

Table A-6.A. Water flooding (including hot-water flooding)

Technology	Water flooding (including hot-water flooding)	Water flooding involves groundwater recirculation in a combined injection/ extraction well configuration, where groundwater flow is directed through the LNAPL zone to increase the hydraulic gradient and enhance LNAPL flow, displacement, and removal. The mobilized LNAPL is recovered via hydraulic recovery. Water flooding causes a faster rate of LNAPL flow toward recovery wells. The important process factor in water flooding is the enhanced hydraulic gradient. The recirculated water can be heated prior to injection to decrease the viscosity and interfacial tension of the LNAPL, thereby further facilitating its recovery. Injection and extraction wells can be installed in lines on either side of the LNAPL zone (line-drive approach) or interspersed in a multispot grid pattern.	
Remediation process	Physical mass recovery	Yes	Water flooding enhances LNAPL extraction by increasing the hydraulic gradient toward extraction wells; heating the injected water can further increase the LNAPL extraction rate.
	Phase change	No	Hot-water flooding may slightly increase the solubility of LNAPL components.
	In situ destruction	No	N/A
	Stabilization/ binding	No	N/A
Objective applicability	LNAPL saturation	Yes	Enhances LNAPL fluid flow and recovery and can reduce LNAPL to residual saturation. Hot-water injection can reduce the LNAPL saturation more quickly and may reach a lower residual saturation level than MPE or skimming.
		Example performance metrics	Reduced LNAPL thickness in wells and extent of wells containing LNAPL; reduced LNAPL saturation in soil samples.
	LNAPL composition	No	N/A
		Example performance metrics	N/A
Applicable LNAPL type	Water flooding applies to all LNAPL types. Hot-water flooding is most beneficial for viscous LNAPLs but can accelerate recovery of any LNAPL.		
Geologic factors	Unsaturated zone	Technology is typically not applicable to LNAPL in the unsaturated zone unless saturated conditions can be achieved by first raising the water table.	
	Saturated zone	Permeability	Higher-permeability materials may allow lower residual saturations to be achieved but require higher injection/extraction flow rates to significantly increase the hydraulic gradient. Moderate-permeability materials may facilitate an increase in the hydraulic gradient at a manageable flow rate. Low-permeability materials may exhibit limited enhancement in LNAPL flow using water flooding.
		Grain size	Can achieve lower residual saturation in coarser-grain materials where displacement pressures are lower; see related discussion on permeability, above.
		Heterogeneity	Moderately sensitive to heterogeneity.
		Consolidation	Consolidated media may affect water flooding effectiveness, primarily by heterogeneity that is introduced and the reduction in pore size.