WATER QUALITY STATUS REPORT NO. 113

East Fork of the South Fork of the Salmon River

Valley County, Idaho

1979 - 1993

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ACKNOWLEDGEMENTS

Monitoring of the East Fork of the South Fork of the Salmon River (EFSFSR) has been the responsibility of many technicians and scientists in the Division of Environmental Quality, Idaho Department of Fish and Game, Idaho Department of Lands, U.S. Fish and Wildlife Service, Idaho Department of Health and Welfare Bureau of Laboratories, Krassel District of the Payette National Forest, and the current operators, Hecla Mining Company and Stibnite Mining Incorporated. Each of the key individuals in these agencies and companies deserve the Division of Environmental Quality's appreciation. Earl Dodds, Minerals Technician (retired), and Jane Wurster, Geologist, have persevered on this study in a commendable manner, and for that they deserve special acknowledgement.

The discussion of contaminant analyses in fine sediment, algae, and fish is summarized from discussions with and data by Susan Burch and Bill Mullins of the U.S. Fish and Wildlife Service. Mere reference of those discussions cannot fully acknowledge the efforts of Susan Burch and Bill Mullins who helped to coorelate that data with interpretations of surface water quality data, nor the U.S. Fish and Wildlife Service for allowing access to the data prior to its publication.

The discussion and results of fine sediment deposition and macroinvertebrates has been summarized from the most recent Forest Service reports and included in this report in order to attempt a holistic analyses of the watershed. To the authors of those reports, John Lund, Mary Faurot, and John Gephards, goes a special thanks.

ABSTRACT

The EFSFSR headwaters are located on the western border of the Frank Church River of No Return Wilderness in Valley County, Idaho (Figure 1, Trainor). The main impacts to the EFSFSR occur due to mining activities at Stibnite and Cinnabar. Although monitoring plans had been focused on the entire length of the EFSFSR, trends in data justified modifications in the plans to focus limited resources and funding on the EFSFSR and two major tributaries, Sugar Creek and Meadow Creek, in proximity to Stibnite.

The EFSFSR has been designated as both a Stream Segment of Concern, and a Special Resource Water. The EFSFSR is particularly notable for its role as a spawning and rearing habitat for salmon, steelhead, bull trout and cutthroat trout. Because of: recurring violations of the Idaho "Environmental Protection and Health Act", as specified in the Idaho "Water Quality Standards and Waste Water Treatment Requirements"; a chronically toxic condition in a portion of Meadow Creek; and a notable impairment in macroinvertebrate communities near the mouth of Meadow Creek, the EFSFSR has been submitted to the U.S. Environmental Protection Agency for listing under Section 303 (d) of the U.S. Clean Water Act as a "Water Quality Limited Segment".

Water quality and habitat monitoring has been implemented in the EFSFSR in order to assure compliance of current mining operations in the drainage with Idaho's Water Quality Standards and Wastewater Treatment Requirements and to qualify the effects of reclaiming historical mining sites on surface water quality. The monitoring will also become a very important tool as management strategies are developed for "threatened or endangered species".

Water quality monitoring and analyses indicates that there is a general trend towards improvement in water quality, habitat, and aquatic communities. Improvements should not, however, be construed to mean that water quality is good to excellent as is indicated in independent studies on fine sediment deposition and water chemistry. When analyzed holistically, the water quality of the EFSFSR is in the good to excellent ranges, while water quality in Meadow Creek is impaired and does not fully support beneficial uses.

Continuing improvements to water quality in the headwaters is completely dependent upon actions by the operators of the Yellow Pine and Stibnite Mines. In order to continue the trend, modifications to best management practices, and operating and maintenance of mining facilities must be planned and implemented.

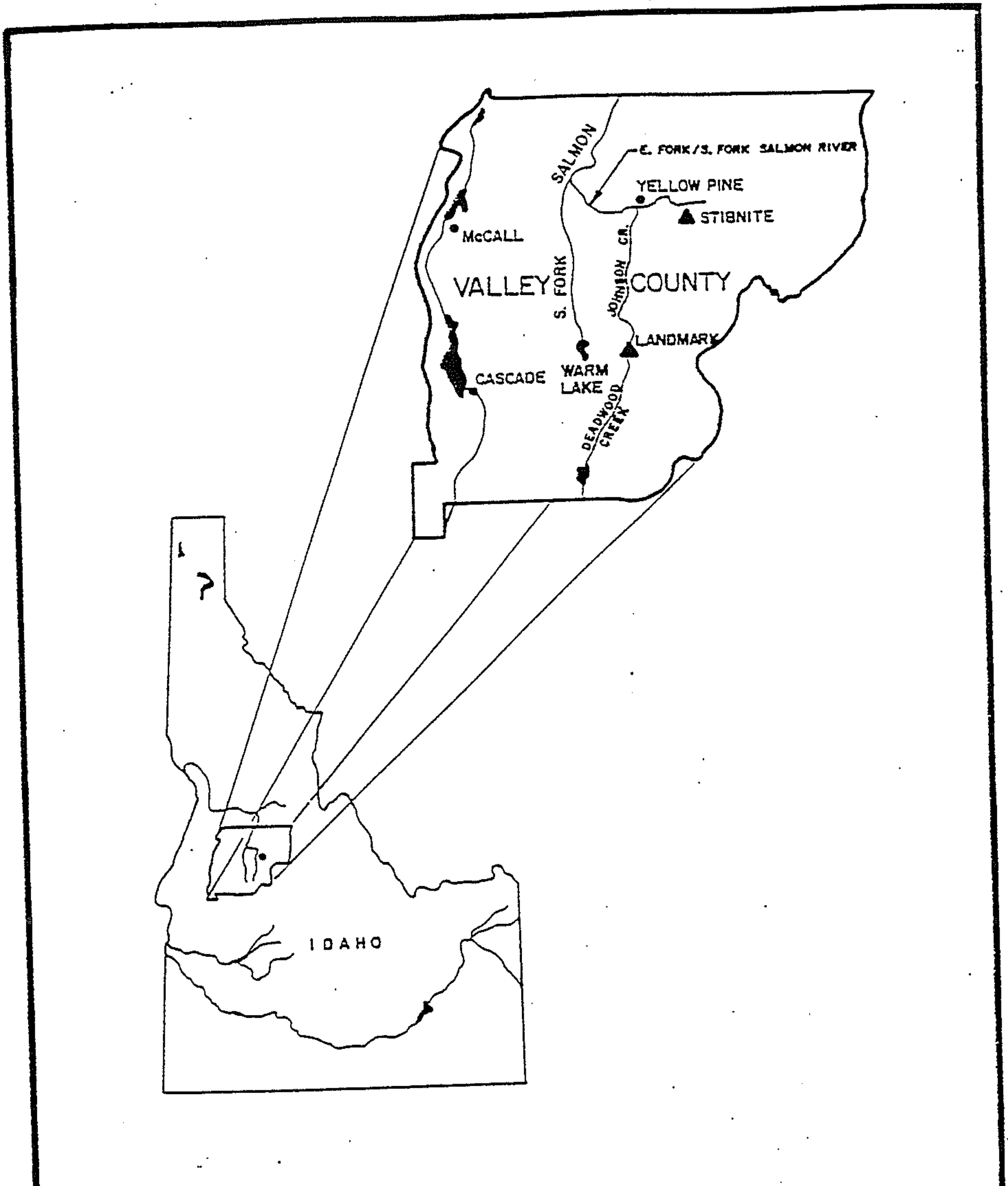

Figure 1. Stibnite Mining Project location map (JMM 1981).

INTRODUCTION

Mining, at the Stibnite and Cinnabar Mines, has been playing an economically important and colorful role in the development of eastern Valley County, Idaho. The Stibnite and Cinnabar Mines, however, have become shrouded in controversy because of their history of pollution discharges to the EFSFSR, and its tributaries, and the listing of Spring/Summer Snake River Chinook Salmon as Endangered Species. Consequently, surface and ground water quality monitoring has become one of the most important tools of resource managers in the watersheds which influence the EFSFSR.

Analysis of water quality trends at individual stations and along stream segments would be extremely difficult if it were not for the number of stations throughout the watershed with which to compare data. Furthermore, it would be ludicrous to attempt to correlate resource management activities and data analyses from one water quality monitoring approach. It is, therefore, the purpose of this report to utilize the analyses and conclusions drawn from fine sediment deposition surveys, macroinvertebrate, chemical analyses of fine sediment, algae and fish tissue, and water quality studies to assess the overall water quality status to the EFSFSR related to mining at Stibnite.

A problem encountered in the development of this report was that there is very little water quality monitoring data from 1986 through 1989. Although data from mine operators' filled the gaps in the data, it is evident that particular attention must be paid to maintaining consistency and frequency of data collection.

Analyses of fine sediment deposition, macroinvertebrate assemblages, contaminants in fine sediment, algae, fish tissue, and water are correlative and support many conclusions. These include the need for increased use and modifications of best management practices; catch up and concurrent reclamation is important; concentrations of arsenic and cyanide in Meadow Creek, which cause chronic and acute effects in cold water biota (EPA 1986), require immediate attention; periodic discharges to the EFSFSR and Meadow Creek have caused acute and/or chronic reactions in aquatic communities; rediversion of Meadow Creek must proceed only after substantial design improvements; and unless major redesign and source control techniques are applied to Stibnite Mining Incorporated's ore processing and spent ore disposal facilities, and the historical mill tailings in and along Meadow Creek, toxic concentrations of metals and cyanide, in Meadow Creek, will persist and cause chronic and acute effects in aquatic biota.

WATER QUALITY MONITORING
MATERIALS AND METHODS

Text and data from reports by the U.S.D.A. Forest Service and U.S. Fish and Wildlife Service have been included in this section in order to correlate studies in the upper reaches of the EFSFSR. For specific discussion or information contained in the reports compiled by the U.S.D.A Forest Service or the U.S. Fish and Wildlife Service the reader is referred to their final reports. DEQ appreciates the cooperation of those agencies and their permission to summarize their reports in this report.

FINE SEDIMENT, ALGAE, AND FISH SAMPLE COLLECTION

One composite sediment sample was collected from each of three sites (Figure 1). Composite samples consisted of two to four grab samples each 6 to 8 inches deep using a stainless steel hand corer with a lexan tube (Burch and Mullins 1994). Individual grab samples were thoroughly mixed in a stainless steel tray with a stainless steel spoon before placing in a clean sample jar.

One algae sample was collected at approximately MP8 of the EFSFSR road. The collection site for the algae sample was selected by availability, as algae was not seen at other locations within the EFSFSR (Burch and Mullins 1994).

Whole fish samples were collected using electro fishing techniques. Steelhead trout smolts and mountain whitefish adults were collected at the confluence of Profile Creek, at MP8 of the EFSFSR road, and below Sugar Creek (see Figure 1, Burch and Mullins 1994). Individual length and weight measurements and estimated year class were recorded. The number of fish in composite samples are noted on Table 3 at the back of this report.

Sediment and algae samples were placed in clean sample jars (Burch and Mullins 1994). Each fish sample was wrapped in aluminum foil and placed into a zip lock bag. All samples were placed on ice immediately after collection and frozen upon return to the laboratory (within 12 hours). Samples were analyzed within 6 months of collection.

CHEMICAL ANALYSIS OF SEDIMENT, ALGAE, AND FISH TISSUE

All samples were analyzed for trace elements by the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility (PACF). Arsenic and selenium were analyzed by the graphite furnace atomic-absorption method, and mercury was analyzed by the cold-vapor atomic absorption method (Burch and Mullins 1994). All other trace elements were analyzed by an ICP (inductively coupled plasma) scan. All trace element concentrations in this document are reported in dry weight unless otherwise noted. Fish tissue concentrations are discussed in wet weight when compared to National Contaminant Biomonitoring Program results for purposes of comparison (Burch and Mullins 1994).

Quality assurance and quality control (QA/QC) of analytical data were reviewed by the PACF (Burch and Mullins 1994). Acceptable performance (recovery variation averaged <20% for all constituents measured) on spikes, blanks, and duplicates were documented in laboratory quality control reports.

WATER CHEMISTRY SAMPLE COLLECTION PROTOCOLS

Sampling methodology within the scope of the study on the EFSFSR Study are governed by those protocols developed for streams in Idaho by the USDA Forest Service, USDOI Bureau of Land Management, and IDHW Division of Environmental Quality. The protocols are contained in eight publications which are periodically reviewed and modified to meet with nationally accepted standards.

Whenever samples are collected for trend, storm event, or compliance monitoring, samplers should treat the samples as legal samples (Burr 1986). Field notes, sample submittal forms, and chain-of-custody paper work must accompany sample submittals and be sent to each participating agency. Consistent well documented procedures, therefore, will enable regulatory agencies to maintain legally acceptable and scientifically reproducible data interpretations. Sampling procedures will include sample collection, preservation, transportation, chain-of-custody protocol, and analysis.

Sample collection is the initial, and perhaps, simplest step in water quality monitoring. It may, however become overly routine, and therefore, proper care must be taken to be consistent with established procedures. Planning and preparation will eliminate sampling mistakes. Field personnel should have and maintain small inventory of basic equipment. There is some variation in this inventory based on personal.

Sample submittal forms, Chain-of-Custody reports, and sample containers should be marked in advance of sample collection. Submittal forms and reports which list the samples to be collected can serve as a checklist to ensure all of the sample are collected. Properly marking samples with the STORET number, type of sample, preservatives or spikes added, and date prior to sample collection will reduce the numbers of samples lost because of illegible markings.

OBJECTIVES

Monitoring water quality in EFSFSR has been designed to improve the efficiency of water management systems, assure compliance with Idaho law, and qualify the status of support for the beneficial uses of water in the drainage. Specifically, the study addresses:

1) Monitoring effectiveness of best management practices used at the Stibnite and Yellow Pine Mine;

2) Monitoring the mine operators' compliance with Idaho's Water Quality Standards and Waste Water Treatment Requirements, permits, and consent orders; and

3) Qualifying the extent to which designated beneficial uses are supported in the EFSFSR and its tributaries

COORDINATION

Monitoring and analyses is coordinated annually by state and federal agencies (Clark 1990). These agencies include the Idaho Department of Health and Welfare Division of Environmental Quality, Idaho Department of Lands Bureau of Minerals, Idaho Department of Fish and Game, U.S. Fish and Wildlife Service and Payette National Forest Krassel Ranger District. Coordination meetings are held in the spring and late summer in the field with local mine operators.

An initial coordination meeting will be held by the regulatory agencies each winter. The primary objective of the meetings is to discuss the results and analyses of the previous monitoring season, the feedback loop process, effectiveness and modifications of best management practices, changes, if any, in designated beneficial use status, possible revisions to the NPS Water Quality Monitoring Plan, and the roles of each agency. Secondary objectives for the winter coordination meeting will be to introduce new staff, review monitoring techniques, and to establish tentative dates for field coordination meetings and interagency monitoring agenda.

Field coordination meetings will be held twice each year. These coordination meetings will be attended by state and federal regulatory agencies, local operators, and possibly community leaders. The primary objective of these meetings is to discuss the results and analyses of the previous monitoring season, the feedback loop process, effectiveness and modifications of best management practices, changes, if any, in designated beneficial use status, revisions to the NPS Water Quality Monitoring Plan, and the roles of each agency, the operators, and the community. Secondary objectives for field coordination meeting will be to introduce new staff and review monitoring techniques.

HISTORY

It would be difficult to understand the significance of water quality data in the EFSFSR without being familiar with historical natural resource uses in the area. Although there are many activities in the area, such as hunting, fishing, and logging, mining has been proven to have the most significant impact on the EFSFSR.

Mining at Stibnite and Cinnabar has played an economically important and colorful role in the development of eastern Valley County, Idaho. The Stibnite and Cinnabar Mines were located and intermittently mined as early as 1900 when gold was discovered there during the Thunder Mountain Gold rush. Significant mineral development did not, however, occur until the early 1930's. In the 1930's the Yellow Pine Open Pit was located in the EFSFSR bed and the entire river flow was diverted around the pit and into a tunnel through a mountain north of the river channel (Klahr, 1987).

The Strategic Mineral Investigations Enabling Act in 1939 triggered the listing of antimony and tungsten as strategic metals and essential to national defense (Trainor, 1993). After the discovery of high grade antimony and tungsten-bearing ore that same year, intensive mining and milling began. Antimony and tungsten became the primary minerals produced in this area during World War II, supplying nearly 95% of the nations's antimony for the war effort. With the collapse of the antimony market in 1952 and problems with the smelter, the mine was closed and dismantled.

The Bradley Mining Company began expansion of its Stibnite operations in 1939 with the location of strategic mineral reserves. This expansion led to the construction of a mining, milling and smelting operation which supported a local population of approximately 1,500 persons (Trainor 1993). The subsequent collapse of the antimony market proved to be a temporary demise of the town.

When mining was discontinued in the early 1950s, Meadow Creek was allowed to return to its natural channel, which was blocked by the old Bradley Mill tailings (JMM 1994). The result of this rechannelization was the beginning of the Meadow Creek Pond. Subsequent to the formation of the pond, the old mill tailings were destabilized and was downstream to the EFSFSR.

Increasing gold prices in the 1970s partially revived the local economy, and by 1978 engineering plans were being drafted for cyanidation of the oxide gold ores from West End and Midnight Creek pits. In 1982 full scale mining of the West End pits began, and cyanidation and spent ore disposal facilities were constructed on top of mill and smelter tailings in the Meadow Creek drainage.

Hecla Mining Corporation secured the lease on an adjacent property and processed low-grade oxide ore stockpiled in the 1940's and developed an open-pit mine and one-time heap leach pad.

The mine ceased operations in 1991, and has begun reclamation with an anticipated completion date of 1995.

An estimated 4.2 million tons of was encapsulated by cyanidation spent ore disposal facilities which incorporated the use of a retaining structure known as the Meadow creek Keyway (JMM 1994). The disposition of the Bradley Mill tailings has been the subject of many debates in the modern history of the mine facilities. Among the many proposed actions to resolve water quality problems associated with the tailings are; complete buriel, stream stabilization, and removal.

The Cinnabar Mine was discovered about 1902 during the Thunder Mountain Gold Rush (Pioneer Technical Services, 1992). Claims around the lode and mill sites were patented in the late 1920's and are currently held by the J.J. Oberbillig Estate. The United Mercury Mines Company began development of lodes which become known as the Hermes Mine. Prior to 1930 only minor or sporadic development occurred. In 1942, Bonanza Mining Inc. took over the mine facilities and report some development and production. Major mine development was recorded under the management of Holly Minerals. Originally ore was roasted to liberate free vapor mercury and sulphur dioxide. Mercury was collected after cooling gases in flue condensers. The roasting systems burned to the ground in 1956 and were replaced with a floatation and electrowhining process. Activities were suspended in 1958, but periodic exploration of the lodes have been pursued in hopes of reopening production.

The Cinnabar Mine Site has been investigated many times from 1983 through 1993 in response to complaints or queries regarding water quality, petroleum, and hazardous materials. In 1984 the Idaho Department of Health and Welfare - Division of Environment and Central District Health visited the site in an attempt to characterize threats to human health, safety, or the environment (Clark and Lappin, 1984). Many barrels, storage tanks, transformers and other containers of potentially hazardous materials were located and identified. Characterization of these materials is incomplete. In May of 1988 DEQ was notified of an oil spill resulting from damage or vandalism to a 100,000 gallon fuel storage tank at the Cinnabar Mine. Coordinated efforts with Pioneer Metals Corporation resolved water quality problems resulting from the spill. In 1992 the USDA Forest Service contracted a Preliminary Assessment of the site, which has resulted in EPA's contracting of a Site Investigation, which will begin during the summer of 1994.

In 1983 and 1984 several water quality problems were noted at the Stibnite Mine and processing facilities which involved cyanide and turbidity. The U.S. Forest Service, Department of Lands and the Idaho Department of Health and Welfare - Division of Environment entered into discussions with Superior Mining Company to resolve the problems. Of these problems, sediment production and delivery from the West End Pit, old mine workings, and the haul roads were. perhaps, the most obvious. The operator developed a comprehensive water management plan and implemented an extensive network of best management practices to control discharges.

In 1985 the Division of Environment - Hazardous Materials Bureau compiled an initial investigation of the historical mining facilities at Stibnite (Harr 1985). Although a "Preliminary Assessment" was completed, no actions were instigated towards a site removal or cleanup.

In 1985 a Consent Order for violations of turbidity standards was entered into by Superior Mining Company and the Division of Environment. This Consent Order established compliance points and a standard of 5 Nephelometric Turbidity Units (NTUs) over background for discharges from West End Creek and the sediment basin at the Box Culvert.

In 1986 through 1987, turbidity violations and a spill of cyanide leach solution occurred. These events led to an investigation and subsequent issuance of a Notice of Violation by the Division of Environmental Quality on December 12, 1986. Pioneer Metals, the successor to Superior Mining Company, and the Division of Environmental Quality entered into a Consent Order, to mitigate for violations, on May 12, 1987.

On October 6, 1987, the Division of Environmental Quality issued a separate Notice of Violation concerning sediment delivery to the EFSFSR. The issue was resolved through the compliance schedule of the existing Consent Order.

In 1988, a truck containing Ammonium Nitrate/Fuel Oil (AN/FO) went off of a mine road upstream from the confluence of Sugar Creek and the EFSFSR. Apparently, none of the AN/FO entered the water, and there were no apparent natural resource damages attributed to this incident.

