

Appendix A

Excerpts from Lower Duwamish Waterway Superfund Site Record of Decision

These tables and figures were extracted from the Lower Duwamish Waterway Superfund Site Record of Decision dated November 2014 and Lower Duwamish Waterway Record of Decision Table and Figure Revisions Memorandum dated August 2015.

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8.2.1 Cleanup Levels

Table 19 lists sediment cleanup levels for RAOs 1, 2, and 4, and Table 20 lists sediment cleanup levels for RAO 3. Sediment cleanup levels for contaminants for RAO 3 are point-based and applicable to any sample location; for the other RAOs, cleanup levels are applied to a specific area (see Table 19). Benthic cleanup levels are based on the benthic SCO in the SMS (WAC 173-204-562). For RAO 3, the SCO numerical chemical criteria can be overridden by the SCO biological criteria (see text box "What are the Sediment Management Standards?" on page 26) unless they are co-located with exceedances of remedial action levels (RALs) associated with human health COCs, which are also point-based. Exceedances of RALs for human health COCs cannot be overridden by toxicity testing.

Table 19. Cleanup Levels for PCBs, Arsenic, cPAHs, and Dioxins/Furans in Sediment for Human Health and Ecological COCs (RAOs 1, 2 and 4)

COC	Cleanup Levels				Application Area and Depth		
	RAO 1: Human Seafood Consumption	RAO 2: Human Direct Contact	RAO 4: Ecological (River Otter)	Basis for Cleanup Levels ^a	Spatial Scale of Application ^b	Spatial Compliance Measure ^e	Compliance Depth ^b
PCBs (µg/kg dw)	2	1,300	128	background (RAO 1) RBTC (RAO 2) RBTC (RAO 4)	LDW-wide	UCL95	0 – 10 cm
	NA	500	NA	RBTC	All Clamming Areas ^c	UCL95	0 – 45 cm
	NA	1,700	NA	RBTC	Individual Beaches ^d	UCL95	0 – 45 cm
Arsenic (mg/kg dw)	NA	7	NA	background	LDW-wide	UCL95	0 – 10 cm
	NA	7	NA	background	All Clamming Areas ^c	UCL95	0 – 45 cm
	NA	7	NA	background	Individual Beaches ^d	UCL95	0 – 45 cm
cPAH (µg TEQ/kg dw)	NA	380	NA	RBTC	LDW-wide	UCL95	0 – 10 cm
	NA	150	NA	RBTC	All Clamming Areas ^c	UCL95	0 – 45 cm
	NA	90	NA	RBTC	Individual Beaches ^d	UCL95	0 – 45 cm
Dioxins/Furans (ng TEQ/kg dw)	2	37	NA	background (RAO 1) RBTC (RAO 2)	LDW-wide	UCL95	0 – 10 cm
	NA	13	NA	RBTC	All Clamming Areas ^c	UCL95	0 – 45 cm
	NA	28	NA	RBTC	Individual Beaches ^d	UCL95	0 – 45 cm

NOTE: where there are multiple cleanup levels for a cleanup area, the lowest cleanup level is shown in bold.

- Background – see Table 3 and Section 5.3.4.1; RBTC – Risk-based threshold concentration (based on 1 in 1,000,000 excess cancer risk or HQ of 1)
- In intertidal areas including beaches used for recreation and clamming, human-health direct contact cleanup levels (for PCBs, arsenic, cPAHs, and dioxins/furans) must be met in the top 45 cm because in intertidal areas exposure to sediments at depth is more likely through digging or other disturbances. Human health cleanup levels for RAO 1 (seafood consumption) and ecological cleanup levels must be met in surface sediments (top 10 cm). In subtidal areas, cleanup levels for all COCs must be met in surface sediments (top 10 cm).
- Clamming areas are identified in Figure 6.
- Beach play areas are identified in Figure 6.
- The UCL 95 is the upper confidence limit on the mean. The determination of compliance with RAOs 1, 2 and 4 cleanup levels will be made by one of two methods: 1) comparison of the UCL 95 of LDW data with the RBTC or background-based cleanup level, or 2) for background-based cleanup levels, a statistical comparison of the distribution of LDW data to the OSV BOLD study background dataset (USACE et al. 2009) may be used. In either case, testing will use an alpha level of 0.05 and a beta level of 0.10. For details, see ProUCL technical manual (EPA 2013b) or most current version). For either method, a sufficient number of samples must be collected to assure statistical power for the test.

Table 22. Remedial Alternatives and Associated Remedial Technologies, Remedial Action Levels, and Actively Remediated Acres

Remedial Alternatives and Technologies ^a	Remedial Action Levels ^a					Actively Remediated Area (Acres)
	PCBs (mg/kg OC) ^b	Arsenic (mg/kg dw)	cPAHs (µg TEQ/kg dw)	Dioxins/ Furans (ng TEQ/kg dw)	Benthic SMS (41 Contaminants) ^b	
Alternative 1 No Further Action after removal or capping of Early Action Areas	n/a	n/a	n/a	n/a	n/a	29 acres
Alternative 2 (2R) – dredge emphasis with upland disposal/MNR Alternative 2 with CAD (2R-CAD) – dredge emphasis with contained aquatic disposal/MNR	65 to 110 (LDW-wide); 10-yr post-construction target: 65 ^c	93	5,500	50	CSL to 3 × CSL 10-yr post-construction target: CSL	32 acres
Alternative 3 removal (3R) – dredge emphasis with upland disposal/MNR Alternative 3 combined technologies (3C) – ENR/ in situ / cap/ MNR where appropriate, otherwise dredge with upland disposal	65 (LDW-wide)	93 (LDW-wide) 28 (intertidal)	3,800 (LDW-wide) 900 (intertidal)	35 (LDW-wide) 28 (intertidal)	CSL (biological or chemical)	58 acres
Alternative 4 removal (4R) – dredge emphasis with upland disposal/MNR Alternative 4 combined technologies (4C) – ENR/ in situ / cap/ MNR where appropriate, otherwise dredge with upland disposal	12 to 35 (LDW-wide) 10-yr post-const. target: 12 ^c	57 (LDW-wide) 28 (intertidal)	1,000 (LDW-wide) 900 (intertidal)	25 (site-wide) 28 (intertidal)	SCO to CSL 10-yr post-const. target: SCO	107 acres
Alternative 5 removal (5R) – dredge emphasis with upland disposal Alternative 5 removal with treatment (5R-T) – dredge with soil washing treatment and disposal/re-use Alternative 5 combined technologies (5C) – ENR/ in situ / cap where appropriate, otherwise dredge with upland disposal	12 (LDW-wide)	57 (LDW-wide) 28 (intertidal)	1,000 (LDW-wide) 900 (intertidal)	25 (LDW-wide) 28 (intertidal)	SCO (biological or chemical)	157 acres
Alternative 6 removal (6R) – dredge emphasis with upland disposal Alternative 6 combined technologies (6C) – ENR/ in situ / cap where appropriate, otherwise dredge with upland disposal	5 (LDW-wide)	15 (LDW-wide) 28 (intertidal)	1,000 (LDW-wide) 900 (intertidal)	15 (LDW-wide) 28 (intertidal)	SCO (biological or chemical)	302 acres
Selected Remedy (5C Plus) – ENR/ in situ / cap where appropriate; otherwise, dredge with upland disposal^e	12 (LDW-wide) 65 (intertidal) 195 (subtidal subsurface)	57 (LDW-wide) 28 (intertidal)	1,000 (LDW-wide) 900 (intertidal)	25 (LDW-wide) 28 (intertidal)	2 X SCO chemical criteria^d with 10-year post-construction target to meet SCO	177 acres

- a. Areas where remedial action levels (RALs) are applied are as follows: LDW-wide RALs, in the upper 10 cm of sediment throughout the LDW and in the upper 60 cm in potential scour areas (i.e., Recovery Category 1 areas). In intertidal areas, intertidal RALs are applied in the upper 45 cm of sediment (above -4 ft MLLW). Alternative 5C Plus added an intertidal PCB RAL of 65 mg/kg OC in the top 45 cm in intertidal areas, and added a subtidal PCB RAL of 195 mg/kg OC for the top 60 cm in areas of potential vessel scour within Recovery Category 2 and 3 areas. These additional potential vessel scour areas comprise: north of the 1st Avenue South bridge (located at approximately RM 2) in water depths from -4 to -24 ft MLLW, and south of the 1st Avenue S bridge, in water depths from -4 to -18 ft MLLW.
- b. See Table 15 for SCO and CSL values. PCB RALs are normalized to organic carbon (OC) for consistency with the SMS, and because the organic content of sediments affects the bioavailability and toxicity of PCBs. The terms SCO and CSL in this table mean the benthic SCO and CSL; SCO is equivalent to the term "SQS" used in the RI/FS and Proposed Plan. Lower human health-based RALs for PCBs and arsenic in this table take precedence over benthic SCO or CSL values.
- c. The RALs for SMS contaminants (except arsenic) are a range for Alternatives 2 and 4. The upper RALs are used where conditions for recovery are predicted to be more favorable (Recovery Category 3 areas); the lower RALs are used where conditions for recovery are predicted to be limited or less certain (Recovery Category 1 or 2 areas), or where the BCM does not predict recovery to the 10-yr post-construction target concentration.
- d. The Alternative 5C Plus RAL of "2 X SQS not to exceed CSL" in the Proposed Plan is modified in the Selected Remedy to "2 X benthic SCO", see Section 12.
- e. The Selected Remedy includes additional requirements to address contaminated shoals in the navigation channel, see Sections 12 and 13.

