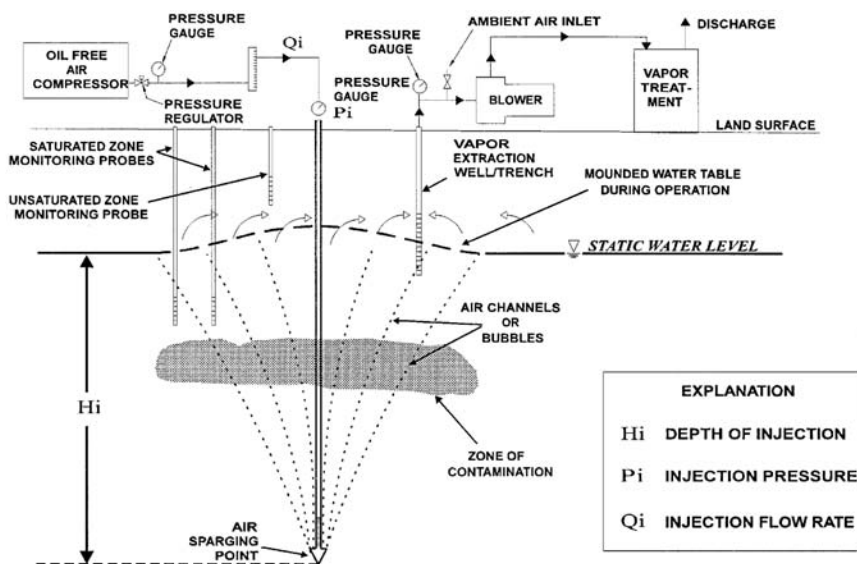


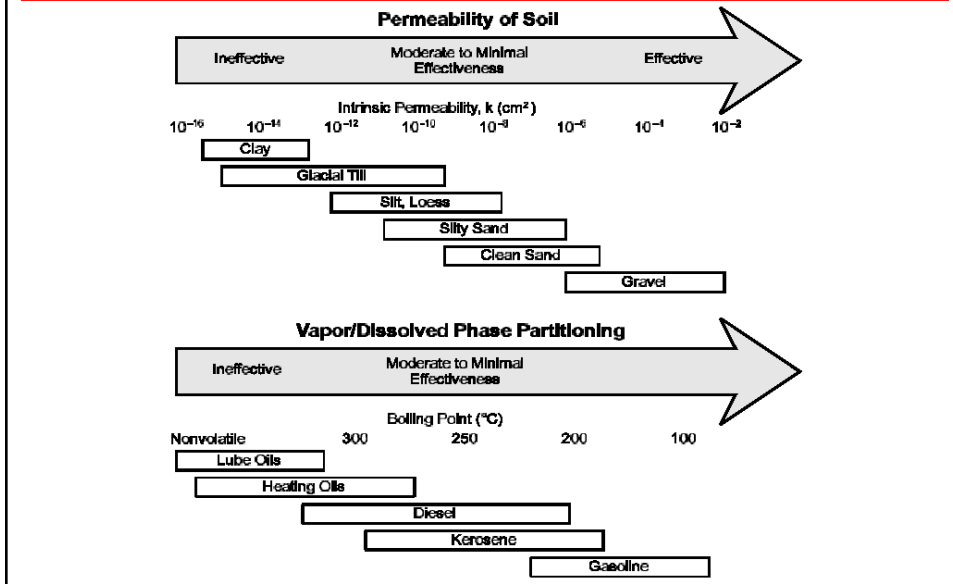
Air Sparging

- An *in situ* remedial technology that reduces concentrations of volatile organics dissolved in groundwater, adsorbed to soils, and trapped in soil pores in saturated zone
- Involves the injection of contaminant-free air into the subsurface saturated zone, enabling a phase transfer of hydrocarbons from a dissolved state to a vapor phase, or enhanced aerobic biodegradation
- Applicable to the lighter gasoline constituents (i.e., BTEX); less applicable to diesel fuel and kerosene
- Often used together with soil vapor extraction

