GROUNDWATER & ENVIRONMENT NEWSLETTER

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PERMEABLE REACTIVE BARRIERS

A permeable reactive barrier (PRB) is an in-situ method of groundwater remediation where a barrier material e.g. a trench, backfilled with reactive material (e.g. iron filings, activated carbon, peat, wood-chip et al) is used to absorb and/or transform the contaminant as the groundwater plume passes through the barrier.

The method generally combines a passive chemical or biological treatment zone with groundwater flow management. The barrier is placed perpendicular to the flow direction to intersect the plume. The contaminants are concentrated & either degraded or retained in the barrier material. The barrier material will either degrade or retain the contaminants in a concentrated form. The main types are:

Funnel and Gate

This comprises low permeability (e.g. k~1E-6 cm/s) cut-off walls (the funnel) which concentrate the plume flow through a high k gate (or opening), which contains in situ reaction zones. The type of cut-off walls normally used in current practice is trenched slurry walls or sheet piles. Other innovative methods include deep soil mixing & jet grouting et al.

Iron Treatment Wall

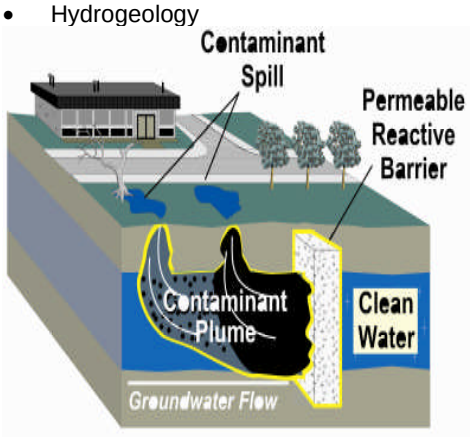
An iron treatment wall consists of zero-valent iron (ZVF) granules or other iron bearing minerals for treatment of chlorinated organic contaminants such as TCE, DCE, and VC. As the iron is oxidized by reaction with the plume, a chlorine atom is removed from the contaminant by one or more reductive dechlorination mechanisms, using electrons from the oxidation of the iron. The iron granules are dissolved by the process, but this occurs so slowly that the remediation barriers can be expected to remain effective for many years or decades.

Often multiple barriers are used to achieve treatment of complex chemical mixtures.

Design Parameters

Factors to be considered in the design:

- Plume size/ dimension/ thickness/ shape
- Minimisation of residence time
- Hydrogeology



Data Requirements:

- Hydraulic gradient;
- Contaminant characteristics (type, concentration, mixtures, areal extent);
- Depth to ground water, including level fluctuations/ seasonality;
- Depth to impermeable aquitard;
- Site stratigraphy;
- Background water quality,
- Flow rate, and direction;
- Soil permeability; and
- Buffering capacity

Time Scale

PRB may take many years before effective clean-up is achieved. The most important factors influencing clean up time are:

- Type of contaminants
- Nature of aquifer influencing the groundwater contaminant transport

Advantages:

- Can be applied in urban areas
- Useful for a variety of groundwater contaminants, including chlorinated solvents, other organics, metals, inorganics (e.g. nitrates) & radionuclides et al.
- After installation of PRBs the site is still available for other use and activities.
- No mixing of clean and contaminated water.
- Acquisition and operational costs are relatively lower (EPA 2002).
- Lower influence to the groundwater regime (compared to e.g. pump & treat)
- Minimal exposure at surface as contaminants are not pumped out
- No surface construction required

Disadvantages

- May not be highly effective with petroleum hydrocarbons
- Contaminated soil is not removed.
- More suitable for relatively shallow & simple aquifer systems
- Limited to sites underlain by a continuous aquitard at depths within the limits of trenching equipment.
- Treatment wall permeability may decrease due to precipitation of metal salts, clogging & biofouling of reactive media leading to flow being impeded
- More suitable for well characterised & localised plumes.
- Detailed prior aquifer/hydrogeological information is needed
- Treatment media may lose their reactive capacity, requiring periodic replacement
- Spent reactive media needs to be removed after the operation & represents a waste disposal issue
- Requires ongoing monitoring & maintenance over prolonged periods
- Volume cost of treatment medium.

Indicative Costs

COST (Australian $$) PER 0.764555m^3 (of GW Treated) - (USEPA, FRTR V04).

- $0.22 – Small Site - Easy
- $0.29 Small Site - Difficult
- $0.11 Large Site - Easy
- $0.185- Large Site – Difficult

References

Permeable reactive barrier network http://www.prb-net.org
EPA Clean-up Information System http://www.clu-in.com
http://www.clu-in.org/techfocus/default.focus/sec/PermeableReactiveBarriers/PermeableTreatmentZonesandApplicationofZeroValentIron/cat/Overview/

Next issue –In-situ Chemical Oxidation

Rust never sleeps

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