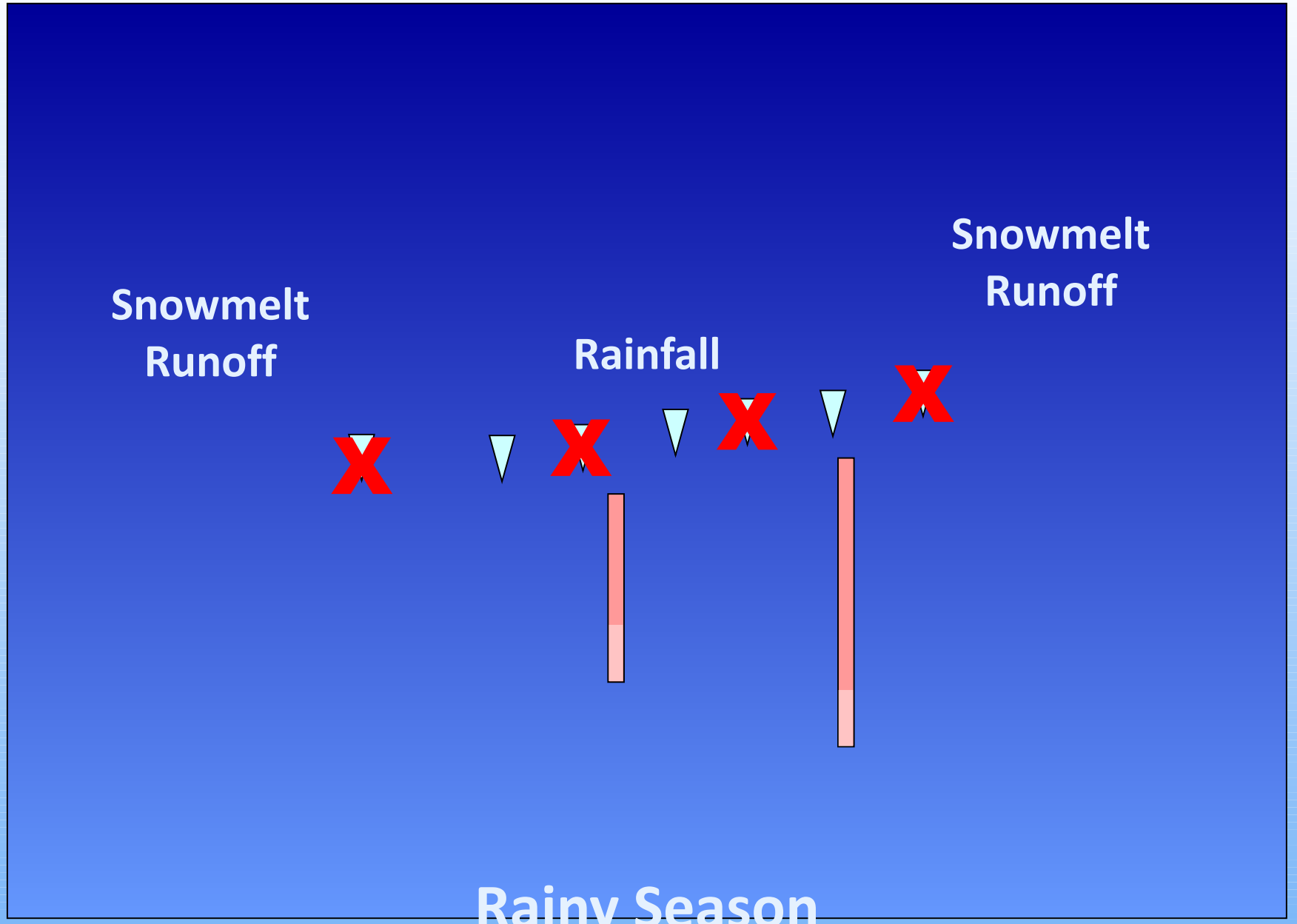
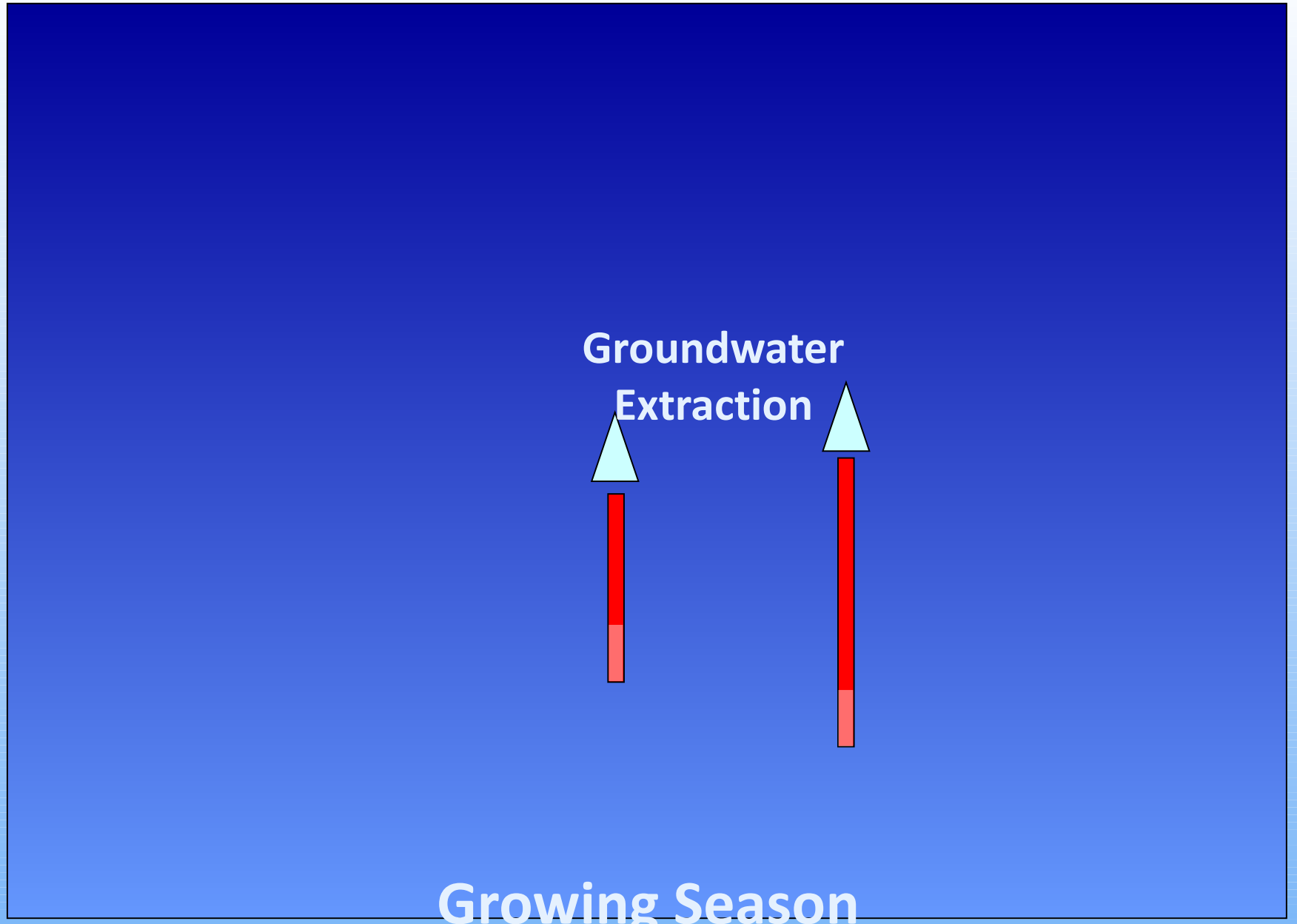

Snowmelt
Runoff
Rainfall
Snowmelt
Runoff
Rainy Season
(Droughts)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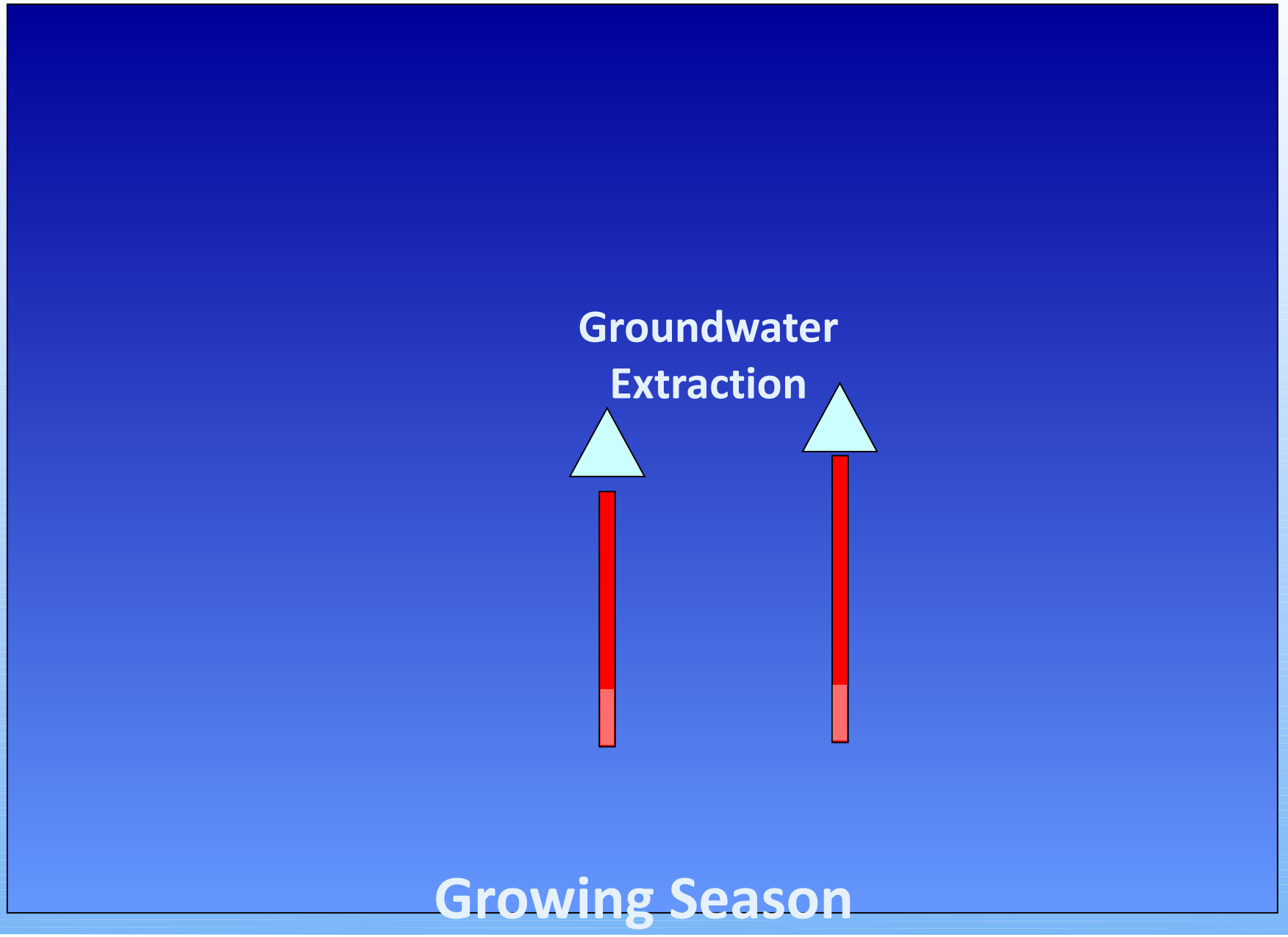
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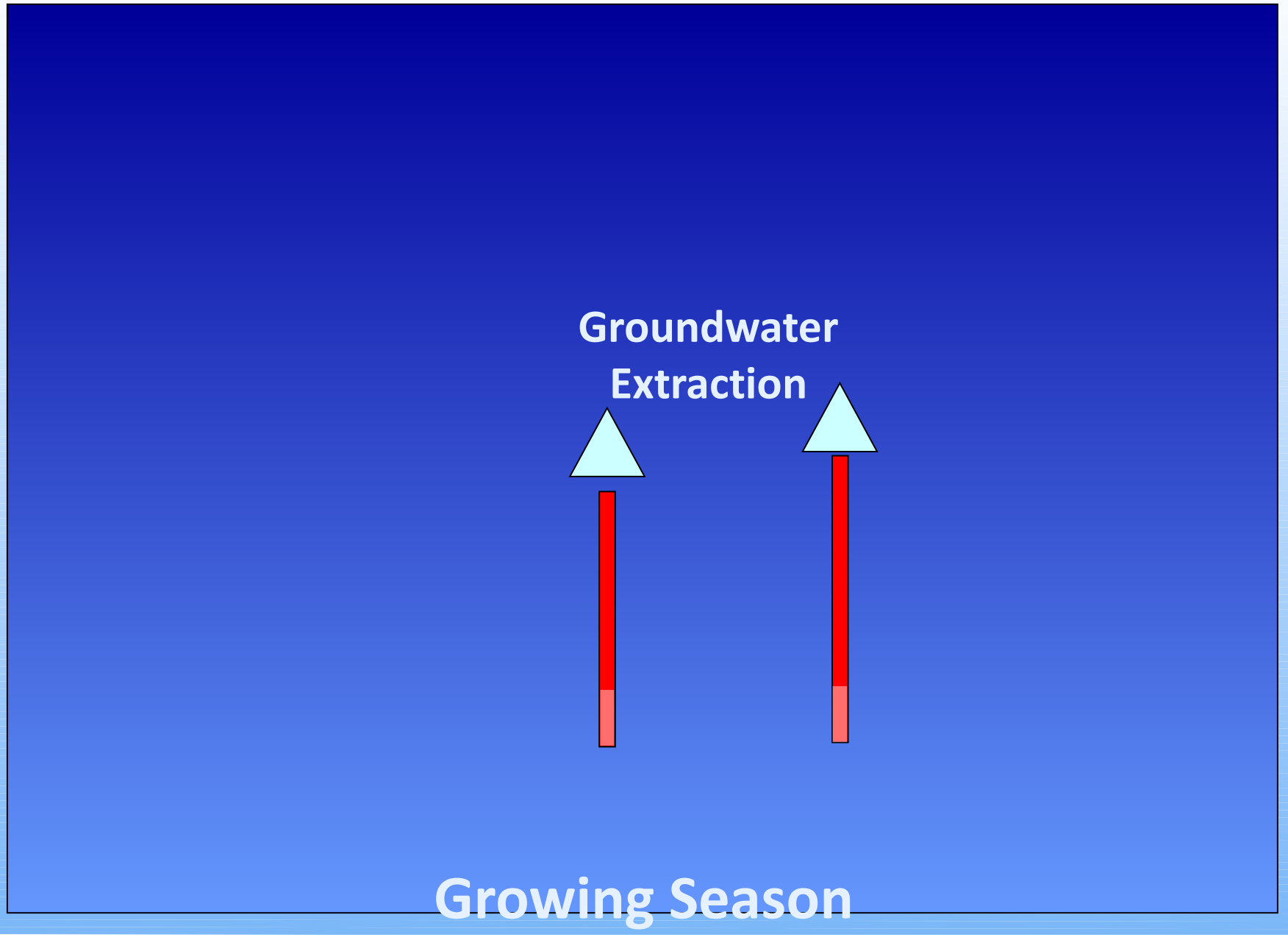
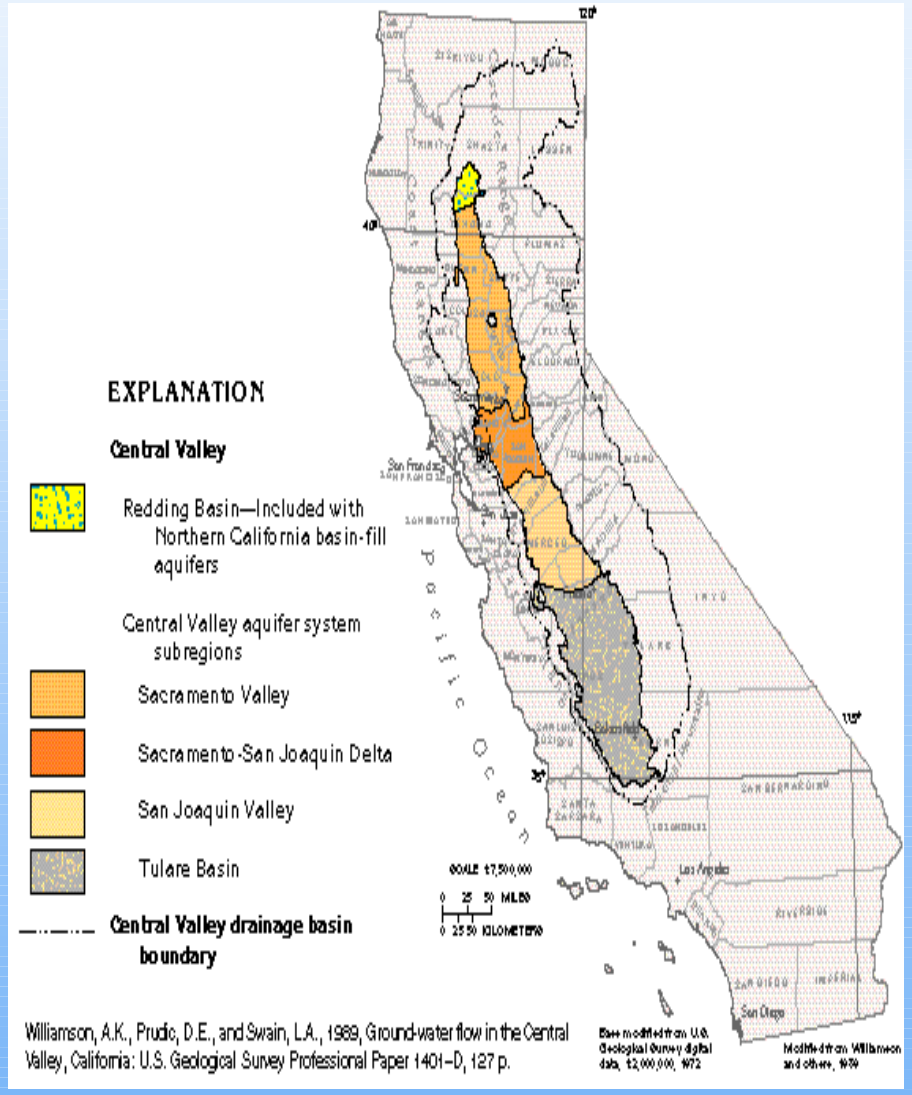
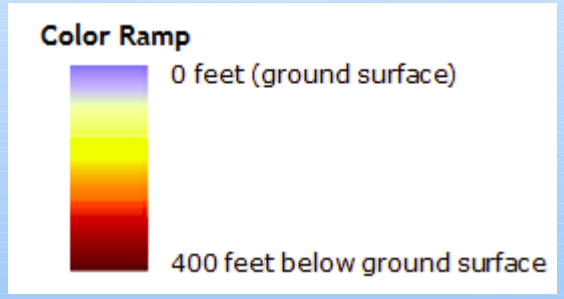

