Permeable Reactive Barriers: Lessons Learned/New Directions (PRB-4)

EXECUTIVE SUMMARY

Lessons Learned/New Directions was prepared by the ITRC Permeable Reactive Barriers Team to update previous guidance written by the team. The goal for this document was to compile the information and data on permeable reactive barriers (PRBs) that have been generated over the last 10 years of technology development and research, as well as to provide information on non-iron-based reactive media that can be used in PRBs. This document also provides an update on a developing technology somewhat related to PRBs in which source zone contamination is treated with iron-based reactive media.

A PRB is defined as an in situ permeable treatment zone designed to intercept and remediate a contaminant plume. Zero-valent iron is the most common media used in PRBs to treat a variety of chlorinated organics, metals, and radionuclides. Reactive media such as carbon sources (compost), limestone, granular activated carbon, zeolites, and others had also been deployed in recent years to treat metals and some organic compounds.

The proper design of a PRB is highly dependent on a complete and accurate site characterization. A conceptual site framework is discussed as a means to perform a detailed characterization for PRB deployment. Collection of hydrogeologic, geochemical, microbial, and geotechnical data along with the complete vertical and horizontal plume delineation are necessary to characterize a PRB site. The Triad concept is also introduced as a means to gather site data.

The design of a PRB can be enhanced using probabilistic modeling to incorporate the variability of the input design parameters. Construction advancements include the use of biopolymer for trench stabilization or the use of vertical hydraulic fracturing for reactive media emplacement. Several other factors that can affect the construction and performance of the PRB, such as variability in the reactive media or permeability contrasts between the reactive media and the aquifer must be considered in the system design.

Hydraulic, geochemical, and microbial assessment of the PRB is all part of the performance assessment of the PRB system. Evaluation of the longevity of a PRB system has been examined using long-term column tests. The two systems studied resulted in predictions of decades before the PRBs will lose reactivity. Depending on several site-specific conditions, PRBs are now expected to last 10–30 years before reactivity or hydraulic issues will result in the need for maintenance.

Monitoring is discussed in terms of performance and compliance objectives. Details are offered on monitoring well placement, frequency of sampling, sampling parameters and methods. Passive sampling techniques such as low-flow sampling or the use of permeable diffusion bags are recommended for PRBs to obtain the most representative samples. All regulatory permits necessary for the installation of a PRB are identified, and some state specific permit information is provided. The need for institutional controls, evaluation of downgradient water chemistry, identification of reactive media impurities, and information on biostat addition as well as the development of contingency and closure plans are highlighted as other regulatory concerns.

An offshoot of the technology involves the use of iron media to treat source zones. This remedial measure is not considered a PRB but is presented since the reactive media and treatment

mechanism are related. A detailed discussion and site-specific examples are presented of this developing technology.

Health and safety issues are addressed with emphasis on concerns related to PRB installation as well as the typical construction concerns that are part of this remedy. Stakeholders, defined as any nonregulatory interested party, also have some outlined concerns with this technology that should be addressed as part of the PRB deployment.

The costs of PRB systems are compared to those of other technologies. While not as cost-effective as groundwater remedies like monitored natural attenuation or bioremediation, PRBs can compare favorably to groundwater pump-and-treat systems. Since PRBs provide a mostly passive remediation technology, cost reductions can be found in the operation and maintenance of the system. The document provides site-specific examples of PRB system costs.

Since the 1994 introduction of the first zero-valent iron PRB in the United States, this technology has developed from innovative to accepted standard practice. Several issues surrounding the use of PRBs—such as accurately predicting the longevity of a system—have yet to be conclusively answered, but as the technology continues to mature and some of the early PRB installations age, these challenging issues will become the main focus for additional research and development.