APPENDIX C1
SUPPORTING DOCUMENTATION FOR DTSC TECHNOLOGY SCREENING

TABLE OF CONTENTS

Page

Table C1-1. Cleanup Options Selected and Characteristics of Sites Evaluated by DTSC Study

DTSC Site Type (Number of Sites)	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
Schools Properties (32*)	0	0	0	1	0	32	0	0
Military Facility (55*)	3	5	3	1	9	37	3	3
Voluntary Cleanup (51*)	0	1	8	5	0	40	5	1
State Response/NPL (32*)	0	0	5	7	0	22	0	4
Corrective Action (7)	0	0	0	0	3	4	0	0
Facility Closure (11)	0	0	0	0	0	11	0	0

Total number of sites represented: 188

Cubic Yards of Impacted Soil (Number of Sites)	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
<100 (21*)	0	0	1	0	0	21	0	0
≥100 - 1000 (56*)	0	1	3	3	3	50	2	2
≥1000 - 10,000 (60*)	0	0	7	8	3	43	2	3
>10,000 (29*)	0	1	4	3	6	17	3	1

Total number of sites represented: 166 (Impacted volume data not available for all 188 sites.)

Maximum Depth of Impacted Soil (Number of Sites)	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
<2 feet (41*)	2	1	4	3	3	39	1	1
≥2 - 5 feet (45*)	0	0	6	5	1	35	4	1
≥5 - 10 feet (30*)	0	0	4	0	2	26	1	3
>10 feet (8*)	0	1	1	2	1	4	0	0

Total number of sites represented: 124 (Depth of impact not available for all 188 sites.)

Other Affected Media	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
Soil Only (113*)	2	2	11	7	6	94	2	3
Groundwater (53*)	1	2	3	6	4	39	5	2
Soil Vapor (9*)	0	0	0	1	0	8	2	0
Sediment (8*)	0	0	2	2	0	5	0	1
Surface Water (5*)	0	0	1	1	0	4	0	1
Indoor Air (1)	0	0	0	0	0	1	0	0

Total number of sites represented: 182 (Information on other affected media not available for all 188 sites.)

Notes:
*Some sites selected multiple cleanup options. Hence, this number is not the sum of frequencies indicated in this row.
CAMU - corrective action management unit
ICs - institutional controls
NPL - National Priorities List

Table C1-1 (Continued)

Metals Contaminants Present	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
Antimony	0	0	0	1	2	8	0	2
Arsenic	1	1	9	6	3	64	4	3
Cadmium	0	2	0	4	1	18	0	1
Chromium III	0	0	2	5	2	9	0	1
Chromium VI	0	0	1	0	0	5	0	0
Copper	1	0	2	4	1	13	1	2
Lead	0	3	11	9	6	107	7	7
Mercury	1	0	4	0	0	11	3	0
Molybdenum	1	0	0	0	0	3	0	0
Nickel	0	0	2	3	0	7	0	1
Thallium	0	0	1	0	0	5	0	0
Zinc	1	0	1	2	2	7	0	2

Total number of sites represented: 168 (Information on metals present not available for all 188 sites.)

Other Contaminants Present	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
None reported	0	1	8	2	6	47	1	3
Fuel-related compounds	1	1	6	3	0	43	2	1
Volatile organic compounds	0	0	4	1	1	33	5	1
Polynuclear aromatic hydrocarbons	0	2	5	3	2	26	4	2
Pesticides/herbicides	2	0	3	1	1	28	3	1
Polychlorinated biphenyls	2	1	5	1	1	24	0	2
Dioxins/furans	0	0	1	2	1	6	0	2
Semivolatile organic compounds	0	0	2	1	2	4	0	0
Other inorganics	0	0	2	0	0	5	0	0
Gases (e.g., methane)	0	0	1	1	0	3	0	0

Total number of sites represented: 174 (Information on other contaminants present not available for all 188 sites.)

