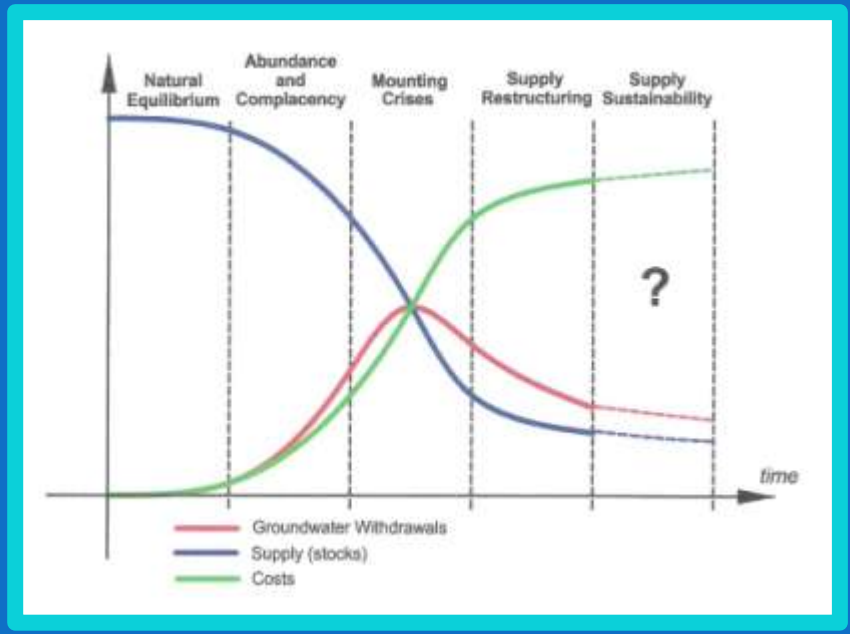
The Lifetime Stages of an Artesian Groundwater System

A Conceptual Model for Water Supply Planning



STATEMENT OF PURPOSE

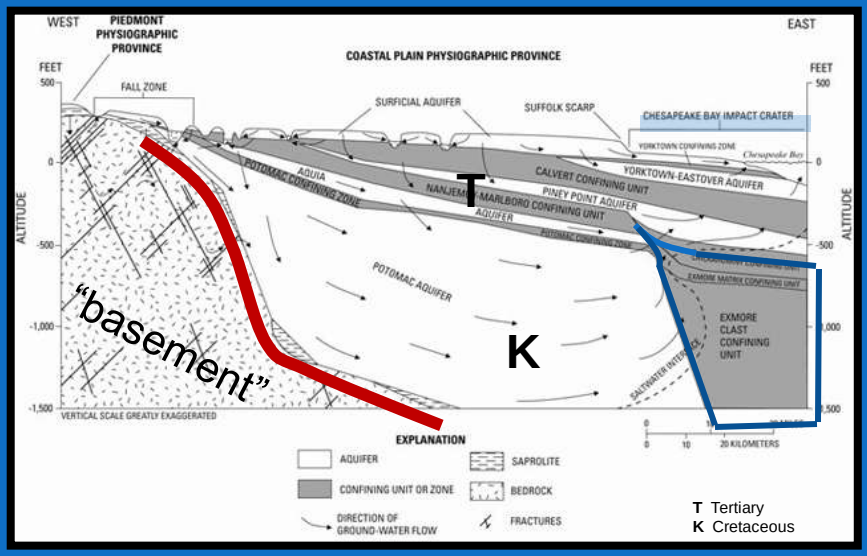
1) This presentation describes a conceptual model of the lifetime behavior of an artesian groundwater supply from conditions of natural equilibrium through overdraft to sustainable supply and

2) demonstrates how this model can aid water supply planning and management.

The Groundwater Supply of the Virginia Coastal Plain

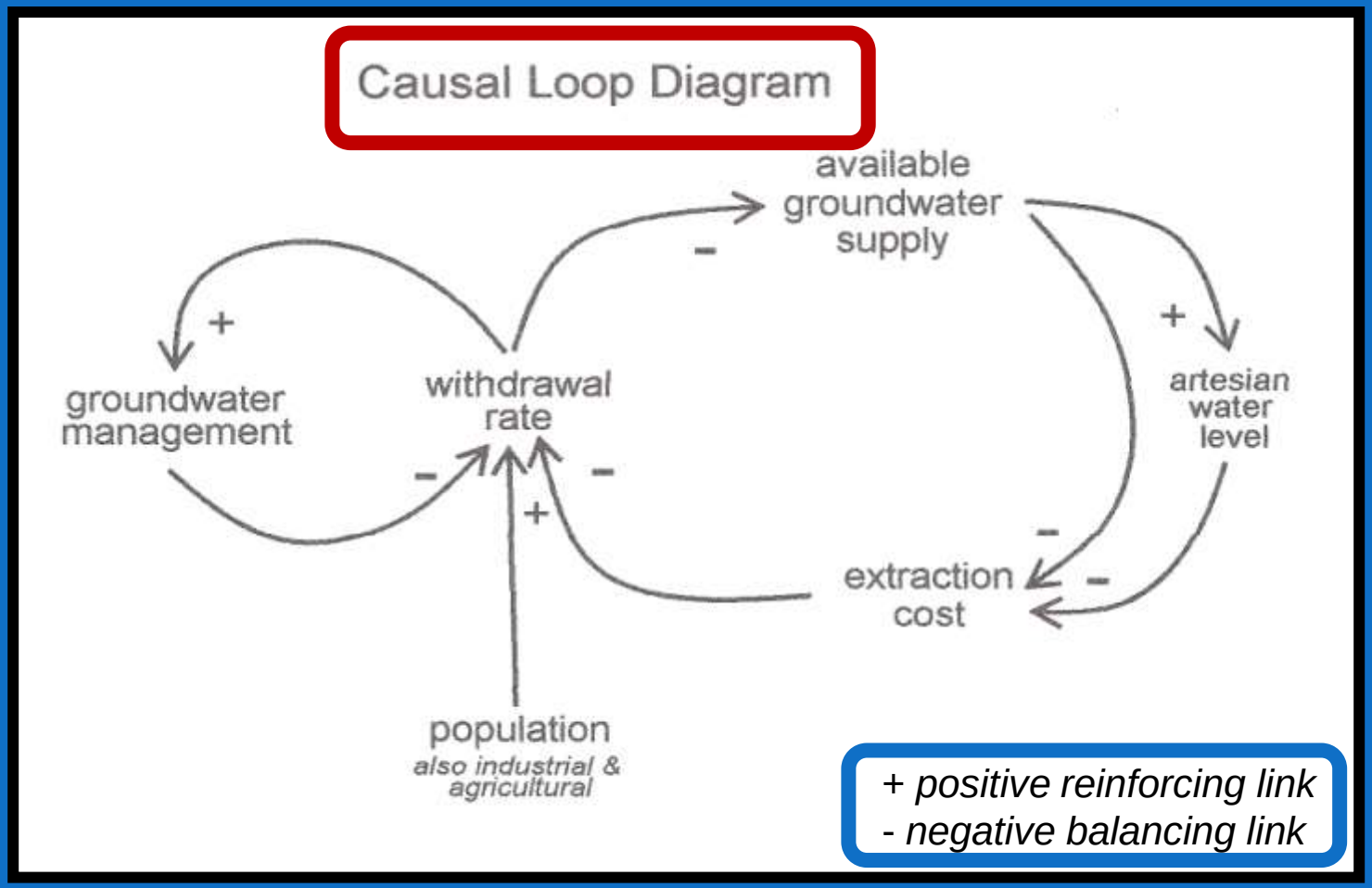
Landsat imagery courtesy of Goddard Space Flight Center and U.S. Geological Survey

An extensive, eastward thickening, multilayered, leaky aquifer system.

