



Geochemical data for stream sediment and surface water samples from Panther Creek, the Middle Fork of the Salmon River, and the Main Salmon River, collected before and after the Clear Creek, Little Pistol, and Shellrock wildfires of 2000 in central Idaho

by

**Robert G. Eppinger¹, Paul H. Briggs¹, Betsy Rieffenberger², Carol Van Dorn³,
Zoe Ann Brown¹, James G. Crock¹, Philip H. Hageman¹, Allen Meier¹,
Stephen J. Sutley¹, Peter M. Theodorakos¹, and Stephen A. Wilson¹**

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**U.S. DEPARTMENT OF THE INTERIOR
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¹ U.S. Geological Survey, Denver, Colorado

² U.S. Forest Service, Salmon-Challis National Forest, Salmon, Idaho

³ U.S. Forest Service, Santa Fe National Forest, Santa Fe, New Mexico

TABLE OF CONTENTS

	Page
Introduction.....	4
Acknowledgments.....	4
Geologic Setting.....	5
Methods of Study.....	Y5
Sample Media.....	5
Sample Collection and Preparation.....	6
Stream Sediments.....	6
Heavy Mineral Concentrates.....	6
Water.....	7
Analytical Techniques.....	8
Techniques Used on Stream Sediment and Concentrate Samples.....	10
Inductively Coupled Plasma-Atomic Emission Spectrometry—Stream Sediments.....	10
Atomic Absorption Spectrometry—Stream Sediments.....	11
LECO Analyzer—Stream Sediments.....	12
Titration—Stream Sediments.....	13
Coulometric Titration—Stream Sediments.....	13
Semiquantitative Emission Spectrography—Concentrates.....	13
Techniques Used on Water Samples.....	14
Inductively Coupled Plasma-Atomic Emission Spectrometry.....	14
Ion Chromatography.....	14
Inductively Coupled Plasma-Mass Spectrometry.....	14
Ferrous Iron by Colorimetry.....	14
Mercury by Flow Injection-Cold Vapor-Atomic Fluorescence Spectrometry.....	15
Alkalinity by Titration.....	15
Which Technique Should I Use?.....	15
Description of Data Files.....	16
Field Numbers.....	16
Coordinates.....	16
Geochemical Analyses.....	17
Descriptions of Tables and Fields within Tables.....	17
Tables containing sample and site descriptive information.....	17
Tables containing geochemical analyses.....	19
Table containing wildfire study fields.....	21
Photographs.....	21
References.....	25
Appendix.....	28

LIST OF FIGURES

	Filename
Figure 1. Map showing location of study area in central Idaho.....	FIGURE1.PDF
Figure 2. Sample site map for stream sediment and surface water samples collected from Panther Creek, the Middle Fork of the Salmon River, and the Main Salmon River.....	FIGURE2.PDF

LIST OF TABLES

	Page
Table 1. Count of types of samples collected in this study.....	6
Table 2. Elements determined and analytical methods used for all sample media.....	9
Table 3. List of sample site photographs.....	23

LIST OF TABLES IN APPENDIX

	Page
Table A1. Limits of determination for stream sediment samples analyzed by 40-element inductively coupled plasma-atomic emission spectrometry, total extraction (ET).....	28
Table A2. Limits of determination for selected elements in stream sediment samples analyzed by other methods.....	29
Table A3. Limits of determination for nonmagnetic heavy-mineral concentrate samples analyzed by semiquantitative emission spectrography (ES).....	30
Table A4. Limits of determination for acidified water samples analyzed by inductively coupled plasma-atomic emission spectrometry (EW).....	30
Table A5. Limits of determination for anions in water samples determined by ion chromatography (IC).....	31
Table A6. Limits of determination for water samples analyzed by inductively coupled plasma-mass spectrometry (MW).....	32

INTRODUCTION

During a 3-week period in the summer of 1996, the U.S. Geological Survey conducted a reconnaissance baseline geochemical study in central Idaho. Areas covered include Panther Creek, the Middle Fork of the Salmon River from Boundary Creek to the mouth, and the Main Salmon River from North Fork to Corn Creek (Fig. 1). Stream sediment samples were collected at all sample sites. Filtered and unfiltered stream water samples were collected at most sites.

The purpose of the baseline study was to establish a “geochemical snapshot” of the area, as a datum for monitoring future change in the geochemical landscape, whether natural or human-induced. Events that could change the geochemical landscape include, but are not limited to, mining, flood, landslide, wildfire, or resource extraction activities. Geochemical data for the 1996 baseline study were published in Eppinger and others (2001). Data in the present report includes and supercedes that released in Eppinger and others (2001).

In the summer of 2000, there were numerous large wildfires in central Idaho. In particular, the Clear Creek (206,000 acres; 83,370 hectares), Little Pistol (74,000 acres; 29,950 hectares), and Shellrock (64,000 acres; 25,900 hectares) fires swept across much of the area that was sampled. In 2001, ten months after the wildfires, the entire area was resampled by occupying and recollecting at the same sample sites initially sampled in 1996. This work was done and the request of the U.S. Forest Service, Salmon-Challis National Forest. Presented herein are the analytical data for both the 1996 pre-wildfire and 2001 post-wildfire sampling periods. Also presented are digital images of the 2001 post-wildfire sample sites.