Groundwater
Extraction
Growing Season
(Droughts)

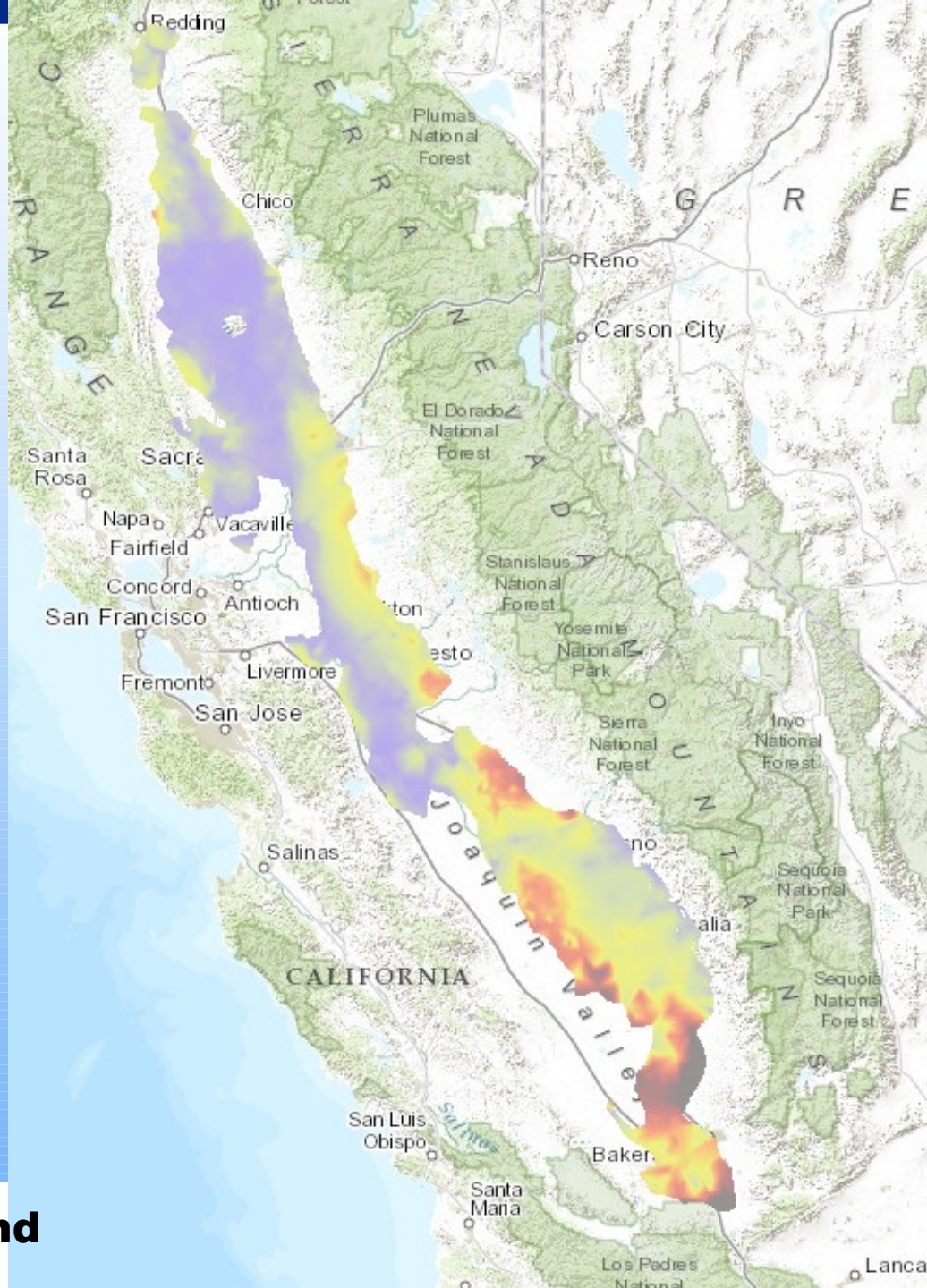
Groundwater Challenges

- State GW source
- Problems
  - Depletion
  - Seawater intrusion
  - Subsidence
- Management strategies?



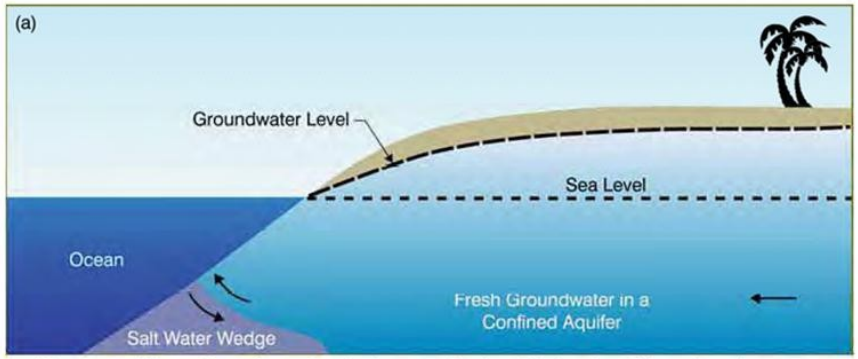
Groundwater Depletion



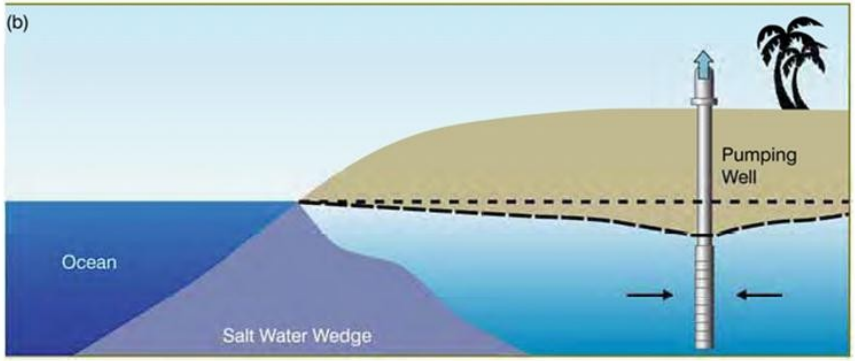


http://gis.water.ca.gov/app/groundwater

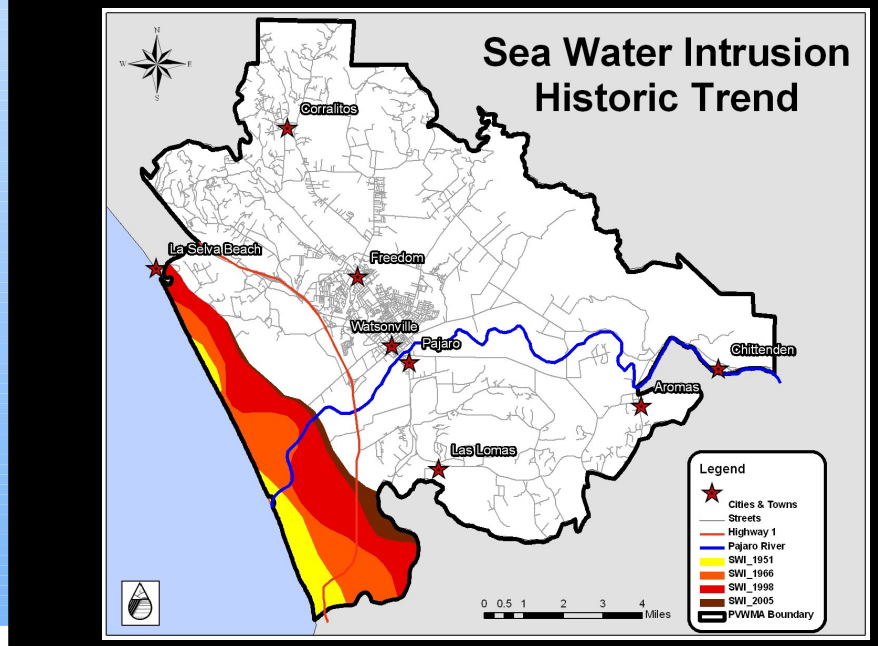
Seawater Intrusion



a) *Historic condition—Groundwater levels above sea level equilibrium level. No wells and no seawater intrusion.*



b) *Current stage—Excessive pumping results in long-term decreases in groundwater levels, pushing the salt water wedge closer to the pumping well trying to reach equilibrium.*

