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WATER QUALITY STUDY OF RICHARDSON CLEARWATER CREEK NEAR BIG DELTA, ALASKA

by

Mary A. Maurer
Alaska Division of Mining & Water Management
Alaska Hydrological Survey

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INTRODUCTION

Richardson Clear-water Creek is a pristine, spring-fed, perennial stream that flows northwestward for 14 miles to the Tanana River, approximately 80 miles southeast of Fairbanks, Alaska. The creek is identified as Clear Creek on the U.S. Geological Survey Big Delta (A-S) Quadrangle (fig. 1), but is known locally as Richardson Clearwater Creek to differentiate it from Delta Clearwater Creek, a spring-fed stream east of Delta Junction, Alaska.

The Richardson Clear-water Creek receives the majority of its flow from ground water rather than surface water runoff. Consequently, streamflow fluctuates within a very narrow range. The stream's headwaters are formed by numerous springs that emanate from a low bank at the 1000 foot elevation contour line in section 4 of Township 9 South, Range 9 East, Fairbanks Meridian (near site 10 in fig. 2). The largest of these springs contributes approximately 12 cubic feet per second of flow. The stream also receives flow from small springs along its length and two spring-fed tributaries.

Richardson Clearwater Creek is an unusual Interior Alaska stream because of its short length, laminar flow, stable channel, and exceptional clarity. The streambed is composed of gravel and cobble-sized rock which is underlain by fine-grained sand. The aquatic moss ***Cratoneuron filicinum*** grows in long, sinuous submerged clumps or mats attached to the streambed. Stream banks are vegetated and show no sign of erosion, The riparian habitat is a mature spruce and birch forest. Ice scar marks on mature spruce trees along the creek's lower reaches indicate ice jams occur during spring breakup. Beavers are active near the headwaters and have impounded the tributaries in the recent past.

Richardson Clearwater Creek supports populations of coho salmon, chum salmon, Arctic grayling, round whitefish, and longnose suckers. Of these species, only coho salmon spawn and over-winter in the creek. The other species utilize the stream as a summer feeding area (Ridder, 1980). The Arctic grayling fishery is popular with local summer residents who have recreational cabins along the lower reaches of the creek. Summer access is by boat or floatplane.

State lands in the Richardson Clearwater Creek area are managed for recreational use and fish and wildlife habitat protection, according to the Delta-Salcha Area Plan (Alaska Department of Natural Resources, 1982). In the early 1980's agricultural development was proposed for lands that lay to the south and upgradient of Richardson Clear-water Creek. However, no lands have been cleared for agriculture in the area during the last 20 years.

In May 1998 the Carla Lake forest fire started as the result of a lightening strike on the Fort Greeley military reservation, about 15 miles southwest of Delta Junction, The tire spread north and crossed Richardson Clearwater Creek (fig. 1). Firefighters successfully defended the threatened cabins along the creek, and suppressed the fire in the late summer of 1998. The fire burned a total of 53,720 acres. Presently, the State is proposing timber salvage operations in the burn area.

Carla Lake forest fire effects on Richardson Clearwater Creek are unknown. Forest tires can produce changes in a stream's flow regime, organic matter content, turbidity, color, chemical oxygen demand, and potassium concentration (Lotspeich and others, 1970). Fire control efforts such as trail and ditch construction in permafrost areas also have the potential to produce erosion and increase sediment loading.

In 1983 the Alaska Department of Natural Resources, Alaska Hydrologic Survey (AHS) collected streamflow and water-quality data on Richardson Clearwater Creek to document baseline conditions within the proposed agricultural area. In hindsight these data also document pre-fire water quality conditions. This report presents the data collected in the 1983 AHS investigation. The purpose of the report is to make previously unpublished data available to land managers and the public.

ACKNOWLEDGEMENTS

The State of Alaska and the Agricultural Action Council funded this study. Steve Mack (formerly of AHS) was project manager. Roy Ireland (AHS), Steve Mack, George McCoy, Roger Allely, and Larry Dearborn (all formerly of AHS) assisted with field data collection. Barbara Murray (University of Alaska Museum Herbarium, Fairbanks, AK) identified the aquatic moss. Dave Hendren (Alaska Department of Natural Resources, Division of Forestry) provided a map of the Carla Lake tire. Jim Vohden (AHS) reviewed the report.

METHODS

Streamflow was measured with a Marsh McBirney current meter according to U.S. Geological Survey methods (Carter and Davidian, 1968). Water temperature, dissolved oxygen, and specific conductance were measured in the field with a Model 4041 Hydrolab that was pre- and post-calibrated according to the user manual. On-site pH was measured with an Orion Research model 201 digital pH meter. Bicarbonate alkalinity was measured on-site by titrating an untreated, unfiltered 100-ml water sample with 0.01639N sulfuric acid to an endpoint of pH 4.5 (U.S. Environmental Protection Agency, 1983).

Although no water-quality assurance plan was written, sampling and treatment was in general accordance with U.S. Geological Survey (1977) procedures. Grab samples were obtained at mid-channel and mid-depth of the stream. All samples were processed in the field. Water for dissolved inorganic constituent analysis and dissolved nutrient analysis was filtered through a 0.45-μm membrane filter and poured into pre-cleaned plastic bottles. Water for total nutrient analysis was collected in pre-cleaned plastic bottles. Nutrient samples were frozen within eight hours of returning from the field. Water for organic compound analysis was collected in l-liter amber glass bottles. Water for total metal analysis was poured into pre-cleaned plastic bottles, and acidified with doubledistilled 70-percent nitric acid. All samples were placed in a cooler with ice while in transit from the field to the laboratory.

Anatec Laboratories in Santa Rosa, California analyzed dissolved inorganic constituent and trace metal samples according to the methods of the American Public Health Association (1980) or the U.S. Environmental Protection Agency (1983). The Alaska Department of Fish and Game Limnology Laboratory in Soldotna, Alaska analyzed nutrient samples according to methods described in Koenings and others (1987). Northern Testing Laboratories, Inc. in Fairbanks, Alaska analyzed tannin and lignin samples according to the methods of the American Public Health Association and others (1980). Water Analysis and Consultants in Eugene, Oregon analyzed pesticide and herbicide samples under contract to Northern Testing Laboratories, Inc. according to the methods of the U.S. Environmental Protection Agency (198 1).

Benthic invertebrate samples were collected from mineral substrate and the aquatic moss *Cratoneuron filicinum* with a 0. l-meter' cylindrical substrate sampler, similar to a modified-Hess sampler. The sampler is 2 feet in height and is constructed of heavy gauge aluminum. Netting tits over the frame and is held in place by aluminum rim bands. The netting that faces the water current has 600-micron NITEX nylon mesh, whereas the backside and attached bag has 300-micron mesh. Mineral substrate samples were obtained by working the sampler into the streambed and rubbing the rocks to dislodge invertebrates. Moss samples were obtained by placing the sampler over the moss, detaching the moss from the streambed, and placing the moss in the net bag. Organisms were preserved in a 70 percent alcohol solution. Rose bengal bacteriological stain was added to facilitate sorting. All organisms were hand-picked from mineral substrate samples. A one-eighth or one-sixteenth subsample was taken from moss samples. Benthic invertebrates were identified to the lowest practicable level using the taxonomic keys of Pennak (1978), Usinger (1956), Flint (1960), Jensen (1966), Smith (1968), Edmunds and others (1976), Baumann and others (1977), Wiggins (1977), and Merritt and Cummins (1978).

RESULTS AND DISCUSSION

Chemical Water Quality

Streamflow and on-site water-quality measurements are shown on table 1. Streamflow fluctuates within a very narrow range at each site. Water temperature ranges from -0.1°C in October to 12.4°C in July. Mainstem water temperatures are generally similar among sites, except on July 26 when water temperatures near the stream's headwaters (site 6) dropped significantly (fig. 3). By mid-summer, water held in seasonally frozen soils probably recharges the shallow groundwater. Discharge of this colder ground water at headwater springs may account for the lower water temperature at site 6. The pH ranges from near neutral (pH 6.9 at site 9) to basic (pH 8.2 at site 7). Specific conductance ranges from 193 to 285 µS/cm @ 25°C. Dissolved oxygen concentrations are generally high, except in spring water at site 9. Alkalinity ranges from 97 to 152 mg/L as $CaCO_3$, indicating the water has good acid-neutralizing capacity.

