Remedial Investigation and Feasibility Study

Gas Works Park Site
Seattle, Washington

for
Puget Sound Energy and the City of Seattle

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GeoEngineers
Earth Science + Technology

TABLES

Table 2-1
Upland Investigations
Gas Works Park Site
Seattle, Washington

Year	Survey Name	Investigation Description	Surface Soil	Subsurface Soil	Groundwater	NAPL/ Tar	Storm Drain Solids	Air
1971-1973	Not named	Pre-park development. Collected hand augers/dug test pits. Observations only; reported on construction drawings.	X	X				
1984	1984 Soil Characterization	EPA investigated surface and subsurface soil quality. Surface sampling focused on northeast corner, Play Barn area and Prow. Borings were site-wide.	X	X				
1984	1984 Risk Evaluation	University of Washington collected surface soil samples for a human health evaluation for park users.	X					
1985	1985 Soil Characterization	Tetra Tech collected surface soil samples for analysis of PAHs (all samples) and cyanide (selected samples).	X					
1986-1987	1987 Hydrogeology Evaluation	Tetra Tech collected subsurface soil and groundwater to characterize groundwater quality and hydrogeology.		X	X			
1988	1988 Monitoring	HDR continued ongoing monitoring of the park soil and groundwater and performed a focused field study to assess plans for an irrigation system.	X		X			
1989	1989 GW CSM	HDR installed permanent monitoring wells to evaluate groundwater migration.			X			
1997-1998	1998 Fate and Transport Evaluation	PSE partnered with EPRI to evaluate the fate and transport of MGP-related contaminants, including NAPL and tar, at Harbor Patrol, central and western park areas.		X	X	X		
1997-1998	1998 FFS	Parametrix conducted a focused feasibility study to determine cleanup options for upland soil and groundwater.		X	X	X		
1997-1998	1998_AVS-SVE	Parametrix and RETEC sampled soil and groundwater to evaluate the feasibility of an air sparging system near the former light oil plant in the southeast area of the park.		X	X	X		
1999	1999 UST Decommissioning	Gary Struthers Associates collected confirmation soil samples from a 2,000-gallon diesel fuel UST being decommissioned at Harbor Patrol.		X				
2000-2010	2000-2010 Quarterly GW Sampling	RETEC and later AMEC conducted quarterly (2000 to 2007) and annual (2008 to 2010) groundwater sampling in accordance with a 2000 groundwater compliance monitoring plan.			X			
2002	2002 Cracking Tower Geotechnical Investigation	GeoEngineers drilled two borings within the fenced Cracking Towers area for a geotechnical evaluation of their foundations; no chemical data were collected.		X				
2002-2003	2003 Supplemental Source Characterization	NAPL and tar samples were collected and used for supplemental source characterization by Battelle.				X		
2004	2004 NW Park Investigation	Parametrix collected surface and subsurface soil samples from the northwest corner of Gas Works Park for planning public access.	X	X				
2005	2005 Cracking Tower Soil Investigation	Corvus collected subsurface soil samples within the fenced Cracking Towers area for a soil quality study.		X				
2006	2006 Metro Site Preliminary Investigation	SAIC completed several borings to evaluate the Metro site as a potential source of hydrocarbons.		X				
2007	2007 NE Soil-Gas Survey	Floyd|Snider conducted a soil gas survey in the northeast corner of the GWPS to determine where soil gas was associated with the presence of shallow subsurface tar and/or DNAPL.						X
2007	2007 NE Park Investigation	Floyd|Snider and AECOM collected subsurface soil in the northeastern meadow and eastern shoreline area to the extent and mobility of NAPL.		X		X		

Year	Survey Name	Investigation Description	Surface Soil	Subsurface Soil	Groundwater	NAPL/ Tar	Storm Drain Solids	Air
2007	2007 Supplemental Source Characterization	Floyd|Snider collected and Battelle analyzed a subsurface soil sample and several tar and NAPL samples for supplemental source characterization.		X		X		
2007	2007 Western Shoreline Investigation	Floyd|Snider drilled soil borings and installed temporary monitoring wells along western shoreline to evaluate NAPL presence, geology and groundwater flow in this area.		X	X	X		
2007-2008	2007-2008 Quarterly Air Quality Monitoring	Floyd|Snider conducted quarterly air quality monitoring within the park (Cracking Towers, Prow Upwind, Weather Station Location, East Shore, and Play Barn Basement) and the Harbor Patrol facility.						X
2008	2008 Catch Basin Sampling	Floyd|Snider collected and analyzed catch basin solids and conducted a video inspection of storm drain lines as part of their Phase 1 source control evaluation.					X	
2009 - 2010	2010 Catch Basin Sampling	Storm drain solids from selected catch basins and surrounding soil were collected for Floyd|Snider's Phase 3 source control evaluation. Surface soil samples were also collected from the Waterway 19 storm drain ditch.	X				X	
2010	2010 3-D Model Sampling	GeoEngineers and Aspect conducted a hydrogeologic investigation (well levels, borings, slug and pump tests) to support development of a site-wide, three-dimensional numerical groundwater flow model.		X				
2010	2010 Agency Split Samples	Ecology analyzed split soil samples from the 2010 hydrogeologic investigation (GeoEngineers 2010).		X				
2011	2011 Agency Evaluation of Kite	Ecology collected and analyzed surface soil from Kite Hill.	X					
2011	2011 Sink Hole Sampling	Seattle Structural collected subsurface soil samples and a grab sample from a sinkhole and analyzed as part of a bulkhead structural review and assessment at Harbor Patrol.	X	X				
2012	2012 Play Area Investigation	AMEC sampled soil as part of a preliminary investigation for a proposed Children's Play Area near the Play Barn structures.	X	X				
2013	2013 Supplemental Investigation	GeoEngineers conducted an upland supplemental investigation that included a geophysical survey, existing monitoring well elevation survey, TarGOST® laser-induced fluorescence testing, soil sampling, geotechnical investigation of Kite Hill, monitoring well installation, NAPL testing, slug testing, NAPL physical properties evaluation and groundwater monitoring.	X	X	X	X		
2014	2014 Play Area Investigation	GeoEngineers conducted soil and groundwater sampling in and around the Play Area.		X	X			
2015	2015 Arsenic Treatment Bench Scale Testing	Anchor conducted a bench scale study of various injection agents for treatment of arsenic in groundwater			X			
2016	2016 Play Area Investigation	GeoEngineers collected additional groundwater samples to define arsenic extent in Play Area. Also collected soil XRF and conventional data.		X	X			
2017	2017 Play Area Investigation	GeoEngineers collected additional soil XRF data and installed monitoring wells during installation of groundwater injection infrastructure		X	X			
2017	2017 Play Area Baseline	GeoEngineers collected baseline groundwater samples for arsenic analysis from Play Area prior to reagent injection.			X			
2017	2017 Catch Basin Sampling	SPU continued catch basin sampling as part of source control evaluation. Samples collected in 2017, processed in 2018.					X	
2017-2019	Play Area Post-Treatment Sampling	GeoEngineers collected additional rounds of groundwater samples following reagent injection for arsenic analyses.			X			

See text for full acronym and abbreviation list.

Table 2-2
Sediment Investigations
Gas Works Park Site
Seattle, Washington

Year	Study Name	Investigation Description	Surface Sediment	Subsurface Sediment	Physical	Biological	Offshore Groundwater/ Porewater
1981–1986	King County Lake Monitoring Program	Multi-year Lake Union surface sediment monitoring study conducted by King County.	X				
1984	1984 EPA Sediment Investigation	EPA investigation of surface sediment quality in the vicinity of Gas Works Park.	X				
1984	1984 King County Human Health Risk Evaluation	King County collected crayfish tissue samples for human health and ecological risk evaluations.				X	
1985	1985 Lake-wide Sediment Investigation	Ecology conducted a lake-wide evaluation of surface sediment quality based on chemistry, bioassays and infaunal community structure. Only one sample was located within the AOI.	X			X	
1987	1987 PCB Risk Evaluation	The City collected crayfish tissue samples for human health and ecological risk evaluations.				X	
1990	1990 Lake-wide Sediment Investigation	Ecology conducted a lake-wide survey of surface sediment quality based on chemistry and biological samples.	X			X	
1991	1991 King County Human Health Risk Evaluation	King County collected fish and crayfish tissue for a human health risk assessment based on seafood ingestion.				X	
1991	1991 Northlake Shipyard Investigation	GeoEngineers conducted a surface and subsurface sediment investigation for the shipyard adjacent to the GWPS.	X	X			
1995	1995 EPA Sediment Investigation	EPA investigated shoreline and surface sediment quality in the vicinity of Gas Works Park.	X				
1995-2000	King County Lake Monitoring Program	King County conducted a multi-year monitoring program of Lake Union surface sediment quality.	X				
1996-1997	King County University Regulator Studies	King County collected surface sediment samples.	X				
1997, 1999	King-County Post-Separation Risk Evaluation	King County collected fish and crayfish tissue samples for human health and ecological risk evaluations.				X	
1999	1999 RETEC Phase 1 Investigation	RETEC's Phase 1 study investigated surface and subsurface sediment quality in the nearshore and surface sediment quality in offshore areas of the AOI. Physical surveys including an underwater diver-assisted towed video survey and a side-scan sonar survey were conducted.	X	X	X		
1999	Phase 1 Split Sample Analysis	Split grab and core samples from RETEC's Phase 1 study were analyzed for supplemental characterization.	X	X			
2000	2000 King County Post-Separation Sediment Investigation	King County collected sediment grab and biological samples in northeast Lake Union.	X			X	
2001	King County Lake Monitoring Program	Additional surface sediment samples across Lake Union were discovered from studies conducted by King County. Data were provided by R. Jack through electronic communication.	X				
2002	2002 Agency Sediment Investigation	Biological and surface sediment samples were collected across the sediment portion of the AOI by Ecology and Texas A&M University in March and repeated in July due to sampling handling/ laboratory quality control issues; samples collected in March were split with RETEC.	X			X	

Year	Study Name	Investigation Description	Surface Sediment	Subsurface Sediment	Physical	Biological	Offshore Groundwater/ Porewater
2002	2002 Bathymetric and Side-Scan Sonar Surveys	A side-scan sonar survey (City) and a detailed multibeam bathymetric survey (Parametrix) were performed.			X		
2002	2002 RETEC Phase 2 Investigation	RETEC's Phase 2 investigation included collecting surface and subsurface sediment for chemical and biological testing (surface only). Geotechnical and radioisotope data were also collected; a nearshore bathymetric survey was performed.	X	X	X	X	
2002-2003	Phase 2 Split Sample Analysis	Split sediment, NAPL and tar samples from RETEC's Phase 2 study were collected and used for supplemental source characterization.	X	X			
2004-2005	2004-2005 RETEC Phase 3 Investigation	RETEC's collected surface and subsurface sediment to complete the eastern sediment RI/FS. Samples collected were used to refine the horizontal and vertical extent of chemical concentrations and investigate potential contaminant sources, sediment physical properties and transport pathways. Data regarding offshore groundwater/porewater, geotechnical properties, bathymetry, soft sediment, seeps and DNAPL, debris extent, storm drains, currents and wave forces, organic carbon, and PAH partitioning were also collected.	X	X	X		X
2005	2005 RETEC Biological Evaluation	RETEC collected surface sediment for chemical and bioassay testing to address bioassay data gaps and to establish cleanup levels.	X			X	
2005	2005 Western Area RI/FS	Floyd|Snider collected surface and subsurface sediment to complete the western area RI/FS. Geotechnical properties of the sediment were also evaluated.	X	X	X		
2006	2006 Bathymetric Survey	Floyd|Snider performed a multibeam bathymetry survey to delineate bathymetry and debris.			X		
2009	2009 Northlake Shipyard Investigation	Ecology and Environment, Inc. collected subsurface sediment at Northlake Shipyard to investigate the extent of sandblast grit. Additional bathymetric data were also collected.		X	X		
2014	2014 Northlake Shipyard Post-Dredging Confirmational Sampling	Hart Crowser collected post-dredging surface sediment at Northlake Shipyard to document post-dredging sediment conditions.	X				

See text for full acronym and abbreviation list.

Table 2-3
Previous Upland Cleanup and Remedial Actions
Gas Works Park Site
Seattle, Washington

Year	Cleanup/Remedial Action Technology	Cleanup/Remedial Action Description	Performing Party	Location	Type/Status[a]	Reference
1971 / 1972	Soil cover	Washington Natural Gas covered soil impacted by a spill with a thin layer of fill. Test holes 7, 8 and 10 were located within the spill and cover area.	WNG	South Central Area	Independent Remedial Action	Cole and Machno 1971 EPA 1995
1973	Excavation	Targeted areas were identified for removal to depths ranging from 1.5- to 8-feet below grade or to water level during plant demolition and initial regrading for park development. An estimated 5,000 truck yards of impacted fill material were removed from the GWPS for off-site disposal. Additionally, an estimated 500 truck yards of rubble were removed.	City	South Central; Central; Southeast; East; Northeast Area	Independent Remedial Action	Richard Haag Associates 1973a Richard Haag Associates 1973b
1973-1974	Multiple actions including institutional controls	MGP structures were wholly removed for off-site disposal, partially removed and buried or cleaned and left in place as part of the landscape for the planned industrial-themed park. Some structures left in place were fenced.		Northern Third and Eastern Two Thirds of the Park	Independent Remedial Action	See Appendix 1B
1976	Soil cover	The City regraded the majority of the park with net removal near the shoreline and net fill away from the shoreline. A cover layer of biosolids mixed with sawdust and other organic materials was placed over the GWP. This material was mixed with imported fill and/or excavated GWP soil and graded and/or tilled into the upper surface soil layer. Kite Hill was created by mounding 20,000 cy of excavated GWP materials and covering the mound with thousands of yards of imported fill. The remaining 15,000 cy of excavated GWP materials were removed from the GWP. Excavated material and debris were covered with as much as 6 feet of clean soil during the construction of Kite Hill.	City	Park-wide	Independent Remedial Action	Richard Haag Associates 1973c HDR 1988b Sabol et al. 1988 Ongerth and Pane 1985 Parametrix and Key 1998
1984	Soil cover	Approximately 1 foot of clean soil was placed over the most impacted areas of the park.	City	Various	Independent Remedial Action	HDR 1988a Sabol et al. 1988
1985	Cap	In 1985, tar was observed seeping up through the asphalt sidewalk in the northwest section of the park, south of the railroad right-of-way. This area is in the general vicinity of the old tar refinery originally located on the GWP. The City attempted to pave (seal) some of the larger seeps (5 or 6 inches in diameter). However, the seeps continued to penetrate the asphalt, particularly during the warmer months.	City	West Central Area	Independent Remedial Action	Tetra Tech 1985
1997	Removal and disposal; clean backfill	Characterization of known and suspected tar seeps was conducted in October 1997 using backhoe test pits. With concurrence from Ecology, the City and PSE defined the extent of the shallow tar with the backhoe, removed as much tar as practicable, and backfilled the excavations with clean fill. Tar and tar-impacted soil were removed from the GWP. Twenty-two drums of semi-solid tar were removed in October 1997: one drum from TP-6 and 21 drums from TP-10, TP-11, and TP-12. Also, approximately 24 cy of tar-contaminated soil were removed from the TP-10 excavation.	City/PSE	North of Kite Hill; Southeast Corner	1999 CD/CAP Cleanup Action	Parametrix 1999 Parametrix and Key 1998
1998	Product removal and disposal	As part of an assessment of soil quality within the Cracking Tower area, HWA Geosciences discovered a partially buried tank beneath the two relief-holder scrubbers. Approximately 2,500 gallons of viscous tarry liquid was present in the tank. Most of the product was removed. The remaining non-pumpable product was left in the tank. The tank access covers were replaced and secured.	Seattle Parks Department	Cracking Tower Area	Interim Action (under 1997 AO)	Parametrix and Key 1998
1998	Institutional controls	Fencing around the Cracking Towers was improved; barriers to public access were placed in the northwest corner; and signs were erected warning park users not to eat dirt or to drink from, wade in, or swim in Lake Union. Fencing is inspected weekly.	City	Cracking Towers; Northwest Corner	1999 CD/CAP Cleanup Action	Parametrix 1999
1998-1999	Removal and disposal	Prior to installation of the AS/SVE treatment system, an Interim Remedial Action was conducted from 1998 to 1999. This action included installation of a network of recovery wells in the southeastern corner of the park. A vacuum truck was used to recover oil and groundwater from the wells.	City/PSE	Southeast Corner	1999 CD/CAP Cleanup Action	Parametrix 1999
1999	Removal and disposal	In 1999, Harbor Patrol decommissioned the 2,000-gallon diesel fuel UST (UST Site #12408). Soil samples collected below and around the UST indicated elevated diesel fuel and PAH concentrations; a groundwater sample also exceeded diesel and cPAHs cleanup levels. The UST and some affected soil were removed, but because Harbor Patrol is within the GWPS and it is an ongoing MTCA cleanup site, further soil removal was not attempted.	City	Harbor Patrol	Independent Remedial Action	Garry Struthers Associates 1999

Year	Cleanup/Remedial Action Technology	Cleanup/Remedial Action Description	Performing Party	Location	Type/Status[a]	Reference
1999-Present	Removal and disposal and clean backfill	Seattle Parks Department does periodic inspections for upwelling tar. Recent communications with Seattle Parks Department personnel indicate that surface seepage of tar is infrequent and generally involves covering “button-sized” or “thread-like” occurrences with clean soil. Residual upwelling tar is removed when discovered.	Seattle Parks Department	Site-wide	1999 CD/CAP Cleanup Action	Floyd|Snider 2008a
2000-2001	Soil cap	A 12- to 18-inch-thick vegetated soil cap was placed on approximately 5.7 acres of the upland in the north-central and southeastern portions of the park. These areas were scarified and rough-graded to a depth of 4-6 inches below ground surface. The soil cap consists of grass turf layer, 12 to 18 inches of sandy loam soil and a geogrid identifier layer. The soil cap is inspected regularly. Approximately 15 tons of soil excavated during grading activities was removed from the GWPS and treated at a low temperature thermal desorption recycling facility in Lakewood, Washington.	City/PSE	North Central; Southeast Area	1999 CD/CAP Cleanup Action	ThermoRETEC 2001
2001-2006	Air sparging/soil vapor extraction	An in situ groundwater AS/SVE treatment system was installed in the southeastern corner of the park. The AS/SVE system included various air injection wells, horizontal air collection pipes, and a geomembrane liner system consisting of a geonet drainage layer and HDPE liner to prevent uncontrolled emission of vapors containing VOCs. The AS/SVE treatment system operated in the southeast corner of the park from 2001 until December 2006, when it was turned off. Approximately 4 pounds of benzene were extracted via the SVE system, additional contamination was bioremediated.	City/PSE	Southeast Corner	1999 CD/CAP Cleanup Action	EcoCompliance 2007-2009
2001-2011	Monitored natural attenuation	Monitored natural attenuation was selected as the remedy for the area of impacted groundwater downgradient from the former ATCO plant. Monitoring results show that naphthalene concentrations in groundwater at wells closest to the shoreline in this area have either declined (MLS-6-1, a performance monitoring well) or stayed stable (CMP-1, a compliance monitoring well) over time, and have not exceeded the upland groundwater screening level.	City/PSE	Harbor Patrol; Southwest Corner	1999 CD/CAP Cleanup Action	Parametrix 1999 ThermoRETEC 2001
2005	Institutional controls	A restrictive covenant was recorded to prevent actions that disturb contaminated soil or groundwater.	Seattle Parks Department	Site-wide	1999 CD/CAP Cleanup Action	Appendix 2E
2005	Soil cap	The northwestern corner of the GWPS was recontoured and geotextile fabric and 1 to 4 feet of topsoil were added following the installation of an irrigation system.	City	Northwest Corner	1999 CD, Amendment 1 Cleanup Action	City of Seattle Parks and Recreation 2005
2007	Removal, disposal and clean backfill	Two tar occurrences were removed by the Seattle Parks Department from the seasonally submerged areas along the eastern shoreline in January 2007. An additional occurrence observed in May 2007 in the northeastern area of the upland was partially removed, and covered with geotextile fabric and clean fill.	Seattle Parks Department	Eastern Shoreline; Northeast Corner.	1999 CD, Amendment 1 Cleanup action; Interim action (under 2005 AO)	Floyd|Snider 2008a
2008	Removal, disposal and clean backfill	In August 2008, Seattle Parks Department partially removed tar seeps observed in the eastern shoreline and in the valley west of the Cracking Towers. A total of four seeps were identified. Excavated areas were backfilled.	Seattle Parks Department	Eastern Shoreline; Cracking Tower	1999 CD, Amendment 1 Cleanup Action	Floyd|Snider 2008a
2012	Soil cap	In November 2012, the northeast corner was capped with clean soil by Ecology. A geotextile fabric was placed between the clean soil and the former ground surface below.	Ecology	Northeast Corner	1999 CD, Amendment 1 Cleanup Action; Ecology Remedial Action	Hart Crowser 2012b
2014	Soil cap	In fall 2014, Kite Hill underwent drainage improvements and was capped. Work included removal and placement of a cap consisting of a gravel drainage layer, geotextile and clean soil.	PSE/City	Kite Hill	1999 CD, Amendment 1 Cleanup Action	GeoEngineers 2015
2017-2020	In situ chemical fixation	In 2017, an interim action to address arsenic in groundwater beneath the Play Area was approved by Ecology and initiated by installing a network of injection wells within the footprint of the Play Area to allow in situ remediation of dissolved arsenic by chemical fixation. Following installation of the injection infrastructure, multiiple rounds of injection of an iron-based reagent were completed in 2017 through 2019, with groundwater performance monitoring conducted throughout the interim action to evaluate effectiveness of the remediation. Significant reduction of dissolved arsenic was observed throughout the footprint of the Play Area.	PSE/City	Play Barn	Interim Action (under 2005 AO and Amendments 1, 2, 3)	GeoEngineers 2017

Notes:

See text for full acronym list.

[a]Remedial action types/status:

Independent remedial action (WAC 173-340-515). Action performed by PLPs without Ecology oversight or approval.

Interim Action – 1997 AO (WAC 173-340-430 and -530). Interim action performed under the 1997 Agreed Order with Ecology oversight/approval.

1999 CD/CAP (WAC 173-340-400 and -520). Cleanup action performed under the 1999 Consent Decree and Cleanup Action Plan.

1999 CD, Amendment 1 and 2005 CAP (WAC 173-340-400 and -520). Cleanup action performed under 1999 Consent Decree, Amendment No. 1 and 2005 Cleanup Action Plan.

Interim Action – 2005 AO (WAC 173-340-430 and -530). Interim action performed under the 2005 Agreed Order with Ecology oversight/approval.

Department Remedial Action (WAC 173-340-510(4)). Remedial action performed by Ecology.

Interim Action – 2005 AO & Amendments 1, 2, 3 (WAC 173-340-430 and -530). Interim action performed under the 2005 Agreed Order and Amendments 1 (2013), 2 (2017), and 2 (2017) with Ecology oversight/approval.

Table 3-1

Ambient Lake Union Sediment Concentrations

Gas Works Park Site

Seattle, Washington

Parameter	No. of Samples	No. of Non-Detects	% Non-Detects	Concentration (mg/kg)		
				Mean[a]	Minimum Detected Value	Maximum Detected Value
Conventionals						
Sulfide	21	1	5%	1,330	140	3,600
PAHs						
Total PAH	62	2	3%	47	1.4	316
cPAH TEQ	61	2	3%	5.4	0.186	31.1
TPH						
Diesel Range Hydrocarbons	8	6	75%	357	934	1,010
SVOCs						
4-Methylphenol	45	25	56%	0.19	0.05	1
Benzoic Acid	42	19	45%	1.3	0.5	2.7
Bis(2-ethylhexyl)phthalate	48	6	13%	6.8	0.2	190
Carbazole	20	9	45%	0.18	0.03	0.6
Dibenzofuran	47	24	51%	0.11	0.04	1
Di-n-butylphthalate	48	22	46%	0.22	0.03	1
Di-n-octylphthalate	42	39	93%	0.11	0.01	3.8
Hexachlorobenzene	37	34	92%	0.003	0.001	0.05
Pentachlorophenol	41	23	56%	0.11	0.08	0.55
Phenol	47	33	70%	0.21	0.03	1.9
Pesticides						
Chlordane	5	2	40%	62	5.0	290
4,4'-DDE	15	4	27%	13	5.0	34
PCBs						
Total PCBs (Aroclors)	23	3	13%	0.69	0.04	6.4
Butyltins						
Tributyltin	17	0	0%	1.5	0.02	4.1
Metals						
Arsenic	50	8	16%	53	10	270
Cadmium	47	5	11%	1.9	0.6	6.5
Chromium	47	4	9%	73	24	411
Copper	47	0	0%	358	69	2,140
Lead	47	0	0%	504	157	3,930
Mercury	53	3	6%	1.7	0.4	27
Methylmercury	Not analyzed					
Nickel	33	0	0%	58	5.4	597
Silver	33	12	36%	2.2	0.15	25

Notes:

[a] The arithmetic mean is used when all values are detected; otherwise the Kaplan-Meier mean is used.

See text for full acronym and abbreviation list.

Table 3-2

Species Occurrence

Gas Works Park Site

Seattle, Washington

Common Name	Scientific Name	Occurrence	Habitat Use	
			Upland	Aquatic
Birds				
American Crow	*Corvus brachyrhynchos*	Year-round	X	
American Coot	*Fulica americana*	Seasonal		X
American Goldfinch	*Carduelis tristis*	Year-round	X	
American Robin	*Turdus migratorious*	Year-round	X	
American Wigeon	*Anas americana*	Seasonal		X
Bald Eagle	*Haliaeetus leucocephalus*	Year-round	X	
Barn Swallow	*Hirundo rustica*	Seasonal	X	
Belted Kingfisher	*Megaceryle alcyon*	Year-round	X	
Bewick's Wren	*Thryomanes bewickii*	Seasonal	X	
Black-capped Chickadee	*Poecile atricapillus*	Year-round	X	
Bufflehead	*Bucephala albeola*	Seasonal		X
Bushtit	*Psaltriparus minimus*	Year-round	X	
Canada Goose	*Branta canadensis*	Year-round	X	X
Canvasback	*Aythya valisineria*	Seasonal		X
Caspian Tern	*Hydroprogne caspia*	Seasonal		X
Cliff Swallow	*Petrochelidon pyrrhonota*	Seasonal	X	
Common Goldeneye	*Bucephala clangula*	Seasonal		X
Common Loon	*Gavia immer*	Seasonal		X
Common Merganser	*Mergus merganser*	Seasonal		X
Cooper's Hawk	*Accipiter cooperii*	Seasonal	X	
Dark-eyed Junco	*Junco hyemalis*	Seasonal	X	
Double-crested Cormorant	*Phalacrocorax auritus*	Year-round	X	X
European Starling	*Sturnus vulgaris*	Year-round	X	
Gadwall	*Anas strepera*	Year-round		X
Glaucous-winged Gull	*Larus glaucescens*	Year-round	X	X
Great Blue Heron	*Ardea herodias*	Year-round		X
Herring Gull	*Larus argentatus*	Seasonal	X	X
House Finch	*Carpodacus mexicanus*	Year-round	X	
House Sparrow	*Passer domesticus*	Year-round	X	
Killdeer	*Charadrius vociferus*	Year-round	X	
Lesser Scaup	*Aythya affinis*	Seasonal		X
Mallard	*Anas platychynchos*	Year-round	X	X
Northern Flicker	*Colaptes auratus*	Year-round	X	
Northern Shoveler	*Anas clypeata*	Seasonal		X
Pied-billed Grebe	*Podilymbus podiceps*	Year-round		X
Red-necked Grebe	*Podiceps grisegena*	Seasonal		X
Red-tailed Hawk	*Buteo jamaicensis*	Year-round	X	
Red-winged Blackbird	*Agelaius phoeniceus*	Year-round	X	
Ring-billed Gull	*Larus delawarensis*	Year-round		X
Rock Pigeon	*Columba livia*	Year-round	X	
Ruby-crowned Kinglet	*Regulus calendula*	Year-round	X	
Song Sparrow	*Melospiza melodia*	Year-round	X	
Western Osprey	*Pandion haliaetus*	Seasonal	X	
Yellow-rumped Warbler	*Dendroica coronata*	Year-round	X	
Mammals				
Beaver[a]	*Castor canadensis*	Year-round		X
Eastern gray squirrel	*Sciurus carolinensis*	Year-round	X	
Muskrat	*Ondatra zibethicus*	Year-round		X
Nutria	*Myocastor coypus*	Year-round		X
Raccoon	*Procyon lotor*	Year-round	X	
Rat	*Rattus* spp.	Year-round	X	
River otter	*Lontra canadensis*	Year-round		X
Vole	*Microtus* spp.	Year-round	X	
Fish[b]				
White crappie	*Pomoxis annularis*	Year-round		X
Bluegill sunfish	*Lepomis macrochirus*	Year-round		X
Bull trout	*Salvelinus confluentus*	Unknown[c]		X
Brown bullhead	*Ameiurus nebulosus*	Year-round		X
Chinook salmon	*Onchorhynchus tshawytscha*	Seasonal		X
Coho salmon	*Onchorhynchus kisutch*	Seasonal		X
Largescale sucker	*Catosomus macrocheilus*	Year-round		X
Largemouth bass	*Micropterus salmoides*	Year-round		X
Northern squawfish	*Ptychocheilus oregonensis*	Year-round		X
Peamouth chub	*Mylocheilus caurinus*	Year-round		X
Pumpkinseed	*Lepomis gibbosus*	Year-round		X
Sculpin	*Cottus* spp.	Year-round		X
Smallmouth bass	*Micropterus dolomieui*	Year-round		X
Sockeye salmon	*Onchorhynchus nerka*	Seasonal		X
Starry flounder	*Platichthys stellatus*	Seasonal[d]		X
Steelhead (rainbow trout)	*Onchorhynchus mykiss*	Seasonal		X
Three-spine stickleback	*Gasterosteus aculeatus*	Year-round		X
Yellow perch	*Perca flavescens*	Year-round		X

Common Name	Scientific Name	Occurrence	Habitat Use	
			Upland	Aquatic
Invertebrates[e]				
Amphipods	Various	Year-round		X
Clams	*Pisidium* spp.	Year-round		X
Crayfish	*Pacifastacus leniusculus*	Year-round		X
Earthworms	*Lumbriculus* spp., *Aporrectodea* spp., *Octolasion* sp.	Year-round	X	
European crane fly	*Tipula paludosa*	Year-round	X	
Insects	Chironomidae	Year-round	X	X
Nemertean worms	*Prostoma* spp.	Year-round		X
Oligochaete worms	Tubificidae, Naididae	Year-round		X
Snails	*Physella* spp., *Gyraulus* spp.	Year-round		X
Plants[f]				
American waterweed	*Elodea canadensis*	Seasonal		X
Benthic algae, diatoms	Various	Seasonal		X
Birch	*Betula* spp.	Year-round	X	
Butterfly bush	*Buddleja davidii*	Year-round	X	
English ivy	*Hedera helix*	Year-round	X	
Eurasian milfoil	*Myriophyllum spicatum*	Seasonal		X
Himalayan blackberry	*Rubrus armeniacus*	Year-round	X	
Iris	*Iris* spp.	Year-round	X	X
Katsura tree	*Cercidiphyllum japonicum*	Year-round	X	
London plane tree	*Platanus acerifolia*	Year-round	X	
Plum	*Prunus domestica*	Year-round	X	
Pricky current	*Ribes lacustre*	Year-round	X	
Purple loosestrife	*Lythrum salicaria*	Seasonal	X	X
Red alder	*Alnus rubra*	Year-round	X	
Red maple	*Acer rubrum*	Year-round	X	
Red osier dogwood	*Cornus stolonifera*	Year-round	X	
Reed canarygrass	*Phalaris arundinacea*	Seasonal	X	X
Rushes	*Juncus effuses, J. acuminatus*	Seasonal	X	X
Rye grass	*Lolium perenne*	Year-round	X	
Scot's broom	*Cytisus scoparius*	Year-round	X	
Sedge	*Carex stipata*	Seasonal	X	X
Shore sedge	*Carex lenticularis lasiocarpa*	Seasonal	X	
Slough sedge	*Carex obnupta*	Seasonal	X	
Smooth labrador-tea	*Rhododendron neogladulosum*	Year-round	X	
Snowberry	*Symphoricarpos albus*	Year-round	X	
Spirea	*Spirea douglasii*	Year-round	X	
Western red cedar	*Thuja plicata*	Year-round	X	
Trailing blackberry	*Rubus ursinus macropetalus*	Seasonal	X	
Willow	*Salix* spp.	Year-round	X	

Notes:

[a] Evidence of beaver activity was noted along the eastern shoreline in December 2013.

