WATER-QUALITY DATA FOR THE BOISE RIVER, BOISE TO STAR, IDAHO, JANUARY TO MARCH 1988

By S.A. Frenzel and T.F. Hansen

U.S. GEOLOGICAL SURVEY

Open-File Report 88-474

Prepared in cooperation with

CITY OF BOISE

Boise, Idaho

1988

DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

District Chief
U.S. Geological Survey, WRD
230 Collins Road
Boise, ID 83702
(208) 334-1750

Copies of this report can be purchased from:

U.S. Geological Survey
Books and Open-File Reports
Federal Center, Bldg. 810
Box 25425
Denver, CO 80225
(303) 236-7476

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS

Inch-pound units in this report may be converted to metric units using conversion factors listed below. Constituent concentrations are given in mg/L (milligrams per liter) or μg/L (micrograms per liter), which are equal to parts per million or parts per billion; and in μg/g (micrograms per gram) or g/kg (grams per kilogram), which are equal to parts per million or parts per thousand. Specific conductance is reported in μS/cm (microsiemens per centimeter at 25 degrees Celsius). Data on fish are presented in metric units; inch-pound conversions are given in text or in table headnotes.

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
inch (in.)	25.40	millimeter

Temperature in °C (degrees Celsius) can be converted to °F (degrees Fahrenheit as follows: °F = (1.8)(°C) + 32. Water temperatures are reported to the nearest one-half degree.

