WATER QUALITY ALONG THE SOUTH FORK OF THE COEUR D'ALENE RIVER 1966 to 1988

A Thesis

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by

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AUTHORIZATION TO SUBMIT

THESIS

This thesis of Susan B. Callcott, submitted for the degree of Master of Science with a major in Geology and titled "Water Quality Along The South Fork Of The Coeur D' Alene River," has been reviewed in final form, as indicated by the signatures and dates given below. Permission is now granted to submit final copies to the College of Graduate Studies for approval.

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ABSTRACT

Since 1890, mining of lead, silver and zinc has occurred in the Coeur D' Alene mining district. In the early days, jig tailings containing sphalerite and other heavy metal sulfides were discharged directly into the South Fork Coeur D' Alene River resulting in the elimination of aquatic life. Over the past 20 years, water quality legislation and modern milling techniques have combined to reduce sediment load and eliminate point source pollution from mine and mill sites, thereby improving the water quality along the South Fork. However, "background" levels of metals continue to pose problems for aquatic life in the river.

This project recorded 18 sampling stations along the South Fork and Main Stem of the Coeur D' Alene River over a six month period; these values are compared to the metal concentrations reported in historic data collected by Mink (1969) and the EPA (Environmental Protection Agency) (1972 -1984). The sampling station at Cataldo on the Main Stem and the stations upstream of Wallace on the South Fork did not exhibit excessive concentrations of the elements analyzed. Zinc displayed the highest overall concentrations during the study period; it exceeded toxicity limits for the survival of aquatic life. Station 12, located downstream of Smelterville Flats, exhibited the highest consistent concentration of zinc along the river. The highest zinc concentrations of all occurred in March from overland runoff through tailings, from

the smelter dust on the land surface mixed with runoff, from the Smelterville Flats aquifer, and in July from ground water inflow. May displayed the lowest overall zinc concentration during the sampling period.

Past EPA studies indicate that cadmium and lead, although declining in concentration, still exceed EPA toxicity limits for the survival of fish along the South Fork. Since 1980, zinc levels at Smelterville Flats exceeded EPA's standard drinking levels. Although still above chronic levels for aquatic life, zinc concentrations are on the decline. Zinc levels at Cataldo have declined steadily since 1976 and have not exceeded drinking standard limits.

The 1988 data compared to Mink's data from 1969 at Cataldo on the Main Stem indicate somewhat of a decrease in zinc concentrations. Station 12 at Smelterville Flats is variable for 1969 and 1988; but the majority of the 1988 zinc concentrations are lower than Mink's data, particularly during July and August.

EPA bioassays conducted in 1986 record a number of benthic insect species living along the South Fork; a good return of game fish downstream of the South Fork confluence has been detected in the Main Stem of the Coeur D' Alene River. Thus, an overall improvement occurred over the past 20 years along the South Fork of the Coeur D' Alene River.

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Purpose and Objectives

Purpose

The purpose of the project is to relate historic changes in waste management practices in the district to the temporal pattern of water quality to the South Fork of the Coeur D' Alene River. This is important in order to identify any changes in water quality along the South Fork due to water quality legislation and improvements in milling techniques. This problem was selected to determine if sediment load and point source pollution from mine and mill sites has been reduced within the river.

General Objective

The general objective is to relate the temporal pattern of water quality in the South Fork of the Coeur D' Alene River to the historic changes in waste discharges within the Coeur D' Alene Mining District. This is important in order to determine if water quality legislation and modern milling techniques have helped reduce sediment load and contribute some improvement in water quality on the South Fork Coeur D' Alene River throughout the mining district.

Specific Objectives

The specific objectives of this thesis are:

1. Identify and describe historic waste discharge

patterns within the district noting the site of the discharge and any changes in quality of the discharges.

2. Compile and evaluate historic water quality data on the South Fork of the Coeur D' Alene River and on a limited reach of the Coeur D' Alene River below the confluence of the North and South Forks.
3. Formulate a sampling and analysis plan to allow collection of water quality data for comparison with the historic data base. Any such plan should include: sampling locations, methods of sampling and preservation of samples, and methods of laboratory analysis.
4. Initiate and complete a sampling program on the Coeur D' Alene River for the period of March through August, 1988.
5. Compare and analyze the water quality data base to identify temporal and spatial patterns and relate those patterns to the compiled history of water discharge within the mining district.
6. Present conclusions with respect to the impacts of historic waste management programs within the district on river water quality. Present conclusions with respect to anticipated impacts of Superfund cleanup activities on future river water quality.

INTRODUCTION

Location and Economy

The Coeur d' Alene River, one of Idaho's major rivers, is located in the panhandle of Idaho in Shoshone and Kootenai counties. It consists of three primary sections: North Fork, South Fork, and Main Stem. The North Fork is undeveloped economically, is unpolluted and displays healthy aquatic life. The South Fork headwaters originate in the Bitterroot Range of the Idaho - Montana border and flow 31 miles within the Coeur d' Alene Mountains, Figure 1.

The Coeur d' Alene River basin rises to a maximum elevation of 6838 feet and a minimum elevation of 2125 feet. Terrain is rugged with slopes of approximately 30 degrees. The South Fork flows through a narrow, steep valley from one half mile wide to eight miles wide. The South Fork contributes 270 square miles of drainage area to the entire 1380 square miles of the Coeur d' Alene basin (Mink, 1971).

The South Fork joins the North Fork at Enaville to form the Main Stem which flows west into Lake Coeur d' Alene. An outlet of the lake, the Spokane river near the Idaho - Washington border is a contributor to the Columbia river basin.

For many years, residents in this mining district have earned their living by mining and through tourism. Ten large

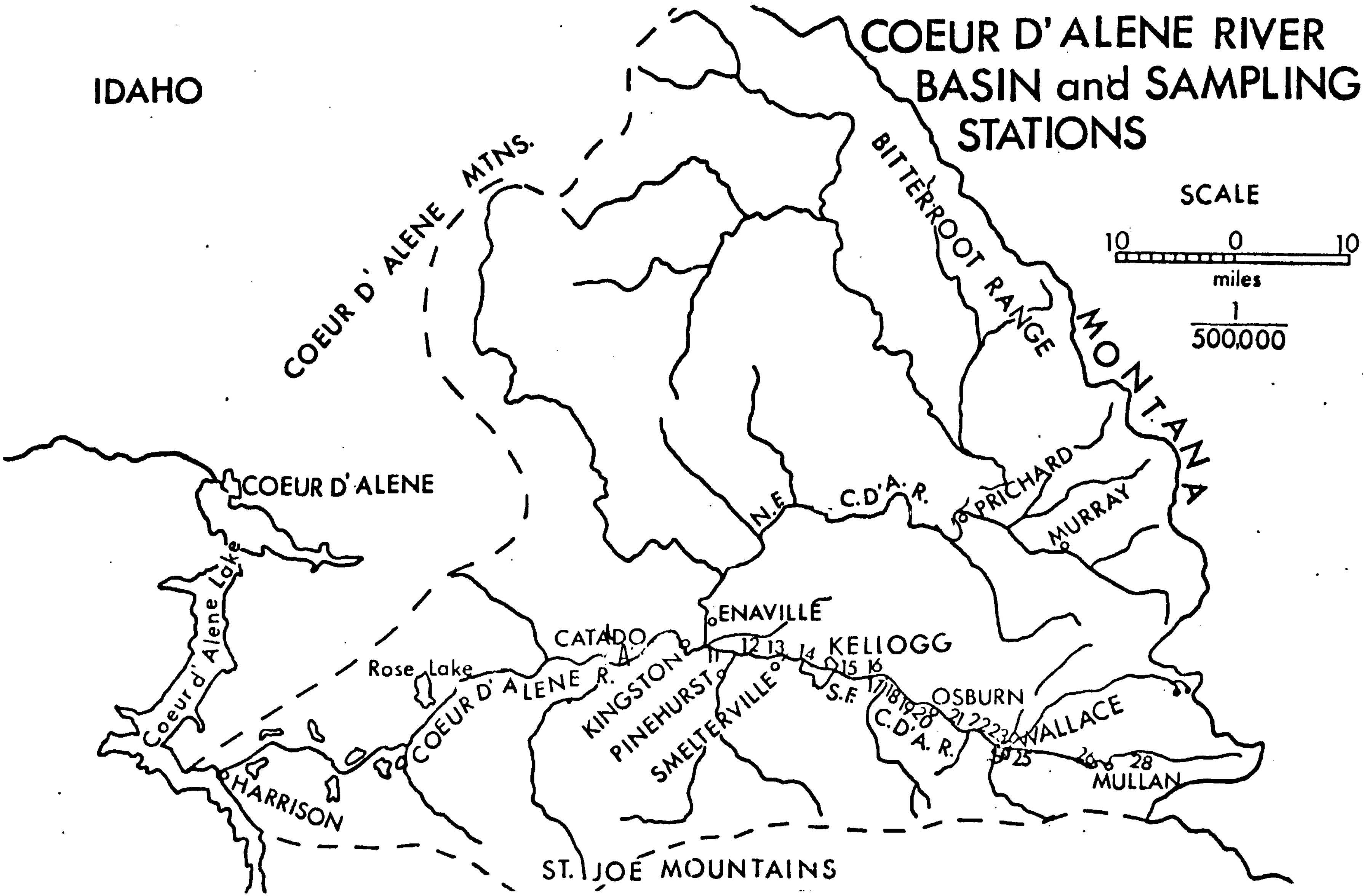

Figure 1. Location map illustrating sampling stations in the Coeur D' Alene River Basin.

mines, several smaller mines and major industries including: an antimony plant, a lead-silver smelter, an electrolytic zinc plant, a phosphoric acid plant, a sulfuric acid plant and a fertilizer plant in the past have provided many of the jobs in the valley.

Ownership of the Bunker Hill mine and smelter complex historically belonged to Gulf Resources and Chemical Corporation. In 1981, the metallurgical plants and the Bunker Hill mine closed, leaving 2200 workers unemployed, because of poor ore prices. Bunker Hill was sold to Bunker Limited Partnership from Gulf in 1982. By 1986, silver prices were so low that most other mines along the South Fork also were forced to close or layoff workers. Currently, a few hundred workers are employed in the mines, but many of the plants have been closed permanently.

Geology

As described in Hobbs (1965), the geology within this basin is part of the Precambrian Belt Supergroup that consists of fine grained argillites, quartzites, carbonates and dolomitic rocks. Ancient siliceous sedimentary rocks having undergone deformation and metamorphism, make up the Belt Supergroup underlying the Coeur d' Alene River basin. The river valleys are filled predominately with unconsolidated sand and gravel alluvium.

Faulting and resulting mineralization have formed deposits of valuable minerals including sulfides of silver, lead antimony, zinc and traces of gold, copper and cobalt (Funk, 1975). Mostly impermeable, the Pre-Cambrian rocks were deformed and faulted by an east-west trending Osborne fault. The South Fork generally follows this fault where mineral deposits have been exploited.

According to Eisenbarth and Wrigley (1978), the South Fork mining district led the nation in mineral production for many years: first in silver and antimony, second in lead, third in garnets, and ninth in gold.

Hydrology

Groundwater discharge is the major source of water for the South Fork (Mink, 1971). The river flow rates vary according to season and must be considered with water quality evaluations. Flow chart records are shown in Figure 2 for the months March through August of 1988. High flow occurs in spring due to snow melt in the higher elevations. During high flow, metal concentrations may appear high because of overland runoff through tailings and from the smelter dust on the land surface mixed with runoff. Low flow takes place in the fall with higher metal concentration levels.

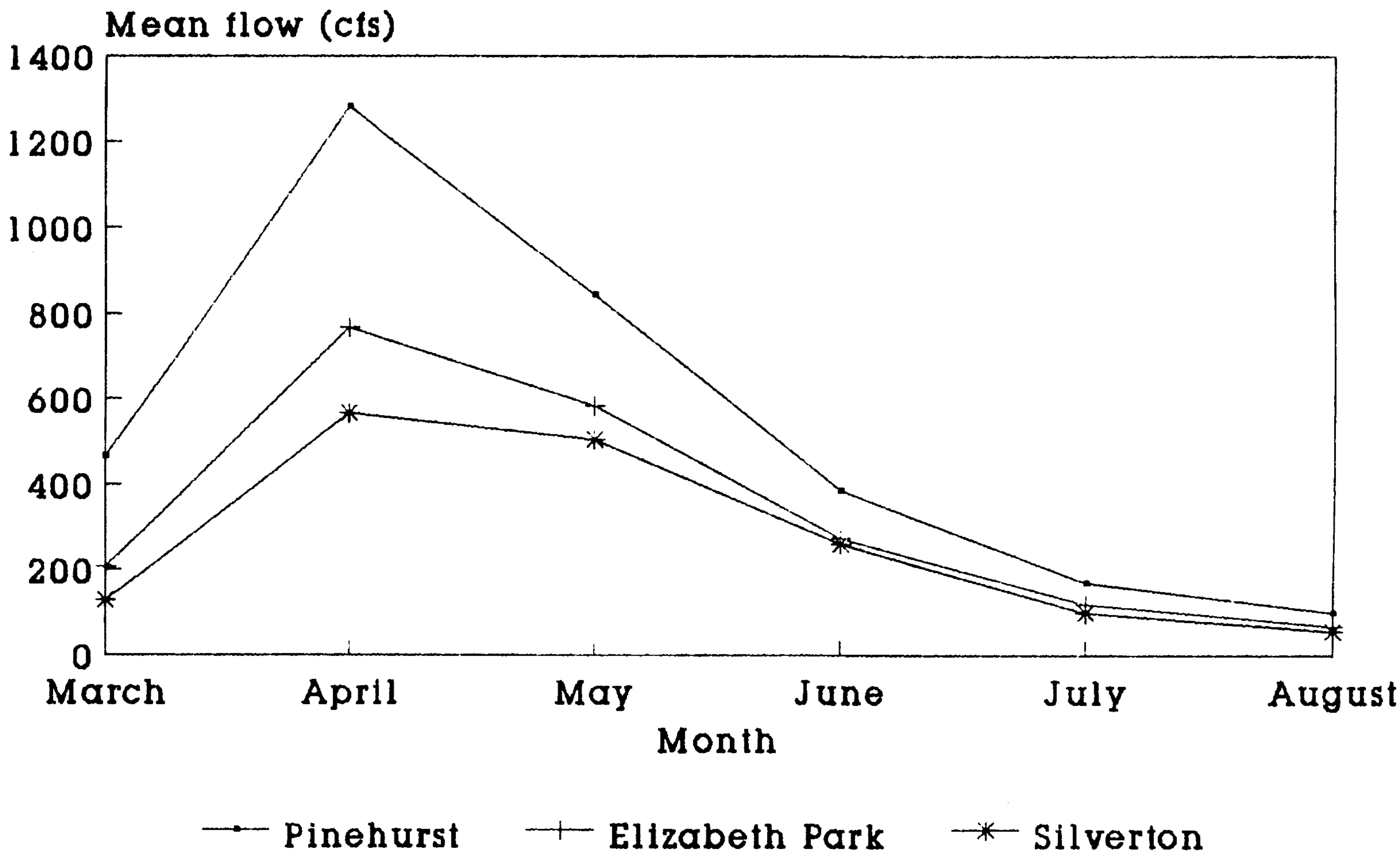

Figure 2. Average stream flow of the South Fork River as measured at Pinehurst, Elizabeth Park and Silverton recording stations by the USGS - Sandpoint office.

Climate and Vegetation

Climate in the mining district is moderate with mild summers and near freezing winters. Mean seasonal temperatures for September 1987 to August 1988 are: Fall (September to November) = High 64, Low 34; Winter (December to February) = High 34, Low 22; Spring (March to May) = High 58, Low 35; and Summer (June to August) = High 80, Low 48. 100 F was the highest recorded and -10 F was the lowest. Precipitation is primarily in the form of winter snow with summer showers. Average precipitation for September 1987 to August 1988 are: Fall (September to November) = .61"; Winter (December to February) = 4.1"; Spring (March to May) = 3.58"; and Summer (June to August) = 1.02" as shown in Figure 3. Temperature and precipitation data were obtained from the NOAA Climatological Data Bulletin - Idaho, for September 1987 to August 1988.

The mountain sides are tree covered wherever possible. Trees are harvested for use in mines and as fuel. Lodgepole pines, Douglas firs, bushy plants and grasses dominate the slopes. However, in Kellogg, a 1910 fire destroyed most trees and smelter fumes inhibited future growth (Mink, 1971).

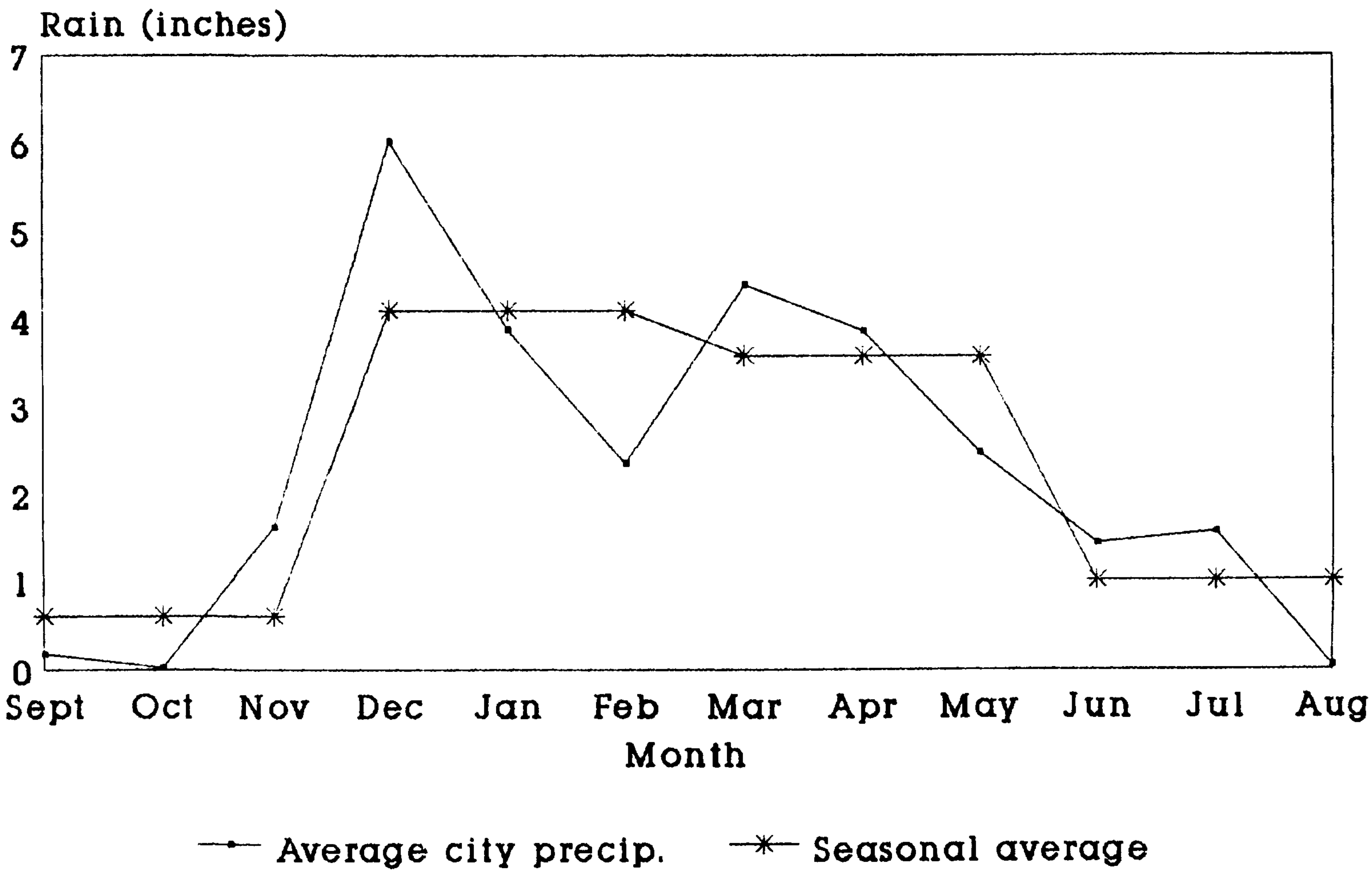

Figure 3. Average precipitation and seasonal averages as recorded at Kellogg, Idaho and Wallace, Idaho. The South Fork River flows beside these cities.

Previous Work

Research work pertaining to water quality in the Coeur d' Alene mining district covers the past 55 years. Ellis (1940) noted mine waste had not critically disturbed the river but that suspended solids from mills from Wallace to the joining of the North Fork prohibited aquatic life.

Chupp (1955) found lethal levels of lead and zinc in soil, plants and water along the Main Stem of the Coeur d' Alene River which proved deadly to some waterfowl.

Sappington (1969) studied native cutthroat trout bioassays along the river.

Savage (1970) concluded that macro-invertebrates could not colonize in the South Fork due to abundant tailings sediment. She also found that zinc concentrations during low flow were toxic to aquatic life.

Mink (1971) reported water quality along the South Fork and noted the particularly high zinc concentrations in the upper regions of the river.

Funk (1975) studied the water quality of the Coeur d' Alene River system, the Coeur d' Alene lake and the Spokane River system. He also researched the passage of metallic elements through the food chain.

Rouse (1976), along with the US Bureau of mines and Bunker Hill Company, studied seepage from the tailings pond and control measures which should be applied to help control the problems.

Eisenbarth and Wrigley (1978) stated that calcium and magnesium concentrations were low due to low occurrence in surrounding rocks and soils. Sodium and potassium were leached from soils, while bicarbonates were low due to little carbonate rock. Electric conductivity (EC) was slightly high but acceptable for agriculture purposes. PH remained within Idaho water quality standards (between 6.5 and 9.0) and temperature reached 20 degrees Celsius for a short time, not long enough to kill trout.

Gross (1982) concluded the "major problems posed by abandoned tailing impoundments are physical rather than chemical. Movement of fine grain tailing material into a stream are more serious than chemical leaching of heavy metal ions."

The EPA has monitored water quality along the South Fork, primarily during the low flow - late summer periods, for the years 1972, 1975, 1976, 1979, 1982, 1984, and 1986. EPA's information was derived from the STORET data system. As of the 1986 survey data, cadmium and zinc were still above chronic levels which were harmful to aquatic life.

Many more research papers have been compiled by University of Idaho and Washington State University graduate students in relation to the Coeur D'Alene River Basin. Nancy Savage and C.M. Wai each have composed literature searches for the various study aspects in these areas.

Update and Laws

Federal water quality standards were established and implemented to help reduce sediment load and reduce point source pollution from being discharged into the South Fork River.

1. In 1968, mill settling ponds were constructed to help reduce discharge/sediment load from ore waste into the river.
2. The South Fork Sewer District was formed in 1972 to eliminate raw sewage discharge into the river.
3. The Clean Water Act (1972) set effluent limits on industrial and municipal point source discharges into the US waters.
4. Bunker Hill completed a waste treatment system removing 95 percent of zinc concentrations in 1974.
5. In 1975, EPA Region X prohibited Bunker Hill from discharging unpermitted pollutants from its facilities into public waters.
6. RCRA (1976) established cleanup standards for active hazardous waste sites.
7. The Safe Drinking Water Act set standards for contaminated public water supply systems and for liability where the public health is threatened.
8. In 1980, the Comprehensive, Environmental Response, Compensation and Liability Act (CERCLA - Superfund)

established means of cleaning up abandoned or inactive hazardous waste around the country; one of which is the Bunker Hill mining district.

9. The 1986 Superfund Amendments of Reauthorization Act (SARA) updates CERCLA 1980.

Overview of Contaminants in the Area

Since 1890, mining of lead, silver and zinc has occurred in the Coeur d' Alene mining district. In 1943, a maximum of 30 mills operated to help with the war effort (Gross, 1982); for one century, mine waste have contributed to contamination of the Coeur d' Alene River. Zinc was not recovered in the early mining years; it was discarded as waste into the South Fork. Heavy metal sulfides in exposed tailings ponds have been oxidized and heavy metal ion concentrations from a variety of sources have leached into the river. Over the years, South Fork water quality, as well as air quality, has been affected by lead and zinc smelters, mining operations and raw sewage.

In the early days, thousands of tons of jig tailings containing zinc and other metal sulfides were deposited along side the banks and floor of the river. All solids and liquids were dumped into the river system thereby changing the environment and causing concern among citizens. Mining and metallurgical operations produced waste such as acid, suspended material and dissolved metals. Heavy metals of concern are zinc and cadmium because of their solubility in a sulfate system.

