Division of Spill Prevention and Response

INTRODUCTION TO GROUNDWATER

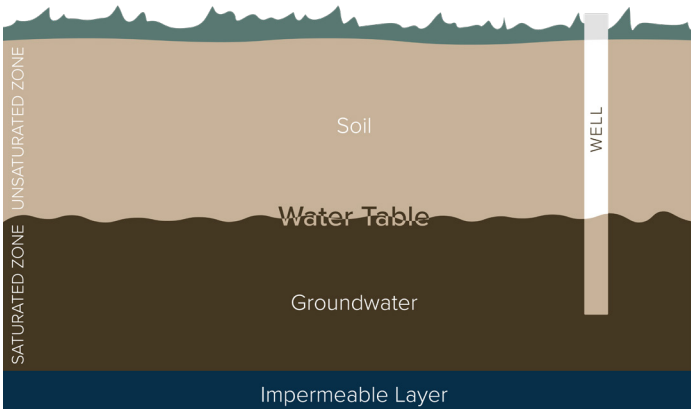
Contaminated Sites Program Fact Sheet Series

Groundwater is one of our most important natural resources. It supplies roughly a third of the water used in municipal water supplies across the nation, and supplies about 90 percent of drinking water used in rural communities that opt out of city water departments. Groundwater cleanup is very important in Alaska because many of our communities and individuals get their drinking water from wells.

What Is Groundwater?

Groundwater is water stored under the surface of the ground in the tiny pore spaces between rock, sand, soil, and gravel. It occurs in two "zones": an upper, **unsaturated zone** where most of the pore spaces are filled with air, and a deeper, **saturated zone** in which all the pore spaces are filled with water throughout the year.

To picture this, think of filling a cup with gravel. Then add enough water to half fill the cup. The top of the water layer represents the **water table**. Below it, where the gravel is covered with water, is the saturated zone. Above it, where there is just gravel, would be the unsaturated zone. The bottom of the cup forms a barrier to the water continuing to move downward. This barrier can occur in nature as bedrock, clay, or permafrost and is called an **aquitard**.



The water table may be a few feet or many hundreds of feet below ground surface. In **permafrost** areas, the ground is saturated with water, but remains frozen all year.

How well loosely arranged rock (such as sand and gravel) holds water depends on the size and shape of the rock particles. Layers of loosely arranged particles of uniform size (such as sand) tend to hold more water than layers of rock with materials of different sizes. This is because smaller rock materials can settle in the spaces between larger rocks, decreasing the space available to hold water.

How Does Groundwater Move?

Several things happen to precipitation that falls on the land surface. Some of the water flows overland into streams, lakes, or the ocean. If the surface soil is porous, some water seeps into the ground by a process called infiltration. Water seeping into the soil clings to soil particles, and may be drawn into the rootlets of growing plants. After the plant uses the water, it is released as vapor into the atmosphere. Excess soil moisture is pulled downward by gravity. At some depth, either shallower or deeper depending on the location, the pores in soil or rocks become saturated with water.

Groundwater generally flows downhill, just as surface water does. However, "downhill" for groundwater is determined by the slope of the barrier below it, not the ground above it. The slope of the underground barrier often is in the same direction as the ground above it, but that is not always the case.

The speed at which groundwater flows also is determined by the **permeability** of the soil or rock in the saturated zone. If the saturated zone consists of less permeable material (such as clay),

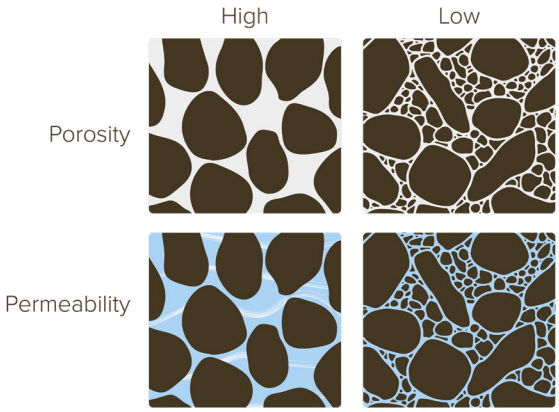
water flows through it more slowly. Groundwater can move as quickly as several feet per day, and as slowly as a foot per century. If there is an obstacle to groundwater flower, such as permafrost, groundwater may move around it in many different locations.

