GROUNDWATER 101

Photos by Julie Black

By **Kathy Jesperson** • *On Tap* Editor

Ike Dixon and Junior Dilsworth who work for Three-D Drilling Company of Kingwood, West Virginia, drill a well in Albright, West Virginia.

Why do small systems rely on groundwater?

Perhaps groundwater's availability is why the lion's share of small drinking water systems obtain their water from wells. According to the U.S. Environmental Protection Agency (EPA), approximately 80 percent of all community water systems are groundwater systems. The agency also notes that "Larger systems are more likely than smaller systems to use surface water as their primary source; most small systems use groundwater."

One of our most valuable resources is right beneath our feet, and we can't even see it. The old adage "out of sight, out of mind" certainly applies to groundwater.

Despite its being buried beneath the ground, people have known about groundwater since ancient times. In the *Bible*, for example, "Exodus," refers to water and wells several times and specifically discusses "water under the Earth."

Other historic scripts also reveal that ancient humans had knowledge of groundwater, and they knew they had to dig wells to be able to use it. But even though we know it's there, it has only been within recent times that scientists have learned to estimate how much groundwater there is.

It's All in Storage

"An estimated one million cubic miles of the world's groundwater is stored within one-half mile of land surface," says the U.S. Geological Survey (USGS). "Only a fraction of this groundwater reservoir, however, can be practically tapped and made available on a perennial basis through wells and springs. The amount of groundwater in storage is more than 30 times greater than the nearly 30,000 cubic miles in volume in all the fresh water lakes and more than the 300 cubic miles of water in all the world's streams at any given time."

Groundwater is stored in geological formations called aquifers. Aquifer means "water bearer." It refers to "saturated permeable rocks of a geologic formation, group of formations, or part of a formation that is water bearing," notes the Texas Natural Resources Conservation Commission (TNRCC). The commission also says that, "to be an aquifer, the water-bearing formation should yield water in sufficient quantities to provide a usable supply; otherwise the formation will have a different name."

While aquifers are typically classified as confined and unconfined, they can be broken down into even smaller group types. According to USGS, "the principal water-yielding aquifers in North America can be grouped into six types:

- unconsolidated sand and gravel,
- semi-consolidated sand,
- sandstone,
- carbonate-rock,
- interbedded sandstone and carbonate-rock, and
- basalt and other types of volcanic rocks."

Gravity Makes It Move

When people attempt to visualize groundwater, most of the time they picture it flowing in large underground rivers or lakes. But that's not quite true. While it's hard to imagine exactly what it looks like "down there," groundwater is simply water that's underground, saturating the pores or cracks in soil and rocks.

Groundwater normally flows in the direction of the general topography of the land surface because gravity is the main force acting on it. So, groundwater typically flows downhill toward rivers and lakes at the bottom of valleys. In addition, groundwater must make its way through small spaces between rocks. Therefore, groundwater moves very slowly.

How slowly does it go? Groundwater usually moves inches per day, whereas rivers move more swiftly—feet per second (ft/sec). In sandy soils, however, groundwater moves a bit more quickly, between one to five feet per day. Even at this rate, groundwater and substances dissolved in it may take five years to travel about one mile. In comparison, a small twig moving downstream in a river at one to two ft/sec would only take an hour to travel one mile.

Community Well Funding

Does your community need a new well? Are you looking for a way to finance the project?

As with most drinking water projects, the primary funding sources for community wells are Rural Utilities Services (RUS) loans and grants and the U.S. Environmental Protection Agency's (EPA) drinking water state revolving loan fund (DWSRF). Other sources, such as community development block grant money and state programs, may be available, too. (See "Besides SRF and RUS funding, what are some alternatives?" in the Winter 2003 *On Tap* for more information about water infrastructure financing.)

Community wells may also be funded from two programs not typically used in drinking water projects: the clean water state revolving loan fund (CWSRF), most often used for wastewater treatment, and the Superfund program, both overseen by EPA.

Although primarily used for wellhead protection, the CWSRF is sometimes used for community wells and drinking water protection. If your community's wells have been contaminated by industrial waste, the Superfund offers a potential way to pay for new ones.

