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Environmental Contaminant Surveys in Three National Wildlife Refuges in Wyoming

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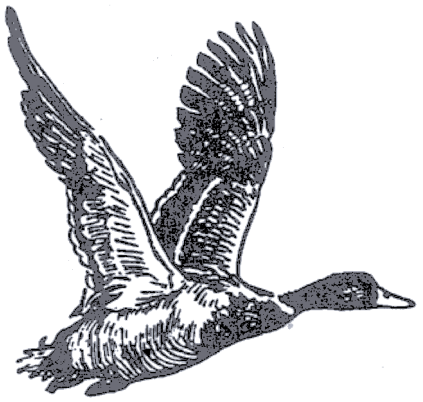
U.S. FISH & WILDLIFE SERVICE
REGION 6

CONTAMINANTS PROGRAM

ENVIRONMENTAL CONTAMINANT SURVEYS IN THREE NATIONAL WILDLIFE REFUGES IN WYOMING

By
Pedro Ramirez, Jr. and Joni Armstrong



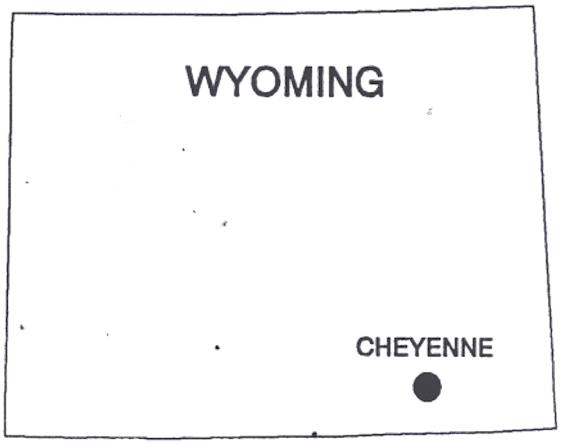


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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Environmental contaminants surveys were conducted at National Elk, Seedskadee, and Hutton Lake National Wildlife Refuges (NWR) to provide information on existing conditions to identify potential habitat quality problems, and to determine if non-point sources of pollution may be affecting the refuges. Pondweed (Potamogeton spp.) samples from Hutton, Rush, and Creighton Lakes and Lake George at Hutton Lake NWR and Hay Farm Pond at Seedskadee NWR had boron concentrations greater than 300 ug/g dry weight, the level suspected of causing reduced growth in mallard ducklings (Eisler 1990). The source of the boron is unknown. One pondweed sample from Flat Creek at the National Elk Refuge had a selenium concentration of 3.2 ug/g dry weight, slightly above the 3 ug/g level of concern for bioaccumulation in fish and wildlife recommended by Lemly and Smith (1987). The source is unknown, but runoff from the adjacent highway may account for the selenium. Continued monitoring of boron and selenium concentrations in aquatic vegetation and aquatic invertebrates is recommended for Seedskadee, Hutton Lake and National Elk NWR's. Specific sites in need of monitoring include: Lake George and Creighton Lake at Hutton Lake, Flat Creek adjacent to U.S. Highway 89 at the National Elk Refuge, and Hay Farm Pond at Seedskadee NWR.

INTRODUCTION

Environmenta contaminants are a major issue of concern on national wildlife refuges. The 90-million acre National Wildlife Refuge (NWR) System managed by the U.S. Fish and Wildlife Service (Service) has served as a barometer of environmental contaminant problems in fish and wildlife resources. The System is a network of over 650 refuges and waterfowl production areas. effects of selenium contamination and the problems associated with irrigation drainwater were first documented at Kesterson NWR in California. Nationwide, refuges are threatened by aerial drift of pesticides, pesticide-laden agricultural runoff, trace elements, oil and hazardous materials spills, and hazardous waste sites. National Wildlife Refuges in Wyoming are: National Elk, Seedskadee, Hutton Lake, Bamforth, and Pathfinder. Environmental contaminants surveys were conducted at National Elk, Seedskadee, and Hutton Lake NWR to provide information on existing conditions to identify potential habitat quality problems, and to determine if non-point sources of pollution may be affecting the refuges (Figure 1).

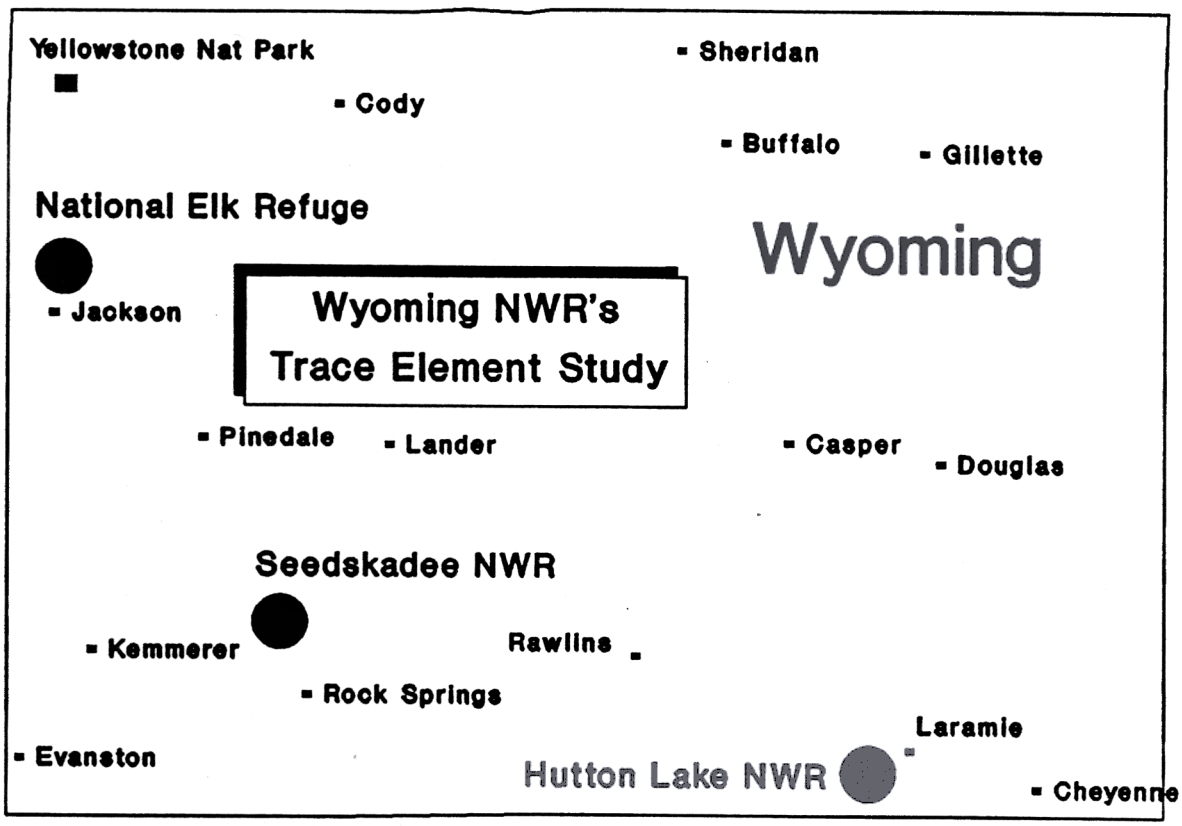

Figure 1. Location of the National Elk Refuge and the Seedskadee and Hutton Lake National Wildlife Refuges, Wyoming.

STUDY AREA DESCRIPTION

Hutton Lake NWR, in Albany County, was established in 1932 for the conservation of migratory birds. The refuge is underlain by the Frontier Formation, a sandy shale and sandstone formation (Love and Christiansen 1985). The 1,428 acre refuge contains Hutton, Hoge, Rush, Creighton and George Lakes. Livestock grazing is the major land use in areas surrounding the refuge.

The 24,663 acre National Elk Refuge, in Teton County immediately north of Jackson, has provided wintering habitat for elk (Cervus elaphus) since 1912. refuge also contains wetlands along Flat Creek and the Gros Ventre River. major land uses in areas surrounding the refuge include: residential/urban, outdoor recreation, and ivestock grazing.

Seedskadee NWR is located in Sweetwater County approximately 20 miles north of Green River. The refuge encompasses 14,842 acres of riparian and upland habitat along the Green River. The refuge was established in 1965 to mitigate for wildlife habitat losses resulting from the construction of Fontenelle and Flaming Gorge reservoirs and to provide habitat for migratory birds. The refuge is underlain by the Bridger Formation of sandstone, claystone and conglomerate (Love and Christiansen 1985). The major land uses in the surrounding areas include: oil and gas exploration and development, trona (soda ash) and coal mining, ivestock grazing, and outdoor recreation.

