FRED Reports

Kenai River Water Quality Investigation
Annual Progress Report, 1989-1990

by
V. P. Litchfield and G. B. Kyle

Number 111

Alaska Department of Fish & Game
Division of Fisheries Rehabilitation,
Enhancement and Development

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ABSTRACT

The Kenai River, located on the Kenai Peninsula in Southcentral Alaska, flows through state, federal, and private lands. This river drainage supports major runs of salmon including the largest chinook salmon found anywhere in the world, and the largest salmon sport fishery (>400,000 angler-days) in Alaska. Its importance to the local economy is staggering; for example, in 1986 sport angler expenditures were estimated at $44.2 million and in 1987 an estimated 7 million sockeye salmon bound for the Kenai River were harvested by commercial fisherman. In recent years, usage of the river has increased greatly, development along its banks has expanded, and contamination sites adjacent to the river have been identified. Given the importance of the Kenai River to fishery resources, it is astounding that little is known about the water quality. In late 1989, a study was initiated to establish a baseline for water quality, biological, and physical parameters at ten river locations and seven major tributaries. Project planning and sampling effort entailed inter-agency cooperation among the Alaska Department of Fish and Game (ADF&G), the U.S. Fish and Wildlife Service (USF&WS), the Alaska Department of Natural Resources (ADNR), and the Kenai River Advisory Board (KRAB). The first year's results indicate that water quality parameters were within concentrations found to be non-harmful to aquatic life, although during the season there were elevated concentrations of some parameters during intense use, especially in the lower river.

INTRODUCTION

The Kenai River begins at the outlet of Kenai Lake in Cooper Landing, flows 132 km (82 miles) and empties into Cook Inlet near the city of Kenai. All five species of Pacific salmon are present in the Kenai River drainage as well as nearly 20 other fish species (Bendock and Bingham 1988). Over 400,000 angler-days of sport fishing occur on the Kenai River each year and an estimated 44.2 million dollars were spent by sport anglers in 1986 (Jones and Stokes 1987). In addition, in 1987 a record-high estimate of 7 million of the 9.5 million sockeye salmon commercially harvested in upper Cook Inlet were bound for the Kenai River (D. L. Waltemyer[1] pers. comm.).

The main stem of the Kenai River, as well as it's tributaries, provide vital habitat areas for spawning and rearing fish, and thus, protection of these areas is critical. For example, juvenile chinook salmon migrate both up and downstream in the Kenai River (Litchfield and Flagg 1986) and Bendock (1989) reported that there is a significant difference in juvenile chinook salmon populations during summer and winter rearing areas. Thus, mobility is a vital mechanism of rearing fish in the Kenai River and there appears to be few areas in the Kenai River that is not in some way essential to fish habitat. Therefore, the presumption is that no part of the river can sustain a negative impact without resulting in some detrimental impact to aquatic life.

Habitat protection is widely accepted to be a fundamental direction of efforts to preserve aquatic resources. Since water is a major component of aquatic habitats, the importance of ensuring its integrity is essential. It is for this reason that a cooperative, multiple-agency project was initiated in the fall of 1989 to investigate the water quality of the Kenai River (KRAB 1989). The goal of this project is to establish baseline data necessary for assessing water quality. This progress report presents the analysis of water-quality and biological samples collected during November 1989-November 1990.

In addition to this project, a liver enzyme study in the Kenai River was initiated in the fall of 1989 by the University of Alaska-Anchorage to investigate the presence of pollutants in sculpins (*Cottus* sp.). Initial results need further verification before any conclusions are made, and a proposal for additional investigations has been submitted (C. E. Paige[2] pers. comm.). This information will be used in conjunction with

[1]Alaska Department of Fish and Game, 34828 Kalifornsky Beach Road, Soldotna AK 99669.

[2] University of Alaska-Anchorage, 3211 Providence Drive, Anchorage AK 99508.

hydrocarbon sampling conducted as part of the Kenai River water-quality study to investigate the occurrence of ingested hydrocarbons.

Study Site Description-- The Kenai River has nine major tributaries emptying into the mainstem including Russian, Killey, Funny, and Moose rivers, and Cooper, Juneau, Soldotna, Slikok, and Beaver creeks. Within the Kenai River drainage there are numerous lakes; however the two largest lakes are Kenai and Skilak, which are both classified as glacial (Koenings *et al.* 1986). The major glacial tributaries to these include Snow, Trail, and Skilak Rivers. Important and numerous wetland areas are found within this watershed. The average gradient from Kenai Lake to Skilak Lake is 7.3 m/km (24 ft/mile) and from the outlet of Skilak Lake to the river mouth is 0.8 m/km (4 ft/mile) (U.S. Army Corp of Engineers 1978). The river drains a watershed of 5,563 km^2 (2,148 sq. miles), of which 91% is federally controlled. The discharge of the Kenai River at the Soldotna gaging station ranged from a minimum of 37 m^3/s (1,300 cfs) to a maximum of 759 m^3/s (26,000 cfs) with a mean of 191 m^3/s (6,745 cfs) for the 1989-1990 calendar year (R. L. Rickman[3] pers. comm.). The highest flows occur during August-October with the lowest flows occurring during the late-winter months (January-March).

METHODS AND PROCEDURES

Sampling was conducted at ten sites within the Kenai River and seven major tributaries (Figure 1). The mainstem sample stations were selected primarily for their location in relation to major tributaries and secondarily for intensity of use and development. The mainstem Kenai River stations are referenced according to River Mile (RM) similar to other publications on this watershed. Sampling was conducted on a monthly basis during the ice-free period for the mainstem stations and quarterly for the tributaries. Physical data collected included temperature, dissolved oxygen,

[3]United States Geological Survey, 1209 Orca Street, Anchorage AK 99501.

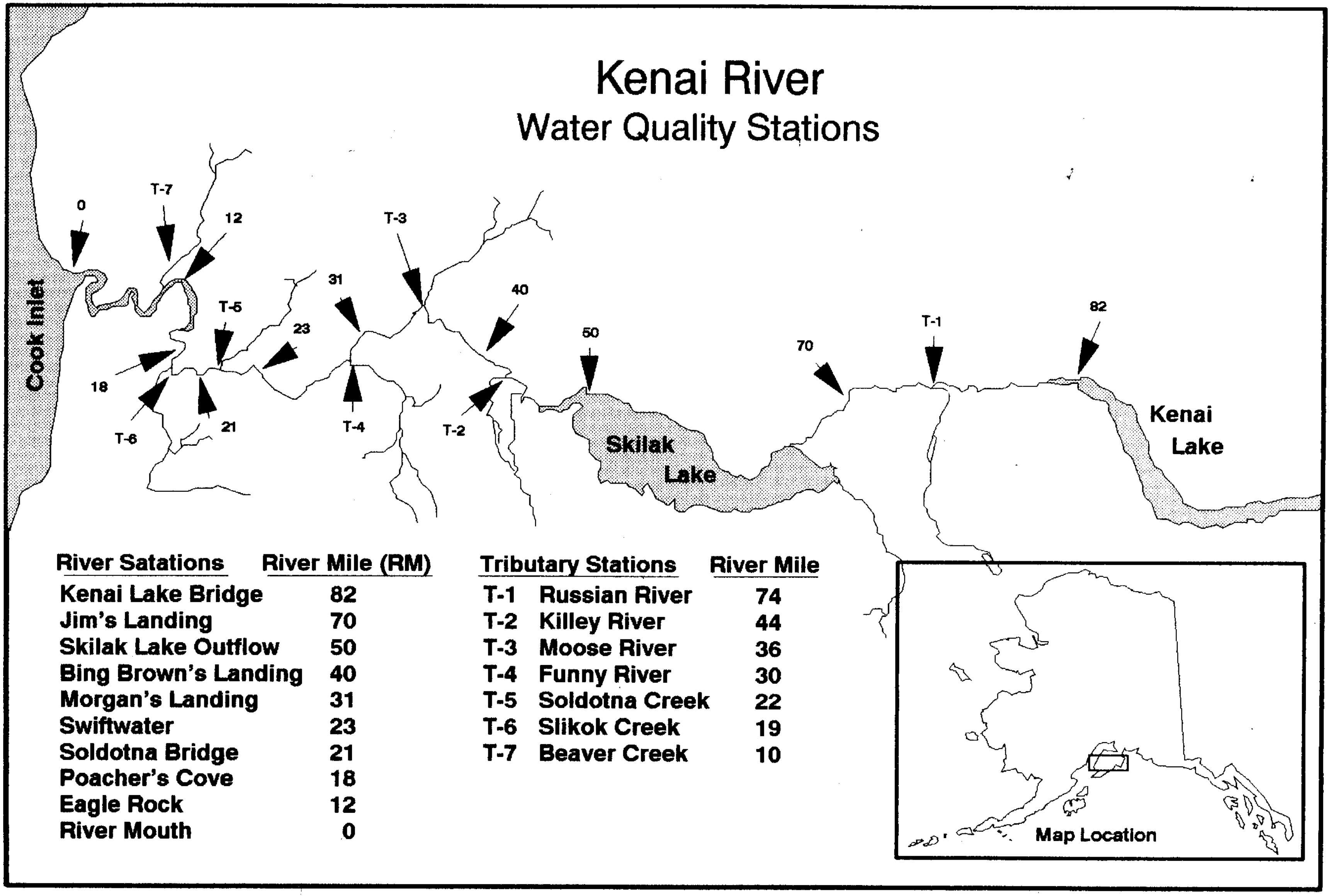

Figure 1. Location of water quality sample stations in the mainstem (River Mile 0-82) and in seven tributaries (T1-7) of the Kenai River.

depth, light penetration, and Secchi disk readings. Mid-river surface and subsurface water was collected and examined for chemical and biological water-quality parameters. In addition, benthic invertebrate samples were collected twice in the spring and once in the fall. The tributaries were sampled near the confluence with the Kenai River but far enough upstream to eliminate mainstem influence. A drift boat was used in the fall of 1989 when access was limited, and a motorized boat was used in the spring and throughout the summer of 1990.

Light penetration was measured every 0.25 m using a Protomatic® submarine photometer, and water transparency was measured with a 20-cm Secchi disk. The depth at which the disk disappeared on descent and reappeared upon retrieval was averaged to obtain the mean depth of water transparency. Subsurface temperature and dissolved oxygen were recorded using a YSI model-57 temperature/dissolved oxygen meter. Biological oxygen demand (BOD) was determined from two surface samples by reading one sample immediately upon return to the lab and the other one after five days of being stored in the dark at 20°C (APHA 1985). Subsurface water was collected for nutrient analysis with a plastic bilge pump lowered 0.5 m below the surface. A translucent, pre-cleaned carboy (2.2 L) was first rinsed with river water, then filled, and kept cool in the dark until transported to the limnology laboratory. The water was refrigerated overnight and processed early the following morning. The filtered and non-filtered water samples were either refrigerated or frozen, depending on analytical test, and stored in pre-cleaned polybottles.

Water samples were analyzed by the ADF&G Limnology Laboratory in Soldotna using methods detailed by Koenings *et al.* (1987). In general, filterable reactive phosphorus (FRP) was analyzed by the molybdate-blue/ascorbic-acid method of Murphy and Riley (1962), as modified by Eisenreich *et al.* (1975). Total phosphorus was determined by the FRP procedure, after persulfate digestion. Nitrate and nitrite

®Mention of commercial products and trade names does not constitute endorsement by ADF&G, FRED Division.

(NO_3 + NO_2) were determined as nitrite, following Stainton *et al.* (1977), after cadmium reduction of nitrate. Total Kjeldahl nitrogen (TKN) was determined as total ammonia following sulfuric acid block digestion (Crowther *et al.* 1980). Reactive silicon was determined using the method of ascorbic acid reduction to molybdenum-blue after Stainton *et al.* (1977). Turbidity was measured with a HF model-DRT turbidimeter and reported as nephelometric turbidity units (NTU). Alkalinity levels were determined by acid titration (0.02 N H_2SO_4) to pH 4.5, using a Corning model-399A specific ion meter.

Analysis of water samples for metals was conducted by Elemental Research Inc. of Vancouver B. C. Canada. A "full element" scan utilizing inductively coupled plasma mass spectrometry instrumentation (ICP-MS) was conducted on all samples which identifies concentrations of 70 different elements (Appendix 1). Both filtered and unfiltered water was preserved (125 ml each) with 0.5 ml of 1:1 nitric acid. All river stations and tributaries, with the exception of Russian River, were sampled once in the fall of 1989. In 1990, samples were collected in the spring, summer, and fall for analysis. Metal concentrations are reported as μg/L which is equivalent to parts per billion (ppb).

Water samples for analysis of hydrocarbons were sent to Analytical Resources Incorporated of Seattle, Washington. Total petroleum hydrocarbon (TPH) was determined using the Environmental Protection Agency (EPA) infra-red method number 418.1 (EMSL 1983). This method provides only a single total hydrocarbon value but is useful in surveying areas of potential contamination because of its relatively low cost. Volatile organics analysis (VOA) was determined using EPA method number GC-MS 624 (Federal Register 1984) which is a more costly analysis but identifies and quantifies individual compounds (μg/L) at much lower detection limits (Appendix 2). Water for hydrocarbon analysis was collected beginning in May of 1990. Over the course of the summer, all river sites and tributaries were tested for both TPH and VOA. Subsurface water was collected in pre-cleaned 500-ml amber glass containers for TPH analysis, and two 40-ml viles for VOA. Care was taken to seal the vials without the presence of air. Samples were chilled to 4° C prior to shipment, and two blanks were included in every shipment.

Benthic invertebrate samples were collected during periods of low flow, when the gravel substrate was exposed. Nine river sites and two tributaries were sampled in May of 1990. An attempt was made in June to sample the same sites but the water level prevented access to similar habitat. Sampling did not re-occur until November due to high-water conditions, and was reduced to six river sites and two tributaries because of insufficient organisms found in several locations during the spring sampling. Three randomly selected samples were taken at each location for analysis.