Prior to 1968, most of the effluents were discharged directly into the South Fork. In the fall of 1968, water quality legislation required the installation and use of mill tailing impoundments to reduce the suspended solid load and to treat waste. Mill tailings discharged into tailings ponds were the first to be contained. The zinc plant and lead smelter plant also discharged zinc rich waters to the South Fork.

Mink (1972) notes that settling ponds were successful in treating effluent and reducing concentration levels. But, the effluent were not necessarily reduced to acceptable limits chemically.

In recent years, federal water quality standards and modern milling techniques have combined to reduce sediment load and eliminate point source pollution from mine and mill sites, water quality has been improved. However, even with the government and local mining companies efforts to reduce contamination levels in the river, "background" contaminants continue to pose problems unassociated with recent mining operations.

METHODS

River Water Sample Station Locations

The South Fork River water samples used in this 1988 study are described in the following section. Figure 4 shows station locations. Sample station locations 11 to 28 along the South Fork, follow Mink's (1971) sample stations as closely as possible. Samples A, and 13A were added to the scheme, while 24 and 27 were omitted because of road construction and inability to reach the stream safely.

All station locations are described by driving I-90 west-to-east toward Montana. Station A is along the Main Stem of the Coeur d' Alene River, just below the juncture of the North and South Forks. It may be reached at Cataldo Exit 40 and sampled near the old bridge.

Station 11 is located off Exit 43 at Kingston, then toward Enaville to the bridge crossing the South Fork. This is the first station on the South Fork; it measures quality characteristics before the South Fork joins the North Fork to form the Main Stem.

To reach station 12 one follows Pinehurst Exit 45, turns left and samples under the double bridge overpass. The effects of the South Fork upstream from Pine Creek and from

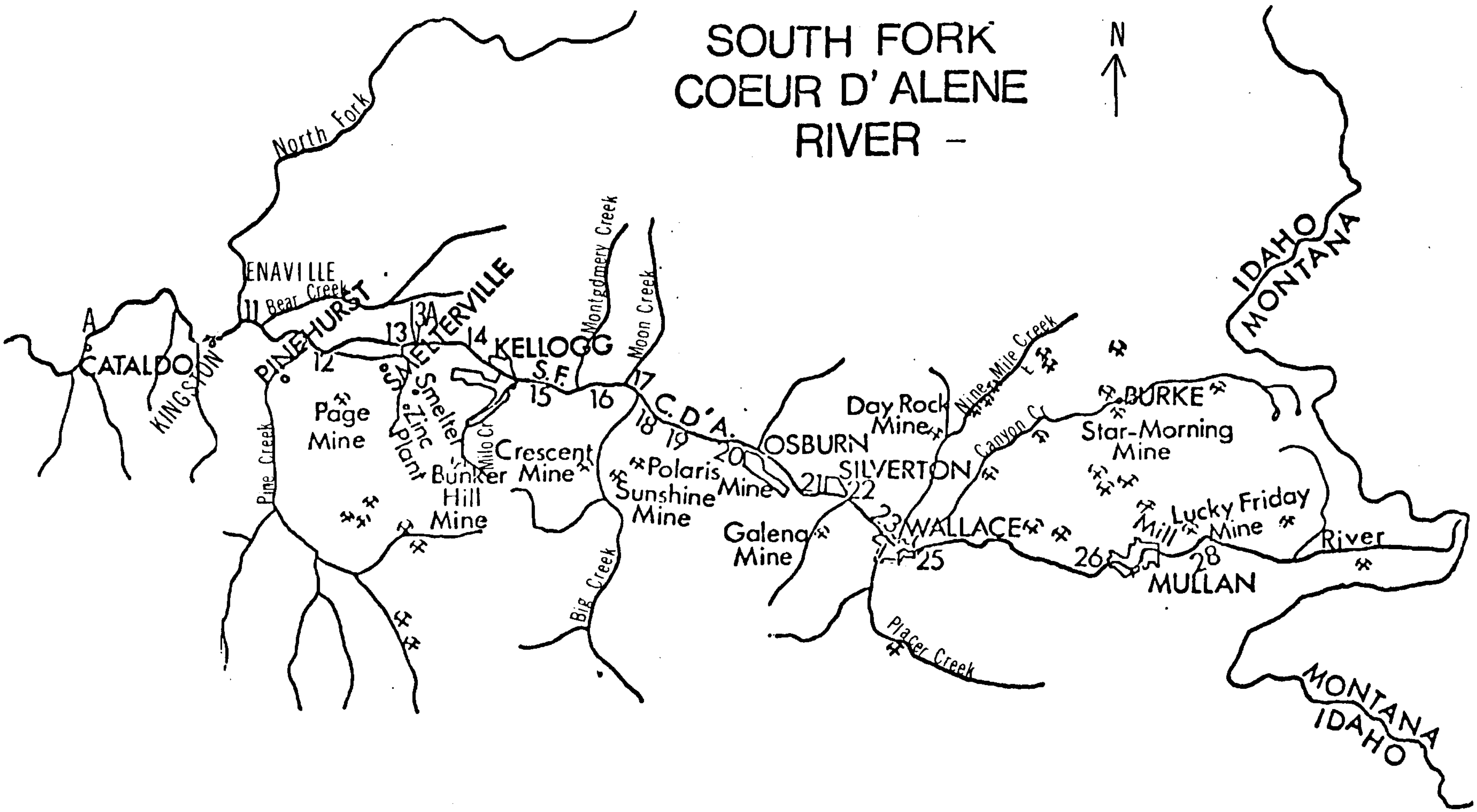

Figure 4. Location map illustrating sampling stations and tributaries along the South Fork and Coeur D' Alene Rivers.

Pine Creek are measured at this sample location, along with upstream effects and effects from the Smelterville Flats aquifer.

Station 13 is located above the discharge of Pine Creek. One takes the airport exit for station 13.

Station 13A is located upstream of the station 13 seepage to facilitate a comparison between the two.

Station 14 is under the bridge below the city of Kellogg; it can be reached from Bunker Avenue Exit. Effects from Milo Creek are measured at this station.

Station 15 is located above Kellogg at mile marker #51, but below Elizabeth Park where residents used to dump raw sewage.

Station 16 is below a residential sector near Elk Creek at mile marker #53.

Exit 54 brings stations 17 and 18 into view. Station 18 is upstream of Big Creek and station 17 is downstream of Big Creek. This station measures discharge from the Sunshine and Crescent operations.

Station 19 is across from a gravel pit along the highway; station 20 is measured where the South Fork crosses under the highway; both stations are downstream of Osburn.

Station 21 is located below Silverton; station 22 samples above Silverton from Exit 60.

Station 23 is located downstream of Wallace and Nine Mile, Canyon, and Placer Creeks. Station 25 is above Wallace and upstream of these creeks.

Station 26 is located below Mullan at mile marker #67; it measures quality below the abandoned Star Morning and Lucky Friday Mines.

The location of station 28 is near Exit 69 above Mullan and the Lucky Friday Mine. This station is the furthest from the confluence and water quality should be least affected by mine and municipal wastes.

Data Collection and Analysis

Samples of river water were collected in 500 ml linear polyethelene bottles. These samples were obtained every two weeks from March 15 to August 18, 1988. Sample bottles were rinsed with river water; stagnant areas were avoided. Temperature (degrees Celsius), electric conductivity (EC - umhos) and pH were analyzed in the field. When bicarbonates were to be tested, samples were kept cool. All samples were collected according to the Manual of Methods for Chemical Analysis of Water by the EPA, 1974.

After all samples were obtained, they were then filtered and acidified using the Bunker Hill laboratory facility. Sixty milliliters samples were then shipped to the United States Bureau of Mines - Spokane Research Center to be analyzed for the following metals: antimony (Sb), arsenic (As), calcium(Ca), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), potassium (K), magnesium (Mg), manganese (Mn), nickel (Ni), sodium (Na), and zinc (Zn). The metals were analyzed by a Perkin-Elmer Plasma II ICP (Inductively Coupled Plasma) spectrometer. Arsenic analyses should be considered as approximations.

July and August samples were analyzed for the same metals in Albany, Oregon at the Bureau of Mines. Detection limits were comparative between the two labs and coefficient of variation was based on a value of 10 or less to ensure accuracy for all samples (Eric Zahl, personal communication).

RESULTS AND DISCUSSION

Water Quality Analysis

The South Fork is the section of the Coeur d' Alene River system which has received the greatest contaminant loads over the last century. For almost 100 years, contaminants have entered these waters. During the period of this study, analyses were made for the elements calcium, cadmium, copper, iron, potassium, magnesium, manganese, sodium, lead, sulfur, and zinc to determine the concentration of these elements, as well as where and when the greatest abundance of elements enter into the river. Data results for this study may be found in Appendix A. These data were then compared with EPA studies conducted over the past twenty years to identify any improvements in the water quality. EPA data are presented in Appendix B.

As a general rule, the sampling station at Cataldo on the Main Stem of the Coeur D' Alene River and the stations upstream of Wallace on the South Fork did not exhibit excessive concentrations of the elements analyzed.

The elements potassium, manganese, and sodium are commonly found in industrial wastes or municipal wastes. Many of the potassium levels were below detection limits; however a slight increase in concentration occurred in the latter months of summer. Manganese results were relatively constant along the river for each sampling date. April results decreased compared to March, and then increased slightly each month through August. Sodium was generally lower in the first half of each month than in the second half of the month, and increased slightly in July and August. Results indicate station 12 usually had higher sodium concentrations than any of the other sample locations.

Calcium and magnesium were analyzed to determine hardness along the river and because they help reduce toxicity for some aquatic life. Both elements decreased in concentration from March to April during the study period. Calcium decreased during the first half of May, and then increased slightly from April through August. Calcium concentrations usually were higher than other stations at station 12 below Smelterville Flats.

Cadmium, copper and lead did not reach detectable limits during this study. Therefore past EPA data of cadmium and lead concentrations were used to analyze there changes over time. Sulfur was analyzed only over three months; it showed a general increase in concentration from April through June.

Iron was relatively constant among the stations and throughout the sampling period. Two comparatively high concentrations were observed at station 12 on May 13 (filtered) and station 13 on June 23 (filtered). Unfiltered samples generally were higher than filtered samples indicating a source of iron in the unfiltered sample, presumably from suspended solid particles.

Zinc decreased in April following a high in March and decreased again through the first half of May. The end of May indicated a slight increase in zinc concentration that continued through July and then remained constant throughout August. Station 12 always had higher concentrations than the other sampling locations.

Zinc is the only element in this study that displayed concentrations that are appreciably above the detection limits. Zinc displays the highest concentrations during the period March to August; it exceeds toxicity limits for the survival of aquatic life. Station 12 exhibited the highest continual concentration of zinc along the river.

The average zinc concentrations at each sampling station during the course of field work are shown in Figure 5. Station 12 is located downstream of the Smelterville Flats and airport;it displays significantly higher concentrations than the other stations. Station 18 shows the next highest levels; it is located upstream of Big Creek. As noted, station 17 is lower in zinc than station 18; this relationship may be due to dilution from Big Creek with its waste water treatment facilities. Both the upper portion of the South Fork above

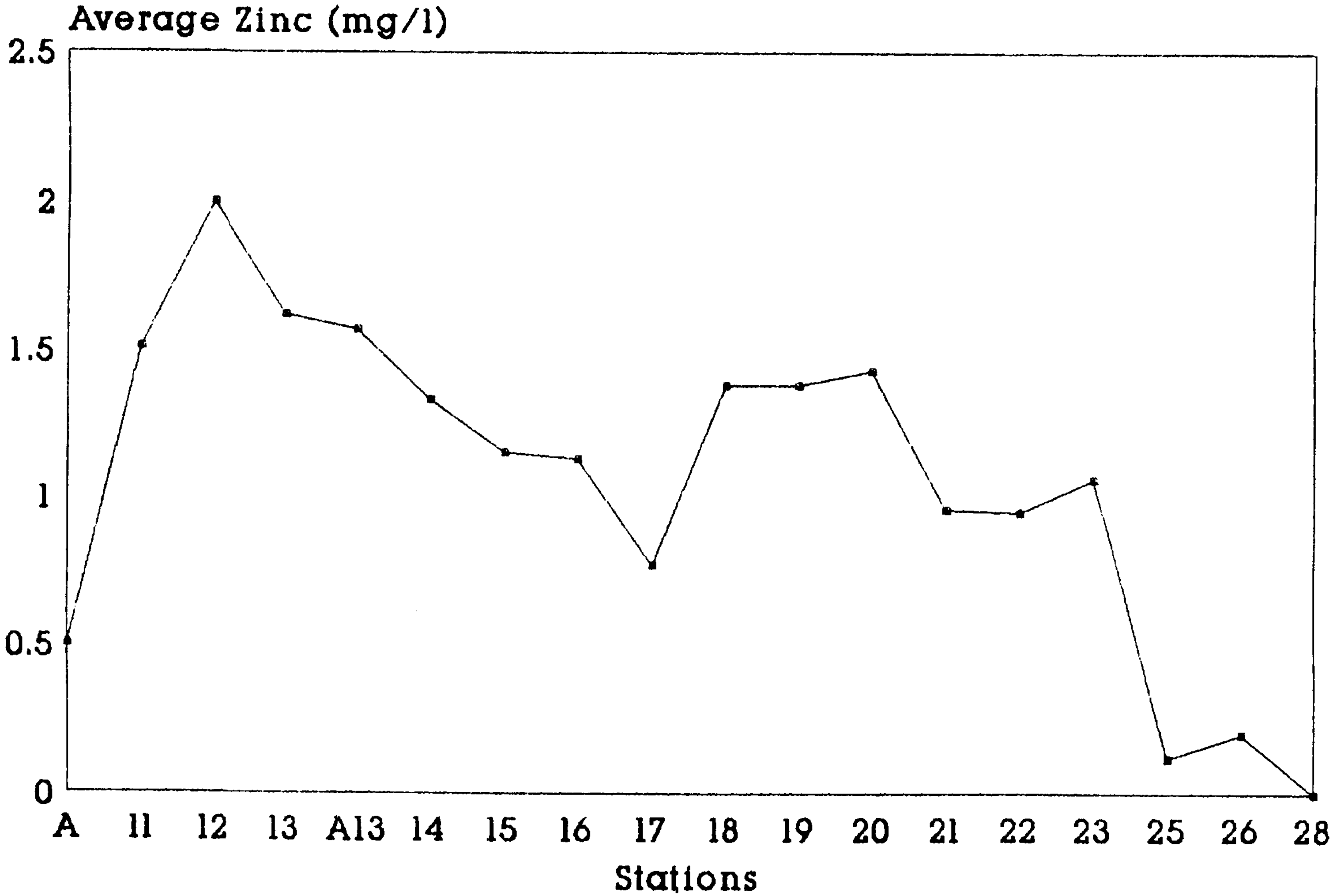

Figure 5. The average zinc concentration is illustrated at each sampling location along the South Fork during the March to August 1988 study.

Wallace and station A in Cataldo are comparatively low in zinc concentration which indicates that some parts of the river display much better quality than other parts.

The highest zinc concentration for a sampled month occurred in March (Figure 6) at station 12. Stations 17 and 18 follow the same pattern as the average pattern mentioned above. However, station 19 is uncharacteristically high in zinc for March, even though this station usually is consistent with stations 18 and 20. March's high zinc concentrations paobably are caused by high snowmelt runoff from contaminated hillsides.

The second highest zinc concentration for a sampled month occurred in late July (Figure 7). Concentrations along the river follow the same pattern as in March. These concentrations apparently derive from ground water inflow affected by settling pond seepages, and leaching from old tailings near low flow.

May 13 (Figure 8) displayed the lowest overall zinc concentration during the sampling study. Once, again, the graph pattern is similar to the other graphs.

Station 12 displays the highest overall zinc concentration during the study (Figure 9). As mentioned above, the month of March has the greatest concentration. A general decrease occurs through the first half of May and then increases steadily throughout the study. Station 12, below Smelterville Flats is affected by the Smelterville Flats upper

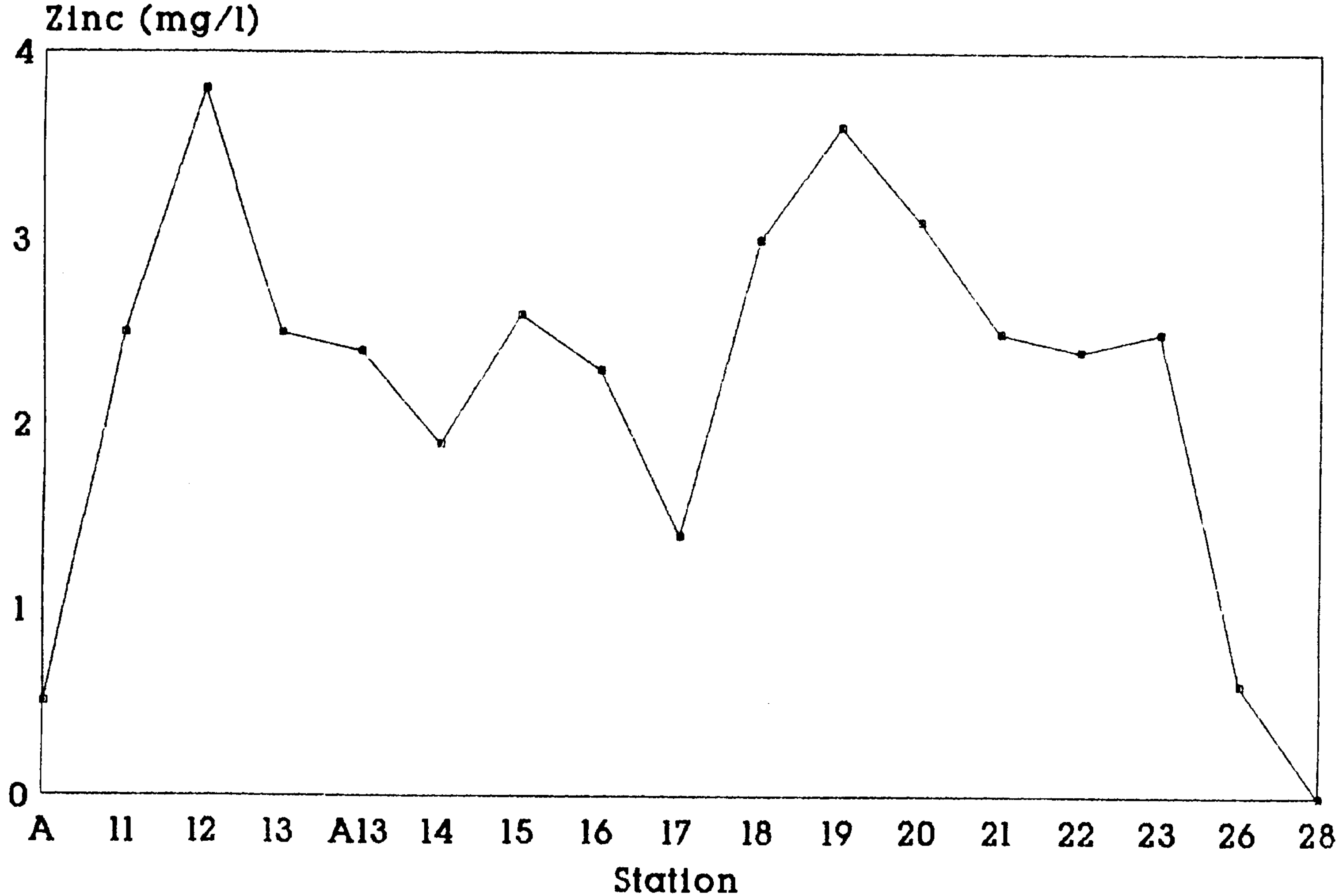

Figure 6. The highest zinc concentration occurred March 15, 1988 and is illustrated at each sampling station on the South Fork River.

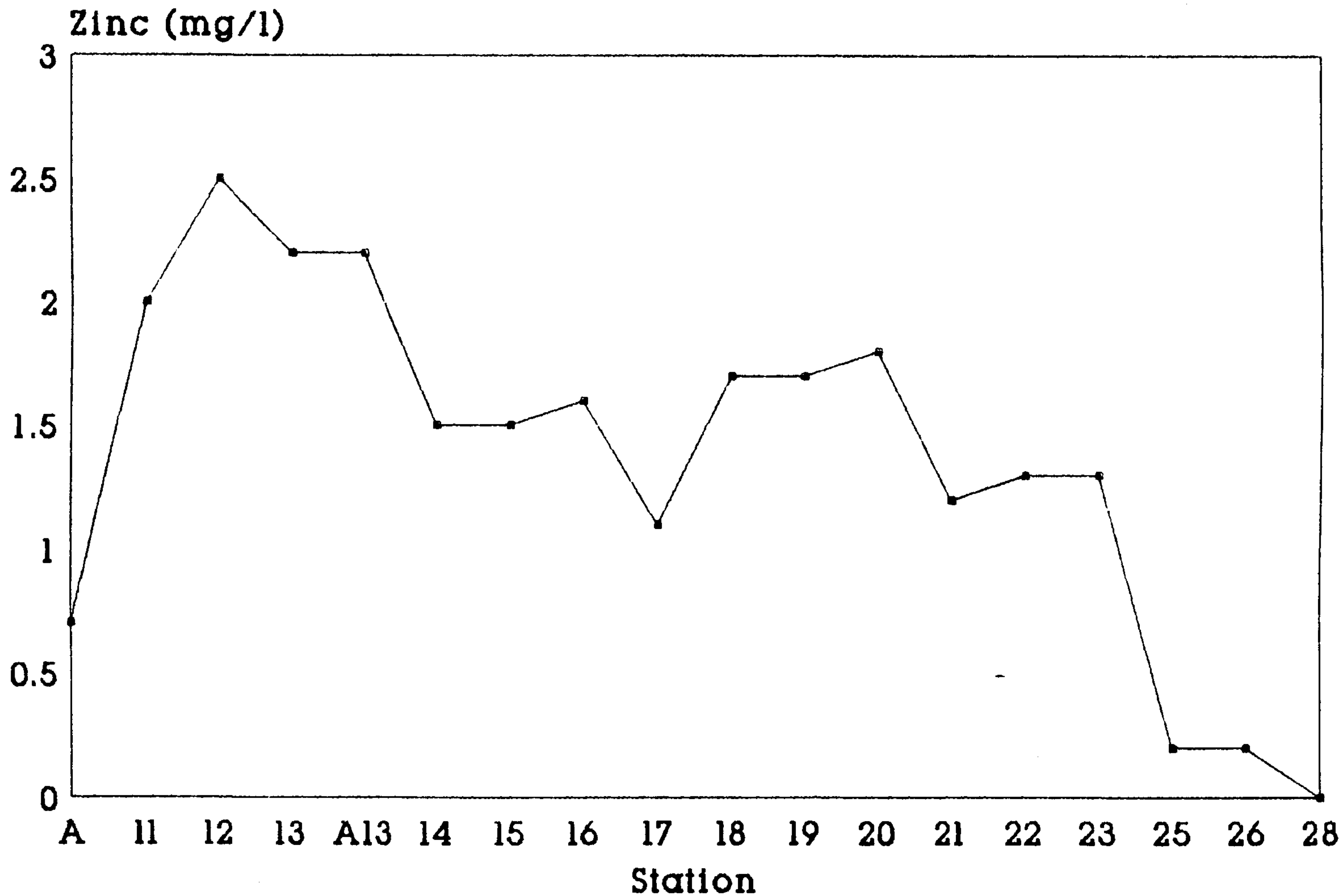

Figure 7. The second highest zinc concentration occurred July 21, 1988 and is illustrated at each sampling station on the South Fork.