[b] Fish assemblage information from Landolt and Busch (1991).

[c] Bull trout have not been recorded in Lake Union; however, the lake is listed as foraging, migratory, and overwintering habitat for this species.

[d] Starry flounder were collected in September 1990 in Lake Union (Landolt and Busch 1991). This is a marine species with a high tolerance to low salinity conditions; their presence is likely due to saltwater intrusion during the summer months.

[e] Invertebrate information from Yake et al. (1986).

[f] Plants identified from Construction Completion Report (ThermoRetec 2001) and Richard Haag Associates (1975) planting plan for the park and site observations.

Table 3-3

Overwater Structures

Gas Works Park Site

Seattle, Washington

Overwater Structure	Description
Gas Works Park	
None	
Harbor Patrol	
Log boom	Along the eastern edge of the shoreline, extending approximately 125 feet into the lake. Used to control wave action within the boat moorage area at Harbor Patrol.
Timber-supported pier	West of the log boom, extending approximately 150 feet from the shoreline into Lake Union. Used for Harbor Patrol vessel moorage. Outer portion of the pier runs parallel to the shoreline and includes several mooring dolphins for docking large vessels.
Concrete wharf	Northwest of timber pier is a 100-foot-long pier supported by concrete piling. Rebuilt in the 1980s; supports aboveground fuel tanks for Harbor Patrol emergency response vessels.
Floating docks	One 75-foot-long floating dock northwest of concrete fueling wharf is used for emergency response vessel moorage. A second floating dock (50 feet long) runs along eastern edge of the boathouse.
Boathouse	A boathouse is northwest of the 75-foot floating dock. Extends approximately 50 feet into Lake Union. Rests on lake bottom.
Waterway 20	
Miscellaneous structures	Harbor Patrol uses approximately 125 feet of WDNR-owned shoreline within waterway for storage of floating debris and navigation hazards removed from Lake Union. Recovered material within the storage area is surrounded by a log boom.
King County Metro	
Timber-supported piers	Three timber pile-supported piers are located offshore of the Center for Wooden Boats facility. One pier runs parallel to the shoreline; the others extend out into Lake Union. The latter two piers offer approximately 200 feet of moorage space.
Gas Works Park Marina	
Pile-supported dock	Marina is composed of two pile-supported wooden docks with 70 slips. Utilities are present beneath the dock at various depths.
Floating homes	Majority of slips are occupied by floating homes or live-aboard vessels.

Table 4-1

Summary of Site-Specific Screening Levels for Contaminants of Concern

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Concern		Medium				
						Sediment	
			Soil[a]	Upland Groundwater[b]	Offshore Groundwater[c]	Sediment Cleanup Objective	Cleanup Screening Level
			mg/kg	µg/L	µg/L	mg/kg	mg/kg
Conventionals	Sulfide		--	--	--	39	61
BTEX	Benzene		--	43	0.44	--	--
	Ethylbenzene		--	6,910	29	--	--
	Toluene		--	48,500	--	--	--
PAHs	Total PAH		--	--	--	17	30
	Fluoranthene		3,200	--	6	--	--
	Naphthalene		3,200	9,880	160	--	--
	Pyrene		2,400	--	8	--	--
	cPAHs	Benzo(a)anthracene	0.137	0.0296	0.01	Included in Total cPAHs TEQ Screening Level	
		Benzo(a)pyrene	0.137	0.0296	0.01		
		Benzo(b)fluoranthene	0.137	0.0296	0.01		
		Benzo(k)fluoranthene	0.137	0.0296	0.01		
		Chrysene	0.137	0.0296	0.016		
		Indeno(1,2,3-cd)pyrene	0.137	0.0296	0.01		
		Dibenzo(a,h)anthracene	0.137	0.0296	--		
	Total cPAHs TEQ		--	--	0.02	0.021	0.21
TPH	Diesel Range Hyrdocarbons		--	--	--	340	510
SVOCs	4-Methylphenol		--	--	--	0.26	2.0
	Benzoic Acid		--	--	--	2.9	3.8
	Bis(2-ethylhexyl)phthalate		--	--	3.0	0.50	22
	Carbazole		--	--	2.0	0.90	1.1
	Dibenzofuran		--	--	16	0.20	0.68
	Di-n-Butyl phthalate		--	--	--	0.38	1.0
	Di-n-Octyl phthalate		--	--	--	0.039	>1.1
	Hexachlorobenzene		--	--	--	0.005	0.005
	Pentachlorophenol		--	--	--	0.02	0.02
	Phenol		--	--	--	0.12	0.21
Pesticides	Chlordane		--	--	--	0.001	0.001
	4,4'-DDE		--	--	--	0.021	0.033
PCBs	Total PCBs (Aroclor)		--	--	--	0.02	0.02
Butyltins	Tributyltin		--	--	--	0.047	0.32
Metals	Arsenic		20	n/a[d]	8	11	24
	Cadmium		--	--	0.72	2.1	5.4
	Chromium		--	--	--	62	62
	Copper		--	--	11	400	1,200
	Lead		--	--	2.5	360	>1,300
	Mercury		--	--	0.10	0.66	0.8
	Methylmercury		--	--	--	0.000058	0.000058
	Nickel		--	--	52	50	110
	Silver		--	--	3.2	0.57	1.7

Notes:

[a] 1999 Consent Decree Soil Cleanup Level.

[b] 1999 Consent Decree Groundwater Cleanup Level. See Section 4.1.2 for description of Upland groundwater.

[c] Applies 10 centimeters below the mudline, at the base of the biologically active zone. See Sections 4.1.3 for descriptions of Offshore groundwater.

[d] Arsenic, which is not a 1999 Consent Decree COC in upland groundwater, is evaluated in offshore groundwater.

-- = Chemical not identified as a COC

See text for full acronym and abbreviation list.

Table 4-2

Offshore Groundwater Screening Levels

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Potential Concern	CASRN	Risk-Based Criteria: Surface Water Criteria: Chapter 173-201A WAC[a]: Protection of Aquatic Organisms: Fresh Water: Acute (µg/L)	Chapter 173-201A WAC[a]: Protection of Aquatic Organisms: Fresh Water: Chronic (µg/L)	Chapter 173-201A WAC[a]: Protection of Human Health Based on Consumption of: Water and Organism (µg/L)	40 CFR 131.45[b]: Protection of Human Health Based on Consumption of: Water and Organism (µg/L)	Section 304 of the Clean Water Act[c]: Protection of Aquatic Organisms: Fresh Water: Acute (µg/L)	Section 304 of the Clean Water Act[c]: Protection of Aquatic Organisms: Fresh Water: Chronic (µg/L)	Section 304 of the Clean Water Act[c]: Protection of Human Health Based on Consumption of: Water and Organism (µg/L)	WAC 173-340-730[d]: Protection of Human Health Based on Fish Consumption: MTCA Method B (formula value): Carcinogen (µg/L)	WAC 173-340-730[d]: MTCA Method B (formula value): Non-Carcinogen (µg/L)	Drinking Water Criteria - Surface Water: Federal MCL[e] (µg/L)	Drinking Water Criteria - Surface Water: State MCL[f] (µg/L)	Drinking Water Criteria - Surface Water: MTCA Method B Screening Levels for Potable Groundwater Standard Formula Value (WAC 173-340)[g]: Carcinogen (µg/L)	MTCA Method B Screening Levels for Potable Groundwater Standard Formula Value (WAC 173-340)[g]: Non-Carcinogen (µg/L)	Sediment Criteria: Groundwater SL for Protection of Sediment[h]: Sediment Cleanup Objective (µg/L)	Sediment Criteria: Groundwater SL for Protection of Sediment[h]: Cleanup Screening Level (µg/L)	Lowest Risk-Based Criterion (ug/L)	PQL[i] (µg/L)	Offshore Groundwater Screening Level (µg/L)
Conventionals	Sulfide	TS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.05	--
BTEX	Benzene	71-43-2	--	--	0.44	--	--	--	0.58	6.3	550	5	5	0.8	32	--	--	0.44	0.20	0.44
BTEX	Ethylbenzene	100-41-4	--	--	200	29	--	--	68	--	1,900	700	700	--	800	--	--	29	0.20	29
BTEX	Toluene	108-88-3	--	--	180	72	--	--	57	--	5,400	1,000	1,000	--	640	--	--	57	0.20	57
PAHs	Benzo(a)anthracene	56-55-3	--	--	0.014	0.00016	--	--	0.0012	--	--	--	--	--	--	cPAH TEQ		0.00016	0.01	0.01
PAHs	Benzo(a)pyrene	50-32-8	--	--	0.0014	0.000016	--	--	0.00012	0.060	7.2	0.2	0.2	0.023	4.8	cPAH TEQ		0.000016	0.01	0.01
PAHs	Benzo(b)fluoranthene	205-99-2	--	--	0.014	0.00016	--	--	0.0012	--	--	--	--	--	--	cPAH TEQ		0.00016	0.01	0.01
PAHs	Benzo(k)fluoranthene	207-08-9	--	--	0.014	0.0016	--	--	0.012	--	--	--	--	--	--	cPAH TEQ		0.0016	0.01	0.01
PAHs	Chrysene	218-01-9	--	--	1.4	0.016	--	--	0.12	--	--	--	--	--	--	cPAH TEQ		0.016	0.01	0.016
PAHs	Dibenzo(a,h)anthracene	53-70-3	--	--	0.0014	0.000016	--	--	0.00012	--	--	--	--	--	--	cPAH TEQ		0.000016	0.01	0.01
PAHs	Fluoranthene	206-44-0	--	--	16	6	--	--	20	--	25	--	--	--	640	--	--	6.0	0.01	6
PAHs	Indeno(1,2,3-cd)pyrene	193-39-5	--	--	0.014	0.00016	--	--	0.0012	--	--	--	--	--	--	cPAH TEQ		0.00016	0.01	0.01
PAHs	Pyrene	129-00-0	--	--	310	8	--	--	20	--	720	--	--	--	480	--	--	8	0.01	8
PAHs	Naphthalene	91-20-3	--	--	--	--	--	--	--	--	1,400	--	--	--	160	--	--	160	0.01	160
PAHs	Total PAH	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PAHs	Total cPAHs TEQ	--	--	--	--	--	--	--	--	0.060	--	--	--	0.023	--	0.00017	0.0017	0.00017	0.02	0.02
SVOCs	4-Methylphenol	106-44-5	--	--	--	--	--	--	--	--	--	--	--	--	800	--	--	800	2.0	800
SVOCs	Benzoic Acid	65-85-0	--	--	--	--	--	--	--	--	--	--	--	--	64,000	11,000	15,000	11,000	20	11,000
SVOCs	bis(2-Ethylhexyl)phthalate	117-81-7	--	--	0.23	0.045	--	--	0.32	0.99	110	6	6	6.3	320	0.035	1.5	0.035	3.0	3.0
SVOCs	Carbazole	86-74-8	--	--	--	--	--	--	--	--	--	--	--	--	--	2.0	2.5	2.0	1.0	2.0
SVOCs	Dibenzofuran	132-64-9	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	16	1.0	16
SVOCs	Di-n-Butyl phthalate	84-74-2	--	--	450	8	--	--	20	--	810	--	--	--	1,600	1.9	4.9	1.9	1.0	1.9
SVOCs	Di-n-Octyl phthalate	117-84-0	--	--	--	--	--	--	--	--	--	--	--	--	160	0.0000036	0.00010	0.0000036	1.0	1.0
SVOCs	Hexachlorobenzene	118-74-1	--	--	0.000051	0.000005	--	--	0.000079	0.00013	0.066	1	1	0.055	13	0.00048	0.00	0.000005	1.0	1.0
SVOCs	Pentachlorophenol[k]	87-86-5	14	8.6	0.046	0.002	19	15	0.03	0.41	330	1	1	0.22	80	0.26	0.26	0.002	10	10
SVOCs	Phenol	108-95-2	--	--	18,000	9,000	--	--	4,000	--	150,000	--	--	--	2,400	31	54	31	1.0	31
Butyltins	Tributyl Tin	688-73-3	--	--	--	--	0.46	0.072	--	--	--	--	--	--	--	--	--	0.072	0.193	0.193
Metals	Arsenic	7440-38-2	360	190	10	0.018	340	150	0.018	0.027	4.9	10	10	0.058	4.8	380	820	0.018	0.05	8[j]
Metals	Cadmium	7440-43-9	3.7	1	--	--	1.8	0.72	--	--	11	5	5	--	8	310	790	0.72	0.002	0.72
Metals	Chromium	7440-47-3	550	180	--	--	570	74	--	--	67,000	100	100	--	24,000	62	62	62	0.005	62
Metals	Copper	7440-50-8	17	11	1300	--	--	--	1300	--	800	1,300	1,300	--	640	18,000	54,000	11	0.002	11
Metals	Lead	7439-92-1	65	2.5	--	--	65	2.5	--	--	--	15	15	--	--	36	130	2.5	0.02	2.5
Metals	Mercury	7439-97-6	2.1	0.012	--	--	1.4	0.77	--	--	--	2	2	--	--	13	15	0.012	0.10	0.10
Metals	Nickel	7440-02-0	1400	160	150	80	470	52	610	--	310	--	100	--	320	400	1,700	52	0.10	52
Metals	Silver	7440-22-4	3.4	--	--	--	3.2	--	--	--	7,200	--	100	--	80	67	200	3.2	0.003	3.2

Notes:

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC, adopted August 1, 2016. Based on protection of aquatic organisms and human health.

[b] Revision of certain Federal water quality criteria applicable to Washington, 40 CFR 131.45, effective date December 28, 2016. Based on protection of human health.

[c] National recommended water quality criteria for the protection of aquatic organisms and human health, Section 304 of the Clean Water Act; https://www.epa.gov/wqc/national-recommended-water-quality-criteria (accessed Oct 2019).

[d] MTCA Method B surface water screening levels calculated according to WAC 173-340-730(3)(b)(iii)(a) (equation 730-1) and WAC 173-340-730(3)(b)(iii)(b) (equation 730-2).

[e] National Primary Drinking Water Regulation; https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations (accessed Oct 2019).

[f] Washington Primary Drinking Water Standards, WAC 246-290-130.

[g] MTCA Method B groundwater screening levels calculated according to WAC 173-340-720(3)(b)(iii)(A) (equation 720-1) and WAC 173-340-720(4)(b)(iii)(B) (equation 720-2).

[h] Groundwater value protective of sediment using sediment cleanup objectives and cleanup screening levels in Table 4-3 and Table 4-4, respectively; calculation details in Table 4F-1.

[i] PQL is lowest practical value from Analytical Resources, Inc. The PQL for total cPAHs TEQ is derived by applying TEFs to individual cPAH PQLs and summing.

[j] Arsenic screening level is based on arsenic natural background groundwater concentration of 8 µg/L in the Puget Sound Basin (Ecology 2022).

[k] Washington State (Chapter 173-201A) freshwater aquatic life criteria for pentachlorophenol are pH dependent. The values presented correspond to a pH of 7.8 based on the average pH in offshore groundwater samples using the formula provided in WAC 173-201A-240).

-- = no value available

Gray shading identifies the basis for the Lowest Risk-Based Criterion.

Blue shading identifies the basis for the offshore groundwater screening level (after PQL adjustment, if applicable).

See text for full acronym and abbreviation list.

Table 4-3

Sediment Screening Levels - Sediment Cleanup Objectives

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Potential Concern	Risk-Based Criteria			Lowest Risk-Based Criterion	Modifying Criteria		Sediment Cleanup Objective
		Direct Contact - Benthic Organisms	Direct Contact - People	Bioaccumulation - People/Higher Trophic Level Organisms[c]				
		Freshwater Sediment Criteria[a]	Sediment Ingestion and Dermal Contact[b]	Ingestion of Fish/Shellfish		Natural Background[d]	PQL[e]	
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Conventionals	Ammonia	230	--	--	230	--	0.40	230
	Sulfide	39	--	--	39	--	1.0	39
PAHs	Total PAH	17	--	--	17	--	--	17
	Total cPAHs TEQ	--	0.90 (beach play)/0.68 (net fishing)	Natural Background or PQL	Natural Background or PQL	0.021	0.008	0.021
TPH	Diesel Range Hydrocarbons	340	--	--	340	--	50	340
SVOCs	4-Methylphenol	0.26	--	--	0.26	--	0.02	0.26
	Benzoic Acid	2.9	--	--	2.9	--	0.1	2.9
	Bis(2-ethylhexyl)phthalate	0.50	--	--	0.50	--	0.02	0.50
	Carbozole	0.90	--	--	0.90	--	0.02	0.90
	Dibenzofuran	0.20	--	--	0.20	--	0.02	0.20
	DI-n-Butylphthalate	0.38	--	--	0.38	--	0.02	0.38
	DI-n-Octylphthalate	0.039	--	--	0.039	--	0.02	0.039
	Hexachlorobenzene	--	3.9 (beach play)/2.5 (net fishing)	Natural Background or PQL	Natural Background or PQL	--	0.005	0.005
	Pentachlorophenol	1.2	--	Natural Background or PQL	Natural Background or PQL	--	0.02	0.02
	Phenol	0.12	--	--	0.12	--	0.02	0.12
Pesticides	Chlordane	--	--	Natural Background or PQL	Natural Background or PQL	--	0.001	0.001
	Dieldrin	0.0049	--	--	0.0049	--	0.001	0.0049
	4,4'-DDD	0.31	--	--	0.31	--	0.001	0.31
	4,4'-DDE	0.21	--	--	0.021	--	0.001	0.021
	4,4'-DDT	0.10	--	--	0.1	--	0.001	0.1
PCBs	Total PCBs (Aroclor)	0.11	--	Natural Background or PQL	Natural Background or PQL	--	0.02	0.02
Butyltins	Monobutytin	0.54	--	--	0.54	--	0.004	0.54
	Dibutyltin	0.91	--	--	0.91	--	0.006	0.91
	Tributyltin	0.047	--	--	0.047	--	0.004	0.047
	Tetrabutyltin	0.097	--	--	0.097	--	0.005	0.097
Metals	Arsenic	14	4.8 (beach play)/3.0 (net fishing)	Natural Background or PQL	Natural Background or PQL	11	0.1	11
	Cadmium	2.1	--	--	2.1	0.8	0.2	2.1
	Chromium	72	--	Natural Background or PQL	Natural Background or PQL	62	0.5	62
	Copper	400	--	--	400	45	0.2	400
	Lead	360	--	--	360	21	2	360
	Mercury	0.66	--	--	0.66	0.2	0.025	0.66
	Methylmercury	--	--	Natural Background or PQL	Natural Background or PQL	--	0.000058	0.000058
	Nickel	26	--	--	26	50	1	50
	Selenium	11	--	--	11	--	0.5	11
	Silver	0.57	--	--	0.57	0.24	0.2	0.57
	Zinc	3,200	--	--	3,200	93	1	3,200

Notes:

[a] Sediment Management Standards (Chapter 173-204 WAC); Table VI.

[b] Ingestion and dermal contact screening levels calculated using exposure scenarios (beach play child and tribal netfishing adult) and parameters from Ecology's SCUM Guidance (Ecology 2019b). SCO values based on a cancer risk of 1 x 10^{-6} or a hazard quotient of 1; calculation details in Table 4F-2 and Table 4F-3.

[c] Bioaccumulation SCO and CSL values developed per Section 9, Option 1 from Ecology's SCUM guidance (Ecology 2019b).

[d] Natural background values from Ecology's SCUM guidance (Ecology 2019b).

[e] PQL is lowest practical value from Analytical Resources, Inc. The PQL for total cPAHs TEQ is derived by applying TEFs to individual cPAH PQLs and summing.

-- = no value available

Gray shading identifies the basis for the Lowest Risk-Based Criterion.

Blue shading identifies the basis for the screening level (after PQL adjustment, if applicable).

See text for full acronym and abbreviation list.

Table 4-4

Sediment Screening Levels - Cleanup Screening Levels

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Potential Concern	Risk-Based Criteria			Lowest Risk-Based Criterion	Modifying Criteria		Cleanup Screening Level
		Direct Contact - Benthic Organisms	Direct Contact - People	Bioaccumulation - People/Higher Trophic Level Organisms[c]		Regional Background[d]	PQL[e]	
		Freshwater Sediment Criteria[a]	Sediment Ingestion and Dermal Contact[b]	Ingestion of Fish/Shellfish				
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Conventionals	Ammonia	300	–	–	300	–	0.40	300
	Sulfide	61	'–	'–	61	–	1.0	61
PAHs	Total PAH	30	'–	–	30	–	–	30
	Total cPAHs TEQ	n/a	9.0 (beach play)/6.8 (net fishing)	Regional Background or PQL	Regional Background or PQL	0.21	0.008	0.21
TPH	Diesel Range Hydrocarbons	510	–	–	510	–	50	510
SVOCs	4-Methylphenol	2.0	–	–	2.0	–	0.02	2.0
	Benzoic Acid	3.8	–	–	3.8	–	0.1	3.8
	Bis(2-ethylhexyl)phthalate	22	–	–	22	–	0.02	22
	Carbozole	1.1	–	–	1.1	–	0.02	1.1
	Dibenzofuran	0.68	–	–	0.68	–	0.02	0.68
	DI-n-Butylphthalate	1.0	–	–	1.0	–	0.02	1.0
	DI-n-Octylphthalate	>1.1	–	–	>1.1	–	0.02	>1.1
	Hexachlorobenzene	–	39 (beach play)/25 (net fishing)	Regional Background or PQL	Regional Background or PQL	–	0.005	0.005
	Pentachlorophenol	1.2	–	Regional Background or PQL	Regional Background or PQL	–	0.02	0.02
	Phenol	0.21	–	–	0.21	–	0.02	0.21
Pesticides	Chlordane	–	–	Regional Background or PQL	Regional Background or PQL	–	0.001	0.001
	Dieldrin	0.0093	–	–	0.0093	–	0.001	0.0093
	4,4'-DDD	0.86	–	–	0.86	–	0.001	0.86
	4,4'-DDE	0.033	–	–	0.033	–	0.001	0.033
	4,4'-DDT	8.1	–	–	8.1	–	0.001	8.1
PCBs	Total PCBs (Aroclor)	2.5	–	Regional Background or PQL	Regional Background or PQL	–	0.02	0.02
Butyltins	Monobutytin	4.8	–	–	4.8	–	0.004	4.8
	Dibutyltin	130	–	–	130	–	0.006	130
	Tributyltin	0.32	–	–	0.32	–	0.004	0.32
	Tetrabutyltin	0.097	–	–	0.097	–	0.005	0.097
Metals	Arsenic	120	48 (beach play)/30 (net fishing)	Regional Background or PQL	Regional Background or PQL	24	0.1	24
	Cadmium	5.4	–	–	5.4	–	0.2	5.4
	Chromium	88	–	Regional Background or PQL	Regional Background or PQL	62	0.5	62
	Copper	1,200	–	–	1,200	–	0.2	1,200
	Lead	>1,300	–	–	>1,300	–	2	>1,300
	Mercury	0.8	–	–	0.8	–	0.025	0.8
	Methylmercury	–	–	Regional Background or PQL	Regional Background or PQL	–	0.000058	0.000058
	Nickel	110	–	–	110	–	1	110
	Selenium	20	–	–	20	–	0.5	20
	Silver	1.7	–	–	1.7	–	0.2	1.7
	Zinc	4,200	–	–	4,200	–	1	4,200

Notes:

[a] Sediment Management Standards (Chapter 173-204 WAC); Table VI.

[b] Ingestion and dermal contact screening levels calculated using exposure scenarios (beach play child and tribal netfishing adult) and parameters from Ecology's SCUM Guidance (Ecology 2019b). CSL values based on a cancer risk of 1 x 10-5 or a hazard quotient of 1; calculation details in Table 4F-2 and Table 4F-3.

[c] Bioaccumulation SCO and CSL values developed per Section 9, Option 1 from Ecology's SCUM guidance (Ecology 2019b).

[d] cPAH regional background value is from Ecology's SCUM guidance (Ecology 2019b). The arsenic regional background value is preliminary; calculation details in Appendix 4A. The chromium value is the natural background value from Ecology's SCUM guidance; no regional background value is available for chromium.

[e] PQL is lowest practical value from Analytical Resources, Inc. The PQL for total cPAHs TEQ is derived by applying TEFs to individual cPAH PQLs and summing.

– = no value available

Gray shading identifies the basis for the Lowest Risk-Based Criterion.

Blue shading identifies the basis for the screening level (after PQL adjustment, if applicable).

See text for full acronym and abbreviation list.

Table 4-5

Summary of Contaminants of Concern

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Concern (COCs)		Medium			
			Soil[a]	Upland Groundwater[a]	Offshore Groundwater[b]	Sediment[c]
Conventionals	Sulfide		--	--	--	X
BTEX	Benzene		--	X	X	--
	Ethylbenzene		--	X	X	--
	Toluene		--	X	--	--
PAHs	Total PAH		--	--	--	X
	Fluoranthene		X	--	X	--
	Naphthalene		X	X	X	--
	Pyrene		X	--	X	--
	cPAHs	Benzo(a)anthracene	X	X	X	--
		Benzo(a)pyrene	X	X	X	--
		Benzo(b)fluoranthene	X	X	X	--
		Benzo(k)fluoranthene	X	X	X	--
		Chrysene	X	X	X	--
		Indeno(1,2,3-cd)pyrene	X	X	X	--
		Dibenzo(a,h)anthracene	X	X	--[d]	--
	Total cPAHs TEQ		--	--	X	X
TPH	Diesel Range Hyrdocarbons		--	--	--	X
SVOCs	4-Methylphenol		--	--	--	X
	Benzoic Acid		--	--	--	X
	Bis(2-ethylhexyl)phthalate		--	--	X	X
	Carbazole		--	--	X	X
	Dibenzofuran		--	--	X	X
	Di-n-Butyl phthalate		--	--	--	X
	Di-n-Octyl phthalate		--	--	--	X
	Hexachlorobenzene		--	--	--	X
	Pentachlorophenol		--	--	--	X
	Phenol		--	--	--	X
Pesticides	Chlordane		--	--	--	X
	4,4'-DDE		--	--	--	X
PCBs	Total PCBs (Aroclor)		--	--	--	X
Butyltins	Tributyltin		--	--	--	X
Metals	Arsenic		X	--	X	X
	Cadmium		--	--	X	X
	Chromium		--	--	--	X
	Copper		--	--	X	X
	Lead		--	--	X	X
	Mercury		--	--	X	X
	Methylmercury		--	--	--	X
	Nickel		--	--	X	X
	Silver		--	--	X	X

Notes:

[a] Identified as COC in the upland Consent Decree (Ecology 1999).

[b] Identified as a COC based on offshore groundwater data; see Section 4.2.2.

[c] Identified as a COC based on the Sediment Management Standards (WAC 173-204) and Gas Works Sediment Area SCSD (Appendix 4C); see Section 4.2.3.

[d] Not identified as a COC. However, dibenzo(a,h)anthracene will be evaluated as part of Total cPAHs TEQ.

x = Chemical identified as a COC

-- Chemical not identified as a COC

See text for full acronym and abbreviation list.

Table 4-6

Identification of Offshore Groundwater Contaminants of Concern

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Potential Concern	Unit	Sample Information			Screening Results	
			Total Number of Samples	Frequency of Detection (%)	Maximum Detected Concentration	Screening Level	COC? (Maximum > SL)
Conventionals	Sulfide	µg/L	5	60	38	--	NO
BTEX	Benzene	µg/L	7	86	640	0.44	YES
	Ethylbenzene	µg/L	7	86	180	29	YES
	Toluene	µg/L	7	43	5.5	57	NO
PAHs	Benzo(a)anthracene	µg/L	7	43	7.7	0.01	YES
	Benzo(a)pyrene	µg/L	7	43	9	0.01	YES
	Benzo(b)fluoranthene	µg/L	7	43	4.4	0.01	YES
	Benzo(k)fluoranthene	µg/L	7	43	5.9	0.01	YES
	Chrysene	µg/L	7	43	11	0.016	YES
	Dibenzo(a,h)anthracene[a]	µg/L	7	0	All ND	0.01	NO
	Fluoranthene	µg/L	7	100	45	6	YES
	Indeno(1,2,3-cd)pyrene	µg/L	7	43	4.6	0.01	YES
	Pyrene	µg/L	7	100	58	8	YES
	Naphthalene	µg/L	7	100	7,400	160	YES
	Total PAH	µg/L	7	100	8,200	--	NO
	Total cPAH TEQ	µg/L	7	43	11	0.02	YES
SVOCs	4-Methylphenol	µg/L	2	0	All ND	800	NO
	Benzoic Acid	µg/L	2	0	All ND	11,000	NO
	bis(2-Ethylhexyl)phthalate	µg/L	2	100	3.2	3.0	YES
	Carbazole	µg/L	7	86	95	2.0	YES
	Dibenzofuran	µg/L	7	86	34	16	YES
	Di-n-Butyl phthalate	µg/L	2	100	1.3	1.9	NO
	Di-n-Octyl phthalate	µg/L	2	0	All ND	1.0	NO
	Hexachlorobenzene	µg/L	2	0	All ND	1.0	NO
	Pentachlorophenol	µg/L	2	0	All ND	10	NO
	Phenol	µg/L	7	14	4.0	31	NO
Butyltins	Tributyl Tin	µg/L	5	80	0.116	0.193	NO
Metals	Arsenic	µg/L	7	57	580	8	YES
	Cadmium	µg/L	2	50	1.7	0.72	YES
	Chromium	µg/L	2	100	22	62	NO
	Copper	µg/L	2	100	130	11	YES
	Lead	µg/L	2	100	222	2.5	YES
	Mercury	µg/L	2	50	1.1	0.10	YES
	Nickel	µg/L	2	100	47	52	NO
	Silver	µg/L	2	50	1.9	3.2	NO

Notes:

[a] Not identified as a COC. However, dibenzo(a,h)anthracene will be evaluated as part of Total cPAHs TEQ.

ND = not detected

-- = not available

Shading indicates chemical is an offshore groundwater COC.

See text for full acronym and abbreviation list

Table 4-7

Sediment Contaminants of Concern by Pathway

Gas Works Park Site

Seattle, Washington

Analyte Group	Analyte	Benthic COC[a]	Human Health Direct Contact COC[b]	Bioaccumulation COC[c]
Conventionals	Sulfide	X		
PAHs	Total cPAH TEQ		X	X
	Total PAH	X		
TPH	Diesel Range Hydrocarbons	X		
SVOCs	4-Methylphenol	X		
	Benzoic Acid	X		
	bis(2-Ethylhexyl)phthalate	X		
	Carbazole	X		
	Dibenzofuran	X		
	Di-n-Butyl phthalate	X		
	Di-n-Octyl phthalate	X		
	Hexachlorobenzene		X	X
	Pentachlorophenol			X
	Phenol	X		
Pesticides	Chlordane			X
	4,4'-DDE	X		
PCBs	Total PCBs (Aroclor)	X		X
Butyltins	Tributyl Tin	X		
Metals	Arsenic	X	X	X
	Cadmium	X		
	Chromium	X		X
	Copper	X		
	Lead	X		
	Mercury	X		
	Methylmercury			X
	Nickel	X		
	Silver	X		

Notes:

[a] Benthic COCs selected in Section 4.2.3.1.

[b] Human health direct contact COCs selected in Section 4.2.3.2.

[c] Bioaccumulation COCs selected in Section 4.2.3.3.