Air Sparging



Effectiveness of Air Sparging



Mass Removal Processes

- *In situ* air stripping of dissolved VOCs
 - Henry's law constant
 - Air channels
- Volatilization of trapped and adsorbed phase contamination present below the water table and in the capillary fringe
 - Vapor pressure
- Aerobic biodegradation of both dissolved and adsorbed phase contaminants
 - Diffusion limited oxygen transfer
 - only important with long-term system operation

Contaminant Applicability

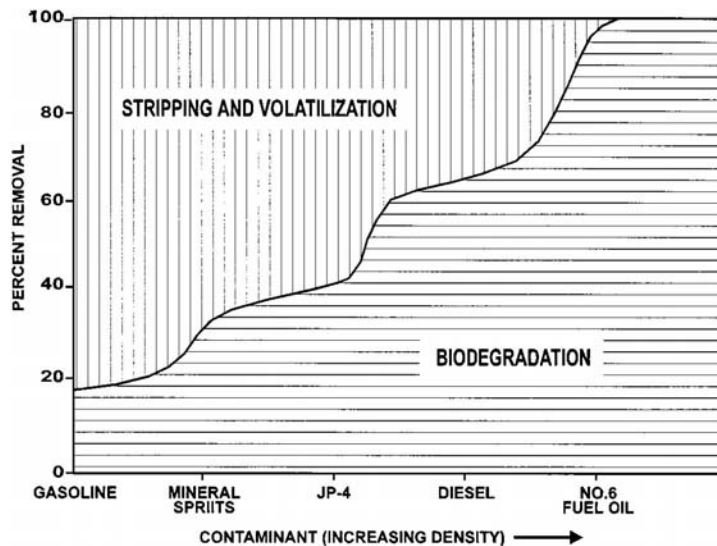
Contaminant	Strippability	Volatility	Aerobic biodegradability*
Benzene	High ($H = 5.5 \times 10^{-3}$)	High ($V_p = 95.2$)	High ($t_{1/2} = 240$)
Toluene	High ($H = 6.6 \times 10^{-3}$)	High ($V_p = 28.4$)	High ($t_{1/2} = 168$)
Xylenes	High ($H = 5.1 \times 10^{-3}$)	High ($V_p = 6.6$)	High ($t_{1/2} = 336$)
Ethylbenzene	High ($H = 8.7 \times 10^{-3}$)	High ($V_p = 9.5$)	High ($t_{1/2} = 144$)
TCE	High ($H = 10.0 \times 10^{-3}$)	High ($V_p = 60$)	Very low ($t_{1/2} = 7704$)
PCE	High ($H = 8.3 \times 10^{-3}$)	High ($V_p = 14.3$)	Very low ($t_{1/2} = 8640$)
Gasoline constituents	High	High	High
Fuel oil constituents	Low	Very low	Moderate

Note: H = Henry's law constant ($\text{atm}\cdot\text{m}^3/\text{mol}$); V_p = vapor pressure (mmHg) at 20°C; $t_{1/2}$ = half-life during aerobic biodegradation, hours.