Table 23. Criteria for Assigning Recovery Categories^a

Criteria	Recovery Categories		
	Category 1 Recovery Presumed to be Limited	Category 2 Recovery Less Certain	Category 3 Predicted to Recover
Physical Criteria			
Physical Conditions	Vessel scour	Observed vessel scour	No observed vessel scour
	Berthing areas	Berthing areas with vessel scour	Berthing areas without vessel scour Not in a berthing area
Sediment Transport Model	STM-predicted 100-year high-flow scour (depth in cm)	> 10 cm	< 10 cm
	STM-derived net sedimentation using average flow conditions	Net scour	Net sedimentation
Rules for applying criteria	If an area is in Category 1 for any one criterion, that area is designated Category 1	If conditions in an area meet a mixture of Category 2 and 3 criteria, that area is designated Category 2	An area is designated Category 3 only if it meets all Category 3 criteria
Empirical Contaminant Trend Criteria – used on a case-by-case basis to adjust recovery categories that would have been assigned based on physical criteria			
Empirical Contaminant Trend Criteria	Resampled surface sediment locations	Increasing PCBs or increasing concentrations of other detected COCs that exceed the SCO (> 50% increase)	Equilibrium and mixed (increases and decreases) results (for COCs that exceed the SCO)
	Sediment cores (top 2 sample intervals in upper 60 cm)		

a. Recovery categories were not assigned to the Early Action Areas, for which remediation should be complete by the time of the remedial actions addressed in this ROD. At the time of the remedial design, EPA will consider assignment of categories to these areas based upon the logic in this table; this information will inform long term monitoring decisions.

Table 26. Applicable or Relevant and Appropriate Requirements, LDW Superfund Site

Topic	Standard or Requirement	Regulatory Citation		Project-Specific Comments
		Federal	State	
Hazardous Substance Cleanup; Sediment Quality	Washington State cleanup standards; Marine Sediment Cleanup Standards; Sediment Cleanup Objectives (SCO); Cleanup Screening Levels (CSL)		Model Toxics Control Act (MTCA) (RCW 70.105D; WAC 173-340); MTCA Sediment Management Standards (SMS) (RCW 70.105D; WAC 173-204)	Substantive MTCA requirements that are more stringent than CERCLA requirements are ARARs. A combination of sediment dredging, capping, enhanced natural recovery (ENR), monitored natural recovery (MNR), and potentially in-situ amendment as treatment, along with the minimally necessary use of fish and shellfish consumption advisories as ICs to reduce fish and shellfish consumption, will be employed to meet the substantive requirements of SCO compliance for the protection of human health, marine benthic invertebrates and higher trophic level species, as set forth in WAC 173-204-560-562, 564 to the extent technically possible, or without a net adverse environmental impact, and at a minimum, the substantive requirements of CSL compliance. Institutional Controls (ICs) will be required as set forth in WAC 173-340-440(4)(a).
Surface Water Quality	Surface water quality standards. Federal recommended Ambient Water Quality Criteria (AWQC); National Toxics Rule (NTR); State Water Quality Standards (WQS)	AWQC per Clean Water Act Section 304(a) (33 U.S.C. § 1314(a)) at http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm ; NTR at 40 CFR 131.36(b)(1) as applied to Washington, 40 CFR 131.36(d)(14)	Water Pollution Control Act (RCW 90.48); WQS (WAC 173-201A); Aquatic Life Criteria (ALC) numerical criteria (WAC 173-201A-240)	Sediment remediation described immediately above will improve surface water quality to an unknown degree in combination with source control implementation under state-lead authority. Surface water concentrations shall be at least as stringent as all of the following: 1) all WQS in WAC 173-201A; 2) AWQC unless it can be demonstrated that such criteria are not relevant and appropriate for the LDW or for a specific hazardous substance; and 3) the NTR. See WAC 173-340-730(3)(b), consistent with Sections 121(d)(2)(A)(ii) and (B)(i) of CERCLA and 40 CFR 300.430(e).
Solid Waste Disposal	Requirements for solid waste handling management and disposal	Solid Waste Disposal Act (42 U.S.C. 6901-6992K; 40 CFR 257-258)	Solid Waste Management (RCW 70.95; WAC 173-350)	Substantive requirements for non-dangerous or non-hazardous waste generated during remedial activities unless wastes meet recycling or other exemptions will be complied with.
Waste Treatment, Storage, and Disposal	Dangerous or Hazardous Waste Management	Resource Conservation and Recovery Act, Hazardous Waste (42 U.S.C. §§ 6901-6992K, 40 CFR 260-279)	Dangerous Waste Management (RCW 70.105; WAC 173-303)	Dredged materials contains solid waste subject to solid waste handling requirements above. It would also be hazardous/dangerous waste if it contained a listed waste or displayed a hazardous waste characteristic (e.g., per Toxicity Characteristic Leaching Procedure). Based on the Remedial Investigation (RI), hazardous/dangerous waste is not anticipated in LDW sediments. If it is encountered 40 CFR Part 262 generator rules in Washington at WAC 173-303-17-202 would be complied with for accumulating or managing such waste on-site for up to 90 days. Unanticipated circumstances could require compliance with other hazardous/dangerous waste requirements. State dangerous waste is defined more broadly than Federal hazardous waste.
Land Disposal of Waste	Management and disposal of materials containing polychlorinated biphenyls (PCBs)	Toxic Substances Control Act (15 U.S.C. § 2605; 40 CFR 761.61(c))	Dangerous Waste Management (RCW 70.105; WAC 173-303- 140, 141)	Based on the RI, dredged materials with PCB remediation waste as defined in 40 CFR 761.3 is not anticipated. Any such dredged material will be subject to EPA-approved plans for all cleanup activities, including any sampling, as well as all on-site disposal-related activities. Risk based disposal of PCB remediation wastes must not pose unreasonable risk of injury to health or the environment. Written EPA approval is required for any PCB remediation waste off-site disposal.
	Hazardous waste	Resource Conservation and Recovery Act Land Disposal Restrictions (42 U.S.C. §§ 6901-6992K; 40 CFR 268)		See Dangerous or Hazardous Waste Management project-specific comments above. Any dangerous or hazardous waste land disposal shall meet substantive land disposal requirements.
Dredge/Fill and Other In-Water Construction Work	Discharge of dredged/fill material into navigable waters or wetlands	Clean Water Act Sections 401, 404 (33 U.S.C. §§ 1341, 1344; 40 CFR 121.2 (content of 401 certifications), 230 (disposal sites/mitigation), 232 (definitions/exemptions); 33 CFR 320, 322-3, 328-30 (Army Corps of Engineers 404 Permitting))	Hydraulic Code Rules (RCW 77.65; WAC 220-110) Dredged Materials Management Program (DMMP) (RCW 79.105.500; WAC 332-30-166 (3))	401: EPA will issue the equivalent of state certification assuring water quality standards will not be violated by remedial action discharges along with necessary conditions including any mixing zone parameters consistent with WAC 173-201A-400, as developed in remedial design. 404: Substantive dredge or fill criteria and requirements for discharges will be met, along with substantive mitigation requirements for unavoidable loss of aquatic habitat; mitigation will be assessed and defined as necessary in remedial design. Hydraulic codes provide construction criteria, requirements and limitations, including for dredging, piers, piles, docks, bulkheads and bank protection, specified technical provisions, special concerns. The use of an established open-water disposal site for dredged material for which there is no practical alternative upland disposal site or beneficial use as set forth in WAC 332-30-166(3) will be approved by the designated federal and state DMMP agencies.
	Navigation and commerce	Rivers and Harbor Act Section 10 (33 U.S.C. § 403)		Unauthorized obstruction or alteration of navigable waterways is prohibited. Dredging/capping residual elevations will be designed to preserve navigation and commerce. In-water disposal is not anticipated; any in-water disposal site will not obstruct or alter navigation upon completion.