Historical Site Activity	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
School	0	0	0	0	0	5	0	0
Residential	0	0	0	0	0	14	0	0
Retail Stores/Office	0	0	0	0	0	4	0	0
Agriculture	0	0	1	1	0	15	4	0
Manufacturing/Industry	0	1	5	4	3	23	0	5
Firing range	0	0	0	2	1	6	4	0
Foundry/smelter	0	0	0	2	1	2	0	1
Reclamation/junkyard/scrapyard	0	3	1	4	0	26	0	0
Vehicle maintenance/storage/refueling	0	1	0	0	0	16	0	0
Hazardous waste treatment & storage	1	1	0	0	1	8	0	0
Landfill/refuse burning/disposal pit	2	0	2	0	7	15	2	2
Shipyard/dry docks	0	0	1	1	0	7	0	1
Mining	0	0	0	1	0	5	0	0
Other	0	1	2	2	0	18	0	0

Total number of sites represented: 176 (Information on historical activities not available for all 188 sites.)

Notes:
*Some sites selected multiple cleanup options. Hence, this number is not the sum of frequencies indicated in this row.
CAMU - corrective action management unit
ICs - institutional controls
NPL - National Priorities List

Table C1-1 (Continued)

Projected Future Land Use	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
Residential, potentially residential	0	0	1	6	0	31	5	3
Industrial	1	4	6	4	8	7	0	0
School	0	0	0	1	0	31	0	0
Commercial	0	2	5	2	0	14	3	2
Recreational or natural area	0	0	2	1	0	9	0	0
Other	0	0	2	1	0	7	0	0

Total number of sites represented: 121 (Information on projected future land use not available for all 188 sites.)

Site Size (Number of sites)	Cleanup Option Selected (Number of sites)							
	No Action	ICs	Capping in Place	Consolidation and capping	CAMU	Excavation and disposal	Reuse/ Recovery	Treatment
≤1 acre (47*)	0	1	5	1	1	40	0	1
>1 - 10 acres (59*)	0	1	5	3	5	50	4	2
>10 - 50 acres (38*)	0	2	2	6	1	27	2	2
>50 - 100 acres (8*)	0	0	1	2	2	3	0	1
>100 acres (8*)	0	0	0	1	0	7	1	1

Total number of sites represented: 160 (Site size not available for all 188 sites.)

Notes:

*Some sites selected multiple cleanup options. Hence, this number is not the sum of frequencies indicated in this row.

CAMU - corrective action management unit

ICs - institutional controls

NPL - National Priorities List

Table C1-2 Technologies Applicable at Sites with Metals in Soil

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies				
Isolation (Excavation and Disposal)	Impacted soil is excavated and isolated beneath an engineered cap or within an engineered disposal unit (e.g., landfill, CAMU).	• Consolidation beneath a cap is applicable to a wide variety of soils and immobile contaminants. • Placement in an engineered unit is applicable to most soils and a wide variety of contaminants.	• Long-term maintenance. • Land use restrictions. • May not be protective if groundwater is shallow.	
Immobilization by Solidification/Stabilization (S/S)	Use of chemical or physical processes to treat wastes. Solidification technologies encapsulate waste to form a solid material. Stabilization technologies reduce the hazard potential by converting waste to less soluble, mobile, or toxic forms.	• Often used as a pre-treatment for land disposal activities to meet land disposal restrictions. • Assess applicability with treatability study.	• Short-term to medium-term technology. Long-term effectiveness not demonstrated for many contaminant/process combinations. • May result in significant increase in volume. • Certain wastes are incompatible with S/S. Limited effectiveness if soil contains SVOCs, pesticides, and some VOCs. • Generally not effective in soils with high organic content. • Used in conjunction with other technologies.	3, 4
Immobilization by Vitrification	Mobility of metal contaminants is decreased by high-temperature treatment of contaminated area. The high temperature component of the process destroys/ removes organic materials. Radionuclides and heavy metals are retained within the vitrified product.	• Applicable to most soils and for a wide variety of inorganic and organic contaminants. Particularly well suited for treatment of lead, chromium, arsenic, zinc, cadmium, and copper wastes. • Sites with moisture content less than 25%.	• High energy requirements and cost. • Unsuitable for treatment of mercury unless present at very low levels. • Complex process that typically includes excavation, pretreatment, mixing, feeding, melting, and vitrification. Requires off-gas collection and treatment as well as forming/casting the product. • Used in conjunction with other technologies.	3