Benthic samples were obtained using a stovepipe sampler modified to work in high water velocity. The sampler surveyed an area 34 cm in diameter and a total of 907 cm^2. Metal teeth lined the bottom of the sampler which allowed contact with the substrate and created a solid seal with the river sediment. The area was disturbed to release benthic organisms, and the larger stones were scraped to release attached organisms. Benthic invertebrates were washed down and trapped in a bucket attached to the stovepipe sampler, and preserved in 70% ethanol. The following data were recorded at each site: substrate size and percent embedded, amount and type of vegetation present, water velocity, water depth, date, and location description. All benthic samples were sent to the Arctic Environmental Information and Data Center (AEIDC) of the University of Alaska-Anchorage for analysis. The samples were sorted and identified to the family level, and to genera for Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). These three orders are more commonly known as the EPT grouping. The mayfly family (Baetidae) has a high tolerance to polluted water and its presence in relation to total EPT was used as an indicator of water quality. Insect taxa richness (number of insect families) and the number of EPT genera were estimated for each station. The ratio of EPT individuals to total individuals and the ratio of Baetids/EPT individuals were calculated for each sample and then averaged for the number of samples. The EPT to total individuals ratio reflects a higher water quality as this value increases to a maximum of 1, while the Baetids/total EPT ratio indicates less water quality degradation as the ratio decreases. Baetid mayflies are probably the most tolerant of the EPT genera, and in general water quality is high when this group is less dominant.

Finally, coliform bacterial testing (total coliform and fecal streptococcus) analysis was conducted on water samples collected during June-November of 1990. Fecal coliform analysis was conducted on samples collected during July-November of 1990. Water for bacterial analysis was collected in sterilized polypropylene containers and processed immediately upon returning to the lab (within 4-6 h of collection). The membrane filter methods 909A, 909C, 910B (APHA 1985) were used for total coliform, fecal coliform, and fecal streptococcus, respectively. A 100-ml sample was first poured through a pre-sterilized filter, vacuum filtered, rinsed with a phosphate buffer solution, and finally the seston was placed on an absorbent pad containing the appropriate nutrient media in a petri dish. The sample was then incubated either in an oven or water-bath incubator for the proper length of time. Bacterial counts were made using a low-power stereoscopic microscope with a fluorescent light source. A series of dilutions were necessary for samples collected from the lower river sites due to the presence of high total coliform and non-coliform densities, and high turbidity. In the event of interference or contamination of a sample, the results were discarded and the sample was re-analyzed.

RESULTS AND DISCUSSION

Physical Parameters-- Due to the influence of saltwater at RM 0, many physical, chemical and biological parameters for this station were vastly different from the rest of the river. Consequently, it is important to note this when making comparisons.

Seasonal temperatures among the nine river stations (RM 12-82) ranged from -1 to 12°C and averaged 6.4°C, and in the seven tributaries ranged from -0.5 to 11.5°C and averaged 6.6°C. The maximum temperature tolerance of salmon based on short exposures is 18°C (EPA 1986). Thus, warm temperatures in the Kenai River that potentially could affect survival of salmon is not a concern; however, cooler temperatures of glacial systems can affect fish growth and production (Koenings *et al.* 1986).

Dissolved oxygen (DO) concentrations for the river stations ranged from 9.0 to 13.3 mg/L and averaged 11.1 mg/L, and for the tributaries ranged from 7.3 to 11.4 mg/L and averaged 9.7 mg/L. Criteria for dissolved oxygen content in water varies according to exposure time and life stages. However, the State of Alaska Water Quality Standard Regulations (ADEC 1991) require that DO shall be greater than 7 mg/L in waters used by anadromous and resident fish, and in no case shall DO be less than 5 mg/L to a depth of 20 cm in the interstitial waters of gravel used for spawning. Thus, according to these standards, the Kenai River is not oxygen-limited. Furthermore, the biochemical oxygen demand (BOD) measurements support this conclusion, as BOD ranged from 0 to 1.1 mg/L and averaged 0.1 mg/L over the season. Basically, BOD is the measurement of oxygen required for the decomposition of organic material commonly found in waste waters, effluent, and polluted waters. Thus, BOD is very low in the Kenai River indicating no excessive demands by organisms associated with polluted waters.

Secchi disk readings in the mainstem of the Kenai River ranged from 0.4 to 1.75 m and averaged 0.71 m over the season. The seasonal variation of turbidity ranged from 2 to 18 NTU for river sites (RM 12-82) (Figure 2A) and reached 260 NTU at RM 0. Turbidity in the tributaries ranged from a low of 0.4 NTU in the Russian River to a high of 78 NTU in the Killey River. Although at times turbidity was quite high in the river, the one-percent light level exceeded the mean depth at most stations and dates sampled (Figure 2B). As the one-percent light level defines the depth range at which photosynthesis occurs, most of the time throughout the river, turbidity did not limit the vertical extent of photosynthesis. Although a large percentage of the turbidity can be attributed to natural sources (glacial meltwater), erosion advanced by man-related activities can be a contributing factor.

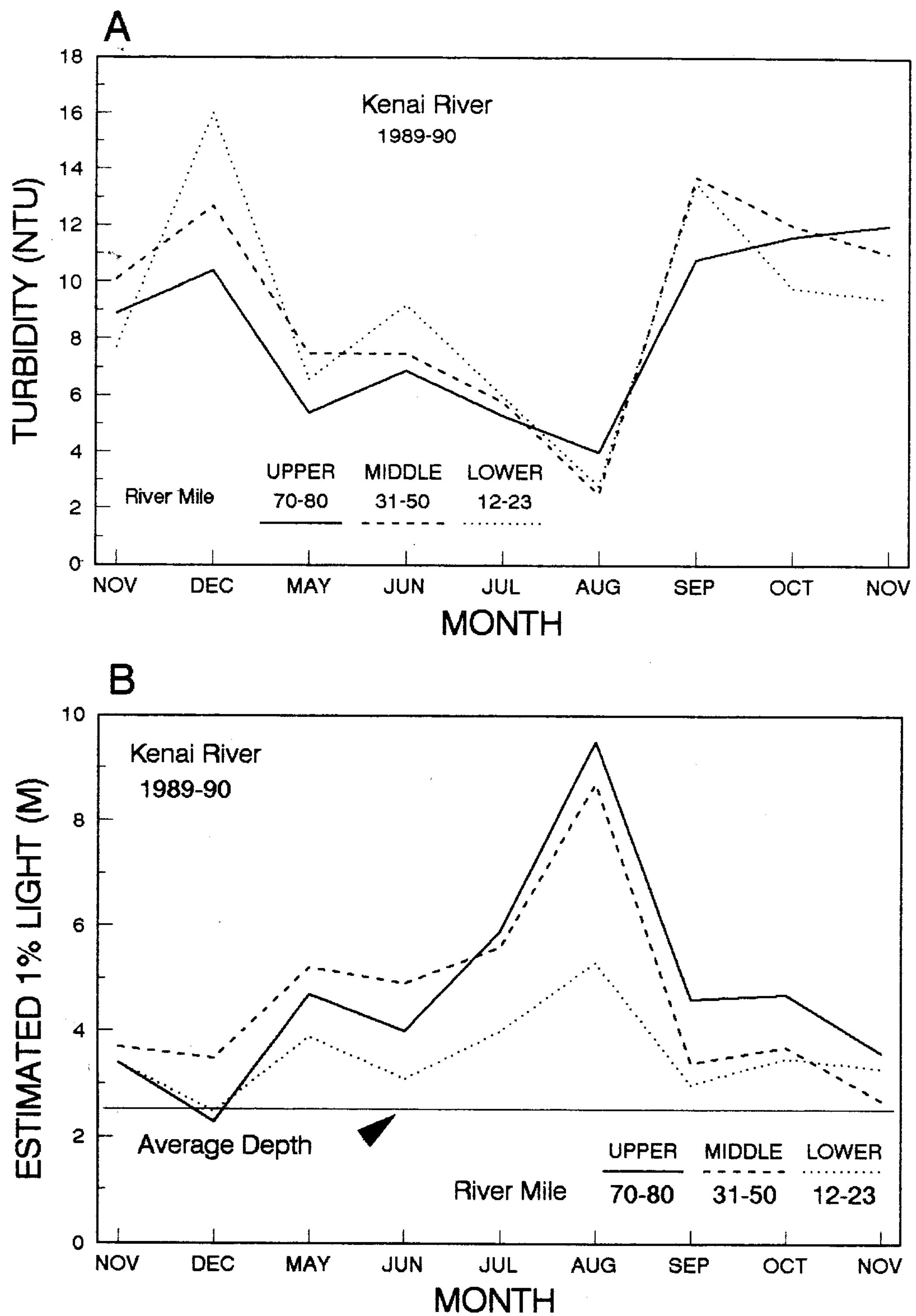

Figure 2. Monthly turbidity (A) and one-percent light levels (B) for the lower, middle, and upper stations sampled in the Kenai River, 1989-1990.

General Water Quality Parameters and Nutrients-- A summary of general water quality parameters and nutrients for the Kenai River and tributaries are presented in Tables 1-3. Conductivity, a measure of the ability to carry an electrical current, is important as it is highly correlated with the amount of dissolved materials in solution, and therefore is an indicator of fertility. Conductivity for the river stations (RM 12-82) ranged from 30 to 81 μmhos/cm during the season and averaged 62 μmhos/cm, and in the tributaries ranged from 21 to 177 μmhos/cm. These concentrations were within the normal range for waters in Alaska. However, the station at RM 0 near the mouth of the Kenai River had a much higher conductivity (~10,000 μmhos/cm) due to the influence of saltwater. In the mainstem of the Kenai River (RM 12-82), pH varied from 7.1 to 7.7 and averaged 7.4, while in the tributaries pH ranged from a low of 6.6 in the Killey River to a high of 8.2 in Soldotna Creek. The pH values are within the State of Alaska Water Quality Standard Regulations (ADEC 1991) criteria which require that pH shall not be less than 6.5 or greater then 9.0 for the propagation of fish and aquatic life. Alkalinity levels are largely dependent on the presence of carbonate and bicarbonate ions, and is important as it determines the ability of water to resist changes in pH, which consequently is important in many chemical reactions. In-river alkalinity ranged from 20 to 36 mg/L and averaged 25 mg/L over the season, while in the tributaries alkalinity ranged from 5 to 94 mg/L and averaged 51 mg/L. Alkalinity values both within the mainstem and in the tributaries were well within the range of most waters in Alaska. Finally, some of the tributaries (e.g. Killey River, Funny River, Slikok Creek and Beaver Creek) had substantially higher concentrations of iron compared to the nine mainstem sample stations. Although high iron concentrations are associated with high turbidity (glacial particles), the less-turbid tributaries such as Beaver and Slikok creeks have a substantial amount of ground water seepage which upon contact with sediments produces elevated concentrations of iron.

Total phosphorus (TP), nitrogen, and silicon are three of the most important nutrients necessary for plant growth. In the Kenai River, TP ranged from 5.8 to 41.4 μg/L and averaged 18.9 μg/L, while in the tributaries TP ranged from 6 to

Table 1. General water quality parameters and nutrient concentrations for Kenai River stations (RM 31-82) sampled during November 1989 - November 1990. Values are seasonal means with ranges in parentheses.

Parameter/River Mile	82	70	50	40	31
Conductivity	66	67	59	58	58
(umhos/cm)	(57-70)	(30-81)	(53-63)	(50-61)	(37-71)
pH (units)	7.4	7.4	7.4	7.4	7.4
	(7.1-7.5)	(7.1-7.6)	(7.2-7.7)	(7.2-7.6)	(7.2-7.6)
Alkalinity (mg/L)	24.6	26.6	25.6	22.8	24.8
	(20.0-27.5)	(23.0-30.0)	(22.0-36.0)	(21.0-25.0)	(21.0-35.0)
Turbidity (NTU)	9.7	7.0	8.4	9.9	9.2
	(4.2-14.0)	(3.6-12.0)	(2.0-14.0)	(3.2-18.0)	(2.4-16.0)
Color (Pt. units)	6	5	4	4	5
	(3-11)	(3-10)	(3-6)	(3-6)	(3-9)
Calcium (mg/L)	10.6	11.2	9.8	9.3	9.3
	(8.0-14.1)	(9.9-12.3)	(9.1-11.1)	(8.7-10.1)	(8.5-10.4)
Magnesium (mg/L)	0.6	0.5	0.4	0.5	0.8
	(<0.2-1.3)	(<0.2-0.8)	(<0.2-0.8)	(<0.2-1.4)	(<0.2-1.3)
Total iron (ug/L)	434	420	473	598	628
	(269-824)	(203-641)	(121-855)	(390-782)	(275-921)
Total-P (ug/L)	16.3	14.4	14.4	21.6	21.6
	(9.0-22.2)	(8.9-20.8)	(5.8-23.5)	(10.7-24.2)	(11.1-41.4)
TFP (ug/L)	4.2	3.3	3.1	3.7	4.4
	(1.4-11.6)	(1.2-5.4)	(1.6-5.7)	(1.9-7.9)	(1.9-7.2)
FRP (ug/L)	3.5	3.0	2.4	2.9	3.6
	(1.1-12.0)	(1.4-4.8)	(1.0-3.8)	(1.0-4.2)	(1.3-6.8)
TKN (ug/L)	59.3	58.2	49.1	65.9	80.7
	(37.3-116.9)	(45.0-87.0)	(39.4-66.2)	(41.5-90.7)	(40.3-157.6)
Ammonium (ug/L)	7.9	8.1	7.2	8.3	9.6
	(<1.1-19.7)	(1.7-15.7)	(<1.1-11.7)	(<1.1-19.4)	(21.1-27.7)
Nitrate + Nitrite	166.9	185.0	161.8	155.8	146.1
(ug/L)	(137.1-194.5)	(173.1-197.5)	(130.3-192.8)	(115.7-190.6)	(81.7-190.2)
Reactive silicon	1,540	1,643	1,404	1,466	1,606
(ug/L)	(1,361-1,648)	(1,406-1,969)	(1,181-1,683)	(1,358-1,707)	(1,208-2,147)

Table 2. General water quality parameters and nutrient concentrations for Kenai River stations (RM 0-23) sampled during November 1989 - November 1990. Values are seasonal means with ranges in parentheses.

