

Table A-7.A. Surfactant-enhanced subsurface remediation

Technology	Surfactant- enhanced subsurface remediation	Injection wells deliver surfactant solution to LNAPL zone while extraction wells capture mobilized/solubilized LNAPL.	
Remediation process	Physical mass recovery	Yes	Surfactant enhances LNAPL solubility and mobility and recovery by significantly reducing LNAPL/water interfacial tension.
	Phase change	No	LNAPL is solubilized above its typical aqueous solubility. When mobilized, it is driven as a separate phase.
	In situ destruction	No	Surfactants may enhance aerobic and anaerobic microbial hydrocarbon digestion by increasing the availability of the LNAPL. However, their degradation may be favored over that of the LNAPL.
	Stabilization/ binding	No	N/A
Objective applicability	LNAPL saturation	Yes	SESR reduces LNAPL saturation and even mobilizes otherwise residual LNAPL from pores. Properly designed surfactant systems enhance removal efficiency of residual LNAPL potentially by several orders of magnitude compared to extraction remediation approach alone, which rely on standard dissolution to remove residual LNAPL.
		Example performance metrics	Reduced LNAPL transmissivity; reduction or elimination of measurable LNAPL in wells.
	LNAPL composition	Yes	Abate accumulation of unacceptable constituent concentrations in soil vapor and/or dissolved phase from an LNAPL source.
		Example performance metrics	LNAPL composition change; soil and groundwater VOC concentrations to below regulatory standard.
Applicable LNAPL type	All LNAPL types, though mobility enhancement for those with higher oil-water interfacial tension are less efficient.		
Geologic factors	Unsaturated zone	When unsaturated zone LNAPL is near water table, water table can be raised (via mounding effect) to flood the zone with surfactant. When unsaturated zone LNAPL is far above water table, infiltration techniques may be used to flush the zone with surfactant but are not as effective as saturated zone treatment. More homogeneity and moderate permeability result in more effective treatment through even distribution of surfactant. See saturated zone geologic factors.	
	Saturated zone	Permeability	Surfactant delivery and LNAPL recovery are more rapid and more effective in higher-permeability soil.
		Grain size	LNAPL recovery is more rapid and effective in larger-grained soils (sands) than in smaller-grained soils (e.g., silt and clay).
		Heterogeneity	High levels of heterogeneity can reduce surfactant solution delivery efficiency, which increase the required number of pore volumes.
		Consolidation	High consolidation may reduce pore sizes, permeability, and injection feasibility; unconsolidated/loosely consolidated may allow larger spacing within well network (i.e., tend to be more favorable for recovery).