Science, Technology, Innovation and Engineering

Critical Contributors to Meeting the SDGs Discussed Through Focus on Groundwater

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STI-E as viewed through groundwater resources

Important components

Basics of Groundwater

Ties to addressing SDG 6 (as well as SDGs 2, 3 and 11, with mention of 8, 9, and 17)

Examples from Africa

- -Rural water supply – development and protection (6, 2, 3)
- -Large community water supply – utilization and capacity (6, 3, and 11 plus some 8 & 9)

Summary: STI-E as necessary to advance solutions to SDGs

STI-E as viewed through groundwater resources

Important components --- Use Science, Technology, Innovation and Engineering to:

- Investigate: Investigate / Explore a system of importance
- Understand: Use this investigation / exploration to better understand that system and how it works
- Study: Use this new knowledge and understanding to study / research opportunities to advance a solution to a SDG
- Predict / Design: Use the above steps to predict future system behavior and design long-term solutions leading to sustainability

Summary: STI-E (IUSP) is necessary to advance solutions to SDGs

Science, Technology, Innovation, and Engineering

Tools to Address SDGs Through

IUSP

Investigation

Understanding

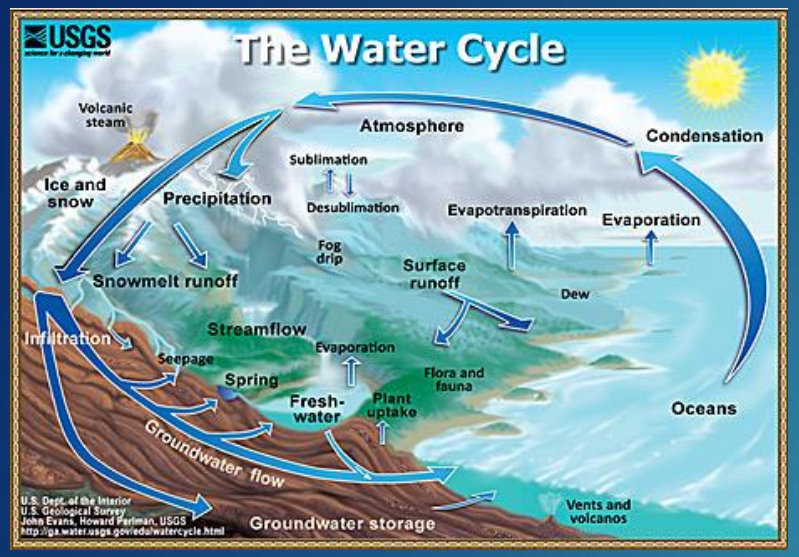
Study / Identification

Prediction / Design

Contributes to the ability to Collaborate among Partners

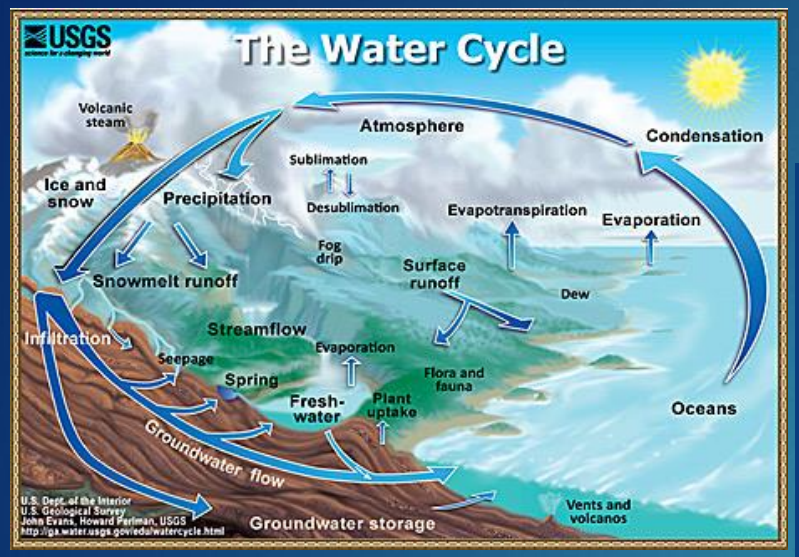
Contributes to the Identification / Comparison of Alternatives

What is Groundwater ?



Groundwater makes up ~30% of all freshwater and ~96% of freshwater not in glaciers / ice caps

What is Groundwater ?



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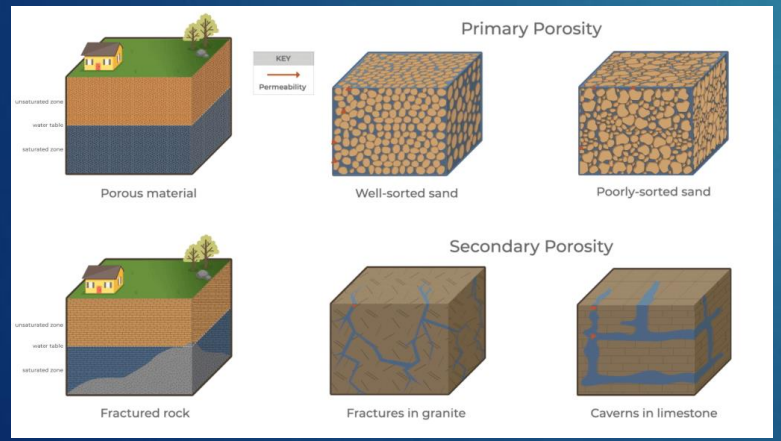

Water in Pores / Fractures

Water in the subsurface exists within pores (e.g., in sands and gravels) or in fractures (e.g., in hard rock such as granite.

Groundwater is that water in the subsurface where the pores or fractures are fully filled (saturated) with water.

Areas where water exists but only fills a portion of the pore or fracture are termed parts of the unsaturated zone.

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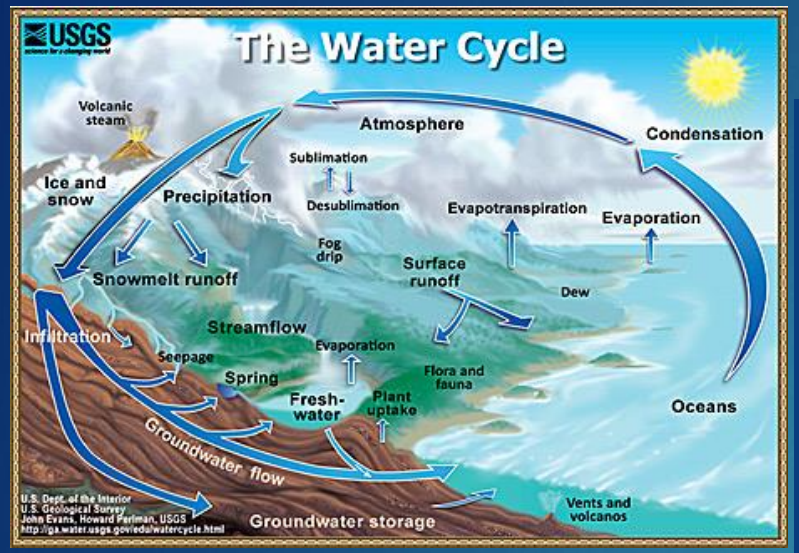