METHODS

Water, sediment and biota were collected at the National Elk Refuge and Seedskadee National Wildlife Refuge (NWR) in 1988 and 1989 (Figures 2 & 3). Water, sediment and biota were collected at Hutton Lake NWR in 1990 (Figure 4). Water and sediment were also collected from the following sites adjacent to the National Elk Refuge to determine f non-point sources are contributing pollutants into the refuge: Cache Creek approximately one mile upstream from Jackson; a small canal adjacent to Broadway Street in Jackson; the outfal from the Jackson National Fish Hatchery; and a culvert conveying runoff from a car wash onto the highway right-of-way and possibly the refuge.

Water was collected in 1,000-ml chemically-clean polyethylene jars. The pH in the water samples was lowered to 2.0 using nitric acid. Sediment was collected using an Ekman dredge or a stainless steel spoon. The samples were placed in chemically-clean 500-ml glass jars and frozen. Pondweed (Potamogeton spp.) leaves and stems were collected by hand. Detritus and sediment were washed off, and the samples were placed in Whirl-Pak bags and frozen. Aquatic invertebrates were collected using a light trap, as described by Espinosa et al. (1972). The invertebrates were placed in chemically-clean 40-ml glass vials, and frozen. Aquatic invertebrates collected included: waterboatmen (Family Corixidae), damselfly larvae (Order Odonata), amphipods (Order Amphipoda) and copepods (Class Copepoda). Birds were collected with a shotgun using steel shot. The livers were removed and placed in chemically-clean glass jars and frozen. All samples were submitted to one of the following laboratories under contract with the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF): Hazelton

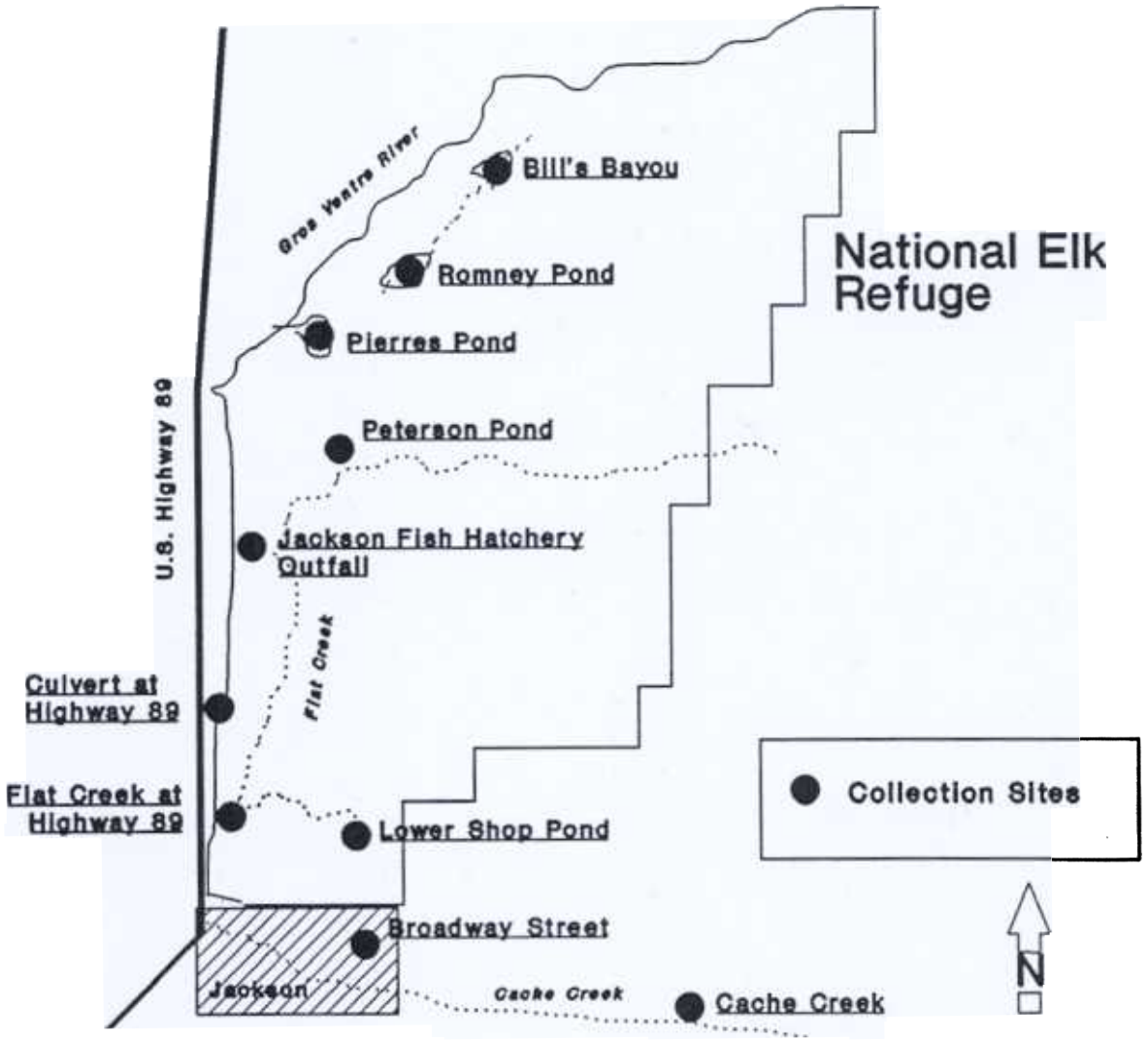

Figure 2. Collection sites for water, sediment and biota from the National Elk Refuge, Teton County, Wyoming.

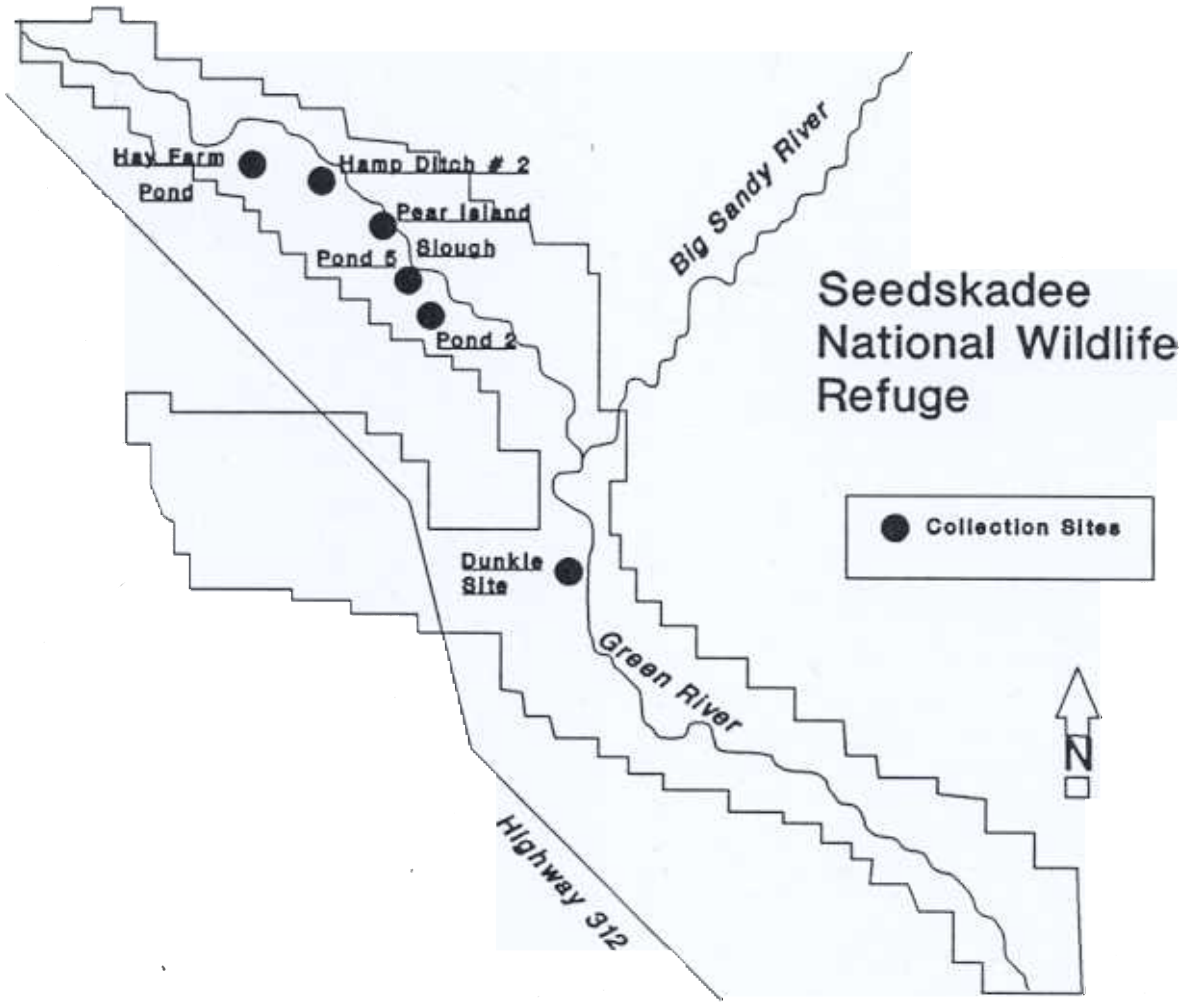

Figure 3. Collection sites for water, sediment and biota at Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming.