Parameter/River Mile	23	21	18	12	0
Conductivity	62	63	64	63	9,796
(umhos/cm)	(59-67)	(60-69)	(61-70)	(60-68)	(37-35,000)
pH (units)	7.4	7.4	7.4	7.4	7.7
	(7.1-7.6)	(7.1-7.6)	(7.1-7.7)	(7.2-7.7)	(7.4-8.2)
Alkalinity (mg/L)	24.6	24.4	24.7	25.2	54.0
	(23.0-30.0)	(22.0-29.5)	(22.0-30.0)	(23.0-29.5)	(24.0-108.0)
Turbidity (NTU)	9.4	9.2	8.6	7.9	101.4
	(3.0-16.0)	(2.8-16.0)	(4.0-16.0)	(3.0-12.0)	(10.0-260.0)
Color (Pt. units)	6	6	5	4	4
	(3-10)	(3-10)	(4-8)	(3-5)	(3-4)
Calcium (mg/L)	9.4	9.7	9.6	9.7	192.6
	(8.5-10.0)	(9.2-10.5)	(8.5-10.2)	(8.5-11.1)	(9.3-863.0)
Magnesium (mg/L)	0.9	0.7	0.6	0.7	295.2
	(0.3-1.5)	(<0.2-1.3)	(<0.2-1.3)	(<0.2-1.0)	(3.4-962.0)
Total iron (ug/L)	631	672	617	564	6,971
	(266-1,134)	(279-1,118)	(183-1,100)	(307-861)	(967-18,514)
Total-P (ug/L)	22.0	18.1	21.8	19.5	353.2
	(9.9-33.3)	(10.3-28.5)	(9.9-27.8)	(10.4-29.5)	(70.8-1,438)
TFP (ug/L)	4.1	4.0	5.0	4.8	15.7
	(2.0-6.5)	(2.0-5.4)	(1.6-8.5)	(1.9-8.7)	(3.9-38.1)
FRP (ug/L)	3.4	3.5	4.4	4.6	14.4
	(1.2-6.8)	(1.3-5.5)	(1.3-8.1)	(1.1-7.9)	(3.1-37.0)
TKN (ug/L)	73.6	71.2	74.3	74.6	290.9
	(43.4-119.2)	(45.6-122.2)	(36.5-126.4)	(39.5-137.0)	(96.9-594.0)
Ammonium (ug/L)	8.5	9.0	8.1	11.7	10.5
	(<1.1-17.3)	(<1.1-17.8)	(<1.1-13.0)	(<1.1-19.8)	(<1.1-20.6)
Nitrate + Nitrite	148.9	151.2	150.2	153.4	134.5
(ug/L)	(107.0-187.8)	(109.9-186.3)	(104.1-187.2)	(106.0-189.7)	(100.7-178.0)
Reactive silicon	1,714	1,758	1,714	1,659	1,145
(ug/L)	(1,335-2,206)	(450-3,476)	(422-3,094)	(427-3,046)	(539-1,591)

Table 3. General water quality parameters and nutrient concentrations for Kenai River tributary stations (T-1 - T-7) sampled during May-November 1990.

Parameter/Station	T-1	T-2	T-3	T-4	T-5	T-6	T-7
Conductivity	91	49	148	88	146	121	113
(umhos/cm)	(82-99)	(21-71)	(98-169)	(45-108)	(83-177)	(68-144)	(69-148)
pH (units)	7.6	7.0	7.4	7.4	7.4	7.3	7.3
	(7.4-7.7)	(6.6-7.3)	(6.8-8.2)	(6.9-7.6)	(6.9-7.9)	(7.2-7.6)	(7.2-7.6)
Alkalinity (mg/L)	37.4	16.7	79.4	44.5	68.6	55.7	54.6
	(29.0-49.0)	(5.0-26.0)	(46.0-92.0)	(20.0-53.5)	(32.0-94.0)	(24.0-74.0)	(30.0-76.0)
Turbidity (NTU)	0.8	27.8	3.0	3.6	2.4	2.8	9.6
	(0.4-1.2)	(1.6-78.0)	(1.6-5.2)	(1.8-8.8)	(1.4-3.8)	(1.8-3.8)	(3.8-16.0)
Color (Pt. units)	5	9	31	21	23	23	25
	(4-6)	(5-11)	(23-39)	(14-32)	(15-29)	(18-28)	(17-41)
Calcium (mg/L)	14.4	5.9	22.2	10.9	15.8	14.1	13.7
	(9.3-17.5)	(2.6-9.0)	(14.3-25.3)	(4.9-13.2)	(9.6-22.7)	(7.7-17.0)	(7.8-17.0)
Magnesium (mg/L)	1.0	1.1	3.5	3.1	5.0	4.0	3.9
	(<0.2-1.8)	(0.6-2.0)	(2.2-5.0)	(1.5-4.2)	(3.0-6.4)	(1.5-5.7)	(2.3-5.7)
Total iron (ug/L)	53	1,334	654	1,642	621	1,158	2,250
	(23-120)	(222-4,706)	(319-952)	(425-5,179)	(426-895)	(401-1,812)	(1,704-3,107)
Total-P (ug/L)	8.9	72.9	40.9	43.3	73.6	35.6	76.0
	(6.0-13.3)	(10.5-202.7)	(24.1-52.8)	(27.8-62.7)	(15.0-80.9)	(21.6-42.0)	(62.5-96.4)
TFP (ug/L)	3.7	4.3	19.4	20.3	48.7	21.4	25.5
	(0.9-7.7)	(2.3-5.8)	(14.8-26.2)	(14.8-28.9)	(37.3-59.1)	(12.9-32.0)	(21.3-31.5)
FRP (ug/L)	3.6	4.7	16.9	18.9	42.9	20.5	24.2
	(1.0-7.0)	(1.5-7.2)	(11.6-25.4)	(12.6-23.7)	(23.7-60.9)	(10.8-32.8)	(19.5-31.7)
TKN (ug/L)	98.9	115.5	265.9	212.8	233.6	214.7	253.9
	(57.1-167.8)	(70.1-208.3)	(236.0-313.8)	(115.3-282.9)	(195.1-294.0)	(181.9-260.9)	(182.0-330.3)
Ammonium (ug/L)	11.9	11.1	11.9	14.5	17.0	13.5	11.2
	(<1.4-36.2)	(1.4-28.6)	(<1.1-32.9)	(<1.1-37.6)	(<1.1-35.2)	(2.7-25.4)	(<1.1-21.5)
Nitrate + Nitrite	478.6	118.0	16.3	39.5	21.9	146.7	43.4
(ug/L)	(278.6-736.6)	(20.6-277.5)	(<3.4-58.4)	(7.2-69.0)	(5.1-50.6)	(20.5-289.5)	(3.6-75.3)
Reactive silicon	2,024	2,076	4,801	6,415	8,366	7,068	4,890
(ug/L)	(1,453-2,420)	(935-4,477)	(1,422-8,453)	(2,301-8,921)	(1,692-12,921)	(1,616-11,036)	(1,552-7,590)

203 $\mu g/L$. However, because colorimetric measurements of TP in turbid solutions elevated due to the backscattering of light, TP concentrations of Kenai River samples are artifically high and need to be corrected. Koenings *et al.* (1987) found that nearly 40% of the measureable TP in turbid (glacial) lakes was due to high absorbance. In addition, Koenings *et al.* (1987) found that nearly 75% of TP (corrected for turbidity) in glacial lakes was comprised of rock phosphorus, which is biologically unavailable. Applying these correction factors to water samples collected from the Kenai River result in an average TP of 7.8 $\mu g/L$, which is not considered high for Alaska waters. Similarly, the highest TP concentration found for the tributaries was Killey River which also had the highest turbidity levels of the tributaries sampled within the Kenai River drainage. Total Kjeldahl nitrogen, a measure of organic nitrogen and total ammonia, ranged from 37 to 158 $\mu g/L$ and averaged 67 $\mu g/L$ in the Kenai River, and ranged from 57 to 330 $\mu g/L$ in the tributaries. Finally, reactive silicon ranged from 422 to 3,476 $\mu g/L$ and averaged 1,612 $\mu g/L$ for the nine river stations, and for the tributaries ranged from a seasonal mean of 2,024 $\mu g/L$ for the Russian River to a high of 8,367 $\mu g/L$ for Soldotna Creek. As the soil type common to the watersheds of many Kenai River tributaries is clay, which is comprised mainly of aluminum silicate, higher concentrations of silicon at these sites were not unusual. In particular, high silicon concentrations were observed in the tributaries during late fall when flow rates were high. Overall, the Kenai River and its tributaries do not show signs of either nutrient deficiency or excessive unnatural organic enrichment. A detailed listing of water-quality parameters and nutrients analyzed for all samples by date is provided in Appendix 3.

Metals-- The examination of metal concentrations in natural water can be quite complex as some metals are beneficial in small amounts but lethal in higher concentrations. The Environmental Protection Agency (EPA) regulates fourteen of the metals analyzed for maximum contamination levels (MCL) in public drinking water, while only a few are regulated for aquatic life. Considerable research has revealed different toxicity levels for various fish species as well as exposure times and concentrations (EPA 1986). Also, metals have been found to react differently with other water-quality parameters that can contribute to toxicity. For example, metal toxicity generally decreases as alkalinity increases, but toxicity of water will differ dependent upon such factors as concentrations of organic ligands, pH, and salinity (Thurston *et al.* 1979).

Seasonal mean concentrations for 18 metals that were present above detection limits are presented in Table 4 for the ten stations sampled in the mainstem of the Kenai River, and in Table 5 for stations sampled in the seven tributaries. Although both filtered and unfiltered samples were collected, the dissolved or filtered metal samples which are not bound in particulates were analyzed. This is because aquatic toxicity levels (ATL) for the regulated metals, which are defined as either the EPA criteria for freshwater aquatic life or the lowest range of acute toxicity to fish (EPA 1986), are reported for dissolved samples. Eight of the more common metals that were found in concentrations above the detection limits are graphically presented in Figures 3 and 4 for the mainstem river stations and in Figure 5 for the tributary stations. As indicated on Figures 3-5, none of the seasonal mean concentrations exceeded known aquatic toxicity levels reported by the EPA. Finally, at RM 0, located at the mouth of the Kenai River, most metals were present in higher concentrations, but this was presumably due to the influence of saltwater.

Hydrocarbons-- Of the 51 total petroleum hydrocarbon (TPH) samples analyzed only one had a concentration at the detection limit of 1,000 $\mu g/L$ (ppb). This sample was from the mouth of the river (RM 0). Two other tributary samples, Soldotna and Slikok creeks detected trace levels of TPH. All three of these samples were taken in early May during spring runoff. All other samples taken during May, June, July, and September did not detect TPH. As the State of Alaska Water Quality Standard Regulations (ADEC 1991) stipulate concentrations of TPH above 15 $\mu g/L$ (ppb) unacceptable for aquatic life, TPH analysis (EPA 418.1) cannot be used to evaluate concentrations above Alaska regulations but does detect levels exceeding 1,000 $\mu g/L$.

Table 4. Seasonal mean concentrations (ug/L) of metals found in samples from the mainstem of the Kenai River in 1990.

Element (ug/L)	River Mile									
	82	70	50	40	31	23	21	18	12	0
Aluminum	21.5	19.2	25.0	29.8	22.3	26.3	34.0	32.8	35.3	3,003.2
Calcium	9,650	10,175	8,850	9,275	7,900	9,050	9,175	8,525	8,825	139,125
Chronium	0.6	0.6	0.7	0.6	0.5	0.6	0.7	0.8	0.7	18.9
Iron	54.3	50.3	48.8	61.0	50.3	59.5	72.8	70.3	112.5	4,122.5
Nickel	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	53.4
Zinc	4.2	7.6	5.6	6.0	5.3	5.1	10.4	10.6	12.0	28.9
Lead	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3.3
Magnesium	675	693	645	675	603	750	755	708	758	321,500
Silicon	1,375	1,575	1,300	1,360	1,170	1,327	1,433	1,375	1,438	8,430
Potassium	613	620	963	973	830	930	940	850	880	72,725
Manganese	0.9	1.0	0.5	1.5	1.7	2.9	3.3	3.5	3.8	150.1
Cobalt	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	3.5
Copper	3.4	2.9	2.1	2.0	321.0	1.4	2.0	2.5	1.4	115.8
Arsenic	0.4	0.8	0.8	0.8	0.6	0.6	0.6	0.8	0.6	0.3
Strontium	61.0	62.5	52.8	49.8	46.3	51.0	50.8	46.5	49.5	2,568.8
Barium	18.3	16.5	21.0	22.5	18.5	23.3	44.3	44.5	40.8	95.5
Titanium	2.3	2.2	2.2	3.1	1.9	2.3	3.1	2.5	3.0	314.4
Cadmium	0.1	0.1	0.1	0.1	2.1	0.1	0.1	0.1	0.1	0.2

Table 5. Seasonal mean concentrations (ug/L) of metals found in samples collected from seven Kenai River tributaries in 1990.