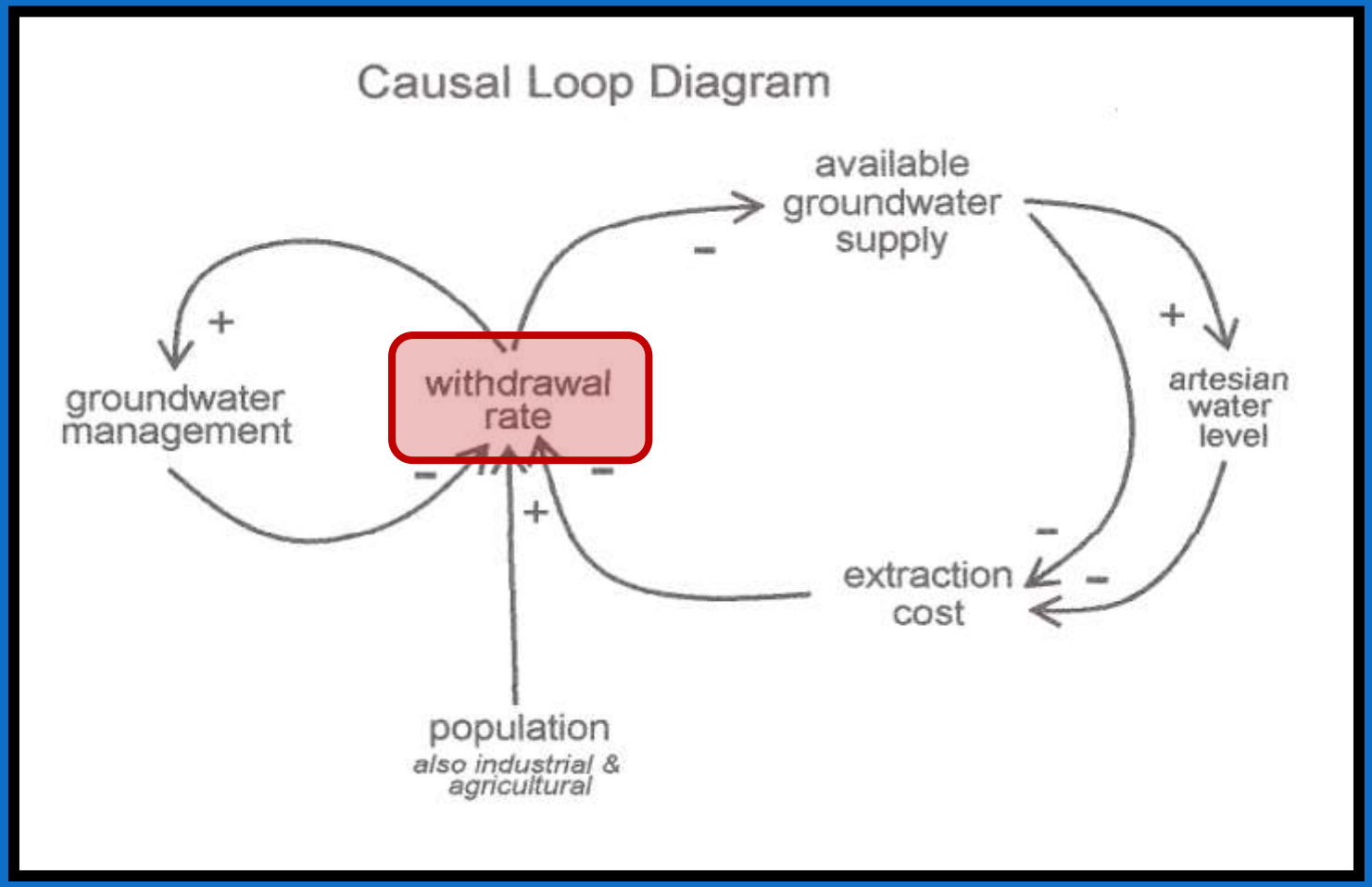


Original source: http://va.water.usgs.gov/projects/va089.html

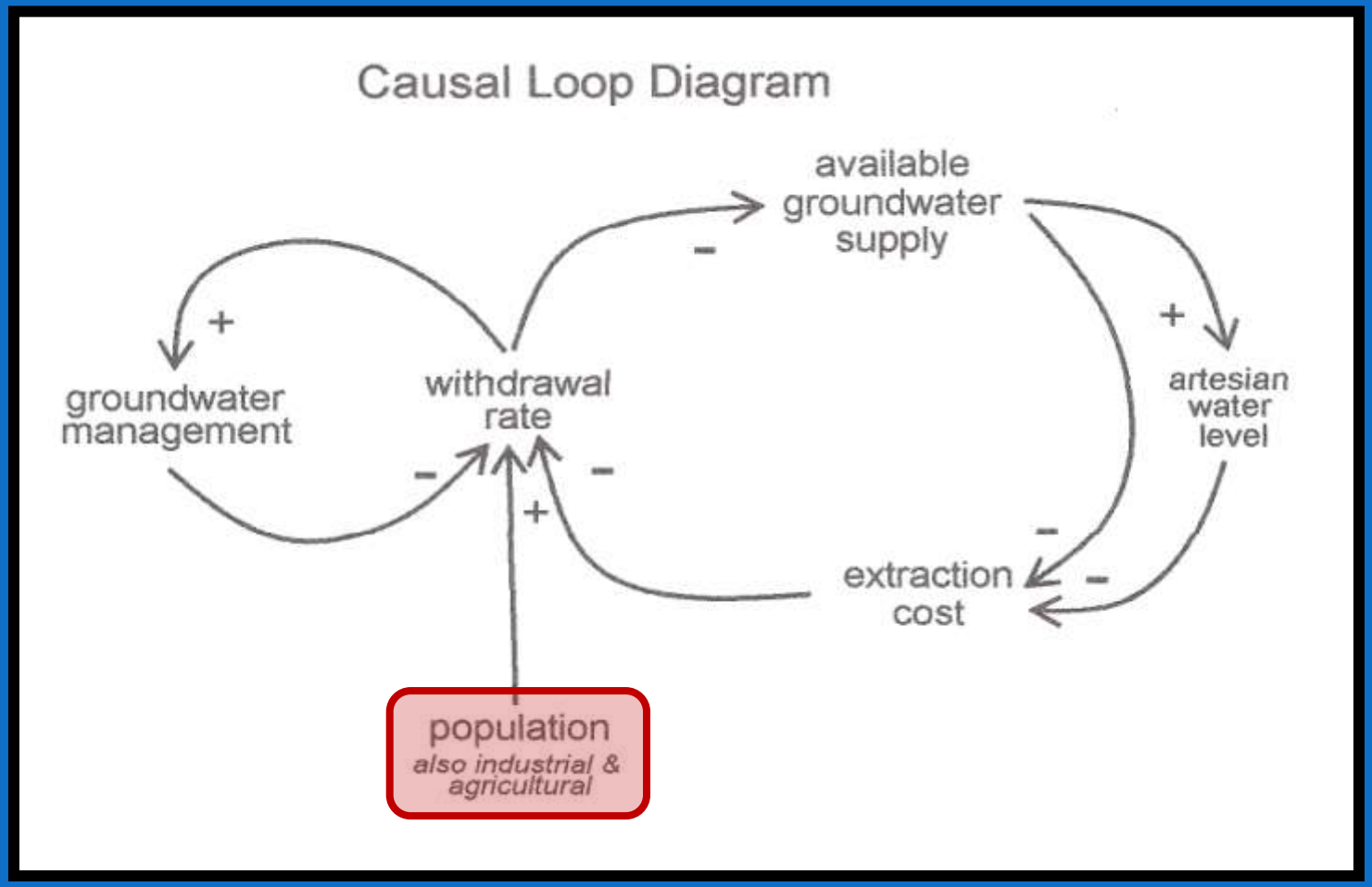
An artesian groundwater supply like that of the Virginia Coastal Plain may be viewed as a system composed of six components interconnected causally.



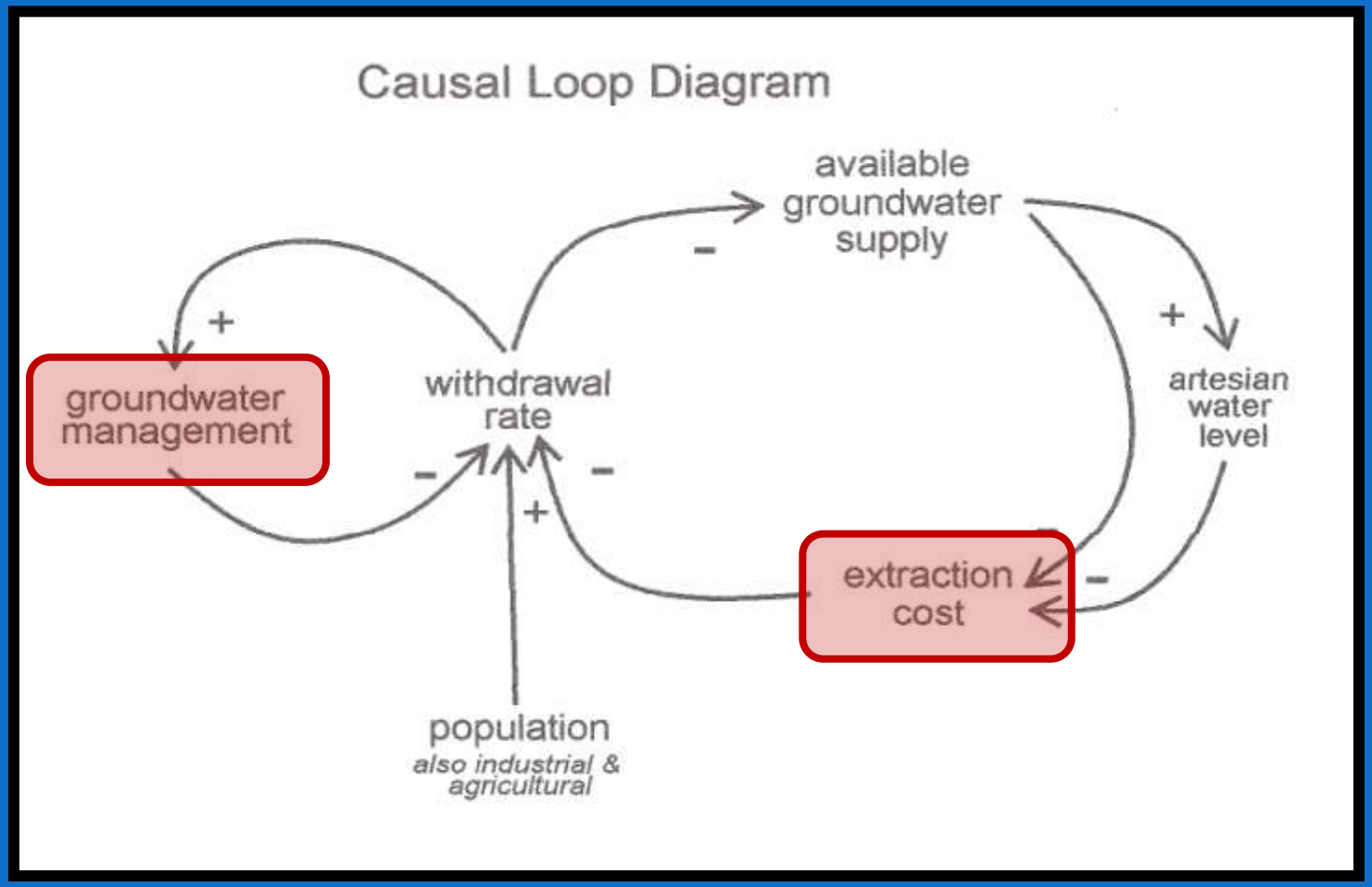
The foremost causal factor influencing the groundwater supply is withdrawal rate.