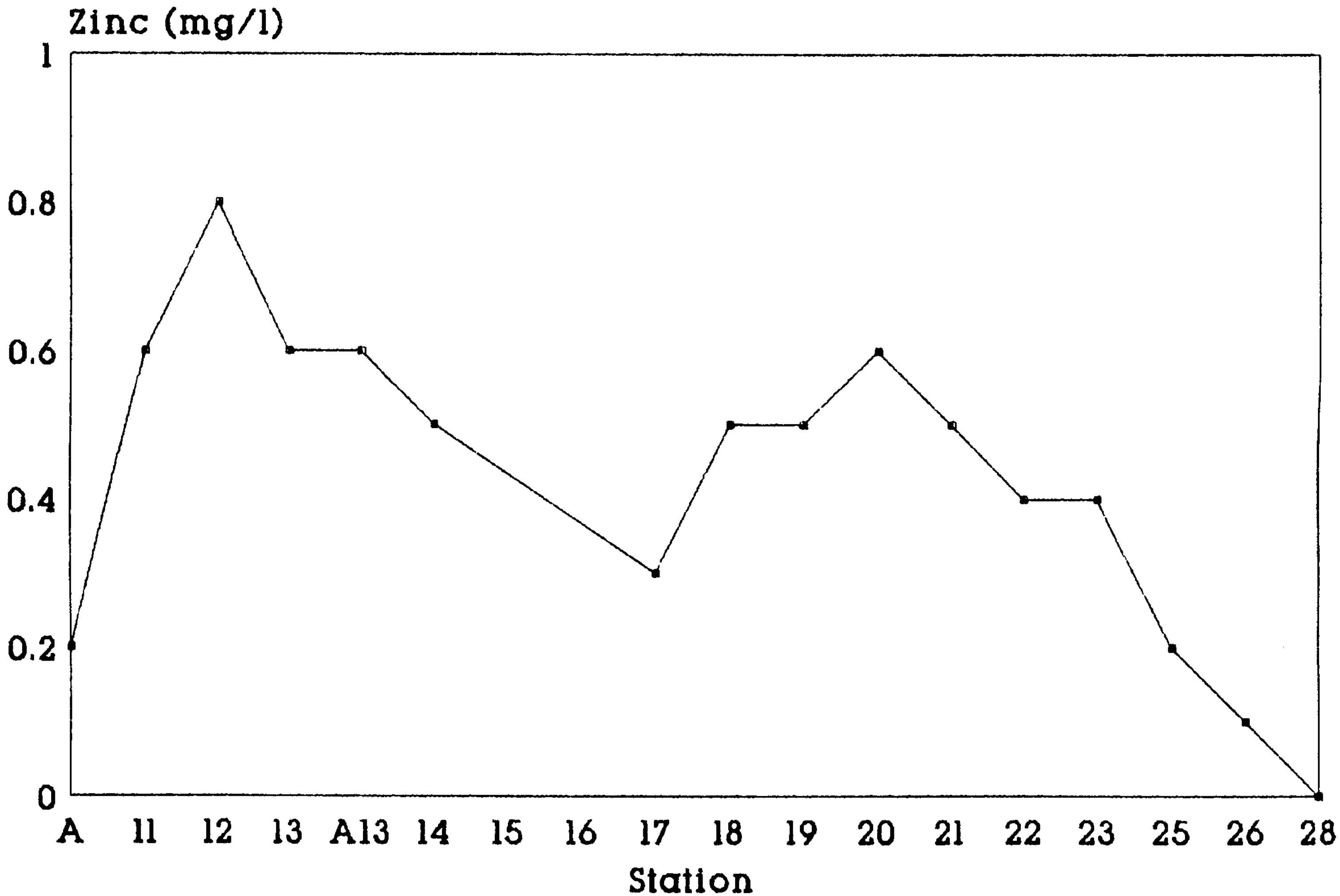

Figure 8. The lowest zinc concentration occurred May 13, 1988 and is illustrated at each sampling station on the South Fork.

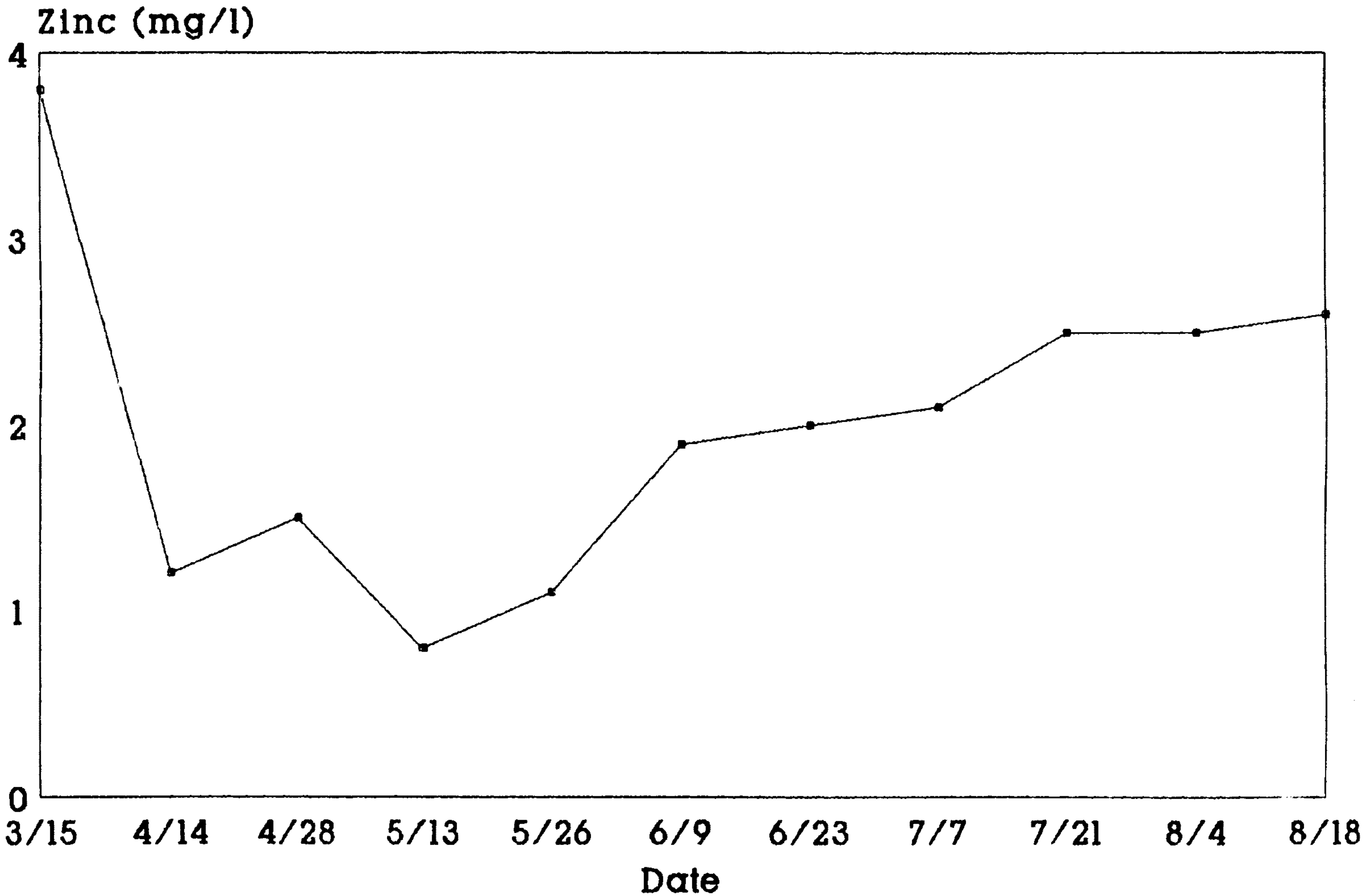

Figure 9. The highest overall zinc concentration during the study occurred at sampling station 12, below Smelterville Flats and is illustrated at the various sampling dates.

aquifer which is currently being studied by University of Idaho student thesis research projects.

Toxicity of Water Quality

Contaminants entering the basin have proven toxic to aquatic life in the South Fork. For most of its mining life, the South Fork has been void of biota because of the high concentrations of cadmium, lead, and zinc and because of high sediment load. Table 1 gives federal water quality criteria levels of toxicity and MCL's for drinking water. Toxicity levels generally increase with temperature and decrease with water hardness (Funk, 1975). An abundance of cadmium and zinc are of greatest concern for aquatic life survival, whereas excessive amounts of cadmium and lead cause concern for human and animal health because they accumulate in body tissues (EPA Region X, 1972-86).

It is possible for cadmium to have a synergistic effect with zinc and cause concentrations to be toxic to some fish (.03 mg/l Cd + .15 mg/l Zn to kill salmon fry according to Mink 1971). The federal standard MCL for cadmium is .01 mg/l and the EPA chronic toxicity level is .66 ug/l with a hardness of 50 mg/l. As noted by EPA (Woodward-Clyde, 1986), cadmium accumulates in kidneys and can cause damages such as: bone softening, hypertension, abnormal liver functions, moderate anemia, and nonspecific nervous system disorders. Zinc, selenium, copper, and iron are found to reduce the ability of

TABLE 1

FEDERAL AND STATE WATER QUALITY CRITERIA FOR METALS OF CONCERN

Metals	Chronic Toxicity (ug/l)	Acute Toxicity (ug/l)	Drinking Water Standards MCL (mg/l)
Arsenic	190	360	.05
Cadmium	.66+	1.8+	.01
Chromium	120+	980+	.05
Copper	6.5+	9.2+	1.0
Lead	1.3+	34+	.05
Selenium	35	260	.01
Zinc	47	320	5.0

+Based on hardness of 50 mg/l as $CaCO_3$.

Source:US EPA 1988

cadmium to cause tissue damage. During this study of the South Fork, cadmium concentrations did not reach detection limits often enough to quantify results.

However, according to data collected by EPA studies (Region X, 1972 - 1984), cadmium exceeds both EPA drinking standards and chronic toxicity levels (Figure 10) at Smelterville Flats. After a great decrease between 1972 and 1974, cadmium appears to be declining steadily in concentration. Downstream of the South Fork confluence at Cataldo, (Figure 11) cadmium concentrations have varied but have dropped below EPA MCL's since 1979; but it remains toxic to fish.

Lead and copper induce synergistic effects with zinc (Mink, 1971). However, nickel, lead, copper, and chromium are not generally detrimental to aquatic life except for the synergistic effects with zinc (Mink, 1971). Lead's federal standard MCL is >05 mg/l with a chronic toxicity of 1.3 ug/l (hardness of 50 mg/l). High concentrations of lead may lead to lead poisoning, anemia, and accumulation of lead in the bones (Woodward-Clyde, 1986). According to this same report, lead can cause damage to the central nervous system; signs of lead accumulations in the body include fatigue, headaches, convulsions, cerebral palsy, blindness, mental retardation and reproductive abnormalities. Lead concentrations during this study did not produce enough results above the detection limits to quantify analysis.

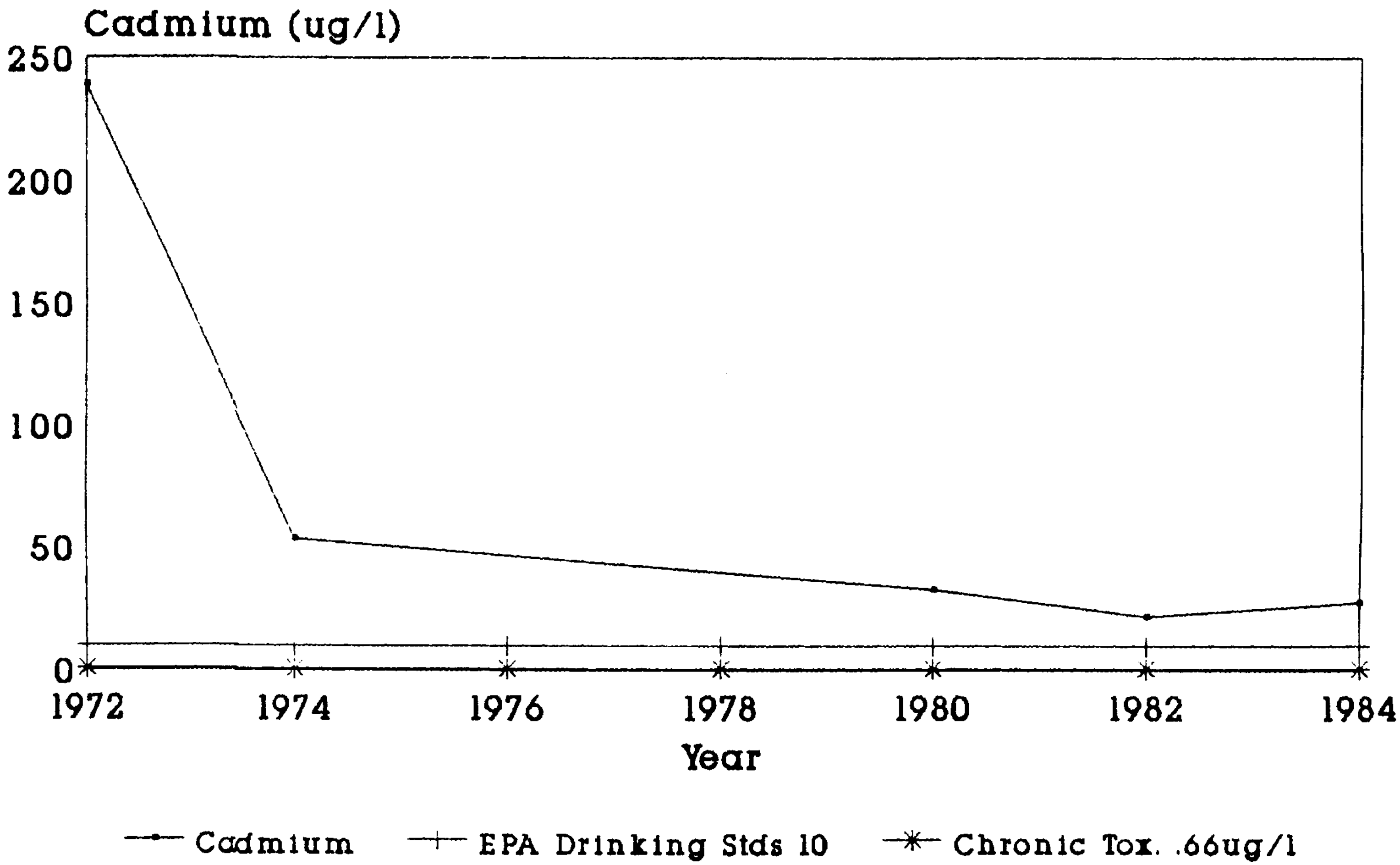

Figure 10. EPA cadmium concentrations at Smelterville station 12, EPA drinking standards of 10 ug/l, and chronic toxicity levels of 0.66 ug/l are illustrated over time from Woodward-Clyde 1986 data. Toxicity levels are based on CaCO3 hardness of 50 mg/l.

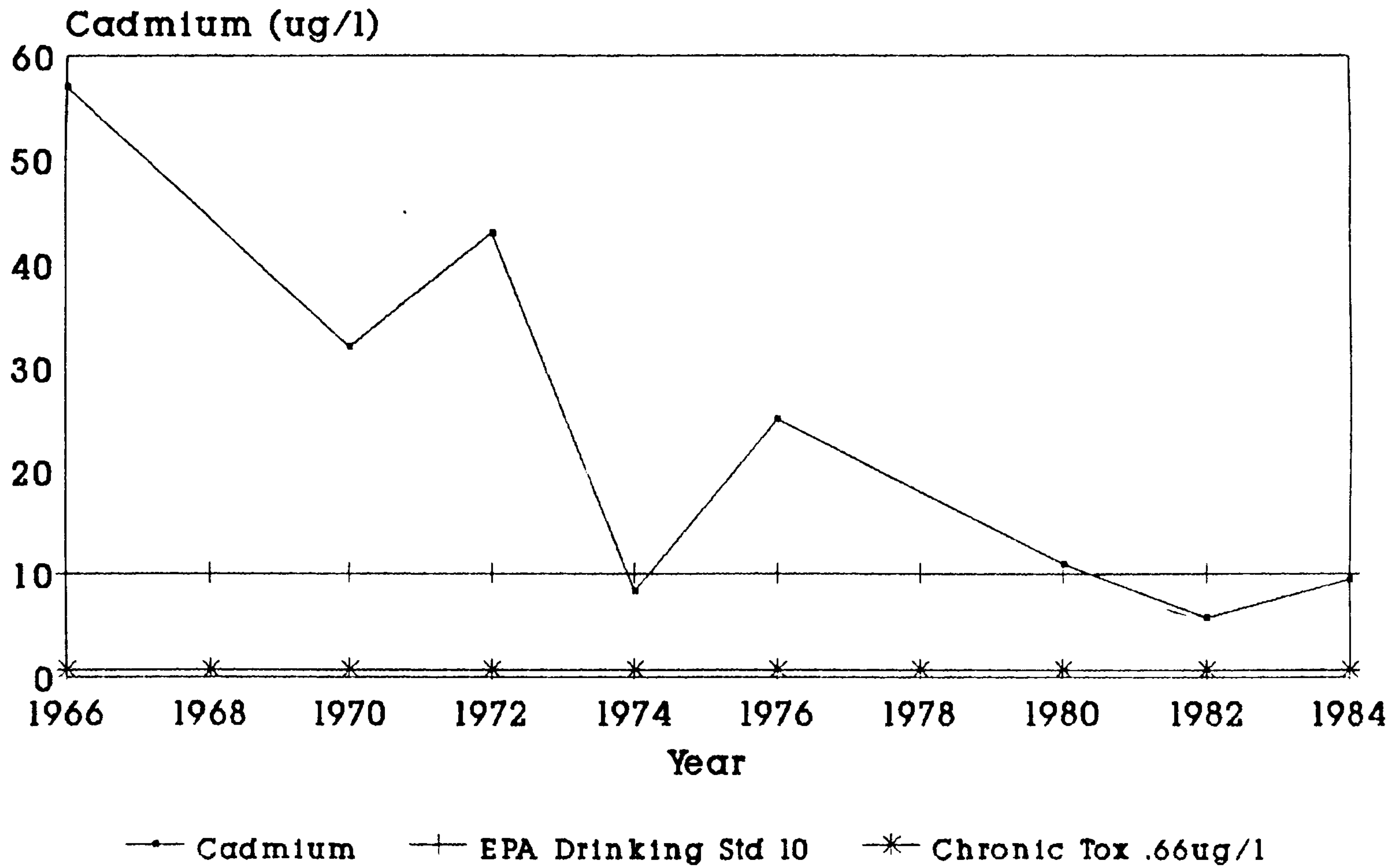

Figure 11. EPA cadmium concentrations at Cataldo station A, on the Coeur D' Alene River, EPA drinking standards of 10 ug/l, and chronic toxicity levels of 0.66 ug/l are illustrated over time from Woodward-Clyde 1986 data. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l.

However, past EPA studies indicate that lead has been between acute and chronic levels. Along the South Fork at Smelterville Flats, lead levels dropped significantly from 1972 to 1979. By 1979 and continuing until recently, lead has fallen below EPA MCL's, but still exceeds chronic toxicity levels for the survival of biota (Figure 12). Downstream in the Coeur D' Alene River at Cataldo, lead levels have also decreased below EPA MCL's (Figure 13), but remain above slightly toxic levels.

As reported by Mink (1971) concerning Sappington's (1969) work, cutthroat trout cannot live when zinc levels range from 0.1 ppm to 1.0 ppm Zn. Though calcium and magnesium may reduce the toxicity of zinc and cadmium slightly, when zinc is reported as high as 21 ppm at station 13 on 9-14-69 by Mink (1971), limited reduction in toxicity will occur. Zinc's federal drinking water standard is 5 mg/l and the chronic toxicity limit is 47 ug/l (.047 mg/l). Within humans, too much zinc may cause irritability, muscular stiffness and pain, loss of appetite, and nausea if water with 40 mg/l zinc is consumed over time (Woodward-Clyde, 1986). The data presented herein demonstrate that zinc concentrations in the South Fork are hazardous to fish but not to humans.

Zinc is the major element of concern in this study. Figure 14 shows EPA chronic and acute levels during low flow in August along the South Fork stations in relation to each stations zinc concentration at that time. Only station 28,

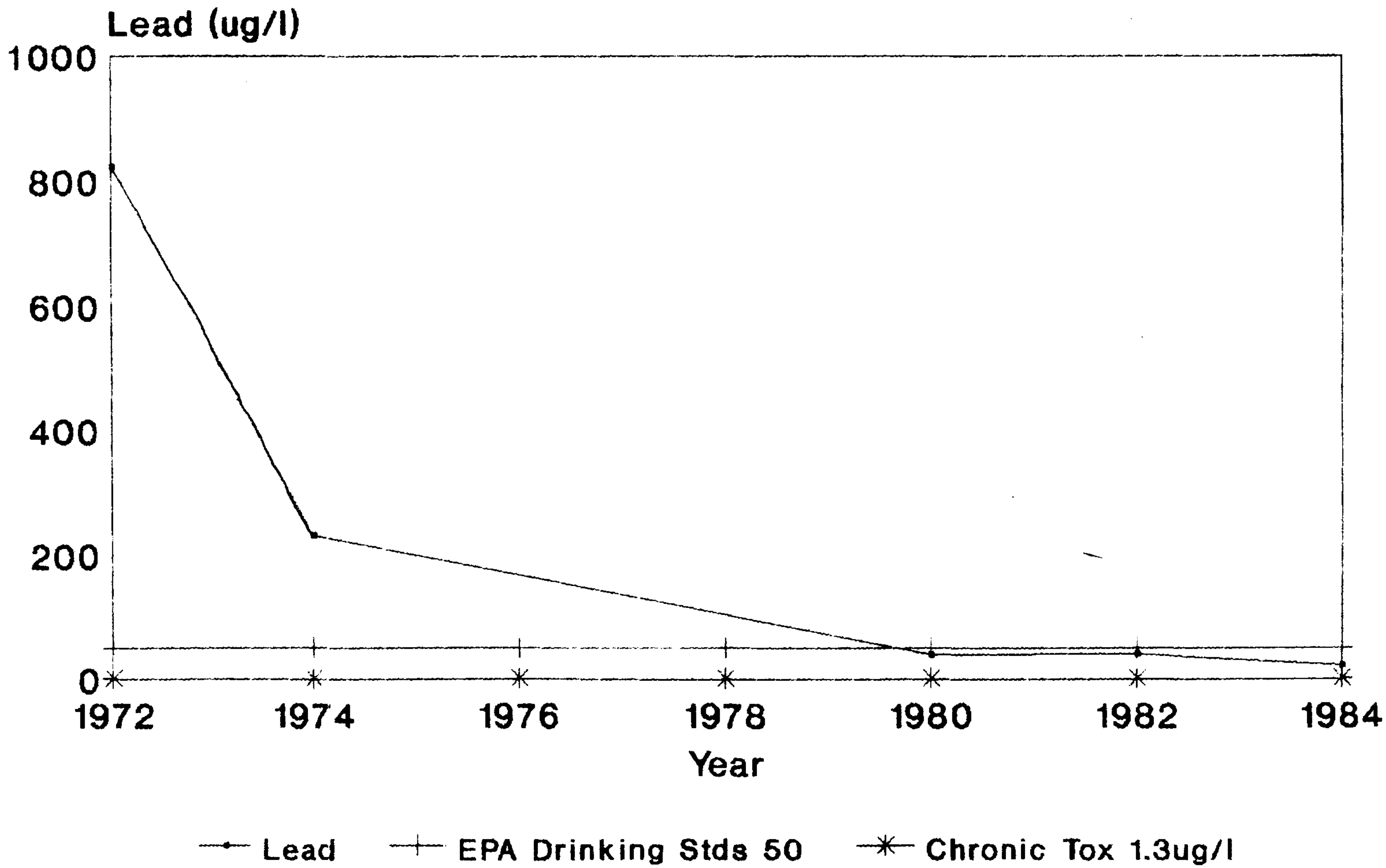

Figure 1. EPA lead concentrations in the South Fork of the Coeur'd Alene River, near Smelterville , from 1972-1984. EPA drinking water standards of 50 ug/l are illustrated over time from Woodward-Clyde 1986 data. Toxicity levels are baced on $CaCO_3$ hardness of 50 mg/l (Callcott, 1989).