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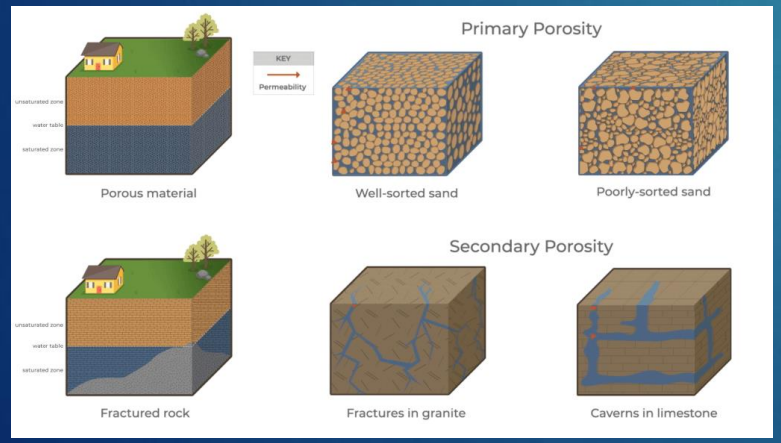
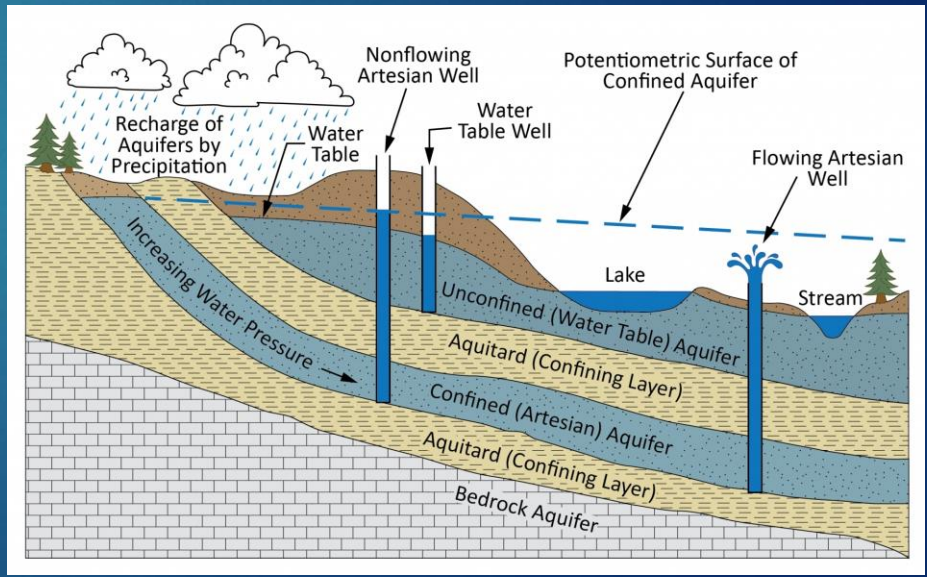


Aquifers / confining layers

Geologic zones containing saturated pores or factures where the water can move relatively freely are generally categorized as being in "aquifers"

Areas of saturated water where the resistance to water movement is relatively high compared to surrounding regions are generally terms confining layers (or aquitards)

We will talk about systems of aquifers and confining layers



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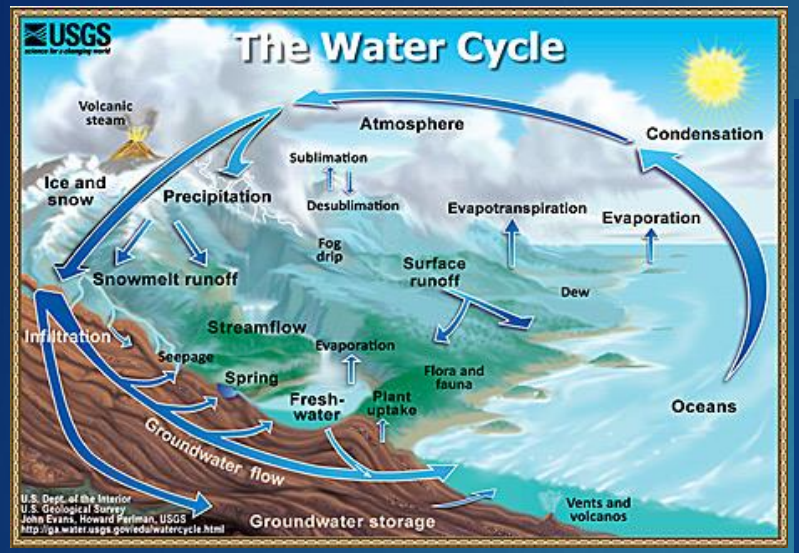

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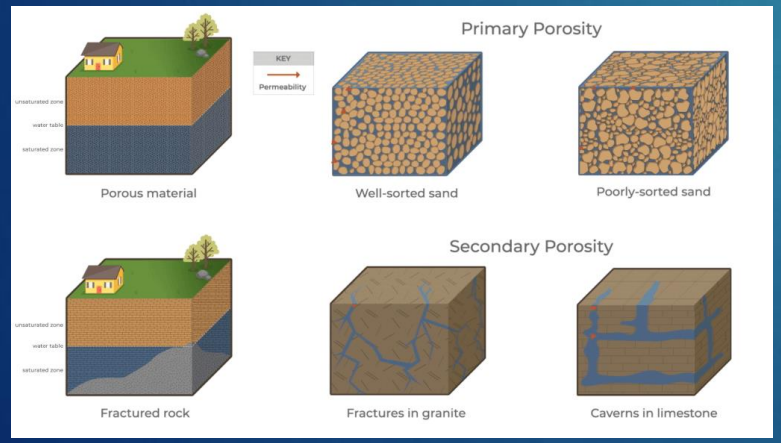
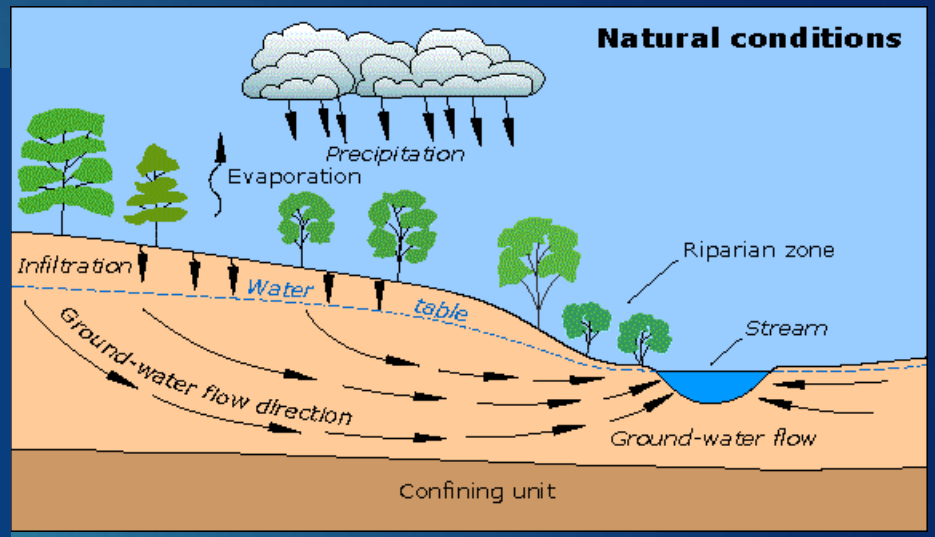


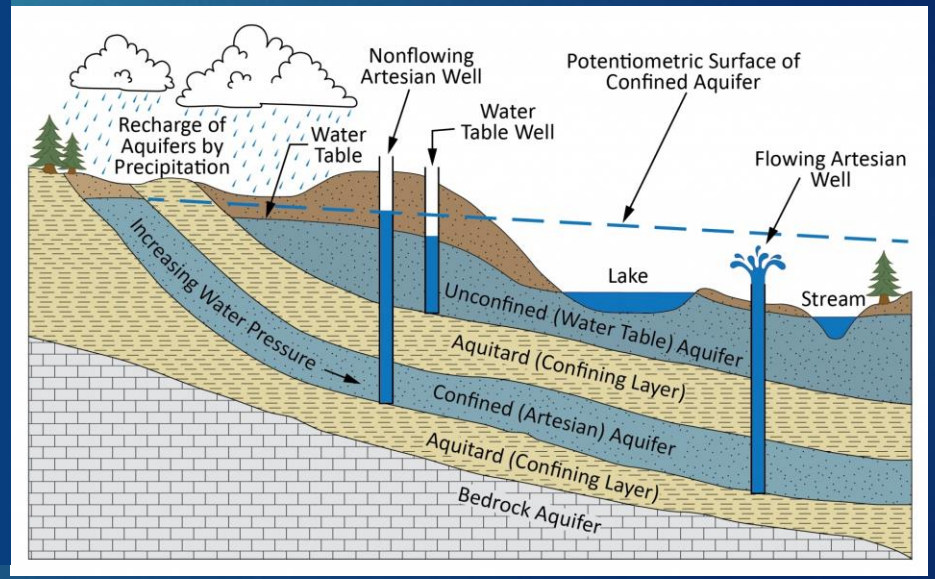
Recharge and Discharge

Water that infiltrates from the ground surface (precipitation / rivers / lakes) and moves to the saturated groundwater system is termed RECHARGE

