APPENDIX 3B

Sampling Information, Methods, and Data Quality

The WACAP Quality Assurance Project Plan (QAPP), May 2004, outlines the quality assurance and quality control objectives for WACAP.

Snow QA/QC

Field

Quality assurance and quality control procedures for handling US Geological Survey (USGS) snow chemistry samples were well established, with annual regional surveys dating back to 1993. A detailed description of sampling protocols was contained in each field kit, and experienced personnel led each site visit. Information about snowpack physical characteristics was recorded on prepared data sheets. All original data sheets were carried as personal baggage during transit and were photocopied and kept in separate locations, as soon as facilities permitted.

Approximately 10% of the total number of samples were field processing blanks and field replicates. Field blanks were collected to detect possible contamination from collection methods, laboratory processing, DI rinse water, filtering apparatus, and Teflon collection bags. Field replicates were also useful for this purpose, but in addition to contamination, they also reflect the natural variability in snow chemistry and the precision of analytical techniques.

Laboratory

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS Colorado District laboratory involves systematically analyzing blanks, an internal reference sample, USGS standard reference water samples, and certified nutrient standards from High Purity Standards, Inc. International blind audit samples from Environment Canada were analyzed twice per year. Approximately 40% of sample batch run time for the analytical instrumentation was dedicated to analyzing blanks, duplicates, reference samples, and standards. Calibration verifications were made with standards at the beginning and end of each batch of sample analyses on the ion chromatograph.

Quality control at the USGS National Research Program laboratory involves systematic analysis of blanks, standard reference materials, and spike addition samples. Details, results, and figures are described in the Quality Assurance/Quality Control section of the database.

Ionic charge balance was calculated as the sum of cations (hydrogen ion, calcium, magnesium, sodium, potassium, and ammonium) minus the sum of anions (alkalinity, chloride, nitrate, and sulfate) divided by the total cations and anions in solution. Alkalinities were predominantly negative for snow samples; only positive values for alkalinity were included with the sum of anions in charge-balance calculations. Analytical results and charge balance values were examined and outliers for the snow sample database and rerun were performed as necessary.

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for snow is given in Table 3B-1.

Metals

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS Colorado District laboratory involves systematically analyzing blanks, an internal reference sample, USGS standard reference water samples, and certified nutrient standards from High Purity Standards, Inc. International blind audit samples from Environment Canada were analyzed twice per year. Approximately 40% of sample batch run time for the analytical instrumentation was dedicated to analyzing blanks, duplicates, reference samples, and standards. Calibration verifications were made with standards at the beginning and end of each batch of sample analyses on the ion chromatograph.

Quality control at the USGS National Research Program laboratory involves systematic analysis of blanks, standard reference materials, and spike addition samples. Details, results and figures are described in the Quality Assurance/Quality Control Section of the database (Table 3B-2).

Ionic charge balance was calculated as the sum of cations (hydrogen ion, calcium, magnesium, sodium, potassium, and ammonium) minus the sum of anions (alkalinity, chloride, nitrate, and sulfate) divided by the total cations and anions in solution. Alkalinities were predominantly negative for snow samples; only positive values for alkalinity were included with the sum of anions in charge-balance calculations. Analytical results and charge balance values were examined and outliers for the snow sample database and rerun were performed as necessary.

Passive Air Sampler QA/QC

Passive Air Sampler Deployment Summary

Table 3B-3 lists the latitude, longitude, and elevation of each site where a PASD was deployed.

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for PASDs is given in Table 3B-4.

Table 3B-1. SOC Recovery and EDLs in Snow Over the Entire Analytical Method (Usenko et al., 2005).

Chemical Class / Compounds	log K_{ow}	50 L Melted Snow[2] Avg. % Rec	% RSD	EDL[3] pg/L
Amide Pesticides				
Propachlor	2.4	139.5	19.5	3.7
Alachlor	2.6	79.7	1.0	43.4
Acetochlor	3.03[1]	65.6	6.9	25.2
Metolachlor	3.1	89.0	1.4	13.8
Organochlorines Pesticides and Metabolites				
HCH, gamma	3.8	87.9	6.3	12.3
HCH, alpha	3.8	71.7	7.4	18.2
HCH, beta	4.0	100.7	7.2	32.1
HCH, delta	4.1	111.8	5.2	20.7
Methoxychlor	4.5	59.1	20.9	16.4
Heptachlor epoxide	4.6	31.8	32.0	14.7
Endrin aldehyde	4.8	40.6	13.8	23.2
Endrin	5.2	90.2	26.8	47.6
Heptachlor	5.2	49.9	19.6	121.7
o,p'-DDE	5.5	55.3	12.9	24.7
Chlordane, oxy	5.5	28.1	31.5	9.4
Dieldrin	5.5	109.1	23.5	105.6
Chlordane, cis	5.9	32.7	29.1	16.3
p,p'-DDD	5.9	66.5	14.6	44.0
Nonachlor, trans	6.1	56.4	16.7	0.9
o,p'-DDD	6.1	41.5	25.7	24.7
Chlordane, trans	6.1	60.9	15.3	0.4
Nonachlor, cis	6.1	30.2	27.3	0.6
Aldrin	6.4	43.7	25.9	107.6
o,p'-DDT	6.5	36.4	5.6	23.4
p,p'-DDE	6.8	50.1	19.6	10.3
Mirex	6.9	51.5	10.6	27.1
p,p'-DDT	6.9	61.9	24.3	26.2
Organochlorine Sulfides and Metabolites				
Endosulfan sulfate	3.7	65.4	17.3	1.0
Endosulfan I	4.7	51.3	17.7	4.9
Endosulfan II	4.8	53.3	18.1	2.0
Phosphorothioate Pesticides				
Methyl parathion	2.7	74.6	1.0	52.0
Malathion	2.9	54.8	13.6	8.4
Diazinon	3.7	75.0	11.7	9.1
Parathion	3.8	56.9	9.6	3.2
Ethion	5.1	46.7	30.0	6.2
Chlorpyrifos	5.1	59.7	22.5	6.9
Thiocarbamate Pesticides				
EPTC	3.2	64.8	25.2	45.0
Pebulate	3.8	99.9	33.2	63.8
Triallate	4.6	73.6	18.5	10.1
Triazine Herbicides and Metabolites				
Atrazine desisopropyl	1.36[1]	nd[5]	nd[5]	na[6]
Atrazine desethyl	1.78[1]	nd[5]	nd[5]	na[6]
Simazine	2.2	nd[5]	nd[5]	na[6]
Cyanazine	2.2	107.8	2.3	26.2
Atrazine	2.3	105.8	4.2	11.5
Prometon	2.7	62.8	15.6	34.6
Miscellaneous Pesticides				
Metribuzin	1.70[1]	77.4	2.1	24.5
Etridiazole	2.6	206.2	26.1	22.5
Dacthal	4.3	109.9	10.5	1.7
Trifluralin	5.3	47.6	30.2	0.7
Hexachlorobenzene	5.5	55.3	14.6	0.2
Polycyclic Aromatic Hydrocarbons				
Acenaphthylene	3.9	52.7	1.8	19.8
Acenaphthene	4.0	101.3	2.1	11.3
Fluorene	4.2	93.2	4.7	8.3
Anthracene	4.5	73.0	7.3	19.9
Phenanthrene	4.5	82.7	5.1	8.8
Pyrene	5.1	74.4	10.5	4.9
Fluoranthene	5.2	77.9	10.7	4.0
Chrysene + Triphenylene	5.7	71.2	11.2	13.3
Benzo(a)anthracene	5.9	70.5	11.1	14.6
Retene	6.4	61.0	4.0	33.4
Benzo(k)fluoranthene	6.5	66.7	10.3	5.0
Benzo(a)pyrene	6.5	59.3	10.9	7.9
Benzo(b)fluoranthene	6.6	68.4	11.4	6.9
Indeno(1,2,3-cd)pyrene	6.7	61.5	9.1	31.5
Dibenz(a,h)anthracene	6.8	62.9	8.5	28.9
Benzo(e)pyrene	6.9	59.3	10.9	8.9
Benzo(ghi)perylene	7.0	59.2	9.4	16.5
Polychlorinated Biphenyls (PCBs)				
PCB 74	6.3	45.5	23.2	124.8
PCB 101	6.4	48.5	21.4	31.0
PCB 138	6.7	53.3	18.1	2.8
PCB 153	6.9	51.3	17.7	1.3
PCB 118	7.0	52.8	21.8	1.3
PCB 187	7.2	56.0	18.1	0.9
PCB 183	8.3	55.1	17.8	1.2
Average Recoveries and Standard Deviations[4]				
Average		68.3	14.8	21.9
Max		206.2	33.2	124.8
Min		28.1	1.0	0.2

[1]Estimated log K_{ow}. [2]Recoveries validated at 6 ng/L and were corrected for background concentrations of SOCs in snow. [3]Sample-Specific Estimated Method Detection Limits. [4]Average recoveries and percent relative standard deviations do not include compounds that were not detected or not applicable. [5]Not Detected (nd) due to lost during silica cleanup. [6]Not Applicable (na) due to lost during silica cleanup.

Table 3B-2. Trace Metals and Detection Limits for Snow Sample Analyses at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations are in µg/L.

