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Geochemical Characterization of Surface Water and Streambed Sediment of the Blackfoot River, Montana, During Low Flow Conditions, August 16-20, 1998

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Open-File Report 00-003

2000

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U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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Table of Contents

Tables

Figures

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I. Abstract

The Blackfoot River (western Montana) and its major tributaries were sampled from the headwaters of the basin to near its confluence with the Clark Fork River over the course of 5 days, August 16-20, 1998. Discharge was measured, fine-grained (<63 μm) streambed sediment samples were collected, and the dissolved (<0.2 μm) phase of the surface water was sampled using ultraclean techniques. Results show that water and sediment collected from near the historic Upper Blackfoot Mining District contained the highest concentrations of trace metals in the basin, despite the onset of remediation efforts in 1993. Downstream trends for water and sediment were similar, in that a rapid decline in metal concentrations occurred below the old mining district. Many solute trace metals were at their highest several kms downstream from the mining district, where the river flows through a marsh system that has collected mine wastes in the past. Solute metal concentrations were elevated as much as 20 km downstream from the headwaters. Elevated (above the average of tributaries) streambed sediment concentrations of Al, Ba, Be, Cd, Mn, Ni, and Si extended up to 30 km downstream from the headwaters, and elevated As, Co, Cu, Fe, Pb, V, and Zn in sediments extended almost 100 km downstream of the mining district. Comparison of sediment samples with those collected in August, 1989 and August, 1995 do not show evidence of basin-scale long term changes. The area of the proposed McDonald Gold Project near the confluence of the Landers Fork with the Blackfoot River was not contributing anomalously high dissolved metal loads into the basin.

II. Introduction:

One of the current research priorities of the Mineral Resources Program of the United States Geological Survey (USGS) is to evaluate geochemical baselines in watersheds where mineral deposits erode naturally or are exposed by mining and mineral processing. Because the Blackfoot River contains both historic and proposed mines, it was chosen as a case study for the USGS's investigations on geochemical baselines. The purposes of this study are: 1) to bring the McDonald Gold project area into the geochemical context of the Blackfoot River watershed, and 2) to examine the longitudinal dispersion of mining-related contaminants into the Blackfoot from the historical mining area in the headwaters. Previous Blackfoot River basin-wide scale geochemical investigations include those by Moore et al. (1991) and Menges (1997).

The Blackfoot River in west central Montana is a major tributary of the Clark Fork River, which in turn flows into the Columbia River (Figure 1). The Blackfoot drains 6000 kilometer^2 and flows westward for 215 km through glacially-shaped stairstep valleys with gradients ranging from 0.5 to 60 m/km (Moore et al., 1991). The river is a Class I trout stream and is classified by Montana's water quality standards as B-1, indicating it can support all beneficial uses such as drinking water, recreation, and fisheries (MDHES, 1994).

Historical mining in the headwaters (from 1865 to 1953) has been linked to water and bed sediment contamination and declines in benthic organisms and trout populations for as much as tens of kilometers from the source in the upper basin (Moore et al., 1991, Menges, 1997). The collection of mines that form the Upper Blackfoot Mining Complex have been undergoing voluntary remediation since 1993 by ASARCO, Inc. and the Atlantic Richfield Company (ARCO), the current and previous owners of the properties, respectively. Current mining interests in the watershed are focussed on the McDonald Meadows, near the confluence of the Landers Fork and the Blackfoot River. An earlier U.S. Geological Survey open-file report (Nagorski et al., 1998) examined the solute geochemistry of the Landers Fork and Blackfoot River in the vicinity of the proposed gold mine.

III. Methods

1. Sampling design:

Fourteen sites along the Blackfoot River (BFR) and fourteen tributaries were sampled over the course of five days, August 16-20, 1998. During this time, weather conditions varied from sunny to partly cloudy, and no precipitation was noted with the exception of 0.25 cm on 8/16/98 and 0.5 cm on 8/20/98 in Bonner/Missoula (river km 0); and a trace amount (<0.25 cm) in Ovando (approx. river km 85) on 8/20/98 (WRCDC, 1999.) Sampling began at the headwaters and progressed downstream, with the exception that two near-headwater sites (Meadow Creek and BFR-above Meadow Creek) were sampled on the fifth day. Also on the final sampling day, a site near the headwaters, (BFR below Meadow Creek) was resampled to check for any changes in river chemistry compared to Day 1. Considering that the average measured water velocity was 0.5 m/sec, the estimated travel time downstream from the headwaters to the confluence (215 km) with the Clark Fork River was 5.2 days. As a result, we roughly followed a parcel of water as it traveled down the basin.

Sites along the Blackfoot River were selected so that the mainstem was sampled above and below the major tributaries. Several of the small headwater tributaries were not sampled. These include Mike Horse Creek, Anaconda Creek, and Beartrap Creek (which together form the headwaters of the Blackfoot River), Shave Gulch, Paymaster Gulch, and Swamp Gulch, many of which have been impacted by mining. Other tributaries not included in this study were omitted because they were estimated to have relatively small contributions to the mainstem. The selected tributaries were sampled as close to their confluence to the Blackfoot as possible; generally, this was within one kilometer of the confluence. Most of the sites were restricted to fishing accesses and near road crossings (bridges). However, at some of the upper basin sites, where the channels were completely wadable, sites were accessed by foot. This was the case for Meadow Creek, BFR above Meadow Creek, Landers Fork, and Nevada Creek.

At each site, pH, dissolved oxygen, temperature, and conductivity were measured in situ. An Orion model 230A meter with a Ross electrode was used for pH measurement; an Orion model 820 meter was used for dissolved oxygen measurements; a Hach Conductivity/TDS meter was used for conductivity measurements; and a Barnant 100 Thermocouple

Thermometer Model No. 600-2820 (JKT) was used for measuring temperature. The pH and dissolved oxygen meters were calibrated at the beginning of each sampling day, and their calibration status was checked and corrected if necessary before taking measurements at each site (Table 1).

2. *Streamflow:*

Discharge measurements were made using either a Pygmy or Price AA current meter, depending on the approximate average depth of the channel (<0.5 or >0.5 meters, respectively), and an Aqua Calc 5000 calculator (Rickly Hydrological Co.) following the manufacturer's instructions. A bridge crane was used for measuring streamflow at two sites where the channel was too deep to wade (BFR-below Monture (river km 74.4) and BFR-Whitaker (river km 30.3)), but all other sites allowed the use of the wading rod. Two active USGS gauging stations in the basin are at the Northfork and at BFR-Bonner (at river km 12.7). The Northfork was gauged by this project's researchers, and the resulting discharge measurement compared well with the streamflow reported by the real-time USGS gauge data (6.23 ± 0.08 cubic meters per second (m^3/s) vs. 6.40 ± 0.31 m^3/s, respectively) (USGS, 1999). Gauge data for the BFR-Bonner site reported by the stations was then used for BFR-Marco Flats (at river km 6.0) site without measuring streamflow.

To measure streamflow, a transect was set up at each site with a measuring tape strung across the channel. The wading rod (or bridge crane) was walked along the tape markings, and depth and velocity measurements were made at intervals of 0.1 to 1.4 m, depending on the width and morphology of the river. Sections in which depth and velocity appeared to be more variable were measured at tighter intervals than sections which appeared fairly uniform. The number of stations measured per transect varied from 6 to 45 stations (mean=17); the width of channels measured for this project ranged from 1 to 46 m, and the deepest water measured was 4 m. Although a minimum of 10 stations per transect is recommended by Rantz et al. (1982), such a scale was not possible nor practical for streams which were only 1-2 m in width. The current meter was set at 60% of the depth of the station, and velocity measurements were integrated over 40 seconds. If the depth of the station was greater than 1 m, two velocity measurements were taken; one at 20% and one at 80% of the river depth.

Precision was determined by measuring some sites multiple times for discharge. When a replicate measurement was made, a new transect several feet away from the original one was followed to reduce bias in the measurement. Accuracy was tested by gauging a station maintained by the USGS for real-time flow data (at the Northfork), as discussed above. At sites where discharge was 0.28 m^3/s or less, the largest precision error found was 0.003 m^3/s. At sites with discharge between 0.28-1.84 m^3/s, reproducibility was within 0.11 m^3/s. At the Northfork site, where mean streamflow was 6.23 m^3/s, the duplicate measurements were different by 0.17 m^3/s.

Error bars on the discharge measurements were assigned so that the site-specific replicate measurements represent the variability. For sites where discharge was measured only once, error bars represent the largest variability found within the appropriate discharge bracket, as described above. Hence, sites with <0.28 m^3/s were given an error of ± 0.003 m^3/s ; sites with 0.28-1.84 m^3/s were given an error of $\pm$ 0.11 m^3/s, and sites with >1.84 m^3/s cfs were assigned an error of $\pm$ 0.17 m^3/s.

3. *Water:*

Depth-integrated water samples were collected along single transects at each sampling site. Single water samples were collected at twelve of the sites, four samples were collected at thirteen of the sites, and ten were collected at three sites. Samples were taken after streamflow was measured in order to best approximate equal discharge areas of the stream from which to sample. The purpose of collecting multiple samples per site was to define the spatial variability along the sampling transect. Four samples per site were deemed adequate for this estimation, based on previous studies in the basin (Nagorski et al., 1998). However, at three sites, ten samples were collected to test whether four samples could indeed capture the variability in differently-sized river sections. One of these sites was close to the headwaters (BFR below Meadow Creek); another was on a major tributary (Landers Fork); and the third was close to the bottom of the basin (BFR-Whitaker). Sites where only 1 sample was collected were generally chosen for their smaller size, and efforts were made to integrate across the transects as best as possible with the single sample bottle. The mean within-site variability found at the sites with multiple samples was used to estimate the mean within-site variability at the sites with single samples. Error bars on the data represent the percent relative standard deviation of the concentrations found at sites with multiple samples. Error bars at sites with single samples were derived from taking the average percent relative standard deviation at all sites with multiple samples.

Samples were collected using ultra-clean sampling techniques to minimize trace-metal contamination of water samples (Windom et al. 1991; Benoit, 1994; Taylor and Shiller, 1995). These measures include the exclusive use of materials that have undergone extensive acid-washing (2 hours in 6 N HCl and 24 hours in 1% (by volume) trace metal grade HNO_3, with a minimum of 3 rinses with Milli-Q deionized water before and after each acid treatment), double-bagging of sample bottles in sealed plastic bags, and sample filtration under a class 100 laminar flow hood. In the field, two people were required to obtain the water samples, and both wore clean latex gloves that were changed between each site. One person was designated as "dirty hands" and the other as "clean hands." The former handled the outside bag, whereas only the latter could open the inner bag and take the sample bottle. The clean hands person opened the sample bottle moments before sampling, emptied out the Milli-Q water which was stored in it, and rinsed the bottle and cap with ambient river water. The sample was then taken by filling the 1-liter LDPE Nalgene sample bottle to capacity and capping the bottle as it remained submerged in the water. Care was taken to always sample water upstream of where the sampler was standing and to sample upstream of bridges. The sample bottle was then returned to its double bags and stored on ice for transport to the laboratory. Field blanks were taken by emptying out the Milli-Q water from randomly-selected sample bottles at field sites, thereby exposing the bottles to the atmosphere. The field blank bottles were handled in the same care as were the sample bottles, with clean gloves and protected in double ziploc bags. Upon return to the laboratory, the bottles were filled with MilliQ water, and samples were filtered and acidified in the same manner as described for environmental samples.

Filtration under ultra-clean conditions in the University of Montana's Murdock Environmental Biogeochemistry Laboratory took place at the end of each sampling day so that all samples were filtered within about 12 hours of collection. Gelman Sciences Serum Acrodisc GF filters (each with a borosilicate glass fiber prefilter layer over a polyethersulfone membrane) were used. As discussed in Nagorski et al. [1998], no detectable changes in the dissolved (<0.2 μm) metal concentrations in the unfiltered samples is expected for this time period of about 12 hours. According to an experiment done by Nagorski et al. [1998] in which five replicate samples taken from the Blackfoot were stored on ice for 2, 12, 41, 65, and 160 hours before being filtered and preserved, only Fe and Mn concentrations changed after 65 hours-- a time much longer than the holding times used in this study. Sixty mL of sample was filtered into non-acid washed amber glass bottles for anion and carbon analysis. Another 125 mL was filtered into ultra-clean LDPE bottles for analysis by Inductively Coupled Argon Plasma Emission Spectrometry (ICAPES) for cations and Hydride Generator Atomic Absorption Spectrometry (HGAAS) for arsenic. Each of these samples was acidified with approximately 200 µL (to bring the pH to <2) of ultrapure, double distilled from quartz, Optima (Fisher Scientific) HCl. The sample bottles were stored in sealed plastic bags until analysis.

4. Sediment:

Streambed sediment samples were taken following collection of the water samples. At half of the sites, 4 samples were collected, and at the other half, 1 sample was collected. Error bars were determined the same way as described for water samples, in which the mean variability found at sites with multiple samples was applied to sites with single samples.

Sediment was sampled by scooping the top 1-2 centimeters of fine-grained bed sediment with a plastic spoon. Sediment availability varied among sites, and hence the area from which sediment was integrated per sample varied from approximately 30-100 meters of streambank length. Efforts were made to collect an equal amount of sample from each side of channel bank. The scooped sediment was sieved with ambient stream water through a 63µm nylon mesh screen set in a plastic funnel casing. The sieved sediment-water mixtures were collected in 250 mL acid washed polypropylene bottles and were stored on ice for transport to the laboratory. The sieving apparatus was thoroughly rinsed before and after each sample collection with ambient stream water.

Upon returning to the laboratory at the end of the field day, the samples were centrifuged at 2000 rpm for 15 minutes, the water was decanted, and the sediments were dried at 70 degree (Celcius) for one day. Each dried sample then was crushed to a fine powder in the sample bottle by pounding using an acid washed glass rod.

A microwave aqua-regia digest procedure was used to prepare the samples for analysis. This method entailed adding 0.5 ml of Milli-Q water, 1.25 ml trace metal grade HNO_3, and 3.75 ml trace metal grade HCl to 0.5 g of sediment sample, microwaving the mixture for 6 minutes on high power (ca. 570 watts), and adding Milli-Q water to bring the cooled solution to 50 grams. The digests were then centrifuged for 5 minutes at 2500 rpm and the clarified solutions were transferred to acid-washed polyethylene bottles for chemical analysis. The digests were analyzed using the ICAPES.

5. Laboratory analysis:

Trace element and major ion concentrations in the water and sediment digests were analyzed using a Thermo Jarrel-Ash ICAPES (IRIS). Ultrasonic nebulization (Cetac, U-5000AT+) according to EPA Method 200.15 (Martin et al., 1994) was used for determination of concentrations in water samples, although the addition of nitric acid and hydrogen peroxide to the samples was avoided to minimize the risk of sample contamination. Previous lab work found no analytical improvement as a result of the addition of the nitric acid, and hydrogen peroxide was unnecessary because arsenic was determined using HGAAS. Cyclone nebulization according to EPA Method 200.7 (EPA, 1991) was used for the sediment digests.

Anions were measured on a Dionex Ion Chromatograph (IC) within 48 hours of sample collection according to EPA Method 300.0 (Pfaff, 1993). Remaining sample in the amber bottles was acidified with reagent-grade HCl to pH<2 and was used for determination of organic carbon. Organic carbon was measured using a Shimadzu Carbon Analyzer according to Standard Method 505A (Franson, 1985) 46 days after sample collection. Alkalinity was measured by titration with sulfuric acid to pH 4.5 within 1 day of sample collection.

Total arsenic was measured using atomic absorption spectroscopy with hydride generation (HGAAS) following Standard Method 303A (Franson, 1985). However, the arsenic reduction method was modified to follow a method developed at the University of Montana Murdock Environmental Biogeochemical Laboratory (Mickey, written communication, 1997). This method calls for the addition of potassium iodide and HCl to all standards and samples to achieve final concentrations of 2% KI and 1 M HCl. The additions were made at least 2 hours prior to analysis to allow for complete reduction of oxidized arsenic species. Solutions of 0.35% sodium borohydride (stabilized with 0.5% NaOH) and 6N HCl, were run together with the samples through the hydride generator.

6. Quality assurance/ quality control:

All laboratory analysis took place under a strict quality control program. All instruments were calibrated at the start of each day's analysis, and calibration was checked and corrected if necessary at intervals of approximately every 10 samples analyzed. Precision was checked by running replicate samples and standards. Accuracy was determined through the use of external and internal standards, spikes, and blanks. The detection limits used, called the Practical Quantifiable Limits (PQL), were defined as the concentrations at which elements could be reproduced to within 30%.

For water samples, all of the mean percent differences between duplicate runs of samples on all instruments were less than 8.5 (Tables 2.1 and 2.3). Spike recoveries for all analytes measured above detection were between 92-115% (Tables 2.2 and 2.4). On the ICAPES, USGS standards T-143 and T-145 were run 12 and 7 times, respectively, during analysis of water samples. The mean measured concentrations of these standards fell within the reported acceptable range for all elements except for Ba in T-143 and T-145 and Sr in T-145, which were slightly low (Tables 3.1 and 3.2). USGS standards T-143 and T-113 were run on the HGAAS during arsenic analysis, and their measured values fell within the reported ranges (Table 4.1). On the Ion Chromatograph, the external standard "QC SPEX" was analyzed during sample analysis as well. With the exception of fluoride and nitrate, which were below detection in all of the samples, all levels were acceptable (Table 4.2). Accuracy was checked on the HGAAS, organic carbon analyzer, and the Ion Chromatograph by running in-house standards (fortified lab blanks), and the mean % differences between the standards and the measured concentrations of arsenic, organic carbon, and the anions were less than 10% (Table 4.3). Lab blanks were below the detection limits on all instruments (Tables 5.1 and 5.3). Field blanks were mostly below detection, with the exception that some Ca (0.02 mg/L), Mg (0.01 mg/L), and Na (0.23 mg/L) was detected in a few blanks (Table 5.2 and 5.4). These levels are likely from contamination from the filters themselves, and the levels are low enough to not interfere with concentrations in environmental samples.

During ICAPES analysis of the sediment digests, the mean percent difference between duplicate runs of samples was less than 10%, with the exception of B, whose mean percent difference was 26.6 (Table 6.1). Mean percent recoveries for spikes of all analytes were between 89-105% (Table 6.2). As with the water samples, USGS standards T-143 and T-145 were analyzed using ICAPES during sediment analysis. All elements fell within the reported range, with the exception of Ca in T-143, which was slightly high (Tables 7.1-7.2). Eight samples of Standard Reference Sample STSD-3 were digested and analyzed with the environmental samples (Table 7.3) (Lynch, 1990.) All lab blanks were below detection limits (Table 8.1), as were digest blanks, with the exception of trace amounts of Ca, Cr, Fe, Mg, Na, Si, and Ti (Table 8.2).

IV. Results and Discussion

The results of streamflow measurements, field-measured parameters (pH, D.O., conductivity, and temperature), and laboratory analyses of alkalinity, and anion, organic carbon, and cation concentrations are listed in Table 9. Table 10 contains the results of sediment sample analyses.

1. *Streamflow:*

Considering that the furthest downstream site in the basin had a discharge of 21.0 m^3/s, and that the summation of the mean discharge of all the tributaries measured was 15.7 m^3/s, the river as a whole was gaining from the ground water. Although not all tributaries were measured, those omitted (ca. 15 of them) were either dry during the sampling event or appeared to hold <5% of the flow of the mainstem near their inputs.

The tributary that had the greatest relative contribution to streamflow was the Landers Fork. This tributary contained twice as much streamflow as did the BFR 0.5 km upstream of the BFR-Landers Fork confluence. Alice Creek and the Northfork were the next largest contributors to the mainstem. Alice Creek's discharge matched that of the BFR 5.1 km upstream of its confluence. The Northfork's discharge was 84% of that of the BFR 21 km upstream of its confluence with it. All other tributaries contributed proportionally less to the mainstem BFR closest to their confluences.

Examination of differences in streamflow between the mainstem sites gives insight into where stretches of the river are gaining, losing, or have no net gain nor loss. Gaining (losing) reaches were designated as those where there was a gain (loss) in streamflow (accounting for the input of tributaries) between two sites after accounting for the maximum measurement error (see the Streamflow Methods section for explanation of the measurement error). Gaining reaches were found between river kms 209.8 and 203.3, where the river flows through a wetland area; between river kms 175.9 and 153.3, where the river enters a narrow canyon downstream from the town of Lincoln; between river kms 108.5 and 74.4, where the Northfork and Monture Creek basins join the Blackfoot; and between river kms 74.4 and 30.3, where the Blackfoot again flows through into a tighter canyon section. Losing stretches are found between river kms 186.6 and 175.9, upstream of the town of Lincoln but below the confluence with the Landers Fork; between 117.6 and 108.5, where the river enters the Nevada Valley, and between kms 30.3 and 6.0 at the lowest end of the basin measured. All other stretches of the river between the sampling sites did not have a quantifiable gain nor loss.

2. *Water:*

a. Mainstem

Dissolved (<0.2 µm) Al, Cd, Co, Cu, Mn, Ni, S, SO_4^{2-} and Zn exhibited a peak in the headwaters followed by a sharp decline (Figure 2). Several of these constituents (Al, Cd, Co, Cu, and Ni) fell below their detection limits by about 20 km from the headwaters and remained at undetectable levels for the duration of the basin. Al, Co, Cu, Mn, Ni, S, SO_4^{2-} and Zn were at their highest basin-wide levels at river km 210.0, and not at river km 212.5, which is closer to the old Mike Horse Mine. These elements were enriched in the headwaters over more typical basin samples by factor of 3-5 times, although Mn and Zn were enriched by 2-4 orders of magnitude (Figure 2). Conductivity, Fe, K, Li, Na, and Si were also higher at km 210.0 than at km 212.5, and pH was lower (7.3 compared to 7.7).

The relatively low concentrations of the solute metals in the highest headwater site (km 212.5), closest to the mine, might be due to the remediation efforts. However, the increase in concentrations a few kms downstream of the mines (km 210.0) are likely still due to the impacts from the mining. The sampling sites at river kms 210.0 and 209.8 and at Meadow Creek are in a marsh area, part of a system of three marshes that extend from river km 211.6 to 196.6. The marshes have collected metal wastes from the past mine operations, including those released during a tailings dam break in 1975 (Moore et al., 1991.) Studies by Moore et al. (1991) concluded that the marsh system did not act as a sink for all of the mine-related solute and sediment metals.

Other elements did not follow the pattern of declining downstream from a peak at the furthest upstream couple of sites. Iron did not exhibit a peak until river km 203.3 (BFR-above Alice Creek), where the BFR emerges from the the second of three marshes beneath the mining district (Figures 2m). Arsenic was below detection (<0.2 µg/L) at river km 212.5, but its concentration gradually increased to its peak of 2.3 µg/L at river km 108.5, below the confluence with Nevada Creek (Figure 2f). Ca concentrations almost doubled between the headwaters and river km 153

(Figure 2i). Mainstem Ba, K, Li, Mg, Na, Si, and Sr concentrations fluctuated little downstream, even though tributary concentrations of these elements varied far more widely (Figures 2h, 2n, 2o, 2p, 2r, 2u, and 2v).

Pearson's r correlations were calculated for discharge, conductivity, pH, and all dissolved constituents that were above detection (Table 11). The dataset was divided up into "near headwaters" (river km 212.5 to 193.2; n=5) and "downstream from headwaters" (river km 187.7 to 6.0; n=9). The separation was done primarily because many metals fall below the detection limit below the headwaters. Good (Pearson's r > 0.900 and p<0.01) positive correlations were found in the near headwaters area for SO_4^{2-} and conductivity, SO_4^{2-} and Mn, and conductivity and Mn. Good negative correlations were noted for: SO_4^{2-} and alkalinity, conductivity and alkalinity, conductivity and Ba, Ba and Mn, and Mg and discharge. For the sites below the headwaters, good positive correlations were calculated for conductivity and Ca, organic carbon and Na, As and K, As and Li, K and Li, K and Na, and Si and Sr. A good negative correlation was found for organic carbon and Ba.

All samples in the basin were below detection for dissolved nitrite (<0.05 mg/L), nitrate (<0.05 mg/L), phosphate (<0.05 mg/L), F (<0.05 mg/L), Cl (<2 mg/L), Ag (<1 μg/L), Be (<0.05 μg/L), Cr (<1 μg/L), Mo (<1 μg/L), Pb (<6 μg/L), and V (<2 μg/L).

b. Tributaries

Most tributaries were below detection for dissolved Al, Cd, Co, Cu, Mn, Ni, and Zn. Tributaries with exceptionally high concentrations (relative to the mainstem) of measured parameters include: Hogum Creek, with the highest Fe and Sr detected in all the samples; Nevada Creek, with the highest dissolved organic carbon, As, K, Li, Na, and Si of all basin-wide samples; Meadow Creek and Elk Creek, which were the only tributaries with detectable (>5 μg/L) Al; Union Creek, with the highest alkalinity and Mg in the basin samples; Elk Creek, with the highest Ca but the lowest Ba; and Meadow Creek, which recorded the highest tributary concentrations of Cd, Co, Cu, Mn, Ni, S, and Zn. The Landers Fork contained relatively low concentrations of sulfate, organic carbon, Na, and Si, and its Cd, Co, Cu, Fe, Mn, Ni, and Zn concentrations were all below detection. It was the only site in the basin with Mn at levels below detection (<0.3 μg/L) and was one of only three sites with Fe below detection (<5 μg/L).

c. Dissolved loads

Loads were calculated by multiplying the discharge at each site with the concentration of the parameter of interest (Table 12). The error associated with each load calculation was found using the formula:

Error = $(B^2 \Delta A^2 + A^2 \Delta B^2)^{1/2}$, (Wolfs, 1998)

where B= discharge;

ΔB = discharge error;

A=concentration of solute

ΔA= concentration error (%RSD of replicates)

Loads could not be quantified at sites where solute concentrations were below the specific element's PQL (Table 12). For example, Cd and Cu loads are calculated only to river km 203.3, and Zn is calculated as far downstream as river km 187.7.

Results indicate that solute loads generally increase with distance downstream and that loads are more heavily controlled by discharge than by solute concentrations (Table 12). For example, between river km 186.6 and 175.9, the river discharge decreased by approximately one-half and the As, Ba, Ca, K, Li, Mg, Na, S, Si, and Sr loads exhibited a correspondingly large decrease. Falling away from the typical pattern is Mn, which increases in load down to river km 209.8, but decreases between there and river km 175.9. Downstream of there, it again increases until river km 108.5, at which point its load drops futher downstream. Other exceptions are SO_4^{2-} and S, whose load decreases between river kms 203.3 and 193.2, even though discharge increases within that river section. Zn defies the patterns as well in that its load increases up to river km 209.8 but then decreases until river km 187.7, downstream of which it is no longer quantifiable.

d. Identifying reactive solutes:

Reactivity, i.e. the loss of solutes from the water column due to precipitation and/or adsorption, could be evaluated through examination of the load data. Theoretically, elemental loads will stay the same or increase downstream as long as a) streamflow is staying the same or increasing and b) the element is not dropping out of solution faster than it is being replaced. Where loads are increasing, it is not possible to determine (with this dataset) the degree of conservative vs. reactive behavior. However, it is possible to identify elements that are reactive to the extent that their loads decrease between two sites that are not losing streamflow. This evaluation was done at all of the mainstem reaches, with the exception of the three sites that exhibited a loss in streamflow (segments above river kms 175.9, 108.5, and 6.0). Results showed that SO_4^{2-}, Al, Cd, Cu, Mn, S, and Zn were reactive along some portions of the basin, but mostly in the headwaters area. Aluminum and Cu loads decreased at river km 203.3 compared to 209.8. Sulfate (and S) loads decreased between river km 203.3 and 193.2. Cadmium loads decreased along both aforementioned reaches. Manganese loads dropped along three reaches: between river km 203.3 and 193.2, between km 193.2 and 187.7, and between km 108.5 and 74.4. Zinc loads decreased along four consecutive mainstem sites near the headwaters, from river km 209.8 to 186.6.

At several mainstem sites, loads were examined for conservative vs. reactive behavior of solutes at tributary confluences. Five sites were identified as occurring downstream of tributaries and whose discharge were within the measurement error of the cumulative discharge of the nearsest upstream site (within 10 km) and a tributary. (Conservative vs. reactive behavior of solutes downstream of tributary inputs could be determined only if there were no discrepancies in flow between sites). These sites were at river km 210.0 (BFR-below Meadow Cr.), river km 193.2 (BFR-below Alice Cr. and Hardscrabble Cr.), river km 187.7 (BFR-below Hogum Cr.), river km 186.6 (BFR-below Landers Fork), and river km 108.5 (BFR-below Nevada Cr.). For each site, an expected load was calculated for each solute element. The expected load represented the load that would be expected below the tribuary input if the solute behaved conservatively. It was calculated by simply adding the load of the upstream mainstem site to the load of the tributary. The error was calculated using the formula:

Error of expected load = $(\Delta A^2 + \Delta B^2)^{1/2}$, (Wolfs, 1998)

where ΔA=Load error at the upstream mainstem site

ΔB =Load error at the tributary

The solute was considered conservative if its expected load below the tributary was no different from the measured load. The solute was considered to be reactive if the expected load was greater than the measured load.

The results of this analysis show that all detectable elements at all 5 sites were conservative at the tribuary confluences, with the following exceptions: Mn and SO_4^{2-} at river km 193.2 (BFR below Hardscrabble and Alice Creeks); Fe and Mn at river km. 187.7 (BFR below Hogum Creek); and Fe and Mn at river km 108.5 (BFR below Nevada Creek).

e. Evaluation of the tributary load contributions to the BFR:

As seen in Figure 3, there is generally a positive, approximately linear relationship between the solute loads of alkalinity, As, SO_4^{2-}, Ba, Ca, K, Li, Mg, Na, Si, and Sr carried by tributaries of the BFR and their size (expressed as discharge). Mn loads showed no clear pattern, indicating that its load contributions from tributaries could not be predicted from their sizes. Because no more than two tributaries contained above detection limit levels of Al, Cd, Co, Cr, Cu, Ni, and Zn, no conclusions could be made about the relationship between loads of those metals with tributary sizes.

Outliers in the data included Hogum Creek, with anomalously high loads of Fe; Clearwater River with anomalously low amounts of most solute loads, especially Fe; and Nevada Creek with highly anomalous large loads of As, SO_4^{2-}, K, Li, Mn, Na, Si, and Sr. The cause for Nevada Creek's anomalies is not possible to establish from this dataset, but possibilities include the tertiary volcanic rocks in the basin, which are essentially unique in the Blackfoot watershed to the Nevada Creek basin, and the presence of several abandoned mines in the Nevada Creek drainage basin.