Table 4-8

Identification of Sediment Contaminants of Concern - Protection of Benthic Organisms

Gas Works Park Site

Seattle, Washington

Analyte Group	Contaminants of Potential Concern	Unit	Sample Information			Screening Results	
			Total Number of Samples	Frequency of Detection (%)	Maximum Detected Concentration	Sediment Cleanup Objective	COC? (Maximum > SL)
Conventionals	Ammonia (Total as N)	mg/kg	2	100	67.8	230	NO
	Sulfide	mg/kg	83	98	13,000	39	YES
PAHs	Total PAH	mg/kg	111	100	11,200	17	YES
TPH	Diesel Range Hydrocarbons	mg/kg	1	100	2,420	340	YES
SVOCs	4-Methylphenol	mg/kg	80	27.5	1.5	0.26	YES
	Benzoic Acid	mg/kg	80	21.3	4.3	2.9	YES
	Beta-Hexachlorocyclohexane	mg/kg	2	0	Only ND Values	0.0072	NO
	bis(2-Ethylhexyl)phthalate	mg/kg	80	87.5	10	0.5	YES
	Carbazole	mg/kg	67	50.7	6.1	0.9	YES
	Dibenzofuran	mg/kg	110	50.9	14	0.2	YES
	Di-n-Butyl phthalate	mg/kg	80	11	0.66	0.38	YES
	Di-n-Octyl phthalate	mg/kg	80	1.3	0.48	0.039	YES
	Pentachlorophenol	mg/kg	80	10	0.62	1	NO
	Phenol	mg/kg	103	8.7	1.9	0.12	YES
Pesticides	Dieldrin	µg/kg	2	0	Only ND Values	4.9	NO
	4,4'-DDD	µg/kg	29	72.4	89	310	NO
	4,4'-DDE	µg/kg	29	3.4	35.3	21	YES
	4,4'-DDT	µg/kg	29	0	Only ND Values	100	NO
PCBs	Total PCBs (Aroclor)	mg/kg	55	78.2	1.62	0.11	YES
Butyltins	Monobutyltin	mg/kg	1	100	0.088	0.54	NO
	Dibutyltin	mg/kg	1	100	0.174	0.91	NO
	Tributyl Tin	mg/kg	53	96.2	8.46	0.047	YES
	Tetrabutyl Tin	mg/kg	1	0	Only ND Values	0.097	NO
Metals	Arsenic	mg/kg	95	61.1	2,390	14	YES
	Cadmium	mg/kg	81	77.8	4	2.1	YES
	Chromium	mg/kg	55	100	121	72	YES
	Copper	mg/kg	84	100	1,890	400	YES
	Lead	mg/kg	84	100	1,150	360	YES
	Mercury	mg/kg	83	83.1	3.3	0.66	YES
	Nickel	mg/kg	55	100	268	26	YES
	Selenium	mg/kg	2	50	0.67	11	NO
	Silver	mg/kg	56	33.9	8	0.57	YES
	Zinc	mg/kg	84	100	1,490	3,200	NO

Notes:

ND = not detected

Shading indicates chemical is a benthic COC.

Table 5-1

Analytical Data Summary - Soil

Gas Works Park Site

Seattle, Washington

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
Depth Interval 0 to 1 foot bgs[a]												
VOCs		%	µg/kg		µg/kg				%			
Benzene	5	0	5.5	50	--	--	--	--	--	--	--	Not a COC
Ethylbenzene	5	60	50	50	5.5	6.0	6.0	6.4	--	--	--	Not a COC
Toluene	2	100	--	--	6.3	6.4	6.3	6.4	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
cPAH TEQ (Calculated) using 1/2 the RL	32	100	--	--	0.19	16	4.5	170	100	100	1,200	0.137 mg/kg[b]
TPAH	37	100	--	--	0.034	100	22	710	--	--	--	Not a COC
Benzo(a)anthracene	32	100	--	--	0.078	6.3	2.6	51	91	91	370	0.137 mg/kg
Benzo(a)pyrene	37	100	--	--	0.034	12	2.9	150	95	95	1,100	0.137 mg/kg
Benzo(b)fluoranthene	25	100	--	--	0.14	4.7	1.4	35	100	100	260	0.137 mg/kg
Benzo(k)fluoranthene	25	100	--	--	0.057	2.8	1.3	15	96	96	110	0.137 mg/kg
Chrysene	32	100	--	--	0.11	9.4	3.7	59	97	97	430	0.137 mg/kg
Dibenzo(a,h)anthracene	32	63	0.058	4.0	0.028	6.0	1.7	37	56	88	270	0.137 mg/kg
Fluoranthene	32	100	--	--	0.13	14	5.6	93	No Exceedance	No Exceedance	No Exceedance	3,200 mg/kg
Indeno(1,2,3-cd)pyrene	32	100	--	--	0.12	8.7	3.6	47	97	97	340	0.137 mg/kg
Pyrene	32	100	--	--	0.21	20	8.9	100	No Exceedance	No Exceedance	No Exceedance	2,400 mg/kg
Total benzofluoranthenes (b+k (+j))	32	100	--	--	0.23	10	3.8	47	100	100	350	0.137 mg/kg
Naphthalene	32	66	0.058	10	0.033	6.0	1.4	33	No Exceedance	No Exceedance	No Exceedance	3,200 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	13	77	10	10	3.7	12	10	27	7.7	7.7	1.3	20 mg/kg
Depth Interval 1 to 15 feet bgs												
VOCs		%	µg/kg		µg/kg				%			
Benzene	97	42	0.50	12,000	0.50	4,200	170	38,000	--	--	--	Not a COC
Ethylbenzene	76	46	0.50	12,000	0.70	14,000	650	170,000	--	--	--	Not a COC
Toluene	69	48	0.50	12,000	0.60	6,500	450	51,000	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
cPAH TEQ (Calculated) using 1/2 the RL	209	94	0.014	1.2	0.019	48	6.7	1,000	83	85	7,500	0.137 mg/kg[b]
TPAH	228	97	0.040	4.0	0.015	1,800	55	130,000	--	--	--	Not a COC
Benzo(a)anthracene	213	92	0.0030	1.5	0.0090	29	4.4	720	80	83	5,300	0.137 mg/kg
Benzo(a)pyrene	227	86	0.021	1.9	0.014	40	7.2	810	79	85	5,900	0.137 mg/kg
Benzo(b)fluoranthene	168	85	0.021	1.9	0.0090	25	4.2	480	73	79	3,500	0.137 mg/kg
Benzo(k)fluoranthene	169	79	0.0070	2.1	0.0050	19	3.3	380	69	78	2,800	0.137 mg/kg
Chrysene	213	93	0.0030	1.5	0.012	34	5.0	760	80	83	5,500	0.137 mg/kg
Dibenzo(a,h)anthracene	209	65	0.0050	4.0	0.0030	9.1	1.7	110	56	77	800	0.137 mg/kg
Fluoranthene	205	98	0.027	0.73	0.0090	87	6.2	3,300	0.5	0.5	1.0	3,200 mg/kg
Indeno(1,2,3-cd)pyrene	209	80	0.021	4.0	0.0060	34	5.7	490	71	82	3,600	0.137 mg/kg
Pyrene	205	97	0.026	0.73	0.0050	110	11	4,000	1.0	1.0	1.7	2,400 mg/kg
Total benzofluoranthenes (b+k (+j))	210	88	0.021	1.9	0.018	46	7.6	910	80	85	6,600	0.137 mg/kg
Naphthalene	214	81	0.0020	68	0.0070	1,500	2.2	110,000	3.3	3.3	34	3,200 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	121	86	2.0	13	1.3	340	7.9	20,000	26	26	1,000	20 mg/kg

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values: Minimum	Reporting Limit for Nondetected Values: Maximum	Detected Concentrations: Minimum	Detected Concentrations: Mean	Detected Concentrations: Median	Detected Concentrations: Maximum	Frequency of Exceedance: Excluding Nondetected Values	Frequency of Exceedance: Including Nondetected Values	Maximum Exceedance Factor of Detected Concentrations	Screening Level
Depth Interval >15 feet bgs												
VOCs		%	µg/kg		µg/kg				%			
Benzene	47	72	0.90	1,100	1.4	14,000	1,100	110,000	--	--	--	Not a COC
Ethylbenzene	45	69	0.90	560	1.2	22,000	2,600	310,000	--	--	--	Not a COC
Toluene	45	69	1.1	3,100	0.60	11,000	540	180,000	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
cPAH TEQ (Calculated) using 1/2 the RL	56	84	0.0050	0.071	0.0030	25	1.2	430	52	52	3,200	0.137 mg/kg[b]
TPAH	59	93	0.028	0.10	0.029	860	40	12,000	--	--	--	Not a COC
Benzo(a)anthracene	59	78	0.0050	0.49	0.0020	26	2.2	400	51	53	2,900	0.137 mg/kg
Benzo(a)pyrene	59	78	0.0050	0.49	0.0050	24	1.6	340	53	54	2,500	0.137 mg/kg
Benzo(b)fluoranthene	50	70	0.0050	0.49	0.0060	12	0.5	140	40	42	1,000	0.137 mg/kg
Benzo(k)fluoranthene	50	64	0.0050	0.49	0.0030	7.5	0.38	96	36	38	700	0.137 mg/kg
Chrysene	59	81	0.0050	0.10	0.0030	26	2.0	380	58	58	2,800	0.137 mg/kg
Dibenzo(a,h)anthracene	56	63	0.0050	0.49	0.0030	2.9	0.30	35	38	41	260	0.137 mg/kg
Fluoranthene	57	91	0.0080	0.030	0.0060	58	2.7	760	No Exceedance	No Exceedance	No Exceedance	3,200 mg/kg
Indeno(1,2,3-cd)pyrene	56	70	0.0050	0.49	0.0080	10	0.5	120	45	46	880	0.137 mg/kg
Pyrene	57	88	0.0080	0.030	0.0080	81	5.6	1,200	No Exceedance	No Exceedance	No Exceedance	2,400 mg/kg
Total benzofluoranthenes (b+k (+j))	56	73	0.0050	0.49	0.011	24	1.4	350	54	55	2,600	0.137 mg/kg
Naphthalene	59	92	0.014	0.10	0.0050	350	14	6,700	1.7	1.7	2.1	3,200 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	34	91	11	12	1.1	220	13	4,100	32	32	210	20 mg/kg
All Depth Intervals, Combined												
VOCs		%	µg/kg		µg/kg				%			
Benzene	149	50	0.50	12,000	0.50	8,700	670	110,000	--	--	--	Not a COC
Ethylbenzene	126	55	0.50	12,000	0.70	17,000	1,200	310,000	--	--	--	Not a COC
Toluene	116	57	0.50	12,000	0.60	8,400	370	180,000	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
cPAH TEQ (Calculated) using 1/2 the RL	297	93	0.0050	1.2	0.0030	40	5.5	1,000	79	81	7,500	0.137 mg/kg[b]
TPAH	324	97	0.028	4.0	0.015	1,400	51	130,000	--	--	--	Not a COC
Benzo(a)anthracene	304	90	0.0030	1.5	0.0020	26	3.6	720	75	78	5,300	0.137 mg/kg
Benzo(a)pyrene	323	86	0.0050	1.9	0.0050	34	5.4	810	76	81	5,900	0.137 mg/kg
Benzo(b)fluoranthene	243	84	0.0050	1.9	0.0060	20	3.0	480	69	73	3,500	0.137 mg/kg
Benzo(k)fluoranthene	244	78	0.0050	2.1	0.0030	15	2.3	380	65	71	2,800	0.137 mg/kg
Chrysene	304	91	0.0030	1.5	0.0030	29	4.0	760	77	79	5,500	0.137 mg/kg
Dibenzo(a,h)anthracene	297	64	0.0050	4.0	0.0030	7.7	1.4	110	52	71	800	0.137 mg/kg
Fluoranthene	294	97	0.0080	0.73	0.0060	73	5.6	3,300	0.3	0.3	1.0	3,200 mg/kg
Indeno(1,2,3-cd)pyrene	297	80	0.0050	4.0	0.0060	27	4.4	490	69	77	3,600	0.137 mg/kg
Pyrene	294	96	0.0080	0.73	0.0050	97	9.0	4,000	0.7	0.7	1.7	2,400 mg/kg
Total benzofluoranthenes (b+k (+j))	298	86	0.0050	1.9	0.011	38	6.4	910	77	81	6,600	0.137 mg/kg
Naphthalene	305	81	0.0020	68	0.0050	1,100	2.3	110,000	2.6	2.6	34	3,200 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	168	86	2.0	13	1.1	291	8.6	20,000	26	26	1,000	20 mg/kg

Notes:

[a] Soil samples in this depth interval were obtained in areas that have not been capped.

[b] cPAH TEQ is not a COC for soil, but is screened for consistency with the MTCA approach for evaluating mixtures of cPAHs (WAC 173-340-708[8][e]).

-- = not applicable

See text for full acronym and abbeviation list.

Table 5-2

Analytical Data Summary – Upland Groundwater

Gas Works Park Site

Seattle, Washington

Analyte[a]	Fraction	Total Samples in All tables	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level
				Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
Water Table													
VOCs			%	µg/L		µg/L				%			
Benzene	Total	36	66.7	0.20	0.20	0.15	480	20	6,700	31	31	160	43 µg/L
Ethylbenzene	Total	36	61.1	0.20	0.20	0.15	150	14	1,400	No Exceedance	No Exceedance	--	6910 µg/L
Toluene	Total	36	55.6	0.20	4.0	0.10	270	0.56	4,500	No Exceedance	No Exceedance	--	48500 µg/L
PAHs			%	µg/L		µg/L				%			
cPAH (Calculated) using 1/2 the RL	Total	36	36.1	0.0080	0.76	0.0080	0.30	0.088	1.1	25	67	38	0.0296 µg/L[b]
TPAH	Total	36	97.2	0.055	0.055	0.035	470	8.2	7,300	--	--	--	Not a COC
Benzo(a)anthracene	Total	36	22.2	0.010	1.0	0.0060	0.30	0.14	1.2	19	64	40	0.0296 µg/L
Benzo(a)pyrene	Total	36	30.6	0.010	1.0	0.0060	0.30	0.12	0.84	25	67	28	0.0296 µg/L
Benzo(b)fluoranthene	Total	36	16.7	0.010	1.0	0.028	0.20	0.12	0.47	14	64	16	0.0296 µg/L
Benzo(k)fluoranthene	Total	36	16.7	0.010	1.0	0.014	0.10	0.060	0.22	11	61	7.4	0.0296 µg/L
Chrysene	Total	36	33.3	0.010	1.0	0.0060	0.30	0.12	1.2	22	64	40	0.0296 µg/L
Dibenzo(a,h)anthracene	Total	36	11.1	0.010	1.0	0.0060	0.00	0.017	0.080	2.8	56	2.7	0.0296 µg/L
Fluoranthene	Total	36	80.6	0.010	0.20	0.0080	1.4	0.60	11	No Exceedance	No Exceedance	--	90 µg/L
Indeno(1,2,3-cd)pyrene	Total	36	19.4	0.010	1.0	0.011	0.20	0.062	0.54	17	67	18	0.0296 µg/L
Pyrene	Total	36	83.3	0.010	1.0	0.0050	1.3	0.58	11	No Exceedance	No Exceedance	--	2590 µg/L
Naphthalene	Total	36	86.1	0.055	0.21	0.013	840	3.4	10,000	2.8	2.8	1.0	9880 µg/L
Metals			%	µg/L		µg/L				%			
Arsenic (Preserved)	Dissolved	19	100	--	--	0.50	19	3.4	140	32	32	18	8 µg/L[c]
Arsenic (Unpreserved)	Dissolved	9	100	--	--	16	3,800	300	26,000	100	100	3,300	8 µg/L[c]
Deep Wells													
VOCs			%	µg/L		µg/L				%			
Benzene	Total	34	85.3	0.20	0.20	0.16	2,000	470	9,100	68	68	210	43 µg/L
Ethylbenzene	Total	34	79.4	0.20	0.20	0.11	640	460	2,200	No Exceedance	No Exceedance	--	6910 µg/L
Toluene	Total	34	73.5	0.20	10	0.11	1,300	19	5,800	No Exceedance	No Exceedance	--	48500 µg/L
PAHs			%	µg/L		µg/L				%			
cPAH (Calculated) using 1/2 the RL	Total	34	29.4	0.0080	7.0	0.011	0.30	0.10	1.4	24	85	47	0.0296 µg/L[b]
TPAH	Total	34	100	--	--	0.12	450	76	7,000	--	--	--	Not a COC
Benzo(a)anthracene	Total	34	23.5	0.010	10	0.010	0.30	0.090	1.3	21	85	44	0.0296 µg/L
Benzo(a)pyrene	Total	34	26.5	0.010	10	0.0080	0.20	0.090	1.1	21	85	37	0.0296 µg/L
Benzo(b)fluoranthene	Total	34	23.5	0.010	10	0.0050	0.10	0.066	0.56	15	79	19	0.0296 µg/L
Benzo(k)fluoranthene	Total	34	8.8	0.010	10	0.015	0.00	0.017	0.045	2.9	79	1.5	0.0296 µg/L
Chrysene	Total	34	29.4	0.010	10	0.012	0.20	0.087	1.2	24	85	40	0.0296 µg/L
Dibenzo(a,h)anthracene	Total	34	2.9	0.010	10	0.017	0.00	0.017	0.017	No Exceedance	76	0.60	0.0296 µg/L
Fluoranthene	Total	34	85.3	0.010	10	0.021	1.5	0.91	6.7	No Exceedance	No Exceedance	--	90 µg/L
Indeno(1,2,3-cd)pyrene	Total	34	17.6	0.010	10	0.010	0.10	0.072	0.21	12	79	7.1	0.0296 µg/L
Pyrene	Total	34	82.4	0.010	10	0.032	1.3	1.0	6.2	No Exceedance	No Exceedance	--	2590 µg/L
Naphthalene	Total	34	100	--	--	0.084	4,000	54	13,000	26	26	1.3	9880 µg/L
Metals			%	µg/L		µg/L				%			
Arsenic (Preserved)	Dissolved	17	100	--	--	0.40	5,100	9.9	82,000	53	53	10,000	8 µg/L[c]
Arsenic (Unpreserved)	Dissolved	8	87.5	--	--	21	82,000	14,000	310,000	88	100	39,000	8 µg/L[c]

Analyte[a]	Fraction	Total Samples in All tables	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level
				Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
All Wells													
VOCs			%	µg/L		µg/L				%			
Benzene	Total	70	75.7	0.20	0.20	0.15	1,300	160	9,100	49	49	210	43 µg/L
Ethylbenzene	Total	70	70	0.20	0.20	0.11	420	37	2,200	No Exceedance	No Exceedance	--	6910 µg/L
Toluene	Total	70	64.3	0.20	10	0.10	830	5.3	5,800	No Exceedance	No Exceedance	--	48500 µg/L
PAHs			%	µg/L		µg/L				%			
cPAH (Calculated) using 1/2 the RL	Total	70	32.9	0.0080	7.0	0.0080	0.30	0.088	1.4	24	76	47	0.0296 µg/L[b]
TPAH	Total	70	98.6	0.055	0.055	0.035	460	32	7,300	--	--	--	Not a COC
Benzo(a)anthracene	Total	70	22.9	0.010	10	0.0060	0.30	0.11	1.3	20	74	44	0.0296 µg/L
Benzo(a)pyrene	Total	70	28.6	0.010	10	0.0060	0.30	0.10	1.1	23	76	37	0.0296 µg/L
Benzo(b)fluoranthene	Total	70	20	0.010	10	0.0050	0.20	0.068	0.56	14	71	19	0.0296 µg/L
Benzo(k)fluoranthene	Total	70	12.9	0.010	10	0.014	0.10	0.045	0.22	7.1	70	7.4	0.0296 µg/L
Chrysene	Total	70	31.4	0.010	10	0.0060	0.20	0.097	1.2	23	74	40	0.0296 µg/L
Dibenzo(a,h)anthracene	Total	70	7.1	0.010	10	0.0060	0.00	0.017	0.080	1.4	66	2.7	0.0296 µg/L
Fluoranthene	Total	70	82.9	0.010	10	0.0080	1.4	0.82	11	No Exceedance	No Exceedance	--	90 µg/L
Indeno(1,2,3-cd)pyrene	Total	70	18.6	0.010	10	0.010	0.10	0.070	0.54	14	73	18	0.0296 µg/L
Pyrene	Total	70	82.9	0.010	10	0.0050	1.3	0.64	11	No Exceedance	No Exceedance	--	2590 µg/L
Naphthalene	Total	70	92.9	0.055	0.21	0.013	2,500	15	13,000	14	14	1.3	9880 µg/L
Metals			%	µg/L		µg/L				%			
Arsenic (Preserved)	Dissolved	36	100	--	--	0.40	2,400	6.0	82,000	42	42	10,000	8 µg/L[c]
Arsenic (Unpreserved)	Dissolved	17	94.1	--	--	16	38,000	1,200	310,000	94	100	39,000	8 µg/L[c]

Notes:

[a] The data set for non-arsenic COCs was derived from groundwater sampling events conducted in April 2013 and December 2014.

[b] cPAH TEQ is not a COC for upland groundwater, but is screened for consistency with the MTCA approach for evaluating mixtures of cPAHs (WAC 173-340-708[8][e]).

[c] Arsenic is not a COC for upland groundwater, but is screened for the evaluation of cross-media impacts.

[d] The data set for arsenic was derived from groundwater sampling events conducted in October 2013, December 2014, September/October 2016 and December 2020. 2020 samples analyzed by method SW6010C lab filtered non-preserved. Previous samples analyzed by method SW6010C field filtered preserved with HNO3. Reference Section 5 for a discussion of why these data sets were selected.

-- = not applicable

See text for full acronym and abbreviation list.

Table 5-3

Analytical Data Summary – Offshore Groundwater
Gas Works Park Site
Seattle, Washington

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentration	Screening Level
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
VOCs			µg/L		µg/L				%			
Benzene	7	86	1.0	1.0	1.2	130	36	640	86	100	1,500	0.44 µg/L
Ethylbenzene	7	86	1.0	1.0	1.0	76	71	180	57	57	6.2	29 µg/L
Toluene	7	43	1.0	30	1.6	3.0	2.0	5.5	--	--	--	Not a COC
PAHs			µg/L		µg/L				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	7	43	0.70	1.4	5.3	8.3	8.3	11	43	100	570	0.02 µg/L
Total PAH	7	100	All Detected	All Detected	67	1,600	290	8,200	--	--	--	Not a COC
Benzo(a)anthracene	7	43	1.0	2.0	4.3	5.9	5.7	7.7	43	100	770	0.01 µg/L
Benzo(a)pyrene	7	43	1.0	2.0	4.0	6.5	6.6	9.0	43	100	900	0.01 µg/L
Benzo(b)fluoranthene	7	43	1.0	2.0	2.2	3.4	3.5	4.4	43	100	440	0.01 µg/L
Benzo(k)fluoranthene	7	43	1.0	2.0	2.8	4.0	3.4	5.9	43	100	590	0.01 µg/L
Chrysene	7	43	1.0	2.0	5.1	8.0	8.0	11	43	100	690	0.016 µg/L
Dibenzo(a,h)anthracene	7	0	1.0	2.0	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Fluoranthene	7	100	All Detected	All Detected	1.8	17	8.8	45	57	57	7.5	6 µg/L
Indeno(1,2,3-cd)pyrene	7	43	1.0	2.0	2.5	3.5	3.3	4.6	43	100	460	0.01 µg/L
Pyrene	7	100	All Detected	All Detected	1.7	20	8.6	58	57	57	7.3	8 µg/L
Naphthalene	7	100	All Detected	All Detected	1.6	1,300	76	7,400	29	29	46	160 µg/L
SVOCs			µg/L		µg/L				%			
bis(2-Ethylhexyl)phthalate	2	100	All Detected	All Detected	1.8	2.5	2.5	3.2	50	50	1.1	3 µg/L
Carbazole	7	86	1.0	1.0	1.2	18	3.2	95	57	57	48	2 µg/L
Dibenzofuran	7	86	1.0	1.0	1.0	7.6	2.9	34	14	14	2.1	16 µg/L
Metals			µg/L		µg/L				%			
Arsenic	7	57	50	50	22	200	110	580	57	100	73	8 µg/L
Cadmium	2	50	0.20	0.20	1.7	1.7	1.7	1.7	50	50	2.4	0.72 µg/L
Copper	2	100	All Detected	All Detected	14	72	72	130	100	100	12	11 µg/L
Lead	2	100	All Detected	All Detected	11	120	120	220	100	100	89	2.5 µg/L
Mercury	2	50	0.20	0.20	1.1	1.1	1.1	1.1	50	100	11	0.1 µg/L
Nickel	2	100	All Detected	All Detected	11	29	29	47	No Exceedance	No Exceedance	No Exceedance	52 µg/L
Silver	2	50	0.20	0.20	1.9	1.9	1.9	1.9	No Exceedance	No Exceedance	No Exceedance	3.2 µg/L

Notes: 73

-- = not applicable

See text for full acronym and abbreviation list.

Offshore groundwater considered >0.5 feet bml.

Table 5-4

Analytical Data Summary – Sediment, Sediment Cleanup Objectives

Gas Works Park Site
Seattle, Washington

			Reporting Limit for Nondetected		Detected Concentrations				Frequency of Exceedance			
Analyte	Total No. Samples	Frequency of Detection	Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values	Maximum Exceedance Factor of Detected Concentrations	Screening Level (Sediment Cleanup Objectives)
Surface (0-0.5 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	56	8.9	0.0010	1.9	0.0030	7.4	1.2	34	--	--	--	Not a COC
Ethylbenzene	56	13	0.0010	0.036	0.0020	2.3	2.2	5.8	--	--	--	Not a COC
Toluene	56	11	0.0010	0.43	0.0070	1.2	1.1	2.4	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	112	100	--	--	0.47	54	11	1,400	100	100	67,000	0.021 mg/kg
Total PAH	111	100	--	--	3.37	470	76	11,200	78	78	660	17 mg/kg
Fluoranthene	110	100	--	--	0.63	82	12	1,900	--	--	--	Not a COC
Pyrene	110	100	--	--	0.62	97	14	2,200	--	--	--	Not a COC
Naphthalene	110	90	0.079	0.39	0.04	7.2	1.4	120	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	67	51	0.027	0.37	0.03	1.2	0.54	6.1	15	15	6.8	0.9 mg/kg
Dibenzofuran	110	51	0.027	0.90	0.03	1.8	0.65	14	40	55	70	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	95	61	6.0	60	6.0	110	58	2,400	59	94	220	11 mg/kg
Nickel	55	100	--	--	10	64	55	270	67	67	5.4	50 mg/kg
Subsurface (>0.5 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	183	38	0.0010	61	0.0010	97	3.6	3,500	--	--	--	Not a COC
Ethylbenzene	183	37	0.0010	28	0.0010	45	9.3	940	--	--	--	Not a COC
Toluene	183	29	0.0010	61	0.0020	21	0.62	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	281	66	0.012	1.2	0.015	79	11	2,900	65	90	140,000	0.021 mg/kg
Total PAH	282	82	0.019	0.53	0.015	1,500	110	69,000	53	53	4,100	17 mg/kg
Fluoranthene	266	72	0.018	1.5	0.016	150	15	5,600	--	--	--	Not a COC
Pyrene	262	71	0.018	1.7	0.016	160	14	5,700	--	--	--	Not a COC
Naphthalene	281	74	0.017	0.53	0.010	430	7.7	20,000	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	178	45	0.019	0.54	0.024	13	1.3	150	25	25	170	0.9 mg/kg
Dibenzofuran	282	53	0.010	1.5	0.012	30	2.5	830	44	52	4,200	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	265	42	3.0	50	3.0	70	20	1,200	30	70	110	11 mg/kg
Nickel	139	100	--	--	18	46	42	160	24	24	3.3	50 mg/kg
Zone 1 (0.5-3 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	36	42	0.0010	61	0.0050	67	3.1	700	--	--	--	Not a COC
Ethylbenzene	36	50	0.0010	0.042	0.025	71	3.4	940	--	--	--	Not a COC
Toluene	36	31	0.0010	61	0.0030	58	0.046	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	74	96	0.014	0.13	0.19	150	31	2,900	96	99	140,000	0.021 mg/kg
Total PAH	74	99	0.19	0.19	0.037	2,900	490	69,000	80	80	4,000	17 mg/kg
Fluoranthene	71	99	0.19	0.19	0.016	280	61	5,600	--	--	--	Not a COC
Pyrene	65	99	0.19	0.19	0.021	320	70	5,700	--	--	--	Not a COC
Naphthalene	74	96	0.020	0.19	0.075	680	12	20,000	--	--	--	Not a COC

			Reporting Limit for Nondetected		Detected Concentrations				Frequency of Exceedance			
Analyte	Total No. Samples	Frequency of Detection	Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values	Maximum Exceedance Factor of Detected Concentrations	Screening Level (Sediment Cleanup Objectives)
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	34	68	0.020	0.54	0.024	7.3	1.7	75	44	44	83	0.9 mg/kg
Dibenzofuran	74	69	0.020	0.88	0.028	49	6.0	830	64	76	4,200	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	63	75	3.0	50	6.0	100	33	1,200	67	86	110	11 mg/kg
Nickel	22	100	--	--	21	66	60	160	68	68	3.3	50 mg/kg
Zone 2 (3-6 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	49	47	0.0010	28	0.0010	81	1.5	1,400	--	--	--	Not a COC
Ethylbenzene	49	43	0.0010	28	0.0010	26	12	170	--	--	--	Not a COC
Toluene	49	33	0.0010	28	0.0020	2.3	0.32	14	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	78	72	0.013	0.85	0.051	53	12	600	72	96.2	29,000	0.021 mg/kg
Total PAH	78	86	0.048	0.18	0.054	1,100	130	16,000	58	57.7	940	17 mg/kg
Fluoranthene	73	78	0.018	0.36	0.041	100	15	1,300	--	--	--	Not a COC
Pyrene	74	77	0.018	1.2	0.036	100	18	970	--	--	--	Not a COC
Naphthalene	78	81	0.048	0.18	0.027	340	7.3	6,400	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	50	56	0.019	0.36	0.025	17	1.1	96	30	30	110	0.9 mg/kg
Dibenzofuran	78	63	0.018	0.37	0.023	20	1.2	330	50	54	1700	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	77	43	3.0	50	3.0	48	20	410	34	65	37	11 mg/kg
Nickel	44	100	--	--	21	44	39	110	23	23	2.1	50 mg/kg
Zone 3 (6-9 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	36	42	0.0010	61	0.0010	240	0.051	3,500	--	--	--	Not a COC
Ethylbenzene	36	31	0.0010	12	0.020	22	5.6	120	--	--	--	Not a COC
Toluene	36	28	0.0010	12	0.0020	15	0.14	85	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	57	54	0.012	0.29	0.015	13	1.1	240	53	77	11,000	0.021 mg/kg
Total PAH	57	81	0.019	0.36	0.039	280	4.9	7,900	32	32	470	17 mg/kg
Fluoranthene	53	72	0.019	0.38	0.018	22	0.50	550	--	--	--	Not a COC
Pyrene	54	69	0.019	0.41	0.016	25	0.60	600	--	--	--	Not a COC
Naphthalene	57	60	0.017	0.36	0.010	92	1.6	1,700	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	33	30	0.019	0.38	0.028	3.4	0.75	19	12.1	12	21	0.9 mg/kg
Dibenzofuran	57	37	0.010	1.4	0.023	9.9	1.5	120	26	35	600	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	55	33	3.0	40	3.0	11	9.5	30	15	60	3.6	11 mg/kg
Nickel	30	100	--	--	18	38	39	50	3.3	3.3	1	50 mg/kg
Zone 4 (>9 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	62	27	0.0010	15	0.0020	22	6.6	140	--	--	--	Not a COC
Ethylbenzene	62	27	0.0010	15	0.00300	55	9.3	730	--	--	--	Not a COC
Toluene	62	26	0.0010	15	0.01	19	2.1	180	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	72	36	0.013	1.2	0.018	32	2.4	250	35	83	12,000	0.021 mg/kg
Total PAH	73	60	0.020	0.53	0.015	920	34	12,000	36	36	730	17 mg/kg
Fluoranthene	69	39	0.019	1.5	0.052	79	3.0	820	--	--	--	Not a COC
Pyrene	69	41	0.019	1.7	0.022	82	2.8	760	--	--	--	Not a COC
Naphthalene	72	54	0.020	0.53	0.015	400	14	5,700	--	--	--	Not a COC

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level (Sediment Cleanup Objectives)
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	61	31	0.019	0.53	0.027	20	1.0	150	16	16	170	0.9 mg/kg
Dibenzofuran	73	37	0.019	1.5	0.012	25	1.5	190	33	40	940	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	70	17	3.0	40	4.0	91	9.0	840	5.7	69	76	11 mg/kg
Nickel	43	100	--	--	22	43	43	57	16	16	1.1	50 mg/kg
All Depths												
VOCs		%	mg/kg		mg/kg				%			
Benzene	239	31	0.0010	61	0.0010	91	3.1	3,500	--	--	--	Not a COC
Ethylbenzene	239	31	0.0010	28	0.0010	41	4.9	940	--	--	--	Not a COC
Toluene	239	25	0.0010	61	0.0020	19	0.82	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	393	75	0.012	1.2	0.015	69	11	2,920	75	93	140,000	0.021 mg/kg
Total PAH	393	87	0.019	0.53	0.015	1,200	88	69,000	60	60	4,000	17 mg/kg
Fluoranthene	376	80	0.018	1.5	0.016	130	14	5,600	--	--	--	Not a COC
Pyrene	372	80	0.018	1.7	0.016	140	14	5,700	--	--	--	Not a COC
Naphthalene	391	78	0.017	0.53	0.010	290	3.4	20,000	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	245	47	0.019	0.54	0.024	9.6	0.81	150	22	22	170	0.9 mg/kg
Dibenzofuran	392	52	0.010	1.5	0.012	22	1.6	830	43	53	4,150	0.2 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	360	47	3.0	60	3.0	85	30	2,400	38	76	220	11 mg/kg
Nickel	194	100	--	--	10	51	44	268	36	36	5.4	50 mg/kg

Notes:

-- = not applicable

See text for full acronym and abbreviation list.

