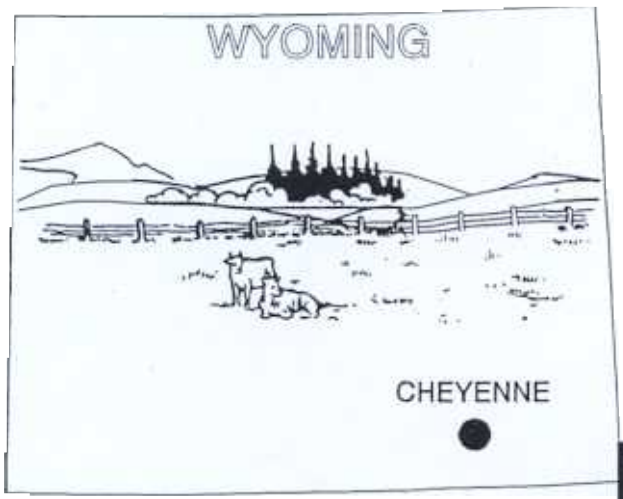
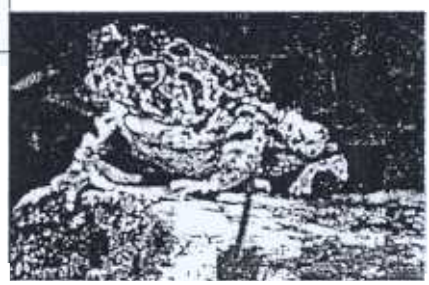
Contaminant Report Number: R6/704C/92

U.S. FISH & WILDLIFE SERVICE
REGION 6

CONTAMINANTS PROGRAM

TRACE ELEMENTS IN WATER, SEDIMENTS AND BIOTA FROM WETLANDS IN THE LARAMIE BASIN AND THEIR RELATIONSHIP TO THE RECOVERY OF THE ENDANGERED WYOMING TOAD
(Bufo hemiophrys baxteri)





U.S. FISH AND WILDLIFE SERVICE
Fish and Wildlife Enhancement
2617 East Lincolnway, Suite A
Cheyenne, Wyoming 82001

Project Numbers covered by this report:

89-6-077
90-6-065
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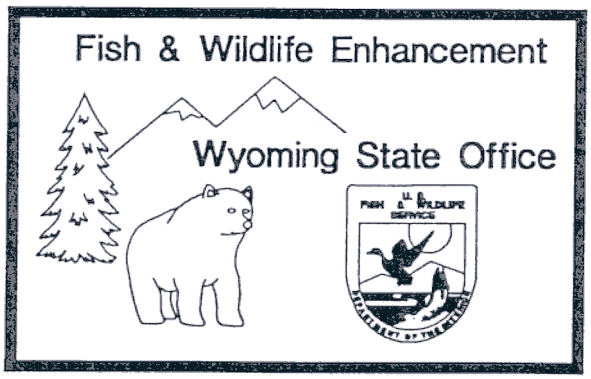
U.S. Fish and Wildlife Service
Region 6

Environmental Contaminants Program

TRACE ELEMENTS IN WATER, SEDIMENTS AND BIOTA FROM WETLANDS IN THE LARAMIE BASIN AND THEIR RELATIONSHIP TO THE RECOVERY OF THE ENDANGERED WYOMING TOAD (*Bufo hemiophrys baxteri*)

By
Pedro Ramirez, Jr.
September 1992



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ABSTRACT

The U.S. Fish and Wildlife Service conducted a monitoring study in 1989, 1990 and 1991 to determine if trace elements occur at levels that may affect the Wyoming toad (Bufo hemiophrys baxteri), a federally-listed endangered species. The study will provide information to help the Wyoming Toad Recovery Team to select reintroduction sites and in habitat acquisition efforts. Biologists collected water, sediment, aquatic invertebrates, algae and emergent insects from Mortenson Lake, historically occupied areas and proposed reintroduction sites. No major problems are apparent with trace elements in water, sediment and biota from sites providing existing or potential habitat for the Wyoming toad. Two algae samples from Lake Gellat had elevated cadmium concentrations of 1.19 and 2.19 µg/g dry weight; however, the source of cadmium is unknown as cadmium concentrations in water and sediment were below detection limits. Additional analyses of algae from Lake Gelatt should be performed to verify cadmium concentrations.

INTRODUCTION

The Wyoming toad (Bufo hemiophrys baxteri), a relictual subspecies restricted to the Laramie Basin, Albany County, Wyoming, experienced a drastic decline in the mid-1970's leading to its listing as an endangered species in 1984 (Lewis et al. 1985). Pesticide applications, primarily fenthion, for mosquito control within the toad's habitat, predation, disease and habitat modification are factors that could have contributed to the reduction of the Wyoming toad population (Lewis et al. 1985). The Wyoming toad was first discovered in 1946 by Dr. George T. Baxter of the University of Wyoming. The Wyoming toad is believed to be a disjunct population related to the Manitoba toad (Bufo hemiophrys hemiophrys) which occurs in Minnesota, South Dakota, and North Dakota in the United States, and Manitoba, Alberta, and Saskatchewan in Canada. The Wyoming toad is currently restricted to Mortensen Lake, and surrounding wet meadows located approximately 15 miles southwest of Laramie in Albany County. Breeding occurs in shallow water usually less than six inches deep. The Wyoming toad breeds in vegetated margins and bays of lakes, in ponds and in irrigated meadows.

Scientists from the University of Wyoming studied the possible effects of fenthion and its carrier, diesel, on the Wyoming Toad. Researchers conducted 96-hour bioassays using larvae and eggs from a surrogate species, the Manitoba toad (B. hemiophrys). Freda et al. (1988) did not observe toxic effects from concentrations similar to those applied in the field. The study however, did not address indirect or long-term effects on adult toads.

The role of trace elements in the decline of the Wyoming toad is unknown. The U.S. Fish and Wildlife Service conducted a monitoring study in 1989, 1990 and 1991 to determine if trace elements occur at levels that may affect the species. The study will provide information to help the Wyoming Toad

Recovery Team to select reintroduction sites and in habitat acquisition efforts.