Element (ug/L)	Tributaries: Russian River T-1	Killey River T-2	Moose River T-3	Funny River T-4	Soldotna Creek T-5	Slikok Creek T-6	Beaver Creek T-7
Aluminum	2.1	50.8	2.7	10.1	2.4	4.3	10.5
Calcium	16,333	6,025	19,500	11,125	13,600	12,850	11,625
Chronium	1.0	0.8	0.8	0.9	0.6	0.8	0.7
Iron	65.3	155.3	407.5	315.0	297.5	565.0	895.0
Nickel	1.4	0.9	0.9	0.8	0.6	0.6	0.9
Zinc	4.9	8.3	6.7	9.9	16.6	16.0	23.8
Lead	0.1	0.1	0.1	0.9	0.2	0.2	0.2
Magnesium	953	910	3,025	2,975	3,675	3,250	2,525
Silicon	2,100	2,975	5,525	6,200	7,500	6,875	5,275
Potassium	547	903	1,240	1,145	1,800	1,525	1,600
Manganese	1.1	14.0	67.0	50.2	193.3	75.3	186.8
Cobalt	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Copper	5.9	3.5	6.8	4.5	4.4	3.5	4.4
Arsenic	0.4	0.4	3.7	2.0	4.7	1.7	3.0
Strontium	101.3	29.0	94.5	51.3	85.5	66.3	65.3
Barium	14.0	24.1	29.0	24.5	73.5	57.3	88.5
Titanium	1.4	4.9	4.4	3.7	5.2	3.5	4.8
Cadmium	0.1	0.2	0.1	0.1	0.1	0.1	0.1

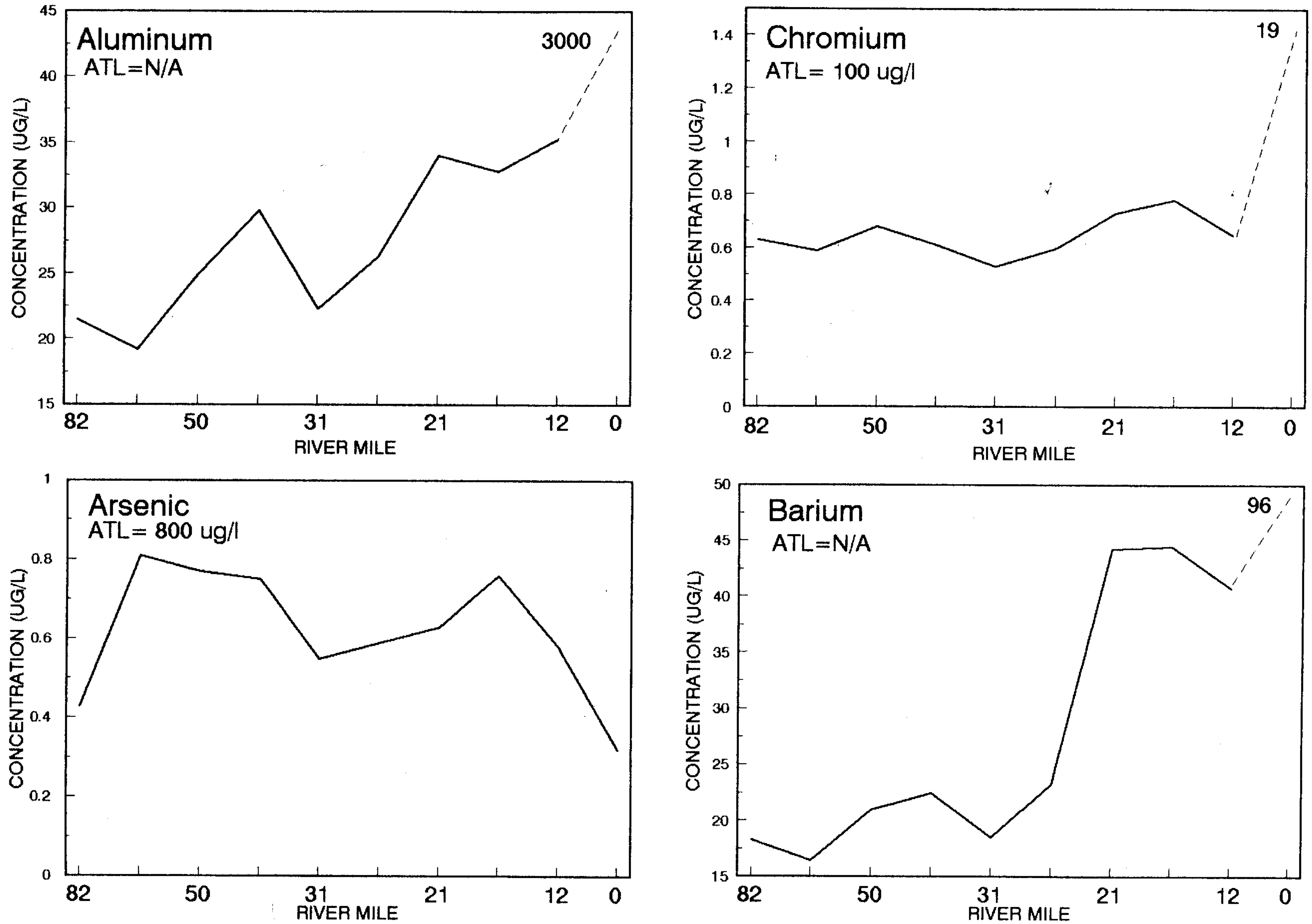

Figure 3. Seasonal mean concentrations (ug/L) of aluminum, chromium, arsenic, and barium sampled at the ten stations within the Kenai River, 1989-1990.

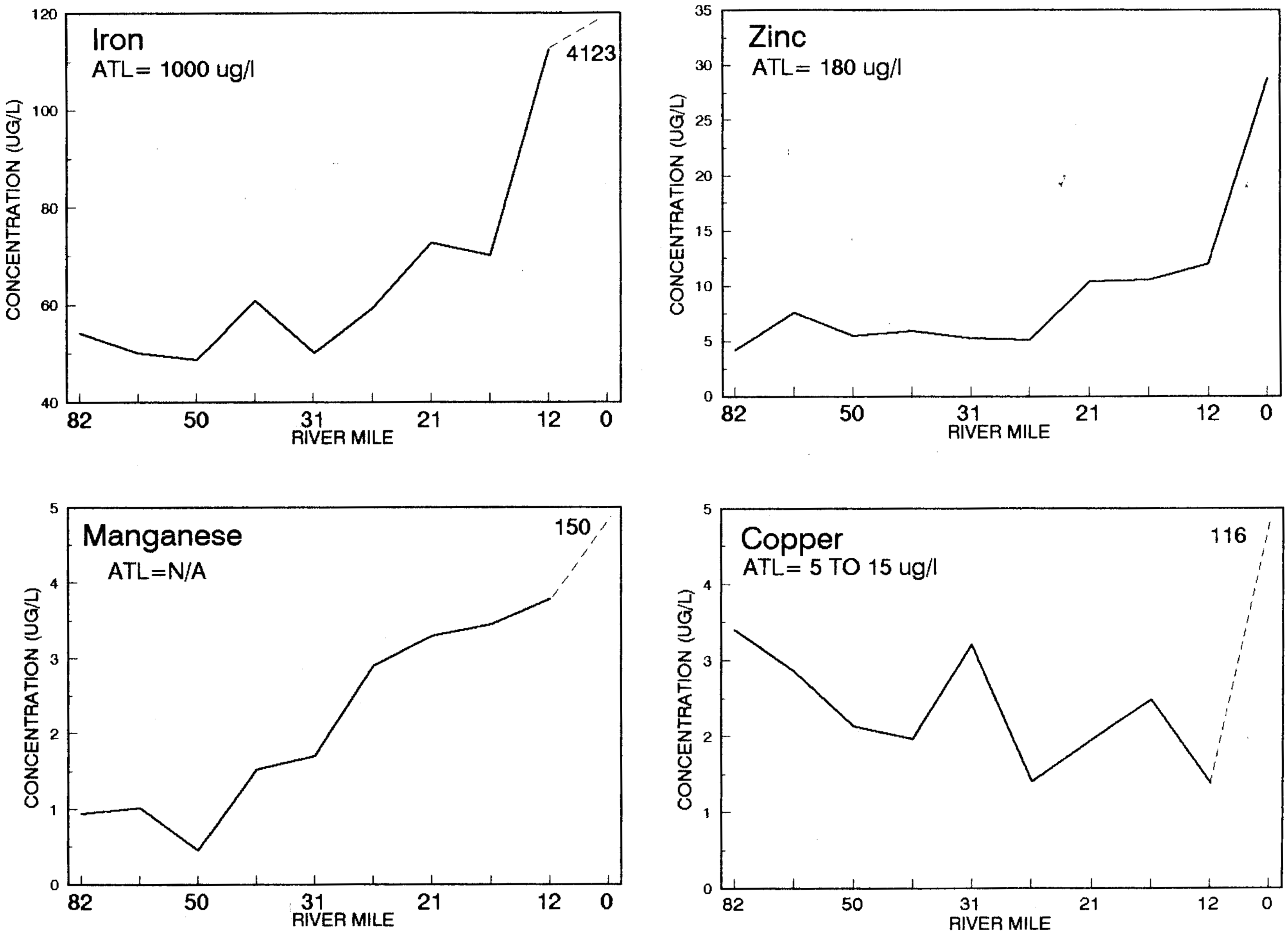

Figure 4. Seasonal mean concentrations (ug/L) of iron, zinc, maganese, and copper sampled at the ten stations within the Kenai River, 1989-1990.

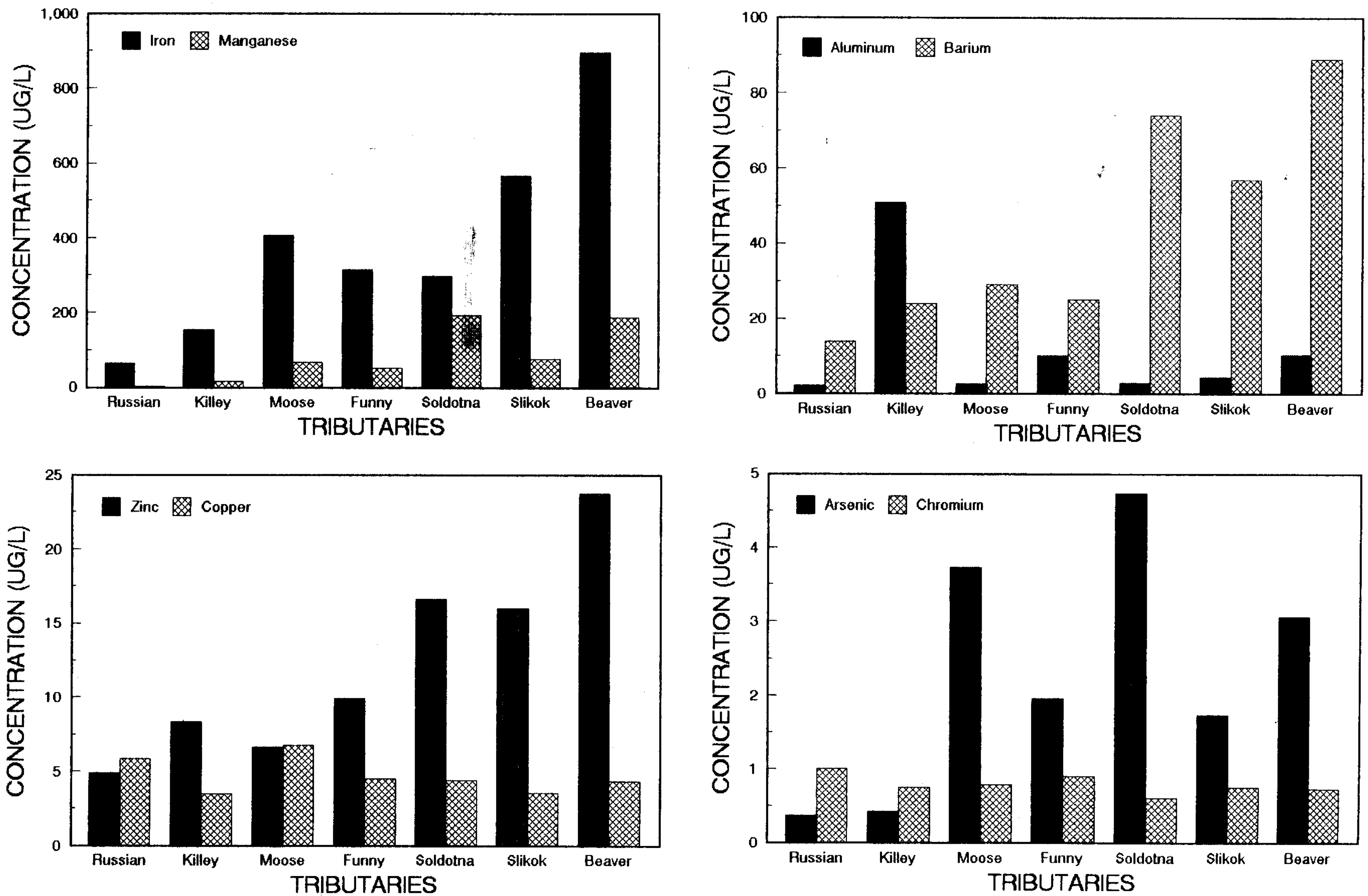

Figure 5. Seasonal mean concentrations (ug/L) of eight metals sampled within seven tributaries of the Kenai River, 1989-90.

In contrast to the TPH analysis, 22 of the 58 samples tested for volatile organics analysis (VOA) exhibited values higher than detection limits (Table 6). The EPA outlines toxicity levels for various water uses and aquatic life including acute and chronic sensitivities in Quality Criteria for Water (EPA 1986). One of the most toxic compounds is benzene, which has an acute toxicity at a concentration of 5,300 μg/L for freshwater aquatic organisms. The highest concentration for benzene found in the Kenai River samples was 1.7 μg/L. In addition, the highest concentration of all nine hydrocarbon compounds listed in Table 6 was trichlorofluoromethane (23 μg/L). This compound is a freon which is nonflammable, has no acute toxicity to aquatic life, and is commonly found in cleaning solvents.

Although none of the hydrocarbon compounds exceeded known toxicity levels, any amount in the sample is noteworthy due to the fact that levels can be much higher closer to the source of contamination. In addition, components of gasoline (e.g., toluene, benzene, total xylenes) were highest in the lower river (RM 12-18) during June and July, and possibly reflects the increased boat traffic that occurs at this time, as during other sample times these compounds were either not detected or were at lower concentrations.