Table 5-5

Analytical Data Summary – Sediment, Cleanup Screening Levels

Gas Works Park Site
Seattle, Washington

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level (Cleanup Screening Levels)
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
Surface (0-0.5 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	56	8.9	0.0010	1.9	0.0030	7.4	1.2	34	--	--	--	Not a COC
Ethylbenzene	56	13	0.0010	0.036	0.0020	2.3	2.2	5.8	--	--	--	Not a COC
Toluene	56	11	0.0010	0.43	0.0070	1.2	1.1	2.4	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	112	100	--	--	0.47	54	11	1,400	100	100	6,700	0.21 mg/kg
Total PAH	111	100	--	--	3.4	470	76	11,200	71	71	370	30 mg/kg
Fluoranthene	110	100	--	--	0.63	82	12	1,900	--	--	--	Not a COC
Pyrene	110	100	--	--	0.62	97	14	2,200	--	--	--	Not a COC
Naphthalene	110	90	0.079	0.39	0.042	7.2	1.4	120	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	67	51	0.027	0.37	0.034	1.2	0.54	6.1	15	15	5.5	1.1 mg/kg
Dibenzofuran	110	51	0.027	0.90	0.033	1.8	0.65	14	25	26	21	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	95	61	6.0	60	6.0	110	58	2,400	52	84	100	24 mg/kg
Nickel	55	100	--	--	10	64	55	270	9.1	9.1	2.4	110 mg/kg
Subsurface (>0.5 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	183	38	0.0010	61	0.0010	97	3.6	3,500	--	--	--	Not a COC
Ethylbenzene	183	37	0.0010	28	0.0010	45	9.3	940	--	--	--	Not a COC
Toluene	183	29	0.0010	61	0.0020	21	0.62	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	281	66	0.012	1.2	0.015	79	11	2,900	59	63	14,000	0.21 mg/kg
Total PAH	282	82	0.019	0.53	0.015	1,500	110	69,000	49	49	2,300	30 mg/kg
Fluoranthene	266	72	0.018	1.5	0.016	150	15	5,600	--	--	--	Not a COC
Pyrene	262	71	0.018	1.7	0.016	160	14	5,700	--	--	--	Not a COC
Naphthalene	281	74	0.017	0.53	0.010	430	7.7	20,000	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	178	45	0.019	0.54	0.024	13	1.3	150	24	24	140	1.1 mg/kg
Dibenzofuran	282	53	0.010	1.5	0.012	30	2.5	830	34	36	1,200	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	265	42	3.0	50	3.0	70	20	1,200	18	53	51	24 mg/kg
Nickel	139	100	--	--	18	46	42	160	0.7	0.7	1.5	110 mg/kg
Zone 1 (0.5-3 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	36	42	0.0010	61	0.0050	67	3.1	700	--	--	--	Not a COC
Ethylbenzene	36	50	0.0010	0.042	0.025	71	3.4	940	--	--	--	Not a COC
Toluene	36	31	0.0010	61	0.0030	58	0.046	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	74	96	0.014	0.13	0.19	150	31	2,900	95	95	14,000	0.21 mg/kg
Total PAH	74	99	0.19	0.19	0.037	2,900	490	69,000	76	76	2,300	30 mg/kg
Fluoranthene	71	99	0.19	0.19	0.016	280	61	5,600	--	--	--	Not a COC
Pyrene	65	99	0.19	0.19	0.021	320	70	5,700	--	--	--	Not a COC
Naphthalene	74	96	0.020	0.19	0.075	680	12	20,000	--	--	--	Not a COC

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level (Cleanup Screening Levels)
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	34	68	0.020	0.54	0.024	7.3	1.7	75	44	44	68	1.1 mg/kg
Dibenzofuran	74	69	0.020	0.88	0.028	49	6.0	830	53	54	1,200	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	63	75	3.0	50	6.0	100	33	1,200	49	60	51	24 mg/kg
Nickel	22	100	--	--	21	66	60	160	4.5	4.5	1.5	110 mg/kg
Zone 2 (3-6 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	49	47	0.0010	28	0.0010	81	1.5	1,400	--	--	--	Not a COC
Ethylbenzene	49	43	0.0010	28	0.0010	26	12	170	--	--	--	Not a COC
Toluene	49	33	0.0010	28	0.0020	2.3	0.32	14	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	78	72	0.013	0.85	0.051	53	12	600	64	68	2,900	0.21 mg/kg
Total PAH	78	86	0.048	0.18	0.054	1,100	130	16,000	55	55	530	30 mg/kg
Fluoranthene	73	78	0.018	0.36	0.041	100	15	1,300	--	--	--	Not a COC
Pyrene	74	77	0.018	1.2	0.036	100	18	970	--	--	--	Not a COC
Naphthalene	78	81	0.048	0.18	0.027	340	7.3	6,400	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	50	56	0.019	0.36	0.025	17	1.1	96	28	28	87	1.1 mg/kg
Dibenzofuran	78	63	0.018	0.37	0.023	20	1.2	330	35	35	490	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	77	43	3.0	50	3.0	48	20	410	17	44	17	24 mg/kg
Nickel	44	100	--	--	21	44	39	110	0	0	1	110 mg/kg
Zone 3 (6-9 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	36	42	0.0010	61	0.0010	240	0.051	3,500	--	--	--	Not a COC
Ethylbenzene	36	31	0.0010	12	0.020	22	5.6	120	--	--	--	Not a COC
Toluene	36	28	0.0010	12	0.0020	15	0.14	85	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	57	54	0.012	0.29	0.015	13	1.1	240	39	44	1,100	0.21 mg/kg
Total PAH	57	81	0.019	0.36	0.039	280	4.9	7,900	28	28	260	30 mg/kg
Fluoranthene	53	72	0.019	0.38	0.018	22	0.50	550	--	--	--	Not a COC
Pyrene	54	69	0.019	0.41	0.016	25	0.60	600	--	--	--	Not a COC
Naphthalene	57	60	0.017	0.36	0.010	92	1.6	1,700	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	33	30	0.019	0.38	0.028	3.4	0.75	19	12	12	17	1.1 mg/kg
Dibenzofuran	57	37	0.010	1.4	0.023	9.9	1.5	120	21	23	180	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	55	33	3.0	40	3.0	11	9.5	30	1.8	42	1.7	24 mg/kg
Nickel	30	100	--	--	18	38	39	50	0	0	No Exceedance	110 mg/kg
Zone 4 (>9 feet bml)												
VOCs		%	mg/kg		mg/kg				%			
Benzene	62	27	0.0010	15	0.0020	22	6.6	140	--	--	--	Not a COC
Ethylbenzene	62	27	0.0010	15	0.0030	55	9.3	730	--	--	--	Not a COC
Toluene	62	26	0.0010	15	0.014	19	2.1	180	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	72	36	0.013	1.2	0.018	32	2.4	250	32	40	1,200	0.21 mg/kg
Total PAH	73	60	0.020	0.53	0.015	920	34	12,000	32	32	410	30 mg/kg
Fluoranthene	69	39	0.019	1.5	0.052	79	3.0	820	--	--	--	Not a COC
Pyrene	69	41	0.019	1.7	0.022	82	2.8	760	--	--	--	Not a COC
Naphthalene	72	54	0.020	0.53	0.015	400	14	5,700	--	--	--	Not a COC

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values: Minimum	Reporting Limit for Nondetected Values: Maximum	Detected Concentrations: Minimum	Detected Concentrations: Mean	Detected Concentrations: Median	Detected Concentrations: Maximum	Frequency of Exceedance: Excluding Nondetected Values	Frequency of Exceedance: Including Nondetected Values	Maximum Exceedance Factor of Detected Concentrations	Screening Level (Cleanup Screening Levels)
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	61	31	0.019	0.53	0.027	20	1.0	150	15	15	140	1.1 mg/kg
Dibenzofuran	73	37	0.019	1.5	0.012	25	1.5	190	26	27	280	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	70	17	3.0	40	4.0	91	9.0	840	2.9	63	35	24 mg/kg
Nickel	43	100	--	--	22	43	43	57	0	0	No Exceedance	110 mg/kg
All Depths												
VOCs		%	mg/kg		mg/kg				%			
Benzene	239	31	0.0010	61	0.0010	91	3.1	3,500	--	--	--	Not a COC
Ethylbenzene	239	31	0.0010	28	0.0010	41	4.9	940	--	--	--	Not a COC
Toluene	239	25	0.0010	61	0.0020	19	0.82	630	--	--	--	Not a COC
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	393	75	0.012	1.2	0.015	69	11	2,900	71	74	14,000	0.21 mg/kg
Total PAH	393	87	0.019	0.53	0.015	1,200	88	69,000	55	55	2,300	30 mg/kg
Fluoranthene	376	80	0.018	1.5	0.016	130	14	5,600	--	--	--	Not a COC
Pyrene	372	80	0.018	1.7	0.016	140	14	5,700	--	--	--	Not a COC
Naphthalene	391	78	0.017	0.53	0.010	290	3.4	20,000	--	--	--	Not a COC
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	245	47	0.019	0.54	0.024	9.6	0.81	150	21	21	140	1.1 mg/kg
Dibenzofuran	392	52	0.010	1.5	0.012	22	1.6	830	32	33	1,200	0.68 mg/kg
Metals		%	mg/kg		mg/kg				%			
Arsenic	360	47	3.0	60	3.0	85	30	2,400	27	61	100	24 mg/kg
Nickel	194	100	--	--	10	51	44	270	3.1	3.1	2.4	110 mg/kg

Notes:

-- = not applicable

See text for full acronym and abbreviation list.

Table 5-6

Biological Testing Results in Surface Sediment

Gas Works Park Site

Seattle, Washington

Survey Name	Investigation	Sample ID	*Hyalella azteca* 10-day		*Chironomus tentans* 10-day		*Chironomus tentans* 20-day	
			Survival[a]	Growth[b]	Survival[a]	Growth[b]	Survival[a]	Growth[b]
TAMU02	RETEC Split Samples (March 2002)	LU-1[c]	92		80	1.74		
TAMU02	RETEC Split Samples (March 2002)	LU-2[c]	94		70	2.09		
TAMU02	RETEC Split Samples (March 2002)	LU-3	99		84	1.86		
TAMU02	RETEC Split Samples (March 2002)	LU-4	98		78	2.25		
TAMU02	RETEC Split Samples (March 2002)	LU-5	100		90	2.36		
TAMU02	RETEC Split Samples (March 2002)	LU-6	98		68	2.49		
TAMU02	RETEC Split Samples (March 2002)	LU-7	99		82	2.92		
TAMU02	RETEC Split Samples (March 2002)	LU-8	99		84	2.45		
TAMU02	RETEC Split Samples (March 2002)	LU-9	100		72	2.92		
TAMU02	RETEC Split Samples (March 2002)	LU-10	98		78	2.75		
TAMU02	RETEC Split Samples (March 2002)	Ref-1	93		82	2.57		
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU01	81	0.045	52	0.24	32	2.01
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU02	92	0.074	58	0.98	86	2.69
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU04	96	0.092	78	1.23	96	2.79
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU05	87	0.044	72	0.82	84	1.74
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU06	91	0.079	82	1.10	90	2.94
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU07	94	0.075	78	0.84	88	2.78
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU08	95	0.083	82	1.20	94	2.68
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU10	96	0.089	76	1.00	92	2.84
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU12	92	0.11	80	0.83	90	3.40
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU13	84	0.055	74	0.52	66	2.29
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU14	95	0.076	74	0.71	96	2.72
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU15	97	0.079	80	0.92	92	2.43
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU16	92	0.068	66	0.45	60	1.86
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU17	83	0.042	62	0.30	44	1.66
RETEC02-Grabs	RETEC Phase 2 (October 2002)	Ref-NLU21	81	0.058	78	0.93	80	2.32
RETEC02-Grabs	RETEC Phase 2 (October 2002)	Ref-NLU22	70	0.039	76	0.83	64	2.02
RETEC02-Grabs	RETEC Phase 2 (October 2002)	Control	90	0.039	72	1.28	82	2.50
NLUBio05	RETEC Phase3 (April 2005)	NLU13	84				54	1.18
NLUBio05	RETEC Phase3 (April 2005)	NLU51	0				0	N/A
NLUBio05	RETEC Phase3 (April 2005)	NLU55	51				54	0.77
NLUBio05	RETEC Phase3 (April 2005)	NLU55-diluted	74				48	1.82
NLUBio05	RETEC Phase3 (April 2005)	NLU64	89				86	2.34
NLUBio05	RETEC Phase3 (April 2005)	NLU66	92				72	2.57
NLUBio05	RETEC Phase3 (April 2005)	NLU69	87				96	2.30
NLUBio05	RETEC Phase3 (April 2005)	NLU73	89				92	1.94
NLUBio05	RETEC Phase3 (April 2005)	NLU76	82				94	1.71
NLUBio05	RETEC Phase3 (April 2005)	NLU81	90				82	2.64
NLUBio05	RETEC Phase3 (April 2005)	NLU82	79				76	2.25
NLUBio05	RETEC Phase3 (April 2005)	NLU83	94				84	2.33
NLUBio05	RETEC Phase3 (April 2005)	NLU84	98				88	2.18
NLUBio05	RETEC Phase3 (April 2005)	NLU85	95				82	2.36
NLUBio05	RETEC Phase3 (April 2005)	NLU86	87				62	1.25
NLUBio05	RETEC Phase3 (April 2005)	NLU87	94				88	2.25
NLUBio05	RETEC Phase3 (April 2005)	NLU117	0				34	1.62
NLUBio05	RETEC Phase3 (April 2005)	NLU117-diluted	30				40	1.90
NLUBio05	RETEC Phase3 (April 2005)	NLUEPA5	88				88	2.17
NLUBio05	RETEC Phase3 (April 2005)	NLUEPA19	97				82	2.14
NLUBio05	RETEC Phase3 (April 2005)	Ref-1	84				92	1.97
NLUBio05	RETEC Phase3 (April 2005)	Ref-2	86				80	2.46
NLUBio05	RETEC Phase3 (April 2005)	Control	98				82	1.54

Notes:

[a] survival = mean %

[b] growth = mean weight/larva, mg dw

[c] sample location highly uncertain

N/A = not applicable; high mortality precludes meaningful interpretation of growth

Table 5-7

Biological Criteria Exceedances in Surface Sediment

Gas Works Park Site

Seattle, Washington

Survey Name	Investigation	Sample ID	*Hyalella azteca* 10-day		*Chironomus tentans* 10-day		*Chironomus tentans* 20-day		Final SMS Classification
			Survival	Growth	Survival	Growth	Survival	Growth	
TAMU02	RETEC Split Samples (March 2002)	LU-1[a]	Pass		Pass	**CSL**			**CSL**
TAMU02	RETEC Split Samples (March 2002)	LU-2[a]	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-3	Pass		Pass	**SCO**			**SCO**
TAMU02	RETEC Split Samples (March 2002)	LU-4	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-5	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-6	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-7	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-8	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-9	Pass		Pass	Pass			**Pass**
TAMU02	RETEC Split Samples (March 2002)	LU-10	Pass		Pass	Pass			**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU01	Pass	Pass	**CSL**	**CSL**	**CSL**	Pass	**CSL**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU02	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU04	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU05	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU06	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU07	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU08	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU10	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU12	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU13	Pass	Pass	Pass	**CSL**	Pass	Pass	**CSL**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU14	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU15	Pass	Pass	Pass	Pass	Pass	Pass	**Pass**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU16	Pass	Pass	Pass	**CSL**	**SCO**	Pass	**CSL**
RETEC02-Grabs	RETEC Phase 2 (October 2002)	NLU17	Pass	Pass	Pass	**CSL**	**CSL**	**SCO**	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLU13	Pass				**CSL**	**CSL**	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLU51	**CSL**				**CSL**	**CSL**	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLU55	**CSL**				**CSL**	**CSL**	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLU64	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU66	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU69	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU73	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU76	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU81	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU82	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU83	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU84	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU85	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU86	Pass				Pass	**CSL**	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLU87	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLU117	**CSL**				**CSL**	Pass	**CSL**
NLUBio05	RETEC Phase3 (April 2005)	NLUEPA5	Pass				Pass	Pass	**Pass**
NLUBio05	RETEC Phase3 (April 2005)	NLUEPA19	Pass				Pass	Pass	**Pass**

Notes:

[a] sample location highly uncertain.

Shading = failure of SCO numeric criteria

Shading = failure of CSL numeric criteria

Table 5-8

Statistical Results for Pair-wise Comparisons of ALU versus AOI Sediment

Gas Works Park Site

Seattle, Washington

Analyte Group	Analyte	Statistical Result			Too Few Detects to Test
		AOI > ALU	ALU > AOI	No Detectable Difference	
Conventionals	Sulfide	--	--	X	--
PAHs	Total cPAH TEQ	X	--	--	--
	Total PAH	X	--	--	--
TPH	Diesel Range Hydrocarbons	--	--	--	X
SVOCs	4-Methylphenol	--	--	X	--
	Benzoic Acid	--	--	X	--
	bis(2-Ethylhexyl)phthalate	--	X	--	--
	Carbazole	--	--	X	--
	Dibenzofuran	X	--	--	--
	Di-n-Butyl phthalate	--	X	--	--
	Di-n-Octyl phthalate	--	--	--	X
	Hexachlorobenzene	--	--	--	X
	Pentachlorophenol	--	--	X	--
	Phenol	--	X	--	--
Pesticides	Chlordane	--	--	--	X
	4,4'-DDE	--	X	--	--
PCBs	Total PCBs (Aroclor)	--	X	--	--
Butyltins	Tributyl Tin	--	--	X	--
Metals	Arsenic	--	--	X	--
	Cadmium	--	--	X	--
	Chromium	--	--	X	--
	Copper	--	--	X	--
	Lead	--	X	--	--
	Mercury	--	X	--	--
	Methylmercury	--	--	--	X
	Nickel	--	--	X	--
	Silver	--	--	X	--

AOI Sediment COC

ALU Sediment COC

Table 5-9

Identification of Concentration Gradients in Sediment

Gas Works Park Site

Seattle, Washington

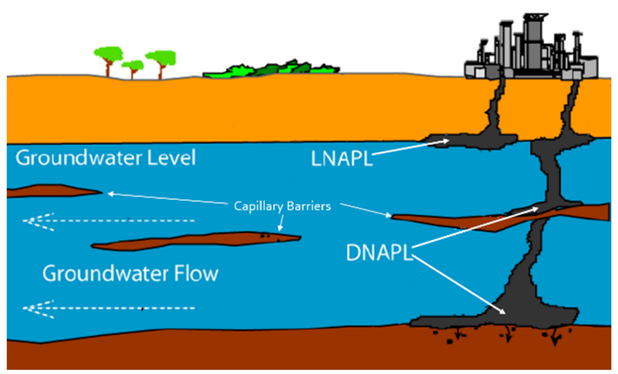
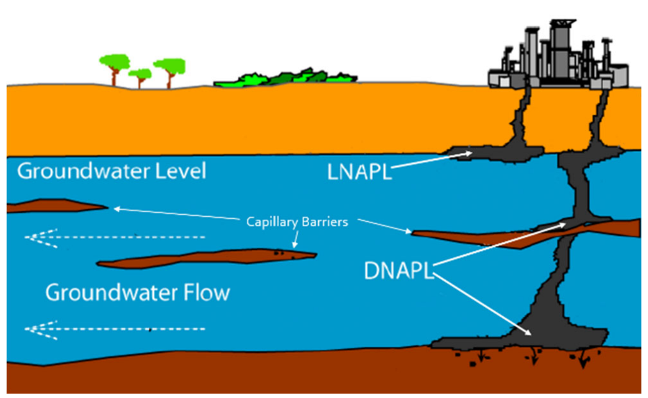
Analyte Group	Analyte	Apparent Gradient from Nearshore
Conventionals	Sulfide	No
TPH	Diesel Range Hydrocarbons	No
SVOCs	4-Methylphenol	No
	Benzoic Acid	No
	Carbazole	Yes
	Di-n-Octyl phthalate	No
	Hexachlorobenzene	Evaluate sources
	Pentachlorophenol	No
	Phenol	No
Pesticides	Chlordane	No
Metals	Cadmium	No
	Chromium	No
	Copper	No
	Methylmercury	No
	Nickel	Evaluate sources
	Silver	No

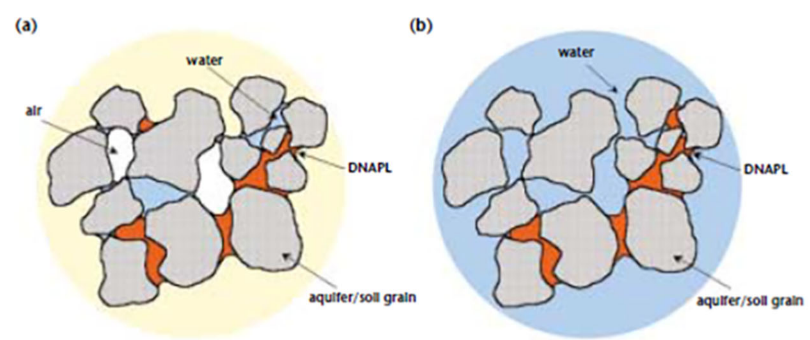
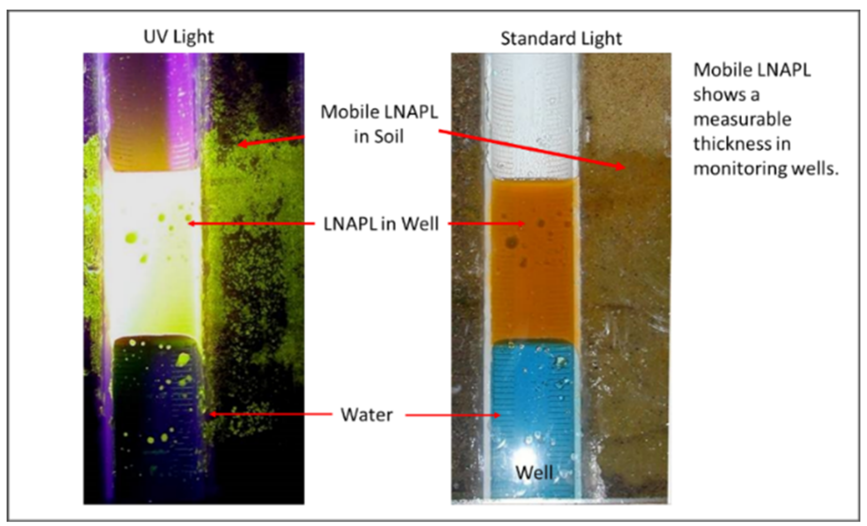
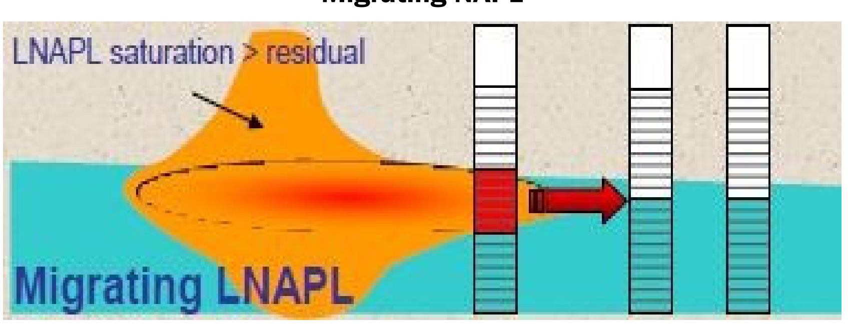
AOI COC (yellow: Carbazole)

ALU COC (green: all other analytes except Hexachlorobenzene and Nickel)

Table 5-10

NAPL and NAPL-Related Terminology
Gas Works Park Site
Seattle, Washington

Term and Graphic	Definition	Gas Works Park Site (GWPS) Presence and Terminology Used in the Remedial Investigation/Feasibility Study Report
	NAPL And Types Of NAPL	
NAPL Non-Aqueous Phase Liquid  Edublogs.org 2017	NAPLs are organic compounds or mixtures of compounds that are immiscible (resistant to mixing) with water. The term NAPL refers to the undissolved liquid phase of a compound and not to the aqueous phase constituents that may be dissolved in water (modified from EPA 1992).	NAPL is a general term used in the RI/FS to refer to nonaqueous phase liquids. NAPL can refer to light NAPL (LNAPL) and/or dense NAPL (DNAPL), or combinations and mixtures of both.
LNAPL Light Non-Aqueous Phase Liquid  Modified from Eberhard-Karls-University of Tuebingen 2012	Light NAPLs are organic compounds (or mixtures of compounds) such as petroleum oil, gasoline, and diesel fuel that float. LNAPLs have densities less than water (density < 1.0 g/cm³) and are immiscible (resistant to mixing) with water (modified from ITRC 2009).	In the RI/FS, the term LNAPL refers to three types of LNAPL encountered at the GWPS: ■ Fuel oil, petroleum-based LNAPL. ■ Benzol, monoaromatic-rich LNAPL (also referred to as “light oil” in the RI/FS report and other references). ■ Naphthalene-rich LNAPL. Properties of on-site LNAPL: ■ Low viscosity compared with DNAPLs at the Site. ■ Specific gravity: 0.92 at 70 degrees measured in MW-09 (that of water at the same temperature is 1.0). ■ LNAPL saturation in soil (%Pv), where measured, ranges from 4.8 percent to 46.6 percent; only one sample was more than 20 percent LNAPL saturated.
DNAPL Dense Non-Aqueous Phase Liquid  Modified from Eberhard-Karls-University of Tuebingen 2012	Dense NAPLs are organic compounds (or mixtures of compounds) such as coal tar, creosote, and other organic compounds that don’t mix well with water (are immiscible) and tend to sink (density > 1.0 g/cm²). (modified from ITRC 2003).	In the RI/FS, the term DNAPL refers to three types of DNAPL encountered at the GWPS: ■ Naphthalene-rich DNAPL previously referred to as “middle oil” and infrequently referred to as “medium oil.” ■ PAH-rich DNAPL, previously referred to as coal tar or creosote (a coal-tar-based product that may also contain petroleum) as generic terms. ■ Lower PAH DNAPL with petroleum. Properties of on-site DNAPL: ■ DNAPL viscosity ranges from 22 to 1,128 centistokes (measured at 70 degrees). ■ Specific gravity: ranges from 1.02 to 1.11 at 70 degrees (that of water at the same temperature is 1.0). ■ DNAPL saturation in soil (%Pv), where measured, ranges from 2.1 percent to 14.5 percent.

Term and Graphic	Definition	Gas Works Park Site Presence and Terminology Used in the Remedial Investigation/Feasibility Study Report
	NAPL Stability Terminology for GWPS	
Residual NAPL  Figure 3 Residual DNAPL in (a) unsaturated and (b) saturated porous media Environment Agency 2003	The term "residual NAPL" refers to NAPL that is trapped in the pore spaces between soil particles or sediment particles and cannot be easily moved hydraulically (modified from API 2006). Residual NAPL refers to NAPL at the range of saturations greater than zero up to the NAPL saturation, at which NAPL capillary pressure equals pore entry pressure. Includes NAPL that is discontinuous and immobile under the applied gradient (modified from ITRC 2009).	Almost all NAPL at the GWPS is in residual form. Residual NAPL is used to refer to LNAPL and DNAPL. Residual NAPL is described in many ways in the RI/FS report to communicate the specific nature and occurrence of residual NAPL: ■ Residual NAPL (LNAPL and DNAPL that is not mobile) ■ Less than residual saturation ■ Stable ■ Immobile ■ Smear (typically associated with LNAPL) ■ Slight to moderate sheen ■ Heavy sheen and/or trace NAPL ■ Blobs, droplets, coating grains Note: The term "Residual NAPL" as used in the RI/FS is not the same as residual saturation defined in MTCA (WAC 173-340-747(10)) "the concentration of hazardous substances in the soil at equilibrium conditions."
Mobile NAPL  ENSR | AECOM 2007	NAPL that exceeds residual NAPL saturation and is hydraulically connected in the pore space. Has the potential to be mobile in the environment. Mobile NAPL is measurable in wells because the well creates a void space for mobile NAPL to move into. Mobile NAPL includes migrating NAPL, but not all mobile NAPL is migrating NAPL. Mobile NAPL can also be referred to as non-residual NAPL (modified from ITRC 2009).	Mobile NAPL refers to NAPL that exceeds residual saturation. Evidence of mobile NAPL is limited to the following areas: ■ East area near the Play Area in monitoring wells MW-09 (NAPL Areas 10 and 11), and MW-44S and MW-45S (LNAPL Area 13). ■ West area near Harbor Patrol (DNAPL Area 4). Other terms used to describe mobile NAPL include: ■ Pooling (DNAPL in till depressions), ■ Non-residual, and ■ Measurable thickness or measurable NAPL (in wells).
Migrating NAPL  ITRC 2009	A non-residual NAPL body that is observed to spread or expand laterally, vertically, or otherwise result in an increased volume of NAPL-impacted media. NAPL migration is typically documented by time-series data (modified from ITRC 2009).	No evidence of migrating NAPL has been documented with time-series data. Industrial activities ended more than 60 years ago and NAPL is expected to be in equilibrium at the GWPS. A possible exception are rare observations of ebullition.

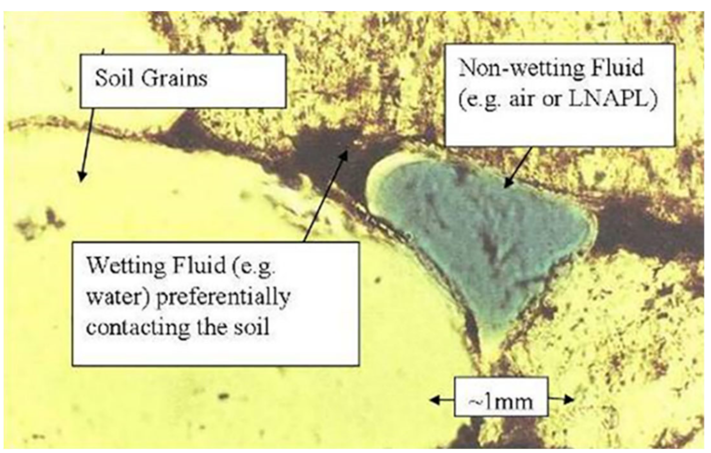
Term and Graphic	Definition	Gas Works Park Site Presence and Terminology Used in the Remedial Investigation/Feasibility Study Report
NAPL Field Screening Terms		
Sheen Testing  Ecology 2016	Sheen testing involves placing a small amount of soil in a pan of water and observing the water surface for signs of sheen. A black plastic gold pan typically is used for sheen testing. ■ NS (no sheen)—No visible sheen on the water surface. ■ SS (slight sheen)—Light, colorless, dull sheen; spread is irregular, not rapid. Natural organic oils or iron bacteria in the soil may produce a slight sheen. ■ MS (moderate sheen)—Pronounced sheen over limited area; probably has some color/iridescence; spread is irregular, may be rapid; sheen does not spread over entire water surface. ■ HS (heavy sheen)—Heavy sheen with pronounced color/iridescence; spread is rapid; the entire surface is covered with sheen. (modified from Ecology 2016).	Sheens were considered in categorization of NAPL. *Heavy Sheen and/or trace NAPL* and *Heavy sheen with NAPL* categories were used to map NAPL areas. GWPS RI/FS NAPL Impacts Categories and Descriptions: ■ No Impacts – No visual or olfactory evidence of hydrocarbons present. ■ Staining and/or Odor – Presence of hydrocarbon or naphthalene-like odor, hydrocarbon staining of the soil or sediment matrix, or both. ■ Slight to Moderate Sheen – Observations of hydrocarbon sheen ranging from trace to slight to moderate or medium sheens that may be described as spotty, white, colored or rainbow sheens. ■ Heavy Sheen and/or Trace NAPL – Observations of heavy, oily or strong hydrocarbon sheens; minor NAPL observations described as trace NAPL; small, scattered or occasional oil blobs (< 1/8 inch in size), or NAPL veinlets; or oily water or oil emulsions. ■ Heavy Sheen with NAPL – Observations of sheens plus NAPL where NAPL is described as present, abundant or saturated, including observations of oil/NAPL drops or blobs (> 1/8 inch in size), oil or oil/NAPL on equipment. The NAPL may occur in lenses, layers, fractures, seams or veins. NAPL implies a lower-viscosity liquid that occurs in and moves through the interstitial pore space or voids in the soil or sediment matrix.
Free Product  Wilson et. al. 1990	General term used to refer to NAPL. Typically used to refer to NAPL observed during drilling (residual or mobile) and NAPL that has accumulated in wells.	Free Product is generally not used to refer to NAPLs in the RI/FS. The term 'free product' is used in the RI/FS to refer to free product mobility testing. NAPLs subjected to free product mobility testing did not show evidence of migration at centrifugal forces representative of 1,000 times gravitational forces (Appendix 2A). Free Product was occasionally used in historical boring logs to refer to NAPL observed during drilling.
Tar		
Tar  Floyd | Snider 2008	Heavy, viscous product obtained when distilling organic materials such as wood, coal, or peat. Although a tar-like product can be obtained from petroleum, the term tar does not properly apply to a product obtained from petroleum (modified from Tver and Barry 1980).	Tar, when used to describe conditions at the GWPS, refers to a solid or semi-solid and is not considered a NAPL. The term tar is included here for completeness. In the RI/FS, tar is the term used to refer to semisolid, pliable solid or solid material. Tar at the GWPS is dark in color and consists mostly of high molecular weight PAHs with low aqueous solubility. Tar typically occurs as small discrete masses, layers, or deposits within the Fill unit at or near the uncapped soil or sediment surface. Small tar masses are interspersed sporadically within the Fill unit, with some larger deposits identified (Figure 5C-2). The nature and extent of tar has been interpreted separately from LNAPL and DNAPL. Changes in viscosity resulting from higher temperatures during hot summer days have historically resulted in mobilization and surfacing of tar in limited areas. Surfacing of tar has not been observed in areas with a protective soil cap.

