Ground-Water Source Development and Well Head Protection

Ground water sources have been used for drinking water supplies ever since man stumbled upon the first spring. Historically, ground water has always been regarded as superior to surface water as a source of quality drinking water. Communities were often located near springs for obvious reasons. However, as populations increased, smaller springs were unable to meet the demand for water.

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Technology eventually triumphed, and man was able to treat even the most polluted surface water. We became so proficient at treating water that filtered surface supplies became the primary source of water for many communities. This was advantageous for large populations that required large volumes of water. It was not necessarily the best choice for smaller communities.

During the boom in drinking water technology, the science of ground-water hydrology received less attention. Drilling for ground water was not regarded as "feasible" in many areas where surface water was readily available. Ground-water resources were not developed and many smaller communities were left with new treatment plants and large bills, for both the construction of the treatment facilities and for long-term treatment costs.

Using ground water has many benefits. Water treatment costs are minimized when a utility starts with the best quality raw water. Because ground water often has low turbidity and is less contaminated, it is less expensive to treat than surface water. Ground water is also less likely to contain water-borne disease organisms such as Giardia and Cryptosporidium.

Most fresh water on earth (about 85 percent) occurs as ice in glaciers. The remaining 15 percent is mostly ground water, compared to less than one percent of the world's fresh water occurring as surface water. That includes all the lakes, reservoirs, rivers, soil moisture, and water vapor on earth! (Basic Ground-Water Hydrology, U.S. Geological Survey Water Supply Paper 2220).

The occurrence of ground water is largely controlled by local geologic conditions and the amount of rainfall. Tennessee receives approximately 50 inches of rainfall per year, so rainfall is usually not a problem. Western Tennessee is underlain by sand and gravel formations which generally can produce sufficient ground water to meet most needs. In middle and eastern Tennessee, obtaining large amounts of ground water is a bit more complicated; but it can be done.

Middle and eastern Tennessee are underlain by rock formations. Yields in the range of 1 to 3 million gallons per day (MGD) are possible from many limestone aquifers that make up the Valley and Ridge Physiographic Province. While there are exceptions in areas of middle Tennessee and the Cumberland Plateau region, there is potential for obtaining significant quantities of ground-water in much of eastern Tennessee.

A thorough ground-water investigation should include a review of the geology of the study area. Some formations are much more likely to contain ground-water than others. In addition to local geologic conditions, stream characteristics should be studied. Discharge measurements are made to identify reaches of streams that are gaining water from the ground-water system and those areas with streams that lose surface water to the ground water system. This information is critical to locating the best sites for drilling productive test wells.

Public Water Systems which use springs determined to be under the influence of surface water, those systems that use less than two MGD, and any PWS planning to build or upgrade a conventional surface water treatment facility should consider developing their available ground-water resources. It is cost effective to do so.

Since water movement in eastern Tennessee is often along fractures and bedding-plane openings, it is important to drill several test wells to adequately explore for ground water. Unproductive wells are often drilled in areas where the utility happens to own property or near existing springs. Wells should be located in favorable geo-

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logic formations which have losing reaches of streams. Wells drilled near springs are often not productive since ground water has already been forced to land surface as it encounters less permeable rock formations. Public Water Systems (PWS) which use springs determined to be under the influence of surface water, those systems that use less than two MGD, and any PWS planning to build or upgrade a conventional surface water treatment facility should consider developing their available ground-water resources. It is cost effective to do so.

Costs for construction of treatment facilities are greatly reduced for direct filtration of groundwater compared to costs for conventional surface-water plants. Long term costs for treating ground water are also significantly lower because of lower chemical costs, less sludge disposal, lower operating expenses, and fewer monitoring requirements. In addition, ground water often has better taste, lower concentrations of trihalomethanes, and there is much less risk of transmitting water-borne disease organisms.

Once a ground water source is developed, the next step is to make sure it remains a high-quality source. This is best accomplished by implementing a Well Head Protection Program (WHPP). The objective of a WHPP is to delineate areas contributing recharge to a well or spring. This enables a PWS to be aware of existing threats to ground water and to make sure that future development has minimal risk of contaminating a public water supply.

Well Head Protection Programs in Tennessee will consist of two zones of protection. Zone 1 is an area with a fixed radius around the source. The radius for Zone 1 varies from 250 to 750 feet, depending on the size of the PWS. Zone 1 is important because contaminants in the immediate vicinity of well or spring can reach the water supply quickly.

Regardless of whether the PWS is in east or west Tennessee, Zone 2 will be delineated based on hydrologic parameters such as ground water flow direction, the size of the area believed to provide recharge, and local geologic conditions. Systems underlain by sand and gravel formations (west Tennessee) can use computer models to estimate their recharge areas. Because the assumptions of numerical models are not met in areas underlain by rock formations, PWS in middle and eastern Tennessee are required to use hydrologic mapping to delineate their recharge areas.

Well-head protection areas in west Tennessee will be delineated by "10 year time of travel" modeling. That is, water falling near the extreme boundary of the area will take 10 years to reach the well. This time frame will allow for less persistent chemicals to degrade before reaching the well. Data critical to modeling in western Tennessee include the direction of ground-water flow, the hydraulic gradient (slope of the water table), and pumping rate.

PWS in middle and eastern Tennessee are required to map the water table in the vicinity of wells or springs to identify ground-water divides. Contours on these maps, referred to as potentiometric maps, are similar to contours on topographic maps. Structural features such as sinkholes, faults, geologic contacts, and surface water bodies should also be considered since these features can influence ground-water flow. Control points (water levels in wells) of known elevation are necessary for accurate mapping. Dye tracing may be required to better define boundaries in areas with complex geology.

Once the area contributing recharge to a ground-water source is identified, a Contaminant Source Inventory must be compiled. The large number of potential threats to water quality in developed areas will come as a surprise to many. Chemicals used in industrial and agricultural activities present an array of contaminants that could result in the need for expensive treatment. Commonly used household products should also be considered in recharge areas with numerous septic tanks.

Delineation of recharge areas and an awareness of potential threats to water quality can then be used to establish mechanisms to protect our valuable ground-water supplies. Protection zones can be managed through zoning, ordinances, by establishing best management practices, and through agreements between public and private entities. It is important that the public be involved in the process. If included from the start, customers can be a valuable ally. After all, it's their water supply.

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Ground water is one of our most valuable natural resources. It can provide safer and relatively inexpensive potable water. Money that once went towards cleaning up a polluted surface-water source can be better spent improving the distribution system and providing higher salaries to keep competent personnel from seeking other ways of making a living. Check into your available ground-water.

You can't lose! ■

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