Table C1-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies				
Toxicity or Mobility Reduction by Chemical Treatment	Introduction of chemical reagents to change the chemical oxidation state of the metal in order to reduce its mobility or toxicity.	• Assess applicability through treatability study using site-specific materials. • Often used as a pretreatment for other treatment technologies, e.g., reduction of Cr(VI) is a common form of treatment because Cr(III) can be precipitated as a hydroxide by a subsequent treatment process.	• Long-term stability of reaction products is a concern because changes in geochemistry may reverse some reactions. • Used in conjunction with other technologies.	1, 3
Removal by Pyrometallurgical Extraction	Separation of metals from soil in form of metal, metal oxide, ceramic product, or other products that have potential market value. Typical processes to concentrate and purify the metal include smelting, roasting, and retorting.	• Most applicable to large volumes of highly contaminated soils (>5-20% metals concentrations), especially when metal recovery is expected. • May be applicable to low concentrations of easily volatilized metals (e.g., mercury).	• Often performed off-site because few mobile treatment units are available. • Not cost effective for many environmental projects. • Usually preceded by physical separation and concentration to produce uniform feed material, to upgrade metal content, and/or to enhance separation performance.	3, 4

Table C1-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies				
Removal by Soil Washing	Water-based process for scrubbing soils to remove contaminants by dissolving/ suspending in wash solution or concentration into smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing.	• Assess applicability with bench scale treatability study. • Applicable to SVOCs, fuels, and heavy metals. • Applicable to coarse-grained soils. Soils with low fines content (<20% of particles with diameters <2 mm) are easier to process. • Most easily implemented when a single metal contaminant occurs in a particular insoluble fraction of soil that can be separated by particle size classification. • Economically feasible with >5,000 tons of soil.	• Commercialization of process not yet extensive. • Complex waste mixtures make formulating washing fluid difficult. • High humic content in soil may require pretreatment. • Difficult to remove organics adsorbed to clay-size particles. • Aqueous stream will require treatment at demobilization. • Multiple treatment steps may be required to address washing solvent remaining in treated residuals. • Some soil fractions may still require disposal in an engineered unit.	1, 3, 4
In Situ Technologies				
Isolation by Capping	Impacted soils are isolated by placement of a low permeability barrier to surface water infiltration.	• Applicable to most soils and metals with limited mobility. • Frequently used to address impacted soils in industrial areas.	• Long-term maintenance. • Land-use restrictions. • May not be protective if groundwater is shallow.	3

