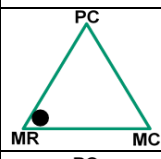
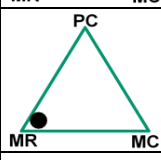
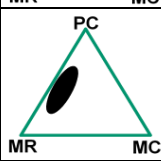
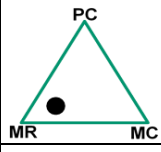
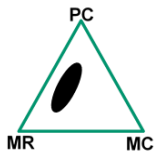
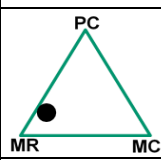
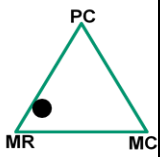
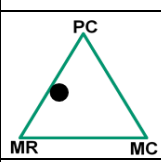
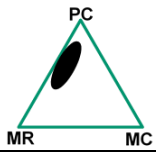
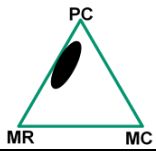
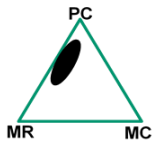
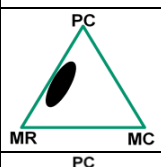
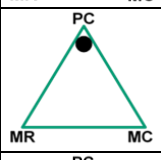
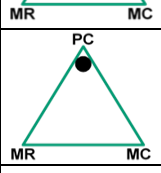
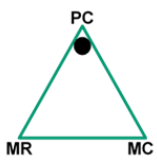
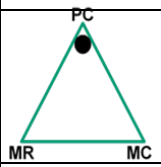
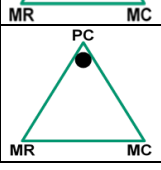
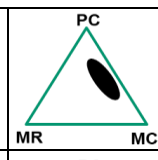
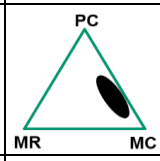
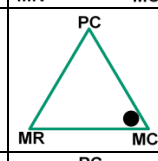
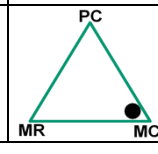
Table 6-2. Summary information for remediation technologies

LNAPL technology	Technology Group / Objective [a]	Advantages	Disadvantages [b]	Applicable geology [c]		Applicable to zone [d]		Applicable type of LNAPL [e]		Potential time frame [f]					Appendix A reference table numbers
				F	C	U	S	LV/LS	HV/HS	VS	S	M	L	VL	
Excavation		Proven, 100% removal of LNAPL mass possible	Accessibility, depth limitations, waste disposal	F	C	U	S	LV/LS	HV/HS	VS					1
Skimming (LNAPL only)		Proven	Limited to practicably recoverable LNAPL fraction, spacing, ROI [g]		C		S	LV/LS	HV/HS			M	L		2
Vacuum enhanced skimming (LNAPL & vapor)		Proven, vapor control, volatile depletion, enhance aerobic bio	Limited to mobile and recoverable LNAPL	(F)	C	U	S	LV/LS	HV/HS			M	L		3
Total liquid extraction (LNAPL & water)		Proven, hydraulic control, expose trapped LNAPL	Limited to mobile and recoverable LNAPL, multiple fluid streams to treat/dispose		C		S	LV/LS	HV/HS			M	L		4
Multi phase extraction (MPE) (LNAPL, water & vapor)		Proven, hydraulic control, vapor control, expose trapped LNAPL, volatile depletion, enhance aerobic bio, treat residual LNAPL	Generated fluids separation, multiple fluid streams to treat/dispose	(F)	C	U	S	LV/LS	HV/HS		S	M			5
Water flooding (incl. hot water flooding)		Recover submerged LNAPL	Limited to mobile and recoverable LNAPL, hydraulic control required, homogeneity, flood sweep efficiency [h]		C		S	LV/LS	HV/HS		S				6
Surfactant-enhanced subsurface remediation (SESR)		Mobilize residual LNAPL	Hydraulic control required, dissolved COCs [i] treatment, homogeneity, water treatment, sweep efficiency, chemical residuals		C		S	LV/LS	HV/HS	VS	S				7
Cosolvent flushing		Mobilize/dissolve residual LNAPL	Hydraulic control required, vapor generation, water treatment, sweep efficiency, chemical residuals		C		S	LV/LS	HV/HS	VS	S				8
Steam injection		Proven	Vapor control, access, sweep efficiency, energy required	(F)	C	U	S	LV/LS	HV/HS	VS	S				9
Thermal conduction heating		Proven	Vapor control, energy required, spacing, access	F	C	U	S	LV/LS	HV/HS	VS	S				10
Electrical resistance heating		Proven	Vapor control, energy required, spacing, access	F		U	S	LV/LS	HV/HS	VS	S				11
In-situ smoldering		Able to treat heavy hydrocarbons	Vapor control, spacing, access		C	U	S	LV/LS		VS	S				12
Air sparging/ soil vapor extraction (AS/SVE)		Proven, vapor control	Spacing, energy required	(F)	C	U	S		HV/HS		S	M			13
Biosparging/ bioventing		Proven, lower energy	Potential for vapor migration	(F)	C	U	S	LV/LS	HV/HS			M	L		14
In situ chemical oxidation (ISCO)		Minimal infrastructure	Vapor generation, rebound, spacing, delivery efficiency (ROI)		C	U (ozone oxidant)	S		HV/HS	VS	S				15
Enhanced anaerobic biodegradation		Accelerate ambient biodegradation, minimal infrastructure	Spacing, delivery efficiency (ROI)		C		S	LV/LS	HV/HS				L	VL	16
Natural source zone depletion (NSZD)		No disruption, low carbon footprint	Regulatory acceptance emerging	F	C	U	S	LV/LS	HV/HS					VL	17

Activated carbon		Minimal infrastructure, sequestration	Spacing, delivery efficiency (ROI); longer-term degradation unproven	F	C		S		HV/HS	VS	S				18
Phytotechnology		Natural treatment system	Limited to root zone depth, acclimation period	F	C	U	S	LV/LS	HV/HS				L	VL	19
Physical or hydraulic containment		Proven	Accessibility, depth and geologic limitations, only addresses migrating LNAPL	F	C		S	LV/LS	HV/HS					VL	20
In situ soil mixing (stabilization)		Little to no waste, proven	Accessibility, depth limitations	F	C	U	S	LV/LS	HV/HS	VS	S				21

a. Mass removal (MR), phase change (PC) or mass control (MC). MR and MC are technologies to address saturation concerns; PC technologies address compositional concerns.
b. Any of these technologies may have particular state-specific permitting requirements. Check with your state regulatory agency.
c. F = fine (clay to silt), C = coarse (sand to gravel). (F)=may be useful for silt but not clay.
d. U = unsaturated zone, S = saturated zone.
e. LV/LS = low volatility, low solubility, medium or heavy LNAPL (e.g., weathered gasoline, diesel, jet fuel, fuel oil, crude oil); HV/HS = high volatility, high solubility, light LNAPL with significant percentage of volatile or soluble constituents (e.g., gasoline, benzene); > residual req = requires LNAPL saturation greater than residual.
f. VS = Very short = <1 year; S = Short = 1–3 years; M = Medium = 2–5 years; L = Long = 5–10 years; VL = Very long = >10 years.
g. ROI = radius of influence.
h. Sweep efficiency is analogous to ROI, but injection technology refers to effectiveness of injectate dispersal (sweep).
i. COC = constituent of concern.