For the initial 1996 study, sampling was conducted from July 8 through June 28. Weather during this period was warm and precipitation sparse. Only one rain event occurred during the sampling period—a brief rainstorm on the evening of July 16, with about ¼” (0.64 cm) of total precipitation. River levels were lower than normal for this time of year because of lower-than-normal precipitation during the previous winter and spring. In 2001, the sampling was conducted from June 7 through June 21, constrained by unusually low water conditions following an exceedingly dry winter and spring. Precipitation during the sampling period was negligible.

The study area lies within the Salmon River Mountains, and much of the area—particularly along the Middle Fork of the Salmon River—lies within the Frank Church-River of No Return Wilderness (Fig. 1). Topographic relief is high. Peaks at the heads of drainages commonly have elevations above 9,000 ft (2,740 m), while river-level elevations are typically several thousand feet lower, ranging from around 5,700 ft (1,740 m) at Boundary Creek on the Middle Fork of the Salmon River, to less than 3,000 ft (914 m) at Corn Creek on the Main Salmon River. Terrain ranges from rugged, steep peaks, ridges, and cirques at higher elevations, through tree-covered mountains and meadows at intermediate elevations, to steep, narrow, heavily vegetated canyons at lower elevations. Climatic conditions vary from warm summer days with frequent thunderstorms to cold winter days with heavy snowfall accumulations.

Access to the Panther Creek basin is by U.S. Forest Service gravel roads 030 from North Fork, Idaho, and 055, which runs along Panther Creek. Access to the Main Salmon River from North Fork to Corn Creek is by U.S. Highway 93 and U.S. Forest Service gravel road 030, which runs along the Main Salmon, ending at Corn Creek, and by raft or jet boat. Access to the Middle Fork of the Salmon River is exclusively by oar-powered raft or pack trail.

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GEOLOGIC SETTING

Precambrian metamorphic rocks, the Late Cretaceous Idaho batholith, and Eocene plutons related to the Challis Volcanics are the predominant rock types in the study area. Faults in the area are mainly northeast and northwest trending.

The metamorphic rocks are principally quartzites and gneisses of the Precambrian Yellowjacket and Apple Creek Formations. Sporadic roof pendants and xenoliths of schist, quartzite, and calc-silicate rocks of uncertain Precambrian to Paleozoic age are found locally in close spatial association with the Idaho batholith.

The Idaho batholith varies from leucocratic granite to biotite granodiorite and hornblende-biotite granodiorite. It is typically salt-and-pepper gray in color and locally porphyritic with large microcline phenocrysts. The batholith is widespread in central Idaho, covering some 25,000 square miles (64,700 sq km).

Eocene plutons found in the study area are generally intermediate to granitic in composition and typically have an overall pink color, such as the large Casto Pluton, which crops out along portions of the Middle Fork of the Salmon River. These plutons are the crystalline, unerupted counterparts to the voluminous Challis Volcanics that are found in much of central Idaho.

METHODS OF STUDY

SAMPLE MEDIA

Geochemical sample media collected include stream-sediment, heavy-mineral-concentrate (1996 only), and water samples. The chemical composition of a stream-sediment sample is controlled primarily by the major geologic units within the drainage basin and to a lesser degree by metal-scavenging materials such as amorphous iron- and manganese oxides, clays, and organic matter. Minor elemental constituents within the stream sediment, such as elements related to mineral deposits within the drainage basin, may be detected in the sediment analysis, but commonly have a small overall influence on the sample because of dilution by barren material.

Since elements related to mineralized rocks are commonly found in heavy minerals, heavy-mineral-concentrate samples from stream sediment were also collected. Heavy-mineral concentrates provide chemical information about ore-related and rock-forming dense minerals, and permit chemical determination of some elements not easily detected in stream-sediment samples. Further, microscopic identification of nonmagnetic minerals in heavy-mineral-concentrate samples may provide additional useful mineralogical information. Heavy-mineral concentrate samples were collected only in the 1996 study.

Water samples were collected from available natural water sources, principally from flowing streams and rivers, but also from hot springs. Mineral deposits rich in sulfide minerals (whether mined or unmined), solid waste from mine dumps and mill tailings derived from such deposits, and sulfide-rich rocks from areas of hydrothermally altered bedrock, are possible

sources of acid and metal loading in the environment. Locally, hot springs and certain geologic units can contribute high concentrations of dissolved constituents to surface waters.

SAMPLE COLLECTION AND PREPARATION

A count of the various types of samples collected from each of the three basins studied is listed in [Table 1](#). In the table, “site dupes” refers to sample quality control site duplicates collected in the field. A sample site map is provided in [figure 2](#).

Table 1. Count of types of samples collected in this study.

