WATER AND PEOPLE

Unit 1: The Water Cycle & Water Sources

Viewing Earth from space, one might want to rename our plant the water planet. Water covers a vast area of Earth's surface and it appears to be a limitless resource —looks can be deceiving. Approximately 97 percent of the water on Earth is found in the oceans. Without expensive treatment, this salt water is unfit for human consumption. The remaining three percent of water is freshwater, but all of this is not easily accessible for our use; two percent of the water is trapped in glaciers in the North and South poles. A little less than one percent of the remaining water is very deep in the ground and virtually inaccessible or polluted and not able to be consumed. The remaining fraction of one percent is what is left for water treatment plant operators to finish into our drinking water. A mere drop in the proverbial bucket.

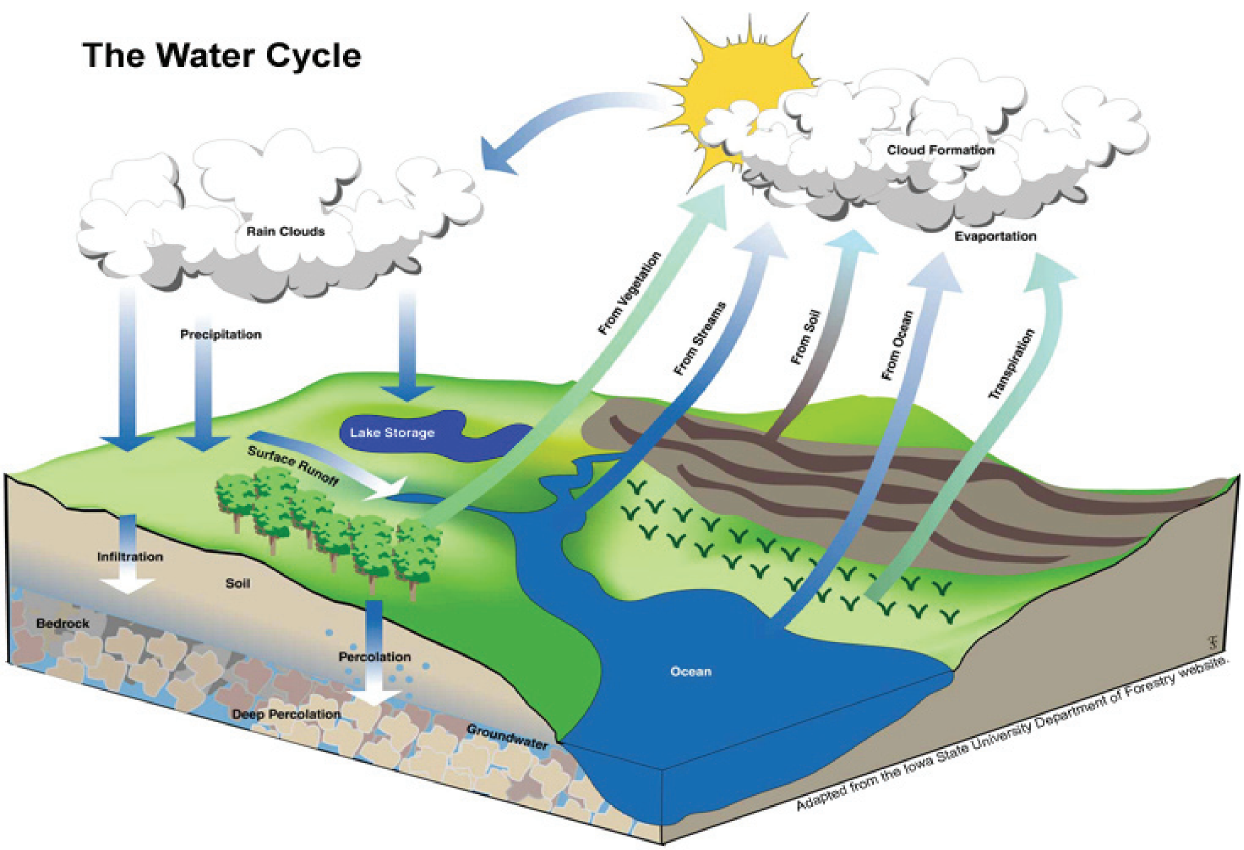
Unit 3 Objectives:

- Students will review the different parts of the water cycle
- Students will learn about groundwater and aquifers
- Students will conduct a groundwater experiment

Water is a precious and vital resource that is in constant movement around the planet. This movement has done it's job purifing the water for millenia but with the advent of modern technology, we have been able to make our water safe to consume by disinfecting and filtering to remove waterborne pathogens. These pathogens still sicken people today who do not have access to a clean supply of drinking water. Certain water sources are very suseptible to pathogens while others are more protected. Regardless of the water source, it is cleaned to ensure a safe, healthy supply.