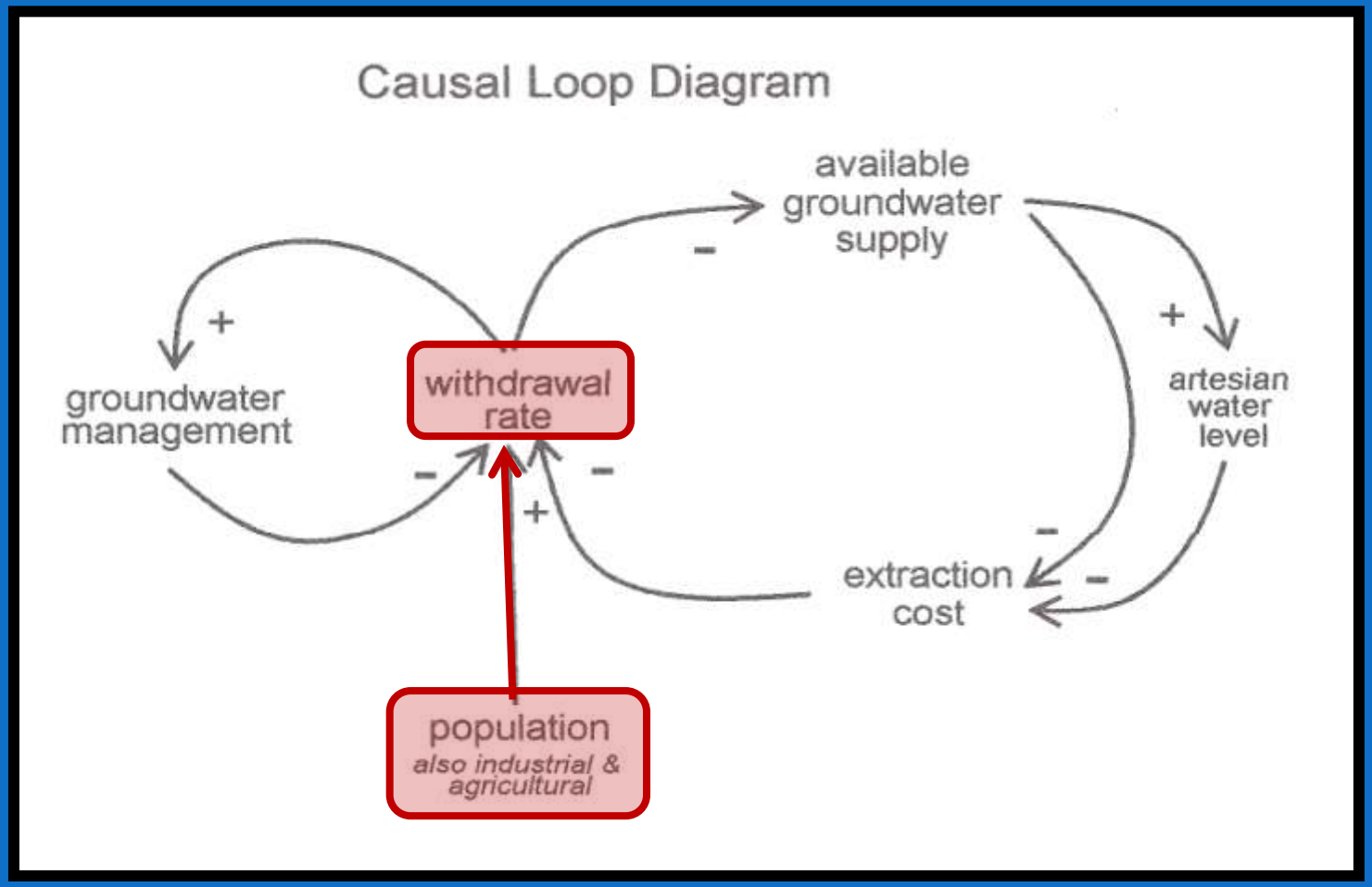
Groundwater withdrawals are driven chiefly by population, industrial water use, and irrigation.



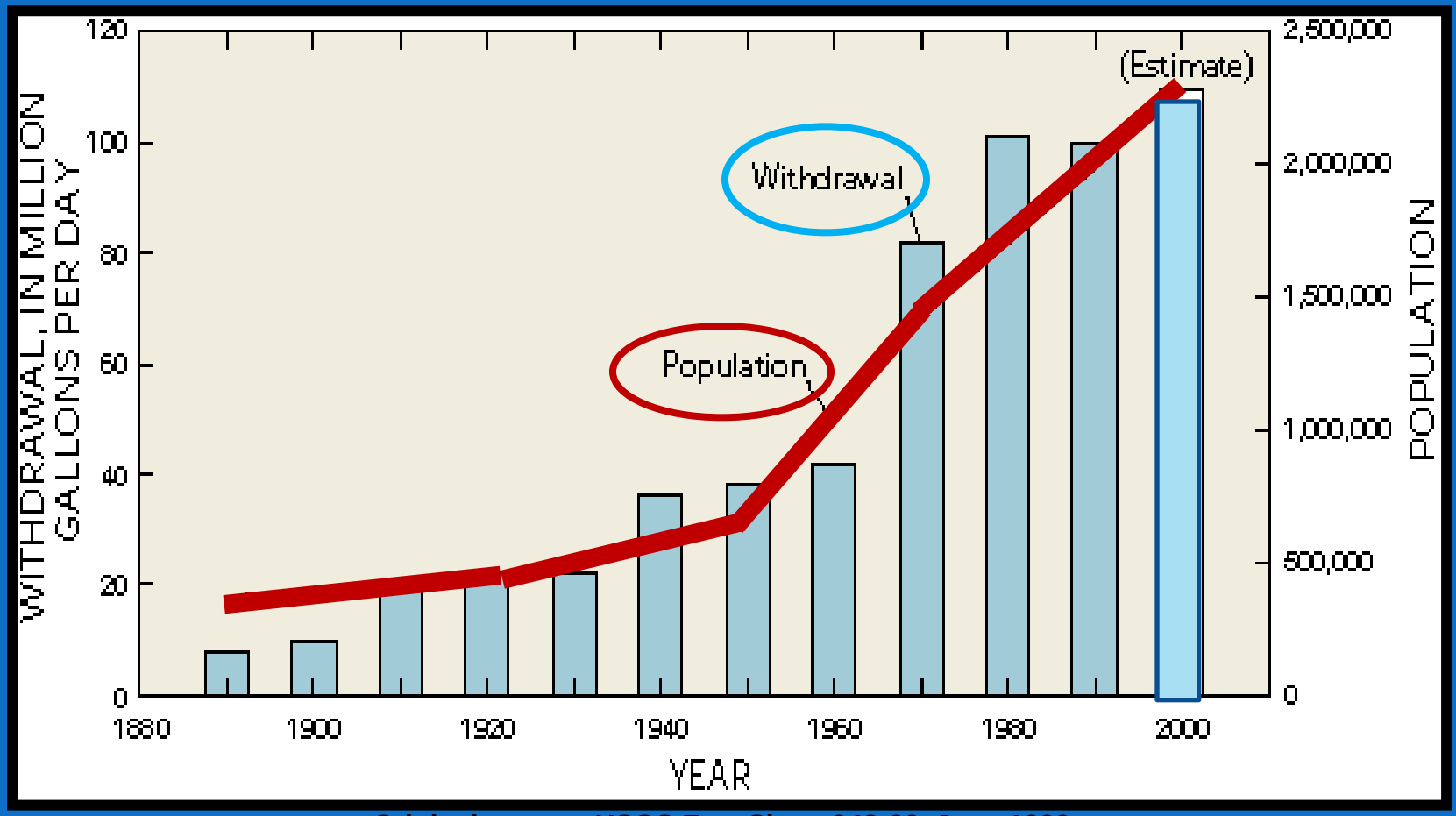
The chief balancing influences on groundwater withdrawals are extraction cost and groundwater management.



A growing population produces a proportional increase in groundwater withdrawals.

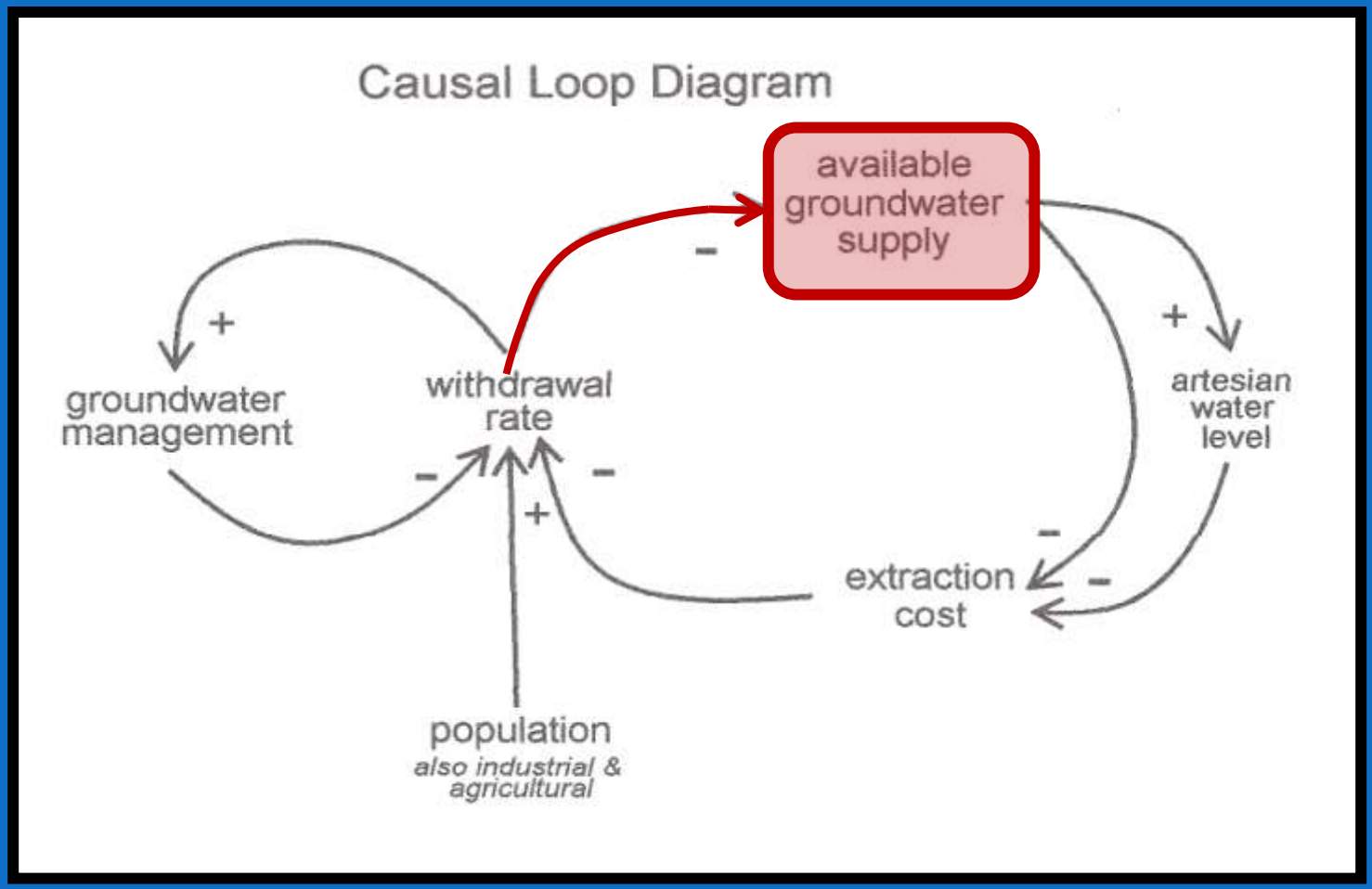


Groundwater withdrawals on the Virginia Coastal Plain have tracked a growing population