	Total	Panther Creek	Middle Fork Salmon	Main Salmon
Water				
1996	80	11	48	21
<i>Site dupes, 1996</i>	4	1	2	1
2001	93	31	44	18
<i>Site dupes, 2001</i>	4	1	3	0
Stream Sediments				
1996	86	24	42	20
<i>Site dupes, 1996</i>	4	1	2	1
2001	92	32	42	18
<i>Site dupes, 2001</i>	5	1	4	0
Concentrates, 1996	34	6	10	18

Discrepancies in the above table for 1996 and 2001 sample totals reflect the fact that not every site sampled in 1996 was resampled in 2001 and vice versa. Paired sites where samples were collected in both 1996 and 2001 include 24 sites on Panther Creek, 42 sites on the Middle Fork of the Salmon River, and 17 sites on the Salmon River.

Stream Sediments

Each stream-sediment sample consisted of alluvium from the active stream channel, composited by collecting sediment increments from several places at the sample site, generally along a 30-ft (10-m) stretch of the channel. In order to improve sample representativity, an attempt was made to collect 20 to 30 increments at each site. However, at some sites sparse distribution of available sediment reduced the number of increments to less than 10. The sediment was sieved on site with a 10 mesh (2 mm) stainless steel screen. A 2-lb (0.9-kg) sample of minus-10 mesh sediment was collected in a cloth bag and air-dried.

In the laboratory, stream sediment samples were air-dried and sieved at 80 mesh (0.177 mm), following the method of Peacock and others (1996). The coarse fraction was discarded. The fine sediment fractions were pulverized to a fine flour consistency (minus-100 mesh/0.149 mm), with clean quartz sand pulverized between each sample to reduce risk of cross-contamination. For each sample, an approximate 6.5-oz (185-g) portion was saved for chemical analyses; any remaining material was subsequently archived.

Heavy Mineral Concentrates

Panned concentrate samples were collected from the same active alluvium as sediment samples, from around boulders and in coarse gravels. The pan concentrate samples were not composited as the stream sediment samples were, but were collected as grab samples in areas where heavy minerals tend to accumulate. A 14-inch stainless steel gold pan was filled with

stream sediment sieved to minus-10 mesh (2 mm) with a stainless steel screen, resulting in approximately 16 lb (7.2 kg) of material. This sieved alluvium was panned at the site when running water was available, or collected in a cloth bag for later panning. The alluvium was panned until most of the less-dense minerals (primarily quartz and feldspar), organic materials, and clays were removed. Generally, one to three percent of the original sample remained after panning. The panned sample was bagged, air-dried, and saved for further laboratory preparation.

In the laboratory, panned concentrate samples were sieved to minus-20 mesh (0.84 mm), and then gravity separated using bromoform (specific gravity about 2.85) to remove remaining light minerals, primarily quartz and feldspar. The resultant heavy-mineral-concentrate sample was separated into magnetic, weakly magnetic, and nonmagnetic fractions using a modified Frantz Isodynamic Separator (Taylor and Theodorakos, 1996). The magnetic fraction was extracted at a setting of 0.25 ampere and contains primarily magnetite and ilmenite. The weakly magnetic fraction was extracted at a setting of 1.75 ampere and consists largely of ferromagnesian silicates and iron oxides. The remaining nonmagnetic fraction may contain many ore-related minerals including sulfide minerals, gold and other native metals, and some accessory oxides and silicates. The nonmagnetic heavy-mineral-concentrate samples were split using a Jones splitter. One split was hand ground with an agate mortar and pestle for chemical analysis and the other split was used for microscopic mineralogical analysis. Clean quartz sand was hand ground between samples to clean the mortar and pestle, thereby reducing the risk of cross-contamination between samples.

Water

This study was reconnaissance in nature, covering a large area in a short period of time. Thus, for collection of water samples, we did not adhere strictly to the rigorous “parts per billion” protocol established by the U.S. Geological Survey Water Resources Division (Horowitz and others, 1994). Rather, procedures were streamlined to facilitate the sample collection process, as described below.

A clean 1-liter polypropylene bottle was used for water sampling. The bottle was rinsed prior to sample collection. While rigorous width- and depth-integrated sampling protocol was not followed, an attempt at collecting integrated samples was made by collecting at intervals across the entire width of the stream or river (width integration). We collected samples below riffles or white water—natural zones of mixing—as a proxy for depth integration. The filled 1-liter bottles were capped and shaken prior to collecting sub-samples from them. Sub-samples were collected in polypropylene bottles rinsed on site with unfiltered water for unfiltered water samples and with filtered water for filtered samples. Bottles for acidified samples were pre-rinsed in the laboratory with a 10 percent nitric acid solution. In all cases, care was taken at each site to minimize contamination by rinsing bottles and equipment; and by using new, unpowdered vinyl gloves, disposable equipment (filters, syringes, etc.), and clean plastic sheets to cover on-site work areas.

