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U.S. FISH & WILDLIFE SERVICE
REGION 6

CONTAMINANTS PROGRAM

ENVIRONMENTAL CONTAMINANTS MONITORING IN SELECTED WETLANDS OF WYOMING [BIOLOGICALLY ACTIVE ELEMENTS STUDY]

By
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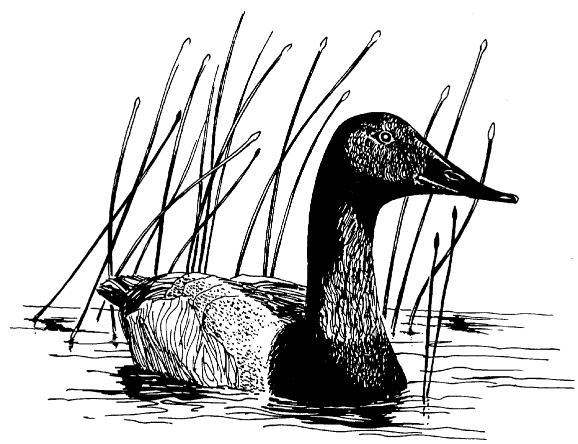

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Sediment, water and biota were collected from selected wetlands in Wyoming for the Biologically Active Elements (BAE) Study in 1988, 1989 and 1990 to identify contaminant problems that may warrant further study. This report also will assist in developing a comprehensive contaminants monitoring program for the state and will provide baseline contaminants data for wetland areas. Sites surveyed included areas affected by historical and current mining; wetlands receiving oilfield or oil refinery discharges; wetlands receiving irrigation return flows; stock ponds and natural depressions in areas with seleniferous soils and wetlands influenced by urban runoff. Monitoring is recommended for wetlands receiving oilfield produced waters and agricultural return flows. An intensive study is necessary to determine the impacts of oilfield produced waters on breeding aquatic birds. Areas with intensive agriculture, such as the Greybull River Valley and Bighorn Basin, require periodic monitoring to determine if return flows and or pesticide applications are adversely impacting migratory birds. Land management agencies proposing to develop wetlands in areas underlain with Cretaceous shale should be made aware of the selenium hazards to fish and wildlife.

INTRODUCTION

Sediment, water and biota were collected from selected wetlands in Wyoming for the Biologically Active Elements (BAE) Study in 1988, 1989 and 1990 to identify contaminant problems that may warrant further study. This report also will assist in developing a comprehensive contaminants monitoring program for the state and will provide baseline contaminants data for critical or sensitive wetland areas. Figure 1 shows the sites monitored during 1988, 1989 and 1990. Figures 2, 3 and 4 show potential contaminant sources leading to the selection of the sites for the BAE study.

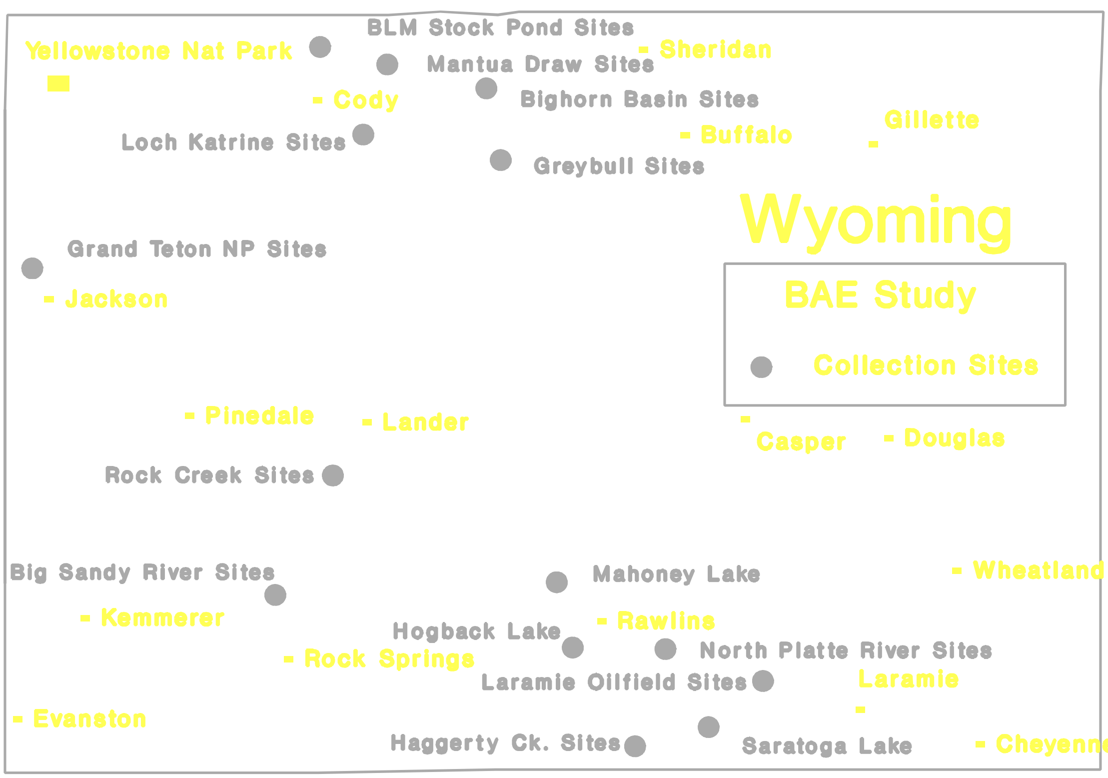

Figure 1. Collection sites for water, sediment and biota for the Biologically Active Elements (BAE) Study, Wyoming, 1989 - 1990.

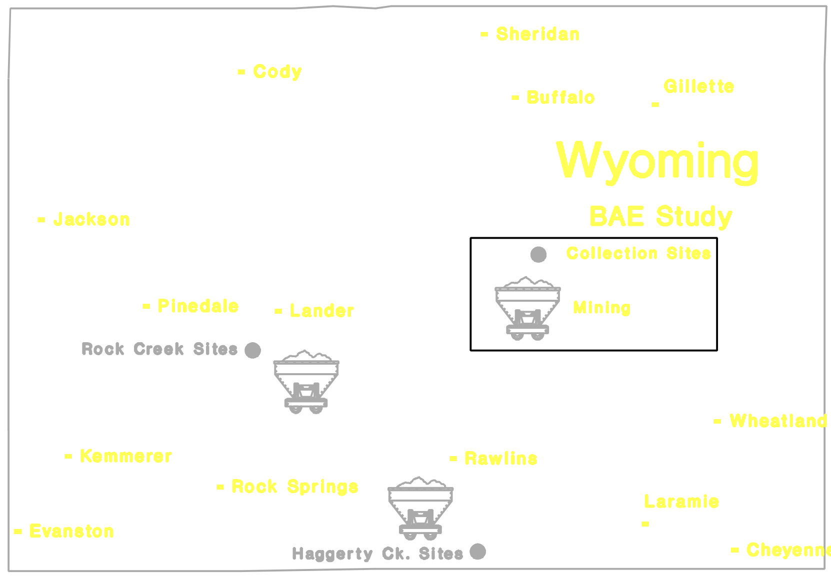

Figure 2. BAE Study sites surveyed for mining induced trace element contamination.

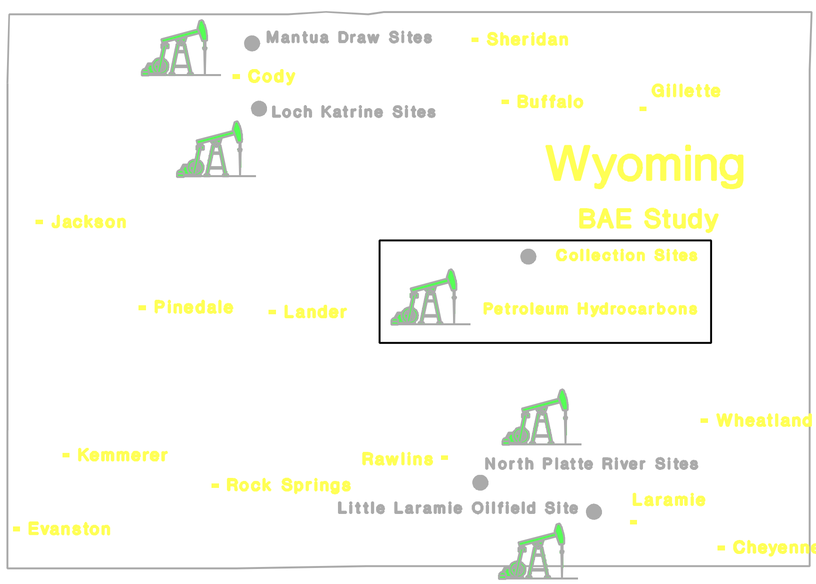

Figure 3. BAE Study sites surveyed for petroleum hydrocarbon contamination.

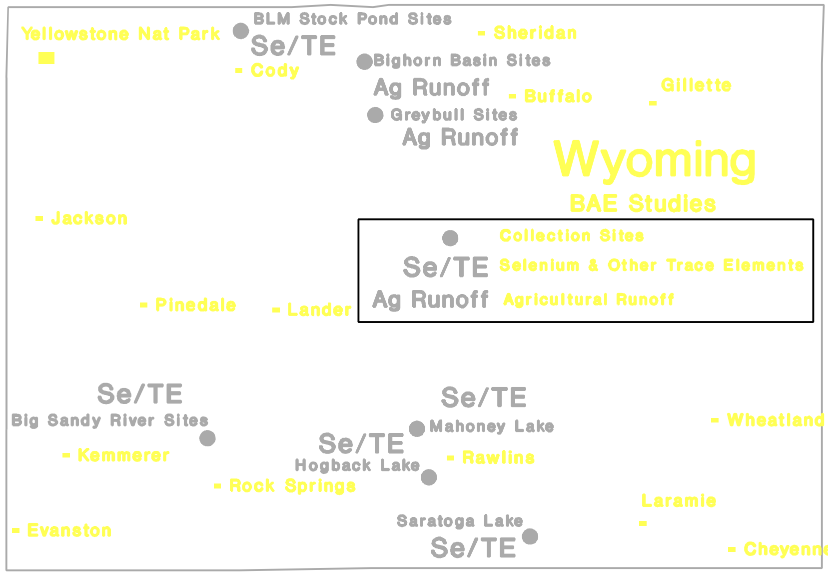

Figure 4. BAE Study sites surveyed for trace elements and or agricultural runoff induced contamination.

The sites at Rock Creek-South Pass in Fremont County and Haskins and Haggerty Creeks in Carbon County were selected to survey areas affected by historical and current mining (Figure 2). The Little Laramie Oilfield, North Platte at Sinclair and North Platte near Dugout Draw were selected to determine if problems exist in wetlands receiving oilfield or oil refinery discharges (Figure 3). The sites at Bighorn County were selected to determine if contaminant problems exist in reaches of the Greybull River receiving irrigation return flows (Figure 4). Mahoney and Hogback Lakes were selected to determine selenium and other trace element concentrations in sediments from natural depressions that could be developed as stock ponds to provide water for livestock and attract waterfowl. Saratoga Lake was sampled to determine if selenium or other trace elements are present at concentrations adverse to fish and wildlife.