Evaluation of the Landers Fork's contribution to the Blackfoot River was done to specifically examine whether the mineralized area near the confluence was contributing anomalously high amounts of dissolved constituents to the river. The plots in Figure 3 show that the Landers Fork was not contributing anomalously high loads of dissolved constituents, because it falls in line with most other tributaries. Because the amount by which it increases the trace metal load is not anomalously high for its size, a geochemical signal of the ore body in the area is not discernable in the solute phase.

3. Bed sediment

a. Mainstem

A rapid downstream decline in the mainstem concentrations is seen for Al, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, S, Si, V, and Zn (Figure 4). Bed sediment collected below the Mike Horse Mine (river km 212.5) contained the highest concentrations of As, Cd, Co, Cu, Fe, Mn, Ni, Pb, S, and Zn of all the mainstem and tributary samples. These elements were elevated over the rest of the basin by up to 3 orders of magnitude. The furthest downstream site in the basin, at river km 6.0, contained the lowest concentrations of Al, As, Co, Cr, Cu, Fe, K, Mn, Ni, Pb, and Zn in the mainstem.

Arsenic, Co, Cu, Fe, Pb, V, and Zn eached baseline concentrations (defined as the average concentration of all tributaries excluding Meadow Creek) at river km 117.6, almost 100 km downstream from the mines. Aluminum, Ba, Be, Cd, Mn, Ni, S, reached baseline concentrations by river km 186.6 (below input of he Landers Fork), about 30 km downstream of the headwaters.

Not all elements were at a maximum in the headwaters. In fact, the sample taken below the Mike Horse Mine contained the lowest concentrations of Be, Li, Na, P, Ti in the Blackfoot mainstem and the lowest Ba in all the basin samples. Barium, Ca, Cr, K, Li, Mg, Na, P, Sr, and Ti do not show clear downstream spatial trends below the mine (Figure 4.) Calcium and Mg are at their lowest (at no more than half their average concentrations) between river kms 210.0 and 186.6. Chromium, K, P, Sr, and Ti exhibit relatively little fluctuation; their maximum concentrations in the mainstem are no more than twice their minimum concentrations. Barium concentrations peak at river km 203.3; P peaks at river km 193.2, and Li peaks at river km 175.9. Sulfur exhibits a unique pattern of decreasing sharply below the headwaters, then increasing in the lower half of the basin, perhaps due to tribuary inputs, and then decreasing again at the lowest site (Figure 4u).

Downstream from the mine, the influence of tribuaries with atypical concentrations of some elements is seen on the mainstem. For example, Sr concentrations increase below the input of Hogum Creek (river km 187.7) and Nevada Creek (river km 108.5), which have anomalously high Sr levels. A 2 to 4-fold increase in Mg and Ca in the BFR mainstem occurs below the confluence with the Landers Fork (river km 186.6), which contained the highest Mg and Ca concentrations of the tribuaries sampled. The relatively low-metal concentration sediments from input of tributaries in the upper basin may explain the rapid downstream decline in metal concentrations in the upper basin, since Pass Creek, Alice Creek, and Hardscrabble Creek contain significantly lower concentrations of elements such as As, Cd, Cu, Fe, Mn, Ni, Pb, and Zn (Table 10).

Elemental concentrations in the sediments from the Landers Fork fell within the mean (±1 standard deviation) of concentrations in all other tributaries (excluding Meadow Creek), with the exception that it had significantly higher Ca and Mg and lower P and S concentrations. This result implies that a geochemical signal of the McDonald ore body was not found in the streambed sediments.

b. Tributaries

Meadow Creek, which joins the Blackfoot several kms downstream from the Mike Horse Mine in the marshy area, contained the highest Al, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, S, Si, and Zn of all tributaries sampled. (It is noted that Meadow Creek was sampled in the marshy area and only 10 m upstream of its confluence with the Blackfoot, and as a result, its high concentrations of solute and sediment metals may be due to influence of the contaminated marsh itself.) Monture Creek had the lowest concentrations of Al, As, Cr, Cu, Fe, K, Mg, Na, Ni, Si, Ti, V, and Zn of all the basin samples; no other site contained as many elements which were at minimum basin concentrations. The Hardscrabble Creek sample showed the highest Ba and the lowest Co and Li of the tribuaries. Hogum Creek contained the highest Be of the tributaries and the highest Cr, P, and Sr of all the basin samples. The Landers Fork had the lowest Ba and highest Mg concentrations of all the tribuaries and the highest Ca of all the basin-wide samples. The Landers Fork also contained the lowest S concentrations found in all of the mainstem and tributary samples. Arrastra Creek had the highest V and B (together with Elk Creek) and the lowest Mn of all the tributaries, and the highest Li concentrations of all the sites. The highest Na concentration was found in the Nevada Creek sample, and the sample from Elk Creek had the highest K of both mainstem and tributary samples. All samples in the basin were below detection for Mo, although BF-above Meadow Creek was at the detection limit of 2 ppm, and Gold Creek's sample contained 12 ppm. The Clearwater River and Gold Creek had the lowest Sr in the basin, and the Clearwater River, Monture Creek, and Elk Creek were the only sites with As concentrations below detection (<6.5 ppm). Elk Creek and Gold Creek were the only sites with Pb below detection (<6 ppm).

c. Comparisons with 1989 and 1995 bed sediment data

In August 1989, Moore et al. (1991) collected bed sediment samples at many of the same sites sampled in this study. In 1995, Menges (1997) revisited the sites for bed sediment collection, and she digested and analyzed both the 1989 and 1995 samples using the same method employed in this study. Hence, direct comparisons among the data sets can be made. However, it is noted that although Menges (1997) collected three samples per site, Moore et al. (1991) collected only one per site. Hence, the within-site variance is unknown for the 1989 dataset. For the plots constructed in this report, error bars were constructed for the 1989 data by assigning the variance found in the 1995 dataset for each element.

Generally, the downstream trends of metal concentrations are the same for each of the datasets (Figure 5). In all of them, there is a downstream rapid decline in such elements as Al, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn, which are typically at least one order of magnitude higher in the headwaters than in most of the mainstem. Although there are some site-specific changes, a systematic decline in metal concentrations through time is not apparent.

Examination of the site below the Mike Horse Mine (river km 212.5 in 1998 and river km 211.8 in 1989 and 1995) reveals some differences downstream from some of the remediation efforts (Figure 5). There appears to be a decrease in mean concentrations of Al, Cu, Na, and P over the three study years. However, although As, Cd, Co, Fe, K, Mn, Ni, Sr, Ti, and Zn also decreased in 1995 compared to 1989, their concentrations in 1998 were higher than in 1995. Furthermore, both Ca and Pb show marked increases over the three study years (10-fold increase in Ca and doubling of Pb in 1998 compared to 1989). The increase in Ca, the largest change evident from the datasets, may be explained by the use of lime in the remediation treatments.

Examination of the other end of the basin, at the furthest downstream site which was sampled in all three study years (river km 74.4; BFR-below Monture Creek), shows some of the largest changes in the lower basin (Figure 5). Mean Al, As, Ca, Co, Cu, Fe, K, Mg, Na, Ni, Pb, Sr, Ti, and Zn appear to have decreased over the three study periods at the site (mostly by about 10%, but 30% for As and Fe and 50% for Ca and Pb). Also, Mn and P showed little change between 1995 and 1998, but in both years concentrations were higher than in 1989. However, it is important to note that this site is situated immediately downstream of the confluence of Monture Creek and the BFR mainstem. Because of the short distance below the confluence (approximately 300 m), bed sediments are likely not fully mixed on both banks. It is unknown from the Moore et al. (1991) dataset whether the sole 1989 sediment sample came from one or both banks, while Menges (1997) collected all three of her samples from the bank on the side of Monture Creek's input, and the 4 samples collected for this project were split between the two banks. As a result, the apparent changes over time at this site are inconclusive at best. In addition, it should be considered that most of the other sites do not exhibit a similarly large decline in metal concentrations, and the headwaters sites do not show systematic declines in metal concentrations over the three study years.

V. Summary and Conclusions

Bed sediment and water quality analysis of samples taken from the Blackfoot River and its major tributaries show an overall downstream decline in trace metal concentrations from the general vicinity of the historic Upper Blackfoot Mining Complex. Solute contaminants extended for 10-20 km downstream of the mining complex, while elevated metal concentrations in sediments extended for up to 100 km below the headwaters. Comparison of the trends in water and sediment dispersion trains reveal that many solute peaks occured one or two sites further downstream from the headwaters than the sediment samples, which showed peak concentrations mostly at the futhest upstream site. This indicates that solute concentrations near the remediated mining district might have been transferred to the solid phase, but the marshes resupplied the dissolved phase with some trace metals.

Solute SO_4^{2-}, Al, Cd, Cu, Mn, and Zn were identified as behaving non-conservatively in portions of the headwaters area, and Fe and Mn were reactive at at least two tributary-mainstem confluences. Tributaries generally had a positive, linear relationship between solute load and amount of streamflow, although this relationship could not be established for many heavy metals due to their undetectable concentrations. Nevada Creek was an outlier, in that it carried anomalously high loads of many constituents. Meadow Creek generally had the highest solute and sediment concentrations of all tributaries, and it was sampled where it flowed through the contaminated marsh system. The Landers Fork had no anomalously high loads nor sediment concentrations despite its proximity to an unmined ore body. No basin-wide changes in sediment concentrations of metals were found compared to those collected in 1989 and 1995. Aluminum, As, Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn were still at least one order of magnitude higher in the headwaters than in most of the mainstem.

VI. Acknowledgements : Thanks to Jan Shifflett, Clara Wheeler, Dan Cole, Sarah Day, and Anna Breuninger for assistance with field work and with laboratory analysis of the samples.

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Table 1: pH meter and dissolved oxygen meter calibrations

Summary: pH meter calibration standard checks	7.00 standard	10.00 standard	pH meter calibration slopes	D.O. meter calibration slopes
Total number of standard checks	81	81	(n=15)	(n=5)
Mean reading	7.00	10.00	mean= 98.69	mean = 83.74
Std. Dev.	0.01	0.02	stdev = 2.11	stdev = 1.34
Min. reading	6.96	9.95		
Max. reading	7.04	10.05		

Table 2 : Duplicates and Spike Recoveries on instruments used for water analyses

Table 2.1

Summary: ICAPES replicate comparisons of water samples

Element	Number of replicates above PQL	Mean % difference of replicates	Std. dev. of mean of % difference of replicates
Ag	0	-	-
Al	3	5.3	2.8
Ba	10	5.3	5.1
Be	0	-	-
Ca	10	3.9	4.9
Cd	3	7.6	5.1
Co	3	5.1	1.8
Cr	0	-	-
Cu	3	4.4	3.7
Fe	6	3.9	3.6
K	10	6.4	4.4
Li	10	3.6	5.5
Mg	10	3.8	4.7
Mn	10	3.2	3.5
Mo	0	-	-
Na	10	7.6	5.3
Ni	3	8.5	6.2
Pb	0	-	-
S	10	4.6	4.6
Si	10	4.3	4.8
Sr	10	4.3	4.8
Ti	0	-	-
V	0	-	-
Zn	5	6.1	6.4

Table 2.2

Summary: ICAPES Spike (fortified sample) recoveries

Element	Unit	Spike values	Number of samples above PQL	Mean % recovery	Stand. dev. of mean percent recovery
Ag	µg/L	0	-	-	-
Al	µg/L	30	1	115	-
Ba	µg/L	200	11	92	3
Be	µg/L	0	-	-	-
Ca	mg/L	13	11	107	8
Cd	µg/L	0	-	-	-
Co	µg/L	0	-	-	-
Cr	µg/L	0	-	-	-
Cu	µg/L	3	2	102	4
Fe	µg/L	50	7	114	2
K	mg/L	1	11	97	3
Li	µg/L	5	11	96	2
Mg	mg/L	10	11	96	2
Mn	µg/L	0	-	-	-
Mo	µg/L	0	-	-	-
Na	mg/L	5	11	95	2
Ni	µg/L	0	-	-	-
Pb	µg/L	0	-	-	-
S	mg/L	2	11	107	7
Si	mg/L	10	11	106	4
Sr	µg/L	100	11	97	3
Ti	µg/L	0	-	-	-
V	µg/L	0	-	-	-
Zn	µg/L	10	2	99	3

Table 2.3

Summary: HGAAS, Carbon Analyzer, and IC Replicate Comparisons

Analyte	Number of replicate pairs above PQL	Mean % diff. of replicates	Std. dev. of mean of % difference of duplicate pairs
Arsenic	17	4.6	4.0
Alkalinity	11	5.1	4.4
Organic C	9	8.0	5.4
Sulfate	20	1.5	3.3

PQL= Practical Quantifiable Limit

Table 2.4

Summary: HGAAS, Carbon Analyzer, and IC Spike (fortified sample) recoveries

Analyte	Unit	Spike Value	Number of samples above PQL	Mean % recovery	Stand. dev. of mean percent recovery
Arsenic	µg/L	1.0	13	115	6.4
Organic C	mg/L	2	8	102	11
Sulfate	mg/L	3	20	101	4.2

Table 3: Summary of USGS standards measured on ICAPES during water sample analyses.

Table 3.1

Summary: USGS Standard T-143 measured on ICAPES (n=12)				
Element	Units	Reported Mean (Range)*	Measured Mean (Std. Dev.)	Measured mean within Reported Range?
Ag	µg/L	19.6 (2.8)	19.8 (0.8)	yes
Al	µg/L	22.1 (16.6)	21.2 (1.0)	yes
Ba	µg/L	81.9 (9)	72.1 (2.1)	no
Be	µg/L	8.5 (1.32)	7.8 (0.1)	yes
Ca	mg/L	53.7 (4.4)	52.48 (1.01)	yes
Cd	µg/L	19.1 (3)	17.1 (0.6)	yes
Co	µg/L	17 (2.4)	15.0 (0.34)	yes
Cr	µg/L	37 (5.2)	32.2 (1.0)	yes
Cu	µg/L	22.3 (3.8)	22.2 (0.4)	yes
Fe	µg/L	222 (28)	210 (4.1)	yes
K	mg/L	2.5 (0.42)	2.38 (0.09)	yes
Li	µg/L	18 (4.2)	16.70 (0.35)	yes
Mg	mg/L	10.4 (1)	9.93 (0.19)	yes
Mn	µg/L	18.2 (3.8)	16.5 (0.4)	yes
Mo	µg/L	36.1 (8.6)	34.0 (0.7)	yes
Na	mg/L	34 (3.2)	32.48 (0.87)	yes
Ni	µg/L	71 (10)	65.13 (1.15)	yes
Pb	µg/L	83.4 (14.2)	77 (2)	yes
S	mg/L	(Not reported)	-	-
Si	mg/L	10.94 (1.64)	11.87 (0.49)	yes
Sr	µg/L	306 (30)	276 (6)	yes
Ti	µg/L	(Not reported)	-	-
V	µg/L	30 (6)	27.12 (0.64)	yes
Zn	µg/L	20 (4.4)	17.8 (0.4)	yes

*Reported Range is 2 pseudosigmas from the mean

Table 3.2

Summary: USGS Standard T-145 measured on ICAPES (n=7)				
Element	Units	Reported Mean (Range)*	Measured Mean (Std. Dev.)	Measured mean within Reported Range?
Ag	µg/L	7.55 (1.84)	7.0 (0.6)	yes
Al	µg/L	67.6 (22)	58.5 (1.7)	yes
Ba	µg/L	37.1 (3.8)	32.76 (1.09)	no
Be	µg/L	9.04 (1.4)	8.22 (0.12)	yes
Ca	mg/L	30.7 (2.6)	28.09 (0.59)	yes
Cd	µg/L	9.33 (1.64)	8.7 (0.5)	yes
Co	µg/L	10 (1.8)	9.0 (0.3)	yes
Cr	µg/L	15.3 (2.8)	12.4 (0.5)	no
Cu	µg/L	11 (2.8)	10.8 (0.6)	yes
Fe	µg/L	101 (16)	95 (2)	yes
K	mg/L	2.13 (.32)	1.91 (0.08)	yes
Li	µg/L	27.3 (5)	23.6 (0.5)	yes
Mg	mg/L	8.68 (0.9)	7.95 (0.17)	yes
Mn	µg/L	20.9 (3)	18.8 (0.5)	yes
Mo	µg/L	9.23 (2.58)	8.18 (0.17)	yes
Na	mg/L	41.2 (3.8)	38.10 (1.33)	yes
Ni	µg/L	11 (2.6)	10.2 (0.1)	yes
Pb	µg/L	12.7 (2.4)	12 (1)	yes
S	mg/L	(Not reported)	-	-
Si	mg/L	5.28 (0.66)	5.66 (0.29)	yes
Sr	µg/L	203 (18)	179 (5)	no
Ti	µg/L	(Not reported)	-	-
V	µg/L	11.7 (3.4)	9.67 (0.26)	yes
Zn	µg/L	10 (4.8)	8.7 (0.9)	yes

*Reported Range is 2 pseudosigmas from the mean

Table 4 : External and Internal Standards Measurements on instruments used for water analyses

Table 4.1

Summary: External standards measured on HGAAS *Concentrations in µg/L.*			
Standard	Reported value (Range)*	leasured values (mean (std. dev.)	Measured values within Report. Range?
USGS T-143 (n=5)	15.2 (2.4)	15.5 (1.7)	yes
USGS T-113 (n=5)	23.8 (3.0)	25.1 (2.0)	yes

*Reported Range is 2 pseudosigmas from the mean

Note: USGS Standards T-143 and T-113 were diluted to 10% for analysis in order to fall within the calibration range of the AAS.

Table 4.2

Summary: External standard "QC SPEX" measured on IC *(Concentrations in mg/L)*			
Analyte	Reported Mean (Range)	Measured Mean (Stand. De	Measured Mean w/in Reported Range?
Fluoride (n=4)	3.0 (0.47)	3.3 (0.4)	no
Chloride (n=6)	30.0 (2.62)	28.8 (2.3)	yes
Nitrate-N (n=4)	5.0 (0.84)	5.2 (0.1)	no
Nitrite-N (n=4)	2.0 (0.21)	1.9 (0.1)	yes
Phosphate-P (n=4)	1.0 (0.29)	1.1 (0.1)	yes
Sulfate (n=6)	30.0 (5.27)	31.4 (1.3)	yes

*Reported Range is the 95% Confidence Interval

Table 4.3

Summary: Internal standards (fortified lab blanks) measured on HGAAS, Carbon Analyzer, and IC		
Standard	Mean % difference of fortified lab blank and measured concentration	Standard Deviation of mean % differences
Arsenic (n=93)	5.4	4.6
Organic C (n=41)	5.6	6.2
Fluoride (n=60)	6.5	11.3
Chloride (n=68)	4.0	6.4
Nitrate-N (n=60)	2.3	2.2
Nitrite-N (n=60)	1.1	1.2
Phosphate-P (n=59)	9.8	11
Sulfate (n=68)	2.4	2.3

Table 5: Laboratory and Field Blanks measured on all instruments for water analyses

Table 5.1

Summary: ICAPES measurement of Lab Blanks				
Element	Units	PQL	Total number of blanks	Number of blanks below PQL
Ag	µg/L	1	6	6
Al	µg/L	5	6	6
Ba	µg/L	1	6	6
Be	µg/L	0.05	6	6
Ca	mg/L	0.01	6	6
Cd	µg/L	0.5	6	6
Co	µg/L	0.5	6	6
Cr	µg/L	1	6	6
Cu	µg/L	0.8	6	6
Fe	µg/L	5	6	6
K	mg/L	0.10	6	6
Li	µg/L	0.5	6	6
Mg	mg/L	0.01	6	6
Mn	µg/L	0.3	6	6
Mo	µg/L	1	6	6
Na	mg/L	0.15	6	6
Ni	µg/L	2	6	6
Pb	µg/L	6	6	6
S	mg/L	0.02	6	6
Si	mg/L	0.02	6	6
Sr	µg/L	2	6	6
Ti	µg/L	2	6	6
V	µg/L	2	6	6
Zn	µg/L	0.2	6	6

PQL= Practical Quantifiable Limit
BPQL= Below Practical Quantifiable Limit

Table 5.2

Summary: ICAPES measurement of Field Blanks					
Element	Units	PQL	Total number of blanks	Number of blanks below PQL	Highest Conc. found
Ag	µg/L	1	8	8	
Al	µg/L	5	8	8	
Ba	µg/L	1	8	8	
Be	µg/L	0.05	8	8	
Ca	mg/L	0.01	8	0	0.02
Cd	µg/L	0.5	8	8	
Co	µg/L	0.5	8	8	
Cr	µg/L	1	8	8	
Cu	µg/L	0.8	8	8	
Fe	µg/L	5	8	8	
K	mg/L	0.10	8	8	
Li	µg/L	0.5	8	8	
Mg	mg/L	0.01	8	1	0.01
Mn	µg/L	0.3	8	8	
Mo	µg/L	1	8	8	
Na	mg/L	0.15	8	7	0.23
Ni	µg/L	2	8	8	
Pb	µg/L	6	8	8	
S	mg/L	0.02	8	8	
Si	mg/L	0.02	8	8	
Sr	µg/L	2	8	8	
Ti	µg/L	2	8	8	
V	µg/L	2	8	8	
Zn	µg/L	0.2	8	8	

Table 5.3

Summary: Laboratory blanks measured on HGAAS, Carbon Analyzer, and IC				
Analyte	Units	PQL	Total number of blanks	Number of blanks BPQL
Arsenic	µg/L	0.2	17	17
Alkalinity	mg/L	1.0	0	-
Organic C	mg/L	1.0	11	11
Fluoride	mg/L	0.05	10	10
Chloride	mg/L	2	10	10
Nitrate-N	mg/L	0.05	10	10
Nitrite-N	mg/L	0.05	10	10
Phosphate-	mg/L	0.05	10	10
Sulfate	mg/L	1.00	10	10

Table 5.4

Summary: Field Blanks measured on HGAAS, Carbon Analyzer, and IC				
Analyte	Units	PQL	Total number of blanks	Number of blanks BPQL
Arsenic	µg/L	0.2	8	8
Alkalinity	mg/L	1.0	8	8
Organic C	mg/L	1.0	8	8
Fluoride	mg/L	0.05	8	8
Chloride	mg/L	2	8	8
Nitrate-N	mg/L	0.2	8	8
Nitrite-N	mg/L	0.02	8	8
Phosphate-	mg/L	0.2	8	8
Sulfate	mg/L	2.00	8	8

Table 6: Duplicates and Spike Recoveries for Sediment Analyses

Table 6.1

Summary: ICAPES duplicate comparisons of sediment digest samples

Element	Number of dupl. pairs above PQL	Mean % difference of dupl. pairs	Stand. dev. of mean of % difference of dupl. pairs
Al	11	2.5	1.8
As	11	5.1	4.6
B	5	26.6	21.6
Ba	11	3.5	2.6
Be	11	8.4	4.5
Ca	11	5.0	3.1
Cd	3	7.1	2.7
Co	11	3.0	2.7
Cr	11	5.6	5.6
Cu	11	4.1	4.6
Fe	11	2.6	2.0
Hg	0	-	-
K	11	8.0	8.1
Li	11	4.9	3.5
Mg	11	2.5	3.3
Mn	11	2.2	1.3
Mo	0	-	-
Na	11	9.2	5.6
Ni	11	2.9	2.0
Pb	11	2.0	1.6
S	11	4.1	8.0
Sb	0	-	-
Se	0	-	-
Si	11	9.7	12.2
Sn	1	3.4	-
Sr	11	2.0	2.4
Ti	11	1.4	0.8
Tl	0	-	-
V	11	1.7	1.7
Zn	11	1.6	1.7

Table 6.2

Summary: ICAPES Spike recoveries during sediment digest analysis

Element	Number of samples above PQL	Mean % recovery	Stand. dev. of mean % recovery
Al	14	98	17
As	8	101	5
B	5	101	2
Ba	18	93	4
Be	9	95	4
Ca	8	93	5
Cd	2	94	2
Co	9	96	4
Cr	9	98	4
Cu	18	98	8
Fe	11	89	4
Hg	0	-	-
K	0	-	-
Li	9	105	6
Mg	8	91	9
Mn	18	91	5
Mo	0	-	-
Na	9	93	14
Ni	9	96	5
Pb	18	99	4
S	0	-	-
Sb	0	-	-
Se	0	-	-
Si	0	-	-
Sn	0	-	-
Sr	9	100	4
Ti	17	98	5
Tl	0	-	-
V	9	99	4
Zn	18	96	4

Table 7 : Summary of USGS standards measured on ICAPES during sediment digest analyses.

Table 7.1

Summary: USGS Standard T-143 measured on ICAPES (n=15)				
Elemen	Units	Reported Mean (Range)*	Measured Mean (Std. Dev.)	Measured mean within Reported Range?
Al	mg/L	0.221 (0.166)	*BPQL*	-
As	mg/L	0.0152 (0.0024)	*BPQL*	-
B	mg/L	0.035 (0.0104)	0.033(0.002)	Yes
Ba	mg/L	0.081 (0.009)	0.083 (0.004)	Yes
Be	mg/L	0.0085 (0.0013)	0.008(0.0002)	Yes
Ca	mg/L	53.7 (4.4)	59.14 (2.63)	No
Cd	mg/L	0.019 (0.003)	0.02 (0.001)	Yes
Co	mg/L	0.017 (0.0024)	0.02 (0.002)	No
Cr	mg/L	0.037 (0.005)	0.03 (0.005)	Yes
Cu	mg/L	0.022 (0.004)	0.02 (0.002)	Yes
Fe	mg/L	0.222 (0.028)	0.231 (0.007)	Yes
K	mg/L	2.5 (0.42)	2.6 (0.2)	Yes
Li	mg/L	0.018 (0.004)	0.019 (0.001)	Yes
Mg	mg/L	10.4 (1)	10.87 (0.31)	Yes
Mn	mg/L	0.018 (0.004)	0.018 (0.001)	Yes
Mo	mg/L	0.036 (0.009)	0.04 (0.003)	Yes
Na	mg/L	34 (3.2)	34.9 (2.0)	Yes
Ni	mg/L	0.071 (0.010)	0.072 (0.002)	Yes
P	mg/L	(Not reported)	*BPQL*	-
Pb	mg/L	0.083 (0.014)	0.09 (0.01)	Yes
S	mg/L	(Not reported)	6.86 (0.20)	-
Sb	mg/L	0.0166 (0.003)	*BPQL*	-
Se	mg/L	0.0963 (0.0033)	*BPQL*	-
Si	mg/L	10.94 (1.64)	10.84 (0.52)	Yes
Sn	mg/L	(Not reported)	*BPQL*	-
Sr	mg/L	0.306 (0.030)	0.294 (0.009)	Yes
Ti	mg/L	(Not reported)	*BPQL*	-
Tl	mg/L	0.01 (0.002)	*BPQL*	-
V	mg/L	0.030 (0.006)	0.03 (0.002)	Yes
Zn	mg/L	0.020 (0.004)	0.019 (0.0004)	Yes

*Reported Range is 2 pseudosigmas from the mean

Table 7.2

Summary: USGS Standard T-145 measured on ICAPES (n=14)				
Element	Units	Reported Mean (Range)*	Measured Mean (Std. Dev.)	Measured mean within Reported Range?
Al	mg/L	0.0676 (0.022)	*BPQL*	-
As	mg/L	0.0099 (0.0021)	*BPQL*	-
B	mg/L	0.0456 (0.0016)	0.045 (0.003)	Yes
Ba	mg/L	0.0371 (0.0038)	0.038 (0.002)	Yes
Be	mg/L	0.00904 (0.0014)	0.009 (0.0002)	Yes
Ca	mg/L	30.7 (2.6)	32.35 (0.99)	Yes
Cd	mg/L	0.0093 (0.0016)	*BPQL*	-
Co	mg/L	0.010 (0.0018)	0.01 (0.001)	Yes
Cr	mg/L	0.0153 (0.0028)	0.013 (0.004)	Yes
Cu	mg/L	0.011 (0.0028)	0.012 (0.001)	Yes
Fe	mg/L	0.101 (0.016)	0.103 (0.006)	Yes
K	mg/L	2.13 (.32)	2.2 (0.1)	Yes
Li	mg/L	0.0273 (0.005)	0.027 (0.001)	Yes
Mg	mg/L	8.68 (0.9)	8.882 (0.114)	Yes
Mn	mg/L	0.0209 (0.003)	0.021 (0.001)	Yes
Mo	mg/L	0.0092 (0.0026)	*BPQL*	-
Na	mg/L	41.2 (3.8)	40.9 (1.9)	Yes
Ni	mg/L	0.011 (0.0026)	*BPQL*	-
P	mg/L	(Not reported)	*BPQL*	-
Pb	mg/L	0.0127 (0.0024)	*BPQL*	-
S	mg/L	(Not reported)	10.06 (0.14)	-
Sb	mg/L	0.088 (0.0019)	*BPQL*	-
Se	mg/L	0.0101 (0.0026)	*BPQL*	-
Si	mg/L	5.28 (0.66)	5.41 (0.09)	Yes
Sn	mg/L	(Not reported)	*BPQL*	-
Sr	mg/L	0.203 (0.018)	0.192 (0.004)	Yes
Ti	mg/L	(Not reported)	*BPQL*	-
Tl	mg/L	0.0153 (0.0054)	*BPQL*	-
V	mg/L	0.0117 (0.0034)	*BPQL*	-
Zn	mg/L	0.010 (0.0048)	0.009 (0.0003)	Yes

*Reported Range is 2 pseudosigmas from the mean

Table 7.3

Summary: Stream Sediment Reference Material STSD-3*			
Element	Units	Reported Mean (Std.Dev.)	Measured (n=8) Mean (Std. Dev.)
Al	ppm	(NR)	12756 (730)
As	ppm	22 (6)	29 (1)
B	ppm	(NR)	*BPQL*
Ba	ppm	(NR)	374 (40)
Be	ppm	(NR)	1.02 (0.09)
Ca	ppm	(NR)	11921 (355)
Cd	ppm	1.0 (0.2)	2.6 (0.5)
Co	ppm	14 (1)	13.9 (0.3)
Cr	ppm	34 (6)	23.5 (1.0)
Cu	ppm	38 (2)	36.2 (1.1)
Fe	percent	3.4 (0.1)	2.90 (0.72)
K	ppm	(NR)	936 (80)
Li	ppm	(NR)	14.3 (0.9)
Mg	ppm	(NR)	5596 (414)
Mn	ppm	2630 (140)	2122 (66)
Mo	ppm	7 (2)	3.2 (0.6)
Na	ppm	(NR)	173 (17)
Ni	ppm	25 (3)	22.4 (0.6)
P	ppm	(NR)	1553 (31)
Pb	ppm	39 (5)	35.4 (1.4)
S	ppm	(NR)	1361 (33)
Sb	ppm	2.4 (1.2)	*BPQL*
Se	ppm	(NR)	*BPQL*
Si	ppm	(NR)	529 (33)
Sn	ppm	(NR)	*BPQL*
Sr	ppm	(NR)	54.0 (2.0)
Ti	ppm	(NR)	268.7 (19.4)
Tl	ppm	(NR)	*BPQL*
V	ppm	61 (22)	40.6 (1.5)
Zn	ppm	192 (11)	171.9 (2.7)

NR= Not Reported

*Note: Differences between reported and measured concentrations may be due to differences in the digestion methods. No description of preparation methods is given for the reported values of STSD-3.