In 1989 and 1990, the Division of Environmental Quality and the U.S. Forest Service issued Pioneer Metals a Notice of Violation and Notice of Noncompliance, respectively. These citations were issued for the discharge of acute concentrations (EPA 1986) of cyanide (0.022 mg/l total) to the Meadow Creek Pond and Channel adjacent to Pioneer Metals' spent ore disposal area, and diesel fuel in the ground water beneath the ore processing facility.

During the winter of 1990-1991, MinVen Corporation began negotiations and successfully purchased the Stibnite Mine from Pioneer Metals. On August 1, 1991 Stibnite Mining Incorporated (aka MinVen Corporation aka Dakota Mining Company) entered into a Consent Order amending and superseding previous consent orders and incorporating monitoring and clean up protocols for diesel, cyanide, and turbidity.

On April 4, 1992, discharges from Stibnite Mining Incorporated's (SMI) land application site was documented by Division of Environmental Quality. Division of Environmental Quality and Stibnite Mining Incorporated entered into negotiations for modification of land application procedures. Stibnite Mining Incorporated relocated its land application site and modified procedures later in 1992.

In July of 1992, a diesel spill was identified by Stibnite Mining Incorporated in the processing facility. Stibnite Mining Incorporated notified Division of Environmental Quality of the incident and implemented immediate cleanup actions. Division of Environmental Quality responded to the site and documented a significant area of soils and ground water contamination. The contaminants of particular concern included diesel, cyanide, chloroform, and nitrates.

On January 26, 1993, Division of Environmental Quality issued Stibnite Mining Incorporated a Notice of Violation for violations of Idaho's Water Quality Standards and Waste Water Treatment and Rules, Regulations and Standards for Hazardous Waste. The Notice of Violation was for contamination of ground water due to diesel and nitrates, and improper storage and handling of materials (IDHW 1993) regulated under Subtitle C of the Resource Conservation and Recovery Act as supplemented by the Idaho Hazardous Waste Management Act of 1983 (HWMA). The RCRA issues were resolved after Stibnite Mining Incorporated and Division of Environmental Quality entered into a Consent Order regarding the hazardous materials on May 5, 1993.

In April and May of 1993, Division of Environmental Quality documented disposal of spent ore, containing cyanide, immediately adjacent to Meadow Creek. Because of good faith negotiations regarding diesel and cyanide contamination, modification of the ore processing facilities, and permitting of the cyanidation facility, and Stibnite Mining Incorporated's immediate removal of the spent ore, an administration action was not pursued.

On October 20, 1993 Stibnite Mining Incorporated and Division of Environmental Quality entered into two consent orders requiring the ore processing facility to be permitted prior to any operation after the 1993 operating season, and for ground water pollution assessment and cleanup.

Stibnite Mining Incorporated is preparing NEPA documents and permit applications for a expansion of the mining facilities. Stibnite Mining Incorporated and Division of Environmental Quality are in the process of negotiating the terms of facility modifications, ground water pollution remediaton, and permits governed by the "Rules and Regulations Governing Ore Processing by Cyanidation". Stibnite Mining Incorporated and the U.S. Forest Service are also preparing a Environmental Impact Statement (EIS), under regulation of National Environmental Protection Act, for mine expansion.

The U.S. Forest Service has also prepared a Preliminary Assessment/Site Investigation for listing of the mine under the Comprehensive Environmental Response and Liabilities Act (CERCLA). This document may also be prelude to remediation of water quality problems related to old mine and mill tailings.

ISSUES

Primary issues which necessitate ongoing monitoring of the EFSFSR is the concentration of intensity to which the watershed is used by the public, and native populations of terrestrial and aquatic fauna. Designated beneficial uses identified for the watershed include domestic water supplies, cold water biota, salmonid spawning, and primary and secondary contact recreation. The EFSFSR is critical habitat for Summer and Spring Chinook Salmon, which have been listed as endangered, and Bull Trout, West Slope Cutthroat Trout and Steelhead Trout, which have been listed as Species of Special Concern. Therefore, monitoring of the watershed is particularly important to assure effectiveness of best management practices and engineering design implementation for water pollution abatement.

Many solid or chemical waste products, which result from multiple use of public resources, are of concern to regulators, the mine operators, and the public. These include sediment, chlorine, cyanide, arsenic, nitrates, petroleum products, and solvents. All of these products are closely monitored in proximity to the Stibnite and Yellow Pine mines, but only a few have been shown to be discharged at concentrations which threaten or have damaged designated beneficial uses. These include sediment, cyanide, arsenic, trace metals, petroleum, and nitrates. Additionally, however, catastrophic spills of any of the substances use in normal operations of the mines may have a devasting effect on the aquatic community.

DESCRIPTION OF STUDY AREA

The EFSFSR is a tributary of the South Fork of the Salmon which in turn is a major tributary to the Main Salmon. As described in its name, it is an important drainage for salmonid spawning and rearing, particularly summer chinook, steelhead trout, bull trout, and westslope cutthroat trout. Both the EFSFSR and the South Fork of the Salmon River are Special Resource Waters, and listed as such in Idaho's Water Quality Standards and Waste Water Treatment Requirements (Klahr 1987). The drainage is deeply incised and heavily wooded with conifers. The upper reaches of the EFSFSR, and its tributaries Meadow Creek and Sugar Creek are bordered by roads, mine workings, and mill and smelter tailings (Figure 2). The drainage has been developed for both recreational and mining activities. Both mine operators and the U.S. Forest Service have begun closure and reclamation of historical and recent mine disturbances.

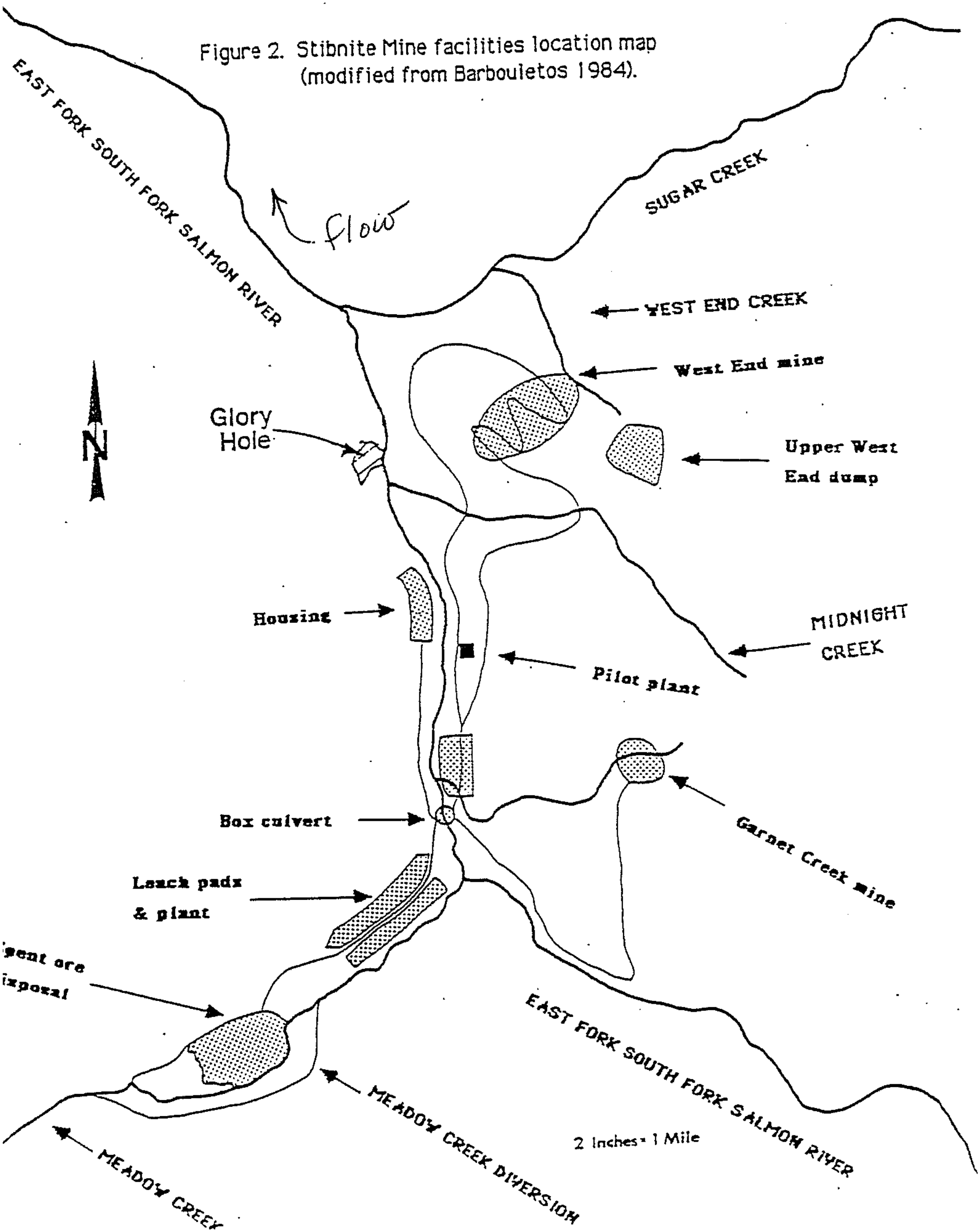

Figure 2. Stibnite Mine facilities location map (modified from Barbouletos 1984).

MONITORING TECHNIQUES AND RESULTS

Monitoring data from trend and compliance surveys, as well as special studies, were analyzed conjunctively in order to evaluate the overall health of the EFSFSR, Meadow Creek, and Sugar Creek. Initial screening of parameters and monitoring stations, however, was done to reduce the data into a manageable format. Additional water quality data was incorporated from data sets compiled by the operators of the Stibnite and Yellow Pine Mine. Incorporation of this data was justified because of the convention the operators used established stations, analytical techniques, and Quality Assurance/Quality Control (QA/QC) protocols.

FINE SEDIMENT DEPOSITION STUDY

This portion of the water quality status report is a synapsed version of the Payette National Forest's Fine Sediment Deposition in Selected Tributaries to the Salmon River in the Payette National Forest, Report of Monitoring Results 1989- 1990 (Ries et al 1991) in the sections which discussed the EFSFSR, Sugar Creek and Meadow Creek. The synopsis is provided to familiarize the reader with sediment monitoring, and conclusions drawn by sediment data analyses, and to allow the reader to follow correlations made in water chemistry analyses and conclusions.

In the upper reaches of the EFSFSR, the developed sources for sediment production and delivery include the Cinnabar Mine, the Stibnite Mine, the Yellow Pine Mine (Ries et al 1991), the ore processing facilities along Meadow Creek and the extensive roadways to, through and around the mined lands. Areas exhibiting the most significant land disturbance include the West End Pit, the Midnight Pit, the Homestake Pit and Waste Dump (reclaimed), and the spent ore disposal site on Meadow Creek.

Fine sediment deposition was measured using cobble embeddedness and free matrix sampling techniques described in Ries et al (1991). A Mann-Whitney U Test was used to compare cobble embeddedness and the percentage of free matrix particles in developed and undeveloped watersheds (Ries et al 1991).

Tamarack Creek near its confluence with the EFSFSR has been used as a reference site. Data from this site was used to compare background and man-caused sediment loading of the EFSFSR. Tamarack Creek has generally exhibited considerable stability in metals and sediment loads, except for an unusually high value in 1990. The level of embeddedness at the two EFSFSR of the Salmon locations and at Sugar Creek above West End Creek remained somewhat constant. In Sugar Creek below West End Creek, there has been a trend of significantly decreasing embeddedness, which indicates a reduction in sediment coming from West End Creek.

In general, cobble embeddedness and free matrix indices in stream reaches affected by mining in the early 1980's have improved, while indices in unaffected areas have remained fairly stable (Ries et al 1991). Several factors may account for the improvements. These factors include: 1) Increased use of best management practices that specifically prohibit sediment production and delivery; 2) Stabilization and reclamation of abandoned mined lands around the glory hole and Meadow Creek Mill Site; 3) Stabilization and reclamation of the Homestake pit and waste dump; and 4) Drought conditions observed over the last ten years.

MACROINVERTEBRATE STUDY

This portion of the water quality status report is a synapsed version of the Payette National Forest's Aquatic Ecosystem Inventory by Magnum (1993), and Biological Assessment by Faurot and Gebhards (1993). The synopsis is provided to familiarize the reader to macroinvertebrate monitoring and conclusions drawn by macroinvertebrate data analyses, and to allow the reader to follow correlations made in water chemistry analyses and conclusions.

Macroinvertebrate data have been collected from ten stations in the headwaters of the EFSFSR for over ten years. Three replicate samples were collected with a modified surber sampler from riffles at each site. Samples were collected from each site every August. Analysis of the field samples were prepared by either Aquatic Ecosystems Laboratory in Provo, Utah, or by Hibbs Analytical Laboratory in Boise, Idaho.

Studies have included but were not limited to number of organisms, total number of species, DAT taxa diversity index, biomass, and Biologic Condition Index (BCI). Taxa richness, however, was consistently displayed throughout the reports (Faurot and Gebhards 1993). Taxa richness and the BCI information conflicts somewhat. Taxa richness indicates that some environmental factor(s) exist which impair taxa richness these may be high concentrations of contaminants, or poor substrate conditions in Meadow Creek and the EFSFSR from the confluence with Meadow Creek and the confluence with Sugar Creek, while the BCI implies there is a potential for good to excellent fisheries habitat. Indications, that impairment of communities exists, is consistent with the hypothesis that one would expect some effect from historical sources of pollution in Lower Meadow Creek and in proximity to sulfide zones in the Glory Hole on the EFSFSR. It is also consistent with the hypothesis that one might expect to see lingering effects from the high water years of 1983 and 1984 when large volumes of sediment were delivered to the creeks and river as subsequent drought years may not have provided sufficient flow to flush the streams.

There are indications that taxa richness is increasing. For instance, the percentage of sample sets (75%), collected in 1991 and 1992, which exhibit less diversity than reference sites decreased significantly from the percent of sample sets (100%), collected between 1986 and 1989. Increasing taxa richness in macroinvertebrate communities may be attributed to modifications and increased use of best management practices on mine roads and in proximity to abandoned mine facilities. Increasing taxa richness may also be attributed to soils stabilization and mine reclamation at the Homestake Pit and Waste dump, the Bradley Pit and Waste Dump, the smelter site, and in proximity to the old hospital. Increasing taxa richness may also be the result of removal of fine sediment from the substrate through the natural flushing mechanism.

At sites on Sugar Creek below West End Creek and on the EFSFSR trends in taxa diversity which indicated impairment of macroinvertebrates during the base period of 1986 - 1990 were also on a upswing in 1991 - 1992. In other words the per centage of sample sets which showed lower taxa diversity than reference sample sets decreased. This may also be indicative of modifications and increased use of best management practices, and/or a dilution of the metals-laden EFSFSR by the influent Sugar Creek.

Most likely, increasing taxa diversity and numbers of individuals is the cumulative result of several conditions. Restriction of sediment production and delivery plus the natural flushing mechanism, even in drought years, resulted in less cobble embeddedness which provided an improvement of macroinvertebrate habitat.

Although there have been many methods of data collection and analyses, there is a consistency in the general conclusions drawn from each study. Macroinvetebrate study indicates that there may be some improvement in taxa richness in Sugar Creek, Meadow Creek, and the EFSFSR from the mid 1980s through 1992. There is, however, good evidence that macroinvertebrate communities are impaired in Meadow Creek below the Diversion, and in the EFSFSR between Meadow Creek and Sugar Creek. In other words, improvements in taxa richness does not mean that there is no impairment in the aquatic communities.

The USDA Forest Service and IDHW Division of Environmental Quality are planning a data management scheme which will allow for more extensive statistical analysis of historical data. This data will be reported in its entirety in future water quality status reports.

FINE SEDIMENT, ALGAE, AND FISH TISSUE CONTAMINANT STUDY

In September 1992, sediment, algae, and fish samples were collected from the EFSFSR below the influence of Stibnite Mine, and analyzed for trace elements. Results of analyses indicate elevated concentrations of arsenic, chromium, and mercury in sediment samples collected below the influence of mining activities (Burch and Mullins 1994). The one algae sample collected had an elevated level of arsenic, and trace element concentrations in whole steelhead trout smolts and adult mountain whitefish samples had elevated arsenic, cadmium, copper, lead, mercury, and selenium concentrations when compared to National Contaminant Biomonitoring Program

(NCBP) data (Burch and Mullins 1994). The results of these analyses indicate there are elevated trace elements in fish and their habitats in the EFSFSR system (Burch and Mullins 1994).

The objective of the study plan was to measure concentrations of trace elements in sediment, algae, and fish in the EFSFSR to determine if there are elevated levels which could potentially affect anadromous and resident fish or their habitat, and to establish baseline conditions in the event of a potential future catastrophic release of toxic material into the EFSFSR (Burch and Mullins 1994). Collection sites were selected upstream of the currently operating Stibnite Mine, and downstream of the Stibnite Mine complex.

In October, 1991, the U.S. Fish and Wildlife Service (Service) Idaho State Office (ISO) in cooperation with the Idaho Department of Health and Welfare, Division of Environmental Quality (DEQ) collected water, sediment, and algae samples from Meadow Creek for trace element analysis (Burch and Mullins 1993). Elevated concentrations of arsenic, barium, copper, iron, lead, manganese, and mercury were detected in sediments, and elevated levels of arsenic, barium, boron, copper, iron, lead, and mercury were detected in algae samples (Burch and Mullins 1994). This information was summarized in conversations with Susan Burch and Bill Mullins regarding their study of trace element concentrations in sediment and algae collected from Meadow Creek.

Sediments collected from the EFSFSR contained detectable concentrations of aluminum, arsenic, barium, beryllium, chromium, iron, magnesium, manganese, mercury, nickel, strontium, vanadium, and zinc (see Table 1 from Burch and Mullins 1994). Two sediment samples from Sugar Creek and Profile Creek, had detectable concentrations of copper, lead, and selenium. Sediments from Sugar Creek and the Control Station (EFSFSR above Stibnite Mine) contained detectable levels of boron (Burch and Mullins 1994).

Mountain whitefish and steelhead trout were the two species of fish collected using electro fishing techniques in the EFSFSR (See Table 3, Burch and Mullins 1994). Aluminum, arsenic, barium, chromium, copper, iron, magnesium, manganese, mercury, selenium, strontium, and zinc were detected in all fish samples collected from all three sites. At present, it appears that aluminum, barium, boron, iron, magnesium, manganese, nickel, strontium, and zinc are not at concentrations which are harmful to fish (Burch and Mullins 1994). Arsenic concentrations of fish tissue ranged from 1.69 ppm (0.51 ppm wet weight) in steelhead trout collected from Profile Creek to 6.38 ppm (1.88 ppm wet weight) in steelhead collected from the Sugar sampling site (Burch and Mullins 1994). The potential for bioaccumulation or bioconcentration of cadmium is high to very high for mammals, birds, fish, mosses, lichens, algae, mollusks, crustacea, lower animals, and higher plants (Jenkins, 1981).

TABLE 1. Trace Element Concentrations in Sediment, Algae, and Fish Collected from the EFSFSR South Fork Salmon River, Idaho, August 1992. (From Burch and Mullins 1994)
[Concentrations in micrograms per gram, (μg/g), dry weight]

Sample/Location	Age[a]	Aluminum	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Copper	Iron	Lead
Sediment Below Sugar Creek		5,820.00	779.70	73.40	0.78	5.53	<0.20	64.39	7.31	14,140	12.19
Sediment At Profile Creek		7,545.00	216.90	88.53	0.33	<4.96	<0.20	102.80	10.93	13,550	7.33
Sediment Control (EFSFSR above Stibnite mine)		5,945.00	54.80	66.73	0.39	5.15	<0.20	52.20	<4.97	10,830	<4.97
Algae Mile Post 8		1,470.00	244.70	102.20	<0.48	<2.40	<0.48	3.40	6.42	4,270	<2.40
Steelhead Trout (2)[b] Profile Creek	1+	42.57	1.69	1.89	0.21	1.11	0.29	5.13	3.28	90.62	1.01
Mountain Whitefish (1) Profile Creek	3-4	81.78	2.21	1.60	<0.10	0.65	<0.10	17.63	2.45	210.60	<0.49
Steelhead Trout (2) At Mile Post 8	1+	37.69	2.87	1.25	<0.10	<0.49	<0.10	1.48	5.51	49.99	<0.49
Mountain Whitefish (1) At Mile Post 8	3-4	47.82	2.82	1.71	0.11	2.13	0.13	5.30	2.21	90.82	0.59
Steelhead Trout (1) Below Sugar Creek	2+	39.00	5.52	1.06	0.14	2.85	<0.10	4.02	5.66	86.12	0.49
Steelhead Trout (3) Below Sugar Creek	1+	39.47	6.38	1.28	<0.10	<0.49	<0.10	1.58	4.35	77.56	<0.49
Mountain Whitefish (2) Below Sugar Creek	3-5	85.40	4.96	1.50	<0.10	0.96	<0.10	11.35	3.83	243.70	<0.50

[a] Estimated age in years.
[b] Number of fish in composite sample.