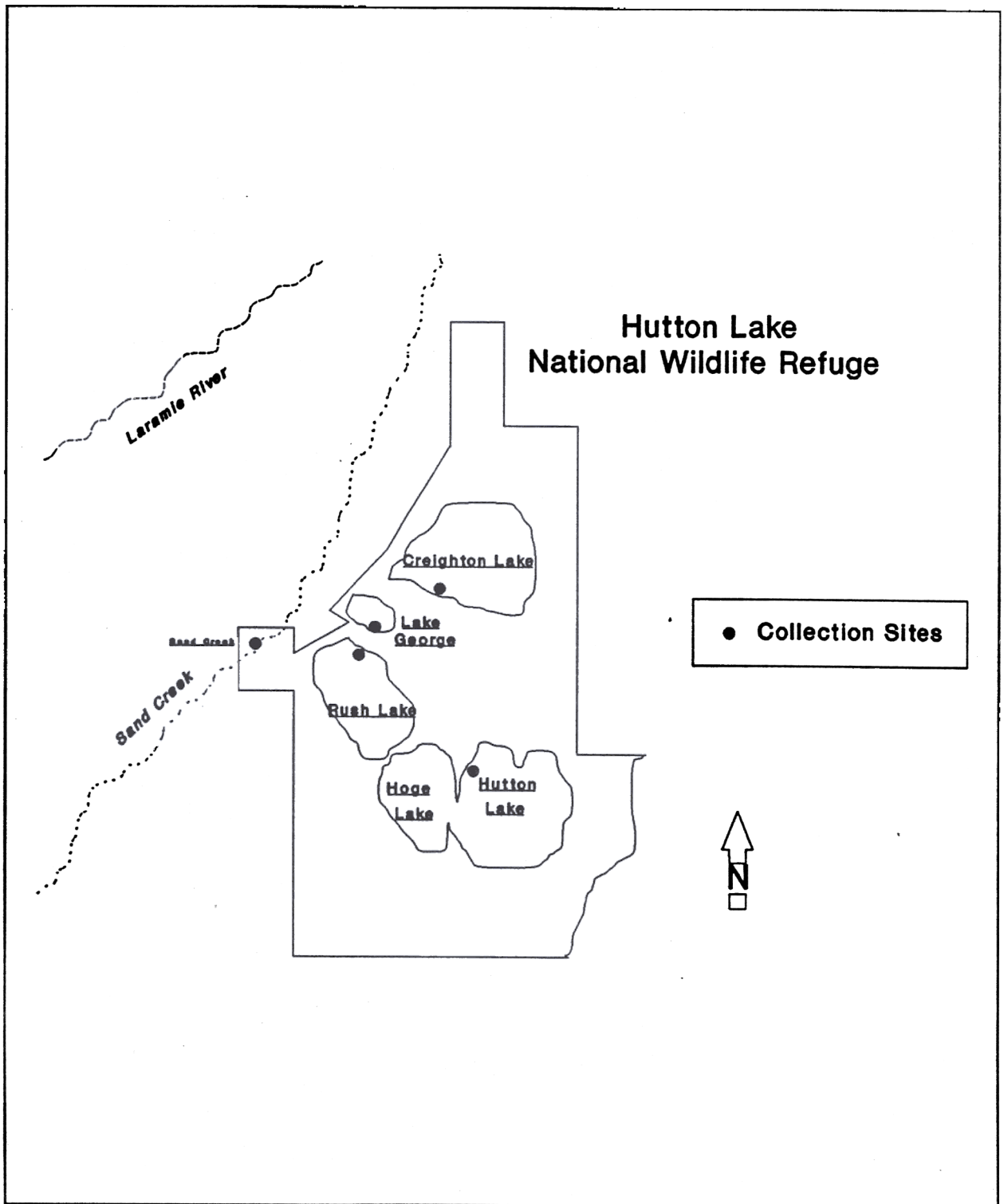

Figure 4. Collection sites for water, sediment and biota samples from Hutton Lake National Wildlife Refuge, Albany County, Wyoming.

Laboratories America, Inc., Wisconsin; Environmental Trace Substances Research Center, Missouri; and Research Triangle Institute, North Carolina; for trace element analyses. The laboratories analyzed for mercury using cold vapor atomic absorption spectroscopy, hydride generation atomic absorption (AA) spectroscopy for arsenic and selenium, and inductively coupled plasma atomic emission spectrophotometer (ICP) scans for all other trace elements. PACF assured laboratory quality control. Laboratories confirm the precision and accuracy of the analyses for the Service with procedural blanks, duplicate analyses, test recoveries of spiked materials, and reference material analyses. All Service contaminants analyses received a PACF quality assurance review. The primary method used to assess accuracy was percent recovery of spiked analyte PACF compared the recovery reported to all other samples submitted to a laboratory for analyses to the average recovery for that laboratory and analyte If the reported recoveries were within the 95 % confidence interval for the mean recovery, PACF considered the accuracy of the analysis acceptable. Besides spike recoveries, the laboratories usually analyzed standard reference materials, PACF compared results from these determinations to both the laboratory average and the certified value. PACF considered accuracy for all sample analyses for this study acceptable. Laboratories reported percent moisture and dry weight concentrations.

Trace element concentrations in sediments were compared to background levels reported for soils from the western United States and the Northern Great Plains by Harms et al. (1990).

RESULTS AND DISCUSSION

Hutton Lake NWR

Analytical results from water, sediment and biota collected at Hutton Lake NWR are presented in Appendix A. Trace elements in water were not present in concentrations considered adverse to fish and wildlife. Trace elements in sediments collected at the refuge were present at background levels, with the exception of aluminum. Aluminum concentrations in sediment from Hutton Lake and Sand Creek were 22,400 and 28,100 ug/g dry weight, respectively. Background concentrations of aluminum reported for soils from the Northern Great Plains region range from 3,400 ug/g to 12,000 ug/g dry weight (Harms et al. 1991).

Pondweed samples from Hutton, Rush, and Creighton Lakes and Lake George had boron concentrations greater than 300 ug/g dry weight, the level suspected of causing reduced growth in mallard ducklings (Eisler 1990). The elevated boron concentrations in pondweed may be attributable to natural occurrences of this element in the Frontier Formation. One pondweed sample collected from Lake George had a mercury concentration of 1.009 ug/g dry weight (0.11 ug/g wet weight). Adverse reproductive effects in birds have been reported at mercury concentrations of 0.05 to 0.1 ug/g wet weight in the diet (Eisler 1987). The source of the mercury is unknown although mercury was not detected in four other pondweed samples collected at this site. An aquatic invertebrate sample collected from Lake George had a selenium concentration of 5.45 ug/g dry weight, above the 3 ug/g level of concern for bioaccumulation in fish and wildlife recommended by Lemly and Smith (1987). Other trace elements in aquatic vegetation and aquatic invertebrates were not elevated

National Elk Refuge

Analytical results from water, sediment and biota collected at the National Elk Refuge are presented in Appendix B. The following trace elements were present below detection limits in all water samples collected from the National Elk Refuge: antimony, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, tin and vanadium. The EPA criterion for the protection of freshwater aquatic life is more than 87 ug/ of aluminum, not more than once every three years when the pH is between 6.5 and 9.0 (EPA 1988). A water sample collected from Cache Creek had an aluminum concentration of 1010 ug/l. Additional monitoring is needed to determine if the aluminum concentration in water at Cache Creek exceeds 87 ug/l more than once in a three-year period. Concentrations of all other trace elements were below the EPA criteria for the protection of freshwater aquatic life.