Acknowledgements - Art Anderson, U.S. Fish and Wildlife Service; Dave Withers, University of Wyoming; and Debbie McCleary, Wyoming Game and Fish Department generously provided their time and expertise for the water, sediment and biota collections. Appreciation is extended to the landowners in the study area for allowing access to their property.

DESCRIPTION OF STUDY AREA

The Laramie Basin is a long, wide intermontane valley bordered by the Medicine Bow Mountains to the west and the Laramie Mountains to the east encompassing 2,250 square miles with elevations of 7,000 to 7,500 feet. Numerous playa lakes or ponds occur in "blowout areas" created by high winds. Most of these ponds occur in areas containing alluvial gravel deposits. Many of the ponds in the Laramie Basin receive irrigation return flows as well as inputs from natural runoff and springs. Habitat types in the study area include: wet meadow communities, grassland-greasewood communities, irrigated pasture, irrigated cropland, lakes and ponds. Baltic rush (Juncus balticus), common threesquare (Scirpus americanus), and spikerush (Eleocharis spp.) are found in the wet meadow communities.

The 65-acre Mortenson Lake and surrounding lands totaling 1,850 acres were acquired in 1991 by the Nature Conservancy for the conservation and recovery of the Wyoming toad. Mortenson Lake is one of three lakes in the Soda lakes complex. The Soda lakes complex are connected by irrigation canals during the toad breeding season. A seep running along two-thirds of Mortenson Lake's south shore contributes water into the lake. The western and northern shores of Mortenson Lake are dominated by a bullrush/sedge marsh. Mortenson Lake supports a trout fishery. The surrounding land was used primarily for grazing prior to its acquisition by the Nature Conservancy. The Service recently acquired the Mortenson Lake area from the Nature Conservancy for the management of endangered species and other wildlife.

METHODS

Biologists collected water, sediment, aquatic invertebrates, algae and emergent insects from Mortenson Lake, historically occupied areas and proposed reintroduction sites (Figure 1).

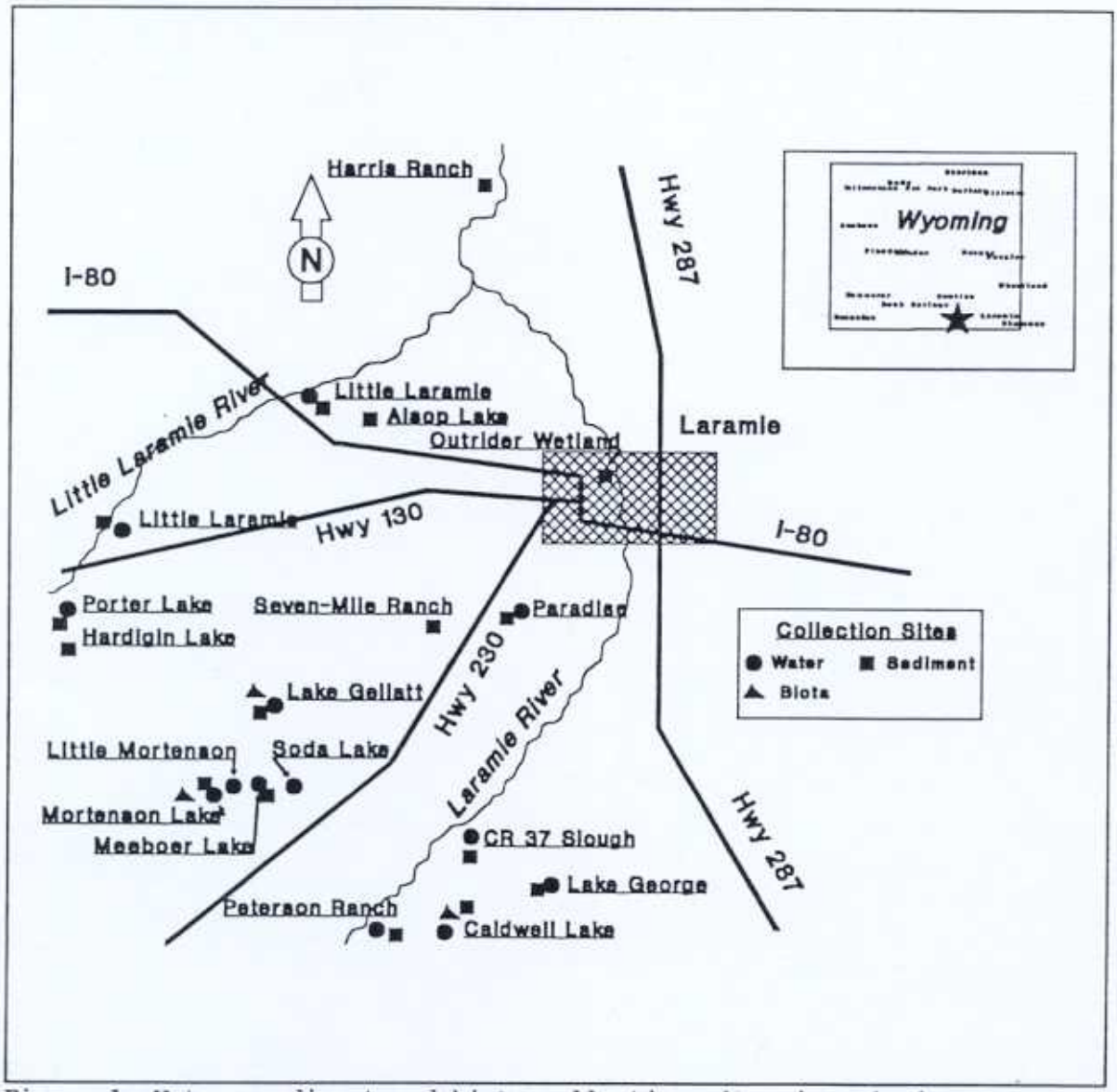

Figure 1. Water, sediment and biota collection sites in existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

A composite sample of chorus frogs (Pseudacris clarkii) was collected from Mortensen Lake. Two Wyoming toad carcasses recovered at Mortensen Lake were also submitted for chemical analyses. Emergent insects were collected with a sweep net. Aquatic invertebrates were collected with light traps similar to those described by Espinosa and Clark (1972). Algae was collected manually and cleaned of any detritus or sediment The U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF and Hazelton Laboratories of America, Inc., Madison, Wisconsin analyzed water and sediment samples for trace element concentrations. Hazelton Laboratories America, Inc. is under contract with the (PACF). The laboratory analyzed for mercury using cold vapor atomic absorption spectroscopy for mercury, 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 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. Laboratories reported percent moisture and dry weight concentrations.