88-474

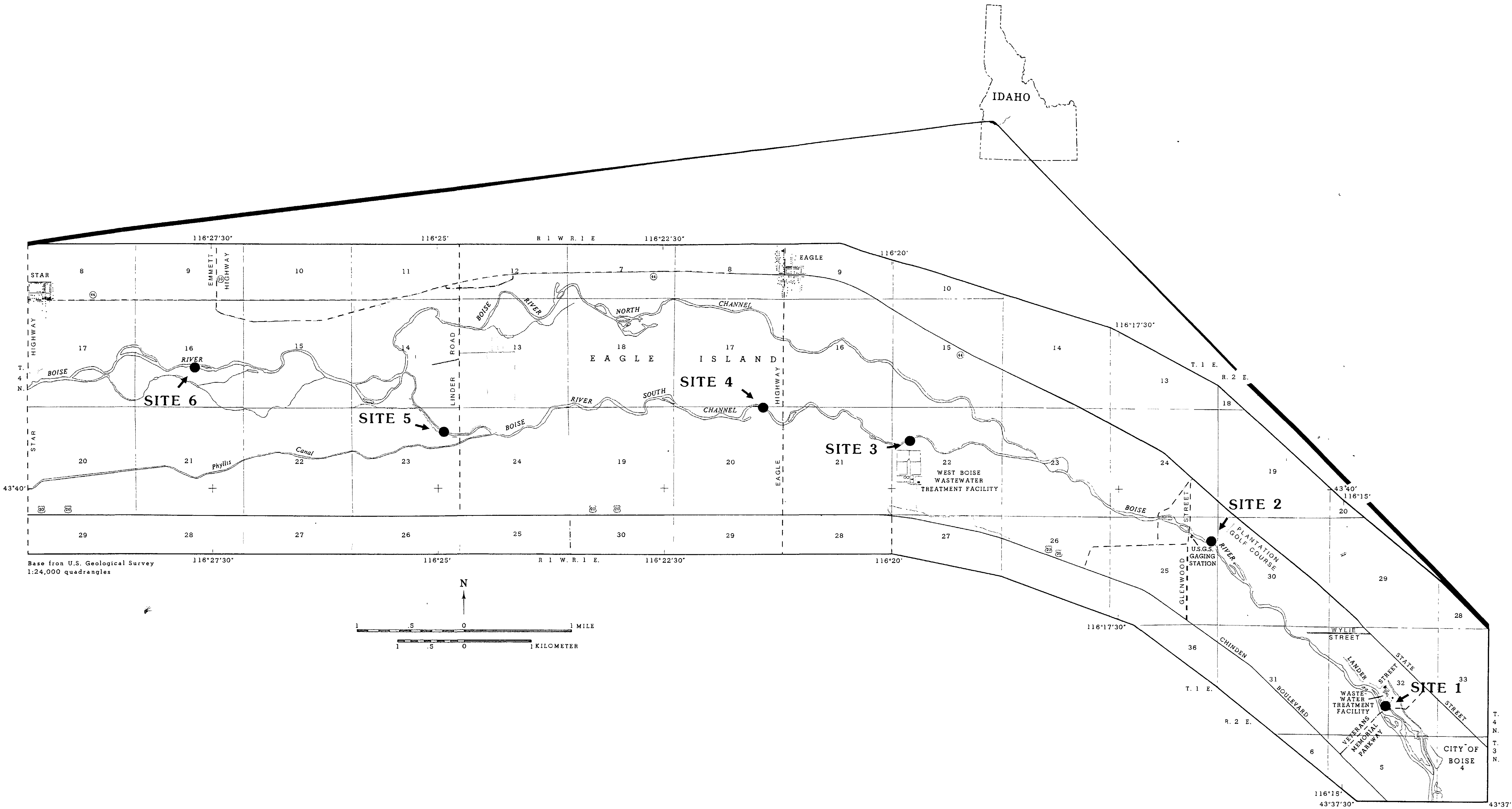

Figure 1.--Location of study area.

WATER-QUALITY DATA FOR THE BOISE RIVER, BOISE TO STAR, IDAHO, JANUARY TO MARCH 1988

By

S.A. Frenzel and T.F. Hansen

ABSTRACT

Physical and chemical data were collected at six sites and biological data were collected at five sites on the Boise River between Veterans Memorial Parkway in Boise and Star, Idaho, from January to March 1988. Data were collected to determine the effect of sewage effluent from two Boise wastewater treatment facilities on the water and biological quality of the Boise River. Similar data were collected from October to December 1987. Results of all data analyses will be discussed in an interpretive report.

INTRODUCTION

The City of Boise operates two municipal WTF's (wastewater treatment facilities) that provide secondary sewage treatment and discharge the treated effluent into the Boise River. The Lander Street WTF discharges effluent immediately downstream from the Veterans Memorial Parkway bridge, and the West Boise WTF discharges effluent into the south channel of the Boise River near Eagle Island State Park (fig. 1).

The NPDES (National Pollutant Discharge Elimination System) permits initially drafted to replace Boise's expired permits contained trace-element limits that were about equal to those currently (1987) being achieved by the Lander Street and West Boise WTF's. The City of Boise requested that the EPA (U.S. Environmental Protection Agency) modify the draft NPDES permits so that trace-element criteria were based on site-specific data rather than on laboratory-derived national criteria published in the EPA's Gold Book (U.S. EPA, 1986). The basis of the City's request was that EPA national criteria may not accurately reflect the bioavailability or toxicity of a pollutant because of local physical, chemical, or biological characteristics of receiving water. New NPDES permits were issued in March 1987 without specific trace-element limits, but with requirements for increased biomonitoring and a physical, chemical, and biological evaluation of the Boise River to determine the effects of effluent from the two WTF's on the river. Additional toxics control at the two WTF's may be deemed necessary on the basis of information gathered during the biomonitoring and river evaluation.

Purpose and Scope

The purpose of this study was to determine the effects of effluent discharged from the City of Boise's Lander Street and West Boise WTF's on the Boise River. Data were collected at the beginning (October to December 1987) and end (January to March 1988) of the low-flow period. Data collected from October to December are presented in a report by Frenzel and Hansen (1988). An interpretive report will incorporate data from both sampling periods and will emphasize the effects of trace elements from effluent on the water and biological quality of the Boise River. The scope of this report is limited to data collected at the end of the low-flow period from January to March 1988 and includes data collected by the Idaho Department of Fish and Game.