At most sites, three sub-samples were collected: (1) an unacidified, filtered raw water sample (FU) for anion analysis, (2) an acidified, unfiltered sample (RA) for trace and major cation analysis of both dissolved and suspended species, (3) an acidified, filtered sample (FA) for trace and major cation analysis of dissolved species. The unacidified samples were kept in an iced cooler in the field and in a refrigerator in the laboratory prior to analysis. Samples were filtered with sterile 0.45-micron disposable filters and acidified to $\text{pH} < 2$ with ultra-pure, concentrated nitric acid to prevent precipitation of metals and bacterial growth.

At a few sites in the 1996 study (principally hot springs) water was collected for ferrous iron content. Sample collection bottles were protected from direct sunlight. The ferrous iron water samples were filtered as described above; collected in opaque, dark brown polypropylene bottles to prevent light penetration; and acidified with ultra-pure, concentrated hydrochloric acid to $\text{pH} < 2$. For the 2001 study, ferrous iron was determined on all samples using field-portable kits, described below under the Analytical Techniques section.

Mercury was not determined on water samples collected in the 1996 study. However, in 2001 water samples for Hg analysis were collected. At each water sample site, a filtered (0.45 micron disposable filter), preserved ($\text{K}_2\text{Cr}_7\text{O}_7\text{-HNO}_3$) sample was collected in an acid-rinsed (HNO_3) glass bottle with Teflon lid.

Other water data collected and recorded on-site include temperature, pH, conductivity, dissolved oxygen content, an estimate of the water flow rate, and total alkalinity. Conductivity and pH were collected with Orion meters calibrated with standards at each site prior to sample measurement. For pH, two calibration buffer standards that bracketed the sample's pH were used. Dissolved oxygen content was determined using a field-portable CHEMetrics, Inc. colorimetric test kit. Total alkalinity measurements were collected from using a field-portable CHEMetrics, Inc. titration kit. Alkalinity is a measure of total acid-neutralizing capacity of water and is reported in ppm as CaCO_3 . Alkalinities for all 1996 water samples were determined with the field kit. Alkalinities for 2001 water samples were determined with the field kit, but for those samples with alkalinity concentrations below 25 ppm an additional unfiltered, unacidified sample was collected and refrigerated for laboratory analysis.

Flow rates were not calculated, but rather are ballpark estimates and should be used conservatively. These flow estimates were determined by the 3 river guides on the trip, whose combined river floating experience totaled over 90 years, with much of that experience on Idaho rivers. Later, the flow estimates for the Middle Fork, the Main Salmon, and Panther Creek were compared with published flow records for the 1996 sampling period (Brennan and others, 1996), with unpublished records maintained by the Middle Fork Ranger District, and with provisional flow data for the 2001 sampling period available from the U.S. Geological Survey Water Resources Discipline website (<http://id.waterdata.usgs.gov/>). The flow estimates for the 1996 study were found to be within $\pm 25\%$ and for the 2001 study were found to be within $\pm 12\%$ at locations where flows are officially recorded.

ANALYTICAL TECHNIQUES

A large number of chemical elements were determined, using a variety of quantitative and semi-quantitative analytical techniques. [Table 2](#) shows the various elements determined and analytical methods used for each of the sample media collected in the study. A brief description and published references for each analytical method is given below. Descriptions and quality assurance/quality control (QA/QC) protocol for most of the analytical methods used in this study are found in Arbogast (1996) and Taggart (2002). U.S. Geological Survey laboratories analyzed all water and heavy-mineral concentrate samples. Stream sediment samples were analyzed by XRAL Laboratories, Inc. of Don Mills, Ontario, Canada, under a contract with the U.S. Geological Survey.

Table 2. Elements determined and analytical methods used for all sample media. [method codes: MW, water by ICP mass spectrometry; EW, water by ICP atomic emission spectrometry; IC, water by ion chromatography; AF, atomic fluorescence spectrometry, CO, colorimetry, TI, titration, ET, solid by ICP atomic emission spectrometry; EP, solid by partial-extraction ICP atomic emission spectrometry; FA, fire assay atomic absorption; HY, solid by hydride generation atomic absorption spectrometry; CV, solid by cold-vapor atomic absorption spectrometry; CT, coulometric titration; LE, Leco analyzer; DI, for organic carbon, the calculated difference between LE and CT values; ES, solid by semi-quantitative emission spectrography]

Sample Media	Method	Elements determined
Water, filtered/acidified (FA) and unfiltered/acidified (RA)	MW	Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Ho, In, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Pr, Rb, Re, Sb, Se, Si, Sm, Sn, SO ₄ ²⁻ , Sr, Ta, Tb, Te, Th, Tl, Tm, U, V, W, Y, Yb, Zn, Zr
	EW	Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Si, Sr, Ti, V, Zn
Water, Filtered/not acidified (FU)	IC	Cl ⁻ , F ⁻ , NO ₃ ⁻ , SO ₄ ²⁻
Water, Filtered/preserved (HG)	AF	Hg
Water, Filtered/acidified (FE)	CO	Fe ²⁺
Water, unfiltered/not acidified (ALK)	TI	Alkalinity
Stream Sediments	ET	Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Ga, Ho, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Sc, Sn, Sr, Ta, Th, Ti, U, V, Y, Yb, Zn
	EP	Ag, As, Au, Bi, Cd, Cu, Mo, Pb, Sb, Zn
	FA	Au
	HY	As, Sb, Se, Te, Tl
	CV	Hg
	CT	CO ₂
	TI	FeO
	LE	total carbon, total sulfur
	DI	organic carbon
Heavy Mineral Concentrates	ES	Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Ge, La, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Pd, Pt, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, Zr