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Table 6-1

Physical and Chemical Parameters for COCs and Impacted Media

Gas Works Park Site

Seattle, Washington

Chemical	Molecular Weight[a] (g/mol)	K_d (L/kg)	Aqueous Solubility (mg/L)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m^3/mol)	K_{oc} (L/kg)	Log K_{ow}	Soil Half-life (yrs)	Groundwater Half-life (yrs)
Benzene	78.11	22 to 97[b]	1,790[e]	95[e]	0.0056[e]	100 to 449[g]	2.13[e]	0.03[h]	1.0[h]
Naphthalene	128.18	500 to 1,820[b]	31[e]	0.085[e]	0.00044[e]	2,000 to 8,430[g]	3.30[e]	0.09[h]	0.37[h]
Benzo(a)pyrene	252.32	761,000 to 2,180,000[b]	0.0016[e]	Negligible	0.00000046[e]	3,520,000 to 10,100,000[g]	6.13[e]	0.79[h]	3.2[h]
Chrysene	228.29	112,000 to 338,000[b]	0.002 to 0.00345[e]	Negligible	0.0000052[e]	519,000 to 1,560,000[g]	5.81[e]	1.9[h]	7.5[h]
Carbazole	167.21	732[f]	1.8[e]	0.00000075[e]	0.00000012[e]	3,390[j]	3.72[e]	--[h]	--[h]
Dibenzofuran	168.19	501[f]	3.1[e]	0.0025[e]	0.00021[e]	2,320[k]	4.12[e]	0.048[h]	0.059[h]
Arsenic	74.92	464 to 2,820[c]	Variable[d]	Negligible	Negligible	n/a	n/a	n/a	n/a
Nickel	58.69	65[l]	Variable[i]	Negligible	Negligible	n/a	n/a	n/a	n/a

Notes:

[a] Lide 1992 (CRC Handbook of Chemistry and Physics) (assumed arsenic acid for arsenic molecular weight).

[b] For site-specific values per geologic unit see Table 6A-2 (PAHs) and Table 6A-3 (benzene).

[c] Site-specific arsenic Kd values for fill (2,821 L/kg) and outwash (464 L/kg) geologic units are described in Appendix 2B-2. The site-specific arsenic Kd value for recent deposits (1,654 L/kg) is the mean value of calculated Kd values from co-located sediment and porewater sample results for arsenic.

[d] Arsenic chemical and physical information - http://www.atsdr.cdc.gov/toxprofiles/tp2-c4.pdf. Aqueous solubility values include: Arsenic (insoluble) arsenic acid (302,000 mg/L at 12.5 deg C), arsenic pentoxice (2,300,000 mg/L at 20 deg C), and arsenic trioxide (17,000 mg/L at 16 deg C).

[e] EPI Suite - Estimation Program Interface Version 4.00. U.S. EPA and Syracuse Research Corporation.

[f] Calculated Kd values based on published Koc value and average fraction organic carbon (foc) of 0.216 reported in PAH Partitioning in Black Carbon-Impacted Sediments from Lake Union (Appendix 2D). Kd = foc*Koc

[g] Back-calculated Koc values are based on site-specific K_d values and average foc of 0.216 reported in PAH Partitioning in Black Carbon-Impacted Sediments from Lake Union (Appendix 2D). Koc = Kd/foc

[h] Howard et al. 1991 (Handbook of Environmental Degradation Rates). Assumes anaerobic conditions for groundwater half-lives for benzo(a)pyrene and chrysene.

[i] Nickel chemical and physical information - http://www.atsdr.cdc.gov/toxprofiles/tp15.pdf. Aqueous solubility values include: Nickel (1.13 mg/L at 37 deg C), nickel acetate (170,000 mg/L at 68 deg C), nickel ammonium sulfate (104,000 mg/L at 20 deg C), and nickel carbonate (93 mg/L at 25 deg C).

[j] CLARC Master Data Table (Ecology 2019a)

[k] PubChem Database (https://pubchem.ncbi.nlm.nih.gov).

[l] https://semspub.epa.gov/work/HQ/175235.pdf

-- = not available

n/a = not applicable

See text for full acronym and abbreviation list.

Table 6-2

Analytical Data Summary – Porewater
Gas Works Park Site
Seattle, Washington

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentration	Screening Level
			Minimum	Maximum	Minimum	Mean	Median	Maximum	Excluding Nondetected Values	Including Nondetected Values		
VOCs		%	µg/L		µg/L				%			
Benzene	6	0	1.0	1.0	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.44 µg/L
Ethylbenzene	6	0	1.0	1.0	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	No Exceedance	Not Calculated	29 µg/L
Toluene	6	0	1.0	1.0	Not Detected	Not Detected	Not Detected	Not Detected	--	--	--	Not a COC
PAHs			µg/L		µg/L				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	6	0	0.70	0.92	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.02 µg/L
Total PAH	6	50	1.0	1.0	4.5	5.9	5.6	7.7	--	--	--	Not a COC
Benzo(a)anthracene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Benzo(a)pyrene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Benzo(b)fluoranthene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Benzo(k)fluoranthene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Chrysene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.016 µg/L
Dibenzo(a,h)anthracene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Fluoranthene	6	17	1.0	1.3	1.0	1.0	1.0	1.0	No Exceedance	No Exceedance	No Exceedance	6 µg/L
Indeno(1,2,3-cd)pyrene	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	100	Not Calculated	0.01 µg/L
Pyrene	6	17	1.0	1.3	1.3	1.3	1.3	1.3	No Exceedance	No Exceedance	No Exceedance	8 µg/L
Naphthalene	6	33	1.0	1.0	1.2	3.4	3.4	5.6	No Exceedance	No Exceedance	No Exceedance	160 µg/L
SVOCs			µg/L		µg/L				%			
Carbazole	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	No Exceedance	Not Calculated	2 µg/L
Dibenzofuran	6	0	1.0	1.3	Not Detected	Not Detected	Not Detected	Not Detected	Not Calculated	No Exceedance	Not Calculated	16 µg/L
Metals			µg/L		µg/L				%			
Arsenic	6	17	50	50	70	70	70	70	17	100	8.8	8. µg/L

Notes:

-- = not applicable

See text for full acronym and abbreviation list.

Porewater inlcudes samples collected to 0.5 feet bml.

Exceedance statistics based on offshore groundwater screening levels.

Table 6-3

Analytical Data Summary – Catch Basin Solids

Gas Works Park Site

Seattle, Washington

Analyte	Total No. Samples	Frequency of Detection	Reporting Limit for Nondetected Values		Detected Concentrations				Frequency of Exceedance		Maximum Exceedance Factor of Detected Concentrations	Screening Level
			Minimum	Maximum	Minimum	Median	Mean	Maximum	Excluding Nondetected Values	Including Nondetected Values		
PAHs		%	mg/kg		mg/kg				%			
Carcinogenic PAH (Calculated) using 1/2 the RL	24	100	--	--	0.12	1.9	0.92	6.5	92	92	31	0.21 mg/kg
Total PAH	24	100	--	--	1.0	18	9.1	73	25	25	2.4	30 mg/kg
SVOCs		%	mg/kg		mg/kg				%			
Carbazole	23	22	0.064	0.95	0.21	0.30	0.27	0.52	0	0	No Exceedance	1.1 mg/kg
Dibenzofuran	24	25	0.063	0.64	0.062	0.20	0.19	0.34	0.0	0.0	No Exceedance	0.68 mg/kg
Metals[a]		%	mg/kg		mg/kg				%			
Arsenic	23	48	9.0	30	10	22	19	53	13	17	2.2	24 mg/kg

Notes:

[a] Nickel was not analyzed in catch basin solids

-- = not applicable

See text for full acronym and abbreviation list.

Table 9-1

Potential Applicable Laws Governing Cleanup

Gas Works Park Site

Seattle, Washington

Subject Regulated	State or Local Statutes and Implementing Regulations	Federal Statutes and Implementing Regulations	Notes
Cleanup Levels			
Soil	MTCA (WAC 173-340 Sections 740 and 745)	--	Site specific soil cleanup levels established in 1999 Consent Decree.
Groundwater	MTCA (WAC 173-340 Section 720)	--	State cleanup levels for groundwater.
Sediment	SMS (WAC 173-204)	--	Criteria used to identify sediments that have no adverse effects on biological resources and correspond to no significant health risk to humans. Site-specific cleanup levels developed per WAC 173-204-340(3) and in consultation with Ecology.
Surface Water	MTCA (WAC 173-340 Sections 720 and 730)	--	Requirements for establishing numeric or risk-based goals and selecting cleanup actions. Anticipated to be relevant and appropriate to Site remediation.
	--	CWA Section 304	National recommended water quality criteria for the protection of aquatic organisms and protection of human health based on consumption of organisms.
	Washington Water Pollution Control Act - State Water Quality Standards for Surface Water (RCW 90.48; WAC 173-201A-130)	CWA (33 USC 1251–1376; 40 CFR 100–149; 40 CFR 131)	Ambient water quality criteria for the protection of aquatic organisms and human health. MTCA requires the attainment of water quality criteria where relevant to the circumstances of the release. State water quality standards, conventional water quality parameters and toxic criteria. Narrative and quantitative limitations for surface water protection. Permitting for sediment cleanup action will define required measures for compliance with surface water standards during cleanup implementation.
	--	Safe Drinking Water Act (40 CFR 141)	Safe Drinking Water Act National Primary Drinking Water Standards: maximum contaminant levels, maximum contaminant level goals, proposed maximum contaminant levels and proposed maximum contaminant level goals. Anticipated to be relevant and appropriate to Site remediation. Permitting for sediment cleanup action will define measures to be taken to comply with standards during implementation.
Protection of Species and Habitats			
Habitat Impacts and Mitigation	Washington Department of Fisheries Habitat Management Policy (POL 410), Compensatory Mitigation Policy for Aquatic Resources (RCW 75.20 and 90.48)	Memorandum of Agreement between EPA and USACE (mitigation under CWA Section 404(b)(1); US Fish and Wildlife Mitigation Policy (46 Federal Register 7644); Fish and Wildlife Coordination Act (16 USC 661 et seq.)	Policies and procedures have been established by state and federal agencies to evaluate and mitigate habitat impacts. Mitigation requirements for projects are defined in project permitting and vary with the type of work conducted. The project alternatives evaluated in the FS have been designed to avoid net loss of sensitive or critical habitats. The need for significant mitigation over and above that already included in the FS alternatives is considered unlikely. Project final design and permitting (e.g., as part of the Biological Assessment to be performed during project permitting) will include evaluation of project impacts and definition of any mitigation required or appropriate to the work being performed.
Protection of Essential Fish Habitat	No state equivalent	Magnuson-Stevens Fishery Conservation and Management Act (50 CFR 600.920)	Essential fish habitat has a specific definition under the Magnuson-Stevens Act. In practice, the state's hydraulic project approval addresses similar issues. Requirements for protection of essential fish habitat will be part of the USACE permit.
Protection of Migratory Birds	No state equivalent	Migratory Bird Treaty Act (16 USC 703; 50 CFR 10.12)	Species protected by the Migratory Bird Treaty Act use Lake Union on a seasonal basis; potential impacts will be addressed as part of the USACE permit.
Protection of Fish and Fish Habitat	Hydraulic Code Rules (WAC 77.55.100; WAC 220-110)	No federal equivalent	Rules designed to protect fish; substantive requirements apply to sediment remedy.
Critical Areas	SMC Critical Areas Requirements (SMC 25.09); Growth Management Act (RCW 36.70A)	No federal equivalent	This chapter implements the City of Seattle Comprehensive Plan to promote safe, stable and compatible development that avoids adverse environmental impacts and potential harm on the parcel and to adjacent property, the surrounding neighborhood and the drainage basin. MTCA remedial actions are exempt from the procedural requirements of this law, but must comply with the substantive requirements. May affect habitat goals in relation to portions of final remedy. An "environmentally critical area" exemption would likely be required.
Protection and Restoration of Endangered or Threatened Species and Critical Habitats	Fish and Wildlife or Natural Resource Conservation Areas (various RCW Titles 77 and 79; WAC 232-12)	Endangered Species Act of 1973 (16 USC 1531 et seq.; 50 CFR 200; 50 CFR 216; 50 CFR 402; 16 USC 1361 et seq.)	State rules primarily address salmon and their recovery along with general conservation strategies for state lands and state resources. GWPS is used by species protected under the ESA. Consultation with natural resource trustees will take place as part of the USACE permit. Actions must be performed so as to conserve endangered or threatened species, including consultation with the U.S. Department of Interior. Chinook salmon federally listed as a threatened species. Federal agencies must confer with National Oceanic and Atmospheric Administration Fisheries on any action that may impact listed species. Project permitting will include compliance with ESA requirements, as necessary, including consultation with state and federal permitting agencies, completion of a Biological Assessment, and incorporation of measures to avoid adverse impacts to endangered or threatened species.
Activities Within or Adjacent to Wetlands		Executive Order 11990, Protection of Wetlands (40 CFR 6, Appendix A); EPA (1989) Wetland Actions Plan	Actions must be performed so as to minimize the destruction, loss or degradation of wetlands as defined by Executive Order 11990 Section 7. Requirement for no net loss of remaining wetlands. Minor wetland fringe is present in cove at northeast corner of Site. Cleanup alternatives are not anticipated to negatively impact this wetland fringe.
Water Quality			
General	Water Pollution Control Act (RCW 90.48); Water Quality Standards for Surface Waters of Washington (WAC 173-201A)	CWA (33 USC 26 §1251 et seq.; 40 CFR 1, Subchapter D)	State implements most components of the CWA. Water quality is considered in the development of cleanup objectives, short-term performance during construction and long-term performance of the remedy.
Discharge of Dredge, Excavated or Fill Materials	No state equivalent	CWA Section 404	Applies to waters of the U.S.; affects sediment remedies that have a removal or capping component. Requires a USACE Nationwide 38 or Section 404 individual permit, which will be part of the Joint Aquatic Resources Permit Application permit.
Discharge of Return Water from Dredged Material	Water Pollution Control Act (RCW 90.48); Water Quality Standards for Surface Waters of Washington (WAC 173-201A)	CWA Section 401	State certifies consistency with CWA. Applies to sediment remedies; any requirements are typically specified in a Consent Decree or Cleanup Action Plan.

Subject Regulated	State or Local Statutes and Implementing Regulations	Federal Statutes and Implementing Regulations	Notes
Discharge of Stormwater	Water Pollution Control Act (RCW 90.48); National Pollutant Discharge Elimination System Program (WAC 173-220)	CWA Section 402	Applies to both sediment and upland remedies. Dewatering of sediment may, and upland construction would, require a state-issued NPDES permit.
Hazardous Waste Cleanup	MTCA Cleanup Regulation (RCW 70.105D; WAC 173-340)	Comprehensive Environmental Response, Compensation and Liability Act (42 USC 103; 40 CFR I, Subchapter J)	State law has precedence; primary regulations governing upland cleanup actions at the Site. Although most state and local permits are waived because the work will be conducted under a Consent Decree, MTCA requires compliance with substantive permit requirements. All federal permits governing the remedial action are still required.
Sediment Quality, Investigation and Cleanup	SMS (RCW 90.48 and 70.105D; WAC 173-204)	No federal equivalent	Primary regulations governing sediment cleanup actions at the Site. MTCA is one of the authorities defining the SMS; thus, waivers of state and local permits also apply to sediment cleanups.
Evaluation of Environmental Impacts	State Environmental Policy Act (RCW 43.21C; WAC 197-11; WAC 173-802)	National Environmental Policy Act (42 USC 55 § 4321 et seq.; 40 CFR V, Parts 1500-1508)	Evaluation of project environmental impacts and definition of appropriate measures for impact mitigation.
Impacts to Navigation	Hydraulic Code Rules (WAC 77.55.100; WAC 220-110)	Rivers and Harbors Act Section 10	Rules designed to protect navigation. No navigation channel designated in Lake Union. To be addressed as part of the JARPA process.
Shoreline Construction or Development within 200 Feet of Shoreline	Shoreline Management Act (RCW 90.48; RCW 90.58; WAC 173-16; WAC 173-14)	Coastal Zone Management Act (Public Law 92-583; 16 USC Chapter 33; 16 USC 1451 et seq.)	The state Shoreline Management Act is authorized under the federal Coastal Zone Management Act and establishes requirements for substantial development occurring within the waters of the State of Washington or within 200 feet of a shoreline. MTCA remedial actions are exempt from the procedural requirements of this law, but must comply with the substantive requirements.
	Shoreline Master Use Program (SMC 23.60)	--	Among the goals of the Shoreline Master Use Plan are to protect the ecosystems of the shoreline areas; encourage water-dependent uses; provide for maximum public use and enjoyment of the shorelines of the City; and preserve, enhance and increase views of the water and access to the water. MTCA remedial actions are exempt from the procedural requirements of this law, but must comply with the substantive requirements. A Seattle DPD Land Use Permit will be needed for shoreline substantial development (i.e., grading near Lake Union).
Treatment and Disposal			
Management, Transport and Disposal of Hazardous Wastes	Solid and Hazardous Waste Management Act (RCW 70.105); Dangerous Waste Regulations WAC 173-303)	Resource Conservation and Recovery Act (40 CFR 260 and 261; 49 USC 51, Transportation of Hazardous Material; 49 CFR 171-180)	Federal regulations are implemented by the state. Pertains to soil, sediment, water, and debris waste handling and landfill disposal. Management and disposal process is administered by the state and all substantive requirements must be met. Transportation is regulated by the US Department of Transportation. Federal regulation 40 CFR 261.24(a) states that the disposal of soil/sediments that contain manufactured gas plant wastes that fail the Toxicity Characteristic Leaching Procedure test are not regulated under RCRA Subtitle C at federally regulated sites, so no toxicity tests are required for disposal of manufactured gas plant wastes in nonhazardous waste landfills. Furthermore, the universal treatment standards required by RCRA's Land Ban Regulations for all regulated constituents that are contained in the waste will not be triggered.
Management, Transport and Disposal of Solid Wastes	Solid and Hazardous Waste Management Act (RCW 70.95; WAC 173-305, 173-350 and others)	RCRA (40 CFR 257 Subpart A)	Affects land disposal and transportation of dredged or excavated material and debris from the Site; process is administered by the state and all substantive requirements must be met.
In-water Sediment Disposal or Capping	--	USACE permitting requirements (CWA Sections 401 and 404) (40 CFR 230; 33 CFR 320, 323, 325 and 328)	Permitting requirements for discharges into waters of the U.S.
	--	USACE permitting requirements (Rivers & Harbors Act Section 10) (33 CFR 320 and 322)	Permitting requirements for dredging or disposal in navigable waters of the US. Project implementation will include USACE permitting.
	State HPA Permitting (Washington Hydraulics Code) (WAC 220-110)	--	Permitting for work that would use, divert, obstruct or change the natural flow or bed of any salt or fresh waters. Project implementation and permitting will include coordination with WDFW staff. This coordination will address all substantive requirements of the HPA permitting process, including evaluation of potential mitigation requirements and definition of work procedures and timing. Dredging, capping and other in-water work activities will be performed at appropriate times of the year to comply with fisheries protection requirements.
	State Aquatic Lands Management Laws (RCW 79.90 through 79.96; WAC 332-30)	--	Sediment capping on state-owned lands, if performed as part of the remedy, will comply with rules for management of state-owned aquatic lands.
	State Constitution (Articles XV, XVII, XXVII) Public Trust Doctrine		
Upland Disposal of Dredged Sediments	Washington Dangerous Waste Regulations Designation Procedures (WAC 173-303-070)	Federal hazardous waste criteria are less broad than state criteria for dangerous waste.	State and federal laws prohibit land disposal of certain hazardous or dangerous wastes. Sediments managed by upland disposal will comply with disposal site criteria. The need for additional waste profiling will be addressed as part of the engineering design for the project.
	Minimum Functional Standards for Solid Waste Handling (WAC 173-304); Solid Waste Handling Standards (WAC 173-350)	Solid Waste Disposal Act (42 USC Sec. 325103259, 6901-6991), as administered under 40 CFR 257, 258	Applicable to nonhazardous waste generated during remedial activities and disposed of off-site unless wastes meet recycling exemptions. Sediments managed by upland disposal will comply with disposal site criteria. FS alternatives are based on existing permitted facilities in compliance with these regulations and permitted to accept impacted dredged materials. Upland beneficial reuse of sediments, which would be regulated under WAC 173-350, is not contemplated under any FS alternative.
Wastewater	State Discharge Permit Program; NPDES Program (WAC 173-216, -220)	NPDES (40 CFR 122, 125)	Permitting and treatment requirements for direct discharges into surface water. Anticipated to be relevant only if collected waters are discharged to on-site water body. Discharges must comply with substantive requirements of the NPDES permit. Applicable for off-site discharges; a permit would be required. RI/FS alternatives do not contemplate discharge of collected waters to on-site water body. Construction stormwater requirements will be satisfied for upland handling of sediment, including development of a Storm Water Pollution Prevention Plan and implementation of best management practices. NPDES program requirements will be reviewed as part of project final design. A Construction Stormwater General Permit will need to be issued by Ecology for discharge of stormwater as part of construction activity.
	City of Seattle Wastewater Treatment Requirements (Metro District Wastewater Discharge Ordinance), King County Industrial Waste Program	National Pretreatment Standards (40 CFR 403)	Permitting and pretreatment requirements for discharges to a POTW. Discharges to POTWs are considered off-site activities; pretreatment and permitting requirements would be applicable. Alternatives include water pretreatment and POTW discharge. Such work would be subject to POTW permitting and pretreatment standards. Project design and implementation must incorporate waste characterization, pretreatment and permitting. Permitting requirements will be reviewed as part of project final design. A City of Seattle DPD Side Sewer Permit will be needed for use of the sewer for construction dewatering (stormwater collected). A King County Industrial Waste Program Discharge Authorization will be needed for discharge of construction dewatering to the sewer system.
Underground Injection	UIC Program (WAC 173-218)	--	The Washington UIC Program manages the injection of materials below ground for waste disposal, remediation, etc. The UIC program is applicable to the GWPS for in situ remediation of groundwater. Permanent and temporary Injection wells used to inject solutions of remediation reagents are managed under UIC as Class V injection wells as defined in WAC 173-218-040(5)(a)(x). Existing injection wells at the GWPS installed for remediation of arsenic in the Play Area are registered under the UIC program. Additional injection wells or temporary injection points installed for the cleanup action will require registration with the UIC Program as Class V injection wells. Following the cleanup action, all injection wells will require decommissioning in accordance with UIC guidelines.

Subject Regulated	State or Local Statutes and Implementing Regulations	Federal Statutes and Implementing Regulations	Notes
Air Quality			
Ambient Air Quality and Emissions	Washington State Clean Air Act (70.94 RCW); Ambient Air Quality Standards (WAC 173-746); Northwest Air Pollution Agency ambient and emission standards; General Requirements for Air Pollution Sources (WAC 173-400); Regional Emission Standards for Toxic Air Pollutants	Clean Air Act (42 USC 85, Air Pollution, Prevention and Control)	Administered by the state and local authorities; substantive requirements apply to construction activities during implementation of the remedy. Potentially applicable to alternatives involving sediment treatment or upland handling. On-site treatment of dredged materials using methods that may require an air pollution control permit is not contemplated in the FS alternatives. Off-site sediment handling and treatment and disposal facilities contemplated for use under the FS alternatives comply with applicable air regulations and maintain appropriate permits. Permitting requirements and compliance of facilities used for dredged material management will be reviewed as part of project final design.
Toxic Air Contaminants	Source of toxic air contaminant requires a notice of construction (Puget Sound Air Pollution Control Agency Regulation III)	--	--
Fugitive Dust	Regional Emission Standards for fugitive dust; Best Available Control Technology to control dust (Puget Sound Air Pollution Control Agency Regulation I); Puget Sound Clean Air Agency regulations for fugitive dust emissions (Section 9.15 of Regulation I)	--	--
Other			
Health and Safety	Washington Industrial Safety and Health Act (RCW 49.17; WAC 296-62, 296-843 and others)	OSHA (29 USC 15; 29 CFR 1910, 1926)	Applicable to investigation and construction phases of a cleanup. Development of a Health and Safety Plan with appropriate controls, worker certifications and monitoring. Relevant requirement for environmental remediation operations. All work activities performed at the site will comply with OSHA and WISHA requirements. Project final design will include definition of contractor safety requirements, including preparation and compliance with a project Health and Safety Plan, worker training, record-keeping requirements and other applicable measures.
Objects, Landscapes or Structures of Historical or Archaeological Significance	Regulations regarding these resources are part of SEPA, the Governor's Executive Order 05-05, and Shoreline Management Act (i.e., no one single regulation or authority); RCW 27.53; WAC 365-196-450 and others also apply.	National Historic Preservation Act (16 USC 470 et seq. Section 106)	State laws govern local projects; federal law governs those requiring federal permits or funds. Protection of significant historical, archaeological and traditional cultural sites from damage or loss during development. Gas Works Park was listed in the National Register of Historical Places in 2013. Will require coordination with the state's Department of Archaeological and Historic Preservation (State Historic Preservation Office), and include evaluating compliance with Section 106 of the federal law.
Historical Character of Park and Aboveground Installations	Landmarks Preservation Board (SMC 22.901T)	--	Ensures that changes to protected characteristics of Gas Works Park are minimal and that the historical character of the property is preserved. Requires a Certificate of Approval before changes are made to landmark sites. Applicable only to permanent above-ground installations that may be included in remedial activities. Any changes to permanent above-ground installations will be designed to maintain protected characteristics.
Construction in State Waters	Construction in State Waters, Hydraulic Code Rules (RCW 75.20; WAC 220-1101)	Rivers and Harbors Appropriation Act (33 USC 401; 40 CFR 230; 33 CFR 320, 322, 323, 325)	Requirements for construction and development projects for the protection of fish and shellfish in state waters. State HPA permit required unless project implemented under MTCA Consent Decree or Order. Under Consent Decree, substantive requirements would still be addressed. Project implementation and permitting will include coordination with WDFW staff. This coordination will address all substantive requirements of the HPA permitting process, including information submittals, evaluation of potential mitigation requirements, and definition of work procedures and timing. Dredging, capping and other in-water work activities will be performed at appropriate times of the year to comply with fisheries protection requirements. USACE Section 404 permit or Nationwide 38 permit required.
Impacts to Tribal Treaty Rights	--	Treaty of Point Elliott (12 Stat. 927); Treaty of Medicine Creek (10 Stat. 1132)	U.S. treaties protect certain rights of recognized Tribes of Native Americans, including property rights, water rights and fish/shellfish gathering rights. Impacts to treaty rights are typically addressed during project permitting. Project alternatives evaluated in the FS protect environmental quality at the Site and result in no significant changes to Site features. Consultation with area Tribal nations will be conducted during project permitting to ensure that there are no adverse impacts to Tribal treaty rights.
Noise Control	Noise Control Act of 1974 (WAC 173-60); SMC Title 25.800	Noise Control Act of 1974 (RCW 70.107)	Maximum noise levels. Potentially relevant depending on remedial activities and equipment selected. Construction activities will be limited to normal working hours, to the extent possible, to minimize noise impacts.
Activities within 100-Year Floodplain	--	40 CFR 257; 40 CFR 264.18(b); 40 CFR 761.75	Not applicable; water levels are managed by USACE.
Earthwork and Grading Activities	SMC Title 22.804	--	For any upland grading activity that may need to be performed, a City of Seattle DPD Grading Permit will be needed.
Electrical Installations	Seattle Electric Code Supplement for Class 1 Division 2 Environments	National Electric Code (National Fire Protection Association 70)	Electrical installations to support remedial activities at the site. Potentially applicable to the site to support remedial activities. All electrical installations to be weatherized per National Electrical Manufacturers Association 4 standards.
Overall Remedial Design	Seattle Design Commission	--	Ensures that City investment enhances livability through design excellence. Potentially applicable if the cleanup is considered to be a City capital improvement project. Project design will be reviewed by the Design Commission, if necessary.
Investigation, Use and Modification of Park Property	Seattle Municipal Code 18.30	--	A Seattle Department of Parks and Recreation Revocable Use Permit will be needed to use, occupy and modify park property.
Traffic Control and Truck Haul Routes	Seattle Municipal Code (SMC Title 15)	--	A City of Seattle Department of Transportation Street Use Permit will be needed for traffic control and truck haul routes.

Notes:

ADA = Americans with Disabilities Act
CFR = Code of Federal Regulations
CWA = Clean Water Act
DPD = Seattle Department of Planning and Development
EPA = U.S. Environmental Protection Agency
ESA = Endangered Species Act
FR = Federal Register
FS = feasibility study
HPA = hydraulic project approval
MTCA = Model Toxics Control Act
NPDES = National Pollutant Discharge Elimination System
OSHA = Occupational Safety and Health Administration
POTW = publicly owned treatment works
RCW = Revised Code of Washington
SDWA = Safe Drinking Water Act
SEPA = State Environmental Policy Act
SMA = Shoreline Management Act
SMC = Seattle Municipal Code
SMS = Sediment Management Standards
USACE = U.S. Army Corps of Engineers
USC = U.S. Code
WAC = Washington Administrative Code
WISHA = Washington Industrial Safety and Health Act

Table 9-2

Preliminary Sediment Cleanup Levels for GWPS Contaminants of Concern

Gas Works Park Site

Seattle, Washington

Analyte Group	GWPS Contaminants of Concern		Sediment[a,b] mg/kg	Basis	Exposure Pathways and Receptors
PAHs	Total PAH		30	CSL (risk-based concentration)	Benthic
	cPAHs	Benzo(a)anthracene	Included in Total cPAHs TEQ Screening Level		
		Benzo(a)pyrene			
		Benzo(b)fluoranthene			
		Benzo(k)fluoranthene			
		Chrysene			
		Indeno(1,2,3-cd)pyrene			
		Dibenzo(a,h)anthracene			
	Total cPAHs TEQ		0.21	CSL (regional background concentration)	Human health direct contact, bioaccumulation
SVOCs	Carbazole		0.90	SCO (risk-based concentration)	Benthic
	Dibenzofuran		0.20	SCO (risk-based concentration)	Benthic
Metals	Arsenic		24	CSL (preliminary regional background concentration)	Benthic, human health direct contact, bioaccumulation
	Nickel		50	SCO (risk-based concentration)	Benthic

Notes:

[a] Preliminary sediment cleanup levels included for analytes identified as GWPS COCs only. Sediment screening levels for ALU COCs are presented in Table 9-3.