Methods of Data Collection

Dispersion characteristics of the effluent mixing zone downstream from each WTF were determined from cross-sectional field measurements using fluorometric dye tracing as described by Hubbard and others (1982) and Kilpatrick and Cobb (1984). Prior to dye injection, three cross sections were located within the expected mixing zones, which were determined using the equation given by Kilpatrick and Cobb (1984, p. 47). Rhodamine WT dye was injected into each WTF's effluent discharge using the slug-injection method (Kilpatrick and Cobb, 1984, p. 9-12). Dye clouds were sampled at the three cross sections below each WTF and, where dye concentrations were equal at all points in the cross section, the effluent was considered to be mixed completely with the river.

Samples for water-quality analyses were collected by cross-sectional, depth-integrated sampling methods (Guy and Norman, 1970, p. 30-32). At each site, water was composited in a churn splitter and aliquots were withdrawn, processed onsite, and sent for analysis to the U.S. Geological Survey National Water-Quality Laboratory in Arvada, Colo. After the water samples were collected, bottom-material samples in depositional areas near each cross section were collected using a stainless steel Ponar dredge or a 1-quart Teflon[1] bottle. Multiple grab samples were composited at each site, wet sieved through a 2.0-mm (0.078-in.) stainless steel mesh, then sent to the U.S. Geological Survey National Water-Quality Laboratory. Material finer than 0.063 mm (0.002 in.) was analyzed for trace elements and organic carbon.

---

[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Benthic invertebrates were collected using 12 artificial substrates each at sites 1, 2, 3, 5, and 6. Substrates consisted of 5/8-in. mesh wire cloth, 12 in. by 12 in. by 6 in., filled with 3- to 6-in. diameter cleaned river rocks. Substrates were placed randomly within riffles and were retrieved about 45 days later. During substrate retrieval, a 0.210-mm (0.008-in.) mesh drift net was placed immediately downstream from the substrates to capture dislodged organisms. Rocks from the substrates were scrubbed to remove invertebrates, and material cleaned from the rocks was poured through the drift net. Material retained in the drift net was placed in plastic containers and the containers were filled with 70 percent alcohol.

Invertebrate samples were sorted in the laboratory by using a series of sieves to remove debris. Only the invertebrates retained on a 0.250-mm (0.010-in.) or larger sieve were identified. Due to the large numbers of invertebrates colonizing the substrates, subsamples were taken from each substrate for identification. Benthic invertebrates were identified to the lowest taxonomic level possible by using keys from reports by Usinger (1956), Edmondson (1959), Jensen (1966), Edmunds and others (1976), Baumann and others (1977), Wiggins (1977), and Merritt and Cummins (1984). Diversity of insects colonizing artificial substrates was calculated using the Shannon-Weaver equation (Averett, 1981, p. B4):

$$d = - \Sigma \ (n_i/n)\log_2(n_i/n)$$

where

d = diversity or information content of the sample,
n_i = number of individuals in the ith taxa, and
n = number of individuals in the sample.

Fish populations at sites 1, 2, 3, 4, and 6 were determined by the Idaho Department of Fish and Game. Site 4, within the effluent mixing zone of the West Boise WTF, was sampled instead of site 5, which did not have a pool-riffle sequence similar to the other sites. Sites were electrofished, and fish populations were estimated using the three-pass removal method (Terry Holubetz, Idaho Department of Fish and Game, written commun., 1988). Electrofished sites were about 200 m (656 ft) long; however, to allow comparisons of fish populations between sites, densities were calculated as fish per 1,000 m^2 (10,760 ft^2) of stream-surface area.