Tables 8: Laboratory and Digest Blanks for Sediment Analyses

Table 8.1

Summary:ICAPES measurement of Lab Blanks				
Element	Units	PQL	Total number of blanks	Number of blanks below PQL
Al	mg/L	0.1	7	7
As	mg/L	0.065	7	7
B	mg/L	0.005	7	7
Ba	mg/L	0.005	7	7
Be	mg/L	0.001	7	7
Ca	mg/L	0.01	7	7
Cd	mg/L	0.01	7	7
Co	mg/L	0.01	7	7
Cr	mg/L	0.005	7	7
Cu	mg/L	0.005	7	7
Fe	mg/L	0.015	7	7
Hg	mg/L	0.05	7	7
K	mg/L	0.50	7	7
Li	mg/L	0.005	7	7
Mg	mg/L	0.01	7	7
Mn	mg/L	0.005	7	7
Mo	mg/L	0.02	7	7
Na	mg/L	0.1	7	7
Ni	mg/L	0.015	7	7
P	mg/L	0.07	7	7
Pb	mg/L	0.06	7	7
S	mg/L	0.07	7	7
Sb	mg/L	0.085	7	7
Se	mg/L	0.08	7	7
Si	mg/L	0.02	7	7
Sn	mg/L	0.03	7	7
Sr	mg/L	0.005	7	7
Ti	mg/L	0.005	7	7
Tl	mg/L	0.01	7	7
V	mg/L	0.01	7	7
Zn	mg/L	0.005	7	7

PQL= Practical Quantifiable Limit

Table 8.2

Summary: ICAPES measurement of Digest Blanks					
Element	Units	PQL	Total number of blanks	Number of blanks below PQL	Highest Conc. found
Al	mg/L	0.1	4	4	
As	mg/L	0.065	4	4	
B	mg/L	0.005	4	4	
Ba	mg/L	0.005	4	4	
Be	mg/L	0.001	4	4	
Ca	mg/L	0.01	4	0	0.08
Cd	mg/L	0.01	4	4	
Co	mg/L	0.01	4	4	
Cr	mg/L	0.005	4	3	0.007
Cu	mg/L	0.005	4	4	
Fe	mg/L	0.015	4	2	0.136
Hg	mg/L	0.05	4	4	
K	mg/L	0.50	4	4	
Li	mg/L	0.005	4	4	
Mg	mg/L	0.01	4	3	0.039
Mn	mg/L	0.005	4	4	
Mo	mg/L	0.02	4	4	
Na	mg/L	0.1	4	3	0.112
Ni	mg/L	0.015	4	4	
P	mg/L	0.07	4	4	
Pb	mg/L	0.06	4	4	
S	mg/L	0.07	4	4	
Sb	mg/L	0.085	4	4	
Se	mg/L	0.08	4	4	
Si	mg/L	0.02	4	2	0.10
Sn	mg/L	0.03	4	4	
Sr	mg/L	0.005	4	4	
Ti	mg/L	0.005	4	3	0.006
Tl	mg/L	0.01	4	4	
V	mg/L	0.01	4	4	
Zn	mg/L	0.005	4	4	

Table 9: All water data

Elements BPQL: NO2-N (<0.05 mg/L), NO3-N (<0.05 mg/L), PO4-P (<0.05 mg/L), Ag, Be, Cr, Mo, Pb, Tl, V

Sample name	Sample date	Discharge (cfs)	pH	D.O.	Cond	Water temp.	Air temp.	Alk.	F	Cl	Sulfate	Org. C	As	Al	Ba	Ca	Cd	Co	Cu	Fe	K	Li	Mg	Mn	Na	Ni	S	Si	Sr	Zn
Pass Creek	8/16/98	0.55	7.91	8.49	0.17	12.2	22.0	75	*BPQL*	1.7	4.3	0.9	0.9	(<5)	215	18.5	(<0.5)	(<0.5)	(<0.8)	5	0.4	0.8	7.35	3.2	2.01	(<2)	1.28	5.14	55	0.4
Pass Cr. DUP	8/16/98	0.42	7.90	8.50	0.17	12.3		85				0.8																		
Pass Cr. DUP	8/16/98		7.90	8.50	0.16																									
MHM-1	8/16/98	3.38	7.71	8.12	0.26	13.0	22.2	80	0.06	0.3	48.3	0.9	0.3	(<5)	142	25.3	2.6	(<0.5)	3.6	5	0.6	1.3	14.49	160.2	2.33	(<2)	14.18	3.66	73	540.5
MHM-2	8/16/98	3.25	7.67	8.13	0.27	12.6		90	0.06	0.4	48.0	0.7	0.3	(<5)	144	25.2	2.7	(<0.5)	3.5	5	0.6	1.3	14.43	161.2	2.48	(<2)	14.34	3.69	73	539.2
MHM-3	8/16/98	3.84	7.70	8.12	0.27	12.9		85	0.06	0.7	48.1	0.7	0.2	(<5)	142	25.1	2.6	(<0.5)	3.5	5	0.6	1.3	14.39	154.5	2.39	(<2)	14.23	3.65	73	521.4
MHM-4	8/16/98							90	0.06	0.6	48.6	0.9	0.2	(<5)	142	25	2.5	(<0.5)	3.7	5	0.6	1.3	14.36	153.5	2.36	(<2)	14.23	3.66	73	540.0
BF ab. Meadow-1	8/20/98	5.97	7.28	8.72	0.30	12.9	20.3	47	0.10	0.6	88.7	1.0	0.1	12	107	27.6	2.3	1.0	4.2	30	1.0	2.1	14.49	254.7	4.51	3	27.04	7.10	79	794.0
BF ab. Meadow-2	8/20/98	5.57	7.26	8.73	0.30	12.9		45	0.10	0.5	88.8	0.9	0.1	9	102	26.7	2.1	0.9	4.1	28	0.9	2.0	13.82	242.1	4.04	3	25.63	6.49	75	738.6
BF ab. Meadow Cr. 3	8/20/98		7.26	8.74	0.30	12.9		47	0.13	0.5	88.7	1.0	0.1	11	103	27.2	2.0	1.0	4.0	26	1.0	2.1	14.23	247.4	4.15	3	26.04	6.96	76	778.9
BF ab. Meadow Cr. 4	8/20/98							44	0.10	0.5	88.9	1.1	0.1	10	98	25.9	2.0	0.8	3.9	24	0.9	2.1	13.66	234.9	3.84	3	25.08	6.63	74	736.9
Meadow Cr.	8/20/98	1.65	7.52	8.25	0.29	12.1	20.0	45	0.09	0.5	85.6	1.0	0.1	6	98	26	1.9	0.6	3.7	18	0.9	2.0	13.51	191.7	3.82	2	24.56	6.51	74	670.9
Meadow Cr.	8/20/98		7.53	8.23	0.29	12.2																								
Meadow Cr.	8/20/98		7.54	8.23	0.29	12.3																								
BF. bel. Meadow-1	8/16/98	7.85	7.59	8.50	0.29	14.9	18.9	50	0.13	0.5	87.3	1.0	0.1	10	102	26.1	1.7	0.7	3.9	22	0.9	2.0	13.43	206.6	3.55	2	24.14	6.66	73	678.7
BF. bel. Meadow-2	8/16/98	6.83	7.54	8.51	0.30			50	0.13	0.5	88.5	1.0	0.1	10	104	25.7	1.9	0.6	3.8	21	0.9	2.0	13.42	207.4	3.62	3	24.25	6.60	74	678.3
BF. bel. Meadow-3	8/16/98	7.55	7.52	8.50	0.30			50	0.13	0.5	87.1	1.0	0.0	12	104	26.1	1.8	0.7	3.9	18	0.9	2.0	13.55	210.4	3.71	2	24.44	6.70	74	686.6
BF. bel. Meadow-4	8/16/98							50	0.13	0.6	87.2	1.0	0.1	8	103	26.2	1.8	0.8	3.9	19	0.9	2.0	13.46	209.2	3.62	2	24.36	6.68	73	674.8
BF. bel. Meadow-5	8/16/98							50	0.13	0.5	87.4	0.9	0.0	12	107	26.3	1.8	0.8	4.0	23	0.9	2.0	13.66	215.0	3.80	3	24.94	6.81	74	695.8
BF. bel. Meadow-6	8/16/98							50	0.13	0.4	87.2	1.1	0.1	11	102	26.1	1.8	0.9	3.9	19	0.9	2.0	13.50	208.5	3.61	3	24.41	6.66	73	682.7
BF. bel. Meadow-7	8/16/98							50	0.13	0.6	87.3	1.2	0.1	11	107	26.6	1.7	0.9	4.1	21	0.9	2.0	13.69	216.2	3.85	3	24.97	6.82	75	702.8
BF bel. Meadow-8	8/16/98							50	0.13	0.6	87.3	1.0	0.1	11	104	25.8	2.1	0.7	4.1	23	0.9	2.0	13.52	208.9	3.71	3	24.37	6.63	75	676.1
BF bel. Meadow-9	8/16/98							55	0.13	0.5	87.5	1.0	0.1	11	101	26.2	1.8	0.7	3.9	21	0.9	2.0	13.46	205.5	3.49	3	23.96	6.62	73	673.5
BF bel. Meadow-10	8/16/98							55	0.13	0.6	87.2	1.1	0.1	11	96	24.6	1.7	0.7	3.7	20	0.8	1.9	12.79	195.8	3.43	2	22.99	6.27	69	645.4
BF bel. Meadow Day 5	8/20/98		7.46	8.95	0.29	13.1	20.6	46				1.1	0.1	7	102	26.4	2.0	0.6	3.6	16	0.9	2.0	13.65	221.5	4.04	2	24.84	6.46	74	698.8
BF bel. Meadow Day 5	8/20/98		7.46	8.90	0.30	13.2			0.10	0.6	86.9																			
BF bel. Meadow Day 5	8/20/98		7.47	8.88	0.30	13.0																								
BF ab. Alice-1	8/16/98	15.57	7.85	8.50	0.26	17.4	25.5	80	0.09	0.7	44.2	1.2	0.2	(<5)	200	25.7	0.8	(<0.5)	1.1	36	0.7	1.3	12.64	82.8	1.96	(<2)	13.23	5.92	75	83.2
BF ab. Alice-2	8/16/98		7.86	8.50	0.26	17.5		75	0.11	1.5	44.4	1.5	0.2	(<5)	201	25.9	0.6	(<0.5)	1.1	36	0.7	1.3	12.71	84.1	1.93	(<2)	13.27	5.94	74	85.8
BF ab. Alice-3	8/16/98		7.86	8.49	0.25	17.5		80	0.06	1.2	44.2	1.3	0.2	(<5)	199	25.9	0.6	(<0.5)	1.2	38	0.7	1.3	12.59	82.6	1.97	(<2)	13.22	5.91	74	83.7
BR ab. Alice-4	8/16/98							75	0.05	1.0	44.3	1.5	0.2	(<5)	192	24.6	(<0.5)	(<0.5)	(<0.8)	37	0.7	1.3	12.31	77.7	1.94	(<2)	12.79	6.08	73	84.2
Alice Creek	8/16/98	15.79	8.18	8.42	0.24	17.0	26.0	105	0.07	0.5	2.8	1.3	0.4	(<5)	281	27.4	0.5	(<0.5)	(<0.8)	19	0.7	2.3	11.18	2.3	1.63	(<2)	0.84	5.41	73	(<0.2)
Alice Cr. DUP	8/16/98	16.34	8.16	8.43	0.23	17.0		115																						
Alice Cr. DUP	8/16/98	15.68	8.16	8.42	0.23	17.1																								
Alice Cr. DUP	8/16/98	13.14																												
Hardscrabble Cr.	8/16/98	1.19	8.41	8.52	0.33	16.1	25.8	155	0.11	0.5	1.6	4.1	1.0	(<5)	385	39.3	(<0.5)	(<0.5)	(<0.8)	32	1.7	6.4	14.59	1.6	3.26	(<2)	0.49	9.82	130	(<0.2)
Hardscrabble Cr.	8/16/98	1.17	8.40	8.51	0.33							4.1																		
Hardscrabble Cr.	8/16/98		8.40	8.52	0.32																									
BH-1	8/17/98	33.65	8.16	9.43	0.24	11.9	18.0	100	0.07	0.6	13.3	1.4	0.4	(<5)	240	26.8	(<0.5)	(<0.5)	0.8	23	0.9	2.3	11.60	2.6	2.08	(<2)	4.15	6.74	114	0.9
BH-2	8/17/98	31.70	8.20	9.43	0.24	11.9	18.1	105	0.07	0.6	13.4	1.0	0.4	(<5)	226	26.2	(<0.5)	(<0.5)	(<0.8)	21	0.8	2.2	11.31	2.5	1.92	(<2)	4.00	6.32	110	2.0
BH-3	8/17/98		8.18	9.42	0.24	11.8	18.1	100	0.09	0.6	13.4	1.1	0.4	(<5)	223	26.4	(<0.5)	(<0.5)	(<0.8)	22	0.8	2.2	11.37	2.5	1.91	(<2)	3.97	6.47	108	2.0
BH-4	8/17/98							110	0.08	0.6	13.2	1.1	0.4	(<5)	223	26.4	(<0.5)	(<0.5)	(<0.8)	20	0.8	2.2	11.31	2.5	2.09	(<2)	3.97	6.49	109	1.5
Hogum Cr.	8/17/98	2.44	7.79	8.68	0.17	11.9	14.9	80	0.13	0.4	4.9	2.5	1.1	(<5)	138	18.9	(<0.5)	(<0.5)	(<0.8)	168	0.9	4.4	6.19	10.9	4.57	(<2)	1.38	9.64	416	(<0.2)
Hogum Cr. DUP	8/17/98	2.44	7.81	8.68	0.17	12.0	14.8	80																						
Hogum Cr. DUP	8/17/98	3.07	7.80	8.67	0.17	12.0	14.7																							
		3.09																												
BC-1	8/17/98	37.61	8.26	9.70	0.23	12.3	22.0	95	0.09	0.6	12.6	1.0	0.4	(<5)	214	26.3	(<0.5)	(<0.5)	(<0.8)	16	0.8	2.6	10.84	1.0	2.35	(<2)	3.72	6.83	141	0.5
BC-2	8/17/98	39.04	8.28	9.72	0.23	12.3	22.1	110	0.05	0.6	12.8	1.2	0.4	(<5)	211	26.1	(<0.5)	(<0.5)	(<0.8)	16	0.8	2.6	10.84	1.0	2.40	(<2)	3.70	6.78	140	0.5
BC-3	8/17/98		8.28	9.72	0.24	12.4	22.1	102	0.08	0.6	12.8	1.7	0.4	(<5)	211	25.9	(<0.5)	(<0.5)	(<0.8)	15	0.8	2.6	10.76	1.0	2.27	(<2)	3.70	6.78	139	0.5
BC-4	8/17/98							110	0.07	0.6	12.8	1.3	0.4	(<5)	214	25.8	(<0.5)	(<0.5)	(<0.8)	16	0.8	2.6	10.75	1.1	2.13	(<2)	3.76	6.80	140	0.8
LD-1	8/17/98	72.08	8.31	9.72	0.26	12.5	23.9	150	*BPQL*	0.4	2.9	0.6	0.5	(<5)	237	32.8	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.53	(<0.3)	1.01	(<2)	0.86	3.89	54	(<0.2)
LD-2	8/17/98		8.31	9.71	0.26	12.6	24.0	145	*BPQL*	0.4	2.9	1.1	0.6	(<5)	244	33.4	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.68	(<0.3)	0.78	(<2)	0.84	3.89	55	(<0.2)
LD-3	8/17/98		8.32	9.71	0.27	12.5	23.9	120	*BPQL*	0.4	2.9	0.7	0.6	(<5)	246	33.6	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.76	(<0.3)	1.01	(<2)	0.89	3.71	56	(<0.2)
LD-4	8/17/98							130	*BPQL*	0.4	2.9	0.5	0.5	(<5)	247	33.5	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.71	(<0.3)	0.91	(<2)	0.88	3.72	56	(<0.2)
LD-5	8/17/98							130	*BPQL*	0.4	2.9	0.5	0.5	(<5)	245	33.3	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.65	(<0.3)	0.90	(<2)	0.88	3.70	55	(<0.2)
LD-6	8/17/98							135	*BPQL*	0.5	2.9	0.6	0.5	(<5)	243	33.8	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.72	(<0.3)	0.95	(<2)	0.87	3.68	55	(<0.2)
LD-7	8/17/98							130	*BPQL*	0.4	2.9	0.5	0.5	(<5)	247	33.1	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.68	(<0.3)	0.75	(<2)	0.87	3.94	57	(<0.2)
LD-8	8/17/98							125	*BPQL*	0.4	2.9	0.6	0.5	(<5)	251	33.5	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.74	(<0.3)	0.77	(<2)	0.86	3.97	56	(<0.2)
LD-8 DUP	8/17/98							130	*BPQL*				0.6																	
LD-9	8/17/98							135	*BPQL*	0.4	2.9	0.4	0.5	(<5)	245	33.7	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.69	(<0.3)	0.92	(<2)	0.88	3.70	55	(<0.2)
LD-10	8/17/98							125	*BPQL*	0.4	2.9	0.5		(<5)	242	33.7	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.2	11.70	(<0.3)	0.75	(<2)	0.85	3.66	55	(<0.2)
BD-1	8/17/98	109.07	8.24	9.82	0.26	10.6	17.3	145	*BPQL*	0.5	5.8	0.7	0.5	(<5)	235	31.1	(<0.5)	(<0.5)	(<0.8)	6	0.6	2.3	11.37	0.5	1.14	(<2)	1.72	4.82	82	(<0.2)
BD-1 DUP	8/18/98		8.26	9.84	0.26	10.6	17.2	135				0.7																		
BD-2	8/17/98		8.24	9.83	0.26	10.6	17.2	140	*BPQL*	0.5	6.3	0.7	0.5	(<5)	230	31	(<0.5)	(<0.5)	(<0.8)	6	0.6	2.4	11.38	0.5	1.27	(<2)	1.64	4.92	86	(<0.2)

Sample name	Sample date	Discharge (cfs)	pH	D.O.	Cond.	Water temp.	Air temp.	Alk.	F	Cl	Sulfate	Org. C	As	Al	Ba	Ca	Cd	Co	Cu	Fe	K	Li	Mg	Mn	Na	Ni	S	Si	Sr	Zn
BD-3	8/17/98							125	*BPQL*	0.5	6.9	0.8		(<5)	233	30.4	(<0.5)	(<0.5)	(<0.8)	7	0.6	2.4	11.39	0.5	1.40	(<2)	2.05	5.15	93	(<0.2)
BD-4	8/17/98							110	*BPQL*	0.5	7.3	1.3	0.5	(<5)	231	30.3	(<0.5)	(<0.5)	(<0.8)	7	0.6	2.4	11.37	0.5	1.64	(<2)	2.18	5.00	95	(<0.2)
BF at Lincoln	8/17/98	54.07	8.10	7.78	0.27	15.5	22.3	120	*BPQL*	0.5	6.6	0.9	0.5	(<5)	232	35.6	(<0.5)	(<0.5)	(<0.8)	(<5)	0.6	2.4	11.49	1.2	1.16	(<2)	1.97	4.97	91	(<0.2)
BF at Lincoln	8/17/98		8.12	7.77	0.27	15.5	22.3																							
BF at Lincoln	8/17/98		8.10	7.79	0.27	15.5	22.3																							
BF at Ogden	8/17/98	207.18	8.31	9.60	0.31	14.5	25.3	170	0.08	0.9	5.7	0.9	1.1	(<5)	228	42.8	(<0.5)	(<0.5)	(<0.8)	11	0.8	3.4	12.32	3.3	1.68	(<2)	1.76	5.79	110	(<0.2)
BF at Ogden	8/17/98		8.31	9.61	0.32	14.6	25.2																							
BF at Ogden	8/17/98		8.30	9.61	0.32	14.5	25.2																							
Arrastra Cr.	8/18/98	23.30	8.27	10.46	0.20	8.6	12.9	90	0.05	0.4	2.7	0.7	0.4	(<5)	100	24.5	(<0.5)	(<0.5)	(<0.8)	(<5)	0.4	2.0	9.84	0.7	1.30	(<2)	0.78	4.69	73	(<0.2)
Arrastra Cr.	8/18/98		8.26	10.48	0.20	8.6	13.0																							
Arrastra Cr.	8/18/98		8.27	10.48	0.20	8.7	13.0																							
BF ab. Nevada-1	8/18/98	239.29	8.37	9.96	0.31	16.4	23.9	145	0.08	0.9	5.6	1.0	1.5	(<5)	227	41.8	(<0.5)	(<0.5)	(<0.8)	18	0.9	3.5	12.66	7.7	1.90	(<2)	1.71	6.21	111	(<0.2)
BF ab. Nevada-2	8/18/98		8.37	9.98	0.31	16.3	23.8	150	0.11	0.9	5.5	0.8	1.5	(<5)	228	41.7	(<0.5)	(<0.5)	(<0.8)	18	0.9	3.6	12.74	7.7	1.88	(<2)	1.70	6.23	112	(<0.2)
BF ab. Nevada-3	8/18/98		8.39	9.99	0.31	16.2	23.8	140	0.11	0.9	5.5	1.0	1.4	(<5)	216	40.7	0.6	(<0.5)	(<0.8)	17	0.8	3.5	12.38	7.5	1.67	(<2)	1.64	6.08	108	(<0.2)
BF ab. Nevada-4	8/18/98							140	0.11	0.8	5.5	1.0	1.4	(<5)	222	41.6	(<0.5)	(<0.5)	(<0.8)	17	0.9	3.5	12.54	7.6	1.63	(<2)	1.65	6.12	109	(<0.2)
Nevada Cr.	8/18/98	42.58	8.49	9.43	0.40	17.8	18.7	155	0.21	2.7	28.0	7.3	7.87	(<5)	121	42.9	(<0.5)	(<0.5)	(<0.8)	18	3.2	11.7	10.98	18.2	13.35	(<2)	8.19	12.58	293	(<0.2)
Nevada Cr.	8/18/98	41.40	8.50	9.44	0.40	17.6	18.6	160				7.0																		
Nevada Cr.	8/18/98		8.51	9.43	0.40	17.6	18.7																							
BF bel. Nevada-1	8/18/98	262.20	8.44	9.78	0.32	17.1	22.5	135	0.13	1.2	9.2	1.9	2.4	(<5)	203	40.6	(<0.5)	(<0.5)	(<0.8)	15	1.3	4.8	12.04	8.7	3.67	(<2)	2.70	6.82	140	(<0.2)
BF bel. Nevada-2	8/18/98		8.47	9.74	0.32	17.0	22.5	145	0.13	1.2	9.2	1.9	2.3	5.47	209	42.6	(<0.5)	(<0.5)	(<0.8)	15	1.3	5.1	12.57	8.8	3.99	(<2)	2.81	7.50	147	(<0.2)
BF bel. Nevada-3	8/18/98		8.47	9.74	0.32	17.0	22.4	145	0.13	1.2	9.3	2.0	2.3	(<5)	189	38.3	(<0.5)	(<0.5)	(<0.8)	13	1.2	4.7	11.59	8.1	3.61	(<2)	2.57	6.89	133	(<0.2)
BF bel. Nevada-4	8/18/98							145	0.13	1.2	9.3	1.7	2.3	5.42	210	42.5	(<0.5)	(<0.5)	(<0.8)	14	1.4	5.1	12.62	8.7	4.27	(<2)	2.84	7.53	148	(<0.2)
Northfork-1	8/18/98	222.85	8.37	10.26	0.27	15.3	20.3	140	*BPQL*	0.4	4.0	0.7	0.7	(<5)	226	31.	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.0	13.91	0.5	0.98	(<2)	1.21	3.91	65	(<0.2)
Northfork-2	8/18/98	8/4/04	8.38	10.29	0.27	15.2	20.4	135	*BPQL*	0.4	4.0	0.6	0.7	(<5)	230	30.9	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.0	13.96	0.5	0.95	(<2)	1.22	3.93	65	(<0.2)
Northfork-3	8/18/98		8.37	10.28	0.27	15.2	20.2	140	*BPQL*	0.5	4.0	0.7	0.7	(<5)	229	31.1	(<0.5)	(<0.5)	(<0.8)	(<5)	0.5	2.0	13.88	0.6	0.93	(<2)	1.22	3.93	65	(<0.2)
Northfork-4	8/18/98							125	*BPQL*	0.5	4.1	0.8	0.8	(<5)	229	30.9	0.6	(<0.5)	(<0.8)	(<5)	0.5	2.0	13.89	0.6	1.02	(<2)	1.23	3.93	65	(<0.2)
Monture-1	8/18/98	66.92	8.64	10.43	0.19	16.4	21.9	85	*BPQL*	0.4	3.8	1.3	0.8	(<5)	248	21.4	(<0.5)	(<0.5)	(<0.8)	16	0.6	2.5	9.35	2.9	1.32	(<2)	1.13	3.60	61	(<0.2)
Monture-1 DUP	8/19/98	62.96	8.65	10.48	0.19	16.4	21.8	95																						
Monture-2	8/18/98		8.65	10.47	0.19	16.4	21.8	105	*BPQL*	0.4	3.8	1.3	0.8	(<5)	244	21.3	(<0.5)	(<0.5)	(<0.8)	15	0.6	2.6	9.34	2.8	1.45	(<2)	1.13	3.58	60	(<0.2)
Monture-3	8/18/98							85	*BPQL*	0.4	3.8	1.3	0.8	(<5)	242	21.3	(<0.5)	(<0.5)	(<0.8)	15	0.6	2.4	9.32	2.8	1.27	(<2)	1.09	3.45	60	(<0.2)
Monture-4	8/18/98							85	*BPQL*	0.6	3.7	1.2	0.7	(<5)	245	21.2	(<0.5)	(<0.5)	(<0.8)	15	0.6	2.5	9.33	2.8	1.18	(<2)	1.10	3.49	60	(<0.2)
BF bel. Monture-1	8/19/98	627.35	8.30	9.93	0.25	12.4	25.8	120	0.05	0.8	5.8	1.4	1.1	(<5)	203	28.4	(<0.5)	(<0.5)	(<0.8)	7	0.7	3.1	10.98	1.7	2.10	(<2)	1.57	3.82	83	(<0.2)
BF bel. Monture-2	8/19/98		8.36	9.98	0.24	12.0		129	0.07	1.0	6.6	1.4	1.3	(<5)	209	33.4	(<0.5)	(<0.5)	(<0.8)	6	0.9	3.7	12.58	1.6	2.53	(<2)	1.93	4.71	100	(<0.2)
BF bel. Monture-2 DUP	8/20/98		8.38	9.96	0.24	12.0		129	0.07	0.9	6.9																			
BF bel. Monture-3	8/19/98							137	0.07	2.0	7.1	1.5	1.3	(<5)	205	34.7	(<0.5)	(<0.5)	(<0.8)	6	0.9	3.7	12.77	1.6	2.53	(<2)	2.00	4.51	103	(<0.2)
BF bel. Monture-4	8/19/98							134				1.4	1.3	(<5)	218	36.6	0.5	(<0.5)	(<0.8)	6	1.0	4.0	13.50	1.7	2.77	(<2)	2.13	5.08	110	(<0.2)
Clearwater-1	8/19/98	62.91	8.62	9.56	0.15	22.0	20.7	60	*BPQL*	0.6	1.8	3.0	0.4	(<5)	105	17.7	(<0.5)	(<0.5)	(<0.8)	6	0.4	1.1	5.61	2.7	1.09	(<2)	0.47	3.26	32	(<0.2)
Clearwater-2	8/19/98	64.88	8.66	9.57	0.15	22.0		75	*BPQL*	0.7	1.8	3.0	0.4	(<5)	103	17	(<0.5)	(<0.5)	(<0.8)	7	0.4	1.1	5.41	2.6	1.14	(<2)	0.46	3.16	31	(<0.2)
Clearwater-3	8/19/98		8.66	9.59	0.15	21.8		60	*BPQL*	0.6	1.8	3.1	0.4	(<5)	96	16	(<0.5)	(<0.5)	(<0.8)	6	0.4	0.9	5.06	2.4	1.03	(<2)	0.43	2.82	28	(<0.2)
Clearwater-4	8/19/98							75	*BPQL*	0.6	1.8	3.1	0.3	(<5)	102	17.2	(<0.5)	(<0.5)	(<0.8)	6	0.4	1.1	5.42	2.6	1.10	(<2)	0.45	3.18	31	(<0.2)
BF-Whitaker-1	8/19/98	904.01	8.72	11.30	0.26	17.8	25.7	135	0.05	0.8	6.1	1.9	1.2	(<5)	204	30.9	(<0.5)	(<0.5)	(<0.8)	7	0.9	4.0	11.99	1.4	2.63	(<2)	1.78	4.51	91	(<0.2)
BF-Whitaker-2	8/19/98		8.76	11.26	0.26	18.0		110	0.07	0.9	5.9	1.6	1.2	(<5)	199	31	(<0.5)	(<0.5)	(<0.8)	6	0.9	4.0	11.95	1.4	2.60	(<2)	1.74	4.41	91	(<0.2)
BF-Whitaker-2 DUP	8/19/98		8.75	11.25	0.26	17.9		119				1.6																		
BF-Whitaker-3	8/19/98							119	0.06	0.9	6.0	1.6	1.2	(<5)	203	31.6	(<0.5)	(<0.5)	(<0.8)	6	0.9	4.0	12.07	1.5	2.59	(<2)	1.78	4.52	92	(<0.2)
BF-Whitaker-4	8/19/98							120	0.07	0.9	5.9	1.6	1.1	(<5)	188	28.7	(<0.5)	(<0.5)	(<0.8)	5	0.9	3.6	11.15	1.4	2.47	(<2)	1.64	3.90	84	(<0.2)
BF-Whitaker-5	8/19/98							117	0.06	0.9	6.0	1.5	1.2	(<5)	197	30.6	(<0.5)	(<0.5)	(<0.8)	6	0.9	3.9	11.83	1.5	2.59	(<2)	1.73	4.41	90	(<0.2)
BF-Whitaker-6	8/19/98							118	0.07	1.5	5.9	1.7	1.2	(<5)	209	31.6	(<0.5)	(<0.5)	(<0.8)	7	1.0	4.1	12.28	1.7	2.70	(<2)	1.82	4.54	94	0.3
BF-Whitaker-6.5	8/19/98							126	0.07	0.9	5.9	1.5	1.2	(<5)	196	30.2	(<0.5)	(<0.5)	(<0.8)	7	0.9	3.9	11.65	1.5	2.58	(<2)	1.73	4.42	88	(<0.2)
BF-Whitaker-7	8/19/98							121	0.07	1.0	6.0	1.6	1.2	(<5)	206	31.5	(<0.5)	(<0.5)	(<0.8)	7	0.9	4.1	12.11	1.6	2.72	(<2)	1.80	4.55	93	(<0.2)
BF-Whitaker-8	8/19/98							118	0.07	0.9	5.9	1.7	1.2	(<5)	184	28.4	(<0.5)	(<0.5)	(<0.8)	5	0.8	3.6	10.91	1.4	2.47	(<2)	1.61	3.86	82	(<0.2)
BF-Whitaker-9	8/19/98							120	0.06	1.2	6.1	1.6	1.2	(<5)	203	31.3	(<0.5)	(<0.5)	(<0.8)	7	0.9	4.0	12.07	1.7	2.75	(<2)	1.78	4.52	91	(<0.2)
BF-Whitaker-10	8/19/98							123	0.05	0.8	6.0		1.2	(<5)	197	30.4	(<0.5)	(<0.5)	(<0.8)	6	0.9	4.0	11.75	1.6	2.65	(<2)	1.73	4.40	90	(<0.2)
Gold Creek	8/20/98	30.80	8.62	9.67	0.23	17.4	26.4	109	*BPQL*	0.6	2.1	1.2	0.4	(<5)	89	30.2	(<0.5)	(<0.5)	(<0.8)	(<5)	0.4	1.1	8.02	0.6	1.39	(<2)	0.55	4.46	35	(<0.2)
Gold Creek	8/20/98		8.67	9.64	0.23	17.4																								
Gold Creek	8/20/98		8.69	9.68	0.23	17.8																								
Union Cr.	8/19/98	11.85	8.49	9.66	0.39	19.7	24.0	195	*BPQL*	2.0	7.1	3.7	1.4	(<5)	95	40	(<0.5)	(<0.5)	1.1	8	1.8	2.4	18.28	29.9	3.71	(<2)	1.84	7.79	92	(<0.2)
Union Cr.	8/19/98		8.45	9.69	0.39	20.0																								
Union Cr.	8/19/98		8.48	9.68	0.39	20.0																								
Elk Creek	8/20/98	4.61	8.54	9.96	0.33	17.7	27.6	149	*BPQL*	1.1	10.6	3.1	1.0	7.07	32	46	(<0.5)	(<0.5)	(<0.8)	21	2.6	14.2	9.35	5.5	6.20	(<2)	2.99	10.81	118	(<0.2)
Elk Creek	8/20/98		8.56	9.98	0.33	17.7																								
Elk Creek	8/20/98		8.56	9.99	0.33	17.7																								
BF-Marco Flats-1	8/20/98	740	8.79	10.25	0.26	18.2	25.5	125	0.11	0.8	6.3	2.5	1.1	(<5)	195	31.3	(<0.5)	(<0.5)	(<0.8)	5	0.9	3.8	11.75	1.5	2.71	(<2)	1.72	4.07	88	(<0.2)
BF at Marco Flats-1 DU	8/20/98		8.77	10.26	0.26			122																						
BF-Marco Flats-2	8/20/98		8.76	10.23	0.26			121	0.05	0.9	5.9	1.8	1.1	(<5)	196	31.4	(<0.5)	(<0.5)	(<0.8)	5	0.9	3.8	11.77	1.5	2.61	(<2)	1.74	4.08	88	(<0.2)
BF-Marco Flats-3	8/20/98							126	0.07	0.9	5.8	1.6	1.2	(<5)	200	31.3	(<0.5)	(<0.5)	(<0.8)	5	0.9	3.9	11.83	1.6	2.67	(<2)	1.75	4.08	90	(<0.2)
BF-Marco Flats-4	8/20/98							122	0.06	0.9	5.9	1.6	1.1	(<5)	202	31.8	(<0.5)	(<0.5)	(<0.8)	6	1.0	3.9	11.94	1.7	2.79	(<2)	1.74	4.41	91	(<0.2)