Water from the ground surface that moves back to the atmosphere (evaporation or transpiration) is generally called Evapotranspitation

Water the leaves a groundwater system by natural flow or by water withdrawal at wells is termed discharge





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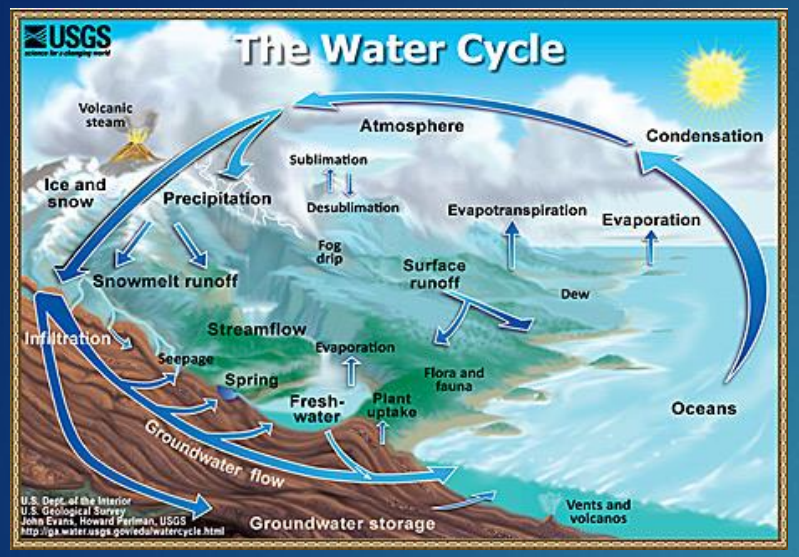

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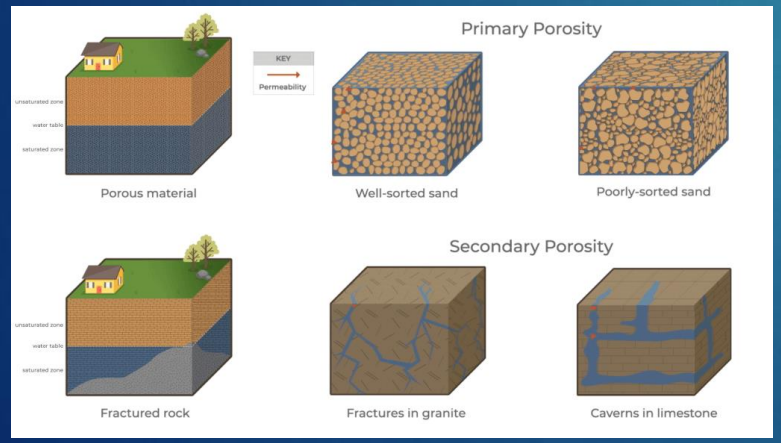
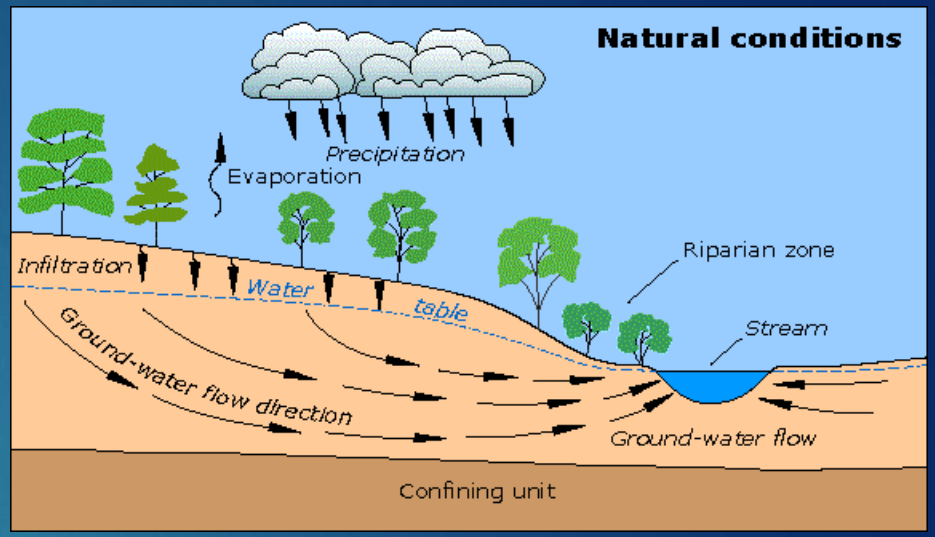
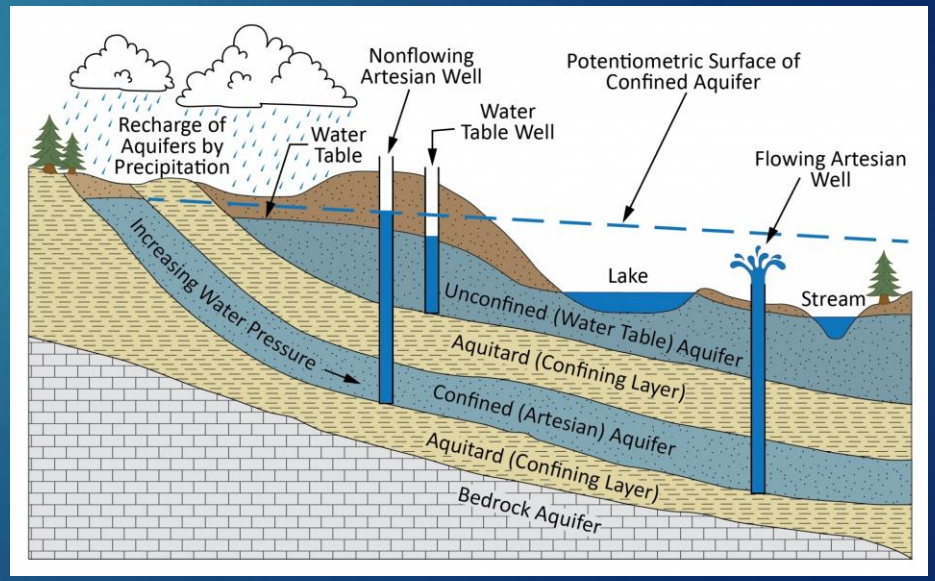


Groundwater Velocity

In general, the velocity of groundwater movement is very slow – commonly on the order of meters per year to a few kilometers per year.

Higher velocities are observed approaching wells or other constructed points of groundwater withdrawal.





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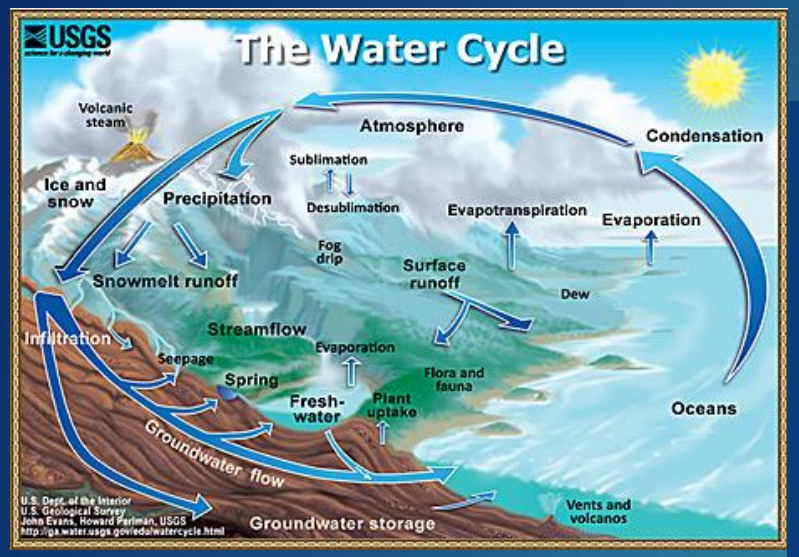