Locations of Sampling Sites

General areas for site locations were based on results of the dispersion characteristics study. Sites downstream from each WTF were located where effluent was mixed completely with the river. Sites were selected so that physical characteristics of the river such as velocity, depth, and substrate composition were similar upstream and downstream from the WTF's. Additional sites were located within the effluent mixing zone of the West Boise WTF and near Star. Numbers and locations of sampling sites in the Boise River, shown in figure 1, are:

1) At Veterans Memorial Parkway, immediately upstream from the Lander Street WTF;
2) Above Glenwood Street, downstream from the effluent mixing zone of the Lander Street WTF;
3) South channel, immediately upstream from the West Boise WTF;
4) South channel near Eagle Highway, within the effluent mixing zone of the West Boise WTF;
5) South channel near Linder Road, downstream from the effluent mixing zone of the West Boise WTF; and
6) Downstream from the confluence of north and south channels near Star.

RESULTS

Water-quality data are presented in table 1. Benthic invertebrate data are presented in table 2; data are mean numbers per artificial substrate based on analysis of 10 substrates per site. Data on fish populations are presented in tables 3, 4, and 5.

Table 1.--Water-quality analyses, February 1988

[ft^3/s, cubic feet per second; mg/L, milligrams per liter; *, calculated value; mm Hg, millimeters mercury; µS/cm, microsiemens per centimeter; °C, degrees Celsius; NTU, nephelometric turbidity unit; µg/L, micrograms per liter; <, less than the given value, which is the detection level; hex, hexavalent; --, no data available; µg/g, micrograms per gram; g/kg, grams per kilogram]

Water-quality constituent	Sampling sites, Date (1988), Time (24-hour)					
	1 2/ 9 1430	2 2/ 9 1130	3 2/ 9 0930	4 2/10 1415	5 2/10 1200	6 2/10 0930
Onsite determinations						
Instantaneous discharge (ft^3/s)	128	147	61.9	73.9	99.2	236
Dissolved oxygen (mg/L)	12.0	10.4	9.3	12.6	10.8	10.0
Percent saturation*	98	89	80	114	93	85
Barometric pressure (mm Hg)	696	696	696	703	703	704
pH (standard units)	8.3	7.8	7.9	8.3	7.8	7.7
Alkalinity (mg/L as $CaCO_3$)	57	73	71	83	110	97
Bicarbonate (mg/L as HCO_3)	70	89	86	101	134	118
Specific conductance (µS/cm)	118	175	172	291	293	248
Water temperature (°C)	3.5	5.0	5.0	7.5	6.0	5.0
Laboratory analyses						
pH (standard units)	8.1	7.7	7.8	7.9	7.9	7.9
Alkalinity (mg/L as $CaCO_3$)	55	65	66	92	107	79
Hardness, total (mg/L as $CaCO_3$)*	46	55	55	79	90	66
Residue, dissolved, at 180 °C (mg/L)	81	113	114	159	184	178
Dissolved solids, sum (mg/L)*	81	110	110	160	180	170
Specific conductance (µS/cm)	131	191	192	265	311	311
Turbidity (NTU)	2.4	3.2	2.4	2.0	2.8	3.1
Calcium, dissolved (mg/L as Ca)	15	18	18	25	28	21
Magnesium, dissolved (mg/L as Mg)	2.1	2.4	2.6	4.1	4.9	3.2
Potassium, dissolved (mg/L as K)	.7	1.8	1.7	2.2	2.5	2.8
Silica, dissolved (mg/L as SiO_2)	13	14	14	17	19	16
Sodium, dissolved (mg/L as Na)	7.5	16	15	24	29	36
Sodium adsorption ratio*	.5	.9	.9	1	1	2

Table 1.--Water-quality analyses, February 1988 (Continued)