[b] Preliminary points of compliance are discussed in detail in Section 9.3.1. Benthic COCs = upper 10 cm in the Benthic Toxicity Area. Direct Contact COCs = upper 45 cm in the Direct Contact Beach Play and Wading Exposure Area and upper 10 cm in the Direct Contact Wading Exposure Area. Bioaccumulation COCs - upper 10 cm in the Bioaccumulation Exposure Area. Sediment point of compliance areas are shown on Figure 9-1.

See text for full acronym and abbreviation list.

Table 9-3

Summary of Sediment Screening Levels for ALU Contaminants of Concern

Gas Works Park Site

Seattle, Washington

Analyte Group	ALU Contaminants of Concern	Sediment[a]	
		Sediment Cleanup Objective	Cleanup Screening Level
		mg/kg	mg/kg
Conventionals	Sulfide	39	61
TPH	Diesel Range Hyrdocarbons	340	510
SVOCs	4-Methylphenol	0.26	2.0
	Benzoic Acid	2.9	3.8
	Bis(2-ethylhexyl)phthalate	0.50	22
	Di-n-Butyl phthalate	0.38	1.0
	Di-n-Octyl phthalate	0.039	>1.1
	Hexachlorobenzene	0.005	0.005
	Pentachlorophenol	0.02	0.02
	Phenol	0.12	0.21
Pesticides	Chlordane	0.001	0.001
	4,4'-DDE	0.021	0.033
PCBs	Total PCBs (Aroclor)	0.02	0.02
Butyltins	Tributyltin	0.047	0.32
	Cadmium	2.1	5.4
	Chromium	62	62
	Copper	400	1,200
	Lead	360	>1,300
	Mercury	0.66	0.8
	Methylmercury	0.000058	0.000058
	Silver	0.57	1.7

Notes:

[a] Sediment screening levels for analytes identified as ALU COCs. Preliminary sediment cleanup levels for GWPS COCs are presented in Table 9-2.

See text for full acronym and abbreviation list.

Table 9-4

Summary of Preliminary Groundwater Cleanup Levels

Gas Works Park Site

Seattle, Washington

			Preliminary Groundwater Cleanup Levels[a,b]	
			µg/L	Basis[c]
BTEX	Benzene		0.44	Protection of surface water (based on ingestion of water and organisms)
	Ethylbenzene		29 (68)	Protection of surface water (based on ingestion of water and organisms)
	Fluoranthene		6 (16)	Protection of surface water (based on ingestion of water and organisms)
	Naphthalene		160	Protection of surface water (based on ingestion of water and organisms)
	Pyrene		8 (20)	Protection of surface water (based on ingestion of water and organisms)
	cPAHs	Benzo(a)anthracene	0.01	Protection of surface water (based on ingestion of water and organisms), adjusted to PQL
		Benzo(a)pyrene	0.01	Protection of surface water (based on ingestion of water and organisms), adjusted to PQL
		Benzo(b)fluoranthene	0.01	Protection of surface water (based on ingestion of water and organisms), adjusted to PQL
		Benzo(k)fluoranthene	0.01 (0.012)	Protection of surface water (based on ingestion of water and organisms), adjusted to PQL
		Chrysene	0.016 (0.12)	Protection of surface water (based on ingestion of water and organisms)
		Indeno(1,2,3-cd)pyrene	0.01	Protection of surface water (based on ingestion of water and organisms), adjusted to PQL
	Total cPAHs TEQ		0.02	Protection of sediment, adjusted to PQL
	Bis(2-ethylhexyl)phthalate		3.0	Protection of sediment, adjusted to PQL
	Carbazole		2.0	Protection of sediment
	Dibenzofuran		16	Protection of surface water (based on drinking water ingestion)
Metals	Arsenic		8	Protection of surface water (based on ingestion of water and organisms), adjusted to background
	Cadmium		0.72	Protection of surface water (based on toxicity to aquatic organisms)
	Copper		11	Protection of surface water (based on toxicity to aquatic organisms)
	Lead		2.5	Protection of surface water (based on toxicity to aquatic organisms)
	Mercury		0.10	Protection of surface water (based on toxicity to aquatic organisms), adjusted to PQL
	Nickel		52	Protection of surface water (based on toxicity to aquatic organisms)
	Silver		3.2	Protection of surface water (based on toxicity to aquatic organisms)

Notes:

[a] Cleanup levels are only applicable to offshore groundwater. Values in parenetheses will be the preliminary cleanup levels if surface water criteria in 40 CFR 131.45 are not reinstated.

[b] Groundwater conditional point of compliance is generally set at 10 centimeters below the mudline, at the base of the biologically active zone. For arsenic, the conditional point of compliance may be set farther upgradient, closer to the source, if conditions allow.

[c] Preliminary groundwater cleanup levels are based on protection of surface water and sediment (see Table 4-2). The basis refers to the media and pathways associated with the selected cleanup level.

See text for full acronym and abbreviation list.

TABLE 10-1 CLEANUP MANAGEMENT AREAS

Management Area	Description	Environmental Condition Driving Cleanup	Management Area Cleanup Objectives
GWMA-1	Deep groundwater in the uplands between the Play Area and Lake Union. The groundwater is below the park facility and is not subject to use.	• Arsenic in deep groundwater immediately upland of the Lake Union shoreline is present at concentrations greater than the preliminary cleanup level.	• Treat arsenic in upland groundwater to the extent feasible using AKART.
SMA-1	Approximately 0.54 acre uncapped bank soil area along approximately 1,000 linear feet of the eastern park shoreline. Includes the upland portion of the tar mound in the northeast corner of the park. This shoreline area can be accessed by park users for recreation.	• Uncapped bank soil containing tar and PAHs at concentrations greater than preliminary cleanup levels is a potential direct contact exposure for park users. • Contaminants can be transported to the adjacent sediment area by erosion.	• Remove tar mass to the extent feasible. • Prevent direct contact exposure to remaining soil. • Prevent erosion of soil to lakeshore sediment. • Accommodate future park uses
SMA-2	Approximately 0.16 acre uncapped bank soil area along approximately 400 linear feet of the shoreline adjacent to Kite Hill in the southwestern area of the park. This shoreline area can be accessed by park users for recreation.	• Uncapped bank soil containing tar and PAHs at concentrations greater than preliminary cleanup levels is a potential direct contact exposure for park users. • Contaminants can be transported to the adjacent sediment area by erosion.	• Prevent direct contact exposure to soil. • Prevent erosion of soil to lakeshore sediment
SMA-3	Approximately 1.0 acre nearshore sediment area along the eastern shoreline north of the Till Ridge generally between elevations OHWM and +10' (USACE). This area can be accessed by park users for recreation (beach play and wading) and for net fishing and is used for shallow draft vessel navigation.	• PAH and arsenic concentrations in sediment are greater than preliminary cleanup levels. • Sediments demonstrate benthic toxicity. • Offshore groundwater VOCs, PAHs, and arsenic can be transported to surface water.	• Achieve preliminary cleanup levels for sediment within the biologically active zone and/or the top 45 cm in the beach play and wading exposure area. • Prevent discharge of groundwater containing contaminants that are at concentration greater than preliminary cleanup levels • Accommodate future park uses
SMA-4	Approximately 0.28 acre nearshore sediment area between the Prow and Harbor Patrol generally between elevations OHWM and +10' (USACE). This area can be accessed by park users for recreation (wading) and for net fishing and is used for shallow draft vessel navigation.	• PAH concentrations in sediment are greater than preliminary cleanup levels. • Sediments demonstrate benthic toxicity. • Offshore groundwater VOCs and PAHs can be transported to surface water.	• Achieve preliminary cleanup levels for sediment within the biologically active zone. • Prevent discharge of groundwater containing mobile contaminants that are at concentration above the preliminary cleanup levels.

Management Area	Description	Environmental Condition Driving Cleanup	Management Area Cleanup Objectives
SMA-5	Approximately 0.60 acre nearshore sediment area between Harbor Patrol and the northwest corner of the AOI generally between OHWM and +5' (USACE). Includes areas adjacent to Metro Lake Union South Yard and Harbor Patrol, as well as Waterway 20. Waterway 20 is used as a public boat ramp (wading access) and can be accessed for net fishing. Other uses include vessel navigation and moorage, including Harbor Patrol and Center for Wooden Boats activities.	• PAH concentrations in sediment are greater than preliminary cleanup levels • Sediments demonstrate benthic toxicity. • Offshore groundwater VOCs and PAHs can be transported to surface water.	• Achieve preliminary cleanup levels for sediment within the biologically active zone. • Prevent discharge of groundwater containing contaminants that are at concentration above the preliminary cleanup levels
SMA-6	Approximately 2.3 acre shallow sediment area offshore of the Prow extending to approximately elevation -5' (USACE). This area is used for shallow draft vessel navigation and can be accessed for net fishing. A portion of this area east of the prow can be accessed by park users for recreation (beach play and wading).	• PAH concentrations in sediment are greater than preliminary cleanup levels • Sediments demonstrate benthic toxicity.	• Achieve preliminary cleanup levels for sediment within the biologically active zone and/or the top 45 cm in the beach play and wading exposure area.
SMA-7	Approximately 2.0 acre sediment area in the eastern offshore portion of the GWPS. Approximate elevations are between +10' and -17' (USACE). This area can be accessed for net fishing and is used for vessel navigation and moorage and includes a portion of the Gas Works Park Marina.	• PAH and arsenic concentrations in sediment are greater than preliminary cleanup levels. • Sediments demonstrate benthic toxicity. • Shallow subsurface NAPL in sediments can be released to the water column. • Offshore groundwater VOCs, PAHs and arsenic can be transported to surface water.	• Achieve preliminary cleanup levels for sediment within the biologically active zone. • Prevent emergence or disturbance of shallow NAPL in sediments. • Prevent discharge of groundwater containing contaminants that are at concentration greater than preliminary cleanup levels.
SMA-8	Approximately 0.59 acre sediment area associated with NAPL Area 8 offshore of the Prow generally between between +5' and -15' (USACE). This area can be accessed for net fishing and is used for vessel navigation.	• PAH concentrations in sediment are greater than preliminary cleanup levels • Sediments demonstrate benthic toxicity. • Shallow subsurface NAPL in sediments can be released to the water column.	• Achieve preliminary cleanup levels for sediment within the biologically active zone • Prevent emergence or disturbance of shallow NAPL in sediments.

Management Area	Description	Environmental Condition Driving Cleanup	Management Area Cleanup Objectives
SMA-9	Approximately 2.8 acre sediment area offshore of the western park shoreline including the area adjacent to the Harbor Patrol bulkhead. Approximate elevations are between +10' and -18' (USACE) where offshore of SMA 4 and between +5' and -18' (USACE) where offshore of SMA 5. This area can be accessed for net fishing and is used for vessel navigation, and moorage, including Harbor Patrol activites and part of a shipyard facility.	• PAH concentrations in sediment are greater than preliminary cleanup levels • Sediments demonstrate benthic toxicity. • Shallow subsurface NAPL in sediments can be released to the water column. • Offshore groundwater VOCs, PAHs and arsenic can be transported to surface water.	• Achieve preliminary cleanup levels for sediment within the biologically active zone. • Prevent emergence or disturbance of shallow NAPL in sediments. • Prevent discharge of groundwater containing contaminants that are at concentration greater than preliminary cleanup levels.
SMA-10	Approximately 0.55 acre sediment area in the northeastern area of the AOI generally at +10' on the nearshore side and between +0' and -16' (USACE) offshore. This area is used for vessel navigation and moorage and includes part of the Gasworks Park Marina.	• PAH concentrations in sediment are greater than preliminary cleanup levels	• Achieve preliminary cleanup levels for sediment within the biologically active zone.
SMA-11	Approximately 6.2 acre sediment area in the south and eastern parts of the AOI generally between -5' and -20' (USACE) where offshore of SMA-6 and between the OHWM and elevation -23' (USACE) where offshore of the till ridge shoreline. This area can be accessed by park users for recreation (beach play and wading) and for net fishing and is used for vessel navigation.	• PAH concentrations in sediment are greater than preliminary cleanup levels	• Achieve preliminary cleanup levels for sediment within the biologically active zone and/or the top 45 cm in the beach play and wading exposure area.

Management Area	Description	Environmental Condition Driving Cleanup	Management Area Cleanup Objectives
SMA-12	Approximately 7.2 acre sediment area along the western park shoreline between SMA-9 and SMA-13 and the western AOI boundary generally between elevations between -18’ and -20’ (USACE). This area can be accessed for net fishing and is used for vessel navigation, and moorage, including part of a shipyard facility.	• PAH and arsenic concentrations in sediment are greater than preliminary cleanup levels, and co-located shipyard-related metals concentrations are also elevated. • Sediments demonstrate benthic toxicity. • Shallow subsurface NAPL in sediments can be released to the water column. • Lake bottom depositional area with contaminant concentrations not expected to achieve preliminary cleanup levels or ambient conditions naturally within a reasonable restoration timeframe.	• Achieve preliminary cleanup levels for sediment within the biologically active zone. • Prevent emergence or disturbance of shallow NAPL in sediments.
SMA-13	Approximately 10 acre sediment area at the western limits of the AOI. This area can be accessed for net fishing and is used for vessel navigation.	• PAH and arsenic concentrations in sediment are greater than preliminary cleanup levels, and co-located shipyard-related metals concentrations are also elevated. • Sediments demonstrate benthic toxicity. • Lake bottom depositional area with thick soft sediment. Contaminant concentrations not expected to achieve preliminary cleanup levels or ambient conditions naturally within a reasonable restoration timeframe.	• Achieve preliminary cleanup levels for sediment within the biologically active zone.
SMA-14	Approximately 23 acre sediment area at the southern limits of the AOI. This area can be accessed for net fishing and is used for vessel navigation.	• PAH concentrations in sediment are greater than preliminary cleanup levels. • Lake bottom depositional area with thick soft sediment. Contaminant concentrations already at or below ambient conditions due to natural recovery.	• Achieve sediment preliminary cleanup levels within the biologically active zone.

Notes:

See text for full acronym and abbreviation list.

TABLE 11-1. ARSENIC IN UPLAND GROUNDWATER AKART EVALUATION

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
***In-situ* Groundwater Treatment**	**Groundwater Natural Attenuation**	**Reduction of dissolved concentrations through naturally occurring attenuation processes. Involves groundwater monitoring to demonstrate effectiveness. Primarily applicable to lower concentration contaminants downgradient from or following treatment of source areas.**	**Attenuation by precipitation and adsorption can be applicable for inorganic contaminants such as arsenic. Natural attenuation of dissolved arsenic by precipitation and adsorption has been demonstrated at the GWPS and would be expected to effectively attenuate lower concentrations of arsenic, particularly in fill unit groundwater.**	**Technically implementable. Significant monitoring well network already established at the GWPS. Monitoring conditions downgradient of current shoreline wells would require offshore monitoring.**	**Negligible capital cost. Moderate O&M cost. Low overall cost relative to active remediation options.**	**Retained.** **Natural attenuation of dissolved arsenic has been demonstrated at the GWPS. Applicable for areas of lower arsenic concentrations downgradient of the Play Area source area, particularly fill unit groundwater.**
	Fixation	**Direct injection or mixing of chemical reagents with groundwater to modify geochemical conditions and promote precipitation of inorganic contaminants. In-situ fixation of arsenic has been demonstrated at the GWPS during the Play Area Interim Action.**	**Demonstrated by treatability testing to be effective for precipitation of arsenic in the target shoreline area (groundwater from well MW-36D was used for testing). Effectiveness of arsenic fixation was further confirmed by the interim action during which a ferrous sulfate reagent was used to precipitate arsenic at the Play Area resulting in over 95-percent reduction of dissolved arsenic in outwash groundwater.**	**Readily implementable using common reagent injection methods and equipment. Demonstrated implementable during interim action.**	**Moderate capital and O&M cost.**	**Retained.** **Proven technology at the GWPS for treating arsenic in groundwater.**
	Chemical Oxidation	Injection of a dilute oxidant solution (i.e., hydrogen peroxide, ozone, potassium permanganate, sodium persulfate, ferric chloride, etc.) into the contaminated zone to convert hazardous compounds to nonhazardous or less toxic forms that are more stable, less mobile, or inert.	Chemical oxidation has been demonstrated at a lab scale during treatability testing to effectively break down thioarsenates in Play Area groundwater. However, the oxidation was used as a precursor to fixation. Oxidation on its own would not be expected to effectively attenuate arsenic. In addition, the organics present in soil and groundwater would present a high oxidant demand, reducing the effectiveness of injected oxidant.	Generally implementable for dissolved contaminants using standard reagent injection processes.	Moderate capital and O&M costs. High-cost uncertainty with respect to oxidant demand of treatment zone and presence of NAPL and presence of other organics in site soil.	Not retained. In-situ chemical oxidation is not expected to be as effective as other in-situ treatment methods.
	Enhanced Bioremediation	Injection of an electron acceptor (oxygen) or an electron donor (i.e., hydrogen, or hydrogen-releasing material) into the contaminated zone to enhance aerobic or anaerobic conditions suitable to promote transformation of contaminants.	Limited effectiveness at generating conditions conducive to precipitating arsenic. pH and arsenic concentrations in the targeted shoreline outwash groundwater would be expected to inhibit microbial growth and limit the effectiveness of bioremediation.	Generally implementable, using common injection methods.	Moderate capital cost. Moderate O&M cost.	Not retained. Low anticipated effectiveness under conditions present.

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
In-situ Groundwater Treatment (continued)	Permeable Reactive Barrier Wall	PRB walls utilize in-situ treatment methods in a passive configuration, treating groundwater as it passes through the reactive material. PRBs are effective at preventing groundwater contaminants from migrating to on-site or off-site receptors. A PRB for dissolved arsenic would focus on adsorption or precipitation, rather than destruction, using materials such as zero-valent iron or organoclay materials capable of arsenic adsorption. PRBs are typically constructed downgradient of source areas to provide treatment of groundwater flowing away from source areas. PRBs are not typically used within plumes unless the treatment method affects downgradient contaminant concentrations.	PRBs have been used at numerous sites for treatment of inorganic contaminants, including arsenic, in contaminated groundwater. Effectiveness relies on selecting a contaminant-specific reactive treatment component. Ineffective at treating source area contamination. Ineffective or reduced effectiveness where treated groundwater subsequently flows through contaminated media (e.g., contaminated sediment) downgradient of the PRB.	Technically implementable using a variety of PRB installation methods. However, the depth of treatment required (deep outwash groundwater), subsurface structures and debris along shoreline, and limited space for construction between the shoreline and Play Area reduces implementability. Reactive component can be placed between impermeable barriers to form a funnel and gate configuration.	Moderate to high capital costs. Moderate to high O&M cost. O&M costs increase for treatment methods that require frequent replenishment. Higher capital and O&M costs for deep outwash arsenic applications due to depth.	Not retained. Does not treat groundwater across a large footprint, including within upgradient source areas, only within PRB. Limited ability to treat groundwater downgradient of limited shoreline area where PRB installation is feasible. Other in-situ application methods would more effectively treat a larger contaminant using the same general chemical treatment method as a PRB. Downgradient conditions would likely re-contaminate groundwater prior to reaching Lake Union sediment, limiting overall effectiveness.
Groundwater Extraction and Treatment	Vertical Extraction Wells	Groundwater extraction using vertical extraction wells to achieve contaminant mass removal. Objectives of groundwater extraction include removal of dissolved contaminants below ground.	May be effective for partial removal of high-concentration dissolved phase contaminants as a mass removal element. Effectiveness relies on treatment and disposal of extracted groundwater.	Groundwater extraction is technically implementable using standard methods. The need for treatment infrastructure to treat extracted groundwater to meet discharge requirements will reduce the implementability for long-term implementation.	Moderate capital cost. High O&M cost assuming long-term operation and water treatment.	Not retained in favor of treatment technologies. Groundwater extraction for mass removal would be applied in cooperation with MNA to address conditions following partial mass removal. Treatment and disposal of extracted groundwater would have a high cost.
Physical Groundwater Barrier	Low Permeability Barrier Wall	Placement of a low-permeability vertical barrier to restrict the migration of deep outwash groundwater toward Lake Union and direct groundwater flow above the zone of highest arsenic concentrations. Use of sheet pile or slurry wall methods would depend on subsurface conditions and anticipated wall depth. Containment of deeper outwash groundwater with the highest arsenic concentrations may require alternative installation methods.	Can be effective for containing contaminated groundwater or redirecting groundwater away from a source or receptor. Overall effectiveness would require addressing groundwater redirected above low-permeability wall.	Technically implementable. Installation of a deep barrier with an overlying permeable zone would be difficult with traditional sheet pile. Sheet pile installation may be difficult in some areas near the shoreline due to anticipated subsurface obstructions. Barrier sheets may require trenching for installation due to obstructions. Some slurry wall construction methods involve in-situ mixing, which may spread contaminants vertically.	Moderate to high capital cost. Low to moderate O&M cost.	Not retained in favor of treatment technologies. Prevents contaminant migration through a specific path but does not involve treatment. Implementation issues associated with barrier wall installation along the shoreline.
Hydraulic Barrier	Groundwater Extraction Wells	Groundwater pumping to establish a hydraulic capture zone and restrict groundwater flow and contaminant migration in the downgradient direction.	Potentially effective for hydraulic control of impacted groundwater. Requires continuous long-term operation to maintain containment and maintenance of treatment components to prevent discharge of contaminated groundwater.	Technically implementable using standard groundwater extraction methods. The need for treatment infrastructure and long-term operation to treat extracted groundwater to meet discharge requirements will reduce the implementability.	Moderate capital cost and high O&M cost. High O&M costs associated with long-term pumping and treatment of extracted groundwater.	Not Retained. High cost and intrusive infrastructure for a long period.

Notes:

Bold indicates that the Remediation Technology was retained.

See text for full acronym and abbreviation list.

TABLE 11-2. SEDIMENT REMEDIATION TECHNOLOGY SCREENING

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
***In-Situ* Sediment Treatment**	Electro-Chemical Reduction Technology (ECRT)	Treatment is accomplished by the mineralization of organic contaminants through the electro-chemical geo-oxidation process.	Reaction rates are inversely proportional to grain size, such that ECRTs remediate faster in finer-grained materials typically found at contaminated sediment sites, including the GWPS. Innovative technology with minimal proven effectiveness for GWPS contaminants. Treatability testing would be required.	Demonstrated implementable on pilot scale. Implementability of electro-chemical methods for full-scale in-water use is uncertain A pilot study at the Georgia Pacific Log Pond indicated multiple operational problems following installation of anodic and cathodic electrodes in the sediment[1].	High capital and O&M costs.	Not retained. High uncertainties associated with this innovative process and unproven effectiveness for most GWPS and ALU contaminants.
	In situ Amendment Mixing	Materials commonly used for amended sediment caps such as organoclay, granular activated carbon, and zero-valent iron are mixed *in situ* with contaminated sediment rather than being placed as a cap.	Can be effective if mixing does not exacerbate contaminant mobility or release. Some AOI sediment conditions (high-water content soft sediment, shallow NAPL-impacted sediment) suggest mixing an amendment into surface sediment will have limited applicability due to high risk of contaminant mobilization.	Difficult to implement due to uncertainties about contaminant mobility/release. Not expected to be acceptable to regulators, reducing administrative implementability.	Moderate capital cost. Low O&M cost.	Not retained. AOI sediment conditions would make this process difficult to perform without releasing contaminants.
	Activated Carbon	**Activated carbon (AC) is capable of adsorbing a wide range of hydrocarbons, including GWPS contaminants PAHs, benzene, and certain species of arsenic. AC can be mixed or implemented in series with other amendments to bind additional contaminants in the sediments, such as NAPL. The sorption capacity of AC is utilized quickly in the presence of NAPL. The lightweight nature of the material can be difficult to effectively place as a uniform sand/AC mixture, but AC is commonly used in mats to ensure effective placements.**	**Effective and commonly used for adsorbing more mobile dissolved organic compounds. Adsorption of organic contaminants to AC is often 10 to 100 times greater than absorption to natural organic matter. Limited sorption effectiveness for arsenic.**	**AC is very commonly used for removal of organic contaminants in process water treatment and has more recently been applied to sediment capping, having been implemented on a wide range of sites. Placement of AC can be difficult due to the near neutral buoyancy of AC, but proprietary AC products (mats, heavy AC granules) have addressed this issue.**	**Moderate to high capital cost. Moderate O&M cost.**	**Retained.** **Effective, implementable and commonly used as a cap element to prevent migration of mobile contaminants through the cap.**
	Organophilic Clay (Organoclay)	**Organoclay is a bentonite clay that is chemically modified from hydrophilic to organophilic and is used to target hydrocarbon free product for control of NAPL through absorption. Some organophilic clay products can also adsorb arsenic.**	**Effective for removing NAPL and adsorbing dissolved PAHs and metals. Commonly used for sediment capping applications with NAPL. Some organoclay products are available that can adsorb arsenic and can be mixed with other organoclays to address multiple chemicals with a layered barrier.**	**Technically implementable using standard cap placement methods. Organoclays have been used in several full-scale applications. Applicable in bulk placement or incorporated in reactive mats.**	**Moderate to high capital cost. Moderate O&M cost.**	**Retained.** **Effective, implementable and has been successfully used at many full-scale sites.**

[1] EPA 2007. Electrochemical Remediation Technologies (ECRTs) – In situ Remediation of Contaminated Marine Sediments, Innovative Technology Evaluation Report. EPA/540/R-04/507. June 2007

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
In-Situ Sediment Treatment (continued)	Zero-Valent Iron (ZVI)	ZVI targets metals and certain chlorinated volatile organic compounds. Zero-valent iron particles have a reactive surface that chemically reduces (transforms) and subsequently immobilizes a variety of arsenic species.	One of the most effective metal oxides for fixing As(III) and As(V) in appropriate geochemical conditions. Data from Play Area Interim Action treatability testing showed positive results for ZVI performance.	Technically implementable using readily available materials and standard cap placement methods.	High capital cost. Moderate O&M	Retained for dissolved arsenic in offshore groundwater. Demonstrated effectiveness for arsenic treatment at other sites and during Play Area treatability testing.
Sediment and Debris Removal	Land-Based Excavation	Removal of bank soil and nearshore sediment using common land-based earthwork equipment such as a backhoe during low-water periods. This technology may be used in conjunction with shoring/sheet pile walls, coffer dams, and dewatering techniques to conduct excavation in the dry.	Commonly used and effective for removing contaminated soil and sediment from shoreline areas that can be reached by land-based equipment. When combined with coffer-dam methods, can effectively remove sediment with limited potential for release of contaminants to surface water. If conducted under wet conditions, higher potential to generate contaminated residuals that require management.	Technically implementable for bank and nearshore shallow sediment areas. Permit and monitoring requirements can result in relatively higher costs and duration.	Moderate to high capital cost, depending on disposal requirements. Negligible O&M cost.	Retained. Effective and implementable for removal of bank soil, debris and/or sediment along the shoreline.
	Mechanical Dredging	Removal of sediment using conventional barge-mounted dredging techniques and equipment. Barge-mounted dredging is most often performed off-shore beyond the reach of land-based equipment and in water depths that allow access for the equipment. Contaminated sediment is removed through the water column. Mechanical dredging for remediation uses specialized dredging equipment and water quality controls specific for the project. Mechanical dredging would be reserved primarily for consolidated sediment that can be efficiently removed using environmental dredging methods.	Commonly used and effective at removing contaminated sediment. Removal effectiveness is dependent on sediment density, bottom slope and depth, presence of NAPL, equipment type and skill of the dredge operator. Almost all dredging generates contaminated residuals that must be managed. Pollution controls are necessary to reduce release of contaminants during dredging. Low removal productivity effectiveness in lake bottom area of AOI due to soft sediment/fluid mud. Low effectiveness for NAPL-impacted sediment due to the high risk of contaminant releases.	Mechanical dredging is commonly performed using readily available equipment to remove contaminated sediments. Technically implementable in some areas of the AOI. Mechanical dredging methods have lower implementability potential for the soft sediment conditions present in lake bottom area of the AOI. The reduced implementability results from the inability to completely capture sediment and contaminants released from the sediment during removal due to limits associated with environmental dredging methods and equipment that would be required (i.e., tight-closing environmental buckets).	High to very high capital cost, depending on disposal requirements. Negligible O&M cost.	Retained. Effective and implementable for removal of sediment and debris in areas that do not contain soft sediment or NAPL.

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
Sediment and Debris Removal (continued)	**Hydraulic Dredging**	**Pumps are used to remove a mixture of water and sediment. Cutter heads are commonly added to enhance entrainment of more consolidated sediment but are expected to exacerbate mobilization of contaminants. Small scale operations conducted with the assistance of divers are capable of dredging near structures. Dredged sediment is processed on-site by dewatering prior to transport off-site for disposal.**	**Effective at removing solid-phase contaminants in sediment including areas inaccessible to excavation or mechanical dredging methods. Best suited for low density, high-water solids in areas generally less than 20 ft. of water. Not effective when debris is present. Slow removal process limits effectiveness to small-scale applications for contaminated sediment. Methods to increase removal rate, such as cutter heads, can increase potential to release contaminants and are more suited to clean dredging projects.**	**Potentially implementable, but large-scale implementation would require significant land area, equipment, and cost to dewater and handle dredged sediment. Hydraulic dredging produces a large volume of water that must be treated and discharged or disposed. Small scale, diver-assisted hydraulic dredging to remove sediment around existing structures would be implementable.**	**Moderate to high capital cost. Negligible O&M cost.**	**Retained for diver-assisted removal in limited areas (e.g., below over-water structures) that are inaccessible to excavation or mechanical dredging methods.** **Not retained for large scale due to the need for extensive dewatering facilities and large volume of water that must be treated and discharged or disposed.**
Sediment Capping	**Low Permeability (Enhanced) Cap - Clay / AquaBlok®**	**Installation of a low-permeability cap over contaminated sediment areas to prevent exposure, isolate contaminants, and prevent localized groundwater transport through impacted sediment. Clay cap installation would involve placement of low-permeability clay soil or bentonite aggregate (i.e., AquaBlok®) forming a low-permeability layer in conjunction with other cap components. Granular clay cap materials such as AquaBlok® can be used as thin isolation cap, for post-dredging residual management, or for directing groundwater discharge away from contaminated surface sediment.**	**Effective at isolating human and ecological receptors from potential direct exposure to contaminated sediment. Effective at directing groundwater away from impacted areas. Can be implemented in deep waters due to high particle density. Overall effectiveness requires addressing redirected groundwater.**	**Technically implementable using standard cap placement methods. Localized increased discharge at perimeter of low-permeability surface would need to be addressed.**	**Moderate to high capital cost compared to other capping technologies. Moderate O&M.**	**Retained.** **Effective, in conjunction with other capping methods, for directing groundwater discharge away from targeted impacted sediment.**
	Low Permeability (Enhanced) Cap - Geomembrane / Composite	**Installation of a low-permeability cap consisting of a thin composite or geomembrane placed over contaminated sediment to prevent exposure, isolate contaminants, and prevent localized groundwater discharge through impacted sediment. Cap would require placement of a bedding layer and layers of armor and habitat material to stabilize the cap.**	**Effective at isolating human and ecological receptors from potential direct exposure to contaminated sediment. Effective at directing groundwater away from impacted areas. Overall effectiveness requires addressing redirected groundwater.**	**Technically implementable using standard cap placement methods. Localized increased discharge at perimeter of low-permeability surface would need to be addressed.**	**Moderate capital cost. Moderate O&M cost due to the need to monitor and maintain cap surfaces within zone of high wave energy.**	**Retained.** **Effective, in conjunction with other capping methods, for directing groundwater discharge away from targeted impacted sediment.**

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
	Low Permeability (Enhanced) Cap - Grout Mats	Geotextile form or 'pillow' filled with cement to form a rigid, low permeability surface, typically 3 to 8 inches thick. Prevents direct discharge of groundwater in area covered by mat. Typically restricted to use on slopes or surfaces not susceptible to settlement. Able to provide a thin cap profile that is also resistant to erosion for areas where a granular habitat-friendly surface is not necessary.	Effective at isolating human and ecological receptors from potential direct exposure to contaminated sediment using a robust cap profile that is resistant to erosion. Effective at directing groundwater away from impacted areas. Can be implemented in deep water. Overall effectiveness requires addressing redirected groundwater.	Technically implementable. Placement can be limited by the presence of structures or large debris. Grout mat surface may need to incorporate elements such as geogrids that allows placement of habitat substrate material over the grout mat where appropriate. Localized increased discharge at perimeter of low-permeability surface would need to be addressed.	Moderate capital cost. Low to moderate O&M costs.	Retained. Effective for directing groundwater discharge away from targeted impacted sediment. Implementable in limited areas where a thin, but robust, cap profile is needed.
Sediment Capping (continued)	Amended Sand (Enhanced) Cap	Amended capping involves incorporating a layer, or a mixture, of a retained in situ treatment amendment (activated carbon, organoclay, and/or ZVI) with a conventional sand cap to achieve contaminant treatment within the cap. Armoring is placed over the chemical isolation layer, where necessary to prevent erosion and ensure cap longevity.	Effective for treating and containing contaminants within the cap, particularly in high flux conditions. Commonly used for sediment capping applications with mobile contaminants and NAPL. Multiple chemicals can be addressed with a layered application of multiple treatment amendments.	Technically implementable using standard cap placement methods. Amendments are applicable mixed in bulk with sand cap material or incorporated into reactive mats.	Moderate to high capital cost. Moderate O&M cost.	Retained. Effective, implementable and has been successfully used at many full-scale sites.
	Conventional Sand Cap	Installation of a 2- or 3-foot chemical isolation layer comprised of clean sand isolates contaminants. Attenuation of impacted groundwater within the cap can consist of adsorption, biodegradation, and abiotic transformation. Armoring is placed over the chemical isolation layer, where necessary to prevent erosion and ensure cap longevity.	Commonly used technology and is effective for isolating and preventing exposure to contaminated sediment by human and environmental receptors. Guidance and design standards are readily available (i.e., US Army Corps of Engineers) to ensure effective cap design.	Technically implementable using standard cap placement methods. Sediment caps have been successfully constructed in multiple Puget Sound locations, and at aquatic sites across the country.	Low to moderate capital cost depending on the design of the cap to resist wave erosion, or the installation of other features to minimize wave energy on the cap. Low to moderate O&M cost	Retained. Effective, implementable common method to contain contaminated sediment.
Natural Recovery Processes	Monitored Natural Recovery (MNR)	Reduction of chemical concentrations of contaminants through natural processes such as deposition of clean sediment, mixing and biodegradation. Monitoring is performed to verify natural recovery within a reasonable time frame.	Effective in areas with relatively low contaminant concentrations/risk where sedimentation rates and incoming sediment quality are adequate to meet restoration goals. Risk reduction occurs incrementally over the restoration period.	Technically implementable. Monitoring would be required to confirm recovery rate.	Negligible capital cost. Moderate O&M cost.	Retained. Effective, implementable common method for low-level sediment contamination.