Topic	Standard or Requirement	Regulatory Citation		Project-Specific Comments
		Federal	State	
Endangered Species and Critical Habitat	Taking or jeopardy to endangered or threatened species; adverse modification of critical habitat	Endangered Species Act (16 U.S.C. §§ 1531-1544; 50 CFR 17 (listings, prohibitions), 402 (interagency consultations), 222-224 (endangered and threatened marine species), 226.212 (critical habitat for Northwest salmon and steelhead))		It is unlawful to take (or possess, deliver, carry, transport or ship) any endangered species, or violate any regulation (promulgated pursuant to Section 4) re endangered or threatened species. EPA in consultation with the Services shall insure any authorized action is not likely to jeopardize endangered or threatened species or adversely modify critical habitat, absent an exemption. EPA shall prepare a Biological Assessment for the Services which will produce a Biological Opinion including any reasonable and prudent alternatives or measures to be taken which will guide remedy implementation, including within specified time periods ("fish windows") for specified activities.
Migratory Birds	Taking or adversely affecting migratory birds.	Migratory Bird Treaty Act, (16 U.S.C §§ 703-712; 50 CFR 10 and 21)		Remedy will be carried out in a manner to avoid adversely affecting migratory bird species as defined in federal regulations, including individual birds and their nests.
Eagles	Taking or harming eagles	Bald and Golden Eagle Protection Act (16 U.S.C. § 668, 50 CFR 22)	Bald Eagle Protection Rules (RCW 77.12.655; WAC 232-12-292)	Taking or harming of eagles, their eggs, nests or young is prohibited; substantive requirements for the protection of bald eagle habitat including nesting, perching and roosting sites will be met.
Floodplain Protection	Adverse impacts; potential harm	Floodplain Management Procedures (40 CFR 6, Appendix A, Section 6, see also Executive Order 11988)		The required evaluation of potential effects of authorized remedial action, to avoid adverse impacts and to minimize impacts for which no practicable alternative exists, followed as necessary by the development of avoidance and/or minimization plans, will be undertaken during remedial design.
Shoreline management	Construction and development		Shoreline Management Act RCW 90.58; WAC 173-26; City of Seattle Master Plan SMC 23.60; King County Master Plan K.C.C. 21A.25)	Master plans within their jurisdiction apply within 200 feet of the shoreline to the extent they impose or establish more stringent requirements. Compliance as may be necessary will be evaluated during remedial design.
Air Emissions	Ambient air quality standards; fugitive emission/fugitive dust	Clean Air Act (42 U.S.C. §§ 7401-7671q; 40 CFR 50)	Washington Clean Air Act (RCW 70.94; WAC 173-400)	Any source of fugitive emissions or fugitive dust must take reasonable precautions to 1) prevent the release of air contaminants, 2) prevent fugitive dust from becoming airborne, and 3) maintain and operate the source to minimize emissions. See especially WAC 173-400-040(4) and (9).
Native American Graves and Sacred Sites	Protections	Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001 et seq.); American Indian Religious Freedom Act (42 U.S.C. §§ 1196 et seq.)		Requirements for the protection of Native American remains, funerary objects and associated cultural artifacts when burial sites are encountered; and protection of tribal exercise of traditional tribal religions, including traditional cultural properties, sites and archeological resources. See also Executive Order 13007 which requires federal agencies to avoid physical damage to tribal sacred sites, and interfering with access of tribes thereto. Compliance will be maintained throughout remedy implementation as may be necessary
Noise	Permissible noise levels		Noise Control Act (RCW 70.107; WAC 173-60-040-050)	Maximum levels at specified times for specified durations are in 173-60-040, subject to exemptions in 173-60-050, including 050(3)(a) (sounds originating from temporary construction sites as a result of construction activity) and (3)(f) (sounds created by emergency equipment and work necessary in the interests of law enforcement or for health, safety or welfare of the community).
Historic Preservation		National Historic Preservation Act Section 106 (16 U.S.C. § 470; 36 CFR 800)		The effect if any of remedial activity on any district, site, building, structure or object included or eligible for inclusion in the National Register of Historic Places will be evaluated in consultation with the State Historic Preservation Office during remedial design.

13.2.1 Application of Cleanup Technologies

The RALs listed in Figure 22 and Figure 23 (above) and Table 27 and Table 28 (page 125) will be applied in intertidal and subtidal areas in Recovery Category Areas 1, 2, and 3 to identify areas for active remediation, as described and in Figures 19 and 20. Recovery Category areas are shown in Figure 12. Figure 17 shows Recovery Category 1, and potential scour areas in Recovery Categories 2 and 3. All of this information will be used to determine the appropriate compliance depth for application of RALs and technology to be applied at a particular location, as described in this section.

Table 27. Selected Remedy RAO 3 RALs

SMS Contaminant of Concern for RAO 3	RAL for Recovery Category 1 Areas ^a (Benthic SCO)	RAL for Recovery Category 2 & 3 Areas (2 x Benthic SCO) ^b
Metals (mg/kg dw)		
Arsenic	57	n/a
Cadmium	5.1	10.2
Chromium	260	520
Copper	390	780
Lead	450	900
Mercury	0.41	0.82
Silver	6.1	12.2
Zinc	410	820
PAHs (mg/kg OC)		
2-Methylnaphthalene	38	76
Acenaphthene	16	32
Anthracene	220	440
Benzo(a)anthracene	110	220
Benzo(a)pyrene	99	198
Benzo(g,h,i)perylene	31	62
Total benzofluoranthenes	230	4650
Chrysene	110	220
Dibenzo(a,h)anthracene	12	24
Dibenzofuran	15	30
Fluoranthene	160	320
Fluorene	23	46
Indeno(1,2,3-cd)pyrene	34	68
Naphthalene	99	198
Phenanthrene	100	200
Pyrene	1,000	2,000
Total HPAHs	960	1,920
Total LPAHs	370	740

SMS Contaminant of Concern for RAO 3	RAL for Recovery Category 1 Areas ^a (Benthic SCO)	RAL for Recovery Category 2 & 3 Areas (2 x Benthic SCO) ^b
Phthalates (mg/kg OC)		
Bis(2-ethylhexyl)phthalate	47	94
Butyl benzyl phthalate	4.9	9.8
Dimethyl phthalate	53	106
Chlorobenzenes (mg/kg OC)		
1,2,4-Trichlorobenzene	0.81	1.62
1,2-Dichlorobenzene	2.3	4.6
1,4-Dichlorobenzene	3.1	6.2
Hexachlorobenzene	0.38	0.76
Other SVOCs and COCs, (µg/kg dw except as shown)		
2,4-Dimethylphenol	29	58
4-Methylphenol	670	1,340
Benzoic acid	650	1,300
Benzyl alcohol	57	114
n-Nitrosodiphenylamine, mg/kg OC	11	22
Pentachlorophenol	360	720
Phenol	420	840
PCBs (mg/kg OC)		
Total PCBs	12	n/a

Notes:

General:

- PCBs and arsenic are also human health COCs (see Table 28 for RALs for human health COCs), and RALs for the the human health category take precedence over RAO 3 RALs. The surface sediment (10 cm) Recovery Category 1 RALs for PCBs and arsenic are the same for human health and benthic invertebrates, but the 2 X SCO Recovery Category 2 and 3 criteria are not applicable to PCBs and arsenic. Figure 22 and Figure 23 list all RALs for human health COCs.
- Table 23 describes Recovery Categories and Figure 12 shows Recovery Category areas.
 - The RAL applies to the 10 cm and 45 cm depth intervals for intertidal areas and to the 10 cm and 60 cm depth intervals for subtidal areas. See Figure 22 and Figure 23 .
 - For Recovery Category 2 and 3 areas, the RAL applies to the 10 cm depth interval. See Figure 22 and Figure 23.

