All About Aquifers

Subsurface water

As precipitation infiltrates into the subsurface soil, it generally forms an unsaturated zone and a saturated zone. In the unsaturated zone, the voids—that is, the spaces between grains of gravel, sand, silt, clay, and cracks within rocks—contain both air and water. Although a lot of water can be present in the unsaturated zone, this water cannot be pumped by wells because it is held too tightly by capillary forces. The upper part of the unsaturated zone is the soil-water zone. The soil zone is crisscrossed by roots, openings left by decayed roots and animal and worm burrows, which allow the precipitation to infiltrate into the soil zone. Water in the soil is used by plants in life functions and leaf transpiration, but it also can evaporate directly to the atmosphere. Below the unsaturated zone is a saturated zone where water completely fills the voids between rock and soil particles.

Infiltration replenishes aquifers

Natural refilling of deep aquifers is a slow process because ground water moves slowly through the unsaturated zone and the aquifer. The rate of recharge is also an important consideration. It has been estimated, for example, that if the aquifer that underlies the High Plains of Texas and New Mexico—an area of slight precipitation—was emptied, it would take centuries to refill the aquifer at the present small rate of replenishment. In contrast, a shallow aquifer in an area of substantial precipitation such as those in the coastal plain in southern Georgia may be replenished almost immediately!

Artificial recharge gives natural infiltration a push!

People all over the world make great use of the water in underground aquifers all over the world. In fact, in some places, they pump water out of the aquifer faster than nature replenishes it. In these cases, the water table, below which the soil is saturated and possibly able to yield enough water that can be pumped to the surface, can be lowered by the excessive pumping. Wells can "go dry" and become useless.

In places where the water table is close to the land surface and where water can move through the aquifer at a high rate, aquifers can be replenished artificially. For example, large volumes of ground water used for air conditioning are returned to aquifers through recharge wells on Long Island, New York. Aquifers may be artificially recharged in two main ways:

- **Rapid-infiltration pits:** One way is to spread water over the land in pits, furrows, or ditches, or to erect small dams in stream channels to detain and deflect surface runoff, thereby allowing it to infiltrate to the aquifer
- **Ground-water injection:** The other way is to construct recharge wells and inject water directly into an aquifer

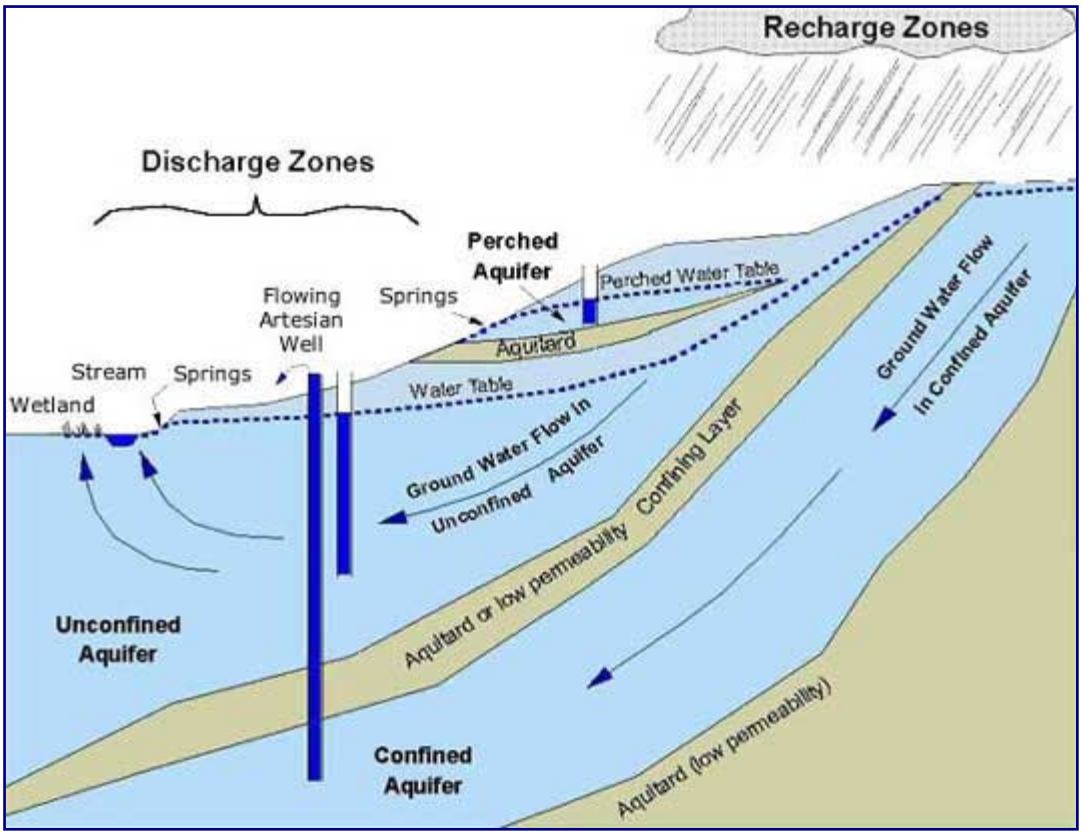
What is water quality?