Water-quality constituent	Sampling sites, Date (1988), Time (24-hour)					
	1 2/ 9 1430	2 2/ 9 1130	3 2/ 9 0930	4 2/10 1415	5 2/10 1200	6 2/10 0930
Laboratory analyses--Continued						
Sodium, percent*	26	38	37	39	41	54
Nitrogen, ammonia, total (mg/L as N)	.02	.72	.62	.28	.39	.20
Chloride, dissolved (mg/L as Cl)	2.9	8.0	7.2	10	13	21
Fluoride, dissolved (mg/L as F)	.50	.70	.70	.60	.60	.70
Sulfate, dissolved (mg/L as SO_4)	6.6	12	12	17	20	25
Aluminum, total (μg/L as Al)	240	310	280	350	440	350
Cadmium, total (μg/L as Cd)	<1	<1	<1	<1	<1	<1
Chromium, total (μg/L as Cr)	1	<1	<1	<1	1	1
Chromium hex, total (μg/L as Cr)	<1	<1	<1	<1	<1	<1
Copper, total (μg/L as Cu)	4	4	5	4	3	5
Cyanide, total (μg/L as CN)	<10	<10	<10	<10	<10	<10
Iron, total (μg/L as Fe)	280	330	300	420	460	370
Lead, total (μg/L as Pb)	<5	<5	<5	<5	<5	<5
Nickel, total (μg/L as Ni)	<1	<1	<1	<1	<1	<1
Silver, total (μg/L as Ag)	1	--	<1	<1	<1	<1
Zinc, total (μg/L as Zn)	<10	10	10	20	10	20
Aluminum, bottom (μg/g as Al)	1,700	2,000	2,200	2,800	1,400	1,800
Arsenic, bottom (μg/g as As)	3	3	3	5	2	3
Cadmium, bottom (μg/g as Cd)	<1	<1	<1	<1	<1	<1
Chromium, bottom (μg/g as Cr)	<10	<10	<10	<10	<10	<10
Copper, bottom (μg/g as Cu)	6	7	8	9	4	3
Cyanide, bottom (μg/g as CN)	<10	<10	<10	<10	<10	<10
Iron, bottom (μg/g as Fe)	2,400	2,600	2,500	4,000	1,800	2,500
Lead, bottom (μg/g as Pb)	10	<10	<10	<10	<10	<10
Nickel, bottom (μg/g as Ni)	<10	<10	<10	<10	<10	<10
Zinc, bottom (μg/g as Zn)	20	20	30	40	20	20
Carbon, organic, bottom (g/kg)	1.8	1.8	6.8	6.1	2.6	2.1

Table 2.--Taxa and densities of benthic invertebrates per artificial substrate

[Densities are rounded to two significant figures, or to the nearest whole number; --, classified at a lower level or not present]

TAXA PHYLUM Class Subclass Order Suborder Family Genus species	Site 1	Site 2	Site 3	Site 5	Site 6
Date of substrate placement (1988)	1/21	1/21	1/22	1/22	1/22
Date of substrate retrieval (1988)	3/ 2	3/ 2	2/29	2/29	2/29
ARTHROPODA	--	--	--	--	--
Arachnida	--	--	--	--	--
Acari	370	340	100	200	86
Crustacea	--	--	--	--	--
Amphipoda	--	--	--	--	--
Gammaridae	--	1	--	24	--
Cladocera	13	--	3	3	3
Copepoda	--	--	--	3	3
Cyclopoida	--	13	3	6	6
Harpacticoida	--	6	--	--	--
Decapoda	--	--	--	--	--
Astacidae	--	--	--	--	--
Pacifastacus sp.	--	--	--	1	--
Isopoda	--	--	--	--	--
Asellidae	--	--	--	5	--
Ostracoda	--	--	--	1	6
Insecta	--	--	--	--	--
Coleoptera	--	--	--	--	--
Hydrophilidae	--	--	--	--	--
Helophorus sp.	--	--	--	1	--
Staphylinidae	--	--	--	1	--
Collembola	--	--	3	3	--
Diptera	56	91	120	72	75
Chironomidae	8,000	6,100	2,500	3,200	4,000
Empididae	3	3	1	7	3
Simuliidae	220	400	3,300	230	670