RESULTS AND DISCUSSION

Trace Elements in Water

Dissolved concentrations of trace elements in water are shown on Appendix A. Total concentrations of trace elements in water are shown on Appendix B.

Aluminum

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). Aluminum in water and sediments is much more toxic to fish and amphibians when mobilized by low pH (EPA 1988, Freda et al. 1989). Water from all collection sites had pH's ranging from 8.0 to 9.0. Aluminum concentrations in water from all sites except Caldwell Lake and one sample from Mortenson Lake were above 87 ug/l. Aluminum concentrations may be much different from the values observed. Further monitoring may be necessary to determine if concentrations fluctuate below 87 ug/l.

Arsenic

EPA criterion for protection of freshwater aquatic life is 190 ug/l. Studies have documented mortality and malformations of toad embryos at 40 ug/l (Eisler 1988). Arsenic concentrations in water from all sites except Little Mortenson Lake were below 40 ug/l. Lower water levels at Little Mortenson Lake in 1989 could account for the elevated dissolved arsenic concentration (59 μg/l) due to evaporative concentration. Water levels were higher at adjacent lakes that had arsenic concentrations ranging from <1 to 2 ug/l. Total arsenic concentrations in Little Mortenson Lake were 0.001 mg/l in 1990 and 0.008 in 1991.

Boron

Total and dissolved boron concentrations in water from all sites ranged from 133 to 615 ug/l and 28 to 11,800 ug/l, respectively. These levels are below the 100,000 to 300,000 ug/l concentrations suspected of causing embryo mortality and teratogenesis in aquatic vertebrates (Eisler 1990).

Copper

Copper concentrations in water from all sites except Mortenson Lake were below detection limits. The total copper concentration in water from Mortenson Lake was 180 ug/l in 1990; however, water samples collected from this site in 1989 were below detection limits (< 130 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). Analyses of additional water samples could help determine if copper is exceeding the criteria.

Other Trace Elements

Antimony, beryllium, cadmium, chromium, lead, mercury, molybdenum, nickel, silver, thallium, tin, and vanadium concentrations in water from all sites were below detection limits. Iron, selenium and zinc concentrations at all sites were below EPA's Criteria for the Protection of Freshwater Aquatic life.

Trace Elements In Sediments

Trace element concentrations in sediments are shown in Appendix C. Several trace elements exceeded background concentrations found in soils from the northern great plains (Harms et al. 1990). Aluminum concentrations in sediments from Caldwell Lake, Paradise, Peterson Ranch, and Porter Lake exceeded the maximum background concentration of 12,000 ug/g dry weight reported by Harms et al. (1990). Boron in sediment from Paradise exceeded the background concentration of 99 ug/g dry weight.

Trace Elements In Biota

Trace element concentrations in algae, aquatic invertebrates, emergent insects, a chorus frog and two Wyoming toad carcasses are shown in Appendix D. Arsenic, silver, boron, beryllium, cadmium, molybdenum, lead, antimony, thallium, and vanadium were present below detection limits in the chorus frog and Wyoming toad carcasses. Zinc was present at levels below those found in frogs and toads from areas adjacent to zinc and steel smelters in Poland with zinc, cadmium and lead contamination (Dmowski and Karolewski 1979). Other trace elements were present at concentrations not considered elevated for amphibians (Hall and Mulhern 1984). Little information exists on trace element dietary thresholds for amphibians. Of the trace elements present above detection limits, most occurred in concentrations not considered adverse to fish or high vertebrates such as birds, with the exception of cadmium. The mean cadmium concentration in algae samples from Lake Gelatt was 1.69 ug/g dry weight (0.27 ug/g wet weight). Eisler (1985) recommended that cadmium concentrations greater than 0.1 ug/g wet weight in wildlife dietary items should be viewed with caution. The source of cadmium is unknown as cadmium concentrations in water and sediment from Lake Gelatt were below detection limits, <0.003 mg/l and <0.53 ug/g, respectively. Although the study's major focus was on trace elements, two Wyoming toad carcasses were analyzed for organophosphate pesticides and none were detected.

MANAGEMENT RECOMMENDATIONS

No major problems are apparent with trace elements in water, sediment and biota from sites providing existing or potential habitat for the Wyoming toad with the exception of Lake Gelatt and the elevated cadmium concentrations in algae. Additional analyses of algae from Lake Gelatt should be performed to verify if cadmium poses a risk to the reintroduction of the Wyoming toad at this site.

LITERATURE CITED

Dmowski, K. and M. A. Karolewski. 1979. Cumulation of zinc, cadmium and lead in invertebrates and in some vertebrates according to the degree of an area contamination. Ekologia Polska. 27(2):333-349.

Eisler, R. 1988. Arsenic hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85(1.12). 92 pp.

Eisler, R. 1985. Selenium hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85(1.5). 57 pp.

Eisler, R. 1985. Cadmium hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85(1.2). 46 pp.

Eisler, R. 1990. Boron hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish and Wildl. Serv. Biol. Rep. 85(1.20). 32 pp.

Environmental Protection Agency. 1980. Ambient water quality criteria for copper - 1980. EPA Report 440/5-80-036. National Technical Information Service, Springfield, VA.

Environmental Protection Agency. 1988. Ambient water quality criteria for aluminum - 1988. EPA Report 440/5-86-008. National Technical Information Service, Springfield, VA.

Espinosa, L. R. and W. E. Clark. 1972. A polypropylene light trap for aquatic invertebrates. California Fish and Game. 58:149-152.

