



## Importance of Understanding Factors Affecting Public-Supply-Well Vulnerability to Contamination



Information on contaminant input, contaminant mobility and persistence, and intrinsic susceptibility within the area that contributes water to a well can help answer the question,

*“Which contaminants in an aquifer might reach the well and when, how, and at what concentration might they arrive?”*

Preferential flow pathways (pathways that provide little resistance to flow) are an additional factor affecting the vulnerability of water from public-supply wells because such pathways influence the relative importance of each of the other factors. Many types of information can be used to evaluate the influence of these factors on the quality of water from a public-supply well. The choice of information (or measures) to use depends on the knowledge that is desired and the scale of the assessment.

U.S. Geological Survey scientists found that the following measures—each related to a different aspect of public-supply-well vulnerability—are particularly useful for understanding the quality of water pumped from individual public-supply wells: (1) the sources of recharge that contribute water to a well, and the contaminants associated with the recharge—a measure of contaminant input; (2) the geochemical conditions encountered by water drawn into a well—a measure of contaminant mobility and persistence; and (3) the groundwater-age mixture of different waters that blend (or mix) in a well—a measure of intrinsic susceptibility.

*“...a good vulnerability assessment can help a water system focus its limited resources on those factors that present the greatest threat.”*  
Mike Ekberg, Miami (Ohio) Conservancy District

### Why is it important to understand the sources of recharge water for a well?

Different sources of recharge can contain different types and amounts of drinking-water contaminants.

- Identifying the sources of recharge that contribute water to different wells helps explain differences in contaminants and contaminant concentrations in wells that are close to each other but that draw in water from different recharge areas.
- A change in the source(s) of recharge for a public-supply well can bring about a change in the quality of the water produced by the well. Consequently, even a change in the general characteristics of the water from a well—temperature, pH, alkalinity, and dissolved-solids concentration—warrants investigation so that any new source(s) of water (and associated contaminants) for the well can be identified and managed to minimize adverse effects.

*“... information on using groundwater-chemistry data to help assess well vulnerability is a good addition to the wellhead protection concepts published by the USEPA in the early 1990s.”*  
Mike Wireman, U.S. Environmental Protection Agency, National Groundwater Expert

### Why is it important to understand the geochemical conditions encountered by water drawn into a supply well?

Geochemical conditions influence whether a contaminant that has been released to the groundwater will travel with the groundwater, react with the aquifer material, or degrade before reaching a public-supply well.

- Changes in groundwater flow in some aquifers have altered geochemical conditions and caused contaminants such as arsenic and uranium (which occur naturally in aquifer rock or sediment) to dissolve into the groundwater and migrate to public-supply wells. Consequently, monitoring is needed when developing aquifers for increased water supply so that changes in aquifer geochemical conditions that can affect drinking-water-contaminant concentrations do not go unnoticed.
- Communities that determine whether the water from their public-supply well(s) is being drawn from oxic, anoxic, or multiple geochemical (redox) zones within an aquifer will have insight into which drinking-water contaminants in the groundwater are likely to reach their well(s) and which are likely to be assimilated by the aquifer before the water arrives at a well.

*“Redox reactions are something that all professionals should consider when designing, installing and sampling wells.”*

Frederick Bloetscher, Associate Professor, Florida Atlantic University; AWWA, Water Resources Division Trustee

### **Why is it important to understand the ages of the different waters that blend (or mix) in a public-supply well?**

Public-supply wells produce water that recharged the aquifer over an extended period of time. The resulting groundwater-age mixture for a well directly affects the quality of the water produced by the well. For example, if a particular well's water corresponds to a period of recharge that is longer than the duration of contaminant input, some in-well dilution of contaminants entering the well will occur.

- Knowledge of groundwater-age mixtures can be used to help prioritize protection efforts. For example, managing contaminant sources within source-water protection areas defined by groundwater traveltime is more beneficial for wells that produce predominantly young water than for wells that produce water that is generally older than the specified traveltime.
- Understanding that there is a tradeoff when a well is deepened to decrease its vulnerability to anthropogenic contaminants in young, shallow groundwater can help guide development decisions; deeper water that has been in contact with the aquifer material for a longer period of time often contains higher concentrations of naturally occurring drinking-water contaminants that can be more difficult to remove from the water, such as arsenic.
- Recognizing that several years or even decades of monitoring will not be enough to characterize water-quality changes in wells that produce predominantly old water can lead to better monitoring programs. A combined monitoring and modeling approach is needed for such wells to determine how long contaminant concentrations will continue to increase in the produced water after nonpoint-source-contaminant input at the water table is reduced.

*“Preferential flow pathways are significant in many hydrogeologic settings and need to be taken into account by those involved in establishing source water protection areas for public water-supply wells.”*

Darcy Campbell, U.S. Environmental Protection Agency, Region 8

### **Why is it important to know whether a preferential flow pathway is influencing the quality of water from a public-supply well?**

A preferential flow pathway is a subsurface route that provides little resistance to groundwater flow, such as a bedrock fracture or the wellbore of a non-pumping well. Preferential flow pathways often deliver the youngest, most vulnerable groundwater to a well.

- When preferential flow pathways are indicated, protecting a delineated area around a public-supply well from contamination is necessary but may be insufficient for protecting the well's water from contamination. This is because preferential flow pathways make it difficult to know where the youngest groundwater that is drawn into a well actually originates. In such cases, a general campaign to engage the entire community in groundwater protection might be worthwhile.
- Because preferential flow pathways often deliver young vulnerable groundwater to wells, the ability to recognize the influence of preferential flow pathways on the quality of water from a well can help resource managers prioritize monitoring and protection of their most vulnerable wells. One way to identify the influence of preferential flow pathways is to look for water-quality patterns in historic well records. For example, seasonal water-quality fluctuations in the records for a deep public-supply well can indicate preferential flow because recharge water is not likely to travel from the water table through the aquifer matrix to a deep well screen within a single season.
- If manmade preferential flow pathways (such as wells screened through multiple aquifers or screened through different geochemical zones within the same aquifer) are affecting the quality of water being produced by a public-supply well, resource managers have an opportunity to devise effective means of preventing or minimizing flow through these features and reduce the vulnerability of the water from the well to contamination.

*“The variety of tools in this circular (Circular 1385 from the USGS NAWQA TANC study) will be valuable to source water protection practitioners.”*

Chi Ho Sham, The Cadmus Group, Inc.; American Water Works Association, Water Resources Division Trustee

### **For additional information:**

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