Table C1-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
In Situ Technologies				
Immobilization by Solidification/Stabilization (S/S)	Use of chemical or physical processes to treat wastes. Solidification technologies encapsulate waste to form a solid material. Stabilization technologies reduce the hazard potential by converting waste to less soluble, mobile, or toxic forms. Vertical auger mixing is most common method for mixing binders with soil.	• Appropriate for soil conditions conducive for mixing binders. • Useful for treating surface or shallow contamination that involves spreading and mixing binders with soil using conventional excavation equipment. • Assess applicability through treatability study conducted using site-specific materials.	• Limited data on performance. • Interference with binding process caused by soil chemical composition, moisture content, and ambient temperature. • Achieving complete, uniform mixing of binder with contaminated soil. • Not useful for metals occurring as anions or metals that have low-solubility hydroxides. • Mixing binders in presence of bedrock, large boulders, cohesive soils, and clays. • Used in conjunction with other technologies.	2, 3
Immobilization by Vitrification	Mobility of metal contaminants is decreased by high-temperature treatment of contaminated area. The high temperature component of the process destroys or removes organic materials. Radionuclides and heavy metals are retained within the vitrified product.	• Applicable to most soils and for a wide variety of inorganic and organic contaminants. Particularly suitable for treatment of soils with lead, chromium, arsenic, zinc, cadmium, and copper. • Soil should be able to carry the current and solidify as it cools.	• Still in demonstration phase. Limited commercial availability. • High cost relative to other cleanup alternatives. Costs increase with increasing moisture content. • Maximum treatment depth is approximately 20 feet. • Too much alkali metal content increases the conductivity to a point where insufficient heating occurs. • Not suitable for treatment of mercury, unless include off-gas recovery. • May not be appropriate for sites with high levels of organics (off-gassing) or inorganics (potential to exceed glass solubility limits).	2, 3

Table C1-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
In Situ Technologies				
Toxicity or Mobility Reduction by Chemical Treatment	Introduction of chemical reagents to change the chemical oxidation state of the metal in order to reduce its mobility or toxicity. Reagents introduced via soil mixing (e.g., backhoe, trenching, augers).	• Sites with shallow metals contamination that can be effectively addressed through soil mixing. • Assess applicability through treatability study conducted using site-specific materials.	• Non-specific nature of chemical reagents may create new problems. Agents that treat one metal may target other reactive metals and make them more toxic or mobile. • Reagent delivery problems due to reactive transport and soil heterogeneity. • Control of in situ geochemical conditions so that reaction proceeds. • Usually requires multiple applications. • Used in conjunction with other technologies.	1, 2, 3
Removal by Soil Flushing	Extraction of contaminants from the soil with water or other suitable aqueous solutions. Soil flushing is accomplished by passing the extraction fluid through in-place soils using an injection or infiltration process. Considered a mature technology because of its use in the oil industry, but there has been very little commercial success for environmental applications.	• Assess applicability through treatability study performed under site-specific conditions. • Can mobilize contaminants from coarse-grained soils with relatively high hydraulic conductivity. • Can be used to treat VOCs, SVOCs, fuels, and pesticides, but it may be less cost-effective than alternative technologies. • Used only where flushed contaminants and flushing fluid can be contained and recaptured.	• Limited information available on application of this technology to metals-impacted sites. • Difficult to treat low permeability or heterogeneous soils. • Surfactants can reduce effective soil porosity. • Reactions of flushing fluids with soil can reduce contaminant mobility. • Ability to control contaminant and flushing fluids. • Aboveground separation and treatment costs for recovered fluids can drive the economics of the process.	1, 2, 3

Table C1-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
In Situ Technologies				
Removal by Electrokinetic Remediation (ER)	Process removes metals and organic contaminants from low permeability soil. Uses electrochemical and electrokinetic processes to desorb, and then remove, metals and polar organics.	• Heavy metals, anions, and polar organics in soil, mud, sludge, and marine dredging. • Can treat concentrations ranging from a few parts per million (ppm) to tens of thousands of ppm. • Most applicable in low permeability soils. Such soils are typically saturated and partially saturated clays and silt-clay mixtures that are not readily drained.	• Demonstrated at several sites with mixed results. Success varies depending on metals present in soil. Effectiveness sharply reduced for wastes with a moisture content of less than 10%. • Presence of buried metallic or insulating material can induce variability in the electrical conductivity of the soil. • Inert electrodes must be used so that no residue will be introduced into the treated soil mass. Metallic electrodes may dissolve as a result of electrolysis and introduce corrosive products into the soil mass. • Extreme pH at the electrodes and reduction-oxidation changes induced by the process electrode reactions may inhibit effectiveness. • Oxidation/reduction reactions can form undesirable products (e.g., chlorine gas). • Unfavorable soil conditions include high cation exchange capacity, high buffering capacity, high naturally-occurring organic content, salinity, and very low moisture content.	1, 2, 3