Table 28. Remedial Action Levels, ENR Upper Limits, and Areas and Depths of Application

			Intertidal Sediments (+11.3 ft MLLW to -4 ft MLLW)				Subtidal Sediments (-4 ft MLLW and Deeper)				
			Recovery Category 1 RALs, ENR ULs, and Application Depths		Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths		Recovery Category 1 RALs, ENR ULs, and Application Depths		Recovery Category 2 and 3 RALs, ENR ULs, and Application Depths		Shoaled Areas ^b in Federal Navigation Channel
Risk Driver COC	Units	Action Levels	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 45 cm (1.5 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft)	Top 10 cm (4 in)	Top 60 cm (2 ft) ^c	Top to Authorized Navigation Depth Plus 2 ft
Human Health Based RALs											
PCBs (Total)	mg/kg OC	RAL	12	12	12	65	12	12	12	195	12
		UL ^a for ENR	--	--	36	97	--	--	36	195	--
Arsenic (Total)	mg/kg dw	RAL	57	28	57	28	57	57	57	--	57
		UL ^a for ENR	--	--	171	42	--	--	171	--	--
cPAH	µg TEQ/kg dw	RAL	1000	900	1000	900	1000	1000	1000	--	1000
		UL ^a for ENR	--	--	3000	1350	--	--	3000	--	--
Dioxins/Furans	ng TEQ/kg dw	RAL	25	28	25	28	25	25	25	--	25
		UL ^a for ENR	--	--	75	42	--	--	75	--	--
Benthic Protection RALs											
39 SMS COCs ^d	Contaminant-specific	RAL	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO	Benthic SCO	2x Benthic SCO	--	Benthic SCO
		UL ^a for ENR	--	--	3x RAL	--	--	--	3x RAL	--	--

- a. The ENR Upper Limit (UL) is the highest concentration that would allow for application of ENR in the areas described. For areas with no ENR limit listed, ENR is not a currently designated technology (see Section 13.2.1.2 for further discussion).
- b. Shoaled areas are those areas in federal navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth that USACE uses to maintain the channel for navigation purposes. The authorized channel depths are (1) from RM 0 to 2 (from Harbor Island to the First Avenue South Bridge), 30 ft below MLLW; (2) from RM 2 to RM 2.8 (from the First Avenue South Bridge to Slip 4), 20 ft below MLLW; and (3) from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin), 15 ft below MLLW. For shoaled areas, the compliance intervals will be determined during Remedial Design; these are typically 2-4 ft core intervals. For areas in the channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply as indicated in the other subtidal columns.
- c. Applied only in potential vessel scour areas. These are defined as subtidal areas (i.e., below -4 ft MLLW) that are above -24 ft MLLW north of the 1st Ave South Bridge, and above -18 ft MLLW south of the 1st Ave South Bridge (see Figure 17).
- d. There are 41 SMS COCs, but total PCBs and arsenic ENR ULs are based upon human health based RALs only (see Table 20).