Table 2.--Taxa and densities of benthic invertebrates per artificial substrate
(Continued)

TAXA PHYLUM Class Subclass Order Suborder Family Genus species	Site 1	Site 2	Site 3	Site 5	Site 6
Ephemeroptera	--	--	--	3	--
Baetidae	--	--	--	--	--
Baetis spp.	470	830	2,700	2,700	5,000
Ephemerellidae	--	--	--	--	--
Ephemerella sp.	44	370	13	230	190
Heptageniidae	--	--	6	1	6
Heptagenia sp.	--	1	--	7	1
Rhithrogena sp.	--	--	6	1	2
Stenonema sp.	--	1	--	1	10
Tricorythidae	--	--	--	--	--
Tricorythodes sp.	10	1	3	160	100
Lepidoptera	--	--	--	--	--
Pyralidae	--	--	--	--	--
Petrophila sp.	1	8	8	3	26
Odonata	--	--	--	--	--
Coenagrionidae	--	--	--	1	--
Plecoptera	--	1	3	--	--
Capniidae	--	--	--	--	1
Perlidae	--	--	--	--	--
Claassenia sp.	1	--	--	--	--
Perlodidae	7	75	60	29	--
Form 1	10	48	21	4	1
Form 2	14	44	110	58	4
Trichoptera	64	3	3	22	22
Hydropsychidae	56	330	190	33	89
Cheumatopsyche sp.	5	51	64	19	37
Hydropsyche sp.	56	410	190	36	110
Hydroptilidae	--	--	--	--	--
Hydroptila sp.	16	4	--	1	14
Limnephilidae	--	--	--	--	--
Psychoglypha sp.	--	--	--	1	--

Table 2.--Taxa and densities of benthic invertebrates per artificial substrate (Continued)

TAXA PHYLUM Class Subclass Order Suborder Family Genus species	Site 1	Site 2	Site 3	Site 5	Site 6
MOLLUSCA	--	--	--	--	--
Gastropoda	--	--	--	1	--
Pulmonata	--	--	--	--	--
Basommatophora	--	--	--	--	--
Ancylidae	--	--	--	3	--
Physidae	--	--	--	2	--
Planorbidae	1	--	--	4	1
Mean number of invertebrates	9,500	9,100	9,400	7,100	10,000
Number of noninsect taxa	3	4	3	10	5
Number of insect families	11	11	10	16	12
Diversity index for insect families	0.70	1.53	1.93	1.69	1.65

Table 3.--Population densities of fish, January and February 1988[1]

[Values are numbers of fish per 1,000 square meters (10,760 square feet) of stream-surface area]

Species	Site				
	1	2	3	4	6
Native rainbow trout	0.5	0.1	6.7	6.7	0.2
Native brown trout	.3	0	.2	1.2	0
Hatchery rainbow trout	1.4	.6	1.0	8.7	1.3
Whitefish	30	56	140	100	25
Largemouth bass	0	.3	0	.1	0
Nongame fish	120	640	54	180	260

[1] Data from Terry Holubetz (Idaho Department of Fish and Game, written commun., 1988).

Table 4.--Length and weight of native trout, January and February 1988[1]

[Length in millimeters; weight in grams; dash indicates not applicable; to convert millimeters to inches, multiply by 0.03937; to convert grams to ounces, multiply by 0.03527]