Inorganic constituent concentrations are similar among sites (table 2). The calculated hardness value ranges from 111 to 146 mg/L as $CaCO_3$, indicating moderately hard to hard water (Hem, 1985). Total filterable residue concentration ranges from 140 to 200 mg/L, which indicates a moderate amount of dissolved mineral content in the water. The ion balance error ranges from 0.02 to 9.3% for 38 samples, which indicates that there are no major errors in the reported concentrations of major inorganic constituents.

The trilinear diagram is a graphical representation of water type, based on the average percentages of total cations (positively charged ions) and anions (negatively charged ions), in milliequivalents per liter (meq/L). The percentages are based on the average ioı concentrations at each site. Richardson Clearwater Creek sites have very similar ionic composition (fig. 4). Calcium is the predominant cation and bicarbonate is the predominant anion. Therefore, the water type is calcium bicarbonate for all sites.

Slight differences in ionic composition among surface waters can also be illustrated on a trilinear diagram (fig. 5). The water type for Richardson Clearwater Creek in October is compared to the water type of the Tanana River and Delta Rivers in October, based on data collected by the U.S. Geological Survey (USGS, 1979). The USGS water-quality data are listed in the appendix. The sampling sites are shown in fig. 1. The datasets are comparable because most of the streamflow in October is from ground water sources rather than surface water runoff. All three surface waters have calcium bicarbonate water (fig. 5). However, the Richardson Clearwater Creek water type overlaps the Tanana River water type, but not the Delta River water type, in the diamond-shaped area of the trilinear diagram (fig. 5). The Delta River has a higher percentage of sulfate. Based on these data, it appears Richardson Clearwater Creek is not being directly recharged by seepage losses from the Delta River.

Total and dissolved nutrient concentrations are generally low at all sites (table 3). Nitrate and nitrite nitrogen concentrations rose slightly in October. Filterable reactive phosphorus (soluble orthophosphate) concentrations are generally less than 10 µg/L as P. No seasonal trend is observed in the phosphorus fractions. Reactive silicon, a primary nutrient required by diatoms, is present in concentrations that range from 4.2 to 6.2 mg/L as Si.

Total trace element concentrations are either below detection limits or are present in low concentrations (table 4). Total concentrations of barium and strontium range up to several hundred micrograms per liter (µg/L), which is more typical of ground water (Hem, 1985). This is further evidence of the large ground-water contribution to streamflow. Iron concentrations are generally low. The highest iron concentration (430 µg/L) was measured in a small spring (site 9) along the stream, which is highly visible because a reddish-colored iron hydroxide precipitate coats the ground at the spring's orifice.

The pesticides endrin, lindane, methoxychlor, toxaphene, 2,4-D, and 2,4,5-TP are not detected at any site (table 5). These compounds are typically applied to agricultural lands. Tannin and lignin are naturally occurring plant substances that contribute to the organic carbon content of water. Runoff from agricultural lands often increases tannin and lignin levels in water. Tannin and lignin concentrations in Richardson Cleat-water Creek range from <0. 10 to 0.19 mg/L (table 5). The highest tannin and lignin concentration (0.27 mg/L) was measured in a tributary of Delta Creek (site 8) immediately downstream of a beaver dam. By comparison, tannin and lignin concentrations range from 0.04 to 4.2 mg/L in surface waters of Canada's pacific region (Environment Canada, 1987).

Biological Water Quality

Stream benthic invertebrates are excellent indicators of water quality because community structure reflects ambient stream water-quality conditions over time. Benthic invertebrate abundance and taxonomic diversity respond to a wide range of impacts such as sedimentation, organic loading, and changes in chemical water quality. In Richardson Clear-water Creek benthic invertebrates were sampled in mineral substrate (composed of gravel and pebble-sized rocks) and a filamentous aquatic moss, *Cratoneuron filicinum*. One or two samples were collected at five sites in July and seven sites in October. Number of organisms per meter^2 and taxonomic groups collected in July and October are listed on tables 6 and 7, respectively. Taxonomic groups present in moss and mineral substrate are similar. Chironomid midges are the most abundant taxonomic group in moss. Other common moss taxa are baetid mayflies, seed shrimp (Ostracoda), and water mites (Hydracarina). The most common taxa in mineral substrate are chironomid midges, seed shrimp, water mites, and flatworms (Turbellaria). Invertebrate abundance and taxonomic composition are similar between headwater and downstream sites.

Benthic invertebrate numbers are one and a half times higher in October than in July, which is due to the appearance of mayfly and stonefly nymphs in moss and mineral substrates, and non-insect invertebrate groups in moss (table 8). Benthic invertebrate numbers are five times higher in moss than in mineral substrate (fig 6). The mean number of benthic invertebrates is 246,140 organisms per meter^2 in moss and 44,730 organisms per meter^2 in mineral substrate (table 8). Invertebrate numbers in sparse moss are usually higher than in mineral substrate (fig. 6).

Benthic invertebrate numbers are typically higher in Richardson Clear-water Creek than in other Interior Alaska streams. For example, the mean number of benthic invertebrates in streams of the Forty-Mile River drainage ranges from 200 to 1,000 organisms per meter^2 (Lotspeich and others, 1970; Maurer, 1987). The Richardson Clearwater Creek has higher and more consistent groundwater input than most Interior Alaska streams. Consequently, streamflow is more consistent and the streambed is more stable. Such habitat conditions are optima1 for benthic invertebrate colonization. In addition, high water clarity, high dissolved gas content, and sufficient nutrient concentrations support abundant plant and animal life. For example, aquatic mosses are present because they require free carbon dioxide for photosynthesis, which is abundant in spring-fed streams (Ruttner, 1963).

High benthic invertebrate numbers in moss are the result of form and function. Long, thickly vegetated moss mats provides the invertebrates with more surface area for attachment and protection from predators. Few benthic invertebrates feed directly on moss. Instead, moss acts as a food trap. Benthic invertebrates, especially chironomid midges, feed on the epiphytic algae, diatoms, and fine particulate organic matter that adhere to the moss.

CONCLUSIONS

Chemical water quality in Richardson Clear-water Creek is good, characterized by highly oxygenated water, basic pH, moderate hardness, good acid-neutralizing capacity, and low concentrations of trace metals and nutrients.

Biological water quality, based on benthic invertebrate abundance, is very good in Richardson Clear-water Creek. The number of organisms per meter^2 is substantially higher in the creek than in other Interior Alaska streams. Chrionomid midges are the most abundant taxa. The presence of aquatic moss enhances benthic invertebrate abundance.

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Appendix: U.S. Geological Survey water-quality data for the Delta and Tanana Rivers

(Ref. Source: Water resource data for Alaska, water year 1979:
U.S. Geological Survey Water-Data Report AK-79-1, Anchorage, AK, p. 318)

ANALYSES OF SAMPLES COLLECTED AT MISCELLANEOUS SITES

YUKON ALASKA--Continued

WATER QUALITY DATA, WATER YEAR OCTOBER 1978 TO SEPTEMBER 1979

640735145500000 - DELTA R NR BIG DELTA AK (LAT 64 07 55 LONG 145 50 00)

DATE	TIME	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)
OCT											
16...	1530	255	8.2	4.0	120	28	35	7.6	3.0	3.7	110
JUN											
20...	1805	106	7.0	13.0	81	19	22	6.4	2.4	2.n	76

DATE	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
OCT										
16...	45	1.0	.1	5.6	148	156	.28	.00	<10	2
JUN										
20...	27	1.2	.1	4.3	103	103	.11	.00	40	4

154780000 - TANANA R AT BIG DELTA AK (LAT 64 09 20 LONG 145 51 00)

DATE	TIME	SPECIFIC CONDUCTANCE (MICROMHOS)	PH (UNITS)	TEMPERATURE (DEG C)	HARDNESS (MG/L AS CACO3)	HARDNESS, NONCARBONATE (MG/L CACO3)	CALCIUM DISSOLVED (MG/L AS CA)	MAGNESIUM, DISSOLVED (MG/L AS MG)	SODIUM, DISSOLVED (MG/L AS NA)	POTASSIUM, DISSOLVED (MG/L AS K)	BICARBONATE (MG/L AS HCO3)
OCT											
16...	1630	277	7.9	.0	130	27	37	8.1	4.1	2.3	125
JUN											
20...	1745	214	7.4	13.0	97	16	28	6.5	5.1	1.7	98