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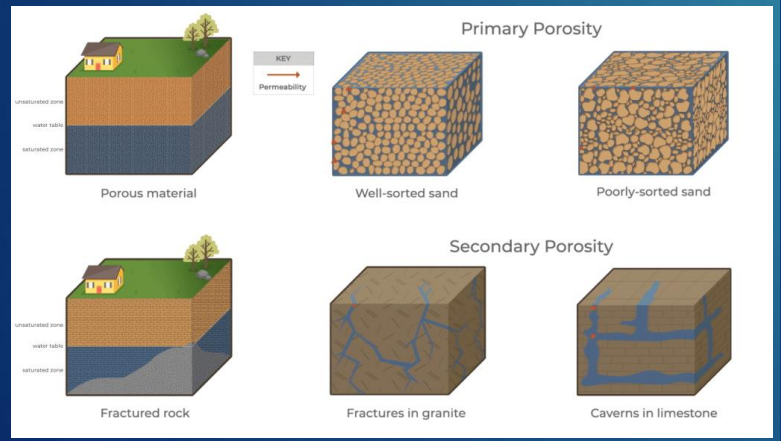
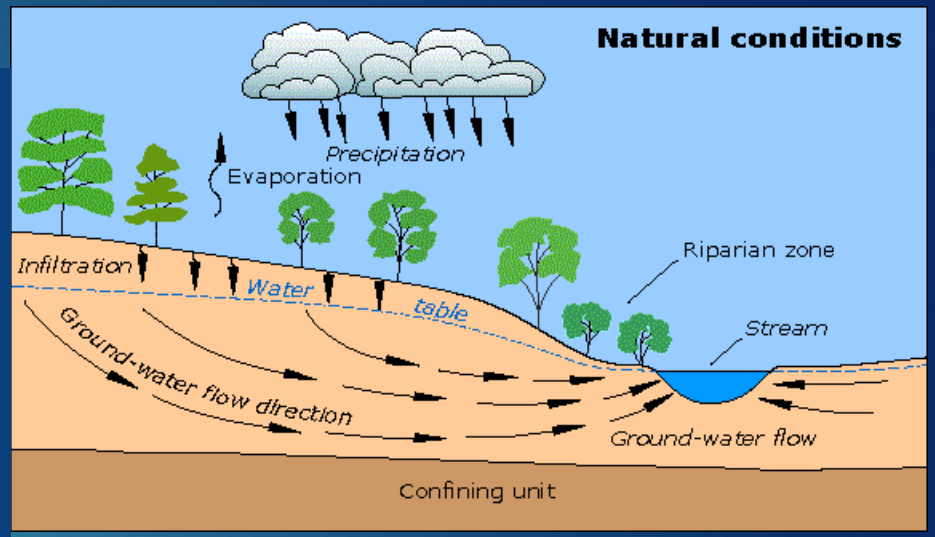


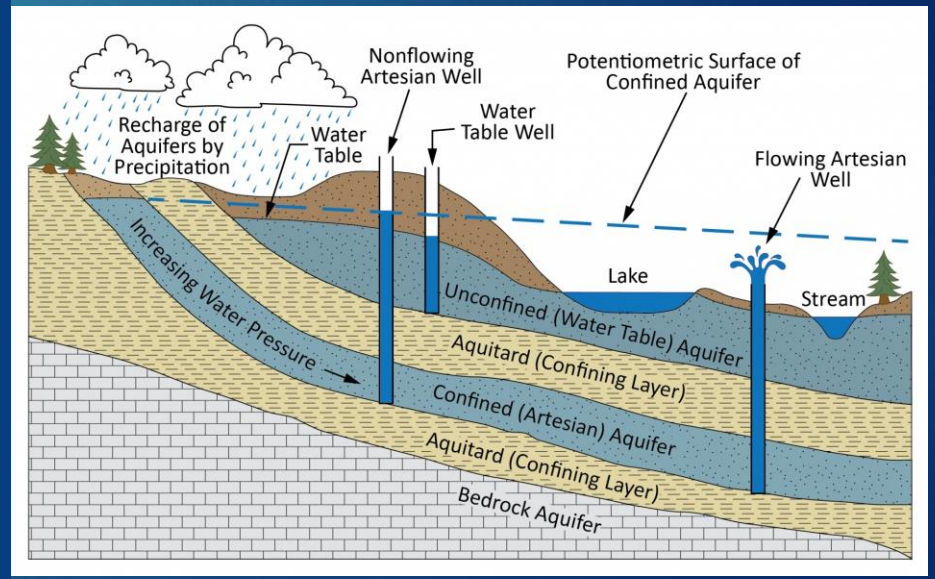
Storage and Permeability

Two critical measures of groundwater behavior:

Permeability is a measure of the resistance of the geologic medium to the movement of water. The higher the permeability, the greater the amount of groundwater flow for a given change in energy.

Storage is a measure of the volume of water that can be withdrawn from an aquifer through decreasing the water pressure. It is a measure of how productive an aquifer can be.





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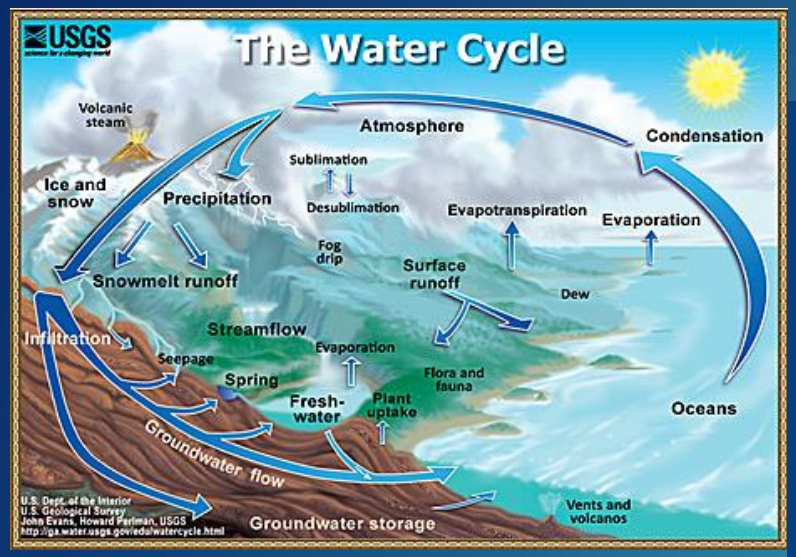

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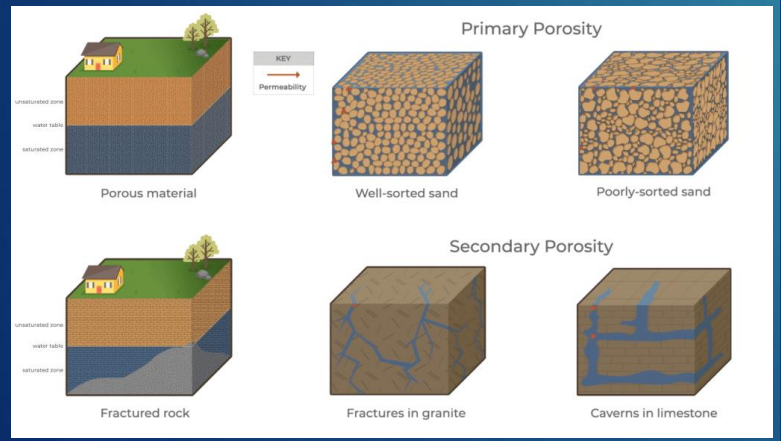
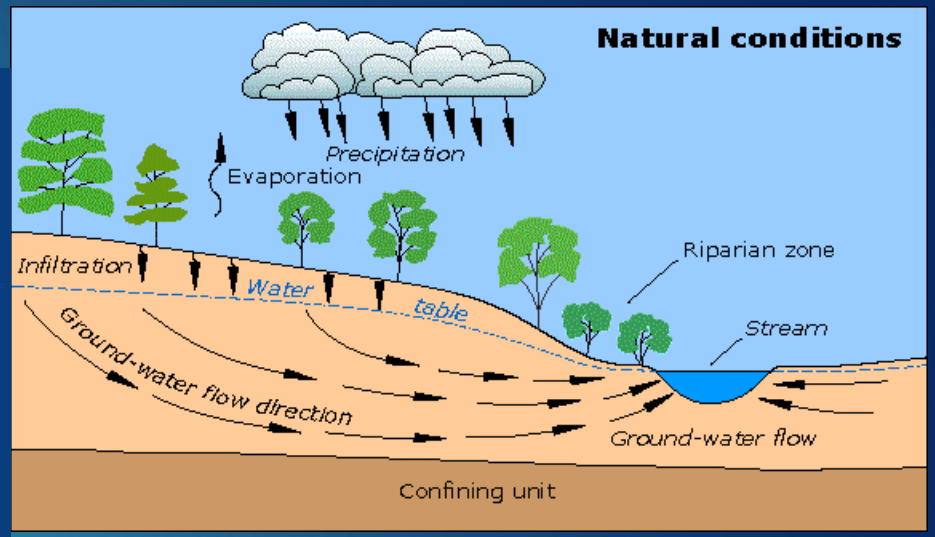
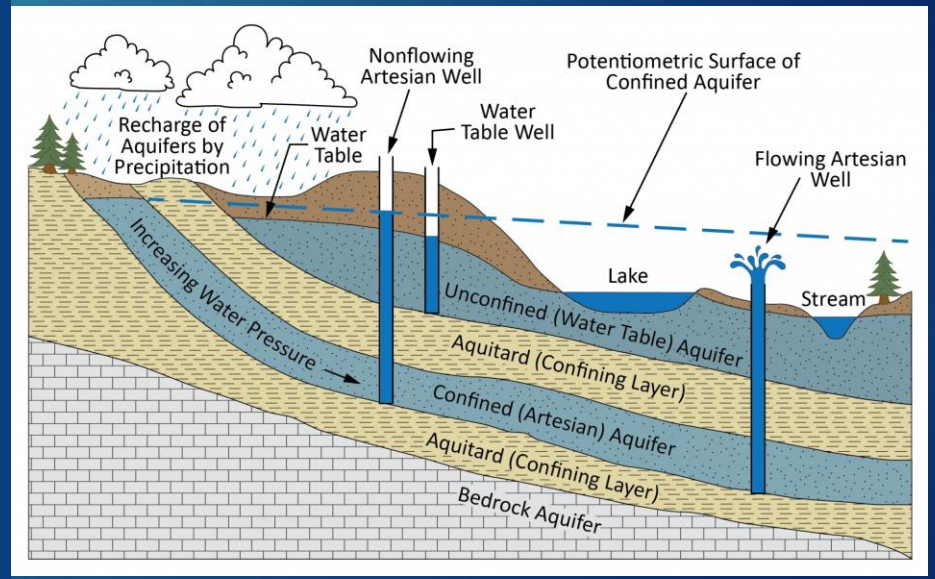