STUDY AREA DESCRIPTION

Sites Surveyed for Mining-induced Trace Element Contamination

Rock Creek near South Pass in Fremont County is a historical mining district. Intensive mining for gold and other precious metals occurred in this area during the 1800's and into the 1950's. An inactive copper mine is located at the headwaters of Haggerty Creek in the Sierra Madre Mountains in south-central Carbon County. The Ferris-Haggerty copper mine operated from the late 1800's until 1903. The current mine operators are reworking their claim intermittently. Haggerty Creek flows through the mining claim and receives mine portal dewater discharge as well as surface runoff from the mine tailings. The mine discharge contains effluent exceeding State water quality standards for copper. Studies conducted by the Wyoming Department of Environmental Quality (DEQ) indicate that the mine effluent has sterilized a four-mile reach of Haggerty Creek from the mine to State Highway 70. Wyoming DEQ is taking legal action against the mine operators.

Sites Surveyed for Petroleum-induced Contamination

Oilfield produced waters are used in Wyoming to create or enhance wetlands. The discharges must meet State water quality standards. In the Oregon Basin Oilfield in Park County, Custer Lake and Loch Katrine receive 75 percent of their inflow from oil field production waters. Several species of aquatic birds, including dabbler ducks (Anas spp.), avocets (Recurvirostra americana) and black-necked stilts (Himantopus mexicanus) nest at the wetland complex at Custer Lake and Loch Katrine (Eric Greenquist, BLM Biologist, Cody, Wyoming, personal communications, July 1989). North of the Oregon Basin, the Mantua Discharge in Park County contributes oil field production waters to

Mantua Draw that drains into the Shoshone River. In the Little Laramie Oil Field, Albany County, oil produced waters are discharged into Browns Creek, a tributary to the Little Laramie River.

Sites Surveyed for Trace Element and/or Agricultural Runoff-induced Contamination

Ralston Reservoir is located seven miles west of Powell in Park County near Alternate Highway 14. Ralston Reservoir receives water diverted from the Shoshone River. Lovell Lake is located two miles southeast of Lovell in Big Horn County and receives irrigation return flows from adjacent fields and drainage canals. Collection sites along the Greybull River Valley included the Greybull River and irrigation canals 12 to 15 miles west of Basin in Big Horn County. The sites receive irrigation return flows from irrigated farmland along the river. Wordell Reservoir receives water diverted from the Greybull River.

Other sites surveyed for possible trace element contamination included Bureau of Land Management (BLM) stock ponds and closed basins, Saratoga Lake and a portion of the Big Sandy River drainage. Cat Track Pond, Middle Dam Pond and Sand Coulee are small stock ponds in the BLM Cody Resource Area, Park County, and range from 1 to 10 acres in size. These stock ponds are located approximately 12 to 15 miles west of Powell. Hogback and Mahoney Lakes are intermittent closed basins in the BLM Rawlins Resource Area, Carbon County. These depressions are usually dry; however, the BLM has made efforts to enhance Mahoney Lake to create habitat for aquatic birds. Saratoga Lake is located adjacent to Saratoga in south-central Carbon County.

METHODS

Table 1 lists the collection sites and matrices collected at each site. Specific collection site locations are listed in Appendix A.

Table 1. Collection sites and matrices collected for the BAE Study, Wyoming.
[TE = trace element analyses; OP = organophosphate analyses; PH = petroleum hydrocarbon analyses; OC=organochlorine analyses]

SITE	WATER	SEDIMENT	AQUATIC PLANTS	FISH	BIRDS
Loch Katrine	PH/TE	PH/TE	TE		PH
Mantua Draw	PH/TE	PH/TE			
BLM Stock Ponds	TE	TE	TE		
Bighorn Basin	TE	TE	TE		
Bighorn River				TE	
Greybull River	OP/TE	OP/TE	TE		
Rock Creek	TE	TE	TE		
N. Platte River	PH/TE	PH/TE			
Haggerty Creek	TE				
Big Sandy River	TE	TE	TE		
Little Laramie Oilfield	PH/TE	PH/TE	TE		
Grand Teton NP					OC/TE
Other Sites	TE	TE	TE		

Aquatic vegetation (Potamogeton sp.) was collected by hand and the detritus and sediment were then washed off. The samples were placed in Whirl-Pak bags and frozen. 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. 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. Trumpeter swan (Cygnus buccinator) eggs were collected in and near Grand Teton National Park, Teton County, Wyoming, by John Squires, University of Wyoming graduate student. The eggs were dissected, and the contents were placed in chemically-clean glass jars and frozen.

All samples were submitted to the following laboratories under contract with the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF): Research Triangle Institute, North Carolina, for trace element analyses and Mississippi State Chemical Laboratory, Mississippi, for organic compound analyses. The laboratories analyzed for mercury using cold vapor atomic absorption spectroscopy for mercury, hydride generation atomic absorption (AA) spectroscopy for arsenic and selenium, inductively coupled plasma atomic emission spectrophotometer (ICP) scans for all other trace elements and gas chromatography/mass spectrometry for organic compounds. The laboratories confirmed the precision and accuracy of the analyses 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 expected laboratory accuracy to be within the following standards established for each type of analysis:

ANALYTE	ACCEPTABLE RECOVERY RANGE OF SPIKED ANALYTE
Metals (ICP)	80 - 120 %
Metals (AA)	85 - 115 %
Organochlorine Pesticides	80 - 120 %

PACF compared the recovery reported with a batch of 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 compares results from these determinations to both the laboratory average and the certified value. PACF considered accuracy for all sample analyses for this study acceptable. Analytical results presented in this report for sediment and biota are expressed in dry weight concentrations unless indicated otherwise. Moisture contents are also presented for readers wishing to convert data to a wet weight concentration.

RESULTS AND DISCUSSION

Sites Surveyed for Mining-induced Trace Element Contamination

Trace element concentrations in water, sediment and aquatic vegetation collected from sites surveyed for mining-induced contamination are shown in Appendix B. Water collected from Rock Creek at the South Pass Mining Area, Fremont County, had elevated concentrations of aluminum and lead, 470 ug/l and 19 ug/l, respectively. EPA criterion for the protection of freshwater aquatic life states that aluminum should not exceed 87 ug/l more than once every three years when the pH is between 6.5 and 9.0 (EPA 1988). Adverse impacts to aquatic organisms, including reduced survival, impaired reproduction and reduced growth, have been reported for waterborne lead concentrations of 1.0 to 5.1 ug/l (Eisler 1988). The concentration of chromium in sediment collected from Rock Creek was 58.4 ug/g. Sediments with chromium concentrations ranging from 25 to 75 ug/g are considered moderately polluted (Baudo et al. 1990). Other elements present in Rock Creek sediments at concentrations Baudo et al. (1990) considered indicative of pollution included: arsenic at 5.1 ug/g; copper at 25.7 ug/g; manganese at 415.8 ug/g; and nickel at 36.2 ug/g. The 155.8 ug/g barium in sediment indicates heavy pollution (Baudo et al. 1990). An aquatic plant sample from Rock Creek had concentrations of 9.68 ug/g of chromium and 8.39 ug/g of vanadium.

Water collected from Haggerty Creek, two miles downstream from the Ferris-Haggerty copper mine, contained elevated concentrations of aluminum (1,430 ug/l), copper (48 ug/l), and lead (15 ug/l). EPA's Copper criterion for the protection of freshwater aquatic life is based on the hardness of water. The 1-hour average concentration of copper should not exceed the criteria more than once every three years (EPA 1980). Depending on the hardness of the water, copper concentrations should not exceed 34 ug/l. Analyses of additional water samples could help determine if copper is exceeding the criteria.

Wetland Sites Surveyed for Petroleum-induced Contamination

Loch Katrine and Mantua Draw Oilfield Produced Water Discharges

Trace element concentrations in water, sediment and biota from oilfield sites are presented in Appendix C. Oil field produced waters can contain elevated concentrations of trace elements such as mercury, barium, cadmium, chromium, copper, and zinc. Total Dissolved Solids (TDS) can range from less than 10,000 mg/l to over 350,000 mg/l (Kemmer 1988). Boron concentrations in water from Mantua Discharge, Loch Katrine Discharge and Custer Lake ranged from 2,520 ug/l to 3,830 ug/l. These boron concentrations are below the 100,000 to 300,000 ug/l concentrations suspected of causing embryo mortality and teratogenesis in aquatic vertebrates (Eisler 1990). Polynuclear aromatic and aliphatic hydrocarbons were not detected in water from Mantua Discharge and Loch Katrine Discharge or Custer Lake. MICROTOX bioassays of surface water samples collected at Loch Katrine Discharge were inconclusive because of the large variability in reagent response to different sample concentrations. No response was detected in the MICROTOX bioassay of surface water from Custer Lake. Polynuclear aromatic hydrocarbons were not detected in sediment from Lower Mantua Draw. Chromium was also elevated in the sediment sample from Lower Mantua Draw (43.1 ug/g). Baudo et al. (1990) consider sediment with chromium concentrations greater than 25 ug/g as polluted. Sediments from Custer Lake, Loch Katrine Discharge and Mantua Discharge had one or more polynuclear aromatic hydrocarbon compounds present. Several aliphatic hydrocarbon compounds were detected in sediments from Lower Mantua Draw, Mantua and Loch

Katrine discharges and Custer Lake (Table 2). Sediments from Custer Lake had the highest concentration of total hydrocarbons (14.6 ug/g wet weight or 34.9 ug/g dry weight) and oil and grease (5,450 ug/g wet weight or 13,038 ug/g dry weight).

A duckling carcass was collected from Custer Lake and submitted for PAH analyses. The cause of death was unknown. Aromatic hydrocarbons detected in the carcass included Chrysene and Benzo(e)pyrene at 0.02 and 0.01 ug/g wet weight, respectively. Aliphatic hydrocarbons detected included: n-Dodecane, n-Tridecane, n-Tetradecane, Octylcyclohexane, n-Pentadecane, n-Hexadecane, n-Heptadecane, n-Octadecane, Phytane, n-Nonadecane, and n-Eicosane. The carcass had a total hydrocarbon concentration of 1.11 ug/g wet weight (5.41 ug/g dry weight).

The 307 ug/g boron concentration in Potamogeton from Loch Katrine was above the 300 ug/g concentration suspected of causing reduced growth in mallard (Anas platyrhynchos) ducklings (Eisler 1990). None of the vegetation samples exceed the 1,000 ug/g concentration suspected of causing embryo mortality in mallards (Eisler 1990). MICROTOX bioassay results and preliminary chemical analyses of aquatic vegetation and a duckling carcass from the above oilfield sites suggest that additional bioassays and biomonitoring of higher level food chain organisms are needed.