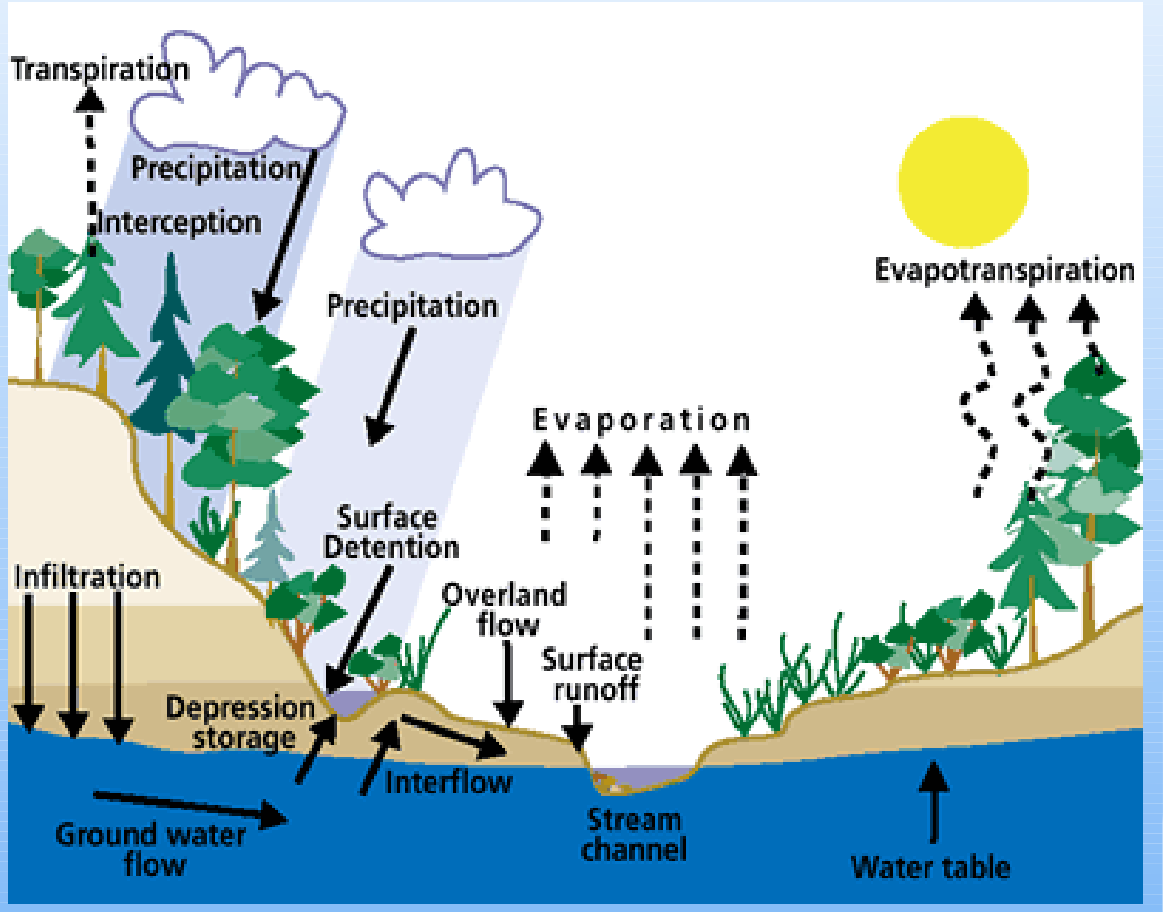


Subsidence

- What's going on here?
- A dropping of the land surface as a result of ground water being pumped.
- Cracks and fissures can appear in the land. Subsidence can be an

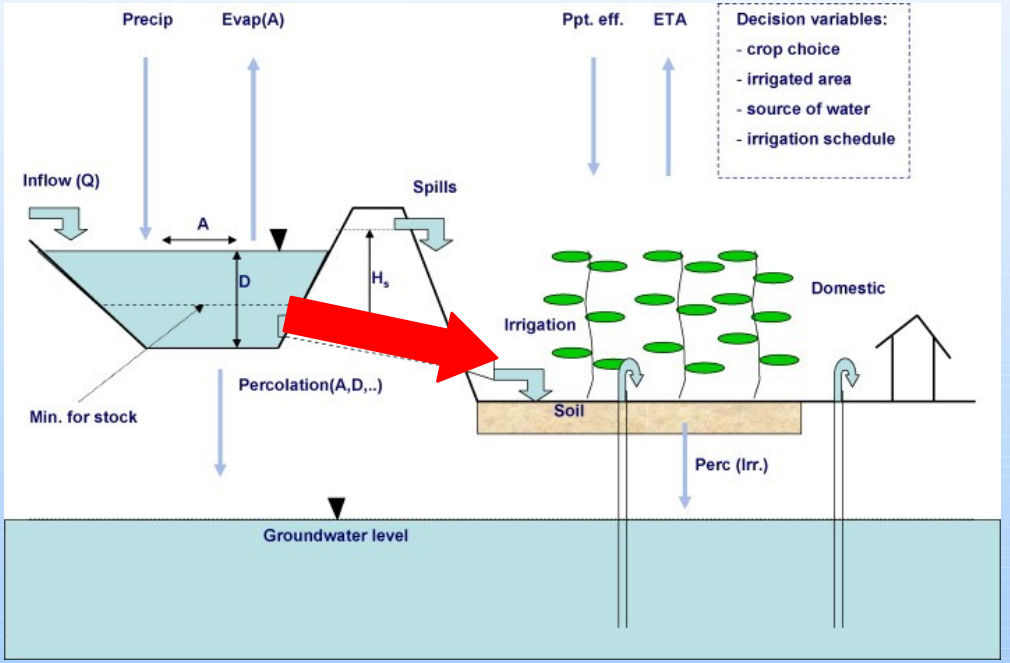
Solutions: Water Budget

- **Water Balance!**
- **ΔS = P – R – G – ET**
  - **S: Storage**
  - **P: Precipitation**
  - **R: Runoff**
  - **G: Ground infiltration**



Solutions: Conjunctive Use

- Coordinated use of surface water and groundwater to meet crop demand
- ***Active***: artificial recharge; SW intentionally percolated or injected into aquifers for later

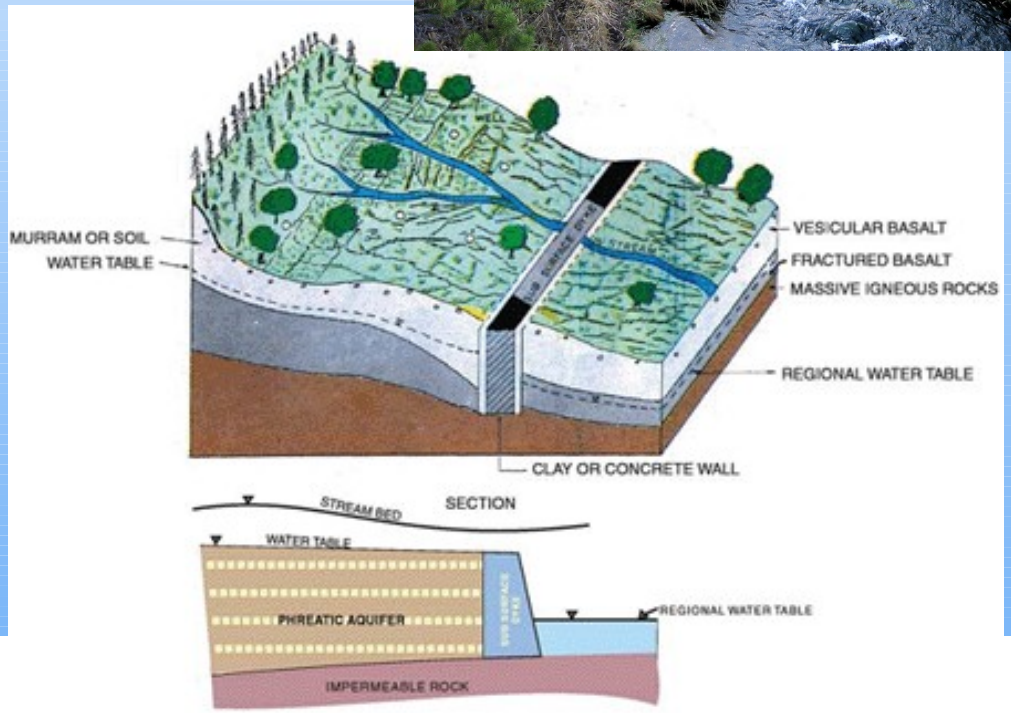


Solutions: Management of Artificial recharge (MAR)

- Groundwater management: artificial recharge to store excess water + improving water quality
  - Water traps
  - Drainholes
  - Cutwaters
  - Infiltration basins

SoINs: Other Recharge methods

- Water traps: increase infiltration in streambeds. The traps are earthen dams of variable height
- Cutwaters: excavations of



"Use the water that you need, but not a drop more"

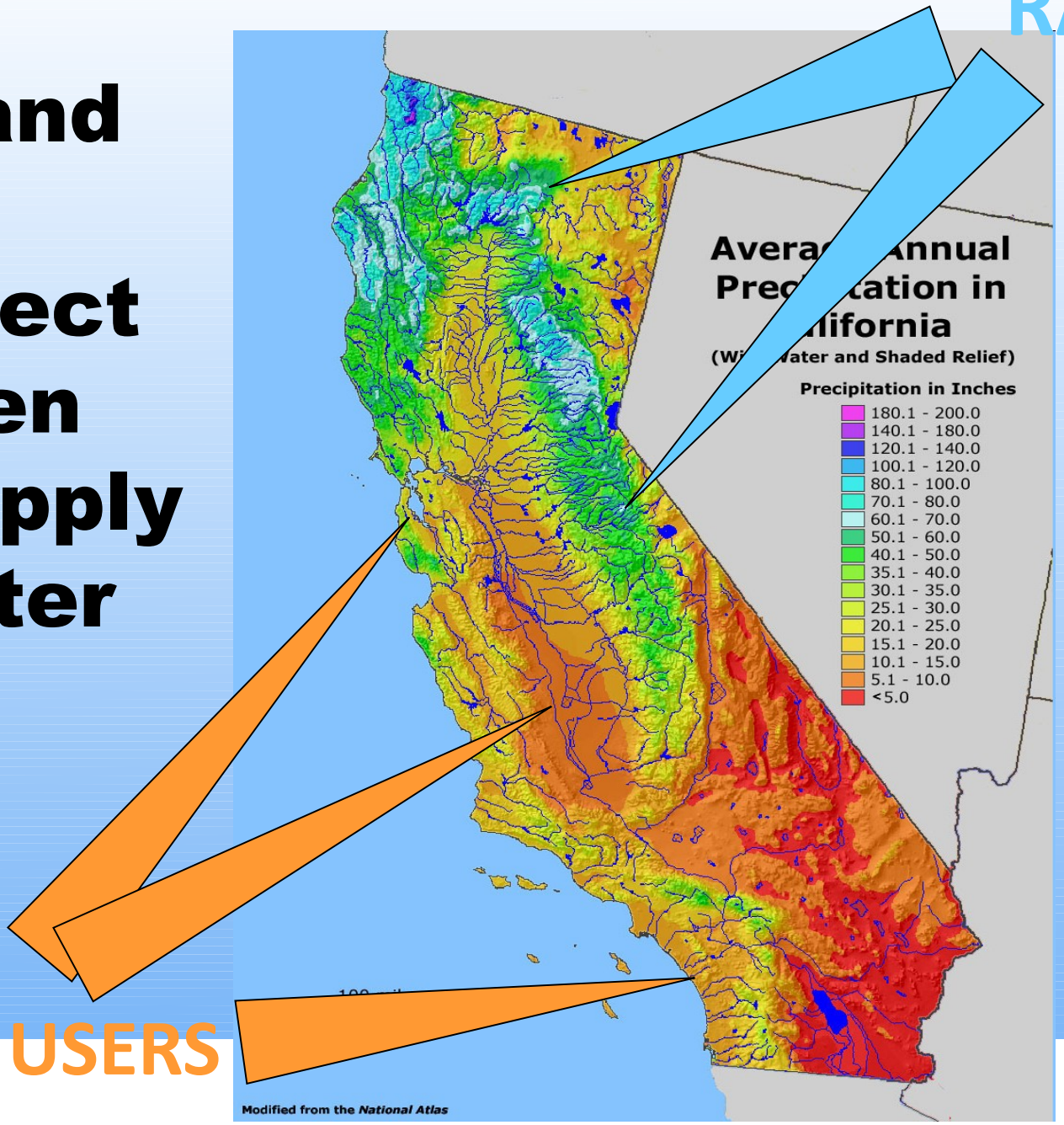
"Usa el agua que necesites, pero ni una gota mas"