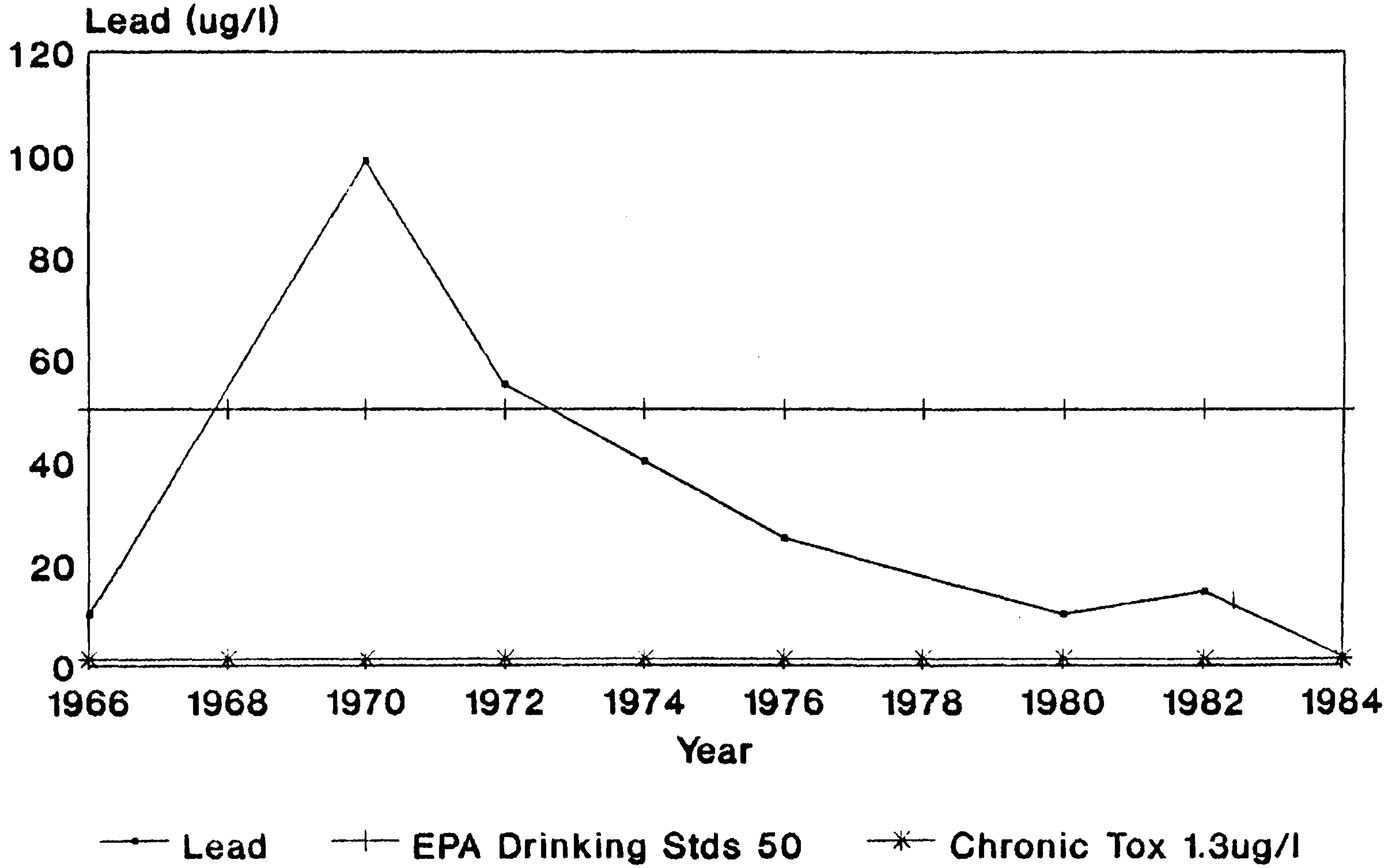

Figure 13. EPA lead concentrations at Cataldo station A, on the Coeur D' Alene River, EPA drinking standards of 50 ug/l, and chronic toxicity levels of 1.3 ug/l are illustrated over time from Woodward-Clyde 1986 data. Toxicity levels are based on CaCO3 hardness of 50 mg/l.

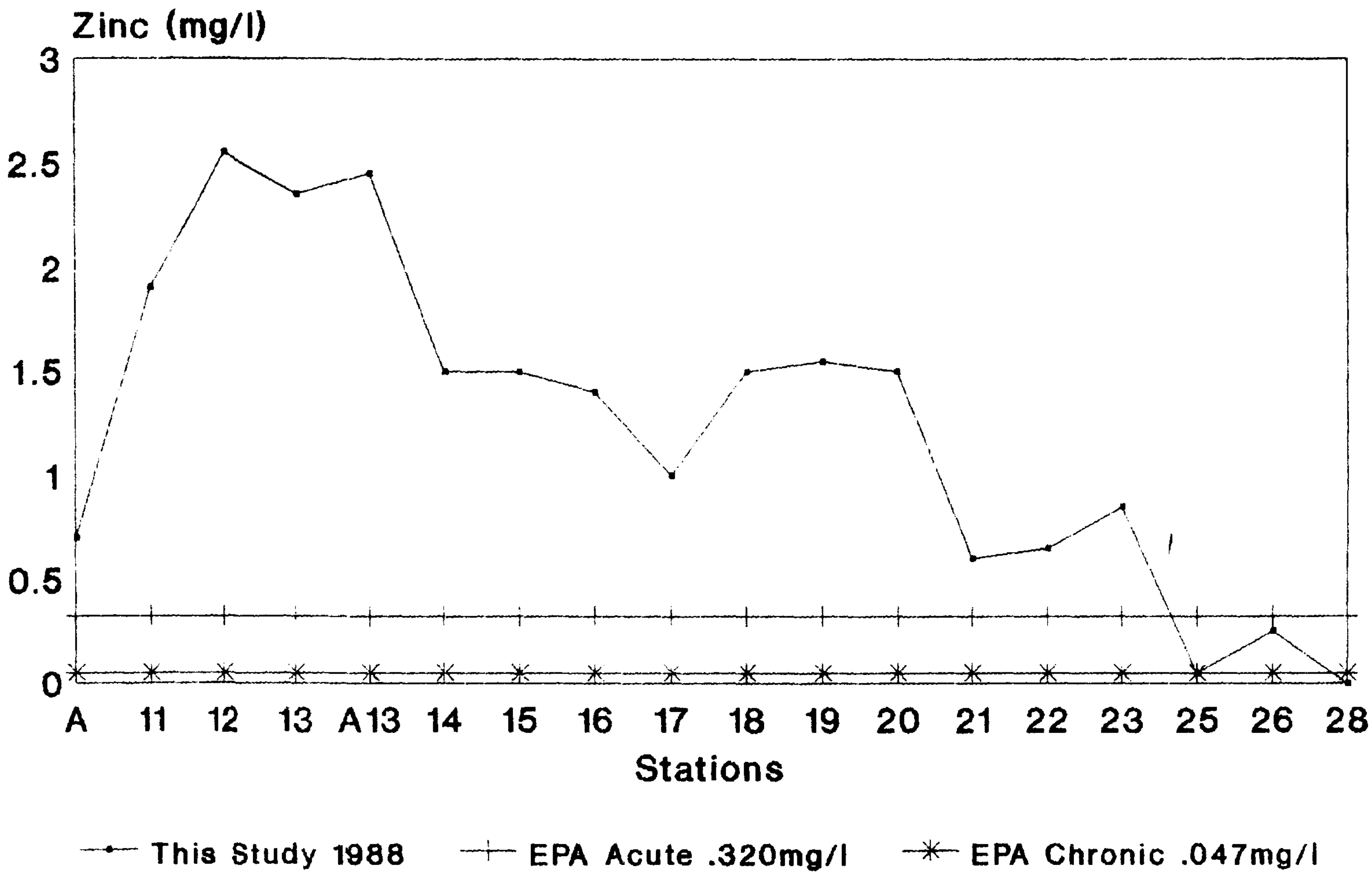

Figure 14. EPA acute toxicity level of zinc at 0.320 mg/l, chronic toxicity level of zinc at 0.047 mg/l and August zinc concentrations from this 1988 study are illustrated at each sampling station. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l.

above the Lucky Friday Mine, displays concentrations that are below the chronic level of .047 mg/l. Acute levels (.320 mg/l) are exceeded at all stations except those above Wallace (stations 25 to 28). Zinc does fall below EPA drinking water standards of 5 mg/l.

At Smelterville Flats (station 12) (Figure 15), zinc concentrations were lowest in May. The sample in March displayed a high concentration of zinc, probably the result of groundwater discharge from the Smelterville Flats aquifer entering the river. Concentrations gradually increased as river flow declined in the fall.

The Cataldo station (station A) of the Coeur D' Alene River displayed its lowest zinc concentration during the high flow period in April (Figure 16). Dilution by high flow from the South Fork and the North Fork contributed to the low zinc levels. Slight increase of levels occurred through June whereupon the zinc concentrations remained constant.

Past EPA data are updated with this 1988 studies more current results. Zinc concentrations in the South Fork at Smelterville Flats decreased rapidly from 1972 to 1974 (Figure 17); they then dropped gradually to levels below EPA drinking standards by 1980. Though still above chronic levels for aquatic life, zinc concentrations are continuing to decline. The Coeur D' Alene River at Cataldo has not exceeded EPA

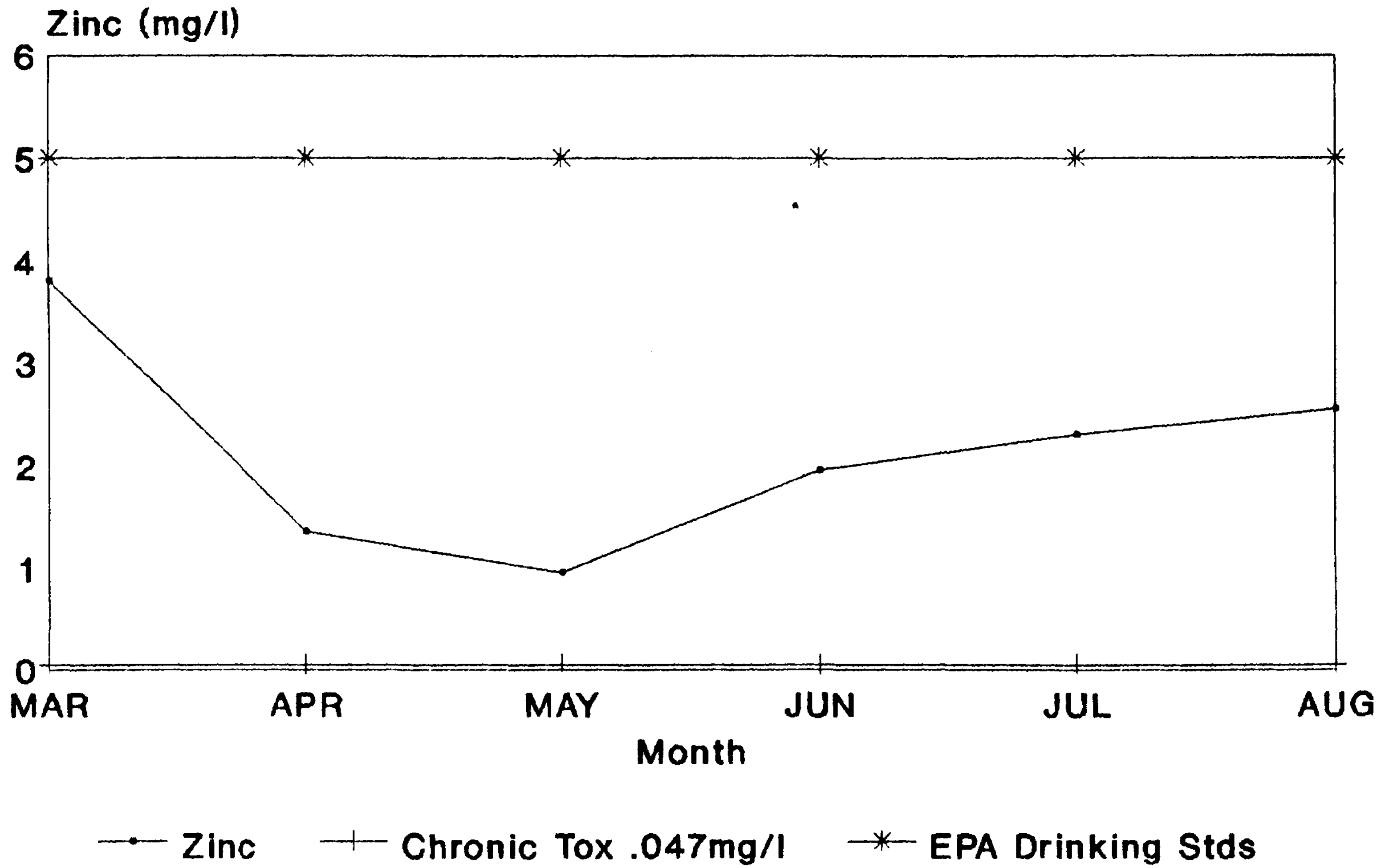

Figure 15. Zinc concentrations at Smelterville station 12 are illustrated each month of the 1988 study along with chronic toxicity level of 0.047 mg/l and EPA drinking standards of 5.0 mg/l. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l.

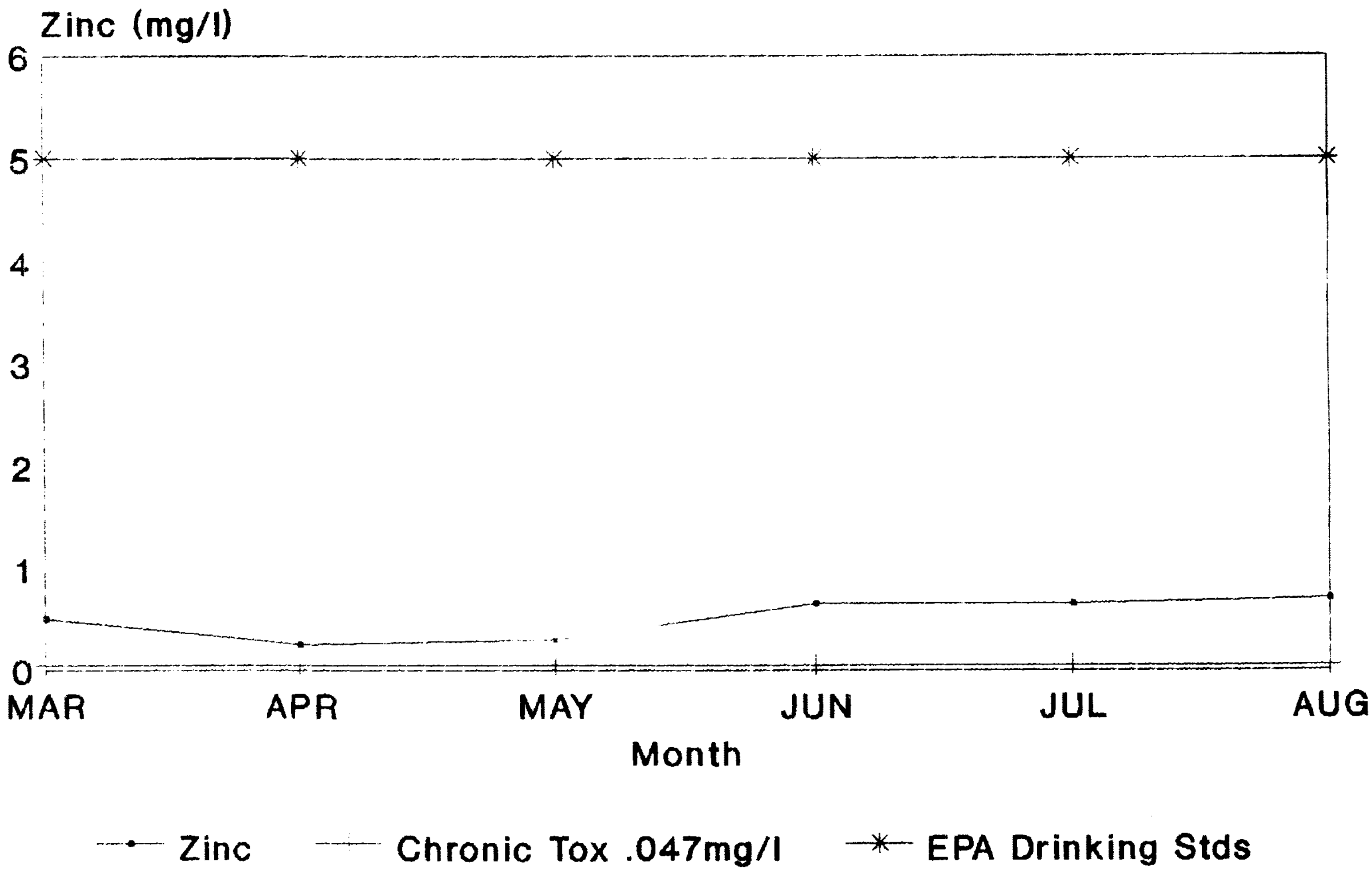

Figure 16. Zinc concentrations at Cataldo station A on the Coeur D' Alene River are illustrated each month of the 1988 study along with chronic toxicity level of 0.047 mg/l and EPA drinking standards of 5.0 mg/l. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l.

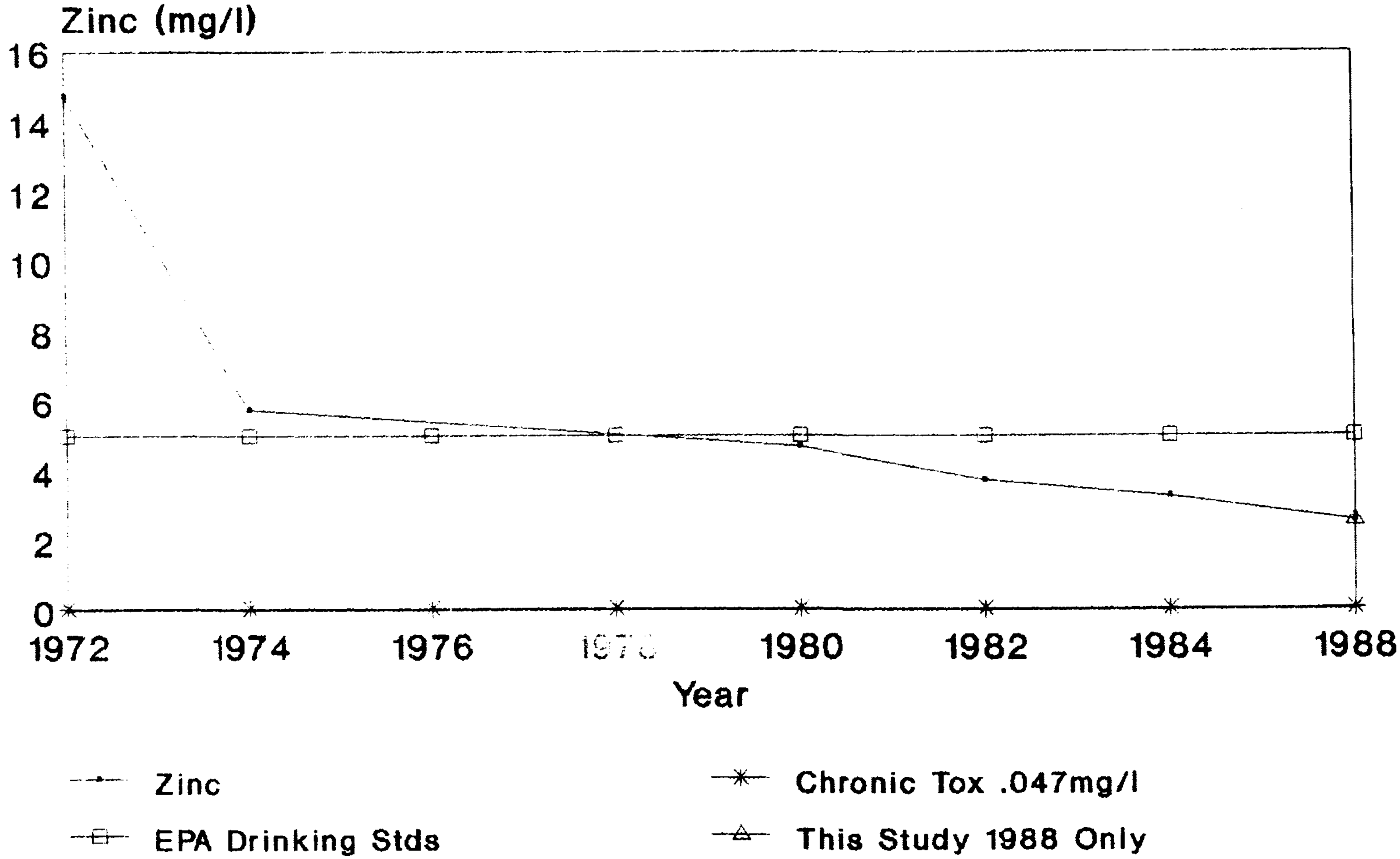

Figure 17. EPA zinc concentrations updated with this studies 1988 zinc data at Smelterville station 12 are illustrated over time, along with EPA drinking standards of 5.0 mg/l and chronic toxicity levels of 0.047 mg/l. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l and past EPA data are from Woodward-Clyde 1986 report.

MCL's, but zinc concentrations have varied greatly from 1966 to 1979 (Figure 18). Zinc levels appear to be declining steadily.

According to EPA bioassays conducted in 1986 (Woodward-Clyde, 1986), acute mortality of rainbow trout fingerlings and other minnows has occurred downstream from Canyon Creek. On the other hand, a number of benthic insect species reportedly are showing an ability to live along the South Fork. "Region 10 Laboratory conducted heavy metal analyses on game fish collected from Coeur D' Alene Lake, the Main Stem lateral lakes and the South Fork at Mullan. Results from these analyses do not indicate that the heavy metals, which are at very elevated levels in the sediments, are accumulating in edible fish tissue at levels considered dangerous to sports fisherman. High levels of cadmium and lead, however, were found in liver and kidney organs which may have significance to predatory birds." Though the river is still toxic to some lab tested invertabrates and hatchery trout, the less sensitive indigenous species are surviving in the South Fork; a return of game fish downstream of the South Fork confluence has been detected in the Main Stem of the Coeur D' Alene River.

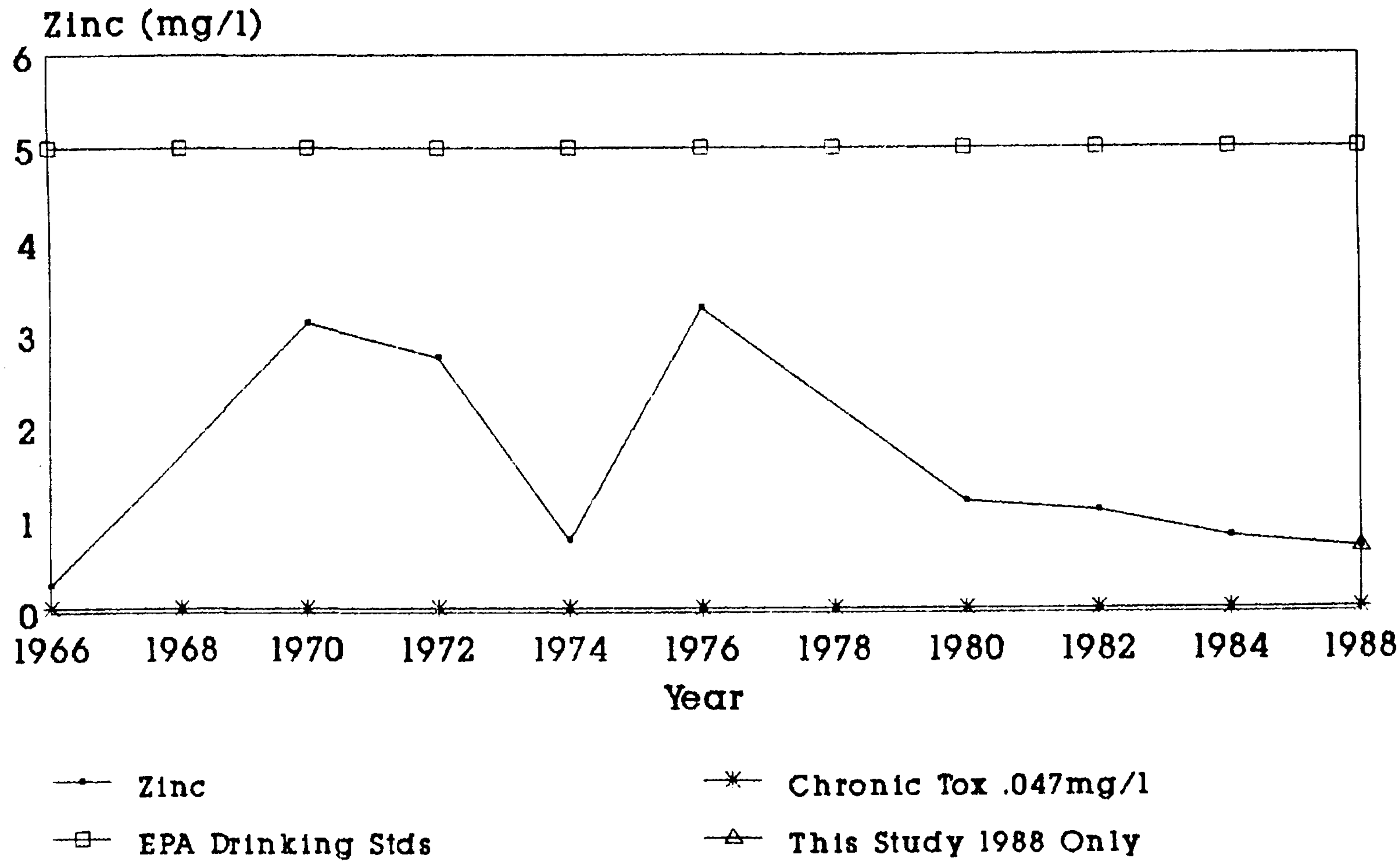

Figure 18. EPA zinc concentrations updated with this studies 1988 zinc data at Cataldo station A on the Coeur D' Alene River are illustrated over time, along with EPA drinking standards of 5.0 mg/l and chronic toxicity levels of 0.047 mg/l. Toxicity levels are based on $CaCO_3$ hardness of 50 mg/l and past EPA data are from Woodward-Clyde 1986 report.