TABLE 1.(cont) **Trace Element Concentrations in Sediment, Algae, and Fish Collected from the EFSFSR South Fork Salmon River, Idaho, August 1992. (From Burch and Mullins 1994) Concentrations in micrograms per gram, (μg/g), dry weight]**

Sample/Location	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
Sediment Below Sugar Creek	2,640.00	326.40	5.14	<4.93	9.70	0.53	18.22	11.32	32.98
Sediment At Profile Creek	2,940.00	623.60	1.66	<4.96	11.93	0.55	21.64	14.25	31.69
Sediment Control -	2,721.00	184.00	0.28	<4.97	5.06	<0.50	12.64	14.52	26.60
Algae At Mile Post 8	2,267.00	313.90	1.67	<2.40	<2.40	<1.84	34.58	3.06	24.55
Steelhead Trout Profile Creek	754.50	9.89	0.31	<0.48	1.33	2.69	15.74	<0.48	54.11
Mountain Whitefish Profile Creek	786.60	8.20	0.34	<0.49	0.60	3.18	23.35	<0.49	49.50
Steelhead Trout At Mile Post 8	760.60	9.37	0.32	<0.49	<0.49	2.84	17.80	<0.49	56.64
Mountain Whitefish At Mile Post 8	1,034.00	18.84	0.60	<0.49	0.89	6.82	35.17	<0.49	54.21
Steelhead Trout Below Sugar Creek	635.50	5.51	0.59	<0.48	0.85	2.77	11.35	<0.48	52.44
Steelhead Trout Below Sugar Creek	726.00	11.51	0.39	<0.49	<0.49	2.96	14.88	<0.49	54.06
Mountain Whitefish Below Sugar Creek	693.80	15.56	0.87	<0.50	0.68	4.91	18.63	<0.50	41.83

In whole fish collected from the EFSFSR, copper concentrations ranged from 2.45 ppm (0.75 ppm wet weight) in mountain whitefish collected near MP8, to 5.66 ppm (1.78 ppm wet weight) in steelhead trout collected from the Sugar Creek site (Burch and Mullins 1994). The steelhead samples collected at sites MP8 and Sugar Creek (total of three samples: 5.51 ppm, 5.66 ppm, and 4.35 ppm wet weight), and mountain whitefish taken from Sugar Creek (3.83 ppm wet weight).

Of the steelhead trout collected from Profile Creek, one of two steelhead samples collected from Sugar Creek, and mountain whitefish collected at MP8 had detectable concentrations of lead. The fish were found to contain 1.01 ppm (0.30 ppm wet weight), 0.49 ppm (0.15 ppm wet weight), and 0.59 ppm (0.17 ppm wet weight), respectively (Burch and Mullins 1994).

Elevated concentrations of selenium were also found in fish. Selenium concentrations in fish tissue collected from the EFSFSR ranged from 2.69 ppm (0.80 ppm wet weight) in steelhead trout at the Profile Creek site to 6.89 ppm (2.32 ppm wet weight) in mountain whitefish from MP8 (Burch and Mullins 1994).

WATER CHEMISTRY

Water chemistry data has been compiled for the EFSFSR, in proximity to the Stibnite Mine, since 1978. Study of water quality in the area was instigated by proposals to reopen the historical mines at Stibnite. The data has been included in the planning and evaluation process for the West End, Midnight, Homestake, and Garnet Creek Pits. The data has also been included in various water quality status reports produced by Hecla Mining Company, Pioneer Metals, and Stibnite Mine Incorporated and the Division of Environmental Quality. Water quality data from both trend and compliance monitoring, as well as that compiled by the operators, has been considered in this analysis.

Although there are in excess of forty (40) water quality monitoring stations and thirty (30) analytical parameters, an initial screening of stations and analytes was done for this report. The screening was based on several premises: 1) Stations which were reference sites or below major stream reaches were analyzed; 2) Parameters, for which concentrations may cause chronic or acute effects in cold water biota, were analyzed; and 3) Parameters which, although they exhibit no toxic effects to human health or aquatic communities, occurred in such high concentrations as to possibly identify trends in metals loading were analyzed. This screening resulted in analysis of the stations listed in TABLE 2, and the parameters; Total Arsenic, Total Antimony, Total Iron, Total Zinc, and Cyanide (both WAD and Total). Subsequent to initial analyses, Total Zinc was dropped from the analyses as it did not display either trends nor relative concentrations of toxicity. This screening should not be construed as indicating usefulness, or lack there of, for monitoring stations not analyzed. Nor should the screening be construed as an elimination for analytical parameters from subsequent monitoring.

Water quality monitoring has been performed in accordance with established protocols for sample collection, transportation, chain-of-custody, and Field and Laboratory QA/QC (Bauer 1986 and Franson A. ed 1985). The protocols for data collection and analysis are contained in Appendix A of this report. Results from laboratory analysis are contained in the Tables of Appendix B.

Water quality analysis has been undertaken from two directions. First, water analysis for each station was considered to determine if there were trends in the data set for each station, if there were occasions of concentrations of arsenic, which may cause chronic or acute effects in cold water biota, and to determine if there may be sources for contaminants upstream of each station. Secondly, the stations were grouped according to the their location on Meadow Creek, Sugar Creek, or the EFSFSR. Comparing Total Arsenic within these three groups would determine if trends are exhibited along the entire length of the stream segment, and again assist in identification of sources for contaminants.

Most metal concentrations at the reference Station 2040320 (Meadow Creek above the Diversion) hovered at or below the detection limits (Figure 3). The exceptions to this were Total Iron and Total Zinc. Total Iron varied widely, exhibited three extraordinary spikes in 1982 through 1984, and had an average value of about 100 ug/l. Total Zinc did not vary greatly but exhibited spikes in 1983 and 1984 which coincided with those spikes in Total Iron. The cause for the spikes was most likely due to flushing of iron and zinc oxides which accumulated on rocks and in sediment above the mean water marked during the high flow period. These spikes are consistent with spikes found at other stations during the same periods. Overall, background concentrations of metals at the Meadow Creek reference station are well below concentrations which cause chronic effects in aquatic biota.

Water quality analysis for the Meadow Creek Pond took into consideration data from both Station 2040584 (Meadow Creek Pond next to Spent Ore Pile) and Station 2040585 (Old Meadow Creek Channel Adjacent to the Spent Ore Pile) (Figures 4 and 5). Analysts considered three analytes of concern; Total Arsenic, Total Cyanide, and Weak Acid Dissociable (WAD) Cyanide. All three components have reached concentrations which will cause chronic effects in cold water biota, and have intermittently exceeded acute criteria. Spikes in 1991 and 1993 may indicate longer periods of acute concentrations of cyanide and arsenic in the Meadow Creek Pond and Old channel. The cause of these concentration is almost certainly the leaching of the historic Bradley Mill and Smelter tailings as precipitation, process waste water and spring water comes into contact with the tailings in the Meadow Creek Drainage.

With the exception of the period between 1987 and 1988 Station 2040368 (Meadow Creek below Keyway) has been continuously monitored. Although concentrations of cyanide have periodically reached levels which may cause chronic effects in cold water biota, Total Arsenic is consistently present in excess of the chronic cold water biota standards (EPA 1986) with occasional exceedences of the acute cold water biota standard (Figure 6).

TABLE 2. Water Quality Status: Monitoring Stations Analyzed

STORET Number	Station Location
1. 2040307	Sugar Creek below the confluence with West End Creek. (storm event and compliance)
2. 2040309	Sugar Creek above the confluence with West End Creek. (trend, storm event, and compliance)
3. 2040314	EFSFSR below Sugar Creek. (trend and compliance)
4. 2040315	EFSFSR above Meadow Creek. (trend)
5. 2040316	Sugar Creek at Bridge. (trend)
6. 2040317	West End Creek above Sugar Creek. (trend)
7. 2040319	Meadow Creek above confluence with EFSFSR. (trend)
8. 2040320	Meadow Creek above Diversion. (trend)
9. 2040322	Meadow Creek below diversion. (trend)
10. 2040365	EFSFSR above Box Culvert. (storm event and compliance)
11. 2040368	Meadow Creek below keyway. (trend)
12. 2040584	Meadow Creek Pond next to Spent Ore Pile. (trend and compliance)
13. 2040585	Old Meadow Creek Channel adjacent to the Spent Ore (trend)
14. 2040580	Sugar Creek above confluence with Cinnabar Creek (trend)
15. 2040581	Sugar Creek below confluence with Cinnabar Creek (trend)
16. 2040582	Cinnabar Creek above confluence with Sugar Creek (trend)

Meadow Creek Above Diversion

Total Metals

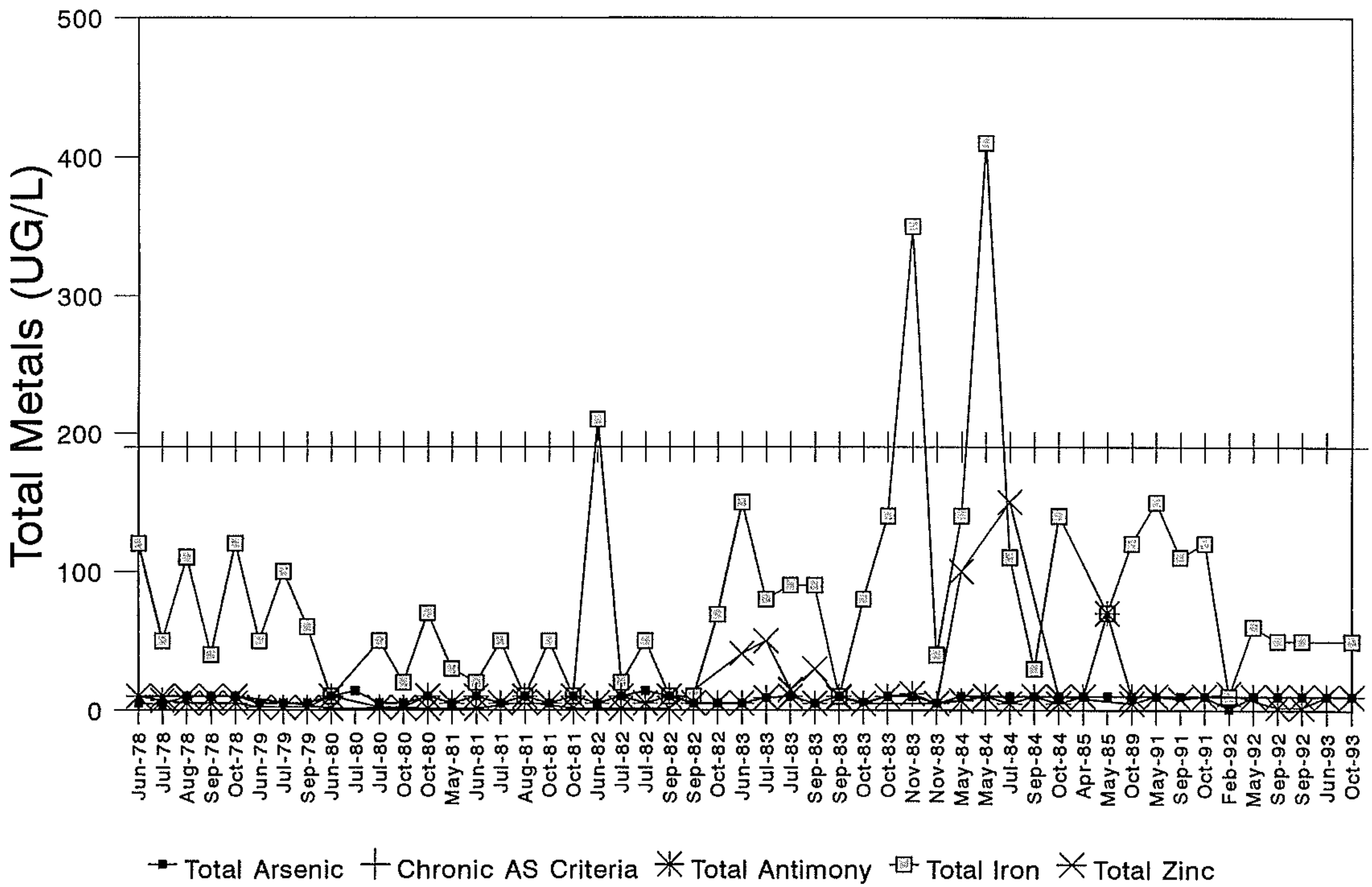

Figure 3

Meadow Creek Pond

Total Arsenic

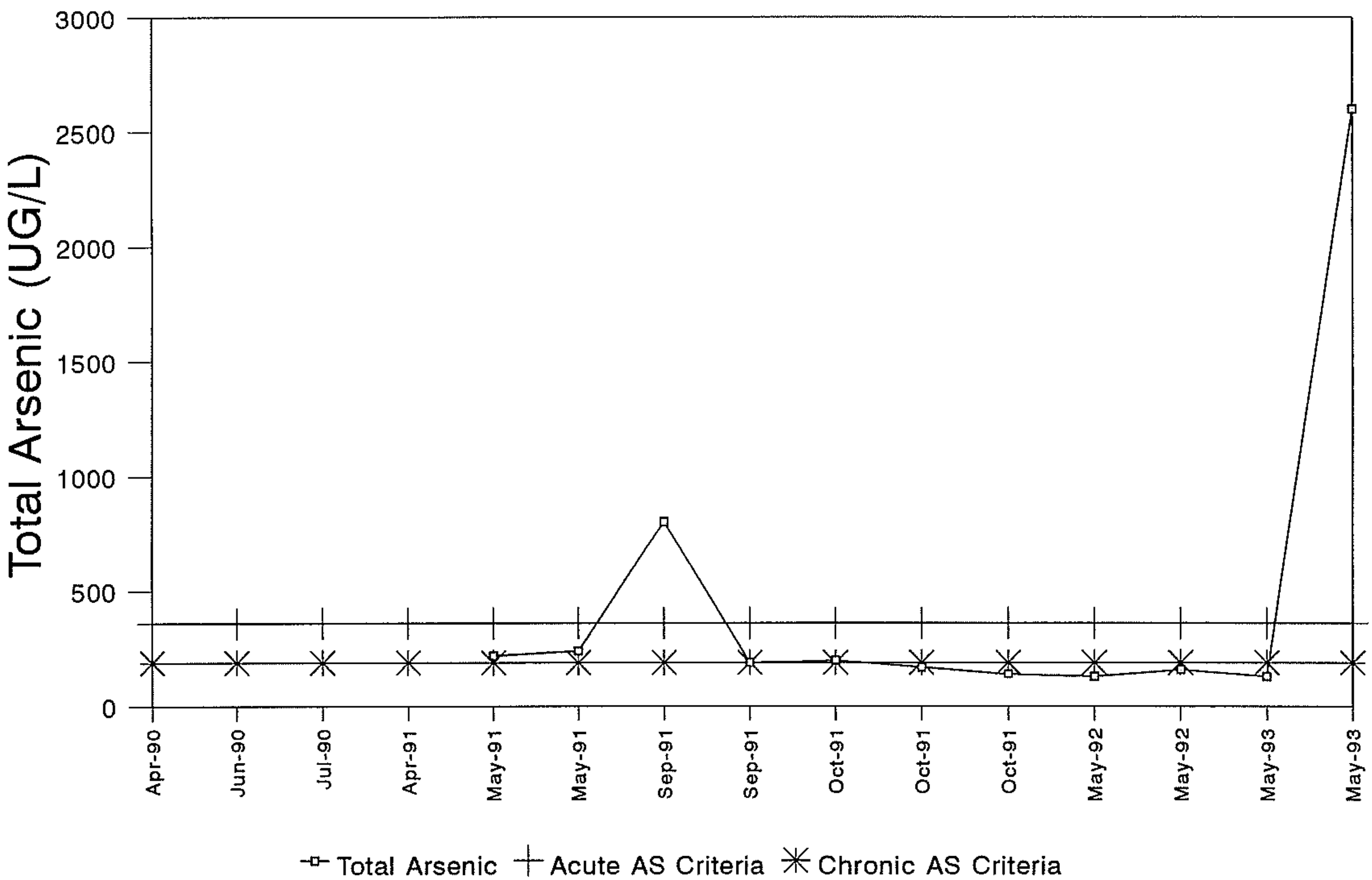

Figure 4

Meadow Creek Pond

Total and WAD Cyanide

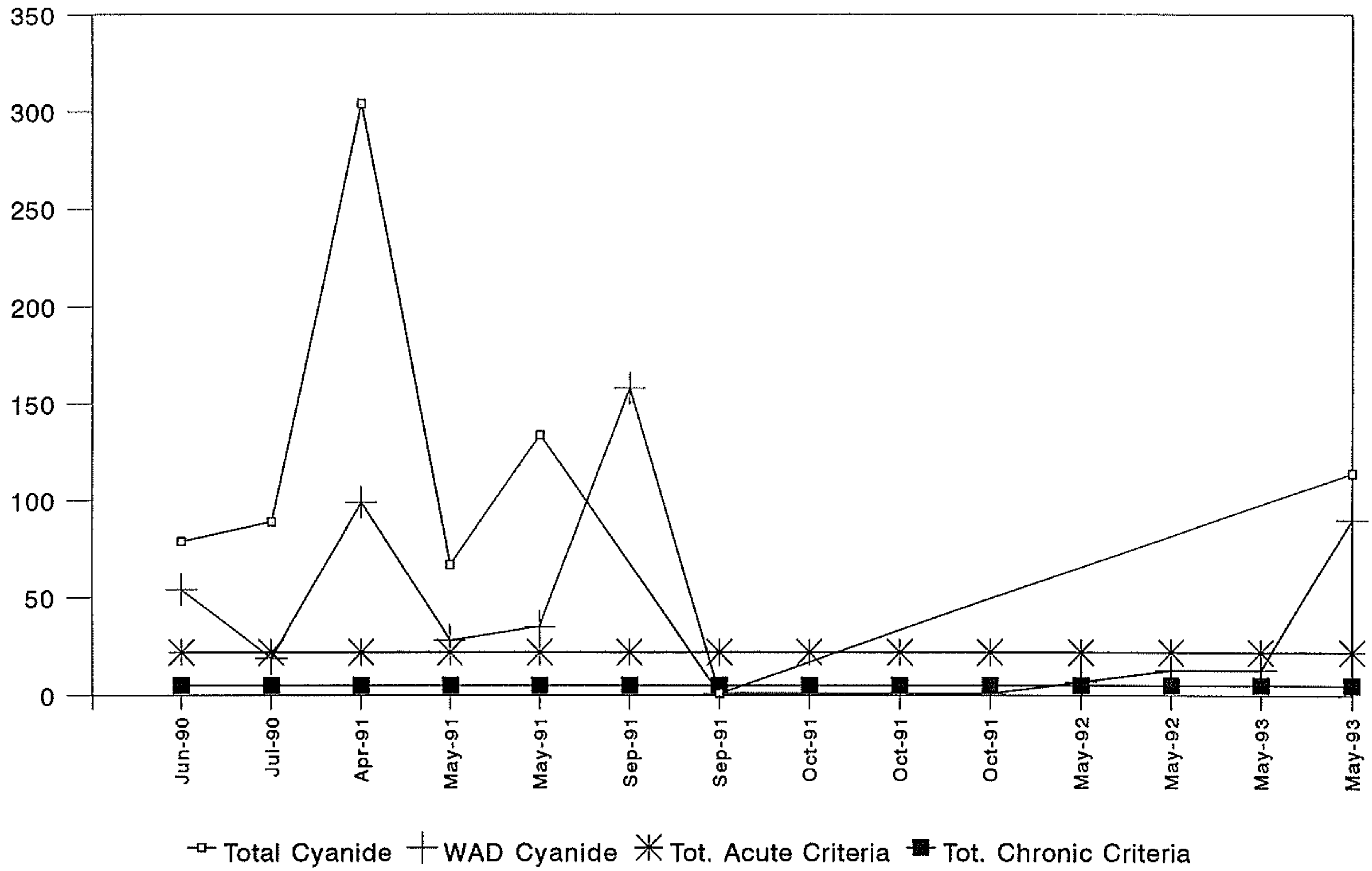

Figure 5

Meadow Creek Below Keyway

T. Arsenic and T. Antimony

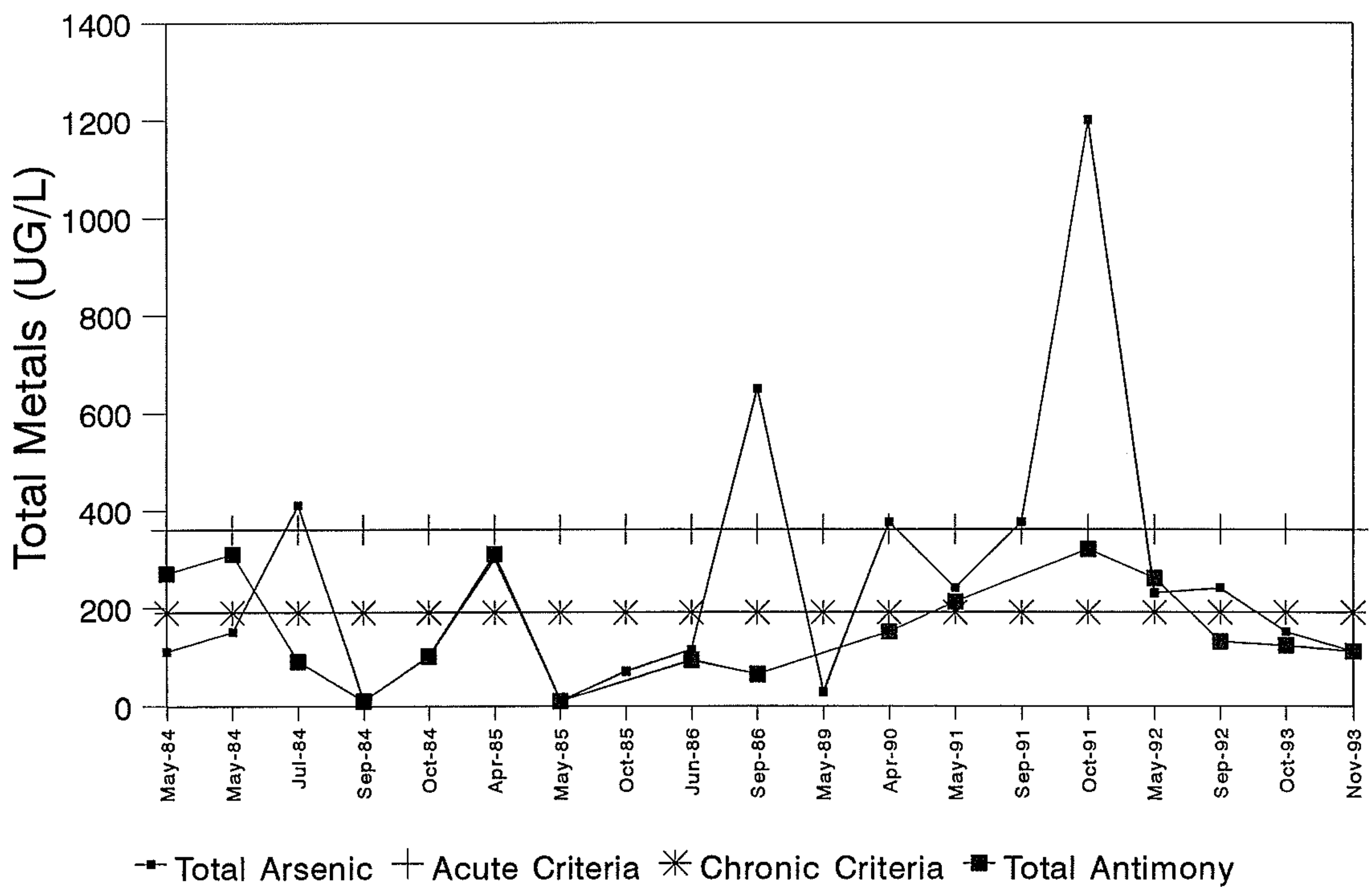

Figure 6

Station 2040322 is located on Meadow Creek below the confluence of the Meadow Creek Diversion and the Old Meadow Creek Channel. Both total arsenic and cyanide concentrations are usually well below chronic or acute cold water biota standards (Figure 7). Arsenic and cyanide concentrations at Station 2040322 are well below those at Station 2040368. These lower concentrations are most likely due to dilution of the contaminated flow from the Old Meadow Creek Channel by the uncontaminated flow through the Meadow Creek Diversion. Periodic peaks in the data indicate that there are events during which total arsenic concentrations would be such as to cause acute reactions in cold water biota. This substantiates the hypothesis that oxidized metals, including arsenic, are flushed from mill tailings, spent ore or from the Meadow Creek Pond into ground and surface water during precipitation and high flow events.