Analyte	Detection Limit	Analyte	Detection Limit
Al	< 0.2	Nd	< 0.0006
As	< 0.02	Ni	< 0.02
B	< 3	Pb	< 0.004
Ba	<0.005	Pr	< 0.0003
Be	< 0.005	Rb	< 0.0006
Bi	< 0.0009	Re	< 0.0002
Cd	< 0.002	Sb	< 0.001
Ce	< 0.0002	Se	< 0.05
Co	< 0.002	Sm	< 0.0002
Cr	< 0.2	Sr	< 0.03
Cs	< 0.009	Tb	< 0.0001
Cu	< 0.04	Te	< 0.005
Dy	< 0.0004	Th	< 0.0004
Er	< 0.0002	Tl	< 0.001
Eu	< 0.0002	Tm	< 0.0001
Gd	< 0.0002	U	< 0.0004
Ho	< 0.0001	V	< 0.07
La	< 0.0002	W	< 0.001
Li	< 0.008	Y	< 0.0002
Lu	< 0.0001	Yb	< 0.0002
Mn	< 0.01	Zn	< 0.04
Mo	< 0.03	Zr	< 0.0008

Table 3B-3. Extended Details of Passive Sampling Device (PASD) Locations. Mapping datum is WGS84.

Park Code	# of PSDs	Target Watershed	Latitude	Longitude	Elev (m)	Veg Site
BAND	1		35.8642	-106.4178	2926	BAND5
BIBE *Elevational Gradient*	4		29.1870	-102.9718	560	BIBE1
			29.3079	-103.1828	1067	BIBE2
			29.2534	-103.2979	1920	BIBE4
			29.2465	-103.3049	2316	BIBE5
CRLA	1		42.9233	-122.0162	2713	CRLA5
DENA	2	Wonder N	63.5421	-150.9781	564	DENA2
		Wonder S	63.4549	-150.8761	686	DENA2
GAAR	1	Matcharak	67.7500	-156.2300	505	GAAR1
GLAC	2	Snyder	48.6264	-113.8050	1609	GLAC3
		Oldman	48.5126	-113.4564	2036	GLAC4
GLBA	1		58.6022	-135.8831	8	GLBA1
GRSA	1		37.7149	-105.4704	3338	GRSA5
GRTE	1		43.1300	-110.7800	3048	GRTE5
KATM	1		58.5711	-155.8036	370	KATM3
LAVO	1		40.4476	-121.5662	2713	LAVO5
MORA	2	Golden	46.8866	-121.9002	1369	MORA4
		LP19	46.8226	-121.8963	1372	MORA3
NOAT	1	Burial	68.4100	-159.2200	388	NOAT3
NOCA	1		48.6824	-121.3217	1600	NOCA5
OLYM	2	PJ	47.9500	-123.4200	1392	OLYM4
		Hoh	47.9000	-123.7900	1433	OLYM3
ROMO *Elevational Gradient*	5		40.2368	-105.7992	2560	ROMO1
		Lone Pine	40.2203	-105.7582	2720	ROMO2
			40.2303	-105.7335	3018	ROMO3
		Mills	40.2922	-105.6420	3042	ROMO6
			40.2290	-105.7117	3536	ROMO4
SEKI *Elevational Gradient*	4		36.5176	-118.8003	658	None (Potwisha)
			36.5762	-118.7862	1573	SEKI2
		Emerald	36.5985	-118.7212	2332	SEKI4
			36.6005	-118.6789	2816	SEKI05
STLE *Elevational Gradient*	4		56.7910	-132.5110	1	STLE1
			56.8047	-132.5317	254	STLE2
			56.8095	-132.5407	567	STLE3
			56.8250	-132.5715	815	STLE4
WRST	1		61.3856	-143.6014	648	WRST3
YOSE	1		37.7744	-119.3371	3048	YOSE5

Table 3B-4. SOC Recovery and EDLs in Passive Air Sampling Devices Over the Entire Analytical Method.

	XAD[a]		EDL[b]		XAD[a]		EDL[b]
	Avg. % Rec	% RSD	ng/g dw		Avg. %Rec	%RSD	ng/g dw
Amide Pesticides							
Propachlor	100.7	3.8	0.05	Acetochlor	87.9	3.1	0.1
Alachlor	97.0	2.1	0.1	Metolachlor	102.6	1.9	0.02
Organochlorine Pesticides and Metabolites							
HCH, gamma[c]	92.2	0.4	0.01	Chlordane, cis	82.6	3.7	0.02
HCH, alpha[c]	89.9	1.0	0.01	p,p'-DDD[e]	106.3	3.2	0.05
HCH, beta[c]	94.5	1.1	0.00	Nonachlor, trans	99.3	1.6	0.00
HCH, delta[c]	102.9	0.8	0.02	o,p'-DDD[e]	94.9	1.7	0.02
Methoxychlor	110.0	1.4	0.01	Chlordane, trans	104.1	1.1	0.001
Heptachlor epoxide	122.4	1.3	0.03	Nonachlor, cis	93.9	2.5	0.001
Endrin aldehyde	92.9	1.4	0.003	Aldrin	99.2	1.3	0.01
Endrin	107.3	2.2	0.03	o,p'-DDT[f]	67.5	8.8	0.04
Heptachlor	111.6	2.6	0.01	p,p'-DDE[d]	91.0	1.8	0.01
o,p'-DDE[d]	104.2	7.7	0.02	Mirex	86.5	2.5	0.004
Chlordane, oxy	118.2	1.4	0.03	p,p'-DDT[f]	94.4	1.5	0.01
Dieldrin	95.2	1.8	0.02				
Organochlorine Sulfide Pesticides and Metabolites							
Endosulfan sulfate	94.7	3.6	0.0002	Endosulfan II	97.8	2.3	0.003
Endosulfan I	102.0	1.1	0.003				
Phosphorothioate Pesticides							
Methyl parathion	80.7	1.4	0.1	Ethion	100.4	8.5	0.1
Malathion	74.0	5.8	0.1	Chlorpyrifos	81.8	2.6	0.003
Diazinon	81.2	2.2	0.04	Chlorpyrifos oxon	150.6	9.9	0.2
Parathion	77.1	3.4	0.1				
Triazine Herbicides and Metabolites							
Simazine	102.7	1.3	0.1	Atrazine desethyl	107.7	3.4	0.1
Cyanazine	210.0	2.0	0.1	Atrazine desisoproply	102.7	1.4	0.02
Atrazine	90.2	1.0	0.04				
Miscellaneous Pesticides							
Metribuzin	90.8	7.0	0.02	Trifluralin	82.6	4.5	0.001
Etridiazole	116.5	0.7	0.1	Hexachlorobenzene	93.3	1.0	0.0002
Triallate	91.9	2.2	0.01	EPTC	83.8	1.4	0.2
Dacthal	95.4	3.7	0.002	Pebulate	88.8	1.3	0.1
Polycyclic Aromatic Hydrocarbons							
Acenaphthylene	48.4	25.6	0.03	Benzo[k]fluoranthene (BkF)	79.6	2.4	0.01
Acenaphthene	81.2	4.4	0.04	Benzo[a]pyrene (BaP)[g]	88.2	0.0	0.02
Fluorene	92.1	2.2	0.04	Benzo[b]fluoranthene (BbF)	99.2	0.7	0.007
Anthracene	20.9	154.8	0.1	Indeno[1,2,3-cd]pyrene (Ind)	93.7	1.4	0.01
Phenanthrene	99.4	2.2	0.1	Dibenz[a,h]anthracene	89.9	2.4	0.02
Pyrene (Pyr)	89.4	2.7	0.01	Benzo[e]pyrene (BeP)	101.8	3.6	0.009
Fluoranthene (Fla)	92.2	3.0	0.01	Benzo[ghi]perylene (BghiP)	88.9	2.5	0.01
Chrysene/Triphenylene	87.5	1.9	0.005	Retene	114.2	3.0	0.02
Benzo[a]anthracene	63.8	44.8	0.01				
Polychlorinated Biphenyls							
PCB 74	93.5	0.6	0.1	PCB 118	70.9	4.6	0.001
PCB 101	88.7	3.1	0.003	PCB 187	91.0	1.5	0.001
PCB 138	111.8	1.7	0.001	PCB 183	91.9	1.6	0.0002
PCB 153	103.9	1.6	0.001				
Averages and % RSD							
average	93.7	5.6	0.03	max	210.0	154.8	0.2
				min	20.9	0.0	0.00

[a] Recoveries were corrected for background concentrations of SOCs in needles. [b]Sample-specific estimated method detection limits calculated from a sample taken from Hoh Lake in Olymic National Park. [c]Hexachlorocyclohexane. [d]Dichlorodiphenyldichloroethylene. [e]Dichlorodiphenyldichloroethane. [f]Dichlorodiphenyltrichloroethane. [g]Data obtained from one sample.

Vegetation QA/QC

Vegetation Sample Summary

Table 3B-5. Vegetation Sample Summary by Park.

Park Type	Park	Sampling Month	# Sites	# Conifer samples	# Lichen samples
Core	DENA	8/2004	6	12	29
	GAAR	7/2004	1	0	7
	GLAC	8/2004	5	15	25
	MORA	8/2004	5	18	19
	NOAT	6/2004	3	0	15
	OLYM	9/2004	5	15	21
	ROMO	9/2004	5	18	6
	SEKI*	10/2004	8	32	26
Secondary	BAND	6/2005	5	6	6
	BIBE	6/2005	5	5	2
	CRLA	8/2005	5	6	5
	GLBA	7/2005	4	4	4
	GRSA	6/2005	5	5	2
	GRTE	7/2005	5	6	3
	KATM	6/2005	6	5	6
	LAVO	8/2005	5	5	5
	NOCA	7/2005	5	5	5
	STLE	7/2005	5	6	10
	WRST	7/2005	5	7	7
	YOSE	8/2005	5	6	4
Total:	**20**	**8**	**98**	**176**	**207**

Table 3B-6. Vegetation Sample Summary. Species collected at each site are recorded in Appendix 1A-3.

