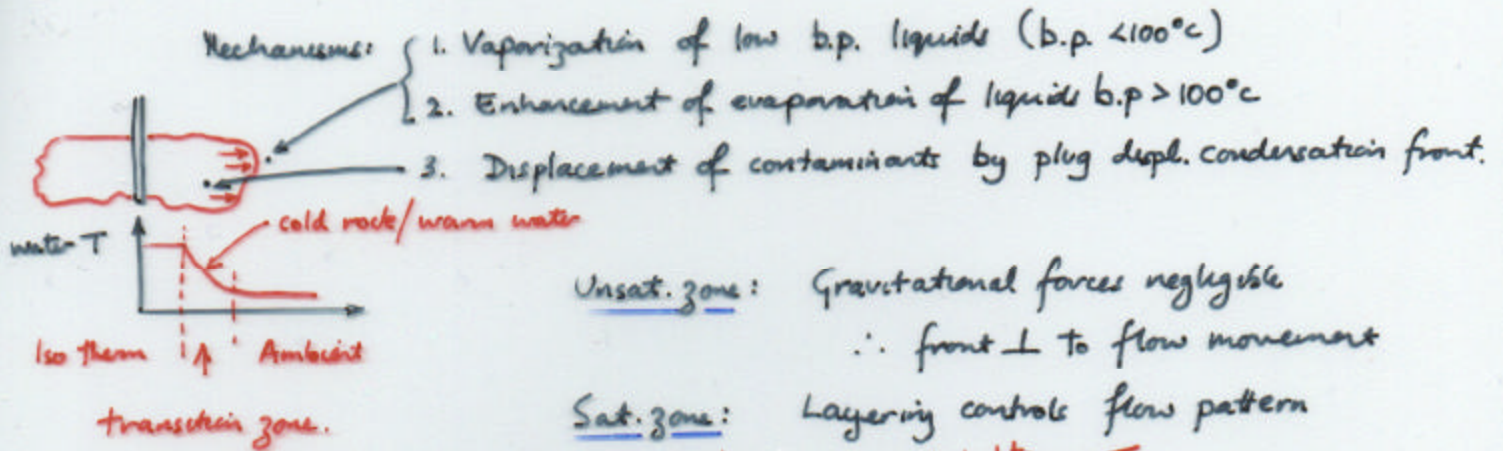
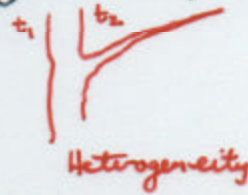
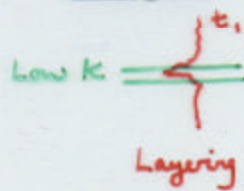


6.2 Steam Enhanced Extraction (SEE)

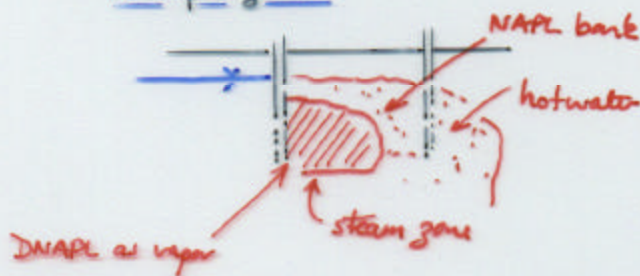


Unsat. zone: Gravitational forces negligible
 \therefore front \perp to flow movement

Sat. zone: Layering controls flow pattern



Multiple zones:



After steam breakthrough,
 vapors are recovered directly.

Desorption of organics enhanced due to thermal energy. Heat (due to steam) overcomes "latent heat of adsorption".

\therefore partitioning to aqueous phase favorable.

Dead-end pore fluids also removed - heat + apply vacuum \rightarrow
 induces boiling and vaporization \rightarrow remove additional fluids.

Field Implementation

Steam injection well + condensate and vacuum extraction wells.

Low-carbon steel wells (temperatures).

Supersaturate steam to prevent condensation down b/h. (increases pressure).

100% steam @ b/h base.