Technology Category	Remediation Technology	Description	Effectiveness	Implementability	Relative Cost	Screening Results
	Enhanced Natural Recovery	**Natural recovery is enhanced by placement of a thin layer of sand. Technology relies on natural mixing processes (e.g., bioturbation) and deposition of clean sediment, and/or biodegradation to reduce contaminant levels. Like MNR, monitoring is performed to confirm performance and rate of recovery.**	**Effective in areas with relatively low contaminant concentrations/risk where sedimentation rates and incoming sediment quality are adequate to meet restoration goals. Initial placement of material typically equivalent to the thickness of biologically active zone, supplements natural sedimentation, reducing risks in the short-term. Long-term risk reduction continues incrementally over the restoration period following the initial enhancement.**	**Feasibility depends on the specific physical environment and constituent concentrations. Allows sensitive habitats such as those with significant vegetation to be preserved; however, may require several thin-layer placements to minimize impacts. Has been used throughout Puget Sound.**	**Low to moderate capital and O&M costs.**	**Retained.** **Effective, implementable common method for low-level sediment contamination.**

Notes:

Bold indicates that the Remediation Technology was retained.

AC = activated carbon
ALU = ambient Lake Union
AOI = area of investigation
As = arsenic
As (III) = arsenite species
As (V)= arsenate species
ENR = enhanced natural recovery
ECRT = Electro-Chemical Reduction Technology
GWPS = Gas Works Park Site
MNR = monitored natural recovery
NAPL = nonaqueous phase liquid
O&M = operation and maintenance
PAHs = polycyclic aromatic hydrocarbons

TABLE 11-3. APPLICATION OF RETAINED TECHNOLOGIES TO SCU CONDITIONS

Retained Remediation Technology	Remediation Technology Description	Specific Conditions where Remediation Technology Applies[1]
ARSENIC IN UPLAND GROUNDWATER REMEDIATION TECHNOLOGIES		
Groundwater Natural Attenuation	Reduction of dissolved arsenic by natural adsorption and precipitation processes. Monitoring groundwater to evaluate performance of natural attenuation.	• Upland groundwater where arsenic is present at concentrations greater than preliminary cleanup levels, to a lower degree, at the shoreline and in downgradient limits of the arsenic plume.
Fixation	In-situ treatment of arsenic-impacted upland groundwater with chemical reagents to modify geochemical conditions and promote precipitation of arsenic.	• Upland groundwater where arsenic in the outwash is present at concentrations greater than preliminary cleanup levels, to a higher degree, immediately upland of the shoreline.
SEDIMENT REMEDIATION TECHNOLOGIES		
In Situ Sediment Treatment (see Amended Sand (Enhanced) Cap below)		
Activated Carbon	Use of activated carbon as a sediment cap component to adsorb organic contaminants migrating into the cap. Activated carbon is blended with a sand cap material or incorporated into geotextile mats to facilitate installation.	• Sediment areas where advective transport of mobile contaminants (benzene, naphthalene) to surface sediment and surface water is occurring.
Organophilic Clay	Use of organoclay as a sediment cap component to absorb NAPL and/or to adsorb dissolved organic contaminants, primarily PAHs, migrating into the cap. Granular or powdered organoclay can be blended with a sand cap material or incorporated into geotextile mats to facilitate installation.	• Isolated lakeshore and lake slope sediment areas where tar is exposed at the surface. • Lake slope and lake bottom sediment areas containing shallow subsurface NAPL. • Sediment areas where advective transport of PAHs to surface sediment and surface water is occurring.
Zero-valent Iron	Use of ZVI as a sediment cap component to promote the adsorption and precipitation of arsenic in sediment and porewater. Granular ZVI can be mixed with sand cap material or placed in layers isolated from other cap materials.	• Sediment areas where advective transport of arsenic to surface sediment and surface water is occurring.

[1] The sediment remediation technologies are protective of benthic toxicity from and direct contact and bioaccumulation exposures to GWPS and ALU COC contaminated sediment. The site-specific conditions noted for each technology are the unique conditions applicable to each technology.

Retained Remediation Technology	Remediation Technology Description	Specific Conditions where Remediation Technology Applies[1]
Sediment and Debris Removal		
Land-Based Excavation	Excavation of contaminated bank soil and shallow nearshore sediment using land-based equipment for mass removal and/or to prepare the sediment surface to achieve the desired finished grade for capping.	• Shoreline bank soil areas that are exposed at the surface and have the potential to be eroded and transported to sediment. • Shoreline bank soil and lakeshore sediment areas where tar is exposed at the surface. • Lakeshore and lake slope sediment areas that are within reach of land-based excavation equipment. • Sediment areas where excavation will not expose NAPL. • Sediment areas where the water depth is appropriate for installation of a cofferdam to manage water and residuals during excavation.
Mechanical Dredging	Removal of offshore contaminated sediment through the water column using barge-mounted mechanical dredging methods. Limited to areas without NAPL-impacted sediment and without a significant thickness of soft sedment.	• Sediment areas where removal of arsenic and PAH contaminated material through the water column while managing loss of contaminants is feasible. • Sediment areas where dredging will not encounter or expose NAPL and potentially release contamination to the water column. • Lakeshore sediment areas and shallow areas of the lake slope where accumulation of soft sediment is less than 2-feet thick, and maximum water depths range from 20 to 30 feet.
Hydraulic Dredging	Removal of sediment using diver-assisted hydraulic dredging method in limited areas around shoreline structures that are inaccessible by land-based excavation or mechanical dredging methods.	• Lakeshore and lake slope sediment areas where arsenic and PAH contaminated sediment is not accessible by land-based excavation or mechanical dredging methods due to access or obstructions.
Sediment Capping		
Low-permeability (Enhanced) Cap - Clay/ AquaBlok®	Placement of low-permeability cap consisting of a clay material such as bentonite or a proprietary product like AquaBlok® in areas of contaminated sediment affected by groundwater discharge. The low permeability cap will prevent direct discharge of groundwater flowing through contaminated sediment. Low-permeability capping would be implemented in conjunction with amended capping in adjacent areas where groundwater is redirected to provide treatment prior to discharge.	• Lakeshore and lake slope sediment areas where tar is exposed at the surface. • Groundwater discharge areas in sediment resulting in transport of mobile contaminants to surface sediment and surface water. • Lakeshore and lake slope sediment areas with shallow subsurface NAPL.
Low-permeability (Enhanced) Cap - Geomembrane/ Composite	Placement of a low-permeability geomembrane or grout mat in nearshore areas of contaminated sediment affected by groundwater discharge. Similar to a clay low-permeability cap, these low-permeabiliy cap methods will prevent the	• Lakeshore and lake slope sediment areas where tar is exposed at the surface. • Groundwater discharge areas in sediment resulting in transport of mobile contaminants to surface sediment and surface water.

Retained Remediation Technology	Remediation Technology Description	Specific Conditions where Remediation Technology Applies[1]
Low-permeability (Enhanced) Cap - Grout Mat	direct discharge of groundwater that is flowing through contaminated sediment. Low-permeability capping would be implemented in conjunction with amended capping in adjacent areas where groundwater is redirected to provide treatment prior to discharge.	• Lakeshore and lake slope sediment areas with shallow subsurface NAPL. • Nearshore, shallow sediment areas where placement of large sheets or mats is feasible.
Amended Sand (Enhanced) Cap	Amended sand capping involves incorporating a layer, or a mixture, of a retained in situ treatment amendment (activated carbon, organoclay, and/or ZVI) with a conventional sand cap to achieve contaminant treatment within the cap. Armoring is placed over the chemical isolation layer, where necessary to prevent erosion and ensure cap longevity.	• Sediment areas where advective transport of mobile contaminants (benzene, naphthalene, PAHs, arsenic) to surface sediment and surface water is occurring. • Isolated lakeshore and lake slope sediment areas where tar is exposed at the surface. • Lake slope and lake bottom sediment areas containing shallow subsurface NAPL.
Conventional Sand Cap	Placement of a clean sand cap at least 2-feet-thick in areas of contaminated sediment that primarily require isolation, with limited attenuation needed within the cap material. Sand cap thickened for some areas to increase degree of isolation and attenuation.	• Lakeshore and lake slope sediment areas where tar is exposed at the surface. • Sediment areas where advective transport of mobile contaminants to surface sediment and surface water is occurring. • Sediment areas containing shallow subsurface NAPL.
Sediment Natural Recovery		
Monitored Natural Recovery	Natural sedimentation to achieve preliminary cleanup levels within the restoration timeframe through burial and mixing.	• Lake bottom sediment areas that are depositional. • Lake bottom sediment areas where PAHs and arsenic are at concentrations low enough to recover to preliminary cleanup levels within the restoration timeframe.
Enhanced Natural Recovery	Placement of small quantities of sand to augment ongoing natural sedimentation, burial and mixing to achieve preliminary cleanup levels within the restoration timeframe.	• Lake bottom sediment areas that are depositional. • Lake bottom sediment areas that are depositional and PAHs and arsenic are at concentrations moderately higher than background. These areas would be capable of recovery to preliminary cleanup levels within a reasonable restoration timeframe following placement of a thin mixing layer of clean sand to accelerate recovery.

Notes:

See text for full acronym and abbreviation list.

TABLE 11-4 APPLICATION OF RETAINED TECHNOLOGIES TO MANAGEMENT AREAS

Management Area	Environmental and Use Conditions Informing Cleanup	Technologies Applicable to Management Area
GWMA-1	▪ Arsenic in deep groundwater immediately upland of the Lake Union shoreline at concentrations greater than preliminary cleanup levels	▪ In situ chemical fixation of arsenic using proven ferrous sulfate treatment ▪ Monitored natural attenuation
SMA-1	▪ Uncapped bank soil impacted by tar and PAHs above preliminary levels ▪ Uncapped bank soil that can be eroded and transported to sediment ▪ Used by the public for recreation	▪ Land-based excavation of exposed tar, including the tar mound ▪ Land-based excavation and capping as needed to integrate upland surface with adjacent sediment remedy
SMA-2	▪ Uncapped bank soil impacted by tar and PAHs above preliminary cleanup levels ▪ Uncapped bank soil that can be eroded and transported to sediment ▪ Used by the public for recreation	▪ Land-based excavation and capping as needed to integrate upland surface with adjacent sediment remedy
SMA-3	▪ PAH and arsenic concentrations in sediment greater than preliminary cleanup levels ▪ Advective transport of VOCs, PAHs, and arsenic ▪ Area of sediment benthic toxicity ▪ Used for vessel navigation and used by the public for recreation.	▪ Land-based excavation ▪ Conventional sand capping ▪ Amended (enhanced) sand capping (ZVI, AC, OC) ▪ Low permeability (enhanced) capping
SMA-4	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Advective transport of VOCs and PAHs ▪ Area of sediment benthic toxicity ▪ Used for vessel navigation and used by the public for recreation.	▪ Land-based excavation ▪ Conventional sand capping ▪ Amended (enhanced) sand capping (AC, OC) ▪ Low permeability (enhanced) capping
SMA-5	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Advective transport of VOCs and PAHs ▪ Area of sediment benthic toxicity ▪ Used for vessel navigation and mooring including the Harbor Patrol. Waterway 20 is used as a public boat ramp and is expected to be used by the public for recreation in the future	▪ Land-based excavation ▪ Small-scale hydraulic dredging in access restricted areas ▪ Mechanical dredging ▪ Conventional sand capping ▪ Amended (enhanced) sand capping (AC, OC) ▪ Low permeability (enhanced) capping
SMA-6	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Area of sediment benthic toxicity ▪ Used for vessel navigation and used by the public for recreation.	▪ Land-based excavation (part) ▪ Mechanical dredging ▪ Conventional sand capping

Management Area	Environmental and Use Conditions Informing Cleanup	Technologies Applicable to Management Area
SMA-7	▪ PAH and arsenic concentrations in sediment greater than preliminary cleanup levels ▪ Advective transport of VOCs, PAHs, and arsenic ▪ Area of sediment benthic toxicity ▪ Shallow subsurface NAPL ▪ Used for vessel navigation and mooring including the Gasworks Park Marina.	▪ Conventional sand capping ▪ Amended (enhanced) sand capping (ZVI, AC, OC) ▪ Low permeability (enhanced) capping
SMA-8	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Area of sediment benthic toxicity ▪ Shallow subsurface NAPL ▪ Used for vessel navigation.	▪ Conventional sand capping ▪ Amended (enhanced) sand capping (OC)
SMA-9	▪ Shallow subsurface NAPL ▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Advective transport of VOCs and PAHs ▪ Areas of sediment benthic toxicity ▪ Used for vessel navigation and mooring including the Harbor Patrol and part of a shipyard facility.	▪ Conventional sand capping ▪ Amended (enhanced) sand capping (AC, OC) ▪ Low permeability (enhanced) capping ▪ Small-scale hydraulic dredging around structures
SMA-10	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Used for vessel navigation and mooring including the Gasworks Park Marina.	▪ Conventional sand capping ▪ Small-scale hydraulic dredging around structures ▪ Mechanical dredging
SMA-11	▪ PAH concentrations in sediment greater than preliminary cleanup levels ▪ Used for vessel navigation and used by the public for recreation.	▪ Conventional sand capping
SMA-12	▪ Shallow subsurface NAPL ▪ PAH and arsenic concentrations in sediment greater than preliminary cleanup levels ▪ Co-located shipyard metals contamination ▪ Areas of sediment benthic toxicity ▪ Used for vessel navigation and mooring including part of a shipyard facility.	▪ Conventional sand capping ▪ Amended (enhanced) sand capping (ZVI, OC)
SMA-13	▪ PAH and arsenic concentrations in sediment greater than preliminary cleanup levels ▪ Co-located shipyard metals contamination ▪ Areas of sediment benthic toxicity ▪ Lake Bottom soft sediment ▪ Used for vessel navigation.	▪ Conventional sand capping ▪ Enhanced natural recovery

Management Area	Environmental and Use Conditions Informing Cleanup	Technologies Applicable to Management Area
SMA-14	▪ PAH concentrations in sediment greater than preliminary cleanup levels, but levels are lower than SMA-13. ▪ Lake Bottom soft sediment ▪ Used for vessel navigation.	▪ Monitored natural recovery ▪ Enhanced natural recovery

Notes:

GWMA = Groundwater management area

SMA = Sediment management area

PAH = polycyclic aromatic hydrocarbon

NAPL = nonaqueous phase liquid

AC = activated carbon

OC = organoclay

VOCs = volatile organic compounds

ZVI = zero-valent iron

TABLE 12-1. SUMMARY OF CLEANUP ACTION ALTERNATIVES

Management Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Description of Alternative	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,300 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Conventional sand capping in nearshore and offshore areas, thickened in nearshore areas with higher potential for advective transport and offshore areas with shallow NAPL (23.5 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,300 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of amended capping technologies in select nearshore areas with higher potential for advective transport (1.5 acres). • Conventional sand capping in areas nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL (22.0 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,300 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport (14.4 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (1.8 acres). • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL (21.7 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (4.0 acres). • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL (19.4 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (5.1 acres). • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL (18.3 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging (1 acre, 8,100 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas (13.1 acres). • ENR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy).. • Offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging (1 acre, 8,100 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of enhanced (low-permeability) cap and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas (23.3 acres). • ENR in depositional offshore areas with lower contaminant concentrations (22.7 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.

Management Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
GWMA-1	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.	• In-situ treatment of arsenic-impacted groundwater within a footprint of approximately 0.20 acres by combined application of fixation and monitored natural attenuation.
SMA-1	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 2,120 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 2,120 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 2,120 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 4,310 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 4,310 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 4,310 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 4,310 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.	• Remove tar mound (approximately 190 cy) with off-site disposal. • Excavate shallow bank soil (approximately 4,310 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.70 acres.
SMA-2	• Excavate shallow bank soil (approximately 140 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 140 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 140 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 280 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 280 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 280 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 280 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.	• Excavate shallow bank soil (approximately 280 cy) where feasible prior to capping to accommodate cap placement and match pre- and post-cap grades immediately below the OHW. • Place permeable vegetated cap on bank area over a footprint of approximately 0.05 acres.
SMA-3	• Dredge nearshore (approximately 4,900 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 4,900 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (amended sand) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 4,900 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (low-permeability) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 9,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (amended sand) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 9,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (low-permeability) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 9,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (low-permeability) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 9,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (low-permeability) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 9,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.35 acres). • Place enhanced (low-permeability) cap (approximately 0.65 acres) in areas of potential advective transport and shallow NAPL.

Management Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
SMA-4	• Dredge nearshore (approximately 1,400 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.20 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 0.08 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 1,400 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.07 acres). • Place enhanced (amended sand) cap (approximately 0.21 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 1,400 cy) using land-based methods where feasible to mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.07 acres). • Place enhanced (low-permeability) cap (approximately 0.21 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 2,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.20 acres). • Place enhanced (low-permeability) cap (approximately 0.08 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 2,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.20 acres). • Place enhanced (low-permeability) cap (approximately 0.08 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 2,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.07 acres). • Place enhanced (low-permeability) cap (approximately 0.21 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 2,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.07 acres). • Place enhanced (low-permeability) cap (approximately 0.21 acres) in areas of potential advective transport and shallow NAPL.	• Dredge nearshore (approximately 2,800 cy) using land-based methods where feasible to reduce mass of contaminants from within the cap limits and mitigate for the elevation effect of cap placement on surface water footprint. • Place conventional 2-foot sand cap (approximately 0.07 acres). • Place enhanced (low-permeability) cap (approximately 0.21 acres) in areas of potential advective transport and shallow NAPL.
SMA-5	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place conventional 2-foot sand cap (approximately 0.42 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 0.18 acres) in areas of potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place enhanced (amended sand) cap (approximately 0.60 acres) in areas of potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place enhanced (low-permeability) cap (approximately 0.60 acres) in areas of potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.42 acres). • Place enhanced (low-permeability) cap (approximately 0.18 acres) in areas of potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place conventional 2-foot sand cap (approximately 0.42 acres). • Place enhanced (low-permeability) cap (approximately 0.18 acres) to address potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place enhanced (low-permeability) cap (approximately 0.60 acres) to address potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place enhanced (low-permeability) cap (approximately 0.60 acres) to address potential advective transport and shallow NAPL.	• Dredge using mechanical or hydraulic methods (approximately 2,900 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary • Place enhanced (low-permeability) cap (approximately 0.60 acres) to address potential advective transport and shallow NAPL.
SMA-6	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Place conventional 2-foot sand cap (approximately 2.3 acres).	• Dredging (approximately 8,100 cy) to the maximum extent practicable to reduce contaminant mass. • Place conventional 2-foot sand cap (approximately 2.3 acres).	• Dredging (approximately 8,100 cy) to the maximum extent practicable to reduce contaminant mass. • Place conventional 2-foot sand cap (approximately 2.3 acres).
SMA-7	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 1.10 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 1.10 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.30 acres). • Place enhanced (amended sand) cap (approximately 1.65 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 1.10 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.30 acres). • Place enhanced (amended sand) cap (approximately 1.65 acres to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.30 acres). • Place enhanced (amended sand) cap (approximately 1.65 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.30 acres). • Place enhanced (amended sand) cap (approximately 1.65 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.30 acres). • Place enhanced (amended sand) cap (approximately 1.65 acres) to address potential advective transport and shallow NAPL.

Management Areas	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6	Alternative 7	Alternative 8
SMA-8	• Place conventional sand cap of 3-foot or greater thickness (approximately 0.59 acres) to address shallow NAPL.	• Place conventional sand cap of 3-foot or greater thickness (approximately 0.59 acres) to address shallow NAPL.	• Place enhanced (amended sand) cap (approximately 0.59 acres) to address shallow NAPL.	• Place conventional sand cap of 3-foot or greater thickness (approximately 0.59 acres) to address shallow NAPL.	• Place enhanced (amended sand) cap (approximately 0.59 acres) to address shallow NAPL.	• Place conventional sand cap of 3-foot or greater thickness (approximately 0.59 acres) to address shallow NAPL.	• Place enhanced (amended sand) cap (approximately 0.59 acres) to address shallow NAPL.	• Place enhanced (amended sand) cap (approximately 0.59 acres) to address shallow NAPL.
SMA-9	• Place conventional sand cap of 3-foot or greater thickness (approximately 2.85 acres) to address potential advective transport and shallow NAPL.	• Place conventional sand cap of 3-foot or greater thickness (approximately 2.85 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place enhanced (amended sand) cap (approximately 2 acres) in areas of potential advective transport and shallow NAPL.	• Place conventional sand cap of 3-foot or greater thickness (approximately 2 acres) in areas containing shallow NAPL. • Place enhanced (amended sand) cap (approximately 0.85 acres) in areas of potential advective transport.	• Place conventional sand cap of 3-foot or greater thickness (approximately 2 acres) in areas containing shallow NAPL. • Place enhanced (amended sand) cap (approximately 0.85 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place enhanced (amended sand) cap (approximately 2 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place enhanced (amended sand) cap (approximately 2 acres) to address potential advective transport and shallow NAPL.	• Place conventional 2-foot sand cap (approximately 0.85 acres). • Place enhanced (amended sand) cap (approximately 2 acres) to address potential advective transport and shallow NAPL.
SMA-10	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge using mechanical or hydraulic methods (approximately 700 cy) to prevent shallowing water depths to less than 15 feet in the vicinity of structures and in navigation areas, where necessary. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge (approximately 900 cy) to the maximum extent practicable to reduce contaminant mass. • Place conventional 2-foot sand cap (approximately 0.55 acres).	• Dredge (approximately 900 cy) to the maximum extent practicable to reduce contaminant mass. • Place conventional 2-foot sand cap (approximately 0.55 acres).
SMA-11	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).	• Place conventional 2-foot sand cap (approximately 6.15 acres).
SMA-12	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place enhanced (amended sand) cap (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place conventional sand cap of 3-foot or greater thickness (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place enhanced (amended sand) cap (approximately 3.40 acres) to address shallow NAPL.	• Place conventional 2-foot sand cap (approximately 3.78 acres). • Place enhanced (amended sand) cap (approximately 3.40 acres) to address shallow NAPL.
SMA-13	• Place sand to accelerate natural recovery processes and monitor(approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor(approximately 10.2 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 10.2 acres).	• Place conventional 2-foot sand cap (approximately 10.2 acres).
SMA-14	• Monitor natural recovery processes (approximately 22.7 acres).	• Monitor natural recovery processes(approximately 22.7 acres).	• Monitor natural recovery processes (approximately 23 acres).	• Monitor natural recovery processes (approximately 22.7 acres).	• Monitor natural recovery processes (approximately 22.7 acres).	• Monitor natural recovery processes (approximately 22.7acres).	• Monitor natural recovery processes (approximately 22.7 acres).	• Place sand to accelerate natural recovery processes and monitor (approximately 22.7 acres).

Notes:

Amendments for the sand cap to be determined based on results of cap modeling.

cy = cubic yards
ENR = enhanced natural recovery
GWMA = Groundwater Management Area
MNR = monitored natural recovery
NAPL = nonaqueous phase liquid
OHW = ordinary high water
SMA = Sediment Management Area

TABLE 13-1. : SMS MINIMUM REQUIREMENTS FOR SEDIMENT CLEANUP ACTIONS: EVALUATION OF ALTERNATIVES

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Description of Alternative	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Conventional sand capping in nearshore and offshore areas, thickened in nearshore areas with higher potential for advective transport and offshore areas with shallow NAPL. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore areas with higher potential for advective transport. • Conventional sand capping in areas nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.
Minimum Requirements for Sediment Cleanup Actions (WAC 173-204-570[3])	**Evaluation of Alternatives**			
Protect human health and the environment	Nearshore shallow dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring, and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore shallow dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will effectively isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore shallow dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will effectively isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will effectively isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.
Comply with all applicable laws	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.
Comply with sediment cleanup standards	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.
Use permanent solutions to the maximum extent practicable	The alternative that uses permanent solutions to the maximum extent practicable is determined through a Disproportionate Cost Analysis (DCA) (WAC 173-340-360(3)(e)). The DCA is presented in Section 13.			

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Provide for a reasonable restoration timeframe	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.
Source Control Measures	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of thick sand capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced and thick sand capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced and thick sand capping for enhanced containment of NAPL.
Sediment Recovery Zone	Alternative does not include a sediment recovery zone.	Alternative does not include a sediment recovery zone.	Alternative does not include a sediment recovery zone.	Alternative does not include a sediment recovery zone..
Institutional Controls	Alternative leaves contamination in place. Therefore institutional controls are required.. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.
Provide for public and affected landowner review and comment	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.
Compliance Monitoring to Ensure Remedy Effectiveness	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. to ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. To ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. To ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. To ensure the protectiveness of the capped, ENR and MNR areas.
Provide for Periodic Review	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Description of Alternative	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas, thickened in offshore areas with shallow NAPL. • ENR and MNR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore and offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas. • ENR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.	• Nearshore and offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging. • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses. • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL. • Conventional sand capping in nearshore and offshore areas. • ENR in depositional offshore areas with lower contaminant concentrations. • Permeable vegetated capping on shoreline bank area. • Shallow tar removal on shoreline. • In situ treatment of upland groundwater arsenic. • Institutional controls.
Minimum Requirements for Sediment Cleanup Actions (WAC 173-204-570[3])	**Evaluation of Alternatives**			
Protect human health and the environment	Nearshore dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Nhanced capping methods (low-permeability and/or amended sand cap) will effectively isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR and MNR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore and off-shore dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.	Nearshore and off-shore dredging will remove contaminant mass and prevent loss of lake habitat as a result of cap placement. Enhanced capping methods (low-permeability and/or amended sand cap) will isolate and treat sediment contaminants. Conventional sand cap technologies will prevent human and ecological receptors from being exposed to contaminants in underlying sediment. ENR technologies will reduce risks where contaminant concentrations are lower. Institutional controls, compliance monitoring and Ecology periodic review will ensure long-term protectiveness of the remedy. In situ treatment in upland groundwater will treat dissolved arsenic in groundwater to the extent feasible near the original source, the Thylox process area.
Comply with all applicable laws	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.	Compliance with applicable laws will be ensured through obtaining required permits and meeting the substantive requirements of exempt State and local permits.
Comply with sediment cleanup standards	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.	Alternative will comply with preliminary cleanup standards for GWPS contaminants and, subject to verification during remedial design, it is assumed that it will comply with screening levels for co-located ALU contaminants.
Use permanent solutions to the maximum extent practicable	The alternative that uses permanent solutions to the maximum extent practicable is determinedthrough a Disproportionate Cost Analysis (DCA) (WAC 173-340-360(3)€). The DCA is presented in Section 13.			

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Provide for a reasonable restoration timeframe	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.	Alternative has a reasonable restoration timeframe. Alternative will achieve preliminary cleanup levels for GWPS contaminants immediately following completion of construction and, subject to verification during remedial design, it is assumed that it will achieve screening levels for co-located ALU contaminants within 10 years following completion of construction. See Appendix 11D for restoration timeframe evaluations.
Source Control Measures	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced and thick sand capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced and thick sand capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced capping for enhanced containment of NAPL.	Alternative includes source control measures in the form of: storm drain modifications (see Appendix 12A; implementation of a City stormwater management program (see Appendix 12B); in situ treatment of arsenic in shoreline groundwater; removal in the tar mound area; grading and capping exposed upland bank soil; nearshore sediment removal; and, the use of enhanced capping for enhanced containment of NAPL.
Sediment Recovery Zone	Alternative does not include a sediment recovery zone..	Alternative does not include a sediment recovery zone.	Alternative does not include a sediment recovery zone.	Alternative does not include a sediment recovery zone.
Institutional Controls	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.	Alternative leaves contamination in place. Therefore institutional controls are required. Institutional controls will be defined during future steps in the cleanup process and will likely include use restrictions, maintenance requirements, and financial assurances.
Provide for public and affected landowner review and comment	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.	Alternative is subject to public and affected landowner review and comment as part of this RI/FS report.
Compliance Monitoring to Ensure Remedy Effectiveness	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. to ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. to ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. to ensure the protectiveness of the capped, ENR and MNR areas.	Alternative includes provisions for compliance monitoring. Monitoring requirements and contingency plans will be developed during future steps in the cleanup process. to ensure the protectiveness of the capped and ENR areas.
Provide for Periodic Review	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.	Alternative includes institutional controls. Therefore, Ecology will conduct a review every five years after the controls are in place to assure that human health and the environment continue to be protected.