Sample type	Genus	Scientific name	Common name	Parks where samples were collected	SOC samples	N samples	N, S & metals samples
Conifer needles	*Abies*	*Abies amabilis*	Pacific silver fir	MORA, NOCA, OLYM, ROMO, SEKI	13	0	0
		Abies concolor	white fir	CRLA, LAVO	9	0	0
		Abies lasiocarpa	subalpine fir	GLAC, GRTE, OLYM	22	0	0
		Abies magnifica	Red fir	CRLA, LAVO, SEKI	12	0	0
		Abies procera	Noble fir	MORA	4	0	0
	Picea	*Picea engelmanii*	Engelmann spruce	GLAC, ROMO	9	0	0
		Picea glauca	white spruce	KATM, WRST	10	0	0
		Picea mariana	black spruce	DENA	12	0	0
		Picea sitchenis	Sitka spruce	GLBA, STLE, WRST	12	0	0
	Pinus	*Pinus albicaulis*	white pine	CRLA, GRTE	3	0	0
		Pinus cembroides	Mexican pinyon	BIBE	3	0	0
		Pinus contorta	lodgepole pine	GRTE, SEKI, YOSE	7	0	0
		Pinus edulis	twoneedle pine	BAND, GRSA	5	0	0
		Pinus flexiilis	limber pine	GRSA, GRTE	5	0	0
		Pinus lambertiana	sugar pine	YOSE	1	0	0
		Pinus ponderosa	ponderosa pine	BAND, YOSE	5	0	0
		Pinus sabiniana	California foothill pine	YOSE	1	0	0
	Psuedotsuga	*Pseudotsuga menziesii*	Douglas-fir	GLAC, NOCA	4	0	0
	Tsuga	*Tsuga heterophylla*	western hemlock	GLAC, MORA, NOCA, OLYM	20	0	0
Lichens	*Alectoria*	*A. sarmentosa*	old man's beard lichen	GLAC, GLBA, MORA, NOCA, OLYM, STLE	26	11	15
	Bryoria	*Bryoria spp.*	horsehair lichen	OLYM	6	6	0
	Cladina	*C. arbuscula*	reindeer lichen	STLE, WRST	2	2	0
	Flavocetraria	*F. cucullata*	reindeer lichen	DENA, GAAR, KATM, NOAT, WRST	8	0	11
	Hypogymnia	*H. apinnata*	tube lichen	WRST	3	3	0
		H. physodes	tube lichen	GLAC, KATM, WRST	7	7	0
	Letharia	*L. columbiana*	wolf lichen	LAVO	1	1	0
		L. vulpina	wolf lichen	CRLA, GLAC, GRTE, LAVO, SEKI, YOSE	29	23	6
	Lobaria	*Lobaria oregana*	Oregon lung lichen	OLYM, STLE	4	4	0
	Masonhalea	*M. richardsonii*	Mason Hale's lichen	DENA, GAAR, NOAT	23	11	12
	Platismatia	*P. glauca*	ragged lichen	GLAC, GLBA, NOCA, OLYM, STLE, WRST	15	10	5
	Sphaerophorus	*S. globosus*	globe ball lichen	GLBA	2	2	0
	Thamnolia	*Thamnolia sp.*	whiteworm lichen	DENA	1	1	0
	Usnea	*Usnea spp.*	beard lichen	BAND, BIBE, GRTE	8	8	0
	Xanthoparmelia	*Xanthoparmelia spp.*	xanthoparmelia lichen	BAND, GRSA, ROMO, YOSE	8	5	3
Needles Count:	***5***		**19**		**157**	**0**	**0**
Lichens Count:	***13***		**16**		**143**	**94**	**52**
Total Count:	***19***		***36***		***300***	***94***	***52***

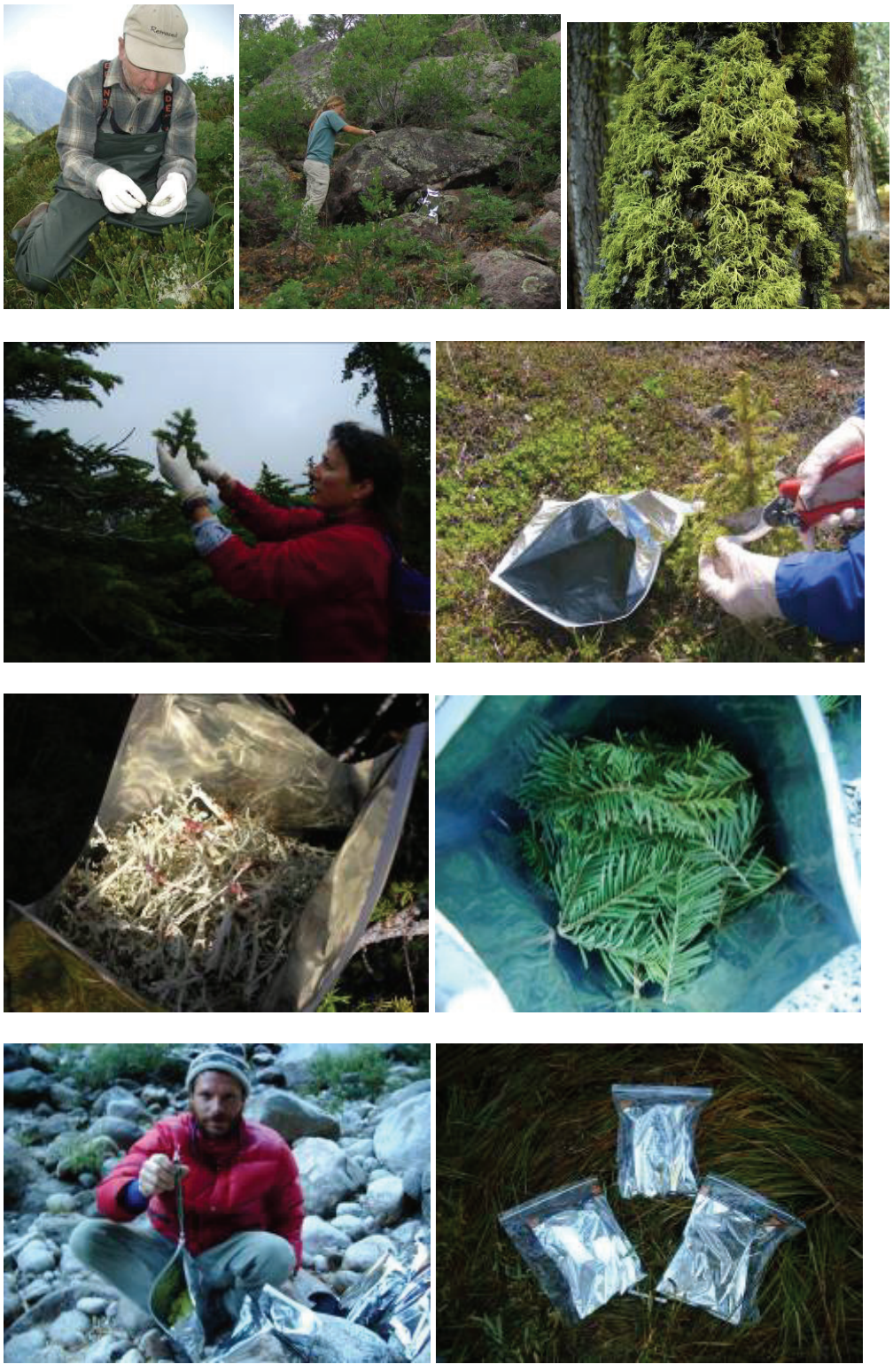

Figure 3B-1. Vegetation Sampling. First row: lichen sampling from tundra, rocks and trees; second row: conifer needle sampling from mid and alpine elevations; third row: lichen and conifer samples in Kapak bags; fourth row: weighing and sealing vegetation samples.

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for conifer needles are given in Table 3B-7 and for lichen in Table 3B-8.

Table 3B-7. SOC Recovery and EDLs in Conifer Needles Over the Entire Analytical Method.

	Local Conifer Needles[a]		EDL[b]		Local Conifer Needles[a]		EDL[b]
	Avg. % Rec	% RSD	ng/g dw		Avg. %Rec	%RSD	ng/g dw
Organochlorine Pesticides and Metabolites							
HCH, gamma[c]	79.1	1.7	1.9	Chlordane, cis	57.6	0.9	0.6
HCH, alpha[c]	80.2	2.1	1.5	p,p'-DDD[e]	71.7	4.8	6.0
HCH, beta[c]	74.8	1.3	1.7	Nonachlor, trans	58.9	3.1	0.2
HCH, delta[c]	91.5	2.1	3.1	o,p'-DDD[e]	71.8	0.5	5.4
Methoxychlor	84.9	2.4	5.3	Chlordane, trans	82.8	4.6	0.05
Heptachlor epoxide	75.4	6.7	1.2	Nonachlor, cis	30.5	1.8	0.1
Endrin aldehyde	24.6	3.7	0.9	Aldrin	72.6	3.8	2.2
Endrin	79.5	5.4	14.6	o,p'-DDT[f]	57.7	1.8	1.7
Heptachlor	85.6	3.2	3.3	p,p'-DDE[d]	81.1	1.2	1.8
o,p'-DDE[d]	67.0	1.0	3.6	Mirex	87.9	0.9	0.4
Chlordane, oxy	78.8	7.1	1.6	p,p'-DDT[f]	66.8	0.9	2.5
Dieldrin	75.1	9.5	5.8				
Organochlorine Sulfide Pesticides and Metabolites							
Endosulfan sulfate	80.6	4.6	0.6	Endosulfan II	63.8	1.0	0.7
Endosulfan I	62.4	2.6	0.2				
Phosphorothioate Pesticides							
Chlorpyrifos	68.8	0.6	0.4	Methyl parathion	51.1	44.4	72.3
Miscellaneous Pesticides							
Dacthal	83.2	3.9	0.1	Triallate	92.8	11.2	1.7
Hexachlorobenzene	71.0	1.5	0.0	Trifluralin	77.2	0.3	0.1
Polycyclic Aromatic Hydrocarbons							
Acenaphthylene	53.2	2.5	2.3	Benzo[a]anthracene	78.2	2.7	13.0
Acenaphthene	80.4	9.5	7.1	Benzo[k]fluoranthene (BkF)	71.9	2.7	6.5
Fluorene	66.3	10.7	3.2	Benzo[a]pyrene (BaP)	92.6	0.8	8.4
Anthracene	79.1	1.2	10.4	Benzo[b]fluoranthene (BbF)	76.3	2.9	7.9
Phenanthrene	51.2	5.8	4.8	Indeno[1,2,3-cd]pyrene (Ind)	84.3	1.0	16.4
Pyrene (Pyr)	79.7	3.1	0.6	Dibenz[a,h]anthracene	62.5	3.0	58.5
Fluoranthene (Fla)	85.6	5.3	3.7	Benzo[e]pyrene (BeP)	81.7	2.7	9.4
Chrysene/Triphenylene	86.6	2.3	4.3	Benzo[ghi]perylene (BghiP)	87.7	1.8	3.0
Polychlorinated Biphenyls							
PCB 74	97.3	2.3	16.7	PCB 118	89.2	0.8	0.2
PCB 101	81.3	2.4	2.2	PCB 187	85.7	0.9	0.04
PCB 138	78.8	1.9	0.2	PCB 183	79.8	1.1	0.04
PCB 153	81.2	1.7	0.05				
Averages, % RSD, and PD[c]							
average	73.2	3.7	5.7	max	97.3	44.4	72.3
				min	24.6	0.3	0.01