In this study, quality assurance/quality control (QA/QC) concerns were addressed through the use of internal reference standards, field blanks, sample site duplicates, and analytical duplicates. QA/QC samples comprised approximately 10 percent of the total number of samples analyzed. Reference standards were interspersed with batches of samples and the analyses of the reference standards were checked to assure that reported values were within ± 20 percent of the accepted values. Analytical duplicates were interspersed with batches of samples and the analyses of the duplicates were checked to assure that the relative standard deviation (RSD) between duplicates was no greater than 20 percent. Water samples included field blanks of de-ionized water, used to check for contamination from sampling equipment and preservatives. Field blanks were collected near the beginning, midway, and near the end of the sampling period, following the same procedures as those used for normal water samples. Sediment and water sample site duplicates were collected randomly. The site duplicates were

collected following the same procedures as those used for normal water and sediment samples. Only the sample site duplicate analyses are retained in the published data files.

In the data files for the various sample media, discrepancies in element concentration for the same sample determined by different analytical methods (for example, gold) may be attributable to the particulate nature of certain elements, different sample weights used, different dissolution and extraction procedures, and to instrumental bias. For gold in particular, the fire assay atomic absorption spectrometric (FA) analytical method provides the most statistically representative results, due to the larger sample weight analyzed and lower determination limits.

For simplicity, reporting units for all sample media are percent (%), parts per million (ppm), or parts per billion (ppb). Water sample analyses, which are commonly reported in the literature as milligrams per liter or micrograms per liter, are given here as ppm or ppb, respectively.

Techniques Used on Stream Sediment and Concentrate Samples

Inductively Coupled Plasma-Atomic Emission Spectrometry—Stream Sediments

Two ICP-AES methods were used in the study for multi-element analyses of stream sediments. The first method, a 40-element total digestion method (designated "ET" in [Table 2](#) and in the data files), was used on all 1996 and 2001 stream sediment samples. The second method, a 10-element, partial-extraction method (designated "EP" in [Table 2](#) and in the data files), was used only on the 1996 samples.

In the first multi-element method (ET), 40-element ICP-AES, samples were digested and analyzed following the procedure of Briggs (1996). Samples (0.2 g) were digested using a mixture of hydrochloric, nitric, perchloric, and hydrofluoric acids, and the solutions were heated at 110° C until dry. Additional perchloric acid and water were added to the residue and the mixture was then taken to dryness at 150° C. Aqua regia and dilute nitric acid were added to the residue to bring the solution to a final volume, the solution was heated at 95° C for an hour, and then, after cooling, the sample was aspirated into the argon plasma and element concentrations were determined simultaneously with a multi-channel ICP-AES instrument. Calibration is performed by standardizing with digested rock reference materials and with a series of multi-element solution standards. Limits of determination for 40-element ICP-AES are shown in [Appendix Table A1](#). *Analytical Performance:* Data were deemed acceptable if recovery for all 40 elements was $\pm 15\%$ at five times the Lower Limit of Determination (LOD) and the calculated Relative Standard Deviation (RSD) of duplicate samples was no greater than 15%.

In the second multi-element method (EP), concentrations of Ag, As, Au, Bi, Cd, Cu, Mo, Pb, Sb, and Zn were determined on samples by a 10-element ICP-AES partial extraction procedure developed by Motooka (1996). This procedure solubilizes metals not tightly bound in the silicate lattice of rocks, soils, and stream sediments; metals tightly bound in highly resistant minerals are not extracted. Samples (1 g) were decomposed with concentrated hydrochloric acid and hydrogen peroxide in a hot-water bath. Metals were extracted in diisobutyl ketone (DIBK)/Aliquat 336 in the presence of ascorbic acid and potassium iodide. The DIBK/Aliquat 336 phase was then aspirated directly into the argon plasma and element concentrations were determined simultaneously with a multi-channel ICP-AES instrument. Limits of determination for 10-element ICP-AES are shown in [Appendix Table A2](#). It is important to note that this procedure is a partial digestion and depending on element availability, results may be biased low when compared to other methods of analyses. In addition, high Cu content in samples can cause interferences for elements determined by this method; for samples with high Cu content, data by

this method should be used cautiously (J. M. Motooka, U.S. Geological Survey, oral commun., 1995). For the above and other reasons, this method was not used for samples collected in the 2001 study. *Analytical Performance:* Data were deemed acceptable if recovery for all 10 elements was $\pm 20\%$ at five times the LOD and the calculated RSD of duplicate samples was no greater than 20%.