Lead concentrations were below detection levels in all matrices except sediments and soils. Soil collected at a site adjacent to a culvert on Highway 89 had the highest lead concentrations (211 and 303 ug/g dry weight). The culvert conveys runoff from a car wash near the highway and discharges water onto the highway right-of-way adjacent to the refuge. Increased lead concentrations in soils from highway right-of-ways result from the exhaust of automobiles burning gasoline with lead additives (Eisler 1988). Aluminum and cadmium in the soil sample were above background levels reported by Harms et al. (1990). Although present above background concentrations, aluminum and cadmium were not at levels known to adversely affect fish and wildlife

The 3.2 ug/g selenium concentration in a pondweed sample from Flat Creek was slightly above the 3 ug/g level of concern for bioaccumulation in fish and wildlife recommended by Lemly and Smith (1987). The source is unknown, but runoff from the adjacent highway may account for the selenium.

An adult green-winged teal collected at the refuge had a selenium concentration in the liver of 31 ug/g dry weight. A 25 ug/g concentration is suspected of causing adverse reproductive effects in waterfowl (U.S. Fish and Wildlife Service 1990). However, the teal was capable of flight, so the elevated selenium concentration cannot be attributed directly to the refuge. Other trace elements in aquatic vegetation and bird livers were present in concentrations not considered adverse to fish and wildlife.

Seedskadee NWR

Analytical results from water, sediment and biota collected at Seedskadee NWR are presented in Appendix C. Trace element concentrations in all matrices analyzed were below levels known to cause adverse effects to fish and wildlife, with the exception of boron. Trace elements in sediments were at or below the background levels reported by Harms et al. (1990). Boron concentrations in three pondweed samples from the Hay Farm Pond at Seedskadee NWR exceeded the 300 ug/g dry weight level suspected to cause reduced growth in mallard ducklings (Eisler 1990). The source of the boron is unknown. Atmospheric deposition from coal-fired power plants may be a possible source

MANAGEMENT RECOMMENDATIONS

Continued monitoring of boron and selenium concentrations in aquatic vegetation and aquatic invertebrates is recommended for Seedskadee, Hutton Lake and National Elk NWR's. A biomonitoring plan for the BEST (Biomonitoring Environmental Status and Trends) Program has been developed for Seedskadee. Specific sites in need of monitoring within these refuges include: Lake George and Creighton Lake at Hutton Lake NWR, Flat Creek adjacent to U.S. Highway 89 at the National Elk Refuge, and Hay Farm Pond at Seedskadee NWR

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Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
			Creighton Lake				
	Water	100.0	0.0060	<0.0004	<0.0010	<0.025	0.190
	Water	100.0	0.0160	<0.0004	<0.0010	<0.025	0.500
Potamogeton	Plant	83.9	2.6100	<0.1550	<0.6200	<3.110	144.100
Potamogeton	Plant	83.7	2.3300	<0.1530	<0.6100	<3.070	245.400
			Hutton Lake				
	Water	100.0	0.0061	0.0004	0.0004	<0.020	1.400
	Sediment	46.0	5.7000	0.0300	0.8600	<2.000	22400.000
Potamogeton	Plant	88.5	1.6500	<0.2170	<0.8700	<4.350	233.910
Potamogeton	Plant	88.0	2.0800	<0.2080	<0.8300	<4.170	272.500
			Rush Lake				
	Water	100.0	0.0043	<0.0004	0.0005	<0.020	0.600
	Sediment	34.2	1.4000	<0.0200	0.3000	<2.000	4810.000
Potamogeton	Plant	90.3	<1.0300	<0.2580	1.5500	<5.150	389.690
Potamogeton	Plant	90.6	<1.0600	<0.2660	<1.0600	<5.320	230.850
Aquatic Invertebrate		87.4	0.7900	0.5240	1.7500	<3.970	51.590
Aquatic Invertebrate		89.7	0.9700	0.5440	1.8400	<4.850	48.540
Aquatic Invertebrate		90.1	<1.0100	0.6060	2.2200	<5.050	79.800
Aquatic Invertebrate		87.9	<0.8300	0.3720	1.5700	<4.130	54.550
Aquatic Invertebrate		88.1	<0.8400	0.4030	1.4300	<4.200	52.100
Canada Goose	Egg	68.5	<0.1000	0.0200	1.0000	<2.000	<3.000
Canada Goose	Egg	66.1	<0.1000	0.0090	1.2000	<2.000	<3.000
Canada Goose	Egg	64.5	<0.1000	<0.0070	0.9400	<2.000	<3.000
			Sand Creek				
	Sediment	50.8	2.5000	<0.0200	1.1000	<2.000	28100.000
	Water	100.0	0.0007	<0.0004	0.0006	<0.020	0.140

Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
			Lake George				
	Sediment	37.4	1.3700	<0.0400	2.0800	<3.990	2603.830
Potamogeton	Plant	88.7	3.1000	<0.2210	<0.8800	<4.420	98.230
Potamogeton	Plant	89.4	2.5500	1.0090	1.1300	<4.720	62.260
Potamogeton	Plant	87.6	1.1300	<0.2020	<0.8100	<4.030	76.610
Potamogeton	Plant	85.8	1.5500	<0.1760	<0.7000	<3.520	221.830
Canada Goose	Egg	65.8	<0.1000	0.0070	1.5000	<2.000	<3.000
Potamogeton	Plant	90.3	2.6800	<0.2580	<1.0300	<5.150	37.110
Algae	Plant	88.7	2.4800	<0.2210	1.0600	<4.420	376.990
Algae	Plant	93.2	13.9700	<0.3680	1.9100	<7.350	482.350
Aquatic Invertebrate		87.0	<0.7700	0.6310	1.6900	<3.850	152.310
Aquatic Invertebrate		86.0	3.3600	0.2640	1.0000	<3.570	305.000
Aquatic Invertebrate		84.4	1.6700	0.1990	5.4500	<3.210	70.510

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
			Creighton Lake				
	Water	3.900	0.400	<0.003	<0.003	<0.005	<0.013
	Water	3.770	0.380	<0.003	<0.003	<0.005	<0.013
Potamogeton	Plant	391.300	5.470	<0.310	<0.310	0.750	5.590
Potamogeton	Plant	407.980	6.870	<0.310	<0.310	0.920	4.600
			Hutton Lake				
	Water	1.300	0.035	<0.001	<0.002	0.020	0.004
	Sediment	21.000	200.000	1.300	<0.200	23.000	16.000
Potamogeton	Plant	672.170	19.570	<0.430	<0.430	0.960	5.040
Potamogeton	Plant	677.500	20.670	<0.420	<0.420	1.250	4.250
			Rush Lake				
	Water	0.640	0.034	<0.001	<0.002	0.010	<0.003
	Sediment	10.000	225.000	0.330	<0.200	6.400	3.000
Potamogeton	Plant	559.790	16.800	<0.520	<0.520	<1.030	9.790
Potamogeton	Plant	592.550	11.810	<0.530	<0.530	1.490	7.870
Aquatic Invertebrate		12.300	<3.970	<0.400	<0.400	2.220	12.860
Aquatic Invertebrate		16.120	<4.850	<0.490	<0.490	2.430	12.720
Aquatic Invertebrate		12.530	<5.050	<0.510	<0.510	1.920	12.530

Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
			Rush Lake				
Aquatic Invertebrate		11.320	<4.130	<0.410	<0.410	1.820	9.590
Aquatic Invertebrate		10.840	<4.200	<0.420	<0.420	1.430	10.920
Canada Goose	Egg	<2.0000	3.900	<0.090	<0.200	<0.900	3.400
Canada Goose	Egg	<2.0000	1.400	<0.100	<0.200	<1.000	3.100
Canada Goose	Egg	<2.0000	2.300	<0.100	<0.200	<1.000	2.300
			Sand Creek				
	Sediment	26.000	204.000	1.400	<0.200	34.000	14.000
	Water	0.100	0.045	<0.001	<0.002	<0.010	<0.002
			Lake George				
	Sediment	16.770	23.320	<0.400	0.880	3.190	44.570
Potamogeton	Plant	820.350	14.160	<0.440	<0.440	0.970	6.020
Potamogeton	Plant	735.850	6.600	<0.470	<0.470	1.230	5.570
Potamogeton	Plant	491.940	16.290	<0.400	<0.400	0.970	4.600
Potamogeton	Plant	430.990	32.540	<0.350	<0.350	1.200	4.790
Canada Goose	Egg	<2.000	4.600	<0.090	<0.200	<0.900	2.900
Potamogeton	Plant	773.200	7.840	<0.520	<0.520	1.030	9.590
Algae	Plant	81.060	10.090	<0.440	<0.440	1.150	6.110
Algae	Plant	522.060	20.290	<0.740	0.740	<1.470	6.180
Aquatic Invertebrate		14.460	<3.850	<0.380	<0.380	1.460	32.850
Aquatic Invertebrate		13.290	10.570	<0.360	<0.360	2.140	57.430
Aquatic Invertebrate		9.040	6.090	<0.320	<0.320	1.220	36.730

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
			Creighton Lake				
	Water	<0.075	<1430.00	<0.049	<0.025	<0.02	<0.015
	Water	<0.080	1450.00	0.062	<0.029	<0.02	<0.015
Potamogeton	Plant	387.580	14161.48	274.530	<3.110	3.42	<1.860
Potamogeton	Plant	717.790	11779.14	400.610	4.050	2.64	2.640

Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
			Hutton Lake				
	Water	1.740	781.00	1.090	<0.010	<0.01	<0.040
	Sediment	14900.000	7370.00	209.000	<2.000	19.00	16.000
Potamogeton	Plant	709.570	15913.04	661.740	<4.350	<3.48	3.040
Potamogeton	Plant	858.330	16416.66	727.500	<4.170	<3.33	3.170
			Rush Lake				
	Water	<0.710	513.00	0.495	<0.01	<0.01	<0.040
	Sediment	3690.000	2730.00	164.000	<1.000	4.60	<40.000
Potamogeton	Plant	1350.520	10927.84	490.720	<5.150	<4.12	3.200
Potamogeton	Plant	760.640	10851.07	506.380	<5.320	<4.26	<3.190
Aquatic Invertebrate		198.410	2246.03	21.190	<3.970	<3.17	2.780
Aquatic Invertebrate		233.010	2485.44	22.230	<4.850	<3.88	5.530
Aquatic Invertebrate		251.520	1909.09	22.630	<5.050	<4.04	5.350
Aquatic Invertebrate		190.910	1776.86	22.070	<4.130	<3.31	<2.480
Aquatic Invertebrate		178.990	2084.03	26.300	<4.200	<3.36	5.040
Canada Goose	Egg	119.000	363.00	1.200	<1.000	<1.00	<40.000
Canada Goose	Egg	114.000	431.00	1.800	<1.000	<1.00	<40.000
Canada Goose	Egg	121.000	385.00	2.400	<1.000	<1.00	<40.000
			Sand Creek				
	Sediment	18400.000	9320.00	247.000	<2.000	17.00	15.000
	Water	<0.380	60.40	0.052	<0.010	<0.01	<0.040
			Lake George				
	Sediment	3929.710	1789.14	75.080	<3.990	3.35	3.430
Potamogeton	Plant	248.670	18849.55	661.060	<4.420	<3.54	<2.650
Potamogeton	Plant	173.580	17735.84	488.680	<4.720	<3.77	<2.830
Potamogeton	Plant	250.810	10887.10	1250.000	<4.030	<3.23	<2.420
Potamogeton	Plant	415.490	12464.79	1809.860	<3.520	<2.82	<2.110
Canada Goose	Egg	128.000	427.00	4.400	<1.000	<1.00	<4.000
Potamogeton	Plant	147.420	18041.24	476.290	<5.150	<4.12	<3.090
Algae	Plant	790.270	4734.51	589.380	<4.420	<3.54	<2.650
Algae	Plant	1455.880	17499.99	4191.170	<7.350	<5.88	<4.410

Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
			Lake George				
Aquatic Invertebrate		240.770	3292.31	53.920	<3.850	<3.08	4.850
Aquatic Invertebrate		298.570	4742.86	68.640	<3.570	<2.86	<2.140
Aquatic Invertebrate		83.330	2961.54	43.780	<3.210	<2.56	3.590

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
			Creighton Lake				
	Water	<0.500	<0.025	28.30	<0.10	<0.025	0.019
	Water	<0.500	<0.025	26.70	<0.10	<0.025	0.053
Potamogeton	Plant	<6.210	<3.110	888.20	<12.42	<3.110	23.290
Potamogeton	Plant	<6.130	<3.070	522.70	<12.27	<3.070	19.140
			Hutton Lake				
	Water	NA	NA	15.20	<0.04	0.004	<0.005
	Sediment	NA	NA	444.00	<40.00	32.300	58.000
Potamogeton	Plant	<8.700	<4.350	1052.17	<17.39	<4.350	21.300
Potamogeton	Plant	<8.330	<4.170	1100.00	<16.67	<4.170	21.330
			Rush Lake				
	Water	NA	NA	10.80	<0.040	0.004	<0.004
	Sediment	NA	NA	350.00	<40.00	9.700	14.000
Potamogeton	Plant	<10.310	<5.150	655.67	<20.62	<5.150	35.670
Potamogeton	Plant	<10.640	<5.320	673.40	<21.28	<5.320	39.260
Aquatic Invertebrate		<7.940	<3.970	79.29	<15.87	<3.970	91.270
Aquatic Invertebrate		<9.710	14.370	86.50	<19.42	<4.850	89.900
Aquatic Invertebrate		<10.100	<5.050	70.10	<20.20	<5.050	94.040
Aquatic Invertebrate		<8.260	<4.130	68.18	<16.53	<4.130	77.850
Aquatic Invertebrate		<8.400	14.370	81.26	<16.81	<4.200	76.970
Canada Goose	Egg	NA	NA	13.80	<40.00	<0.300	57.800
Canada Goose	Egg	NA	NA	12.80	<40.00	<0.300	51.800
Canada Goose	Egg	NA	NA	16.00	<40.00	<0.300	55.400
			Sand Creek				
	Sediment	0.000	0.000	215.00	<40.00	49.100	58.500
	Water	0.000	0.000	3.34	<0.040	0.004	<0.003

Appendix A. Trace element concentrations in water, sediment and biota from Hutton Lake National Wildlife Refuge, Albany County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
			Lake George				
	Sediment	<7.990	<3.990	153.83	38.500	6.870	14.700
Potamogeton	Plant	<8.850	<4.420	784.96	<17.70	<4.420	25.750
Potamogeton	Plant	<9.430	<4.720	402.83	<18.87	<4.720	26.130
Potamogeton	Plant	<8.060	20.320	935.48	<12.27	<4.030	18.230
Potamogeton	Plant	<7.040	<3.520	1746.48	<14.08	<3.520	19.370
Canada Goose	Egg	NA	NA	17.00	< 4.00	<0.300	58.700
Potamogeton	Plant	<10.310	<5.150	435.05	<20.62	<5.150	23.090
Algae	Plant	<8.850	<4.420	361.95	<17.70	<4.420	12.570
Algae	Plant	<14.710	<7.350	651.47	<29.41	<7.350	14.120
Aquatic Invertebrate		<7.690	<3.850	213.85	<15.38	<3.850	115.380
Aquatic Invertebrate		<7.140	17.000	1664.29	<14.29	<3.570	87.140
Aquatic Invertebrate		<6.410	17.440	929.49	<12.82	<3.210	60.640