Coliform Bacteria-- When investigating the quality of a body of water it is important to determine the degree of pollution resulting from organic wastes. The determination of indicator organisms as opposed to direct pathogen analysis is a generally accepted technique for characterizing water quality. The coliform group is defined as "gram-negative aerobic to facultative anaerobic, non-spore forming, rod-shaped bacteria that ferments lactose at 35°C in 24-48 hours" (APHA 1985). Coliform bacteria are easily isolated and cultured in a controlled environment, thus lending further ease to monitoring potentially harmful organisms. In most cases, water that is free of total coliform (TC) is free of all disease-producing bacteria. Fecal coliform (FC) are found predominately in the feces and gut of warm-blooded animals and can be used to determine the source of contamination (e.g. animal, man, or other environmental sources). Fecal streptococcus (FS) can further differentiate

Table 6. Summary of hydrocarbon compunds found in concentrations (ug/L) at or above detection limits for samples collected from the mainstem and tributaries of the Kenai River in 1990.

	River Mile/Tributary/Month										
Compound (ug/L)	RM 82 Jun	RM 31 May	RM 18 Jun	RM 18 Jul	RM 18 Sep	RM 12 Jun	RM 12 Jul	RM 10 Sep	T-3 Sep	T-4 May	T-7 Sep
2-Butanone		5.9			1.0				2.3		
Trichloro-fluoromethane		23.0						0.5/b		1.3	0.8/b
Toluene	1.1	1.5	2.1	0.5/a		3.1	3.2	0.4	0.2		
Acetone			4.7								4.1
Benzene	0.4/a		0.8/a	0.5/a		1.2	1.7		0.2/a		
Ethylbenzene			0.3/a			0.5/a	0.6				
Total Xylenes	0.8/a		1.4/a	0.2/a		2.2	2.3		1.1		
Chloroform	0.9/a										
Chlorobenzene				0.2/b							

/a indicates an estimated value below the statistical average detection limit.
/b indicates an estimated value bur with low spectral match parameters.

the source from either human or animal due to its host-specific qualities. Furthermore, the ratio of FC/FS can be used to determine the source of pollution based on the findings that this ratio for livestock is lower than for human sources (APHA 1985).

Total coliform counts in all the river stations ranged from 0 to 733/100 ml, with the highest counts found predominately in the lower river (RM 0-18). For example, over the season TC averaged 8/100 ml for all stations above the Soldotna bridge (RM 21-82) and averaged 180/100 ml below the bridge (RM 0-18) (Figure 6A). Seasonal average TC counts in the tributaries ranged from 28 to 294/100 ml, with the highest counts found in Beaver Creek and Moose River (Figure 6B). In the mainstem of the Kenai River, FC counts ranged from 0 to 12/100 ml and averaged 2/100 ml over the season above the Soldotna bridge, compared to a range of 8 to 82/100 ml and an average of 29/100 ml below the Soldotna bridge. In the tributaries, FC ranged from 1 to 94/100 ml, with the highest seasonal averages detected in the Killey River, Beaver Creek, and Soldotna Creek. In the upper river (above the Soldotna bridge), FS ranged from 0 to 9/100 ml and averaged 3/100 ml, while in the lower river FS ranged from 0 to 71/100 ml and averaged 13/100 ml. In the tributaries, FS ranged from 0 to 153/100 ml with the highest counts found in the Funny River, Slikok Creek, and Soldotna Creek.

Counts for the three coliform bacteria groups at the upper and lower stations of the Kenai River by month (1990) are presented in Figure 7. It is apparent that the timing of peak counts of TC were substantially different between the upper and lower river stations, as well as for the lower river stations. That is, peak TC counts in the upper stations occurred in October, while at RM 18 TC peaked in August, at RM 12 in July, and at RM 0 in September. Since the lower sampling stations are fairly close to each other, this could suggest localized sources of TC.

Although coliform bacteria counts are an indicator of water quality, Alaska regulation (ADEC 1991) does not contain maximum contamination levels (counts/100 ml) for

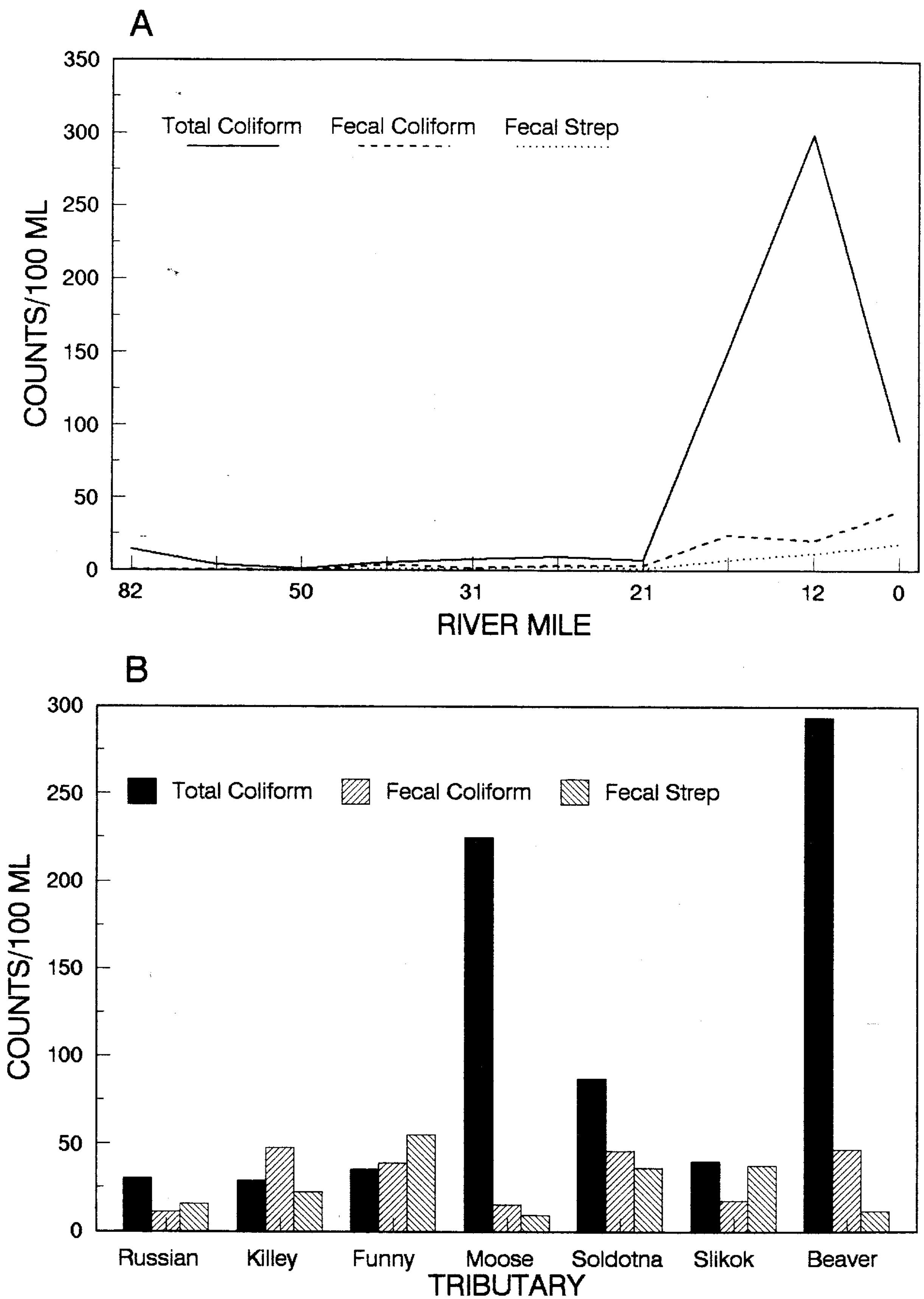

Figure 6. Seasonal mean counts/100 ml of total coliform, fecal coliform, and fecal streptococcus sampled from the ten mainstem stations (A) and seven tributaries (B) of the Kenai River, 1990.

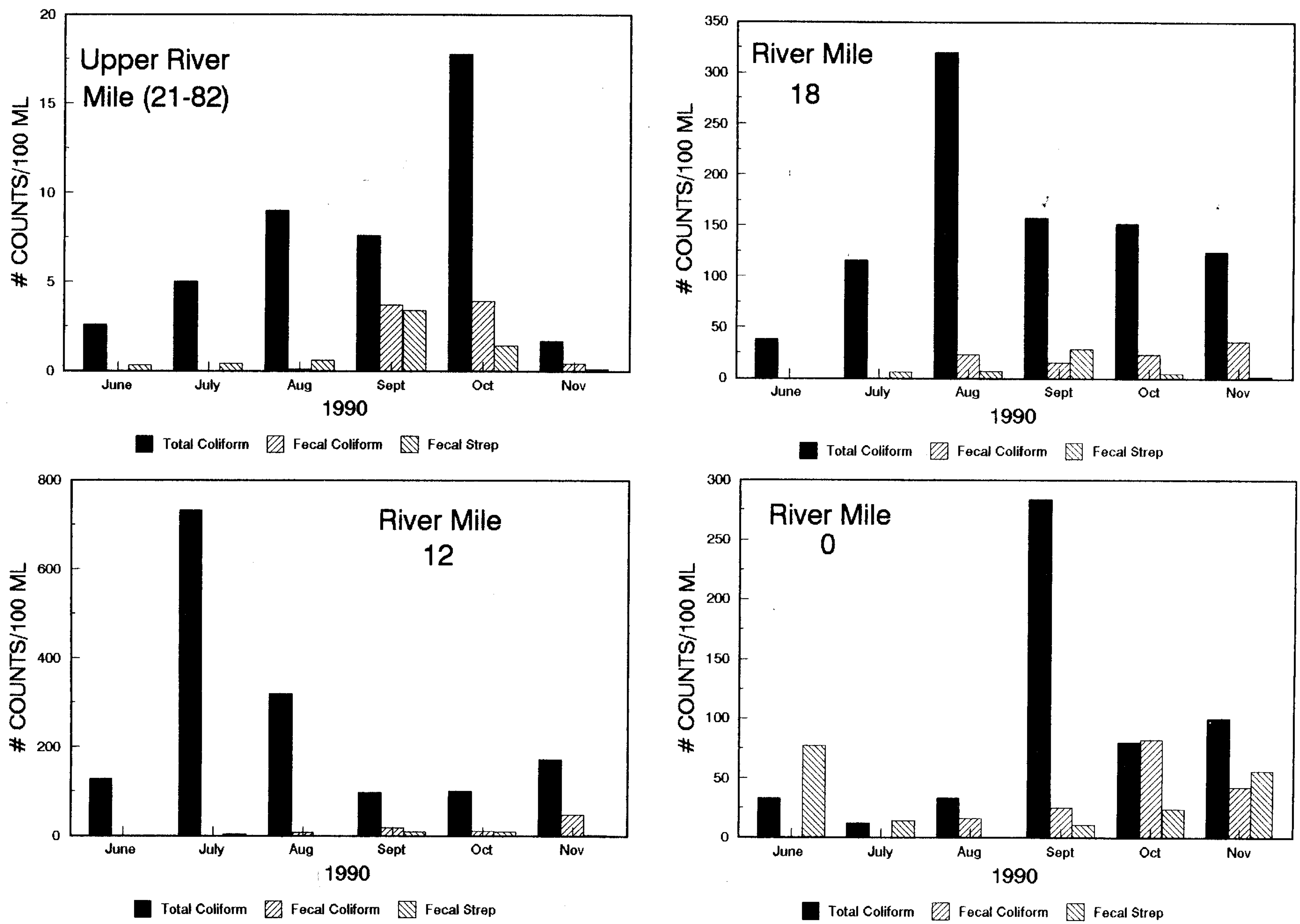

Figure 7. Counts/100 ml of total coliform, fecal coliform, and fecal streptococcus by month for upper stations (RM 21-82) and lower stations (RM 0-18) within the Kenai River, 1990.

any bacteria group in regards to growth and propagation of fish, shellfish, other aquatic life, or wildlife. However, there is FC criteria for secondary water recreation use, which require that the mean of 5 samples taken in a 30-day period shall not exceed 200/100 ml, and no more than 10% of the total samples shall exceed 400/100 ml (ADEC 1991). Thus, the highest FC count (94/100 ml; Killey River) found within the Kenai River watershed was well within the limits of secondary recreation usage.

Finally, analysis of FC conducted by the city of Kenai (Bears 1990) for six in-river samples taken near River Mile 0 averaged 40/100 ml, compared to our results of 41/100 ml. Thus, both results were very close and confirm quality assurance of analytical techniques. Although sources of contamination can potentially be determined by examining FC to FS ratios, the levels found in the Kenai River were too low for statistical analysis.

Macroinvertebrates-- Similar to bacteria, benthic populations can be used to gauge water quality since tolerances of macroinvertebrates differ as organic pollution increases (Hilsenoff 1988) (Table 7). It is important to note that although a benthic organism may have a high tolerance to pollution, it can be found in water of pristine quality. Consequently, the absence of sensitive organisms is a better indication of water degradation. For example, although lower river sites have higher concentrations of the more tolerant family Chironomidae (tolerance = 6), the presence of the stonefly family Leutridae (tolerance = 0) throughout the Kenai River indicates that water quality is acceptable for an organism with a very low tolerance to degradation of aquatic habitat.

There were substantial differences in the number of organisms collected in May compared to November of 1990. Densities were usually <100/m^2 during the November sampling and presumably were a result of the high flows during October which redistributed and deposited silt on the streambed. At the majority of the sites sampled in November, cobble and gravel embeddness was estimated at 70% or greater. Invertebrates are sensitive to large amounts of silt or sand as it prevents

Table 7. Tolerances of macroinvertebrate families to changes in water quality based on a scale of 0-10 with 0 indicating least tolerant and 10 most tolerant, adopted from Hilsenoff (1988).

Scale	Plecoptera (Stoneflies)	Ephemeroptera (Mayflies)	Trichoptera (Caddisflies)	Diptera (True flies)
0	Leuctridae Pteronarcyidae		Glossosomatidae Rhyacophilidae	
1	Chloroperlidae Perlidae Capniidae	Ephemerellidae	Brachycentridae	
2	Nemouridae Perlodidae Taeniopterygidae			
3				Tipulidae
4		Baetidae Heptageniidae	Limnephilidae	
5				
6				Chironomidae Simuliidae Empididae Ceratopogonidae
7				
8				Oligochaeta (not Diptera)
9				
10				Psychodidae

access to the undersurface of stones. The following are results of macroinvertebrate sampling by station. A summary of the number of benthic families, number of EPT genera, the EPT/total ratio, and the Baetids/EPT ratio by station is presented in Table 8.

