Appendix G. Analytical Methods and Reporting Limits

TABLES

Table G-1
Methods and RL goals for PCB Aroclors, PAHs, metals, other SVOCs, and conventionals in sediment/soil

Analyte	Method	Unit	MDL	RL
PCBs as Aroclors (based on 12.5-g dw sample)				
Aroclor 1016	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1221	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1232	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1242	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1248	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1254	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
Aroclor 1260	EPA 8082A	µg/kg dw	1.6[1]	4.0[2]
PAHs (based on 10-g dw sample)				
Acenaphthene[3]	EPA 8270E	µg/kg dw	5.2[1]	20.0[2]
Acenaphthylene[3]	EPA 8270E	µg/kg dw	6.2[1]	20.0[2]
Anthracene[3]	EPA 8270E	µg/kg dw	7.2[1]	20.0[2]
Benzo(a)anthracene[4]	EPA 8270E	µg/kg dw	6.0[1]	20.0[2]
Benzo(a)pyrene[4]	EPA 8270E	µg/kg dw	4.2[1]	20.0[2]
Total benzofluoranthenes[4]	EPA 8270E	µg/kg dw	10[1]	40.0[2]
Benzo(g,h,i)perylene[4]	EPA 8270E	µg/kg dw	14[1]	20.0[2]
Chrysene[4]	EPA 8270E	µg/kg dw	6.1[1]	20.0[2]
Dibenzo(a,h)anthracene[4]	EPA 8270E	µg/kg dw	17[1]	20.0[2]
Fluoranthene[4]	EPA 8270E	µg/kg dw	6.1[1]	20.0[2]

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Methods and RL goals for PCB Aroclors, PAHs, metals, other SVOCs, and conventionals in sediment/soil

Analyte	Method	Unit	MDL	RL
Fluorene[3]	EPA 8270E	µg/kg dw	15[1]	20.0[2]
Indeno(1,2,3-cd)pyrene[4]	EPA 8270E	µg/kg dw	15[1]	20.0[2]
2-methylnaphthalene[3]	EPA 8270E	µg/kg dw	4.5[1]	20.0[2]
Naphthalene[3]	EPA 8270E	µg/kg dw	4.2[1]	20.0[2]
Phenanthrene[3]	EPA 8270E	µg/kg dw	8.7[1]	20.0[2]
Pyrene[4]	EPA 8270E	µg/kg dw	5.7[1]	20.0[2]
cPAHs (based on 10-g dw sample)[5]				
Benzo(a)anthracene[4]	EPA 8270E SIM	µg/kg dw	0.82[1]	5.0[2]
Benzo(a)pyrene[4]	EPA 8270E SIM	µg/kg dw	0.61[1]	5.0[2]
Benzo(b)fluoranthene[4]	EPA 8270E SIM	µg/kg dw	1.4[1]	5.0[2]
Benzo(k)fluoranthene[4]	EPA 8270E SIM	µg/kg dw	0.76[1]	5.0[2]
Chrysene[4]	EPA 8270E SIM	µg/kg dw	1.1[1]	5.0[2]
Dibenzo(a,h)anthracene[4]	EPA 8270E SIM	µg/kg dw	0.89[1]	5.0[2]
Indeno(1,2,3-cd)pyrene[4]	EPA 8270E SIM	µg/kg dw	1.1[1]	5.0[2]
Metals (based on 1-g ww unless otherwise noted)				
Arsenic	EPA 6020B UCT-KED	mg/kg dw	na[6]	0.2[2]
Cadmium	EPA 6020B UCT-KED	mg/kg dw	na[6]	0.1[2,7]
Chromium	EPA 6020B	mg/kg dw	na[6]	0.5[2,7]
Copper	EPA 6020B UCT-KED	mg/kg dw	na[6]	0.5[2,7]
Lead	EPA 6020B	mg/kg dw	na[6]	0.1[2]

Table G-1
Methods and RL goals for PCB Aroclors, PAHs, metals, other SVOCs, and conventionals in sediment/soil

Analyte	Method	Unit	MDL	RL
Silver	EPA 6020B	mg/kg dw	na[6]	0.2[2]
Zinc	EPA 6020B UCT-KED	mg/kg dw	na[6]	6[2,7]
Mercury (based on 0.2-g ww sample)	EPA 7471B	mg/kg dw	na[6]	0.025[2]
SVOCs (based on 10-g dw sample)				
2,4-dimethylphenol	EPA 8270E-SIM	µg/kg dw	2.2[1]	20.0
4-methylphenol	EPA 8270E	µg/kg dw	7.4[1]	20.0[2]
Benzoic acid	EPA 8270E-SIM	µg/kg dw	13[1]	100
Benzyl alcohol[8]	EPA 8270E-SIM	µg/kg dw	2.5[1]	20.0
Bis(2-ethylhexyl)phthalate	EPA 8270E	µg/kg dw	5.5[1]	50.0[2]
Butyl benzyl phthalate	EPA 8270E	µg/kg dw	9.4[1]	20.0[2]
Dibenzofuran	EPA 8270E	µg/kg dw	14[1]	20.0[2]
Dimethyl phthalate	EPA 8270E	µg/kg dw	4.4[1]	20.0[2]
Hexachlorobenzene	EPA 8081B	µg/kg dw	0.15[1]	0.5
n-Nitrosodiphenylamine	EPA 8270E-SIM	µg/kg dw	1.31	5.0
Pentachlorophenol	EPA 8270E-SIM	µg/kg dw	2.13	20.0
Phenol	EPA 8270E	µg/kg dw	4.4[1]	20.0[2]
1,2,4-trichlorobenzene	EPA 8270E-SIM	µg/kg dw	2.7[1]	5.0
1,2-dichlorobenzene	EPA 8270E-SIM	µg/kg dw	0.74[1]	5.0
1,4-dichlorobenzene	EPA 8270E-SIM	µg/kg dw	0.60[1]	5.0