Field Characteristics

The South Fork River in Idaho is classified as a cold water biological medium, meaning the water should be 22 C or less with a maximum average of no greater than 19 C. This requirement reflects the fact that trout can survive for only short periods of time at temperatures above 20 C. Figure 19 indicates the average water temperature along the South Fork over the course of this study (water temperature data are presented in Appendix D). Only during August low flow does the temperature reach 20 C; during most of the year the water temperature is adeqate for the survival of trout.

Specific electrical conductance (EC) measures the concentration of dissolved solids in water. Conductance is a function of water temperature and is related to the type and concentration of ions in solution. As long as EC is less than 600 umhos at 25 C, streams and rivers are capable of supporting aquatic life with respect to this criteria alone. The EC, though variable, always remained below 600 umhos during the period of this study (Figure 20). EC data for this study are presented in Appendix D.

Hardness is a property of water that reflects the presence of calcium plus magnesium. Hardness is usually expressed as milligrams per liter of $CaCO_3$. The South Fork water hardness generally decreases in a downstream direction; for the most part it is approximately 50 mg/l $CaCO_3$. Hardness

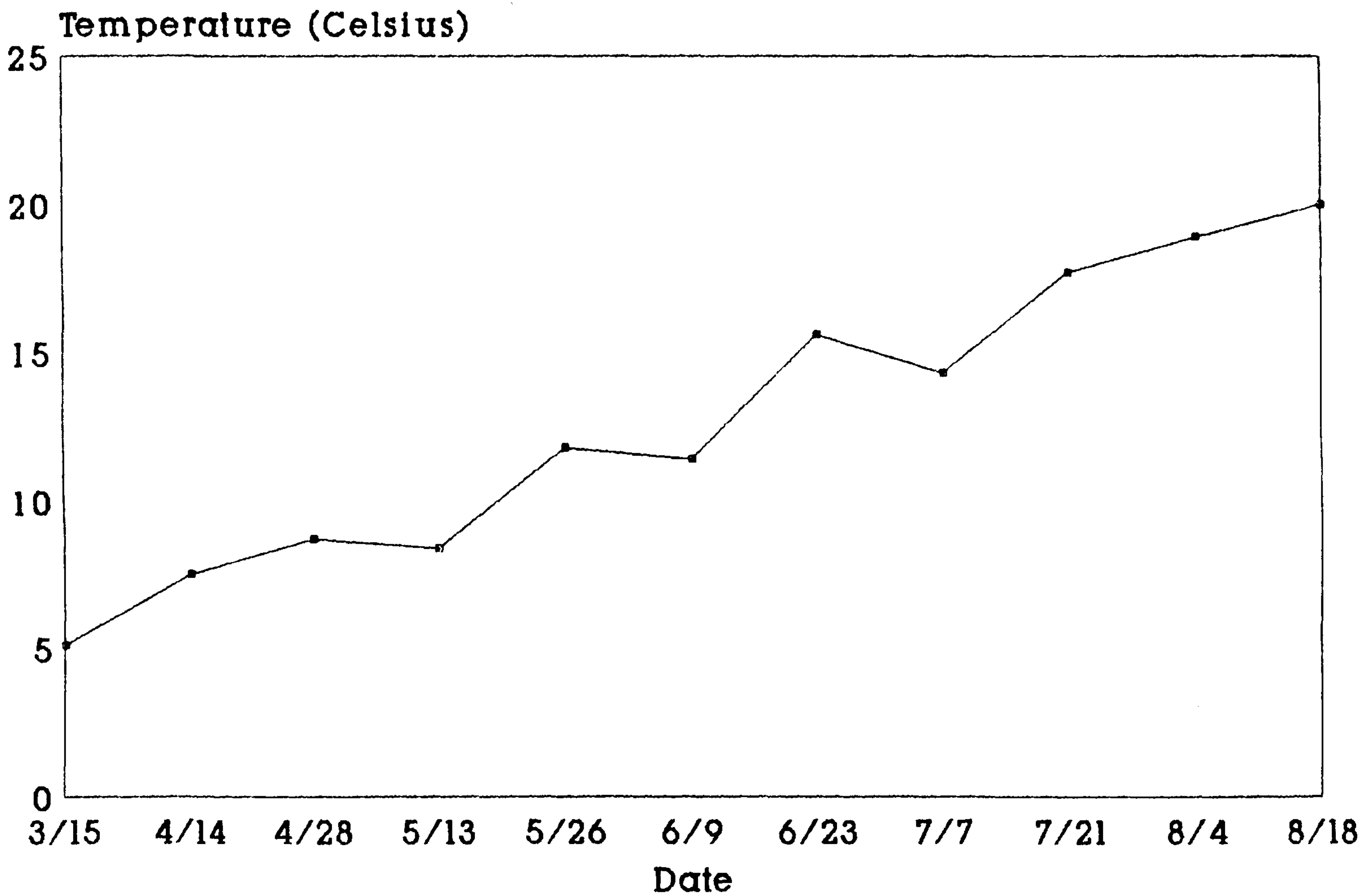

Figure 19. Average water temperature of the South Fork River is illustrated at each sampling date in 1988.

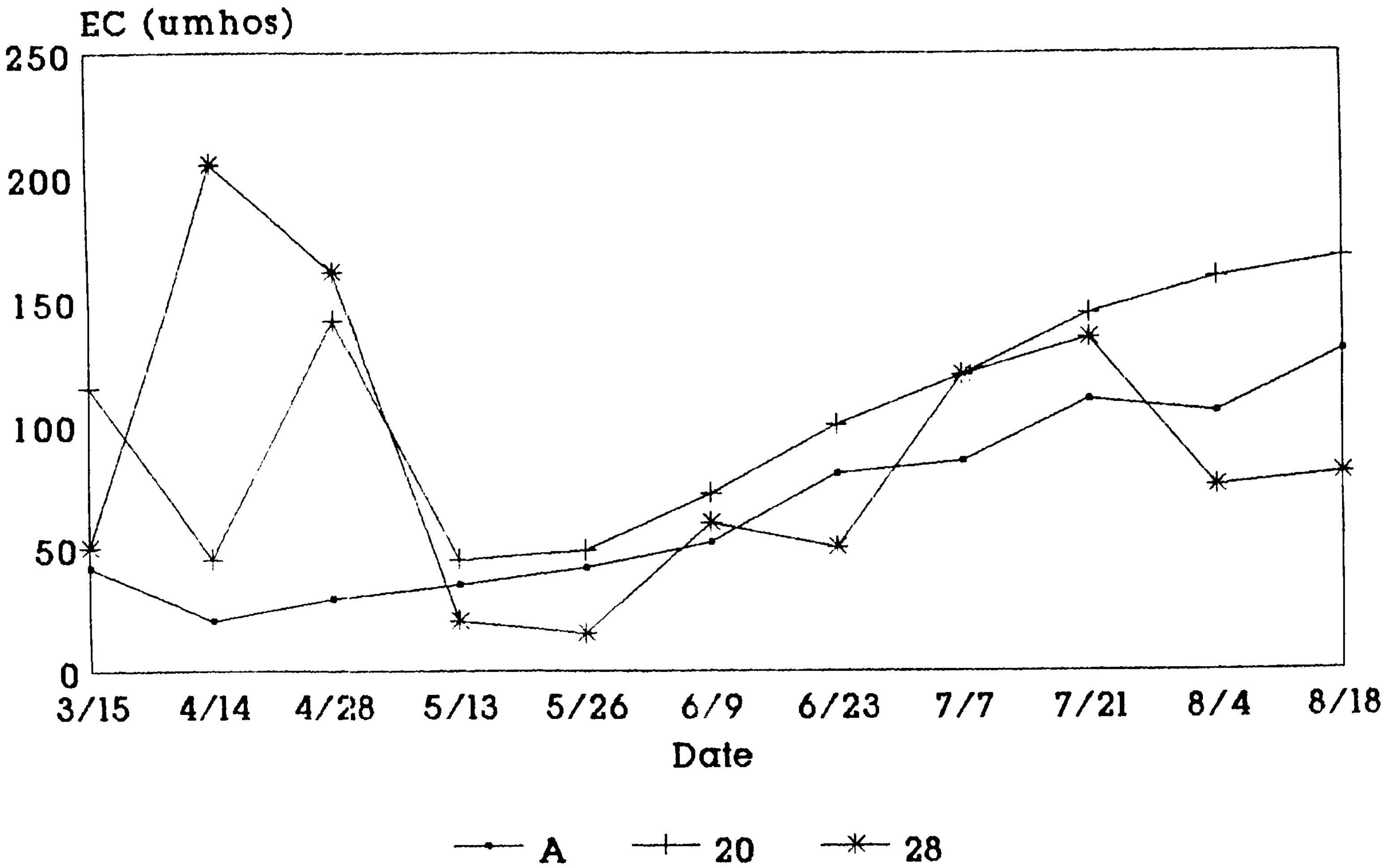

Figure 20. Electric conductivity is illustrated at each sampling date in 1988 for sampling station A at Cataldo on the Coeur D' Alene River, sampling station 12 at Smelterville on the South Fork River, and sampling station 28 above Lucky Friday Mine on the South Fork River.

is also important in controlling toxicity limits; toxicity levels decrease with increasing water hardness (Funk, 1975).

Bicarbonates are a function of temperature and pH. Wissmar's reported (1972) bicarbonate levels ranged from 13 mg/l to 25 mg/l; those of Eisenbarth and Wrigley (1978) ranged from 20 mg/l to 30 mg/l with a maximum of 59 mg/l at Bunker Hill Kellogg. This study in 1988 measured a range from 26 mg/l at Cataldo, to 42 mg/l below Wallace with an average of 38 mg/l. Bicarbonate data are presented in Appendix D.

Major Contributors of Metals

The major contributors of metals into the South Fork are surface water runoff, ground water inflow, and unconfined tailing deposits. Primary sources of contaminants are seepage from settling ponds above and below Kellogg, mine drainage, leaching from old tailings (Eisenbarth and Wrigley, 1978) and the Smelterville Flats aquifer. Two major sources of contamination are between Wallace and Silverton and between Kellogg and Pinehurst. These sources contribute 67 percent to 100 percent of the cadmium, 73 percent to 100 percent of the lead, and 77 percent to 93 percent of the zinc that is measured in the South Fork at Enaville (Tetra Tech, Morrison and Knudsen, 1987). The area from Big Creek to Kellogg, contributes 26 percent of the cadmium and zinc measured in the South Fork at Enaville. Big Creek is the major source for the cadmium and zinc. Low ore production due to a depressed economy forced the closure of many mines, which causes metal contribution to be mostly from non-point sources (EPA Region X, 1972-1986). Concentrations may be higher during high flow rather than being diluted. One possible source of contamination is the soils that are transported by runoff from contaminated hillsides (Woodward-Clyde, 1986).

Seepages and high concentration areas occur along various sections of the South Fork. These sections include:

Mullan to Silverton, Silverton to Big Creek, Big Creek to Kellogg, Kellogg to Smelterville, Smelterville to Enaville, and Enaville to Cataldo. Cadmium and zinc concentration levels are of concern in each section. The data in this study suggest that lead concentrations do not appear to be a problem.

According to Tetra Tech, Morrison and Knudsen (1987), the section of the South Fork from Mullan to Silverton indicates that cadmium and zinc increases. Lead levels reportedly also increase between Wallace and Silverton. Zinc and cadmium metals reportedly increase near Wallace from non-point inflow sources at the confluence of the South Fork and Canyon and Nine-Mile Creeks. These creeks contribute 16 percent to 31 percent of the cadmium, 28 percent to 35 percent of the lead, and 19 percent to 37 percent of the zinc that is measured in the South Fork at Enaville.

The section from Silverton to above Big Creek reportedly shows a decrease in lead, probably because the solubility of lead is low in a sulfate system and because its association with suspended solids (Tetra Tech, Morrison and Knudsen, 1987). No major contributors or seepages exist in this area.

The reach from Big Creek to Kellogg reportedly reflects an increase in cadmium and zinc totalling 26 percent (Tetra Tech, Morrison and Knudsen, 1987). Big Creek contributes only one percent of the metals to the system. Lead remains constant. Possible sources of metals include Milo, Moon, Montgomery, and Elk Creeks (Tetra Tech, Morrison and Knudsen, 1987).

The section along the South Fork which contributes most of the heavy metals is the area from Kellogg to Smelterville. Lead increases between Kellogg and Pinehurst along with increases in zinc and cadmium. This section contributes 33 percent to 63 percent of the cadmium, 5 percent to 30 percent of the lead, and 30 percent to 42 percent of the zinc that is measured in the South Fork (Tetra Tech, Morrison and Knudsen, 1987).

Decreases in metal concentrations occurred between 1972 and 1980 at Smelterville, (station 12). Zinc, cadmium and lead were contributed by Bunker Creek, Government Gulch and surficial wastes. These two creeks were major sources for seeps of these metals before the mid 1970's when treatment facilities and discharges were rerouted away from Government Gulch. These metals, cadmium, lead, and zinc, comprise a major percentage of the load in the South Fork according to an EPA 1986 data survey (EPA Region X, 1972-1986). A portion of the metals have been speculated to result from the Page and Smelterville sewage treatment lagoons (Tetra Tech, Morrison and Knudsen, 1987), but this speculation is incorrect. These ponds are sources of fresh water. Most of the zinc downstream of Smelterville is contributed by Smelterville Flats wastes rather than Page Pond tailings (Gross, 1982).

The section of the South Fork from Pine Creek to Enaville receives less than 10 percent of its cadmium, lead, and zinc from Pine Creek. The South Fork carries 90 - 100 percent of the total metals in the Coeur D' Alene River at Cataldo (Tetra Tech, Morrison and Knudsen, 1987).

Mink 1969 Data compared with Data from this Study

Mink (1969) analyzed the South Fork water quality as part of his thesis. The sample stations for this 1988 study were located as closely as possible to Mink's 1969 stations in order to compare data results over time. Mink's data (Appendix E) and the 1988 data (Appendix F) indicate some improvement in water quality along the South Fork Coeur D' Alene River.

Differences observes in the two data sites include Temperature, EC, Ca, Mg, Fe, and Zn. Cadmium and lead were below detection limits in Mink's study in 1969, as they were during this study. Temperatures in 1988 were warmer than in 1969. EC values generally were lower in 1988 except in July 1988. EC values were higher than in 1969. Calcium concentrations increased slightly over 1969 concentrations. Magnesium levels were similar in March and April of 1988 as compared to levels in 1969, but concentrations increased from May through July of 1988. Iron levels were slightly lower in 1988 than in 1969. Zinc levels were lower in March and April 1988, but they increased over 1969 values in May and June. July 1988 zinc levels decreased from Kellogg downstream to the Coeur D' Alene River at Cataldo as compared with values in 1969. Other values along the river in 1988 were relatively similar to values in 1969. August 1988 levels of potassium, manganese and sodium decreased from Smelterville to Cataldo and then increased upstream to below Silverton. Levels between Wallace and Silverton are similar, whereas above Wallace zinc levels are lower in 1988 than in 1969. In general, an overall improvement has taken place between Mink's study in 1969 and this study in 1988.

A comparison of zinc values in 1969 versus 1988 at Cataldo (station A) and just downstream of Smelterville Flats (station 12) is shown in Figure 21. In 1988, zinc concentrations at these stations in some months were lower than in 1969 as shown by the figure. However, Station 12 is variable in concentration levels for 1969 in particular. March, May and June values in 1988 are slightly higher than those in 1969, whereas April, July, and August levels are much lower than in 1969. July and August 1988 zinc concentrations (during low flow) are significantly lower than Mink's 1969 levels.

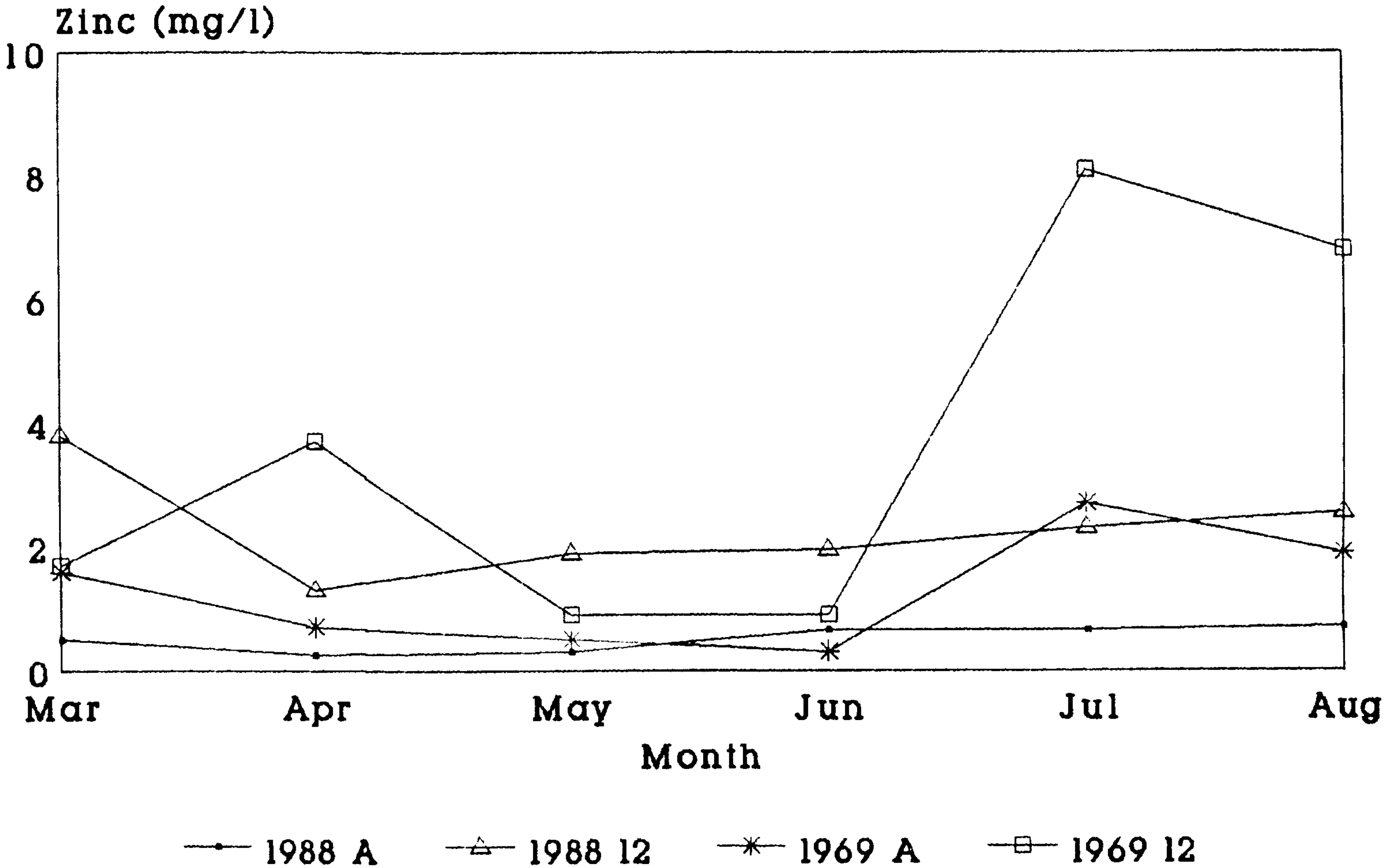

Figure 21. Zinc concentration levels at Cataldo station A and Smelterville station 12 are illustrated comparing Mink's 1969 zinc levels with this studies 1988 zinc levels.

CONCLUSIONS

For almost a century, mine waste was dumped directly into the South Fork Coeur D' Alene River and prohibited the survival of aquatic life. However, over the past 20 years water quality legislation and modern milling techniques have somewhat improved the water quality in the river. Referring to Mink's 1969 data along the South Fork, zinc concentrations have slightly decreased over the years. EPA data also indicated a slight decrease of cadmium, lead and zinc throughout the South Fork mining district. The highest concentrations occur below Smelterville Flats and are probably the result of ground water discharge from the Smelterville Flats aquifer entering the river.

1. The river water sampling program in this study began in March of 1988 and was completed at the end of August, 1988 It spanned one spring snowmelt event. The major sources of contamination into the South Fork are surface water runoff from several waste covered areas, ground water discharges from Smelterville Flats and uncontained tailings deposits. The stream reaches between Wallace and Silverton and between Kellogg and Pinehurst Creek reflect sources of contamination. The Smelterville Flats area is a major contributor of metals to the South Fork.
2. EPA studies and research based theses, primarily Mink 1969, have compiled the historical water quality data base

against which the data in this study are compared. These data cover 20 years of monitoring along the Main Stem and South Fork of the Coeur D' Alene River. During this period, water quality legislation and modern milling techniques have helped reduce sediment load and gradually improved water quality on the river.

3. The sampling plan in this study primarily followed Mink's 1969 masters thesis guidelines thereby facilitating a comparison of data spanning 20 years. Eighteen sample locations along the Coeur D' Alene River and the South Fork of the Coeur D' Alene River are analogous to Mink's sites, as well as to much of EPA's sample locations. Samples were collected and preserved, then sent to a lab for metal concentration analysis using a Perkin-Elmer Plasma II ICP spectrometer. The main metals of interest are cadmium, copper, lead, and zinc. Because cadmium and lead were below detection limits much of the sampling period, zinc became the primary indicator ion.

Problems that were incurred with this study include problems with the pH meter, drought conditions in the area, and low mine productivity.

4. Mink's data from 1969 when compared with those in 1988 (this study) indicate a slight decrease in zinc along the South Fork and into the Main Stem. Zinc concentration is somewhat lower at Smelterville Flats (station 12) during July and August 1988 than it was during the low flow months

of 1969. A decrease in zinc is also noted over the 20 year data base at Cataldo on the Main Stem, sampling station A.

According to EPA studies, zinc concentrations at Smelterville Flats have not exceeded the EPA drinking standards (5mg/l) since 1980. Zinc concentrations have declined over the years, though they are still above EPA's chronic levels for aquatic life at Smelterville Flats. Since 1976, zinc levels at Cataldo have never exceeded drinking standards and have declined somewhat.

Past EPA studies indicate that cadmium, although declining in concentration, exceeds both EPA drinking water standards and chronic toxicity levels at Smelterville Flats. Cadmium levels are still toxic to fish at Cataldo on the Main Stem, but are below drinking standards.

EPA studies also indicate that lead levels have fallen below EPA drinking water standards but still exceed toxicity levels for the survival of fish at Smelterville. At Cataldo, lead levels in 1984 were only slightly above chronic toxicity.

As of 1986, EPA bioassay studies indicate the return of benthic insects along the South Fork and some game fish along the Main Stem of the Coeur D' Alene River.

5. Water Quality legislation and cooperation between state and mining companies have contributed to some improvement of the South Fork Coeur D' Alene River throughout the mining district. A sewer district formed in 1972 to

eliminate raw sewage, the construction of settling ponds and the construction of an NPDES treatment plant also helped improve the quality of the river.