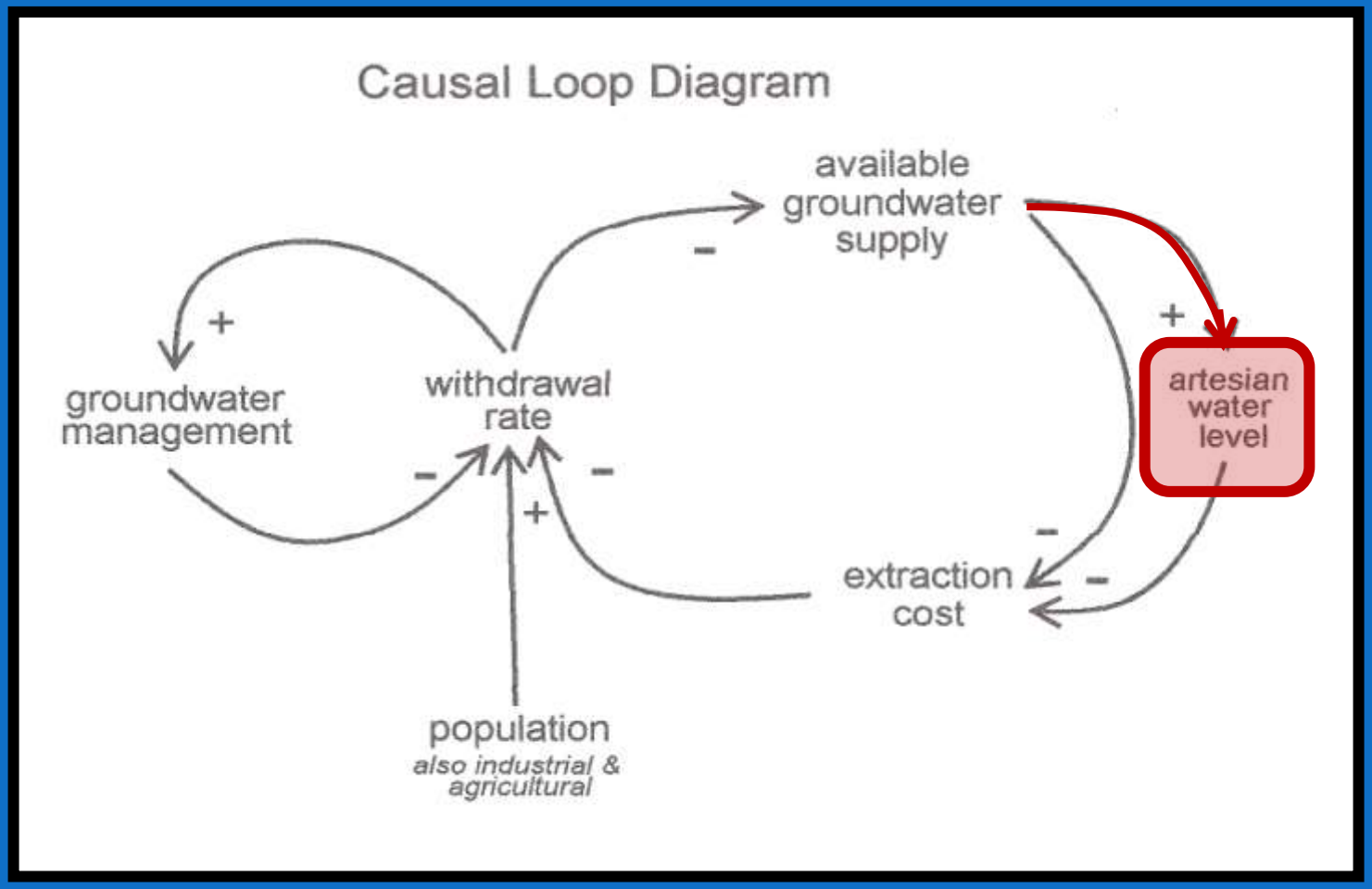


Original source: USGS Fact Sheet 048-99, June 1999

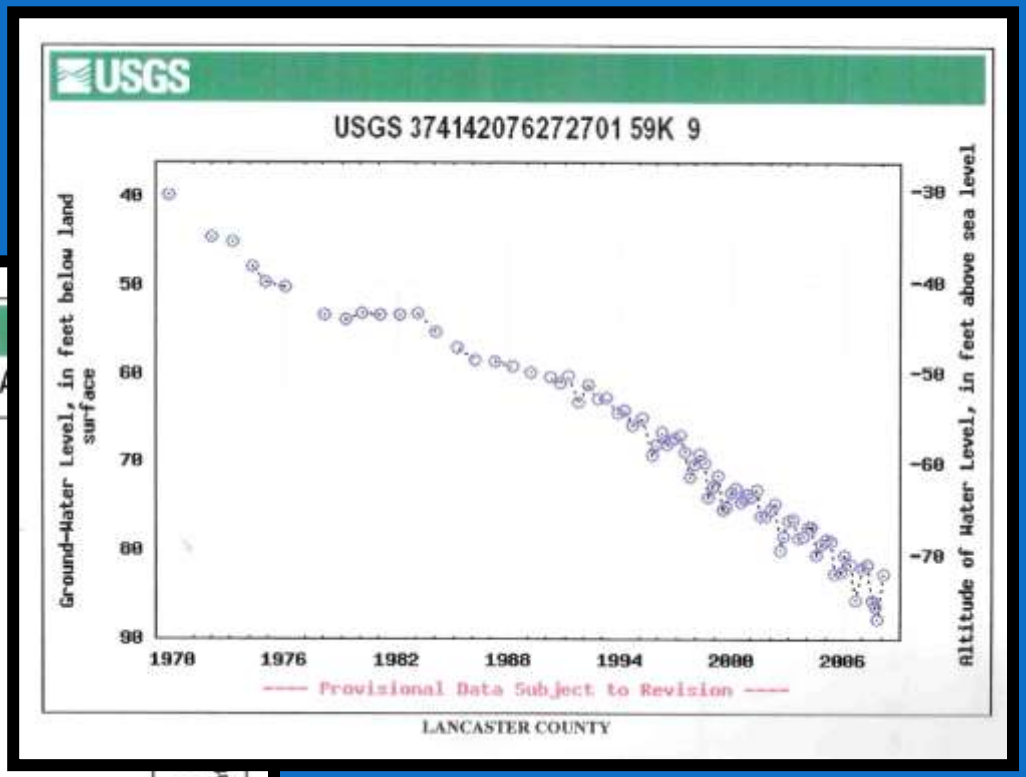
Beyond the natural replenishment rate, increases in groundwater withdrawals result in a proportional loss of available supply.

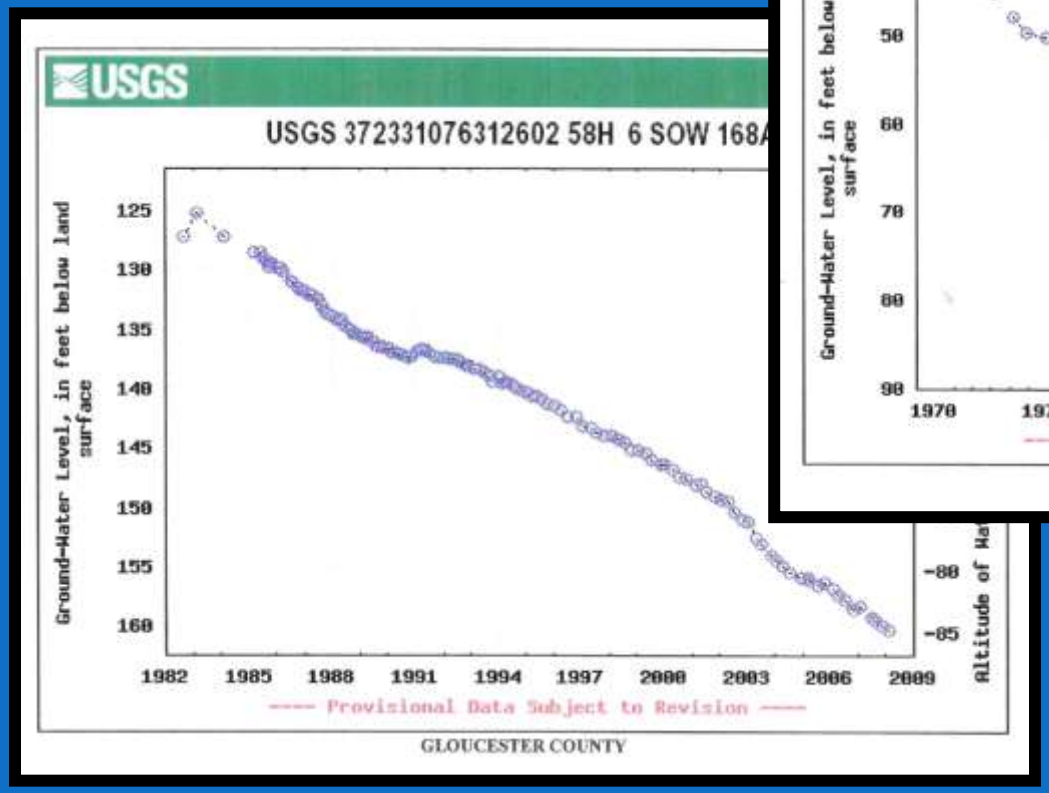


Long-term, persistent, and system-wide decline of artesian water levels is the result of a permanent loss of aquifer storage (available supply).