Station 2040319 is located on Meadow Creek approximately 400 feet above the confluence of Meadow Creek and the EFSFSR. Total arsenic concentrations were usually below that which would be expected to cause chronic effects in cold water biota, but have peaked above concentrations which would be expected to cause chronic effects in cold water biota standard in 1993 (Figure 8). Furthermore, it should be noted that total arsenic concentrations at 2040319 are nearly twice those at 2040322. This may indicate that the old mill tailings or ore processing facilities along the lower section of Meadow creek are compounding sources for arsenic.

Overlaying total arsenic concentration graphs from stations on Meadow Creek some general correlations of arsenic concentrations in Meadow Creek may be made (Figure 9). Arsenic concentrations below the confluence of the Meadow Creek Diversion and the Old Meadow Creek Channel are less than one third of those concentrations which would be expected to cause chronic effects in cold water biota. There are however, peaks in the arsenic concentrations, over time, in the Meadow Creek Pond, below the Keyway, and below the confluence of the diversion and the old channel which would be expected to cause chronic and/or acute effects in cold water biota, particularly during the high precipitation years of 1983, 1984, and 1985.

Metals concentrations at Station 2040309 (Sugar Creek above West End Creek) have, in general, trended just slightly above detection limits (Figures 10 and 11). Exceptions to this trend occurred during the high water years of 1983 and 1984 at which time spikes occurred in analyses for total arsenic, total antimony, and total zinc. These spikes, which have not been observed since, may have resulted from erosion of mine dumps at the Cinnabar Mine which is upstream from the station (clark and Lappin 1984).

Metals concentrations at Station 2040307 (Sugar Creek below West End Creek) correlate very well with metals concentrations above West End Creek (Figures 12 and 13). In general metals concentrations are well below that which may be expected to cause chronic effects in cold water biota, and more often than not, are less than detection limits. This would indicate that there is no significant contributions of total metals to Sugar Creek from mining activities on West End Creek.