Atomic Absorption Spectrometry—Stream Sediments

Several atomic absorption spectrometric (AAS) methods were used for determining antimony, arsenic, gold, mercury, selenium, tellurium, and thallium in stream sediment samples. Determination limits for these techniques are given in [Appendix Table A2](#).

Arsenic and antimony in stream sediment samples were determined atomic absorption spectrometry by XRAL, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in Hageman and Welsch (1996) and Hageman and others (2002). A 0.1 g sample was weighed out into a zirconium crucible and approximately 0.75 g of sodium peroxide was added. The mixture was heated in a muffle furnace at 750°C for four minutes, the cooled. Fifteen ml of water and 5 ml of concentrated HCl was added and the mixture was shaken. Then 0.25 ml of an ascorbic acid-potassium iodide solution was added. The solution was diluted with 20% HCl and stood overnight. Arsenic and antimony were then measured using hydride generation atomic absorption spectrometry. The optimum concentration ranges without sample dilution for these elements in various solid phase sample media are: As-0.6 ppm to 20 ppm and Sb-0.6 ppm to 20 ppm. This method is designated HY in [Table 2](#) and in the data files. *Analytical Performance:* Data were deemed acceptable if recovery of As and Sb was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

Gold in stream sediments was determined by graphite furnace atomic absorption spectrometry for samples collected prior to 1997, and by fire assay atomic absorption spectrometry for samples collected in 1997 and later. In the graphite furnace method, samples were digested using a hydrobromic acid-bromine digestion, an MIBK extraction, and then gold was determined on the solutions by atomic absorption (O'Leary and Meier, 1996). In the fire assay method (XRAL Laboratories, Inc.), a mixture of finely pulverized sample with about three parts of a flux are fused until the product is molten. A lead compound in the flux is reduced by other flux constituents to metallic lead. The metallic lead collects all gold, together with silver, platinum metals, and small quantities of certain base metals present in the sample and falls to the bottom of the crucible to form a lead button. The choice of a suitable flux depends on the character of the ore. The lead button is cupelled to oxidize the lead leaving behind a dore bead containing the precious metals. The dore bead is then transferred to a test tube, dissolved with aqua regia, diluted to a specific volume and determined by atomic absorption spectrometry. The graphite furnace Au and fire assay Au methods are collectively designated FA in [Table 2](#) and in the data files. *Analytical Performance:* Data were deemed acceptable if recovery of gold was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

Mercury in stream sediment samples was determined cold vapor atomic absorption by XRAL, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in O'Leary and others (1996). Mercury was determined by weighing out 0.1 g of sample and digesting it with a mixture of nitric and hydrochloric acids. Potassium permanganate, sulfuric acid and potassium persulphate were added to the solution, followed by a NaCl-hydroxylamine solution. The solution was diluted to 25mL, mixed

thoroughly, allowed to settle, and then transferred to the auto sampler rack of the Perkin-Elmer Flow Injection Mercury System (FIMS-100), a cold-vapor atomic absorption mercury analyzer. Mercury concentration in the solution was determined after liberating the mercury as vapor using stannous chloride reducing agent. This method is designated CV in [Table 2](#) and in the data files. *Analytical Performance:* Data were deemed acceptable if recovery of mercury was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

Selenium in stream sediment samples was determined by continuous-flow hydride generation AAS by XRAL, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in Hageman and Welsch (1996) and Hageman and others (2002). The samples (0.25 g) were digested by adding concentrated nitric, perchloric, and hydrofluoric acids and heating. After cooling, hydrochloric and nitric acids were added and the solutions again heated and cooled. The samples were diluted and selenium concentration was determined using a hydride generation atomic absorption spectrometer. This method is designated HY in [Table 2](#) and in the data files. *Analytical Performance:* Data for selenium were deemed acceptable if recovery of that element was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

Tellurium was determined by weighing 0.25 g of sample into a Teflon tube, adding a mixture of nitric, hydrofluoric, and perchloric acids and heating. After the solution cooled, hydrochloric and nitric acids were added, the solution was heated again, and cooled. The samples were diluted and analyzed using hydride-generation atomic absorption spectrometry, by XRAL Laboratories, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in O'Leary (1996). This method is designated HY in [Table 2](#) and in the data files. *Analytical Performance:* Data for tellurium were deemed acceptable if recovery of that element was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

Thallium was determined by weighing 0.1g of sample into a zirconium crucible, adding 0.75g of sodium peroxide, and mixing. The mixture was heated in a muffle furnace set at 750° C for four minutes and then cooled. Then 15 ml of water and 5 ml of concentrated HCl was added. The mixture was shaken and 0.25 ml of an ascorbic acid-potassium iodide solution was added. The solution was then diluted with 20% HCl and stood overnight. Thallium concentration was determined using hydride generation atomic absorption spectrometry by XRAL Laboratories, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in O'Leary (1996). This method is designated HY in [Table 2](#) and in the data files. *Analytical Performance:* Data for thallium was deemed acceptable if recovery of that element was $\pm 20\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 20%.