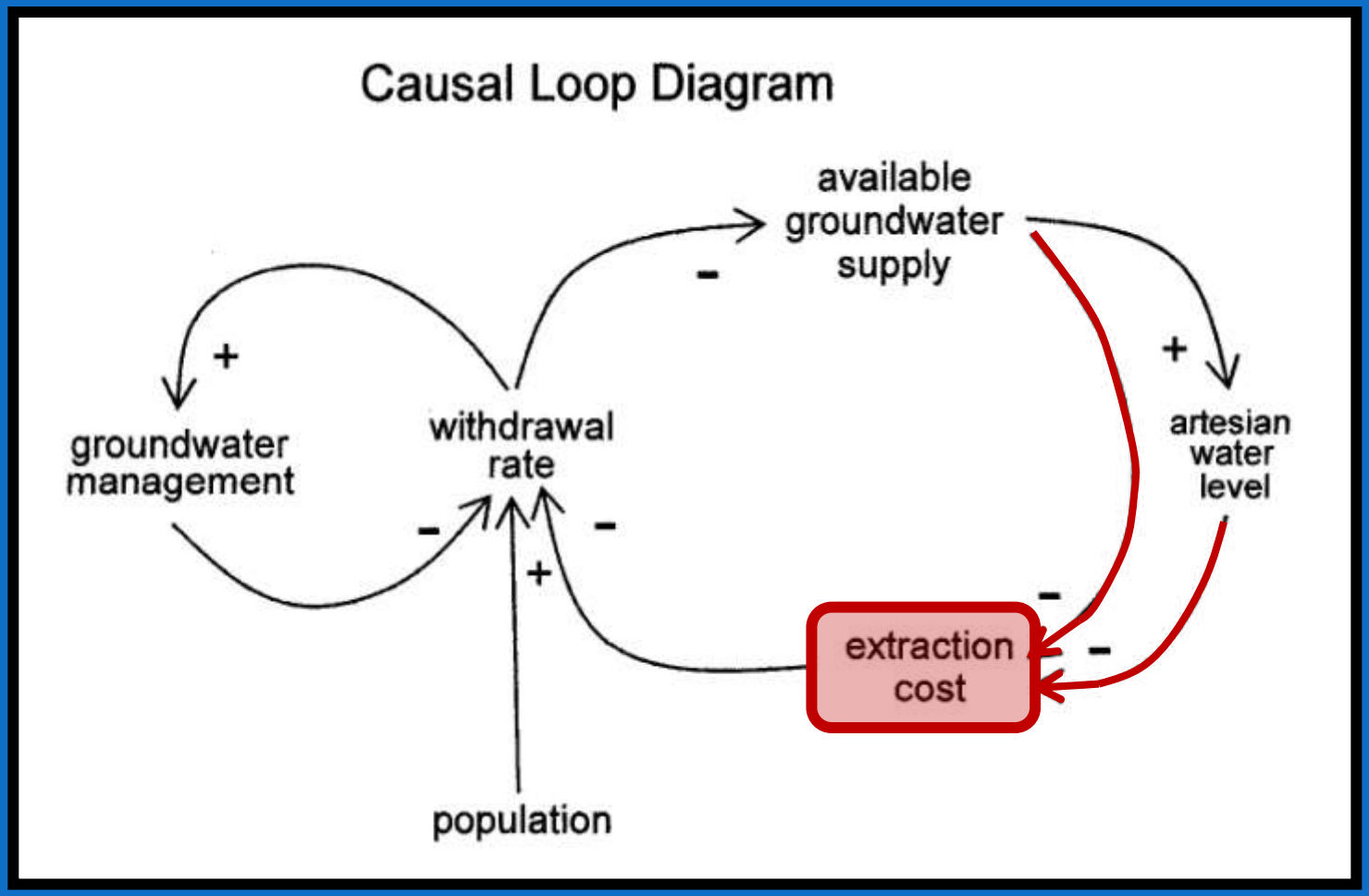


A long-term, persistent, and system-wide decline in artesian water levels of the Virginia Coastal Plain is documented by numerous ground-water hydrographs.





Shrinking groundwater supply and falling artesian water levels result in higher extraction costs.

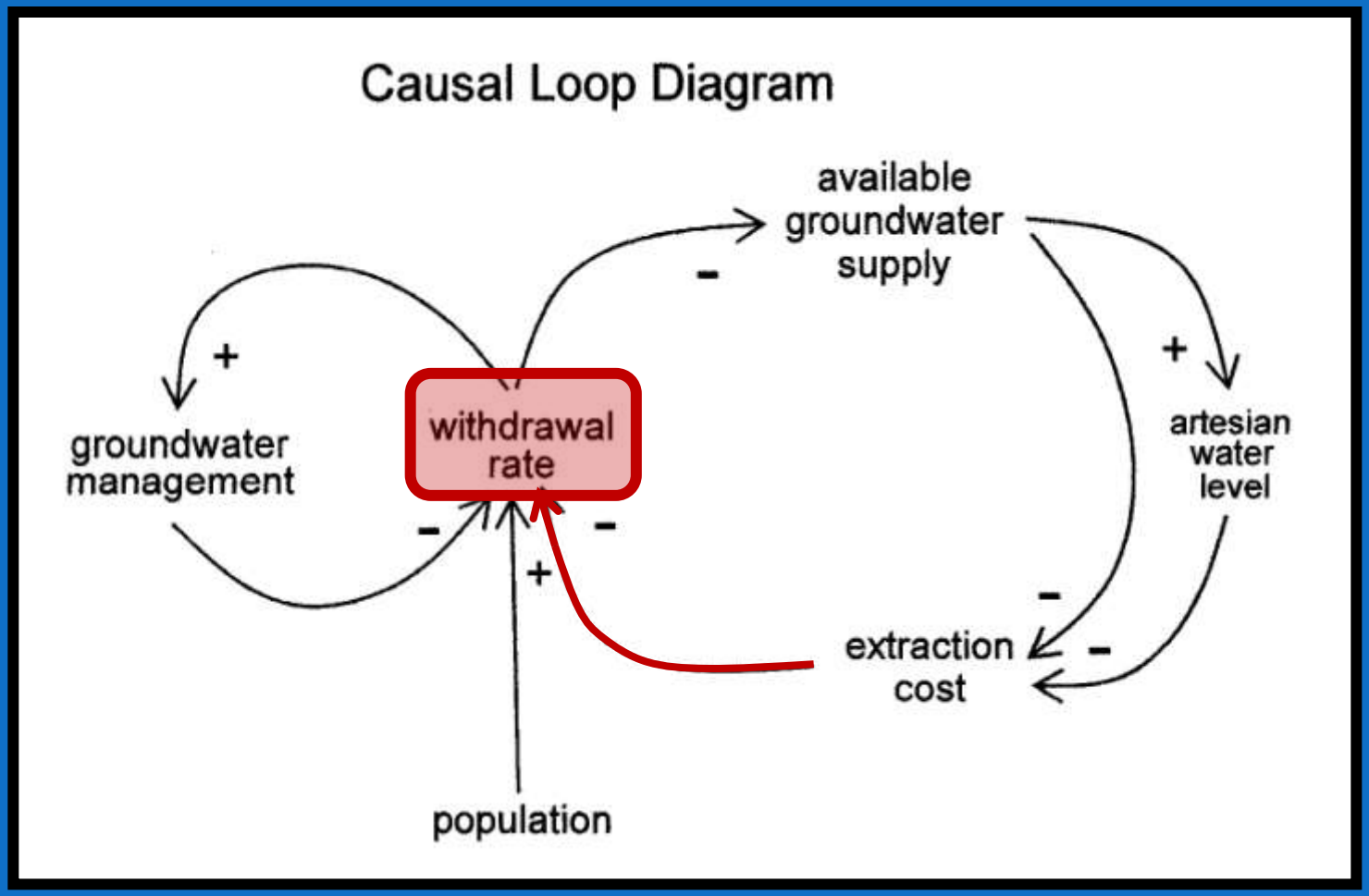


Costs rise because continued groundwater production becomes increasingly difficult, as

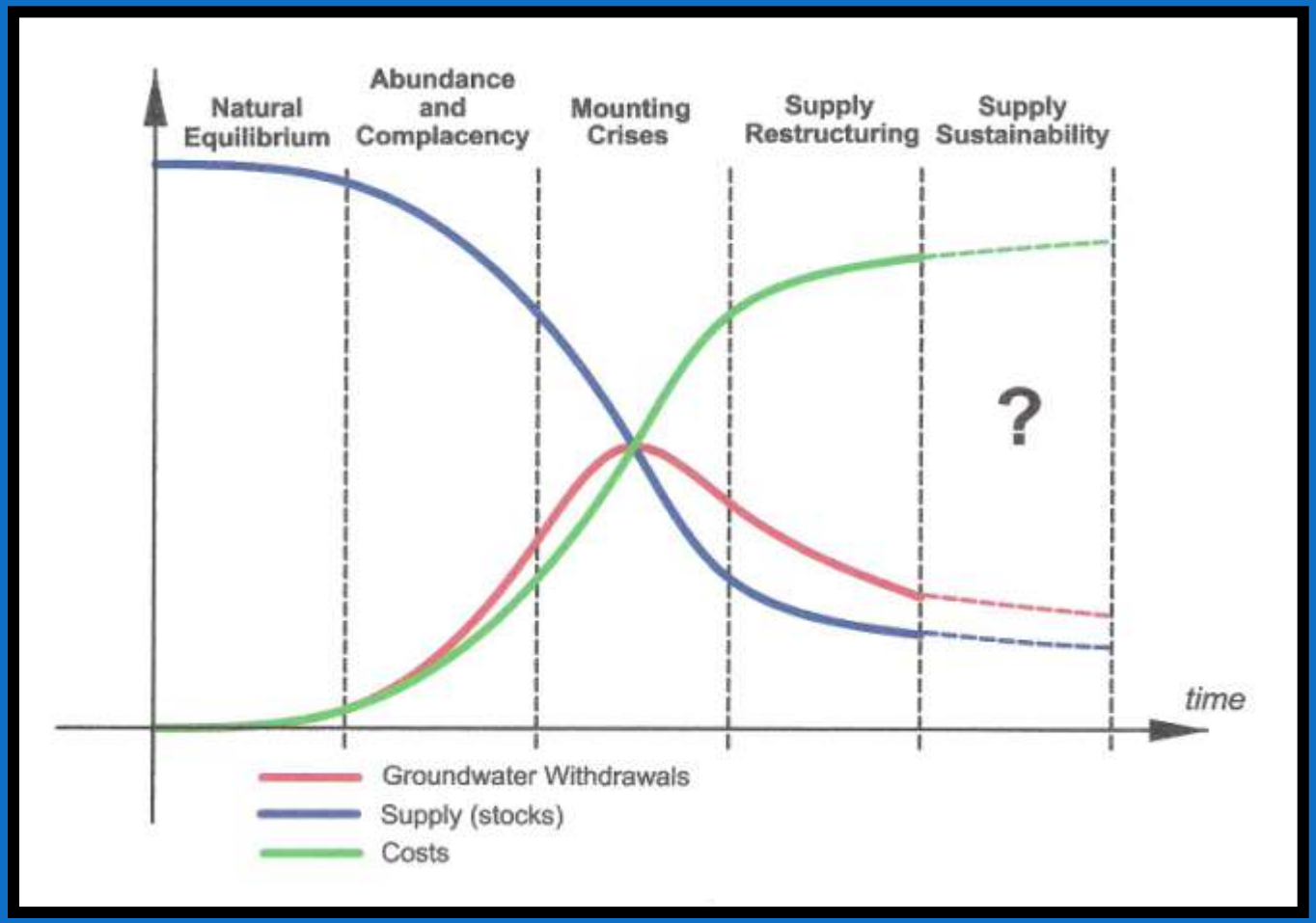
- shallow artesian supplies are depleted,
- deeper aquifers must be tapped,
- poorer quality ground-water must be refined, and
- more regulatory require-ments must be complied with.