Meadow Creek below Diversion

Total Arsenic

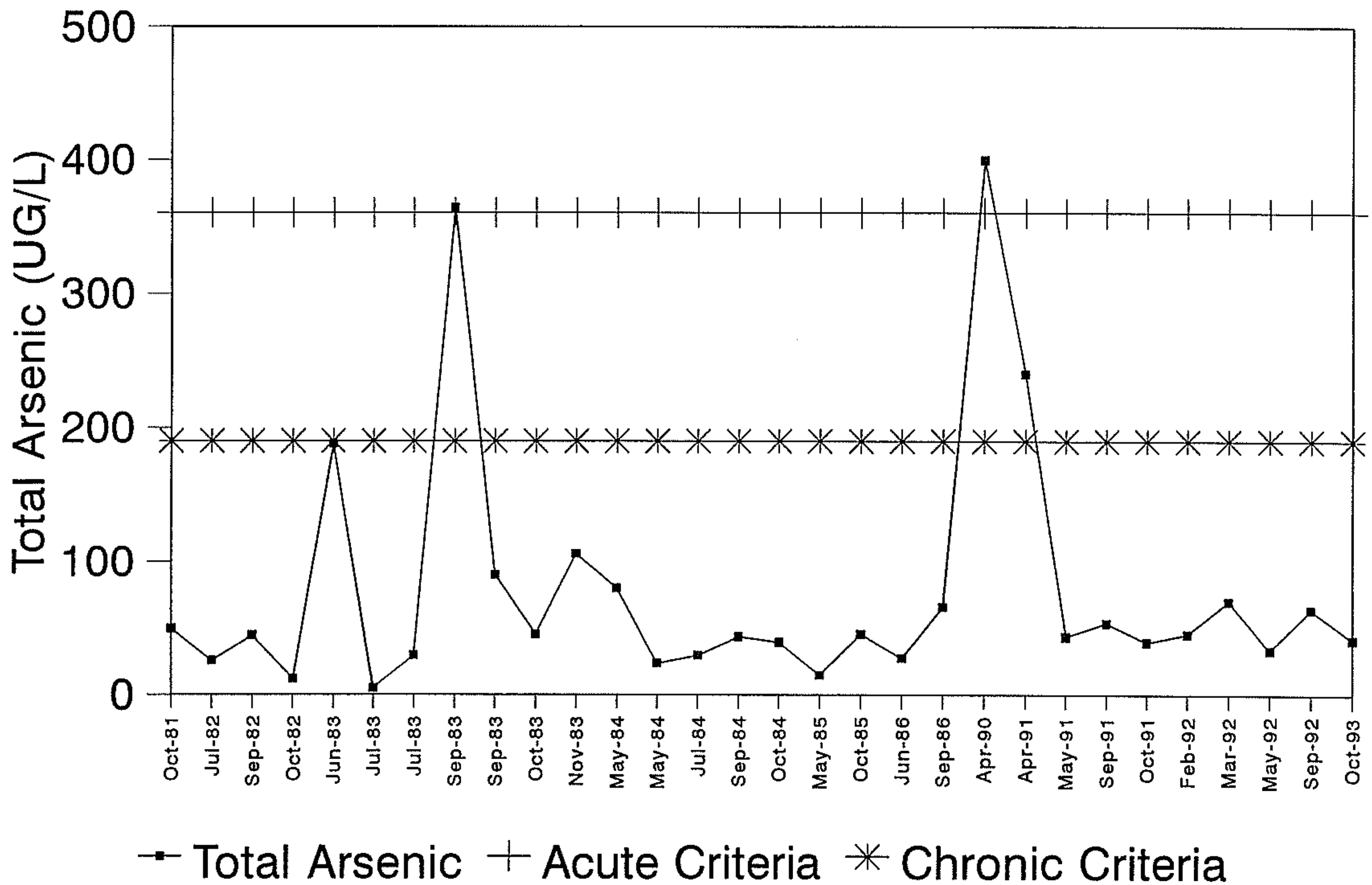

Figure 7

Meadow Creek At Mouth

Total Metals

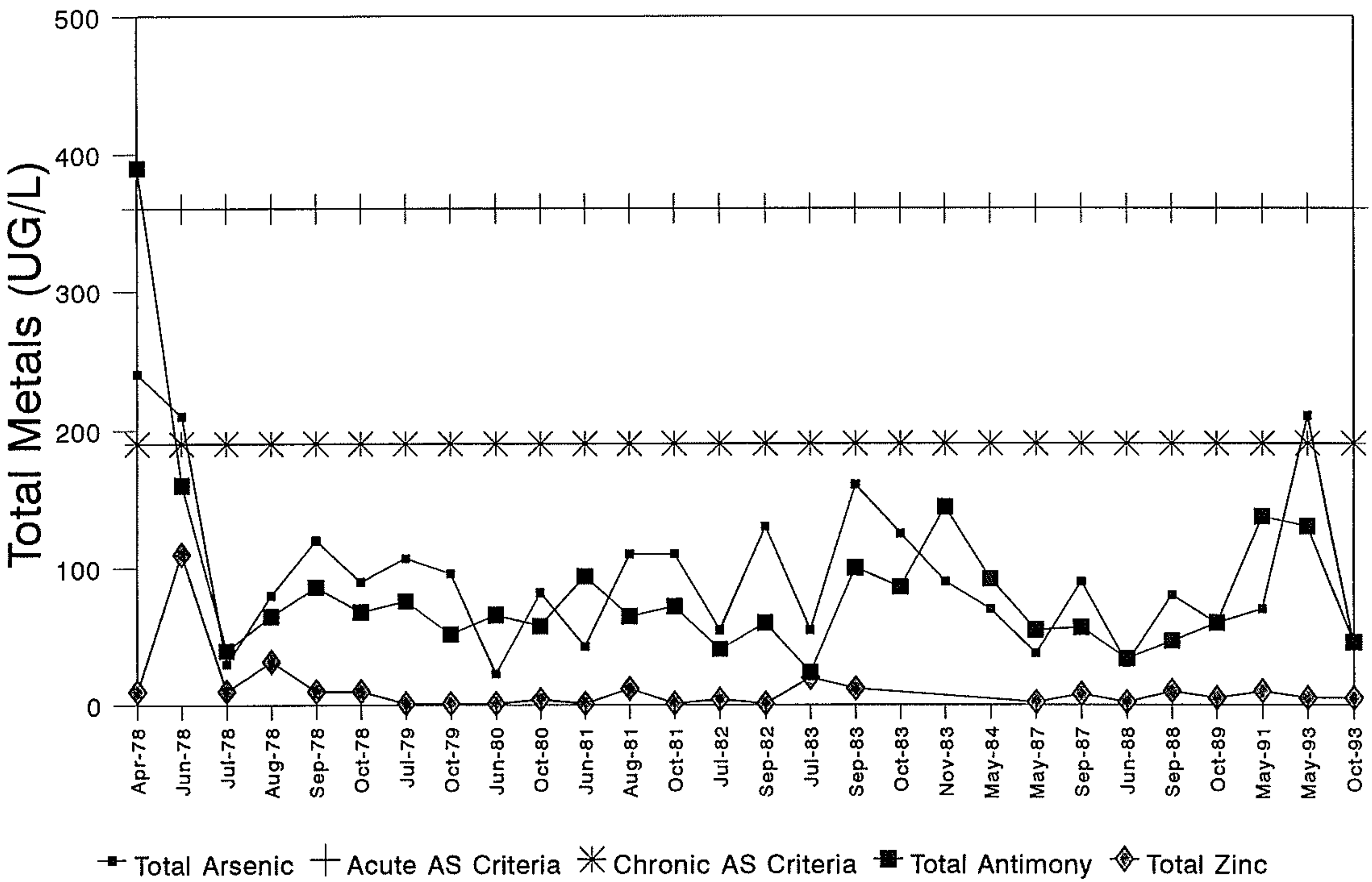

Figure 8

Meadow Creek

Total Arsenic

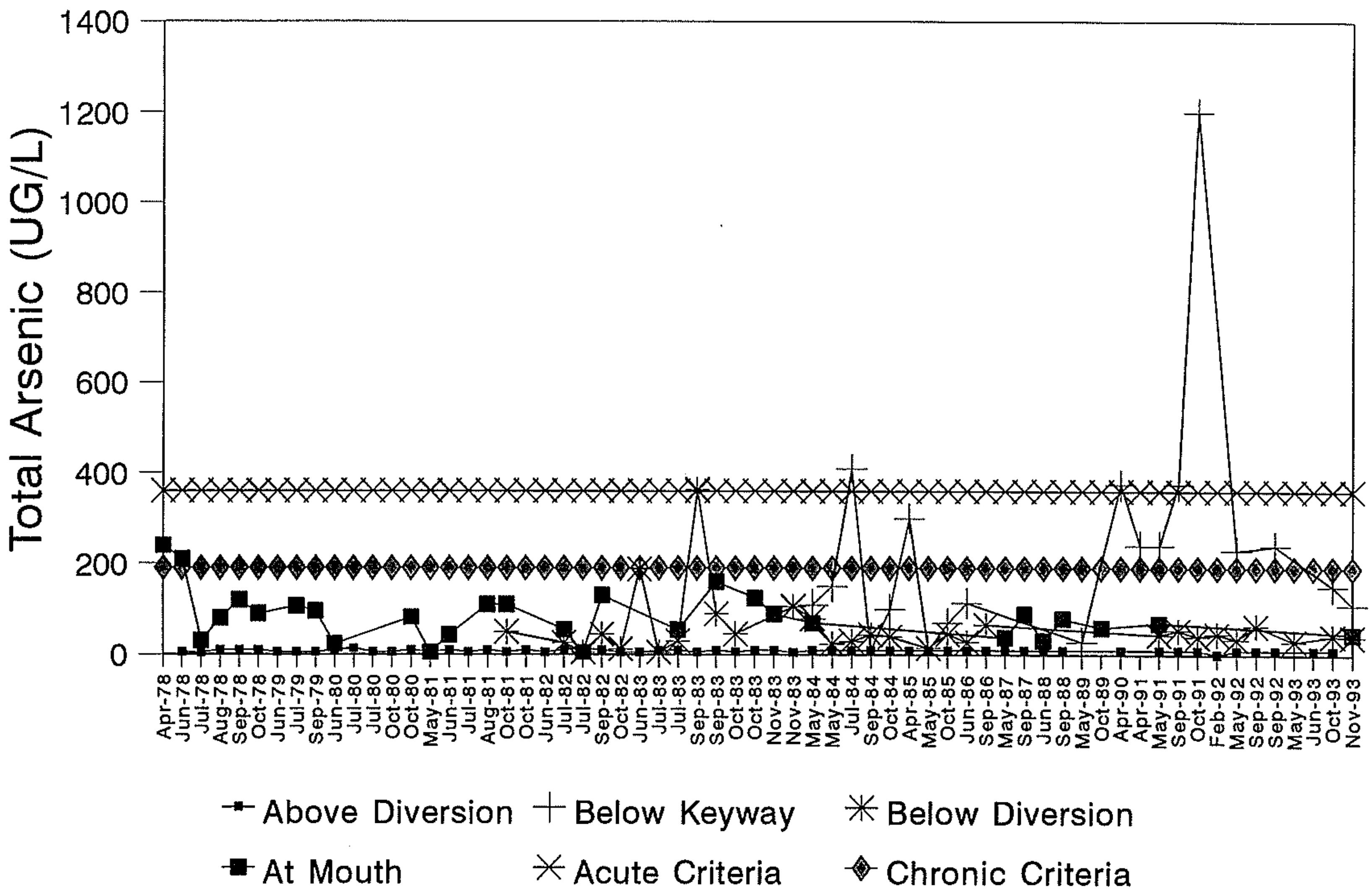

Figure 9

Sugar Creek Above West End Creek

T. Arsenic, T. Antimony, and T. Zinc

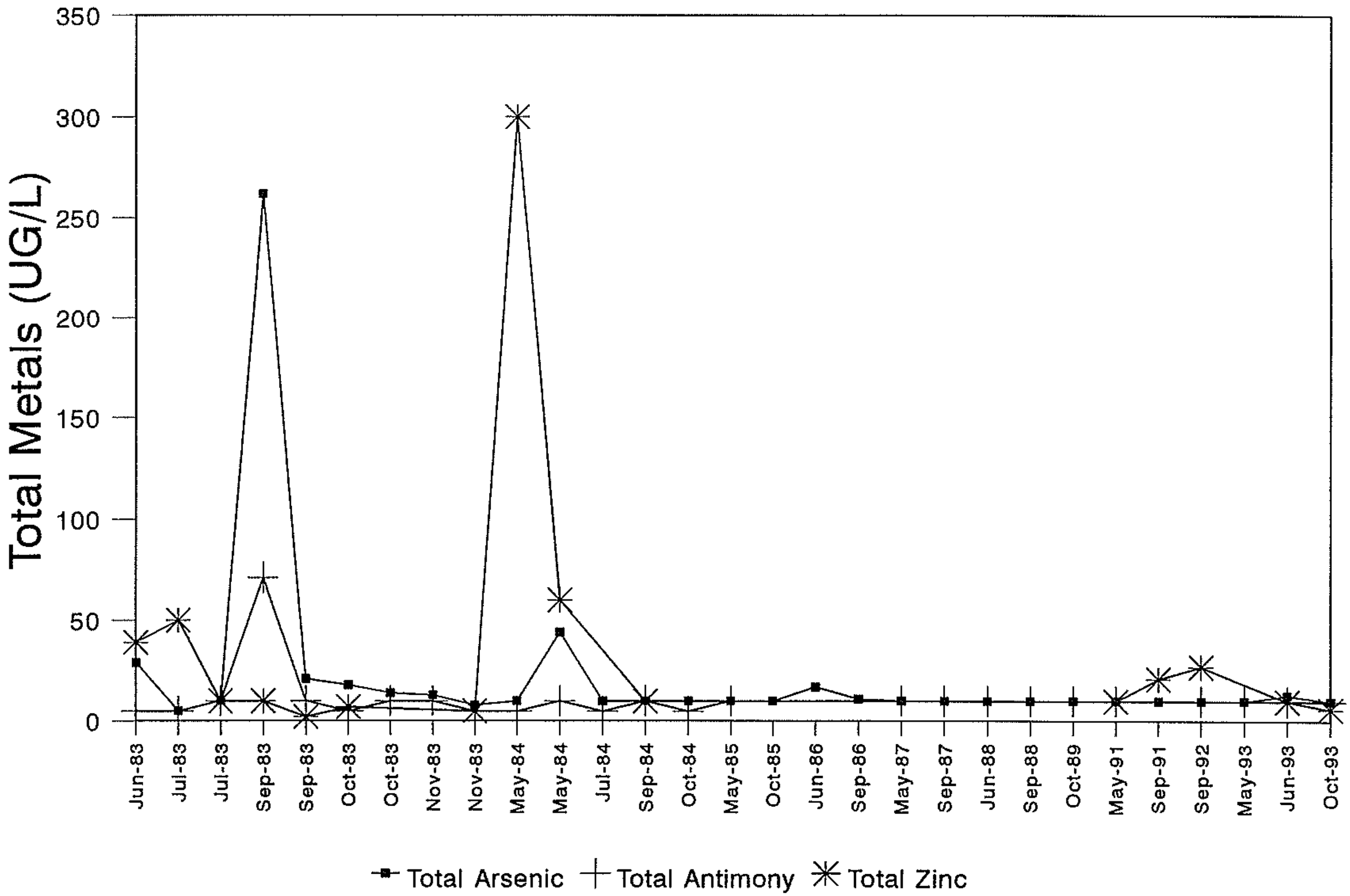

Figure 10

Sugar Creek Above West End Creek

Total Iron

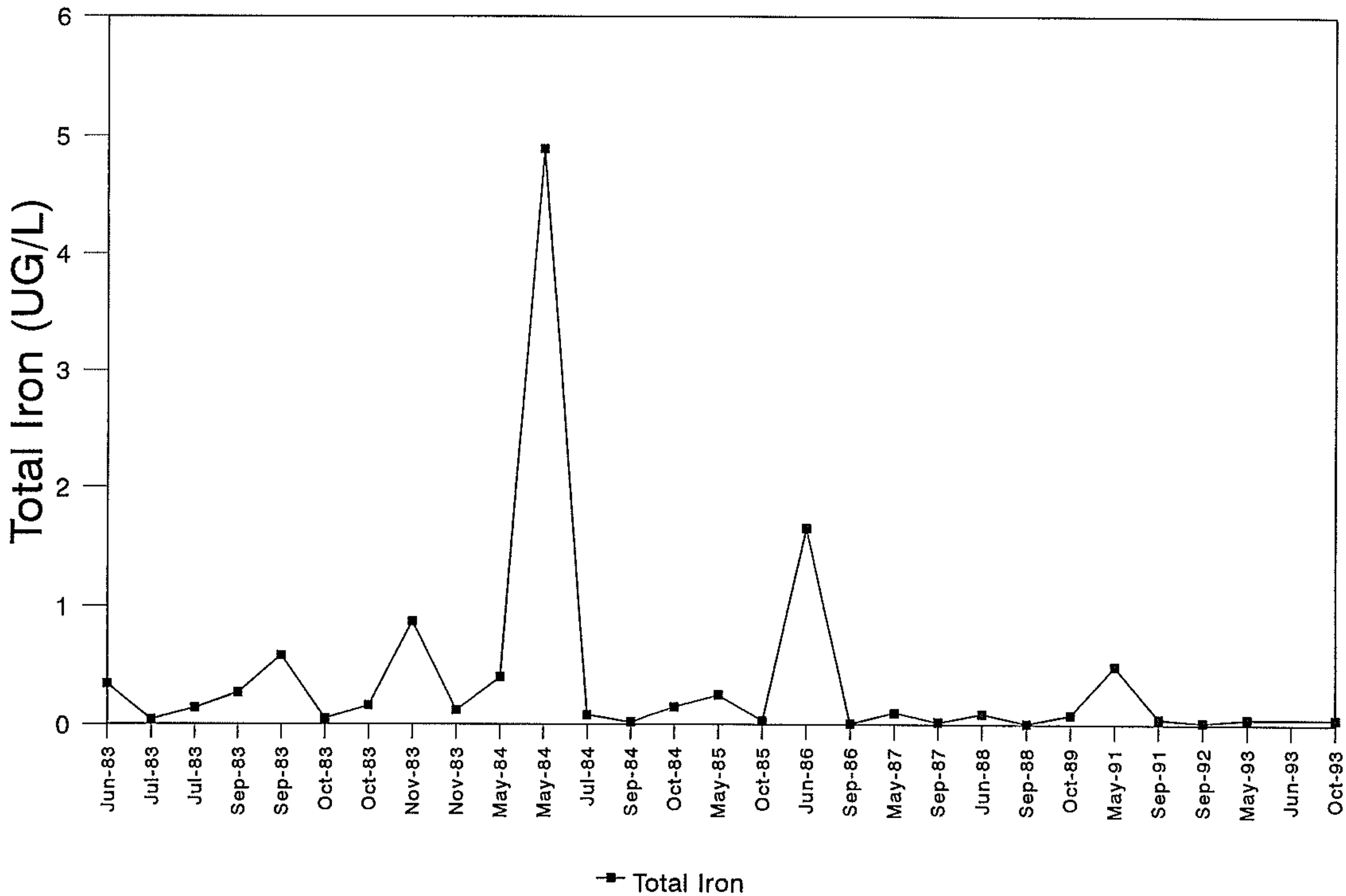

Figure 11

Sugar Creek Below West End Creek

T. Arsenic, T. Antimony, and T. Zinc

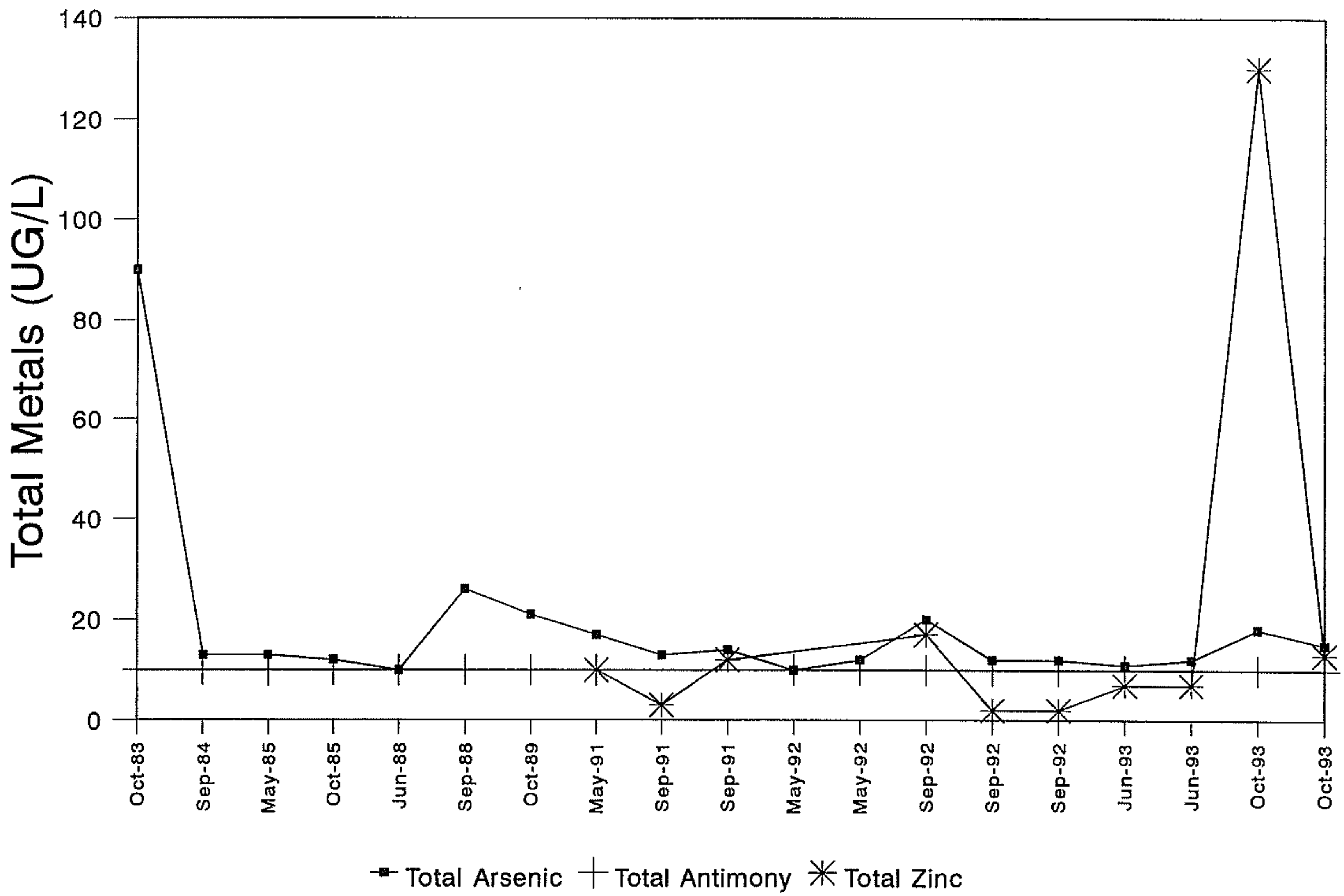

Figure 12

Sugar Creek Below West End Creek

Total Iron

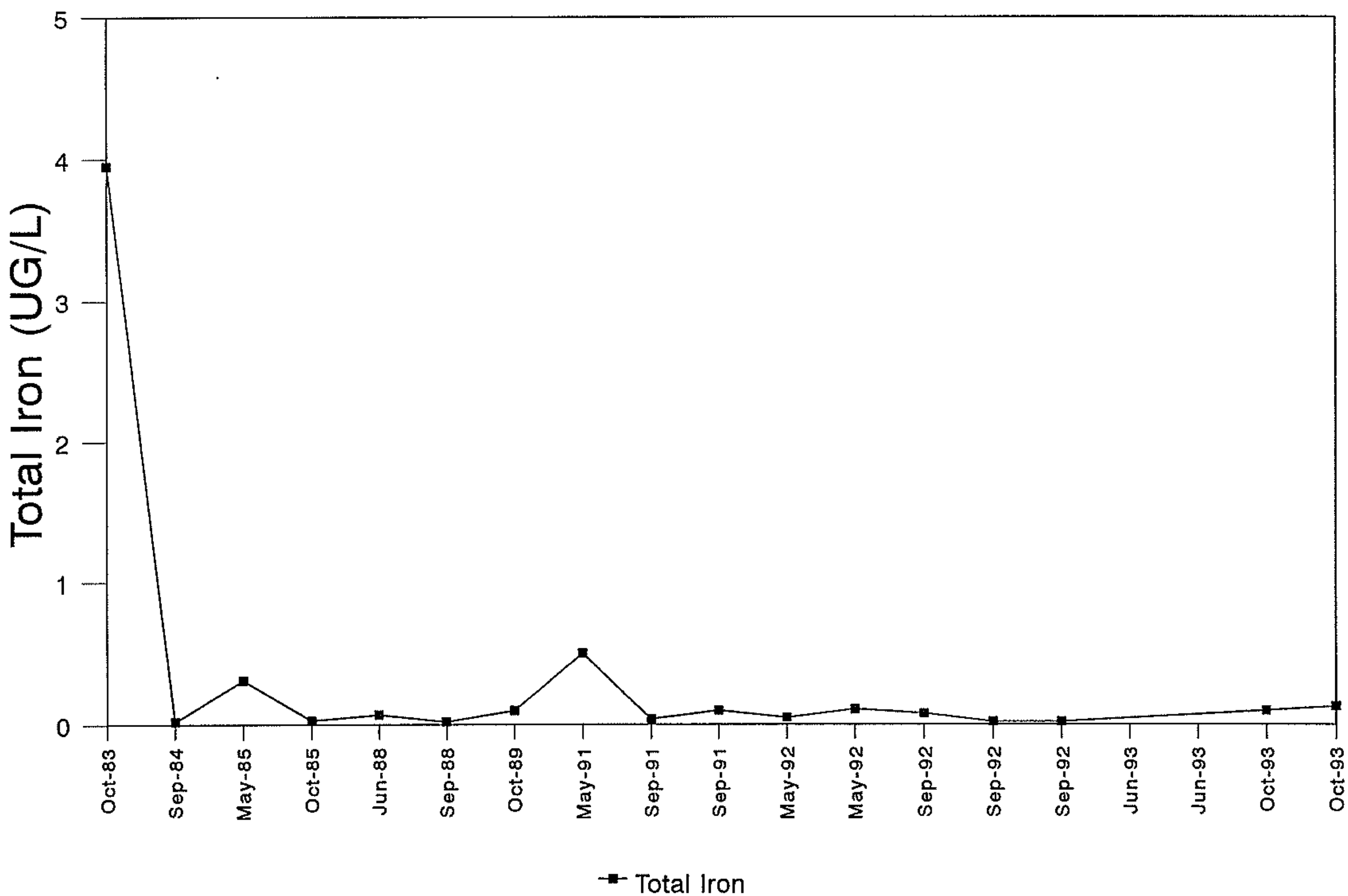

Figure 13

In general metals concentrations in Sugar Creek do not appear to represent a regular threat to cold water biota. There may, however, be periodic discharges from the Cinnabar Mine which may cause acute reactions in cold water biota.

Station 3040315 (EFSFSR above Mines) is the reference site on the EFSFSR. Metals concentrations at the station trend close to the detection limits (Figure 14 and 15). Exceptions to this trend occurred during the high flow periods in 1983, 1984, and 1992. Most likely these spikes occurred as the direct result of erosion along the Thunder Mountain Road which parallels the EFSFSR for several miles above Stibnite.

Metals concentrations on the EFSFSR above Garnet Creek are consistent with trends at with the EFSFSR background station 3040315 and station 3040319 near the mouth of Meadow Creek (Figure 16 and 17). During periods of high runoff in 1983 and 1984, total arsenic concentrations were high enough to cause chronic effects in cold water biota. Other than during these high flows, total arsenic concentrations have not been found to exceed the standards. Although concentrations of arsenic would not be expected to cause chronic effects in cold water biota, except during periods of high flow, trends do indicate an influence from the Meadow Creek Drainage. Lower total arsenic concentrations may, however, indicate that implementing and modifying best management practices on haul and access roads in the vicinity of the Box Culvert and Office area have reduced metals loading.

Total metals concentrations on the EFSFSR below Garnet Creek appear to have decreased since 1984 (Figure 18 and 19). The decrease in total metals coincides with concentrations seen above Garnet Creek. This was also most likely due to modifications of best management practices at the Stibnite Mine after 1984 and the lack of mineral development in proximity to Garnet Creek.

Total metals concentrations on the EFSFSR below Sugar Creek appear to have peaked during 1983 and 1984, and since these high flow years decreased to pre-1980s mining concentrations (Figure 20 and 21). The decrease in total metals correlates with concentrations seen above Garnet Creek. Decreases also coincide with modifications of best management practices at the Stibnite Mine and Yellow Pine Mine after 1984, closure and reclamation of the Yellow Pine Mine, and lower than normal flow due to drought, which may indicate a correlation.

Total arsenic concentrations on the EFSFSR, although not high enough to cause chronic effects in cold water biota, were ten (10) to sixty (60) times higher than background concentrations (Figure 22). Total arsenic concentrations consistently increase towards the downstream stations which indicates a cumulative effect of various activities from the headwaters of the EFSFSR and Meadow Creek through Station 2040314 immediately below the mines. Never-the-less, it appears that the trend in total arsenic concentrations has decreased since 1984. This decrease may be the direct result of several factors: 1) Increased use and modifications of best management practices has reduced arsenic laden sediment production and delivery; 2) Reclamation of the Homestake Pit and Dump, Bradley Pit and Dump, old smelter

