4.3 Surfactant Soil Washing

Mechanisms:
1. Micellular solubilization of hydrophobic hydrocarbons.
2. Conversion into an emulsion
3. Reduce surface tension → ↑ mobility
4. Coalescence of ganglia into single bank

∴ similar to cosolvents and alkalis.

Two regions of interfacial tensions:
1. Low surfactant conc. (.1–.2 wt%) two-phase system (oil/water)
2. High surfactant conc. (2–10 wt%) three-phase with micro-emulsion in equilibrium with (oil/water)

The emulsion will preferentially separate to the water or oil phase depending on:

1. Salinity: ✓ 1% NaCl conc → water
   × 3% NaCl conc → oil
2. Surfactant solution conc. (low conc → water)
3. Temperature ✓ High temp → water

} Best to have micro-emulsions between oil-water since low σ and removable under reasonable hydraulic gradients.

Field Implementation

Two strategies: (1) Solubility enhancement or (2) Displacement process

(1) ← Continuous low conc. (<1% wt) – continuous flush (multiple p.V.)

(2) ← Keep M<1. Use conc. solution 10–40 wt% as finite slug.

Injection and production wells.
Sometimes horizontal.
Heterogeneities may affect results.

Level of Demonstration

Several decontaminations:

Volk Nat. Guard Base (WI)   TCA, TCE to 3 - 300ppm

Sandy soils with f_{oc} = .015 max

$K = 10^{-4} - 10^{-2}$ cm/s

Lab tests → 74 - 94% NAPL recovery in 12 pore volumes

Field - @ 14 pore vols. 3 test holes ~~gto~~ clogged by 3rd day.

Laramie, Wyoming

Creosotes.   Isolation cell of pore volume 5000 gals.

Injection of 30,000 gal surfactant } recovered - 260 gal

140,000 gal waterflood }   - 1600 gal

~ 95% concentration reduced.

Borden (1990) $K = 10^{-4}$ m/s   3×3m cell.

231 l PCE released - migration for 2 months

48l → pumping

52l → excavation of upper 1m.

Backfilled with bentonite cap

12 l → Waterflood

62l → 14.4 pore volumes of surfactant (1 pV = 2400 gal) over 4 months

10 l → Soil samples reveal less than 10l left.

184l. of 231 l

~ 50 l missing

perhaps volatilization, @ sheetpile periphery, or ↓ migration in fractures caused by sheet piling.

Also used for PCBs
Carbon Tet.

Applicability/Limitations

Applicable to most DNAPL sites.
Toxicity and recovery of surfactant are key.
↓ σ may cause downward migration
Recovery strongly affected by heterogeneities

1. Sweep process (conc. > 10%) for high NAPL concentration at sites
2. Solubilization (Conc. ~1%) for low concentration of NAPL this controls fugitive DNAPL migration

Cost and Availability

Hardware available
Full scale application in cont. area completed.
Potential use with co-solvents.

No cost information.

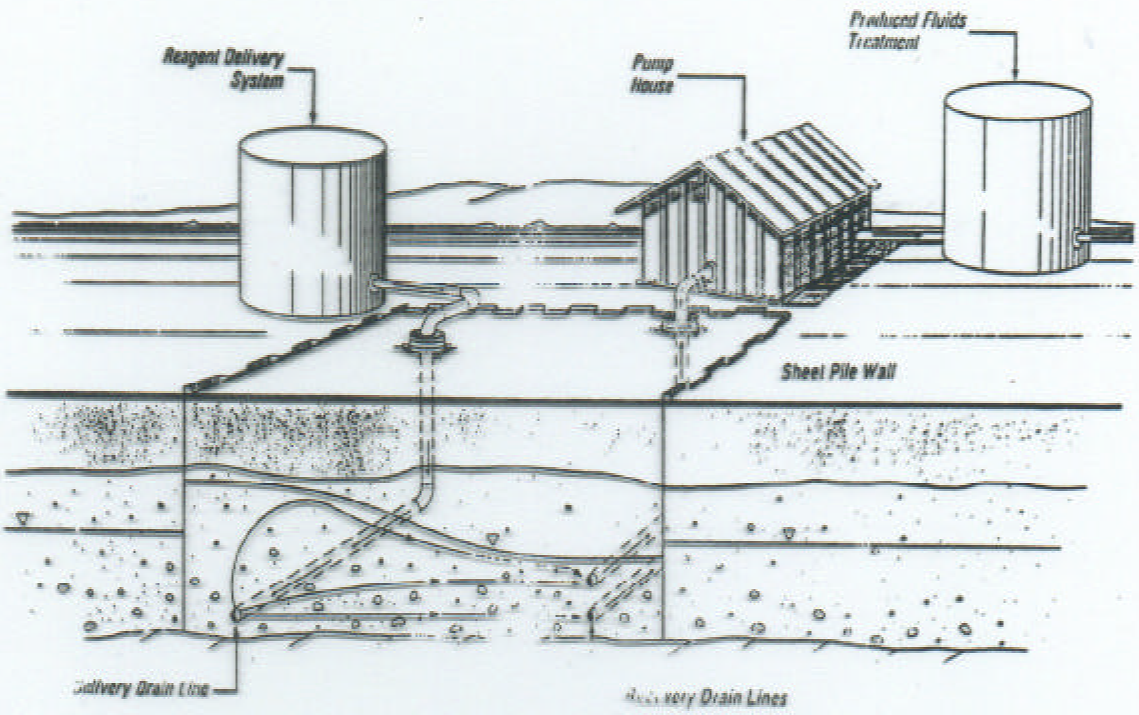

Figure 3.5.3.5 Schematic of dual drain line system for the 1988 field test using water and combined alkali/surfactant flooding of heavy oils [Sale et al., 1989].

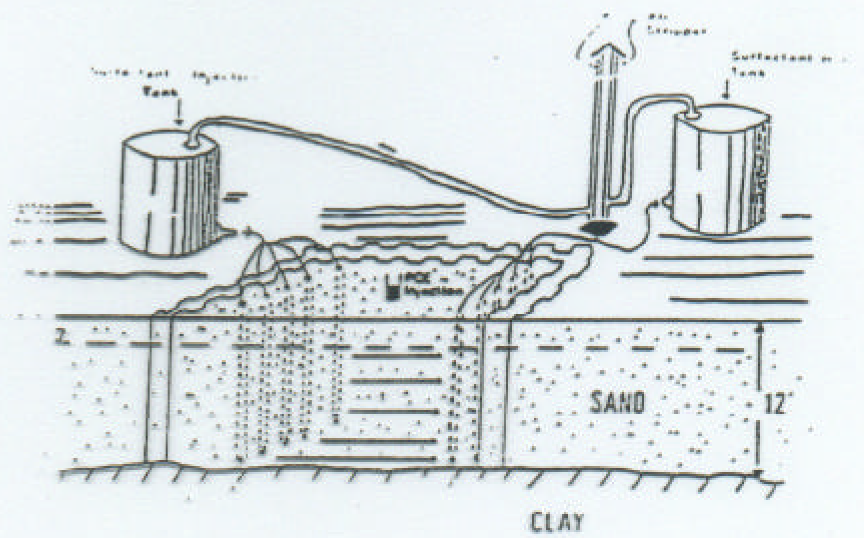

Figure 3.5.3.6 Schematic of field test using water and surfactant flooding for enhanced PCE recovery (Borden, Canada) [Fountain et al., 1990].