Table G-1
Methods and RL goals for PCB Aroclors, PAHs, metals, other SVOCs, and conventionals in sediment/soil

Analyte	Method	Unit	MDL	RL
Conventionals				
Grain size	ASTM D7913 and D7928	%	na	0.1
Percent solids	SM 2540 G-97	% dw	na	0.040
TOC (based on 1-g dw sample)	EPA 9060A	% dw	0.018	0.02
Ammonia	SM 4500-NH3 H-97	mg/kg dw	na	0.4
Total sulfides	SM 4500-S2 D-0	mg/kg dw	na	1

Notes:

1. SW 846 no longer requires MDL values. The laboratories have the option to use these values to assess sensitivity for EPA 8000 series methods. ARL has continued to maintain MDL studies for these analytes following EPA MDL Revision 2 (EPA 2016) procedures.
2. RL values are consistent with the LLOQ values required under EPA SW-846.
3. Compound is a component of the LPAH sum.
4. Compound is a component of the HPAH sum.
5. cPAHs will be analyzed by 8270E-SIM for samples that require cPAH analysis and not the full SVOC list (i.e. 0- to 45-cm sediments in Recovery Category 2/3 intertidal areas).
6. SW 846 no longer requires MDL values.
7. Although the RL value is higher than the PQL listed in SCUM (Ecology 2021), it is lower than the RAO3 cleanup level provided in the ROD (EPA 2014).
8. Because benzyl alcohol is not a CERCLA hazardous substance, benzyl alcohol data will not be included in the data evaluation reports. Benzyl alcohol data obtained through routine SVOC analysis of the PDI sediment samples will be provided to EPA.

ARL: Analytical Resources LLC
ASTM: American Society for Testing and Materials
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
cPAH: carcinogenic polycyclic aromatic hydrocarbon
dw: dry weight
EPA: US Environmental Protection Agency
HPAH: high-molecular-weight polycyclic aromatic hydrocarbon
LLOQ: lower limit of quantitation
MDL: method detection limit
LPAH: low-molecular-weight polycyclic aromatic hydrocarbon

na: not available
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
PDI: pre-design investigation
PQL: practical quantitation limit
PSEP: Puget Sound Estuary Program
RAO: remedial action objective
RL: reporting limit
ROD: Record of Decision
SCUM II: Sediment Cleanup User's Manual II
SIM: selective ion monitoring
SM: Standard Method
SVOC: semivolatile organic compounds
TOC: total organic carbon
UCT-KED: universal cell technology-kinetic energy discrimination
ww: wet weight

Table G-2
Method and RL goals for dioxins/furan congeners in sediment

Analyte	EPA Method 1613B			
	Sediment (ng/kg dw) Based on 10-g sample		TEQ (ng/kg)	
	EDL[1]	LOQ[2]	TEF	TEQ[3]
2,3,7,8-TCDD	0.1	1.0	1	0.5
1,2,3,7,8-PeCDD	0.1	1.0	1	0.5
1,2,3,4,7,8-HxCDD	0.1	1.0	0.1	0.05
1,2,3,6,7,8-HxCDD	0.1	1.0	0.1	0.05
1,2,3,7,8,9-HxCDD	0.1	1.0	0.1	0.05
1,2,3,4,6,7,8-HpCDD	0.1	2.5	0.01	0.0125
OCDD	01	10.0	0.0003	0.0015
2,3,7,8-TCDF	0.1	1.0	0.1	0.05
1,2,3,7,8-PeCDF	01	1.0	0.03	0.015
2,3,4,7,8-PeCDF	0.1	1.0	0.3	0.15
1,2,3,4,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,6,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,7,8,9-HxCDF	0.1	1.0	0.1	0.05
2,3,4,6,7,8-HxCDF	0.1	1.0	0.1	0.05
1,2,3,4,6,7,8-HpCDF	0.1	1.0	0.01	0.005
1,2,3,4,7,8,9-HpCDF	0.1	1.0	0.01	0.005
OCDF	0.1	2.5	0.0003	0.000375

Notes:

1. EDL is a sample-specific DL. The value provided here is an estimate, and the sample-specific values will vary based on sample mass and the analytical conditions at the time of analysis.
2. LOQ is ARL's lowest concentration, at or above the LMCL, at which test accuracy (precision and bias) has been demonstrated. Values below the LOQ are J-qualified. The reported LOQ will be adjusted based on the sample mass of each sample
3. TEQ calculated using ½ RL value multiplied by the 2005 WHO TEF.