Reactive surfaces / microbes

The geology of a groundwater system will impact the quality of water withdrawn from that system based on the geochemistry (rock chemistry) of the rocks and sediments through which the water flows.

In addition, groundwater (particularly shallow groundwater) is subject to contamination by bacteria, viruses and other microbes common entering with recharge or through leaky storage systems.





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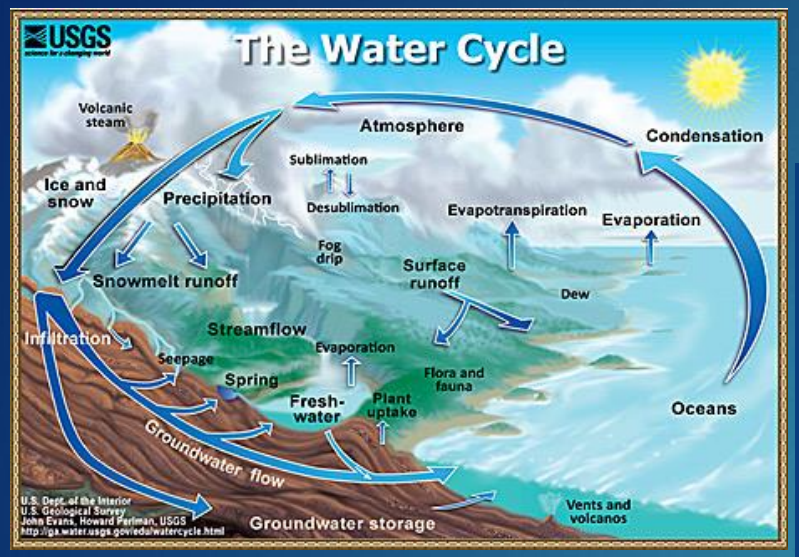

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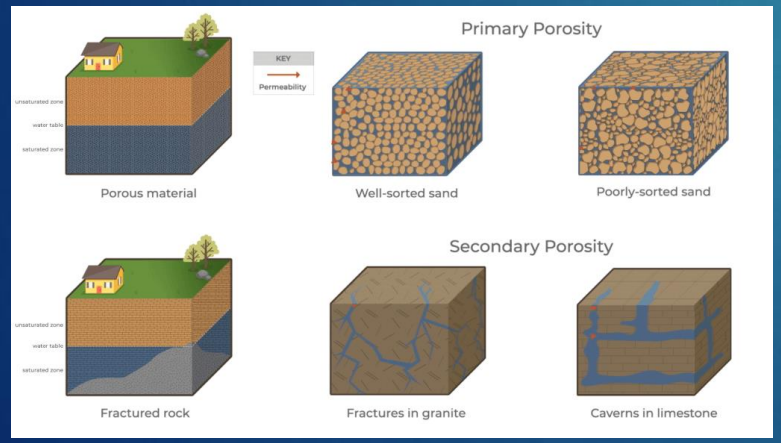


Water in Pores / Fractures

Aquifers / confining layers

Velocity

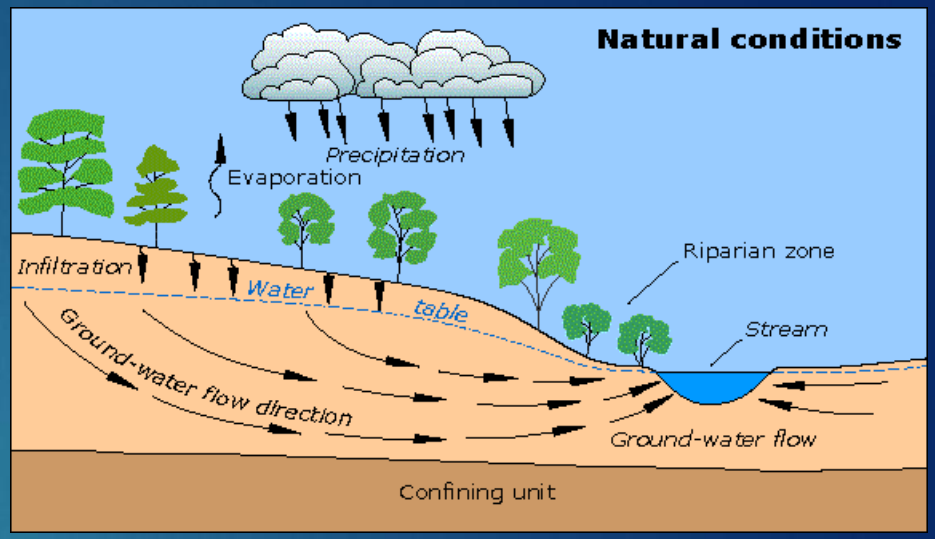
Recharge vs Production

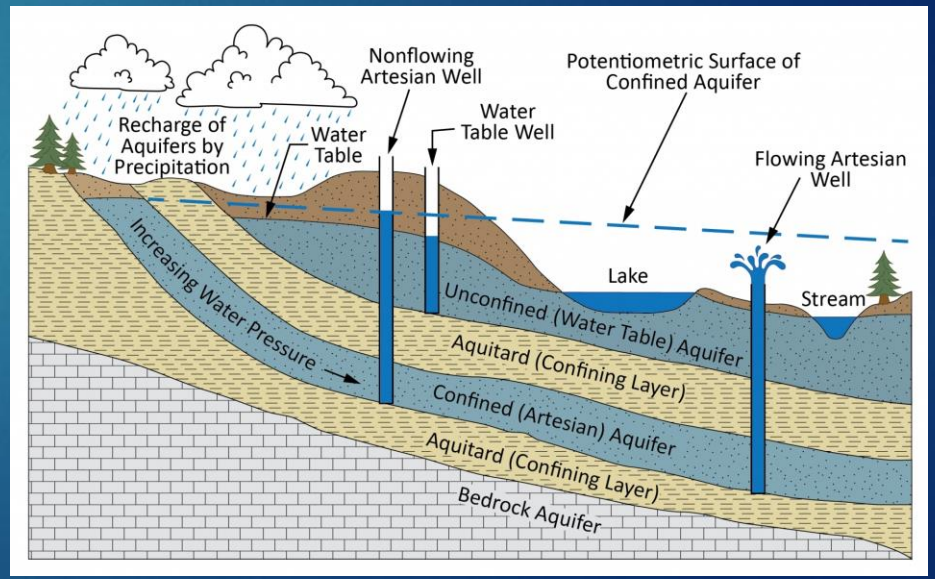
Important Concepts:

- Storage

- Permeability

Reactive Surfaces

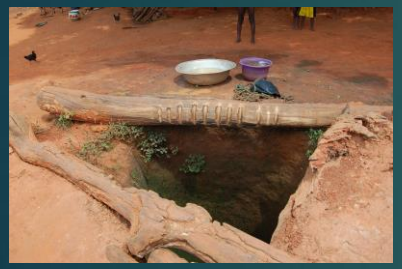




Water Supply – Science to Engineering Solutions

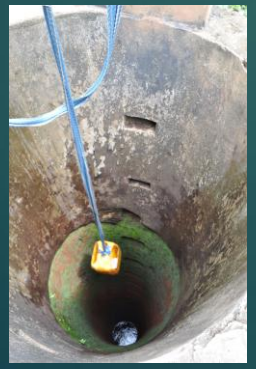






IUSP - Science / technology has changed water collection from by hand, to manual pumps, to motorized pump systems.




https://www.usgs.gov/special-topics/water-science-school/science/groundwater-wells

Necessary Quantity

Rural Water Supply

Necessary Quality

SDGs → 6, 3, 2, 11

STI-E has dramatically impacted water resources (and the associated IMR) in many rural regions of Africa – here is a look at examples from West Africa.

Rural Water Supply

Necessary Quantity

SDGs → 6, 3, 2, 11

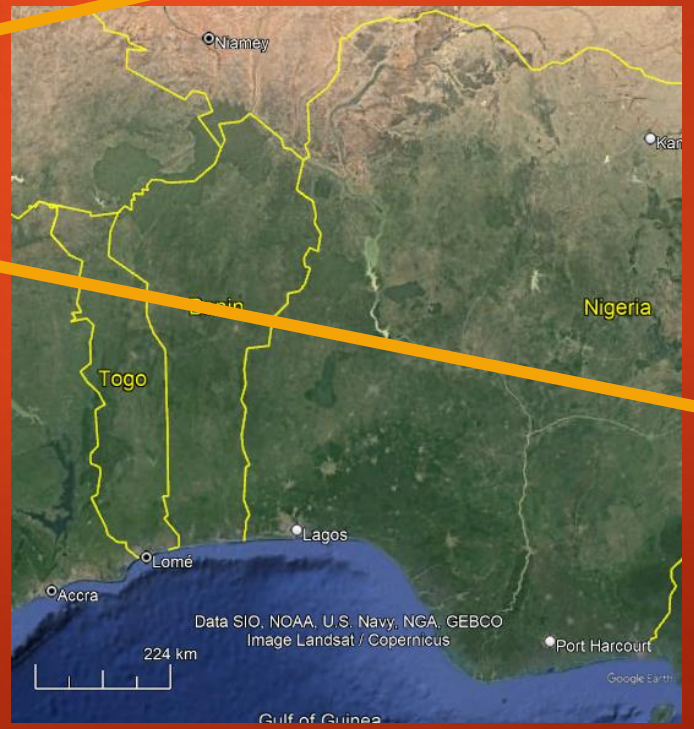
- Nigeria study: prior to using science

  Traditional Methods

  Success Rate: 35%

- Use the science
  - Improved satellite images
  - Geophysics methods (innovations involve electricity, density, radar)

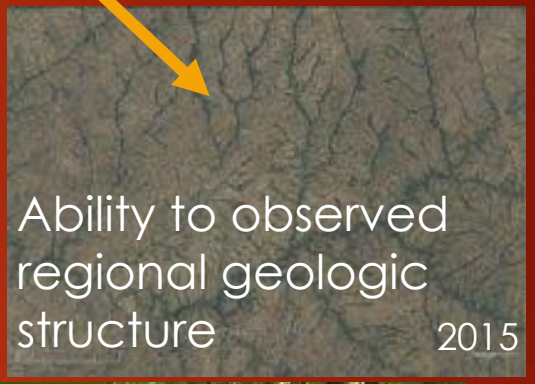
- **Increased to 92% success rate**



Determination of potential groundwater sites using geological and geophysical techniques in the Cross River State, southeastern Nigeria, OKEREKE, E. 0. ESU and A. E. EDET , Journal of African Earth Sciences. Vol. 27, No. 1, pp. 149-163, 1996

Necessary Quality

IUSP



Rural Water Supply

SDGs → 6, 3, 2, 11

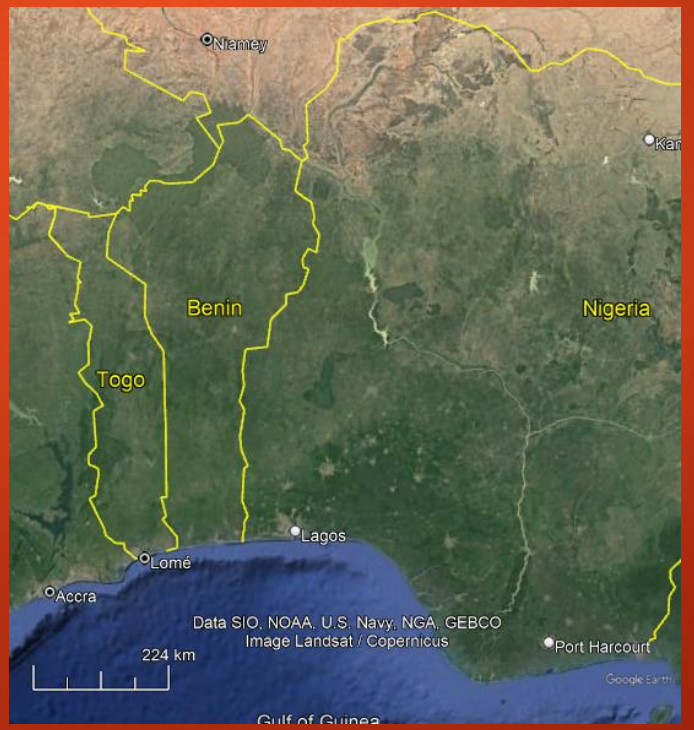
Necessary Quantity

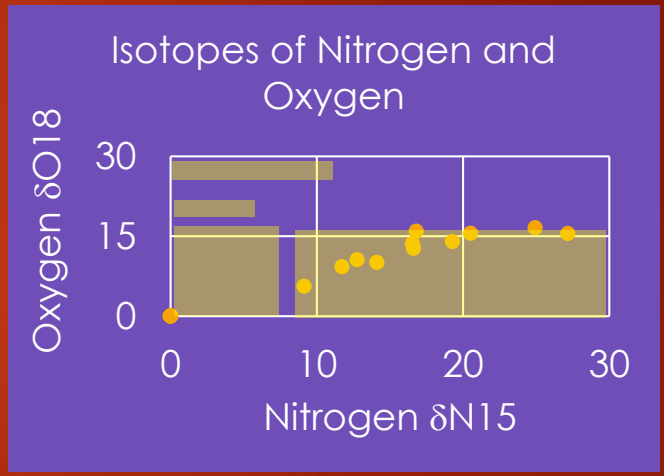
Necessary Quality

Use Science, Technology to:

- Investigate
- Understand
- Study Environmental Challenges

IUSP





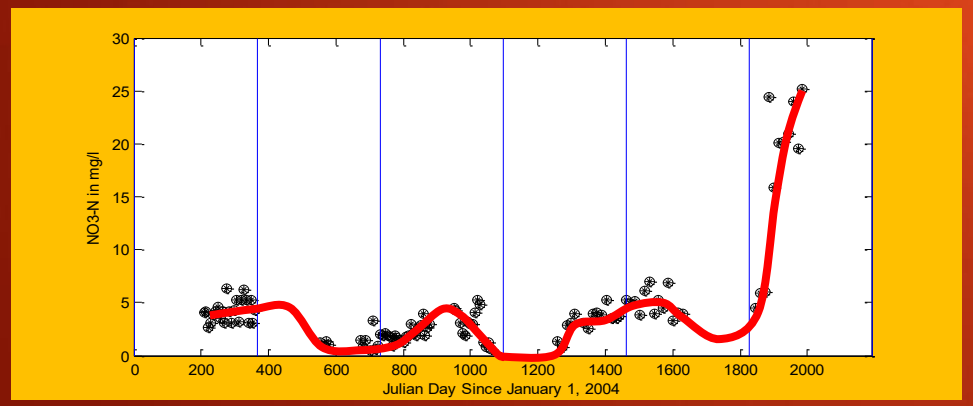
Silliman, S.E., M. Boukari, P. Crane, F. Azonsi, and C.R. Neal, "Observations on Element Concentrations of Groundwater in Central Benin", Journal of Hydrology, 335(3-4), 374-388, 2007 (dx.doi.org/10.1016/j.jhydrol.2006.12.005).

