

Haz Waste: Containment

- Soil
 - Vegetation (phytoremediation)
 - Cap
- Groundwater
 - Pump and Treat (active)
 - Cut-off walls (passive)
- Soil Vapor
 - Soil vapor extraction (active)

Passive Control: Cover

- Capillary barrier
 - Fine sand over coarse sand
 - Water held in upper sand lost by evaporation
 - Good for arid conditions where clay might crack
- Clay cover or composite with membrane
- Drainage layer

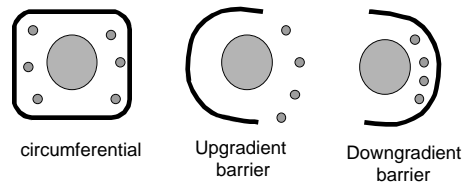
Vertical GW Barriers

- Slurry Trench Cut-off walls
 - Slurry trench allows vertical trench walls
 - Constructed of low permeability materials
 - Usu. $K < 1E-7$ cm/s (soil:bentonite)
 - Key into confining layer if possible
 - Other types
 - Cement-bentonite slurry wall
 - K $1E-5$ to $E-6$ cm/s, excav soil not used
 - Plastic concrete slurry wall
 - K $1E-7$, good strength, high chem resistance
 - Composite slurry wall
 - Geomembrane on trench walls decrease K , but chemccal compatibility concerns

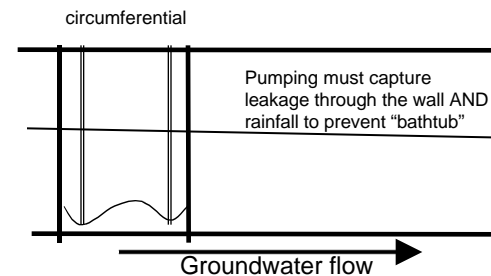
Other Vertical Barriers

- Steel sheet piling
 - Limited drive depth, limited soil types
 - “Sheet” 10-20'H x 20-40'L
 - Joints are “weak” spot where leakage can occur, usually grouted
- Grout curtain
 - Use in fractured rock (not excavatable soil)
 - Pressure inject cement or other chemical slurry into fractures and voids...then grout hardens
 - Hazardous chemicals can break down grout

Vertical Cut-off Wall Dsns: Plan Views



Vertical Cut-off Walls: Profile View



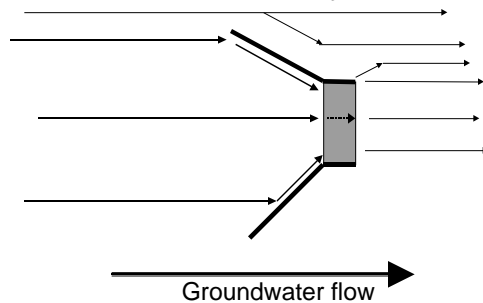
Vertical GW Barriers

- Extreme water table gradients induced across the barriers
 - Note the large “dh” over the small “dl” thickness of the wall
 - If soil:bentonite slurry wall has K of 1E-7 cm/s, what is the flow through the up-gradient barrier if the upgradient water table is 500’ ASL and the water table immediately across the wall is 490’ ASL?
 - 1 m wide wall
 - Confining layer 488’ ASL, wall 20 m long
 - $Q = K(dh/dl)A = 1E-7 \text{ cm/s} * (10'/1\text{m}) * (20\text{m} * 12')$
 - $Q = 0.223 \text{ cm}^3/\text{sec} = 19.3 \text{ L/d}$

Reactive Walls

- “funnel and gate” approach
 - Use cut-off walls with low permeability to contain GW migration
 - Instead of pumping out water “captured” by the cut-off walls, route it through a reactive zone (gate) to treat it
 - Gate of higher permeability than the natural soil
 - Width of gate based on reaction rate with passing GW
 - Types of gates: bioreactive, iron reaction wall, volatilization,...

Reactive Wall System



Reactive Wall

- Routing larger “Q” from aquifer thru zone
- Make zone with larger porosity to minimize velocity and prevent head build-up (ex: gravel)

- Time needed in wall for reactions determines thickness
 - If natural $i = 0.01$, $K = 1E-4 \text{ cm/s}$, $n = 0.3$
 - Put 50 m cross-flow thru 5 m wide wall
 - Velocity in wall with $K = 0.1 \text{ cm/s}$, $n = 0.4$, =?
 - $Q_{aq} = KiA = 1E-4 \text{ cm/s} * (0.01) * 50\text{m} * d = 5E-3 \text{ d cm}^2/\text{s}$
 - $V_{wall} = Q/A_n = 5E-3 \text{ d cm}^2/\text{s} / 5\text{m} * d / 0.04 = 2.5E-5 \text{ cm/s} = 2.16 \text{ cm/d}$ (if gradient the same)
 - Gradient wall = $dh/dl = Q/A K_w = 5E-3 \text{ d cm}^2/\text{s} / 5\text{m} * d / 0.1 \text{ cm/s} = 0.0001 < \text{natural (OK)}$
 - If 1st order reaction ($k = 0.1 \text{ d}^{-1}$) to degrade 1 mg/L to 0.01 mg/L, what wall thickness needed?
 - $dS/dt = k S ; \ln(1/0.01) = k t ; 4.6/0.1 \text{ d}^{-1} = 46 \text{ d} = t$
 - Thickness = $V_{wall} * t = 2.16 \text{ cm/d} * 46 \text{ d} = 1 \text{ m}$

Horizontal Barriers to GW flow

- Landfill liner systems & similar
- For remediation, need to construct under existing contamination, esp. for DNAPLs
 - Hydraulic fracturing by high pressure first, then grout pumped into fractures (soil)
 - Lagoon-sealing
 - Spread bentonite granules on water surface, particles sink, hydrate, and form liner