DATE	SULFATE DISSOLVED (MG/L AS SO4)	CHLORIDE, DISSOLVED (MG/L AS CL)	FLUORIDE, DISSOLVED (MG/L AS F)	SILICA, DISSOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N)	PHOSPHORUS, DISSOLVED (MG/L AS P)	IRON, DISSOLVED (UG/L AS FE)	MANGANESE, DISSOLVED (UG/L AS MN)
OCT										
16...	32	1.4	.1	10	154	158	.21	.00	<10	9
JUN										
20...	29	2.7	.1	8.8	124	131	.15	.00	170	6

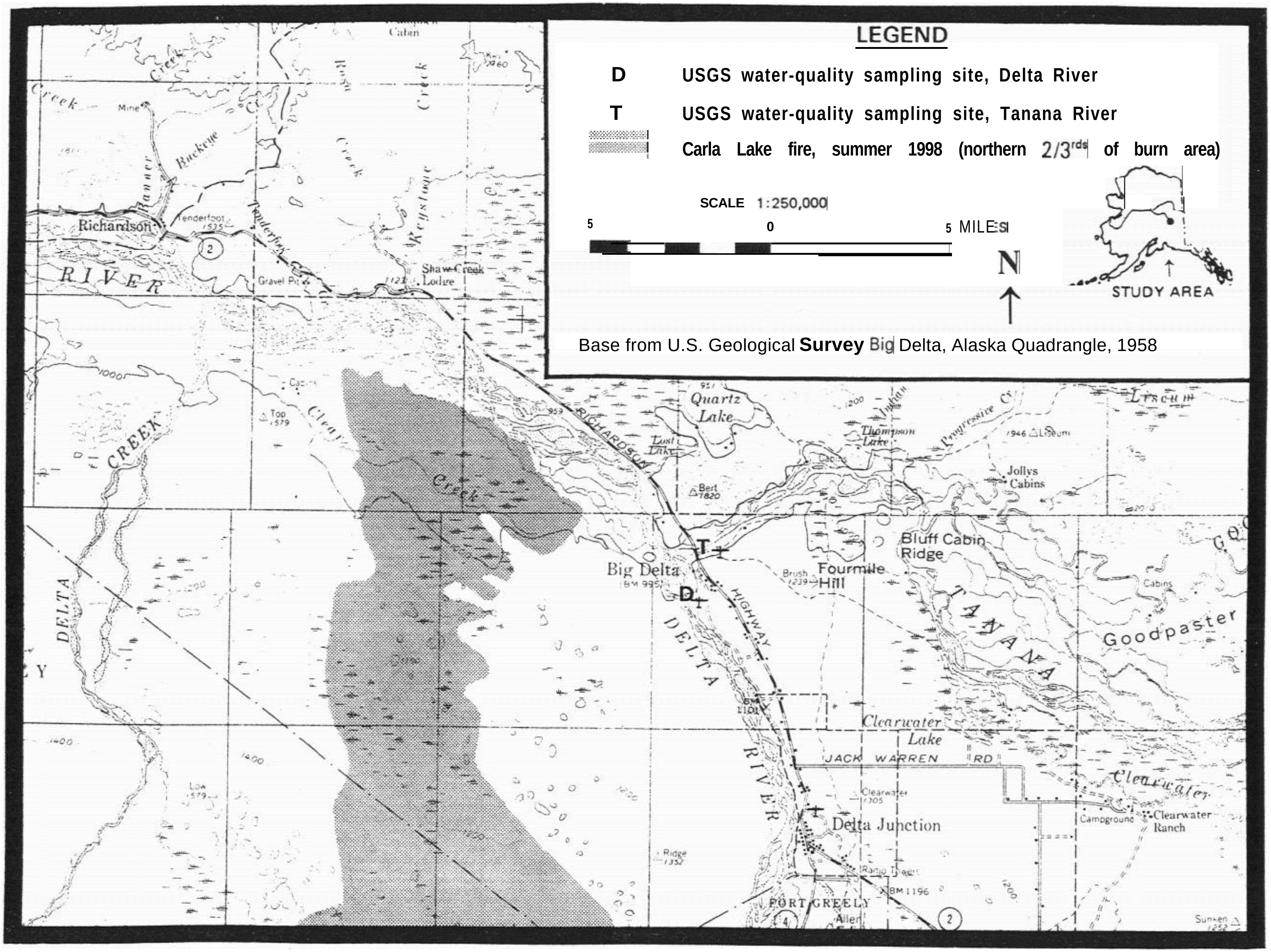


Figure 1. Location of the Richardson Clearwater Creek study area near Big Delta, Alaska.

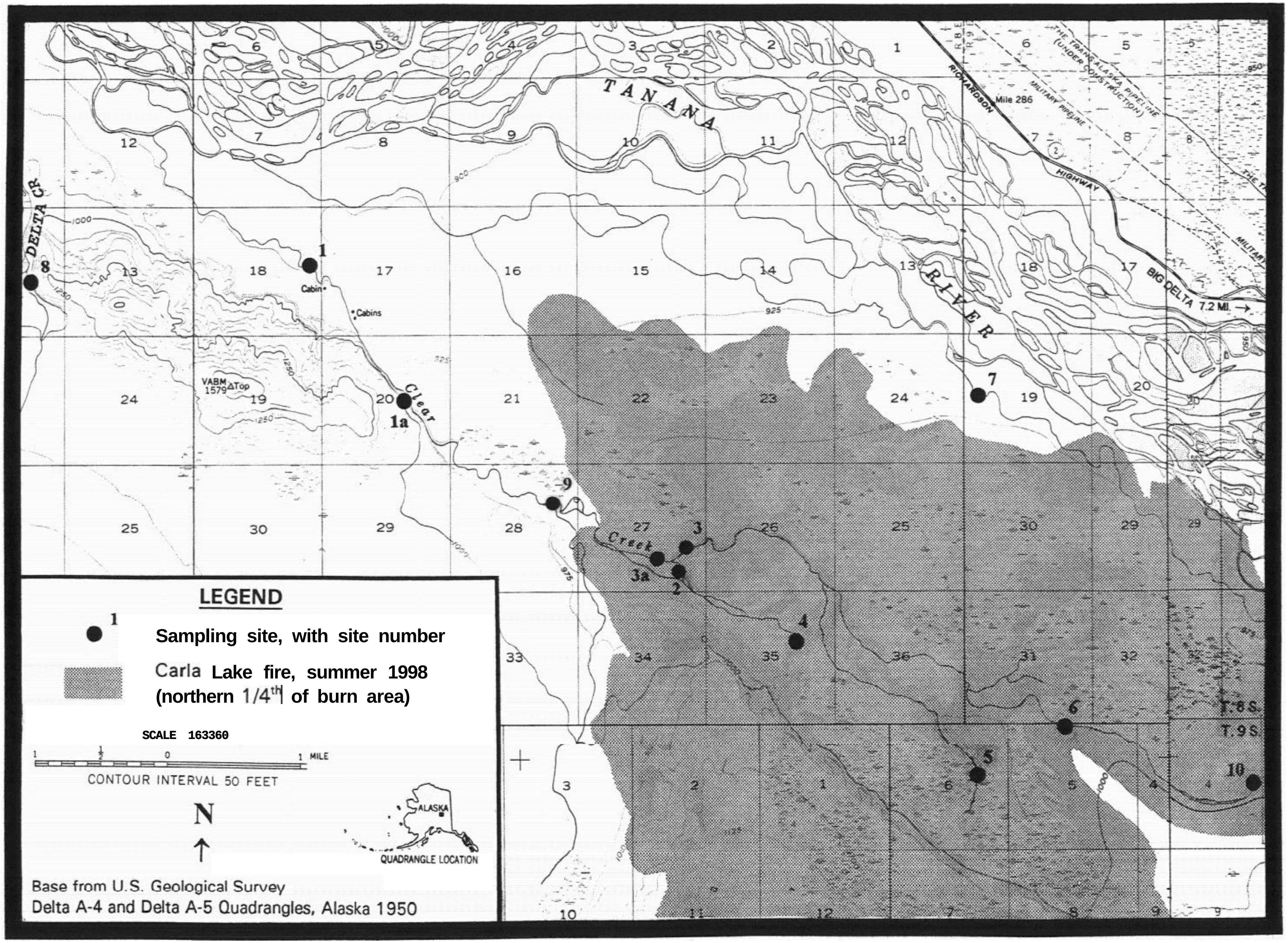


Figure 2. Location of sampling sites, Richardson Clearwater Creek area, near Big Delta, Alaska, 1983.