Kenai Lake (RM 82)-- No organisms were found at this station in May and consequently it was not re-sampled in November.

Jim's Landing (RM 70)-- Overall this station displayed the highest water quality as reflected by the biotic invertebrate community. The EPT/total ratio was the highest of all the stations sampled (0.71 in May and 0.87 in November) and the Baetids/EPT was the lowest (0.02 in May and 0.01 in November). Three genera of stoneflies were found and overall the number of EPT genera was five or greater.

Bing Brown's Landing (RM 40)-- Extremely low densities of invertebrates were found at this station in both May and November, probably as a result of the embeddness of the substrate and the slow flow. However, three genera of stoneflies were collected (including families with tolerance ratings of 0 and 1), indicating that physical habitat characteristics were probably limiting densities rather than water quality.

Morgan's Landing (RM 31)-- Densities were relatively low and the EPT/total ratio in May was only 0.06. In addition, densities were too low to calculate Baetids/total EPT ratios. From the physical data, this station in May appeared to have favorable sized substrate with embeddness less than 30 percent. One genera of stonefly in the family Leutridae (tolerance rating = 0) was found at this station in May.

Swiftwater Landing (RM 23)-- In May, the EPT/total ratio was 0.19 but five EPT genera were found including three genera of stoneflies. Of the EPT genera, the ratio of Baetids was relatively low. The low EPT/total ratio was due to the relatively large number of chironomids found, which may be indicative of some form of organic enrichment. Densities in November were too low to calculate EPT or Baetids ratios.

Table 8. Summary of the number of insect families, number of EPT genera, the EPT/total ratio, and the Baetids/EPT ratio for the Kenai River mainstem and tributary stations sampled for macroinvertebrates in 1990.

Station	Number of insect families	Number of EPT genera	EPT/total ratio	Baetids/EPT ratio
		SPRING 1990		
R-1	0	0		
R-2	6	5	0.71	0.02
R-4	6	4		
R-5	3	2	0.06	
R-6	7	5	0.19	0.23
R-7	6	4	0.14	0.30
R-8	10	7	0.10	0.39
R-10	0	0		
T-4	6	2	0.36	
T-5	7	4	0.11	0.54
T-7	2	1	0.13	1.00
		FALL 1990		
R-2	8	6	0.87	0.01
R-4	4	2		
R-5	6	5		
R-6	3	1		
R-8	2	0		
T-5	9	5	0.38	
T-7	8	4	0.38	0.43

Poacher's Cove (RM 18)-- This site in May displayed the largest diversity of invertebrate fauna including seven EPT genera. The EPT genera included four stonefly species, notably members of the families Leutridae and Pteronarcyidae which have a tolerance rating of 0 on the Hilsenoff (1988) biotic scores. The low EPT/total ratio of 0.10 in May was due to the high density of chironomids (>2,500/m^2). This again could suggest some form of organic enrichment at this station. In November, invertebrate densities were very low (14/m^2), due to the lack of a suitable sampling station.

Soldotna Bridge (RM 21)-- In May, six insect families and four EPT genera were collected at this station, and the EPT/total ratio was low due to the high densities of chironomids and oligochaetes.

Kenai River Mouth (RM 0)-- No organisms were collected at this station in May, probably as a result of the predominantly sandy substrate.

Funny River (T-4)-- Although six insect families were collected in May, only two were EPT genera, including one genera of stonefly. Densities were relatively low (122/m^2).

Soldotna Creek (T-5)-- Samples at this station contained the largest number of caddisflies of all the stations sampled. This group was poorly represented at most of the other stations. Diversity of insect families was high both in May and in November. In May, relatively large numbers of Simulidae (blackflies) were present. This group comprises filter feeders and when found in significant numbers usually indicates the presence of fine particulate organic matter. Significant numbers of oligochaetes were also found. The Baetids/EPT ratio was relatively high indicating dominance of the mayflies.

Beaver Creek (T-7)-- Only mayflies and chironomids were found in May at this station, and thus, the Baetid/EPT ratio equalled 1.00. However, in November the macroinvertebrate densities were quite high despite the high flows of October. The EPT/total ratio in November was 0.38 which was the second highest recorded after Jim's Landing. Relatively large numbers of Simulids were also found.

Finally, benthic invertebrates were collected both in the spring and fall, but densities were not sufficient in the fall samples to draw conclusions. This may be due in part to the inability to sample appropriate habitat in the fall. Based on the limited information available, there appeared to be a decrease in the EPT/total ratio downstream from RM 70, due to the dominance of chironomids at many of the stations. Although this indicates decreasing water quality or increasing organic enrichment, it is important to note that the mere presence of low tolerant species reflects high water quality. Overall, the invertebrate densities may be more a factor of poor habitat rather than a gauge of water quality, although the increase of chironomids could indicate some type of organic enrichment. In addition, species diversity was less in the tributaries than in the mainstem, and along with the higher counts of coliform bacteria in the lower river and tributaries, indicate a higher amount of organic material.

CONCLUSION

Initial investigations of water quality within the Kenai River and seven major tributaries indicate that this drainage is not suffering any major impacts from existing development or use. General water-quality parameters and nutrients from samples collected in the mainstem and tributaries were found within normal levels relative to other Alaska waters. Both metal and hydrocarbon concentrations were detected in the lower section of the Kenai River but not found in concentrations above EPA standards. In addition, coliform bacteria concentrations were higher in the lower river but also were well within EPA standards. Finally, benthic invertebrate populations differed between the upper and lower sections of the river, suggesting either some type of impact or less preferred habitat. However, representatives from the least tolerant benthic species were found throughout the Kenai River, indicating acceptable water quality for these organisms.

Although measured water-quality parameters were within compliance with state and federal standards, impacts of development and use were evident. As the Alaska Water Quality Assessment (ADEC 1990) lists the Kenai River as a suspected water body for pollution from recreation, septic tanks, sewage treatment plants, and urban runoff; recognition of the potential for water-quality degradation already exists. This two-year project assesses the current state of water quality in the Kenai River drainage to serve as a baseline to determine potential impacts of development and use in the future.

RECOMMENDATIONS

1. Continue collecting water-quality data for another year. Two years of data will provide better representation (duplication) of analyzed parameters.

2. Intensify sampling in the lower river where concentrations of water-quality parameters (e.g. metals, hydrocarbons, coliform bacteria) were the highest.

3. Proceed with further detailed analysis of collected data such as correlating habitat type with the occurrence of macroinvertebrates, and integrating other physical parameters with biological data.

ACKNOWLEDGEMENTS

The authors thank Bob Winkleman (USF&WS) and Laurie Kempf (ADF&G) for assisting in collection of data, and the Alaska Department of Natural Resources (ADNR) staff for providing a vehicle, boat, and boat operator. Also, Dennis Randa participated in sampling and provided a drift boat during times that ice prevented the use of a motorized boat. The authors are grateful to the Kenai River Advisory Board for recognizing the need for establishing a baseline for water quality on the Kenai River. Finally, Trout Unlimited Inc. provided funding for the initial project proposal, and the ADNR provided funding for the project.

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APPENDICES

APPENDIX I

Sample of data sheet for metal analysis.

Elemental Research Inc.
309-267 West Esplanade
North Vancouver, B.C.
V7M 1A5, Canada

July 27, 1990

ICP-MS Analysis

Sample station: Kenai Lake Bridge (filtered sample)

Total Element Concentrations in micrograms per litre (ug/L)

ELEMENT	MASS	CONC	ELEMENT	MASS	CONC
Lithium	7	< 1.2	Beryllium	9	< 0.08
Boron	10	6.0	Magnesium	25	760
Aluminum	27	36	Silicon	28	1600
Phosphorus	31	< 3.6	Potassium	39	750
Calcium	44	11000	Scandium	45	1.9
Titanium	47	1.1	Vanadium	51	< 0.02
Chromium	52	< 0.31	Manganese	55	0.97
Iron	56	63	Cobalt	59	0.11
Nickel	60	< 0.31	Copper	63	4.8
Zinc	66	4.8	Gallium	71	0.25
Germanium	74	< 0.08	Arsenic	75	< 0.02
Bromine	79	< 0.49	Selenium	82	< 0.31
Rubidium	85	1.1	Strontium	88	71
Yttrium	89	0.02	Zirconium	90	0.04
Niobium	93	< 0.03	Molybdenum	98	0.42
Ruthenium	101	< 0.05	Rhodium	103	< 0.02
Silver	107	< 0.04	Palladium	108	< 0.04
Cadmium	111	< 0.09	Indium	115	int.std
Tin	120	< 0.08	Antimony	121	0.23
Tellurium	126	< 0.17	Iodine	127	1.5
Caesium	133	< 0.03	Barium	138	16
Lanthanum	139	< 0.04	Cerium	140	< 0.02
Praseodymium	141	< 0.04	Neodymium	146	< 0.06
Samarium	149	< 0.07	Europium	151	< 0.03
Gadolinium	157	< 0.04	Terbium	159	< 0.02
Dysprosium	163	< 0.03	Holmium	165	< 0.02
Erbium	166	< 0.02	Thulium	169	< 0.02
Ytterbium	172	< 0.05	Lutetium	175	< 0.02
Hafnium	178	< 0.03	Tantalum	181	< 0.02
Tungsten	184	< 0.07	Rhenium	185	< 0.04
Osmium	190	< 0.02	Iridium	191	< 0.02
Platinum	194	< 0.03	Gold	197	< 0.02
Mercury	200	< 0.16	Thallium	205	0.05
Lead	208	< 0.10	Bismuth	209	< 0.03
Thorium	232	< 0.02	Uranium	238	0.03

(<) denotes element detection limit.

ANALYTICAL RESOURCES INCORPORATED

Analytical Chemists & Consultants

333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-6490
(206) 621-7523 (FAX)

ORGANICS ANALYSIS DATA SHEET - METHOD 624/524 **Sample: T-4**

Lab ID: 7001 N
Matrix: Waters

QC Report No: 7001 - Alaska Dept. of Fish & Game
Project No: IHP-90-034
Kenai River

Data Release Authorized: [signature] Date Received: 09/13/90

Report prepared 10/15/90 - MAC:C C.G.

Amount Analyzed: 10.0 mls
Instrument: FINN III Conc/Dil: 1 to 1
Date Analyzed: 09/17/90 pH: NA

CAS Number		µg/L
74-87-3	Chloromethane	0.2 UJ
74-83-9	Bromomethane	0.2 UJ
75-01-4	Vinyl Chloride	0.2 UJ
75-00-3	Chloroethane	0.2 UJ
75-09-2	**Methylene Chloride**	**0.2 JB**
67-64-1	**Acetone**	**0.6 B**
75-15-0	Carbon Disulfide	0.2 UJ
75-35-4	1,1-Dichloroethene	0.2 UJ
75-34-3	1,1-Dichloroethane	0.2 UJ
156-60-5	Trans-1,2-Dichloroethene	0.2 UJ
156-59-2	Cis-1,2-Dichloroethene	0.2 UJ
67-66-3	Chloroform	0.2 UJ
107-06-2	1,2-Dichloroethane	0.2 UJ
78-93-3	2-Butanone	1.0 UJ
71-55-6	1,1,1-Trichloroethane	0.2 UJ
56-23-5	Carbon Tetrachloride	0.2 UJ
108-05-4	Vinyl Acetate	0.2 UJ
75-27-4	Bromodichloromethane	0.2 UJ
75-69-4	Trichlorofluoromethane	0.2 UJ

CAS Number		µg/L
78-87-5	1,2-Dichloropropane	0.2 UJ
10061-02-6	Trans-1,3-Dichloropropene	0.2 UJ
79-01-6	Trichloroethene	0.2 UJ
124-48-1	Dibromochloromethane	0.2 UJ
79-00-5	1,1,2-Trichloroethane	0.2 UJ
71-43-2	Benzene	0.2 UJ
10061-01-5	cis-1,3-Dichloropropene	0.2 UJ
110-75-8	2-Chloroethylvinylether	0.5 UJ
75-25-2	Bromoform	0.5 UJ
108-10-1	4-Methyl-2-Pentanone	0.2 UJ
591-78-6	2-Hexanone	0.2 UJ
127-18-4	Tetrachloroethene	0.2 UJ
79-34-5	1,1,2,2-Tetrachloroethane	0.2 UJ
108-88-3	Toluene	0.2 UJ
108-90-7	Chlorobenzene	0.2 UJ
100-41-4	Ethylbenzene	0.2 UJ
100-42-5	Styrene	0.2 UJ
1330-20-7	Total Xylenes	0.2 UJ
1,1,2-Trichloro-1,2,2-trifluoroethane		0.2 UJ

Surrogate Recoveries

d8-Toluene	97.1%
Bromofluorobenzene	90.9%
d4-1,2-Dichloroethane	109%

Data Reporting Qualifiers

Value — If the result is a value greater than or equal to the detection limit, report the value.

U — Indicates compound was analyzed for but not detected at the given detection limit.

J — Indicates an estimated value when result is less than specified detection limit.

B — This flag is used when the analyte is found in the blank as well as a sample. Indicates possible/probable blank contamination.

K — This flag is used when quantitated value falls above the limit of the calibration curve and dilution should be run.

M — Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

APPENDIX III

Page No. 1
11/27/90

MAINSTEM KENAI RIVER STATIONS

WATER QUALITY SUMMARY
General Tests and Metals

DATE	STA (RM)	DEPTH (M)	Sp. Cond. (umhos/cm)	Ph (Units)	Alkalinity (mg/l)	Turbidity (NTU)	Color (Pt)	Calcium (mg/l)	Magnesium (mg/l)	Iron (ug/l)
12/20/89	0	1	37	7.9	108.0	200.0	3	863.0	584.0	9658
05/02/90	0	1	35000	7.9	90.0	13.0	3	384.8	962.8	967
06/06/90	0	1	348	7.5	26.5	110.0	4	9.5	6.1	5862
07/11/90	0	1	203	7.6	25.0	40.0	3	9.3	3.4	2923
08/08/90	0	1	220	7.4	24.0	38.0	4	10.7	4.2	2668
09/12/90	0	1	9760	7.6	41.0	10.0	3	96.0	281.8	1098
10/05/90	0	1	20100	8.2	66.5	140.0	4	47.7	166.0	14077
11/07/90	0	1	12700	7.7	51.0	260.0	4	120.0	353.6	18514
11/01/89	12	1	65	7.5	28.0	8.8	5	9.7	0.3	554
05/02/90	12	1	68	7.7	26.0	6.8	5	9.6	0.7	501
06/06/90	12	1	60	7.6	23.5	8.8	5	8.5	0.8	589
07/11/90	12	1	61	7.5	25.0	6.4	3	9.3	1.0	572
08/08/90	12	1	63	7.3	23.0	3.0	3	9.7	0.7	307
09/12/90	12	1	60	7.3	29.5	12.0	4	9.6	0.9	861
10/03/90	12	1	63	7.3	23.5	10.0	5	11.1	<0.2	637
11/07/90	12	1	64	7.2	23.0	7.6	5	10.0	0.6	494
11/01/89	18	1	65	7.3	26.5	4.0	5	10.2	<0.2	183
12/13/89	18	1	68	7.4	30.0	16.0	5	9.7	1.3	1100
05/02/90	18	1	70	7.7	26.0	6.8	5	9.6	0.7	608
06/06/90	18	1	60	7.6	23.0	9.2	5	8.5	<0.2	594
07/11/90	18	1	62	7.6	24.0	5.8	5	9.3	0.3	536
08/08/90	18	1	62	7.4	23.0	2.4	4	9.7	0.7	256
09/12/90	18	1	61	7.3	24.5	14.0	4	9.6	0.9	1074
10/03/90	18	1	62	7.3	23.0	10.0	8	9.7	0.6	626
11/07/90	18	1	63	7.1	22.0	9.2	4	10.0	0.6	578
11/01/89	21	1	64	7.5	27.0	9.6	9	9.2	0.3	670
12/13/89	21	1	67	7.5	29.5	16.0	8	9.7	1.3	964
05/02/90	21	1	69	7.6	25.0	6.2	10	9.6	0.7	570
06/06/90	21	1	60	7.6	23.0	9.6	6	10.5	<0.2	652
07/11/90	21	1	61	7.6	24.0	6.4	5	9.3	1.0	556
08/08/90	21	1	61	7.4	22.0	2.8	5	9.7	0.7	279
09/12/90	21	1	60	7.2	23.0	14.0	3	9.6	0.9	1118
10/03/90	21	1	61	7.4	23.0	9.6	6	9.3	0.6	651
11/07/90	21	1	62	7.1	23.0	8.8	4	10.0	0.6	592
11/01/89	23	1	63	7.5	27.0	8.4	6	9.7	0.3	519
12/13/89	23	1	67	7.5	30.0	16.0	9	9.7	1.3	630
04/30/90	23	1	66	7.6	24.0	7.2	10	8.7	1.5	601
06/06/90	23	1	59	7.5	23.0	9.2	5	8.5	0.8	756
07/11/90	23	1	61	7.5	24.0	5.4	3	9.3	1.0	452
08/08/90	23	1	62	7.6	24.0	3.0	3	9.7	0.7	266
09/12/90	23	1	59	7.3	23.0	14.0	3	9.6	0.9	1134
10/03/90	23	1	61	7.4	23.5	9.4	5	9.7	0.6	557
11/07/90	23	1	62	7.1	23.0	12.0	9	10.0	0.6	762
11/06/89	31	1	61	7.4	26.5	8.2	5	9.2	1.3	619
12/11/89	31	1	71	7.5	35.0	12.0	6	10.4	0.6	806
05/01/90	31	1	37	7.6	26.0	7.0	9	8.7	1.5	596
06/06/90	31	1	58	7.5	23.0	8.6	5	8.5	0.8	724
07/09/90	31	1	60	7.4	24.0	7.8	6	8.8	<0.2	555

MAINSTEM KENAI RIVER STATIONS

WATER QUALITY SUMMARY
General Tests and Metals

DATE	STA (RM)	DEPTH (M)	Sp. Cond. (umhos/cm)	Ph (Units)	Alkalinity (mg/l)	Turbidity (NTU)	Color (Pt)	Calcium (mg/l)	Magnesium (mg/l)	Iron (ug/l)
09/10/90	31	1	58	7.2	21.0	16.0	3	9.2	0.8	647
10/01/90	31	1	60	7.3	23.0	12.0	4	9.3	0.6	831
11/05/90	31	1	60	7.4	22.5	9.0	5	10.0	0.6	648
11/06/89	40	1	59	7.4	25.0	10.0	6	9.2	1.0	725
12/06/89	40	1	61	7.4	25.0	12.0	5	9.5	<0.2	499
04/30/90	40	1	61	7.6	22.0	8.0	5	8.7	0.8	578
06/04/90	40	1	50	7.5	22.0	8.2	4	9.1	<0.2	524
07/09/90	40	1	59	7.4	23.0	5.6	4	8.8	<0.2	390
08/06/90	40	1	60	7.4	23.0	3.2	5	9.7	1.4	275
09/10/90	40	1	57	7.2	21.0	18.0	3	10.1	<0.2	921
10/01/90	40	1	59	7.2	22.0	12.0	3	9.3	0.6	782
11/05/90	40	1	59	7.4	22.0	12.0	5	9.0	0.6	684
11/06/89	50	1	59	7.5	25.0	12.0	5	9.7	<0.2	745
12/06/89	50	1	60	7.5	24.5	14.0	4	9.5	0.3	855
05/02/90	50	1	329	7.7	36.0	6.8	5	9.6	0.8	422
06/04/90	50	1	53	7.6	26.5	5.8	4	9.1	<0.2	316
07/09/90	50	1	63	7.5	26.0	3.6	3	9.7	<0.2	188
08/06/90	50	1	62	7.4	23.0	2.0	4	10.0	0.6	121
09/10/90	50	1	61	7.2	23.0	7.2	4	11.1	0.8	186
10/01/90	50	1	59	7.2	22.0	12.0	4	9.3	0.6	767
11/05/90	50	1	58	7.3	24.0	12.0	6	10.0	0.6	658
11/06/89	70	1	73	7.5	30.0	5.8	6	11.4	0.3	460
12/11/89	70	1	75	7.6	30.0	8.8	5	11.9	0.6	612
04/04/90	70	1	81	7.5	30.0	3.6	4	9.9	0.3	203
04/30/90	70	1	30	7.6	26.0	5.0	10	11.5	0.8	363
06/04/90	70	1	58	7.4	27.5	6.6	8	9.9	<0.2	463
07/09/90	70	1	81	7.4	26.0	5.2	4	12.3	<0.2	294
08/06/90	70	1	69	7.4	24.5	3.8	4	12.0	0.6	266
09/10/90	70	1	66	7.1	23.0	9.6	3	11.1	0.8	420
10/01/90	70	1	68	7.2	24.0	9.2	4	10.7	0.6	641
11/05/90	70	1	67	7.4	25.0	12.0	4	11.0	0.6	474
11/06/89	82	1	68	7.4	27.0	12.0	8	11.4	<0.2	589
12/11/89	82	1	66	7.6	27.5	12.0	5	10.4	0.6	234
04/04/90	82	1	66	7.5	25.0	12.0	11	9.9	1.0	432
04/30/90	82	1	70	7.5	24.0	5.8	8	10.6	0.8	407
06/04/90	82	1	57	7.5	25.0	7.2	5	9.9	<0.2	390
07/09/90	82	1	70	7.4	26.0	5.4	3	14.1	<0.2	306
08/06/90	82	1	67	7.4	24.0	4.2	3	8.0	<0.2	269
09/10/90	82	1	63	7.1	20.0	12.0	4	10.1	0.8	314
10/01/90	82	1	66	7.1	23.0	14.0	5	10.7	1.0	824
11/05/90	82	1	66	7.3	24.0	12.0	4	11.0	1.3	571

MAINSTEM KENAI RIVER STATIONS

WATER QUALITY SUMMARY
Nutrients and Primary Production

DATE	STA	DEPTH (M)	TP (ug/l)	TFP (ug/l)	FRP (ug/l)	TKN (ug/l)	NH3+NH4 (ug/l)	NO3+NO2 (ug/l)	RSi (ug/l)	Carbon (ug/l)	TPP (ug/l)	Chl a (ug/l)	Phaeo a (ug/l)
12/20/89	0	1	805.1	38.1	37.0	594.8	20.6	138.1	NA	NA	NA	NA	NA
05/02/90	0	1	70.8	26.8	27.0	96.9	4.3	100.7	1204	NA	NA	NA	NA
06/06/90	0	1	210.1	8.1	7.9	280.4	6.0	111.9	1556	NA	NA	NA	NA
07/11/90	0	1	101.9	4.9	3.1	122.2	<1.1	158.7	1441	NA	NA	NA	NA
08/08/90	0	1	112.9	3.9	3.8	129.2	11.6	161.1	1466	NA	NA	NA	NA
09/12/90	0	1	NA	9.4	8.0	153.8	12.1	103.0	1591	NA	NA	NA	NA
10/05/90	0	1	86.9	19.4	14.1	401.9	16.9	124.8	1362	NA	NA	NA	NA
11/07/90	0	1	1438	15.0	14.5	547.9	11.6	178.0	539	NA	NA	NA	NA
11/01/89	12	1	10.4	5.9	6.1	39.5	19.8	136.1	1803	NA	NA	NA	NA
05/02/90	12	1	22.0	5.7	5.5	101.5	5.8	106.0	3046	NA	NA	NA	NA
06/06/90	12	1	29.5	3.4	3.5	83.9	18.4	110.9	942	NA	NA	NA	NA
07/11/90	12	1	19.6	2.4	1.1	59.4	<1.1	163.2	1630	NA	NA	NA	NA
08/08/90	12	1	10.5	1.9	1.9	43.6	10.9	163.0	1630	NA	NA	NA	NA
09/12/90	12	1	NA	8.7	7.9	137.0	13.0	174.2	1729	NA	NA	NA	NA
10/03/90	12	1	23.0	6.3	6.9	61.9	13.0	183.9	2064	NA	NA	NA	NA
11/07/90	12	1	21.2	3.9	3.6	70.3	11.4	189.7	427	NA	NA	NA	NA
11/01/89	18	1	18.7	6.3	6.1	36.5	7.4	129.3	1807	NA	NA	NA	NA
12/13/89	18	1	26.9	8.5	8.1	66.8	8.8	132.3	2200	NA	NA	NA	NA
05/02/90	18	1	27.8	7.2	6.7	116.9	4.5	114.8	3094	NA	NA	NA	NA
06/06/90	18	1	25.3	3.0	3.5	75.5	4.8	104.1	942	NA	NA	NA	NA
07/11/90	18	1	16.9	1.6	1.3	57.1	<1.1	159.2	1582	NA	NA	NA	NA
08/08/90	18	1	9.9	5.0	2.0	46.5	10.2	164.0	1626	NA	NA	NA	NA
09/12/90	18	1	NA	6.9	4.8	126.4	10.9	174.7	1650	NA	NA	NA	NA
10/03/90	18	1	22.6	3.4	4.2	66.1	13.0	185.8	2103	NA	NA	NA	NA
11/07/90	18	1	25.9	3.0	3.3	77.3	11.8	187.2	422	NA	NA	NA	NA
11/01/89	21	1	19.2	4.5	4.9	45.6	7.4	128.4	1760	NA	NA	NA	NA
12/13/89	21	1	25.4	5.4	5.5	57.0	9.8	132.8	2103	NA	NA	NA	NA
05/02/90	21	1	22.3	4.8	4.5	97.0	6.0	122.5	3476	NA	NA	NA	NA
06/06/90	21	1	28.5	2.8	3.6	80.8	4.3	109.9	942	NA	NA	NA	NA
07/11/90	21	1	15.8	2.4	1.3	56.3	<1.1	159.7	1703	NA	NA	NA	NA
08/08/90	21	1	10.3	4.7	1.8	58.4	10.0	164.5	1698	NA	NA	NA	NA
09/12/90	21	1	NA	5.0	3.7	122.2	10.7	173.2	1680	NA	NA	NA	NA
10/03/90	21	1	20.4	4.0	3.2	50.7	14.0	183.4	2013	NA	NA	NA	NA
11/07/90	21	1	20.8	2.0	2.7	73.1	17.8	186.3	450	NA	NA	NA	NA
11/01/89	23	1	19.4	4.9	4.7	53.2	7.9	121.1	1795	NA	NA	NA	NA
12/13/89	23	1	25.3	6.5	6.8	43.4	8.4	133.7	2127	NA	NA	NA	NA
04/30/90	23	1	23.1	5.1	4.5	119.2	4.3	126.4	2206	NA	NA	NA	NA
06/06/90	23	1	29.0	2.9	3.2	76.2	4.5	107.0	1335	NA	NA	NA	NA
07/11/90	23	1	19.9	2.0	1.2	78.7	<1.1	NA	1393	NA	NA	NA	NA
08/08/90	23	1	9.9	3.7	1.7	49.3	9.8	163.5	1448	NA	NA	NA	NA
09/12/90	23	1	33.3	4.3	2.8	111.7	10.4	168.9	1581	NA	NA	NA	NA
10/03/90	23	1	21.2	4.0	3.0	71.7	12.8	182.9	1980	NA	NA	NA	NA
11/07/90	23	1	17.1	3.6	2.9	59.1	17.3	187.8	1564	NA	NA	NA	NA
11/06/89	31	1	16.1	4.7	4.4	157.6	6.4	81.7	1774	NA	NA	NA	NA
12/11/89	31	1	21.8	7.2	6.8	40.3	8.9	125.0	2103	43	NA	NA	NA
05/01/90	31	1	22.9	5.0	4.5	136.0	5.0	129.4	2147	NA	NA	NA	NA
06/06/90	31	1	24.2	2.7	3.0	64.0	4.8	110.9	1280	NA	NA	NA	NA
07/09/90	31	1	17.5	1.9	1.3	59.4	<1.1	157.8	1459	NA	NA	NA	NA
08/06/90	31	1	11.1	5.4	1.7	53.5	9.8	164.5	1388	NA	NA	NA	NA