Table 10: Sediment data results: corrected for dilution and digest weights

	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Si	Sn	Sr	Ti	V	Zn
Sample Name																											
MHM	5807	553.9	*(<0.5)*	149	*(<0.1)*	11814	115	63	6	2192.6	148178	832	4.0	6732	21318	*(<2)*	24	64.8	805	8702	38342	4033	*(<3)*	24.5	71.9	36	17377
Pass Creek	11305	28.6	4.2	611	1.2	5575	1	11	10	58.0	17026	982	14.4	4896	641.6	*(<2)*	49	12.3	955	57	650	231	*(<3)*	17.8	154	28	187
Porcupine Gulch	12847	36.4	4.6	910	1.4	5360	3	9	10	117.8	21426	1100	9.6	3735	584.5	*(<2)*	46	13.6	974	76	320	258	*(<3)*	24.9	159	37	398
BF ab. Meadow-1	23967	90.0	*(<0.5)*	491	3.2	4730	41	44	8	2142.4	79470	685	4.8	2391	5985	*(<2)*	34	41.2	1148	1912	2602	7592	4	20.0	97.8	39	6671
BF ab Meadow-2	18990	64.7	14.0	506	2.9	4546	29	40	10	1207.0	60660	902	9.5	3993	4398	3.1	40	31.8	934	1197	3834	2946	*(<3)*	20.1	138	54	5975
BF ab meadow cr 3	20069	147.4	32.4	364	4.1	5367	54	52	6	1909.1	98235	954	4.1	2911	7484	2.0	35	42.5	1198	1671	6161	7399	*(<3)*	22.0	81.6	46	8916
BF ab. Meadow 4	12398	31.5	6.8	612	1.9	2594	5.6	23	11	398.9	29088	747	9.6	3689	572.3	2.4	34	22.0	750	271	1661	507	*(<3)*	13.2	163	65	1331
BF ab. Meadow-AVG	18856	83.4	13	493	3.0	4309	32	40	9	1414	66863	822	7.0	3246	4610	2.1	36	34.4	1007	1263	3540	4611	*(<3)*	18.8	120	51	5723
Std. dev.	*4807*	*49*	*14*	*102*	*1*	*1196*	*21*	*12*	*2*	*785*	*29488*	*127*	*3*	*730*	*2972*	*1*	*3*	*10*	*207*	*725*	*1963*	*3477*		*4*	*37*	*11*	*3186*
%RSD	*25*	*59*	*104*	*21*	*30*	*26*	*64*	*31*	*27*	*56*	*44*	*15*	*43*	*22*	*64*	*41*	*9*	*28*	*21*	*57*	*55*	*75*		*21*	*31*	*22*	*56*
Meadow Cr.	21246	72.5	*(<0.5)*	414	*(<0.1)*	4682	42	60	9	1880.4	89225	577	5.8	2798	8896	*(<2)*	27	41.9	1001	2001	4958	6829	*(<3)*	19.1	113	36	8079
BF bel. Meadow 1	10153	67.5	9.2	492	1.8	3585	18	34	7	623.4	42102	765	5.1	2653	3755	*(<2)*	28	22.3	1080	904	1272	1441	*(<3)*	14.5	162	55	3176
BF below meadow-2	14748	72.2	3.0	809	2.2	5249	21	38	10	658.3	51325	977	8.6	4015	3847	*(<2)*	53	26.8	1216	994	2132	1315	*(<3)*	21.9	172	60	3571
BF bl Meadow-3	18260	74.4	13.4	580	2.6	4869	27	42	9	1104.9	56130	986	8.9	3896	4679	2.1	42	30.7	1121	1286	3810	2538	*(<3)*	19.9	158	53	4812
BF bl. Meadow-4	23405	77.8	*(<0.5)*	732	2.2	4866	43	54	10	1897.8	63252	1026	9.5	3539	6006	2.4	41	39.7	1169	1641	3480	3510	4	21.0	138	54	5548
BF bl. Meadow-4	24829	78.2	*(<0.5)*	727	2.5	4506	40	58	9	1752.5	65086	832	8.7	3462	5929	*(<2)*	35	39.8	1188	1607	3468	3555	4	20.4	139	54	5532
BF bl. Meadow-4-avg	24117	78.0	*(<0.5)*	730	2.4	4687	42	56	9	1825.1	64169	929	9.1	3501	5968	2.1	38	39.7	1179	1624	3474	3532	4	20.7	139	54	5540
BF below Meadow d-5	16105	74.7	*(<0.5)*	716	1.7	4078	21	28	10	724.0	45991	917	8.6	3523	3107	*(<2)*	40	26.6	1150	813	2168	1098	*(<3)*	20.0	171	57	3431
BF bel. Meadow-AVG	16681	73.4	6.5	665	2.1	4494	26	39	9	987.2	51943	915	8.1	3518	4271	*(<2)*	40	29.2	1149	1124	2571	1985	*(<3)*	19.4	160	56	4106
Std. Dev	*5112*	*4*	*5.9*	*127*	*0*	*661*	*10*	*11*	*1*	*506*	*8655*	*89*	*2*	*533*	*1101*		*9*	*7*	*52*	*331*	*1048*	*1026*		*3*	*14*	*3*	*1020*
%RSD	*31*	*5*	*92*	*19*	*18*	*15*	*37*	*27*	*15*	*51*	*17*	*10*	*21*	*15*	*26*		*22*	*23*	*5*	*29*	*41*	*52*		*15*	*8*	*5*	*25*
BF ab. Alice	10170	25.5	*(<0.5)*	855	1.4	4319	9.8	38	9	258.6	32048	720	8.8	3447	4901	*(<2)*	35	26.8	863	145	432	651	*(<3)*	15.9	154	42	2273
Alice Cr-1	3436	9.1	*(<0.5)*	304	0.7	6956	*(<1)*	9	6	50.4	13906	398	3.7	2827	666.7	*(<2)*	25	9.5	933	13	215	364	*(<3)*	12.3	111	33	40
Alice Creek-1	3443	9.5	*(<0.5)*	317	0.7	6716	*(<1)*	8	7	49.0	14099	444	3.8	2869	704.0	*(<2)*	31	9.9	936	14	219	387	*(<3)*	12.6	115	33	41
Alice Cr-1 L.Dup	3351	9.0	2.4	300	0.8	6672	*(<1)*	8	7	48.8	13529	476	4.1	3095	687.4	*(<2)*	31	9.6	909	13	217	377	*(<3)*	12.8	114	33	40
Alice Cr-1 avg	3410	9.2	1.0	307	0.7	6835.8	*(<1)*	8	7	49.7	14003	421	3.7	2848	685.3	*(<2)*	28.0	9.7	934.5	13	217	375.5	*(<3)*	12.5	113	33	40
Alice Cr.-2	4033	9.6	*(<0.5)*	337	0.8	7024	*(<1)*	9	8	50.5	15141	534	4.9	3215	672.5	*(<2)*	34	10.7	896	14	236	303	*(<3)*	13.6	113	32	40
Alice Cr.-2 d. dup	3899	7.3	*(<0.5)*	314	*(<0.1)*	6599	*(<1)*	7	8	48.0	13855	608	6.2	3600	686.7	*(<2)*	29	10.7	758	15	245	281	*(<3)*	14.5	106	28	40
Alice Cr.-2 avg	3966	8.5	*(<0.5)*	326	0.4	6811	*(<1)*	8	8	49.2	14498	571	5.5	3407	679.6	*(<2)*	31	10.7	827	14	241	292	*(<3)*	14.0	110	30	40
Alice Cr.-3	4850	9.9	2.2	351	0.9	7115	*(<1)*	10	9	52.1	17569	725	6.7	3880	655.5	*(<2)*	50	12.1	883	15	247	331	*(<3)*	15.1	138	35	44
Alice Cr. 4	4675	8.8	5.4	309	0.8	6253	*(<1)*	10	10	53.3	17171	722	7.3	3774	638.7	*(<2)*	39	12.4	800	13	206	352	*(<3)*	15.0	171	42	43
Alice Cr. AVG	4225	9.1	2.2	323	0.7	6754	*(<1)*	9	8	51.1	15810	610	5.8	3477	664.8	*(<2)*	37	11.2	861	14	228	338	*(<3)*	14.1	133	35	42
Std. Dev.	*664*	*1*	*2.3*	*20*	*0*	*361*		*1*	*1*	*2*	*1820*	*145*	*2*	*466*	*22*		*10*	*1*	*60*	*1*	*19*	*35*		*1*	*28*	*5*	*2*
%RSD	*16*	*7*	*104*	*6*	*33*	*5*		*11*	*16*	*4*	*12*	*24*	*27*	*13*	*3*		*27*	*11*	*7*	*8*	*8*	*10*		*9*	*21*	*15*	*5*
Hardscrabble	5618	9.9	3.4	786	0.9	13602	*(<1)*	3	10	43.0	7822	595	4.3	2766	673.7	*(<2)*	64	6.6	1204	9	1278	271	*(<3)*	44.1	93.1	9	48
BH-1	5297	16.1	*(<0.5)*	490	0.8	6476	4	11	9	83.6	21097	723	5.8	2864	1499	*(<2)*	47	14.9	1326	52	419	563	*(<3)*	24.9	125	38	1034
BH-1	5058	16.5	*(<0.5)*	492	0.8	5943	4	12	8	74.7	21026	608	5.6	2770	1538	*(<2)*	40	15.6	1331	53	413	571	*(<3)*	25.4	124	38	1033
BH-1 avg.	5178	16.3	*(<0.5)*	491	0.8	6210	4	12	8	79.1	21061	665	5.7	2817	1518	*(<2)*	43	15.2	1329	52	416	567	*(<3)*	25.1	125	38	1033
BH-2	5813	14.8	6.1	447	0.9	5995	2	12	9	68.9	20328	715	6.6	3239	1029	*(<2)*	55	14.3	1361	38	317	460	*(<3)*	22.9	142	40	811
BH-3	7423	16.9	*(<0.5)*	504	0.9	5091	3	13	10	94.9	22043	915	9.0	3337	1185	*(<2)*	53	14.8	1255	40	535	422	*(<3)*	23.2	148	35	947
BH 4	6815	19.1	8.0	531	1.1	6168	3	14	12	82.6	22796	911	8.7	3719	1349	*(<2)*	56	16.3	1335	42	435	507	*(<3)*	27.4	151	44	1046
BH -AVG	6307	17	3.6	493	0.9	5866	3	13	10	81	21557	802	7.5	3278	1270	*(<2)*	52	15.2	1320	43	426	489	*(<3)*	24.6	142	39	959
Std. Dev.	*1004*	*2*	*4.0*	*35*	*0*	*525*	*1*	*1*	*1*	*11*	*1084*	*130*	*2*	*371*	*211*		*6*	*1*	*45*	*6*	*89*	*63*		*2*	*12*	*4*	*108*
%RSD	*16*	*11*	*110*	*7*	*12*	*9*	*19*	*7*	*15*	*13*	*5*	*16*	*21*	*11*	*17*		*11*	*5*	*3*	*15*	*21*	*13*		*8*	*8*	*10*	*11*
Hogum Cr.	7853	16.0	3.8	558	1.8	7903	*(<1)*	13	22	22.9	17996	744	9.0	3821	1862	*(<2)*	96	34.7	1525	17	446	453	*(<3)*	155.8	108	23	59
BC 1	6625	16.5	*(<0.5)*	548	1.1	6080	3	14	11	92.9	20242	748	6.6	3051	904.0	*(<2)*	45	16.9	1235	40	459	382	*(<3)*	33.4	130	37	754
BC-2	5978	15.3	*(<0.5)*	395	0.9	6404	2	13	10	78.2	19706	655	6.7	2997	547.1	*(<2)*	43	12.6	1321	36	452	524	*(<3)*	29.4	118	31	509
BC-2 lab dup	5591	14.5	*(<0.5)*	392	1.0	5869	2	13	9	75.4	19268	610	6.7	2950	554.6	*(<2)*	44	13.2	1283	35	437	536	*(<3)*	29.6	118	30	504
BC 2 lab dup	5891	14.9	*(<0.5)*	392	0.9	6014	2	13	9	75.6	19482	715	6.8	3006	557.2	*(<2)*	48	12.8	1304	35	447	545	*(<3)*	29.4	120	31	509
BC-2 Avg	5820	14.9	*(<0.5)*	393	0.9	6095	2	13	9	76.4	19485	660	6.7	2984	553.0	*(<2)*	45	12.9	1303	35	445	535	*(<3)*	29.5	119	31	506
BC 3	6528	16.6	5.4	505	1.1	5651	3	12	11	83.4	19110	877	8.3	3390	963.7	*(<2)*	49	15.6	1291	33	510	411	*(<3)*	30.4	139	35	747
BC 4	8054	18.2	*(<0.5)*	468	1.1	6048	3	14	12	91.0	22521	919	9.7	3763	1183	*(<2)*	55	19.4	1303	43	465	387	*(<3)*	28.2	149	40	615
BC-AVG	6757	16.6	1.5	478	1.0	5969	3	13	11	85.9	20340	801	7.8	3297	900.8	*(<2)*	48	16.2	1283	38	470	429	*(<3)*	30.4	134	36	656
Std. Dev.	*936*	*1*	*2.3*	*66*	*0*	*212*	*1*	*1*	*1*	*8*	*1529*	*119*	*1*	*358*	*261*		*5*	*3*	*32*	*5*	*28*	*72*		*2*	*13*	*4*	*118*
%RSD	*14*	*8*	*150*	*14*	*7*	*4*	*25*	*7*	*11*	*9*	*8*	*15*	*19*	*11*	*29*		*10*	*17*	*3*	*12*	*6*	*17*		*7*	*10*	*11*	*18*
LD-1	4252	13.5	3.4	236	0.6	28646	*(<1)*	6	12	27.8	11734	634	11.4	7881	375.8	*(<2)*	44	9.0	665	16	222	213	*(<3)*	20.8	70.1	15	37
LD 2	6527	14.3	5.5	292	0.8	34695	*(<1)*	7	8	26.0	15719	858	19.4	10502	376.4	*(<2)*	51	9.2	717	18	210	313	*(<3)*	25.8	117	20	43
LD-2 L. DUP	6558	14.1	5.0	290	0.8	34744	*(<1)*	7	8	26.0	15797	866	19.6	10531	376.3	*(<2)*	52	9.2	718	18	206	375	*(<3)*	25.9	118	20	43
Digest Dup LD-2	4013	11.4	*(<0.5)*	220	0.6	35694	*(<1)*	6	5	25.6	12217	525	8.8	7500	377.5	*(<2)*	35	7.1	723	15	147	239	*(<3)*	23.7	73.9	16	36
LD-2 Avg	5699	13.3	3.6	268	0.7	35044	*(<1)*	6	7	25.9	14578	750	16.0	9511	376.7	*(<2)*	46	8.5	720	17	188	309	*(<3)*	25.2	103	19	41
LD-3	5191	12.1	*(<0.5)*	249	0.6	33841	*(<1)*	6	6	31.6	14113	672	13.1	8066	392.3	*(<2)*	41	8.1	687	15	136	297	*(<3)*	22.3	98.3	18	40
LD-3	5085	13.2	6.5	246	0.6	32190	*(<1)*	6	6	28.0	13738	689	13.3	8926	396.1	*(<2)*	46	8.1	689	14	179	328	*(<3)*	22.7	99.0	18	40
LD-3 avg	5138	12.6	3.4	248	0.6	33015		6	6	29.8	13926	680	13.2	8497	394.2	*(<2)*	43	8.1	688	14	157	312	*(<3)*	22.5	98.7	18	40
LD-4	4533	14.4	4.1	232	0.7	33701	*(<1)*	6	6	26.2	12546	631	11.4	8686	393.7	*(<2)*	39	7.7	673	15	202	266	*(<3)*	23.7	86.0	16	37
LD-AVG	4906	13.4	3.6	246	0.7	32602	*(<1)*	6	8	27.4	13196	674	13.0	8639	385.1	*(<2)*	43	8.3	691	15	192	275	*(<3)*	23.0	89.5	17	39
Std. Dev.	*645*	*1*	*0*	*16*	*0*	*2768*		*0*	*3*	*2*	*1291*	*55*	*2*	*672*	*10*		*3*	*1*	*20*	*1*	*27*	*46*		*2*	*15*	*2*	*2*
%RSD	*13*	*5*	*9*	*7*	*8*	*8*		*4*	*38*	*7*	*10*	*8*	*17*	*8*	*3*		*7*	*7*	*3*	*9*	*14*	*17*		*8*	*17*	*9*	*5*
BD-1	5270	15.8	4.5	270	0.8	28168	*(<1)*	7	6	33.3	13885	711	12.8	8099	469.0	*(<2)*	41	8.8	687	16	217	283	*(<3)*	24.2	100	18	96
BD-2	3420	12.9	2.3	219	0.6	28490	*(<1)*	6	4	27.3	11802	524	6.8	7136	438.9	*(<2)*	50	7.0	807	17	260	282	*(<3)*	22.0	77.9	18	126
BD-3	6607	17.3	*(<0.5)*	382	0.9	21234	*(<1)*	10	9	57.9	19092	801	10.9	6204	740.9	*(<2)*	48	12.8	978	29	274	341	*(<3)*	25.4	120	29	345
BD 4	5424	17.0	4.1	342	1.0	20295	*(<1)*	9	8	52.1	16356	764	9.7	6461	715.4	*(<2)*	46	11.1	932	24	310	414	*(<3)*	25.0	118	26	348
BD-AVG	5180	15.8	2.8	303	0.8	24547		8	7	42.7	15284	700	10.0	6975	591.0	*(<2)*	46	9.9	851	21	265	330	*(<3)*	24.1	104	23	229
Std. Dev.	*1317*	*2*	*1.9*	*73*	*0*	*4386*		*2*	*2*	*15*	*3148*	*123*	*3*	*846*	*159*		*4*	*3*	*131*	*6*	*39*	*62*		*2*	*19*	*5*	*136*
%RSD	*25*	*13*	*70*	*24*	*18*	*18*		*25*	*26*	*34*	*21*	*18*	*25*	*12*	*27*		*8*	*26*	*15*	*29*	*15*	*19*		*6*	*19*	*24*	*60*
BF @ Lincoln	6482	17.1	5.0	290	1.0	22781	*(<1)*	8	8	45.9	17899	872	16.1	9111	599.8	*(<2)*	53	11.3	853	20	251	292	*(<3)*	23.5	130	28	186
BF at Ogden Mtn. Rd.	5556	12.9	*(<0.5)*	268	0.6	20224	*(<1)*	7	7	42.5	14104	720	11.4	6870	619.8	*(<2)*	47	9.1	893	18	269	277	*(<3)*	20.9	111	20	93

Arrastra Cr	10665	14.3	6.0	369	0.7	7958	(<1)	9	20	78.8	17840	849	19.5	5804	235.6	(<2)	91	12.2	1046	12	693	273	(<3)	26.5	301	46	67
Arrastra Cr.-L.DUP	10757	14.2	3.2	393	0.7	8381	(<1)	10	22	78.7	19174	831	17.6	5754	245.9	(<2)	98	12.9	1097	11	700	298	(<3)	26.3	308	47	69
Arrastra Cr.-avg	10711	14.2	5	381	0.7	8170	(<1)	9	21	78.7	18507	840	18.6	5779	240.8	(<2)	94	12.5	1072	12	696	286	(<3)	26.4	304	47	68
BF above Nevada 1	4445	11.3	3.8	201	0.6	20255	(<1)	5	6	25.8	10957	657	10.3	7050	570.3	(<2)	44	7.6	820	12	313	216	(<3)	23.0	110	15	53
BF above Nevada 2	3130	11.4	2.5	180	0.6	20070	(<1)	5	5	24.2	8605	484	5.9	6002	545.8	(<2)	37	5.9	830	12	273	265	(<3)	21.6	87.6	13	47
BF ab Nevada-2 d.dup	4258	10.1	(<0.5)	195	0.6	20244	(<1)	5	6	26.2	10802	523	8.4	5995	559.5	(<2)	41	7.5	854	14	255	312	(<3)	22.6	106	14	53
BF ab Nevada-2 avg	3694	10.8	1.4	187	0.6	20157	(<1)	5	5	25.2	9704	504	7.2	5998	552.6	(<2)	39	6.7	842	13	264	289	(<3)	22.1	97	14	50
BF above Nevada 3	3152	10.5	3.0	160	0.5	18620	(<1)	4	5	20.0	8588	477	7.0	6183	395.5	(<2)	34	7.0	962	9	221	169	(<3)	20.0	84.8	15	43
BF ab. Nevada-4	5908	11.4	5.5	271	0.8	20528	(<1)	7	8	37.2	13546	773	12.1	7367	310.7	(<2)	57	9.7	874	16	265	280	(<3)	23.4	119	22	67
BF ab. Nevada-AVG	4300	11.0	3.4	205	0.6	19890	(<1)	5	6	27.0	10699	603	9.1	6649	457.3	(<2)	44	7.7	874	13	266	239	(<3)	22.1	103	16	53
Std. Dev.	*1196*	*0*	*1.7*	*47*	*0*	*861*		*1*	*1*	*7*	*2131*	*138*	*2*	*662*	*125*		*10*	*1*	*63*	*3*	*38*	*56*		*2*	*15*	*4*	*10*
%RSD	*28*	*4*	*50*	*23*	*21*	*4*		*17*	*23*	*27*	*20*	*23*	*27*	*10*	*27*		*22*	*18*	*7*	*22*	*14*	*24*		*7*	*15*	*23*	*19*
Nevada Cr.	4693	7.2	2.6	299	0.9	15600	(<1)	5	8	17.0	7269	921	5.8	4062	613.8	(<2)	132	10.2	1106	8	793	203	(<3)	75.7	114	11	30
	Al	**As**	**B**	**Ba**	**Be**	**Ca**	**Cd**	**Co**	**Cr**	**Cu**	**Fe**	**K**	**Li**	**Mg**	**Mn**	**Mo**	**Na**	**Ni**	**P**	**Pb**	**S**	**Si**	**Sn**	**Sr**	**Ti**	**V**	**Zn**
BF below Nevada 1	5606	10.4	(<0.5)	262	0.7	19722	(<1)	6	8	28.0	12450	746	10.0	6233	591.5	(<2)	59	9.7	949	14	368	217	(<3)	31.1	123	16	55
BF below Nevada 2	5207	12.3	(<0.5)	272	0.7	20384	(<1)	6	7	30.7	12263	734	8.9	5937	521.2	(<2)	61	9.5	932	15	374	265	(<3)	32.2	120	16	54
BF bel. Nevada 3	5317	11.9	4.3	265	0.8	20134	(<1)	6	8	28.4	11539	817	10.9	6870	712.0	(<2)	66	9.0	920	12	409	251	(<3)	31.4	120	15	53
BF below Nevada 4	4933	9.2	(<0.5)	259	0.6	20235	(<1)	6	7	27.1	11434	697	8.5	5883	618.6	(<2)	58	8.6	932	13	411	253	(<3)	28.9	117	14	52
BF bl.Nevada-4	4704	10.2	(<0.5)	242	0.7	20630	(<1)	6	7	27.4	11323	561	8.1	5785	609.3	(<2)	52	9.1	912	14	389	283	(<3)	29.8	118	14	52
BF bl Nevada-4 D.Dup	5709	11.4	5.1	267	0.7	21438	(<1)	7	8	27.1	12910	796	10.6	7114	634.8	(<2)	73	9.7	952	13	428	226	(<3)	30.4	127	16	56
BF bl Nevada-4 avg	5116	10.3	1.9	256	0.7	20768	(<1)	6	7	27.2	11889	685	9.1	6261	620.9	(<2)	61	9.1	932	13	409	254	(<3)	29.7	121	14	54
BF bel. Nevada-AVG	5311	11.2	1.7	264	0.7	20252	(<1)	6	8	28.6	12040	746	9.7	6325	611.4	(<2)	62	9.3	933	13	390	247	(<3)	31.1	121	15	54
Std. Dev.	*213*	*1.0*	*1.9*	*7*	*0*	*439*		*0*	*0*	*1*	*409*	*54*	*1*	*392*	*79*		*3*	*0*	*12*	*1*	*22*	*21*		*1*	*1*	*1*	*1*
%RSD	*4*	*9*	*115*	*3*	*4*	*2*		*2*	*4*	*5*	*3*	*7*	*10*	*6*	*13*		*5*	*3*	*1*	*10*	*6*	*8*		*3*	*1*	*3*	*1*
Northfork-1	6630	34.6	8.3	295	0.7	26733	(<1)	5	8	34.3	19953	844	16.4	9020	295.7	(<2)	95	8.3	935	15	619	453	(<3)	21.9	125	22	42
Northfork-1 L.DUP	6557	34.2	6.2	281	0.8	25168	(<1)	5	9	34.1	19171	861	17.6	8988	284.2	(<2)	90	8.0	896	14	606	470	(<3)	21.7	123	22	41
Northfork-1 avg	6594	34.4	7.2	288	0.8	25950	(<1)	5	8	34.2	19562	852	17.0	9004	289.9	(<2)	93	8.1	916	14	612	462	(<3)	21.8	124	22	42
northfork-2 8/18	6968	59.8	5.3	335	0.8	24519	(<1)	6	9	33.2	27316	979	18.8	9221	335.9	(<2)	113	8.5	834	15	545	802	(<3)	22.0	138	23	40
North Fork 3	5738	12.4	4.5	264	0.7	24206	(<1)	5	8	34.8	11699	702	13.9	8598	313.1	(<2)	47	7.6	800	13	413	282	(<3)	18.0	116	19	39
Northfork 4	5400	11.8	(<0.5)	293	0.6	25500	(<1)	6	6	37.2	11871	586	11.2	7249	425.3	(<2)	43	7.8	795	16	421	234	(<3)	19.2	105	19	40
Northfork-AVG	6175	29.6	4.3	295	0.7	25044	(<1)	6	8	34.8	17612	780	15.2	8518	341.1	(<2)	74	8.0	836	14	498	445	(<3)	20.2	121	21	40
Std. Dev.	*729*	*22.7*	*3.0*	*29*	*0*	*818*		*0*	*1*	*2*	*7436*	*172*	*3*	*884*	*59*		*35*	*0*	*56*	*1*	*97*	*257*		*2*	*14*	*2*	*1*
%RSD	*12*	*77*	*68.3*	*10*	*11*	*3*		*6*	*18*	*5*	*42*	*22*	*22*	*10*	*17*		*47*	*5*	*7*	*7*	*20*	*58*		*10*	*11*	*11*	*3*
Monture Cr 8/98	3089	(<6.5)	(<0.5)	365	0.3	4662	(<1)	3	4	13.1	6879	471	5.0	2389	497.0	(<2)	22	4.1	705	7	518	172	(<3)	12.0	56.6	5	22
BF bel Monture-1	4071	9.9	2.1	323	0.7	15245	(<1)	5	6	18.0	10286	642	7.0	5350	523.0	(<2)	59	7.1	1007	11	592	219	(<3)	19.6	96.5	12	38
BF bel Monture-2	4213	9.6	2.7	331	0.7	14160	(<1)	5	6	20.0	9627	671	6.9	5038	494.8	(<2)	54	6.9	983	10	623	171	(<3)	19.0	87.0	11	38
BF bel. Monture 3	3913	12.4	3.4	239	0.7	23752	(<1)	5	5	27.8	10213	686	6.5	5717	323.1	(<2)	51	7.1	951	15	496	150	(<3)	27.0	94.9	14	43
BF bel. Monture-4	4551	14.6	3.4	268	0.7	21613	(<1)	6	6	26.9	11794	753	8.7	6341	338.0	(<2)	57	8.3	976	12	525	253	(<3)	25.8	99.4	15	44
BF bel Monture-4 d.du	4528	12.1	3.1	241	0.8	23124	(<1)	5	6	27.9	10979	760	8.3	6106	318.0	(<2)	54	7.8	936	14	497	159	(<3)	27.4	99.5	16	45
BF bel. Monture-4 avg	4539	13.3	3	254	0.8	22368	(<1)	6	6	27.4	11387	756	8.5	6223	328.0	(<2)	56	8.0	956	13	511	206	(<3)	26.6	99.5	16	45
BF bel. Monure-AVG	4184	11.3	3	287	0.7	18881	(<1)	5	6	23.3	10428	689	7.2	5582	417.2	(<2)	55	7.3	974	12	556	187	(<3)	23.1	94.5	13	41
Std. Dev.	*266*	*2*	*1*	*47*	*0*	*4878*		*0*	*0*	*5*	*670*	*49*	*1*	*509*	*107*		*4*	*1*	*26*	*2*	*61*	*32*		*4*	*5*	*2*	*4*
%RSD	*6*	*16*	*21*	*16*	*5*	*26*		*3*	*5*	*22*	*6*	*7*	*12*	*9*	*26*		*6*	*7*	*3*	*16*	*11*	*17*		*19*	*6*	*16*	*9*
Clearwater-1	7027	BPQL	2.2	478	1.0	5730	(<1)	4	7	13.6	9566	550	9.9	3502	662.9	(<2)	34	7.4	928	10	1008	223	(<3)	10.9	59.3	7	27
Clearwater-2	6932	BPQL	1.2	512	1.0	6086	(<1)	4	8	13.4	10187	524	8.5	3409	689.3	(<2)	44	7.6	968	11	1021	217	(<3)	10.6	59.9	7	28
Clearwater-3	7559	BPQL	3.4	408	1.0	7346	(<1)	4	8	15.3	10762	608	10.6	3654	404.6	(<2)	42	7.2	1114	10	1628	235	(<3)	12.7	100	7	32
Clearwater-AVG	7173	(<6.5)	2	466	1.0	6387	(<1)	4	8	14.1	10171	561	9.7	3522	586	(<2)	40	7.4	1003	10	1219	225	(<3)	11.4	72.9	7	29
Std. Dev.	*338*		*1*	*53*	*0*	*849*		*0*	*0*	*1*	*598*	*43*	*1*	*124*	*157*		*5*	*0*	*98*	*1*	*355*	*9*		*1*	*23*	*0*	*3*
%RSD	*5*		*49*	*11*	*4*	*13*		*10*	*2*	*7*	*6*	*8*	*11*	*4*	*27*		*14*	*3*	*10*	*9*	*29*	*4*		*10*	*32*	*1*	*10*
Elk Creek	10064	(<6.5)	4.6	254	0.8	14463	(<1)	6	16	17.2	14828	1814	16.7	8297	251.8	(<2)	105	8.6	1243	(<6)	413	605	(<3)	31.1	339	31	37
BF Whitaker-1	5723	11.2	6.0	372	0.8	24171	(<1)	6	8	22.2	11887	951	9.6	6385	561.4	(<2)	97	8.7	1014	12	957	162	(<3)	30.8	117	14	47
BF Whitaker-2	4697	10.9	7.5	357	0.7	24338	(<1)	5	6	20.7	10473	868	7.9	5793	738.4	(<2)	86	7.7	1001	10	917	213	(<3)	30.7	97.1	12	41
BF Whitaker-3	5470	8.8	6.2	335	0.7	18393	(<1)	5	8	21.9	11119	800	11.0	6733	355.7	(<2)	65	8.0	881	10	488	242	(<3)	24.7	128	16	42
BF-Whitaker-4	5605	7.8	1.0	323	0.6	21757	(<1)	6	7	24.2	11804	729	9.4	5865	411.1	(<2)	59	8.4	903	13	577	206	(<3)	25.8	122	15	44
BF-Whitaker-AVG	5374	9.7	5	347	0.7	22165	(<1)	6	7	22.3	11321	837	9.5	6194	517	(<2)	77	8.2	950	11	735	211	(<3)	28.0	116	14	43
Std. Dev.	*463*	*1.7*	*3*	*22*	*0*	*2777*	*(<1)*	*0*	*1*	*1*	*662*	*95*	*1*	*446*	*171*		*18*	*0*	*67*	*1*	*237*	*25*		*3*	*13*	*1*	*3*
%RSD	*9*	*17.1*	*55*	*6*	*8*	*13*		*6*	*11*	*7*	*6*	*11*	*14*	*7*	*33*		*23*	*6*	*7*	*12*	*32*	*12*		*11*	*12*	*11*	*6*
Union Cr.	8463	6.7	2.6	322	1.1	7704	(<1)	8	8	28.8	10523	1076	5.8	3757	1880	(<2)	78	11.1	645	17	737	229	(<3)	19.9	120	12	67
Gold Cr.	7244	6.4	3.1	291	0.8	8988	(<1)	5	7	14.6	8690	493	11.0	3600	442.3	12.3	37	6.5	920	(<6)	835	198	(<3)	10.8	81.8	6	24
BF @ Marco 1	3478	8.7	2.4	183	0.5	17881	(<1)	4	5	17.2	8785	511	7.0	5391	224.0	(<2)	41	5.9	986	8	317	196	(<3)	20.5	99.0	18	33
BF at Marco-2	4121	8.9	3.4	225	0.6	16983	(<1)	5	6	19.3	9530	648	8.1	5758	263.6	(<2)	48	6.4	928	9	421	234	(<3)	20.5	108	14	37
BF @ Marco 3	3112	7.8	5.5	203	0.6	19356	(<1)	4	5	17.1	7402	564	5.0	4767	243.2	(<2)	53	5.1	927	9	658	210	(<3)	22.8	86.0	11	32
BF at Marco 4 D.D.	3265	7.1	(<0.5)	172	0.4	14702	(<1)	4	5	16.2	8552	476	5.6	4643	193.2	(<2)	37	5.5	979	10	300	160	(<3)	16.9	92.8	15	32
BF at Marco-4	2940	7.8	3.6	164	0.4	15207	(<1)	4	4	16.3	7884	465	5.1	4921	192.7	(<2)	43	5.1	996	8	309	182	(<3)	17.1	87.7	13	31
BF at Marco-4 L.DUP	2905	7.3	2.4	158	0.5	14613	(<1)	4	5	16.1	7675	462	5.4	4911	187.5	(<2)	36	4.9	969	8	308	185	(<3)	17.0	86.5	14	30
BFat Marco-4 avg	3037	7.4	2.1	165	0.5	14841	(<1)	4	4	16.2	8037	468	5.4	4825	191	(<2)	39	5.1	981	9	306	176	(<3)	17.0	89.0	14	31
BF at Marco-AVG	3437	8.2	3.3	194	0.5	17265	(<1)	4	5	17.4	8439	548	6.4	5185	230	(<2)	45	5.6	956	9	425	204	(<3)	20.2	95.5	14	33
Std. Dev.	*495*	*0.7*	*2*	*26*	*0*	*1889*		*0*	*1*	*1*	*921*	*78*	*1*	*474*	*31*		*7*	*1*	*32*	*0*	*164*	*25*		*2*	*10*	*3*	*3*
%RSD	*14*	*8.7*	*46*	*13*	*12*	*11*		*9*	*12*	*7*	*11*	*14*	*23*	*9*	*13*		*15*	*11*	*3*	*2*	*38*	*12*		*12*	*11*	*19*	*9*