Freda, J.; B. Gern; D. McCleary; and G. Baxter. 1988. 1988 Recovery efforts for the endangered Wyoming Toad, Bufo hemiophrys Baxteri. umpublished manuscript. Dept. Zoology, University of Wyoming, Laramie. 12 pp.

Freda, J.; V. Cavdek and D. G. McDonald. 1989. Role of organic complexation in the toxicity of aluminum to Rana pipiens and Bufo americanus tadpoles. Can. Jour. Fish. Aqua. Sci. 47: 217 - 224.

Hall, R. J. and B. M. Mulhern. 1984. Are anuran amphibians heavy metal accumulators? in Vertebrate Ecology and Systematics - a tribute to Henry S. fitch. R. A. Seigel, L. E. Hunt, J. L. Knight, L. Malaret and N. L. Zuschlag editors. Museum of Natural History. Univ. Kansas. Lawrence, KS. pp: 123 - 133.

Lewis, D. L.; G. T. Baxter; K. M. Johnson and M. D. Stone. 1985. Possible extinction of the Wyoming Toad (*Bufo hemiophrys baxteri*). Jour. Herpetology 19(1): 166-168.

APPENDIX

Appendix A. Dissolved trace element concentrations in water (mg/l) from sites providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Date	Arsenic	Mercury	Selenium	Silver	Aluminum	Boron
WTCLWD01	CR 37 Slough	07-Jun-89	<0.001	<0.0004	<0.001	<0.025	0.335	0.178
WTCLWD01	Caldwell Lake	10-May-89	0.004	<0.0004	<0.001	<0.025	<0.050	0.184
WTCLWD02	Caldwell Lake	10-May-89	0.003	<0.0004	<0.001	<0.025	0.320	0.176
WTSCLWD1	Caldwell Slough	10-May-89	0.009	<0.0004	<0.005	<0.025	0.375	1.790
WTGLWD01	Lake Gelatt	10-May-89	0.007	<0.0004	<0.001	<0.025	0.275	0.370
WTLGWD01	Lake George	10-May-89	0.004	<0.0004	<0.005	<0.025	0.245	0.710
WTLGWD02	Lake George	21-Jul-89	0.004	<0.0004	<0.001	<0.025	0.285	0.615
WTLLRWD1	Little Laramie	10-May-89	0.003	<0.0004	<0.001	<0.025	0.160	0.028
WTLMLWD1	Little Mortensen	10-May-89	0.059	<0.0004	0.007	<0.025	0.475	11.800
WTMBLWD1	Meeboer Lake	10-May-89	0.006	<0.0004	<0.001	<0.025	0.450	1.060
WTMLWD01	Mortensen Lake	10-May-89	0.001	<0.0004	<0.001	<0.025	0.310	0.306
WTMLWD02	Mortensen Lake	21-Jul-89	0.001	<0.0004	<0.001	<0.025	1.020	0.377
WTPWD1	Paradise	10-May-89	0.001	<0.0004	<0.001	<0.025	0.315	0.127
WTPRWD1	Petersen Ranch	10-May-89	0.001	<0.0004	<0.001	<0.025	0.210	0.096
WTPPWD1	Porter Pond	10-May-89	0.100	<0.0004	<0.001	<0.025	0.315	0.132

Sample #	Location	Date	Barium	Beryllium	Cadmium	Chromium	Copper	Iron
WTCLWD01	CR 37 Slough	07-Jun-89	0.088	<0.003	<0.003	<0.005	<0.013	0.930
WTCLWD01	Caldwell Lake	10-May-89	0.098	<0.003	<0.003	<0.005	<0.013	<0.05
WTCLWD02	Caldwell Lake	10-May-89	0.079	<0.003	<0.003	<0.005	<0.013	0.920
WTSCLWD1	Caldwell Slough	10-May-89	<0.025	<0.003	<0.003	<0.005	<0.013	0.085
WTGLWD01	Lake Gelatt	10-May-89	0.026	<0.003	<0.003	<0.005	<0.013	0.205
WTLGWD01	Lake George	10-May-89	0.032	<0.003	<0.003	<0.005	<0.013	<0.050
WTLGWD02	Lake George	21-Jul-89	0.032	<0.003	<0.003	<0.005	<0.013	0.185
WTLLRWD1	Little Laramie	10-May-89	0.040	<0.003	<0.003	<0.005	<0.013	0.190
WTLMLWD1	Little Mortensen	10-May-89	0.025	<0.003	<0.003	<0.005	<0.013	0.145
WTMBLWD1	Meeboer Lake	10-May-89	<0.025	<0.003	<0.003	<0.005	<0.013	0.165
WTMLWD01	Mortensen Lake	10-May-89	<0.025	<0.003	<0.003	0.005	<0.013	0.350
WTMLWD02	Mortensen Lake	21-Jul-89	<0.025	<0.003	<0.003	0.005	<0.013	0.200
WTPWD1	Paradise	10-May-89	0.050	<0.003	<0.003	<0.005	<0.013	0.260
WTPRWD1	Petersen Ranch	10-May-89	0.050	<0.003	<0.003	<0.005	<0.013	0.135
WTPPWD1	Porter Pond	10-May-89	0.085	<0.003	<0.003	<0.005	<0.013	0.260