Table 2. Percent moisture and hydrocarbon concentrations (ug/g wet weight) in sediments from oilfield produced water discharges and receiving wetlands, Park County, Wyoming.(* ND = None Detected)

ANALYTE	SITE			
	Loch Katrine Discharge	Custer Lake	Mantua Discharge	Lower Mantua Draw
% Moisture	39.2	58.2	77.0	74.2
Oil & Grease	380	5450	480	330
Napthalene	ND*	0.02	ND	ND
Fluorene	ND	0.06	0.01	ND
Phenanthrene	ND	0.25	0.03	ND
Anthracene	ND	0.03	ND	ND
Fluoranthrene	ND	0.09	ND	ND
Pyrene	ND	0.05	ND	ND
Chrysene	ND	ND	0.02	ND
Benzo(b)fluoranthrene	ND	0.02	0.02	ND
Benzo(k)fluoranthrene	ND	0.01	ND	ND
Benzo(e)pyrene	ND	0.01	0.14	ND
Benzo(a)pyrene	ND	ND	0.02	ND
Benzo(g,h,i)perylene	0.01	ND	ND	ND
n-Dodecane	0.02	0.06	0.06	ND
n-Tridecane	0.02	0.04	0.07	0.01
n-Tetradecane	ND	0.09	0.09	ND
Octylcyclohexane	ND	0.68	0.04	ND
n-Pentadecane	0.01	1.54	0.33	0.02
Nonylcyclohexane	ND	0.19	0.03	0.01
n-Hexadecane	0.02	0.47	0.20	0.02
n-Heptadecane	0.10	1.50	1.20	0.10
Pristane	ND	2.30	0.28	0.03
n-Octadecane	0.02	0.81	0.19	0.03
Phytane	0.02	4.60	0.49	0.04
n-Nonadecane	0.03	0.48	0.48	0.04
n-Eicosane	0.02	1.30	0.14	0.04

Little Laramie Oilfield Produced Water Discharge

Water collected from the discharge into the wetland as well as 300 yards downstream in Browns Creek had lead concentrations of 15 ug/l, exceeding the Environmental Protection Agency criteria for the protection of freshwater aquatic life from the chronic effects of lead. Aquatic vegetation collected downstream from the discharge had a boron concentration of 801 ug/g, well above the 300 ug/g threshold for adverse effects to waterfowl. Polynuclear aromatic and aliphatic hydrocarbons were not detected in water samples from the Little Laramie Oilfield produced water discharge. Zinc was present in sediment from the Little Laramie Oilfield produced water discharge at a concentration that Baudo et al. (1990) consider heavily polluted (1,218 ug/g).

North Platte River near Sinclair

Water collected from the North Platte River downstream from the Sinclair Refinery had elevated concentrations of aluminum (1,450 and 1,870 ug/l), and lead (15 and 23 ug/l). Barium concentrations in two sediment samples from the North Platte River downstream of the Sinclair Refinery were 69.5 and 84.6 ug/g. These concentrations are considered moderately polluted as defined by Baudo et al. (1990). Elements present in concentrations considered moderately polluted by Baudo et al. (1990) included: chromium (49.1 ug/g); and nickel (21.6 ug/g). Submerged aquatic plants collected from this site had cadmium and zinc concentrations of 0.73 ug/g and 265.85 ug/g, respectively.

Sites Surveyed for Agricultural Runoff-induced Contamination

Trace element concentrations in water, sediment and aquatic vegetation from sites surveyed for agricultural runoff induced contamination are shown in Appendix D.

Ralston Reservoir and Lovell Lakes

Selenium concentrations in sediment samples from Ralston Reservoir and Lovell Lakes were below the 4 ug/g level of concern for bioconcentration in the food chain as recommended by Lemly and Smith (1987). Arsenic, barium and chromium concentrations in sediments are considered moderately polluted if they exceed 3, 20 and 25 ug/g, respectively (Baudo et al. 1990). Arsenic in sediment from Lovell Lake was also elevated (6.13 ug/g). Barium was present in sediments from Lovell Lake and Ralston Reservoir in concentrations considered heavily polluted, 638 and 407 ug/g, respectively. Chromium concentrations in sediment from Lovell Lake and Ralston Reservoir were 36.7 and 32.5 ug/g respectively.

Boron concentrations in aquatic vegetation from Ralston Reservoir and Lovell Lake were above the 300 ug/g dietary level known to cause reduced growth in mallard ducklings; however, none of the samples exceeded the 1,000 ug/g concentration suspected of causing embryo mortality in mallards (Eisler 1990). A Potamogeton sample from Lovell Lake had a selenium concentration of 3.9 ug/g, slightly exceeding Lemly and Smith's (1987) 3 ug/g level of concern for bioaccumulation.

Greybull River Sites

Several trace elements were elevated in water, sediment and aquatic vegetation samples. Water collected from the Greybull River and irrigation canals draining into the Greybull River had elevated concentrations of aluminum, selenium, and lead. Copper was elevated (25 ug/l) in one water sample collected from one canal draining into the Greybull River. Wordell Reservoir had elevated concentrations of lead in the water. Sediment from Wordell Reservoir contained arsenic and boron in concentrations considered heavily polluted, 24.4 and 62.5 ug/g respectively (Baudo et al. 1990). Barium was present in sediments from the Greybull River, a drain and the McNiven Canal at concentrations considered heavily polluted by Baudo et al. (1990)(62.5 to 108.5 ug/g). Nickel in a sediment sample from the Greybull River was present at a concentration of 53.7 ug/g, a level considered heavily polluted by Baudo et al. (1990). Aquatic vegetation collected from the Greybull River and irrigation canals had elevated concentrations of selenium (4.2 ug/g).

Other Sites Surveyed for Trace Element Contamination

Big Sandy River Sites

Trace element concentrations in water, sediments and aquatic vegetation collected from other sites surveyed in Wyoming are shown in Appendix E. Sediment samples from all sites except Big Sandy Seep had selenium concentrations below the 4 ug/g level of concern for bioaccumulation (Lemly and Smith 1987). Boron concentrations in aquatic vegetation from the Big Sandy River and Lower Bone Draw were over 300 ug/g, a level known to cause reduced growth in mallard ducklings (Eisler 1990). None of the vegetation samples exceed the 1,000 ug/g concentration suspected of causing embryo mortality in mallards (Eisler 1990).

Carbon County Sites

Sediment samples from all Carbon County sites had selenium concentrations below the 4 ug/g level of concern for bioaccumulation (Lemly and Smith 1987). All other trace elements in sediment were either below detection limits or present in concentrations not considered elevated.

Park County BLM Stock Ponds

Selenium in water from Cat Track Pond was above the 5 ug/l level of concern for bioaccumulation recommended by Lemly and Smith (1987). Boron concentrations were over 300 ug/g but less than 1,000 ug/g in aquatic vegetation from Cat Track Pond and Middle Dam Pond. Selenium concentrations in Potamogeton samples from Cat Track Pond approached or exceeded the 3 ug/g level of concern for bioaccumulation (Lemly and Smith 1987). Selenium concentrations in aquatic vegetation from Middle Dam pond were below 3 ug/g. Other trace elements in water, sediment and aquatic vegetation were either below detection limits or present in concentrations not considered elevated.

Trumpeter Swan Eggs - Grand Teton National Park Area

Trace element concentrations in trumpeter swan eggs were either below detection limits or present in concentrations not considered elevated (Appendix G). Organochlorine compounds were not detected except for p, p'-DDE and Dieldrin. Seven trumpeter swan eggs had p, p'-DDE concentrations of 0.01 ug/g wet weight and dieldrin was detected in one egg at 0.01 ug/g wet weight. Although present in the egg, these organochlorine compounds were not at concentrations known to cause adverse effects to aquatic bird embryos.

Fish - Bighorn and Wind Rivers

Trace element concentrations in fish collected from the Bighorn and Wind Rivers in Bighorn and Fremont Counties, respectively, are shown in Appendix H. All fish collected from the Bighorn and the Wind Rivers, with the exception of suckers collected from the Wind River above Riverton, had whole-body selenium concentrations exceeding the National Contaminant Biomonitoring Program (NCBP) geometric mean for fish (0.42 ppm wet weight)(Schmitt and Brumbaugh 1990). Carp collected from the Bighorn River near Greybull, a sauger from the Bighorn River near Lovell, and longnose suckers from the Wind River upstream of Riverton had whole body arsenic concentrations slightly exceeding the NCBP geometric means reported for fish (0.14 ppm wet weight) (Schmitt and Brumbaugh 1990). The NCBP geometric mean reported for mercury in fish (0.1 ppm wet weight) was slightly exceeded in fish collected from the Bighorn River reaches near Worland, Greybull and Lovell and in suckers collected from the Wind River. Cadmium was detected only in the white sucker composite sample from the Wind River upstream of Riverton and it exceeded the NCBP geometric mean of 0.03 ppm wet weight. Copper concentrations in whole-body fish collected from the Bighorn River reaches near Thermopolis, Worland and Greybull exceeded the NCBP geometric mean of 0.65 ppm wet weight. The NCBP geometric mean reported for zinc in fish (21.7 ppm wet weight) was slightly exceeded by trout collected from the Bighorn River near Thermopolis and from the Wind River upstream of Riverton.

MANAGEMENT RECOMMENDATIONS

Based on the results of this survey, monitoring is needed for wetlands receiving oilfield produced waters, and agricultural return flows. An intensive study is necessary to determine the impacts of oilfield produced waters on breeding aquatic birds. The Loch Katrine area is an excellent site for initiating such a study. Periodic monitoring of permitted oilfield produced water discharges should be conducted to determine overall compliance by the permittees with the state water quality standards and to assess the risks to migratory birds.

Areas with intensive agriculture, such as the Greybull River Valley, require periodic monitoring to determine if return flows and/or pesticide applications are adversely impacting migratory birds. Ralston Reservoir and Lovell Lakes should be monitored periodically to determine if selenium and boron concentrations in aquatic invertebrates and aquatic vegetation are bioaccumulating to levels adverse to fish and wildlife.

Land management agencies, such as the BLM, should be made aware of the selenium issue and the hazards associated with developing wetlands in areas underlain with Cretaceous shale. A one-page flyer or brochure should be developed to inform private landowners and public land management agencies about seleniferous soils and wetland creation.

Legal action by the Wyoming DEQ against the owners of the Ferris-Haggerty Copper Mine should be followed closely. A preliminary evaluation of the mine discharge impacts to trust resources should be made to determine if a Natural Resource Damage Assessment is necessary. Any work conducted at the upper reaches of Haggerty Creek should be closely coordinated with the Wyoming DEQ, the U.S. Forest Service and the local law enforcement agency due to the sensitivity of the issue.

Additional monitoring of biota at Rock Creek downstream from the historical mining district should be conducted to verify if trace elements pose a threat to trust resources.

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Appendix A. Wetlands included in the environmental contaminants monitoring study in 1988 - 89.