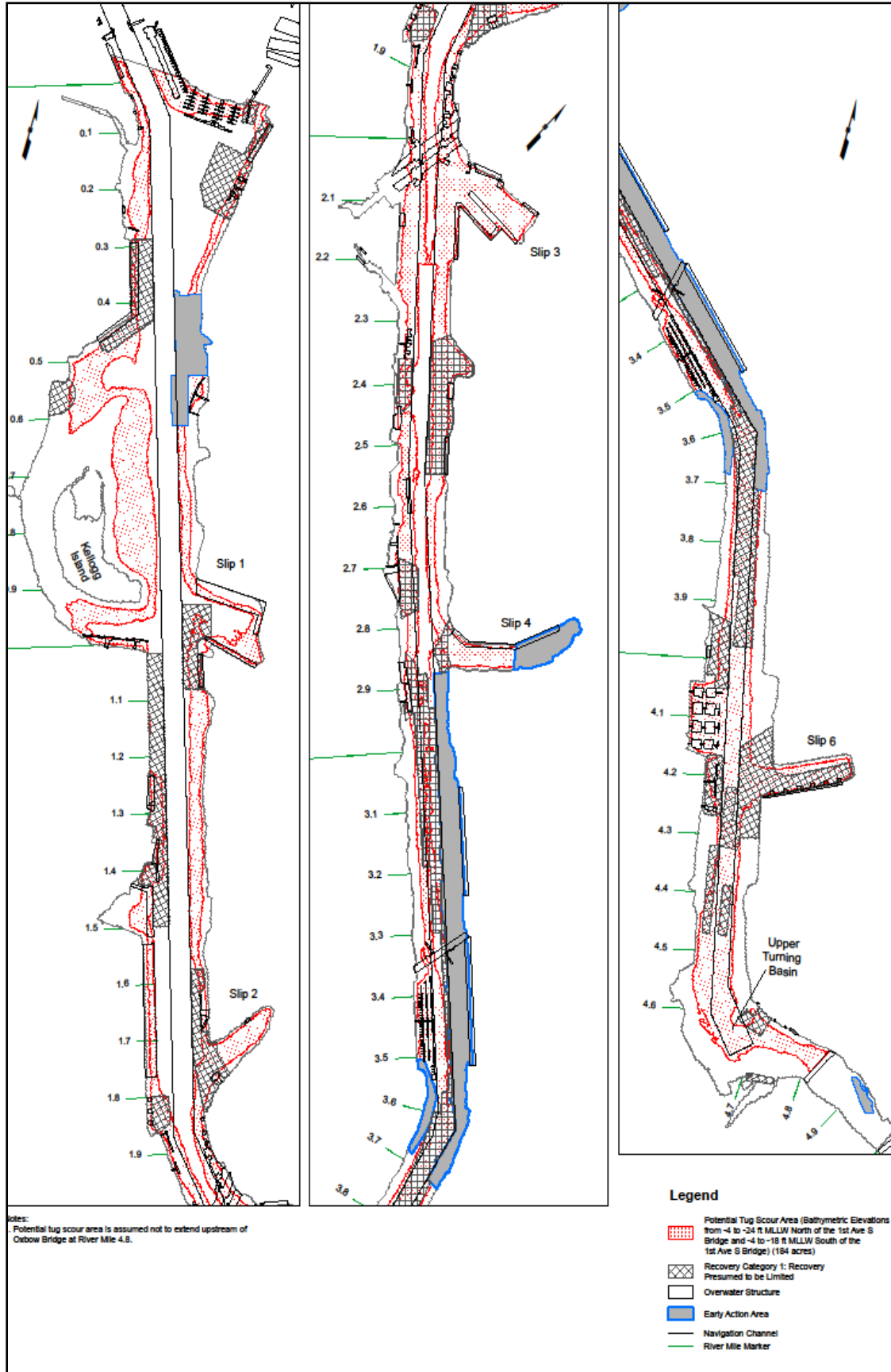


Figure 17. Recovery Category 1 and Potential Tug Scour Areas in LDW

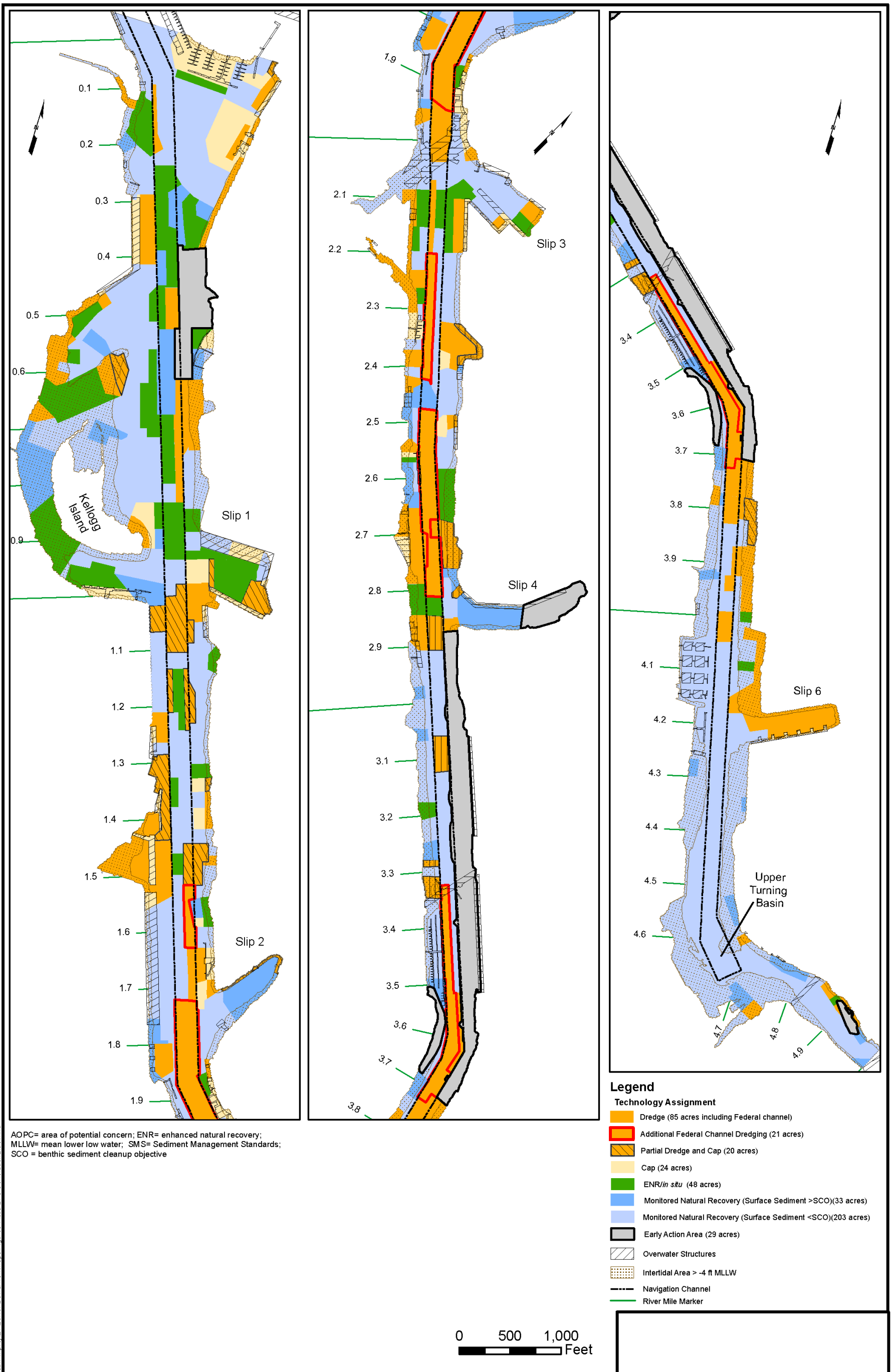
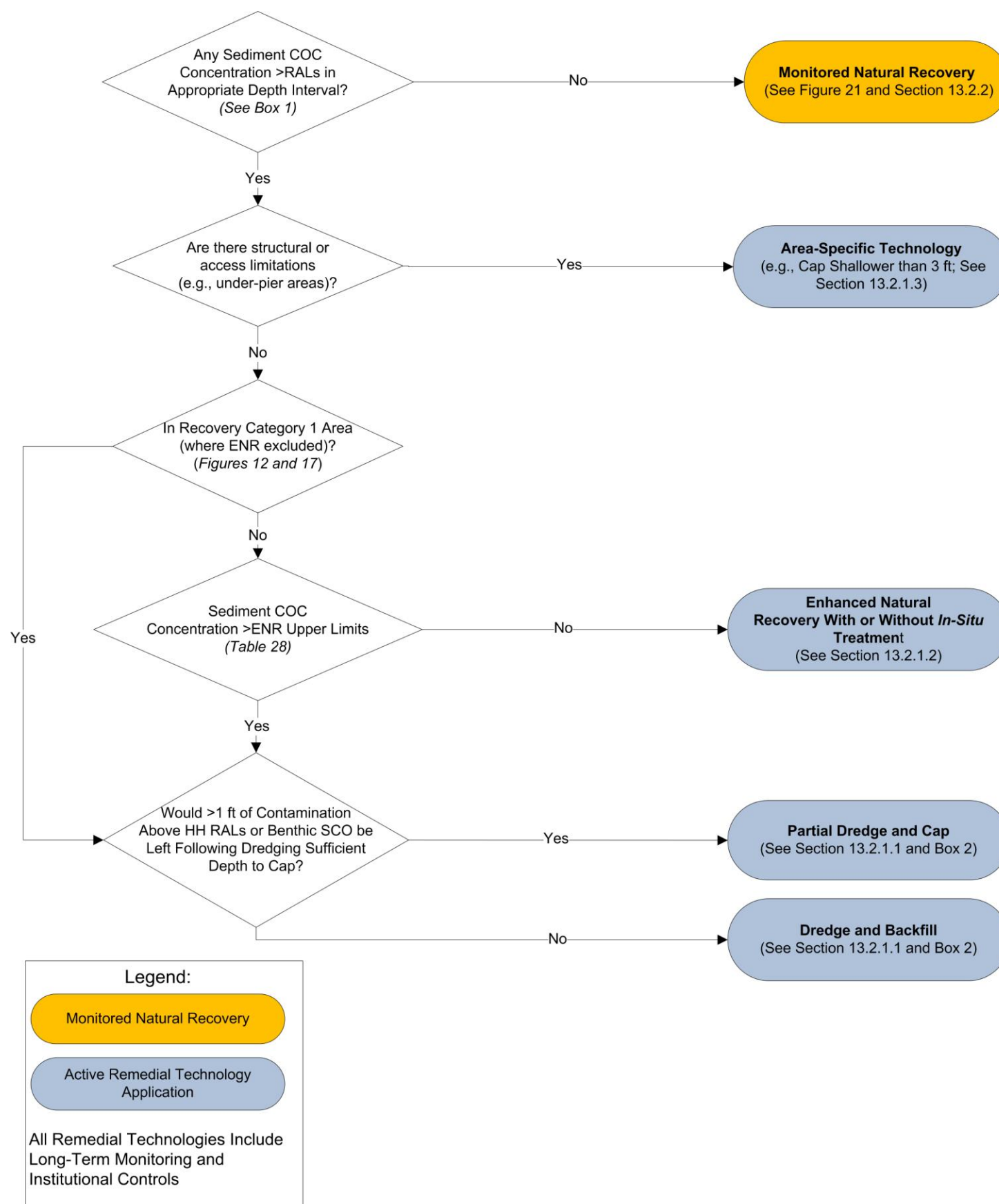


Figure 18. Selected Remedy



Box 1. Intertidal Sediments (+11.3 ft MLLW to -4 ft MLLW)						
Remedial Action Levels (RALs) and Depth Interval to Which They Apply						
Contaminant	Units	Recovery Category 1 Areas		Recovery Category 2 and 3 Areas		Risk Reduction Associated with RALs
		4 in (10 cm) depth interval	1.5 ft (45 cm) depth interval	4 in (10 cm) depth interval	1.5 ft (45 cm) depth interval	
PCBs (Total)	mg/kg-OC	12	12	12	65	Human Health ^{a,b,c,e}
cPAH	µg TEQ/kg-dw	1000	900	1000	900	
Dioxins/Furans	ng TEQ/kg-dw	25	28	25	28	
Arsenic (Total)	mg/kg-dw	57	28	57	28	
39 SMS COCs	Varies by COC	SCO (see Table 27)	--	2xSCO (see Table 27)	--	Ecological ^{d,e}