[a]Samples collected at Walnut Park located in Corvallis, OR, USA. Recoveries were corrected for background concentrations of SOCs in needles.
[b]Sample-specific estimated method detection limits calculated from a sample taken from Mount Rainier National Park. [c]Hexachlorocyclohexane.
[d]Dichlorodiphenyldichloroethylene. [e]Dichlorodiphenyldichloroethane. [f]Dichlorodiphenyltrichloroethane.

Table 3B-8. SOC Recovery and EDLs in Lichen Over the Entire Analytical Method.

	Wolverton Creek[a]		EDL[b]		Wolverton Creek[a]		EDL[b]
	Avg. % Rec	% RSD	ng/g lipid		Avg. %Rec	%RSD	ng/g lipid
Organochlorine Pesticides and Metabolites							
HCH, gamma[c]	73.8	5.6	1.0	Chlordane, cis	62.4	13.2	2.7
HCH, alpha[c]	81.6	4.8	0.9	p,p'-DDD[e]	76.8	7.2	5.3
HCH, beta[c]	80.9	0.6	1.9	Nonachlor, trans	56.9	16.8	0.4
HCH, delta[c]	88.9	6.5	1.0	o,p'-DDD[e]	79.5	0.7	7.3
Methoxychlor	71.3	28.4	7.3	Chlordane, trans	59.0	15.9	0.21
Heptachlor epoxide	58.7	13.2	4.6	Nonachlor, cis	31.3	6.8	0.2
Endrin aldehyde	52.0	9.7	0.5	Aldrin	76.0	4.0	2.6
Endrin	93.8	13.6	6.9	o,p'-DDT[f]	52.4	25.9	13.5
Heptachlor	81.8	3.3	1.5	p,p'-DDE[d]	77.3	1.6	6.4
o,p'-DDE[d]	68.0	1.0	7.1	Mirex	139.5	7.6	1.0
Chlordane, oxy	57.5	12.0	1.7	p,p'-DDT[f]	90.8	40.0	6.3
Dieldrin	120.4	10.0	8.0				
Organochlorine Sulfide Pesticides and Metabolites							
Endosulfan sulfate	38.4	22.6	0.4	Endosulfan II	64.8	5.9	0.2
Endosulfan I	62.0	10.9	1.1				
Phosphorothioate Pesticides							
Chlorpyrifos	92.7	1.6	0.2	Methyl parathion	80.0	3.7	54.3
Miscellaneous Pesticides							
Dacthal	68.6	20.0	0.2	Triallate	99.8	37.2	0.9
Hexachlorobenzene	72.8	1.7	0.01	Trifluralin	94.1	2.0	0.1
Polycyclic Aromatic Hydrocarbons							
Acenaphthylene	50.3	14.5	13.7	Benzo[a]anthracene	87.3	2.4	2.4
Acenaphthene	68.5	19.2	6.3	Benzo[k]fluoranthene (BkF)	54.8	87.3	9.2
Fluorene	74.6	6.2	2.7	Benzo[a]pyrene (BaP)	71.4	30.0	5.3
Anthracene	82.9	0.4	4.9	Benzo[b]fluoranthene (BbF)	55.7	90.5	9.1
Phenanthrene	67.1	17.8	2.3	Indeno[1,2,3-cd]pyrene (Ind)	82.4	2.9	5.9
Pyrene (Pyr)	75.5	2.0	1.7	Dibenz[a,h]anthracene	80.5	6.7	23.0
Fluoranthene (Fla)	77.7	2.8	1.7	Benzo[e]pyrene (BeP)	70.0	16.1	7.0
Chrysene/Triphenylene	87.6	1.3	1.8	Benzo[ghi]perylene (BghiP)	90.2	3.1	2.4
Polychlorinated Biphenyls							
PCB 74	89.0	2.3	9.1	PCB 118	89.9	0.8	0.3
PCB 101	77.3	2.0	3.7	PCB 187	75.7	4.5	0.11
PCB 138	76.2	5.6	0.2	PCB 183	75.9	10.7	0.09
PCB 153	75.5	3.3	0.12				
Averages and % RSD							
average	73.9	12.3	4.6	max	139.5	90.5	54.3
				min	31.3	0.4	0.01

[a]Samples collected at Wolverton Creek in Sequoia and Kings Canyon National Park, CA in 2003. Recoveries were corrected for background concentrations of SOCs in lichen. [b]Sample-specific estimated method detection limits calculated from a sample taken from Mount Rainier National Park. [c]Hexachlorocyclohexane. [d]Dichlorodiphenyldichloroethylene. [e]Dichlorodiphenyldichloroethane. [f]Dichlorodiphenyltrichloroethane.

Metals (Lichen)

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS National Research Program laboratory in Boulder, Colorado (see Table 3B-9), involves systematic analysis of blanks, replicates, standard reference materials, and spike addition samples. Standard Reference Materials used for the quality control of lichen analysis included Commission of European Communities CRM 482 Trace Elements in Lichen and International Atomic Energy Agency IAEA-336 Trace and Minor Elements in Lichen. Details, results and figures are described in the Quality Assurance/Quality Control Section of the database.

Table 3B-9. Metals and Detection Limits for Lichen Sample Analyses Performed at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations in dry weight, assuming a 0.2 g sample size (1:10 dilution).

Analyte	Units	Detection Limit	Analyte	Units	Detection Limit
Al	µg/g	< 1	Mn	µg/g	< 0.2
As	µg/g	< 0.05	Mo	µg/g	< 0.3
B	µg/g	<14	Na	Wt%	< 0.0008
Ba	µg/g	<0.03	Nd	µg/g	< 0.004
Be	µg/g	< 0.03	Ni	µg/g	< 0.1
Bi	µg/g	< 0.01	Pb	µg/g	< 0.04
Ca	Wt%	<0.001	Pr	µg/g	< 0.001
Cd	µg/g	< 0.01	Rb	µg/g	< 0.02
Ce	µg/g	< 0.001	Re	µg/g	< 0.002
Co	µg/g	< 0.01	Sb	µg/g	< 0.01
Cr	µg/g	< 0.5	Se	µg/g	< 0.2
Cs	µg/g	<2	Sm	µg/g	< 0.005
Cu	µg/g	< 0.1	Sr	µg/g	< 0.08
Dy	µg/g	< 0.003	Tb	µg/g	< 0.0007
Er	µg/g	< 0.004	Te	µg/g	< 0.04
Eu	µg/g	< 0.001	Tl	µg/g	< 0.02
Fe	µg/g	<20	Tm	µg/g	< 0.0007
Gd	µg/g	< 0.003	U	µg/g	< 0.004
Ho	µg/g	< 0.001	V	µg/g	< 0.1
K	Wt%	<0.006	W	µg/g	< 0.01
La	µg/g	< 0.001	Y	µg/g	< 0.001
Li	µg/g	< 0.04	Yb	µg/g	< 0.003
Lu	µg/g	< 0.0007	Zn	µg/g	< 0.9
Mg	Wt%	< 0.0003	Zr	µg/g	< 0.09

Nitrogen and Sulfur (Lichen)

As macronutrients, nitrogen and sulfur are used in relatively large quantities by lichens in cellular metabolism and in the production of biomolecules. Even in geographic areas with low nitrogen and sulfur deposition, these elements occur in relatively high concentrations in lichen thalli (~ 1 and 0.1 % dry weight, respectively), and therefore, compared to other contaminants analyzed by WACAP, their quantification is relatively easy. Four types of quality control checks were employed:

1. *Randomization of samples*. Samples were analyzed in random order before analysis to prevent unintentional bias within and between batches.
2. *Field triplicates*. Triplicate samples of each lichen species were collected at each collection site in the core parks as an indicator of error due to field methodology. Triplicate samples that are truly representative of the lichen population at a site will have low variability.
3. *Laboratory replicates*. Duplicate measurements were made of every 10^{th} sample to assess precision of laboratory measurements.
4. *Standard Reference Materials*. NIST 1515 Apple Leaves and NIST 1547 Peach Leaves to assess accuracy of laboratory measurements.
5. *Lichen reference materials*. A 1998 US Forest Service bulk collection of *Alectoria sarmentosa* from Willamette Pass, Oregon, dried, ground and stored in air tight container at UMRAL. This lichen has a relatively low N and S content compared to most lichen species and all NIST SRMS and therefore is more challenging to analyze. An aliquot of the bulk collection was analyzed every 10 samples to assess worst-case precision of laboratory measurements and to compare to laboratory performance to prior years.