NAME	COUNTY	OWNERSHIP	T	R	SEC
Loch Katrine Sites					
CUSTER LAKE	Park	BLM	52N	100W	32
LOCH KATRINE	Park	BLM	52N	100W	29
Mantua Draw Sites					
LOWER MANTUA DRAW	Park	BLM	56N	98W	35
MANTUA DISCHARGE	Park	BLM	56N	98W	16
BLM Stock Pond Sites					
CAT TRACK POND	Park	BLM	56N	100W	35
MIDDLE DAM	Park	BLM	55N	101W	1
SAND COULEE	Park	BLM	55N	101W	1
Bighorn Basin Sites					
LOVELL LAKE	Bighorn	Private	56N	96W	30
RALSTON RESERVOIR	Park	BLM	55N	100W	27
ALKALI LAKE	Park	Private	52N	101W	5
Greybull River Sites					
GREYBULL RIVER	Bighorn	Private	51N	94W	14
GREYBULL RIVER DRAIN	Bighorn	Private	51N	95W	14
McNIVEN LATERAL CANAL	Bighorn	Private	51N	96W	2
WORDELL RESERVOIR	Bighorn	BLM	51N	95W	32
Rock Creek Sites					
ROCK CREEK @ SOUTH PASS	Fremont	BLM	29N	100W	12
North Platte River Sites					
NORTH PLATTE @ SINCLAIR	Carbon	BLM	21N	85W	5
NORTH PLATTE NEAR DUGOUT	Carbon	BLM	22N	86W	24
Haggerty Creek Sites					
HAGGERTY CREEK	Carbon	USFS	14N	87W	30
HASKINS CREEK	Carbon	USFS	14N	87W	30
Big Sandy River Sites					
BIG SANDY SEEP	Sweetwater	BLM	24N	107W	32
BIG SANDY RIVER	Sweetwater	BLM	24N	107W	32
EDEN RESERVOIR WETLAND	Sweetwater	BLM	26N	105W	19
LOWER BONE DRAW	Sweetwater	BLM	26N	107W	32
UPPER BONE DRAW	Sweetwater	BLM	26N	107W	33
Other Sites					
SARATOGA LAKE	Carbon	State	17N	83W	6
MAHONEY LAKE	Carbon	BLM	23N	90W	24
HOGBACK LAKE	Carbon	BLM	21N	88W	35
LITTLE LARAMIE OILFIELD	Albany	Private	16N	75W	4

Appendix B. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for mining induced trace element contamination in Wyoming, 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
Haskins Creek		Water	100.0	<0.0010	<0.0004	<0.001	<0.025	0.13
Haggerty Creek		Water	100.0	<0.0010	<0.0004	<0.001	<0.025	1.43
Rock Creek		Water	100.0	0.0020	<0.0004	0.0010	<0.025	0.47
Rock Creek		Sediment	60.8	5.1000	0.2120	1.1700	<6.38	11147.96
Rock Creek	Potamogeton	Plant	93.8	1.9400	<0.403	<1.61	<8.06	1259.68

LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
Haskins Creek		Water	100.0	0.049	<0.025	0.003	<0.003	<0.005
Haggerty Creek		Water	100.0	0.093	<0.025	0.003	<0.003	<0.005
Rock Creek		Water	100.0	0.064	0.050	0.003	<0.003	<0.005
Rock Creek		Sediment	60.8	7.020	155.870	3.320	0.640	58.420
Rock Creek	Potamogeton	Plant	93.8	18.550	56.940	0.810	0.810	9.680

LOCATION	SPECIES	MATRIX	MOISTURE	Copper	Iron	Magnesium	Manganese	Molybdenum
Haskins Creek		Water	100.0	<0.013	0.300	1.050	<0.006	<0.025
Haggerty Creek		Water	100.0	0.048	0.350	0.900	<0.006	<0.025
Rock Creek		Water	100.0	<0.013	0.813	11.400	0.030	<0.025
Rock Creek		Sediment	60.8	25.770	24974.490	7066.330	415.820	6.380
Rock Creek	Potamogeton	Plant	93.8	17.420	3677.420	2322.580	1558.070	8.060

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony	Tin	Strontium
Haskins Creek		Water	100.0	<0.02	0.015	<0.05	<0.025	0.018
Haggerty Creek		Water	100.0	<0.02	0.015	<0.05	<0.025	0.018
Rock Creek		Water	100.0	<0.02	0.019	<0.05	<0.025	0.209
Rock Creek		Sediment	60.8	36.220	7.270	<12.76	<6.38	28.570
Rock Creek	Potamogeton	Plant	93.8	6.450	10.480	<16.13	11.940	34.840

Appendix B. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for mining induced trace element contamination in Wyoming, 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Thallium	Vanadium	Zinc
Haskins Creek		Water	100.0	<0.1	<0.025	0.014
Haggerty Creek		Water	100.0	<0.1	<0.025	<0.01
Rock Creek		Water	100.0	<0.1	<0.025	0.015
Rock Creek		Sediment	60.8	<25.51	61.990	74.490
Rock Creek	Potamogeton	Plant	93.8	<32.26	8.390	95.970

Appendix C. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for petroleum induced trace element contamination in Wyoming, 1989 - 1990.

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LOCATION	SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
North Platte River Sites near Sinclair								
Sinclair		Water	100.0	0.0020	<0.0004	<0.001	<0.025	1.45
Dugout Draw		Water	100.0	0.0020	<0.0004	<0.001	<0.025	1.87
Sinclair		Sediment	30.3	2.1500	<0.036	0.2200	<3.59	3127.69
Dugout Draw		Sediment	31.3	1.8900	<0.036	<0.15	<3.64	2780.20
Sinclair	Potamogeton	Plant	91.8	3.1700	<0.305	<1.22	<6.1	803.66
Little Laramie Oilfield Sites								
Discharge		Water	100.0	0.0010	<0.0004	<0.001	<0.025	0.46
Wetland		Water	100.0	<0.0010	<0.0004	<0.001	<0.025	2.03
Discharge		Sediment	46.4	1.3600	<0.047	<0.19	<4.66	1861.94
Wetland	Potamogeton	Plant	89.4	1.8900	<0.236	<0.94	<4.72	335.85
Loch Katrine Sites								
Custer Lake		Water	100.0	57.00	<0.02	<0.3	<50.0	<50.0
Custer Lake		Sediment	60.9	3.03	<0.02	<0.3	<10.0	670.0
Custer Lake	Algae	Plant	73.5	5.18	<0.03	<0.6	<10.0	329.0
Loch Katrine	Potamogeton	Plant	81.7	11.90	<0.03	<0.6		1910.0
Loch Katrine		Sediment	35.3	5.01	<0.02	<0.3		47500.0
L Katrine Discharge		Water	100.0	10.00	<0.02	<0.3	<50.0	<50.0
Mantua Draw Sites								
Lower Mantua Draw		Sediment	67.1	15.70	0.0354	2.45	<10.0	21300.0
Mantua Discharge		Water	100.0	18.00	<0.02	<0.3	<50.0	<50.0
Mantua Discharge		Sediment	52.0	4.66	<0.02	0.556	<10.0	20000.0

LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
North Platte River Sites near Sinclair								
Sinclair		Water	100.0	0.111	0.050	0.003	<0.003	0.007
Dugout Draw		Water	100.0	0.109	0.047	0.003	<0.003	<0.005
Sinclair		Sediment	30.3	3.660	84.650	0.360	0.360	6.810
Dugout Draw		Sediment	31.3	3.640	69.580	0.360	0.360	6.110
Sinclair	Potamogeton	Plant	91.8	181.710	54.150	0.610	0.730	3.290

Appendix C. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for petroleum induced trace element contamination in Wyoming, 1989 - 1990.

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LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
Little Laramie Oilfield Sites								
Discharge		Water	100.0	0.114	0.031	0.003	<0.003	0.006
Wetland		Water	100.0	0.870	0.030	0.003	<0.003	<0.005
Discharge		Sediment	46.4	18.840	55.220	0.840	<0.47	6.900
Wetland	Potamogeton	Plant	89.4	801.890	112.260	0.470	<0.47	2.640
Loch Katrine Sites								
Custer Lake		Water	100.0	2880.0	10.0	<1.000	<4.000	<10.00
Custer Lake		Sediment	60.9	26.2	35.5	<0.300	<0.500	<2.50
Custer Lake	Algae	Plant	73.5	34.5	19.8	0.473	<0.700	<3.00
Loch Katrine	Potamogeton	Plant	81.7	307.0	15.0	<0.200	<0.700	3.28
Loch Katrine		Sediment	35.3	209.0	557.0	1.110	<0.500	49.10
L Katrine Discharge		Water	100.0	2520.0	36.0	<1.000	<4.000	<10.00
Mantua Draw Sites								
Lower Mantua Draw		Sediment	67.1	94.7	269	1.66	0.909	43.1
Mantua Discharge		Water	100.0	3830.0	36	<1.00	<4.000	15.0
Mantua Discharge		Sediment	52.0	54.5	203	1.09	<0.500	25.3

LOCATION	SPECIES	MATRIX	MOISTURE	Copper	Iron	Magnesium	Manganese	Molybdenum
North Platte River Sites near Sinclair								
Sinclair		Water	100.0	<0.013	2.950	11.200	0.085	<0.025
Dugout Draw		Water	100.0	<0.013	1.000	9.400	0.034	<0.025
Sinclair		Sediment	30.3	10.260	9899.570	3371.590	298.420	3.590
Dugout Draw		Sediment	31.3	8.660	9039.300	3013.100	259.100	3.640
Sinclair	Potamogeton	Plant	91.8	9.630	3219.510	3487.810	447.560	6.100
Little Laramie Oilfield Sites								
Discharge		Water	100.0	<0.013	0.250	10.100	0.021	<0.025
Wetland		Water	100.0	<0.013	0.200	89.000	0.023	<0.025
Discharge		Sediment	46.4	4.760	4608.210	3227.610	481.340	4.660
Wetland	Potamogeton	Plant	89.4	10.850	1575.470	3452.830	2349.060	4.720

Appendix C. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for petroleum induced trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Copper	Iron	Magnesium	Manganese	Molybdenum
Loch Katrine Sites								
Custer Lake		Water	100.0	<7.00	<30	176000	10.0	<10.00
Custer Lake		Sediment	60.9	<5.00	600	3220	49.8	<5.00
Custer Lake	Algae	Plant	73.5	<4.00	428	4490	46.9	<7.50
Loch Katrine	Potamogeton	Plant	81.7	5.80	2110	7500	90.3	<7.50
Loch Katrine		Sediment	35.3	12.60	20100	11300	287.0	<5.00
L Katrine Discharge		Water	100.0	<7.00	340	176000	11.0	<10.00
Mantua Draw Sites								
Lower Mantua Draw		Sediment	67.1	15.0	35700	3480	698	<5.00
Mantua Discharge		Water	100.0	<7.0	78	109000	11	<10.00
Mantua Discharge		Sediment	52.0	8.6	13800	3940	132	<5.00

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony	Tin	Strontium
North Platte River Sites near Sinclair								
Sinclair		Water	100.0	<0.02	0.015	<0.05	<0.025	0.025
Dugout Draw		Water	100.0	<0.02	0.023	<0.05	<0.025	0.223
Sinclair		Sediment	30.3	6.100	6.460	<7.17	<3.59	42.900
Dugout Draw		Sediment	31.3	3.570	2.550	<7.28	<3.64	35.520
Sinclair	Potamogeton	Plant	91.8	<4.88	7.930	<12.2	17.440	85.850
Little Laramie Oilfield Sites								
Discharge		Water	100.0	<0.02	0.015	<0.05	<0.025	0.178
Wetland		Water	100.0	<0.02	0.015	<0.05	<0.025	10.300
Discharge		Sediment	46.4	5.220	<2.8	<9.33	<4.66	1996.270
Wetland	Potamogeton	Plant	89.4	<3.77	9.530	<9.43	17.550	123.580
Loch Katrine Sites								
Custer Lake		Water	100.0	<10.00	<40.00	<60.0	<90.0	11400
Custer Lake		Sediment	60.9	<3.00	<8.00	<50.0	<35.0	2300
Custer Lake	Algae	Plant	73.5	<4.00	<7.00	<30.0	<45.0	2670
Loch Katrine	Potamogeton	Plant	81.7	<4.00	<7.00		<45.0	476
Loch Katrine		Sediment	35.3	21.60	<7.00		<35.0	1630