Appendix A. Dissolved trace element concentrations in water (mg/l) from sites providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Date	Magnesium	Manganese	Molybdenum	Nickel	Lead	Antimony
WTCLWD01	CR 37 Slough	07-Jun-89	82.80	0.490	<0.025	<0.020	<0.015	<0.05
WTCLWD01	Caldwell Lake	10-May-89	48.90	<0.006	<0.025	<0.020	<0.015	<0.05
WTCLWD02	Caldwell Lake	10-May-89	74.20	0.474	<0.025	<0.020	<0.015	<0.05
WTSCLWD1	Caldwell Slough	10-May-89	406.00	0.056	<0.025	<0.020	<0.015	<0.05
WTGLWD01	Lake Gelatt	10-May-89	208.00	0.211	<0.025	<0.020	<0.015	<0.05
WTLGWD01	Lake George	10-May-89	319.00	0.036	<0.025	<0.020	<0.015	<0.05
WTLGWD02	Lake George	21-Jul-89	300.00	0.095	<0.025	<0.020	<0.015	<0.05
WTLLRWD1	Little Laramie	10-May-89	8.90	0.092	<0.025	<0.020	<0.015	<0.05
WTLMLWD1	Little Mortensen	10-May-89	849.00	0.010	<0.025	<0.020	<0.015	<0.05
WTMBLWD1	Meeboer Lake	10-May-89	186.00	0.010	<0.025	<0.020	<0.015	<0.05
WTMLWD01	Mortensen Lake	10-May-89	38.80	0.022	<0.025	0.020	<0.015	<0.05
WTMLWD02	Mortensen Lake	21-Jul-89	56.90	0.029	<0.025	0.020	<0.015	<0.05
WTPWD1	Paradise	10-May-89	22.10	0.024	<0.025	<0.020	<0.015	<0.05
WTPRWD1	Petersen Ranch	10-May-89	18.60	0.094	<0.025	<0.020	<0.015	<0.05
WTPPWD1	Porter Pond	10-May-89	32.40	0.012	<0.025	<0.020	<0.015	<0.05

Sample #	Location	Date	Tin	Strontium	Thallium	Vanadium	Zinc
WTCLWD01	CR 37 Slough	07-Jun-89	<0.025	2.320	<0.10	<0.025	0.018
WTCLWD01	Caldwell Lake	10-May-89	<0.025	1.460	<0.10	<0.025	0.022
WTCLWD02	Caldwell Lake	10-May-89	<0.025	2.370	<0.10	<0.025	0.020
WTSCLWD1	Caldwell Slough	10-May-89	<0.025	4.840	<0.10	<0.025	0.015
WTGLWD01	Lake Gelatt	10-May-89	<0.025	5.440	<0.10	<0.025	0.016
WTLGWD01	Lake George	10-May-89	<0.025	8.620	<0.10	<0.025	0.015
WTLGWD02	Lake George	21-Jul-89	<0.025	8.260	<0.10	<0.025	<0.010
WTLLRWD1	Little Laramie	10-May-89	<0.025	0.194	<0.10	<0.025	0.016
WTLMLWD1	Little Mortensen	10-May-89	<0.025	6.390	<0.10	<0.025	<0.010
WTMBLWD1	Meeboer Lake	10-May-89	<0.025	1.570	<0.10	<0.025	0.018
WTMLWD01	Mortensen Lake	10-May-89	<0.025	0.294	<0.10	<0.025	0.024
WTMLWD02	Mortensen Lake	21-Jul-89	<0.025	0.660	<0.10	<0.025	0.042
WTPWD1	Paradise	10-May-89	<0.025	0.774	<0.10	<0.025	0.140
WTPRWD1	Petersen Ranch	10-May-89	<0.025	0.582	<0.10	<0.025	0.018
WTPPWD1	Porter Pond	10-May-89	<0.025	0.566	<0.10	<0.025	0.020

Appendix B. Total trace element concentrations in water (mg/l) from sites providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Date	Arsenic	Mercury	Selenium	Silver	Aluminum	Boron
WTCLWT02	Caldwell Lake	10-May-89	0.003	<0.0004	<0.001	<0.025	0.100	0.133
WTCLWT04	Caldwell Lake	01-Sep-89	0.003	<0.0004	0.002	<0.025	1.310	0.505
WTSCLWT02	Caldwell Lake Slough	10-May-89	<0.001	<0.0004	<0.001	<0.025	0.115	0.102
WTHLW01	Hardigin Lake	09-Aug-91	0.015	<0.0002	<0.005	NA	1.280	0.102
WTHRW01	Harris Ranch	09-Aug-91	0.008	0.0002	<0.005	NA	0.138	0.121
WTGLWT1	Lake George	10-May-89	0.002	<0.0004	<0.001	<0.025	0.140	0.462
WTLGWT02	Lake George	07-Jun-89	0.002	<0.0004	0.002	<0.025	0.050	0.830
WTLGW04	Little Gelatt	02-Jul-89	0.002	<0.0004	0.001	<0.025	0.780	1.790
WTLMLW01	Little Mortensen	07-Jun-90	0.001	<0.0004	<0.001	<0.025	1.680	7.910
WTLMLW03	Little Mortensen	06-Aug-91	0.008	<0.0002	<0.005	NA	0.182	6.430
WTMLWT1	Mortensen Lake	10-May-89	0.001	<0.0004	<0.001	<0.025	0.075	0.259
WTMLWT02	Mortensen Lake	10-May-89	0.002	<0.0004	<0.001	<0.025	0.120	0.246
WTSDMW01	Mortensen Lake	06-Aug-91	0.003	<0.0002	<0.005	NA	0.481	0.040
WTMLW05	Mortensen Lake	09-Aug-91	0.003	<0.0002	<0.005	NA	0.449	0.253
WTRRWS01	Red Ryder Wetland	10-May-89	<0.001	<0.0004	<0.001	<0.025	0.145	0.223
WTSMLW01	Seven-Mile Lake	06-Aug-91	0.013	<0.0002	<0.005	NA	0.103	1.020

Sample #	Location	Date	Barium	Beryllium	Cadmium	Chromium	Copper	Iron
WTCLWT02	Caldwell Lake	10-May-89	0.049	<0.003	<0.003	<0.005	<0.013	0.075
WTCLWT04	Caldwell Lake	01-Sep-89	0.051	<0.003	<0.003	0.005	<0.013	0.200
WTSCLWT02	Caldwell Lake Slough	10-May-89	0.051	<0.003	<0.003	<0.005	<0.013	0.060
WTHLW01	Hardigin Lake	09-Aug-91	0.042	<0.001	<0.001	<0.002	0.006	2.000
WTHRW01	Harris Ranch	09-Aug-91	0.117	<0.001	<0.001	<0.002	0.014	0.498
WTGLWT1	Lake George	10-May-89	0.030	<0.003	<0.003	<0.005	<0.013	0.055
WTLGWT02	Lake George	07-Jun-89	0.038	0.003	<0.003	0.005	<0.013	0.100
WTLGW04	Little Gelatt	02-Jul-89	0.039	<0.003	<0.003	0.005	<0.013	0.650
WTLMLW01	Little Mortensen	07-Jun-90	0.040	0.003	<0.003	0.005	<0.013	0.150
WTLMLW03	Little Mortensen	06-Aug-91	0.022	<0.001	<0.001	<0.002	<0.002	0.049
WTMLWT1	Mortensen Lake	10-May-89	0.049	<0.003	<0.003	<0.005	<0.013	<0.050
WTMLWT02	Mortensen Lake	10-May-89	0.036	<0.003	<0.003	<0.005	<0.013	0.105
WTSDMW01	Mortensen Lake	06-Aug-91	0.071	<0.001	<0.001	<0.002	0.004	1.210
WTMLW05	Mortensen Lake	09-Aug-91	0.025	<0.001	<0.001	<0.002	0.005	0.307
WTRRWS01	Red Ryder Wetland	10-May-89	0.036	<0.003	<0.003	<0.005	<0.013	0.230
WTSMLW01	Seven-Mile Lake	06-Aug-91	0.013	<0.001	<.001	<0.002	0.005	0.183