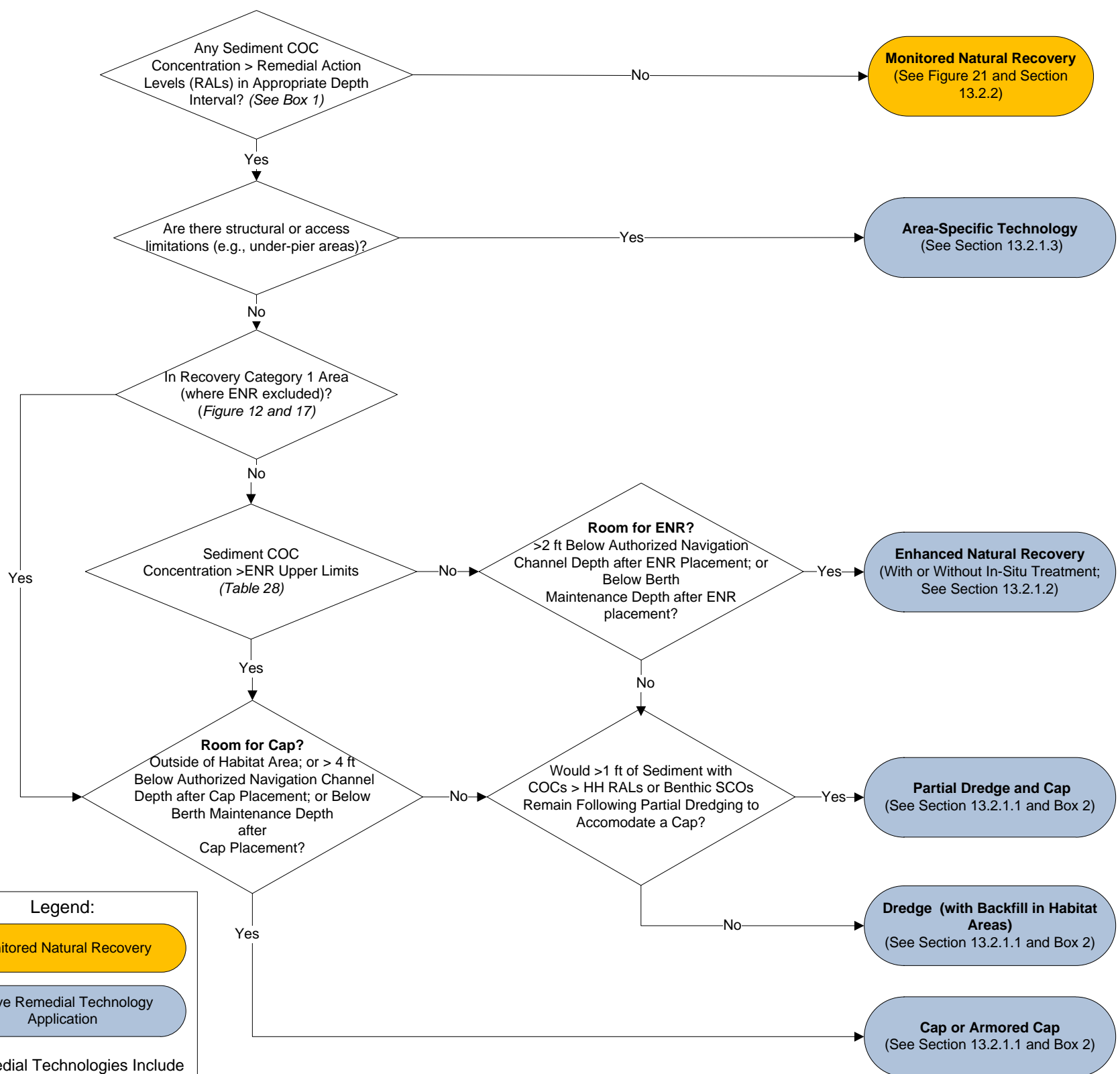
Notes:

- The average concentrations in depth interval (e.g., vertically composited samples) are compared to RALs.
- Human Health RALs and RAO 3 RALs must be met immediately following construction.

^a RAO 1 - Human health seafood consumption
^b RAO 2 - Human health direct contact includes beach play, clamming, and netfishing
^c RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)
^d RAO 3 - Ecological protection of benthic community
^e There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.

Box 2. Habitat Areas
Elevations of intertidal habitat areas are assumed to be unaffected by addition of 6-9" of suitable materials (i.e., ENR)
Cap, dredge and backfill, or partial dredge and cap to pre-construction grade; finish with suitable habitat layer
In clam habitat areas (Figure 6), caps will generally include 4 ft of suitable clean material including a minimum 45 cm clam habitat layer

Figure 19. Intertidal Areas – Remedial Technology Applications



Box 1. Subtidal Sediments (-4 ft MLLW and Deeper)

Remedial Action Levels (RALs) and Depth Interval for Application of RAL

Contaminant	Units	Recovery Category 1 Areas		Recovery Category 2 and 3 Areas		Shoaled Areas of the Federal Channel	Risk Reduction Associated with RALs
		4 in (10 cm) depth interval	2 ft (60 cm) depth interval	4 in (10 cm) depth interval	2 ft (60 cm) depth interval-applied only at potential tug scour areas; See Footnote 2 and Figure 16	See Footnote 3. To a depth of 2 ft below the authorized depth for waterway reach ^f	
PCBs (Total)	mg/kg-OC	12	12	12	195	12	Human Health ^{a,b,c}
cPAH	µg TEQ/kg-dw	1000	1000	1000	--	1000	
Dioxins/Furans	ng TEQ/kg-dw	25	25	25	--	25	
Arsenic (Total)	mg/kg-dw	57	57	57	--	57	
39 SMS COCs	Varies by COC	SCO (see Table 27)	SCO	2xSCO (see Table 27)	--	SCO (see Table 27)	Ecological ^{d,e}

Notes

- The average concentrations in depth interval (e.g., vertically composited samples) are compared to RALs.
 - Potential Tug Scour Areas are Subtidal Elevations Potentially Susceptible to Propellor Wash (North of the 1st Avenue South bridge located at approximately RM 2 in Water Depths from -4 to -24 ft MLLW, and South of the 1st Avenue S Bridge, in Water Depths from -4 to -18 ft MLLW).
 - Shoaled areas are those areas in federal navigation channel with sediment accumulation above the authorized depth including a 2 ft over-dredge depth; see Table 28. For areas in the navigation channel that are not shoaled, Recovery Categories 1 or 2 & 3 RALs apply. Authorized depths are: (1) from RM 0 to 2, 30 ft below MLLW (from Harbor Island to the First Avenue South Bridge); (2) from RM 2 to RM 2.8, 20 ft below MLLW (from the First Avenue South Bridge to Slip 4); and (3) from 15 ft below MLLW from RM 2.8 to 4.7 (Slip 4 to the Upper Turning Basin).
 - Human Health RALs (and RAO 3 PRGs (Benthic SCOs) in Category 1 areas) must be met immediately following construction.
- ^a RAO 1 - Human health seafood consumption
^b RAO 2 - Human health direct contact includes beach play, clamming, and netfishing
^c RAO 4 - Ecological protection for river otter (addressed by meeting human health PCB RAL)
^d RAO 3 - Ecological protection of benthic community
^e There are 41 SMS COCs, but PCB and arsenic are principally RAO 1 COCs. SMS Also lists toxicity test-out criteria using bioassays. Test-out is not allowed for PCBs or arsenic.
^f Depth intervals to determine compliance will be determined during Remedial Design.
- ^g Caps were assumed to be 3 ft for cost estimating purposes; cap thicknesses will be evaluated by EPA during Remedial Design in accordance with EPA and USACE (1998)

Box 2. Habitat Areas (see Section 13.2.1.1)

Elevations of intertidal habitat areas are assumed to be unaffected by addition of 6-9" materials (i.e., ENR)
 Cap, dredge and backfill, or partial dredge and cap to pre-construction grade; finish with suitable habitat layer.