Table 11: PEARSON'S CORRELATIONS OF MEASURED WATER PARAMETERS

BFR headwater sites: River km 212.5 to 193.2 (*n*=5)

		H+	Cond.	Org. C.	Alk.	Sulfate	As	Ba	Ca	Fe	K	Li	Mg	Mn	Na	Si	Sr
Q	*r*	-0.673	-0.805	0.632	0.698	-0.794	0.821	0.867	0.305	0.292	0.060	0.409	-0.971**	-0.892*	-0.594	0.369	0.921*
	p-value	0.213	0.100	0.252	0.190	0.108	0.088	0.057	0.617	0.634	0.924	0.494	0.006	0.042	0.291	0.541	0.026
H+	*r*		0.889*	-0.435	-0.889*	0.888*	-0.776	-0.863	0.495	0.062	0.630	0.287	0.68	0.908*	0.940*	0.3	-0.514
	p-value		0.043	0.464	0.044	0.044	0.123	0.059	0.397	0.921	0.255	0.64	0.207	0.033	0.017	0.624	0.376
Cond.	*r*			-0.488	-0.963**	0.995**	-0.915*	-0.975**	0.225	-0.029	0.527	0.15	0.743	0.974**	0.933*	0.22	-0.705
	p-value			0.405	0.009	0.000	0.029	0.005	0.715	0.963	0.362	0.81	0.15	0.005	0.021	0.722	0.184
Org. C.	*r*				0.242	-0.406	0.214	0.686	0.124	0.869	0.120	-0.015	-0.766	-0.603	-0.467	0.499	0.303
	p-value				0.695	0.497	0.73	0.219	0.842	0.056	0.847	0.981	0.131	0.281	0.428	0.393	0.62
Alk.	*r*					-0.982**	0.946*	0.881*	-0.331	-0.241	-0.643	-0.182	-0.599	-0.906*	-0.911*	-0.407	0.675
	p-value					0.003	0.015	0.048	0.587	0.696	0.242	0.769	0.285	0.034	0.031	0.496	0.211
Sulfate	*r*						-0.945*	-0.952*	0.228	0.062	0.542	0.124	0.715	0.962**	0.919*	0.26	-0.728
	p-value						0.015	0.013	0.712	0.921	0.345	0.843	0.174	0.009	0.027	0.673	0.163
As	*r*							0.847	-0.028	-0.229	-0.382	0.142	-0.694	-0.888*	-0.753	-0.18	0.87
	p-value							0.070	0.965	0.711	0.526	0.82	0.194	0.04	0.142	0.772	0.055
Ba	*r*								-0.128	0.243	-0.39	-0.91	-0.845	-0.987**	-0.900*	-0.035	0.706
	p-value								0.838	0.693	0.516	0.884	0.072	0.002	0.038	0.95	0.183
Ca	*r*									0.357	0.899*	0.898*	-0.259	0.137	0.543	0.823	0.439
	p-value									0.555	0.038	0.038	0.674	0.826	0.344	0.087	0.460
Fe	*r*										0.453	0.092	-0.449	-0.149	-0.003	0.694	-0.001
	p-value										0.443	0.883	0.449	0.810	0.996	0.193	0.999
K	*r*											0.821	-0.103	0.386	0.742	0.911*	0.121
	p-value											0.089	0.869	0.521	0.151	0.032	0.846
Li	*r*												-0.353	0.029	0.467	0.755	0.590
	p-value												0.560	0.963	0.428	0.140	0.295
Mg	*r*													0.857	0.581	-0.46	-0.812
	p-value													0.057	0.304	0.436	0.095
Mn	*r*														0.893*	0.037	-0.755
	p-value														0.041	0.953	0.140
Na	*r*															0.423	-0.42
	p-value															0.478	0.481
Si	*r*																0.298
	p-value																0.627

BFR below the headwaters: River km 187.7 to 6 (*n*=9)

		Q	H+	Cond.	Org. C.	Alk.	Sulfate	As	Ba	Ca	Fe	K	Li	Mg	Mn	Na	Si
H+	*r*	-0.825**															
	p-value	0.006															
Cond.	*r*	-0.218	-0.057														
	p-value	0.574	0.883														
Org. C.	*r*	0.632	-0.750*	-0.105													
	p-value	0.068	0.020	0.788													
Alk.	*r*	-0.115	-0.031	0.843**	-0.261												
	p-value	0.768	0.937	0.004	0.497												
Sulfate	*r*	-0.414	0.187	-0.335	0.230	-0.494											
	p-value	0.268	0.630	0.3779	0.551	0.176											
As	*r*	0.315	-0.531	0.627	0.569	0.451	-0.112										
	p-value	0.409	0.141	0.071	0.11	0.223	0.775										
Ba	*r*	-0.763*	0.838**	0.216	-0.953**	0.316	-0.192	-0.501									
	p-value	0.017	0.005	0.576	0.000	0.408	0.621	0.169									
Ca	*r*	-0.201	0.065	0.941**	-0.188	0.875**	-0.427	0.610	0.284								
	p-value	0.605	0.869	0.000	0.629	0.002	0.252	0.081	0.459								
Fe	*r*	-0.36	-0.095	0.402	-0.025	0.241	0.456	0.372	-0.023	0.317							
	p-value	0.341	0.808	0.283	0.950	0.532	0.217	0.324	0.953	0.407							
K	*r*	0.3	-0.605	0.471	0.755*	0.262	0.207	0.917**	-0.681*	0.392	0.457						
	p-value	0.433	0.084	0.201	0.019	0.496	0.593	0.000	0.043	0.297	0.216						
Li	*r*	0.551	-0.749*	0.463	0.768*	0.325	-0.087	0.939**	-0.734*	0.412	0.262	0.944**					
	p-value	0.124	0.200	0.209	0.016	0.393	0.823	0.000	0.024	0.27	0.496	0.000					
Mg	*r*	0.336	-0.318	0.626	0.070	0.729*	-0.621	0.712*	-0.092	0.776*	0.161	0.448	0.608				
	p-value	0.377	0.405	0.071	0.858	0.026	0.074	0.031	0.814	0.014	0.679	0.226	0.082				
Mn	*r*	-0.137	-0.207	0.802**	0.180	0.525	-0.012	0.842**	-0.107	0.764*	0.684*	0.736*	0.661	0.622			
	p-value	0.726	0.593	0.009	0.642	0.147	0.976	0.004	0.785	0.016	0.042	0.024	0.053	0.073			
Na	*r*	0.447	-0.673*	0.122	0.911**	-0.047	0.34	0.774*	-0.858**	0.036	0.277	0.926**	0.878**	0.219	0.466		
	p-value	0.228	0.047	0.754	0.001	0.904	0.371	0.014	0.003	0.926	0.471	0.000	0.002	0.572	0.206		
Si	*r*	-0.64	0.223	0.454	-0.036	0.207	0.649	0.341	0.119	0.358	0.847**	0.461	0.179	-0.037	0.655	0.289	
	p-value	0.063	0.563	0.220	0.926	0.593	0.058	0.369	0.761	0.345	0.004	0.211	0.645	0.925	0.055	0.450	
Sr	*r*	-0.439	0.054	0.251	0.231	0.050	0.793*	0.379	-0.167	0.173	0.799**	0.59	0.306	-0.084	0.55	0.511	0.935**
	p-value	0.238	0.890	0.515	0.549	0.898	0.011	0.315	0.667	0.656	0.010	0.094	0.423	0.829	0.125	0.160	0.000

Table 12. Blackfoot River Basinwide sampling event: August, 1998. Water load results

	River Km	Discharge (cfs)	$CaCO_3$ (mg/L)	$CaCO_3$ Load (Kg/day)	Sulfate (mg/L)	Sulfate Load (Kg/day)	As (µg/L)	As Load (Kg/day)	Al (µg/L)	Al Load (Kg/day)	Ba (µg/L)	Ba Load (Kg/day)	Ca (mg/L)	Ca Load (Kg/day)	Cd (µg/L)	Cd Load (Kg/day)	Co (µg/L)	Co Load (Kg/day)	Cu (µg/L)
	PQL		1.0		2.00		0.2		5		1		0.01		0.5		0.5		0.8
Samples																			
BLACKFOOT MAINSTEM																			
MHM	**212.5**	3.5	86	737.5	48.2	412.5	0.2	0.002	(<5)		143	1.2	25.14	215.0	2.6	0.02	(<0.5)		3.6
BF ab. Meadow	**210.0**	5.8	46	646.7	88.8	1254.8	(<0.2)		10	0.15	103	1.4	26.85	379.5	2.1	0.03	0.9	0.01	4.0
BF bel. Meadow	**209.8**	7.4	51	917.6	87.4	1586.1	(<0.2)		10	0.19	103	1.9	26.00	472.0	1.8	0.03	0.7	0.01	3.9
BF ab. Alice Cr.	**203.3**	16	78	2956.4	44.3	1689.4	0.2	0.007	(<5)		198	7.6	25.53	973.9	0.6	0.02	(<0.5)		0.9
BF ab. Hogum (BH)	**193.2**	33	104	8305.6	13.3	1066.3	0.4	0.033	(<5)		228	18.3	26.47	2118.6	(<0.5)		(<0.5)		0.5
BF ab. Lander's (BC)	**187.7**	38	104	9788.7	12.8	1197.9	0.4	0.039	(<5)		213	20.0	26.04	2444.8	(<0.5)		(<0.5)		(<0.8)
BF bel. Lander's (BD)	**186.6**	109	131	35006.0	6.6	1755.7	0.5	0.136	(<5)		232	62.1	30.72	8208.4	(<0.5)		(<0.5)		(<0.8)
BF at Lincoln	**175.9**	54	120	15896.6	6.6	870.1	0.5	0.070	(<5)		232	30.7	35.59	4714.7	(<0.5)		(<0.5)		(<0.8)
BF at Ogden	**153.3**	207	170	86290.5	5.7	2899.2	1.1	0.535	(<5)		228	115.7	42.84	21745.2	(<0.5)		(<0.5)		(<0.8)
BF ab. Nevada	**117.6**	239	144	84274.9	5.5	3222.7	1.5	0.854	(<5)		224	131.2	41.45	24300.5	(<0.5)		(<0.5)		(<0.8)
BF bel. Nevada	**108.5**	262	143	91540.6	9.3	5942.2	2.3	1.504	(<5)		203	130.2	41.01	26341.2	(<0.5)		(<0.5)		(<0.8)
BF bel. Monture Cr.	**74.4**	627	130	199503.6	6.6	10150.1	1.3	1.938	(<5)		209	320.9	33.27	51132.4	(<0.5)		(<0.5)		(<0.8)
BF-Whitaker	**30.3**	904	121	266886.4	6.0	13233.3	1.2	2.613	(<5)		199	440.1	30.56	67684.0	(<0.5)		(<0.5)		(<0.8)
BF at Marco	**6**	727	123	219437.7	6.0	10634.9	1.1	1.987	(<5)		198	353.1	31.47	56043.9	(<0.5)		(<0.5)		(<0.8)
TRIBUTARIES																			
Pass Creek	**210.8**	0.5	80	95.1	4.3	5.1	0.9	0.00	(<5)		215	0.3	18.52	22.0	(<0.5)		(<0.5)		(<0.8)
Meadow Cr.	**209.8**	1.7	45	181.9	85.6	346.1	0.1	0.00	6	0.03	98	0.4	25.99	105.1	1.9	0.01	0.6	0.00	3.7
Alice Creek	**198.1**	15	110	4106.5	2.8	106.4	0.4	0.01	(<5)		281	10.5	27.36	1021.4	0.5		(<0.5)		(<0.8)
Hardscrabble Cr.	**196.6**	1.2	155	448.1	1.6	4.7	1.0	0.00	(<5)		385	1.1	39.26	113.5	(<0.5)		(<0.5)		(<0.8)
Hogum Cr.	**192.4**	2.8	80	541.0	4.9	33.2	1.1	0.01	(<5)		138	0.9	18.93	128.0	(<0.5)		(<0.5)		(<0.8)
Lander's Fork (LD)	**187.2**	72	132	23358.8	2.9	514.2	0.5	0.09	(<5)		245	43.2	33.43	5904.0	(<0.5)		(<0.5)		(<0.8)
Arrastra Cr.	**131.1**	23	90	5137.7	2.7	153.0	0.4	0.02	(<5)		100	5.7	24.52	1399.4	(<0.5)		(<0.5)		(<0.8)
Nevada Cr.	**109.1**	42	158	16202.9	28.0	2882.6	7.9	0.81	(<5)		121	12.4	42.86	4408.7	(<0.5)		(<0.5)		(<0.8)
Northfork	**87.1**	220	135	72765.0	4.0	2166.9	0.7	0.38	(<5)		229	123.4	30.99	16704.3	(<0.5)		(<0.5)		(<0.8)
Monture Cr.	**74.8**	65	91	14478.4	3.8	597.7	0.8	0.12	(<5)		245	38.9	21.29	3387.7	(<0.5)		(<0.5)		(<0.8)
Clearwater	**65.8**	64	68	10566.6	1.8	281.8	0.4	0.05	(<5)		102	15.9	16.97	2655.7	(<0.5)		(<0.5)		(<0.8)
Elk Creek	**46.5**	4.6	149	1682.9	10.6	120.1	1.0	0.01	7	0.08	32	0.4	46.01	519.7	(<0.5)		(<0.5)		(<0.8)
Gold Creek	**21.8**	31	109	8225.1	2.1	158.9	0.4	0.03	(<5)		89	6.7	30.24	2281.9	(<0.5)		(<0.5)		(<0.8)
Union Cr.	**20.8**	12	195	5661.3	7.1	206.9	1.4	0.04	(<5)		95	2.8	40.01	1161.6	(<0.5)		(<0.5)		1.1

Cu Load (Kg/day)	Fe (µg/L)	Fe Load (Kg/day)	K (mg/L)	K Load (Kg/day)	Li (µg/L)	Li Load (Kg/day)	Mg (mg/L)	Mg Load (Kg/day)	Mn (µg/L)	Mn Load (Kg/day)	Na (mg/L)	Na Load (Kg/day)	Ni (µg/L)	Ni Load (Kg/day)	S (mg/L)	S Load (Kg/day)	Si (mg/L)	Si Load (Kg/day)	Sr (µg/L)	Sr Load (Kg/day)	Zn (µg/L)	Zn Load (Kg/day)
	5		0.10		0.5		0.01		0.3		0.15		2		0.02		0.02		2		0.2	
0.03	5	0.04	0.6	5.0	1.3	0.01	14.42	123.3	157.4	1.35	2.39	20.4	(<2)		14.25	121.8	3.66	31.3	73	0.6	535.3	4.58
0.06	27	0.38	0.9	13.4	2.1	0.03	14.05	198.6	244.8	3.46	4.13	58.4	3	0.04	25.95	366.8	6.79	96.0	76	1.1	762.1	10.77
0.07	20	0.37	0.9	16.0	2.0	0.04	13.47	244.5	209.5	3.80	3.68	66.7	2	0.05	24.33	441.8	6.63	120.3	73	1.3	681.2	12.37
0.04	37	1.41	0.7	27.4	1.3	0.05	12.56	479.2	81.8	3.12	1.95	74.4	(<2)		13.13	500.8	5.96	227.4	74	2.8	84.2	3.21
	21	1.71	0.8	64.5	2.2	0.18	11.40	912.4	2.5	0.20	2.00	160.1	(<2)		4.02	321.8	6.50	520.6	110	8.8	1.6	0.13
	16	1.47	0.8	76.0	2.6	0.25	10.80	1013.8	1.0	0.10	2.29	214.8	(<2)		3.72	349.4	6.79	638.0	140	13.2	0.6	0.05
	7	1.76	0.6	162.6	2.4	0.63	11.38	3040.3	0.5	0.13	1.36	364.1	(<2)		1.95	520.9	4.97	1329.0	89	23.8	(<0.2)	
	(<5)		0.6	82.8	2.4	0.31	11.49	1522.1	1.2	0.16	1.16	153.7	(<2)		1.97	261.4	4.97	658.5	91	12.1	(<0.2)	
	11	5.52	0.8	430.9	3.4	1.71	12.32	6253.5	3.3	1.69	1.68	852.8	(<2)		1.76	891.3	5.79	2937.4	110	55.6	(<0.2)	
	18	10.32	0.9	515.8	3.5	2.06	12.58	7375.2	7.6	4.45	1.77	1037.7	(<2)		1.67	980.7	6.16	3611.1	110	64.5	(<0.2)	
	14	9.12	1.3	837.8	4.9	3.17	12.21	7840.4	8.6	5.51	3.89	2495.7	(<2)		2.73	1754.9	7.19	4616.2	142	91.0	(<0.2)	
	6	9.74	0.9	1325.1	3.6	5.53	12.46	19147.3	1.6	2.53	2.48	3815.6	(<2)		1.91	2935.7	4.53	6962.3	99	152.3	(<0.2)	
	6	14.17	0.9	1988.6	3.9	8.69	11.80	26126.9	1.5	3.35	2.61	5787.7	(<2)		1.74	3853.4	4.37	9674.2	90	198.3	(<0.2)	
	5	9.53	0.9	1654.2	3.9	6.88	11.82	21057.6	1.6	2.78	2.70	4800.2	(<2)		1.73	3089.4	4.16	7408.7	89	159.0	(<0.2)	
	5	0.01	0.4	0.5	0.8	0.00	7.35	8.7	3.2	0.00	2.01	2.4	(<2)		1.28	1.5	5.14	6.1	55	0.1	0.4	0.00
0.01	18	0.07	0.9	3.7	2.0	0.01	13.51	54.6	191.7	0.77	3.82	15.4	2	0.01	24.56	99.3	6.51	26.3	74	0.3	670.9	2.71
	19	0.72	0.7	24.9	2.3	0.09	11.18	417.2	2.3	0.09	1.63	60.9	(<2)		0.84	31.5	5.41	202.1	73	2.7	(<0.2)	
	32	0.09	1.7	4.9	6.4	0.02	14.59	42.2	1.6	0.00	3.26	9.4	(<2)		0.49	1.4	9.82	28.4	130	0.4	(<0.2)	
	168	1.14	0.9	5.9	4.4	0.03	6.19	41.9	10.9	0.07	4.57	30.9	(<2)		1.38	9.3	9.64	65.2	416	2.8	(<0.2)	
	(<5)		0.5	84.9	2.2	0.39	11.69	2063.6	(<0.3)		0.87	154.5	(<2)		0.87	153.1	3.79	668.5	55	9.8	(<0.2)	
	(<5)		0.4	25.1	2.0	0.11	9.84	561.8	0.7	0.04	1.30	74.2	(<2)		0.76	43.2	4.69	267.8	73	4.2	(<0.2)	
	18	1.83	3.2	331.2	11.7	1.20	10.98	1129.6	18.2	1.87	13.35	1373.4	(<2)		8.19	842.0	12.58	1294.2	293	30.2	(<0.2)	
	(<5)		0.5	262.2	2.0	1.10	13.91	7499.5	0.6	0.30	0.97	523.2	(<2)		1.22	656.0	3.92	2115.5	65	35.0	(<0.2)	
	15	2.42	0.6	95.1	2.5	0.39	9.33	1484.8	2.8	0.45	1.31	207.6	(<2)		1.11	177.0	3.53	561.0	60	9.6	(<0.2)	
	6	0.96	0.4	62.8	1.1	0.16	5.38	841.5	2.6	0.40	1.09	170.6	(<2)		0.45	70.7	3.10	485.5	30	4.8	(<0.2)	
	21	0.24	2.6	29.2	14.2	0.16	9.35	105.6	5.5	0.06	6.20	70.0	(<2)		2.99	33.8	10.81	122.1	118	1.3	(<0.2)	
	(<5)		0.4	31.8	1.1	0.09	8.02	605.2	0.6	0.04	1.39	104.5	(<2)		0.55	41.7	4.46	336.8	35	2.7	(<0.2)	
0.03	8	0.22	1.8	52.4	2.4	0.07	18.28	530.7	29.9	0.87	3.71	107.7	(<2)		1.84	53.4	7.79	226.3	92	2.7	(<0.2)	

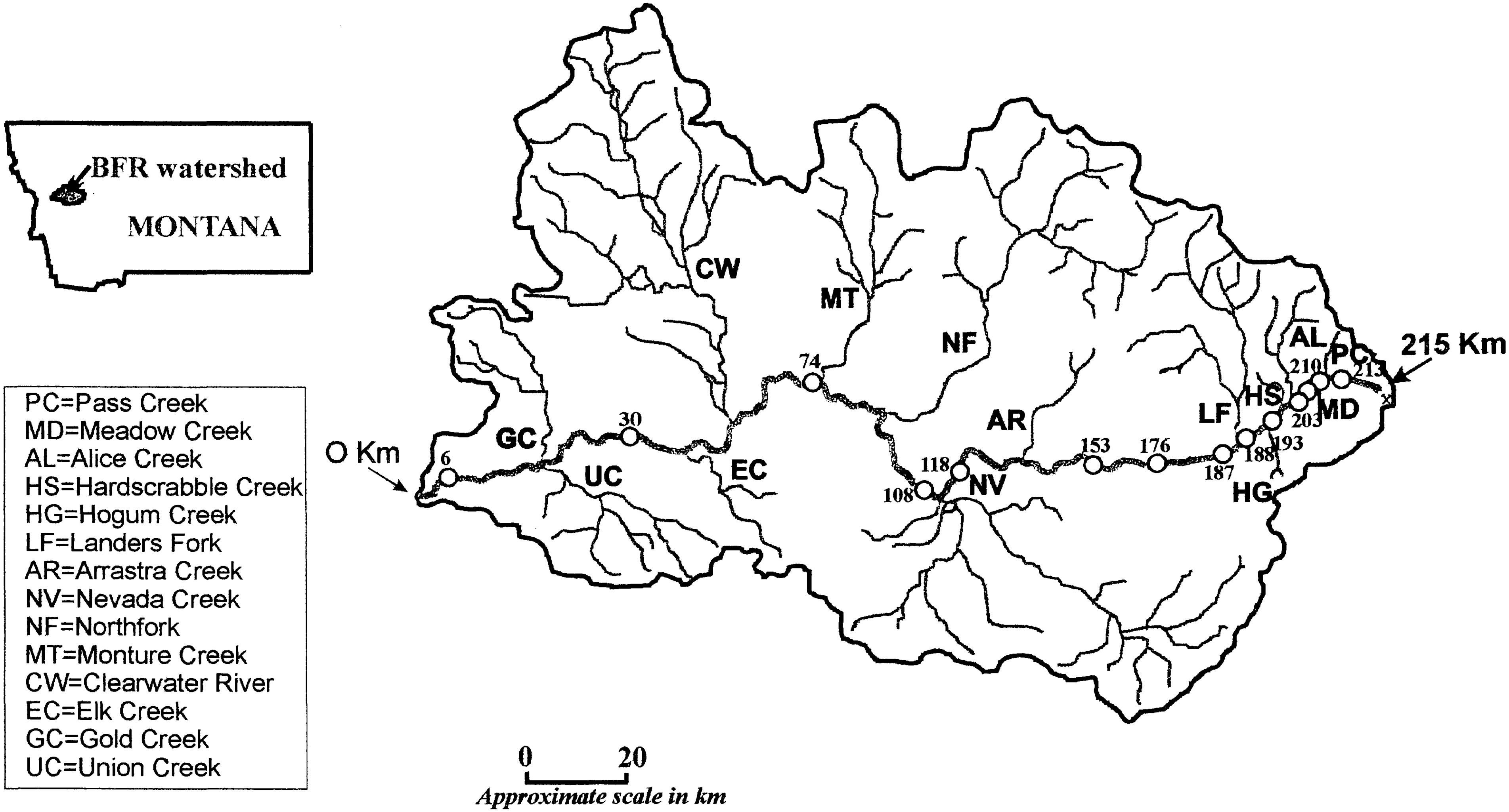


Figure 1: Map of the Blackfoot River watershed with mainstem sampling sites (indicated by circles and river km designations) and sampled tributaries (indicated by name abbreviations).