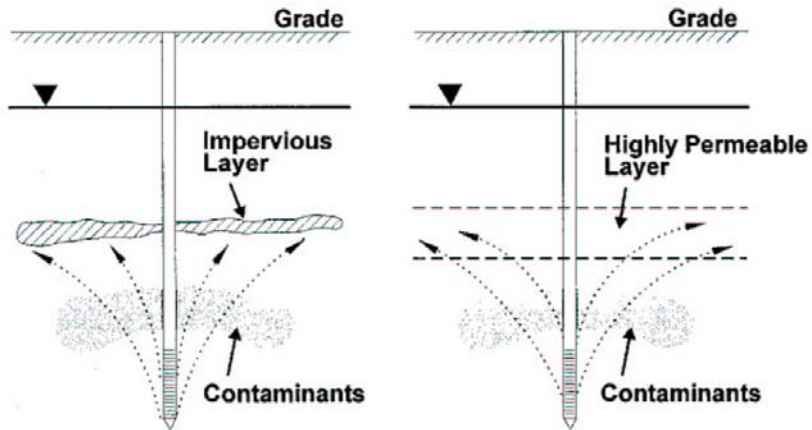
$$H > 10^{-5}$$

$$V_p > 0.5$$

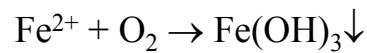
Contaminant Applicability



Geologic Considerations

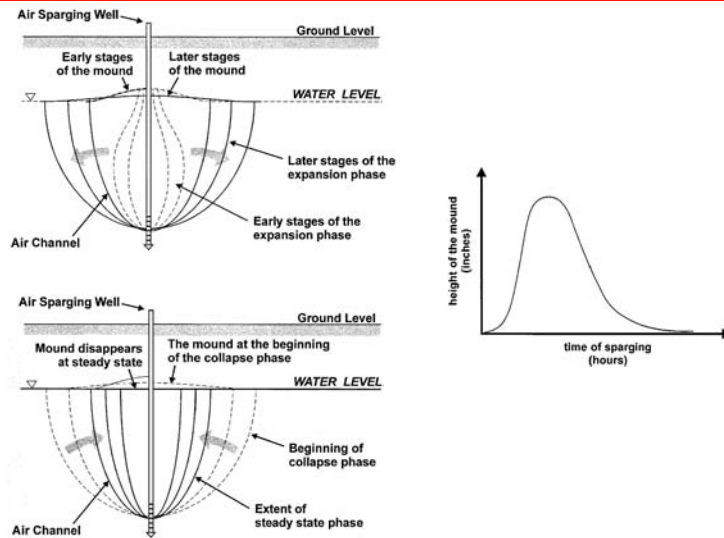


Dissolved Fe and Effectiveness



<u>Dissolved Iron Concentration (mg/L)</u>	<u>Air Sparging Effectiveness</u>
$\text{Fe}^{+2} < 10$	Air sparging effective
$10 \leq \text{Fe}^{+2} \leq 20$	Air sparging wells require periodic testing and may need periodic replacement
$\text{Fe}^{+2} > 20$	Air sparging not recommended

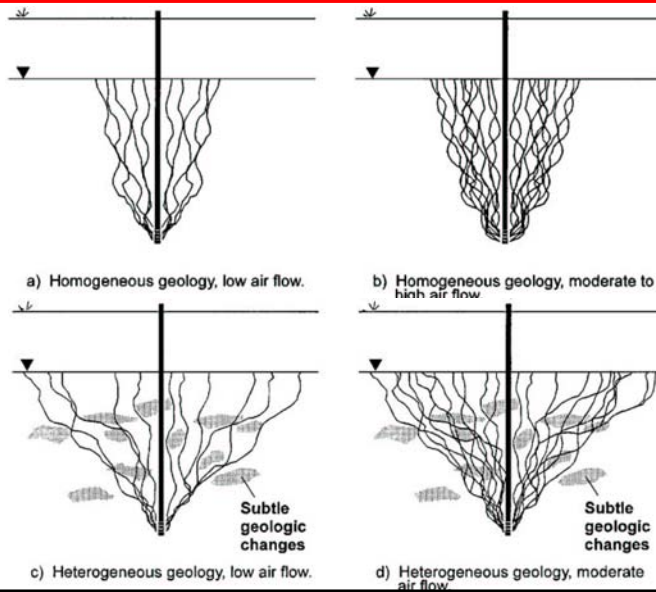
Mounding of Water Table



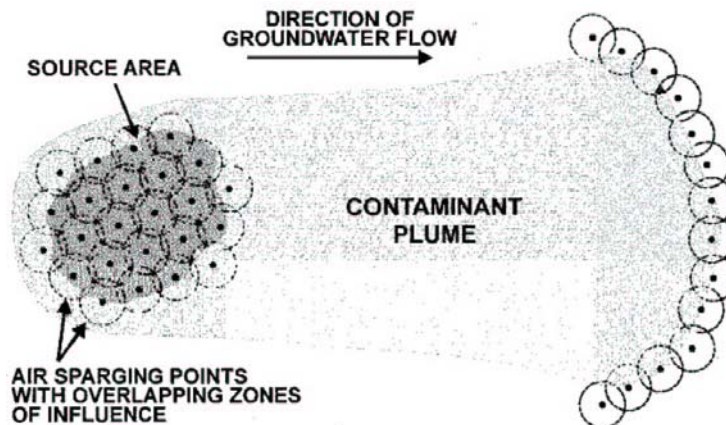
Groundwater Mixing

- Physical displacement by injected air
- Friction drag by flowing air
- Water flow in response to evaporative loss
- Thermal convection
- Migration of fines
- Groundwater mixing important for enhanced mass transfer of VOCs and transport of dissolved oxygen for *in situ* bioremediation