Length	Weight									
	Site 1		Site 2		Site 3		Site 4		Site 6	
	Rainbow trout	Brown trout	Rainbow trout	Brown trout	Rainbow trout	Brown trout	Rainbow trout	Brown trout	Rainbow trout	Brown trout
75	--	--	--	--	--	--	--	50	--	--
100	--	15	--	--	--	--	--	--	--	--
120	20	--	--	--	--	--	--	--	--	--
145	50	--	--	--	55	--	--	--	--	--
150	--	50	--	--	40,60	--	--	--	--	--
155	--	--	--	--	30	--	--	--	--	--
160	--	--	--	--	60,70,70	--	--	--	--	--
165	--	80	--	60	--	--	40	--	--	--
170	--	--	--	--	30	--	--	40	--	--
175	--	--	--	--	80,80	--	--	--	--	--
180	--	--	--	--	--	--	50	--	--	--
185	--	--	--	--	--	--	60	--	--	--
190	--	--	--	--	80,100	--	--	--	--	--
195	--	110	--	110	--	--	100	100,100	--	--
205	--	--	--	--	--	--	--	110	--	--
210	--	--	--	--	--	160	160	--	--	--
230	--	--	--	--	--	--	190	--	--	--
235	--	--	--	--	170	--	180,210	--	--	--
245	--	--	--	--	--	--	170,170	--	--	--
250	--	--	--	--	--	--	200,210	--	--	--
255	--	--	--	--	230	--	200,200, 230	--	--	--
260	--	--	--	--	--	--	230	--	--	--
265	--	--	--	--	--	--	260	--	--	--
275	--	--	--	--	250	--	--	--	--	--
285	--	--	--	--	--	--	260,260 300	--	--	--
290	--	--	--	--	320	--	285	--	--	--
300	--	--	--	--	360,420, 460	--	--	--	--	--
310	--	--	--	--	370,420	--	--	--	--	--
315	--	--	--	--	390,390, 400,400, 460,510	--	300	--	--	--
320	--	--	--	--	490	--	--	--	--	--
330	--	--	--	--	500	--	540	--	--	--
335	--	--	--	--	430	--	--	--	--	--
340	--	--	--	--	520,530	--	--	--	510	--
350	--	--	--	--	--	--	420,590	--	--	--
360	--	--	--	--	--	--	640	--	--	--
380	--	--	--	--	780	--	830	--	--	--
445	--	--	--	--	--	--	800	--	--	--

[1]Terry Holubetz (Idaho Department of Fish and Game, written commun., 1988).

Table 5.--Length and weight of whitefish, January and February 1988[1]

[Length in millimeters; weight in grams; dash indicates not applicable; to convert millimeters to inches, multiply by 0.03937; to convert grams to ounces, multiply by 0.03527]