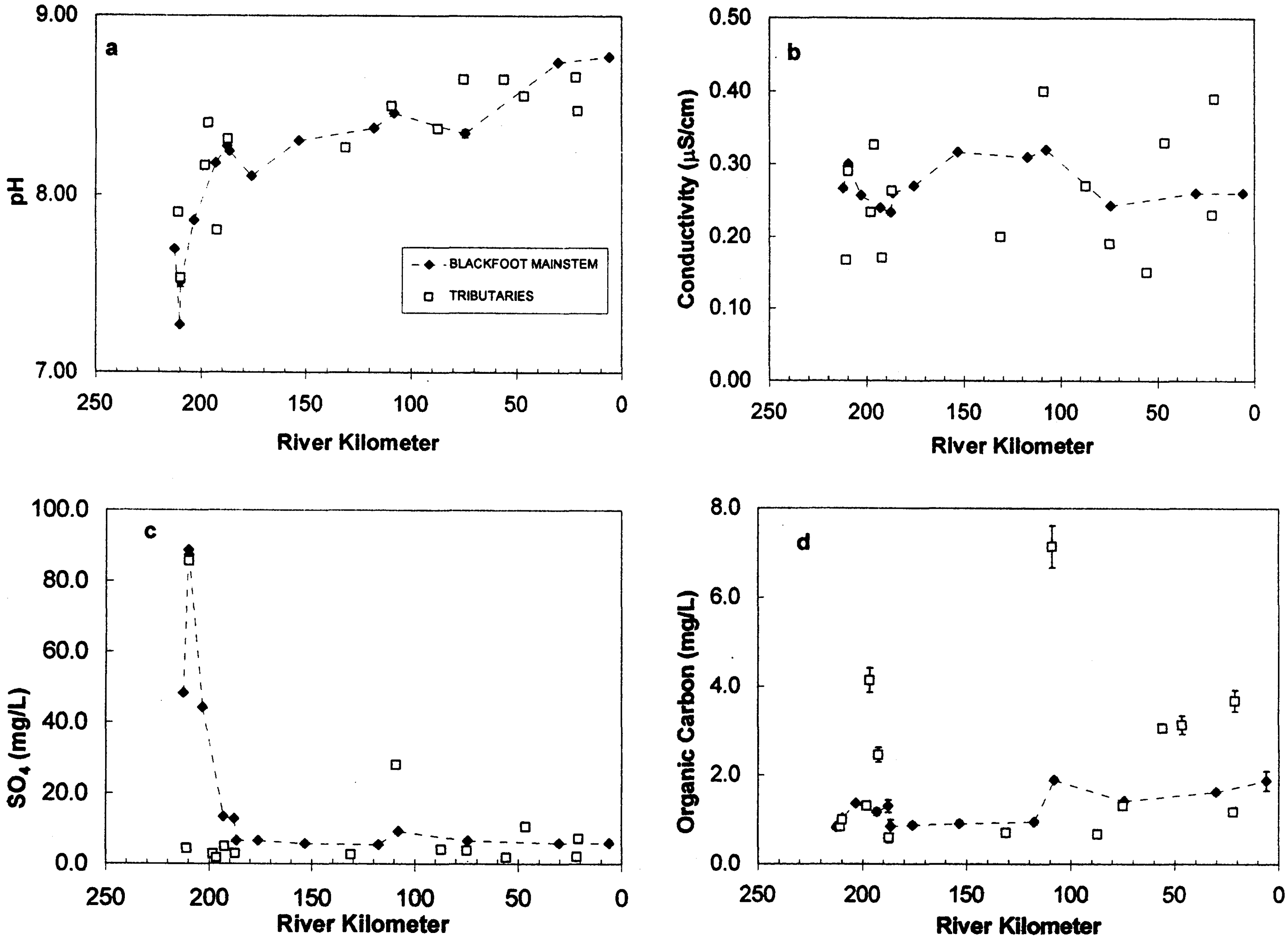
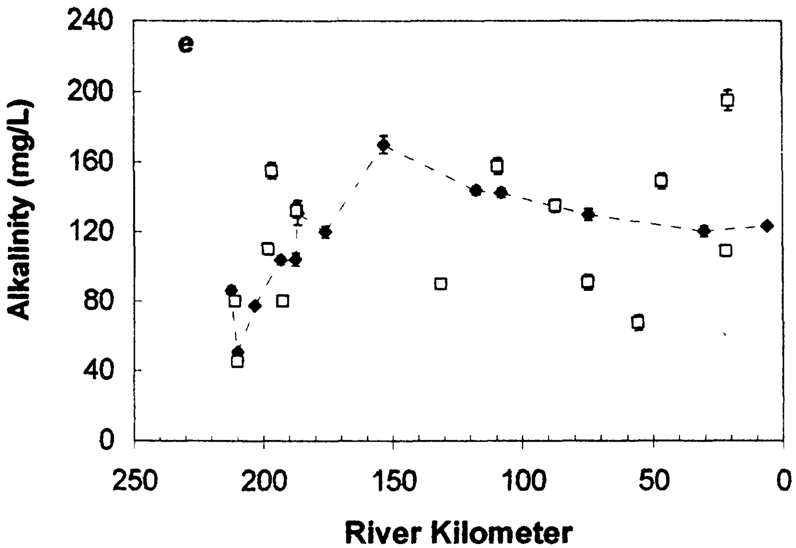
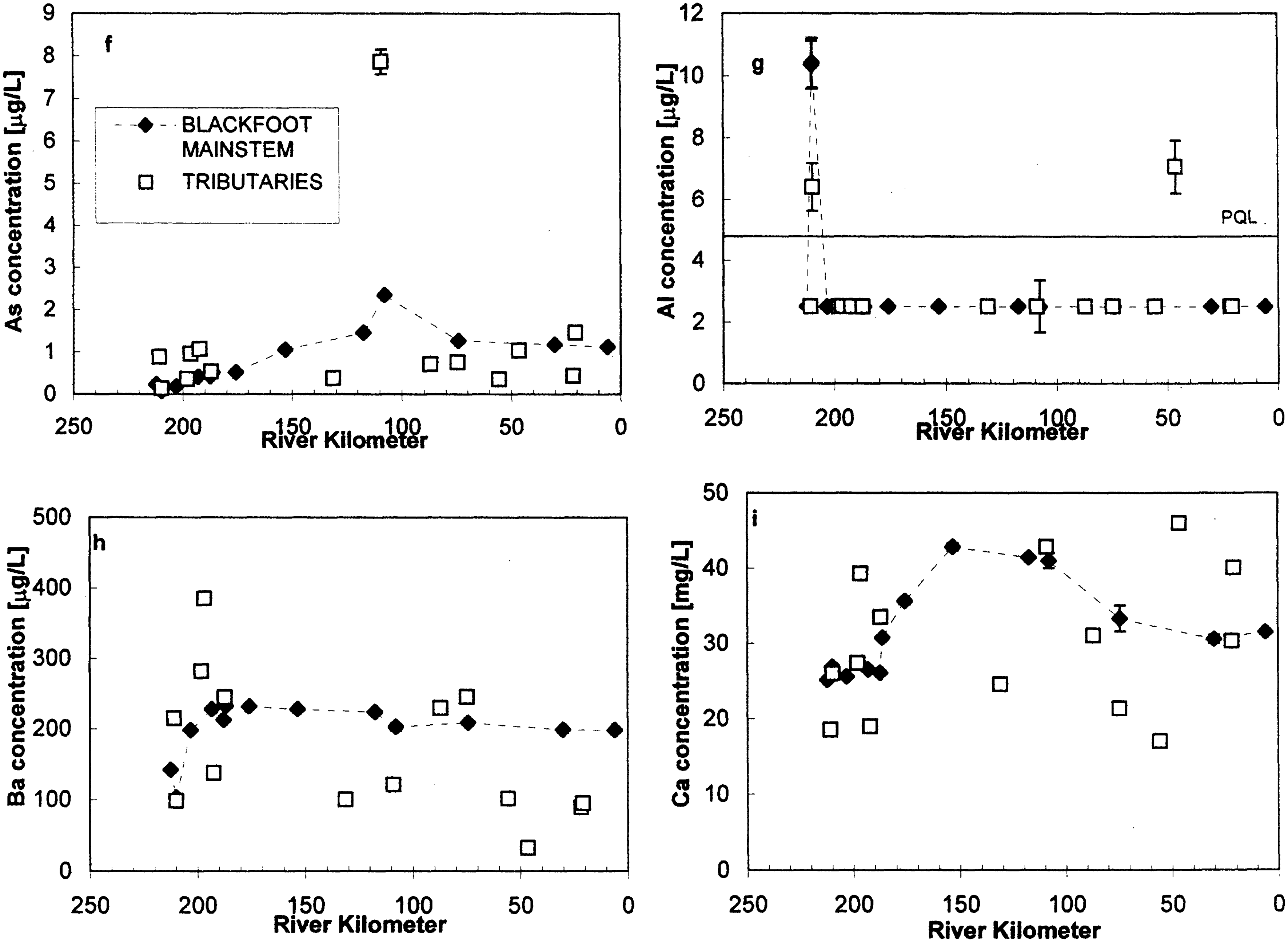
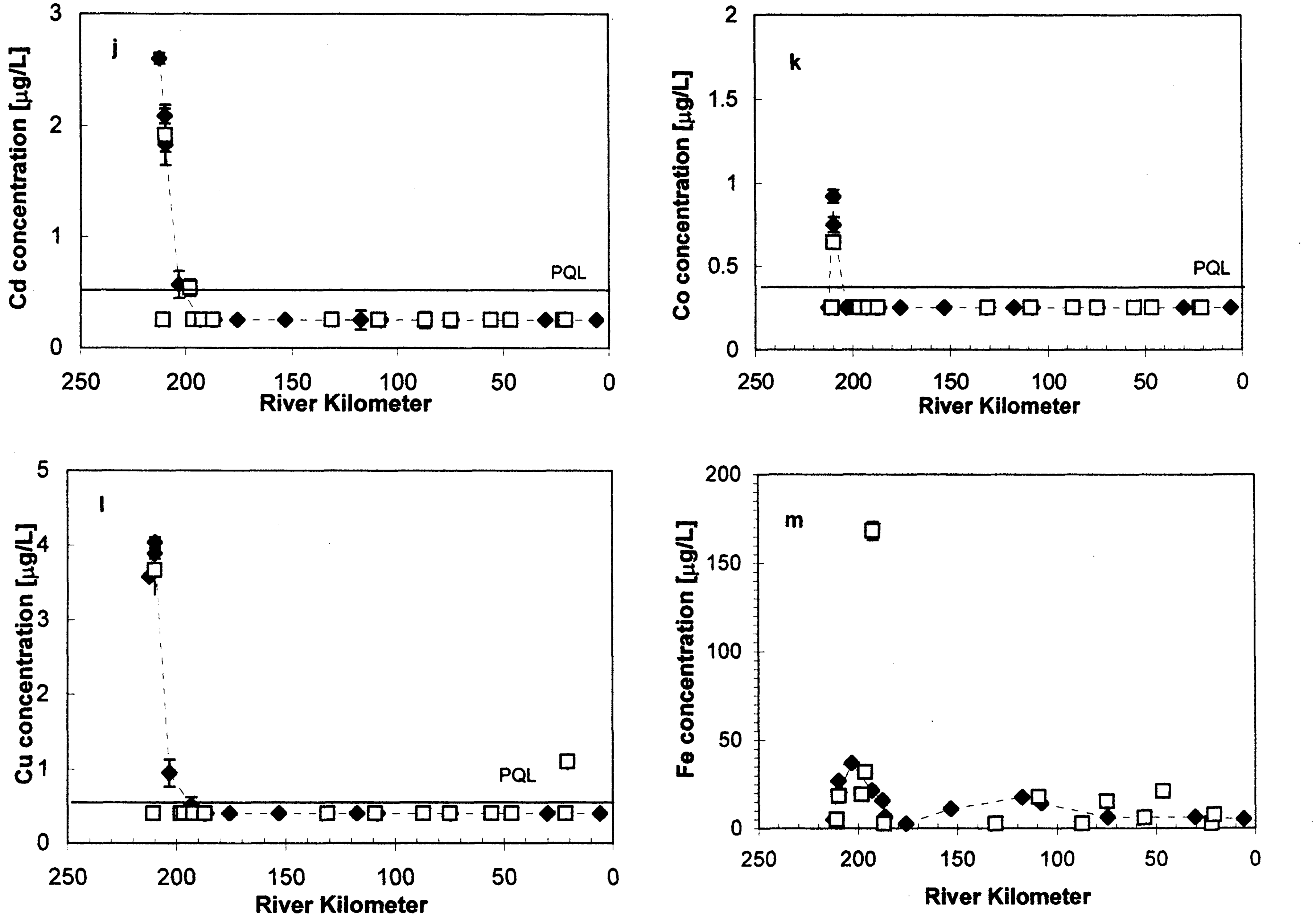


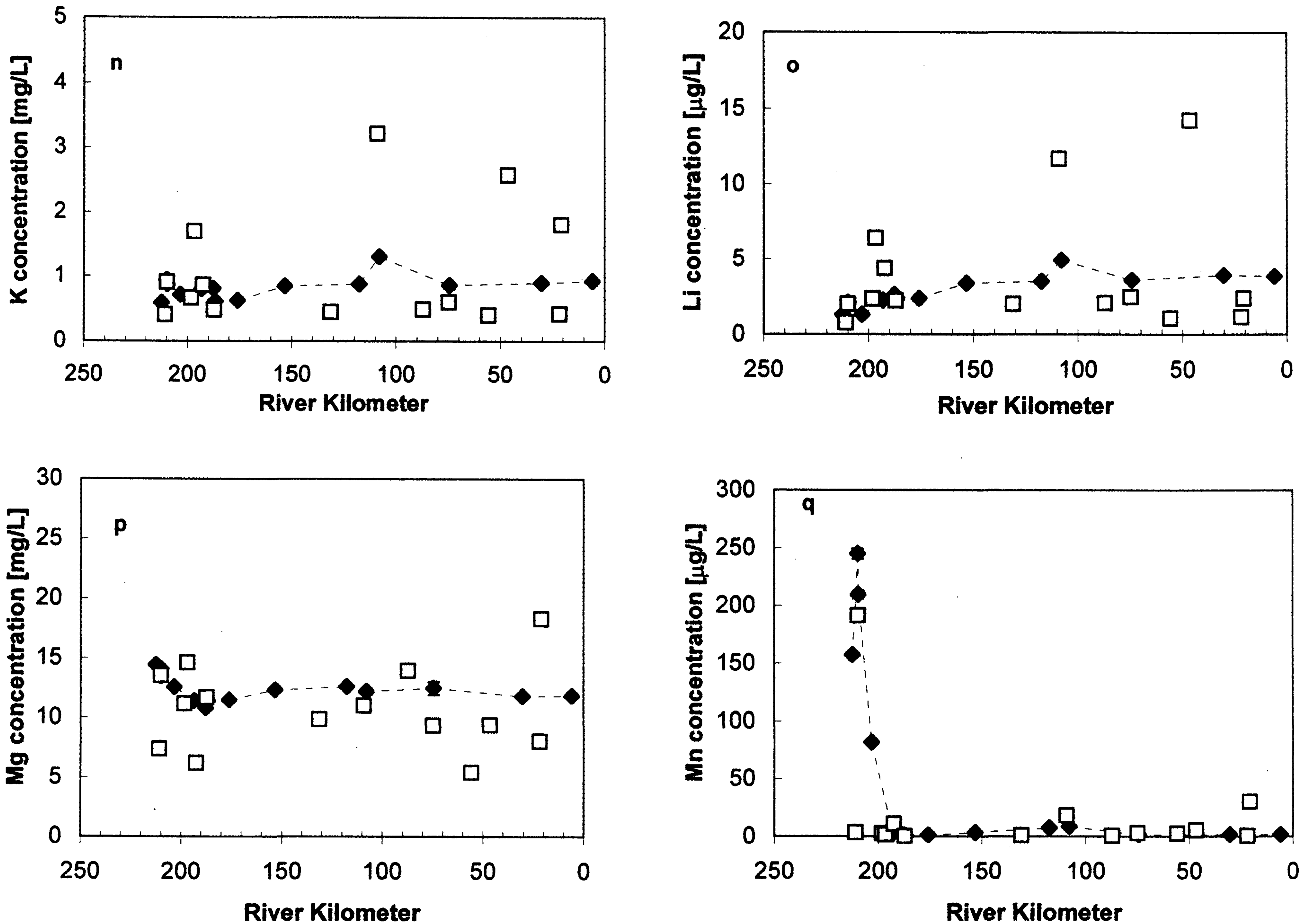
Figure 2: Measured Water Values vs. River Kilometer

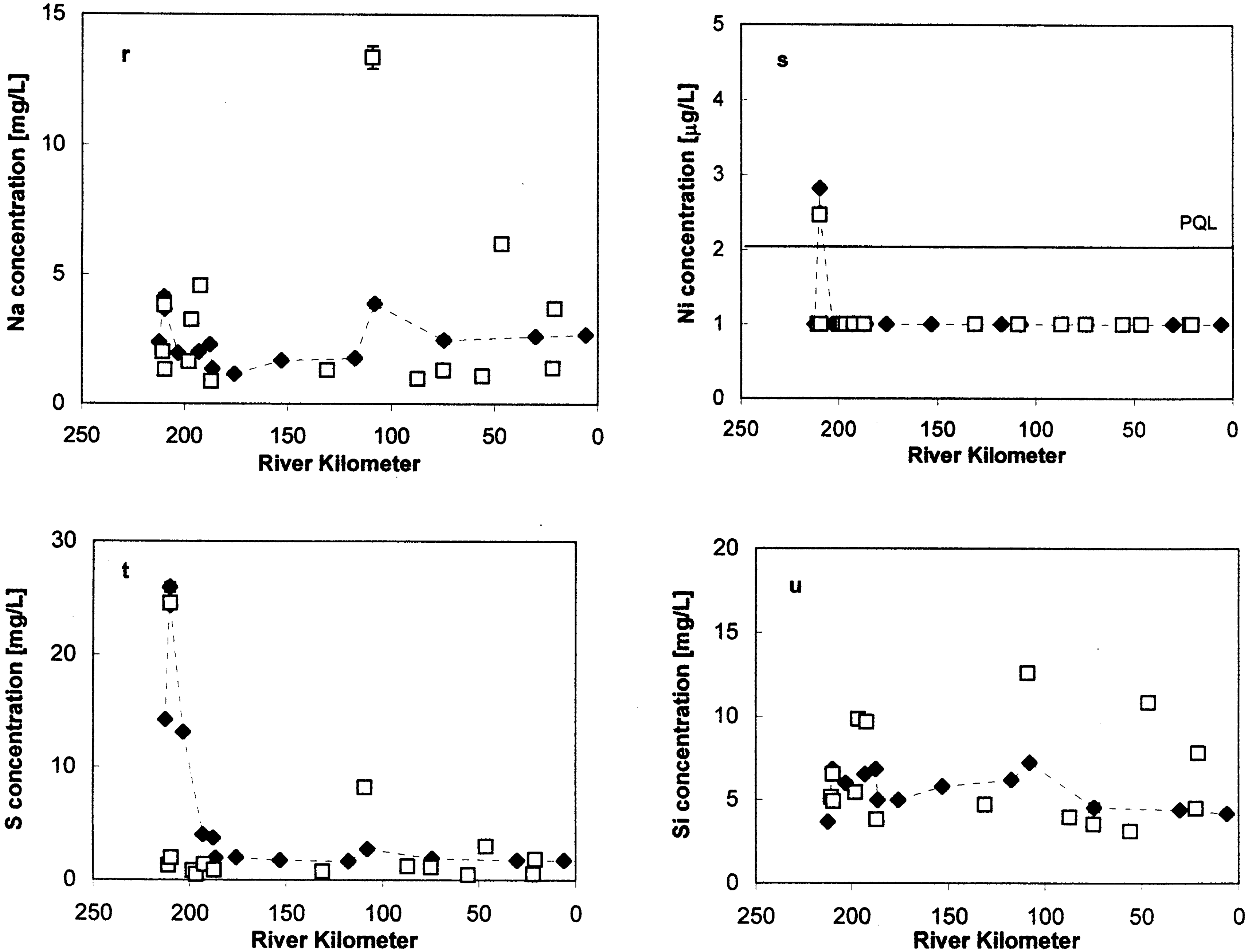
Note: PQLs are represented on figures as permitted by the scale of the sample concentrations.

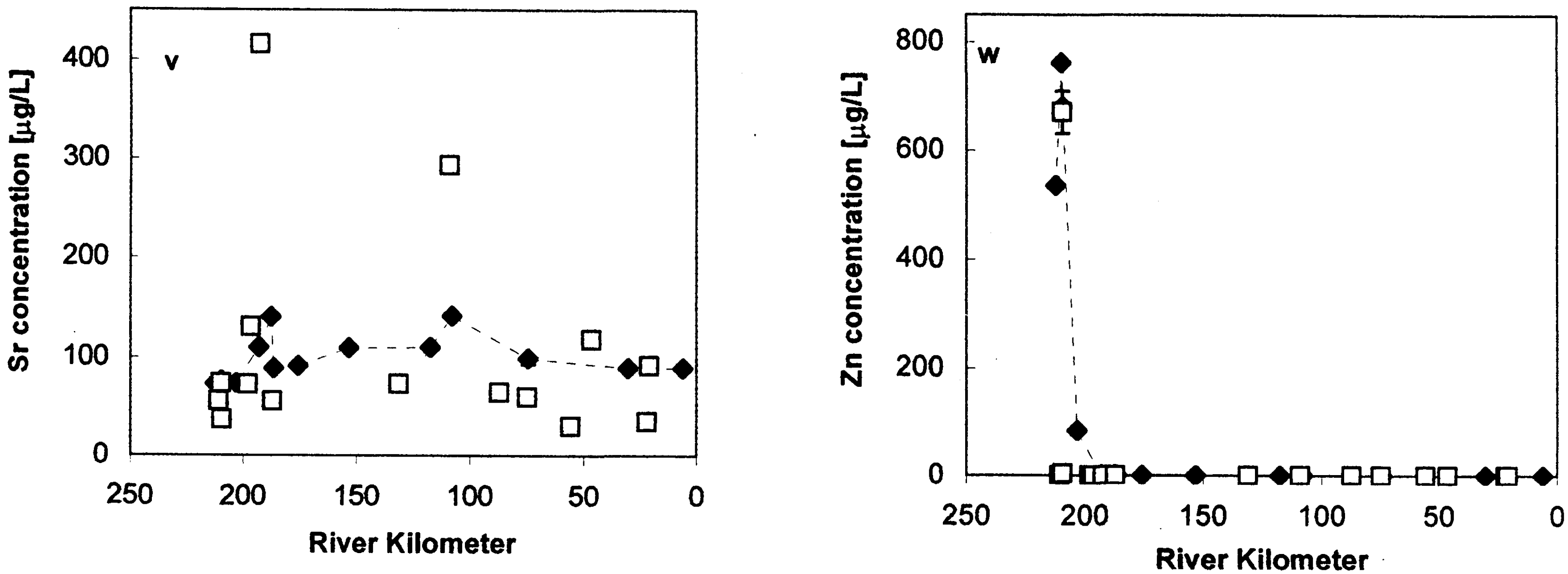

e
Alkalinity (mg/L)
240
200
160
120
80
40
0
250
200
150
100
50
0
River Kilometer


f
As concentration [µg/L]
BLACKFOOT MAINSTEM
TRIBUTARIES
River Kilometer
g
Al concentration [µg/L]
PQL
River Kilometer
h
Ba concentration [µg/L]
River Kilometer
i
Ca concentration [mg/L]
River Kilometer


j
Cd concentration [μg/L]
PQL
River Kilometer
k
Co concentration [μg/L]
PQL
River Kilometer
l
Cu concentration [μg/L]
PQL
River Kilometer
m
Fe concentration [μg/L]
River Kilometer


n
K concentration [mg/L]
River Kilometer
o
Li concentration [µg/L]
River Kilometer
p
Mg concentration [mg/L]
River Kilometer
q
Mn concentration [µg/L]
River Kilometer


r
Na concentration [mg/L]
15
10
5
0
250
200
150
100
50
0
River Kilometer
s
Ni concentration [µg/L]
5
4
3
2
1
0
PQL
250
200
150
100
50
0
River Kilometer
t
S concentration [mg/L]
30
20
10
0
250
200
150
100
50
0
River Kilometer
u
Si concentration [mg/L]
20
15
10
5
0
250
200
150
100
50
0
River Kilometer


v
Sr concentration [µg/L]
0
100
200
300
400
250
200
150
100
50
0
River Kilometer
w
Zn concentration [µg/L]
0
200
400
600
800
250
200
150
100
50
0
River Kilometer

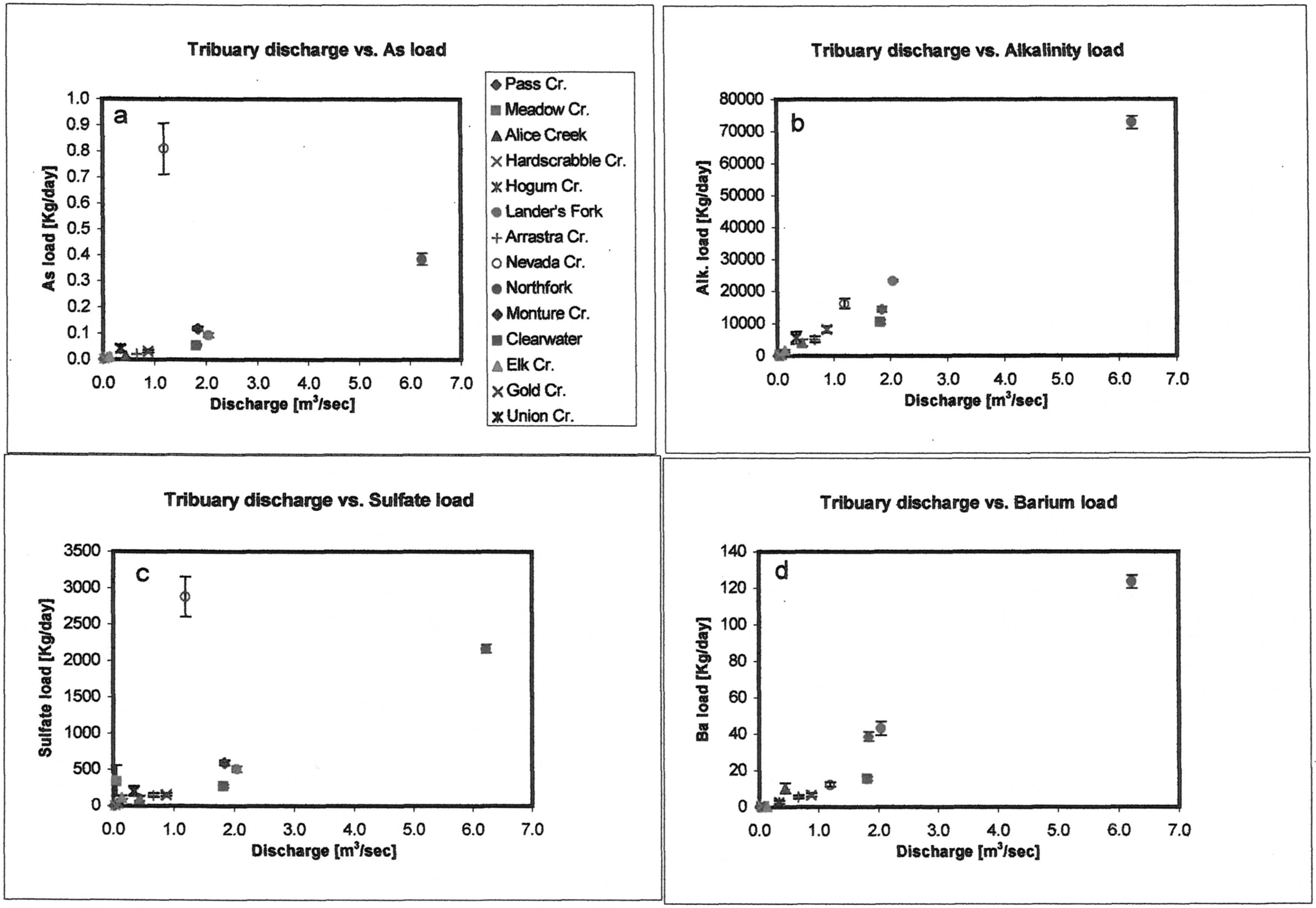
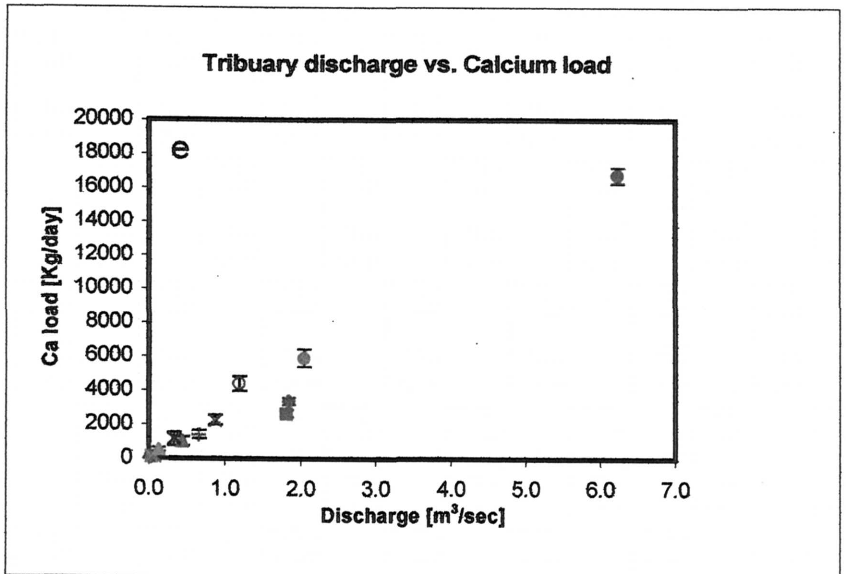
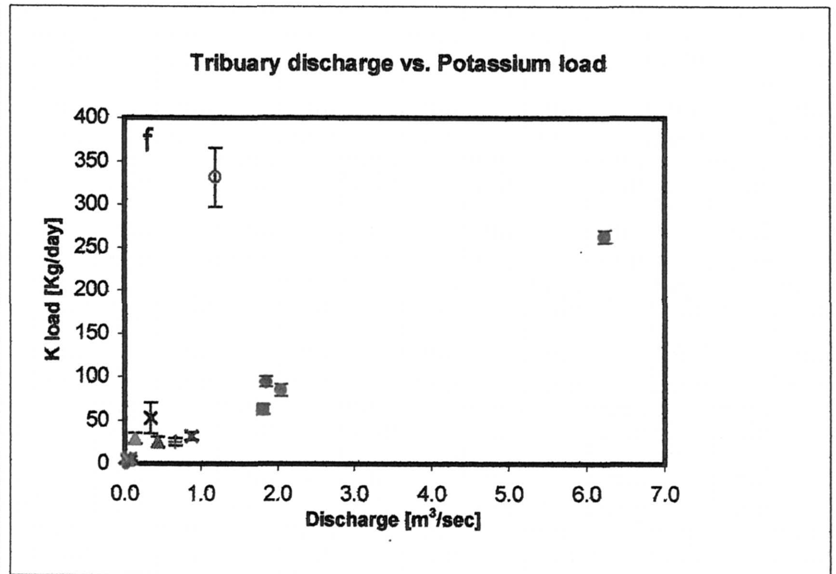
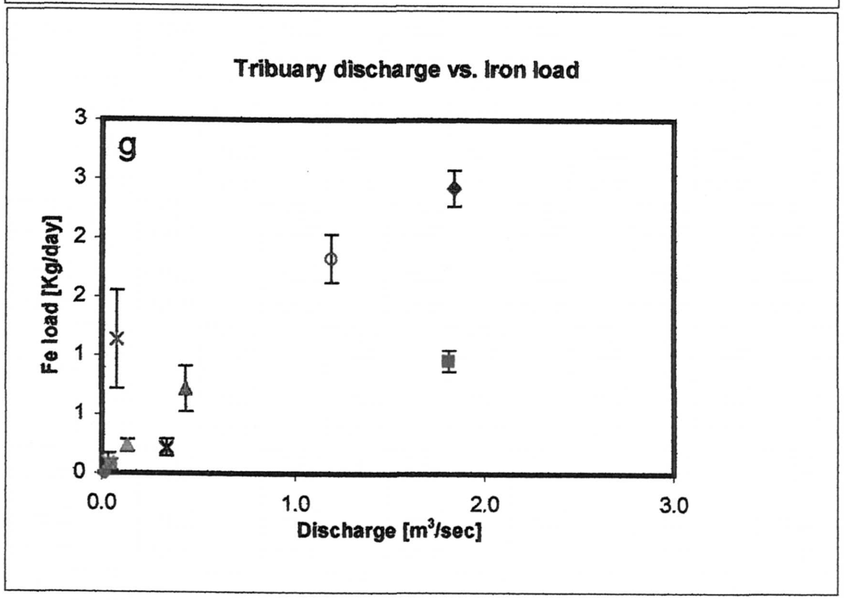
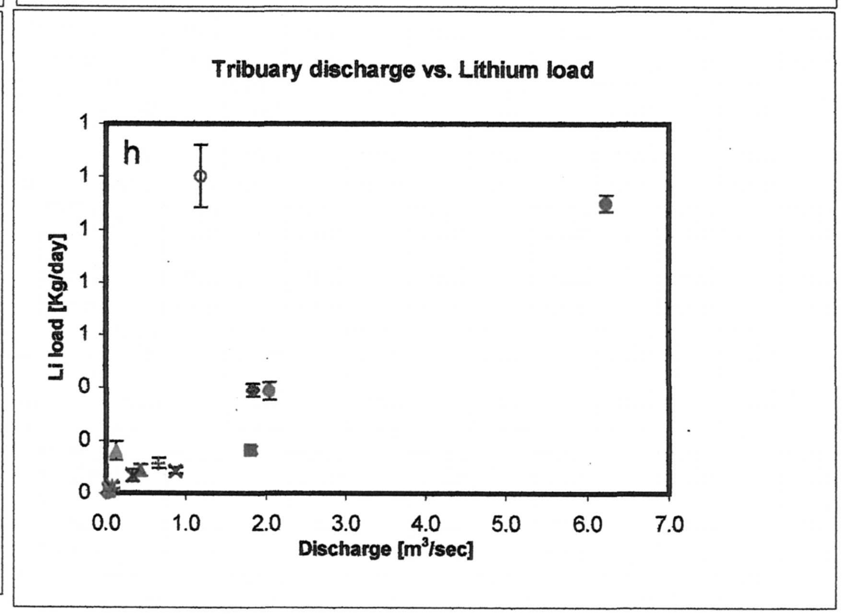