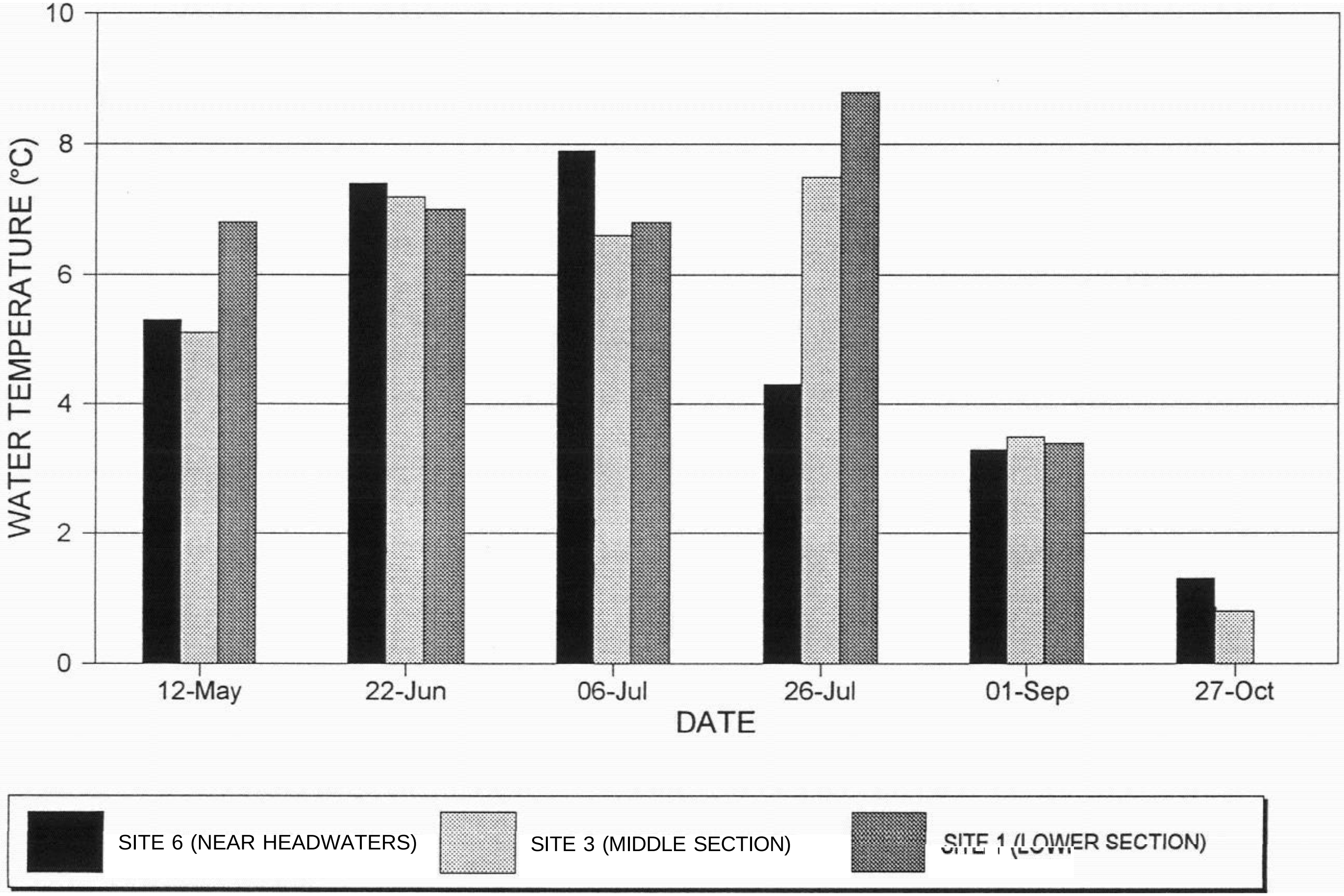
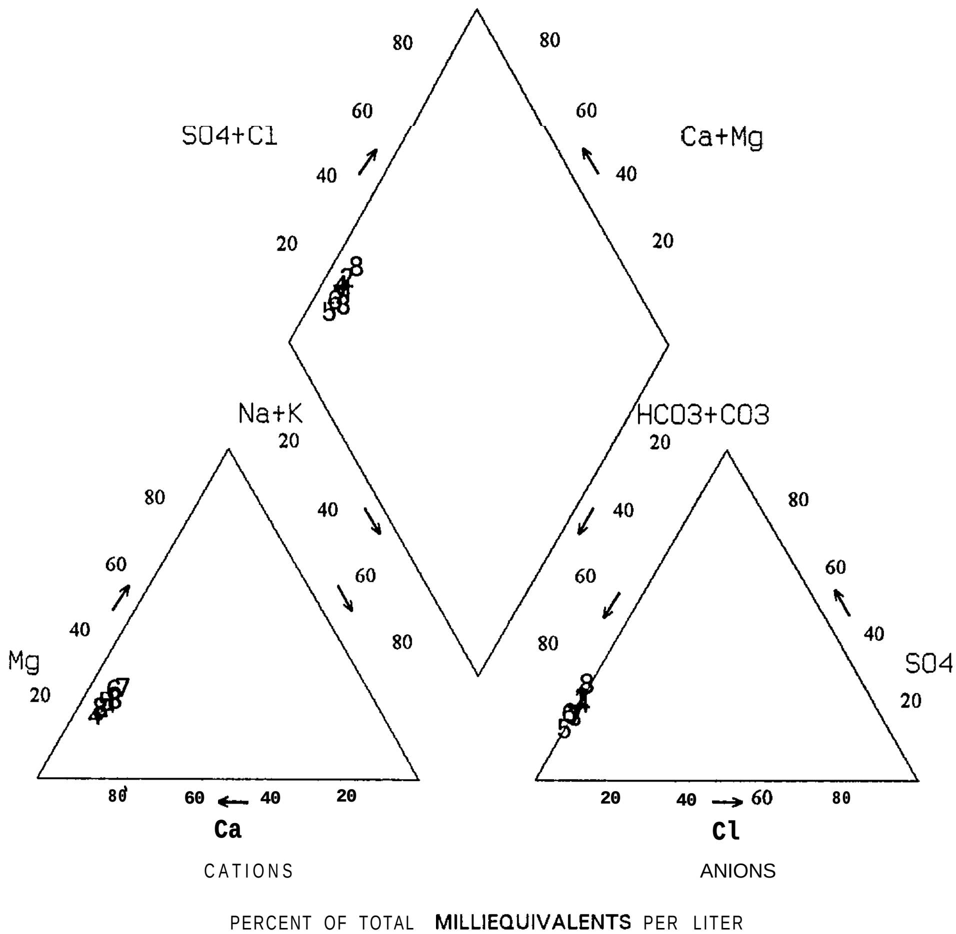


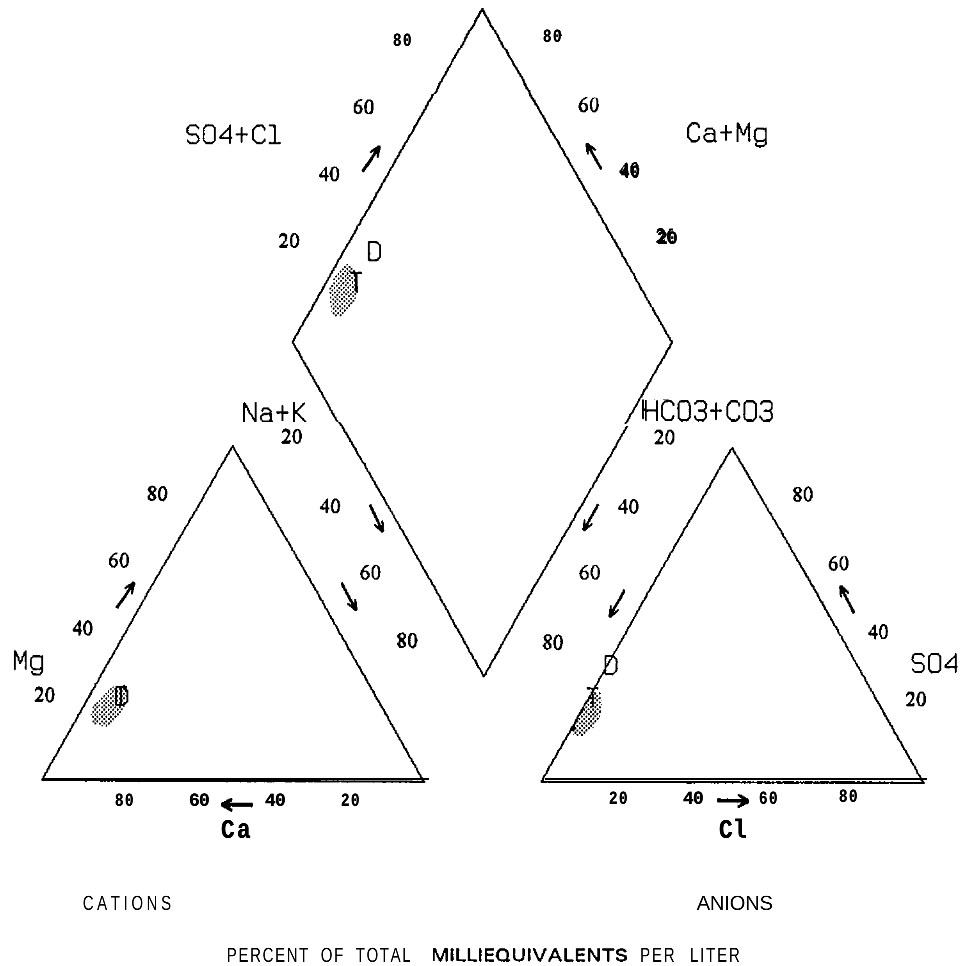
Figure 3. Water temperatures at three Richardson Clearwater Creek sites during 1983