More research is needed to minimize seepage from ponds and through uncontained wastes. Automatic water samplers would allow for a continual, consistent data base for trend analysis. An updated data base should be compiled as more of the mines become productive again. All of this ultimately would help improve water quality and improve the fish and wildlife habitat in the mining district along the river.

APPENDIX A

THIS STUDIES 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

APPENDIX A

THIS STUDY 1988 METAL CONCENTRATIONS
MARCH TO AUGUST

CA
mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	8.4	4.6	6	4.9	5	7.5	9.5	9	10	11	12	13	15
11	23.1	8.1	11.4	6.6	7.2	12.3	15.6	14.4	24.3	25	29	27	37
12	33.9	12	15.3	8.9	9.6	14.5	17.4	18	21.2	29	35	38	43
13	28.7	10.1	13.2	7.9	7.8	12.7	15.5	12.4	24.3	24	32	29	44
A13	21.2	9.5	11.1	7.4	7.4	10.3	13.3	14.1	18.2	21	28	29	38
14	19.1	9.3	10.5	6.9	7.1	9.8	10.6	11.1	16.7	19	23	22	34
15	20	9.3	10.6	6.7	7.2	10.3	12.7	12	16.4	18	24	25	34
16	18.8	9.6	12	BDL	7.1	10.1	13	12.3	15.6	19	25	25	32
17	16.2	7.7	9.9	5.9	6.3	10.1	12.6	12.1	25.2	25	36	36	52
18	25.4	10.8	12.6	6.9	7.4	8.9	12.2	11.5	16.5	16	20	16	19
19	24.5	10.2	12	6.6	7.3	9.3	12.6	9.2	16.2	16	20	18	19
20	23.5	10.9	12.5	7.3	7.3	10.2	12.5	10.5	16.4	17	19	19	18
21	24	9.2	11	6.2	6.2	8.9	9.3	9.2	14.2	13	18	18	19
22	21.42	9.1	10.8	6.2	6.3	7.2	10.2	8.8	10.9	14	18	18	18
23	22.1	8.8	10.6	6.3	6.5	8.7	12.1	9.9	14.1	14	18	18	19
25	BDL	9.1	11.4	7.5	7.4	9.3	11.4	10.6	13.1	15	21	21	21
26	26.2	7.3	10	6.2	6	8	9.3	9.8	13.9	14	21	21	25
28	11.6	5.2	6.6	3.1	3.1	4.2	5.7	5.8	6.7	8.2	11	11	11

F Filtered
U Unfiltered
BDL Below Detection Limit ((0.1mg/l)

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

CD

mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
11	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01	BDL	BDL	BDL	BDL
12	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
A13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
14	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	BDL	BDL	BDL	BDL	BDL	0.007	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = .003mg/l
Chronic Toxicity = .001mg/l
Drinking Water Standard = .01mg/l

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

CU

mg/l

Station	MAR 15	APR 15	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.3	BDL
11	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.2	BDL
12	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.2	BDL
13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.3	BDL
A13	BDL	BDL	BDL	BDL	BDL	BDL	0.006	BDL	BDL	BDL	BDL	0.3	BDL
14	BDL	BDL	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.2	BDL
15	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.2	BDL
16	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.007	BDL	BDL	BDL	BDL	BDL
17	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1	BDL
19	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP12 2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	0.013	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered

U Unfiltered

BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = .018mg/l

Chronic Toxicity = .012mg/l

Drinking Water Standards = 1mg/l

THIS STUDY 1988 METAL CONCENTRATIONS
MARCH TO AUGUST

FE
mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	0.09	BDL	0.1	BDL	0.03	BDL	0.07	BDL	0.1	0.1	BDL
11	BDL	BDL	0.07	0.04	0.22	0.09	0.12	0.14	0.14	BDL	0.1	0.1	0.1
12	BDL	BDL	0.15	0.12	0.67	0.13	0.26	0.17	0.18	BDL	0.2	0.2	0.2
13	BDL	BDL	0.16	0.07	0.12	0.11	0.14	0.15	0.25	BDL	BDL	BDL	0.2
A13	BDL	0.019	0.13	0.03	0.13	0.08	BDL	0.22	0.2	BDL	BDL	BDL	0.2
14	BDL	BDL	0.05	BDL	0.09	0.02	BDL	BDL	0.04	BDL	BDL	BDL	BDL
15	BDL	BDL	0.02	BDL	0.14	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL
16	0.734	BDL	BDL	BDL	0.12	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL
17	BDL	0.012	0.05	0.02	0.08	BDL	BDL	0.03	0.06	BDL	BDL	BDL	BDL
18	BDL	BDL	0.09	0.03	0.18	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL
19	BDL	BDL	BDL	BDL	0.1	BDL	BDL	BDL	0.02	BDL	BDL	BDL	BDL
20	BDL	BDL	BDL	BDL	0.15	BDL	BDL	BDL	0.03	BDL	BDL	BDL	BDL
21	BDL	0.045	BDL	0.05	0.08	BDL	BDL	0.03	0.02	BDL	BDL	BDL	BDL
22	BDL	BDL	BDL	BDL	0.07	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	BDL	BDL	BDL	BDL	0.11	BDL	BDL	0.03	BDL	BDL	BDL	BDL	BDL
25	BDL	BDL	BDL	BDL	0.08	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	BDL	BDL	BDL	0.01	0.12	0.02	BDL	BDL	0.05	BDL	BDL	BDL	BDL
28	BDL	BDL	BDL	0.02	0.05	BDL	BDL	BDL	0.02	BDL	BDL	BDL	BDL
DUP12 2	BDL	BDL	0.159	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = not listed by EPA
Chronic Toxicity = 1mg/l
Drinking Water Standard = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

K

mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	0.5	BDL	BDL	BDL	BDL	BDL	BDL	0.9	0.9	0.8	0.8
11	BDL	BDL	BDL	BDL	0.5	BDL	BDL	0.4	BDL	1.1	1.5	1.1	1.7
12	1.4	BLD	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.3	1.4	1.9	2.1
13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.6	0.7	1.6	1.8
A13	1	BDL	BDL	BDL	BDL	BDL	0.3	BDL	0.7	1.5	1	1.7	1.3
14	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.3	1.2	1.2	1.6
15	1	BDL	BDL	BDL	BDL	BDL	BDL	0.5	BDL	1.1	0.9	1.1	1.9
16	0.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.1	0.9	1.3	1.7
17	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.2	1.3	1.6	1.4
18	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.1	1.5	0.8	1
19	BDL	BDL	BDL	BDL	BLD	BDL	BDL	BDL	BDL	0.9	0.9	1	1.4
20	1.2	BDL	BDL	BDL	0.4	0.6	BDL	BDL	0.7	1.1	1.3	1.2	0.8
21	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	1.1	BDL	1.5	0.8
22	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.2	0.6	1.1
23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.9	0.9	1.7	1.3
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5	1	1.7	1
26	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.8	1	1.8	1.3
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5	0.8	1.3	BDL
DUP12 2	BDL	BDL	0.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	BDL	BDL	BDL	BDL	0.3	BDL	BDL	BDL	BDL	BDL	BDL
DUPA B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = not listed by EPA
Chronic Toxicity = not listed by EPA
Drinking Water Standard = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

MG

mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	2.9	1.5	2.1	1.3	1.4	2.2	3.1	3.1	3.4	3.3	3.4	3.4	3.9
11	7.7	2.4	3.5	1.6	1.9	3.4	4.6	4.8	6.8	6.8	7.4	7.3	9
12	11.4	3.7	4.9	2.4	2.6	4.1	5.3	5.7	6.2	8.2	9	9	11
13	9	2.8	4	1.9	1.9	2.4	4.2	4	6.2	6.3	7.3	7.5	9.5
A13	6.8	2.6	3.3	1.8	1.8	3.4	3.6	4.1	5	5.1	5.9	6.4	7.2
14	5.8	2.6	3.2	1.6	1.7	3.1	3	3.6	4.3	4.2	4.8	4.3	5.7
15	6.4	2.6	3	1.5	1.7	2.5	3.5	3.3	4.1	4.2	4.8	5.1	5.7
16	5.9	2.8	3.5	BDL	1.7	2.5	3.5	3.7	4	4.1	5	4.6	5.2
17	4.8	2.1	2.8	1.2	1.4	2.3	3.2	2.8	4.8	4.3	4.9	5.1	6
18	6.6	3	3.8	1.6	1.8	3.1	3.4	3.6	4.9	4.2	5.1	4.9	5.1
19	7.6	2.8	3.5	1.4	1.6	2.4	3.6	2.9	4.9	4.4	5.2	4.5	5.2
20	7.2	2.8	3.8	1.7	1.7	2.8	3.6	3.3	5	4.4	5.3	5	5
21	7.1	2.5	3.2	1.3	1.4	2.4	2.7	3.1	4.4	3.6	4.9	5.1	5.3
22	6.1	2.5	3	1.3	1.3	2.3	2.7	2.6	3.3	3.7	4.7	4.9	5
23	6.6	2.3	3	1.3	1.4	2.8	3	2.9	4.2	3.6	4.7	4.9	5.1
25	BDL	2.7	3.5	1.9	1.9	3.4	3.4	3.5	4.7	4.6	6.5	6.7	6.6
26	9.2	2.1	2.9	1.2	1.2	2.6	2.6	3.1	4.7	4.5	6.5	7.1	8
28	4.3	1.5	2.1	0.6	0.6	1.6	1.7	1.6	1.9	2.2	2.8	2.9	3.1
DUP12 2	BDL	BDL	4.9	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	3.1	BDL	BDL	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	3	BDL	BDL	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	3.3	BDL	BDL	2.8	3.5	BDL	BDL	BDL	BDL	BDL	BDL
DUPA 8	BDL	BDL	BDL	BDL	BDL	2.2	2.9	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limits (<.1mg/l)

Acute Toxicity = not listed by EPA
Chronic Toxicity = not listed by EPA
Drinking Water Standard = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

MN

mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	0.1	BDL	0.1	BDL	BDL	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.1
11	0.5	0.1	0.2	0.1	0.1	0.2	0.3	0.3	0.4	0.6	0.6	0.6	0.7
12	0.7	0.2	0.3	0.1	0.2	0.2	0.3	0.3	0.5	0.8	0.8	0.7	0.8
13	0.5	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.4	0.6	0.6	0.6	0.8
A13	0.4	0.1	0.2	BDL	0.1	0.1	0.1	0.2	0.3	0.5	0.7	0.8	0.9
14	0.2	0.1	0.2	BDL	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.2	0.2
15	0.1	BDL	BDL	BDL	BDL	BDL	BDL	0.1	0.1	0.1	0.1	0.1	0.2
16	0.1	BDL	BDL	BDL	BDL	BDL	0.1	0.1	0.1	0.1	0.2	0.2	0.2
17	0.2	BDL	BDL	BDL	BDL	BDL	0.1	0.1	0.2	0.3	0.4	0.4	0.4
18	0.1	BDL	0.1	BDL	BDL	BDL	BDL	BDL	0.1	BDL	BDL	BDL	BDL
19	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1	BDL	BDL	BDL
28	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.7	BDL	0.2	BDL
DUP12 2	BDL	BDL	0.3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUPA 8	BDL	BDL	BDL	BDL	BDL	0.1	0.1	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered

U Unfiltered

BDL Below Detection Limit (<.1mg/l)

Acute Toxicity = not listed by EPA

Chronic Toxicity = not listed by EPA

Drinking Water Standards = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS
MARCH TO AUGUST

NA
mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	1.5	1.2	1.2	1.1	0.7	1.5	1.9	1.9	1.7	0.3	1.4	1.6	2.1
11	3.2	1.5	1.8	1.2	0.9	2.1	2.5	2.8	4.4	2.9	4.8	5	6.5
12	4.1	1.8	2.3	1.3	1	2.3	2.5	2.9	3.9	3.9	6	6.6	8.1
13	3.1	1.6	2.1	1.2	0.8	2.1	2.4	2.6	4.8	3.3	5.9	6.5	9
A13	3	1.6	2.1	1.5	0.8	2.2	2.3	2.2	3.5	3.3	5.8	7.4	9.5
14	2.9	1.7	2.1	1.3	0.8	2	1.7	2.5	3.4	3	5.8	5.6	9.8
15	3.4	1.5	2.1	1.3	0.8	2	2.3	2.3	3.3	3	5.8	7.6	10
16	2.9	1.6	2.1	BDL	0.8	2	2.5	2.7	2.9	3	6.7	6.5	9.2
17	3	1.4	2.4	1.3	0.9	2.1	2.6	2.7	6.9	7.3	12	15	19
18	3.2	1.4	2.1	1	0.8	1.8	2.1	2	2.7	0.9	2.4	2.2	2.4
19	4	1.3	1.7	1.1	0.7	BDL	2	BDL	2.6	1.1	2.5	1.6	2.4
20	3.4	1.2	1.8	1.1	0.7	1.7	1.8	1.4	2.8	1.1	2.2	2.1	2.4
21	3.7	1.2	1.7	1	0.5	1.9	1.5	2	2	0.5	2.5	2.5	3
22	3.1	1.2	1.7	1	0.6	1.6	1.7	1.4	1.2	0.4	1.9	2	2.9
23	4.2	1.3	2.2	1.4	0.9	2.1	2.1	2.1	3	2.1	1.8	3.2	3.1
25	BDL	1.1	1.5	1	0.5	1.7	1.3	1.5	1.3	1.1	1.9	2.4	3
26	4.5	1.1	1.7	1.3	0.6	1.7	1.6	1.9	2.1	1.8	3.7	4.3	4.3
28	1.9	1	1.3	1	0.5	1.6	1.5	0.7	0.3	BDL	0.6	BDL	0.7
DUP12 2	BDL	BDL	2.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	1.4	BDL	BDL	0.6	0.2	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	1.9	BDL	BDL	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	1.6	BDL	BDL	1.7	1.8	BDL	BDL	BDL	BDL	BDL	BDL
DUPA B	BDL	BDL	BDL	BDL	BDL	1.6	1.8	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limits (<0.1mg/l)

Acute Toxicity = not listed by EPA
Chronic Toxicity = not listed by EPA
Drinking Water Standard = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS
MARCH TO AUGUST

PB
mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BLD
11	BDL	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
12	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
A13	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BLD
14	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
16	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
17	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
20	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
21	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
22	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.04	BDL	BDL	BDL	BDL	BDL
26	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP12 2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUPA B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit ((0.1mg/l)

Acute Toxicity = .082mg/l
Chronic Toxicity = .003mg/l
Drinking Water Standard = .05mg/l

THIS STUDY 1988 METAL CONCENTRATIONS

MARCH TO AUGUST

S

mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	BDL	BDL	BDL	BDL	BDL	3.9	BDL	BDL	5.7	BDL	BDL	BDL	BDL
11	BDL	BDL	7.9	BDL	BDL	9.3	BDL	BDL	18.3	BDL	BDL	BDL	BDL
12	BDL	BDL	11.7	BDL	BDL	10.3	BDL	BDL	17.6	BDL	BDL	BDL	BDL
13	BDL	BDL	8.4	BDL	BDL	7.4	BDL	BDL	16.3	BDL	BDL	BDL	BDL
A13	BDL	BDL	5.7	BDL	BDL	3.8	BDL	BDL	13.7	BDL	BDL	BDL	BDL
14	BDL	BDL	4.5	BDL	BDL	4.9	BDL	BDL	10.2	BDL	BDL	BDL	BDL
15	BDL	BDL	4.2	BDL	BDL	5	BDL	BDL	10	BDL	BDL	BDL	BDL
16	BDL	BDL	4.5	BDL	BLD	5.3	BDL	BDL	8.9	BDL	BDL	BDL	BDL
17	BDL	BDL	3.9	BDL	BDL	4.3	BDL	BDL	16.9	BDL	BDL	BDL	BDL
18	BDL	BDL	5.5	BDL	BDL	BDL	BDL	BDL	6.7	BDL	BDL	BDL	BDL
19	BDL	BDL	4.1	BDL	BDL	4	BDL	BDL	6.4	BDL	BDL	BDL	BDL
20	BDL	BDL	4.6	BDL	BDL	2.6	BDL	BDL	7.2	BDL	BDL	BDL	BDL
21	BDL	BDL	3.3	BDL	BDL	BDL	BDL	BDL	4.9	BDL	BDL	BDL	BDL
22	BDL	BDL	3.2	BDL	BDL	3.2	BDL	BDL	3.9	BDL	BDL	BDL	BDL
23	BDL	BDL	2.7	BDL	BDL	BDL	BDL	BDL	4.8	BDL	BDL	BDL	BDL
25	BDL	BDL	3.4	BDL	BDL	BDL	BDL	BDL	5.5	BDL	BDL	BDL	BDL
26	BDL	BDL	3.1	BDL	BDL	BDL	BDL	BDL	5.9	BDL	BDL	BDL	BDL
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BLD
DUP12 2	BDL	BDL	11.3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	2.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	3.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	4.1	BDL	BDL	4.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUPA B	BDL	BDL	BDL	BDL	BDL	4	BDL	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = not listed by EPA
Chronic Toxicity = not listed by EPA
Drinking Water Standard = not listed by EPA

THIS STUDY 1988 METAL CONCENTRATIONS
MARCH TO AUGUST

ZN
mg/l

Station	MAR 15	APR 14	APR 28	MAY 13F	MAY 13U	MAY 26F	MAY 26U	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	0.5	0.2	0.3	0.2	0.2	0.4	0.4	0.6	0.7	0.6	0.7	0.7	0.7
11	2.5	0.8	1	0.6	0.6	0.9	1.1	1.4	1.9	1.7	2	1.8	2
12	3.8	1.2	1.5	0.8	0.9	1.1	1.3	1.9	2	2.1	2.5	2.5	2.6
13	2.5	0.9	1.1	0.6	0.6	0.8	1	1.3	2	1.7	2.2	2.3	2.4
A13	2.4	0.9	1.1	0.6	0.6	0.9	0.9	1.2	1.6	1.7	2.2	2.3	2.6
14	1.9	0.9	0.9	0.5	0.5	0.8	0.7	1	1.3	1.3	1.5	1.4	1.6
15	2.6	0.8	0.9	BDL	0.5	0.6	0.8	29	1.1	1.2	1.5	1.4	1.6
16	2.3	0.9	1	BDL	0.5	0.6	0.8	0.9	1.1	1.2	1.6	1.3	1.5
17	1.4	0.5	0.5	0.3	0.3	0.4	0.4	0.5	0.9	0.9	1.1	0.9	1.1
18	3	1.2	1	0.5	0.6	0.8	0.9	1.1	1.4	1.5	1.7	1.4	1.6
19	3.6	1.1	1	0.5	0.6	0.6	0.8	0.8	1.4	1.4	1.7	1.7	1.4
20	3.1	1.2	1.1	0.6	0.6	0.8	0.9	1	1.5	1.6	1.8	1.4	1.6
21	2.5	1	0.8	0.5	0.4	0.6	0.6	0.7	1.1	1	1.2	0.6	0.6
22	2.4	1.2	0.8	0.4	0.5	0.6	0.6	0.7	0.9	1	1.3	0.7	0.6
23	2.5	0.9	0.7	0.4	0.5	1.1	1	0.9	1.1	1.1	1.3	0.8	0.9
25	BDL	0.2	0.1	0.2	BDL	BDL	BDL	0.2	0.2	0.1	0.2	BDL	0.1
26	0.6	BDL	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
28	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP12 2	BDL	BDL	1.4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP25 5	BDL	BDL	0.2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP16 6	BDL	BDL	0.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
DUP20 10	BDL	BDL	1	BDL	BDL	0.8	1	BDL	BDL	BDL	BDL	BDL	BDL
DUPA B	BDL	BDL	BDL	BDL	BDL	0.4	0.4	BDL	BDL	BDL	BDL	BDL	BDL

F Filtered
U Unfiltered
BDL Below Detection Limit (<0.1mg/l)

Acute Toxicity = .120mg/l
Chronic Toxicity = .110mg/l
Drinking Water Standard = 5mg/l

APPENDIX B

EPA HISTORIC METAL CONCENTRATIONS

STATIONS A - 28

APPENDIX B

EPA HISTORIC METAL CONCENTRATIONS
STATION A

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 19	4	15	5	5	1400
AUG 17	4	42	8	20	2750
SEP 5	ND	27	24	10	2900
OCT 11	2	122	7	10	3300
1973					
JUN 7	ND	15	4	10	1210
1975					
OCT 9	4	28	8	20	1950

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 11

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 19	2	42	8	13	400
AUG 23	8	110	10	10	8200
SEP 6	ND	100	14	10	10800
OCT 11	2	340	14	10	ND
1980					
MAY 21	1	8	10	10	790
1981					
NOV 24	ND	58	10	50	3000
DEC 22	ND	54	10	50	2335
1982					
JAN 14	ND	30	10	50	4125
FEB 11	ND	53	10	50	3450
MAR 16	ND	17	10	50	1485
APR 22	ND	12	10	50	1385
MAY 25	ND	5	10	50	529
JUN 16	ND	5	10	50	606
JUL 7	ND	10	10	50	1298
AUG 4	ND	12	10	50	1548
SEP 8	ND	13	10	50	2040
OCT 4	ND	18	10	50	3660
NOV 3	ND	18	10	50	3315
DEC 9	ND	48	10	50	2560
1983					
JAN 6	ND	11	10	50	1000
FEB 8	ND	19	10	50	2050
MAR 7	ND	10	10	50	982
APR 13	ND	10	10	50	1460
MAY 4	ND	6	10	50	763
JUN 8	ND	6	10	50	761
JUL 13	ND	12	10	50	1520
AUG 17	ND	12	10	50	1545
SEP 14	ND	11	10	50	2290

EPA HISTORIC METAL CONCENTRATIONS
STATION 12

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 20	6	48	12	5	6000
AUG 17	4	93	9	20	11400
SEP 6	ND	220	25	10	12600
1973					
JUN 6	4	35	8	10	3950
1974					
OCT 9	19	70	5	50	8800
1975					
MAR 18	ND	92	10	20	6100
1980					
JAN 8	10	75	ND	50	5680
FEB 5	10	165	ND	50	9750
MAR 4	10	146	10	50	8090
APR 1	10	111	10	50	7030
MAY 13	10	18	10	50	4900
JUN 3	10	161	10	50	8880
JUL 1	10	96	10	50	6740
AUG 5	10	17	10	50	2550
SEP 3	10	8	10	50	981
OCT 7	10	16	10	50	629
NOV 4	10	2	10	50	854
1986					
SEP 29	1	22	68	1	2365

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 14

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 20	2	9	7	30	1540
AUG 24	2	15	8	25	1650
SEP 6	ND	12	11	15	1650
OCT 11	2	11	8	10	590
1973					
JUN 6	4	8	4	20	865
1974					
OCT 9	36	10	5	50	3500
1975					
MAR 18	ND	14	10	30	2230
OCT 7	ND	18	8	40	2700
1976					
OCT 6	ND	ND	ND	40	2880
1980					
OCT 8	ND	18	11	26	2700
OCT 15	ND	ND	ND	ND	1620
DEC 1	ND	ND	ND	ND	1950
1981					
FEB 1	ND	ND	ND	ND	900
APR 1	ND	ND	ND	ND	1170
JUN 1	ND	ND	ND	ND	790
AUG 1	ND	ND	ND	ND	1760
OCT 1	ND	ND	ND	ND	2170
DEC 1	ND	ND	ND	ND	2530
1982					
FEB 15	ND	ND	ND	ND	1570
APR 15	ND	ND	ND	ND	820
JUN 15	ND	ND	ND	ND	510
AUG 15	ND	ND	ND	ND	2210
OCT 15	ND	ND	ND	ND	2420
DEC 15	ND	ND	ND	ND	2400

	Zn
1983	
FEB 15	400
APR 15	110
JUN 15	550
AUG 15	1200
OCT 15	2100
DEC 15	2000
1984	
FEB 15	920
APR 15	720
JUN 15	520
AUG 15	1500
OCT 15	1650
DEC 15	1700
1985	
APR 15	870
JUN 15	770
AUG 15	2030
OCT 15	1900
DEC 15	1600
1986	
FEB 15	1610
APR 15	700
JUN 15	980
AUG 15	1820
OCT 15	2148