Table 3B-10 shows that variability in N and S concentrations between sites (WACAP lichens), measured either as the standard deviation or as the size of the standard deviation relative to the mean (100* sd/mean), was greater than that of the field triplicates, which was in turn, greater than variability among laboratory and AlesarWIL replicates. Laboratory precision of nitrogen analyses was excellent, with most values for individual replicates falling within 1% of means; precision of sulfur analyses was good, most individual values were <5% of means. UMRAL measurements of NIST SRMs fell within certified ranges for N. UMRAL values were close to non-certified values for S (NIST does not certify means or ranges for S).

Table 3B-10. Statistical Summary of Quality Control Measures for Total Nitrogen and Sulfur (% dw) in Lichen Samples from the WACAP Core Parks.

Element	Material	Count	UMRAL Mean	UMRAL sd	100 * (sd/mean)	NIST Mean	NIST Certified Range
N	WACAP lichens	58	0.567	0.303	53.44	NA	NA
	Field triplicates	17	0.585	0.096	16.33	NA	NA
	Lab replicate pairs	5	0.456	0.003	0.76	NA	NA
	AlesarWIL	7	0.423	0.012	2.84	NA	NA
	NIST 1515	3	2.313	0.012	0.50	2.25	2.06-2.44
	NIST 1547	4	3.010	0.022	0.72	2.94	2.82-3.06
S	WACAP lichens	56	0.044	0.030	68.28	NA	NA
	Field triplicates	17	0.045	0.005	11.49	NA	NA
	Lab replicate pairs	8	0.028	0.001	4.57	NA	NA
	AlesarWIL	6	0.034	0.004	10.87	NA	NA
	NIST 1515	5	0.193	0.011	5.60	0.180	NA
	NIST 1547	5	0.163	0.019	11.54	0.200	NA

Lake Water QA/QC

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for water are given in Table 3B-11.

Table 3B-11. SOC Recovery and EDLs in Water Over the Entire Analytical Method (Usenko et al., 2005).

Chemical Class / Compounds	log K_{ow}	1 L RO Water[3] Avg. % Rec	1 L RO Water[3] % RSD	50 L RO Water[3] Avg. % Rec	50 L RO Water[3] % RSD
Amide Pesticides					
Propachlor[2]	2.4	110.2	7.0	111.3	1.9
Alachlor[2]	2.6	101.5	4.0	104.6	0.8
Acetochlor[2]	3.03[1]	96.9	2.9	102.4	2.7
Metolachlor[2]	3.1	109.9	4.8	114.7	1.0
Organochlorines Pesticides and Metabolites					
HCH, gamma[2,4]	3.8	99.2	3.5	103.5	1.0
HCH, alpha[2]	3.8	105.1	7.8	115.9	1.4
HCH, beta[2]	4.0	103.0	5.7	113.8	2.2
HCH, delta[2]	4.1	108.4	4.9	118.9	2.0
Methoxychlor[2]	4.5	127.7	21.3	158.8	2.4
Heptachlor epoxide[2]	4.6	57.5	19.2	72.1	6.3
Endrin aldehyde[2]	4.8	78.3	15.1	74.4	32.0
Endrin[2]	5.2	147.2	30.1	138.6	3.8
Heptachlor[2]	5.2	132.3	28.0	157.4	4.0
o,p'-DDE[2,5]	5.5	86.4	14.9	101.9	0.8
Chlordane, oxy[2]	5.5	55.1	21.7	71.8	4.2
Dieldrin[2]	5.5	100.8	12.6	74.5	3.5
Chlordane, cis[2]	5.9	44.5	18.4	60.6	3.3
p,p'-DDD[2,6]	5.9	105.1	20.8	122.0	3.7
Nonachlor, trans	6.1	49.4	14.1	66.3	2.6
o,p'-DDD[2]	6.1	91.5	18.3	110.1	2.0
Chlordane, trans	6.1	42.4	12.4	55.5	3.0
Nonachlor, cis[2]	6.4	62.5	18.8	75.7	1.4
Aldrin[2]	6.5	57.7	21.0	70.6	1.7
o,p'-DDT[7]	6.8	73.4	3.1	91.5	3.5
p,p'-DDE[2]	6.9	83.2	11.5	97.9	0.8
Mirex[2]	6.9	110.3	10.2	118.3	5.5
p,p'-DDT[2]	6.9	82.3	11.6	97.5	0.4
Organochlorine Sulfide Pesticides and Metabolites					
Endosulfan sulfate[2]	3.7	88.4	19.8	93.3	5.2
Endosulfan I[2]	4.7	55.8	17.8	69.0	6.8
Endosulfan II[2]	4.8	88.1	19.2	98.7	2.8
Phosphorothioate Pesticides					
Methyl parathion[2]	2.7	107.9	5.2	114.4	2.4
Malathion[2]	2.9	97.5	4.9	111.2	4.7
Diazinon[2]	3.7	100.9	9.5	114.5	3.0
Parathion[2]	3.8	97.3	7.3	106.1	4.1
Ethion[2]	5.1	99.6	24.4	115.4	3.8
Chlorpyrifos[2]	5.1	81.9	20.4	96.2	4.3
Thiocarbamate Pesticides					
EPTC[2]	3.2	100.6	1.3	104.2	1.9
Pebulate[2]	3.8	125.3	4.6	128.9	3.2
Triallate[2]	4.6	61.1	20.0	79.7	7.4
Triazine Herbicides and Metabolites					
Atrazine desisopropyl	1.36[1]	106.0	6.3	89.3	2.4
Atrazine desethyl	1.78[1]	62.8	7.3	82.8	2.7
Simazine[2]	2.2	115.2	3.6	117.8	0.6
Cyanazine[2]	2.2	60.5	10.9	62.7	4.6
Atrazine[2]	2.3	102.1	2.1	104.6	0.7
Prometon[2]	2.7	68.7	42.7	90.5	8.9
Miscellaneous Pesticides					
Metribuzin[2]	1.70[1]	86.3	14.7	96.1	4.3
Etridiazole[2]	2.6	124.6	4.1	127.7	2.0
Dacthal[2]	4.3	98.7	8.6	104.1	2.9
Trifluralin[2]	5.3	71.2	5.0	62.9	7.8
Hexachlorobenzene[2]	5.5	81.0	13.8	89.1	3.3
Polycyclic Aromatic Hydrocarbons					
Acenaphthylene[2]	3.9	60.3	9.0	63.8	10.9
Acenaphthene[2]	4.0	86.1	5.6	91.9	1.6
Fluorene[2]	4.2	96.9	0.4	102.2	2.5
Anthracene[2]	4.5	41.1	73.6	24.7	69.5
Phenanthrene	4.5	118.3	3.5	104.8	1.3
Pyrene[2]	5.1	84.5	8.6	89.3	1.3
Fluoranthene[2]	5.2	101.2	9.3	105.1	2.7
Chrysene + Triphenylene[2]	5.7	92.1	11.5	106.0	0.9
Benzo(a)anthracene[2]	5.9	76.7	22.3	76.8	20.1
Retene[2]	6.4	121.9	9.6	142.0	3.4
Benzo(k)fluoranthene[2]	6.5	84.6	11.8	100.8	5.3
Benzo(a)pyrene[2]	6.5	98.6	9.1	117.4	5.7
Benzo(b)fluoranthene[2]	6.6	99.9	14.2	117.2	7.4
Indeno(1,2,3-cd)pyrene[2]	6.7	87.9	15.7	103.4	0.5
Dibenz(a,h)anthracene[2]	6.8	102.4	9.4	113.2	2.7
Benzo(e)pyrene[2]	6.9	112.4	19.9	126.4	9.2
Benzo(ghi)perylene[2]	7.0	87.1	9.1	96.9	3.0
Polychlorinated Biphenyls					
PCB 74[2]	6.3	74.5	21.8	106.6	0.9
PCB 101[2]	6.4	66.2	22.3	95.1	1.2
PCB 138[2]	6.7	94.9	3.6	105.1	3.4
PCB 153[2]	6.9	99.3	4.3	110.0	3.5
PCB 118[2]	7.0	57.1	24.8	82.6	0.9
PCB 187[2]	7.2	80.5	5.3	88.5	3.5
PCB 183[2]	8.3	85.3	4.5	94.1	3.9
Average Recoveries and %RSD		89.4	13.1	99.0	4.8
Max		147.2	73.6	158.8	69.5
Min		41.1	0.4	24.7	0.4

[1]Estimated log Kow. [2]Recoveries not statistically different: two sided t-test ($p<0.01$). [3]Recoveries determined at 300 ng total of each compound (300 ng/L for 1 L experiment and 6 ng/L for 50 L experiment). [4]Hexachlorocyclohexane. [5]Dichlorodiphenyldichloroethylene. [6]Dichlorodiphenyldichloroethane. [7]Dichlorodiphenyltrichloroethane