The quality of water is related to all substances contained within it, other than the water (H_2O) itself. A water contaminant is any substance that alters the physical, chemical, biological or radiological qualities of water. A contaminant becomes a pollutant when it exceeds an acceptable concentration or standard.

How pure is New Mexico's ground water?

The quality of ground water in New Mexico varies widely. It contains naturally occurring minerals that dissolve from the soil and rock that it has flowed through. Mountain aquifers, recharged by recent rain and snow melt, often yield high quality water. A tremendous amount of fresh water occurs in the Rio Grande valley fill aquifer, stretching from Colorado to Texas. Some ground water in the southern part of the state is too salty to be used for drinking. High levels of natural uranium occur in some ground waters in northern Santa Fe County, in the Grants-Gallup area, and in Quay County. Naturally high fluoride and arsenic also occur in various areas around the state.

The earth has natural cleansing processes that can filter out, dilute, transform or destroy both natural and human-made contaminants in the subsurface. Ground water becomes polluted when contaminants move through soil and aquifers faster than natural processes can reduce them to acceptable levels. Chemicals and micro-organisms can make ground water unpleasant to drink or pose health risks. Because all water eventually moves through the entire water cycle, pollutants in the air, on land, or in surface water can reach any other part of the cycle, including ground water. The shallow sand-and-gravel aquifers of the river valleys are most vulnerable to contamination.



THE ABC OF AQUIFERS

When you are "talking ground water" it won't be long before you will be asked to explain the word aquifer. This article covers the basics about aquifers. There are many variations of geology and hydrology that may make an aquifer. Some aquifers extend over long distances and to great depths. Many aquifers are small and localized. Aquifers contain ground water but not all sub-surface water is in aquifers! Geologic cross section figures are very useful when explaining ground water.
The word aquifer comes from the Latin words, "Aqua" (water), and "fer" (to carry). An aquifer is often described as a sub-surface geologic formation(s) (solid rock and/or unconsolidated sediments) that contains ground water in sufficient quantities to be used, or have the potential to be used, for drinking water supply or for commercial, industrial or agricultural purposes. Ground water is nearly always found when a well is drilled, although in some places there may be a very low rate of flow to the well. How large does a well's yield have to be to qualify a saturated rock as an aquifer? Half a gallon a minute will provide 700 gallons a day, but many people would not describe such low yielding rock formations as aquifers. So, by some definitions many low yielding domestic wells are not really in aquifers. All water wells pump ground water but they don't all pump from aquifers!

In general, there are three main categories of aquifers: **unconfined, confined** and **perched**. In reality, there can be a number of combinations and variations.

Unconfined Aquifers are covered by permeable geologic formations (either solid rock or unconsolidated sediments) and the upper surface where the rock formations are fully saturated is called the **water table**. These aquifers are also known as water table aquifers. They receive recharge directly from the infiltration of rainfall and surface water.

Confined Aquifers are those that are covered (confined) by an impermeable or semi-permeable layer of rock. Confined aquifers are not directly recharged by vertical infiltration. Confined aquifers need to be connected to an unconfined area through which recharge can occur. The confining impermeable layers rarely form a complete barrier to ground water. There is generally some transfer or flow of ground water between the confined aquifer and the confining layers.

In confined and unconfined aquifers there may be considerable amounts of ground water that are stored in impermeable/semi-permeable sediments such as clays. Water from these sediments can reach a well if they are in contact with permeable layers that are intersected by the well. So although clays are not usually thought of as aquifers they may be a key part of the storage in an aquifer system. When aquifers are polluted, it is almost impossible to flush out contaminants from fine-grained clay layers where much of the aquifer's water may be stored.

Artesian aquifer is the name sometimes used to describe confined aquifers. In confined aquifers, ground water is under pressure. The water level in a confined aquifer well may be close to the surface, perhaps many 10's or even 100's of feet above the aquifer. An overflowing artesian well occurs where the water pressure in the aquifer is sufficient to raise water levels to cause natural flow at the surface. The term artesian is often used incorrectly to describe any well drilled into solid rock.
Water levels in most aquifers vary with the season and during droughts. It is a debatable point whether an "empty" aquifer is still an aquifer and there is no scientific agreement about what to call the permanently depleted portions of over drafted aquifers. For purposes

of wise ground water protection policy, we should consider as aquifers, the full vertical and horizontal extent of seasonally dewatered or over-pumped rock formations.

Perched Aquifers occur where ground water is perched above unsaturated rock formations as a result of a discontinuous impermeable layer. Perched aquifers are fairly common in glacial sediments. They also occur in other sedimentary formations where weathered layers, ancient soils or caliche (a calcareous layer common in semi-arid areas) have created impermeable zones.