LECO Analyzer—Stream Sediments

A LECO analyzer was used to determine total carbon and total sulfur in stream sediments. Total carbon in geologic materials was determined by XRAL Laboratories, Inc., using an automated analyzer. The method is similar to that of Brown and Curry (2002a). A 0.25 g sample was combusted in an oxygen atmosphere at 1370°C to oxidize carbon to carbon dioxide. Moisture and dust were removed and the carbon dioxide gas was measured by a solid state infrared detector. The operating range for total carbon is from 0.05% to about 30%. This method is designated LE in [Table 2](#) and in the data files. *Analytical Performance:* Data were deemed acceptable if recovery of total carbon was $\pm 15\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater the 15%.

Total sulfur was determined by XRAL Laboratories, Inc., using an automated analyzer. The method is similar to that of Brown and Curry (2002b). A 0.25 g sample was mixed with iron chips and LECOCEL and was heated in a combustion tube in a stream of oxygen at high temperature. Sulfur was oxidized to sulfur dioxide. Moisture and dust were removed and the sulfur dioxide gas was then measured by an infrared detector. The reporting range for total sulfur is from 0.05% to about 35%. This method is designated LE in [Table 2](#) and in the data files. *Analytical Performance:* Data were deemed acceptable if recovery of total sulfur was $\pm 15\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 15%.

Titration—Stream Sediments

Stream sediment samples collected in 2001 were analyzed for ferrous iron (FeO) using a titration method by XRAL Laboratories, Inc., using a method that demonstrates an analytical performance identical to or exceeding the performance described in Papp and others (1996a). A 0.5 gram sample was digested using a mixture of sulfuric, hydrofluoric, and hydrochloric acids. The solution was titrated with potassium dichromate using sodium diphenylamine sulphonate as an indicator. The lower reporting limit is 0.01% FeO. This method is designated TI in [Table 2](#) and in the data files. *Analytical Performance:* The data were be deemed acceptable if recovery of FeO was $\pm 15\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 15%. Organic carbon was determined arithmetically as the difference between total carbon and carbonate carbon.

Coulometric Titration—Stream Sediments

Carbonate carbon was determined as carbon dioxide by coulometric titration (Papp and others, 1996b), by XRAL Laboratories, Inc. The sample was treated with hot 2N perchloric acid and the evolved carbon dioxide was passed into a cell containing a solution of monoethanolamine. The carbon dioxide, quantitatively absorbed by the monoethanolamine, was coulometrically titrated using platinum and silver/potassium-iodide electrodes. The lower reporting limit is 0.01% carbon dioxide and samples containing up to 50% carbon dioxide may be analyzed. Sample size was adjusted from 0.5 g for the range 0.01 to 5% carbon dioxide, 0.1 g for the range 5 to 10% carbon dioxide, and 0.02 g for greater than 10% carbon dioxide. This method is designated CT in [Table 2](#) and in the data files. *Analytical Performance:* Data were be deemed acceptable if recovery for carbonate carbon was $\pm 15\%$ at five times the lower limit of determination and the calculated percent RSD of duplicate samples was no greater than 15%.

Organic carbon was determined arithmetically as the difference between total carbon and carbonate carbon.

Semiquantitative Emission Spectrography—Concentrates

The minus-20-mesh nonmagnetic heavy-mineral-concentrate samples were analyzed for 37 major, minor, and trace elements by a direct-current arc, semiquantitative emission spectrographic (SES) technique (Adrian and others, 1996). Spectrographic results were determined by visually comparing spectra derived from the sample and recorded on photographic film against spectra obtained from laboratory reference standards. Standard concentrations are geometrically spaced over any given order of magnitude as follows: 100, 50, 20, 10, 5, 2 etc. Samples whose concentrations were estimated to fall between those values were assigned values of 70, 30, 15, 7, 3, 1.5 etc. Elements determined by SES are Ag, As, Au, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Ge, La, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, Pd, Pt, Sb, Sc, Sn, Sr, Th, Ti, V, W, Y, Zn, and Zr. This method is designated ES in [Table 2](#) and in the data files. Limits of determination for elements determined by SES are listed in [Appendix Table A3](#). Analytical

Performance: The precision of this analytical technique is approximately \pm one reporting interval at the 83 percent confidence level and \pm two reporting intervals at the 96 percent confidence level (Motooka and Grimes, 1976).

Techniques Used on Water Samples

Inductively Coupled Plasma-Atomic Emission Spectrometry

Acidified water samples were analyzed for major (Al, Ca, Fe, K, Mg, Na, and Si) and selected trace elements following the ICP-AES method of Briggs and Fey (1996), revised in Briggs (2002) (designated EW in [Table 2](#) and in the data files). Water samples were aspirated directly into an argon plasma and element concentrations were determined by ICP-AES. Limits of determination for the multi-element ICP-AES method for water samples are shown in [Appendix Table A4](#). *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Ion Chromatography