Appendix B. Total trace element concentrations in water (mg/l) from sites providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Date	Magnesium	Manganese	Molybdenum	Nickel	Lead	Antimony
WTCLWT02	Caldwell Lake	10-May-89	21.80	0.020	<0.025	<0.020	<0.015	<0.05
WTCLWT04	Caldwell Lake	01-Sep-89	30.20	0.032	<0.025	0.020	<0.015	<0.05
WTSCLWT02	Caldwell Lake Slough	10-May-89	16.60	0.384	<0.025	<0.020	<0.015	<0.05
WTHLW01	Hardigin Lake	09-Aug-91	13.70	0.048	<0.008	0.004	<0.010	NA
WTHRW01	Harris Ranch	09-Aug-91	35.90	0.816	<0.008	<0.002	0.012	NA
WTGLWT1	Lake George	10-May-89	230.00	0.076	<0.025	<0.020	<0.015	<0.05
WTLGWT02	Lake George	07-Jun-89	2010.00	0.023	<0.025	0.020	<0.015	<0.05
WTLGW04	Little Gelatt	02-Jul-89	379.00	0.198	<0.025	0.020	<0.015	<0.05
WTLMLW01	Little Mortensen	07-Jun-90	601.00	0.026	0.028	0.020	0.021	<0.05
WTLMLW03	Little Mortensen	06-Aug-91	431.00	0.002	0.008	<0.002	<0.010	NA
WTMLWT1	Mortensen Lake	10-May-89	52.30	<0.006	<0.025	<0.020	<0.015	<0.05
WTMLWT02	Mortensen Lake	10-May-89	47.80	0.011	<0.025	<0.020	<0.015	<0.05
WTSDMW01	Mortensen Lake	06-Aug-91	32.30	0.035	<0.008	<0.002	0.024	NA
WTMLW05	Mortensen Lake	09-Aug-91	53.00	0.012	<0.008	<0.002	<0.010	NA
WTRRWS01	Red Ryder Wetland	10-May-89	47.20	0.030	<0.025	<0.020	<0.015	<0.05
WTSMLW01	Seven-Mile Lake	06-Aug-91	487.00	0.017	0.014	<0.002	<0.010	NA

Sample #	Location	Date	Tin	Strontium	Thallium	Vanadium	Zinc
WTCLWT02	Caldwell Lake	10-May-89	<0.025	0.732	<0.10	<0.025	<0.010
WTCLWT04	Caldwell Lake	01-Sep-89	<0.025	0.942	<0.10	<0.025	0.045
WTSCLWT02	Caldwell Lake Slough	10-May-89	<0.025	0.492	<0.10	<0.025	0.013
WTHLW01	Hardigin Lake	09-Aug-91	NA	0.331	NA	0.019	0.033
WTHRW01	Harris Ranch	09-Aug-91	NA	0.743	NA	0.004	0.020
WTGLWT1	Lake George	10-May-89	<0.025	6.080	<0.10	<0.025	0.012
WTLGWT02	Lake George	07-Jun-89	<0.025	12.800	<0.10	<0.025	0.031
WTLGW04	Little Gelatt	02-Jul-89	<0.025	11.900	<0.10	<0.025	0.038
WTLMLW01	Little Mortensen	07-Jun-90	<0.025	5.050	<0.10	<0.025	0.027
WTLMLW03	Little Mortensen	06-Aug-91	NA	3.050	NA	0.003	0.011
WTMLWT1	Mortensen Lake	10-May-89	<0.025	0.803	<0.10	<0.025	0.020
WTMLWT02	Mortensen Lake	10-May-89	<0.025	0.794	<0.10	<0.025	0.015
WTSDMW01	Mortensen Lake	06-Aug-91	NA	0.817	NA	0.003	0.019
WTMLW05	Mortensen Lake	09-Aug-91	NA	0.513	NA	0.002	0.012
WTRRWS01	Red Ryder Wetland	10-May-89	<0.025	0.778	<0.10	<0.025	0.010
WTSMLW01	Seven-Mile Lake	06-Aug-91	NA	4.800	NA	0.005	0.022

Appendix C. Trace element concentrations in sediment (ug/g dry weight) collected from wetlands providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Moisture	Arsenic	Mercury	Selenium	Silver
WTALS01	Alsop Lake	29.00	3.400	<0.0350	<0.140	<3.520
WTSCLS01	CR 37 SLOUGH	75.70	3.900	<0.1030	2.500	<10.300
WTCLS01	Caldwell Lake	54.70	14.000	<0.0550	0.880	<5.520
WTGLS01	Lake Gelatt	52.80	3.500	<0.0530	1.300	<5.300
WTLGS01	Lake George	45.20	3.600	<0.0460	0.910	<4.560
WTLLRS01	Little Laramie	40.70	8.000	0.0570	0.340	<4.220
WTLLRCS1	Little Laramie Riv.	61.30	0.390	<0.0650	<0.260	<6.460
WTLMLS01	Lower Mortensen	33.30	3.400	<0.0370	<0.150	<3.750
WTMBLS01	Meeboer Lake	23.50	2.500	<0.0330	0.520	<3.270
WTMLS01	Mortensen Lake	52.50	1.600	<0.0530	<0.210	<5.260
WTRRWS01	Outrider Wetland	41.50	4.000	0.0620	0.170	<4.270
WTPS01	Paradise	48.30	14.000	<0.0480	2.700	<4.840
WTPRS01	Peterson Ranch	56.00	9.500	0.0660	1.400	<5.680
WTPLS01	Porter Lake	51.50	6.500	<0.0520	0.210	<5.150