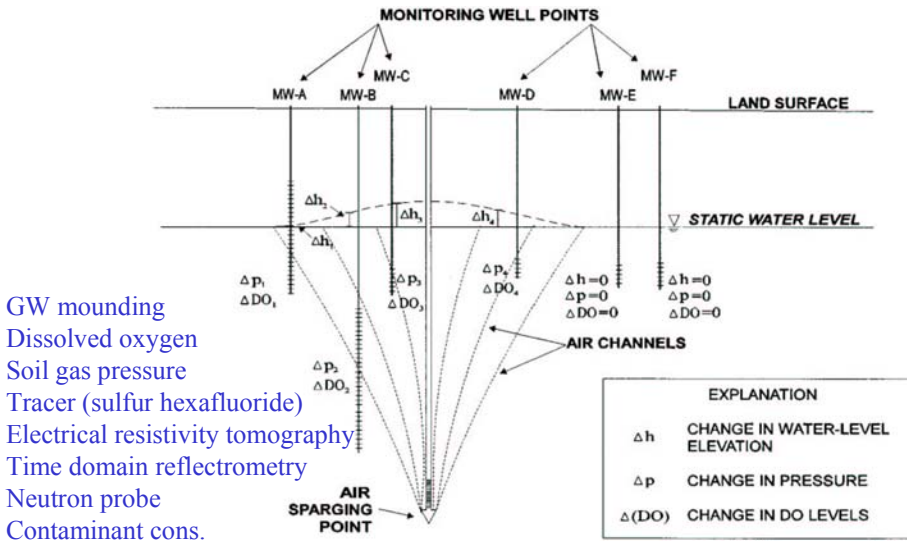
Zone of Influence



Air Sparging Point Locations

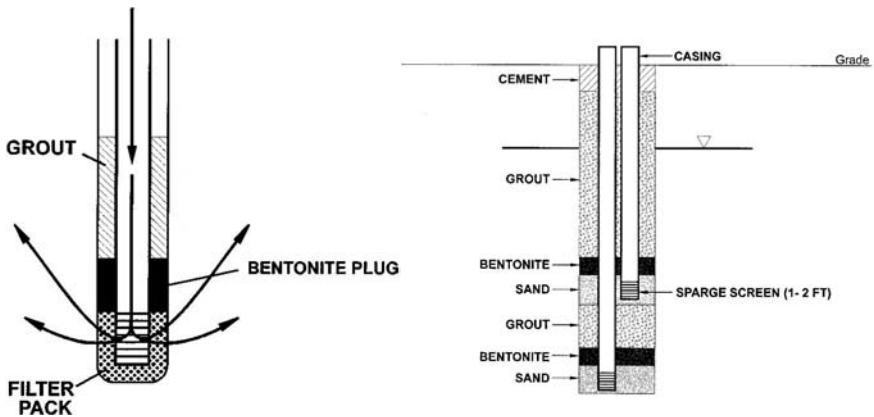


Determining Zone of Influence



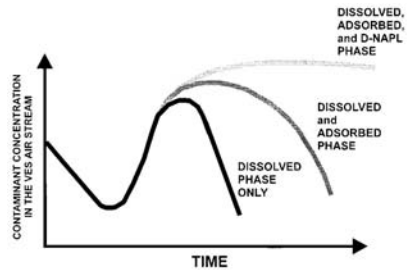
- GW mounding
- Dissolved oxygen
- Soil gas pressure
- Tracer (sulfur hexafluoride)
- Electrical resistivity tomography
- Time domain reflectometry
- Neutron probe
- Contaminant cons.