EXPLANATION

Site No.	Location	Water Type
1	Richardson Clearwater Creek near Vanderbilt's Cabin	Calcium bicarbonate
2	Tributary #2 at mouth	Calcium bicarbonate
3	Richardson Clearwater Creek above tributary #2	Calcium bicarbonate
4	Tributary #2 near headwaters	Calcium bicarbonate
5	Tributary #1 near headwaters	Calcium bicarbonate
6	Richardson Clearwater Creek above Tributary #1	Calcium bicarbonate
7	Tanana River Tributary	Calcium bicarbonate
8	Delta Creek Tributary	Calcium bicarbonate

Figure 4. Trilinear diagram of water analyses from eight sites in the Richardson Clearwater Creek area, near Big Delta, Alaska, 1983.



EXPLANATION

Symbol	Location	Water Type
D	Delta River near Big Delta, Alaska	Calcium bicarbonate
T	Tanana River at Big Delta, Alaska	Calcium bicarbonate
	Richardson Clearwater Creek	Calcium bicarbonate

Figure 5. Trilinear diagram of surface-water analyses in the Big Delta area, Alaska. The Delta River and Tanana River were sampled by the U.S. Geological Survey on October 16, 1978. USGS sites are shown on Figure 1. The shaded area shows the range of five samples collected in Richardson Clearwater Creek by the Alaska Hydrologic Survey on October 27 and 28, 1983.

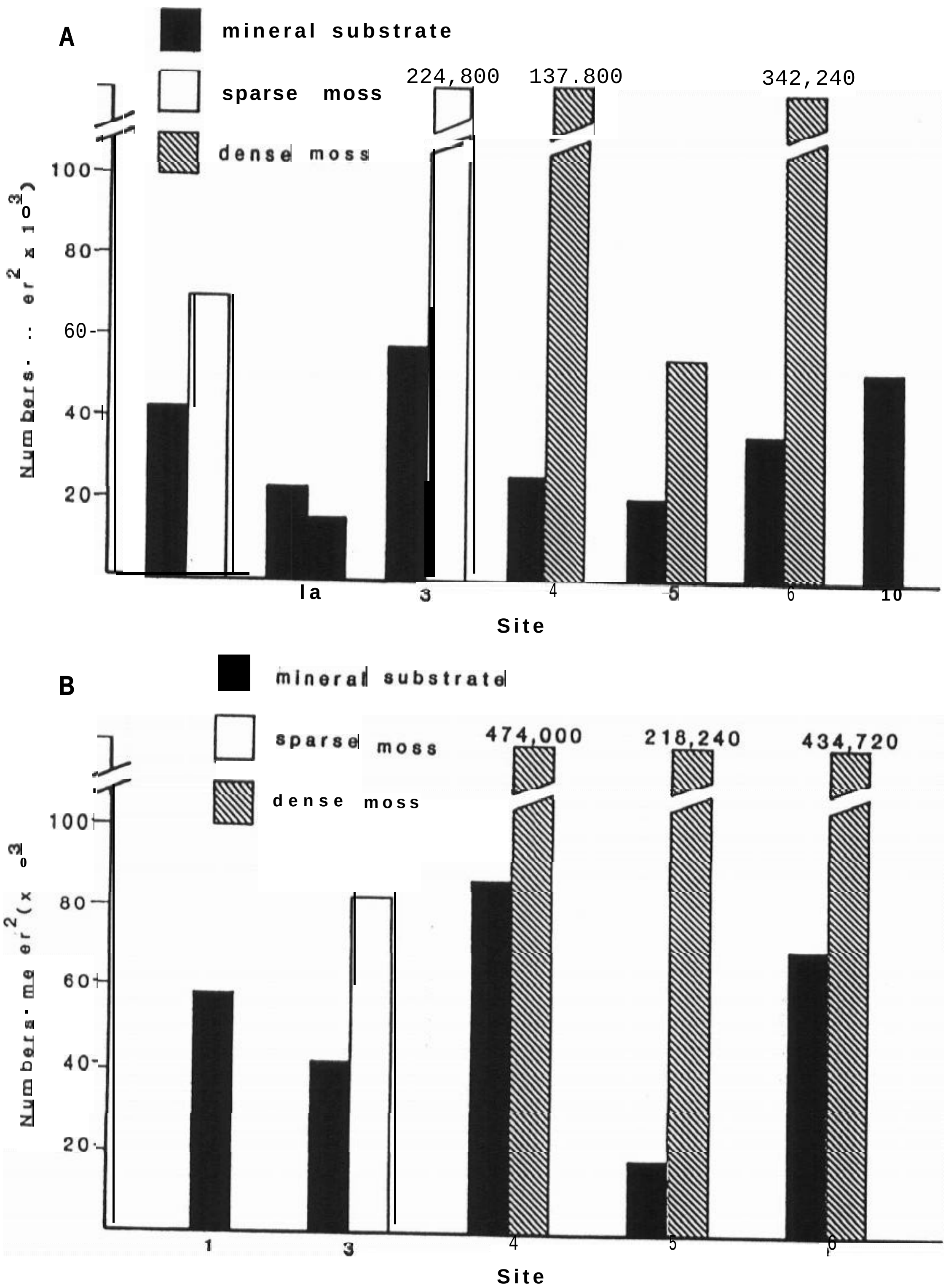


Figure 6. Numbers per meter^2 of benthic Invertebrates at sites In Richardson Clearwater Creek and Its tributaries on (A) July 26-27, 1083 and (B) October 27-28, 1983. Only one sample was taken at site 1 In October because of frazil Ice.

Table 1. Streamflow and on-site water-quality measurements taken in the Richardson Clearwater Creek area, 1983

Site No.	Site	Date	Time	Streamflow (cfs)	Water Temperature (°C)	pH (units)	Specific Conductance (µS/cm @25°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (percent saturation)	Alkalinity (mg/L as $CaCO_3$)
1	Richardson Clearwater Cr near Vanderbilt's Cabin	12 MAY 1983	--	--	6.8	IM	238	12.6	100	--
		19 MAY 1983	--	415	--	--	--	--	--	--
		22 JUN 1983	1030	434	7.0	7.9	228	11.3	96	102
		06 JUL 1983	1025	429	6.8	7.9	213	12.3	100	107
		27 JUL 1983	1355	431	8.8	7.9	201	IM	--	97
		01 SEP 1983	1000	442	3.4	7.6	262	13.4	100	110
		27 OCT 1983	1105	--	-0.1	7.6	IM	13.9	99	110
2	Tributary #2, above confluence with Richardson Clearwater Cr	12 MAY 1983	--	78	--	--	--	--	--	--
		22 JUN 1983	1130	77	5.7	7.4	230	8.6	70	101
		06 JUL 1983	1205	72	6.7	7.5	225	10.0	84	109
		26 JUL 1983	1715	75	7.7	7.9	231	EM	--	105
		01 SEP 1983	1110	77	3.0	7.4	263	12.0	92	108
		27 OCT 1983	1200	76	0.9	7.3	273	13.0	95	98
3a	Richardson Clearwater Cr below Tributary #2	12 MAY 1983	1300	--	5.1	IM	249	10.2	82	--
3	Richardson Clearwater Cr above Tributary #2	12 MAY 1983	1315	218	--	--	--	--	--	--
		22 JUN 1983	1215	256	7.2	8.1	242	10.0	86	107
		06 JUL 1983	1130	259	6.6	7.9	227	10.8	91	121
		26 JUL 1983	1350	244	7.5	8.0	193	IM	--	102
		01 SEP 1983	1137	237	3.5	7.7	268	12.8	100	121
		27 OCT 1983	1205	238	0.8	7.6	276	13.2	96	111
4	Tributary #2, near headwaters	22 JUN 1983	1310	42	8.7	7.7	253	9.2	81	104
		06 JUL 1983	1255	43	8.9	8.0	241	10.7	95	116
		25 JUL 1983	1155	42	7.0	8.0	210	IM	--	113
		01 SEP 1983	1230	43	3.6	7.7	269	12.8	100	112
		27 OCT 1983	1355	43	1.0	7.6	274	13.0	96	102