	Weight				
Length	Site 1	Site 2	Site 3	Site 4	Site 6
130	--	--	--	--	30
140	30	--	--	--	--
145	20,30,40	--	--	--	--
150	30	--	--	--	40
155	30,30,45,80	--	--	--	--
160	--	--	--	--	40
165	40,45,50	50	--	20	30,30,40
175	--	--	100	35	60,70
180	70	--	40,70	30,30,35, 40,40,40	--
185	--	70,80	60	40,40	70,80
190	--	--	70,100,130	50,50,50,50	40,40,60, 70,70,80
195	--	--	--	50,50,60	90
200	90	--	90	60,80	100
205	--	90	--	60	--
210	90,100	--	100,120	80	--
220	--	105,130	--	--	115
225	110,140	140	--	--	--
230	120,120,140	170	--	--	110
235	150	170,170,190	--	--	--
240	--	--	140,170,170, 280	--	--
245	140,140,190	180	190,200	150	260
250	170,180,190, 200	50,180,180, 180,190,200, 240	160	160,200,220, 290	--
255	--	180,190,190, 190,200,210, 255	170,180,190	150	150,170,180, 190
260	170	200,200,220, 230,230,240	180,180,210, 220,230,250, 290	150,180,200, 210,210	190,210
265	210	220,220,230, 230,230,240	200,220,230, 240	190,200,200, 200,220,220, 260	190,200,210, 210
270	160,200	230,240,250, 260,260,270, 280	210,220,220, 220,220,230, 230,240,260	150,170,200, 200,210,210, 210,220,230	200,220,230
275	--	230,230,260 260,260,280, 280,280	220	210,240,250	200,220,230
280	--	290,300	220,240,250, 250,260,270	220,230,240, 240,240,240, 250,310	220,260,270
285	280	250,260,260, 260,270,270, 280,280	260	210,230,230, 240	140,210,220, 250,250,260, 270,270,270
290	280	260,270,290, 300,305,310, 360	280,300,310, 310,310	240,250,310	180,220,220, 240,270,280, 290
295	--	270,270,280, 320,330	250,280,290, 310	280,280,280 320	280
300	280	150,310,360	--	230,260,260, 310	280,280,320 320
305	--	290,310,370	320,370	270,290,300, 310	180,270,280, 300,310,310
310	--	290,380,390, 400	320,320,320 350,380	300,300,320, 320,330,330, 370	300,320,350, 360
315	--	350,390,400, 400,400	350,370,380, 390	290,290,330, 330,340,390	310,350
320	--	300,330,380, 380,390,400	360,370,380, 400,400	260,280,300, 310,320	360,360
325	--	410	--	300,350,370, 390	--
330	--	390,420	--	370,380	320,370
335	--	470,520	380,410,430, 430	340,400	
340	--	--	400,420	390,500	--
350	--	--	--	460	--
360	--	--	--	--	510
365	--	--	--	--	530
370	--	--	--	--	570
375	--	--	710	--	--
380	--	690	--	340	530
395	--	--	--	-	670
405	320	--	--	820	--
415	--	--	970	440,950	425,1050
426	--	860,870	--	--	740

[1] Terry Holubetz (Idaho Department of Fish and Game, written commun., 1988).

REFERENCES CITED

Averett, R.C., 1981, Species diversity and its measurement, in Greesen, P.E., ed., Biota and biological parameters as environmental indicators: U.S. Geological Survey Circular 848-B, p. B3-B6.

Baumann, R.W., Gaufin, A.R., and Surdick, R.F., 1977, The stoneflies (plecoptera) of the Rocky Mountains: American Entomological Society, no. 31, 208 p.

Edmondson, W.T., ed., 1959, Freshwater biology, 2d ed.: New York, John Wiley and Sons, Inc., 1,248 p.

Edmunds, G.F. Jr., Jensen, S.L., and Berner, Lewis, 1976, The mayflies of North and Central America: Minneapolis, University of Minnesota Press, 330 p.

Frenzel, S.A., and Hansen, T.F., 1988, Water-quality data for the Boise River, Boise to Star, Idaho, October to December 1987: U.S. Geological Survey Open-File Report 88-171, 11 p.

Guy, H.P., and Norman, V.W., 1970, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chap. C2, 59 p.

Hubbard, E.F., Kilpatrick, F.A., Martens, L.A., and Wilson, J.F. Jr., 1982, Measurement of time of travel and dispersion in streams by dye tracing: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 3, Chap. A9, 44 p.

Jensen, S.L., 1966, The mayflies of Idaho (ephemeroptera): Salt Lake City, University of Utah, M.S. thesis, 367 p.

Kilpatrick, F.A., and Cobb, E.D., 1984, Measurement of discharge using tracers: U.S. Geological Survey Open-File Report 84-136, 73 p.

Merritt, R.W., and Cummins, K.W., eds., 1984, An introduction to the aquatic insects of North America, 2d ed.: Dubuque, Iowa, Kendall/Hunt Publishing Co., 722 p.

U.S. Environmental Protection Agency, 1986, Quality criteria for water, 1986: Washington, D.C., U.S. Government Printing Office, not paginated.

Usinger, R.L., ed., 1956, Aquatic insects of California: Berkeley, University of California Press, 508 p.

Wiggins, G.B., 1977, Larvae of the North American caddisfly genera (trichoptera): Toronto, University of Toronto Press, 401 p.