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
			Broadway Street Site - Jackson, WY				
	Water	100.0	0.001	<0.004	<0.001	<0.025	<0.050
	Sediment	41.6	7.700	0.084	1.400	<4.280	9930.000
	Sediment	44.9	9.600	0.085	1.100	<4.540	15700.000
			Cache Creek - Jackson, WY				
	Water	100.0	<0.001	<0.004	<0.001	<0.025	1.010
	Sediment	30.1	7.900	0.043	<0.140	<3.580	8090.000
	Sediment	37.3	8.000	0.075	1.600	<3.990	9080.000
			Culvert/Highway 89 near Refuge				
	Sediment	43.4	21.700	0.152	0.530	<4.420	21900.000
	Sediment	40.6	29.500	0.202	1.700	<6.350	40400.000
			Flat Creek at Highway 89				
	Sediment	65.2	19.000	<0.072	1.700	<7.180	12400.000
	Sediment	80.5	19.000	<0.128	3.100	<12.800	14400.000
Potamogeton	Plant	96.6	3.200	<0.806	3.200	<16.100	700.000
Potamogeton	Plant	97.9	<4.800	<1.190	<4.800	<23.800	410.000
			Jackson Fish Hatchery Outfall				
	Sediment	44.3	9.000	<0.045	1.100	<4.349	12300.000
	Sediment	44.1	8.600	<0.045	0.720	<4.470	12500.000
	Water	100.0	0.012	<0.004	<0.001	<0.025	0.065
			Lower Shop Pond at Refuge				
	Water	100.0	<0.001	<0.004	<0.001	<0.025	<0.050
	Sediment	56.1	12.100	<0.057	0.910	<5.690	13000.000
	Sediment	42.7	11.000	<0.044	0.350	<4.360	12100.000
Potamogeton	Plant	93.2	4.400	<0.368	<1.500	<7.350	613.000
Potamogeton	Plant	95.5	11.100	<0.556	2.200	<11.100	1340.000

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis]

Aquatic Birds Collected at the National Elk Refuge - 1988

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
Green-winged Teal	Liver	75.0	<0.100	0.490	4.400	<2.000	<3.000
American Coot	Liver	77.7	0.300	NA	6.800	<2.000	<3.000
American Coot	Liver	76.2	0.300	0.230	5.300	<2.000	<3.000
Green-winged Teal	Liver	70.0	<0.100	1.300	31.000	<2.000	11.000
	Various Ponds Within the National Elk Refuge						
Bill's Bayou	Sediment	27.5	1.890	<0.020	0.366	<10.000	33200.000
Peterson Pond	Sediment	11.0	4.380	<0.020	<0.620	<10.000	10200.000
Pierres Pond	Sediment	39.4	1.980	<0.020	<0.300	<10.000	18500.000
Pierres Pond/Potamogeton	Plant	75.6	1.580	<0.030	<0.600	<10.000	524.000
Romney Pond	Sediment	39.8	8.740	0.033	1.120	<10.000	28300.000
	Flat Creek Wetlands at the National Elk Refuge						
	Sediment	54.9	3.200	0.040	1.100	<2.000	9270.000
	Sediment	48.7	4.100	0.040	0.950	<2.000	11500.000
	Sediment	84.7	7.000	0.040	3.300	<2.000	8040.000
	Sediment	81.8	7.400	0.048	2.600	<2.000	8340.000

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
	Broadway Street Site - Jackson, WY						
	Water	<0.025	0.053	<0.003	<0.003	<0.005	<0.013
	Sediment	13.800	88.400	0.680	1.030	14.200	12.300
	Sediment	45.300	116.000	0.820	1.000	22.500	13.100
	Cache Creek - Jackson, WY						
	Water	<0.025	0.058	<0.003	<0.003	<0.005	<0.013
	Sediment	16.700	77.500	0.430	0.500	11.200	8.080
	Sediment	11.200	87.900	0.480	0.640	12.500	9.090
	Culvert/Highway 89 near Refuge						
	Sediment	67.500	397.000	1.410	9.450	40.100	162.000
	Sediment	204.000	810.000	2.030	10.400	55.100	156.000

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
		Flat Creek at Highway 89					
	Sediment	1110.000	109.000	1.010	3.740	19.300	14.400
	Sediment	104.000	108.000	<1.280	1.790	20.000	18.700
Potamogeton	Plant	28.400	81.600	<1.610	<1.610	<3.230	12.900
Potamogeton	Plant	31.000	84.800	<2.380	<2.380	<4.760	12.900
		Jackson Fish Hatchery Outfall					
	Sediment	37.500	229.000	0.900	0.540	17.200	14.000
	Sediment	29.500	215.000	0.890	0.720	17.900	12.800
	Water	0.038	0.058	<0.003	<0.003	<0.005	<0.013
		Lower Shop Pond at Refuge					
	Water	0.051	<0.025	<0.003	<0.003	<0.005	<0.013
	Sediment	39.500	159.000	1.030	1.140	16.300	13.100
	Sediment	42.900	188.000	0.790	0.790	14.400	10.700
Potamogeton	Plant	162.000	281.000	<0.740	<0.740	2.350	5.880
Potamogeton	Plant	22.400	162.000	<1.110	<1.110	<2.220	6.220
		Aquatic Birds Collected at the National Elk Refuge					
Green-winged Teal	Liver	<3.000	<0.100	<0.100	<0.300	2.000	20.000
American Coot	Liver	<2.000	0.100	<0.100	<0.300	2.000	25.500
American Coot	Liver	<2.000	0.100	<0.100	<0.300	1.000	27.500
Green-winged Teal	Liver	<2.000	<0.100	<0.100	1.400	2.000	111.000
		Various Ponds Within the National Elk Refuge					
Bill's Bayou	Sediment	30.400	440.000	1.050	<25.000	29.800	7.570
Peterson Pond	Sediment	38.000	307.000	0.926	<25.000	26.000	10.500
Pierres Pond	Sediment	38.400	337.000	1.300	<25.000	14.200	7.140
Pierres Pond/Potamogeton	Plant	183.000	109.000	<0.200	<0.700	<3.000	4.710
Romney Pond	Sediment	32.600	340.000	1.090	<25.000	21.800	10.900

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
		Flat Creek Wetlands at the National Elk Refuge					
	Sediment	4.000	98.900	0.680	0.500	18.000	8.900
	Sediment	5.000	114.000	0.780	0.600	19.000	13.000
	Sediment	8.000	133.000	0.450	1.100	23.000	11.000
	Sediment	10.000	117.000	0.480	0.840	21.000	16.000

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
		Broadway Street Site - Jackson, WY					
	Water	0.860	13.0	0.020	<0.025	<0.02	<0.015
	Sediment	10200.000	9130.0	177.000	<4.280	10.20	10.900
	Sediment	13200.000	13700.0	236.000	<4.540	13.20	7.620
		Cache Creek - Jackson, WY					
	Water	0.935	13.7	0.030	<0.025	0.025	<0.015
	Sediment	8350.000	9020.0	159.000	<3.580	8.23	5.580
	Sediment	9900.000	12800.0	196.000	<3.990	10.40	6.300
		Culvert/Highway 89 near Refuge					
	Sediment	20700.000	14900.0	417.000	<4.420	31.20	211.000
	Sediment	32000.000	36600.0	870.000	<6.350	53.70	303.000
		Flat Creek at Highway 89					
	Sediment	13400.000	15100.0	156.000	<7.180	14.90	32.300
	Sediment	13500.000	16000.0	105.000	<12.800	13.10	67.200
Potamogeton	Plant	1940.000	6320.0	1850.000	<16.100	<12.90	<9.680
Potamogeton	Plant	1930.000	7330.0	1920.000	<23.800	<19.00	<14.300
		Jackson Fish Hatchery Outfall					
	Sediment	10100.000	26200.0	344.000	<4.490	8.98	7.630
	Sediment	10200.000	24900.0	282.000	<4.470	10.30	9.210
	Water	<0.050	16.9	<0.006	<0.025	<0.02	<0.015

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
		Lower Shop Pond at Refuge					
	Water	<0.050	31.8	0.013	<0.025	<0.02	<0.015
	Sediment	9880.000	20300.0	373.000	<5.690	9.23	6.950
	Sediment	9130.000	26500.0	333.000	<4.360	8.81	7.070
		Lower Shop Pond at Refuge					
Potamogeton	Plant	878.000	9040.0	374.000	<7.350	<5.88	<4.410
Potamogeton	Plant	1940.000	9560.0	524.000	<11.100	<8.89	<6.670
		Aquatic Birds Collected at the National Elk Refuge					
Green-winged Teal	Liver	288.000	1110.0	0.600	<1.000	<2.00	<4.000
American Coot	Liver	1050.000	827.0	9.200	2.000	<2.00	<4.000
American Coot	Liver	496.000	850.0	10.000	2.000	<2.00	<4.000
Green-winged Teal	Liver	1520.000	724.0	14.000	3.000	<2.00	<4.000
		Various Ponds Within the National Elk Refuge					
Bill's Bayou	Sediment	13600.000	9660.0	412.000	<5.000	12.00	9.620
Peterson Pond	Sediment	12400.000	1790.0	432.000	<5.000	9.93	15.300
Pierres Pond	Sediment	12800.000	4720.0	308.000	<5.000	6.51	17.500
Pierres Pond/Potamogeton	Plant	423.000	3810.0	37.100	<7.500	<4.00	<7.000
Romney Pond	Sediment	12900.000	5830.0	177.000	<5.000	10.70	14.600
		Flat Creek Wetlands at the National Elk Refuge					
	Sediment	9660.000	17500.0	129.000	<2.000	9.20	<10.000
	Sediment	11000.000	16600.0	149.000	<2.000	10.00	13.000
	Sediment	12500.000	7360.0	99.800	<2.000	7.20	25.000
	Sediment	10500.000	10500.0	88.700	<2.000	8.60	21.000