Photo courtesy of USGS

Rising extraction costs stimulate conservation and adoption of alternative sources of water supply, which reduce withdrawal rate.

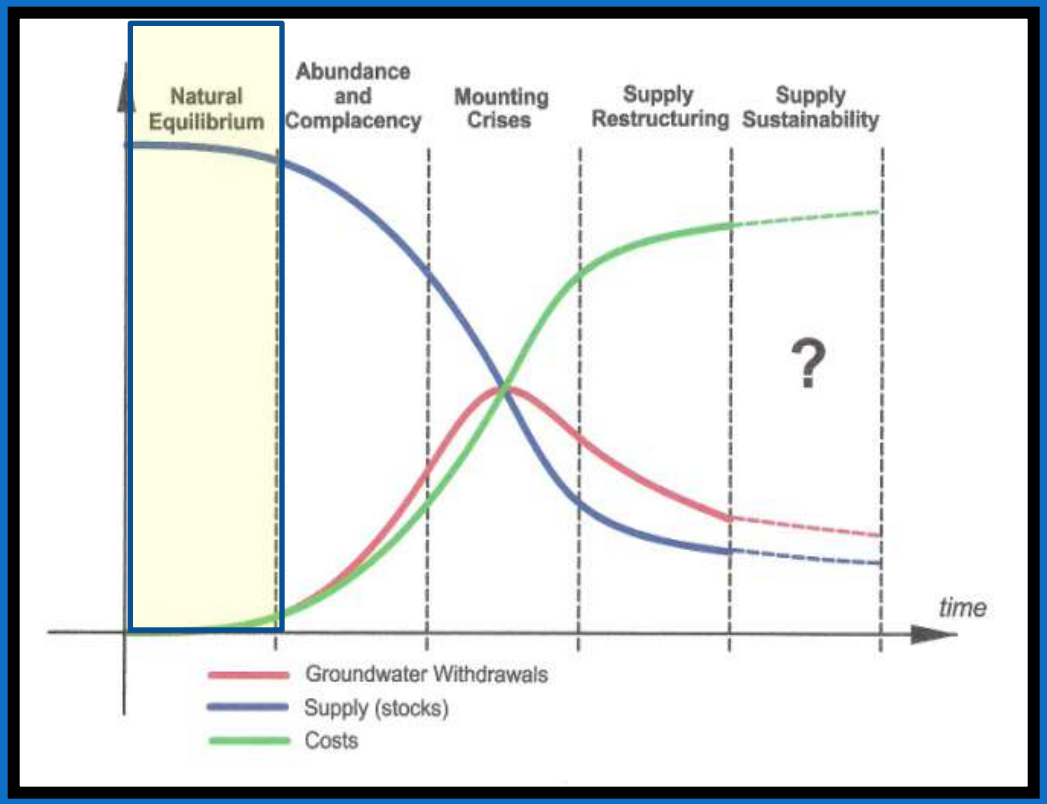


The lifetime of an artesian groundwater supply may be subdivided into five eras.



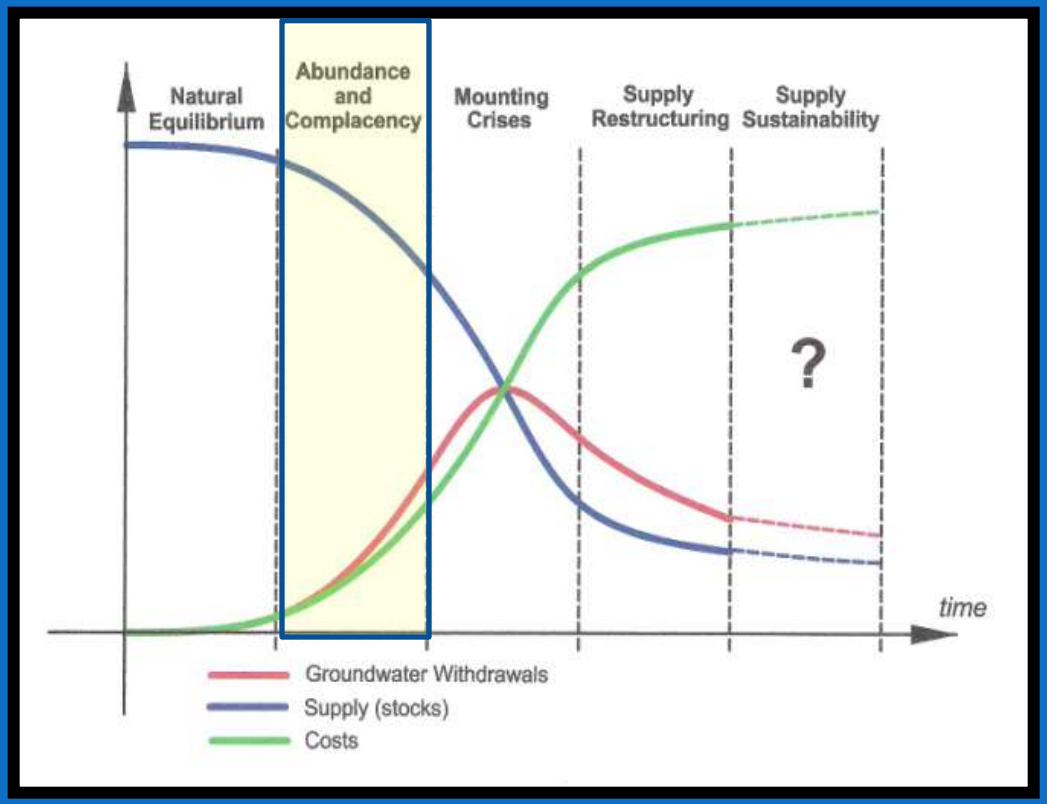
Era of Natural Equilibrium

- **Supply:** Artesian aquifers full
- **Groundwater withdrawals**: Absent or negligible
- **Artesian water levels:** Potentiometric surfaces high & constant
- Recharge equals discharge



Era of Abundance and Complacency

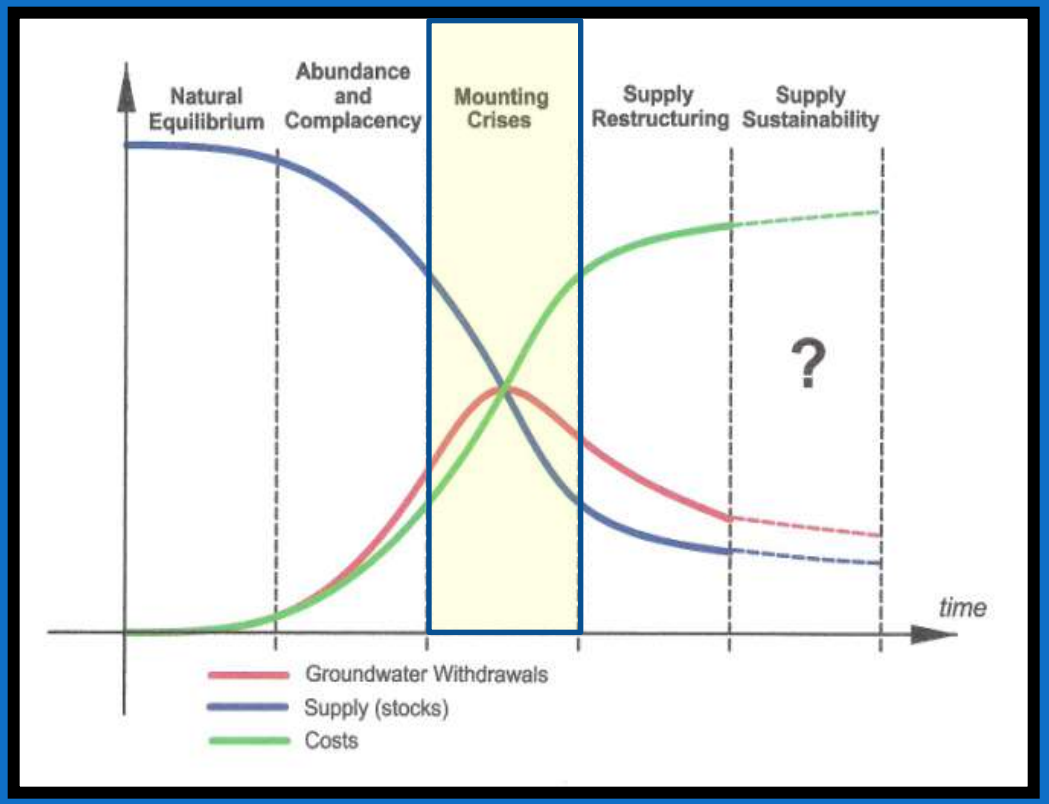
- **Supply**: Abundant
- **Withdrawal rates**: Low but accelerating
- **Artesian water levels**: High but falling slowly and steadily
- **Costs**: Low because the first aquifers to be tapped are the shallowest and least expensive to exploit
- **Comprehensive water supply planning and management**: Absent or rudimentary.