Notes:

ENR = enhanced natural recovery
MNR = monitored natural recovery
SCU = Sediment Cleanup Unit
NAPL = nonaqueous phase liquid
GWPS = Gas Works Park Site
SMS = Sediment Management Standards

TABLE 13-2. DISPROPORTIONATE COST ANALYSIS: CLEANUP ACTION ALTERNATIVES RELATIVE BENEFIT SCORING

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Alternative Description	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,270 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Conventional sand capping in nearshore and offshore areas, thickened in nearshore areas with higher potential for advective transport and offshore areas with shallow NAPL (23.5 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,270 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore areas with higher potential for advective transport (1.5 acres). • Conventional sand capping in areas nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL (22.0 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to prevent loss of aquatic lands due to capping (1.3 acres, 6,270 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport (14.4 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (2,450 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (1.8 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL (21.7 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Disproportionate Cost Analysis Benefit Criteria, [173-340-360(3)(f) and SMS 173-204-570(4)]				
	Relative Benefit Evaluation (Scored from 1 = Low to 10 = High)			
Protectiveness	Score = 4.0	Score = 5.0	Score = 6.0	Score = 6.0
"The extent to which human health and the environment are protected and the degree to which overall risk at a site is reduced by eliminating, reducing, or otherwise controlling risks posed through each exposure pathway and migration route. This also includes evaluating the degree of improvement in overall environmental quality and potential risks to the integrity of the remedy from climate change impacts."	Achieves a moderate level of protectiveness (lowest score among all alternatives) as a result of extensive use of conventional sand capping (14.6 acres of 2-ft sand cap and 8.8 acres of thick sand cap) of sediment contaminants to permanently reduce risk of exposure across SMAs 1 through 12, including strategic application of thick sand cap construction over nearshore areas of potential advective contaminant transport and offshore areas with shallow NAPL. Nearshore dredging (9,800 cy) to accommodate cap thickness contributes to protectiveness through contaminant mass reduction within the zone of highest groundwater discharge. This is equivalent to Alternatives 2 and 3, but is lower relative to alternatives that include increased nearshore dredging for contaminant mass reduction (Alternatives 4 through 7) The lack of enhanced capping for sediment treatment reduces the overall protectiveness score for Alternative 1 by a point compared to Alternative 2. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves a moderate level of protectiveness as a result of the extensive capping (14 acres of 2-ft sand cap and 7.9 acres of thick sand cap) of contaminated sediment, including strategic application of thick sand caps over offshore areas with shallow NAPL and enhanced capping (1.5 acres) in an expanded area of nearshore sediment with potential for advective contaminant transport. Use of enhanced capping in areas of highest potential for contaminant migration more reliably prevents exposure in the long term. Nearshore dredging (9,800 cy) to accommodate cap thickness contributes to protectiveness through contaminant mass reduction within the zone of highest groundwater discharge. This is equivalent to Alternatives 1 and 3, but is lower relative to alternatives that include increased nearshore dredging for contaminant mass reduction (Alternatives 4 to 7). Greater protectiveness relative to Alternative 1 results from use of enhanced capping for sediment treatment relative to the use of a conventional sand cap. Relative to Alternative 3, reduced enhanced capping areas results in a lower protectiveness score (reduced by one point). Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves a moderate level of protectiveness as a result of the extensive capping (14.4 acres of 2-ft sand cap) of contaminated sediment and including the greatest use of enhanced capping (9.1 acres) to treat nearshore areas of potential advective contaminant transport and offshore areas with shallow NAPL. Expansive use of enhanced capping further increases reliability of preventing exposure relative to other alternatives. Nearshore dredging (9,800 cy) to accommodate cap thickness contributes to protectiveness through contaminant mass reduction within the zone of highest groundwater discharge. This is equivalent to Alternatives 1 and 2, but is lower relative to alternatives that include increased nearshore dredging for contaminant mass reduction (Alternatives 4 to 7). Greater protectiveness relative to Alternative 2 results from expanded use of enhanced capping. Protectiveness score is comparable to Alternative 4 as the contribution of expanded nearshore dredging in Alternative 4 is offset by the expanded enhanced capping in Alternative 3. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves a moderate level of overall protectiveness as a result of extensive capping (14.6 acres of 2-ft sand cap and 7 acres of thick sand cap) of contaminated sediment, including strategic application of thick sand caps over offshore areas with shallow NAPL and enhanced capping (1.8 acres) in isolated nearshore areas of potential advective contaminant transport and an isolated offshore area with shallow NAPL. Use of enhanced capping in areas of highest potential for contaminant migration and select offshore areas with shallow NAPL more reliably prevents exposure in the long term. Expanded nearshore dredging (16,000 cy) for greater contaminant mass reduction results in higher protectiveness (higher than Alternatives 1 to 3, same as Alternatives 5 to 7). Protectiveness score similar to Alternative 3 as the contribution of expanded nearshore dredging in Alternative 4 is offset by the expanded enhanced capping in Alternative 3. Relative to Alternative 5, reduced enhanced capping areas results in a lower protectiveness score (reduced by one point). Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Permanence	Score = 4.0	Score = 5.0	Score = 6.0	Score = 6.0
“The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated.”	Achieves a moderate level of permanence (lowest score among all alternatives) relative to other alternatives as a result of extensive use of conventional sand capping (14.6 acres of 2-ft sand cap and 8.8 acres of thick sand cap) to contain sediment contaminants on site while permanently reduce risk of exposure across SMAs 1 through 12, including strategic application of thick sand caps in offshore areas with shallow NAPL. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Limited nearshore dredging (9,800 cy) removes contaminant mass within the zone of highest advective transport increases the degree of permanence (same as Alternatives 2 and 3, but less than Alternatives 4 to 7). The lack of enhanced capping for sediment treatment reduces the permanence score for Alternative 1 by a point compared to Alternative 2.	Achieves a moderate level of permanence resulting from the use capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14 acres of 2-ft sand cap and 7.9 acres of thick sand cap) and enhanced capping (1.5 acres) in an expanded area of nearshore sediment with potential for advective contaminant transport. Addition of enhanced capping, including in situ treatment using cap amendments will increase attenuation of mobile contaminants. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Limited nearshore dredging (9.800 cy) removes contaminant mass within the zone of highest advective transport increases the degree of permanence (same as Alternatives 1 and 3, but less than Alternatives 4 to 7). Greater permanence relative to Alternative 1 results from use of enhanced capping for sediment treatment relative to the use of a conventional sand cap. Relative to Alternative 3, reduced enhanced capping areas results in a lower permanence score (reduced by one point).	Achieves a moderate level of permanence as a result of the greatest use of enhanced capping (9.1 acres) to provide more reliable containment and treat contaminants that may migrate to the sediment/cap surface or surface water. Addition of enhanced capping, including in situ treatment using cap amendments will increase attenuation of mobile contaminants. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Limited nearshore dredging (9.800 cy) removes contaminant mass within the zone of highest advective transport increases the degree of permanence (same as Alternatives 1 and 2, but less than Alternatives 4 to 7). Greater permanence relative to Alternative 2 results from expanded use of enhanced capping. Permanence score is comparable to Alternative 4 as the contribution of expanded nearshore dredging in Alternative 4 is offset by the expanded enhanced capping in Alternative 3.	Achieves a moderate level of permanence through conventional sand capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14.6 acres of 2-ft sand cap and 7 acres of thick sand cap) and the addition of enhanced capping (1.8 acres) in isolated nearshore areas of potential advective contaminant transport and an isolated offshore area with shallow NAPL. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Expanded nearshore dredging (16.000 cy) to increase contaminant mass removal within the zone of highest groundwater discharge increases the degree of permanence relative to Alternatives 1 to 3 (same as Alternatives 5 to 7). Permanence score similar to Alternative 3 as the contribution of expanded nearshore dredging in Alternative 4 is offset by the expanded enhanced capping in Alternative 3. Relative to Alternative 5, reduced enhanced capping areas results in a lower permanence score (reduced by a half point).

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Long-term Effectiveness	Score = 3.5	Score = 4.5	Score = 6.0	Score = 5.5
"Includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes."	Achieves a moderately low level of long-term effectiveness (lowest score among all alternatives) as a result of extensive use of conventional sand capping (14.6 acres of 2-ft sand cap and 8.8 acres of thick sand cap) of sediment contaminants to permanently reduce risk of exposure across SMAs 1 through 12, including strategic application of thick sand caps in offshore areas with shallow NAPL. Conventional sand capping is an effective containment method over a long timeframe due to its simplicity. However, long-term effectiveness of sand capping is expected to be lower than that of enhanced capping for preventing advective transport of mobile contaminants. Nearshore dredging (9,800 cy) and subsequent contaminant mass reduction contributes to long-term effectiveness (same as Alternatives 2 and 3), but to a lesser degree than Alternatives 4 to 7. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The lack of enhanced capping for sediment treatment reduces the overall long-term effectiveness score for Alternative 1 by a point compared to Alternative 2.	Achieves a moderate level of long-term effectiveness through use of conventional sand capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14 acres of 2-ft sand cap and 7.9 acres of thick sand cap) and enhanced capping (1.5 acres) in an expanded area of nearshore sediment with potential for advective contaminant transport. The use of enhanced capping methods will increase the reliability of contaminant containment, particularly where applied to areas of groundwater flux. Nearshore dredging (9,800 cy) and subsequent contaminant mass reduction contributes to long-term effectiveness (same as Alternatives 1 and 3), but to a lesser degree than Alternatives 4 to 7. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. Greater long-term effectiveness relative to Alternative 1 results from use of enhanced capping for sediment treatment relative to the use of a conventional sand cap. Relative to Alternative 3, reduced enhanced capping areas results in a lower long-term effectiveness score (reduced by one and a half point).	Achieves a moderate level of long-term effectiveness through use of conventional sand capping (14.4 acres of 2-ft sand cap) and the greatest use of enhanced capping (9.1 acres) to increase reliability of containment and/or to treat contaminants that may migrate to the sediment/cap surface or surface water. Extensive use of enhanced capping will increase the predictability of performance of the remedy. Nearshore dredging (9,800 cy) and subsequent contaminant mass reduction contributes to long-term effectiveness (same as Alternatives 1 and 2), but to a lesser degree than Alternatives 4 to 7. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. Greater long-term effectiveness score relative to Alternatives 2 and 4 results from expanded use of enhanced capping.	Achieves a moderate level of long-term effectiveness through use of conventional sand capping including strategic application of thick sand caps in offshore areas with shallow NAPL (14.6 acres of 2-ft sand cap and 7 acres of thick sand cap) and enhanced capping (1.8 acres) in isolated nearshore areas of potential advective contaminant transport and an isolated offshore area with shallow NAPL. The use of enhanced capping methods will increase the reliability of contaminant containment, particularly where applied to areas of groundwater flux. Expanded nearshore dredging (16,000 cy) for greater contaminant mass reduction increases long-term effectiveness relative to Alternatives 1 through 3 (same as Alternatives 5 to 7). Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. Relative to Alternatives 3 and 5, reduced enhanced capping areas results in a lower overall long-term effectiveness score for Alternative 4.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Management of Short-term Risks	Score = 6.0	Score = 6.5	Score = 7.5	Score = 6.0
"The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks."	Manages short-term risks to a moderate degree through use of common construction methods for sediment remediation. Moderate risks can be mitigated by isolating the work zone and notifying the public, including commercial and recreational boat traffic. The large volume of sand for capping (approximately 145,000 cy) may result in short-term impacts during transport and placement. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area are expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Nearshore dredging (9,800 cy) and bank excavation using cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials and associated water quality management. These risks are less than for alternatives that include expanded dredging for contaminant mass removal (Alternatives 4 to 8). The large volume of sand for capping may result in short-term impacts from transport and placement of material and reduces the management of short-term risks score for Alternative 1 by a half point compared to Alternative 2.	Manages short-term risks to a moderate degree through use of common construction methods for sediment remediation. Moderate risks can be mitigated by isolating the work zone and notifying the public, including commercial and recreational boat traffic. Similar to Alternative 1, the large volume of sand (approximately 135,000 cy) for capping may result in short-term impacts during transport and placement. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area is expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Volume of sand reduced by use of enhanced capping (1.5 acres), slightly reducing the volume of material transported to and placed at GWPS. Nearshore dredging (9,800 cy) and bank excavation using cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials and associated water quality management. These risks are less than for alternatives that include expanded dredging for contaminant mass removal (Alternatives 4 to 8). Higher score (increased by a half point) relative to Alternative 1 results from use of enhanced capping and associated reduction of short-term risk due to reduced volume of sand to transport and place.	Manages short-term risks to a moderate degree through use of common construction methods for sediment remediation. Moderate risks can be mitigated by isolating the work zone and notifying the public, including commercial and recreational boat traffic. The large volume of sand (approximately 105,000 cy) for capping may result in short-term impacts during transport and placement. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area is expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Volume of sand, and associated impacts associated with transport and placement, is significantly reduced relative to Alternatives 1 and 2 through expanded use of enhanced capping (9.1 acres). Nearshore dredging (9,800 cy) and bank excavation using cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials and associated water quality management. These risks are less than for alternatives that include expanded dredging for contaminant mass removal (Alternatives 4 to 8). Higher score (increased by a half point) relative to Alternative 2 results from expanded use of enhanced capping and associated reduction of short-term risk due to reduced volume of sand to transport and place.	Manages short-term risks to a moderate degree through common construction methods frequently used for sediment remediation, with moderate risks that can be mitigated by isolating the work zone and notifying the public, including commercial and recreational boat traffic. The large volume of cap material (approximately 130,000 cy) for capping results in short-term impacts during transport and placement. Volume of sand reduced by use of enhanced capping (1.8 acres), similar in scale to Alternative 2, but to a greater degree than Alternative 3. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area is expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Expanded nearshore dredging (16,100 cy) and bank excavation using cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials. Lower score (reduced by a point) relative to Alternative 3 results from reduced use of enhanced capping and increased dredging, and associated increase in short-term risk due to increased volume of sand to transport and place and increased volume of contaminated sediment to remove, handle and dispose.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Technical and Administrative Implementability	Score = 7.0	Score = 6.5	Score = 7.0	Score = 6.5
"Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions."	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. Extensive capping poses challenges associated with availability and transportation of suitable cap material. However, the simplicity of conventional sand capping increases technical implementability. Scores half a point higher relative to Alternative 2 as specialized services associated with enhanced capping do not apply.	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of enhanced capping methods (1.5 acres) reduces the volume of overall cap material but is also affected by the use of more specialized, and potentially less readily available services. Enhanced capping methods are relatively innovative but have been proven for similar conditions. Scores lower (reduced by a half point) relative to Alternative 1, as the need for less volume of suitable sand material for conventional sand capping is offset by more innovative, specialized and potentially less readily available services associated with enhanced capping.	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The greatest use of enhanced capping methods (9.1 acres) significantly reduces the volume of overall cap material but is also affected by the use of more specialized, and potentially less readily available services. Enhanced capping methods are relatively innovative but have been proven for similar conditions. Scores higher (increased by a half point) relative to Alternatives 2 due to reduction in the volume of sand cap material required and the use of the lowest degree of dredging.	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of enhanced capping methods (1.8 acres) reduces the volume of overall cap material. The expanded nearshore dredging (16,100 cy) is not expected to significantly reduce implementability. Scores lower (reduced by a half point) relative to Alternative 3 due to increased volume of sand cap material and expanded nearshore dredging.
Consideration of Public Concerns	Score = 4.0	Score = 5.0	Score = 6.0	Score = 6.0
"Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site."	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Alternative Description	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (4.0 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL (19.4 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses (0.7 acre, 3,600 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (5.1 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport, thickened in offshore areas with shallow NAPL. (18.3 acres) • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging (1 acre, 8,100 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses and (0.7 acre, 3,580 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport (13.1 acres). • ENR and MNR in depositional offshore areas with lower contaminant concentrations (32.9 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.	• Nearshore dredging using land-based methods where feasible to reduce mass of contaminants from within the cap limits and prevent loss of aquatic lands due to capping (1.3 acres, 12,600 cy). • Offshore dredging to the maximum extent practicable in areas with a limited risk of mobilizing contaminants because of the dredging (1 acre, 8,100 cy). • Dredging using mechanical or hydraulic methods to avoid shallowing water depths to less than 15 feet where necessary to prevent impacts to existing uses and (0.7 acre, 3,580 cy). • Enhanced capping, consisting of low-permeability and/or amended capping technologies in select nearshore and offshore areas with higher potential for advective transport and shallow NAPL (9.1 acres). • Conventional sand capping in nearshore and offshore areas with lower potential for advective transport (23.3 acres). • ENR in depositional offshore area with lower contaminant concentrations (22.7 acres). • Shoreline soil excavation, including shallow tar removal, prior to capping (4,780 cy). • Permeable vegetated capping on shoreline bank area (0.75 acre). • In-situ treatment of upland groundwater arsenic (0.2 acre). • Institutional controls.

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Disproportionate Cost Analysis – Criteria in MTCA 173-340-360(3)(f) and SMS 173-204-570(4)				
	Relative Benefit Evaluation (Scored from 1 = Low to 10 = High)			
Protectiveness	Score = 7.0	Score = 8.0	Score = 8.5	Score = 9.0
"The extent to which human health and the environment are protected and the degree to which overall risk at a Site is reduced by eliminating, reducing, or otherwise controlling risks posed through each exposure pathway and migration route. This also includes evaluating the degree of improvement in overall environmental quality and potential risks to the integrity of the remedy from climate change impacts."	Achieves a moderately high level of overall protectiveness as a result of the extensive capping (14.1 acres of 2-ft sand cap and 5.4 acres of thick sand cap) of contaminated sediment, including strategic application of thick sand caps over offshore areas with shallow NAPL and enhanced capping (4 acres) in isolated nearshore areas of potential advective contaminant transport and expanded offshore areas with shallow NAPL. Use of enhanced capping in areas of highest potential for contaminant migration and select offshore areas with shallow NAPL more reliably prevents exposure in the long term. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to protectiveness the same as Alternatives 4, 6 and 7. Greater protectiveness relative to Alternative 4 results from expanded use of enhanced capping. Protectiveness score is reduced by a point compared to Alternative 6 due to a smaller enhanced capping area. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves a high level of overall protectiveness as a result of the extensive capping (14.4 acres of 2-ft sand cap and 4 acres of thick sand cap) of contaminated sediment, including strategic application of thick sand caps in offshore areas with shallow NAPL and enhanced capping (5.1 acres) in expanded nearshore and offshore areas to address potential advective contaminant transport and expanded offshore areas with shallow NAPL. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to protectiveness the same as Alternatives 4, 5 and 7.. Greater protectiveness relative to Alternative 5 results from expanded use of enhanced capping. Protectiveness score is reduced compared to Alternative 7 due to reduced capping and enhanced capping areas in addition to the lack of offshore dredging for additional mass removal. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves a high level of overall protectiveness as a result of the extensive capping (13.1 acres of 2-ft sand cap) of contaminated sediment, including enhanced capping (9.1 acres) in expanded nearshore and offshore areas to address potential advective contaminant transport and expanded offshore areas with shallow NAPL. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to protectiveness the same as Alternatives 4, 5 and 6. Expanded use of enhanced capping (9.1 acres) and offshore dredging (8,150 cy at SMA-6) for additional contaminant mass reduction, increase protectiveness relative to Alternative 6. Protectiveness score is reduced relative to Alternative 8 due to reduced use of capping and ENR.. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.	Achieves the highest level of overall protectiveness as a result of extensive capping (23.3 acres of 2-ft sand cap) of contaminated sediment, including enhanced capping (9.1 acres) in nearshore and offshore areas to address potential advective contaminant transport and offshore areas with shallow NAPL and ENR in SMA-14 (23 acres). Expanded use of capping and replacing MNR with ENR in SMA-14 increases protectiveness relative to Alternative 7. The expanded nearshore dredging (16,100 cy) and offshore dredging (8,150 cy) for greater contaminant mass reduction contributes to protectiveness the same as Alternative 7. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. The primary local effect of climate change, sea level rise, is not expected to affect the cleanup action because the lake level of Lake Union is controlled by the Ballard Locks.

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Permanence	Score = 6.5	Score = 7.5	Score = 8.0	Score = 8.5
"The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated."	Achieves a moderately high level of permanence through conventional sand capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14.1 acres of 2-ft sand cap and 5.4 acres of thick sand cap), and the addition of enhanced capping (4 acres) in isolated nearshore areas of potential advective contaminant transport and expanded offshore areas with shallow NAPL. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to permanence the same as Alternatives 4, 6 and 7). Greater permanence relative to Alternative 4 results from expanded use of enhanced capping. Permanence score is reduced by a point compared to Alternative 6 due to a smaller enhanced capping area.	Achieves a moderately high level of permanence through conventional capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14.4 acres of 2-ft sand cap and 4 acres of thick sand cap), and the use of enhanced capping (5.1 acres) in expanded nearshore and offshore areas to address potential advective contaminant transport and expanded offshore areas with shallow NAPL. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to permanence the (same as Alternatives 4, 5, 7 and 8). Greater permanence relative to Alternative 5 results from expanded use of enhanced capping. Permanence score is reduced by a half point compared to Alternative 7 due to reduced enhanced capping areas in addition to the lack of offshore dredging for additional contaminant mass reduction.	Achieves a high level of permanence as a result of extensive capping and material removal. Extensive capping includes conventional capping (13.1 acres of 2-ft sand cap) and the greatest use of enhanced capping (9.1 acres) in nearshore areas of potential advective contaminant transport and offshore areas with shallow NAPL. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to permanence the same as Alternatives 4, 5, 6 and 8). Greater permanence relative to Alternative 6 results from expanded use of enhanced capping and offshore dredging (8,150 cy) for additional mass removal.	Achieves the highest level of permanence among all alternatives, as a result of extensive conventional capping (23.3 acres of 2-ft sand cap) the use of enhanced capping (9.1 acres), and ENR in SMA-14 (23 acres). Expanded use of capping and replacing MNR with ENR in SMA-14 increases permanence relative to Alternative 7. Arsenic in upland groundwater is expected to be successfully treated by in situ methods to reduce the potential for migration. Expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to permanence the same as Alternatives 4 through 7). Offshore dredging (8,150 cy) contributes to permanence through additional mass removal similar to Alternative 7.

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
Long-term Effectiveness	Score = 6.5	Score = 7.0	Score = 7.5	Score = 8
"Includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes."	Achieves a moderately high level of long-term effectiveness through use of conventional sand capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14.1 acres of 2-ft sand cap and 5.4 acres of thick sand cap), and enhanced capping (4 acres) in isolated nearshore areas of potential advective contaminant transport and expanded offshore areas with shallow NAPL. The use of enhanced capping methods will increase the reliability of contaminant containment, particularly where applied to areas of groundwater flux. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to long-term effectiveness the same as Alternatives 4, 6 and 7). Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. Greater long-term effectiveness relative to Alternative 4 results from expanded use of enhanced capping. Long-term effectiveness score is reduced by a half point compared to Alternative 6 due to a smaller enhanced capping area.	Achieves a moderately high level of long-term effectiveness through use of conventional sand capping, including strategic application of thick sand caps in offshore areas with shallow NAPL (14.4 acres of 2-ft sand cap and 4 acres of thick sand cap) and enhanced capping (5.1 acres) in expanded nearshore areas to address potential advective contaminant transport and expanded offshore areas with shallow NAPL. The use of enhanced capping methods will increase the reliability of contaminant containment, particularly where applied to areas of groundwater flux. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to long-term effectiveness the same as Alternatives 4, 5, 7 and 8). Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction. Greater long-term effectiveness relative to Alternative 5 results from expanded use of enhanced capping. Permanence score is reduced by a half point compared to Alternative 7 due to reduced enhanced capping areas and the lack of offshore dredging for additional mass removal.	Achieves a moderately high level of long-term effectiveness through use of conventional sand capping (13.1 acres of 2-ft sand cap) and enhanced capping (9.1 acres) to increase reliability of containment and/or to treat contaminants that may migrate to the sediment/cap surface or surface water. The expanded nearshore dredging (16,100 cy) for greater contaminant mass reduction contributes to long-term effectiveness the same as Alternatives 4, 5, 6 and 8. Expanded use of enhanced capping (9.1 acres) and offshore dredging (8,150 cy at SMA-6) for additional contaminant mass reduction, increase long-term effectiveness relative to Alternative 6. Long-term effectiveness score is reduced relative to Alternative 8 due to reduced use of capping and ENR. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction.	Achieves the highest level of long-term effectiveness among all alternatives, through use of conventional sand capping (23.3 acres of 2-ft sand cap) and enhanced capping (9.1 acres) to increase reliability of containment and/or to treat contaminants that may migrate to the sediment/cap surface or surface water.. Expanded capping and use of ENR rather than MNR in SMA-14 (23 acres) increases long-term effectiveness relative to Alternative 7. The expanded nearshore dredging (16,100 cy) and offshore dredging (8,150 cy) for greater contaminant mass reduction contributes to long-term effectiveness the same as Alternative 7. Preliminary cleanup standards for GWPS contaminants will be achieved immediately following completion of construction and, subject to verification during remedial design, it is assumed that screening levels will be achieved for co-located ALU contaminants within 10 years following completion of construction.
Management of Short-term Risks	Score = 6.5	Score = 7.0	Score = 5.0	Score = 4.5
"The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks."	Manages short-term risks to a moderate degree through common construction methods frequently used for sediment remediation. The large volume of cap material (approximately 125,000 cy) from conventional sand capping methods results in short-term impacts from transport of material to the GWPS. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area are expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. The expanded area of enhanced capping (4 acres) reduces the transport and placement of cap material and associated risks. Expanded nearshore dredging (16,100 cy) (same as Alternatives 4, 6 and 7) and bank excavation using	Manages short-term risks to a moderate degree (highest score among all alternatives) through common construction methods frequently used for sediment remediation. The large volume of cap material (approximately 120,000 cy) from conventional sand capping methods results in short-term impacts from transport of material to the GWPS. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area are expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. The expanded area of enhanced capping (5.1 acres) reduces capping volume and short-term risks associated with material handling and transport.	Manages short-term risks to a moderate degree relative to other alternatives due to the inclusion of offshore dredging (8,150 cy at SMA-6) increasing the potential to suspend sediment and mobilize contaminants to the water column. Larger dredging scope increases the risk of contaminant mobilization during construction. The offshore dredging will need to be offset from the shoreline to avoid undermining and damaging the shoreline structures in the vicinity of the Prow, and also has the potential to uncover deeper, more highly contaminated sediment. The large volume of cap material (approximately 99,000 cy) from conventional sand capping methods results in short-term impacts from transport of material to the GWPS. Impacts associated with transport, likely by barge, can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area	Manages short-term risks to a moderately low degree (lowest score among all alternatives) relative to other alternatives due to the inclusion of offshore dredging (8,150 cy at SMA-6) and extensive capping (23.3 acres of 2-ft sand cap, 9.1 acres of enhanced cap) and ENR in SMA-14 (23 acres). Inclusion of offshore dredging increases the potential to suspend sediment and mobilize contaminants to the water column. Larger dredging scope increases the risk of contaminant mobilization during construction. The offshore dredging will need to be offset from the shoreline to avoid undermining and damaging the shoreline structures in the vicinity of the Prow, and also has the potential to uncover deeper, more highly contaminated sediment. Significantly increased volume of material placed in SMAs 13 and 14 and conventional sand capping methods (155,000 cy), increasing short-term risks associated with handling and transport of material. Impacts associated with transport, likely by barge,

	Alternative 5	Alternative 6	Alternative 7	Alternative 8
	cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials. Higher score (increased by a half point) relative to Alternative 4 results from use of expanded enhanced capping and reduction of short-term risk associated with reduced volume of sand cap material handling and transport.	The elimination of offshore dredging and associated risks increases the degree that short term risks are managed relative to Alternative 7. Expanded nearshore dredging (16,100 cy) (same as Alternatives 4, 5 and 7) and bank excavation using cofferdams and other BMPs will have moderate short-term risks associated with removal, handling, and disposal of contaminated materials. Higher score (increased by a half point) relative to Alternative 5 results from use of expanded enhanced capping and reduction of short-term risk associated with reduced volume of sand cap material handling and transport.	are expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Lower score relative to Alternative 6 results from offshore dredging and associated short-term risks during construction. Higher score compared to Alternative 8 due to reduced use of capping and ENR and reduction of short-term risk associated with reduced volume of sand cap material handling and transport.	can be mitigated by developing a marine traffic plan to coordinate efficient movement of barges to and from GWPS, but impacts to vessel traffic in the area are expected during construction. Impacts associated with cap placement, particularly in lake bottom areas with soft sediment, can be prevented by using thin layer placement methods that will gradually stabilize underlying sediment. Expanded capping and use of ENR rather than MNR in SMA-14 (23 acres) increases short-term risk relative to Alternative 7.
Technical and Administrative Implementability	Score = 6.5	Score = 7.5	Score = 6.5	Score = 6.0
"Ability to be implemented including consideration of whether the alternative is technically possible, availability of necessary off-site facilities, services and materials, administrative and regulatory requirements, scheduling, size, complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations and other current or potential remedial actions."	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of enhanced capping methods (4 acres) reduces the volume of overall cap material. The expanded nearshore dredging (16,100 cy) is not expected to significantly reduce implementability. Score is comparable to the Alternative 4 as comparable volumes of cap material would be imported and placed.	Achieves a moderately high level of technical implementability (highest among all alternatives) through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of enhanced capping methods (5.1 acres) reduces the volume of overall cap material. Expanded nearshore dredging (16,100 cy) is not expected to significantly reduce implementability. Scores higher (increased by one point) relative to Alternative 5 due to reduction in the volume of sand cap material required.	Achieves a moderately high level of technical implementability through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of extensive enhanced capping methods (9.1 acres) results in the lowest overall volume of cap material of all alternatives. Expanded nearshore dredging (16,100 cy) is not expected to significantly reduce implementability. Scores lower (decreased by one point) relative to Alternative 6 as a result of the addition of dredging, transport, and disposal of a significant volume of offshore lake sediment. The offshore dredging (8,150 cy at SMA-6) and the safeguards required to prevent distribution of dredge residuals and address associated water quality issues adds a level of complication that reduces implementability. Higher implementability score compared to Alternative 8 due to reduction in the volume of sand cap material required.	Achieves a moderate level of technical implementability (lowest among all alternatives) through the use of common capping and material removal methods. Administrative implementability challenges are addressed by inclusion of nearshore dredging to allow cap placement without loss of in-water habitat and to prevent shallowing of lake depth at adjacent facilities. The use of extensive enhanced capping methods (9.1 acres) reduces the volume of cap material. However, the expanded use of capping and ENR across large areas of the lake bottom portion of the SCU (SMAs 13 and 14) results in the largest volume of cap material of all alternatives. Expanded nearshore dredging (16,100) is not expected to significantly reduce implementability, and offshore dredging (8,150 cy) contributes to the same level of implementability as Alternative 7. Lower implementability score relative to Alternative 7 due to significantly increased volume of cap material from extensive capping (23.3 acres of 2-ft sand cap and 9.1 acres of enhanced cap) and use of ENR rather than MNR in SMA-14 (23 acres).
Consideration of Public Concerns	Score = 7.0	Score = 8.0	Score = 8.5	Score = 9.0
"Whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site."	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.	Public concerns are not yet known. It is assumed that protectiveness is the greatest public concern, therefore the score for this alternative is the same as the score under the protectiveness criterion. The score will be reviewed and revised as necessary after receiving public comments on the RI/FS.

Notes:

Criteria in MTCA 173-340-360(3)(f) and SMS 173-204-570(4) (Scored from 1 =Low to 10 = High).
ARAR = applicable or relevant and appropriate requirement
CAP = cleanup action plan
CUL = cleanup level
CY = cubic yard
ENR = enhanced natural recovery
MNR = monitored natural recovery
MTCA = Model Toxics Control Act
NAPL = nonaqueous phase liquid
SMS = Sediment Management Standards
WAC = Washington Administrative Code

Scoring Range:

1 to 3.5 = Moderately Low
4 to 6 = Moderate
6.5 to 7.5 = Moderately High
8 to 10 = High.

Table 13-3

Disproportionate Cost Analysis Summary

Gas Works Park Site

Seattle, Washington

Cleanup Action Alternative	1		2		3		4		5		6		7		8	
Relative Benefit Score																
Benefit Criteria (weighting factor)	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted	Score	Weighted
Protectiveness (30%)	4	1.2	5	1.5	6	1.8	6	1.8	7	2.1	8	2.4	8.5	2.55	9	2.7
Permanence (20%)	4	0.8	5	1	6	1.2	6	1.2	6.5	1.3	7.5	1.5	8	1.6	8.5	1.7
Long-term Effectiveness (20%)	3.5	0.7	4.5	0.9	6	1.2	5.5	1.1	6.5	1.3	7	1.4	7.5	1.5	8	1.6
Management of Short-term Risks (10%)	6	0.6	6.5	0.65	7.5	0.75	6	0.6	6.5	0.65	7	0.7	5	0.5	4.5	0.45
Technical and Administrative Implementability (10%)	7	0.7	6.5	0.65	7	0.7	6.5	0.65	6.5	0.65	7.5	0.75	6.5	0.65	6	0.6
Consideration of Public Concern[a] (10%)	4	0.4	5	0.5	6	0.6	6	0.6	7	0.7	8	0.8	8.5	0.85	9	0.9
Total Weighted Relative Benefit Score	**4.4**		**5.2**		**6.3**		**6.0**		**6.7**		**7.6**		**7.7**		**8.0**	
Cost[b]	$60,160,000		$64,400,000		$73,940,000		$70,100,000		$73,080,000		$72,970,000		$82,290,000		$93,930,000	
Benefit/Cost Ratio = Total Weighted Relative Benefit Score ÷ (Cost ÷ $50,000,000)	3.7		4.0		4.2		4.2		4.6		5.2		4.6		4.2	

Notes

[a] Score for "Consideration of Public Concerns" assumed to be the same as the score for "Protectiveness". Score will be revised as necessary after public review of the RI/FS.

[b] Estimated costs are at FS level, with a range of +50% and -30%. See Appendix 13A.