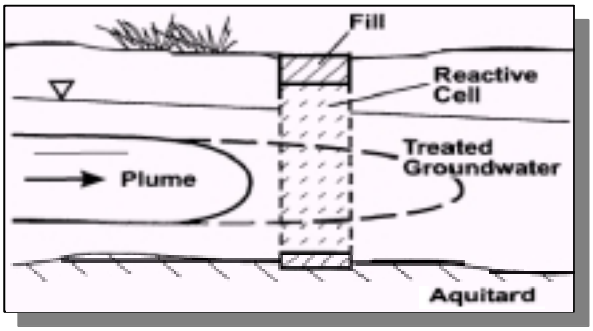
Perchlorate Treatment Technology Fact Sheet

Permeable Reactive Barriers

What Are Permeable Reactive Barriers (PRB)?

The PRB is a groundwater cleanup technology that consists of a wall of reactive material installed in the path of a flowing contaminated groundwater plume to treat pollutants as they penetrate through the wall. The PRB contains materials that target specific contaminants and chemically and/or biologically degrades them. Optimally, after passing through the PRB, the groundwater pollutants will be less toxic, more readily biodegradable, or otherwise removed from the plume. As with any biological treatment system, PRBs require careful control of environmental conditions within the reactive zone to maintain the anaerobic conditions that encourage the bacteria to biodegrade the perchlorate. The regular addition of nutrients and electron donors can potentially be expected depending on the efficiency of the PRB system and the reactive material used.



Conceptual design of PRB system for in situ remediation of perchlorate

PRBs can be installed in one of two basic ways: trench systems or funnel-and-gate systems. As the name implies, trench sytems consist of a trench or series of trenches that are excavated across the entire path of the plume and backfilled with reactive media. Funnel-and-gate systems have solid walls that direct the flow of contaminated groundwater plume through a gate containing the reactive media. PRBs are increasingly being used to treat a variety of groundwater contaminants and are recognized as a cost-effective, passive remediation method. In the case of a PRB designed to treat perchlorate, the reactive material within the PRB creates an anaerobic condition that enables naturally occurring microorganisms to biodegrade perchlorate.

Where Have PRBs Been Used to Treat Perchlorate?

The DOD has successfully used PRBs to treat perchlorate at the Naval Weapons Industrial Reserve Plant McGregor (NWIRP McGregor). NWIRP McGregor is an inactive facility located 20 miles southwest of Waco, Texas. The facility has been owned by the US Army, the US Air Force, and the US Navy over its 50-year history. The perchlorate contamination in the shallow groundwater below this facility is a result of past industrial activities associated with the manufacture of solid-fuel rocket motor propulsion systems. After examining several remediation alternatives, the Southern Division Naval Facilities Engineering Command selected a PRB system to intercept and treat perchlorate-contaminated groundwater, and prevent its movement toward surface waters. The system is believed to represent the first successful *in situ* bioremediation of perchlorate.

Perchlorate Contamination, NWIRP McGregor

Perchlorate has been detected in groundwater at concentrations ranging from 4 to 91,000 parts per billion (ppb). It has also been detected in surface water at the McGregor property line at concentra-

Site Facts

Location: NWIRP McGregor, Texas

Site Description: Former solid rocket motor manufacturing facility consisting of isolated manufacturing cells spread across 9600 acres

Contaminated Media: Groundwater

Treatment Technology: PRB system consisting of interceptor trenches and *in situ* anaerobic biological treatment

Objective: Abate offsite migration of perchlorate and impacts to surface water

Status: Full-scale field demonstration

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tions nearing 5,600 ppb, and in springs within the property area at concentrations up to 22,000 ppb. Water from the McGregor area eventually feeds into the Leon River and Lake Belton, which serve as drinking water sources for surrounding communities.

NWIRP McGregor PRB Description and Performance

The McGregor PRB system consists of three individual trenches, with a combined length of approximately one mile, dug to a depth of up to 25 feet below ground surface (bgs). Each trench is backfilled with highly permeable, reactive material consisting of gravel (for drainage), organic material, and electron donor. These materials create the anaerobic conditions needed to grow the bacteria that degrade the perchlorate. Within three weeks after trench construction and start of operation at McGregor, the perchlorate concentration of groundwater decreased by at least 90% from 27,000 ppb. After more than a year and a half of operation, the PRB system is still effectively reducing the perchlorate in the groundwater. The total estimated amount of perchlorate leaving the site has been reduced from over 60 pounds per month to less than 0.5 pounds per month. Initial results also indicate that trichloroethylene (TCE), another pollutant at the site, is also being biodegraded to below detection limits by the PRB.

Cost Effectiveness

The most costly aspect of the McGregor PRB system was installing the 6,185 feet (over 1 mile) of trenches, costing an estimated $833,000. However, the *in situ* system has allowed the US Navy to save millions of dollars in cleanup costs while reducing perchlorate concentrations to at or below the current detection limit. Capital cost avoidance has been estimated at more than $3 million compared to *ex situ* technologies. In addition, operation and maintenance costs are estimated at $5,000 per year versus $100,000 per year for *ex situ* technologies. The PRB is expected to last between 8 to 15 years before the PRB system must be replaced.

PRB Installation at NWIRP McGregor

PRB System Advantages

- Passive, *in situ* cleanup technology – no external energy source is required
- Sites can be used productively during clean up – limited above ground structures required
- Can remediate groundwater plumes even when the source term of the plume cannot be located
- Should not alter the overall groundwater flow pattern as much as high-volume pumping
- Cost and performance and long-term operational data are limited; however, PRB systems are believed to be effective – they can treat groundwater for an estimated 25% of the costs of conventional pump and treat systems

PRB System Disadvantages

- Groundwater monitoring system usually required for regulatory compliance, to measure performance and provide early warning of potential PRB failure
- Potential clogging from biological or chemical precipitates, requiring additional maintenance
- Because proper construction of a PRB requires excavation of soil down to the water table, depth to groundwater can limit whether PRBs can be installed
- Abnormal seasonal or climatic variations in the groundwater flow that overwhelms the PRB or draught periods that dry the PRB will affect the microbial populations and effectiveness of the system
- Potential construction complications with existing aboveground structures and underground utilities
- Does not treat plume area present down gradient of the barrier installation

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