Rural Water Supply

SDGs → 6, 3, 2, 11

Necessary Quantity

Reduction in gastrointestinal disease among children in village



IUSP

Necessary Quality

Use Science, Technology to:

- Investigate
- Understand
- Study Environmental Challenges

Use Innovation and Engineering to:

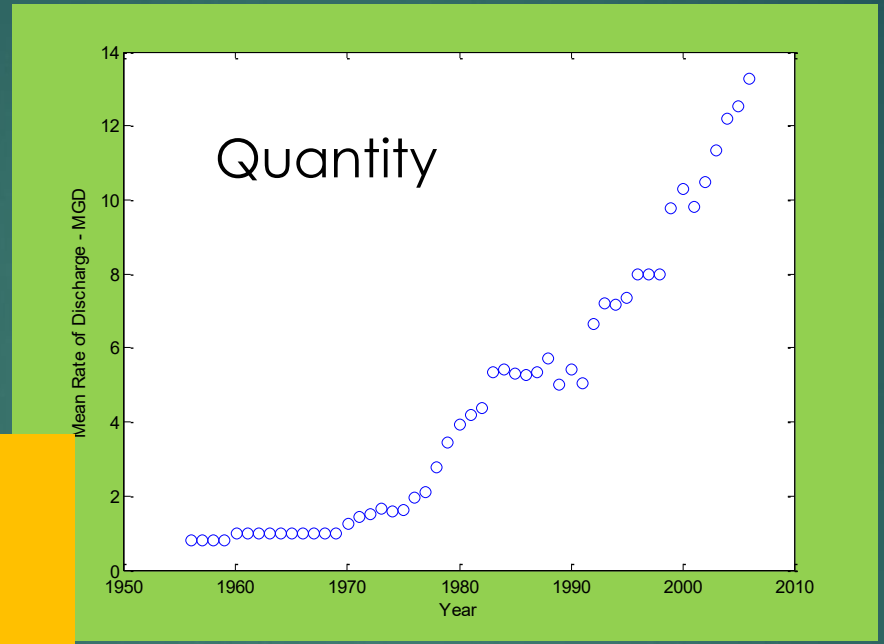
- Propose innovative designs / solutions
- Such as community-based science to monitor water quality

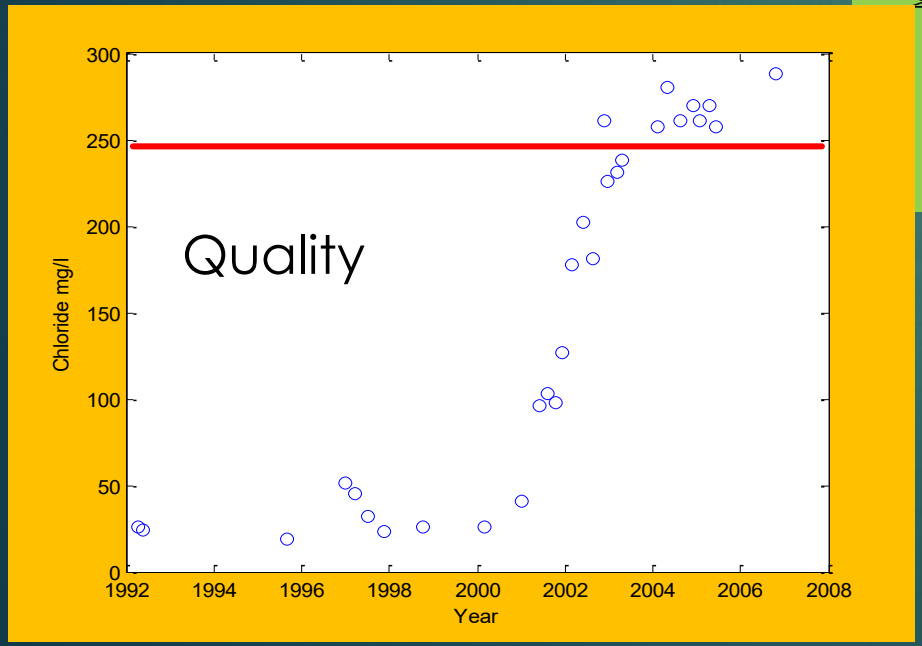
Community Water Supply: Sustainability

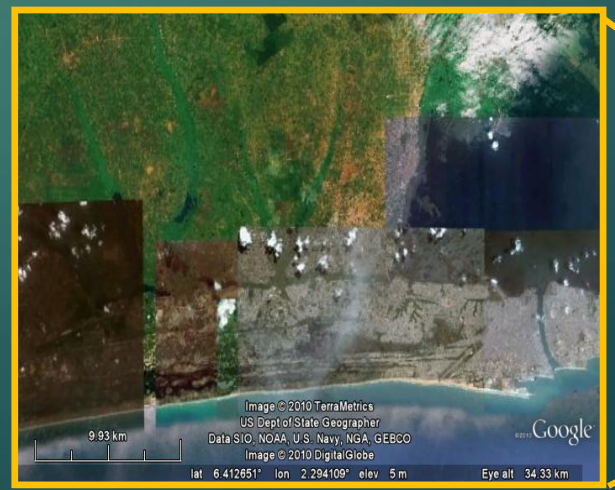
SDGs → 6, 3,11 (7, 9)

Cotonou, Benin and environs

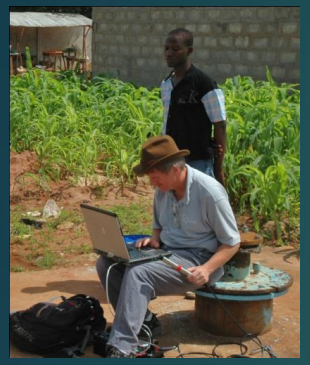
IUSP – Start with investigating what has happened historically. Here, collect data on magnitude of pumping and quality of water in wells.