East Fork of the South Fork of the Salmon River Above Meadow Creek

T. Arsenic, T. Antimony, and T. Zinc

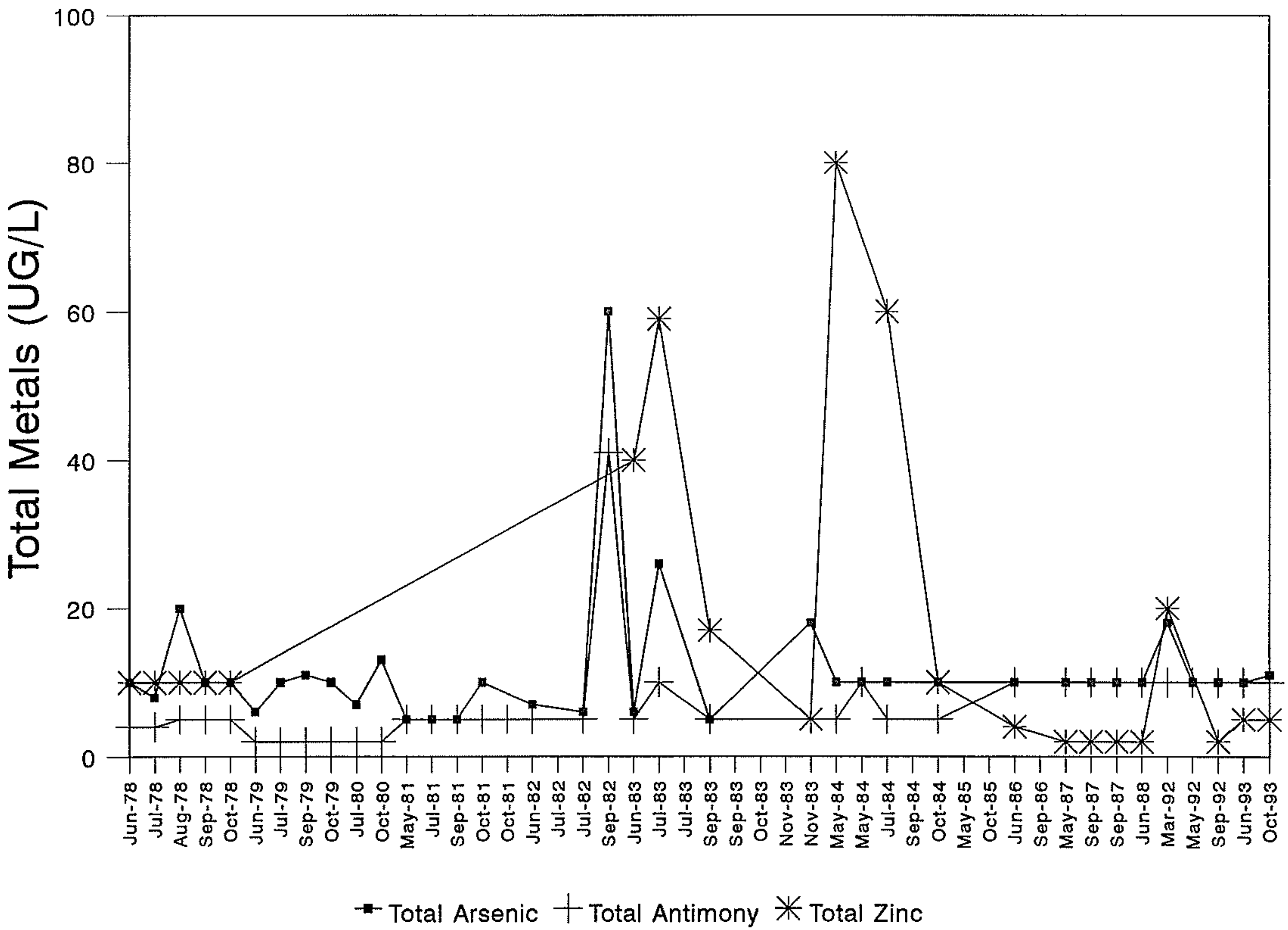

Figure 14

East Fork of the South Fork of the Salmon River Above Meadow Creek

Total Iron

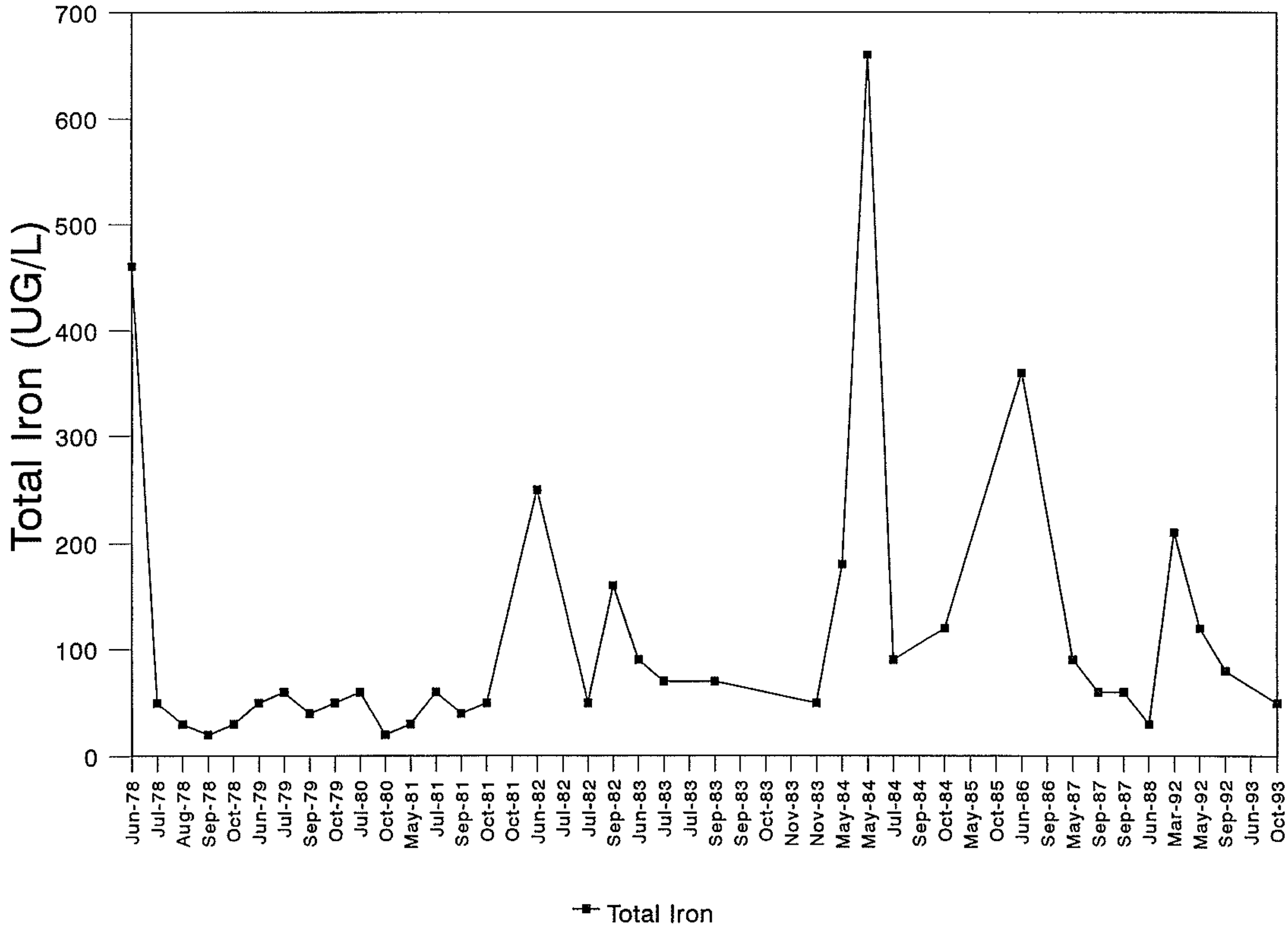

Figure 15

East Fork of the South Fork of the Salmon Above Garnet Creek

T. Arsenic, T. Antimony, and T. Zinc

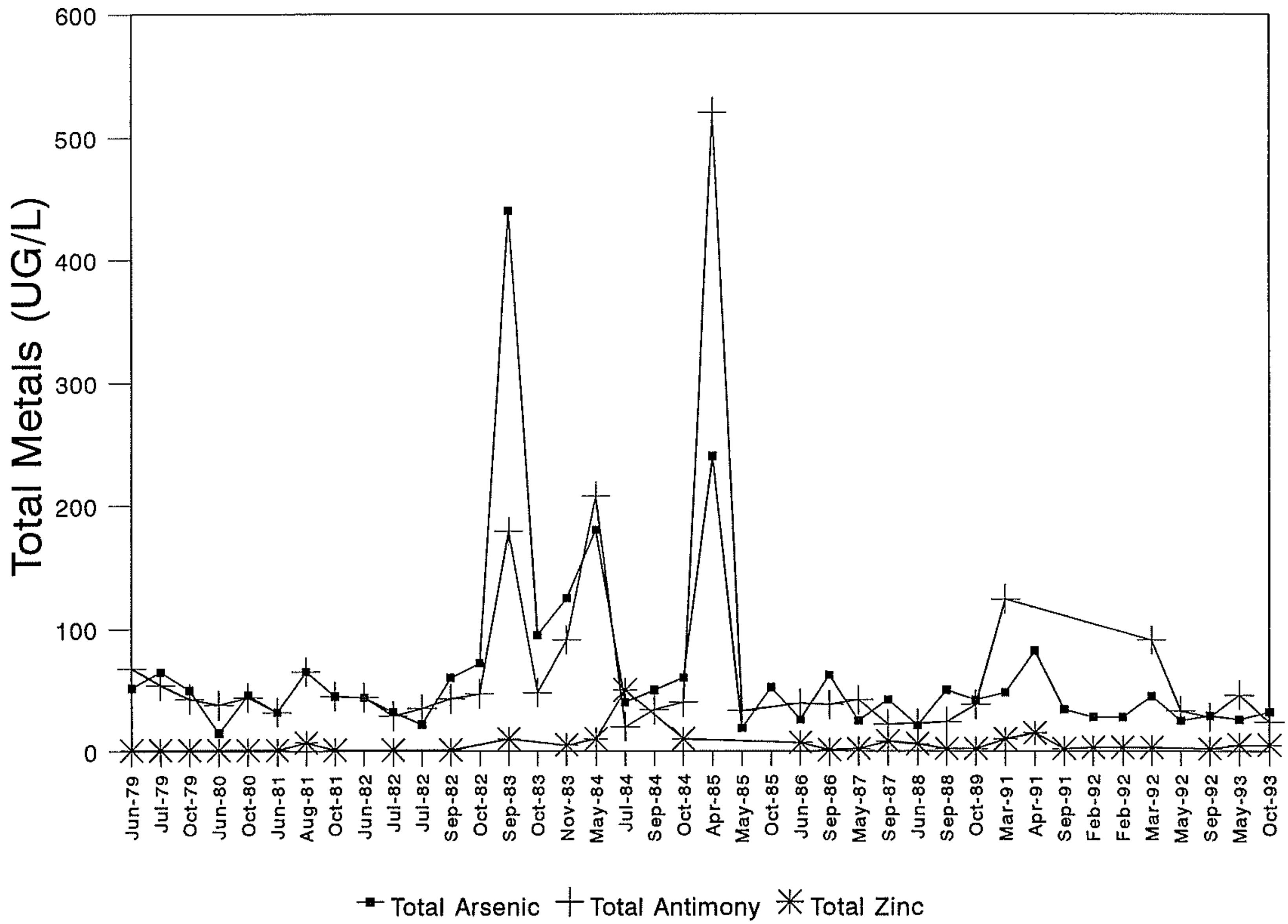

Figure 16

East Fork of the South Fork of the Salmon River Above Garnet Creek

Total Iron

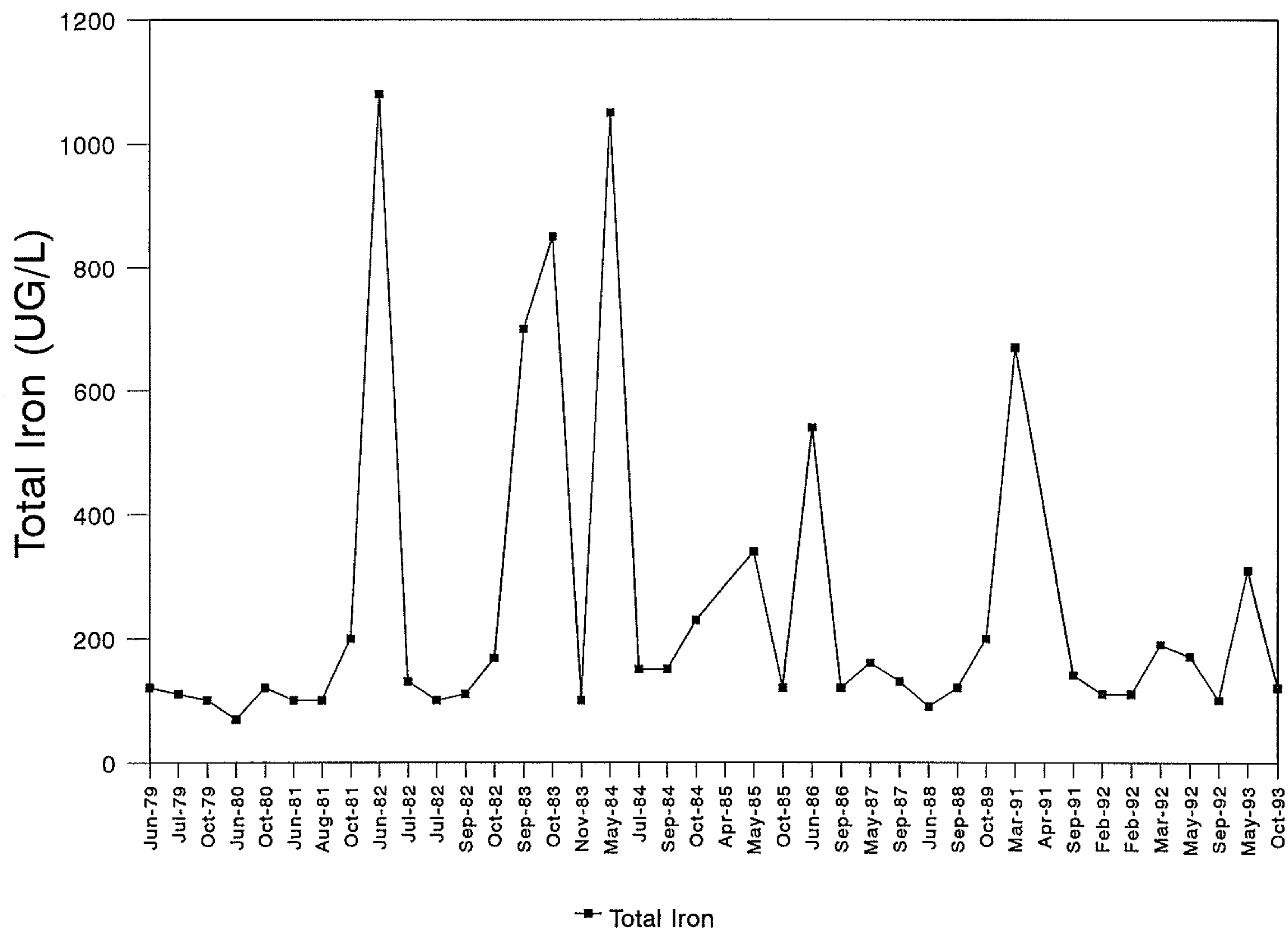

Figure 17

East Fork of the South Fork of the Salmon River Below Garnet Creek

T. Arsenic, T. Antimony, and T. Zinc

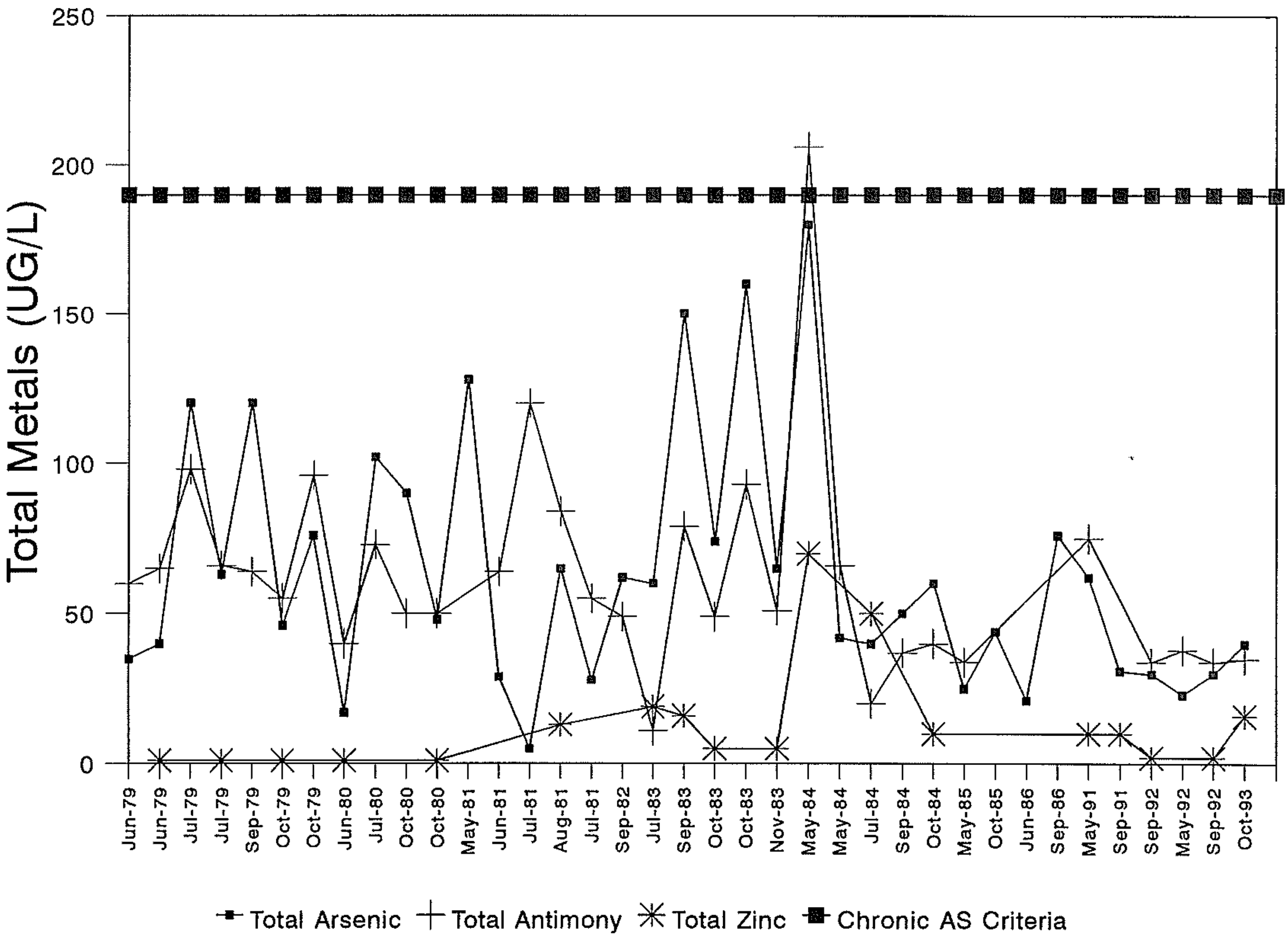

Figure 18

East Fork of the South Fork of the Salmon River Below Garnet Creek

Total Iron

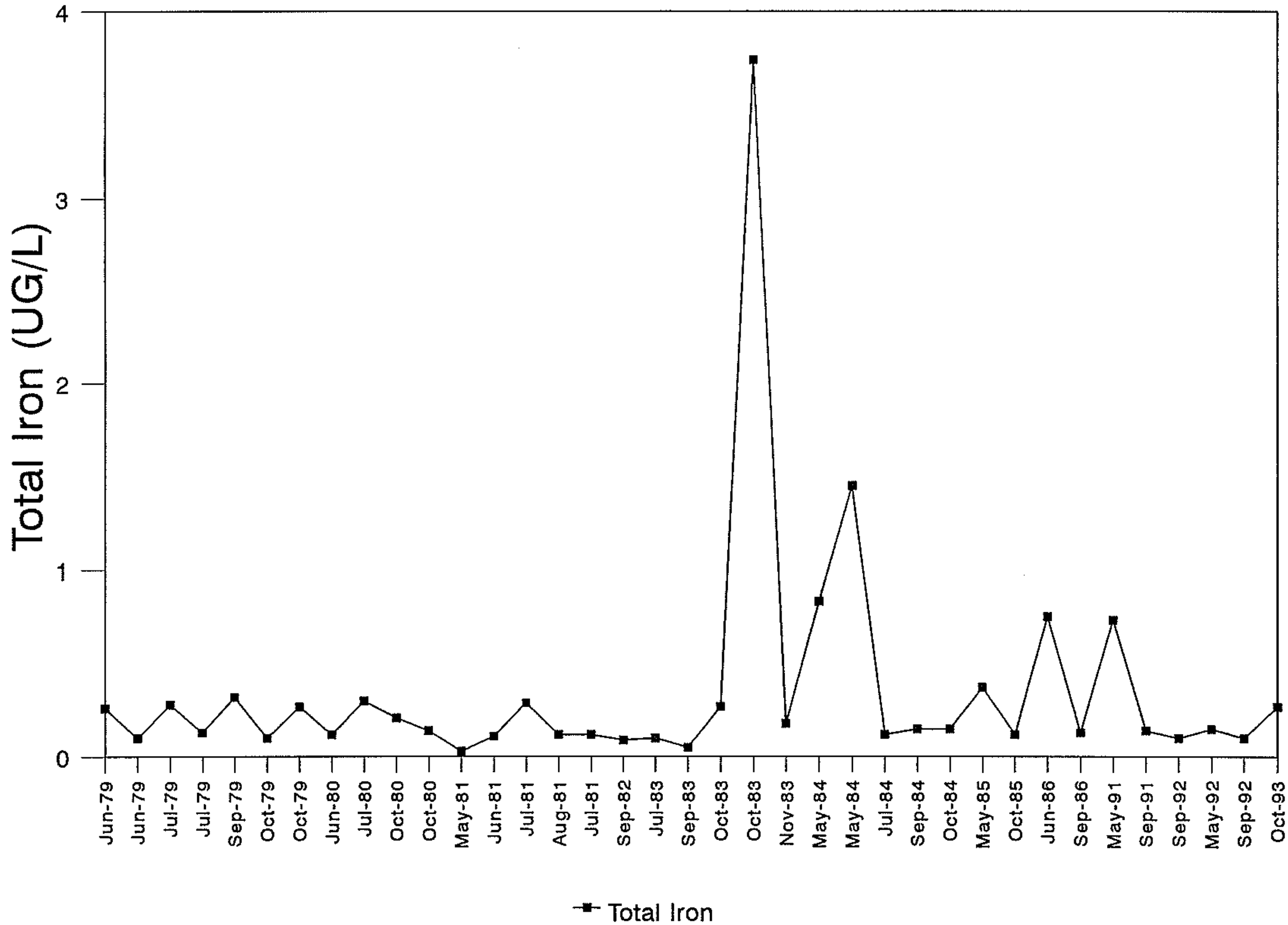

Figure 19

East Fork of the South Fork of the Salmon River Below Sugar Creek

T. Arsenic, T. Antimony, and T. Zinc

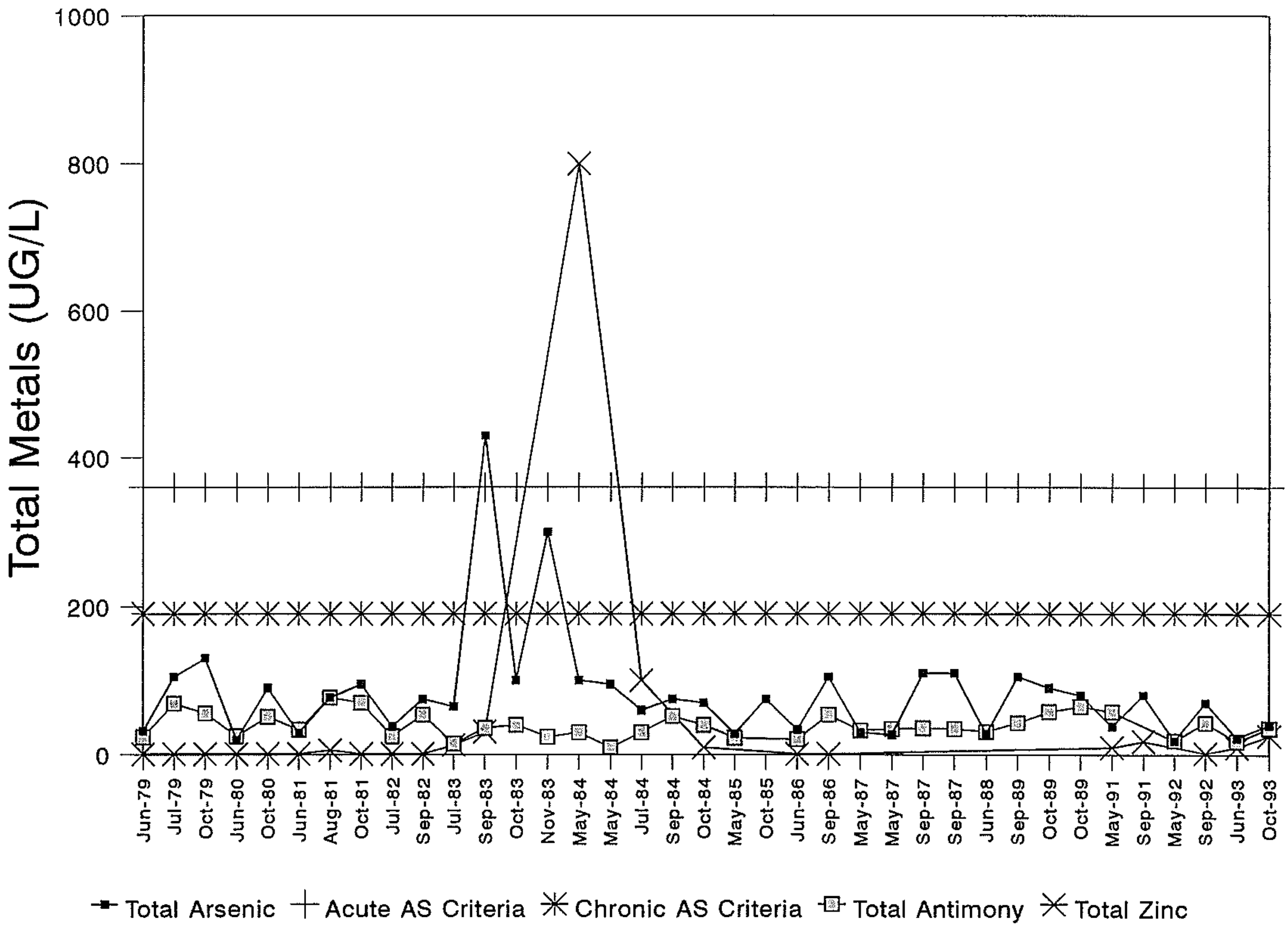

Figure 20

East Fork of the South Fork of the Salmon River Below Sugar Creek

Total Iron

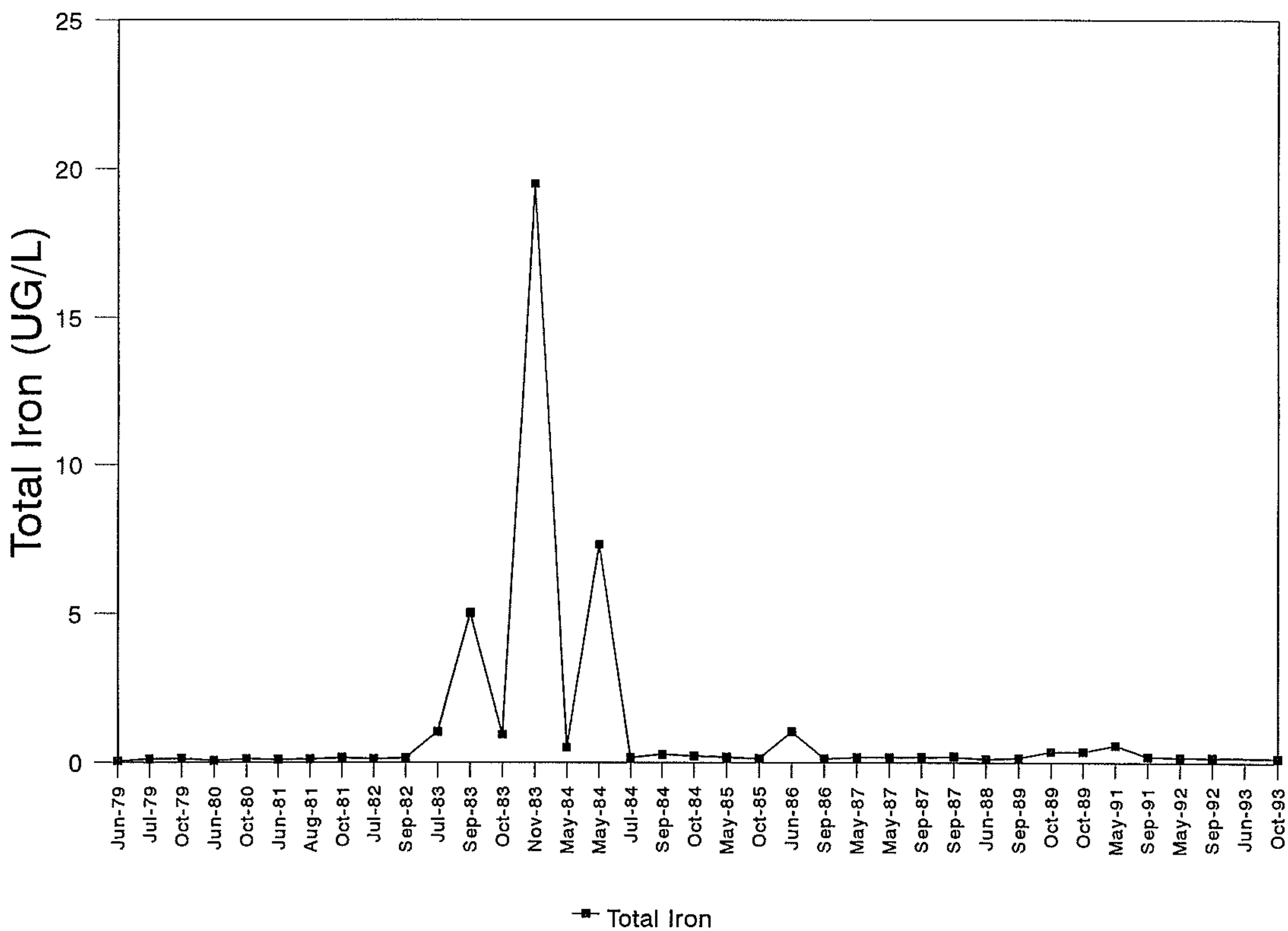

Figure 21

East Fork of the South Fork of the Salmon River
Total Arsenic

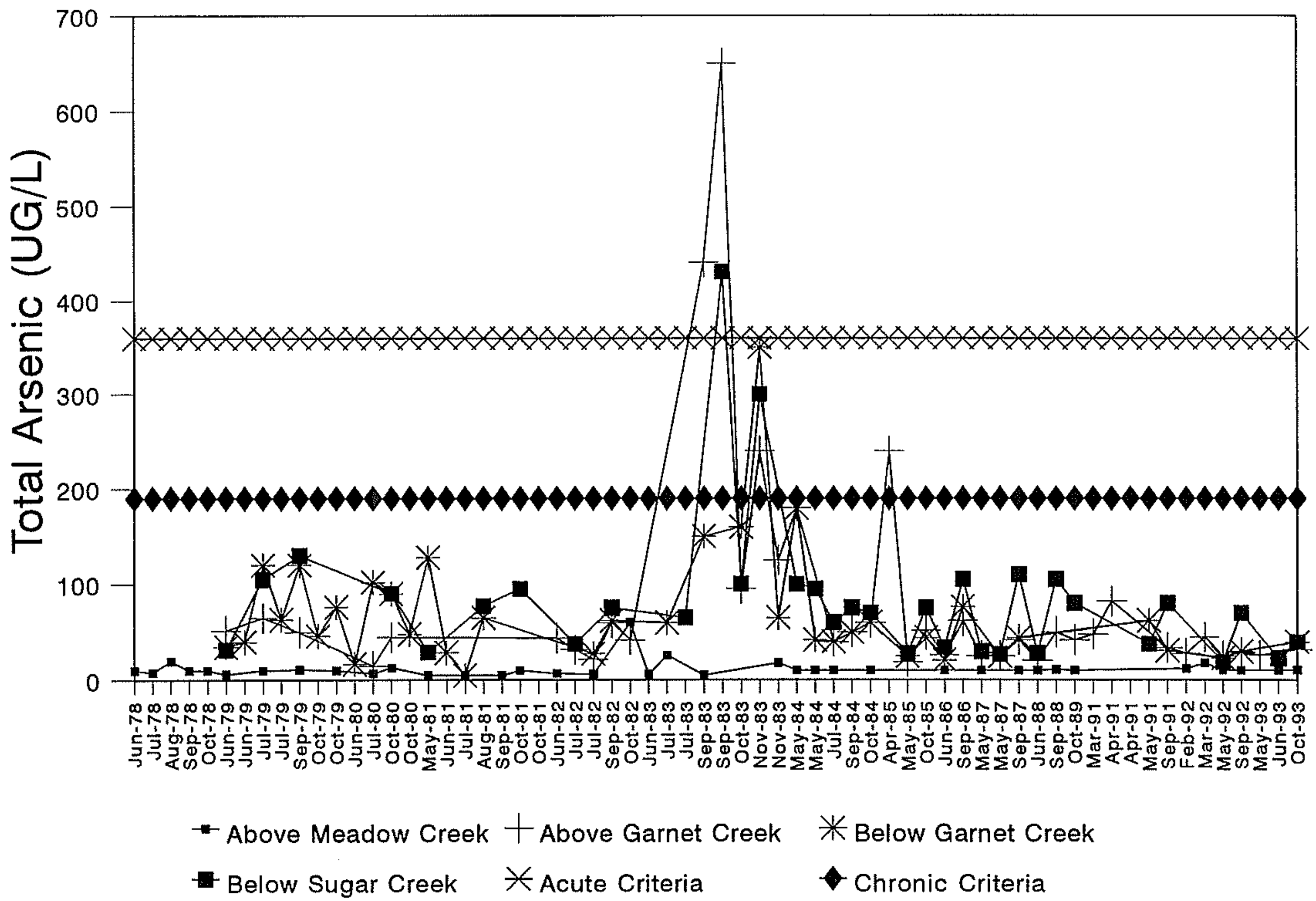

Figure 22

and mill site in the Meadow Creek Drainage, at the hospital site and near Stibnite Mining Incorporated's Office, have most likely increased metals attenuation and reduced sediment production and delivery; and 3) arsenic laden sediment in the substrate of EFSFSR is being depleted from the EFSFSR.

CONCLUSIONS

Analysis of trends at individual stations and along stream segments is difficult at best when one considers the lack of monitoring data and its inconsistency from 1986 through 1989. There is, therefore, a need to increase the frequency and consistency of monitoring the EFSFSR and its tributaries (Burch and Mullins 1994). Furthermore, calculation of loads from tributaries or influent waste streams will become important during the TMDL development process, and therefore, flow measurement will also become important.

Concentrations of trace elements in EFSFSR sediments were compared with several criteria and guidelines (Burch and Mullins 1994). Elevated arsenic levels are consistent with arsenic concentrations measured in sediments collected from the Meadow Creek wetland sample site, located adjacent to a spent ore dump at Stibnite mine. Chromium concentrations are 8 - 14 times higher than levels measured in the Meadow Creek sediments, but, mercury concentrations are consistent with Meadow Creek sediments.

Arsenic was the only trace element elevated in algae. When compared to the 1991 samples collected from Meadow Creek at Stibnite mine, EFSFSR arsenic levels are dramatically lower. However, algae can act as a mechanism, both directly and indirectly, to transport contaminants to higher food chain organisms such as fish, and translocate trace elements into ecosystems located downstream (Burch and Mullins 1994).

Data from fine sediment deposition, macroinvertebrate, and chemical analyses of fine sediment, algae, fish and water are correlative and support several conclusions. The conclusions include:

1) Increased use and modifications of best management practices have significantly reduced production and delivery of arsenic laden sediment;

2) Ongoing reclamation of recent and historical mine facilities has increased metals attenuation by plants and soils, and also reduced production and delivery of arsenic laden sediment;

3) Concentrations of arsenic and cyanide, which are sufficient to cause chronic or acute effects in cold water biota, persist in Meadow Creek in proximity to the Meadow Creek Pond and Old Meadow Creek Channel;

4) Periodic discharges from active mine facilities and ongoing discharges from historic tailings to Meadow Creek have caused acute and/or chronic reactions in macroinvertebrates which have resulted in impaired communities in Meadow Creek;

5) Periodic discharges from active mine facilities and continuous discharges from historic waste dumps to the EFSFSR have caused either chronic or acute reactions in macroinvertebrates resulting in impaired communities;

6) Continued improvements in best management practices, and design and operation of mine facilities should continue the decreasing trend in metals loading to the EFSFSR and its tributaries;

7) Alteration of the Old Meadow Creek Channel below the Meadow Creek Pond under the current plan of operations will disturb historic mill tailings and consequently continue the discharge of arsenic to Meadow Creek, which will cause chronic or acute effects in cold water biota downstream; and

8) Concentrations of metals and cyanide in Meadow Creek which cause chronic and acute effects in aquatic biota will persist unless major redesign and source control techniques are applied to Stibnite Mining Incorporated's ore processing and spent ore disposal facilities, and the historical mill tailings in and along Meadow Creek.

RECOMMENDATIONS

Surface water quality monitoring of cobble embeddedness, free matrix, macroinvertebrate, and chemical surveys of fine sediment, algae, fish and water should continue. In order to properly maintain trend monitoring, stations must be sampled at least three times, and when possible four times, annually for water chemistry for the same parameters and using the same field and laboratory protocols. In order to correlate impairment of macroinvertebrates with pollution sources, macroinvertebrate stations need to be increased to include sites immediately below any major point or nonpoint source. In order to obtain additional information during fine sediment surveys, sediment should be collected at least once for chemical analysis. Flow data from tributaries and influent waste streams must become part of routine monitoring. These changes in monitoring should improve the quality and usefulness of the information.

The effort of the sediment, algae, and fish tissue analyze involved for this study was limited due to time and budget (Burch and Mullins 1994). To adequately evaluate the potential adverse biological affects of these trace elements, a more thorough and well developed investigation should be initiated.

Where available, sediment, aquatic invertebrates, aquatic plants, fish, and water samples should be monitored to obtain baseline contaminant information to characterize the EFSFSR of the salmon River ecosystem above and below the influence of historic mining (Burch and Mullins 1994). In addition, water quality parameters such as pH, dissolved oxygen, alkalinity, hardness, and conductivity should be measured at the time of collection of sediment, algae, and fish (Burch and Mullins 1994).

Routine monitoring should be conducted at approximately 5 - 10 year intervals or if there has been a suspected release of contaminants within the EFSFSR drainage to identify potential temporal and spatial trends in trace elements (Burch and Mullins 1994).

Increased use and modifications of best management practices and ongoing reclamation of recent and historical mine facilities has increased metals attenuation by plants and soils, and reduced production and delivery of arsenic laden sediment to surface waters. Prior to increasing the area of land disturbance in the watershed, reclamation of additional historically or recently mined lands should be reclaimed and revegetated.

Plans should be finalized and implemented for final closure and reclamation of Hecla Mining Company's ore processing facility. Final closure should incorporate water management.

Major modifications of Stibnite Mining Incorporated's ore processing facilities and spent ore disposal facilities need to be designed, implemented and maintained. These modifications would require a permit under the Rules Governing Ore Processing by Cyanidation.

Stibnite Mining Incorporated's Stream Channel Alteration Permit and the Forest Service administered plan of operations should be reviewed and modified. Modifications should include either stabilization of tailings beneath a constructed substrate and rock drop structures along the entire length of the old Meadow Creek, or removal of mill tailings. Modifications should also include diversion of turbid waters produced during construction of rock drop structures or removal of tailings.

Remediation plans need to be developed for metals migration from historical mill and smelter tailings in the Meadow Creek Drainage. This may include removal or encapsulation of tailings.

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APPENDIX A

MONITORING PLAN

METHODS

TREND MONITORING

Stations:

Sample station locations for monitoring are indicated in FIGURE 2. Two additional stations have been added to the previous monitoring plans as cyanide was detected at these locations during compliance investigations. These location are designated as Station A and Station B pending assignment of STORET Station numbers. Three additional stations have been added to the study in proximity to the confluence of Cinnabar Creek and Sugar Creek from which data will be available in future status reports.

Frequency:

Initially sampling was to occur four times per operating season. In 1984, however, the Forest Service and Division of Environmental Quality modified the monitoring agreement. The Forest Service will conduct trend monitoring twice each year. The timing will be coordinated with high and low flow periods. The Division of Environmental Quality will conduct two additional sampling surveys to bring the trend monitoring back up to the original intent.

Parameters:

All samples will be analyzed for parameters listed in TABLE 3. Samples from select stations will be analyzed for the additional parameters as indicated in TABLE 4. Parameters are the same as monitoring programs after 1985 except that sulphate (SO_4) analysis has been substituted for sulfide analysis, and cyanide analysis will be done for total and weak acid dissociable (WAD). Parameters listed in TABLE 4 were dropped from analysis criteria. These latter parameters were found to be consistently non-detectable over the period of approximately six (6) years. Additional parameters may be dropped from the analyses if they are found constant or non-detectable for a period of five or more years.

In addition to those water quality samples taken for laboratory analysis, field measurements should be made. These field measurements should include stream flow, turbidity, conductivity, and pH. Stream flows will also be obtained from the U.S.G.S. electronic data base (WASTORE) for verification.

Quality Assurance:

The Forest Service and Division of Environmental Quality will collect duplicate samples, for precision, obtained with the use of a sample splitter, from Station No. 2040314

TABLE 3. Sample Parameters for Trend Monitoring Stations.

PARAMETER		UNITS	STORET #
1.	Arsenic, total	ug/l	01002
2.	Cyanide, Wad and Total	ug/l	00720
3.	Iron, total	ug/l	01045
4.	Suspended Solids, total	mg/l	00530
5.	pH	S.U.	00403
6.	Conductivity	umhos/cm	00095
7.	Turbidity	NTU	00076
8.	Manganese	ug/l	01055
9.	Antimony	ug/l	01097
10.	Flow	ft^3/sec.	
11.	Free Matrix	%	
12.	Cobble Embeddedness	% weighted embeddedness	
13.	Macroinvertebrates	% of population	
14.	Riparian Evaluation	qualitative	

(EFSFSR below Sugar Creek) each time trend sampling occurs. Acidified samples for antimony, arsenic and iron will be collected at seventeen stations each trend survey.

Trend monitoring will include the use of field spikes for accuracy. These field spikes will be prepared in advance by the Bureau of Laboratories and/or Water Quality Bureau.

Prior field measurement, field instruments should be used to establish the approximate range of measurement, and then calibrated to that range. Calibration should be done at least once a day. Frequency of calibration will, however, be a function of events, such as storms, proximity to acid generating sulphide zones, and variations of sediment production from dumps or construction.

TABLE 4 Additional Parameters for Select Trend Monitoring Stations

PARAMETER		STORET #	STORET Station Numbers
1.	Cyanide, Total and WAD	00720	2040320, 2040319, 2040315, 2040313, 2040584, 2040585*
2.	$T.NO_2+NO_3$	00630	2040320, 2040319, 2040315, 2040313, 2040584, 2040585*
3.	Chloride	00940	2040320, 2040319, 2040315, 2040313, 2040584, 2040585*
4.	Copper, total	01042	2040320, 2040319, 2040315, 2040313, 2040317, 2040584, 2040585
5.	Zinc, total	01092	2040320, 2040319, 2040315, 2040313, 2040317, 2040584, 2040585
6.	Sulfate, total	00945	2040320, 2040319, 2040315, 2040313, 2040317, 2040584, 2040585
7.	Mercury, total	71900	2040320, 2040319, 2040315, 2040313, 2040317, 2040584, 2040585
8.	Free Matrix		Stations 19. through 24.**
9.	Cobble Embeddedness		Stations 19. through 24.**
10.	Macroinvertebrates		Stations 19. through 24.**
11.	Riparian Evaluation		Stations 19. through 24.**
12.	Residual Chlorine		2040368

*Sta. A & Sta. B have been so designated for the sample locations at the base of the spent ore and tailings pond, and in the Meadow Creek Diversion immediately adjacent to the disposal area, respectively. These sites will not be monitored very far into the future and consequently, STORET Number assignments are not being sought.
**Station 19. through 24. refer to those sites being monitored by the U.S. Forest Service below the Stibnite Mining District which has, as yet, not been assigned STORET Station numbers. Assignment of STORET Numbers for these site is being sought.

Responsibilities:

Responsibility for trend monitoring will be shared by the Payette National Forest and Division of Environmental Quality. Jane Wurster, a Geologist for the Krassel Ranger District, and Bruce Schuld, a Water Quality Compliance Officer for the Division of Environmental Quality, will coordinate federal and state activities.

COMPLIANCE MONITORING

Stations:

Compliance stations are listed in TABLE 2. The stations are approximately located in FIGURE 2.

Parameters:

Cyanide, turbidity, and free product petroleum shall be parameters for compliance monitoring. Storm events will be monitored for turbidity and total suspended solids (TSS). A field turbidimeter, calibrated before each hourly monitoring period, will be utilized for turbidity analysis.

Frequency:

Stibnite Mining Inc. will monitor storm events and spring runoff periods. Storm event monitoring will include water quality sampling, and reports. A storm event is defined as 0.2 inches or more of rainfall during an eight (8) hour period. Previously, samples have been collected every four hours during a storm event, as is required for the mine company in consent orders. In order to obtain more accurate data correlating storms and turbidity concentrations, samples will be collected hourly for the duration of the storm.

Arrangements will be made with the mine company to have them notify the Forest Service and Division of Environmental Quality when a storm event is occurring.

Stibnite Mining Inc. will sample groundwater through monitor wells at the site of the petroleum spill and adjacent areas. Monitoring will continue until all free product petroleum is removed, and semi-annually thereafter for at least one year.

Stibnite Mining Inc. will conduct weekly, no fewer than four times monthly, chemical sampling in the stream channel below the keyway, STORET Station #2040369, for WAD cyanide during the operating season. Analyses reports will be submitted each month to the Division of Environmental Quality.

Quality Assurance:

The Division of Environmental Quality will review Stibnite Mining Incorporated's compliance monitoring. This review will include sampling design, field operations, laboratory activities, data analyses, and reporting.

Duplicate samples for both turbidity and TSS will be collected once during each storm event from Sugar Creek below the confluence with West End Creek (STORET Station 2040307) to test precision. Duplicate samples will be obtained from the sample splitter. The split samples will be submitted to the State Bureau of Laboratories for analysis. Duplicate samples, for precision estimates, will be collected from Sugar Creek below the confluence with West End Creek (STORET Station 2040307) each occasion that compliance monitoring occurs.

TREND SUBSTRATE FISH HABITAT AND BENEFICIAL USE MONITORING

The U.S. Forest Service Payette National Forest will continue substrate fish habitat monitoring on both the Headwaters to Sugar Creek, and Sugar Creek to Johnson Creek Sections of the South Fork of the Salmon River. The monitoring will include cobble embeddedness, free matrix, photographic, gradient, stream widths, and large organic debris surveys. In addition, the Forest Service will perform macroinvertebrate sampling. Procedures for substrate fish habitat and beneficial use monitoring shall follow the guidelines described in Water Quality Monitoring Protocols #2 and #5. John Lund, Fisheries Biologist for the Payette National Forest, will coordinate field surveys and data analysis.

Stations:

Seven sample sites are located in the Stibnite area. These sites are described in TABLE 2.

Frequency:

At least once each year in late July or early August. A second sample will be taken in late September if workloads permit.

Responsibility:

Responsibility will primarily rest with Dave Kennel and John Lund of the Payette National Forest. The Division of Environmental Quality will, however, make a concerted effort to assist the Forest's monitoring in order to implement the late monitoring and perhaps an earlier excursion.

SAMPLE COLLECTION PROTOCOL

Whenever samples are collected for trend, storm event, or compliance monitoring, samplers should treat the samples as legal samples (Burr, 1986). Field notes, sample submittal forms, and chain-of-custody paper work must accompany sample submittals and be sent to each participating agency. Consistent well documented procedures, therefore, will enable regulatory agencies to maintain legally acceptable and scientifically reproducible data interpretations. Sampling procedures will include sample collection, preservation, transportation, chain-of-custody protocol, and analysis.

SAMPLE COLLECTION

Sample collection is the initial, and perhaps, simplest step in water quality monitoring. It may, however become overly routine, and therefore, proper care must be taken to be consistent with established procedures. Planning and preparation will eliminate sampling mistakes. Field personnel should have and maintain a small inventory of basic equipment. Equipment and supplies should include:

1) an aerial map showing all sample locations as indicated by STORET numbers;

2) a sample submittal form or list, which in the case of compliance samples could be the Chain-of-Custody Form;

3) one liter cubitainers (new) for most samples, one gallon glass containers for samples suspected to contain petroleum contaminants;

4) preservatives and spikes;

5) photography equipment;

6) field notebook & permanent ink pens;

7) ice chest and ice;

8) a sample splitter;

9) depth integrated sampler (DH-48 or DH-59);

10) turbidity meter and calibration standards;

11) pH meter and calibration standards;

12) conductivity meter and calibration standards;

13) flow meter and wading rod; and

14) fifty foot measuring tape.

There is some variability in this inventory based on personal preferences, but these are the basics. Sample submittal forms, Chain-of-Custody reports, and sample containers should be marked in advance of sample collection. Submittal forms and reports which list the samples to be collected can serve as a checklist to ensure all of the sample are collected. Properly marking samples with the STORET number, type of sample, preservatives or spikes added, and date prior to sample collection will reduce the numbers of samples lost because of illegible markings.