Era of Mounting Crises (1)

- **Supply**: In overdraft and shrinking (D > R)
- **Withdrawal rates**: High
- **Artesian water levels**: Falling persistently and approaching or reaching critical levels

  Well interference and reduction of aquifer transmissivity and storativity accelerate decline of water levels.

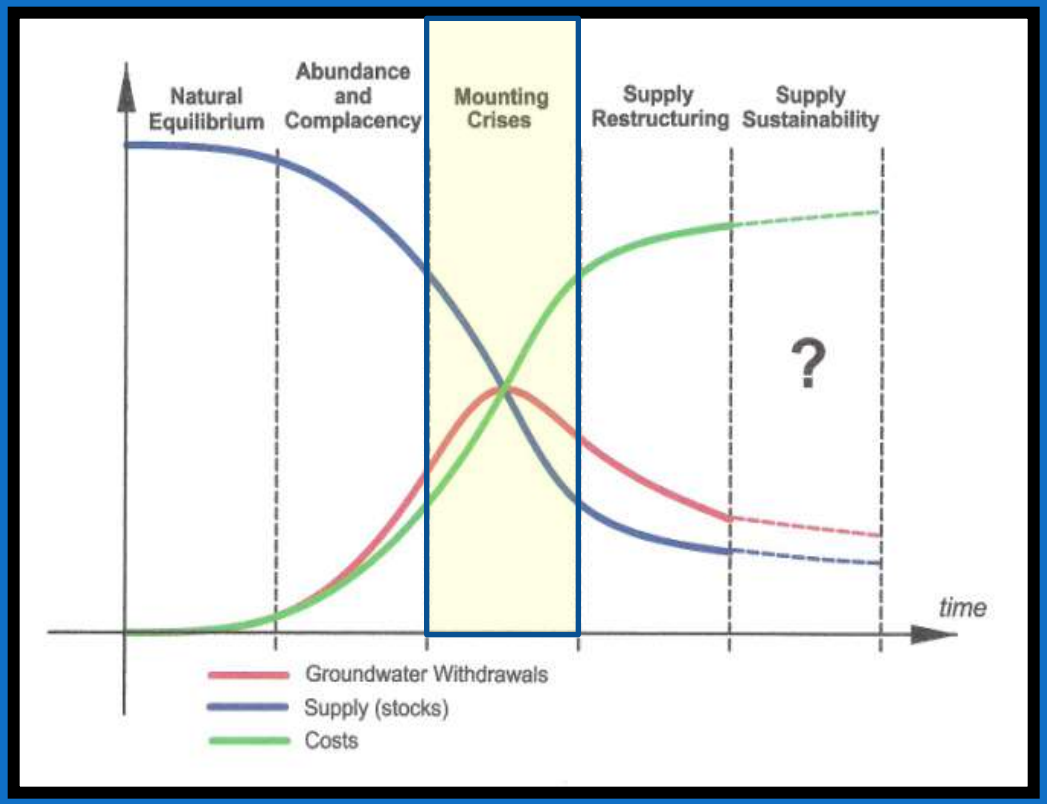


Era of Mounting Crises (2)

- **Costs:** Rising as wells must be drilled (or redrilled) into deeper aquifers and poorer-quality water must be utilized.

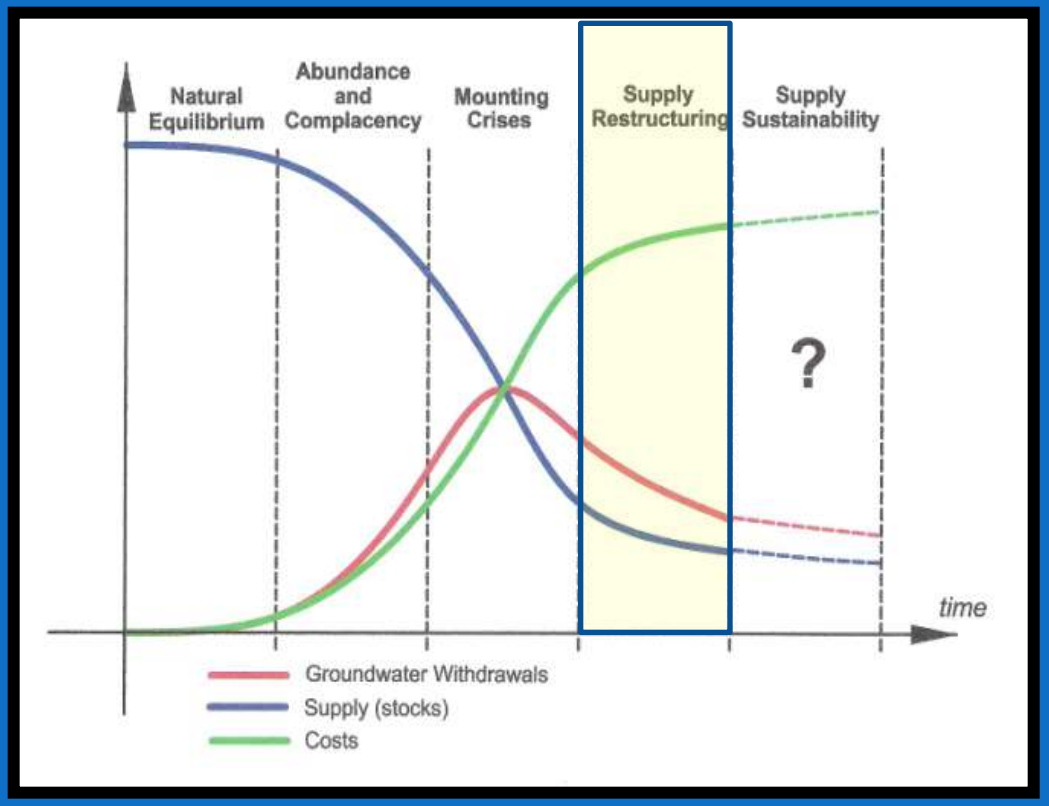
  As supply shrinks and costs increase, rate of withdrawal peaks and begins to decline.

- **Water supply planning and management:** Spurred by higher costs and local shortages



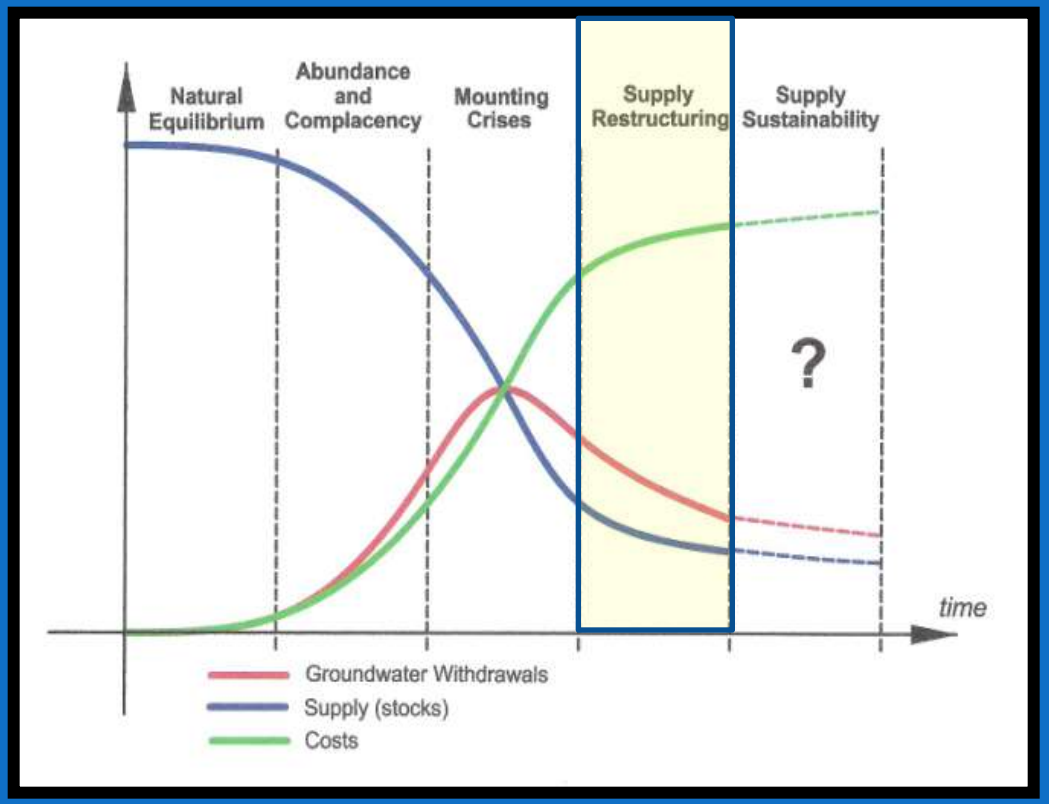
Era of Supply Restructuring (1)

- **Supply**: Groundwater in aquifer storage reduced to a level too low to supply historical levels of demand
- **Withdrawal rates**: Falling as costs rise and use of alternative sources grows
- **Artesian water levels**: Fallen to critical levels throughout aquifer system and stabilizing
- **Costs**: Remaining groundwater supply very expensive to exploit