1 For more information about this technology, refer to http:// clu-in.org/techfocus/
2 EPA. 2006. Engineering Issue Forum Paper: In Situ Treatment Technologies for Contaminated Soil, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, EPA 542/F-06/013. November.
3 Evanko, C.R. and D.A. Dzombak. 1997. Remediation of Metals-Contaminated Soils and Groundwater, Ground-Water Remediation Technologies Analysis Center, Technology Evaluation Report TE-97-01, October.
4 EPA. 1997a. Engineering Bulletin: Technology Alternatives for the Remedial of Soils Contaminated with As, Cd, Cr, Hg, and Pb, U.S. Environmental Protection Agency, Office of Research and Development, EPA/540/S-97/500, August.

Table C1-3 Evaluation of Technologies Applicable to Sites With Metals in Soil Against NCP Analysis Criteria

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARS	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
Institutional Controls	• **Manages potential exposure by restricting access and future land use.**	• May not comply with ARARs.	• Uncertain because does not permanently address contamination.	• Not a treatment alternative.	• Does not create risks during implementation.	• Easily implemented.	• Typically the lowest cost alternative.
Excavation and Off-site Disposal	• Protectiveness achieved by metal removal from site.	• Requires compliance with applicable state and federal transportation and disposal requirements.	• High long-term effectiveness for site. • Protectiveness at disposal site dependent on off-site management choices.	• Disposal reduces mobility. • Reduction in toxicity and volume depends on offsite management choices.	• Requires standard precautions necessary for protection of human health and environment during excavation, transport, and disposal.	• Easily implementable given facility with adequate capacity for waste type, located within a reasonable distance of site. • Uses standard construction equipment and labor.	• Usually reasonable for small to medium volumes of contaminated soil. • **May be cost-prohibitive** for large volumes.
Recovery/ Reclamation	• Protectiveness achieved by metal removal.	• Removal eliminates need to comply with land disposal restrictions. • Action-specific ARARs may be activated by treatment process.	• Highly effective if metal content removed to acceptable levels.	• Removal reduces toxicity, mobility, and volume. • Residual metals immobilized in slag or residue.	• Requires standard precautions for protection of human health and environment during excavation and treatment.	• **Treatment usually performed off-site.** • **Usually preceded by physical separation and concentration of metal.** • **Applicable to highly contaminated soils.**	• Not cost effective for many environmental projects.

Notes: Bold indicates major reason(s) rejected during alternatives analysis for sites evaluated by DTSC Study (see Table 2 of main text of PT&R guidance).
In part, table content based on EPA (1997a, 1999, 2006) and Evanko and Dzombak (1997).

Table C1-3 (Continued)

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARS	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
Containment by Capping	• Contaminated soil remains in place. • Risk of exposure through dermal contact and/ or incidental ingestion reduced through barriers. • Protectiveness of groundwater depends on depth to water, mobility of metals, and cap design that reduces water migration through soil.	• Waste disposal requires compliance with ARARs.	• Long-term protection ensured through **continued cap maintenance and institutional controls.**	• Not a treatment alternative.	• Requires standard precautions for protection of human health and environment.	• Commercially available. • Demonstrated technology. Necessary materials easily attainable. • Uses standard construction equipment and labor.	• Generally less expensive than most forms of treatment.
Solidification/ Stabilization (S/S)	• Protectiveness achieved by reducing metal mobility.	• Treatment unit may require location- or action-specific ARARs. • Treatment may eliminate need to dispose as hazardous waste.	• **Considered to be a short-term to medium-term technology.** • **Long-term effectiveness not demonstrated for many contaminant/ process combinations.**	• If effective, reduces metal mobility. • **Does not address toxicity.** • **May result in increased volume.**	• Requires standard precautions for protection of human health and environment. • May pose short-term risks if ex-situ treatment performed.	• **Assess applicability with treatability study.** • Commercially available.	• Generally lowest cost treatment alternative.