What Is an Aquifer?

An **aquifer** is an area that contains enough groundwater to be pumped to the surface and used for drinking water, irrigation, industry, or other uses. An aquifer may be a few feet or several thousand feet thick, and less than a square mile or hundreds of thousands of square miles in area.

The amount of water an aquifer can produce depends on the volume of the soil and rock in the saturated zone, the size and number of the pores and fractures that can fill with water, and the permeability of the soil or rock.

Water-filled **porosity** is a measurement of the amount of water a material can store, and **permeability** is a measure of how well the water can move through the material.

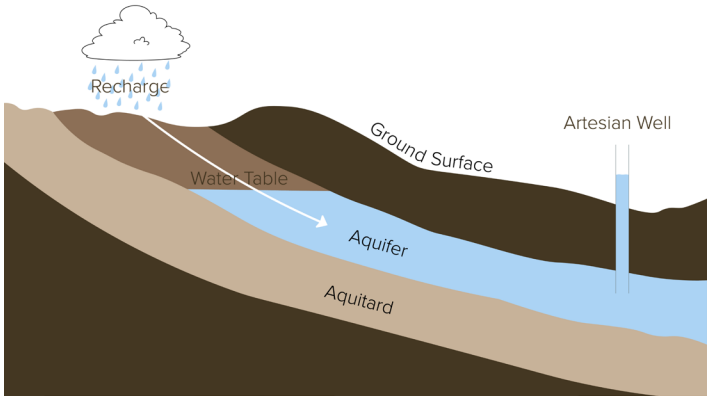


Material such as silt or clay has high water-filled porosity (it can store a lot of water) but low permeability (the water does not flow through it easily). Bedrock usually has low water-filled porosity (it can only store water in cracks, if at all) and low permeability (water can only flow through cracks that interconnect).

Recharge areas are where the aquifer takes in water, and **discharge areas** are where groundwater flows to the land surface. Water moves from areas of recharge, often at higher elevations, to areas of discharge, often at lower elevations, through the saturated zone.

Aquifers receive water from rain or snowmelt that filters down through the unsaturated zone. They also can receive water from surface waters such as lakes and streams. Where the water table meets the surface of the ground, water from the aquifer can appear at the land surface as a seep or spring.

An **aquitard** is a confining geologic layer that slows, but does not prevent, the flow of water to or from an adjacent aquifer. An aquitard does not readily provide water to wells or springs, but may store groundwater and also transmit it slowly from one aquifer to another. Most geologic layers are classified as either aquifers or aquitards.



How Does Groundwater Become Contaminated?

Groundwater can be contaminated in many ways. If surface water that recharges the aquifer is contaminated, the groundwater will also become contaminated. This can, in turn, affect the quality of surface water at discharge areas. Groundwater can also be contaminated by spills of liquid hazardous substances (or solids that can dissolve in water) that filter through the soil into groundwater, by salt water moving in from the ocean, or by minerals that are naturally present in the area.

GLOSSARY

aquifer

saturated zone containing sufficient groundwater that the water can be pumped out.

aquitard

material that retards or restricts the flow of groundwater.

discharge area

where groundwater flows to the land surface.

permafrost

saturated soil that has remained below 32°F (the freezing point of water) for at least two years.

permeability

a measure of how well a material allows fluid to flow through it.

porosity

the percentage of empty (void) space in earth material such as soil or rock.

recharge area

where aquifers take in water.

water table

the top of the saturated zone.

saturated zone

the area below the water table where all the pore spaces are filled with water. Some pore spaces are seasonally filled with water.

unsaturated zone

the area above the water table where most of the pore spaces are filled with air.

Reference List

- Fetter, C.W., Applied Hydrogeology, Second Edition, University of Wisconsin, Oshkosh, 1980.
- Keller, Edward A. Environmental Geology, Sixth edition. Macmillan Publishing Company. 1992.
- U.S. Environmental Protection Agency, Office of Research and Development. Ground Water Handbook, EPA/625/6-87/016. March 1987.
- U.S. Environmental Protection Agency. HAZED, Classroom Activities for Understanding Hazardous Waste. April 1996.
- U.S. Geological Survey, “How Important is Groundwater?”

This fact sheet is one of a series of free publications prepared by DEC to help people understand contaminated site cleanup issues. The others can be found at https://dec.alaska.gov/spar/csp/faq.