The Hydrologic Cycle

The hydrologic cycle is the continuous circulation of water from land and sea to the atmosphere and back again: water *evaporates* from oceans, lakes and rivers into the atmosphere. This water will *condense* in the cooler, upper elevations of the atmosphere forming clouds. As the clouds fill and can no longer hold the water, they will drop the water in the form of *precipitation*. The precipitation falls back to the land where it may evaporate again, *runoff* into the streams and rivers, *infiltrate* (seep) into the soil, or *transpire* back into the atmosphere through the plants and trees. Some of the water will make it into the groundwater and continue the water cycle at a much slower pace. Groundwater will eventually seep into streams and lakes from which it will either evaporate of flow into the oceans. The hydrologic cycle is responsible for recharging the groundwater and surface water supplies that are used for our drinking water.



Groundwater

Precipitation that infiltrates through the soil becomes the groundwater. The places where soil and rock touch create *pores* which the water moves through and where the water is stored. Water movement and storage is greatly influenced by the type of material found in the ground. There are two distinct zones in the soil. The *unsaturated zone* contains the pores that hold both air and water; this zone supports vegetation growth. The *saturated zone* is filled with water, there is no air in the pores. Depending on the amount of water found in the saturated zone, it can form an *aquifer* that can be used for drinking water. The *water table* is where the unsaturated zone and saturated zone meet. The location of the water table will fluctuate depending on the seasons and the levels of precipitation.

Two characteristics of all rocks that affect the pressure and movement of groundwater are *porosity* and *permeability*. Porosity is the size and quantity of the spaces between the rocks; the ability for the material to hold water. A high concentration of pores means there is greater water storage capacity. Permeability refers to the ease with which water can move through spaces in the rocks. If the pores are nicely aligned, the water will pass through quickly. While some material has a great number of pores; clay, for example, they do not line up well and are very, very small. Clay is very porous, but not very permeable. On the other hand, gravel has fewer pores, but they are large and line up very nicely. Water flows freely though gravel and is very permeable.

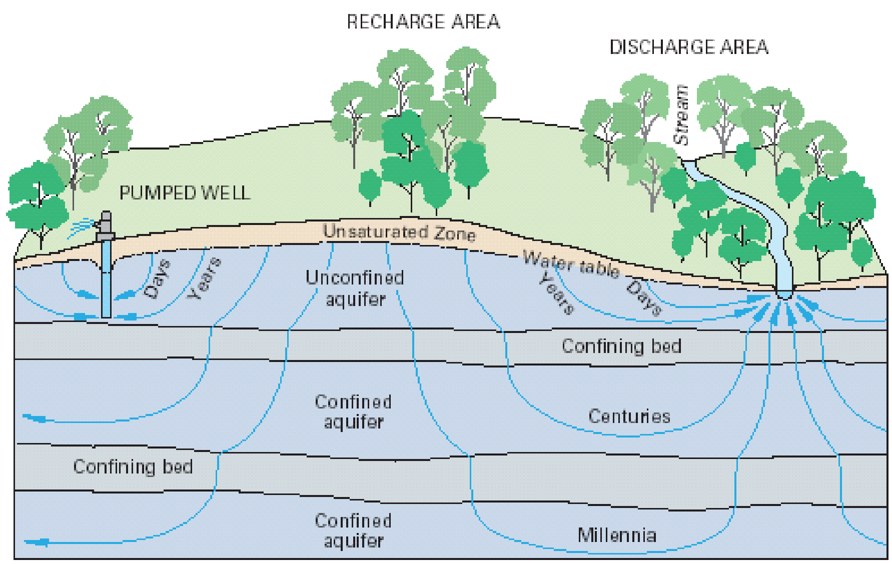
Give each student a copy of the "Porosity and Permeability" worksheet and time to complete it. The top example shows pores that are poorly aligned - soil that is not very permeable. The bottom example shows pores that a nicely aligned - soil that is very permeable.