Appendix C. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for petroleum induced trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony	Tin	Strontium
L Katrine Discharge		Water	100.0	<10.00	<40.00	<60.0	<90.0	12700
Mantua Draw Sites								
Lower Mantua Draw		Sediment	67.1	16.70	22.6	<50.0	<35.0	217
Mantua Discharge		Water	100.0	<10.00	<40.0	<60.0	<90.0	7170
Mantua Discharge		Sediment	52.0	6.63	11.1	<50.0	<35.0	982

LOCATION	SPECIES	MATRIX	MOISTURE	Thallium	Vanadium	Zinc
North Platte River Sites near Sinclair						
Sinclair		Water	100.0	0.168	<0.025	0.011
Dugout Draw		Water	100.0	<0.10	<0.025	<0.01
Sinclair		Sediment	30.3	<14.35	14.490	37.160
Dugout Draw		Sediment	31.3	<14.56	12.880	29.990
Sinclair	Potamogeton	Plant	91.8	<24.39	<6.1	265.850
Little Laramie Oilfield Sites						
Discharge		Water	100.0	<0.1	<0.025	0.012
Wetland		Water	100.0	<0.1	<0.025	0.017
Discharge		Sediment	46.4	<18.66	9.420	1218.280
Wetland	Potamogeton	Plant	89.4	30.94	<4.72	98.110
Loch Katrine Sites						
Custer Lake		Water	100.0	NA	7.00	<10.00
Custer Lake		Sediment	60.9	NA	4.58	5.33
Custer Lake	Algae	Plant	73.5	NA	2.93	7.51
Loch Katrine	Potamogeton	Plant	81.7	NA	6.51	43.00
Loch Katrine		Sediment	35.3	NA	122.00	79.60
L Katrine Discharge		Water	100.0	NA	8.00	24.00
Mantua Draw Sites						
Lower Mantua Draw		Sediment	67.1	NA	79.1	NA
Mantua Discharge		Water	100.0	NA	<4.0	26.00
Mantua Discharge		Sediment	52.0	NA	49.5	NA

Appendix D. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for agricultural runoff induced trace element contamination in Wyoming, 1989 - 1990.

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LOCATION	SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
Greybull River Sites								
Wordell Reservoir		Water	100.0	0.003	<0.0004	0.001	<0.025	3.69
McNiven Canal		Water	100.0	0.002	<0.0004	0.003	<0.025	4.45
Drain - Greybull R.		Water	100.0	0.005	<0.0004	0.002	<0.025	9.80
Greybull River		Water	100.0	0.002	<0.0004	0.004	<0.025	0.20
Drain - Greybull R.		Water	100.0	0.004	<0.0004	0.003	<0.025	8.90
Wordell Reservoir		Sediment	31.2	24.420	0.0480	<0.150	<3.630	4229.65
Drain - Greybull R.		Sediment	30.1	1.390	<0.0360	<0.140	<3.580	3934.19
Greybull River		Sediment	24.7	1.000	<0.0330	0.130	<3.320	1938.91
McNiven Canal		Sediment	14.2	0.850	0.0420	<0.120	<2.910	2202.80
McNiven Canal		Sediment	22.5	0.770	<0.0320	<0.130	<3.230	3354.84
Wordell Reservoir	Sedge/Rush	Plant	81.7	0.930	<0.1370	1.260	<2.730	1377.05
McNiven Canal	Potamogeton	Plant	87.2	1.020	<0.1950	<0.780	<3.910	542.97
Greybull River	Potamogeton	Plant	91.2	5.570	<0.2840	4.200	<5.680	2488.64
Bighorn Basin Sites								
Lovell Lake		Sediment	37.3	6.13	<0.020	0.716	<10.00	26900.00
Ralston Reservoir		Sediment	28.4	1.56	<0.020	1.130	<10.00	30000.00
Lovell Lake	Potamogeton	Plant	87.8	4.49	<0.030	3.900	<10.00	392.00
Ralston Reservoir	Potamogeton	Plant	85.7	2.13	<0.030	1.100	<10.00	542.00

LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
Greybull River Sites								
Wordell Reservoir		Water	100.0	0.190	0.073	<0.003	<0.003	0.016
McNiven Canal		Water	100.0	0.337	0.075	<0.003	<0.003	0.013
Drain - Greybull R.		Water	100.0	0.168	0.096	<0.003	<0.003	0.014
Greybull River		Water	100.0	0.196	0.043	<0.003	<0.003	0.007
Drain - Greybull R.		Water	100.0	0.266	0.118	<0.003	<0.003	0.005
Wordell Reservoir		Sediment	31.2	3.920	62.500	0.440	0.580	4.290
Drain - Greybull R.		Sediment	30.1	4.150	108.580	0.360	0.360	5.940
Greybull River		Sediment	24.7	3.590	62.680	<0.33	<0.33	3.590
McNiven Canal		Sediment	14.2	7.520	63.990	<0.29	<0.29	6.410
McNiven Canal		Sediment	22.5	3.230	90.190	<0.32	0.390	3.740

Appendix D. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for agricultural runoff induced trace element contamination in Wyoming, 1989 - 1990.

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LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
<u>Greybull River Sites</u>								
Wordell Reservoir	Sedge/Rush	Plant	81.7	16.070	39.020	<0.27	<0.27	3.550
McNiven Canal	Potamogeton	Plant	87.2	20.940	48.830	<0.39	<0.39	2.270
Greybull River	Potamogeton	Plant	91.2	34.770	142.050	<0.57	<0.57	8.070
<u>Bighorn Basin Sites</u>								
Lovell Lake		Sediment	37.3	39.9	638.0	0.828	<0.500	36.7
Ralston Reservoir		Sediment	28.4	45.3	407.0	0.983	<25.0	32.5
Lovell Lake	Potamogeton	Plant	87.8	381.0	10.6	<0.200	<0.700	<3.0
Ralston Reservoir	Potamogeton	Plant	85.7	329.0	76.0	<0.200	<0.700	<3.0

LOCATION	SPECIES	MATRIX	MOISTURE	Copper	Iron	Magnesium	Manganese	Molybdenum
<u>Greybull River Sites</u>								
Wordell Reservoir		Water	100.0	<0.013	1.950	34.800	0.026	<0.025
McNiven Canal		Water	100.0	<0.013	2.600	17.000	0.061	<0.025
Drain - Greybull R.		Water	100.0	<0.013	4.650	18.200	0.052	<0.025
Greybull River		Water	100.0	<0.013	0.150	33.000	0.018	<0.025
Drain - Greybull R.		Water	100.0	0.025	4.500	24.000	0.086	<0.025
Wordell Reservoir		Sediment	31.2	11.920	8619.190	6802.330	74.850	3.630
Drain - Greybull R.		Sediment	30.1	8.730	6995.710	3447.780	238.910	3.580
Greybull River		Sediment	24.7	4.780	4130.150	2084.990	188.580	3.320
McNiven Canal		Sediment	14.2	5.940	5174.830	2331.000	217.950	2.910
McNiven Canal		Sediment	22.5	7.030	5522.580	3561.290	211.610	3.230
Wordell Reservoir	Sedge/Rush	Plant	81.7	12.020	1524.590	3606.560	151.370	2.730
McNiven Canal	Potamogeton	Plant	87.2	7.890	734.370	2718.750	403.910	3.910
Greybull River	Potamogeton	Plant	91.2	12.270	4250.000	6159.090	2238.640	5.680
<u>Bighorn Basin Sites</u>								
Lovell Lake		Sediment	37.3	14.30	13800	7350	272.0	<5.00
Ralston Reservoir		Sediment	28.4	11.60	16300	7030	241.0	<5.00
Lovell Lake	Potamogeton	Plant	87.8	<4.00	454	8420	885.0	<7.50
Ralston Reservoir	Potamogeton	Plant	85.7	<4.00	628	8330	81.2	<7.50

Appendix D. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for agricultural runoff induced trace element contamination in Wyoming, 1989 - 1990.

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LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony	Tin	Strontium
Greybull River Sites								
Wordell Reservoir		Water	100.0	<0.02	0.015	<0.05	<0.025	0.780
McNiven Canal		Water	100.0	<0.02	0.015	<0.05	<0.025	0.449
Drain - Greybull R.		Water	100.0	<0.02	0.015	<0.05	<0.025	0.400
Greybull River		Water	100.0	<0.02	0.015	<0.05	<0.025	0.840
Drain - Greybull R.		Water	100.0	<0.02	0.015	<0.05	<0.025	0.580
Wordell Reservoir		Sediment	31.2	10.390	<2.18	<7.27	<3.63	95.490
Drain - Greybull R.		Sediment	30.1	9.730	9.010	<7.15	<3.58	45.490
Greybull River		Sediment	24.7	53.780	5.910	<6.64	3.520	44.620
McNiven Canal		Sediment	14.2	8.620	2.860	<5.83	2.910	38.000
McNiven Canal		Sediment	22.5	8.650	6.390	<6.45	<3.23	52.260
Wordell Reservoir	Sedge/Rush	Plant	81.7	4.590	2.840	<5.46	10.330	154.100
McNiven Canal	Potamogeton	Plant	87.2	3.910	6.250	<7.81	17.030	114.840
Greybull River	Potamogeton	Plant	91.2	7.950	7.160	12.840	20.340	975.000
Bighorn Basin Sites								
Lovell Lake		Sediment	37.3	11.50	10.80	NA	<35.0	389
Ralston Reservoir		Sediment	28.4	16.30	13.70	NA	<35.0	178
Lovell Lake	Potamogeton	Plant	87.8	<4.00	<7.00	NA	<45.0	239
Ralston Reservoir	Potamogeton	Plant	85.7	<4.00	<7.00	NA	<45.0	287

LOCATION	SPECIES	MATRIX	MOISTURE	Thallium	Vanadium	Zinc
Greybull River Sites						
Wordell Reservoir		Water	100.0	<0.1	<0.025	0.060
McNiven Canal		Water	100.0	<0.1	<0.025	0.018
Drain - Greybull R.		Water	100.0	<0.1	<0.025	0.018
Greybull River		Water	100.0	0.126	<0.025	<0.01
Drain - Greybull R.		Water	100.0	0.118	<0.025	0.025
Wordell Reservoir		Sediment	31.2	<14.53	12.860	47.240
Drain - Greybull R.		Sediment	30.1	<14.31	13.090	37.050
Greybull River		Sediment	24.7	<13.28	7.100	18.190
McNiven Canal		Sediment	14.2	<11.66	10.260	13.990
McNiven Canal		Sediment	22.5	<12.9	10.450	24.520

Appendix D. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for agricultural runoff induced trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Thallium	Vanadium	Zinc
Greybull River Sites						
Wordell Reservoir	Sedge/Rush	Plant	81.7	<10.93	3.720	33.880
McNiven Canal	Potamogeton	Plant	87.2	20.31	5.780	37.730
Greybull River	Potamogeton	Plant	91.2	37.05	15.570	39.770
Bighorn Basin Sites						
Lovell Lake		Sediment	37.3	NA	58.10	
Ralston Reservoir		Sediment	28.4	NA	56.10	44.2
Lovell Lake	Potamogeton	Plant	87.8	NA	1.69	13.4
Ralston Reservoir	Potamogeton	Plant	85.7		3.75	12.9