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
		Broadway Street Site - Jackson, WY					
	Water	<0.05	<0.025	0.084	<0.1	<0.025	0.022
	Sediment	<8.56	<4.280	30.700	<17.1	21.300	209.000
	Sediment	<9.07	<4.540	40.300	<18.1	32.300	244.000

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
			Cache Creek - Jackson, WY				
	Water	<0.05	<0.025	0.090	<0.1	<0.025	0.021
	Sediment	<7.15	<3.580	25.000	<14.3	18.600	46.100
	Sediment	<7.97	<3.990	32.000	<15.9	20.300	59.300
			Culvert/Highway 89 near Refuge				
	Sediment	<8.83	<4.420	63.500	<17.7	41.600	1920.000
	Sediment	<12.70	<6.350	135.000	<25.4	72.700	734.000
			Flat Creek at Highway 89				
	Sediment	<14.40	<7.180	70.700	<28.7	26.400	95.400
	Sediment	<25.60	<12.800	72.100	<51.3	30.500	101.000
Potamogeton	Plant	<32.30	<16.100	59.400	<64.5	<16.100	84.500
Potamogeton	Plant	<47.60	<23.800	63.800	<95.2	<23.800	113.000
			Jackson Fish Hatchery Outfall				
	Sediment	<8.98	<4.490	142.000	<18.0	24.600	56.600
	Sediment	<8.94	<4.470	137.000	<17.9	24.200	46.000
	Water	<0.05	<0.025	0.092	<0.1	<0.025	0.023
			Lower Shop Pond at Refuge				
	Water	<0.05	<0.025	0.328	<0.1	<0.025	0.023
	Sediment	<11.40	<5.690	225.000	<22.8	30.800	59.800
	Sediment	<8.73	<4.360	328.000	<17.5	25.800	52.500
Potamogeton	Plant	<14.70	<7.350	243.000	<29.4	<7.350	33.800
Potamogeton	Plant	<22.20	<11.100	480.000	<44.4	<11.100	27.100
			Aquatic Birds Collected at the National Elk Refuge				
Green-winged Teal	Liver	NA	NA	<0.100	<5.0	<0.600	26.000
American Coot	Liver	NA	NA	1.100	<5.0	<0.600	109.000
American Coot	Liver	NA	NA	0.870	<4.0	<0.500	103.000
Green-winged Teal	Liver	NA	NA	<0.100	<5.0	<0.600	141.000

Appendix B. Trace element concentrations in water, sediment and biota from the National Elk Refuge, Teton County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
		Various Ponds Within the National Elk Refuge					
Bill's Bayou	Sediment	<50.00	<35.000	116.000	NA	39.400	55.300
Peterson Pond	Sediment	<50.00	<35.000	51.500	NA	39.000	59.400
Pierres Pond	Sediment	<50.00	<35.000	82.100	NA	27.400	47.300
Pierres Pond/Potamogeton	Plant	<30.00	<45.000	172.000	NA	1.440	13.600
Romney Pond	Sediment	<50.00	<35.000	108.000	NA	35.400	53.500
		Flat Creek Wetlands at the National Elk Refuge					
	Sediment	NA	NA	48.700	<5.0	16.000	40.000
	Sediment	NA	NA	52.100	<5.0	18.000	50.800
	Sediment	NA	NA	93.800	<5.0	16.000	62.500
	Sediment	NA	NA	78.500	<5.0	17.000	54.400

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
			Dunkle Site				
	Water	100.0	0.002	<0.004	<0.001	<0.025	<0.050
	Sediment	53.7	9.300	0.056	0.860	<5.400	17200.000
			Hamp Ditch # 2				
	Water	100.0	<0.001	<0.004	<0.001	<0.025	0.125
	Sediment	39.2	9.000	<0.041	0.490	<4.110	15800.000
Potamogeton	Plant	88.2	1.700	<0.212	<0.850	<4.240	2840.000
Waterboatmen		81.0	<0.530	0.258	1.600	<5.260	27.400
			Hay Farm Pond 2				
	Water	100.0	0.009	<0.004	<0.001	<0.025	0.055
	Sediment	52.9	8.100	<0.053	1.900	<5.310	14900.000
Potamogeton	Plant	93.9	<1.600	<0.410	<1.600	<8.200	592.000
Potamogeton	Plant	87.90	0.830	<0.207	<0.830	<4.130	60.330
Potamogeton	Plant	89.70	0.970	<0.243	<0.970	<4.850	95.150
Potamogeton	Plant	85.90	0.710	0.227	<0.710	<3.550	168.790
Potamogeton	Plant	92.50	1.330	<0.333	2.130	<6.670	252.000
Amphipods		92.7	<1.400	0.575	<1.400	<6.850	930.000
			Pear Island Slough				
	Water	100.0	0.001	<0.004	<0.001	<0.025	0.070
	Sediment	77.6	17.400	<0.112	1.300	<11.200	9030.000
Potamogeton	Plant	84.7	2.000	<0.163	0.650	<3.270	801.000
			Pond 2				
	Water	100.0	0.002	<0.004	<0.001	<0.025	0.110
	Sediment	61.7	15.900	<0.065	0.520	<6.530	10300.000
Potamogeton	Plant	90.1	2.000	<0.253	<1.000	<5.050	297.000
Amphipods		91.7	<1.200	<0.301	<1.200	<6.020	569.000

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
			Pond 5				
	Water	100.0	<0.001	<0.004	<0.001	<0.025	<0.050
	Sediment	48.8	9.400	<0.049	0.200	<4.880	9920.000
Potamogeton	Plant	87.5	1.600	<0.200	0.800	<4.000	3330.000
Aquatic Invertebrates		88.7	<0.880	0.434	2.700	<4.420	155.000
	Sediment Collected from Ponds within Seedskadee NWR - 1988						
	Sediment	37.4	1.000	0.020	1.500	<2.000	10200.000
	Sediment	34.9	1.300	<0.010	0.200	<2.000	9600.000
	Sediment	27.8	2.200	<0.010	<0.200	<2.000	8980.000
	Sediment	36.8	2.900	0.020	0.300	<2.000	14300.000
	American Coots Collected at Seedskadee NWR - 1988						
	Liver	76.7	<0.100	1.300	4.300	<2.000	<3.000
	Liver	77.3	<0.100	0.873	5.100	<2.000	<3.000
	Liver	76.1	0.200	0.761	2.700	<2.000	<3.000
	Liver	75.0	<0.100	0.450	2.100	<2.000	<3.000
	Liver	75.2	0.200	0.440	2.200	<2.000	<3.000

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
			Dunkle Site				
	Water	0.053	0.035	<0.003	<0.003	<0.005	<0.013
	Sediment	43.600	180.000	1.730	0.760	27.800	14.800
			Hamp Ditch # 2				
	Water	0.045	0.057	<0.003	<0.003	<0.005	<0.013
	Sediment	22.000	192.000	1.480	0.660	12.000	11.500
Potamogeton	Plant	127.000	153.000	<0.420	0.680	9.410	9.660
Waterboatmen		5.370	11.800	<0.530	<0.530	<1.50	31.500