Notes: Bold indicates major reason(s) rejected during alternatives analysis for sites evaluated by DTSC Study (see Table 2 of main text of PT&R guidance).
In part, table content based on EPA (1997a, 1999, 2006) and Evanko and Dzombak (1997).

Table C1-3 (Continued)

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
Soil Washing	• Aqueous stream and solid residuals must be treated to achieve protection.	• Excavation may activate action-specific ARARs.	• If effective, eliminates risk and provides permanent solution. • **If ineffective, will need to identify another cleanup alternative.**	• Transfers mass from soil to aqueous solutions which must be treated.	• Requires standard precautions for protection of human health and environment during excavation and treatment.	• **Requires treatability study.** • **High removal efficiencies difficult to attain or require complex treatment process.** • **Applicable to narrow range of soil types and contaminant mixtures.** • **Limited commercial availability.**	• Economically feasible for large soil volumes.
Soil Flushing / Leaching	• Flushing fluid must be captured and treated.	• Must ensure that washing solution complies with chemical- or location-specific ARARs.	• Permanent solution if successful.	• Transfers mass from soil to flushing fluid which must be captured and treated.	• Requires standard precautions for protection of human health and environment during injection.	• **Requires treatability study.** • **Applies to narrow range of soils and contaminant mixtures.** • **Limited data on performance for metals-impacted soils.**	• **Costs for treatment of recovered fluids can drive cost.**

Notes: Bold indicates major reason(s) rejected during alternatives analysis for sites evaluated by DTSC Study (see Table 2 of main text of PT&R guidance).
In part, table content based on EPA (1997a, 1999, 2006) and Evanko and Dzombak (1997).

Table C1-3 (Continued)

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARs	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST
Chemical Treatment	• Protectiveness achieved by reducing metal mobility and/or toxicity. • Must also manage other reactions triggered by reagents.	• Treatment unit may require location- or action-specific ARARs. • Treatment may eliminate need to dispose as hazardous waste.	• Changes in geochemical conditions may affect long-term effectiveness.	• If effective, reduces metal mobility and/or toxicity. May increase mobility or toxicity of naturally-occurring metals.	• Requires standard precautions for protection of human health and environment. • May pose short-term risks if ex-situ treatment	• **Assess applicability through treatability studies.** • Commercially available.	• **Can be higher cost than other cleanup alternatives.** • Generally lower cost treatment alternative.
Vitrification	• Protectiveness achieved by immobilizing metal.	• Excavation may activate action-specific ARARs. • Generation of off-gas may trigger chemical-specific ARARs.	• If successful, produces solid with low leachability. • Limited data on long-term effectiveness.	• Reduces toxicity and mobility by immobilizing metal. • Generally decreases volume. • Some metals may need conversion to less volatile forms prior to treatment.	• Off-gas may require extensive controls, including respiratory protection, fugitive dust control, and air monitoring.	• Requires extensive pilot testing. • In situ methods still in demonstration phase. • Limited commercial availability. • Requires substantial energy source.	• **Typically higher costs than other cleanup alternatives.**
Electrokinetic Remediation	• Protectiveness achieved by metal removal.	• May require location- or action-specific ARARs.	• If successful, removes metal from soil.	• Results in mass removal, reducing metal mobility and toxicity and affected volume.	• Requires standard precautions for protection of human health and environment.	• **To-date demonstrated through bench- and pilot-scale studies with mixed success.**	• Cost likely high because not commercially available.

Notes: Bold indicates major reason(s) rejected during alternatives analysis for sites evaluated by DTSC Study (see Table 2 of main text of PT&R guidance).
In part, table content based on EPA (1997a, 1999, 2006) and Evanko and Dzombak (1997).