-- = no measurement made
IM = instrument malfunction

Table 1 (con). Streamflow and on-site water water-quality measurements taken in the Richardson Clearwater Creek area, 1983

Site No.	Site	Date	Time	Streamflow (cfs)	Water Temper-ature (°C)	pH (units)	Specific Conductance (µS/cm @25°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (percent saturation)	Alkalinity (mg/L as $CaCO_3$)
5	Tributary #1, near headwaters	12 MAY 1983	1130	12	5.1	7.6	268	7.4	59	--
		22 JUN 1983	--	17	a.7	7.7	264	6.2	55	123
		06 JUL 1983	1405	21	9.8	7.7	249	7.8	71	136
		25 JUL 1983	1335	23	8.3	7.9	209	IM	--	125
		01 SEP 1983	1318	19	4.0	7.7	276	9.8	78	134
		27 OCT 1983	1520	22	1.4	7.5	285	9.1	67	--
6	Richardson Clearwater Cr. above Tributary #1	12 MAY 1983	1216	--	5.3	IM	267	8.3	67	--
		22 JUN 1983	1440	79	7.4	7.4	260	8.5	73	112
		06 JUL 1983	1505	81	7.9	7.9	231	9.5	83	124
		26 JUL 1983	1020	82	4.3	7.8	239	IM	--	117
		01 SEP 1983	1417	84	3.3	7.9	279	12.1	95	125
		28 OCT 1983	1010	82	1.3	7.7	266	12.1	91	152
7	Tanana River Tributary	22 JUN 1983	1520	61	11.3	a.2	264	9.7	91	105
		06 JUL 1983	1645	66	12.4	8.0	257	10.9	100	121
		25 JUL 1983	1507	84	8.9	8.0	241	IM	--	116
		01 SEP 1983	1500	72	4.2	7.9	268	13.8	100	119
		28 OCT 1983	1120	59'	0.1	7.9	274	15.2	100	117
8	Delta Creek Tributary	22 JUN 1983	1600	3.7	7.2	7.7	280	9.4	81	102
		06 JUL 1983	1645	4.8	12.4	7.7	257	10.0	97	109
		25 JUL 1983	1100	7.8	a.2	7.8	248	10.7	94	107
		01 SEP 1983	1540	a.3	4.9	7.6	278	13.4	100	110
		28 OCT 1983	1220	4.3'	-0.1	7.3	269	14.3	100	108
9	Red-stain spring along Richardson Clearwater Cr	27 JUL 1983	0830	--	2.3	6.9	227	2.8	21	--
10	Big spring, at headwaters	25 JUL 1983	1845	12	1.9	7.5	212	IM	--	--

-- = no measurement made
IM = instrument malfunction
' = streamflow measurement affected by shore ice

Table 2. Laboratory analyses of major inorganic constituents for surface waters in the Richardson Clearwater Creek area, 1983

Site No.	Date	Calcium, Dissolved (mg/L)	Magnesium, Dissolved (mg/L)	Sodium Dissolved (mg/L)	Potassium, Dissolved (mg/L)	Chloride, Dissolved (mg/L)	Sulfate, Dissolved (mg/L)	Fluoride, Dissolved (mg/L)	Total Filterable Residue, at 180 °C (mg/L)	Hardness, Calculated (mg/L as $CaCO_3$)
1	22 JUN 1983	33	6.9	3.4	3.3	<1.0	30	0.16	180	111
	06 JUL 1983	33	6.9	3.2	3.3	<1.0	28	0.13	180	111
	27 JUL 1983	38	7.3	3.2	2.5	<1.0	31	0.16	180	125
	01 SEP 1983	40	7.2	3.7	2.9	<1.0	30	0.13	140	129
	27 OCT 1983	41	7.5	3.1	3.7	<1.0	36	0.13	200	133
2	22 JUN 1983	35	6.5	2.1	3.6	<1.0	32	0.13	180	114
	06 JUL 1983	36	6.5	2.1	3.6	<1.0	33	0.12	180	117
	26 JUL 1983	43	6.9	2.2	2.5	<1.0	33	0.14	170	136
	01 SEP 1983	43	6.9	2.2	2.9	<1.0	30	0.12	160	136
	27 OCT 1983	41	6.9	2.2	3.7	<1.0	33	0.13	200	131
3	22 JUN 1983	34	7.2	4.1	2.6	<1.0	23	0.13	180	114
	06 JUL 1983	35	7.4	3.9	2.7	<1.0	24	0.13	180	118
	26 JUL 1983	41	8.0	3.9	2.0	<1.0	27	0.14	160	135
	01 SEP 1983	40	8.2	4.2	2.0	<1.0	25	0.12	150	134
	27 OCT 1983	41	7.9	4.1	2.5	<1.0	31	0.13	170	135
4	22 JUN 1983	38	6.2	2.9	3.3	<1.0	29	0.13	180	120
	06 JUL 1983	37	6.2	2.1	3.4	<1.0	29	0.13	170	118
	25 JUL 1983	45	6.7	2.0	2.4	<1.0	33	0.14	160	140
	01 SEP 1983	45	6.7	2.0	2.5	<1.0	30	0.11	150	140
	27 OCT 1983	43	6.7	2.1	2.8	<1.0	32	0.13	180	135
5	22 JUN 1983	39	7.4	3.7	2.3	<1.0	20	0.13	190	128
	06 JUL 1983	37	7.3	2.9	2.5	<1.0	20	0.13	180	122
	25 JUL 1983	42	7.7	3.0	2.0	<1.0	21	0.13	170	136
	01 SEP 1983	43	7.4	3.0	1.9	<1.0	20	0.11	140	138
	27 OCT 1983	44	8.1	3.0	2.0	<1.0	22	0.12	180	143

Sampling locations:
Site 1: Richardson Clearwater Creek near Vanderbilt's Cabin
Site 2: Tributary #2 above confluence with Richardson Clearwater Creek
Site 3: Richardson Clearwater Creek above Tributary #2
Site 4: Tributary #2 near headwaters
Site 5: Tributary #1 near headwaters

Table 2 (con). Laboratory analyses of major inorganic constituents for surface waters in the Richardson Clearwater Creek area, 1983

Site No.	Date	Calcium, Dissolved (mg/L)	Magnesium, Dissolved (mg/L)	Sodium Dissolved (mg/L)	Potassium, Dissolved (mg/L)	Chloride, Dissolved (mg/L)	Sulfate, Dissolved (mg/L)	Fluoride, Dissolved (mg/L)	Total Filterable Residue, at 180 °C (mg/L)	Hardness, Calculated (mg/L as $CaCO_3$)
6	22 JUN 1983	--	--	--	--	--	--	--	--	--
	06 JUL 1983	35	8.4	3.5	2.8	<1.0	26	0.12	180	122
	26 JUL 1983	42	8.7	3.6	1.9	<1.0	29	0.12	160	140
	01 SEP 1983	40	9.2	3.6	2.0	<1.0	27	0.11	140	138
	28 OCT 1983	41	9.1	4.1	2.1	<1.0	29	0.12	180	140
7	22 JUN 1983	34	8.5	4.0	2.8	<1.0	26	0.12	180	120
	06 JUL 1983	33	8.5	3.3	2.9	<1.0	25	0.12	170	117
	25 JUL 1983	39	8.7	3.4	2.4	<1.0	28	0.12	160	133
	01 SEP 1983	37	9.3	2.8	2.4	<1.0	26	0.11	150	131
	28 OCT 1983	39	8.8	3.5	2.1	<1.0	31	0.12	170	133
8	22 JUN 1983	38	6.3	1.6	4.7	<1.0	39	0.12	190	121
	06 JUL 1983	38	6.4	1.5	4.8	<1.0	34	0.12	180	121
	25 JUL 1983	44	8.7	1.0	3.8	<1.0	43	0.12	160	146
	01 SEP 1983	45	6.9	1.4	4.0	<1.0	42	0.10	160	141
	27 OCT 1983	46	7.0	1.7	4.3	<1.0	42	0.12	180	144
9	27 JUL 1983	31	7.4	2.0	3.3	<1.0	42	0.12	150	108