Revised Figure 20. Subtidal Areas – Remedial Technology Application

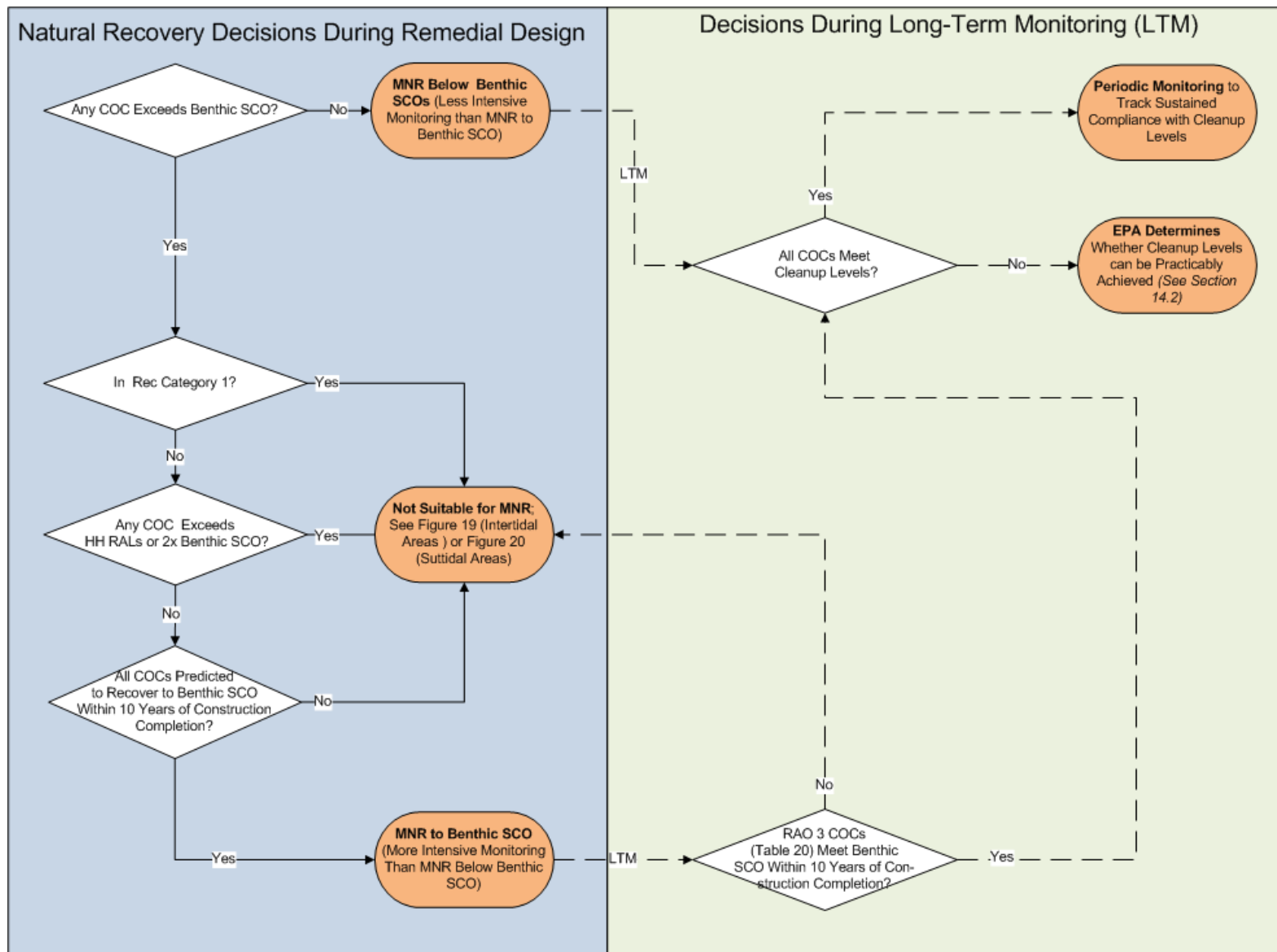


Figure 21. Intertidal and Subtidal Areas – Natural Recovery Application

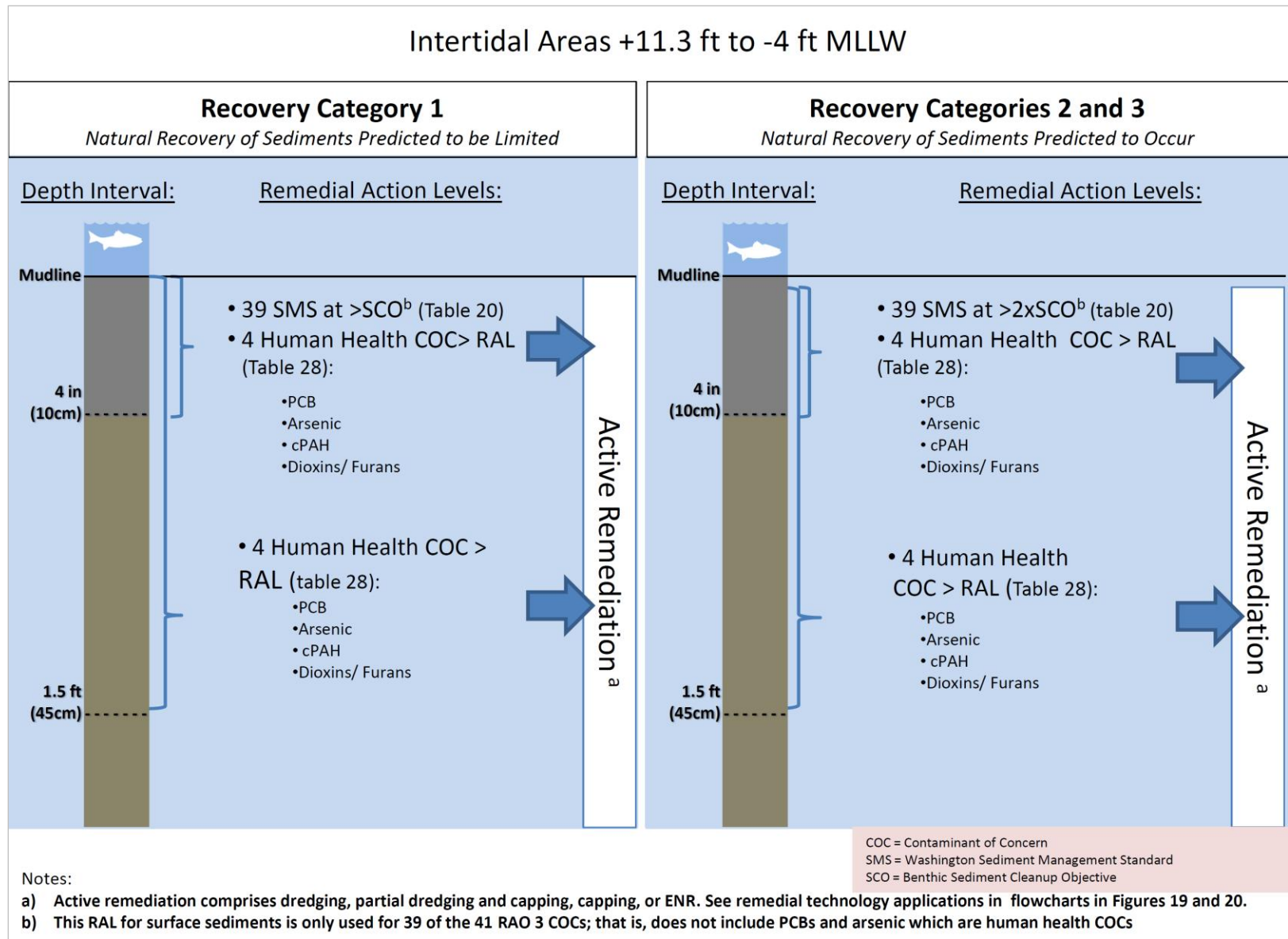


Figure 22. Intertidal Areas - Remedial Action Levels Application

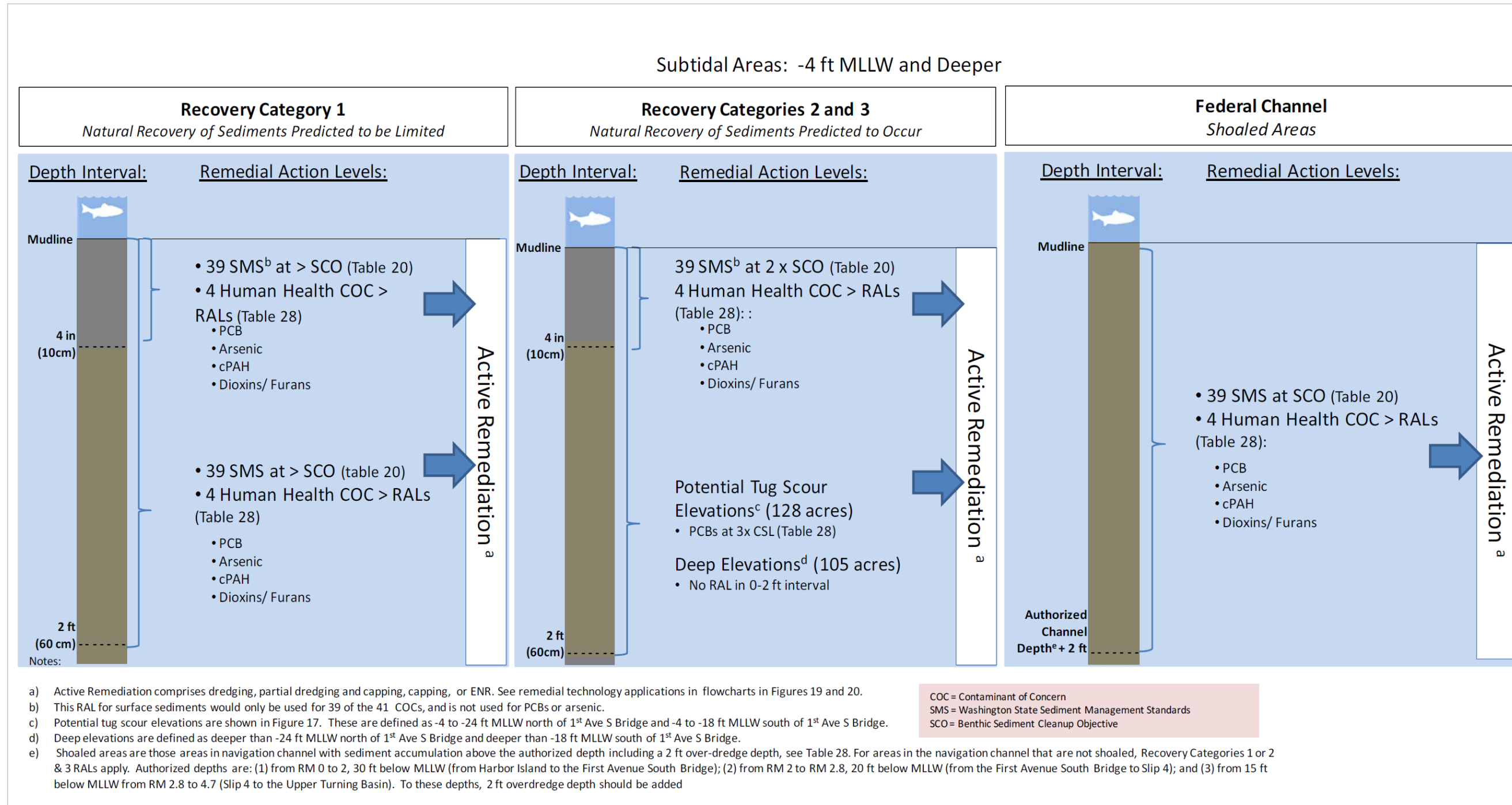


Figure 23. Subtidal Areas – Remedial Action Levels Application

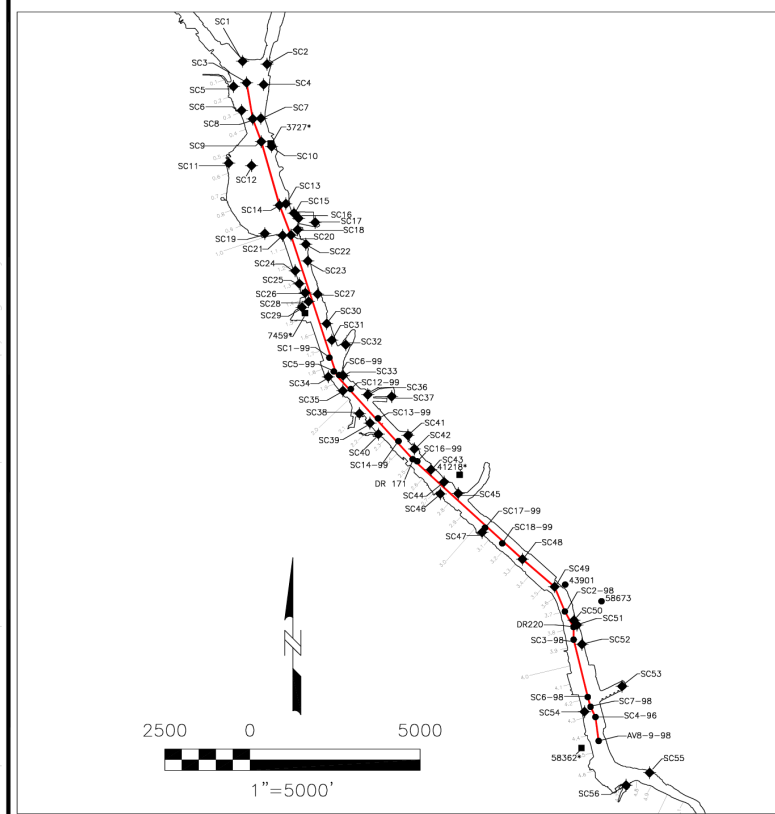
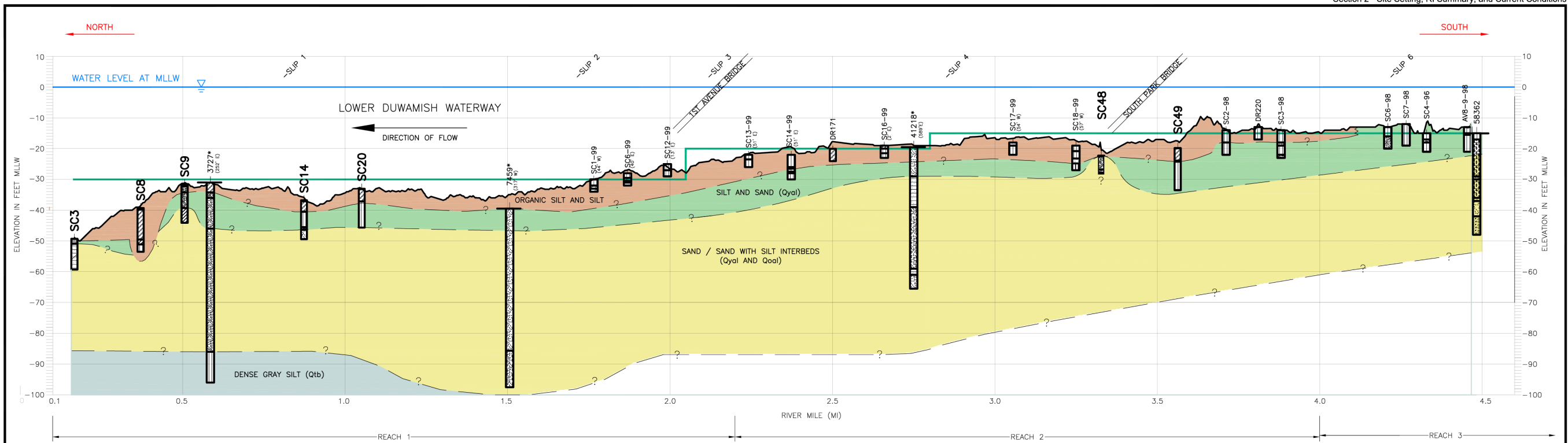
Appendix B

Excerpt from Final Feasibility Study, Lower Duwamish Waterway

This figure was extracted from the Final Feasibility Study, Lower Duwamish Waterway dated October 2012.

APPENDIX B CONTENTS

FS Figure 2-3. Navigation Channel Longitudinal Cross Section..... B-1



LEGEND

- DR-171 ● Historical Subsurface Core
- SC4-96 = PSSDA96 study
- SC2-98 = PSSDA98 study
- SC6-99 = PSSDA99 study
- DR171 = EPASI study
- 3727* ■ Upland Core
- 7459 = Hart Crowser 1979 study
- 41218 = Yonemitsu Geological Services 1979 study
- 3727 = Dames and Moore 1988 study
- 58362 = Seattle Public Utilities (CPT-D77_01) 1985 study
- SC48 ◆ 2006 Subsurface Core
- Authorized navigation depth (ft MLLW)
- Mid-channel mudline elevation (based on 2003 bathymetric survey, ft MLLW; Windward and DEA 2004)
- Water level at MLLW (ft)
- Top of projected core not shown

KEY

- SC1-99 Core Name (Distance from section to Core)
- Top of Core
- Observed Contacts
- Bottom of Core