Thanks

samsandoval@ucdavis.edu
http://watermanagement.ucdavis.edu/cooperative-extension/

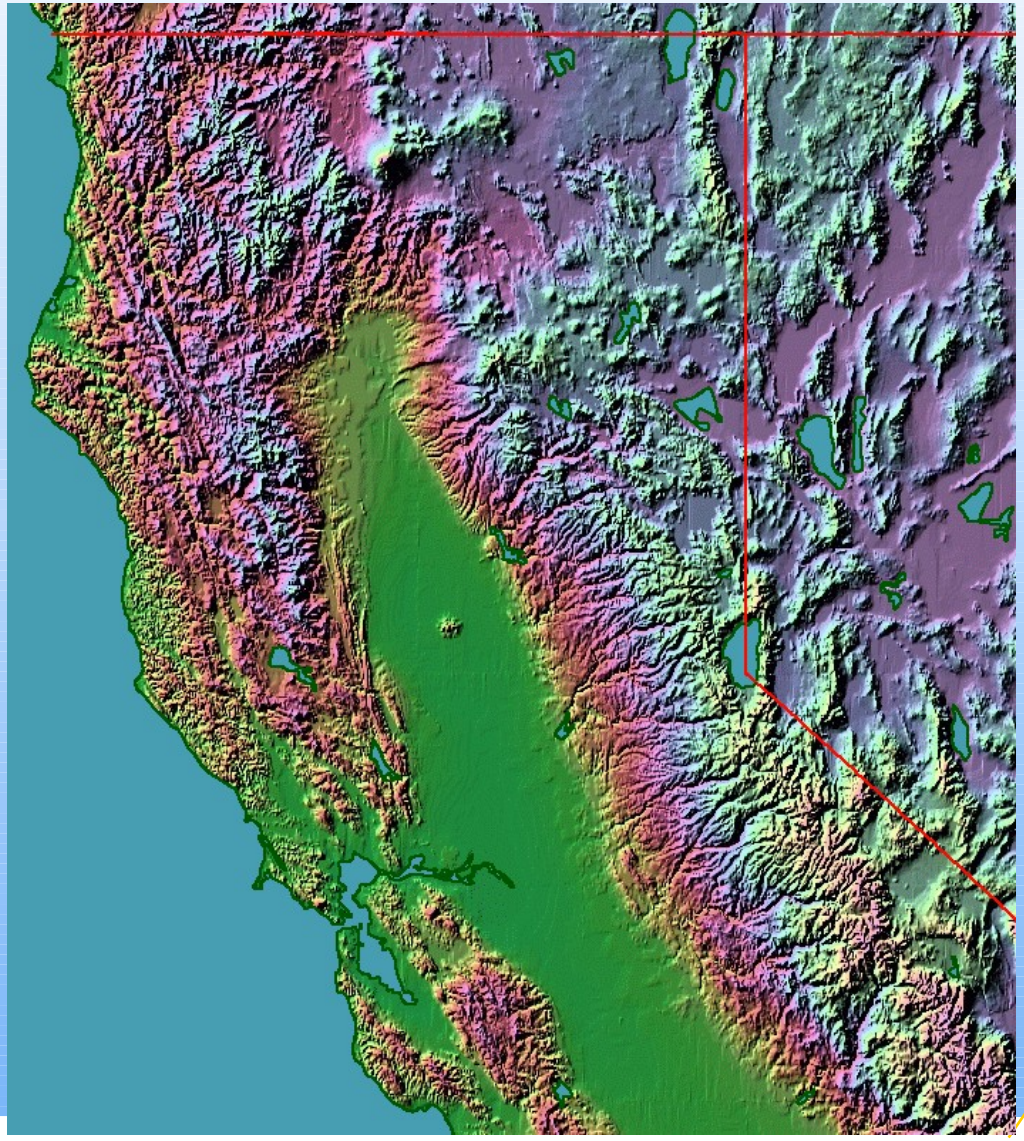
Space and Time Disconnect between Water Supply and Water Use

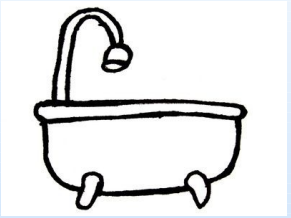
RAIN

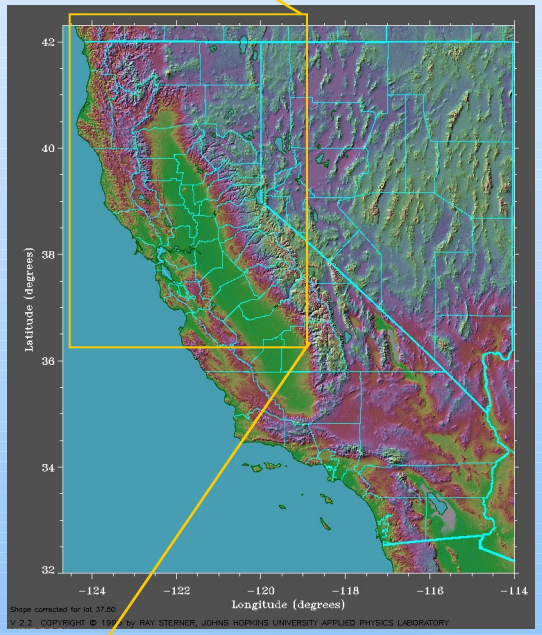


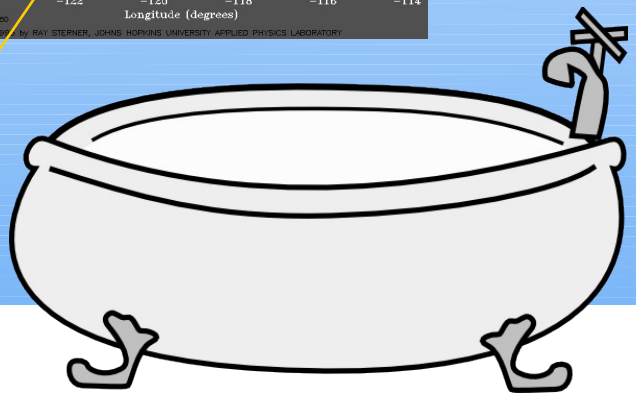
WATER USERS

California groundwater





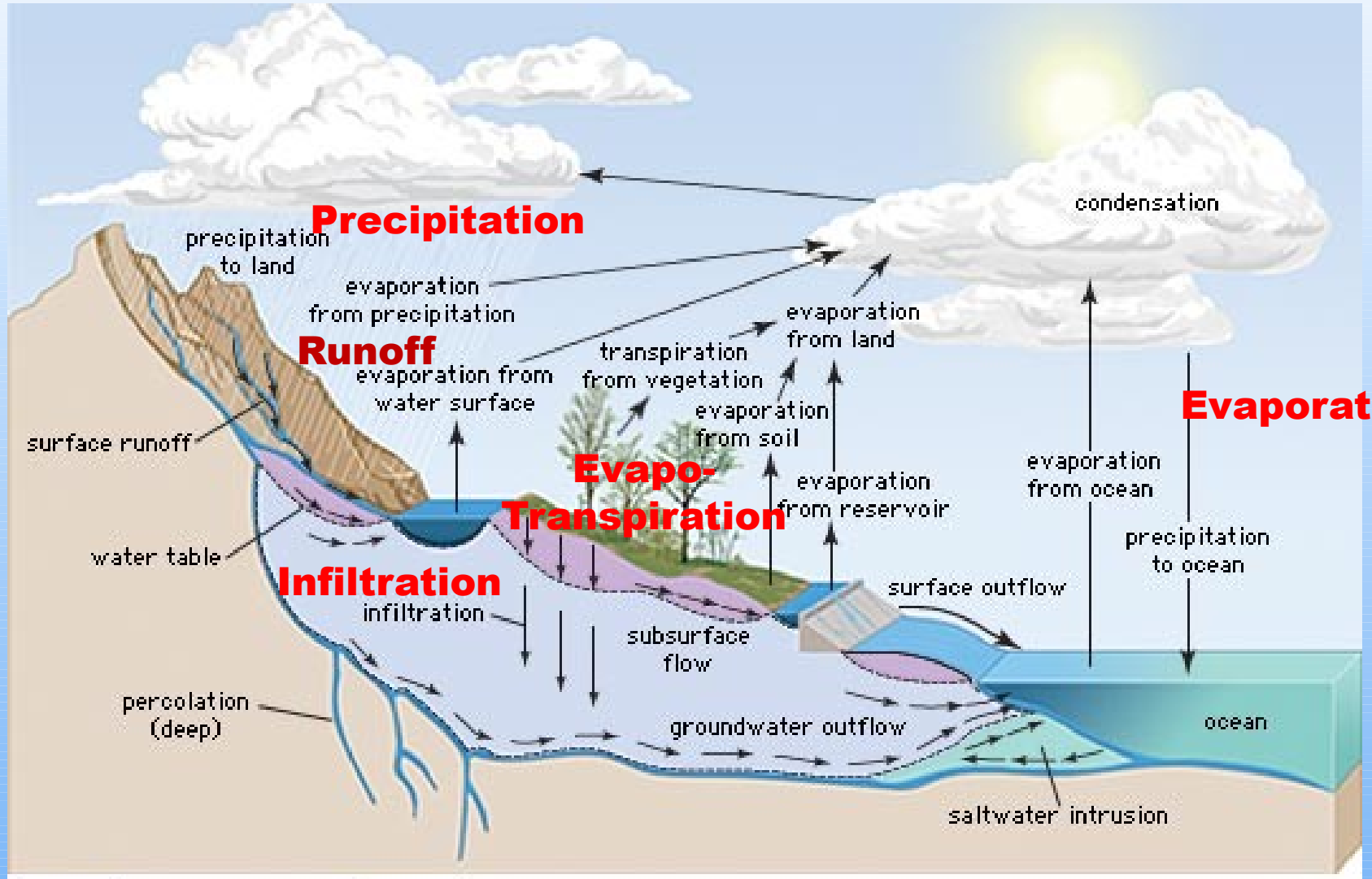




Hydrology

Water Cycle

Hydrology and Hydrologic cycle



Weather, Climate,

Atmosphere and Climate Change

Weather and Climate

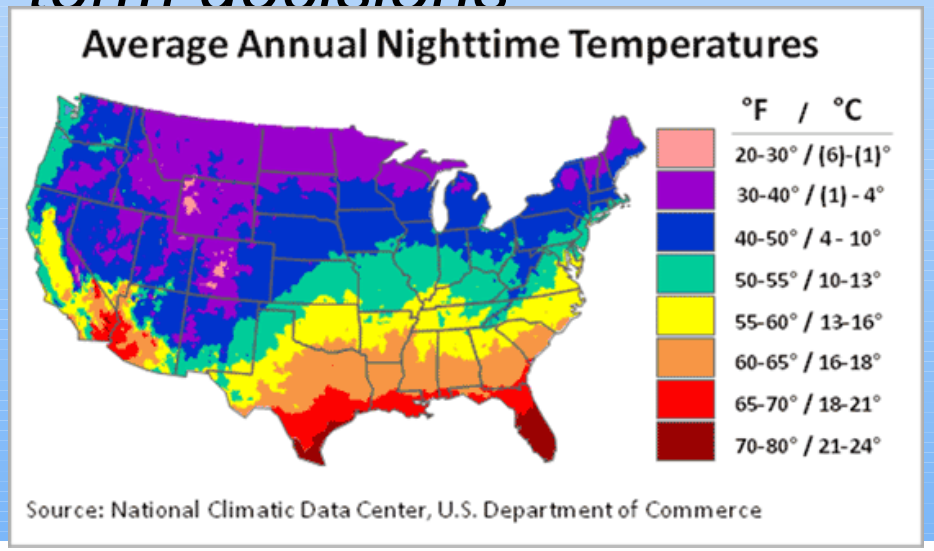
***"Climate is what you expect; weather is what you get"* Mark Twain**