Appendix E. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium	Silver	Aluminum
Carbon County Sites								
Mahoney Lake		Soil	24.2	1.32	<0.033	0.160	<3.30	8258.57
Hogback Lake		Sediment	21.0	3.16	0.038	0.280	<3.16	7835.44
Saratoga Lake		Sediment	29.0	1.03	<0.035	<0.140	<3.52	1661.97
Saratoga Lake	Potamogeton	Plant	86.5	2.37	<0.185	<0.740	<3.70	148.15
Big Sandy River Drainage Sites								
Big Sandy Seep		Sediment	59.1	1.52	<0.020	5.280	<10.00	30000.00
Eden Res. Wetland		Sediment	57.0	1.76	<0.020	<0.300	<10.00	3510.00
Eden Res. Wetland		Sediment	58.1	1.62	<0.020	<0.300	<10.00	2630.00
Lower Bone Draw		Sediment	45.6	4.38	0.034	1.430	<10.00	39700.00
Upper Bone Draw		Sediment	13.8	1.82	<0.020	<0.300	<10.00	22800.00
Big Sandy River	Potamogeton	Plant	84.4	5.59	<0.030	<0.600	<10.00	1480.00
Eden Res. Wetland	Algae	Plant	93.2	5.38	0.034	<0.600	<10.00	7670.00
Lower Bone Draw	Potamogeton	Plant	84.2	1.79	<0.030	0.793	<10.00	614.00

LOCATION	SPECIES	MATRIX	MOISTURE	Boron	Barium	Beryllium	Cadmium	Chromium
Carbon County Sites								
Mahoney Lake		Soil	24.2	10.690	74.270	0.790	4.550	16.360
Hogback Lake		Sediment	21.0	8.290	100.250	0.700	0.820	10.950
Saratoga Lake		Sediment	29.0	4.440	29.860	<0.35	<0.35	3.450
Saratoga Lake	Potamogeton	Plant	86.5	467.410	57.330	<0.35	<0.37	2.520
Big Sandy River Drainage Sites								
Big Sandy Seep		Sediment	59.1	34.10	482.0	0.894	<0.500	29.30
Eden Res. Wetland		Sediment	57.0	65.20	65.2	<0.300	<0.500	5.37
Eden Res. Wetland		Sediment	58.1	57.50	57.5	<0.300	<0.500	4.89
Lower Bone Draw		Sediment	45.6	617.00	617.0	<0.300	<0.500	<2.50
Upper Bone Draw		Sediment	13.8	602.00	602.0	<0.300	<0.500	<2.50
Big Sandy River	Potamogeton	Plant	84.4	662.00	50.6	<0.200	<0.700	3.16
Eden Res. Wetland	Algae	Plant	93.2	7.37	170.0	0.260	1.650	10.70
Lower Bone Draw	Potamogeton	Plant	84.2	937.00	30.6	<0.200	<0.700	<3.00

Appendix E. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Copper	Iron	Magnesium	Manganese	Molybdenum
Carbon County Sites								
Mahoney Lake		Soil	24.2	12.400	14511.870	6820.580	179.420	3.300
Hogback Lake		Sediment	21.0	15.700	18227.850	6607.600	265.820	3.160
Saratoga Lake		Sediment	29.0	2.890	3845.070	1000.000	53.100	3.520
Saratoga Lake	Potamogeton	Plant	86.5	2.590	407.410	4822.220	740.740	3.700
Big Sandy River Drainage Sites								
Big Sandy Seep		Sediment	59.1	11.50	13800	7390	227	<5.00
Eden Res. Wetland		Sediment	57.0	<5.0	2280	4810	1160	<5.00
Eden Res. Wetland		Sediment	58.1	<5.0	2080	4030	1160	11.90
Lower Bone Draw		Sediment	45.6	16.20	21100	9670	518	<5.00
Upper Bone Draw		Sediment	13.8	8.97	15700	6780	339	<5.00
Big Sandy River	Potamogeton	Plant	84.4	4.50	1580	5620	2090	<7.50
Eden Res. Wetland	Algae	Plant	93.2	17.60	9300	7030	1380	<7.50
Lower Bone Draw	Potamogeton	Plant	84.2	<4.00	1370	4070	266	<7.50

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony	Tin	Strontium
Carbon County Sites								
Mahoney Lake		Soil	24.2	13.320	12.930	<6.6	<3.3	327.180
Hogback Lake		Sediment	21.0	18.480	12.780	<6.33	<3.16	70.130
Saratoga Lake		Sediment	29.0	<2.82	3.800	<7.04	4.650	22.820
Saratoga Lake	Potamogeton	Plant	86.5	<2.96	3.630	<7.41	15.040	227.410
Big Sandy River Drainage Sites								
Big Sandy Seep		Sediment	59.1	10.70	24.60	<50.0	<35.0	419
Eden Res. Wetland		Sediment	57.0	<3.00	<8.00	<50.0	<35.0	393
Eden Res. Wetland		Sediment	58.1	<3.00	<8.00	<50.0	<35.0	395
Lower Bone Draw		Sediment	45.6	4.10	18.40	<50.0	<35.0	334
Upper Bone Draw		Sediment	13.8	<3.00	<8.00	<50.0	<35.0	197
Big Sandy River	Potamogeton	Plant	84.4	<4.00	<7.00	<30.0	<45.0	210
Eden Res. Wetland	Algae	Plant	93.2	7.35	<7.00	<30.0	<45.0	73.
Lower Bone Draw	Potamogeton	Plant	84.2	<4.00	<7.00	<30.0	<45.0	245

Appendix E. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from sites surveyed for trace element contamination in Wyoming, 1989 - 1990.

LOCATION	SPECIES	MATRIX	MOISTURE	Thallium	Vanadium	Zinc
Carbon County Sites						
Mahoney Lake		Soil	24.2	<13.19	18.730	49.740
Hogback Lake		Sediment	21.0	<12.66	27.340	77.340
Saratoga Lake		Sediment	29.0	<14.08	6.340	13.590
Saratoga Lake	Potamogeton	Plant	86.5	23.48	<3.7	44.150
Big Sandy River Drainage Sites						
Big Sandy Seep		Sediment	59.1		47.00	34.50
Eden Res. Wetland		Sediment	57.0		4.47	9.18
Eden Res. Wetland		Sediment	58.1		3.72	6.83
Lower Bone Draw		Sediment	45.6		50.20	52.90
Upper Bone Draw		Sediment	13.8		39.00	36.50
Big Sandy River	Potamogeton	Plant	84.4		6.74	18.00
Eden Res. Wetland	Algae	Plant	93.2		15.30	43.20
Lower Bone Draw	Potamogeton	Plant	84.2		12.30	30.60

Appendix F. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from BLM stock ponds surveyed in Park County, Wyoming, 1989.

LOCATION	SPECIES	MATRIX	MOISTURE	Arsenic	Mercury	Selenium
BLM Stock Pond Sites						
Middle Dam		Water		<0.004	<0.0002	<0.0030
Cat Track Pond		Water		0.007	<0.0002	0.0062
Cat Track Pond	Potamogeton	Plant	76.5	0.706	<0.0300	2.5500
Cat Track Pond	Potamogeton	Plant	79.5	0.702	<0.0300	4.2200
Middle Dam	Potamogeton	Plant	86.4	2.470	<0.0300	1.1000
Middle Dam	Potamogeton	Plant	84.0	1.820	<0.0300	1.8400
Cat Track Pond		Sediment	57.2	2.550	<0.0200	0.7060
Cat Track Pond		Sediment	31.1	3.900	0.0207	<0.3000
Middle Dam Outlet		Sediment	36.0	2.240	0.0220	1.4600
Middle Dam Outlet		Sediment	15.8	4.080	0.0398	<0.3000
Sand Coulee		Sediment	47.1	1.390	<0.0200	0.5370

LOCATION	SPECIES	MATRIX	MOISTURE	Aluminum	Boron	Barium
BLM Stock Pond Sites						
Middle Dam		Water		<0.05	0.058	0.013
Cat Track Pond		Water		2.14	0.211	0.013
Cat Track Pond	Potamogeton	Plant	76.5	646.00	868.000	41.500
Cat Track Pond	Potamogeton	Plant	79.5	822.00	969.000	52.600
Middle Dam	Potamogeton	Plant	86.4	2560.00	662.000	34.900
Middle Dam	Potamogeton	Plant	84.0	1480.00	799.000	19.200
Cat Track Pond		Sediment	57.2	30100.00	68.900	351.000
Cat Track Pond		Sediment	31.1	18700.00	60.700	409.000
Middle Dam Outlet		Sediment	36.0	31900.00	62.100	444.000
Middle Dam Outlet		Sediment	15.8	19300.00	51.500	372.000
Sand Coulee		Sediment	47.1	24700.00	116.000	279.000

LOCATION	SPECIES	MATRIX	MOISTURE	Cadmium	Chromium	Cobalt
BLM Stock Pond Sites						
Middle Dam		Water		<0.004	0.011	<0.006
Cat Track Pond		Water		<0.004	<0.010	<0.006
Cat Track Pond	Potamogeton	Plant	76.5	<0.700	<3.000	<4.00
Cat Track Pond	Potamogeton	Plant	79.5	<0.700	<3.000	<4.00

Appendix F. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from BLM stock ponds surveyed in Park County, Wyoming, 1989.

LOCATION	SPECIES	MATRIX	MOISTURE	Cadmium	Chromium	Cobalt
BLM Stock Pond Sites						
Middle Dam	Potamogeton	Plant	86.4	<0.700	3.840	<4.00
Middle Dam	Potamogeton	Plant	84.0	<0.700	<3.000	<4.00
Cat Track Pond		Sediment	57.2	<0.500	62.600	<25.0
Cat Track Pond		Sediment	31.1	<0.500	43.100	<25.0
Middle Dam Outlet		Sediment	36.0	<0.500	56.500	<25.0
Middle Dam Outlet		Sediment	15.8	<0.500	40.700	<25.0
Sand Coulee		Sediment	47.1	<0.500	82.300	<25.0

LOCATION	SPECIES	MATRIX	MOISTURE	Iron	Magnesium	Manganese
BLM Stock Pond Sites						
Middle Dam		Water		0.069	10.00	0.014
Cat Track Pond		Water		1.110	2.35	<0.003
Cat Track Pond	Potamogeton	Plant	76.5	824.000	5080.00	65.700
Cat Track Pond	Potamogeton	Plant	79.5	695.000	4170.00	82.000
Middle Dam	Potamogeton	Plant	86.4	2130.000	4810.00	119.000
Middle Dam	Potamogeton	Plant	84.0	1530.000	5970.00	95.500
Cat Track Pond		Sediment	57.2	25100.000	7070.00	414.000
Cat Track Pond		Sediment	31.1	17000.000	5520.00	409.000
Middle Dam Outlet		Sediment	36.0	23900.000	7080.00	279.000
Middle Dam Outlet		Sediment	15.8	17500.000	5590.00	914.000
Sand Coulee		Sediment	47.1	37500.000	6820.00	306.000

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony
BLM Stock Pond Sites						
Middle Dam		Water		<0.010	<0.04	<0.06
Cat Track Pond		Water		<0.010	<0.04	<0.06
Cat Track Pond	Potamogeton	Plant	76.5	<4.000	<7.00	<30.00
Cat Track Pond	Potamogeton	Plant	79.5	<4.000	<7.00	<30.00
Middle Dam	Potamogeton	Plant	86.4	<4.000	<7.00	<30.00
Middle Dam	Potamogeton	Plant	84.0	<4.000	<7.00	<30.00
Cat Track Pond		Sediment	57.2	29.000	28.40	<50.00
Cat Track Pond		Sediment	31.1	23.300	29.70	<50.00

Appendix F. Trace element concentrations (ug/g or ug/ml) in water, sediment and aquatic vegetation from BLM stock ponds surveyed in Park County, Wyoming, 1989.

