

ground water at high velocity in a direct flow path with little time or opportunity for die-off or removal of microbial pathogens. Consolidated aquifers, fractured bedrock, and karst limestone are aquifers in which surface water may enter into a pumping well by flow along a fracture, a solution-enhanced fracture conduit, or other preferential pathway. Microbial pathogens found in surface water are more likely to be transported to a well via these direct or preferential pathways. *Cryptosporidium* outbreaks have been associated with consolidated aquifers, such as a fractured chalk aquifer (Willocks *et al.* 1998) or a karst limestone (solution-enhanced fractured) aquifer (Bergmire-Sweat *et al.* 1999). These outbreaks show that the oocyst removal performance of consolidated aquifers is undermined by preferential water flow and oocyst transport through rock fractures or through rock dissolution zones. Wells located in these aquifers are not eligible for bank filtration credit because the flow paths are direct and the average ground water velocity is high, so that little inactivation or removal would be expected. Therefore, only unconsolidated aquifer are eligible for bank filtration oocyst removal credit.

A number of devices are used for the collection of ground water including horizontal and vertical wells, spring boxes, and infiltration galleries. Among these, only horizontal and vertical wells are eligible for log removal credit. The following discussion presents characteristics of ground water collection devices and the basis for this proposed requirement.

Horizontal wells are designed to capture large volumes of surface water recharge. They typically are constructed by the excavation of a central vertical caisson with laterals that extend horizontally from the caisson bottom in all directions or only under the riverbed. Horizontal wells are usually shallower than vertical wells because of the construction expense. Ground water flow to a horizontal well that extends under surface water is predominantly downward. In contrast, ground water flow to a vertical well adjacent to surface water may be predominantly in the horizontal direction. Surface water may have a short ground water flow path to a horizontal well if the well extends out beyond the bank.

Hancock *et al.* (1998) analyzed samples from eleven horizontal wells and found *Cryptosporidium*, *Giardia* or both in samples from five of those wells. These data suggest that some horizontal wells may not be capable of achieving effective *Cryptosporidium* removal by bank filtration. Insufficient data are

currently available to suggest that horizontal well distances from surface water should be greater than distances established for vertical wells. Two ongoing studies in Wyoming (Clancy Environmental Consultants 2002) and Nebraska (Rice 2002) are collecting data at horizontal well sites.

A spring box is located at the ground surface and is designed to contain spring outflow and protect it from surface contamination until the water is utilized. Spring boxes are typically located where natural processes have enhanced and focused ground water discharge into a smaller area and at a faster volumetric flow rate than elsewhere (*i.e.*, a spring). Often, localized fracturing or solution enhanced channels are the cause of the focused discharge to the spring orifice. Fractures and solution channels have significant potential to transport microbial contaminants so that natural filtration may be poor. Thus, spring boxes are not proposed to be eligible for bank filtration credit.

Cryptosporidium monitoring results (Hancock *et al.* 1998) and outbreaks are used to evaluate ground water collection devices. Hancock *et al.* sampled thirty five springs for *Cryptosporidium* oocysts and *Giardia* cysts. Most springs were used as drinking water sources and sampling was conducted to determine if the spring should be considered as a GWUDI source. *Cryptosporidium* oocysts were found in seven springs; *Giardia* cysts were found in five springs; and either oocysts or cysts were found in nine springs (26%). A waterborne cryptosporidiosis outbreak in Medford, Oregon (Craun *et al.* 1998) is associated with a spring water supply collection device. Also, a more recent, smaller outbreak of giardiasis in an Oregon campground is associated with a PWS using a spring. The high percentage of springs contaminated with pathogenic protozoan, the association with recent outbreaks, and an apparent lack of bank filtration capability indicate that spring boxes must not be eligible for bank filtration credit.

An infiltration gallery (or filter crib) is typically a slotted pipe installed horizontally into a trench and backfilled with granular material. The gallery is designed to collect water infiltrating from the surface or to intercept ground water flowing naturally toward the surface water (Symons *et al.* 2000). In some treatment plants, surface water is transported to a point above an infiltration gallery and then allowed to infiltrate. The infiltration rate may be manipulated by varying the properties of the backfill or the nature of the soil-water interface. Because the filtration

properties of the material overlying an infiltration gallery may be designed or purposefully altered to optimize oocyst removal or for other reasons, this engineered system is not bank filtration, which relies solely on the natural properties of the system.

A 1992 cryptosporidiosis outbreak in Talent, Oregon was associated with poor performance of an infiltration gallery underneath Bear Creek (Leland *et al.* 1993). In this case, the ground water-surface water interface and the engineered materials beneath did not sufficiently reduce the high oocyst concentration present in the source water. The association of an infiltration gallery with an outbreak, the design that relies on engineered materials rather than the filtration properties of natural filtration media, and the shallow depth of constructed infiltration galleries, such that they typically are not located greater than 25 feet from the surface and surface water recharge, all indicate that infiltration galleries must not be eligible for bank filtration credit.

EPA notes that under the demonstration of performance credit described in section IV.C.17, States may consider awarding *Cryptosporidium* removal credit to infiltration galleries where the State determines, based on site-specific testing with a State-approved protocol, that such credit is appropriate (*i.e.*, that the process reliably achieves a specified level of *Cryptosporidium* removal on a continuing basis).

Wells Located 25 Feet From the Surface Water Source Are Eligible for 0.5 Log Credit; Wells Located 50 Feet From the Surface Water Source Are Eligible for 1.0 Log Credit

A vertical or horizontal well located adjacent to a surface water body is eligible for bank filtration credit if there is sufficient ground water flow path length to effectively remove oocysts. For vertical wells, the wellhead must be located at least 25 horizontal feet from the surface water body for 0.5 log *Cryptosporidium* removal credit and at least 50 horizontal feet from the surface water body for 1.0 log *Cryptosporidium* removal credit. For horizontal wells, the laterals must be located at least 25 feet distant from the normal-flow surface water riverbed for 0.5 log *Cryptosporidium* removal credit and at least 50 feet distant from the normal-flow surface water riverbed for 1.0 log *Cryptosporidium* removal credit.

The ground water flow path to a vertical well is the measured distance from the edge of the surface water body, under high flow conditions (determined by the mapped extent of the 100 year