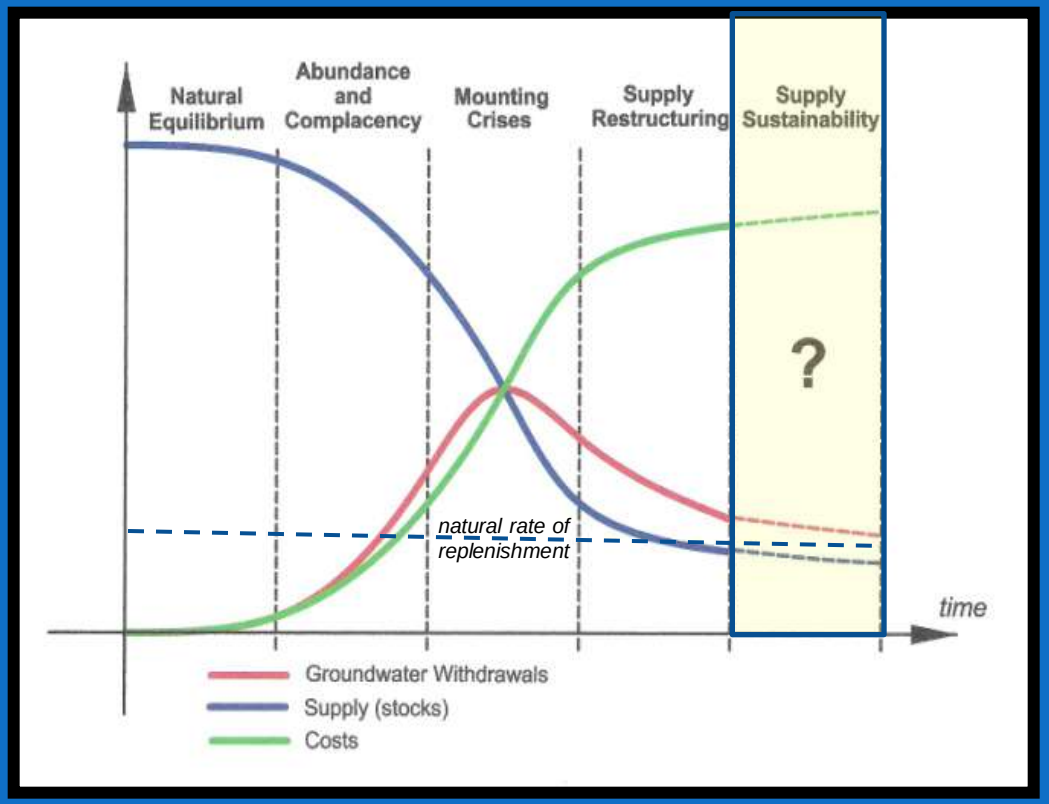
Era of Supply Restructuring (2)

High cost of groundwater relative to alternative water sources and water con-servation and reuse technologies reduces the proportion of groundwater in the water supply budget.

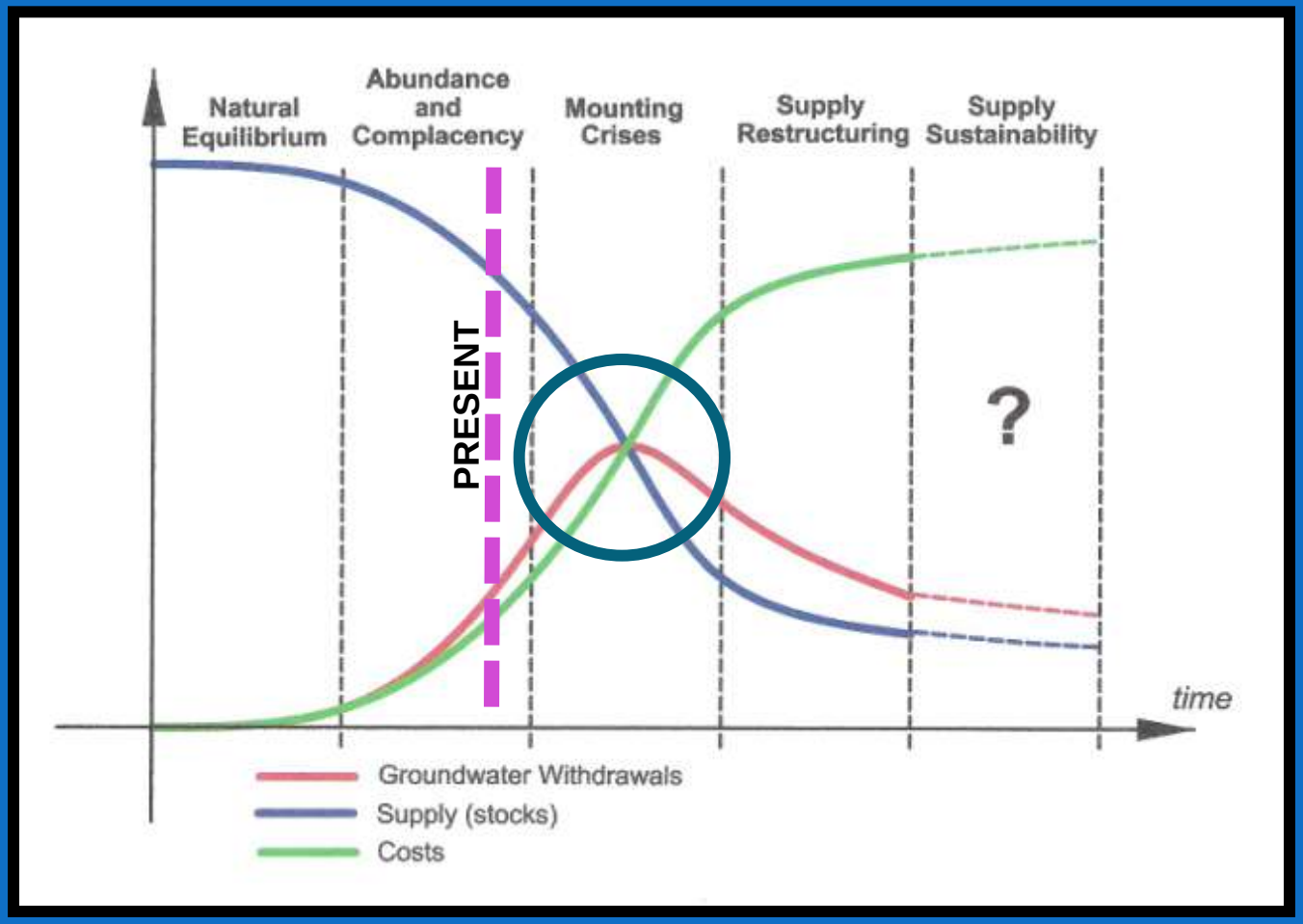


Era of Supply Sustainability

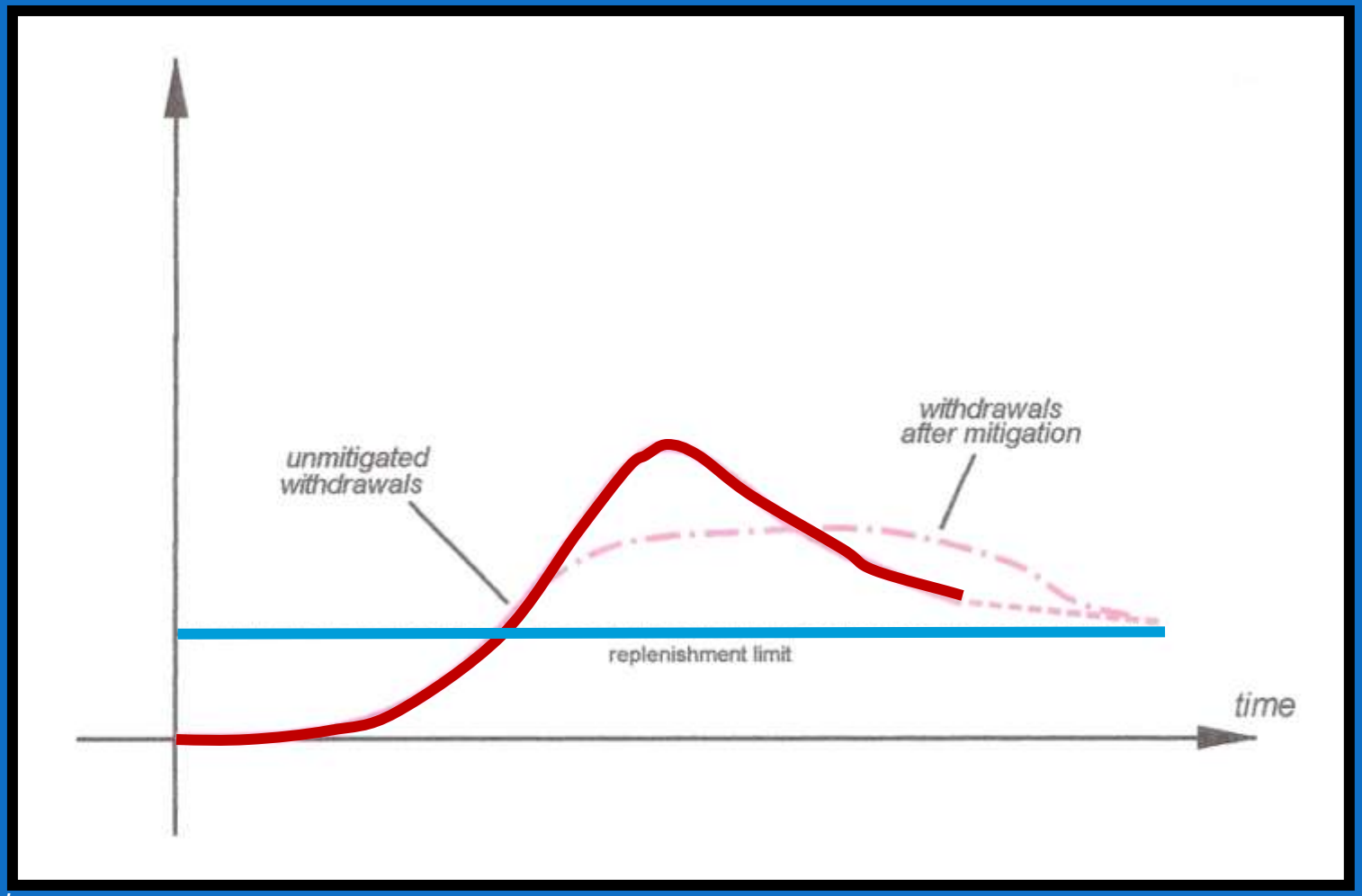
- Groundwater, surface water, desalination, rainwater collection, reuse and recycling technologies, and conservation measures together make up a diversified water system.
- Rate of groundwater withdrawal matches replenishment rate of aquifer system (R = D + W).



Unless the accelerating growth of groundwater withdrawals is halted soon, it may be too late to avoid a crisis of water supply, characterized by supply shortages and water conflicts.



In order to prevent supply shocks, a regional water supply plan must include measures that first arrest and then reduce the rate of groundwater withdrawal to a hydraulically sustainable level.



Civilization exists by geologic consent, subject to change at any moment.

-- Will Durant