LOCATION	SPECIES	MATRIX	MOISTURE	Nickel	Lead	Antimony
Middle Dam Outlet		Sediment	36.0	26.200	29.50	<50.00
Middle Dam Outlet		Sediment	15.8	18.400	18.30	<50.00
Sand Coulee		Sediment	47.1	37.500	24.10	<50.00

LOCATION	SPECIES	MATRIX	MOISTURE	Strontium	Vanadium	Zinc
BLM Stock Pond Sites						
Middle Dam		Water		0.245	0.014	0.015
Cat Track Pond		Water		0.183	0.004	0.016
Cat Track Pond	Potamogeton	Plant	76.5	296.000	1.970	21.500
Cat Track Pond	Potamogeton	Plant	79.5	379.000	2.440	17.900
Middle Dam	Potamogeton	Plant	86.4	209.000	5.410	25.500
Middle Dam	Potamogeton	Plant	84.0	146.000	3.030	19.700
Cat Track Pond		Sediment	57.2	118.000	86.000	86.500
Cat Track Pond		Sediment	31.1	82.800	55.300	49.800
Middle Dam Outlet		Sediment	36.0	95.200	79.300	71.000
Middle Dam Outlet		Sediment	15.8	167.000	54.700	51.300
Sand Coulee		Sediment	47.1	165.000	121.000	106.000

Appendix G. Percent moisture and trace element concentrations (ug/g dry weight) in Trumpeter Swan (Cygnus buccinator) eggs collected in and near Grand Teton National Park, Teton County, Wyoming. (*NA = Not Analyzed by Lab)

SAMPLE #	% MOIST	As	Hg	Se	Ag	Al
GTNP-SE-9	58.5	<0.1	0.036	1.1	NA*	<0.3
GTNP-SE-10	56.2	<0.1	0.031	0.65	NA	0.4
GTNP-SE-11	59.3	<0.1	0.04	0.73	NA	<0.3
GTNP-SE-12	50.2	<0.1	0.018	0.59	NA	0.8
GTNP-SE-13	68.2	<0.1	0.022	0.67	NA	0.99
GTNP-SE-14	68.1	<0.1	0.032	0.74	NA	<0.3
GTNP-SE-15	69.0	<0.1	0.023	0.67	NA	<0.3
GTNP-SE-16	69.3	<0.1	0.024	0.79	NA	0.7
GTNP-SE-17	67.2	<0.1	0.03	0.74	NA	0.4
GTNP-SE-18	69.5	<0.1	0.025	0.57	NA	0.4
GTNP-SE-19	67.2	<0.1	0.016	0.59	NA	<0.4
101	63.1	<0.3	<0.02	0.778	<10.0	<10.0
102	64.0	<0.3	<0.02	1.09	<10.0	<10.0
103	67.8	<0.3	<0.02	0.872	<10.0	<10.0
104	65.6	<0.3	<0.02	1.18	<10.0	<10.0
105	55.7	<0.3	<0.02	0.772	<10.0	<10.0
107	67.1	<0.3	<0.02	1.27	<10.0	<10.0
108	67.0	<0.3	<0.02	1.26	<10.0	<10.0
109	71.3	<0.3	<0.02	0.664	<10.0	<10.0
110	68.9	<0.3	<0.02	0.618	<10.0	<10.0
111	68.0	<0.3	<0.02	0.851	<10.0	<10.0
112	63.3	<0.3	<0.02	1.27	<10.0	<10.0
113	66.0	<0.3	<0.02	1.04	<10.0	<10.0
114	67.5	<0.3	<0.02	1.13	<10.0	<10.0

SAMPLE #	B	Ba	Be	Cd	Co	Cr
GTNP-SE-9	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-10	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-11	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-12	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-13	NA	NA	<0.01	<0.06	NA	0.6
GTNP-SE-14	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-15	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-16	NA	NA	<0.01	<0.06	NA	0.2
GTNP-SE-17	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-18	NA	NA	<0.01	<0.06	NA	<0.2
GTNP-SE-19	NA	NA	<0.01	<0.06	NA	<0.2
101	<2.50	0.776	<0.200	<0.400	<3.00	<2.50
102	<2.50	5.16	<0.200	<0.400	<3.00	<2.50
103	<2.50	4.64	<0.200	<0.400	<3.00	<2.50
104	<2.50	3.29	<0.200	<0.400	<3.00	<2.50
105	<2.50	9.02	<0.200	<0.400	<3.00	<2.50
107	<2.50	1.73	<0.200	<0.400	<3.00	<2.50
108	<2.50	<0.500	<0.200	<0.400	<3.00	<2.50
109	<2.50	14.2	<0.200	<0.400	<3.00	<2.50

Appendix G. Percent moisture and trace element concentrations (ug/g dry weight) in Trumpeter Swan (Cygnus buccinator) eggs collected in and near Grand Teton National Park, Teton County, Wyoming. (*NA = Not Analyzed by Lab (Continued)

SAMPLE #	% MOIST	As	Hg	Se	Ag	Al
110	<2.50	9.37	<0.200	<0.400	<3.00	<2.50
111	<2.50	3.31	<0.200	<0.400	<3.00	<2.50
112	<2.50	2.28	<0.200	<0.400	<3.00	<2.50
113	<2.50	1.29	<0.200	<0.400	<3.00	<2.50
114	<2.50	1.08	<0.200	<0.400	<3.00	<2.50

SAMPLE #	Cu	Fe	Mg	Mn	Mo	Ni
GTNP-SE-9	3.37	48.6	NA	1.6	NA	<0.2
GTNP-SE-10	3.47	59.8	NA	1.6	NA	<0.2
GTNP-SE-11	3.63	58	NA	2.1	NA	0.2
GTNP-SE-12	4.01	36.1	NA	1.1	NA	<0.2
GTNP-SE-13	2.76	67.6	NA	1.1	NA	<0.4
GTNP-SE-14	3.31	54.8	NA	1.6	NA	<0.2
GTNP-SE-15	3.46	70.7	NA	1.3	NA	<0.2
GTNP-SE-16	3.63	66.1	NA	0.97	NA	<0.2
GTNP-SE-17	3.49	92.1	NA	1.2	NA	<0.2
GTNP-SE-18	4.1	63.2	NA	0.47	NA	<0.2
GTNP-SE-19	3.56	69.9	NA	0.67	NA	<0.2
101	4.04	44.2	322	<1.50	<4.00	<4.00
102	3.68	141.0	295	2.19	<4.00	<4.00
103	2.6	100.0	406	1.74	<4.00	<4.00
104	2.79	92.7	383	1.95	<4.00	<4.00
105	<2.50	106.0	414	2.03	<4.00	<4.00
107	3.18	61.4	482	<1.50	<4.00	<4.00
108	2.74	48.8	481	<1.50	<4.00	<4.00
109	6.82	77.4	512	<1.50	<4.00	<4.00
110	5.74	76.3	508	<1.50	<4.00	<4.00
111	4.65	55.2	355	<1.50	<4.00	<4.00
112	4.84	125.0	280	<1.50	<4.00	<4.00
113	4.47	125.0	259	<1.50	<4.00	<4.00
114	4.67	109.0	266	<1.50	<4.00	<4.00

SAMPLE #	Pb	Sb	Sn	Sr	Tl	V
GTNP-SE-9	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-10	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-11	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-12	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-13	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-14	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-15	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-16	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-17	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-18	<0.07	NA	NA	NA	<0.4	NA
GTNP-SE-19	<0.07	NA	NA	NA	<0.4	NA

Appendix G. Percent moisture and trace element concentrations (ug/g dry weight) in Trumpeter Swan (<u>Cygnus</u> <u>buccinator</u>) eggs collected in and near Grand Teton National Park, Teton County, Wyoming. (*NA = Not Analyzed by Lab)(Continued)

SAMPLE #	Pb	Sb	Sn	Sr	Tl	V
101	<6.00	<20.0	<20.0	0.74	NA	<1.50
102	<6.00	<20.0	<20.0	2.4	NA	<1.50
103	<6.00	<20.0	<20.0	2.18	NA	<1.50
104	<6.00	<20.0	25.7	1.66	NA	<1.50
105	<6.00	<20.0	<20.0	25.3	NA	<1.50
107	<6.00	<20.0	<20.0	1.5	NA	<1.50
108	<6.00	<20.0	<20.0	1.27	NA	<1.50
109	<6.00	<20.0	<20.0	2.28	NA	<1.50
110	<6.00	<20.0	<20.0	2.39	NA	<1.50
111	<6.00	<20.0	<20.0	1.05	NA	<1.50
112	<6.00	<20.0	<20.0	1.18	NA	<1.50
113	<6.00	<20.0	<20.0	1.04	NA	<1.50
114	<6.00	<20.0	<20.0	1.09	NA	<1.50

SAMPLE #	Zn
GTNP-SE-9	48.3
GTNP-SE-10	46.6
GTNP-SE-11	56.8
GTNP-SE-12	67.8
GTNP-SE-13	52.6
GTNP-SE-14	49.9
GTNP-SE-15	57.5
GTNP-SE-16	51.7
GTNP-SE-17	45.9
GTNP-SE-18	47.3
GTNP-SE-19	52.0
101	53.3
102	63.3
103	66.7
104	64.4
105	74.0
107	62.6
108	62.6
109	47.7
110	50.5
111	52.9
112	72.9
113	73.3
114	77.9

Appendix H. Trace element concentrations (ug/g dry weight) in fish collected from the Bighorn and Wind rivers, Bighorn and Fremont counties, Wyoming, 1987.