ARL: Analytical Resources LLC
DL: detection limit
dw: dry weight
EDL: estimated detection limit
EPA: US Environmental Protection Agency
HpCDD: heptachlorodibenzo-p-dioxin
HpCDF: heptachlorodibenzofuran
HxCDD: hexachlorodibenzo-p-dioxin
HxCDF: hexachlorodibenzofuran
LMCL: lower method calibration limit
LOQ: limit of quantitation

OCDD: octachlorodibenzo-*p*-dioxin
OCDF: octachlorodibenzofuran
PeCDD: pentachlorodibenzo-*p*-dioxin
PeCDF: pentachlorodibenzofuran
RL: reporting limit
TCDD: tetrachlorodibenzo-*p*-dioxin
TCDF: tetrachlorodibenzofuran
TEF: toxic equivalency factor
TEQ: toxic equivalent
WHO: World Health Organization

Table G-3
Accuracy recovery range for individual PAHs and Other SVOCs

Parameter	LCS/Spiked Sample[1,2]	CRM[1,2]
PAHs		
Acenaphthene	45–120%	51–149%
Acenaphthylene	42–120%	52–148%
Anthracene	45–120%	57–143%
Benzo(a)anthracene	49–120%	58–142%
Benzo(a)pyrene	42–120%	54–146%
Total benzofluoranthenes	30–160%	44–156%
Benzo(g,h,i)perylene	38–126%	49–152%
Chrysene	47–120%	58–142%
Dibenzo(a,h)anthracene	30–133%	50–150%
Fluoranthene	53–145%	55–145%
Fluorene	45–120%	54–146%
Indeno(1,2,3-cd)pyrene	42–163%	0–203%
2-methylnaphthalene	43–120%	na
Naphthalene	43–120%	33–167%
Phenanthrene	49–120%	60–140%
Pyrene	52–134%	60–139%
cPAHs[3]		
Benzo(a)anthracene	42–120%	50–150%
Benzo(a)pyrene	36–120%	45–155%
Benzo(b)fluoranthene	52-137%	51–149%
Benzo(k)fluoranthene	37–129%	51–148%
Chrysene	48–120%	53–147%

Table G-3
Accuracy recovery range for individual PAHs and Other SVOCs

Parameter	LCS/Spiked Sample[1,2]	CRM[1,2]
Dibenzo(a,h)anthracene	66–139%	48–153%
Indeno(1,2,3-cd)pyrene	67–132%	53–147%
Other SVOCs		
1,2-dichlorobenzene	36–120%	NR
1,2,4-trichlorobenzene	35–120%	NR
1,4-dichlorobenzene	36–120%	NR
2,4-dimethylphenol	10–120%	NR
4-methylphenol	29–120%	NR
Benzoic acid	10–160%	NR
Benzyl alcohol	25–123%	NR
Bis(2-ethylhexyl)phthalate	34–130%	NR
Butyl benzyl phthalate	45–132%	NR
Dibenzofuran	43–120%	NR
Dimethyl phthalate	43–120%	NR
n-Nitrosodiphenylamine	27–120%	NR
Pentachlorophenol	26–120%	NR
Phenol	34–120%	NR

Notes:

1. Values listed are performance-based limits provided by ARL.
2. An LCS may be used to assess accuracy when a CRM is unavailable. CRMs will be analyzed for PAHs, PCB Aroclors, and dioxins/furans only. The satisfactory acceptance limit for CRM recovery will include the uncertainty range around the CRM mean, as well as the uncertainty of the method of measurement: limits listed for Puget Sound Reference Material (PCBs and dioxins/furans), Sigma-Aldrich SQC017-40G (SIM-PAH), and CRM 143 BNA (PAHs). Commercial CRMs may change depending on availability.
3. cPAHs will be analyzed by 8270E-SIM for samples that require cPAH analysis and not the full SVOC list (i.e. 0- to 45-cm sediments in Recovery Category 2/3 intertidal areas).

ARL: Analytical Resources LLC
cPAH: carcinogenic polycyclic aromatic hydrocarbon
CRM: certified reference material
LCS: laboratory control sample
na: not applicable
NR: not required
PAH: polycyclic aromatic hydrocarbon
PCB: polychlorinated biphenyl
SIM: selective ion monitoring
SVOC: semivolatile organic compound

References

Ecology. 2021. Sediment cleanup user's manual. Guidance for implementing the cleanup provisions of the sediment management standards, Chapter 173-204 WAC. Third revision December 2021. Pub. No. 12-09-057. Toxics Cleanup Program, Washington State Department of Ecology, Olympia, WA.

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