Factors Influencing Groundwater Movement

Materials

Copies of "Porosity and Permeability" worksheet (located at the end of the unit)

Groundwater moves very slowly. Depending on it's location and the type of material it needs to move, it can take days to millennia to make it from where it infiltrates into the ground to a discharge area, like a lake or a river. If groundwater is moving through large pieces of material like gravel, it will move rapidly. As the particle size decreases, so does the speed of the water. Clay will essentially act as a barrier preventing water from moving past it.



United States Geological Survey - Circular 1224

Consolidated and Unconsolidated Rock

Rock materials can be classified into two main categories; consolidated rock and unconsolidated rock. Consolidated rock, often referred to as bedrock, has limited capacity to hold water. The only available space for water in consolidated rock is found in the fractures which run throughout the bedrock. Unconsolidated rock has pores which can hold a varying amount of water, which depends on the size of the rock material.

Consolidated rock may contain fractures, small cracks and a few pores which can hold water. When one layer of bedrock meets another, a small space is created where the two layers meet. This space has the ability to transmit water great distances. Most bedrock contains vertical fractures that intersect other fractures allowing water to move from one layer to another. Depending on the composition of the bedrock, water can create its own pathways. Water has the ability to dissolve carbonate rock, such as dolomite and limestone, forming solution channels through which water can move both vertically and horizontally. Limestone caves are a good example of solution channels. As the water makes it way though the small channels, they grow and expand, eventually joining and intersecting until a large cave is formed.

Consolidated rock may be buried below many hundred feet of unconsolidated rock or may crop out at the land surface. Bedrock (consolidated rock) creates the exposed cliffs in that are visible throughout the region; West Rock Ridge as well as Sleeping Giant State Park are both examples of exposed bedrock in New Haven county.

Unconsolidated material overlies bedrock and may consist of rock debris transported by glaciers or stream deposits. It may also consist if weathered bedrock particles that form a loose granular or clay soil. Past glacial activity will influence how much unconsolidated rock is found on top of the bedrock, heavy scouring from glaciers will result in very little depth above the bedrock.

The channels in the bedrock and the pores in the unconsolidated material both contribute to the groundwater capacity of an area. The size and quantity of channels in the bedrock will determine if the groundwater yield is plentiful or sparse. Well sorted unconsolidated material is capable of holding large quantities of groundwater. Sand and gravel are highly desirable materials for a high-yield well.

Aquifers

Water storage in the consolidate and unconsolidated materials can create *aquifers*. Aquifers are created when these water-rich areas are tapped for wells. *Recharge* is very important to an aquifer, if the water is constantly removed though a well and it is not replenished, the aquifer will dry up and the well will not produce any water. Infiltration through rainfall is the primary source of groundwater recharge, although streams to contribute to recharge as well. The area where the water exits the aquifer is called the *discharge*. This can happen naturally when an aquifer empties into a lake or a stream, or human-influenced when a well is drilled to access the aquifer.

There are two primary types of aquifers; confined and unconfined. An unconfined aquifer is located in the loose, unconsolidated rock. It is not under great pressure and a well would need to be pumped to removed water from this type of aquifer. A confined aquifer is water trapped under a layer of consolidated rock and is under pressure. When the pressure is sufficient, water from a confined aquifer will flow freely to the surface and create a spring, clay can typically create a confined aquifer. In certain areas, aquifers are a primary source of drinking water, the Ogallala aquifer in the mid-west is a great example of a large aquifer used for drinking. This aquifer covers 10,000 square miles and spans from Texas to the Dakotas.