Sample #	Location	Aluminum	Boron	Barium	Beryllium	Cadmium
WTALS01	Alsop Lake	3880 000	5.770	35.100	0.700	<0.350
WTSCLS01	CR 37 SLOUGH	10200 000	22.400	259.000	1.230	2.060
WTCLS01	Caldwell Lake	31600 000	51.700	167.000	1.210	0.990
WTGLS01	Lake Gelatt	4760 000	13.900	37.400	<0.53	<0.530
WTLGS01	Lake George	4590 000	35.600	75.900	<0.460	0.460
WTLLRS01	Little Laramie	11200 000	17.200	97.800	1.010	0.840
WTLLRCS1	Little Laramie Riv.	7131 780	12.400	108.270	<0.650	3.360
WTLMLS01	Lower Mortensen	4930 000	47.700	59.900	0.600	<0.370
WTMBLS01	Meeboer Lake	1900 000	8.950	17.600	0.460	0.650
WTMLS01	Mortensen Lake	3970 000	19.800	42.600	0.630	<0.530
WTRRWS01	Outrider Wetland	3710 000	18.200	51.100	0.510	0.430
WTPS01	Paradise	21700 000	202.000	154.000	0.680	1.450
WTPRS01	Peterson Ranch	26500 000	19.400	250.000	2.160	0.910
WTPLS01	Porter Lake	16700 000	20.800	168.000	1.340	3.510

Appendix C. Trace element concentrations in sediment (ug/g dry weight) collected from wetlands providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Chromium	Copper	Iron	Magnesium	Manganese
WTALS01	Alsop Lake	7.960	3.240	5730.000	2470.00	90.500
WTSCLS01	CR 37 SLOUGH	21.200	14.400	26200.000	3790.00	795.000
WTCLS01	Caldwell Lake	32.500	22.800	22700.000	8650.00	168.000
WTGLS01	Lake Gelatt	8.160	4.030	6540.000	1990.00	96.100
WTLGS01	Lake George	5.930	3.470	5170.000	1960.00	82.100
WTLLRS01	Little Laramie	17.900	11.200	14000.000	3680.00	216.000
WTLLRCS1	Little Laramie Riv.	13.180	12.270	13720.930	3178.29	183.980
WTLMLS01	Lower Mortensen	7.570	5.020	5440.000	13400.00	115.000
WTMBLS01	Meeboer Lake	4.440	1.830	3670.000	895.00	36.500
WTMLS01	Mortensen Lake	6.630	3.370	5940.000	3520.00	202.000
WTRRWS01	Outrider Wetland	6.240	4.440	11500.000	2720.00	759.000
WTPS01	Paradise	27.400	20.500	22400.000	6530.00	517.000
WTPRS01	Peterson Ranch	39.700	21.200	28500.000	7680.00	332.000
WTPLS01	Porter Lake	20.500	11.300	16600.000	11800.00	356.000

Sample #	Location	Molybdenum	Nickel	Lead	Antimony	Tin
WTALS01	Alsop Lake	<3.52	5.35	<2.110	<7.04	<3.520
WTSCLS01	CR 37 SLOUGH	<10.3	20.00	20.800	<20.60	<10.300
WTCLS01	Caldwell Lake	<5.52	24.90	<3.31	<11.00	<5.520
WTGLS01	Lake Gelatt	6.360	5.93	10.300	<10.60	<5.300
WTLGS01	Lake George	<4.56	<3.65	7.660	<9.12	<4.560
WTLLRS01	Little Laramie	<4.22	13.90	13.200	<8.43	<4.220
WTLLRCS1	Little Laramie Riv.	<6.460	9.69	<3.880	56.59	<6.460
WTLMLS01	Lower Mortensen	<3.75	3.45	<2.250	20.60	<3.750
WTMBLS01	Meeboer Lake	<3.27	<2.61	5.420	<6.54	<3.270
WTMLS01	Mortensen Lake	<5.26	<4.21	<3.16	<10.50	<5.260
WTRRWS01	Outrider Wetland	<4.27	<3.42	10.400	<8.55	<4.270
WTPS01	Paradise	<4.84	25.00	<2.900	<9.67	<4.840
WTPRS01	Peterson Ranch	<5.68	20.40	<3.410	<11.40	<5.680
WTPLS01	Porter Lake	<5.15	11.20	23.500	<10.30	<5.150

Appendix C. Trace element concentrations in sediment (ug/g dry weight) collected from wetlands providing existing or potential habitat for the Wyoming toad, Albany County, Wyoming.

Sample #	Location	Strontium	Thallium	Vanadium	Zinc
WTALS01	Alsop Lake	136.000	<14.10	15.700	17.400
WTSCLS01	CR 37 SLOUGH	77.000	<41.20	62.100	107.000
WTCLS01	Caldwell Lake	165.000	<22.10	64.800	106.000
WTGLS01	Lake Gelatt	213.000	<21.20	23.300	27.500
WTLGS01	Lake George	115.000	<18.20	11.500	19.500
WTLLRS01	Little Laramie	96.800	<16.90	51.300	71.800
WTLLRCS1	Little Laramie Riv.	34.630	198.19	32.300	46.510
WTLMLS01	Lower Mortensen	429.000	<15.00	16.300	22.900
WTMBLS01	Meeboer Lake	28.000	<13.10	8.820	13.700
WTMLS01	Mortensen Lake	314.000	<21.10	12.000	24.000
WTRRWS01	Outrider Wetland	232.000	<17.10	17.000	23.800
WTPS01	Paradise	205.000	<19.30	82.200	95.100
WTPRS01	Peterson Ranch	68.900	<22.70	74.800	103.000
WTPLS01	Porter Lake	340.000	<20.60	37.000	55.900

Appendix D. Trace element concentrations in biota collected from wetlands providing potential or existing habitat for the Wyoming toad, Albany County, Wyoming.