~ Weather

Actual state of the atmosphere at a particular time

~ Climate

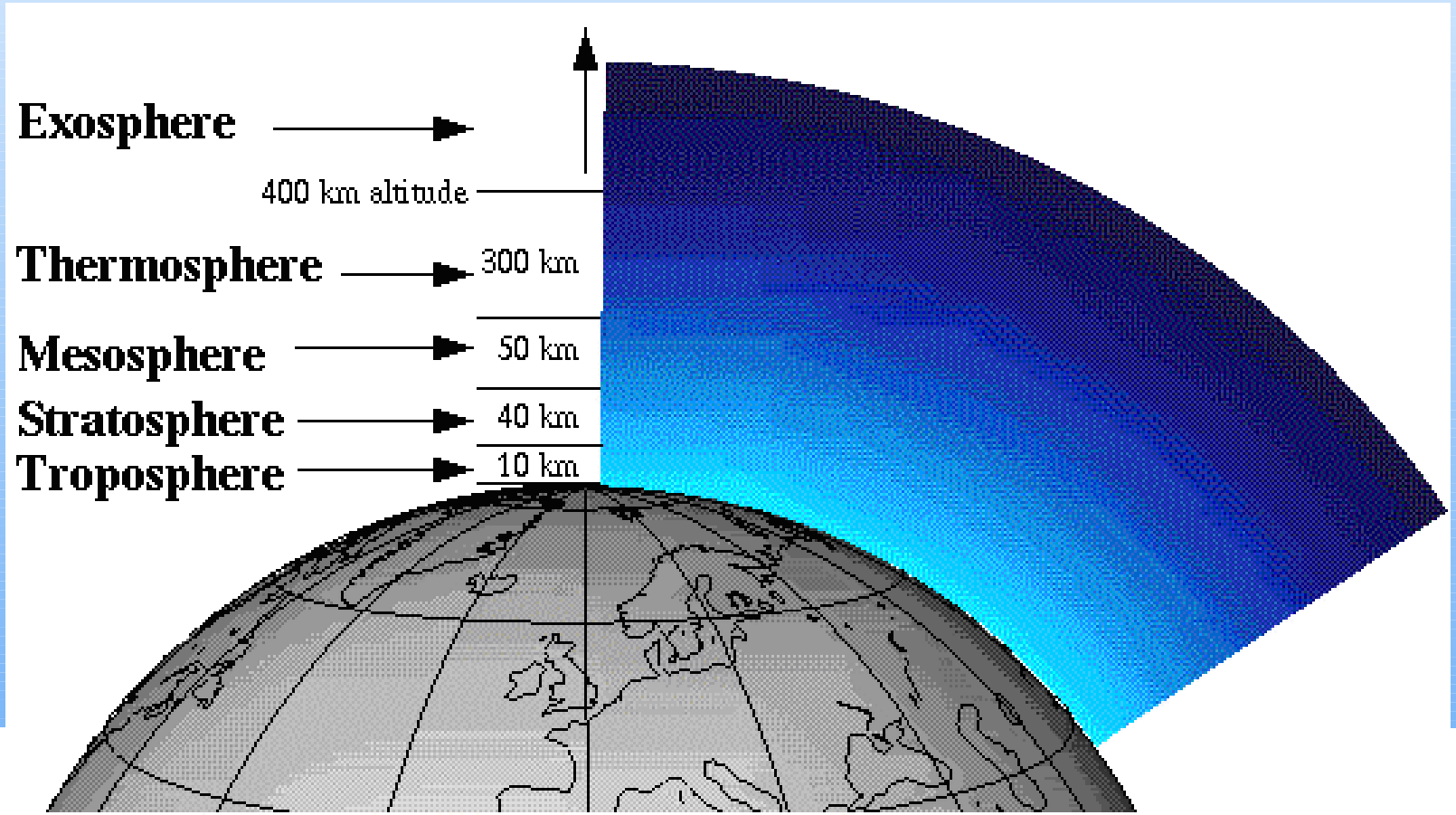
Statistical description of weather over a period of time, usually a few decades. Important for long term decisions

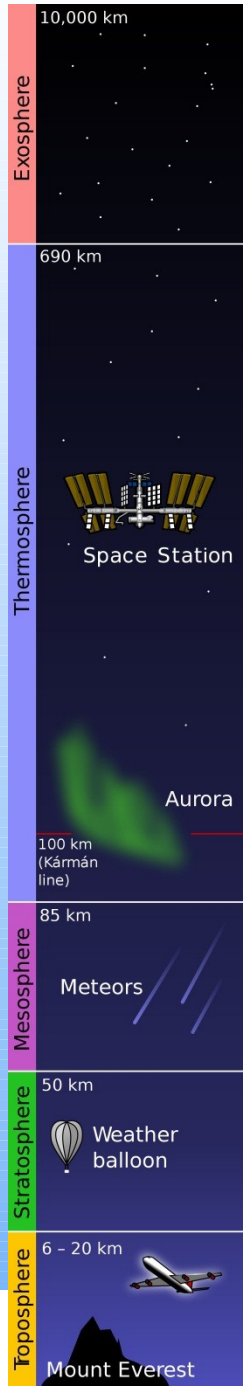


Atmosphere

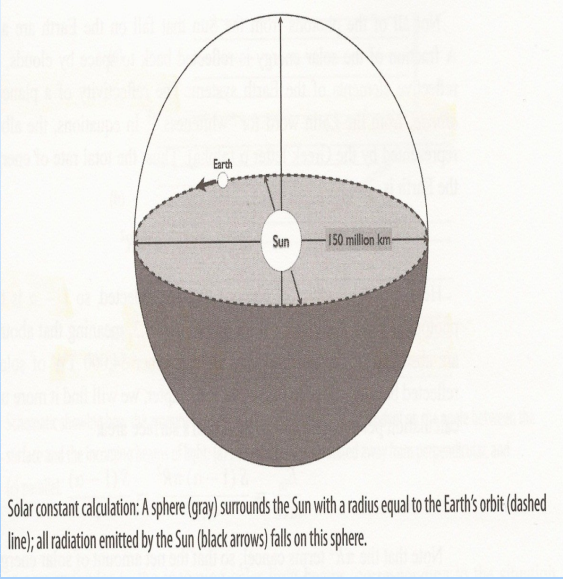
Atmosphere

Not GHG
78% of N2
21% of O2
1% of Argon
99.95%
0.05% GHG

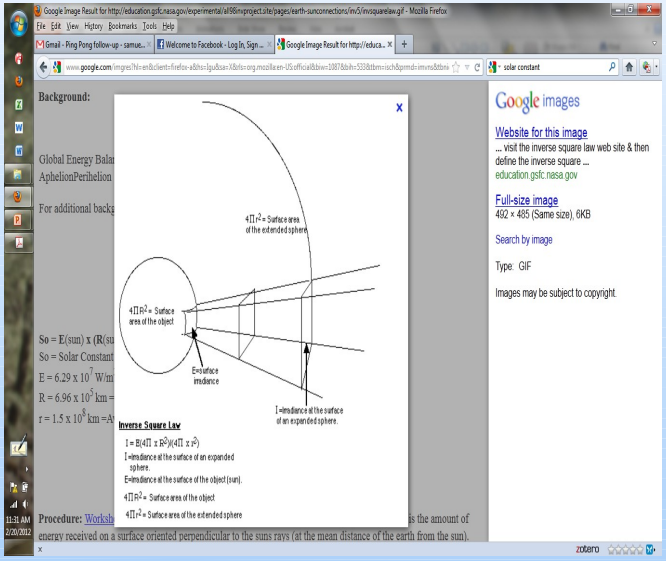


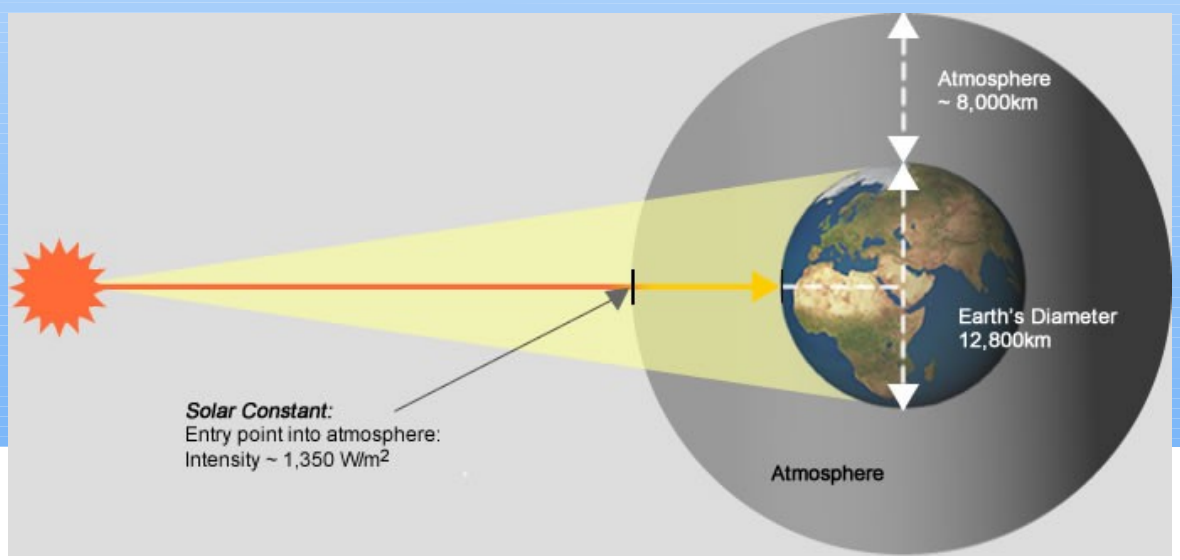


Energy coming from the Sun



Solar constant calculation: A sphere (gray) surrounds the Sun with a radius equal to the Earth's orbit (dashed line); all radiation emitted by the Sun (black arrows) falls on this sphere.



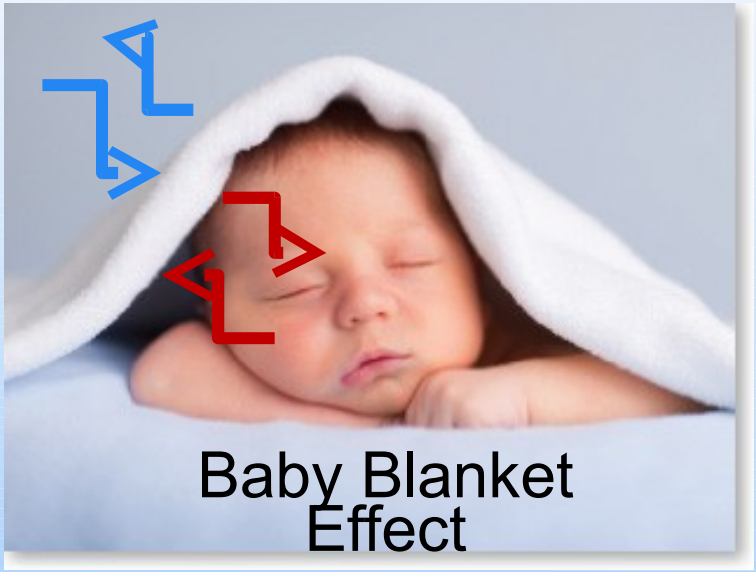


Greenhouse gas effect

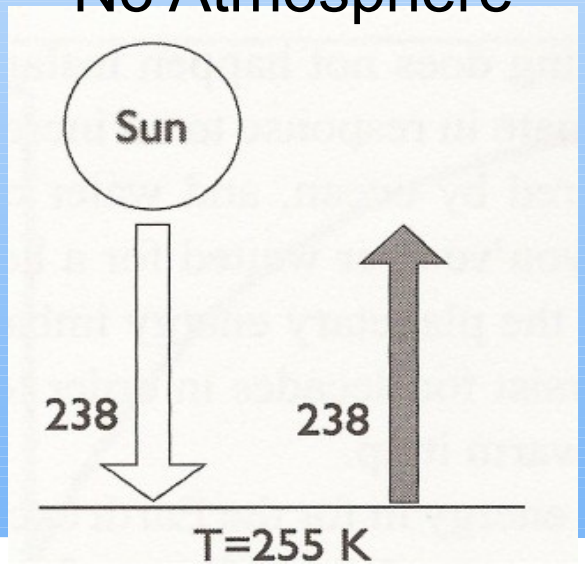
~ **Greenhouse effect**

The heating of the Earth's surface by the atmosphere.

In other words, the atmosphere warms the surface by making it harder for the surface to lose energy to space.