-- = no measurement made

Sampling locations:
Site 6: Richardson Clearwater Creek above Tributary #1
Site 7: Tanana River Tributary
Site 8: Delta Creek Tributary
Site 9: Red-stain spring along Richardson Clearwater Creek

Table 3. Laboratory analyses of nutrients for surface waters in the Richardson Clearwater Creek area, 1983

Site No.	Date	Nitrogen, nitrate plus nitrite, Dissolved (μg/L as N)	Nitrogen, ammonia, Total (μg/L as N)	Nitrogen, ammonia plus organic, Total (μg/L as N)	Phosphorus, Total (μg/L as P)	Phosphorus, Filterable Total (μg/L as P)	Phosphorus, Filterable Reactive* (μg/L as P)	Silicon, Reactive ** (mg/L as Si)
1	22 JUN 1983	62	3	18	6	5	5	4.9
	06 JUL 1983	72	3	25	3	7	7	5.8
	27 JUL 1983	55	2	50	8	5	4	5.8
	01 SEP 1983	89	1	34	10	4	4	5.8
	27 OCT 1983	136	1	32	12	8	11	6.1
2	22 JUN 1983	95	1	25	7	4	4	4.9
	06 JUL 1983	91	1	36	6	6	6	5.6
	26 JUL 1983	66	2	43	7	5	4	5.5
	01 SEP 1983	89	<1	23	9	4	4	5.9
	27 OCT 1983	141	1	22	9	9	9	6.0
3	22 JUN 1983	65	2	33	12	9	10	4.9
	06 JUL 1983	68	3	31	13	10	8	5.7
	26 JUL 1983	65	2	30	13	9	6	5.9
	01 SEP 1983	79	2	27	12	7	8	5.7
	27 OCT 1983	109	1	46	9	12	14	5.9
4	22 JUN 1983	85	3	76	5	5	4	4.7
	06 JUL 1983	75	2	31	6	5	6	5.5
	25 JUL 1983	78	2	34	5	4	4	5.5
	01 SEP 1983	95	1	30	8	4	4	5.6
	27 OCT 1983	144	1	25	8	7	5	5.8
5	22 JUN 1983	66	1	60	10	6	7	5.1
	06 JUL 1983	63	1	43	10	7	7	6.0
	25 JUL 1983	57	<1	35	10	6	5	6.1
	01 SEP 1983	82	<1	25	9	7	7	6.2
	27 OCT 1983	99	1	34	9	10	7	6.1
6	22 JUN 1983	--	--	--	--	--	--	--
	06 JUL 1983	101	3	28	9	8	8	5.2
	26 JUL 1983	98	1	21	8	5	5	5.5
	01 SEP 1983	108	<1	28	7	5	5	5.2
	28 OCT 1983	158	<1	21	8	9	10	6.2
7	22 JUN 1983	116	2	43	9	3	3	4.4
	06 JUL 1983	121	3	45	10	4	4	5.0
	25 JUL 1983	154	2	35	11	4	4	5.4
	01 SEP 1983	140	<1	29	8	4	3	5.1
	28 OCT 1983	195	1	22	8	6	4	5.9
8	22 JUN 1983	85	1	55	10	2	2	4.2
	06 JUL 1983	52	2	55	5	2	2	4.4
	25 JUL 1983	64	1	55	6	3	3	4.7
	01 SEP 1983	54	1	51	4	2	2	4.4
	27 OCT 1983	129	3	36	5	5	3	5.1

* = filterable reactive phosphorus is soluble orthophosphate

* * = reactive silicon is the inorganic form available for algal uptake

-- = no measurement made

Sampling locations:

Site 1: Richardson Clearwater Creek near Vanderbilt's Cabin
Site 2: Tributary #2 above confluence with Richardson Clearwater Creek
Site 3: Richardson Clearwater Creek above Tributary #2
Site 4: Tributary #2 near headwaters
Site 5: Tributary #1 near headwaters
Site 6: Richardson Clearwater Cr above Tributary #1
Site 7: Tanana River Tributary
Site 8: Delta Creek Tributary

Table 4. Laboratory analyses of total trace elements for surface waters in the Richardson Clearwater Creek area, July 6, 1983

Site No.	Aluminum, Total (µg/L)	Antimony, Total (µg/L)	Arsenic, Total (µg/L)	Barium, Total (µg/L)	Beryllium, Total (µg/L)	Boron, Total (µg/L)	Cadmium, Total (µg/L)	Chromium, Total (µg/L)	Copper, Total (µg/L)	Iron, Total (µg/L)
1	<75	<10	<2	150	<2	<50	<0.5	<5	c 5	12
2	<75	<10	<2	160	<2	50	<0.5	<5	<5	9.8
3	<75	<10	<2	170	<2	<50	<0.5	<5	<5	9.3
4	<75	<10	<2	170	<2	<50	<0.5	<5	<5	15
5	<75	<10	<2	160	<2	<50	<0.5	<5	<5	13
6	<75	<10	<2	110	<2	65	<0.5	<5	<5	7.3
7	<75	<10	<2	81	<2	<50	<0.5	<5	<5	91
a	<75	<10	<2	94	<2	<50	<0.5	<5	<5	49
9	--	--	--	--	--	--	--	--	--	430'

— = no measurement made
• = sampled on July 27, 1983

Sampling locations:
Site 1: Richardson Clearwater Creek near Vanderbilt's Cabin
Site 2: Tributary #2 above confluence with Richardson Clearwater Cr
Site 3: Richardson Clearwater Creek above Tributary #2
Site4: Tributary #2 near headwaters
Site 5: Tributary #1 near headwaters
Site 6: Richardson Clearwater Cr above Tributary #1
Site 7: Tanana River Tributary
Site 8: Delta Creek Tributary
Site 9: Spring along Richardson Clearwater Cr

Table 4 (con). Laboratory analyses of total trace elements for surface waters in the Richardson Clearwater Creek area, July 6, 1983

Site No.	Lead, Total (µg/L)	Manganese, Total (µg/L)	Mercury, Total (µg/L)	Nickel, Total (µg/L)	Selenium, Total (µg/L)	Silver, Total (µg/L)	Strontium, Total (µg/L)	Titanium, Total (µg/L)	Vanadium, Total (µg/L)	Zinc, Total (µg/L)
1	<2	<20	<0.05	<5	<2	<2	460	<100	<10	<2
2	<2	<20	<0.05	<5	<2	<2	430	<100	<10	<2
3	<2	<20	co.05	<5	<2	<2	510	<100	<10	6
4	<2	<20	<0.05	<5	<2	<2	440	<100	<10	<2
5	<2	<20	<0.05	<5	<2	<2	570	<100	<10	<2
6	<2	<20	<0.05	<5	<2	<2	500	<100	<10	<2
7	<2	<20	<0.05	<5	<2	<2	470	<100	<10	<2
8	<2	<20	<0.05	<5	<2	<2	390	<100	<10	<2
9	--	<20*	--	--	--	--	--	--	--	--

-- = no measurement made
• = sampled on July 27, 1983

Sampling locations:
Site 1: Richardson Clearwater Creek near Vanderbilt's Cabin
Site 2: Tributary #2 above confluence with Richardson Clearwater Cr
Site 3: Richardson Clearwater Creek above Tributary #2
Site4: Tributary #2 near headwaters
Site 5: Tributary #1 near headwaters
Site 6: Richardson Clearwater Cr above Tributary #1
Site 7: Tanana River Tributary
Site 8: Delta Creek Tributary
Site 9: Spring along Richardson Clearwater Cr

Table 5. Laboratory analyses of organic compounds for surface waters in the Richardson Clearwater Creek area, 1983