MAINSTEM KENAI RIVER STATIONS

WATER QUALITY SUMMARY
Nutrients and Primary Production

DATE	STA	DEPTH (M)	TP (ug/l)	TFP (ug/l)	FRP (ug/l)	TKN (ug/l)	NH3+NH4 (ug/l)	NO3+NO2 (ug/l)	RSi (ug/l)	Carbon (ug/l)	TPP (ug/l)	Chl a (ug/l)	Phaeo a (ug/l)
09/10/90	31	1	41.4	5.4	5.2	91.9	27.7	166.9	1491	NA	NA	NA	NA
10/01/90	31	1	21.9	5.0	3.6	71.7	12.1	190.2	1446	NA	NA	NA	NA
11/05/90	31	1	17.6	2.1	2.2	52.1	10.2	188.2	1364	NA	NA	NA	NA
11/06/89	40	1	20.4	3.4	3.8	152.3	6.2	135.2	1596	NA	NA	NA	NA
12/06/89	40	1	18.5	4.0	4.2	57.8	5.8	137.6	1590	NA	NA	NA	NA
04/30/90	40	1	19.5	3.1	3.2	78.6	5.5	150.7	1707	NA	NA	NA	NA
06/04/90	40	1	24.2	3.1	3.8	57.9	4.5	115.7	1363	NA	NA	NA	NA
07/09/90	40	1	16.6	1.9	1.0	79.3	<1.1	155.8	1471	NA	NA	NA	NA
08/06/90	40	1	10.7	7.9	1.7	41.5	11.2	164.5	1358	NA	NA	NA	NA
09/10/90	40	1	47.3	5.2	4.1	90.7	19.4	166.9	1437	NA	NA	NA	NA
10/01/90	40	1	21.4	3.9	2.5	66.8	10.2	190.6	1333	NA	NA	NA	NA
11/05/90	40	1	15.6	1.2	1.6	54.2	10.9	185.3	1341	NA	NA	NA	NA
11/06/89	50	1	18.2	3.6	3.6	259.8	5.8	135.7	1399	NA	NA	NA	NA
12/06/89	50	1	23.5	3.7	3.8	53.2	5.2	139.1	1379	NA	NA	NA	NA
05/02/90	50	1	11.7	3.2	3.0	52.5	4.5	141.0	1658	NA	NA	NA	NA
06/04/90	50	1	9.3	3.0	3.5	43.2	5.0	130.3	1308	NA	NA	NA	NA
07/09/90	50	1	9.6	1.6	1.0	66.2	<1.1	166.2	1683	NA	NA	NA	NA
08/06/90	50	1	5.8	5.7	1.5	39.4	9.3	174.7	1400	NA	NA	NA	NA
09/10/90	50	1	13.2	2.8	1.8	43.6	10.7	183.9	1396	NA	NA	NA	NA
10/01/90	50	1	20.1	2.5	1.7	50.0	11.7	192.1	1181	NA	NA	NA	NA
11/05/90	50	1	17.9	1.7	2.1	44.3	11.2	192.8	1236	NA	NA	NA	NA
11/06/89	70	1	14.1	4.1	3.9	246.9	7.4	174.5	1848	NA	NA	NA	NA
12/11/89	70	1	15.6	4.2	4.2	50.1	6.0	186.2	1729	124	NA	NA	NA
04/04/90	70	1	10.4	3.0	3.3	45.6	6.5	184.2	1755	NA	NA	NA	NA
04/30/90	70	1	13.5	3.3	3.4	87.0	5.8	399.0	1969	NA	NA	NA	NA
06/04/90	70	1	13.7	4.4	4.8	50.9	5.2	173.1	1610	NA	NA	NA	NA
07/09/90	70	1	10.8	1.6	1.4	78.5	1.7	184.5	1634	NA	NA	NA	NA
08/06/90	70	1	8.9	5.4	1.6	45.8	9.8	188.7	1532	NA	NA	NA	NA
09/10/90	70	1	20.8	4.2	3.4	65.4	15.7	182.4	1509	NA	NA	NA	NA
10/01/90	70	1	19.5	1.9	1.8	55.6	10.9	197.5	1406	NA	NA	NA	NA
11/05/90	70	1	16.5	1.2	2.1	45.0	12.1	194.1	1440	NA	NA	NA	NA
11/06/89	82	1	18.0	4.4	5.0	38.8	5.5	137.1	1645	NA	NA	NA	NA
12/11/89	82	1	19.6	3.5	3.8	94.8	4.5	143.0	1476	<24	NA	NA	NA
04/04/90	82	1	12.9	2.8	3.0	44.8	5.2	145.9	1612	NA	NA	NA	NA
04/30/90	82	1	12.6	3.7	3.3	47.9	5.2	167.8	1648	NA	NA	NA	NA
06/04/90	82	1	21.9	11.6	12.0	116.9	5.5	159.0	1569	NA	NA	NA	NA
07/09/90	82	1	10.2	1.4	1.2	52.5	<1.1	185.0	1610	NA	NA	NA	NA
08/06/90	82	1	9.0	8.2	1.1	55.5	9.3	180.5	1502	NA	NA	NA	NA
09/10/90	82	1	18.9	2.6	2.0	37.3	11.2	173.2	1509	NA	NA	NA	NA
10/01/90	82	1	22.2	2.0	1.5	56.3	12.1	182.9	1361	NA	NA	NA	NA
11/05/90	82	1	17.3	2.0	1.6	47.9	19.7	194.5	1470	NA	NA	NA	NA

KENAI RIVER TRIBUTARIES

WATER QUALITY SUMMARY
General Tests and Metals

DATE	STA	DEPTH (M)	Sp. Cond. (umhos/cm)	Ph (Units)	Alkalinity (mg/l)	Turbidity (NTU)	Color (Pt)	Calcium (mg/l)	Magnesium (mg/l)	Iron (ug/l)
04/04/90	1	1	99	7.7	49.0	1.0	5	17.5	1.8	31
04/30/90	1	1	83	7.6	29.0	1.2	6	12.4	0.8	59
07/09/90	1	1	82	7.7	34.0	0.5	5	9.3	1.0	120
09/10/90	1	1	97	7.5	39.0	0.7	4	16.8	<0.2	23
11/05/90	1	1	92	7.4	36.0	0.4	6	16.0	1.3	34
12/06/89	2	1	66	7.1	26.0	1.6	10	8.5	0.6	222
05/01/90	2	1	59	7.3	20.0	5.0	11	6.8	1.5	668
07/09/90	2	1	21	6.9	5.0	52.0	5	2.7	0.8	4706
09/10/90	2	1	27	6.6	7.0	78.0	10	2.6	0.8	434
11/05/90	2	1	71	6.9	25.5	2.4	9	9.0	2.0	639
11/13/89	3	1	149	6.8	92.0	1.6	30	22.8	4.1	713
04/30/90	3	1	98	7.6	46.0	4.2	35	14.3	2.3	952
07/09/90	3	1	158	8.2	88.0	5.2	39	24.5	2.2	781
09/10/90	3	1	169	7.5	87.0	2.0	28	25.3	4.1	319
11/05/90	3	1	165	7.1	84.0	2.0	23	24.0	5.0	504
11/13/89	4	1	97	6.9	52.0	3.2	19	11.6	4.1	823
05/01/90	4	1	45	7.4	20.0	8.8	26	4.9	2.3	1208
07/09/90	4	1	95	7.6	50.0	2.0	15	13.2	1.5	425
09/10/90	4	1	97	7.5	47.0	2.4	32	12.0	3.3	5179
11/05/90	4	1	108	7.4	53.5	1.8	14	13.0	4.2	574
11/13/89	5	1	144	6.9	76.0	2.2	28	11.6	4.7	895
05/01/90	5	1	83	7.4	32.0	4.0	22	9.6	3.0	736
07/11/90	5	1	177	7.9	94.0	2.2	29	22.7	4.9	426
09/12/90	5	1	169	7.7	69.0	1.4	21	17.2	5.8	458
11/07/90	5	1	155	7.3	72.0	2.2	15	18.0	6.4	588
11/13/89	6	1	140	7.2	74.0	1.8	22	15.3	4.7	1100
05/01/90	6	1	68	7.3	24.0	2.2	28	7.7	1.5	401
07/11/90	6	1	142	7.6	68.5	3.4	18	17.0	4.1	1138
09/12/90	6	1	110	7.3	48.0	3.8	27	13.4	4.2	1338
11/07/90	6	1	144	7.3	64.0	2.6	18	17.0	5.7	1812
11/13/89	7	1	110	7.2	56.0	16.0	17	14.4	4.1	3107
05/02/90	7	1	69	7.2	30.0	3.8	41	7.8	2.3	1846
07/11/90	7	1	147	7.6	76.0	8.4	24	17.0	4.9	1831
09/12/90	7	1	93	7.3	40.0	7.8	20	12.5	2.5	1704
11/07/90	7	1	148	7.2	71.0	12.0	22	17.0	5.7	2764

KENAI RIVER TRIBUTARIES

WATER QUALITY SUMMARY
Nutrients and Primary Production

DATE	STA	DEPTH (M)	TP (ug/l)	TFP (ug/l)	FRP (ug/l)	TKN (ug/l)	NH3+NH4 (ug/l)	NO3+NO2 (ug/l)	RSi (ug/l)	Carbon (ug/l)	TPP (ug/l)	Chl a (ug/l)	Phaeo a (ug/l)
04/04/90	1	1	7.5	4.2	4.6	57.1	4.8	413.5	2420	NA	NA	NA	NA
04/30/90	1	1	9.5	3.2	3.3	104.6	5.5	736.6	2396	NA	NA	NA	NA
07/09/90	1	1	8.0	2.7	1.0	88.5	1.4	278.6	1453	NA	NA	NA	NA
09/10/90	1	1	13.3	7.7	7.0	167.8	36.2	350.0	1641	NA	NA	NA	NA
11/05/90	1	1	6.0	0.9	2.0	76.6	11.7	614.1	2208	NA	NA	NA	NA
12/06/89	2	1	10.5	4.3	5.5	208.3	8.4	116.2	4477	NA	NA	NA	NA
05/01/90	2	1	22.2	5.0	5.7	111.5	5.5	277.5	935	NA	NA	NA	NA
07/09/90	2	1	112.7	4.2	1.5	70.1	1.4	20.6	1525	NA	NA	NA	NA
09/10/90	2	1	202.7	5.8	7.2	107.5	28.6	31.2	1868	NA	NA	NA	NA
11/05/90	2	1	16.2	2.3	3.4	80.1	11.6	144.6	1575	NA	NA	NA	NA
11/13/89	3	1	36.2	26.2	25.4	236.0	10.9	9.4	8453	224	NA	NA	NA
04/30/90	3	1	52.8	17.7	16.3	313.8	8.4	6.0	1422	NA	NA	NA	NA
07/09/90	3	1	52.5	18.4	13.0	282.4	<1.1	4.7	5716	NA	NA	NA	NA
09/10/90	3	1	24.1	14.8	11.6	251.5	32.9	<3.4	6324	NA	NA	NA	NA
11/05/90	3	1	39.0	19.7	18.2	245.9	11.2	58.4	2091	NA	NA	NA	NA
11/13/89	4	1	34.6	16.2	20.7	241.0	19.6	47.2	8921	435	NA	NA	NA
05/01/90	4	1	62.7	14.8	12.6	277.9	6.2	57.0	5309	NA	NA	NA	NA
07/09/90	4	1	27.8	18.9	14.5	115.3	<1.1	7.2	7432	NA	NA	NA	NA
09/10/90	4	1	52.6	28.9	23.7	282.9	37.6	17.2	8112	NA	NA	NA	NA
11/05/90	4	1	39.0	22.7	23.0	146.8	11.6	69.0	2301	NA	NA	NA	NA
11/13/89	5	1	76.2	49.9	49.6	202.0	22.4	24.4	12921	283	NA	NA	NA
05/01/90	5	1	77.1	43.5	41.3	248.7	14.6	13.2	6686	NA	NA	NA	NA
07/11/90	5	1	80.9	53.9	23.9	195.1	<1.1	16.1	9778	NA	NA	NA	NA
09/12/90	5	1	65.0	59.1	60.9	294.9	35.2	5.1	10754	NA	NA	NA	NA
11/07/90	5	1	68.7	37.3	38.8	227.5	12.6	50.6	1692	NA	NA	NA	NA
11/13/89	6	1	40.6	32.0	32.8	197.0	25.4	171.1	11036	250	NA	NA	NA
05/01/90	6	1	21.6	12.9	12.2	260.9	9.8	20.5	6592	NA	NA	NA	NA
07/11/90	6	1	38.3	17.0	10.8	219.6	2.7	174.6	9100	NA	NA	NA	NA
09/12/90	6	1	35.5	19.2	19.1	181.9	13.0	77.8	6997	NA	NA	NA	NA
11/07/90	6	1	42.0	25.8	27.6	214.2	16.8	289.5	1616	NA	NA	NA	NA
11/13/89	7	1	93.3	24.4	25.9	211.0	8.4	71.5	7590	192	NA	NA	NA
05/02/90	7	1	64.8	24.3	22.3	330.3	10.1	3.6	6777	NA	NA	NA	NA
07/11/90	7	1	62.5	26.0	19.5	182.0	<1.1	20.6	2299	NA	NA	NA	NA
09/12/90	7	1	62.8	21.3	21.4	275.3	21.5	75.3	6234	NA	NA	NA	NA
11/07/90	7	1	96.4	31.5	31.7	271.1	17.6	46.2	1552	NA	NA	NA	NA