Air Sparging Wells

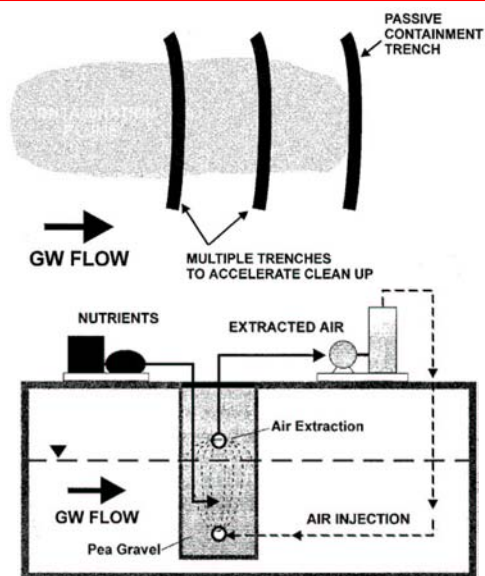


Pilot Test

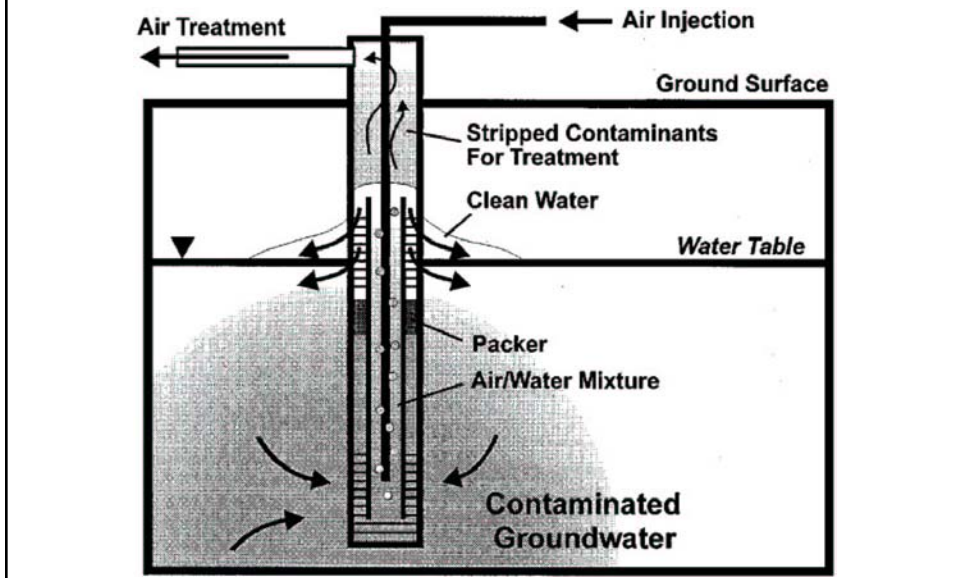
- Zone of air distribution
- Injection air pressure
- Injection flow rate (1-15 cfm per injection point)
- Mass removal efficiency