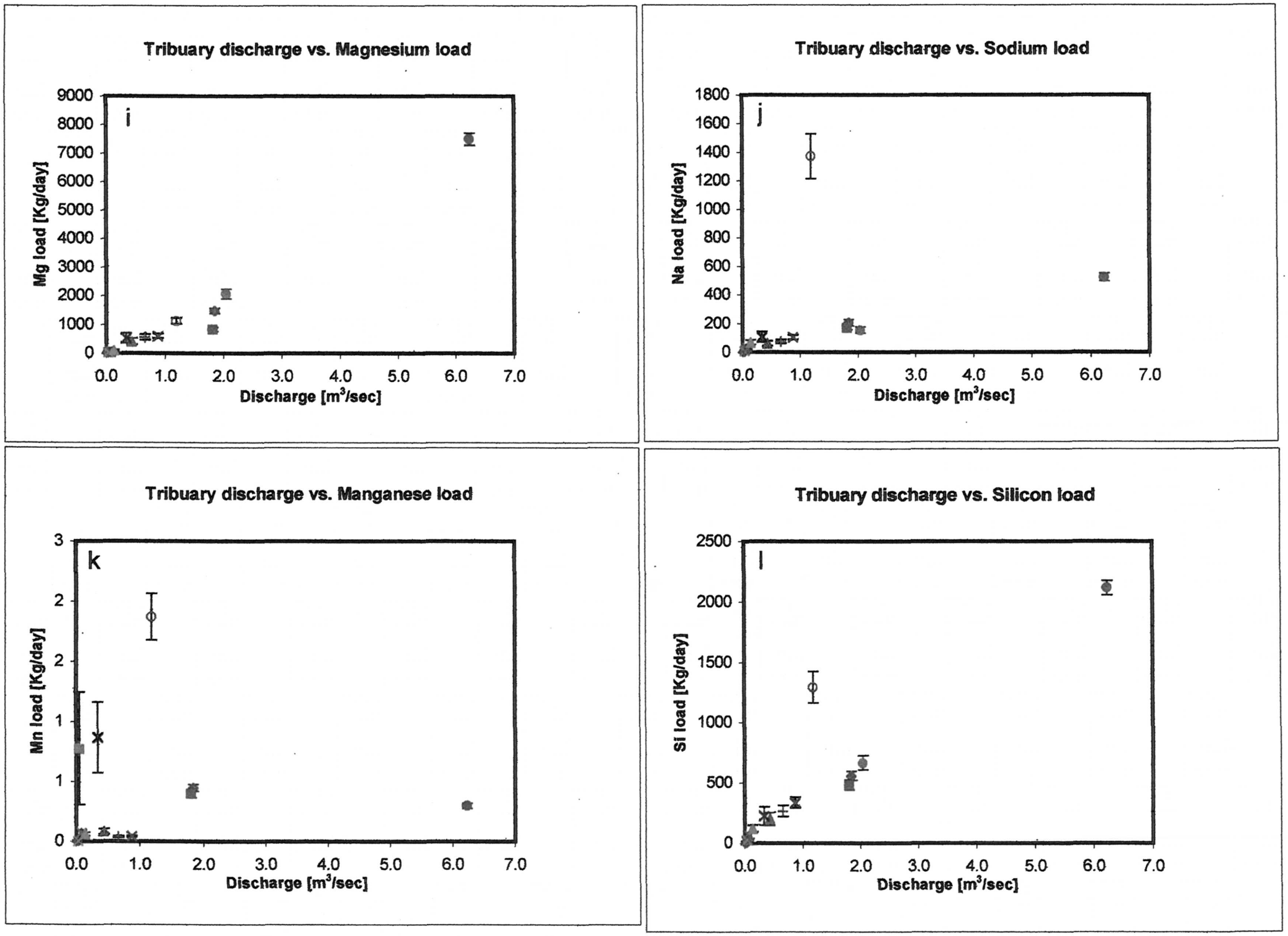
Figure 3 : Dissolved loads versus discharge of the Blackfoot River tributaries.


Tribuary discharge vs. Calcium load
e
Ca load [Kg/day]
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]

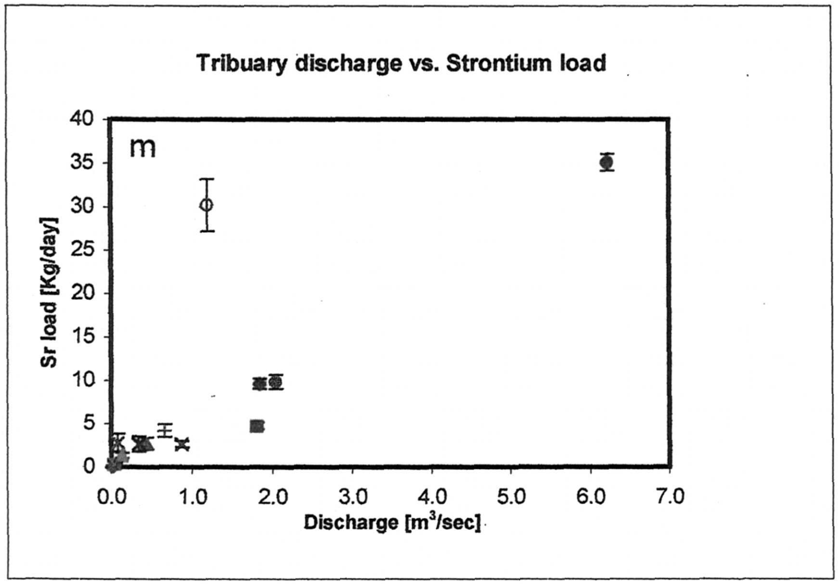

Tribuary discharge vs. Potassium load
f
K load [Kg/day]
400
350
300
250
200
150
100
50
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]


Tribuary discharge vs. Iron load
g
Fe load [Kg/day]
3
3
2
2
1
1
0
0.0
1.0
2.0
3.0
Discharge [m³/sec]


Tribuary discharge vs. Lithium load
h
Li load [Kg/day]
1
1
1
1
1
0
0
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]



Tribuary discharge vs. Magnesium load
i
Mg load [Kg/day]
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]
Tribuary discharge vs. Sodium load
j
Na load [Kg/day]
1800
1600
1400
1200
1000
800
600
400
200
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]
Tribuary discharge vs. Manganese load
k
Mn load [Kg/day]
3
2
2
1
1
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]
Tribuary discharge vs. Silicon load
l
Si load [Kg/day]
2500
2000
1500
1000
500
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
Discharge [m³/sec]


Tribuary discharge vs. Strontium load
m
Sr load [Kg/day]
Discharge [m³/sec]
40
35
30
25
20
15
10
5
0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0

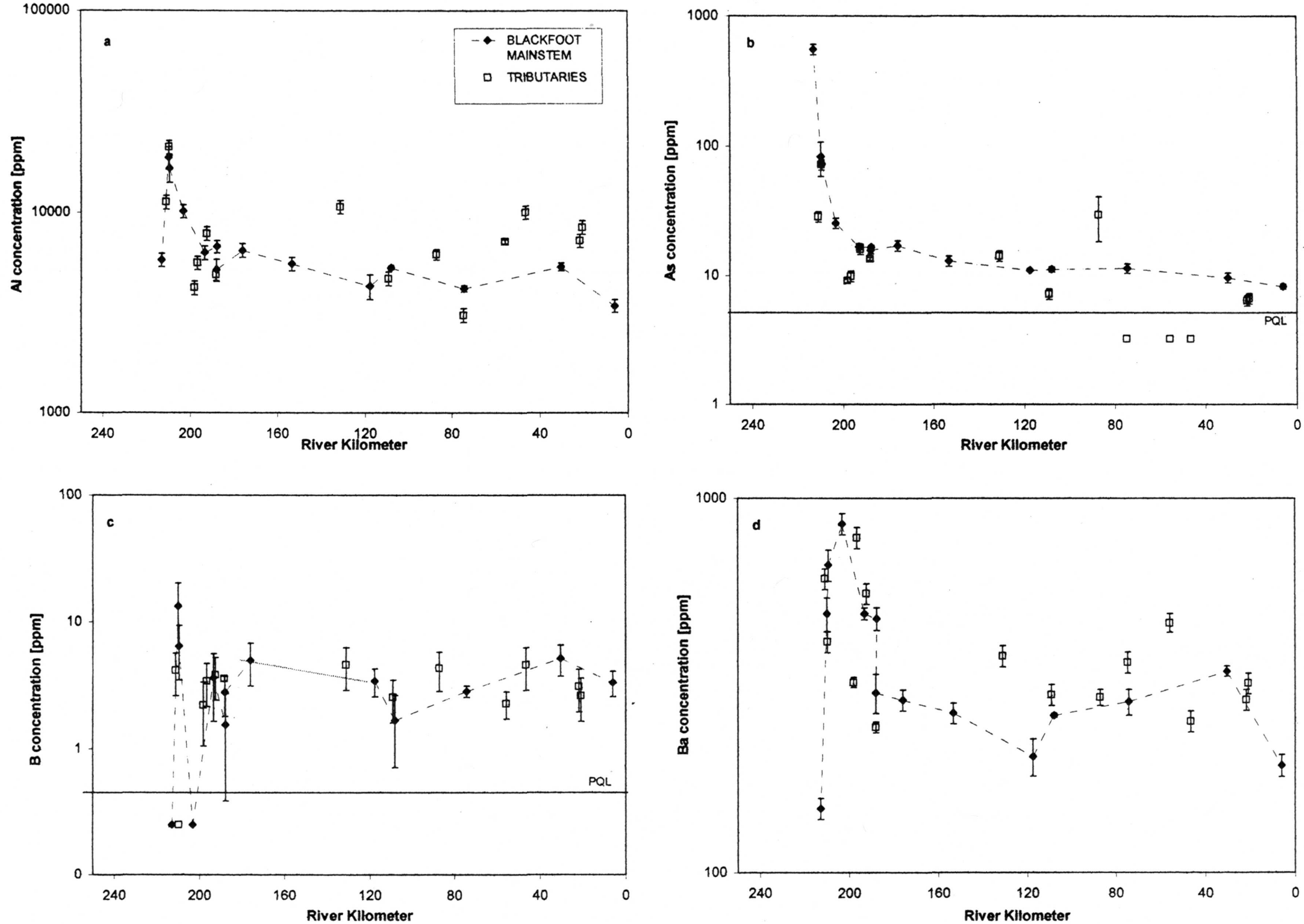
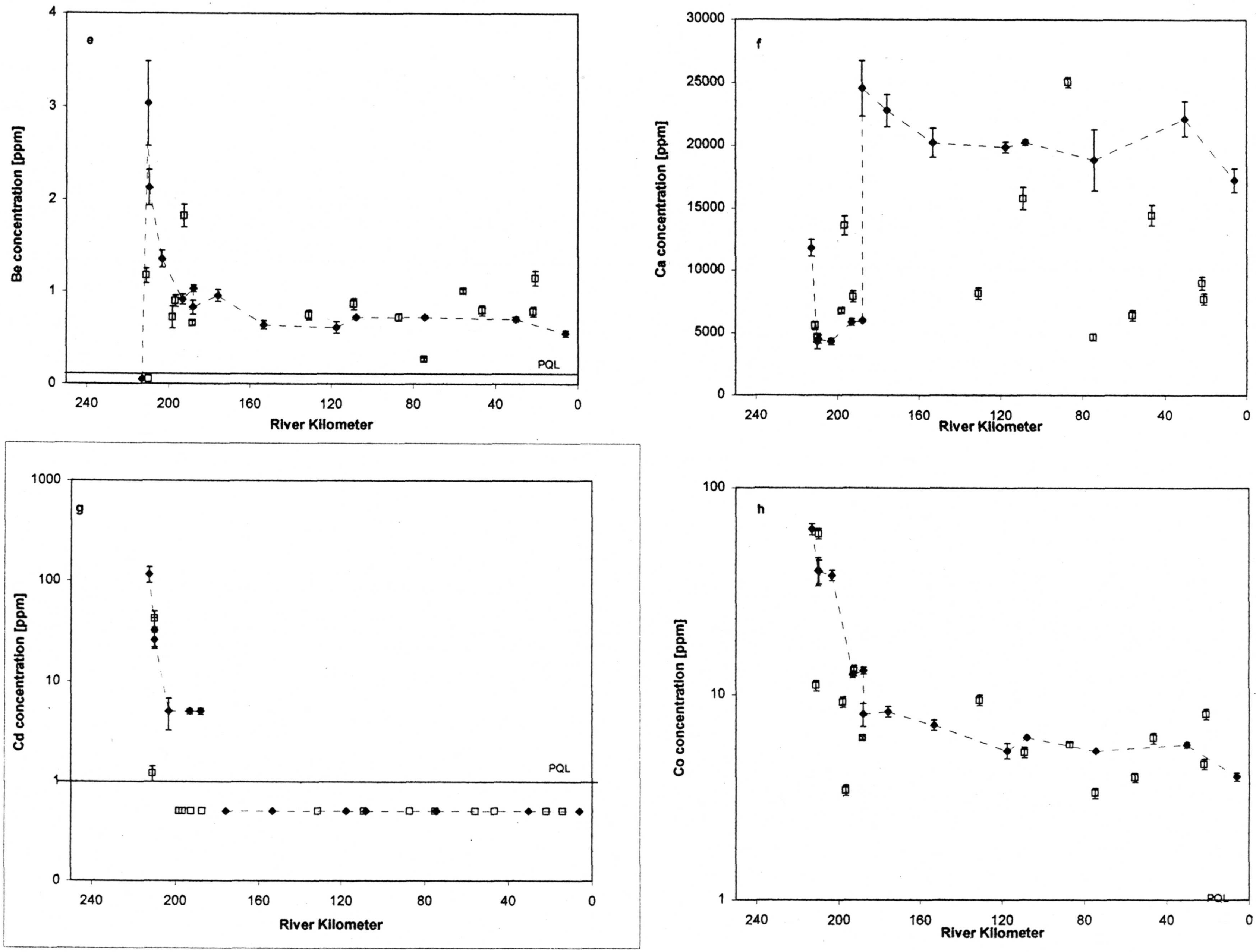
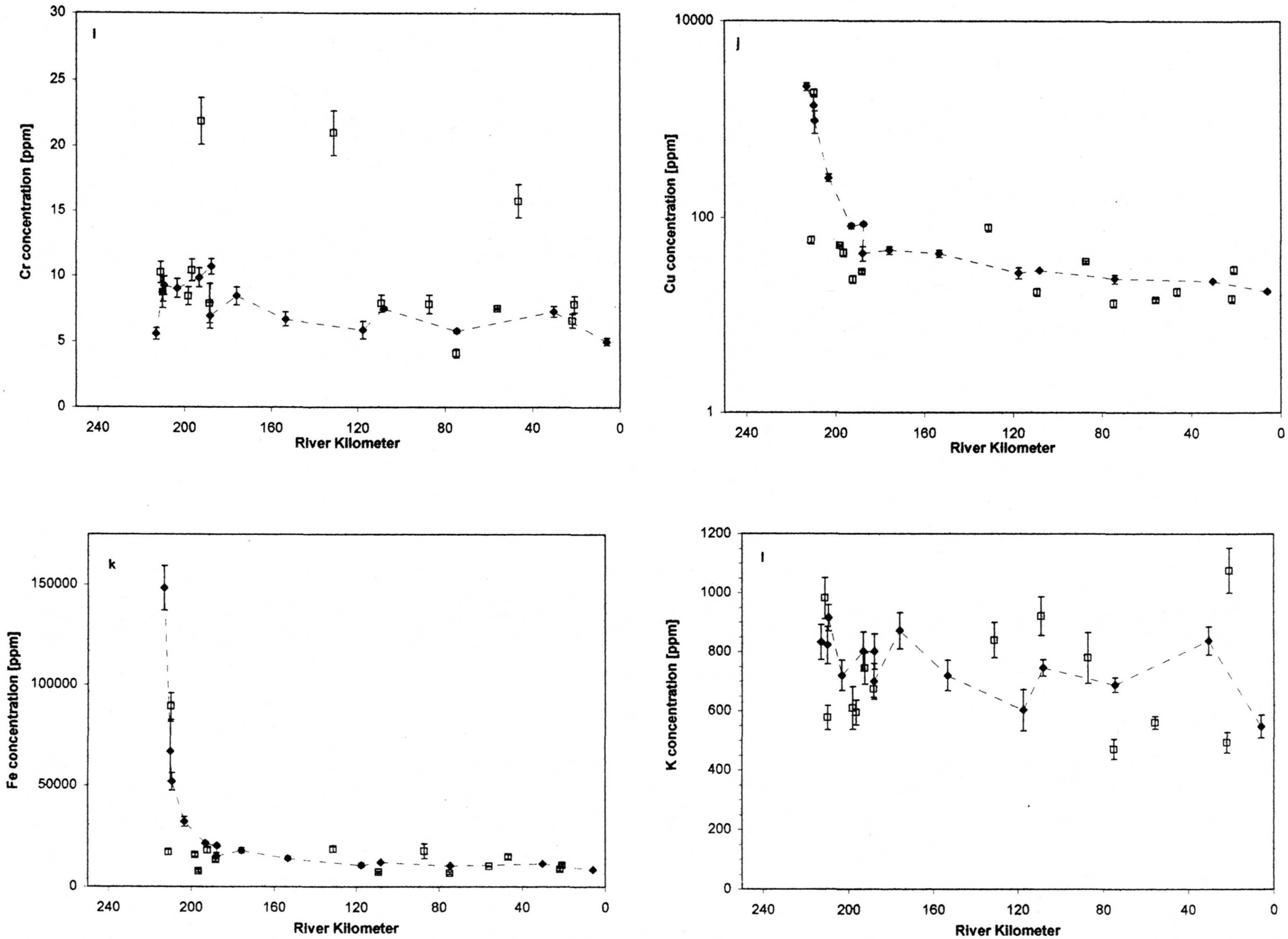
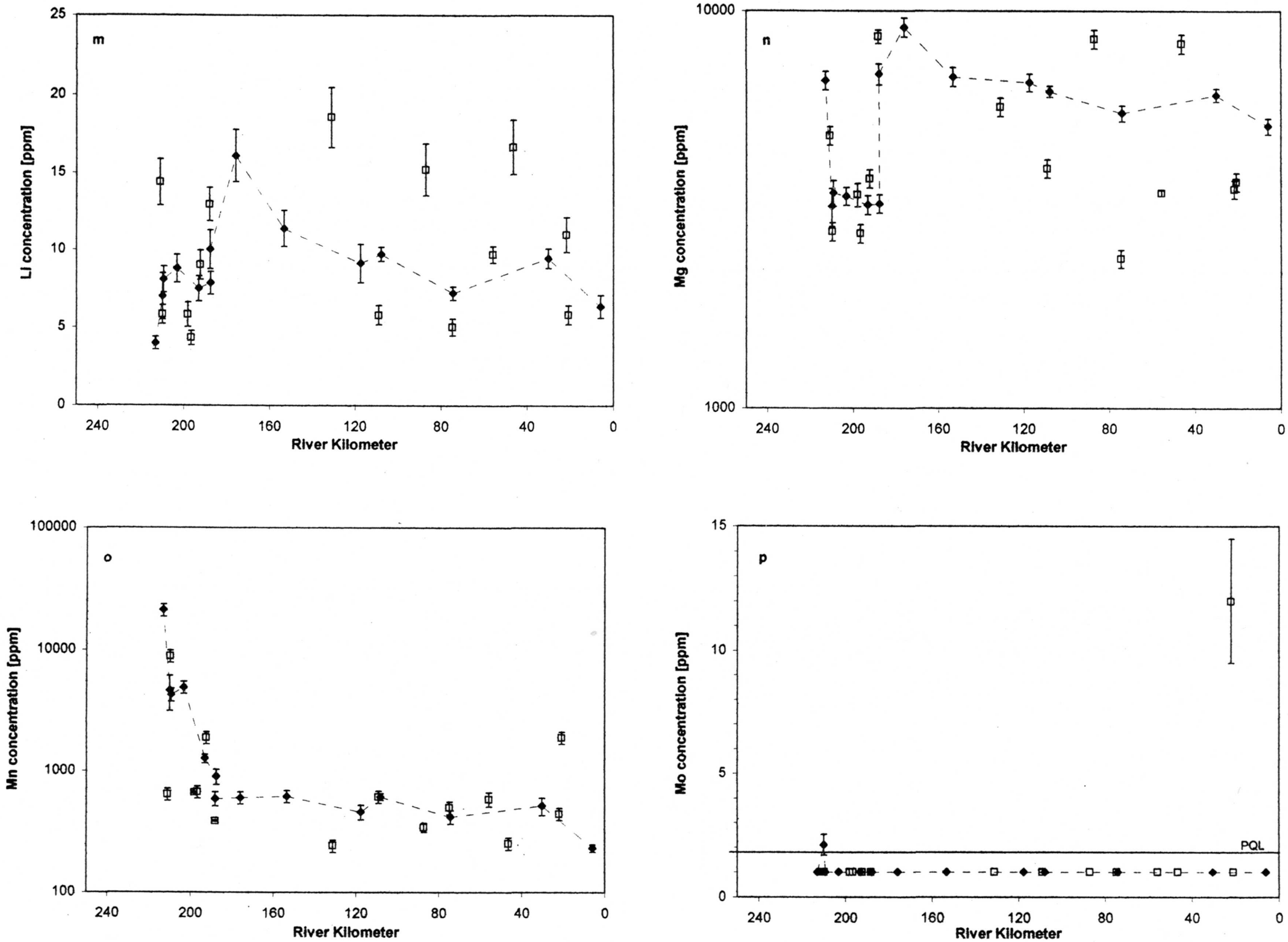


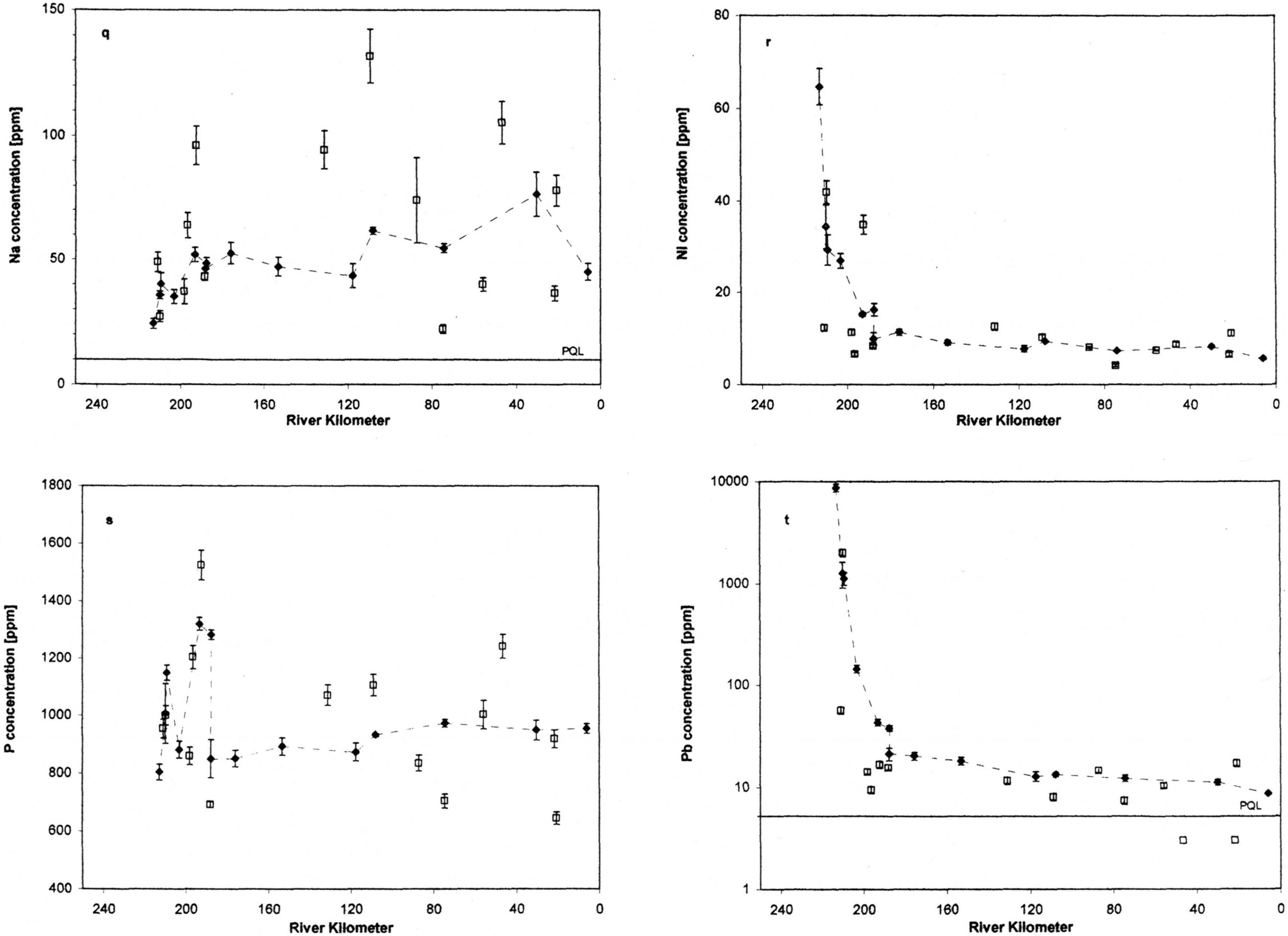
Figure 4: Measured Sediment Values vs. River Kilometer

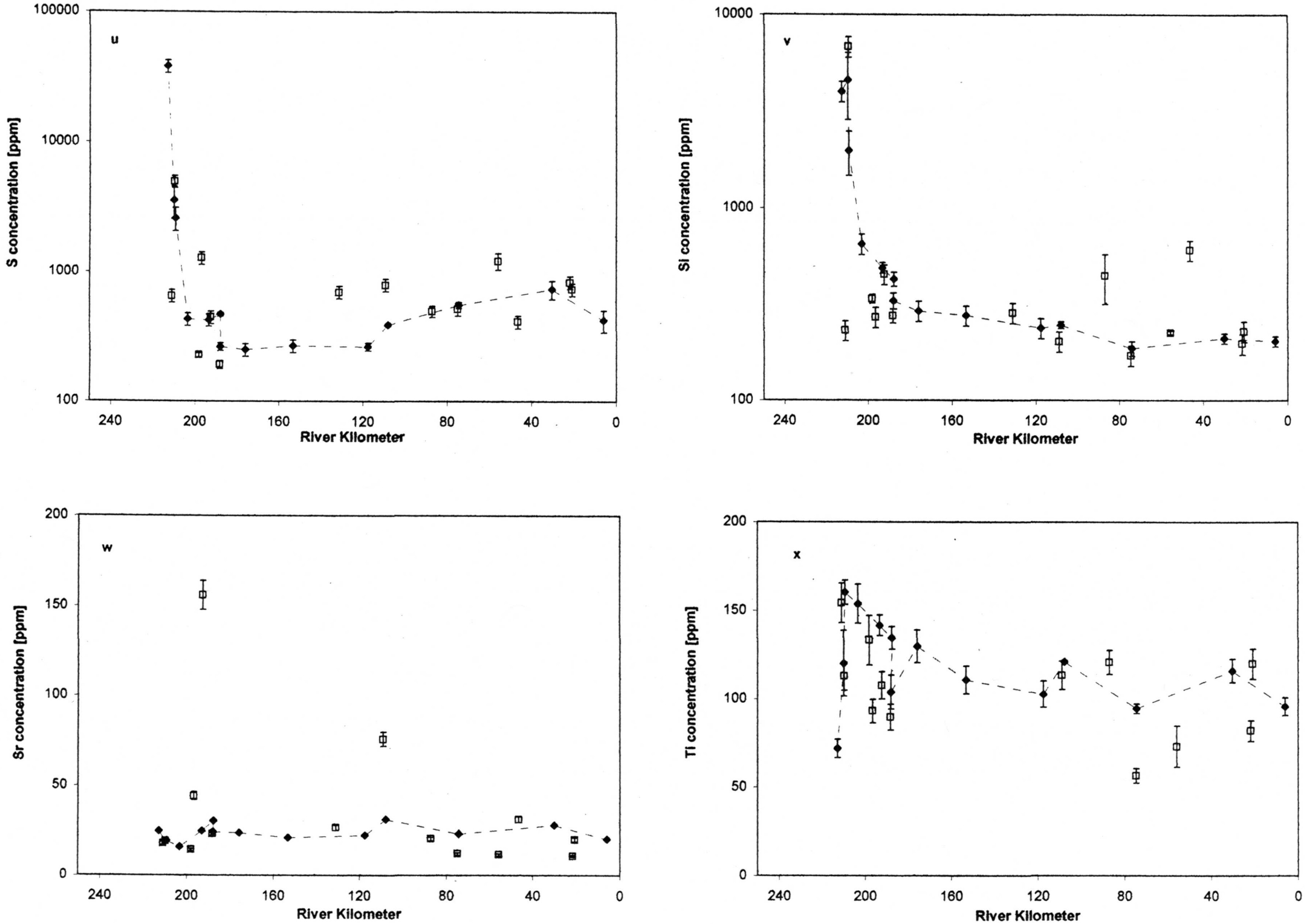
Note: PQLs are represented on figures as permitted by the scale of the sample concentrations.