Site No.	Date	Endrin (µg/L)	Lindane (µg/L)	Methoxychlor (µg/L)	Toxaphene (µg/L)	2,4-D (µg/L)	2,4,5-TP (µg/L)	Tannin and Lignin (mg/L)
1	06 JUL 1983 01 SEP 1983	<0.005 B	<0.003 B	<0.02 B	<0.05 B	<0.05 B	<0.005 B	0.11 <0.10
2	06 JUL1 983 01 SEP 1983	<0.005 <0.005	<0.003 <0.003	<0.02 <0.05	<0.05 <0.05	<0.05 <0.04	<0.005 <0.005	0.16 <0.10
3	06 JUL 1983 01 SEP 1983	<0.005 <0.005	<0.003 <0.003	<0.02 <0.05	<0.05 <0.05	<0.05 <0.04	<0.005 <0.005	0.13 <0.10
4	06 JUL 1983 01 SEP 1983	B B	B B	B B	B B	B B	B B	0.18 0.11
5	06 JUL 1983 01 SEP 1983	B <0.005	B <0.003	B <0.05	B <0.05	B <0.04	B < 0.005	0.19 <0.10
6	06 JUL 1983 01 SEP 1983	<0.005 < 0.005	< 0.003 < 0.003	<0.02 co.05	40.05 <0.05	<0.05 <0.04	<0.005 <0.005	0.16 0.12
7	06 JUL 1983 25 JUL 1983 01 SEP 1983	co.005 < 0.005 < 0.005	< 0.003 < 0.003 < 0.003	<0.02 <0.02 <0.05	<0.05 <0.05 <0.05	<0.05 <0.05 <0.04	<0.005 <0.005 <0.005	0.10 -- <0.10
8	06 JUL 1983 01 SEP 1983	< 0.005 < 0.005	< 0.003 < 0.003	<0.02 <0.05	<0.05 <0.05	<0.05 <0.04	<0.005 <0.005	0.25 0.27

B = sample bottle broken in transit
-- = no measurement made

Sampling locations:
Site 1: Richardson Clearwater Creek near Vanderbiit's Cabin
Site 2: Tributary #2 above confluence with Richardson Clearwater Creek
Site 3: Richardson Clearwater Creek above Tributary #2
Site 4: Tributary #2 near headwaters
Site 5: Tributary #1 near headwaters
Site 6: Richardson Clearwater Creek above Tributary #1
Site 7: Tanana River Tributary
Site 8: Delta Creek Tributarv

Table 6. Taxa and number of organisms per meter^2 of benthic invertebrates collected in Richardson Clearwater Creek, July 25-27, 1983 Sampling sites are shown in Figure 2. Mineral = Mineral Substrate; S Moss = Sparse Moss; D Moss = Dense Moss.

Taxon	Site 1		Site 1a		Site 3		Site 4		Site 5		Site 6		Site 10
	Mineral	S Moss	Mineral	Mineral	Mineral	S Moss	Mineral	D Moss	Mineral	D Moss	Mineral	D Moss	Mineral
Non-insect invertebrates													
Turbellaria (flatworms)	2490	1600	2070	1380	790	3840	570	480	1980	160	1190	19200	20
Nematoda (roundworms)	10	90	50	20	80	160	990	3360	790	160	80	2720	1420
Oligochaeta (earthworms)	260	220	290	100	40	160	370	640	2780	160	250	3520	
Hirudinea (leeches)	10	10											
Pelecypoda (clams)										480			
Hydracarina (water mites)	5350	10330	1510	1100	1940	10720	2200	4640	130	2560	3200	20000	7780
Ostracoda (seed shrimp)	3650	690	1540	110	38120	8480	160	2400	3190	800	1270	22080	1570
Copepoda						160		480		640		4160	
Amphipoda (scuds)						160				960	260		
Ephemeroptera (mayflies)													
Baetis bicaudatus				10	2940	4960	220	800			2630	7040	10
Cinygmula sp.	940	1720	4180	4130	1370	1280	10				1070	800	
Ephemerella doddsi	1930	1580	1020	1720	220	1280	200	160			700		
Plecoptera (stoneflies)	10	70	20				10					640	
Chloroperlidae	10		180	240	60						10		
Perlodidae	90	90	100		50	480		480	10	1120	150	960	330
Isoperla ebria													10
Capniidae			10	10									
Zapada cinctipes	170	380	180	50	120	6880		1600			1920	9920	
Zapada oregonensis	11960	13970	4780	2530	1570	6400	890	13280	30	480	4030	5600	
Trichoptera (caddisflies)	10	10											
Limnephilidae							10	160					
Apatania sp.	80	470		10			30						
Ecclisomyia sp.	210	360	60	30	90		230		290		10	480	270
Glossosoma sp.	770	410	960	1700	380	1120	560				30		
Rhyacophila vepulsa	10	30	30	60	10	160	950	1280	90		290	320	
Diptera (true flies)													
Empididae							60						
Chelifera sp.	410	1580	580	580	150	480	2000	320	60		140	640	
Chironomidae	14400	35900	6090	1980	9410	176160	16180	104000	10970	46720	17790	243840	40430
Dicranota sp.	30	10		10	30	160	30		360	480			10
Atherix sp.							10						
Palpomyia sp.			10					160					
Pericoma sp.		40		10			10		10			160	
Limnophora sp.		10					20						
Simulium sp.	40	170				1440	80	480			30		
Prosimulium sp.						320	20	2880			1790	160	
Total organisms/meter^2	42840	69740	23660	15780	57370	224800	25810	137600	20690	54720	36840	342240	51850

Table 7. Taxa and number of organisms per meter^2 of benthic invertebrates collected in Richardson Clearwater Creek, October 27-28, 1983 Sampling sites are shown in Figure 2. Mineral = Mineral Substrate; S Moss = Sparse Moss; D Moss = Dense Moss.

Taxon	Site 1	Site 3		Site 4		Site 5		Site 6	
	Mineral	Mineral	S Moss	Mineral	D Moss	Mineral	D Moss	Mineral	D Moss
Non-insect invertebrates									
Turbellaria (flatworms)	4320	1540	2980	1900	9920	5180	12960	3420	11840
Nematoda (roundworms)	210	610	70	330	5200	720	4640	110	3840
Oligochaeta (earthworms)	600	570	1600	650	4720	1380	3040	1010	640
Hydracarina (water mites)	800	990	3450	1600	17360	1140	2400	1300	13600
Ostracoda (seed shrimp)	11980	5310	5540	30	4320	570	4960	900	32480
Copepoda				30	560	190	10720		4960
Amphipoda (scuds)								250	
Ephemeroptera (mayflies)									
Baetis bicaudatus	170	1530	7760	27710	219280	370	1440	47340	133600
Cinygmula sp.	710	50	1380	3290	320	20		1750	
Ephemerella doddsi	260	440	860	570	80	10		90	
Plecoptera (stoneflies)	280	70	570	17590	53200	370		1820	4800
Chloroperlidae	20			20				30	
Perlodidae	30	30	120		880	20	800	30	
Capniidae	750	30	40		1520	120		130	
Zapada cinctipes		10	140	150	2800			280	480
Zapata oregonensis	1570	1840	3800	4710	14560	40	480	440	1440
Trichoptera (stoneflies)				10					
Limnephilidae							160		
Apatania sp.	30								
Ecclisomyia sp.	20	110	180	20	320	540		80	640
Glossosoma sp.	110	20	350	2170		10		60	
Rhyacophila vepulsa			40	670	1200	10	160	60	960
Diptera (true flies)									
Chelifera sp.	170	10	60	670	960	100			480
Clinocera sp.	10								
Chironomidae	36120	29300	53820	16250	122160	6970	175840	9790	224000
Dicranota sp.	10	20	20	30	1280	200	160		
Hesperoconopa sp.				100					
Palpomyia sp.				30	960		320		
Pericoma sp.			10		160		160	10	
Limnophora sp.					80				
Simulium sp.	10			6880	7680	20		580	
Prosimulium sp.				1500	4480			260	960
Collembola (springtails)									
Isotomidae						10			
Total organisms/meter^2	58180	42480	82790	86910	474000	17990	218240	69740	434720

Table 8. Taxonomic composition and mean number of organisms per meter ^{2} of benthic invertebrates collected in Richardson Clearwater Creek in mineral substrate and moss, July and October 1983. Mean number of organisms per meter^2 is based on benthic invertebrates collected at sites 3, 4, 5, and 6.

Taxonomic Group	July 1983		October 1983	
	Mineral substrate	Moss	Mineral substrate	Moss
Non-insect Invertebrates	15,100	28,320	7,430	40,450
Mayflies (Ephemeroptera)	2,340	4,080	20,790	91,180
Stoneflies (Plecoptera)	2,210	11,960	6,930	21,410
Caddisflies (Trichoptera)	740	880	940	1,000
True Flies (Diptera)	14,790	144,600	18,180	148,400
Mean number of organisms per meter^2	**35,180**	**189,840**	54,270	302,440