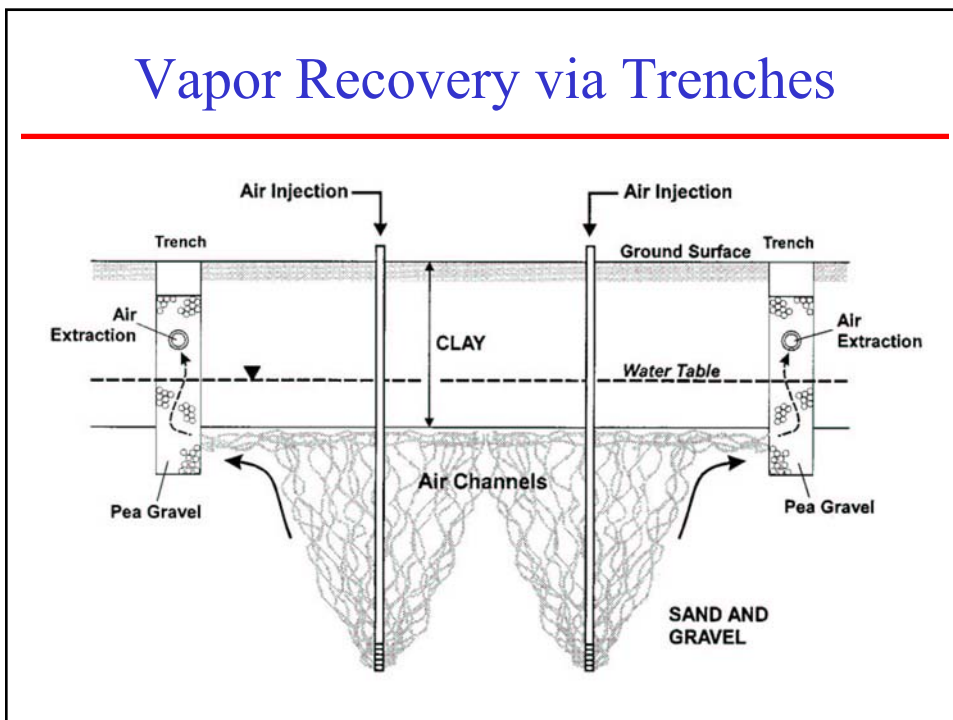
Horizontal Trench Sparging



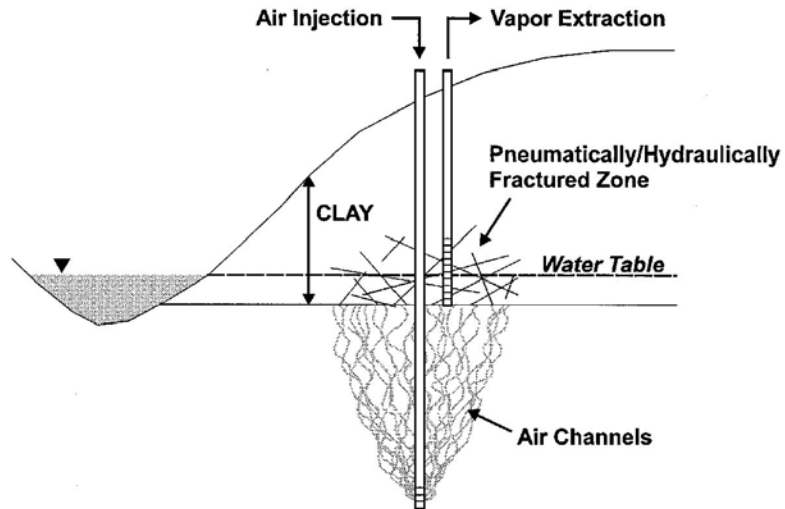
In-well Air Sparging



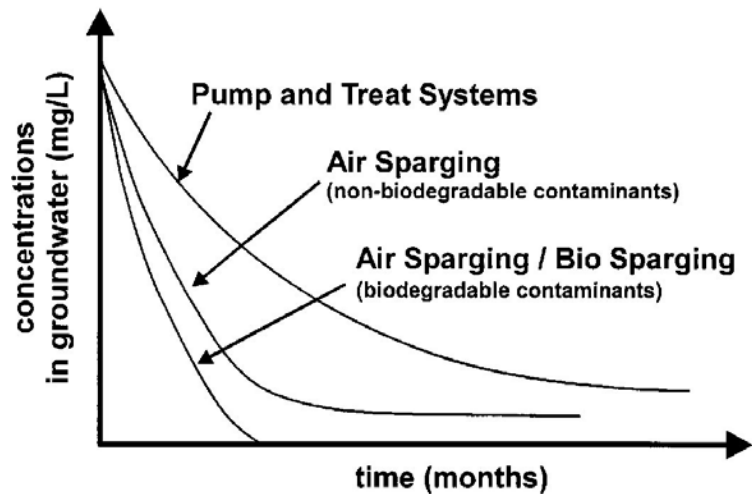
Vapor Recovery via Trenches



Pneumatic Fracturing for Vapor Recovery



Cleanup Rates



Summary of Air Sparging - Advantages

- Readily available equipment; easy installation
- Implemented with minimal disturbance to site operations
- Short treatment times: usually less than 1 to 3 years under optimal conditions
- At about \$20-50/ton of saturated soil, air sparging is less costly than aboveground treatment systems
- Requires no removal, treatment, storage, or discharge considerations for groundwater
- Can enhance removal by SVE

Summary of Air Sparging - Disadvantages

- Cannot be used for treatment of confined aquifers
- Stratified soils may cause air sparging to be ineffective
- Some interactions among complex chemical, physical, and biological processes are not well understood
- Potential for inducing migration of constituents
- Requires detailed pilot testing and monitoring to ensure vapor control and limit migration.