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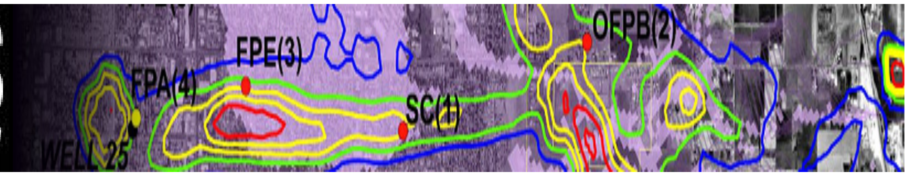

Evaluating Vulnerability of Public-Supply Wells to Contamination

Preliminary findings by the National Water-Quality Assessment (NAWQA) Program point to three factors that commonly affect the movement and fate of contaminants and vulnerability of public drinking-water supply wells, including:

- *When the water entered (or "recharged") the aquifer;*
- *Short circuits that allow water and associated contaminants to move more quickly to public-water supply wells than would be expected along typical flow paths; and,*
- *The general chemistry of the water and aquifer.*

Since 1991, NAWQA has studied the occurrence of more than 600 naturally occurring and anthropogenic compounds in drinking-water wells across the Nation, including in untreated water collected from more than 1,100 wells used for public supply. In general, compounds are detected frequently, often in mixtures, but seldom at concentrations likely to affect human health.

The NAWQA Program and many of its stakeholders, including local, State, and federal governmental agencies, drinking-water suppliers, and non-governmental organizations, recognized the need to better understand why certain compounds occur in public-supply wells and to develop an enhanced scientific basis to support improved drinking-water protection strategies. The Program, therefore, implemented an intensive study focused on understanding factors that affect the movement and fate of contaminants and vulnerability of public-supply wells (refer to USGS Fact Sheet 2005-3022). The study uses nationally consistent sampling protocols and analysis in nine areas across the Nation representing different environmental and hydrologic settings. Because subsurface processes and management practices differ among aquifers and water distribution systems, public-supply wells in different areas of the Nation are not equally vulnerable to contamination, even where there are similar contaminant sources. Study findings are intended to help water managers, policy makers, drinking-water suppliers, and scientists to:

- Better understand how and why contamination of public-supply wells occurs and whether water quality may get better or worse;
- Assess and predict vulnerability of ground water and public-supply wells to contamination, even in unmonitored areas;
- Choose new sites for water supply and develop and prioritize monitoring programs; and,
- Evaluate various pumping, resource-development, and land-management scenarios.

Summary of Significant Findings and Implications

Overall, NAWQA findings show that mixing of water with different ages in wells, short circuiting, and geochemical conditions affect the movement and fate of contaminants and vulnerability of public-supply wells in nearly all study areas across the Nation, despite different geographic and aquifer settings, as described below.

When the water entered (or "recharged") the aquifer. Screened or open intervals of public-supply wells are commonly tens to hundreds of feet in length and can capture water that is "recharged" at different times. Water from public-supply wells is, therefore, generally a mixture of water, entering at various depths, and of various ages associated with different land uses and potential sources of contamination from the land surface at the time of recharge. The mix of water of different ages produced by wells (or "age distribution of water") has several implications for contaminant transport to supply wells, including:

- Wells that draw a notable amount of older water (greater than 50 years) may not fully respond to land-surface activities and sources of contamination for decades. Even where cleanup and protection efforts have been initiated, concentrations of contaminants in these types of public-supply wells can lag years to decades, and even centuries, because of mixing a smaller proportion of young (more contaminated water) with a larger proportion of older water produced by wells. In some settings, observed low concentrations of contaminants in public-supply wells may be the early phases of "creeping normalcy"(which generally is defined as a major change that can be accepted as normal if it happens slowly in unnoticed increments, when it would otherwise be regarded as objectionable if it took place in a single step or short period).
- Water quality in public-supply wells that produce predominantly young water (less than 50 years) can respond relatively quickly (days to years) to land changes near the surface, including source protection efforts.
- Wells that draw a significant amount of young water less than one year old may be more vulnerable to pathogen contamination because pathogen survival is generally on the order of weeks to months.

Short circuiting of more typical flow paths. Under natural conditions, vertical and horizontal movement of ground water is often slow and can take decades to millennia for water to move through an aquifer system. NAWQA findings, however, show that pumping at public-supply wells in the vicinity of "short circuits" commonly allow water and associated contaminants to move more quickly to the wells than expected. Short circuits can include natural features, such as fractures in glacial till, solution channels in carbonate rock, and sinkholes, as well as human-related factors, such as abandoned or poorly constructed wells. Short-circuiting features bring to public-supply wells a higher percentage of young water, which is typically affected by, and more vulnerable to, contamination from human activities associated with urban and (or) agricultural land use than older water. In one study area, for example, seasonally pumped irrigation wells serve as short-circuiting features that allow young water to move downward through a laterally extensive and relatively impermeable confining unit and reach nearby public-supply wells. Surprisingly, the young water enters the public-supply wells beneath much older water flowing along uninterrupted and longer, more regional ground-water flow paths.

General chemistry of the water and aquifer. Processes that occur below land surface, which can affect contaminant sources, transport, and fate, are influenced by conditions within the aquifer, such as the amount of dissolved oxygen and the aquifer material itself. These processes and conditions result in contaminants being degraded, adsorbed, volatilized, dispersed and (or) mobilized as they move in the aquifer. Thus, an improved understanding of the geochemical conditions in the aquifer and contributing areas to wells is critical in determining the ultimate fate of contaminants in a public-supply well. For example, some compounds are stable in conditions with high dissolved oxygen (>0.5 milligrams per liter), and other compounds are stable in conditions with low dissolved oxygen. More compounds often are found in wells that simultaneously produce water from different parts of the aquifer representing both oxygenated and less oxygenated waters.

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For online reports and information: http://oh.water.usgs.gov/tanc/NAWQATANC.htm