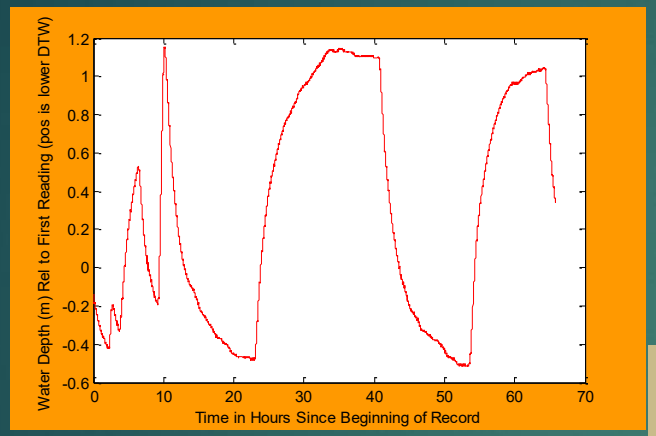


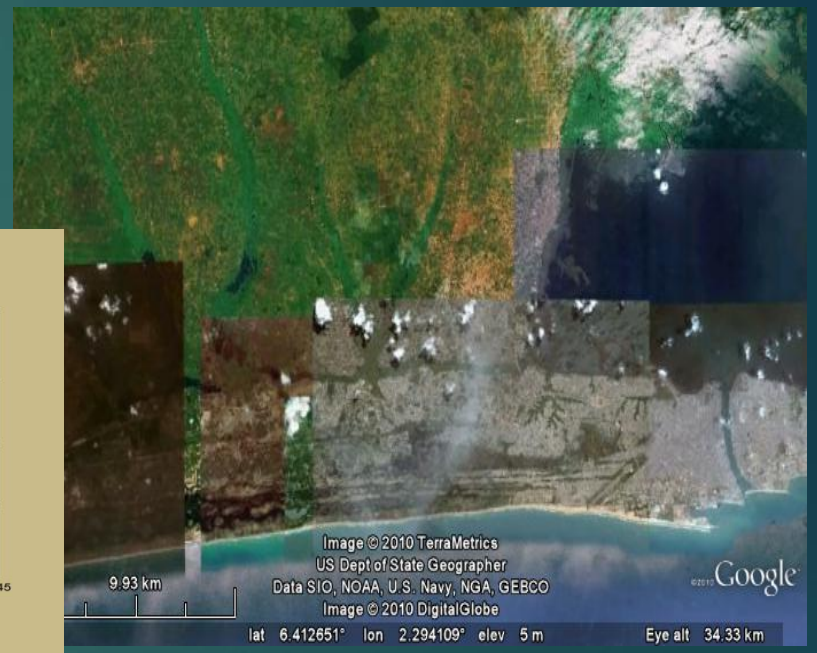


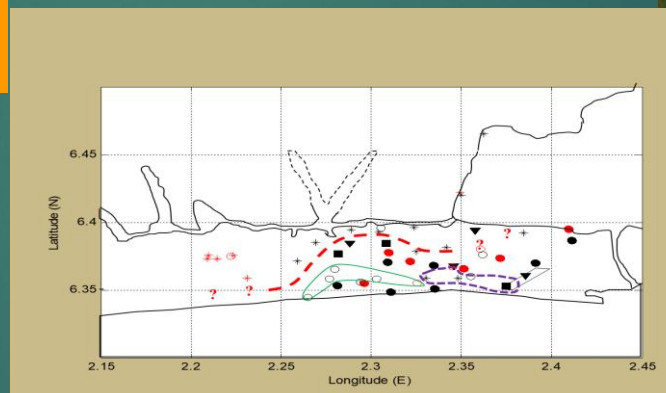


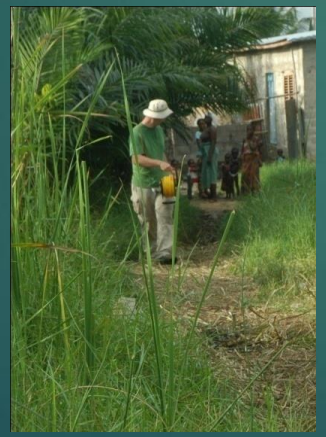
Community Water Supply – Integrate the Science

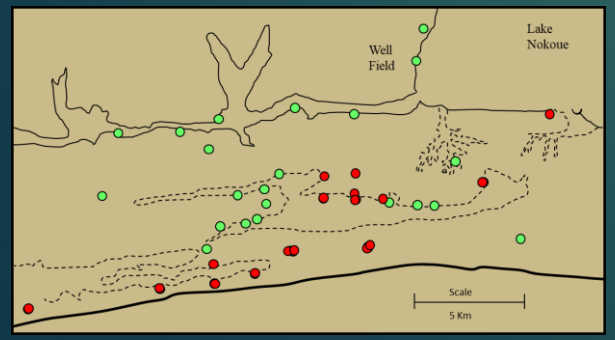


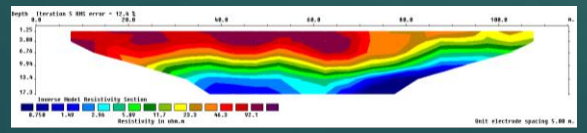










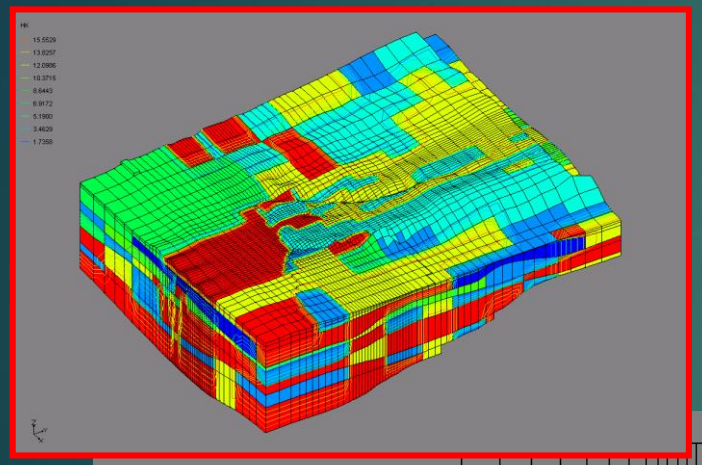


IUSP – Use science, technology and engineering to develop understanding of system of concern and study possible system behaviors under different scenarios. Here use sampling, electronics, geophysics to study.

Community Water Supply: Predict Impact of Management

Science / mathematics allows prediction of future behavior and uncertainty:

- Pumping strategy / Locations
- Changing water use
- Potential threats
- Partnerships to achieve sustainability



IUSP

Contribute to SDGs:

6 (water)
11 (sust community)
17 (partnerships)

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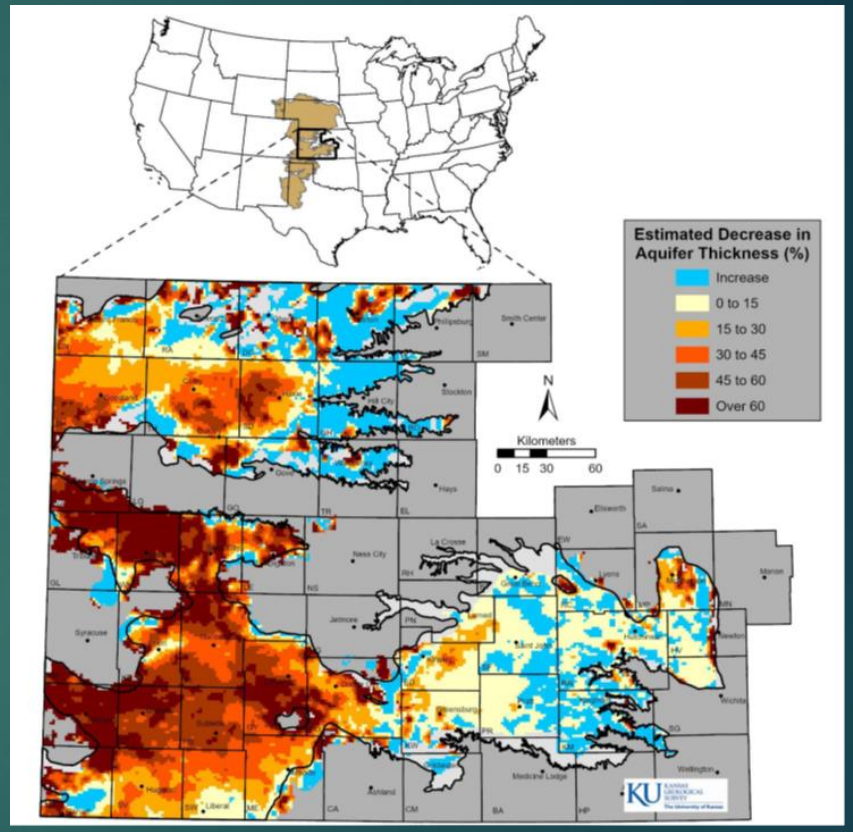
8 (work & econ growth)
9 (indus, innov, partners)

Same Strategy as Used for Planning in USA / Europe

- Multistate Aquifer system
- Heavily pumped in support of ag
- Water levels declining
- Monitoring (data) + theory + math
- Prediction of future conditions
- Prediction of use alternatives



Rex C. Buchanan, B. Brownie Wilson, and James J. Butler, Jr., "The High Plains Aquifer," *Kansas Geological Survey Public Information Circular* 18 (2023) 6 pp.
James J. Butler, Jr., "Groundwater depletion: A global challenge for intergenerational equity," *Interpretation,* Submitted, 2023

Quick Summary and Request for Questions

Science, Technology, Innovation and Engineering

Together form Critical Contributors through IUSP

Motivating Efforts to Meet the SDGs in the realm of groundwater.

Just this April! ***An integrated approach for aquifer characterization and evaluation in a complex geologic terrain (Cross River State, Nigeria): A contribution to support sustainable development and management of groundwater, Journal of African Earth Sciences***