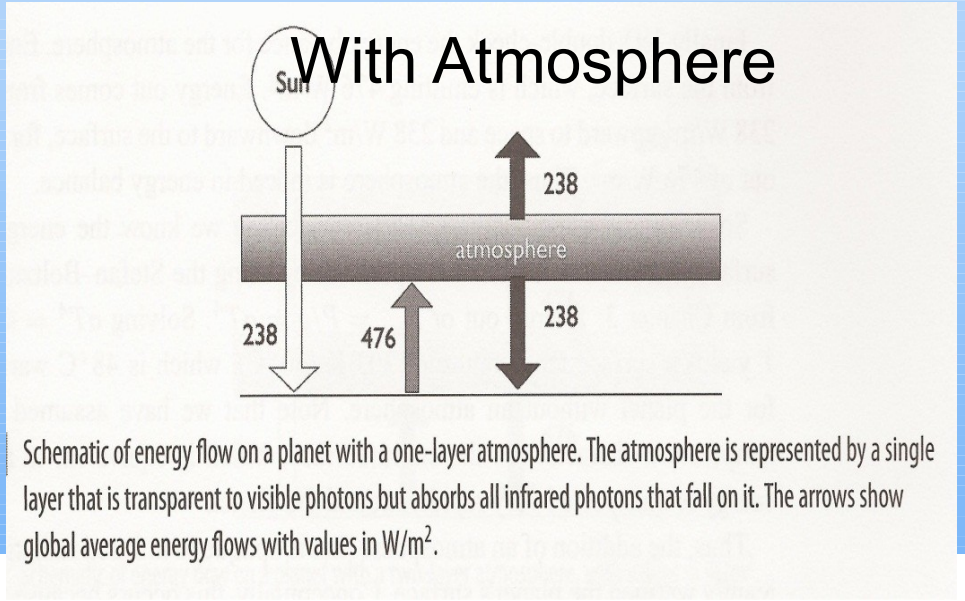


No Atmosphere



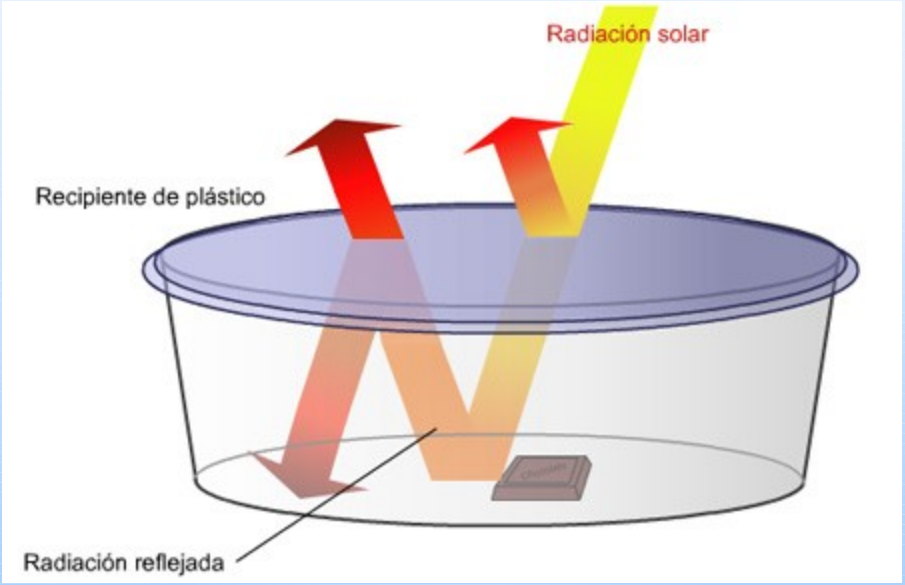
Earth Surface

With Atmosphere

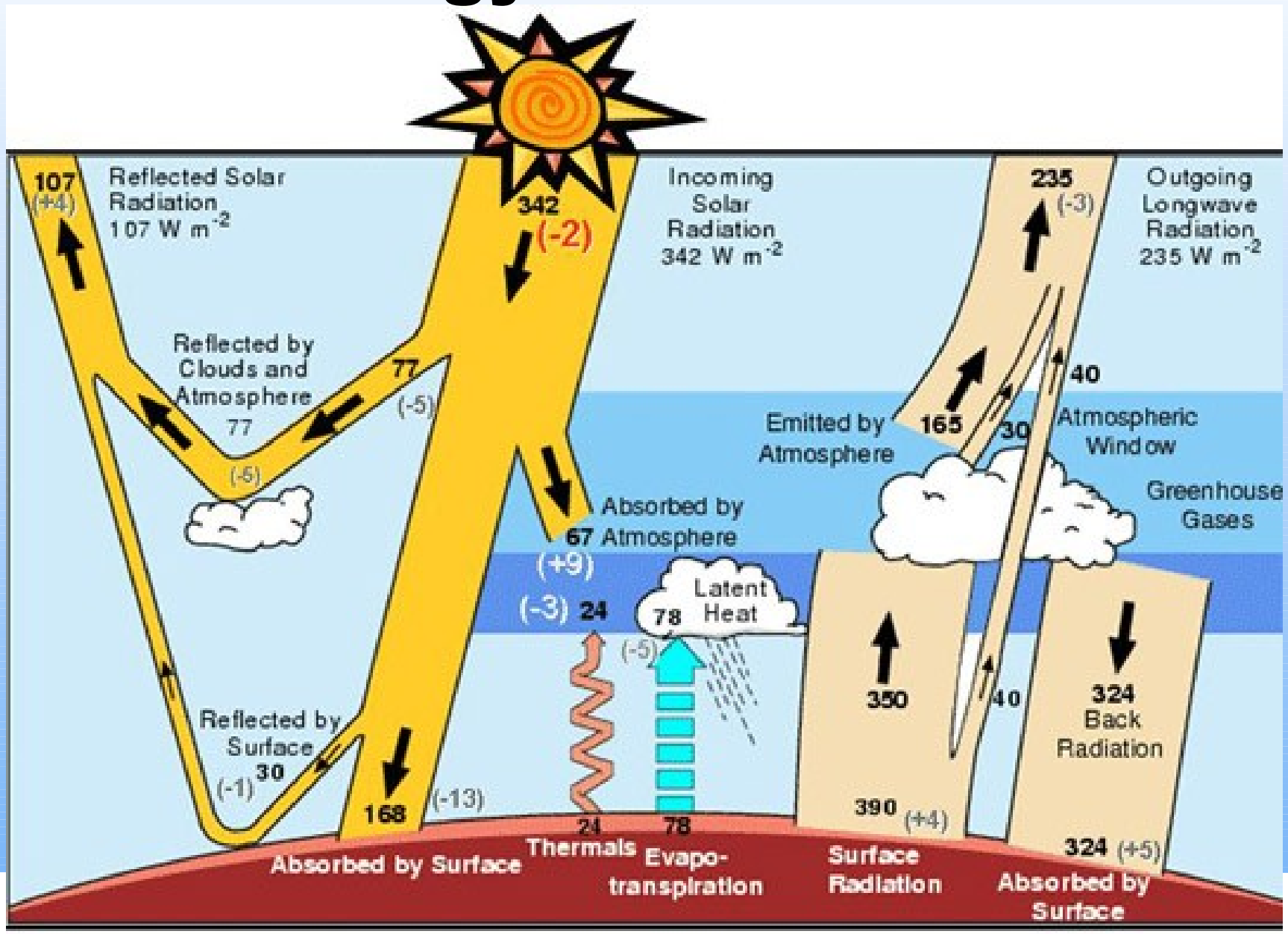


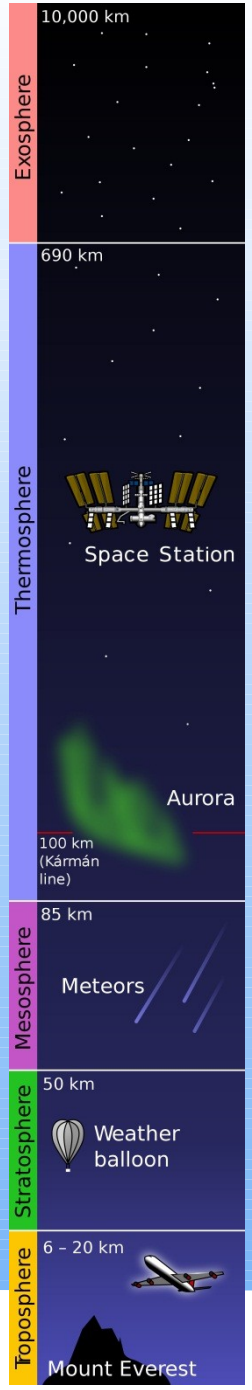
Earth Surface

Greenhouse gas effect



Global energy Balance

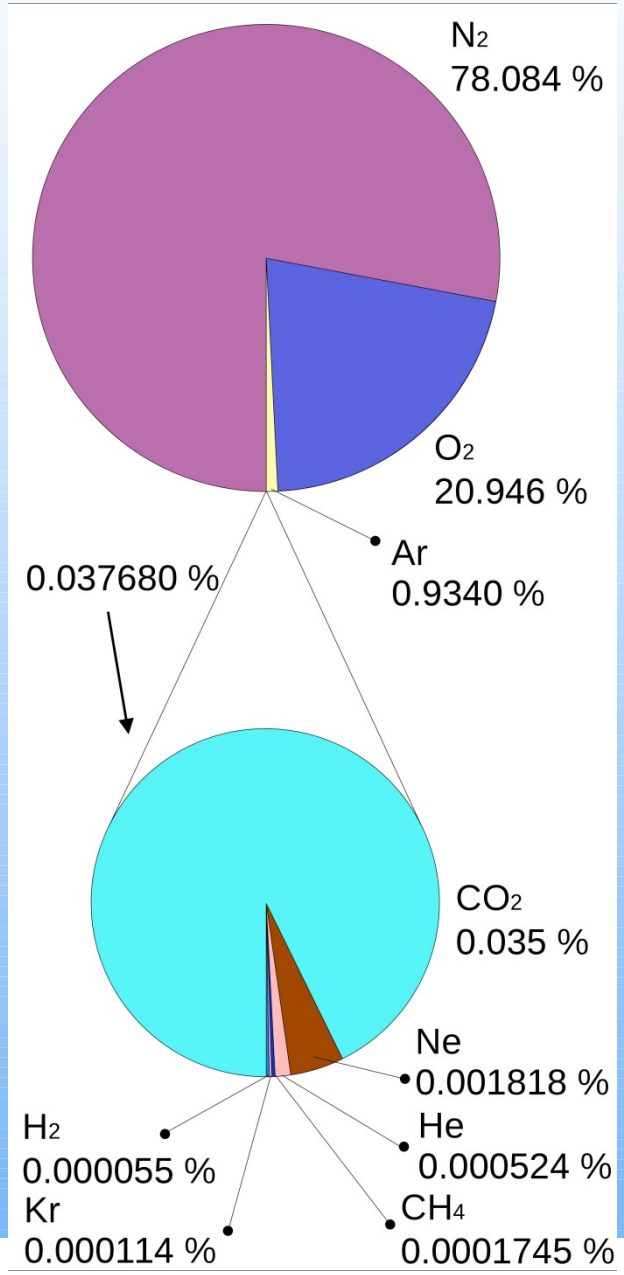




Atmosphere

Not GHG
78% of N2
21% of O2
1% of Argon
99.95%

0.05% remaining
0.039% CO2
0.00018% CH4
0.00003% N2O
Halocarbons
Ozone



Where GHG come from?

- **GHG absorb “energy” (infrared photons) to keep the earth warm(responsible for GHG effect)**
- **Water Vapor**
  Natural: Evaporation from the oceans and is removed through rainfall, humans, animals bacteria and plants (respiration).
  Human induced: Through reservoir evaporation,
- **CO2 (Carbon Dioxide)**
  Natural: Humans, animals bacteria and plants (respiration).
  Human induced: Fossil fuel combustion release to the atmosphere carbon dioxide the that was sequestrated in rocks for hundreds of million of year. Long residence 100K years

Where GHG come from?

- **CH4 (Methane)**
  Natural: wetlands, termites, emissions from the oceans, geological sources.
  Human induced: Rising livestock (cattle, goars and sheep), rice paddies (bacteria in the soil produce methane), landfills, petrochemical industry, burning of forest and other biomass. Long residence, Decades
- **N2O (Nitrous Oxide)**
  Natural: Produced during thunderstorms, is caused by splitting of Nitrogen Molecules
  Human induced: Industrial sources (Agriculture fertilization), fossil fuel combustion (oil and coal)

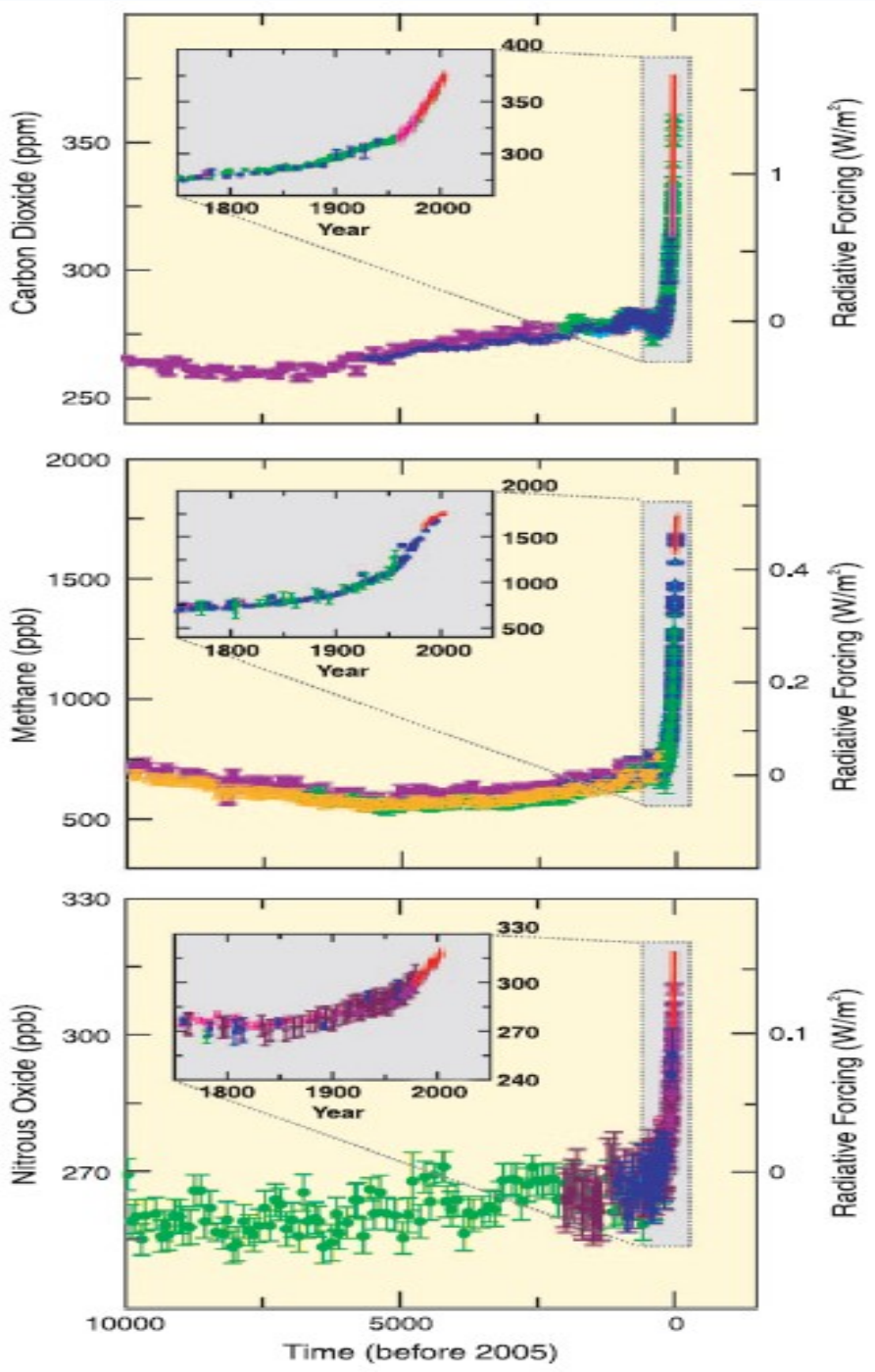
GHG history

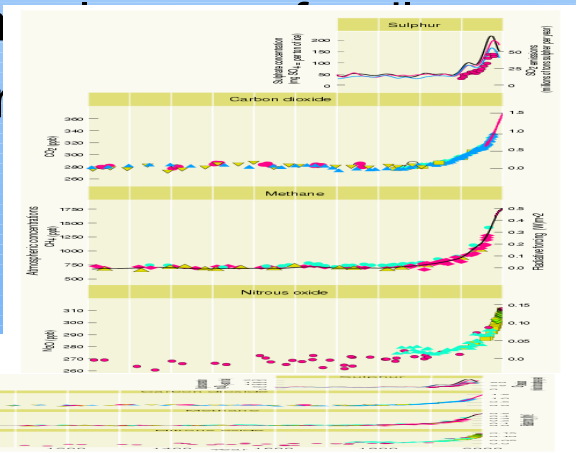
Carbon Dioxide- increases primarily from fossil fuel burning, deforestation