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
			Hay Farm Pond 2				
	Water	0.623	<0.025	<0.003	<0.003	<0.005	<0.013
	Sediment	49.400	188.000	1.700	0.740	21.500	16.000
Potamogeton	Plant	587.000	88.000	<0.820	<0.820	1.970	6.720
Potamogeton	Plant	417.360	74.050	<0.410	<0.410	0.910	5.950
Potamogeton	Plant	739.810	81.260	<0.490	<0.490	1.460	6.800
Potamogeton	Plant	42.130	82.980	<0.350	<0.350	0.850	4.180
Potamogeton	Plant	62.270	145.330	<0.670	<0.670	2.670	5.600
Amphipods		7.950	90.400	<0.680	<0.680	5.210	17.700
			Pear Island Slough				
	Water	0.177	0.059	<0.003	<0.003	<0.005	<0.013
	Sediment	74.800	232.000	1.120	3.350	16.500	12.500
Potamogeton	Plant	13.600	367.000	<0.330	0.460	1.500	4.900
			Pond 2				
	Water	0.082	0.063	<0.003	<0.003	<0.005	<0.013
	Sediment	16.200	134.000	1.310	3.130	16.800	9.920
Potamogeton	Plant	87.400	92.900	<0.510	<0.510	1.010	3.340
Amphipods		10.000	81.700	<0.600	<0.600	3.370	16.100
			Pond 5				
	Water	0.053	0.053	<0.003	<0.003	<0.005	<0.013
	Sediment	12.200	117.000	1.170	0.590	16.000	8.200
Potamogeton	Plant	15.300	189.000	<0.400	1.200	7.280	8.400
Aquatic Invertebrates		<4.420	16.100	<0.440	<0.440	1.150	23.100

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Boron	Barium	Beryllium	Cadmium	Chromium	Copper
	Sediment Collected from Ponds at Seedskadee NWR						
	Sediment	8.400	158.000	0.470	0.400	16.000	13.000
	Sediment	6.000	175.000	0.440	<0.300	17.000	30.200
	Sediment	7.600	172.000	0.440	<0.300	16.000	9.900
	Sediment	10.000	190.000	0.730	0.400	22.000	12.000
	American Coots Collected at Seedskadee NWR						
	Liver	<2.000	0.200	<0.100	<0.300	<1.000	124.000
	Liver	<3.000	0.200	<0.100	<0.300	<1.000	62.600
	Liver	<3.000	0.300	<0.100	<0.300	1.000	112.000
	Liver	<2.000	0.200	<0.100	<0.300	1.000	10.000
	Liver	<2.000	0.200	<0.100	<0.300	2.000	135.000

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
	Dunkle Site						
	Water	<0.050	15.0	<0.006	<0.025	<0.02	<0.015
	Sediment	17400.000	12200.0	322.000	<5.400	16.00	7.340
	Hamp Ditch # 2						
	Water	0.060	13.8	0.013	<0.025	<0.02	<0.015
	Sediment	14900.000	11200.0	455.000	<4.110	14.10	5.180
Potamogeton	Plant	4200.000	8010.0	541.000	<4.240	5.59	<2.540
Waterboatmen		154.00	979.0	26.100	<5.260	<4.21	<3.160
	Hay Farm Pond 2						
	Water	0.095	33.5	0.035	0.072	<0.02	<0.015
	Sediment	13800.000	13000.0	1040.000	<5.310	12.00	5.940
Potamogeton	Plant	597.000	10800.0	865.000	<8.200	<6.56	<4.920
Potamogeton	Plant	202.480	5008.26	672.730	<4.130	<3.31	<2.480
Potamogeton	Plant	290.290	6213.59	715.530	<4.850	<3.88	<2.910
Potamogeton	Plant	360.280	2815.60	843.970	<3.550	<2.84	2.770
Potamogeton	Plant	489.330	5133.33	1773.330	<6.670	<5.33	5.870
Amphipods		1300.000	2100.0	582.000	<6.850	<5.48	<4.110

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Iron	Magnesium	Manganese	Molybdenum	Nickel	Lead
			Pear Island Slough				
	Water	<0.050	21.5	0.048	<0.025	<0.02	<0.015
	Sediment	10400.000	7370.0	609.000	<11.200	8.93	<6.700
Potamogeton	Plant	1300.000	6410.0	3710.000	<3.270	<2.61	<1.960
			Pond 2				
	Water	0.070	18.7	0.096	<0.025	<0.02	<0.015
	Sediment	11600.000	7910.0	390.000	<6.530	9.01	<3.920
Potamogeton	Plant	526.000	3710.0	755.000	<5.050	<4.04	<3.030
Amphipods		880.000	1830.0	484.000	<6.020	<4.82	<3.610
			Pond 5				
	Water	0.050	14.0	0.010	<0.025	<0.02	<0.015
	Sediment	10400.000	6380.0	219.000	<4.480	8.50	<2.930
Potamogeton	Plant	5090.000	7140.0	662.000	<4.000	6.00	<2.400
Aquatic Invertebrates		371.000	1580.0	90.700	<4.420	<3.54	<2.650
		Sediment Collected from Ponds at Seedskadee NWR					
	Sediment	10100.000	7750.0	463.000	3.000	8.00	9.000
	Sediment	9730.000	8890.0	261.000	<2.000	8.80	9.000
	Sediment	10100.000	13600.0	298.000	<2.000	10.00	7.000
	Sediment	14800.000	17500.0	547.000	<2.000	14.00	10.000
		American Coots Collected at Seedskadee NWR					
	Liver	159.000	833.0	10.000	3.000	<2.00	<4.000
	Liver	285.000	810.0	10.000	2.000	<2.00	<4.000
	Liver	1400.000	835.0	13.000	3.500	<2.00	<4.000
	Liver	616.000	668.0	15.000	2.000	<2.00	<4.000
	Liver	1310.000	754.0	21.000	3.600	<2.00	<4.000

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
			Dunkle Site				
	Water	<0.05	<0.025	0.284	<0.1	<0.025	0.022
	Sediment	<10.80	<5.400	107.000	<21.6	38.300	61.200

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
			Hamp Ditch # 2				
	Water	<0.05	<0.025	0.339	<0.1	<0.025	0.028
	Sediment	<8.22	<4.110	110.000	<16.4	35.000	44.200
Potamogeton	Plant	<8.47	<4.240	298.000	<16.9	7.200	91.400
Waterboatmen		<10.50	<5.260	8.630	<21.1	<5.260	155.000
			Hay Farm Pond 2				
	Water	<0.05	<0.025	0.433	<0.10	<0.025	0.023
	Sediment	<10.00	<5.310	450.000	<21.20	31.600	52.400
Potamogeton	Plant	<16.40	<8.200	282.000	<32.80	<8.200	54.100
Potamogeton	Plant	<8.26	12.310	221.490	<16.53	<4.130	14.050
Potamogeton	Plant	<9.71	15.530	243.690	<19.42	<4.850	17.670
Potamogeton	Plant	<7.09	7.160	250.350	<14.18	<3.550	9.080
Potamogeton	Plant	<13.33	<6.670	365.330	<26.67	<6.670	16.130
Amphipods		<13.70	<6.850	221.000	<27.40	<6.850	119.000
			Pear Island Slough				
	Water	<0.05	<0.025	0.475	<0.1	<0.025	0.022
	Sediment	<22.30	<11.200	193.000	<44.6	20.300	36.200
Potamogeton	Plant	<6.54	<3.270	1750.000	<13.1	3.920	33.300
			Pond 2				
	Water	<0.05	<0.025	0.412	<0.1	<0.025	0.028
	Sediment	<13.10	<6.530	186.000	<26.1	25.700	39.000
Potamogeton	Plant	<10.10	<5.050	264.000	<20.2	<5.050	29.500
Amphipods		<12.00	<6.020	168.000	<24.1	<6.020	118.000
			Pond 5				
	Water	<0.05	<0.025	0.346	<0.1	<0.025	0.027
	Sediment	<9.77	<4.880	106.000	<19.5	24.200	33.900
Potamogeton	Plant	<8.00	<4.000	439.000	<16.0	9.040	45.400
Aquatic Invertebrates		<8.85	<4.420	31.500	<17.7	<4.420	133.000

Appendix C. Trace element concentrations in water, sediment and biota from Seedskadee National Wildlife Refuge, Sweetwater County, Wyoming (water in ug/ml, sediment and biota in ug/g dry weight)[NA=No Analysis].

SPECIES	MATRIX	Antimony	Tin	Strontium	Thallium	Vanadium	Zinc
	Sediment Collected from Ponds at Seedskadee NWR						
	Sediment	NA	NA	310.000	<5.0	15.000	35.000
	Sediment	NA	NA	126.000	<5.0	17.000	27.000
	Sediment	NA	NA	149.000	<5.0	16.000	27.000
	Sediment	NA	NA	156.000	<5.0	23.000	48.700
	American Coots Collected at Seedskadee NWR						
	Liver	NA	NA	0.750	<5.0	<0.600	122.000
	Liver	NA	NA	0.780	<5.0	<0.600	124.000
	Liver	NA	NA	0.780	<5.0	<0.600	153.000
	Liver	NA	NA	0.530	<5.0	<0.600	109.000
	Liver	NA	NA	0.300	<5.0	<0.600	168.000