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SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Arsenic	Mercury	Selenium
Carp	1	Bighorn River - Greybull	71.0	0.49	0.490	3.1
Carp	1	Bighorn River - Greybull	73.3	0.59	0.624	3.9
Carp	1	Bighorn River - Greybull	69.1	0.52	0.190	3.5
Ling	1	Bighorn River - Worland	77.1	0.10	0.569	4.9
Ling	1	Bighorn River - Worland	80.5	0.47	0.798	7.7
Ling	1	Bighorn River - Worland	78.1	0.30	0.531	6.1
Ling	1	Bighorn River - Worland	80.0	0.55	0.430	3.9
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	<0.10	0.210	3.2
Brown Trout	2	Bighorn River - Thermopolis	70.1	<0.10	0.190	3.6
White Sucker	5	Bighorn River - Thermopolis	68.5	<0.10	0.270	1.6
White Sucker	4	Bighorn River - Worland	80.5	<0.10	0.380	3.4
White Sucker	2	Bighorn River - Greybull	77.5	<0.10	0.577	3.6
Sauger	1	Bighorn River - Lovell	73.5	0.57	0.771	2.9
Brown Trout	5	Wind River - above Riverton	72.9	<0.10	0.962	2.3
Longnose Sucker	5	Wind River - above Riverton	72.5	0.50	0.390	1.2
White Sucker	2	Wind River - above Riverton	77.7	<0.10	0.400	1.5
Sauger	2	Wind River - below Riverton	71.2	<0.10	0.908	2.0
Longnose Sucker	4	Wind River - below Riverton	73.6	0.31	0.220	1.7
White Sucker	5	Wind River - below Riverton	74.8	0.20	0.625	2.3

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Aluminum	Barium	Boron
Carp	1	Bighorn River - Greybull	71.0	200	14.70	<2.
Carp	1	Bighorn River - Greybull	73.3	975	20.10	<2.
Carp	1	Bighorn River - Greybull	69.1	578	21.90	<3.
Ling	1	Bighorn River - Worland	77.1	43	1.90	<2.
Ling	1	Bighorn River - Worland	80.5	97	4.40	<2.
Ling	1	Bighorn River - Worland	78.1	74	5.10	<3.
Ling	1	Bighorn River - Worland	80.0	36	2.40	<2.
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	37	1.30	<1
Brown Trout	2	Bighorn River - Thermopolis	70.1	17	0.40	<1
White Sucker	5	Bighorn River - Thermopolis	68.5	67	3.50	<1

Appendix H. Trace element concentrations (ug/g dry weight) in fish collected from the Bighorn and Wind rivers, Bighorn and Fremont counties, Wyoming, 1987.

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Aluminum	Barium	Boron
White Sucker	4	Bighorn River - Worland	80.5	154	8.17	<1
White Sucker	2	Bighorn River - Greybull	77.5	321	8.67	<1
Sauger	1	Bighorn River - Lovell	73.5	51	0.61	<1
Brown Trout	5	Wind River - above Riverton	72.9	10	0.78	<1
Longnose Sucker	5	Wind River - above Riverton	72.5	160	9.76	1
White Sucker	2	Wind River - above Riverton	77.7	33	8.25	<1
Sauger	2	Wind River - below Riverton	71.2	10	1.40	<1
Longnose Sucker	4	Wind River - below Riverton	73.6	470	6.68	2
White Sucker	5	Wind River - below Riverton	74.8	390	6.99	1

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Beryllium	Cadmium	Chromium
Carp	1	Bighorn River - Greybull	71.0	<0.10	<0.30	2.0
Carp	1	Bighorn River - Greybull	73.3	0.10	<0.30	4.5
Carp	1	Bighorn River - Greybull	69.1	<0.10	<0.30	3.0
Ling	1	Bighorn River - Worland	77.1	<0.10	<0.30	3.6
Ling	1	Bighorn River - Worland	80.5	<0.10	<0.30	2.0
Ling	1	Bighorn River - Worland	78.1	<0.10	<0.30	3.0
Ling	1	Bighorn River - Worland	80.0	<0.10	<0.30	2.0
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	<0.05	<0.10	<0.5
Brown Trout	2	Bighorn River - Thermopolis	70.1	<0.05	<0.10	<0.5
White Sucker	5	Bighorn River - Thermopolis	68.5	<0.05	<0.10	0.9
White Sucker	4	Bighorn River - Worland	80.5	<0.05	<0.10	1.0
White Sucker	2	Bighorn River - Greybull	77.5	0.06	<0.10	1.0
Sauger	1	Bighorn River - Lovell	73.5	0.05	<0.10	0.6
Brown Trout	5	Wind River - above Riverton	72.9	<0.05	<0.10	<0.5
Longnose Sucker	5	Wind River - above Riverton	72.5	<0.05	<0.10	1.0
White Sucker	2	Wind River - above Riverton	77.7	<0.05	0.41	2.7
Sauger	2	Wind River - below Riverton	71.2	<0.05	<0.10	<0.5
Longnose Sucker	4	Wind River - below Riverton	73.6	<0.05	<0.10	1.0
White Sucker	5	Wind River - below Riverton	74.8	<0.05	<0.10	0.8

Appendix H. Trace element concentrations (ug/g dry weight) in fish collected from the Bighorn and Wind rivers, Bighorn and Fremont counties, Wyoming, 1987.

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Copper	Iron	Magnesium
Carp	1	Bighorn River - Greybull	71.0	2.00	404.0	1620
Carp	1	Bighorn River - Greybull	73.3	1.60	787.0	1720
Carp	1	Bighorn River - Greybull	69.1	0.71	483.0	1520
Ling	1	Bighorn River - Worland	77.1	2.10	114.0	963
Ling	1	Bighorn River - Worland	80.5	3.00	181.0	1190
Ling	1	Bighorn River - Worland	78.1	0.88	116.0	1390
Ling	1	Bighorn River - Worland	80.0	2.20	122.0	1070
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	2.60	81.7	949
Brown Trout	2	Bighorn River - Thermopolis	70.1	10.20	40.0	865
White Sucker	5	Bighorn River - Thermopolis	68.5	2.00	105.0	995
White Sucker	4	Bighorn River - Worland	80.5	3.50	164.0	1630
White Sucker	2	Bighorn River - Greybull	77.5	3.10	261.0	1400
Sauger	1	Bighorn River - Lovell	73.5	0.96	67.3	949
Brown Trout	5	Wind River - above Riverton	72.9	4.90	57.8	970
Longnose Sucker	5	Wind River - above Riverton	72.5	2.50	268.0	1160
White Sucker	2	Wind River - above Riverton	77.7	3.90	461.0	1250
Sauger	2	Wind River - below Riverton	71.2	1.00	36.0	1080
Longnose Sucker	4	Wind River - below Riverton	73.6	2.60	366.0	1120
White Sucker	5	Wind River - below Riverton	74.8	4.40	340.0	1190

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Manganese	Molybdenum	Nickel
Carp	1	Bighorn River - Greybull	71.0	27.0	<1.0	<2.0
Carp	1	Bighorn River - Greybull	73.3	37.0	<1.0	3.0
Carp	1	Bighorn River - Greybull	69.1	30.0	<1.0	<2.0
Ling	1	Bighorn River - Worland	77.1	4.9	<1.0	<2.0
Ling	1	Bighorn River - Worland	80.5	6.9	<1.0	<2.0
Ling	1	Bighorn River - Worland	78.1	8.3	<1.0	<2.0
Ling	1	Bighorn River - Worland	80.0	4.7	<1.0	<2.0
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	9.4	<0.5	<0.7
Brown Trout	2	Bighorn River - Thermopolis	70.1	2.7	<0.5	<0.7
White Sucker	5	Bighorn River - Thermopolis	68.5	14.0	<0.5	0.7

Appendix H. Trace element concentrations (ug/g dry weight) in fish collected from the Bighorn and Wind rivers, Bighorn and Fremont counties, Wyoming, 1987.

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Manganese	Molybdenum	Nickel
White Sucker	4	Bighorn River - Worland	80.5	24.2	0.6	2.3
White Sucker	2	Bighorn River - Greybull	77.5	22.2	<0.5	1.0
Sauger	1	Bighorn River - Lovell	73.5	1.7	<0.5	<0.7
Brown Trout	5	Wind River - above Riverton	72.9	3.0	<0.5	<0.7
Longnose Sucker	5	Wind River - above Riverton	72.5	40.3	<0.5	1.0
White Sucker	2	Wind River - above Riverton	77.7	23.9	<0.5	<0.7
Sauger	2	Wind River - below Riverton	71.2	3.1	<0.5	<0.7
Longnose Sucker	4	Wind River - below Riverton	73.6	31.0	<0.5	<0.7
White Sucker	5	Wind River - below Riverton	74.8	30.0	<0.5	<0.7

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Lead	Silver	Strontium
Carp	1	Bighorn River - Greybull	71.0	<4.	<2	204.0
Carp	1	Bighorn River - Greybull	73.3	<4.	<2	180.0
Carp	1	Bighorn River - Greybull	69.1	<5.	<2	176.0
Ling	1	Bighorn River - Worland	77.1	<4.	<2	44.4
Ling	1	Bighorn River - Worland	80.5	<4.	<2	50.5
Ling	1	Bighorn River - Worland	78.1	<4.	<2	139.0
Ling	1	Bighorn River - Worland	80.0	<4.	<2	46.0
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	<2	<1	25.2
Brown Trout	2	Bighorn River - Thermopolis	70.1	<2	<1	19.0
White Sucker	5	Bighorn River - Thermopolis	68.5	<2	<1	64.2
White Sucker	4	Bighorn River - Worland	80.5	<2	<1	111.0
White Sucker	2	Bighorn River - Greybull	77.5	<2	<1	90.7
Sauger	1	Bighorn River - Lovell	73.5	<2	<1	13.9
Brown Trout	5	Wind River - above Riverton	72.9	<2	<1	15.5
Longnose Sucker	5	Wind River - above Riverton	72.5	<2	<1	51.6
White Sucker	2	Wind River - above Riverton	77.7	<2	<1	30.3
Sauger	2	Wind River - below Riverton	71.2	<2	<1	37.3
Longnose Sucker	4	Wind River - below Riverton	73.6	<2	<1	38.1
White Sucker	5	Wind River - below Riverton	74.8	<2	<1	60.0

Appendix H. Trace element concentrations (ug/g dry weight) in fish collected from the Bighorn and Wind rivers, Bighorn and Fremont counties, Wyoming, 1987.

SPECIES	# FISH IN COMPOSITE	LOCATION	MOISTURE	Vanadium	Thallium	Zinc
Carp	1	Bighorn River - Greybull	71.0	2.60	<5	
Carp	1	Bighorn River - Greybull	73.3	4.20	<5	42.2
Carp	1	Bighorn River - Greybull	69.1	2.00	<5	52.0
Ling	1	Bighorn River - Worland	77.1	<0.60	<5	51.3
Ling	1	Bighorn River - Worland	80.5	<0.60	<5	71.0
Ling	1	Bighorn River - Worland	78.1	<0.60	<5	64.5
Ling	1	Bighorn River - Worland	80.0	<0.60	<5	51.3
Rainbow Trout	5	Bighorn River - Thermopolis	70.2	<0.10	<2	77.2
Brown Trout	2	Bighorn River - Thermopolis	70.1	<0.10	<2	81.0
White Sucker	5	Bighorn River - Thermopolis	68.5	0.30	<2	41.8
White Sucker	4	Bighorn River - Worland	80.5	0.40	<2	67.2
White Sucker	2	Bighorn River - Greybull	77.5	0.95	<2	67.6
Sauger	1	Bighorn River - Lovell	73.5	0.20	<2	31.8
Brown Trout	5	Wind River - above Riverton	72.9	<0.1	<2	102.0
Longnose Sucker	5	Wind River - above Riverton	72.5	0.83	<2	51.3
White Sucker	2	Wind River - above Riverton	77.7	0.30	<2	57.0
Sauger	2	Wind River - below Riverton	71.2	<0.10	<2	42.0
Longnose Sucker	4	Wind River - below Riverton	73.6	0.89	<2	49.6
White Sucker	5	Wind River - below Riverton	74.8	0.86	<2	52.0