Sample Type	Location	Moisture	Arsenic	Mercury	Selenium	Silver
Algae	Caldwell Lake	94.50	4.730	<0.4550	<1.820	<9.090
Algae	Caldwell Lake	92.50	4.930	<0.3330	<1.330	<6.670
Algae	Lake Gelatt	84.10	6.290	<0.1570	<0.630	<3.140
Algae	Lake Gelatt	84.00	9.380	<0.1560	1.440	<3.130
Aquatic Invertebrates	Caldwell Lake	89.30	<0.930	<0.2340	1.780	<4.670
Aquatic Invertebrates	Caldwell Lake	87.40	<0.790	0.7620	1.510	<3.970
Aquatic Invertebrates	Lower Mortensen	84.20	1.140	<0.1580	1.650	<3.160
Chorus Frog	Mortensen Lake	84.20	<0.630	0.4750	2.220	<3.160
Emergent Insects	Mortensen Lake	55.70	<0.230	0.0860	2.710	<1.130
Wyoming Toad	Mortensen Lake	60.83	<0.190	0.5100	2.000	0.000
Wyoming Toad	Mortensen Lake	67.28	<0.230	0.3000	2.200	0.000

Sample Type	Location	Aluminum	Boron	Barium	Beryllium	Cadmium
Algae	Caldwell Lake	1574.550	16.360	45.450	1.090	<0.910
Algae	Caldwell Lake	2466.670	204.000	111.870	<0.670	<0.670
Algae	Lake Gelatt	2622.640	523.900	52.960	<0.310	1.190
Algae	Lake Gelatt	3568.750	180.000	66.880	<0.310	2.190
Aquatic Invertebrates	Caldwell Lake	102.800	10.560	52.430	<0.470	<0.470
Aquatic Invertebrates	Caldwell Lake	228.570	4.210	22.380	<0.400	<0.400
Aquatic Invertebrates	Lower Mortensen	147.470	6.200	55.380	<0.320	<0.320
Chorus Frog	Mortensen Lake	6.330	4.370	10.510	<0.320	<0.320
Emergent Insects	Mortensen Lake	29.120	5.460	4.670	<0.110	0.160
Wyoming Toad	Mortensen Lake	31.000	<5.900	19.000	<0.590	<0.590
Wyoming Toad	Mortensen Lake	15.000	<7.000	21.000	<0.700	<0.700

Sample Type	Location	Chromium	Copper	Iron	Magnesium	Manganese
Algae	Caldwell Lake	<1.820	<4.550	2018.180	2418.18	670.910
Algae	Caldwell Lake	1.600	3.870	3280.000	6453.33	1346.670
Algae	Lake Gelatt	3.270	3.330	5182.390	18679.25	2974.840
Algae	Lake Gelatt	4.310	4.440	8250.000	10250.00	831.250
Aquatic Invertebrates	Caldwell Lake	<0.930	42.340	130.840	4000.00	32.340
Aquatic Invertebrates	Caldwell Lake	1.350	25.400	404.760	1507.94	41.510
Aquatic Invertebrates	Lower Mortensen	0.820	36.900	196.200	3126.58	40.250
Chorus Frog	Mortensen Lake	3.160	13.230	177.220	1715.19	25.570

Appendix D. Trace element concentrations in biota collected from wetlands providing potential or existing habitat for the Wyoming toad, Albany County, Wyoming.

Sample Type	Location	Chromium	Copper	Iron	Magnesium	Manganese
Emergent Insects	Mortensen Lake	1.200	18.170	277.650	1331.83	34.760
Wyoming Toad	Mortensen Lake	7.900	5.600	270.000	1900.00	28.000
Wyoming Toad	Mortensen Lake	2.400	41.000	190.000	1800.00	24.000

Sample Type	Location	Molybdenum	Nickel	Lead	Antimony	Tin
Algae	Caldwell Lake	<9.090	7.27	<5.450	<18.18	<9.090
Algae	Caldwell Lake	<6.670	5.33	<4.000	14.67	6.800
Algae	Lake Gelatt	<3.140	7.99	<1.890	22.52	<3.140
Algae	Lake Gelatt	<3.130	6.81	2.630	36.75	<3.130
Aquatic Invertebrates	Caldwell Lake	<4.670	3.74	<2.800	6.64	17.760
Aquatic Invertebrates	Caldwell Lake	<3.970	3.17	<2.380	<7.94	17.700
Aquatic Invertebrates	Lower Mortensen	<3.160	2.53	<1.900	<6.33	3.420
Chorus Frog	Mortensen Lake	3.540	2.53	<1.900	<6.33	14.560
Emergent Insects	Mortensen Lake	1.810	0.90	<0.680	<2.26	17.630
Wyoming Toad	Mortensen Lake	<4.900	6.00	<1.200	0.00	<5.900
Wyoming Toad	Mortensen Lake	<5.900	2.50	<1.400	0.00	<7.000

Sample Type	Location	Strontium	Thallium	Vanadium	Zinc
Algae	Caldwell Lake	166.730	<36.36	<9.090	<3.640
Algae	Caldwell Lake	546.670	<26.67	10.530	22.000
Algae	Lake Gelatt	1911.950	<12.58	15.350	45.910
Algae	Lake Gelatt	2000.000	21.06	22.190	43.130
Aquatic Invertebrates	Caldwell Lake	1766.360	<18.69	<4.670	91.120
Aquatic Invertebrates	Caldwell Lake	288.890	<15.87	<3.970	128.570
Aquatic Invertebrates	Lower Mortensen	1310.130	<12.66	<3.160	93.040
Chorus Frog	Mortensen Lake	114.560	<12.66	<3.160	181.010
Emergent Insects	Mortensen Lake	20.810	<4.51	<1.130	135.440
Wyoming Toad	Mortensen Lake	550.000	0.00	<0.590	160.000
Wyoming Toad	Mortensen Lake	220.000	0.00	<0.700	230.000