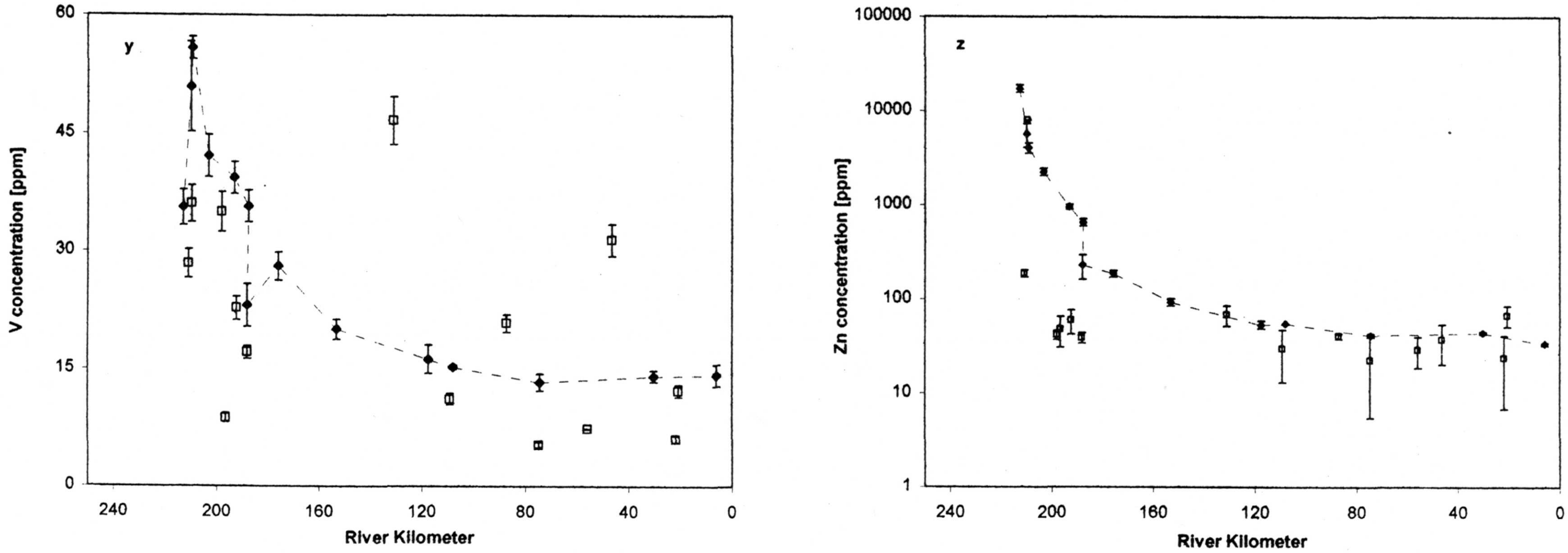

e
Be concentration [ppm]
River Kilometer
PQL
f
Ca concentration [ppm]
River Kilometer
g
Cd concentration [ppm]
River Kilometer
PQL
h
Co concentration [ppm]
River Kilometer
PQL


i
Cr concentration [ppm]
30
25
20
15
10
5
0
240
200
160
120
80
40
0
River Kilometer
j
Cu concentration [ppm]
10000
100
1
240
200
160
120
80
40
0
River Kilometer
k
Fe concentration [ppm]
150000
100000
50000
0
240
200
160
120
80
40
0
River Kilometer
l
K concentration [ppm]
1200
1000
800
600
400
200
0
240
200
160
120
80
40
0
River Kilometer


m
Li concentration [ppm]
River Kilometer
n
Mg concentration [ppm]
River Kilometer
o
Mn concentration [ppm]
River Kilometer
p
Mo concentration [ppm]
PQL
River Kilometer


q
Na concentration [ppm]
150
100
50
0
PQL
240
200
160
120
80
40
0
River Kilometer
r
Ni concentration [ppm]
80
60
40
20
0
240
200
160
120
80
40
0
River Kilometer
s
P concentration [ppm]
1800
1600
1400
1200
1000
800
600
400
240
200
160
120
80
40
0
River Kilometer
t
Pb concentration [ppm]
10000
1000
100
10
1
PQL
240
200
160
120
80
40
0
River Kilometer


u
S concentration [ppm]
100000
10000
1000
100
240
200
160
120
80
40
0
River Kilometer
v
Si concentration [ppm]
10000
1000
100
240
200
160
120
80
40
0
River Kilometer
w
Sr concentration [ppm]
200
150
100
50
0
240
200
160
120
80
40
0
River Kilometer
x
Ti concentration [ppm]
200
150
100
50
0
240
200
160
120
80
40
0
River Kilometer


y
V concentration [ppm]
60
45
30
15
0
240
200
160
120
80
40
0
River Kilometer
z
Zn concentration [ppm]
100000
10000
1000
100
10
1
240
200
160
120
80
40
0
River Kilometer

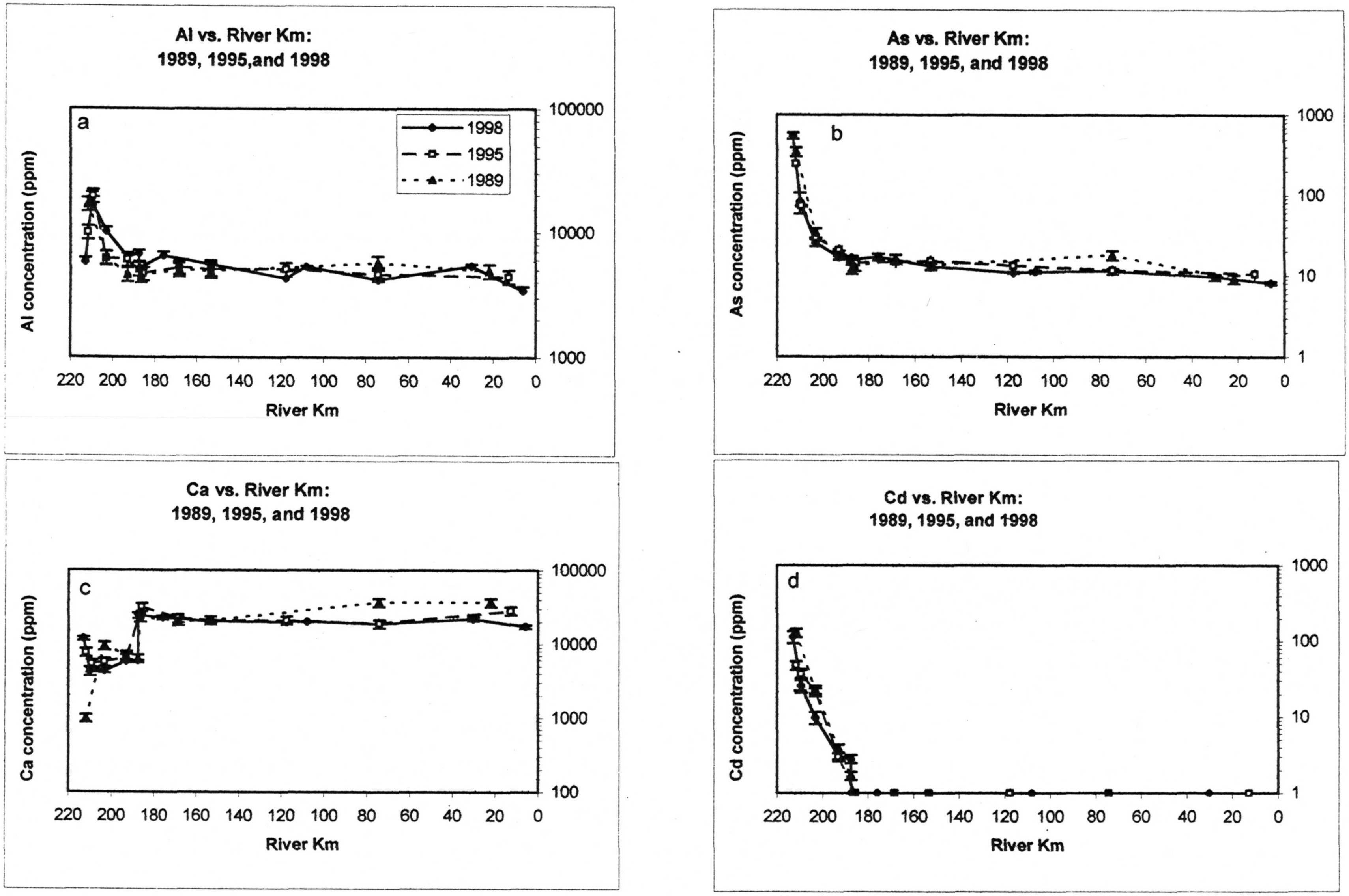
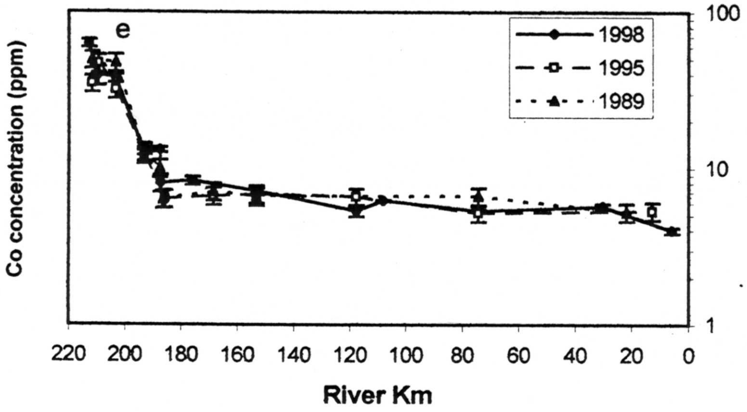
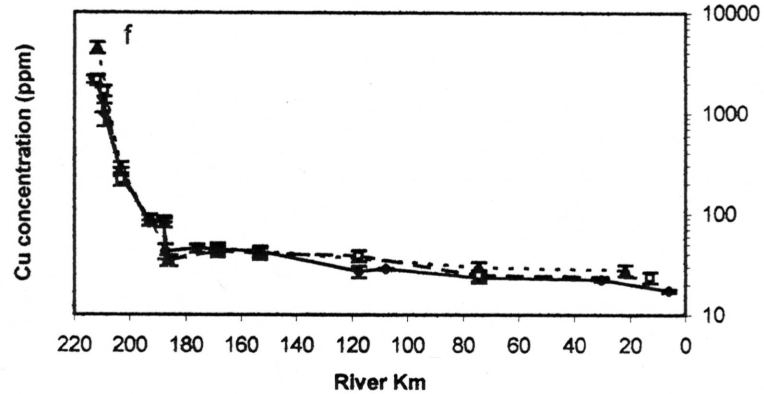


Figure 5: Sediment values vs. River Kilometer for 1989, 1995, and 1998.

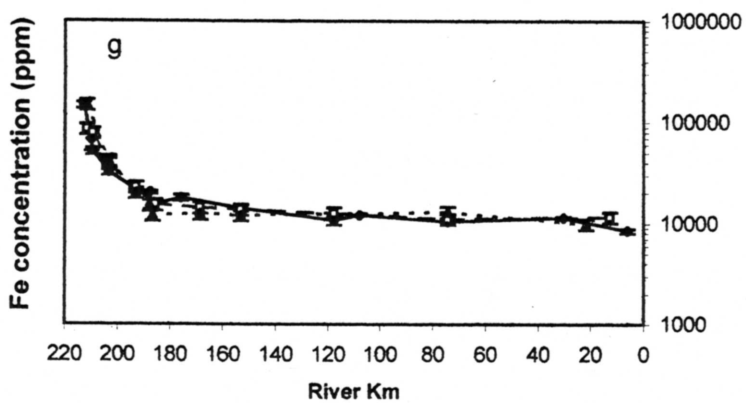
**Co vs. River Km:
1989, 1995, and 1998**



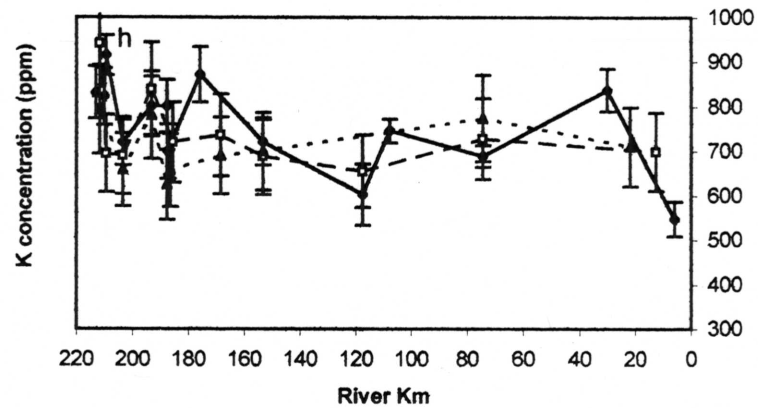
**Cu vs. River Km:
1989, 1995, and 1998**

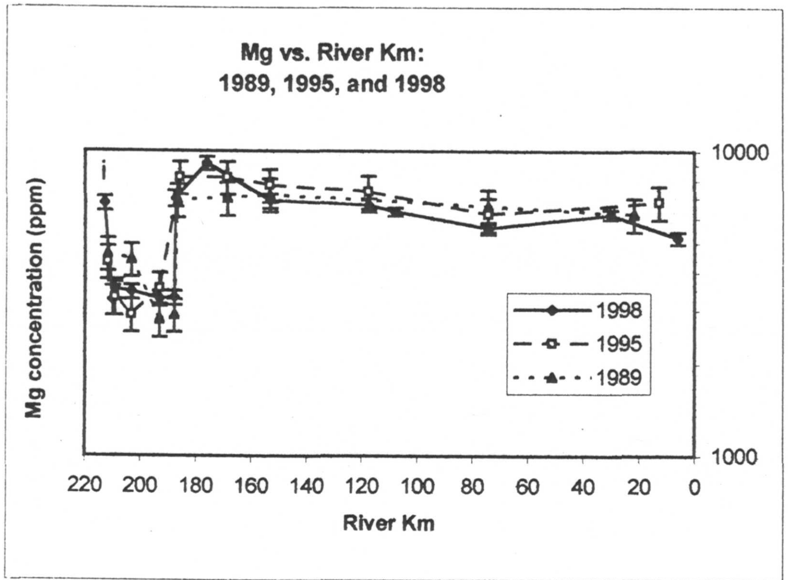


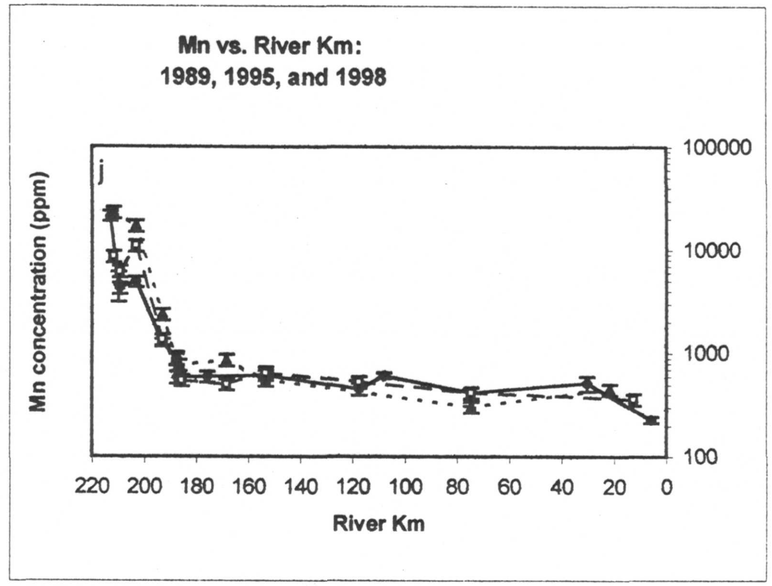
**Fe vs. River Km:
1989, 1995, and 1998**

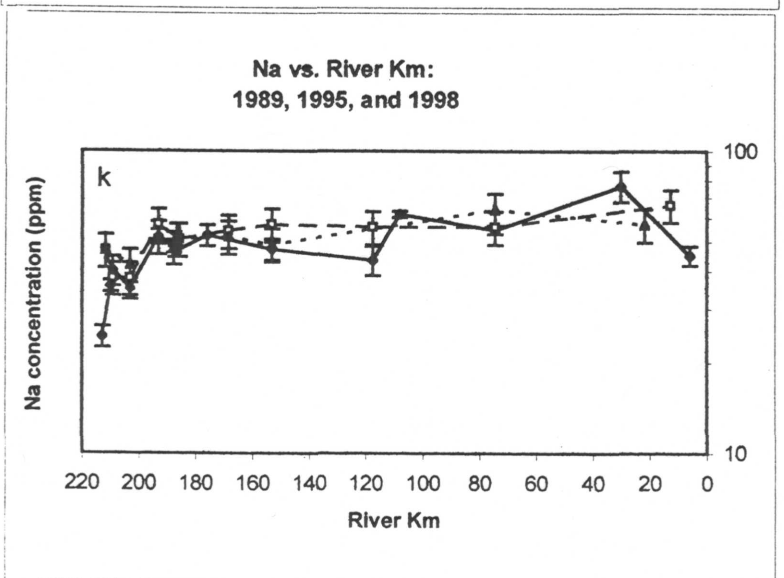


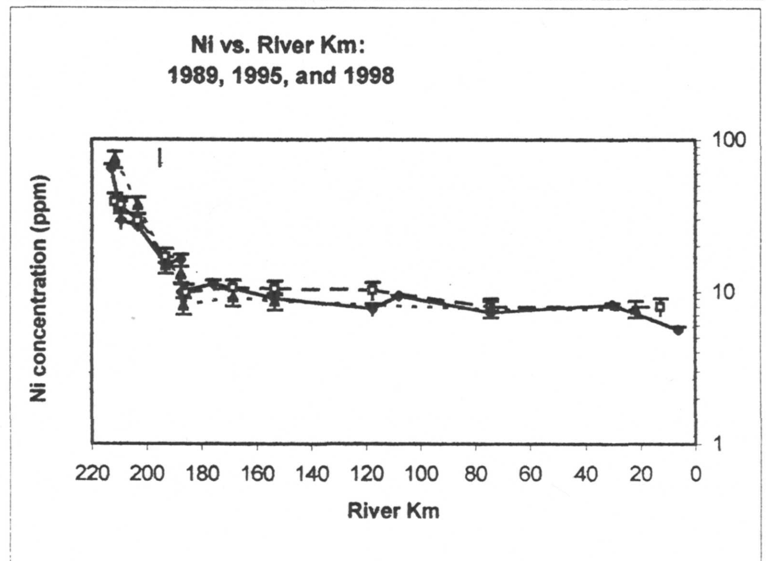
**K vs. River Km:
1989, 1995, and 1998**

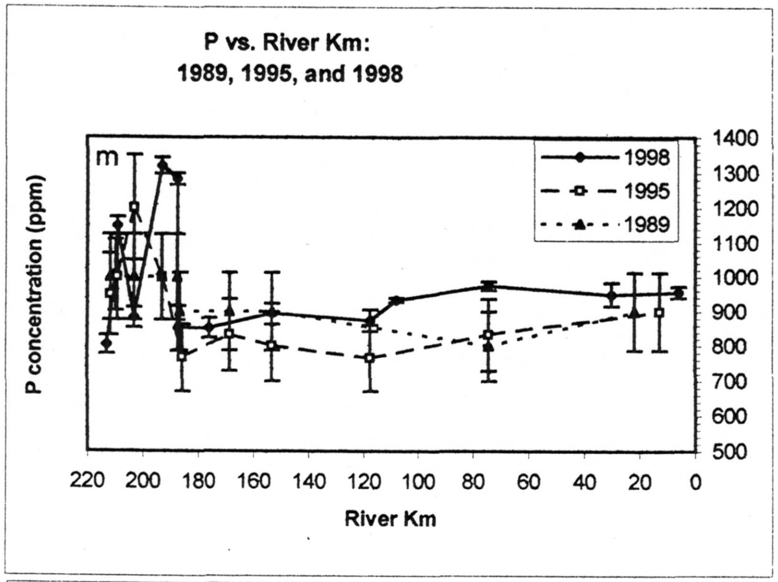


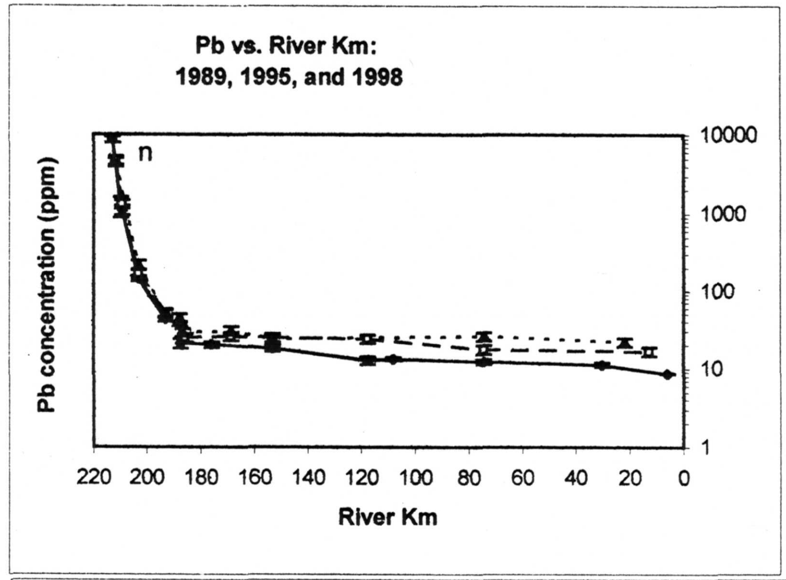

Mg vs. River Km:
1989, 1995, and 1998
i
Mg concentration (ppm)
10000
1000
220 200 180 160 140 120 100 80 60 40 20 0
River Km
1998
1995
1989

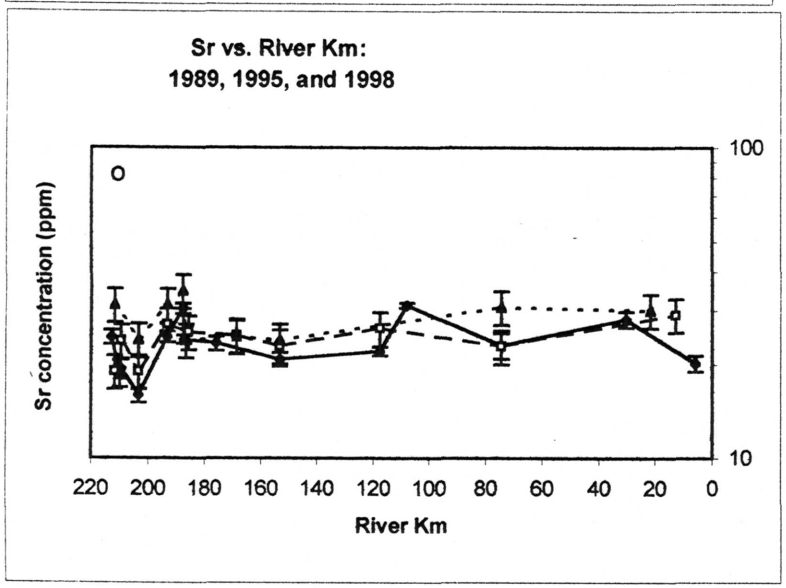

Mn vs. River Km:
1989, 1995, and 1998
j
Mn concentration (ppm)
100000
10000
1000
100
220 200 180 160 140 120 100 80 60 40 20 0
River Km

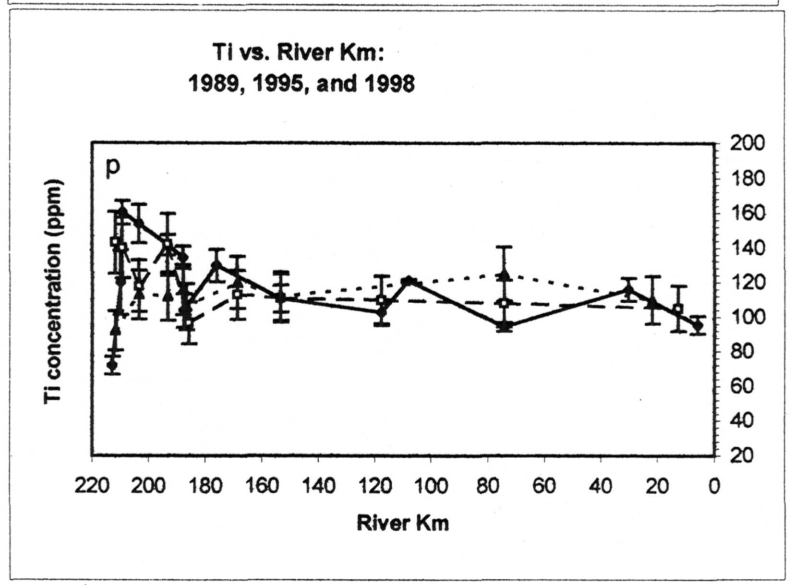

Na vs. River Km:
1989, 1995, and 1998
k
Na concentration (ppm)
100
10
220 200 180 160 140 120 100 80 60 40 20 0
River Km

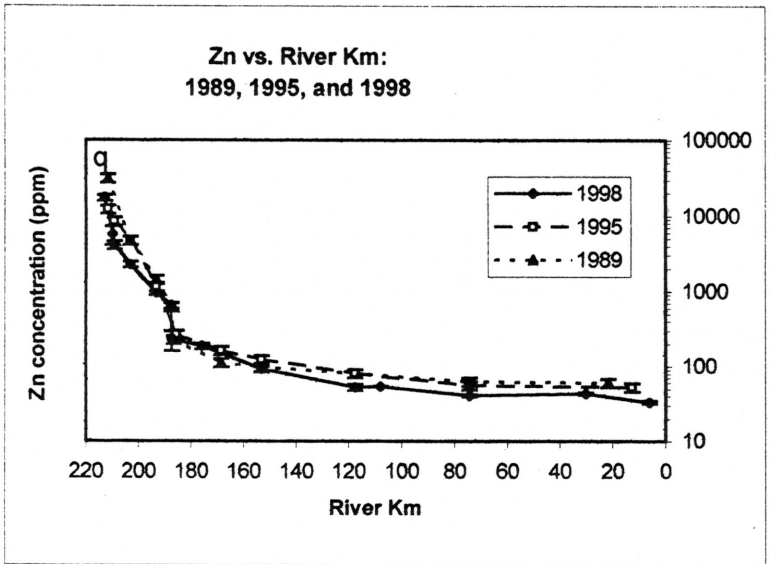

Ni vs. River Km:
1989, 1995, and 1998
l
Ni concentration (ppm)
100
10
1
220 200 180 160 140 120 100 80 60 40 20 0
River Km


P vs. River Km:
1989, 1995, and 1998
m
1998
1995
1989
P concentration (ppm)
1400
1300
1200
1100
1000
900
800
700
600
500
220 200 180 160 140 120 100 80 60 40 20 0
River Km


Pb vs. River Km:
1989, 1995, and 1998
n
Pb concentration (ppm)
10000
1000
100
10
1
220 200 180 160 140 120 100 80 60 40 20 0
River Km


Sr vs. River Km:
1989, 1995, and 1998
o
Sr concentration (ppm)
100
10
220 200 180 160 140 120 100 80 60 40 20 0
River Km


Ti vs. River Km:
1989, 1995, and 1998
p
Ti concentration (ppm)
200
180
160
140
120
100
80
60
40
20
220 200 180 160 140 120 100 80 60 40 20 0
River Km


Zn vs. River Km:
1989, 1995, and 1998
Zn concentration (ppm)
River Km
1998
1995
1989
100000
10000
1000
100
10
220 200 180 160 140 120 100 80 60 40 20 0