Inorganic Compounds

Table 3B-12. Inorganic Lake Water Analytes, Methods, and Detection Limits

Analyte	Method[1]	Detection Limit[2]
Specific Conductance	EPA 120.6; USEPA (1987)	NA
Temperature	USEPA (1987)	NA
Dissolved Oxygen (DO)	USEPA (1987), YSI Model 6920 Datasonde	NA
Turbidity	YSI Model 6920 Datasonde	0.1 NTU
pH (syringe, closed system)	USEPA (1987)	NA
Acid Neutralizing Capacity (ANC)	EPA 310.1 (modified), USEPA (1987)	NA
Chlorophyll a	APHA (1989)	1 µg/L
Total Suspended Solids (Residue)	EPA 160.2; APHA (1989)	0.1 mg/L
True Color	APHA (1989), EPA 100.2 (modified), USEPA (1987)	NA
Dissolved Organic Carbon (DOC)	EPA 415.2, USEPA (1987)	0.1 mg/L
Dissolved Inorganic Carbon (DIC), syringe, closed system	USEPA (1987)	0.1 mg/L
Ammonium (NH_4)	Lachat 10-107-06-3-D	2 µg/L
Nitrate + Nitrite Nitrogen	EPA 353.2	1 µg/L
Silica (SiO2)	EPA 370.1 (modified), U.S. EPA (1987)	5 µg/L
Total Nitrogen (TN)	EPA 353.2 (modified), USEPA (1987)	10 µg/L
Total Phosphorus (TP)	EPA 365.1 (modified), USEPA (1987)	2 µg/L
Chloride (Cl)	EPA 300.6; USEPA (1987)	0.03 mg/L
Nitrate (NO_3)	EPA 300.6; USEPA (1987)	0.03 mg/L
Sulfate (SO_4)	EPA 300.6; USEPA (1987)	0.05 mg/L
Calcium (Ca)	EPA 215.1; USEPA (1987)	0.02 mg/L
Sodium (Na)	EPA 273.1; USEPA (1987)	0.02 mg/L
Potassium (K)	EPA 258.1; USEPA (1987)	0.04 mg/L
Magnesium (Mg)	EPA 242.1; USEPA (1987)	0.01 mg/L

[1] American Public Health Association. 1989. Standard Methods for the Examination of Water and Wastewater. Seventeenth Edition. American Public Health Association, Washington, D.C.

U.S. EPA. 1983. Methods for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory. EPA/600/4-79/020, U.S. Environmental Protection Agency, Office of Research and Development, Cincinnati.

U.S. EPA. 1987. Handbook of Methods for Acid Deposition Studies: Laboratory Analyses for Surface Water Chemistry. EPA 600/4-87/026. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

[2] The method detection limit is determined as a one-sided 99% confidence interval from repeated measurements of a low-level standard across several calibration curves.

Sediment QA/QC

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for sediment are given in Table 3B-13.

Table 3B-13. SOC Recovery and EDLs in Sediment Over the Entire Analytical Method.

	Waldo Lake[a]		EDL[b]	SRM1941b				Waldo Lake[a]		EDL[b]	SRM1941b		
	Avg. % Rec	% RSD	ng/g dw	ng/g dw	PD[c]	% RSD		Avg. %Rec	%RSD	ng/g dw	ng/g dw	PD[c]	% RSD
Amide Pesticides													
Propachlor	49.8	3.3	7.8				Acetochlor	46.1	9.3	9.3			
Alachlor	53.1	12.2	13.3				Metolachlor	58.6	12.2	14.2			
Organochlorine Pesticides and Metabolites													
HCH, gamma[d]	29.6	9.4	117.5				Chlordane, cis	45.7	14.7	18.4	0.7	10.0	29.5
HCH, alpha[d]	50.8	9.0	133.3				p,p'-DDD[f]	60.3	10.2	16.5	5.1	0.0	40.0
HCH, beta[d]	36.2	9.1	175.7				Nonachlor, trans	46.8	17.2	3.7	0.1	53.2	32.8
HCH, delta[d]	51.8	9.4	59.5				o,p'-DDD[f]	55.6	10.8	4.3	1.1		
Methoxychlor	67.4	14.8	18.6	1.0			Chlordane, trans	46.8	15.2	2.0	0.4	5.8	28.2
Heptachlor epoxide	46.8	13.8	89.4				Nonachlor, cis	53.6	13.0	1.5	0.1	55.4	24.2
Endrin aldehyde	51.8	7.9	19.6				Aldrin	29.0	12.5	83.2			
Endrin	70.4	11.5	204.7				o,p'-DDT[g]	44.4	12.0	23.6			
Heptachlor	32.5	12.4	111.9				p,p'-DDE[e]	55.9	12.7	3.4	3.1	0.0	15.8
o,p'-DDE[e]	57.7	11.2	11.3				Mirex	56.3	6.3	41.4			
Chlordane, oxy	43.7	14.8	12.2				p,p'-DDT[g]	54.7	13.5	37.9			
Dieldrin	74.0	13.1	114.8	0.3									
Organochlorine Sulfide Pesticides and Metabolites													
Endosulfan sulfate	61.4	9.6	4.4				Endosulfan II	58.5	10.3	9.0			
Endosulfan I	50.2	13.2	8.1										
Phosphorothioate Pesticides													
Methyl parathion	49.9	5.1	33.0				Parathion	54.0	6.5	15.7			
Malathion	48.3	7.9	65.8				Ethion	60.0	10.4	10.8			
Diazinon	47.9	5.4	5.1				Chlorpyrifos	45.3	9.7	1.2			
Triazine Herbicides and Metabolites													
Simazine	63.2	3.4	58.3				Atrazine	57.6	6.3	9.5			
Cyanazine	136.0	19.3	171.2										
Miscellaneous Pesticides													
Metribuzin	43.6	20.6	30.0				Dacthal	55.5	11.5	6.4			
Etridiazole	21.6	13.9	29.1				Trifluralin	32.9	10.8	1.7			
Triallate	41.1	8.6	24.2				Hexachlorobenzene	33.5	8.0	1.0	7.6	24.1	22.8
Polycyclic Aromatic Hydrocarbons													
Acenaphthylene	20.9	14.7	13.3	138.8			Benzo[a]anthracene	64.5	10.2	11.4	250.4	17.8	17.2
Acenaphthene	33.5	13.5	11.2	51.6			Benzo[k]fluoranthene (BkF)	68.5	10.0	3.3	205.6	0.6	21.6
Fluorene	25.5	12.7	7.2	59.2	12.7	22.3	Benzo[a]pyrene (BaP)	46.7	9.3	2.1	220.7	33.6	23.7
Anthracene	34.8	8.0	24.6	163.3	1.5	13.6	Benzo[b]fluoranthene (BbF)	64.8	9.5	4.0	468.2	0.0	18.7
Phenanthrene	26.0	20.0	13.0	382.6	0.0	18.6	Indeno[1,2,3-cd]pyrene (Ind)	60.1	9.5	29.0	239.9	12.9	17.3
Pyrene (Pyr)	50.6	5.7	1.0	402.8	24.0	22.1	Dibenz[a,h]anthracene	58.2	9.8	23.7	76.4	25.3	22.9
Fluoranthene (Fla)	50.5	5.1	1.1	442.6	24.3	20.8	Benzo[e]pyrene (BeP)	64.6	9.1	6.5	285.5	4.5	22.4
Chrysene/Triphenylene	59.9	9.2	0.8	171.2	48.1	22.3	Benzo[ghi]perylene (BghiP)	55.0	11.1	5.1	227.2	11.3	22.0
Polychlorinated Biphenyls													
PCB 101	70.7	14.2	129.1	4.1	13.2	29.9	PCB 118	74.2	11.6	10.2	3.3	17.2	34.5
PCB 138	74.9	11.7	9.7	4.3	12.3	30.4	PCB 187	76.1	13.1	3.9	2.0	0.0	22.1
PCB 153	73.2	11.8	3.5	4.0	21.6	20.1	PCB 183	76.5	13.1	3.7	0.7	23.0	20.4
Polybrominated Diphenyl Ethers													
BDE 7	58.6	3.0	0.2				BDE 85/155	73.0	2.0	1.8			
BDE 8	77.8	2.2	0.1				BDE 99	75.5	2.4	27.2	0.6		
BDE 10	42.7	6.9	0.2				BDE 100	74.1	2.3	9.4	0.9		
BDE 17	78.1	3.6	0.4				BDE 116	72.8	3.2	1.8			
BDE 25	83.3	3.3	0.8				BDE 118	76.5	4.8	15.1			
BDE 28	70.5	4.7	4.1				BDE 119	75.0	2.9	3.3			
BDE 30	70.6	3.9	0.6				BDE 126	69.2	1.7	2.1			
BDE 32	77.2	1.7	0.7				BDE 138	76.0	1.2	3.3			
BDE 35	82.6	3.2	0.7				BDE 153	76.7	1.3	26.0			
BDE 37	80.3	4.0	1.3				BDE 154	84.8	0.8	0.9			
BDE 49	69.4	5.4	1.3				BDE 155	101.6	0.9	15.6			
BDE 47	71.9	4.5	15.6	1.3			BDE 166	72.4	2.0	2.8			
BDE 66	75.2	5.1	0.6				BDE 181	99.9	2.3	5.8			
BDE 71	67.7	4.8	1.3				BDE 183	73.3	2.3	31.3			
BDE 75	70.0	5.4	4.9				BDE 190	104.4	2.1	5.7			
BDE 77	70.5	6.1	0.8										
Averages, % RSD, and PD[c]													
average	60.3	8.5	23.8	109.3	16.8	23.6	max	136.0	20.6	204.7	468.2	55.4	40.0
							min	20.9	0.8	0.1	0.1	0.0	13.6

[a]Recoveries validated at 26 ng/g wet wt and were corrected for background concentrations of SOCs in sediment. [b]Sample-specific estimated method detection limits. [c]Percent Difference from SRM 1941b certified values n=5. [d]Hexachlorocyclohexane. [e]Dichlorodiphenyldichloroethylene. [f]Dichlorodiphenyldichloroethane. [g]Dichlorodiphenyltrichloroethane.