Level of Demonstration

Lab desorption studies eg. Diesel 1500 mg/kg \rightarrow 19 mg/kg
Plot studies (60 yd²) BTEX (19,000 ppm) } soil conc 2065 mg/kg \rightarrow 12 mg/kg
TCE (1600 ppm) }
763 lbs recovered in 140 hrs. { 29% due to vacuum
71% by steam
Steam injected @ 250 lb/hr @ 6 psig
5 ft well spacing (recovery).

Full scale treatment completed Huntington Beach 135,000 gal diesel
in 40 ft aquifer
37 steam inj; 39 vacuum wells on 2 acres
5 months \rightarrow 14,000 gals.
No off site vapor migration.

Applicability/Limitations

Saturated and unsaturated zone

Petroleum & DNAPLs and mixtures.

Problems in delivery in silts and clays, but less
susceptible than other methods

Shallow application (low pressure & temp) will \rightarrow micro-organisms dormant
but flourish when ceased \rightarrow bioremediation

Deep application (high T) \rightarrow sterilization \therefore repopulation needed

Costs

\$50-125/yd² incl. treatment of wastes ex situ.

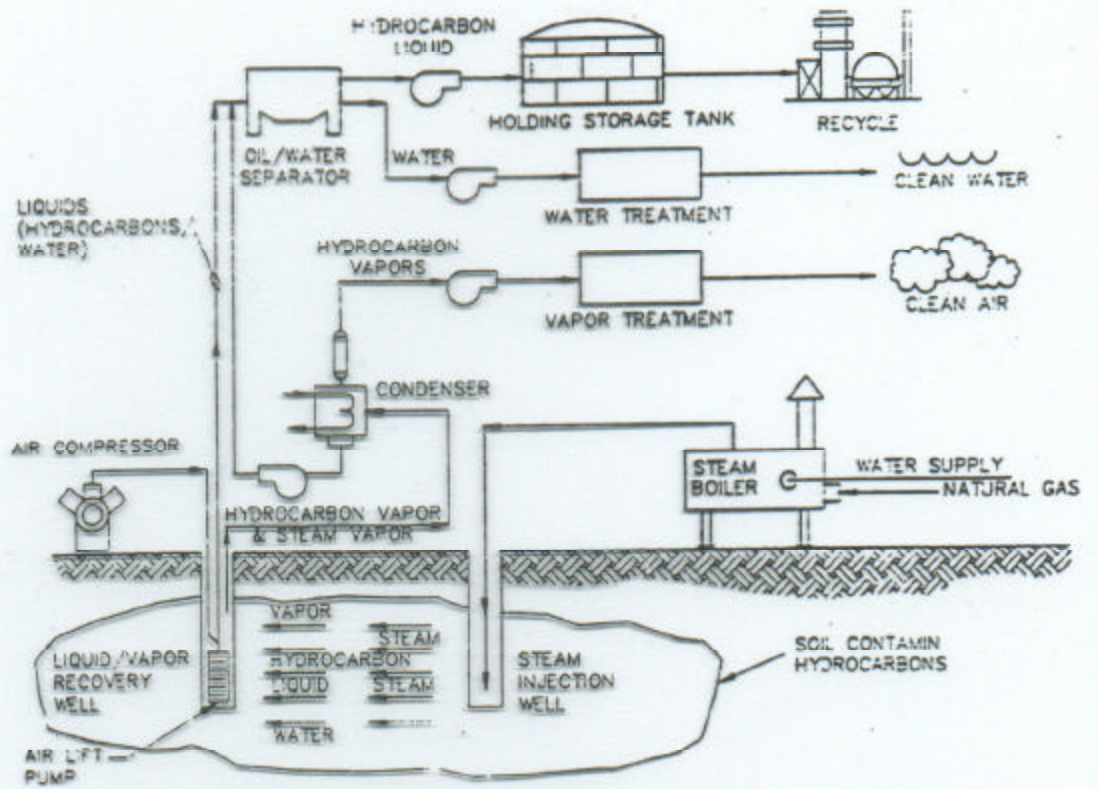


Figure 3.7.2.5 Schematic of in-situ steam enhanced extraction process [USEPA, 1992d].