Depth integrated samples should be collected which are representative of the surface water. Sample locations should be those established by previous plans or mutual consent of the agencies. Samplers should be wary of flow conditions, and avoid taking samples in eddies. Depth integrated samples should be split and contained in separate cubitainers. Up to four samples will be taken at each monitoring station.

Samples must be properly preserved and spiked, and they must be collected in the proper containers. Preservatives and spikes are used to maintain the samples integrity. Containers must be clean, sterile, and meet the State Bureau of Laboratories specifications. Samples which are not properly preserved, spiked, or collected in proper containers do not provide accurate information.

Whether or not a violation is suspected, careful procedures should be used to document facts, corpus delicti. Accurate narration should be written in field books at the time that samples are taken. The minimal information recorded should include:

1) STORET number and common location description;

2) sampler's name and agency;

3) purpose of sample;

4) brief of sampling procedure;

5) preservatives or spikes added;

6) date and time of collection;

7) climatic conditions;

8) photographic records; and

9) company or interagency personnel present during sampling.

TABLE 5. Sample Parameters Excluded from Trend Monitoring*.

PARAMETER		PARAMETER		PARAMETER	
1.	COD	14.	Sodium, Total	27.	Manganese, Dissolved
2.	Total Alkalinity	15.	Potassium, Total	28.	Manganese, Total
3.	Suspended Solids	16.	Silica, Total	29.	Nickel, Dissolved
4.	HCO_3	17.	Arsenic, Dissolved	30.	Nickel, Total
5.	CO_3	18.	Cadmium, Dissolved	31.	Silver, Dissolved
6.	Total Residue	19.	Cadmium, Total	32.	Silver, Total
7.	Total Non-Filterable Residue	20.	Chromium, Total	33.	Zinc, Dissolved
8.	Total Phosphorous	21.	Chromium, Dissolved	34.	Antimony, Dissolved
9.	Total Cyanide	22.	Chromium, Total	35.	Antimony, Total
10.	Total Hardness	23.	Copper, Dissolved	36.	Dissolved Residue
11.	Calcium, Total	24.	Iron, Dissolved	37.	Total Phosphorous
12.	Magnesium, Total	25.	Lead, Dissolved	38.	Mercury, Dissolved
		26.	Lead, Total	39.	Suspended Sediment

Parameters listed in TABLE 4 were dropped from analysis criteria. These parameters were found to be consistently non-detectable over the period of approximately six (6) years.

If water quality violations are suspected, additional information must be recorded. This information includes:

1) description of the suspected violation;

2) reasons for the suspicion;

3) names of company representatives contacted, the time, and the content of the conversation(s);

4) names of regulatory agents contacted, the time, and content of the conversations; and

5) whenever possible, photographs or videos which record site conditions.

TRANSPORTATION AND CHAIN-OF-CUSTODY

Transportation of samples from remote mine sites may be difficult. A few basic procedures must, however, be maintained particularly during incidence of a violation. Once collected and preserved, samples should be place in an ice chest with ice and kept cool. If samples are taken for suspected violations, the samples should be hand delivered to the Division of Environmental Quality or the Bureau of Labs with a completed Chain-of Custody Report. Trend and storm event samples may be sealed in a cooler with ice, and transported via bus to Boise where the Division of Environmental Quality personnel will receive them and deliver them to the Bureau of Laboratories. These samples must also be accompanied with a completed sample list.

Samples which are collected for suspected violations require additional security measures. These samples should be kept locked up when left unattended, and personal delivered to authorized enforcement officers with the proper chain-of-custody forms completed.

REPORTING

Copies of all field notes, sample submittal forms, chain-of-custody forms, and Data Analysis Reports should be circulated amongst the Division of Environmental Quality, U.S. Forest Service Payette National Forest, Department of Lands, and Department of Fish and Game. Copies of laboratory analysis will be forwarded to the Forest Service. Summary reports will be prepared annually by the Division of Environmental Quality. Annual summaries will be prepared by the Division of Environmental Quality prior to the end of each calendar year and distributed for review and comment. Annual summaries will include an assessment of on-site

BMP effectiveness. The review and comments should be the discussed at the seasonal coordination meeting such that any modifications proposed for plans may be discussed and possibly incorporated prior to the following field season. Copies of the summary shall be given to the Forest Service and mine operators. The summary shall be reviewed by the Forest Service and Division of Environmental Quality prior to the first Tuesday in March. At this time modifications may be made on the monitoring program for the following year.

DATA STORAGE

Concurrent with analytical steps, most data will be entered in the STORET data base. The exception to this would be those miscellaneous stations, Stations A and B, which are new and temporary stations in isolated surface impoundments. Substrate fish habitat data will be forwarded by the U.S. Forest Service to the Division of Environmental Quality for entry into STORET. Data from STORET Stations will be used to analyzed long term trends in water quality. Data from these latter stations will not comprise enough information to highlight long lasting trends, but will be used to supplement monitoring of year to year operations at the mines.

APPENDIX B

2040320	Meadow	Creek	Above	Diversion	
DATE FROM TO	TIME OF DAY	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	ZINC ZN,TOT UG/L
78/06/06	1200	5	10	120	10
78/07/18	1200	4	7	50	10
78/08/15	1200	10	5	110	10
78/09/04	1200	10	5	40	10
78/10/10	1200	10	5	120	10
79/06/01	1200	5	2	50	
79/07/27	1200	5	2	100	
79/09/10	1200	5	2	60	
80/06/20	1300	10	10	10	1
80/07/23	1200	14			
80/07/30	1200	5	2	50	
80/10/15	1200	5	2	20	
80/10/22	1210	10	10	70	1
81/05/21	1200	5	5	30	
81/06/23	1055	10	10	20	1
81/07/08	1200	5	5	50	
81/08/04	1245	10	10	10	6
81/10/19	1200	5	5	50	
81/10/20	1400	10	10	10	1
82/06/16	1200	5	5	210	
82/07/21	1345	10	10	20	1
82/07/23	1200	14	5	50	
82/09/23	1000	10	10	10	1
82/09/23	1200	5	5	10	
82/10/28	1200	5	5	69	
83/06/10	1200	5	5	150	41
83/07/21	1200	9	9	80	50
83/07/28	900	10	10	90	15
83/09/09	1200	5	5	90	30
83/09/30	915	10	10	10	9
83/10/08	1200	6	5	80	5
83/10/13	1630	10	10	140	
83/11/04	1345	10	12	350	
83/11/29	1200	5	5	40	5
84/05/23	1200	10	7	140	100
84/05/31	1530	10	10	410	
84/07/18	1200	10	5	110	150
84/09/27	1115	10	10	30	
84/10/24	1200	10	5	140	10
85/04/14	1610	10	10		
85/05/21	1330	10	70	70	

2040320	Meadow	Creek	Above	Diversion	(continued)
DATE FROM TO	TIME OF DAY	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	ZINC ZN,TOT UG/L
89/10/25	1200	10	10	120	5
91/05/22	1200	10	10	150	10
91/09/24	1200	10		110	8
91/10/23	1200	10	10	120	
92/02/06	1000	1		10	12
92/05/13	1200	10	10	60	
92/09/23	1200	10	10	50	2
92/09/29	1200	10	10	50	2
93/06/02	1212	10	10		10
93/10/25	1117	10	10	50	10

Old	Meadow	Creek	Channel	And	Pond
DATE FROM TO	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	CYANIDE CN,TOT UG/L	CYANIDE CN,WAD UG/L
90/04/13				3570	700
90/06/06				79	54
90/07/11				89	19
91/04/26				304	99
91/05/22	220	198	610	67	28
91/05/22	240	160	1400	134	35
91/09/22	800		870		158
91/09/24	190		620	1	1
91/10/24	200	230	960		1
91/10/24	170	220	810		1
91/10/24	140	120	530		1
92/05/13	130	180	290		7
92/05/13	160	260	980		13
93/05/25	130	210	300		13
93/05/25	2600	2000	9780	114	90

2040368	Meadow	Creek	Below	Keyway		
DATE FROM TO	01002 ARSENIC AS,TOT UG/L	ARSENIC Acute Criteria UG/L	ARSENIC Chronic Criteria UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
84/05/23	110	360	190	270	520	90
84/05/31	150	360	190	310	1090	
84/07/18	410	360	190	90	440	70
84/09/27	10	360	190	10	30	
84/10/24	100	360	190	100	640	20
85/04/14	300	360	190	310		
85/05/21	10	360	190	10	120	
85/10/22	70	360	190		320	
86/06/05	114	360	190	92	10	5
86/09/17	650	360	190	64	530	1
89/05/10	28	360	190		300	2
90/04/11	375	360	190	150	810	
91/05/22	240	360	190	212	710	10
91/09/24	375	360	190		1940	5
91/10/24	1200	360	190	320	6700	
92/05/13	230	360	190	260	420	
92/09/29	240	360	190	130	860	18
93/10/25	150	360	190	122		10
93/11/10	110	360	190	110		5

2040322	Meadow	Creek	Below	Diversion		
Date From To	01002 ARSENIC AS,TOT UG/L	AS,TOT Acute Criteria UG/L	AS,TOT Chronic Criteria UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
81/10/20	50	360	190	28	850	3
82/07/21	26	360	190	15	90	2
82/09/23	45	360	190	31	170	
82/10/28	12	360	190	5	25	1
83/06/10	188	360	190	188	350	
83/07/21	5	360	190	5	640	
83/07/28	30	360	190	12	200	59
83/09/09	364	360	190	45	270	26
83/09/30	90	360	190	78	1360	19
83/10/08	46	360	190	12	260	17
83/11/29	106	360	190	196	620	3
84/05/23	80	360	190	50	480	21
84/05/31	24	360	190	28	2040	5
84/07/18	30	360	190	10	130	90
84/09/27	44	360	190	35	200	
84/10/24	40	360	190	30	340	60
85/05/21	15	360	190	26	250	
85/10/22	46	360	190		520	10
86/06/05	28	360	190	25	300	1
86/09/17	66	360	190	10	380	7
90/04/11	400	360	190	250	950	
91/04/09	240	360	190			16
91/05/22	44	360	190	50	660	10
91/09/24	54	360	190		240	2
91/10/23	40	360	190	30	250	1
92/02/06	46	360	190		460	16
92/03/25	70	360	190	79	390	5
92/05/13	34	360	190	31	190	
92/09/23	64	360	190	41	290	2
93/10/23	42	360	190	33	210	5

2040319	Meadow	Creek	At	Mouth	
DATE FROM TO	TIME OF DAY	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	ZINC ZN,TOT UG/L
78/04/20	1200	240	390	550	10
78/06/06	1200	210	160	2200	110
78/07/18	1200	30	40	260	10
78/08/15	1200	80	65	320	32
78/09/04	1200	120	86	250	10
78/10/10	1200	90	68	280	10
79/07/30	1155	107	76	330	1
79/10/10	1240	96	52	280	1
80/06/20	1340	23	66	130	1
80/10/22	1230	82	58	270	4
81/06/23	1125	43	94	230	1
81/08/04	1130	110	65	240	12
81/10/20	1430	110	72	360	1
82/07/21	1440	55	41	140	4
82/09/23	1100	130	60	230	1
83/07/28	1000	55	24	220	20
83/09/30	1000	160	100	2790	12
83/10/13	1640	125	86	580	
83/11/04	1400	90	144	2510	
84/05/31	1440	70	92	1710	
87/05/06	1200	38	55	280	2
87/09/23	1200	90	57	280	8
88/06/09	1200	31	34	100	2
88/09/21	1200	80	47	250	10
89/10/25	1200	60	60	320	5
91/05/23	1200	70	137	770	10
93/05/25	1300	210	130	300	5
93/10/25	1200	44	46	240	5

2040315	EFSFSR	Above	Meadow	Creek	
DATE FROM TO	TIME OF DAY	01002 ARSENIC AS,TOT UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
78/06/06	1200	10	4	460	10
78/07/18	1200	8	4	50	10
78/08/15	1200	20	5	30	10
78/09/04	1200	10	5	20	10
78/10/10	1200	10	5	30	10
79/06/01	1200	6	2	50	
79/07/27	1200	10	2	60	
79/09/10	1200	11	2	40	
79/10/24	1200	10	2	50	
80/07/30	1200	7	2	60	
80/10/15	1200	13	2	20	
81/05/21	1200	5	5	30	
81/07/08	1200	5	5	60	
81/09/17	1200	5	5	40	
81/10/19	1200	10	5	50	
81/10/20	1500		5		
82/06/16	1200	7	5	250	
82/07/21	1510				
82/07/23	1200	6	5	50	
82/09/23	1200	60	41	160	
83/06/10	1200	6	5	90	40
83/07/21	1200	26	10	70	59
83/07/28	945				
83/09/09	1200	5	5	70	17
83/09/30	1045				
83/10/13	1635				
83/11/04	1415				
83/11/29	1200	18	5	50	5
84/05/23	1200	10	5	180	80
84/05/31	1200	10	10	660	
84/07/28	1200	10	5	90	60
84/09/27	1000				
84/10/24	1200	10	5	120	10
85/05/21	1300				
85/10/22	1050				
86/06/05	1200	10	10	360	4
86/09/17	1530				
87/05/06	1200	10	10	90	2
87/09/23	1200	10	10	60	2
87/09/23	1200	10	10	60	2
88/06/09	1200	10	10	30	2

2040315	EFSFSR	Above	Meadow	Creek	(continued)
DATE FROM TO	TIME OF DAY	01002 ARSENIC AS,TOT UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
92/03/25	1200	18	10	210	20
92/03/10	1200	20	5	70	
92/05/11	1200	8	5	5	
92/05/13	1200	10	10	120	
92/07/28	1200	12	5	10	
92/09/23	1200	10	10	80	2
92/10/28	1200	13	5	20	
93/06/02	1200	10	10		5
93/10/25	1320	11	10	50	5

2040313 EFSFSR Above Garnet Creek					
DATE FROM TO	TIME OF DAY	01002 ARSENIC AS,TOT UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
79/06/04	1345	52	68	120	1
79/07/30	1140	65	54	110	1
79/10/10	1235	50	43	100	1
80/06/20	1520	15	38	70	1
80/10/22	1240	46	44	120	1
81/06/23	1130	32	32	100	1
81/08/04	1450	65	65	100	7
81/10/20	1110	45	45	200	1
82/06/16	1200	44	44	1080	
82/07/21	1455	32	29	130	1
82/07/23	1200	22	35	100	
82/09/23	1330	60	43	110	1
82/10/28	1200	72	47	168	
83/09/09	1200	440	179	700	10
83/10/13	1700	95	48	850	
83/11/29	1200	125	91	100	5
84/05/23	1200	180	208	1050	10
84/07/18	1200	40	20	150	50
84/09/27	1015	50	34	150	
84/10/24	1200	60	40	230	10
85/04/14	1815	240	520		
85/05/21	1530	19	33	340	
85/10/22	1230	52		120	
86/06/05	1200	26	39	540	7
86/09/17	1330	62	38	120	1
87/05/06	1200	25	42	160	2
87/09/23	1200	42	22	130	8
88/06/09	1200	21	23	90	6
88/09/21	1200	50	24	120	2
89/10/25	1200	42	38	200	2
91/03/22	1200	48	124	670	10
91/04/09	1200	82			15
91/09/24	1630	34		140	2
92/02/06	1210	28		110	3
92/02/07	1210	28		110	3
92/03/24	1415	45	91	190	3
92/05/13	1200	25	33	170	
92/09/23	1200	29	28	100	2
93/05/25	1200	26	46	310	5
93/10/27	1245	32	24	120	5

2040310	EFSFSR	Below	Garnet	Creek	
Date From To	Time of Day	01002 ARSENIC	01097 ANTIMONY SB,TOT	01045 IRON FE,TOT	01092 ZINC ZN,TOT
79/06/01	1200	35	60	260	
79/06/04	1400	40	65	100	1
79/07/27	1200	120	98	280	
79/07/30	1210	63	66	130	1
79/09/10	1200	120	64	320	
79/10/10	1225	46	55	100	1
79/10/24	1525	76	96	270	
80/06/20	1200	17	40	120	1
80/07/30	1200	102	73	300	
80/10/15	1200	90	50	210	
80/10/22	1450	48	50	140	1
81/05/21	1200	128	1090	30	
81/06/23	1315	29	64	110	
81/07/08	1200	5	120	290	
81/08/04	1455	65	84	120	13
81/07/23	1200	28	55	120	
82/09/23	1200	62	49	90	
83/07/21	1200	60	11	100	19
83/09/09	1200	150	79	50	16
83/10/08	1200	74	49	270	5
83/10/13	1705	160	93	3740	
83/11/04	1200	350	180	14400	
83/11/29	1200	65	51	180	5
84/05/23	1200	180	206	830	70
84/05/31	1400	42	66	1450	
84/07/18	1200	40	20	120	50
84/09/27	1000	50	37	150	
84/10/24	1200	60	40	150	10
85/05/21	1545	25	34	370	
85/10/22	1230	44		120	
86/06/05	1200	21		750	
86/09/17	1330	76		130	
91/05/22	1200	62	75	730	10
91/09/27	1200	31		140	10
92/09/23	1200	30	34	100	2
92/05/13	1200	23	38	150	
92/09/23	1200	30	34	100	2
93/10/25	1200	40	35	270	16

2040314	EFSFSR	1000'	Below	Sugar	Creek
DATE FROM TO	TIME OF DAY	01002 ARSENIC AS,TOT UG/L	01097 ANTIMONY SB,TOT UG/L	01045 IRON FE,TOT UG/L	01092 ZINC ZN,TOT UG/L
79/06/04	1520	32	24	50	1
79/07/30	1330	105	69	110	1
79/10/10	1440	130	56	130	1
80/06/20	1600	20	25	60	1
80/10/22	1530	90	51	120	1
81/06/23	1345	29	34	90	1
81/08/04	1525	77	77	110	6
81/10/20	1005	95	70	160	1
82/07/21	2000	38	25	120	1
82/09/23	1730	75	54	140	1
83/07/28	745	65	15	1040	13
83/09/30	825	430	36	5010	31
83/10/13	1800	100	40	940	
83/11/04	745	300	24	19500	
84/05/23	1200	100	30	510	800
84/05/31	1340	95	10	7300	
84/07/18	1200	60	30	160	100
84/09/07	1200	75	52	270	
84/10/24	1200	70	40	210	10
85/05/21	1730	28	23	180	
85/10/22	1330	75		130	
86/06/05	1200	34	21	1030	1
86/09/17	1200	105	54	130	1
87/05/06	1120	30	33	170	
87/05/06	1135	27	35	170	
87/09/23	1215	110	36	180	
87/09/23	1230	110	35	190	
88/06/09	1200	28	31	110	
89/09/21	1130	105	43	150	
89/10/25	1200	90	58	360	
89/10/25	1200	80	65	360	
91/05/22	1200	38	58	570	10
91/09/24	845	80		200	18
92/05/14	1200	19	19	170	
92/09/23	1200	70	43	160	2
93/06/02	1335	23	18		10
93/10/25	1200	40	36	150	26

2040309	Sugar	Creek	Above	West	End	Creek
DATE FROM TO	TIME	MEDIUM	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	ZINC ZN,TOT UG/L
83/06/10	1200	WATER	29	5	340	39
83/07/21	1200	WATER	5	5	40	50
83/07/28	900	WATER	10	10	140	10
83/09/09	1200	WATER	262	71	270	10
83/09/30	915	WATER	21	10	580	2
83/10/08	1200	WATER	18	5	50	7
83/10/13	1630	WATER	14	10	160	
83/11/04	1345	WATER	13	10	870	
83/11/29	1200	WATER	8	5	120	5
84/05/23	1200	WATER	10	5	400	300
84/05/31	1530	WATER	44	10	4890	60
84/07/18	1200	WATER	10	5	80	
84/09/27	1115	WATER	10	10	20	10
84/10/24	1200	WATER	10	5	150	
85/05/21	1330	WATER	10	10	250	
85/10/22	1200	WATER	10		30	
86/06/05	1200	WATER	17		1660	
86/09/17	1200	WATER	11		10	
87/05/06	1200	WATER	10	10	100	
87/09/23	1200	WATER	10	10	20	
88/06/09	1200	WATER	10	10	90	
88/09/21	1200	WATER	10	10	10	
89/10/25	1200	WATER	10	10	80	
91/05/22	1200	WATER	10	10	490	10
91/09/24	1200	WATER	10		50	21
92/09/23	1200	WATER	10	10	20	27
93/05/13	1200	WATER	10	10	50	
93/06/02	1200	WATER	13	10		10
93/10/25	1200	WATER	10	10	50	6

2040307	Sugar	Creek	Below	West	End	Creek
DATE FROM TO	TIME	MEDIUM	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	ZINC ZN,TOT UG/L
83/10/13	1545	WATER	90	10	3950	
84/09/27	1215	WATER	13	10	20	
85/05/21	1700	WATER	13	10	310	
85/10/22	1320	WATER	12	10	30	
91/09/21	1200	WATER	13		40	3
92/05/13	1200	WATER	10	10	50	
92/09/23	1200	WATER	12	10	20	2
92/09/29	1200	WATER	12	10	20	2
93/06/02	1200	WATER	11	10		7
93/10/25	1200	WATER	15	10	130	13