Methane- increases primarily from intensive agriculture, poor natural gas production practices

Nitrous Oxide- increases primarily from vehicles, agriculture

Sulfur Aerosols (dust)- changes primarily from [illegible] fuel (coal) bur



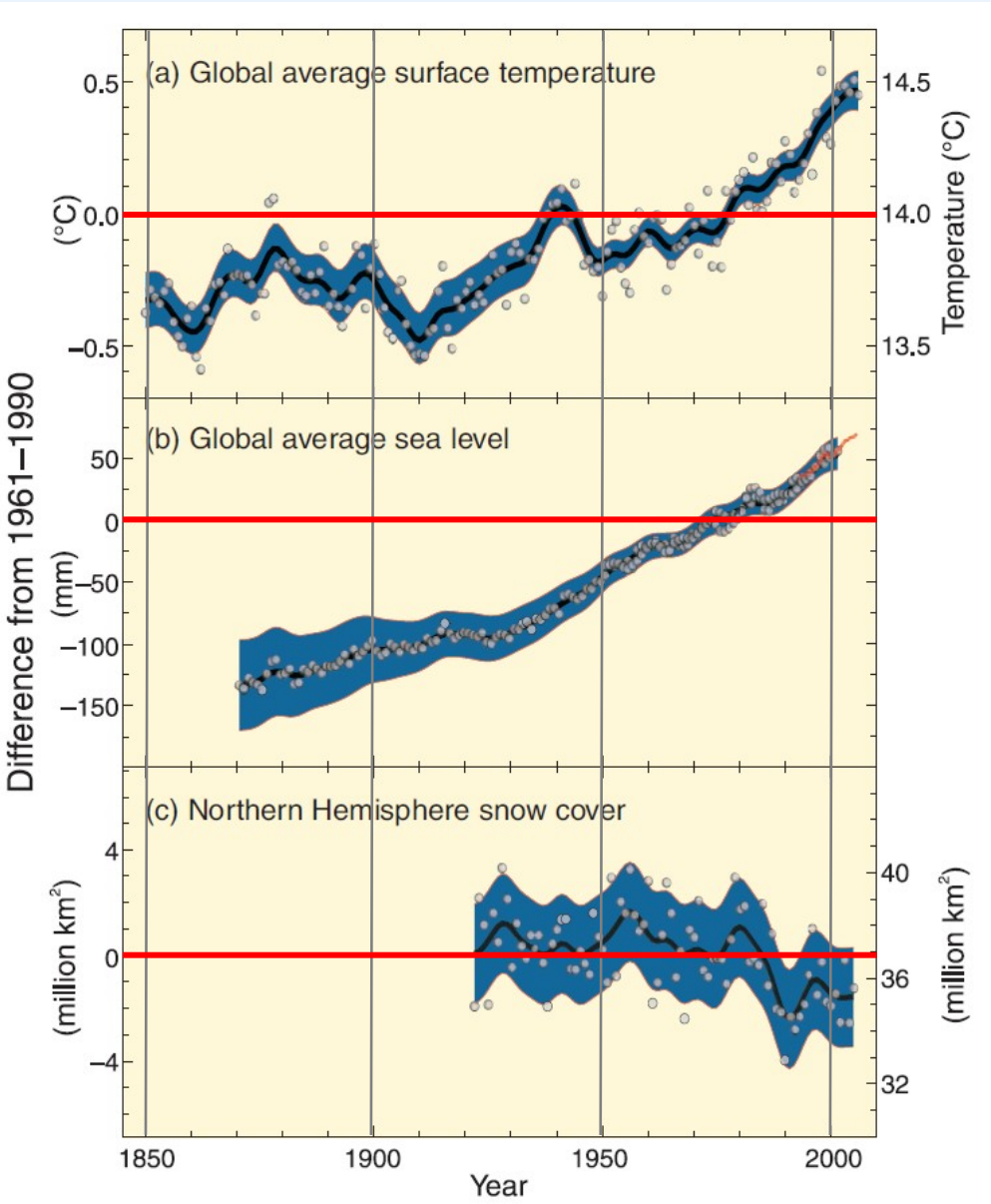


So …
what do you think is happening if the GHG concentration in the Atmosphere is increasing ?

Temperature

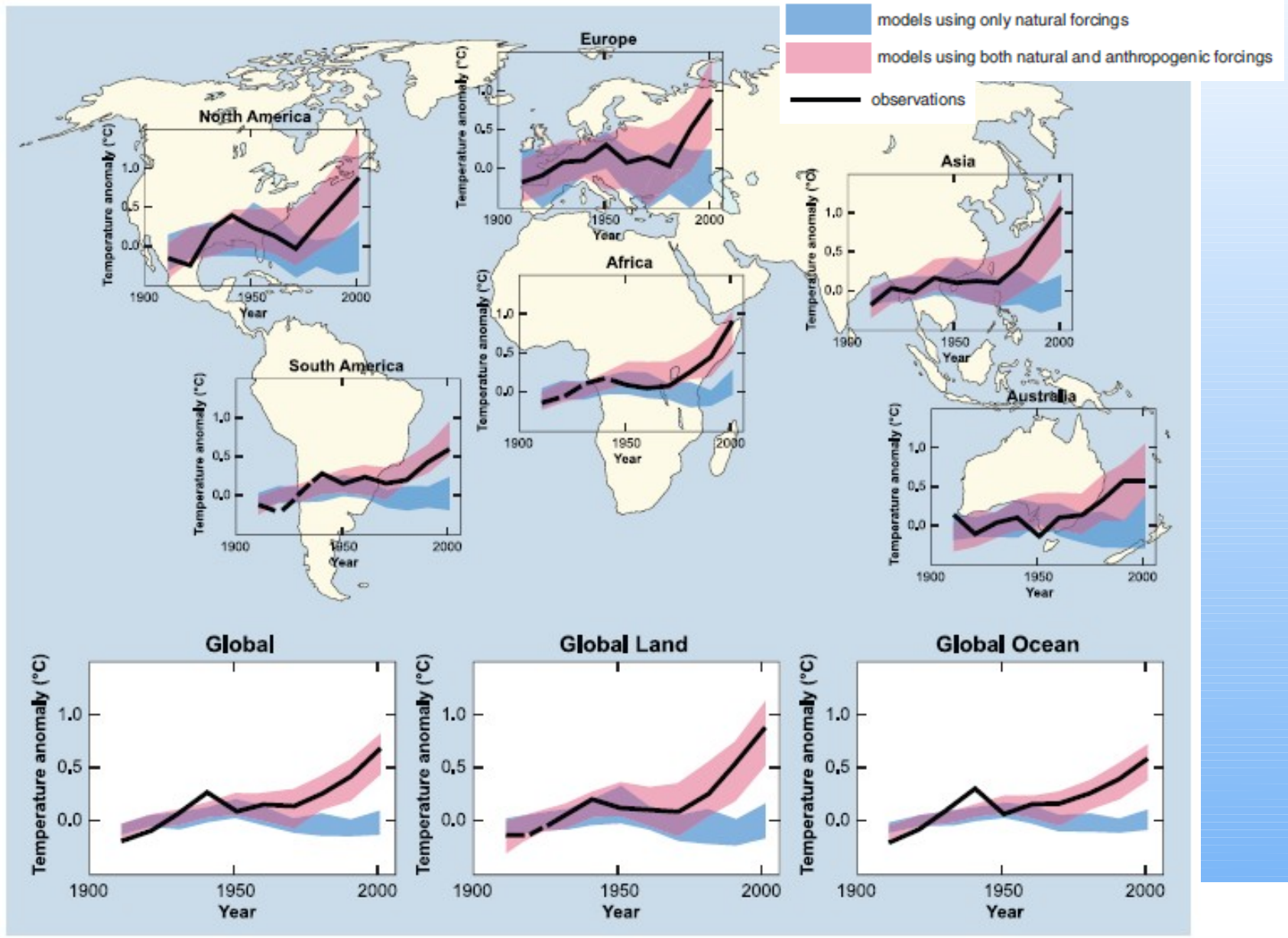
Sea level

Snow cover



IPCC (2007). "Climate Change 2007: Synthesis Report"

Continental temperature Change



Climate Change …

- **Climate change**
  Any systematic change in the long term statistics of climate elements (temperature, pressure, winds) sustained over several decades longer.
  Compare the climate for one period against another, and if the statistics have change, then the climate has changed
- **Anomaly**
  The difference between a climate statistic and a reference value
  Why? Absolute values vary sharply, but changes across space are constant over a much longer distance

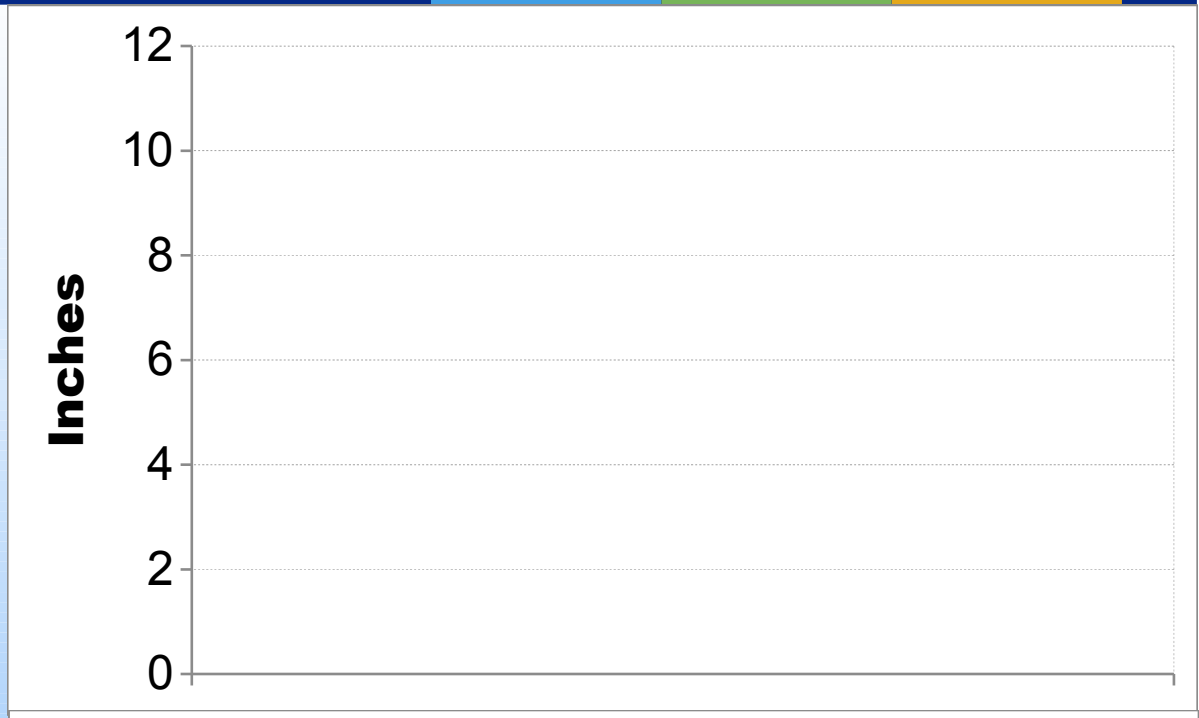
Anomaly = Time Series – Reference Value

Climate change in Napa?