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 15

ug/l

	As	Cd	Cu	Pb	Zn
1986					
SEP 30	ND	ND	1	1	1380

Nd = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 17

ug/l

1984	As	Cd	Cu	Pb	Zn
SEP 25	9	0.09	4	ND	970

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 18

ug/l

	As	Cd	Cu	Pb	Zn
1972					
SEP 6	ND	7	17	15	890
1984					
SEP 25	0.5	0.2	2	13	1100

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 20

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 20	2	10	12	30	1540
AUG 23	2	14	12	ND	840
SEP 6	ND	7	21	20	570
OCT 12	2	14	12	40	ND

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 21

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 19	2	7	12	45	1120
AUG 24	2	16	18	45	7100
SEP 6	ND	9	ND	28	1500
OCT 12	2	18	16	30	2100
1973					
JUN 6	ND	7	4	30	920

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 23

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 18	2	2	7	5	200
AUG 16	2	2	6	10	80
SEP 6	ND	11	23	ND	1550
OCT 12	2	6	7	10	290
1973					
JUN 7	ND	1	6	5	200
1980					
MAY 22	1	0	10	10	5

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 25

ug/l

	As	Cd	Cu	Pb	Zn
1979					
FEB 5	ND	45	10	65	7495
APR 4	ND	53	10	60	9463
MAY 15	ND	9	10	50	1515
JUN 28	ND	11	10	50	1765
SEP 11	ND	33	10	50	5540
NOV 27	ND	77	30	75	7360

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 26

ug/l

	As	Cd	Cu	Pb	Zn
1972					
JUL 18	4	2	8	5	44
AUG 16	2	2	5	10	30
SEP 7	ND	1	14	5	30
OCT 10	2	2	6	5	ND
1980					
JAN 9	10	5	10	50	2430
FEB 5	10	5	10	50	61
MAR 4	10	5	10	ND	360
APR 1	10	5	10	50	660
MAY 13	10	5	10	50	98
JUN 3	10	5	10	50	109
JUL 1	10	1	10	50	59
AUG 5	10	1	10	50	46
SEP 3	10	1	10	50	36
OCT 7	10	1	10	50	21
NOV 4	10	1	10	50	24
1986					
AUG 13	ND	2	2	10	295

ND = No Data listed

EPA HISTORIC METAL CONCENTRATIONS
STATION 28

ug/l

	As	Cd	Cu	Pb	Zn
1984					
Sep 25	0.5	0.01	4	0.1	ND

ND = No Data listed

APPENDIX C

WOODWARD-CLYDE HISTORIC METAL CONCENTRATIONS

APPENDIX C

WOODWARD - CLYDE HISTORIC METAL CONCENTRATIONS
STATION A

Mean yearly observed concentrations, ug/l

	As	Cd	Cu	Pb	Zn
1966	ND	57	18	10	300
1970	ND	32	24.9	98.8	3136.7
1971	ND	14.7	8.5	240	1186.7
1972	ND	43	8.6	55	2754.8
1973	ND	23.8	7.2	87.1	1421.4
1974	ND	8.3	5	40	784.6
1975	ND	21	5	35	2450
1976	ND	25	ND	25	3290
1979	ND	6.8	1.5	9	1650
1980	ND	11	5	10	1210
1982	ND	5.7	0.2	14.5	1105.3
1984	ND	9.4	2.5	1.6	826.5

ND = No Data listed

WOODWARD - CLYDE HISTORIC METAL CONCENTRATIONS
STATION 11

Mean yearly observed concentrations, ug/l

	As	Cd	Cu	Pb	Zn
1966	ND	150	138	300	7500
1970	ND	139	23.9	506	6600
1971	ND	104	44	757	8462.5
1972	ND	131.4	32.3	727	15942
1973	ND	60.4	16.6	266	4920
1974	ND	29.6	7.5	173	5641.7
1975	ND	76.7	13.4	186.6	8105.5
1976	ND	79.8	25.5	270	4484.1
1977	ND	47.3	18.4	199.4	4693.3
1978	ND	56.2	16.7	139.4	3619.2
1979	ND	91.4	13.8	72.4	3164.7
1980	ND	32.3	19	595.7	3620
1981	ND	23.1	8	92.1	2107.8
1982	ND	16.7	2.2	31	2767.7
1984	ND	23.3	15.1	25.4	2563.3

ND = No Data listed

WOODWARD - CLYDE HISTORIC METAL CONCENTRATIONS
STATION 12

Mean yearly observed concentrations, ug/l

	As	Cd	Cu	Pb	Zn
1972	ND	239	71.5	822.5	14750
1974	ND	53.6	12.8	232	5760
1979	ND	48.5	7	20	5800
1980	ND	33	19.2	39.2	4700
1982	ND	21.9	4.7	40.5	3726
1984	ND	27.7	2.4	22.3	3270

ND = No Data listed

WOODWARD - CLYDE HISTORIC METAL CONCENTRATIONS
STATION 14

Mean yearly observed concentrations, ug/l

	As	Cd	Cu	Pb	Zn
1971	ND	40.5	16	106	1700
1972	ND	12.9	12.7	65	2050
1973	ND	9.5	5	55	1235
1974	ND	15	4.8	103.8	1774.7
1975	ND	16.4	6.2	80.2	2570
1976	ND	14.3	4.3	43.3	2973
1979	ND	17.2	7.2	12.3	2650
1980	ND	18.5	8.5	36	2608
1982	ND	13.2	6.1	24.2	2070
1984	ND	20.9	ND	18.4	2140

ND = No Data listed

WOODWARD - CLYDE HISTORIC METAL CONCENTRATIONS
STATION 18

Mean yearly observed concentrations, ug/l

	As	Cd	Cu	Pb	Zn
1971	ND	14	27	66	2300
1972	ND	8	17	75	980
1974	ND	9.8	4	95	968
1979	ND	16.3	7	13	2825
1982	ND	16	7.6	24.7	1997
1984	ND	13.3	ND	25.4	1405

ND = No Data listed

APPENDIX D

THIS STUDIES 1988 FIELD CHARACTERISTICS

WATER TEMPERATURE, EC, BICARBONATES, & PH

APPENDIX D

THIS STUDY 1988 FIELD CHARACTERISTICS

WATER TEMPERATURE (C)

STATION	DATE MAR 15	APR 14	APR 28	MAY 13	MAY 26	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	3.5	7	8	10	12	11	18	13	18	19	19
11	3.5	26	8	9	11	11	16	13	16	17	17
12	3.5	6	8	9	11	11	16	13	17	16	19
13	7	6	7	8	12	11	16	13	18	16	20
A13	6.5	6	8	8	12	11	16	13.5	18	16	18.5
14	6.5	6	8	8	12	11	16	14	17	18	21
15	4	7	8	8	12	11	16	14	17	19	21.5
16	2	10	8	8	12	11	15	14	18	20	21.5
17	3.9	12	8.5	8	12	11	15	14.5	18	20	19.5
18	4	8	9	9	12	11	15	15	18	20	18
19	3.9	7	9	9	12	12	15	15	18	20	21
20	4	7.5	9	9	12	12	15	15	18	20	21.5
21	6	8	9	8	12	12	15	15	18	20	21.5
22	6	7.5	9	8	12	12	15	15	18	20	21
23	6	7.5	10	8	12	12	15	15	18	20	22
25	ND	8	10	8	12	12	15	16	19	20	19
26	6	8	10	8	11	12	15	15.5	18	20	22.5
28	5	8	10	8	12	12	15	15	17	20	16
AVE	5.1	7.5	8.7	8.4	11.8	11.4	15.6	14.3	17.7	18.9	20

ND = NO Data listed

THIS STUDY 1988 FIELD CHARACTERISTICS

EC (umhos)

STATION	DATE MAR 15	APR 14	APR 28	MAY 13	MAY 26	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	42	20	29	35	42	52	80	85	110	105	130
11	115	35	58	42	65	90	155	180	230	260	300
12	160	48	107	55	75	110	170	210	280	305	340
13	155	50	25	45	60	93	150	190	255	270	360
A13	115	40	180	45	52	85	145	160	220	245	315
14	115	40	149	40	50	78	129	140	200	215	279
15	98	35	200	40	50	75	125	140	180	215	280
16	115	43	179	40	41	75	120	140	180	225	282
17	80	30	48	35	50	80	145	180	280	320	418
18	102	30	128	40	40	70	100	120	145	150	165
19	92	40	98	40	45	70	100	120	140	160	170
20	115	45	142	45	49	72	100	120	145	160	168
21	112	40	50	35	39	60	90	110	135	150	160
22	107	45	143	35	40	60	88	108	130	145	151
23	105	39	167	35	42	62	95	115	130	155	160
25	ND	151	198	38	45	70	100	125	210	170	190
26	115	205	240	30	40	60	90	60	185	185	206
28	50	205	162	20	15	60	50	120	135	75	80

ND = No Data listed

THIS STUDY 1988 FIELD CHARACTERISTICS
BICARBONATE LAB RESULTS

STATION NUMBER	BICARB. mg/l
A	26
11	28
12	32
13	34
A13	34
14	36
15	38
16	40
17	36
18	40
19	40
20	40
21	42
22	40
23	42
25	41
26	38
28	32

THIS STUDY 1988 FIELD CHARACTERISTICS

pH

STATION	DATE MAR 15	APR 14	APR 28	MAY 13	MAY 26	JUN 9	JUN 23	JUL 7	JUL 21	AUG 4	AUG 18
A	6.12	5.6	5.6	6.25	5.86	5.88	6.76	6.25	6.5	6.53	6.54
11	6.6	5.45	5.51	5.54	5.88	6.31	6.69	6.66	6.5	6.43	6.34
12	6.68	6.26	5.36	5.78	5.96	5.85	6.3	6.16	6.37	6.3	6.1
13	6.56	5.99	4.81	5.76	6.13	6.01	6.53	6.29	6.4	6.51	6.32
A13	6.55	6.39	5.04	6.06	6.27	6.05	6.69	6.62	6.56	6.46	6.27
14	6.8	6.45	5.19	5.92	6.23	6.33	6.3	6.3	6.37	6.46	6.34
15	6.63	6.35	5.39	6.11	6.37	6.45	6.76	6.64	6.49	6.76	6.89
16	6.59	6.27	5.09	5.21	6.17	6.8	6.71	6.57	6.47	6.69	6.46
17	6.23	6.36	5.72	5.31	6.16	6.4	6.6	6.55	6.52	6.51	6.3
18	6.16	6.01	5.15	5.77	6.08	6.13	6.8	6.61	6.527	6.73	6.2
19	6.6	6.22	5.75	5.95	5.7	6.01	6.6	6.59	6.66	6.7	6.45
20	6.66	6.29	4.99	5.01	5.85	6.21	6.63	6.62	6.33	6.75	6.36
21	6.95	6.38	4.9	5.65	5.82	6.25	6.5	6.7	6.48	6.92	6.61
22	6.84	6.27	ND	5.15	6.21	6.28	6.87	6.9	6.66	6.84	6.6
23	6.67	6.47	ND	5.6	5.61	6.2	6.45	6.99	6.89	6.96	6.46
25	ND	6.66	ND	5.28	6.16	6.98	6.58	6.7	6.92	7.12	6.76
26	6.66	6.05	ND	5.71	5.87	6.29	6.53	6.96	6.78	6.72	6.6
28	7.16	5.86	ND	5.72	5.77	6.29	6.84	6.83	7.48	7.1	6.8

ND = No Data

APPENDIX E

MINK'S DATA

MARCH TO AUGUST 1969

APPENDIX E

MINK DATA MARCH TO AUGUST 1969
MINK, MAR 24, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	3	7	85	8.3	BDL	BDL	1	BDL	4.6	0.3	BDL	BDL	1.6
11	4	6.75	170	12.5	BDL	BDL	1.6	BDL	3.1	1	BDL	BDL	1.3
12	4	6.65	280	19	BDL	BDL	1.1	BDL	BDL	1.6	BDL	BDL	1.7
13	3	6.7	260	17.3	BDL	BDL	1.1	BDL	BDL	1.8	BDL	BDL	7.6
14	3	6.95	250	12	BDL	BDL	1	BDL	7.5	0.3	BDL	BDL	3
15	3	7	140	12.2	BDL	BDL	1	BDL	6.9	0.1	BDL	BDL	2.5
16	4	7.1	140	12.6	BDL	BDL	0.2	BDL	6.8	BDL	BDL	BDL	2.7
17	5	7	120	14	BDL	BDL	1	BDL	7.8	0.1	BDL	BDL	3.1
18	4	7.2	220	13.3	BDL	BDL	1.9	BDL	6.9	0.3	BDL	BDL	3
19	4	6.9	130	15	BDL	BDL	1.6	BDL	7.9	0.1	BDL	BDL	3.3
20	4	7.2	130	13.3	BDL	BDL	1.1	BDL	6.7	BDL	BDL	BDL	3
21	4	7.35	115	14.3	BDL	BDL	1	BDL	7.2	0.1	BDL	BDL	3.7
22	4	7.35	140	15.3	BDL	BDL	1	BDL	6.9	0.2	BDL	BDL	3.7
23	4	7.3	150	11.5	BDL	BDL	1	BDL	7.6	0.1	BDL	BDL	4.4
24	4	7.3	140	15.4	BDL	BDL	1.6	BDL	7.4	0.1	BDL	BDL	4.3
25	4	7.5	120	15	BDL	BDL	1.9	BDL	6.8	BDL	BDL	BDL	0.5
26	4	7.6	105	13.3	BDL	BDL	1	BDL	6.5	BDL	BDL	BDL	0.4
27	3	7.5	95	12.5	BDL	BDL	1.1	BDL	6.3	BDL	BDL	BDL	0.1
28	2	7.5	60	9.3	BDL	BDL	0.8	BDL	5.2	BDL	BDL	BDL	0

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limit (<0.1mg/l)

MINK DATA MARCH TO AUGUST 1969
MINK, APR 23, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	4	6.91	60	5.2	BDL	BDL	1.1	BDL	2.2	0.1	BDL	BDL	0.7
11	5.5	6.8	100	7.8	BDL	BDL	0.1	BDL	3.4	0.4	BDL	BDL	2.1
12	5.5	6.65	150	11.7	BDL	BDL	1.1	BDL	4.9	0.7	BDL	BDL	3.7
13	5	6.55	155	11.3	BDL	BDL	0.1	BDL	4.4	0.7	BDL	BDL	3.2
14	5	6.6	95	8	BDL	BDL	0.7	BDL	3.5	0.1	BDL	BDL	1.5
15	5	6.75	83	8.2	BDL	BDL	1.2	BDL	3.4	0.1	BDL	BDL	1.3
16	5	6.92	90	8.6	BDL	BDL	0.7	BDL	3.3	0.1	BDL	BDL	1.3
17	5	6.92	100	9.7	BDL	BDL	1.1	BDL	3.8	0.1	BDL	BDL	1.7
18	5	7	122	9.4	BDL	BDL	0.7	BDL	3.6	0.1	BDL	BDL	1.5
19	5	7.05	100	9.7	BDL	BDL	1.2	BDL	3.7	0.1	BDL	BDL	1.7
20	5	7.05	88	9.5	BDL	BDL	0.7	BDL	3.3	0.1	BDL	BDL	1.2
21	5	7.1	83	9.2	BDL	BDL	1.1	BDL	3.4	0.1	BDL	BDL	1.2
22	5	7.11	80	9	BDL	BDL	1.2	BDL	3.5	0.1	BDL	BDL	1.1
23	5	7.11	83	9	BDL	BDL	1.1	BDL	3.4	0.1	BDL	BDL	1.4
24	5	7.15	80	8.5	BDL	BDL	1.2	BDL	3.4	0.1	BDL	BDL	1.2
25	4.5	7.21	80	9.2	BDL	BDL	1.2	BDL	3.5	0.1	BDL	BDL	0.2
26	4	7.3	70	8.6	BDL	BDL	1.1	BDL	3.4	0.1	BDL	BDL	0.1
27	4	7.35	78	8.5	BDL	BDL	1.2	BDL	3.5	0.1	BDL	BDL	0
28	4	7.45	62	7.5	BDL	BDL	1.1	BDL	3.4	0.1	BDL	BDL	0

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limit ((0.1mg/l)

MINK DATA MARCH TO AUGUST 1969
MINK, MAY 21, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	8.5	6.3	64	0.6	BDL	BDL	0.8	BDL	0.5	0.3	BDL	BDL	0.5
11	9	6.4	98	0.9	BDL	BDL	0.8	BDL	0.6	0.3	BDL	BDL	0.7
12	9	6.3	128	1.2	BDL	BDL	0.9	BDL	0.7	0.5	BDL	BDL	0.9
13	9	6.2	130	1.1	BDL	BDL	0.8	BDL	0.7	0.5	BDL	BDL	1.2
14	8.5	6.5	65	0.7	BDL	BDL	1.1	BDL	0.5	0.3	BDL	BDL	0.5
15	8.5	6.7	69	0.8	BDL	BDL	0.6	BDL	0.5	0.3	BDL	BDL	0.4
16	8.5	6.8	62	0.7	BDL	BDL	0.7	BDL	0.5	0.3	BDL	BDL	0.5
17	8	7	54	0.7	BDL	BDL	1	BDL	0.4	0.3	BDL	BDL	0.3
18	8.5	6.8	76	0.8	BDL	BDL	1	BDL	0.5	0.3	BDL	BDL	0.4
19	9	6.8	63	0.7	BDL	BDL	0.7	BDL	0.5	0.3	BDL	BDL	0.6
20	9	6.6	63	0.7	BDL	BDL	0.8	BDL	0.5	0.3	BDL	BDL	0.4
21	8	6.9	57	0.6	BDL	BDL	0.7	BDL	0.5	0.2	BDL	BDL	0.3
22	8	6.8	57	0.7	BDL	BDL	0.7	BDL	0.5	0.3	BDL	BDL	0.4
23	8	6.8	58	0.7	BDL	BDL	0.7	BDL	0.5	0.3	BDL	BDL	0.4
24	9	6.9	58	0.7	BDL	BDL	0.6	BDL	0.5	0.3	BDL	BDL	0.3
25	8.5	6.9	57	0.8	DBL	BDL	0.7	BDL	0.5	0.3	BDL	BDL	0.3
26	8.5	6.7	49	0.6	BL	BDL	0.8	BDL	0.4	0.3	BDL	BDL	0.2
27	8	6.9	46	0.7	BDL	BDL	0.9	BDL	0.4	0.3	BDL	BDL	0.1
28	8	6.9	40	0.6	BDL	BDL	0.9	BDL	0.4	0.3	BDL	BDL	BDL

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

MINK DATA MARCH TO AUGUST 1969
MINK, JUNE 12, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	14	6.6	81	0.7	BDL	BDL	1	BDL	0.5	0.1	BDL	BDL	0.3
11	11.5	6.5	133	1.4	BDL	BDL	1	BDL	0.7	0.1	BDL	BDL	0.8
12	11.5	6.4	163	0.2	BDL	BDL	1	BDL	0.9	0.3	BDL	BDL	0.9
13	11.5	5.85	168	1.6	BDL	BDL	1	BDL	0.8	0.4	BDL	BDL	1.1
14	11.5	6.55	81	0.8	BDL	BDL	1	BDL	0.5	0.1	BDL	BDL	0.4
15	10.5	6.7	75	0.9	BDL	BDL	0	BDL	0.5	0.1	BDL	BDL	0.2
16	10.5	6.75	76	0.9	BDL	BDL	0	BDL	0.5	0.1	BDL	BDL	0.2
17	10	6.85	70	0.7	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.2
18	10.5	6.95	120	0.9	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.3
19	10.5	6.85	81	0.8	BDL	BDL	2	BDL	0.5	0	BDL	BDL	0.3
20	10.5	6.7	73	0.8	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.3
21	9.5	6.85	71	0.9	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.2
22	9.5	6.8	68	0.8	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.2
23	9.5	6.9	67	0.7	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.2
24	9.5	6.9	65	0.8	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0.2
25	9.5	7	63	0.8	BDL	BDL	2	BDL	0.5	0.1	BDL	BDL	0
26	9	7.05	56	0.6	BDL	BDL	2.5	BDL	0.4	0.1	BDL	BDL	0
27	8.5	7.05	54	0.7	BDL	BDL	2.5	BDL	0.4	0.1	BDL	BDL	0.1
28	8	7.05	43	0.6	BDL	BDL	2.5	BDL	0.4	0.1	BDL	BDL	BDL

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

MINK DATA MARCH TO AUGUST 1969
MINK, JULY 15, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	12	6.4	118	6.2	BDL	BDL	0.2	0.8	3	1.2	2.9	BDL	2.7
11	12	6.2	264	13	BDL	BDL	0.4	1.6	5.3	1.3	6.2	BDL	7.5
12	12	6.3	315	15.7	BDL	BDL	0.2	2	6.5	1.4	7.5	BDL	8.1
13	11.5	6.25	322	16.5	BDL	BDL	0.3	2	6	BDL	7.4	BDL	8.9
14	10.5	6.75	130	8.9	BDL	BDL	0.2	1.2	3.1	BDL	5.4	BDL	1.8
15	10	7.2	123	9.4	BDL	BDL	0.2	1.2	3.2	BDL	4.9	BDL	1.4
16	10	7.2	127	9.4	BDL	BDL	BDL	0.9	3	BDL	4.3	BDL	1.3
17	10	7.2	123	8.1	BDL	BDL	0.1	0.9	3	BDL	5.4	BDL	0.6
18	10	7.3	185	9	BDL	BDL	0.2	1	2.8	BDL	20.4	BDL	0.7
19	9.5	7.15	115	8.7	BDL	BDL	0.1	1.8	3.1	BDL	2.3	BDL	1.5
20	9.5	7.3	115	9.8	BDL	BDL	0.1	0.9	3	BDL	1.9	BDL	1.3
21	9	7.4	115	8.3	BDL	BDL	0.1	0.9	3.1	BDL	2.5	BDL	1.1
22	8.5	7.45	115	8.1	BDL	BDL	0.2	0.8	3.1	BDL	1.9	BDL	1.1
23	9	7.45	112	8.1	BDL	BDL	0.2	0.6	3	BDL	2.3	BDL	1.2
24	9	7.45	108	7.9	BDL	BDL	0.2	0.6	3.2	BDL	2	BDL	1.2
25	9	7.6	90	7.1	BDL	BDL	0.1	0.6	2.7	BDL	1.9	BDL	0.1
26	9	7.6	76	6.4	BDL	BDL	0.1	0.6	2.2	BDL	2.5	BDL	BDL
27	9	7.7	77	6.1	BDL	BDL	0.1	0.6	2.5	BDL	2.7	BDL	BDL
28	9	7.75	65	5.9	BDL	BDL	0.1	0.5	2.2	BDL	1.4	BDL	BDL

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1 mg/l)

MINK DATA MARCH TO AUGUST 1969
MINK, AUG 16, 1969

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A-10	17.5	7.55	165	11.7	BDL	0	0.1	0.9	3.2	0.5	4.4	BDL	1.9
11	21	6.9	365	27.8	BDL	0	0.1	2.2	4.5	1.7	10.4	BDL	5.1
12	17	6.85	450	31.2	BDL	0	0.2	2.5	4.5	2	13.5	BDL	6.8
13	17.5	6.55	435	29.6	BDL	0	0.1	2.4	4.5	BDL	13.8	BDL	6.5
14	16.5	8.8	180	15	BDL	0	0.1	1	3.6	BDL	7.2	BDL	0.5
15	17	9.1	170	14.6	BDL	0	0.2	1	3.7	BDL	7.4	BDL	0.3
16	16.5	8.9	175	15.7	BDL	0	0.1	1	3.7	0	7.8	BDL	0.3
17	16.5	8.9	180	15.1	BDL	BDL	0.2	1.1	3.7	0	10.2	BDL	0.2
18	16	9.15	295	15.3	BDL	BDL	0.2	1.7	3.6	BDL	BDL	BDL	0.2
19	18	9.5	155	15.1	BDL	0.1	0.1	1	3.7	0	3.4	BDL	0.4
20	18	9.6	150	15	BDL	BDL	0.1	0.9	3.6	0	3.4	BDL	0.6
21	16	7.75	160	15.1	BDL	BDL	0.1	1	3.7	0	3.5	BDL	0.6
22	16	8.6	150	14.3	BDL	BDL	0.1	0.9	3.7	BDL	3.6	BDL	0.7
23	17.5	8.1	155	14.7	BDL	0	0.1	0.9	3.6	BDL	3.4	BDL	0.8
24	18.5	8.2	120	15.5	BDL	0	0.2	0.9	3.9	BDL	2.9	BDL	1
25	18	8.8	120	13.3	BDL	0	0.1	0.8	3.1	0	2.6	BDL	1
26	15	8.5	105	12.9	BDL	0	0.1	0.5	2.6	0	1.8	BDL	BDL
28	15.5	8.5	84	9.4	BDL	0	0.1	0.4	2.7	0	1.5	BDL	BDL

