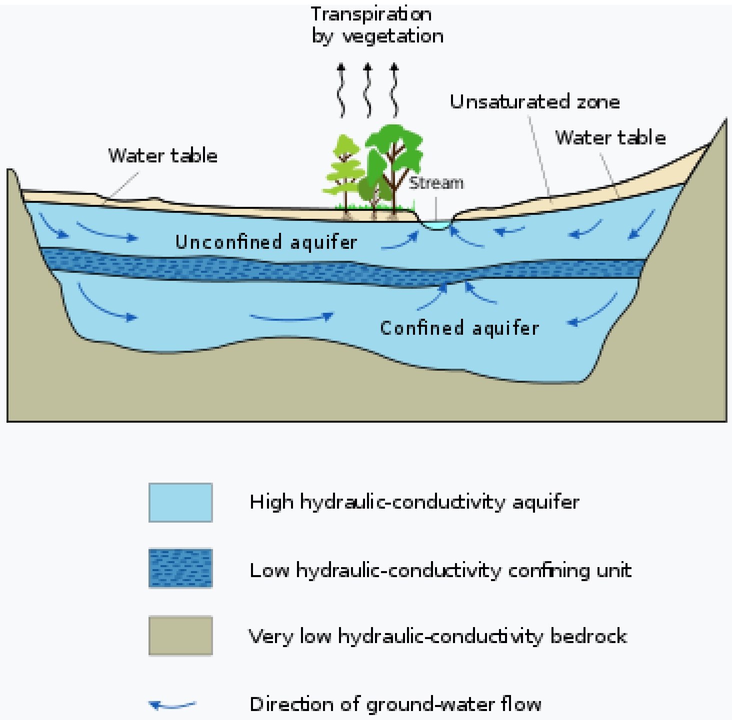
Hydrogeology (*hydro-* meaning water, and *-geology* meaning the study of the Earth) is the area of geology that deals with the distribution and movement of groundwater in the soil and rocks of the Earth's crust (commonly in aquifers). The terms **groundwater hydrology**, **geohydrology**, and **hydrogeology** are often used interchangeably.

Groundwater engineering, another name for hydrogeology, is a branch of engineering which is concerned with groundwater movement and design of wells, pumps, and drains.[1] The main concerns in groundwater engineering include groundwater contamination, conservation of supplies, and water quality.[2]

Wells are constructed for use in developing nations, as well as for use in developed nations in places which are not connected to a city water system. Wells must be designed and maintained to uphold the integrity of the aquifer, and to prevent contaminants from reaching the groundwater. Controversy arises in the use of groundwater when its usage impacts surface water systems, or when human activity threatens the integrity of the local aquifer system.

Aquifer[edit]



Typical aquifer cross-section

Main article: Aquifer

An aquifer is a collection of water underneath the surface, large enough to be useful in a spring or a well. Aquifers can be unconfined, where the top of the aquifer is defined by the water table, or confined, where the aquifer exists underneath a confining bed.[5]

There are three aspects that control the nature of aquifers: stratigraphy, lithology, and geological formations and deposits. The stratigraphy relates the age and geometry of the many formations that compose the aquifer. The lithology refers to the physical components of an aquifer, such as the mineral composition and grain size. The structural features are the elements that arise due to deformations after deposition, such as fractures and folds. Understanding these aspects is paramount to understanding of how an aquifer is formed and how professionals can utilize it for groundwater engineering.[6]

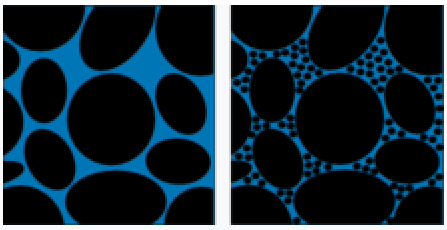
Hydraulic head[edit]
Main article: Hydraulic head

Differences in hydraulic head (h) cause water to move from one place to another; water flows from locations of high h to locations of low h. Hydraulic head is composed of pressure head (ψ) and elevation head (z). The head gradient is the change in hydraulic head per length of flowpath, and appears in Darcy's law as being proportional to the discharge.

Hydraulic head is a directly measurable property that can take on any value (because of the arbitrary datum involved in the z term); ψ can be measured with a pressure transducer (this value can be negative, e.g., suction, but is positive in saturated aquifers), and z can be measured relative to a surveyed datum (typically the top of the well casing). Commonly, in wells tapping unconfined aquifers the water level in a well is used as a proxy for hydraulic head, assuming there is no vertical gradient of pressure. Often only *changes* in hydraulic head through time are needed, so the constant elevation head term can be left out ($\Delta h = \Delta\psi$).

A record of hydraulic head through time at a well is a hydrograph or, the changes in hydraulic head recorded during the pumping of a well in a test are called drawdown.

Porosity[edit]
Main article: Porosity



[Left] High porosity, well sorted [Right] Low porosity, poorly sorted

Porosity (n) is a directly measurable aquifer property; it is a fraction between 0 and 1 indicating the amount of pore space between unconsolidated soil particles or within a fractured rock. Typically, the majority of groundwater (and anything dissolved in it) moves through the porosity available to flow (sometimes called effective porosity). **Permeability** is an expression of the connectedness of the pores. For instance, an unfractured rock unit may have a high *porosity* (it has lots of *holes* between its constituent grains), but a low *permeability* (none of the pores are connected). An example of this phenomenon is pumice, which, when in its unfractured state, can make a poor aquifer.

Porosity does not directly affect the distribution of hydraulic head in an aquifer, but it has a very strong effect on the migration of dissolved contaminants, since it affects groundwater flow velocities through an inversely proportional relationship.

Darcy's law is commonly applied to study the movement of water, or other fluids through porous media, and constitutes the basis for many hydrogeological analyses.

Water content[edit]
Main article: water content

Water content (θ) is also a directly measurable property; it is the fraction of the total rock which is filled with liquid water. This is also a fraction between 0 and 1, but it must also be less than or equal to the total porosity.

The water content is very important in vadose zone hydrology, where the hydraulic conductivity is a strongly nonlinear function of water content; this complicates the solution of the unsaturated groundwater flow equation.

Hydraulic conductivity[edit]

Main article: Hydraulic conductivity

Hydraulic conductivity (K) and transmissivity (T) are indirect aquifer properties (they cannot be measured directly). T is the K integrated over the vertical thickness (b) of the aquifer (T=Kb when K is constant over the entire thickness). These properties are measures of an aquifer's ability to transmit water. Intrinsic permeability (κ) is a secondary medium property which does not depend on the viscosity and density of the fluid (K and T are specific to water); it is used more in the petroleum industry.