Call the National Drinking Water Clearinghouse at (800) 624-8301 or e-mail ndwc_contact@mail.nesc.wvu.edu *to obtain contact information about your state's RUS, DWSRF, CWSRF, Wellhead Protection, or Superfund coordinator.*

Why is this drinking water system characteristic important for small systems?

"Because this trend has important implications for treatment and capital investments as raw water obtained from groundwater sources typically requires less treatment than raw water from surface water sources," notes EPA. So it's less expensive for small systems to produce water for small communities if they use groundwater as their source.

Precipitation replenishes groundwater. Depending upon the local climate and geology, groundwater also is unevenly distributed in quantity and quality. When rain falls or snow melts, not all of the water flows into streams or filters through the ground. Plants use some of that water, and some of it evaporates before it makes its way into streams or the ground. Because of this and how slowly groundwater moves, it can literally take years to replenish depleted reserves.

Confined and Unconfined Aquifers

A confined aquifer (sometimes called an artesian aquifer) is the saturated formation between low permeability layers, such as bedrock, that restrict movement of water vertically (meaning it cannot seep through the ground) into or out of the saturated formation. In other words, this area is drenched, contained, and pressurized.

Drilling a well into this type of aquifer is analogous to puncturing a pressurized pipeline. In some areas, confined aquifers produce water without pumps and are commonly known as flowing artesian wells. When pumping from confined aquifers, water levels often change rapidly over large areas. However, water levels will generally recover to normal when pumping ceases.

An unconfined aquifer (also called a water-table aquifer) is the saturated formation in which the upper surface fluctuates by adding or subtracting water. The upper surface of an unconfined aquifer is called the water table. Water held in an unconfined aquifer is free to move laterally in response to differences in the water table elevations.

Other Groundwater Basics

Between the land surface and the aquifer is a zone that hydrologists call the unsaturated zone. In this zone, a little water exists, but it's mostly in the smaller openings of soil and rocks. Larger openings usually contain air. Molecular attraction holds some water in the unsaturated zone, but it will not flow toward or enter a well. Any excess water will enter the water table.

Below the water table, all of the openings in rocks are full of water that moves through the aquifer to streams, springs, or wells. Natural refilling of an aquifer is a slow process. For example, geologists have estimated that if the aquifer that underlies the High Plains of Texas and New Mexico were drained completely dry, it would take thousands of years to replenish. (See the article "When Enough is Enough: Sustainable Development" in the Summer 2003 *On Tap*.)

What is not an aquifer?

If a water-bearing formation is not an aquifer, what is it? These formations are called aquitards or aquicludes. While they may contain water, they are not aquifers, says USGS.

An aquitard hinders groundwater flow. "Aquitards are semi-permeable, semi-confining geologic formations adjacent to or between aquifers that partially restrict the movement of groundwater," says the TNRCC.

For example, clay deposits generally tend to be confining layers. But, if that clay layer contains sand, it may distinguish it as a leaky aquitard. This means that aquitards not only restrict groundwater movement, they also can leak.

An aquiclude prohibits groundwater flow. In vicinities where clay is thick, widespread, and unfractured, it is called an aquiclude. Aquicludes are also known as confining or impermeable layers. They are generally an impervious barrier to groundwater movement and act as a confining layer to the aquifer. However, clay layers can store a considerable quantity of groundwater; it's just very difficult to retrieve.

Groundwater is everywhere. It may be only a few feet down or buried several hundred feet below ground, but it's there. And, by a number of accounts, we've known of its existence for a long time. Since we know it's there, we should take care of it.

For more information about groundwater, visit the U.S. Geological Survey's Web site at www.usgs.gov. *Additional information also may be found on the University of Kansas' Web site* www.kgs.ukans.edu/HighPlains/atlas/apdrdwn.htm. *The National Ground Water Association has a wealth of information about groundwater on their Web site as well at* www.ngwa.org.

On Tap Editor **Kathy Jesperson** has begun to work toward a masters in public health. She hopes to finish the degree in the next three years.