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

APPENDIX F

THIS STUDIES DATA

MARCH TO AUGUST 1988

APPENDIX F

THIS STUDY MARCH TO AUGUST 1988
MARCH 15, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	3.5	6.12	42	8.4	BDL	BDL	BDL	BDL	2.9	0.1	1.5	BDL	0.5
11	3.5	6.6	115	23.1	BDL	BDL	BDL	BDL	7.7	0.5	3.2	BDL	2.5
12	3.5	6.68	160	33.9	0.02	BDL	BDL	1.4	11.4	0.7	4.1	BDL	3.8
13	7	6.56	155	28.7	BDL	BDL	BDL	BDL	9	0.5	3.1	BDL	2.5
A13	6.5	6.55	115	21.2	BDL	BDL	BDL	1	6.8	0.4	3	BDL	2.4
14	6.5	6.8	115	19.1	BDL	BDL	BDL	BDL	5.8	0.2	2.9	BDL	1.9
15	4	6.63	98	20	BDL	BDL	BDL	1	6.4	0.1	3.4	BDL	2.6
16	2	6.59	115	18.8	BDL	BDL	BDL	0.9	5.9	0.1	2.9	BDL	2.3
17	3.9	6.23	80	16.2	BDL	BDL	BDL	BDL	4.8	0.2	3	BDL	1.4
18	4	6.16	102	25.4	BDL	BDL	BDL	BDL	6.6	0.1	3.2	BDL	3
19	3.9	6.6	92	24.5	BDL	BDL	BDL	BDL	7.6	0.1	4	BDL	3.6
20	4	6.66	115	23.5	BDL	BDL	BDL	1.2	7.2	0.1	3.4	BDL	3.1
21	6	6.95	112	24	BDL	BDL	BDL	BDL	7.1	0.1	3.7	BDL	2.5
22	6	6.84	107	21.4	BDL	BDL	BDL	BDL	6.1	0.1	3.1	BDL	2.4
23	6	6.67	105	22.1	BDL	BDL	BDL	BDL	6.6	0.1	4.2	BDL	2.5
25	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	6	6.66	115	26.2	BDL	BDL	BDL	BDL	9.2	0.1	4.5	BDL	0.6
28	5	7.16	50	11.6	BDL	BDL	BDL	BDL	4.3	0.2	1.9	BDL	BDL
AVE	5.1												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
APRIL 14, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	7	5.6	20	4.6	BDL	BDL	BDL	BDL	1.5	BDL	1.2	BDL	0.2
11	6	5.45	35	8.1	BDL	BDL	BDL	BDL	2.4	0.1	1.5	0.02	0.8
12	6	6.26	48	12	BDL	BDL	BDL	BDL	3.7	0.2	1.8	BDL	1.2
13	6	5.99	50	10.1	BDL	BDL	BDL	BDL	2.8	0.1	1.6	BDL	0.9
A13	6	6.39	40	9.5	BDL	BDL	0.019	BDL	2.6	0.1	1.6	BDL	0.9
14	6	6.56	40	9.3	BDL	BDL	BDL	BDL	2.6	0.1	1.7	BDL	0.9
15	7	6.35	35	9.3	BDL	BDL	BDL	BDL	2.6	BDL	1.5	BDL	0.8
16	10	6.27	43	9.6	BDL	BDL	BDL	BDL	2.8	BDL	1.6	BDL	0.9
17	12	6.36	30	7.7	BDL	BDL	0.012	BDL	2.1	BDL	1.4	BDL	0.5
18	8	6.01	30	10.8	BDL	BDL	BDL	BDL	3	BDL	1.4	BDL	1.2
19	7	6.22	40	10.2	BDL	BDL	BDL	BDL	2.8	BDL	1.3	BDL	1.1
20	7.5	6.29	45	10.9	BDL	BDL	BDL	BDL	2.8	BDL	1.2	BDL	1.2
21	8	6.38	40	9.2	BDL	BDL	0.045	BDL	2.5	BDL	1.2	BDL	1
22	7.5	6.27	45	9.1	BDL	BDL	BDL	BDL	2.5	BDL	1.2	BDL	1.1
23	7.5	6.47	39	8.8	BDL	BDL	BDL	BLD	2.3	BDL	1.3	BDL	0.9
25	8	6.66	151	9.1	BDL	BDL	BDL	BDL	2.7	BDL	1.1	BDL	0.2
26	8	6.05	205	7.3	BDL	BDL	BDL	BDL	2.1	BDL	1.1	BDL	BDL
28	8	5.86	205	5.2	BDL	BDL	BDL	BDL	1.5	BDL	1	BDL	BDL
AVE	7.5												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
APRIL 28, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	8	5.6	29	6	BDL	BDL	0.09	0.5	2.1	0.1	1.2	BDL	0.3
11	8	5.51	58	11.4	BDL	BDL	0.07	BDL	3.5	0.2	1.8	BDL	1
12	8	5.36	107	15.3	BDL	BDL	0.15	BDL	4.9	0.3	2.3	BDL	1.5
13	7	4.81	25	13.2	BDL	BDL	0.16	BDL	4	0.2	2.1	BDL	1.1
A13	8	5.04	180	11.1	BDL	BDL	0.13	BDL	3.3	0.2	2.1	BDL	1.1
14	8	5.19	149	10.5	BDL	0.02	0.05	BDL	3.2	BDL	2.1	BDL	0.9
15	8	5.39	200	10.6	BDL	BDL	0.02	BDL	3	BDL	2.1	BDL	0.9
16	8	5.09	179	12	BDL	BDL	BDL	BDL	3.5	BDL	2.1	BDL	1
17	8.5	5.72	48	9.9	BDL	BDL	0.05	BDL	2.8	BDL	2.4	BDL	0.5
18	9	5.15	128	12.6	BDL	BDL	0.09	BDL	3.8	BDL	2.1	BDL	1
19	9	5.75	98	12	BDL	BDL	BDL	BDL	3.5	0.1	1.7	BDL	1
20	9	4.99	142	12.5	BDL	BDL	BDL	BDL	3.8	BDL	1.8	BDL	1.1
21	9	4.9	50	11	BDL	BDL	BDL	BDL	3.2	BDL	1.7	BDL	0.8
22	9	BDL	143	10.8	BDL	BDL	BDL	BDL	3	BDL	1.7	BDL	0.8
23	10	BDL	167	10.6	BDL	BDL	BDL	BDL	3	BDL	2.2	BDL	0.7
25	10	BDL	198	11.4	BDL	BDL	BDL	BDL	3.5	BDL	1.5	BDL	0.1
26	10	BDL	240	10	BDL	BDL	BDL	BDL	2.9	BDL	1.7	BDL	0.1
28	10	BDL	162	6.6	BDL	BDL	BDL	BDL	2.1	BDL	1.3	BDL	BDL
AVE	8.7												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limit ((0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
MAY 13, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	10	6.25	35	4.9	BDL	BDL	BDL	BDL	1.3	0.1	1.1	BDL	0.2
11	9	5.54	42	6.6	BDL	BDL	0.04	BDL	1.6	0.1	1.2	BDL	0.6
12	9	5.78	55	8.9	BDL	BDL	0.12	BDL	2.4	0.1	1.3	BDL	0.8
13	8	5.76	45	7.9	BDL	BDL	0.07	BDL	1.9	BDL	1.2	BDL	0.6
A13	8	6.06	45	7.4	BDL	BDL	0.03	BDL	1.8	BDL	1.5	BDL	0.6
14	8	5.92	40	6.9	BDL	BDL	BDL	BDL	1.6	BDL	1.3	BDL	0.5
15	8	6.11	40	6.7	BDL	BDL	BDL	BDL	1.5	BDL	1.3	BDL	BDL
16	8	5.21	40	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BLD	BDL
17	8	5.31	35	5.9	BDL	BDL	0.02	BDL	1.2	BDL	1.3	BDL	0.3
18	9	5.77	40	6.9	BDL	BDL	0.03	BDL	1.6	BDL	1	BDL	0.5
19	9	5.95	40	6.6	BDL	BDL	BDL	BDL	1.4	BDL	1.1	BDL	0.5
20	9	5.01	45	7.3	BDL	BDL	BDL	BDL	1.7	BDL	1.1	BDL	0.6
21	8	5.65	35	6.2	BDL	BDL	BDL	BDL	1.3	BDL	1	BDL	0.5
22	8	5.15	35	6.2	BDL	BDL	BDL	BDL	1.3	BDL	1	BLD	0.4
23	8	5.6	35	6.3	BDL	BDL	BDL	BDL	1.3	BDL	1.4	BDL	0.4
25	8	5.28	38	7.5	BDL	BDL	BDL	BDL	1.9	BDL	1	BDL	0.2
26	8	5.71	30	6.2	BDL	BDL	0.01	BDL	1.2	BDL	1.3	BDL	0.1
28	8	5.72	20	3.1	BDL	BDL	0.02	BDL	0.6	BDL	1	BDL	BDL
AVE	8.4												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
MAY 26, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	12	5.86	42	7.5	BDL	BDL	BDL	BDL	2.2	0.1	1.5	BDL	0.4
11	11	5.88	65	12.3	BDL	BDL	0.09	BDL	3.4	0.2	2.1	BDL	0.9
12	11	5.96	75	14.5	BDL	BDL	0.13	BDL	4.1	0.2	2.3	BDL	1.1
13	12	6.13	60	12.7	BDL	BDL	0.11	BDL	2.4	0.2	2.1	BDL	0.8
A13	12	6.27	52	10.3	BDL	BDL	0.08	BDL	3.4	0.1	2.2	BDL	0.9
14	12	6.23	50	9.8	BDL	BDL	0.02	BDL	3.1	0.1	2	BDL	0.8
15	12	6.37	50	10.3	BDL	BDL	BDL	BDL	2.5	BDL	2	BDL	0.6
16	12	6.17	41	10.1	BDL	BDL	BDL	BDL	2.5	BDL	2	BDL	0.6
17	12	6.16	50	10.1	BDL	BDL	BDL	BDL	2.3	0.1	2.1	BDL	0.4
18	12	6.08	40	8.9	BDL	BDL	BDL	BDL	3.1	BDL	1.8	BDL	0.8
19	12	5.7	45	9.3	BDL	BDL	BDL	BDL	2.4	BDL	BDL	BDL	0.6
20	12	5.85	49	10.2	BDL	BDL	BDL	0.6	2.8	BDL	1.7	BDL	0.8
21	12	5.82	39	8.9	BDL	BDL	BDL	BDL	2.4	BDL	1.9	BDL	0.6
22	12	6.21	40	7.2	BDL	BDL	0.02	BDL	2.3	BDL	1.6	BDL	0.6
23	12	5.61	42	8.7	0.007	BDL	BDL	BDL	2.8	BDL	2.1	BDL	1.1
25	12	6.16	45	9.3	BDL	BDL	BDL	BDL	3.4	BDL	1.7	BDL	BDL
26	11	5.87	40	8	BDL	BDL	0.02	BDL	2.6	BDL	1.7	BDL	0.1
28	12	5.77	15	4.2	BDL	BDL	BDL	BDL	1.6	BDL	1.6	BDL	BDL
AVE	11.8												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
JUNE 9, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	11	5.88	52	9	BDL	BDL	BDL	BDL	3.1	0.1	1.9	BDL	0.6
11	11	6.31	90	14.4	BDL	BDL	0.14	0.4	4.8	0.3	2.8	BDL	1.4
12	11	5.85	110	18	BDL	BDL	0.17	BDL	5.7	0.3	2.9	BDL	1.9
13	11	6.01	93	12.4	BDL	BDL	0.15	BDL	4	0.2	2.6	BDL	1.3
A13	11	6.05	85	14.1	BDL	BDL	0.22	BDL	4.1	0.2	2.2	BDL	1.2
14	11	6.33	78	11.1	BDL	BDL	BDL	BDL	3.6	0.2	2.5	BDL	1
15	11	6.45	75	12	BDL	BDL	BDL	0.5	3.3	0.1	2.3	BDL	0.9
16	11	6.8	75	12.3	BDL	0.007	BDL	BDL	3.7	0.1	2.7	BDL	0.9
17	11	6.4	80	12.1	BDL	BDL	0.03	BDL	2.8	0.1	2.7	BDL	0.5
18	11	6.13	70	11.5	BDL	BDL	BDL	BDL	3.6	BDL	2	BDL	1.1
19	12	6.01	70	9.2	BDL	BDL	BDL	BDL	2.9	BDL	1.4	BDL	0.8
20	12	6.21	72	10.5	BDL	BDL	BDL	BDL	3.3	BDL	1.4	BDL	1
21	12	6.25	60	9.2	BDL	BDL	0.03	BDL	3.1	BDL	2	BDL	0.7
22	12	6.28	60	8.8	BDL	BDL	BDL	BDL	2.6	BDL	1.4	BDL	0.7
23	12	6.2	62	9.9	BDL	BDL	0.03	BDL	2.9	BDL	2.1	BDL	0.9
25	12	6.98	70	10.6	BDL	BDL	BDL	BDL	3.5	BDL	1.5	0.04	0.2
26	12	6.29	60	9.8	BDL	BDL	BDL	BDL	3.1	BDL	1.9	BDL	0.2
28	12	6.29	60	5.8	BDL	BDL	BDL	BDL	1.6	BDL	0.7	BDL	BDL
AVE	11.4												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
JUNE 23, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	18	6.76	80	10	BDL	BDL	0.07	BDL	3.4	0.1	1.7	BDL	0.7
11	16	6.69	155	24.3	0.01	BDL	0.14	BDL	6.8	0.4	4.4	BDL	1.9
12	16	6.3	170	21.2	BDL	BDL	0.18	0.7	6.2	0.5	3.9	BDL	2
13	16	6.53	150	24.3	BDL	BDL	0.25	BDL	6.2	0.4	4.8	BDL	2
A13	16	6.69	145	18.2	BDL	BDL	0.2	0.7	5	0.3	3.5	BDL	1.6
14	16	6.3	129	16.7	BDL	BDL	0.04	BDL	4.3	0.3	3.4	BDL	1.3
15	16	6.76	125	16.4	BDL	BDL	0.03	BDL	4.1	0.1	3.3	BDL	1.1
16	15	6.71	120	15.6	BDL	BDL	0.03	BDL	4	0.1	2.9	BDL	1.1
17	15	6.6	145	25.2	BDL	BDL	0.06	BDL	4.8	0.2	6.9	BDL	0.9
18	15	6.8	100	16.5	BDL	BDL	0.03	BDL	4.9	0.1	2.7	BDL	1.4
19	15	6.6	100	16.2	BDL	BDL	0.02	BDL	4.9	BDL	2.6	BDL	1.4
20	15	6.63	100	16.4	BDL	BDL	0.03	0.7	5	BDL	2.8	BDL	1.5
21	15	6.5	90	14.2	BDL	BDL	0.02	BDL	4.4	BDL	2	BDL	1.1
22	15	6.87	88	10.9	BDL	BDL	BDL	BDL	3.3	BDL	1.2	BDL	0.9
23	15	6.45	95	14.2	BDL	BDL	BDL	BDL	4.2	BDL	3	BDL	1.1
25	15	6.58	100	13.2	BDL	BDL	BDL	BDL	4.7	BDL	1.3	BDL	0.2
26	15	6.53	90	13.9	BDL	BDL	0.05	BDL	4.7	BDL	2.1	BDL	0.2
28	15	6.84	50	6.7	BDL	BDL	0.02	BDL	1.9	BDL	0.3	BDL	BDL
AVE	15.6												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
JULY 7, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	13	6.25	85	11	BDL	BDL	BDL	0.9	3.3	0.2	0.3	BDL	0.6
11	13	6.66	180	25	BDL	BDL	BDL	1.1	6.8	0.6	2.9	BDL	1.7
12	13	6.16	210	29	BDL	BDL	BDL	1.3	8.2	0.8	3.9	BDL	2.1
13	13	6.29	190	24	BDL	BDL	BDL	1.6	6.3	0.6	3.3	BDL	1.7
A13	13.5	6.62	160	21	BDL	BDL	BDL	1.5	5.1	0.5	3.3	BDL	1.7
14	14	6.3	140	19	BDL	BDL	BDL	1.3	4.2	0.2	3	BDL	1.3
15	14	6.64	140	18	BDL	BDL	BDL	1.1	4.2	0.1	3	BDL	1.2
16	14	6.57	140	19	BDL	BDL	BDL	1.1	4.1	0.1	3	BDL	1.2
17	14.5	6.55	180	25	BDL	BDL	BDL	1.2	4.3	0.3	7.3	BDL	0.9
18	15	6.61	120	16	BDL	BDL	BDL	1.1	4.2	BDL	0.9	BDL	1.5
19	15	6.59	120	16	BDL	BDL	BDL	0.9	4.4	BDL	1.1	BDL	1.4
20	15	6.62	120	17	BDL	BDL	BDL	1.1	4.4	BDL	1.1	BDL	1.6
21	15	6.7	110	13	BDL	BDL	BDL	1.1	3.6	BDL	0.5	BDL	1
22	15	6.9	108	14	BDL	BDL	BDL	BDL	3.7	BDL	0.4	BDL	1
23	16	6.99	115	14	BDL	BDL	BDL	0.9	3.6	BDL	2.1	BDL	1.1
25	BDL	6.7	125	15	BDL	BDL	BDL	0.5	4.6	BDL	1.1	BDL	0.1
26	15.5	6.96	60	14	BDL	BDL	BDL	0.8	4.5	BDL	1.8	BDL	0.2
28	15	6.83	120	8.2	BDL	BDL	BDL	0.5	2.2	BDL	BDL	BDL	BDL
AVE	14.3												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
JULY 21, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	18	6.5	110	12	BDL	BDL	0.1	0.9	3.4	0.1	1.4	BDL	0.7
11	16	6.5	230	29	BDL	BDL	0.1	1.5	7.4	0.6	4.8	BDL	2
12	17	6.37	280	35	BDL	BDL	0.2	1.4	9	0.8	6	BDL	2.5
13	18	6.4	255	32	BDL	BDL	BDL	0.7	7.3	0.6	5.9	BDL	2.2
A13	18	6.56	220	28	BDL	BDL	BDL	1	5.9	0.7	5.8	BDL	2.2
14	17	6.37	200	23	BDL	BDL	BDL	1.2	4.8	0.2	5.8	BDL	1.5
15	17	6.49	180	24	BDL	BDL	BDL	0.9	4.8	0.1	5.8	BDL	1.5
16	18	6.47	180	25	BDL	BDL	BDL	0.9	5	0.2	6.7	BDL	1.6
17	18	6.52	280	36	BDL	BDL	BDL	1.3	4.9	0.4	12	BDL	1.1
18	18	6.57	145	20	BDL	BDL	BDL	1.5	5.1	BDL	2.4	BDL	1.7
19	18	6.66	140	20	BDL	BDL	BDL	0.9	5.2	BDL	2.5	BDL	1.7
20	18	6.33	145	19	BDL	BDL	BDL	1.3	5.3	BDL	2.2	BDL	1.8
21	18	6.48	135	18	BDL	BDL	BDL	BDL	4.9	BDL	2.5	BDL	1.2
22	18	6.66	130	18	BDL	BDL	BDL	0.2	4.7	BDL	1.9	BDL	1.3
23	18	6.89	130	18	BDL	BDL	BDL	0.9	4.7	BDL	1.8	BDL	1.3
25	19	6.92	210	21	BDL	BDL	BDL	1	6.5	BDL	1.9	BDL	0.2
26	18	6.78	185	21	BDL	BDL	BDL	1	6.5	BDL	3.7	BDL	0.2
28	17	7.48	135	11	BDL	BDL	BDL	0.8	2.8	BDL	0.6	BDL	BDL
AVE	17.7												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
AUGUST 4, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	19	6.53	105	13	BDL	0.3	0.1	0.8	3.4	0.2	1.6	BDL	0.7
11	17	6.43	260	27	BDL	0.2	0.1	1.1	7.3	0.6	5	BDL	1.8
12	16	6.3	305	38	BDL	0.2	0.2	1.9	9	0.7	6.6	BDL	2.5
13	16	6.51	270	29	BDL	0.3	BDL	1.6	7.5	0.6	6.5	BDL	2.3
A13	16	6.46	245	29	BDL	0.3	BDL	1.7	6.4	0.8	7.4	BDL	2.3
14	18	6.46	215	22	BDL	0.2	BDL	1.2	4.3	0.2	5.6	BDL	1.4
15	19	6.76	215	25	BDL	0.2	BDL	1.1	5.1	0.1	7.6	BDL	1.4
16	20	6.69	225	25	BDL	BDL	BDL	1.3	4.6	0.2	6.5	BDL	1.3
17	20	6.51	320	36	BDL	BDL	BDL	1.6	5.1	0.4	15	BDL	0.9
18	20	6.73	150	16	BDL	0.1	BDL	0.8	4.9	BDL	2.2	BDL	1.4
19	20	6.7	160	18	BDL	BDL	BDL	1	4.5	BDL	1.6	BDL	1.7
20	20	6.75	160	19	BDL	BDL	BDL	1.2	5	BDL	2.1	BDL	1.4
21	20	6.92	150	18	BDL	BDL	BDL	1.5	5.1	BDL	2.5	BDL	0.6
22	20	6.84	145	18	BDL	BDL	BDL	0.6	4.9	BDL	2	BDL	0.7
23	20	6.96	155	18	BDL	BDL	BDL	1.7	4.9	BDL	3.2	BDL	0.8
25	20	7.12	170	21	BDL	BDL	BDL	1.7	6.7	BDL	2.4	BDL	BDL
26	20	6.72	185	21	BDL	BDL	BDL	1.8	7.1	BDL	4.3	BDL	0.2
28	20	7.1	75	11	BDL	BDL	BDL	1.3	2.9	BDL	BDL	BDL	BDL
AVE	18.9												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

THIS STUDY MARCH TO AUGUST 1988
AUGUST 18, 1988

STATION	TEMP	pH	EC	Ca	Cd	Cu	Fe	K	Mg	Mn	Na	Pb	Zn
A	19	6.54	130	15	BDL	BDL	BDL	BDL	3.9	0.1	2.1	BDL	0.7
11	17	6.34	300	37	BDL	BDL	0.1	0.8	9	0.7	6.5	BDL	2
12	19	6.1	340	43	BDL	BDL	0.2	1.7	11	0.8	8.1	BDL	2.6
13	20	6.32	360	44	BDL	BDL	0.2	2.1	9.5	0.8	9	BDL	2.4
A13	18.5	6.27	315	38	BDL	BDL	0.2	1.8	7.2	0.9	9.5	BDL	2.6
14	21	6.34	279	34	BDL	BDL	BDL	1.3	5.7	0.2	9.8	BDL	1.6
15	21.5	6.89	280	34	BDL	BDL	BDL	1.6	5.7	0.2	10	BDL	1.6
16	21.5	6.46	282	32	BDL	BDL	BDL	1.9	5.2	0.2	9.2	BDL	1.5
17	19.5	6.3	418	52	BDL	BDL	BDL	1.7	6	0.4	19	BDL	1.1
18	18	6.2	165	19	BDL	BDL	BDL	1.4	5.1	BDL	2.4	BDL	1.6
19	21	6.45	170	19	BDL	BDL	BDL	1	5.2	BDL	2.4	BDL	1.4
20	21.5	6.36	168	18	BDL	BDL	BDL	1.4	5	BDL	2.4	BDL	1.6
21	21.5	6.61	160	19	BDL	BDL	BDL	0.8	5.3	BDL	3	BDL	0.6
22	21	6.6	151	18	BDL	BDL	BDL	0.8	5	BDL	2.9	BDL	0.6
23	22	6.46	160	19	BDL	BDL	BDL	1.1	5.1	BDL	3.1	BDL	0.9
25	19	6.76	190	21	BDL	BDL	BDL	1.3	6.6	BDL	3	BDL	0.1
26	22.5	6.6	206	25	BDL	BDL	BDL	1	8	BDL	4.3	BDL	0.3
28	16	6.8	80	11	BDL	BDL	BDL	1.3	3.1	BDL	0.7	BDL	BDL
AVE	20												

TEMP C
EC umhos
METALS mg/l
BDL Below Detection Limits (<0.1mg/l)

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