Metals

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS National Research Program laboratory in Boulder, Colorado, involves systematic analysis of blanks, replicates, standard reference materials, and spike addition samples (see Table 3B-14). Standard reference materials used for the quality control of sediment analysis included National Institute of Standards and Technology SRM 2704 and 8704 Buffalo River Sediment; and SRM 2702 Inorganics in Marine Sediment. Details, results and figures are described in the Quality Assurance/Quality Control Section of the database.

Table 3B-14. Metals and Detection Limits for Sediment Sample Analyses Performed at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations in dry weight, assuming a 0.1-g sample size (1:10 dilution).

Analyte	Units	Detection Limit	Analyte	Units	Detection Limit
Al	Wt%	< 0.0008	Mo	µg/g	< 0.2
As	µg/g	< 0.07	Na	Wt%	< 0.003
B	µg/g	< 4	Nd	µg/g	< 0.01
Ba	µg/g	<0.08	Ni	µg/g	< 0.06
Be	µg/g	< 0.07	Pb	µg/g	< 0.03
Bi	µg/g	< 0.01	Pr	µg/g	< 0.002
Ca	Wt%	<0.002	Rb	µg/g	< 0.09
Cd	µg/g	< 0.01	Re	µg/g	< 0.003
Ce	µg/g	< 0.01	Sb	µg/g	< 0.01
Co	µg/g	< 0.01	Se	µg/g	< 0.6
Cr	µg/g	< 0.5	Sm	µg/g	< 0.009
Cs	µg/g	<0.02	Sr	µg/g	< 0.1
Cu	µg/g	< 0.1	Tb	µg/g	< 0.001
Dy	µg/g	< 0.005	Te	µg/g	< 0.05
Er	µg/g	< 0.007	Th	µg/g	< 0.01
Eu	µg/g	< 0.003	Ti	Wt%	<0.0001
Fe	Wt%	<0.009	Tl	µg/g	< 0.06
Ga	µg/g	< 0.01	Tm	µg/g	< 0.001
Gd	µg/g	< 0.005	U	µg/g	< 0.007
Ho	µg/g	< 0.002	V	µg/g	< 0.4
K	Wt%	<0.009	W	µg/g	< 0.01
La	µg/g	< 0.007	Y	µg/g	< 0.006
Li	µg/g	< 0.1	Yb	µg/g	< 0.004
Lu	µg/g	< 0.001	Zn	µg/g	< 0.7
Mg	Wt%	< 0.0005	Zr	µg/g	< 0.01
Mn	µg/g	< 0.1			

Fish QA/QC

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. The analyte recovery over the entire analytical method and the estimated method detection limits for fish are given in Table 3B-15.

Table 3B-15. SOC Recovery and EDLs in Fish Over the Entire Analytical Method.

Compounds	Log K_{ow}	Method Recovery[1] (%)		Estimated Method Detection Limit[2] (pg/g ww)		Determined Values for NIST SRM 1946 (ng/g ww)		Deviation from Certified Values[3]
		Avg.	SD	Avg.	%RSD	Avg.	%RSD	% Diff
HCH[4], gamma	3.8	38.2	1.6	17	7.5	1.0	46	0
HCH[4], alpha	3.8	37.6	1.6	0.2	8.1	5.4	6.5	0
HCH4, beta	4.0	44.3	1.7	7.8	1.7	0.46	34	
HCH4, delta	4.1	42.2	1.7	0.6	3.0			
Methoxychlor	4.5	62.1	1.8	99	73			
Heptachlor epoxide	4.6	33.6	2.0	14	2.2	5.3	1.1	0
Endrin	5.2	89.1	2.2	170	26	4.7	0.22	
Heptachlor	5.2	48.5	1.3	1.6	1.42	0.38	37	
Hexachlorobenzene	5.5	37.8	1.9	5.0	1.9	6.6	2.7	0
o,p'-DDE[5]	5.5	53.8	2.1	58	23	0.91	15	0
Chlordane, oxy	5.5	35.1	1.9	5.5	1.9	16	7.9	15
Dieldrin	5.5	95.3	3.6	8.4	21	34	4.8	0
Chlordane, cis	5.9	32.6	1.0	16	6.8	31	8.9	0
p,p'-DDD[6]	5.9	67.8	1.0	99	39	12	9.0	30
Nonachlor, trans	6.1	32.0	1.0	2.9	1.3	90	7.1	9.5
o,p'-DDD6	6.1	55.2	2.1	68	16	1.8	25	17
Chlordane, trans	6.1	31.4	1.0	1.6	0.96	9.7	66	16
Nonachlor, cis	6.4	40.3	1.5	5.0	1.0	49	5.9	16
Aldrin	6.5	39.4	1.6	21	3.5			
o,p'-DDT[7]	6.8	61.1	4.8	97	63	16	20	28
p,p'-DDE[5]	6.9	63.7	4.7	98	12	350	9.3	0
Mirex	6.9	54.0	3.3	6.8	1.5	6.1	3.2	0
p,p'-DDT[7]	6.9	68.1	2.1	94	50	34	6.1	0
Endosulfan sulfate	3.7	46.4	4.0	3.7	0.83	0.44	12	
Endosulfan I	4.7	36.0	3.2	4.9	2.46	0.10	10	
Endosulfan II	4.8	49.0	3.5	8.9	5.8			
Parathion	3.8	44.4	9.6	9.1	1.0			
Ethion	5.1	48.8	10.5	1.9	2.59			
Chlorpyrifos	5.1	45.5	8.9	5.5	0.88			
Etridiazole	2.6	34.8	1.8	15	2.2			

Table 3B-15. SOC Recovery and EDLs in Fish Over the Entire Analytical Method.

Compounds	Log K_{ow}	Method Recovery[1] (%)		Estimated Method Detection Limit[2] (pg/g ww)		Determined Values for NIST SRM 1946 (ng/g ww)		Deviation from Certified Values[3]
		Avg.	SD	Avg.	%RSD	Avg.	%RSD	% Diff
Dacthal	4.3	62.2	2.2	2.6	1.6	4.6	11	
Triallate	4.6	88.0	2.3	11	1.80			
Trifluralin	5.3	42.9	3.4	7.2	0.89			
PCB 74	6.3	78.9	1.2	48	15	4.1	20	15
PCB 101	6.4	66.5	4.5	1.1	2.6	28	29	20
PCB 138	6.7	77.3	5.7	2.6	2.9	134	33	21
PCB 153	6.9	65.0	4.6	2.2	0.87	110	30	0
PCB 118	7.0	74.5	6.1	2.2	0.96	51	6.2	0
PCB 183	8.3	75.9	5.3	0.84	3.7	23	8.6	0
PCB 187	7.2	77.3	5.0	1.4	2.2	54	13	0
Average	6.1	61.4	4.1	79	11	30	15	7
Min	2.6	31.4	0.3	0.2	0.83	0.10	0.22	0
Max	9.4	98.3	12	920	86	350	66	30
Polycyclic Aromatic Hydrocarbons								
Acenaphthylene	3.9	36.0	2.5	38	4.1			
Acenaphthene	4.0	54.4	5.5	50	2.5			
Fluorene	4.2	41.7	1.6	16	1.7			
Anthracene	4.5	51.8	5.4	59	6.8			
Phenanthrene	4.5	56.3	3.8	56	10			
Pyrene	5.1	63.7	5.4	6.7	3.5			
Fluoranthene	5.2	58.4	4.0	7.6	1.8			
Chrysene /Triphenylene	5.7	59.3	0.9	20	12			
Benzo(a)anthracene	5.9	59.4	2.3	26	0.96			
Retene	6.4	55.3	5.8	44	14			
Benzo(k)fluoranthene	6.5	64.6	0.3	23	0.9			
Benzo(a)pyrene	6.5	43.4	5.2	17	1.7			
Benzo(b)fluoranthene	6.6	64.4	0.9	20	1.6			
Indeno(1,,3-cd)pyrene	6.7	60.5	0.3	18	3.33			
Dibenz(a,h)anthracene	6.8	58.0	1.6	19	8.9			
Benzo(e)pyrene	6.9	57.8	0.7	100	34			
Benzo(ghi)perylene	7.0	60.1	0.7	6.3	1.3			
PolyBrominated Diphenyl Ethers[8]								
BDE 10	5.0	64.2	6.4	920	26			
BDE 7	5.0	49.7	2.4	120	43			
BDE 8	5.0	52.0	5.3	710	23			
BDE 12	5.8	45.2	2.3	880	18			

Table 3B-15. SOC Recovery and EDLs in Fish Over the Entire Analytical Method.

Compounds	Log K_{ow}	Method Recovery[1] (%)		Estimated Method Detection Limit[2] (pg/g ww)		Determined Values for NIST SRM 1946 (ng/g ww)		Deviation from Certified Values[3]
		Avg.	SD	Avg.	%RSD	Avg.	%RSD	% Diff
BDE 13	5.8	50.4	2.7	910	21			
BDE 15	5.8	82.2	6.3	860	15			
BDE 30	5.9	47.2	6.6	240	37			
BDE 32	5.9	46.9	2.2	38	7.6			
BDE 17	5.8	55.7	2.4	32	8.4			
BDE 25	5.9	55.9	2.3	43	7.1			
BDE 28	5.9	51.1	2.1	23	2.8	0.94	1.9	26
BDE 35	6.7	52.6	2.0	57	3.8			
BDE 37	6.7	52.3	2.1	40	8.1			
BDE 75	6.8	86.9	6.7	24	5.3			
BDE 49	6.8	94.1	7.1	30	3.6			
BDE 71	6.8	84.8	5.2	22	1.9			
BDE 47	6.8	91.1	7.5	14	1.1	29	10	0
BDE 66	6.8	83.6	8.5	120	26			n/a[9]
BDE 77	7.6	93.6	8.0	83	24			
BDE 100	7.7	79.0	8.4	6.7	1.1	8.4	2.7	0
BDE 119	7.7	78.9	7.2	19	14			
BDE 99	7.7	85.7	6.3	23	1.95	18	5.4	0
BDE 116	7.7	75.6	7.9	91	48			
BDE 85/155	7.7 / 8.6	91.8	8.3	37	10			
BDE 126	8.5	88.6	9.2	36	9.2			
BDE 118	7.7	75.0	11.9	200	86			
BDE 155	8.6	80.8	7.0	2.3	1.0	0.68	11	
BDE 154	8.6	79.7	7.4	8.3	2.7	6.2	18	0
BDE 153	8.6	78.6	6.7	6.5	3.1	2.9	9.3	0
BDE 138	8.6	81.6	7.1	1.1	1.1			
BDE 166	8.6	98.3	7.8	1.9	1.7			
BDE 183	9.4	81.5	5.8	1.6	0.95	0.23	14	
BDE 181	9.4	76.8	4.1	3.5	3.14			
BDE 190	9.4	72.4	5.0	5.0	2.5			

[1] Triplicate recoveries across entire method of ~8 ng/g ww tissue spikes. Blank and sample background corrected.