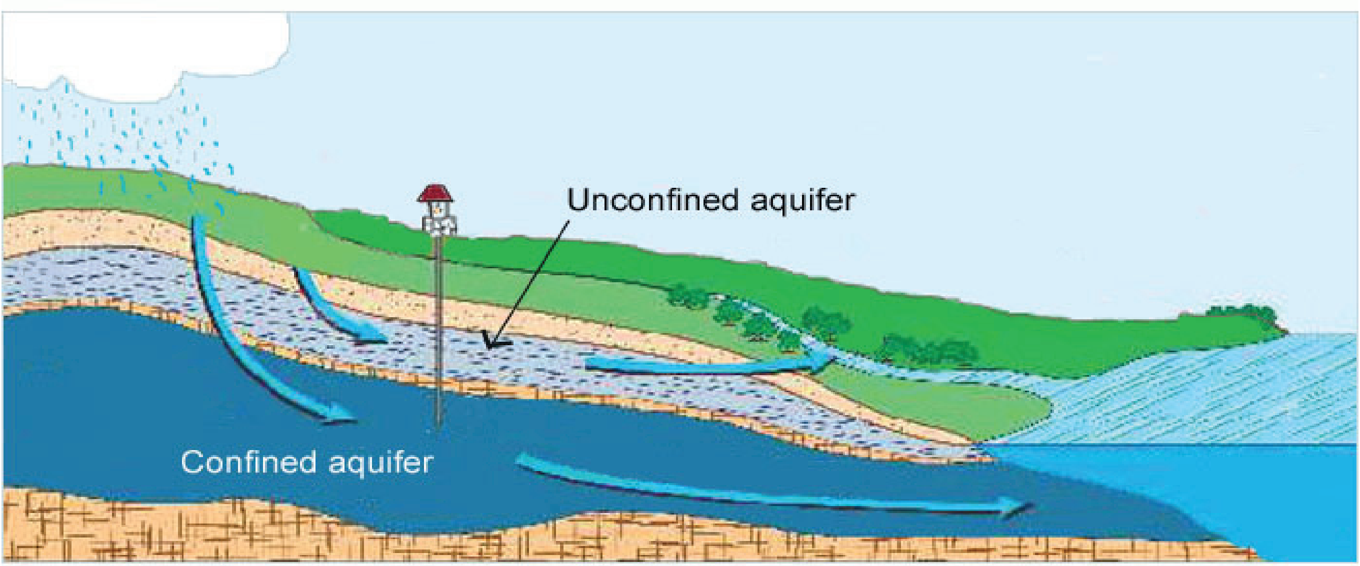


Image Source: http://www.learner.org/courses/envsci/unit/text.php?unit=8&secNum=3#confined_unconfined_aquifer

Patterns in Groundwater Storage and Recharge

Weather and seasons can have an effect on the availability of groundwater. In latitudes where freezing is common, there is less recharge from rain or snow melt during the winter, the precipitation is not able to penetrate the frozen soil. This decrease in recharge can cause the water table to fall. Sporadic freezing of the soil reduces water flow into the saturated zone, complete freezing of the soil during the winter will eliminate all recharge until the spring thaw.

During the growing season, evaporation and transpiration by plants capture most of the water that would otherwise recharge the aquifer. The increase of water removal from the aquifer in spring is usually counteracted by the increase in precipitation and snow melt.

Long-term climatic trends can also have an impact on the aquifers. Several years of below-normal precipitation can cause a progressive decline in groundwater levels, whereas several years of above-normal precipitation can dramatically increase groundwater levels. Both of these can have profound impacts on our lives. If there has been a prolonged drought, the water table can drop below the intake of the well, rendering the well useless until there is an increase in precipitation. During periods of long-term, above-average precipitation, the water table may rise close to the land surface and interfere with home construction and waste disposal.

Groundwater and Surface Water as Water Supply

Both groundwater and surface water (lakes, for example) are used as drinking water supply. Regardless of the source, the water has standards that it has to meet to be suitable for drinking water. Both water supplies are monitored for turbidity, harmful microorganisms, organic matter, minerals, and organic and synthetic chemicals.

The quality and temperature of groundwater remain relatively constant from year to year, but can be variable from well to well. Groundwater is usually a higher-quality source in regard to turbidity (suspended solids in the water), microorganisms, and organic content. It's location under the soil does is an advantage that prevents many problems from entering the water. A disadvantage to groundwater as a drinking source is it's high mineral content. High levels of minerals such as calcium and magnesium can create hard water, which can eventually clog pipes and causes staining on faucets and fixtures. Water's ability to dissolve almost anything creates the hard water issues, whatever rock water comes into contact with, it will slowly dissolve and affect the composition of the water

Surface water is considered to be all water that is exposed to the atmosphere. Examples of surface water are stream, rivers, lakes, and reservoirs; lakes that are used specifically for water supply. The United States Environmental Protection Agency (US EPA) considers all surface water to be contaminated with disease-causing microorganisms and has mandated that this water receive adequate treatment to reduce the risk of illness to the public. There is also an US EPA mandate to reduce surface water turbidity to specific levels. Both of these mandates are accomplished by disinfection and filtration.

Compared to groundwater, surface water os subject to rapid changes in quality, especially during periods of heavy rain, spring runoff, or accidental spills. Surface water is also susceptible to algae blooms which can cause changes in turbidity, taste, odor, and pH.