STRATIGRAPHY**

- RECENT
- UPPER ALLUVIUM/TRANSITION
- LOWER ALLUVIUM
- DENSE POST-GLACIAL AND GLACIAL UNIT

Qtb = TRANSITIONAL SILTS
 Qyal = YOUNGER ALLUVIUM
 Qol = OLDER ALLUVIUM

LITHOLOGY

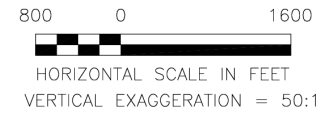
- Clay/Silt
- Organic silt
- Silt
- Sand with silt
- Sand with silt interbeds
- Sand
- Gravel, sandy gravel

NOTES

- 1) MLLW - mean lower low water
- 2) 2006 Phase 2 cores (SC3, SC8, SC9, SC14, SC20, SC48, SC49) are labeled with bold font in cross section.
- 3) AV8-9-98 is an average of Cores 8 and 9 from PSSDA (1998).
- 4) Upland cores from GeoMap NW, Pacific Northwest Center for Geologic Mapping Studies. <http://geomapnw.ess.washington.edu/index.php>
- 5) Cross sections represent regional geology. See core logs in the Subsurface Sediment Data Report (Windward 2007) for detailed stratigraphy.

* Upland cores projected into navigation channel. Lower portions of upland cores used to bound deeper sediment units.

** Stratigraphy terminology is used in Subsurface Data Report (Windward and RETEC 2007) and Sediment Transport Analysis Report (Windward and QEA 2008).



Lower Duwamish Waterway Group
 Port of Seattle | City of Seattle | King County | The Boeing Company

**LOWER DUWAMISH WATERWAY
 FINAL FEASIBILITY STUDY**
 60150279-14.34

**NAVIGATION CHANNEL
 LONGITUDINAL CROSS SECTION**
FIGURE 2-3

DATE: 10/31/12

DRWN: E.M./MO/SEA

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