[2] 3:1 S:N of IS normalized response factors in three separate fish from Denali, Sequoia, and Rocky Mountain National Parks according to EPA Method 8280A

[3] Percentage difference between this method and NIST certified values for SRM # 1946 LakeTrout, 0% difference when method average is within certified confidence interval, n=5

Table 3B-15. SOC Recovery and EDLs in Fish Over the Entire Analytical Method.

Compounds	Log K_{ow}	Method Recovery[1] (%)		Estimated Method Detection Limit[2] (pg/g ww)		Determined Values for NIST SRM 1946 (ng/g ww)		Deviation from Certified Values[3]
		Avg.	SD	Avg.	%RSD	Avg.	%RSD	% Diff

[4] HexachloroCycloHexane

[5] DichloroDiphenyldichloroEthylene

[6] DichloroDiphenylDichloroethane

[7] DichloroDiphenylTrichloroethane

[8] Log K_{ow} Estimated by EPI Suite

[9] Interferant prohibited quantitation

Blank Cells indicate no certified, or refernce value for the SRM, and/or not detected here.

Metals

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS National Research Program Laboratory in Boulder, Colorado, involves systematic analysis of blanks, replicates, standard reference materials, and spike addition samples (see Tables 3B-16 and 3B-17). Standard Reference Materials used for the quality control of fish tissue analysis included National Research Council of Canada SRM DOLT-1 Dogfish Liver, DORM-1 Dogfish Muscle, TORT-1 Lobster hepatopancreas, and National Institute of Standards and Technology Standard Reference Materials SRM 2976 Bivalve Tissue. Details, results and figures are described in the Quality Assurance/Quality Control Section of the database.

Table 3B-16. Metals and Detection Limits for Fish Fillet Tissue Analyses Performed at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations in dry weight, assuming a 0.2-g sample size (1:2 dilution).

Analyte	Units	Detection Limit
Al	µg/g	< 0.9
As	µg/g	< 0.03
B	µg/g	<1
Ba	µg/g	<0.008
Be	µg/g	< 0.02
Bi	µg/g	< 0.002
Ca	Wt%	<0.0008
Cd	µg/g	< 0.005
Ce	µg/g	< 0.001
Co	µg/g	< 0.009
Cr	µg/g	< 0.3
Cs	µg/g	<0.02
Cu	µg/g	< 0.03
Dy	µg/g	< 0.002
Er	µg/g	< 0.002
Eu	µg/g	< 0.0005
Fe	µg/g	<11
Gd	µg/g	< 0.001
Ho	µg/g	< 0.0003
K	Wt%	<0.002
La	µg/g	< 0.0006
Li	µg/g	< 0.03
Lu	µg/g	< 0.0004
Mg	Wt%	< 0.0008

Analyte	Units	Detection Limit
Mn	µg/g	< 0.2
Mo	µg/g	< 0..02
Na	Wt%	< 0.002
Nd	µg/g	< 0.001
Ni	µg/g	< 0.05
Pb	µg/g	< 0.01
Pr	µg/g	< 0.0003
Rb	µg/g	< 0.007
Re	µg/g	< 0.0009
Sb	µg/g	< 0.003
Se	µg/g	< 0.2
Sm	µg/g	< 0.001
Sr	µg/g	< 0.03
Tb	µg/g	< 0.0002
Te	µg/g	< 0.01
Tl	µg/g	< 0.006
Tm	µg/g	< 0.0004
U	µg/g	< 0.0009
V	µg/g	< 0.05
W	µg/g	< 0.001
Y	µg/g	< 0.0003
Yb	µg/g	< 0.009
Zn	µg/g	< 0.4
Zr	µg/g	< 0.002

Table 3B-17. Metals and Detection Limits for Fish Liver Tissue Analyses Performed at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations in dry weight, assuming a 0.1-g sample size (1:2 dilution).

Analyte	Units	Detection Limit	Analyte	Units	Detection Limit
Al	µg/g	< 0.6	Mn	µg/g	< 0.5
As	µg/g	< 0.1	Mo	µg/g	< 0..04
B	µg/g	<5	Na	Wt%	< 0.004
Ba	µg/g	<0.03	Nd	µg/g	< 0.002
Be	µg/g	< 0.02	Ni	µg/g	< 0.06
Bi	µg/g	< 0.005	Pb	µg/g	< 0.009
Ca	Wt%	<0.003	Pr	µg/g	< 0.0005
Cd	µg/g	< 0.01	Rb	µg/g	< 0.01
Ce	µg/g	< 0.002	Re	µg/g	< 0.001
Co	µg/g	< 0.01	Sb	µg/g	< 0.005
Cr	µg/g	< 0.4	Se	µg/g	< 0.3
Cs	µg/g	<0.1	Sm	µg/g	< 0.003
Cu	µg/g	< 0.1	Sr	µg/g	< 0.04
Dy	µg/g	< 0.002	Tb	µg/g	< 0.0005
Er	µg/g	< 0.003	Te	µg/g	< 0.02
Eu	µg/g	< 0.0009	Tl	µg/g	< 0.03
Fe	µg/g	<16	Tm	µg/g	< 0.0004
Gd	µg/g	< 0.002	U	µg/g	< 0.001
Ho	µg/g	< 0.0005	V	µg/g	< 0.05
K	Wt%	<0.004	W	µg/g	< 0.004
La	µg/g	< 0.0008	Y	µg/g	< 0.0006
Li	µg/g	< 0.04	Yb	µg/g	< 0.002
Lu	µg/g	< 0.0005	Zn	µg/g	< 0.5
Mg	Wt%	< 0.001	Zr	µg/g	< 0.01

Moose QA/QC

SOCs

Detailed laboratory QA/QC procedures for SOCs are specified in the WACAP QAPP. Because so few moose samples were analyzed for SOCs, detailed recovery and estimated method detection limits experiments for moose were not conducted. However, the SOC recoveries and estimated method detection limits were similar to those for fish (see Table 3B-15).

Metals

Detailed laboratory QA/QC procedures are specified in the WACAP QAPP. Quality control at the USGS National Research Program laboratory in Boulder, Colorado, involves systematic analysis of blanks, replicates, standard reference materials, and spike addition samples (see Table 3B-18). Standard reference materials used for the quality control of moose tissue analysis included National Institute of Standards and Technology SRM 8414 Bovine Muscle Powder and SRM 1577b Bovine Liver. Details, results, and figures are described in the Quality Assurance/Quality Control Section of the database.

Table 3B-18. Metals and Detection Limits for Moose Tissue Analyses Performed at the USGS National Research Program Laboratory, Boulder, Colorado. Concentrations in dry weight, assuming a 0.2-g sample size (1:2 dilution).

Analyte	Units	Detection Limit	Analyte	Units	Detection Limit
Al	µg/g	< 7	Mn	µg/g	< 0.03
As	µg/g	< 0.007	Mo	µg/g	< 0..006
B	µg/g	<9	Na	Wt%	< 0.0002
Ba	µg/g	<0.03	Nd	µg/g	< 0.0006
Be	µg/g	< 0.006	Ni	µg/g	< 0.03
Bi	µg/g	< 0.004	Pb	µg/g	< 0.006
Ca	Wt%	<0.001	Pr	µg/g	< 0.0002
Cd	µg/g	< 0.004	Rb	µg/g	< 0.003
Ce	µg/g	< 0.002	Re	µg/g	< 0.0004
Co	µg/g	< 0.004	Sb	µg/g	< 0.01
Cr	µg/g	< 0.04	Se	µg/g	< 0.04
Cs	µg/g	<03	Sm	µg/g	< 0.0003
Cu	µg/g	< 0.02	Sr	µg/g	< 0.01
Dy	µg/g	< 0.0003	Tb	µg/g	< 0.0001
Er	µg/g	< 0.0004	Te	µg/g	< 0.006
Eu	µg/g	< 0.0002	Tl	µg/g	< 0.003
Fe	µg/g	<1	Tm	µg/g	< 0.0001
Gd	µg/g	< 0.0005	U	µg/g	< 0.0001
Ho	µg/g	< 0.0001	V	µg/g	< 0.005
K	Wt%	<0.0005	W	µg/g	< 0.003

Analyte	Units	Detection Limit
La	µg/g	< 0.0008
Li	µg/g	< 0.009
Lu	µg/g	< 0.0001
Mg	Wt%	< 0.002

Analyte	Units	Detection Limit
Y	µg/g	< 0.0003
Yb	µg/g	< 0.0003
Zn	µg/g	< 0.9
Zr	µg/g	< 0.002