Weather stations in Napa 1990-2011

Precipitation

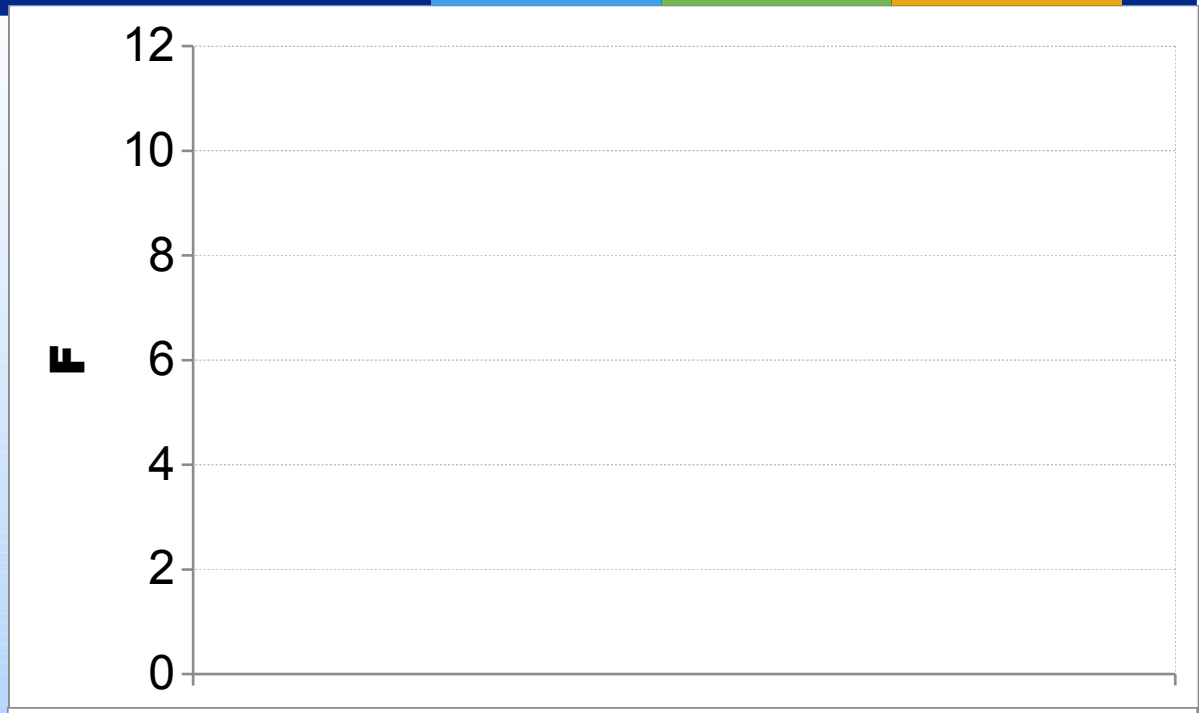
Oakville
Station (North)



Carneros Station
(West Airport)

Temperature

Oakville
Station (North)

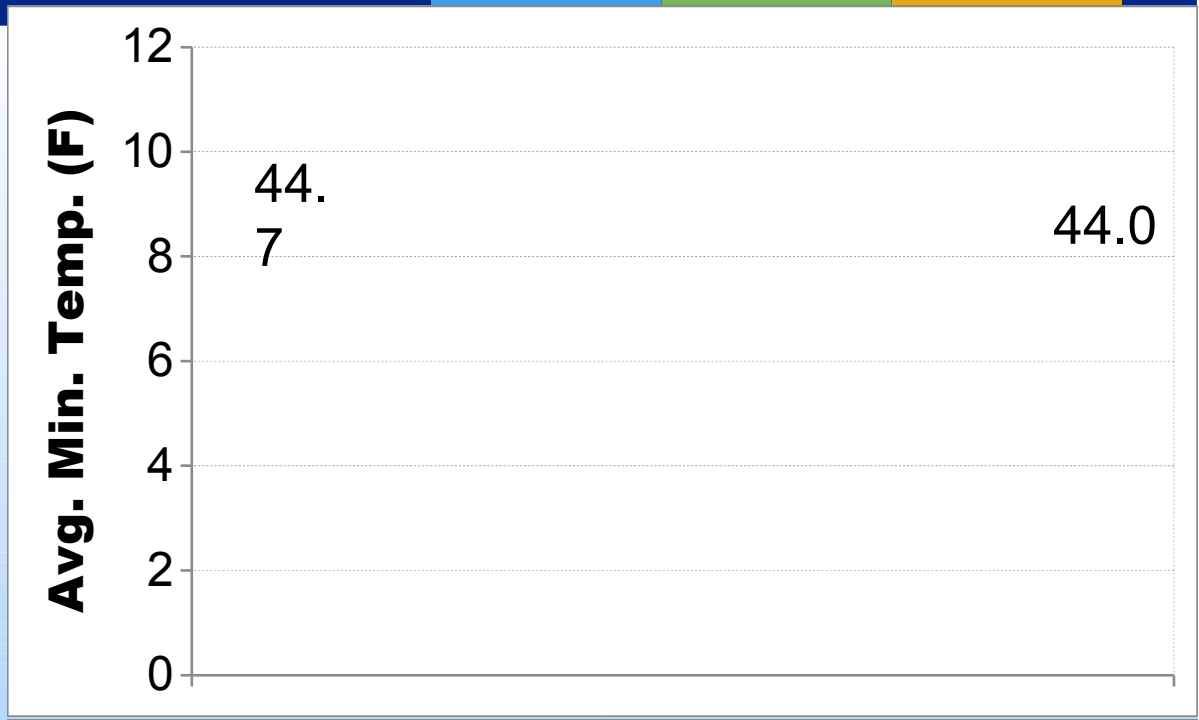


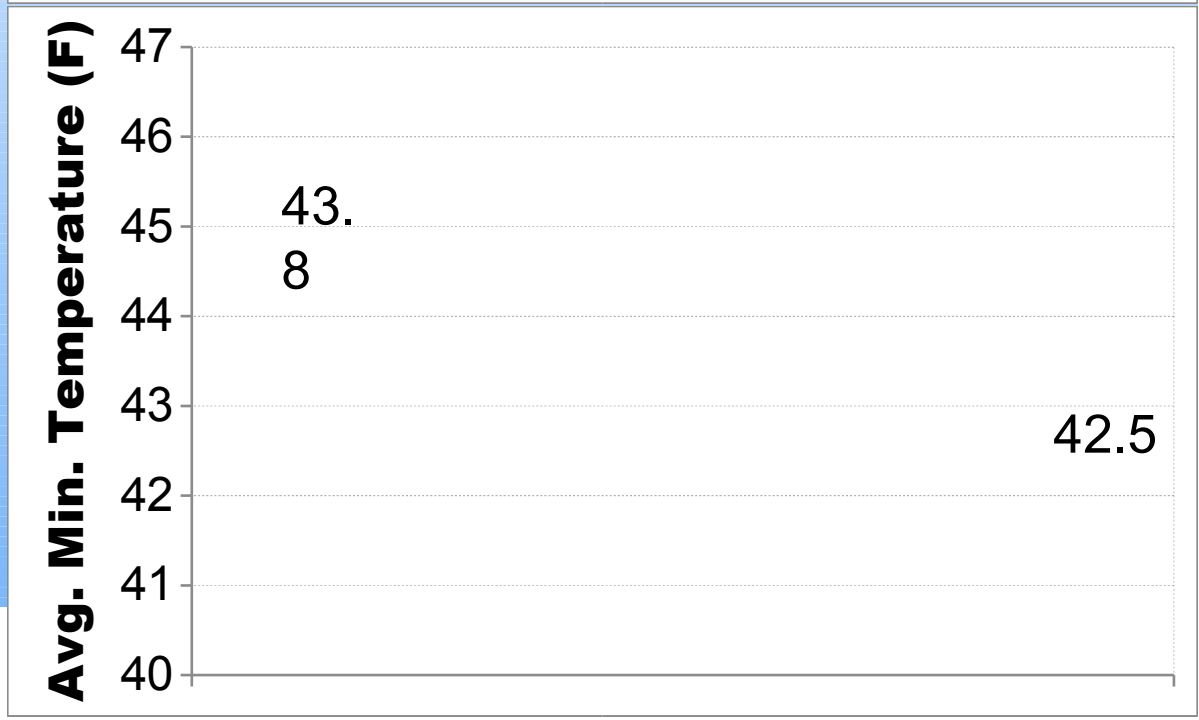
Carneros Station
(West Airport)

Oakville
Station (North)

Avg. Min. Temperature

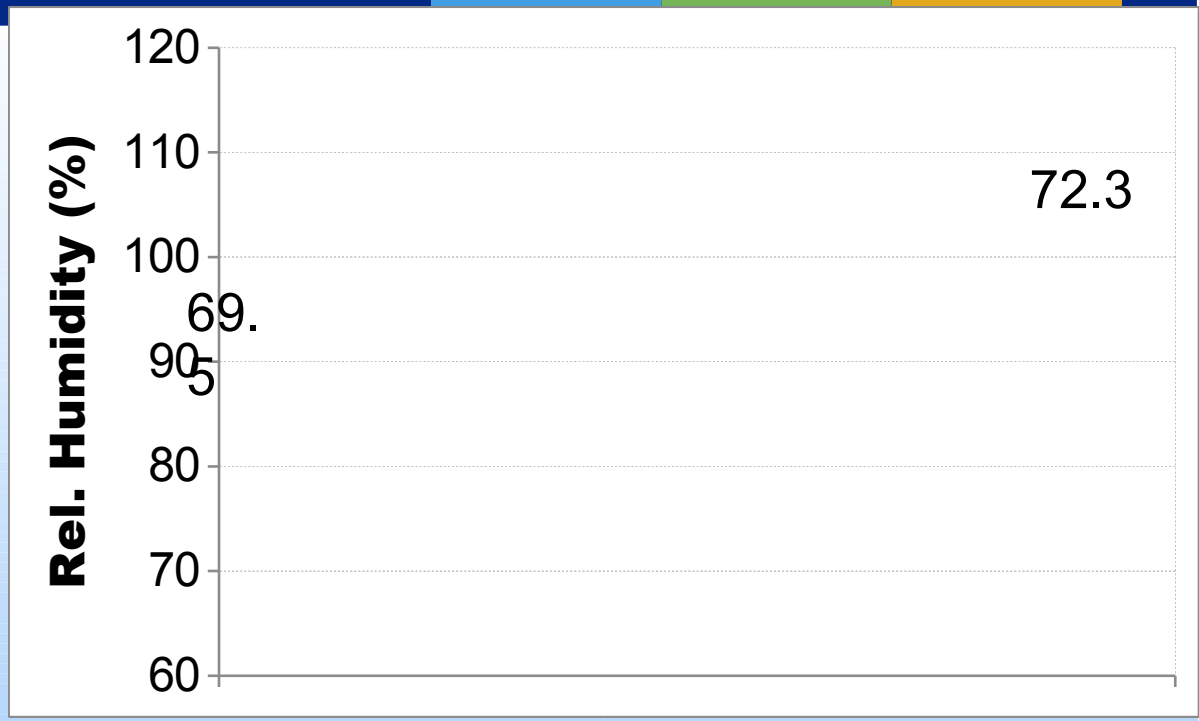
Carneros Station
(West Airport)



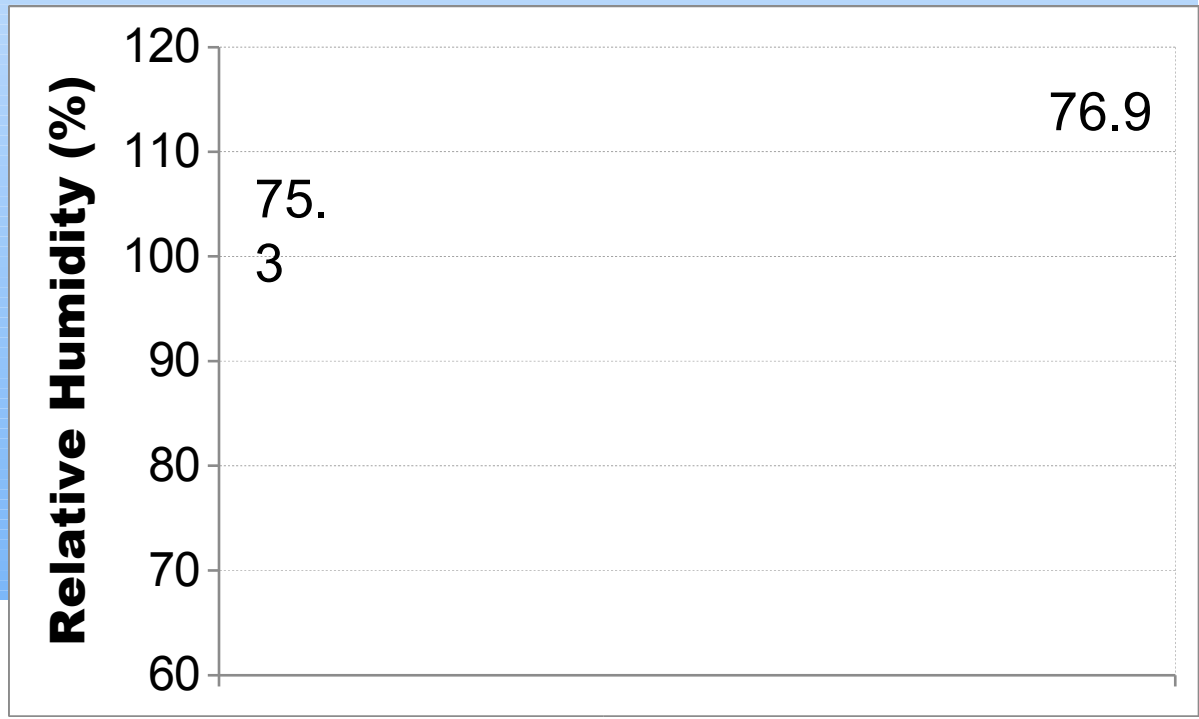


Humidity

Oakville Station (North)



Carneros Station (West Airport)



Thanks

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