The anions Cl^- , F^- , NO_3^- , and SO_4^{2-} were determined sequentially by ion chromatography on unfiltered, unacidified water samples following the methods of d'Angelo and Ficklin (1996) and Theodorakos (2002a). The raw water samples were kept cool from the time of collection until they were analyzed. The samples were injected into an ion chromatograph where ions of interest separate along an ion exchange separator column at different rates, depending on the affinity of each species for the ion-exchange resin. Samples then passed into a flow-through conductivity cell where the anions were detected and their peak heights were recorded. Unknown samples were compared with peak heights of calibration standards to determine sample concentrations. This method is designated IC in [Table 2](#) and in the data files. Limits of determination for anions in raw water samples are shown in [Appendix Table A5](#). *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Inductively Coupled Plasma-Mass Spectrometry

Acidified-filtered and acidified-unfiltered waters were analyzed to determine over 50 elements by ICP-MS using a method developed by the U.S. Geological Survey (Meier and others, 1994; method revised in Lamothe and others, 2002). This method is designated MW in [Table 2](#) and in the data files. The method is used to determine numerous elements directly in the water sample without the need for preconcentration or dilution. Element detection limits are in the sub-part-per-billion range and the working linear range is six orders of magnitude or more. By using derived response curves, percent of ionization, and natural isotopic abundances, estimates of concentrations for the elements can be determined in samples without the need of a calibration standard for every element. The method is most useful for trace elements in the parts-per-billion range; analyses for major elements in the parts-per-million range are less accurate and ICP-AES data should be used. Limits of determination for ICP-MS are shown in [Appendix Table A6](#). *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Ferrous Iron by Colorimetry

Through 1999, ferrous iron was determined in the laboratory by colorimetry, using a microprocessor-controlled, single beam Hach spectrophotometer (Hach Company, 1996; Theodorakos, 2002b). This method is designated CO in [Table 2](#) and in the data files. Samples

were introduced into an AccuVac Ampul and mixed quickly. Phenanthroline in the ampul reacts with ferrous iron in the sample to form an orange color in proportion to the ferrous iron concentration. Ferric iron does not react. The ampul was then placed into the spectrophotometer and concentration was measured. For concentrations higher than 3 ppm, solutions were diluted and re-analyzed. The lower limit of determination for this method is 0.01 ppm. *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Starting in 2000, ferrous iron was determined in the field by visual colorimetry, using a portable CHEMets® test method (kit K-6210, CHEMetrics, Inc.; American Society for Testing and Materials, 2001a). Similar to the above laboratory method, in the ferrous iron CHEMets® test method, ferrous iron reacts with 1,10-phenanthroline to form an orange colored complex in proportion to the ferrous iron concentration. The sample was collected in a glass ampul containing the reagent and mixed for 1 minute. Then the ampul was placed into a comparator containing standards of known ferrous iron concentration and the concentration was visually estimated. The lower limit of determination for this method is 0.1 ppm.

Mercury by Flow Injection-Cold Vapor-Atomic Fluorescence Spectrometry

Mercury was determined on 2001 samples only. This method is designated AF in [Table 2](#) and in the data files. In the laboratory, preserved samples were mixed with stannous chloride. Mercury (II) was reduced to Hg° in a flow injection manifold. The mercury vapor was purged from the aqueous phase with argon, passed through a drying tube, separated, and measured using flow injection cold vapor-atomic fluorescence spectrometry. For water samples, the lower limit of determination for this method is 5 parts per trillion. Operational details on this method are found in Hageman (2002). *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Alkalinity by Titration

On-site alkalinity tests were done on all samples collected throughout the study, using field-portable CHEMets® titration kits (kits K-9810, K-9815, and K-9820, CHEMetrics, Inc.), following the method of the American Society for Testing and Materials (2001b). For 2001 water sites having low alkalinities (< 25 ppm as CaCO_3), samples were also collected for laboratory alkalinity determination. The laboratory method is designated TI in [Table 2](#) and in the data files. In the laboratory, an Orion 960 Autochemistry System was used for endpoint titration analysis. The titrant was added to 50 ml of sample until a pH of 4.5 was achieved. Alkalinity was then calculated and reported in units of ppm as CaCO_3 . The lower limit of determination for this method is 1 ppm. Operational details on this method are found in Theodorakos (2002c). *Analytical Performance:* Data were deemed acceptable if recovery was $\pm 10\%$ at five times the LOD and the calculated percent RSD of duplicate samples was no greater than 10%.

Which Technique Should I Use?

In some instances, the same elements were determined by more than one analytical technique ([Table 2](#)). This section is provided as guidance for those cases where multiple values are listed for a given element in a sample. Filtered/acidified and unfiltered acidified water samples were analyzed by both ICP-MS and ICP-AES. In general, the ICP-AES method is more quantitative and data from this method is preferred over ICP-MS in those instances where values

are given by both methods. This is particularly true for the major elements Al, Ca, Fe, K, Mg, Na, and Si, where concentrations commonly exceeded the dynamic range of the ICP-MS instrument. For solid sample media, gold analyses by fire assay/graphite furnace atomic absorption are in all cases preferred over gold values reported by ICP-AES methods. As described above, high copper content in stream sediment samples can cause interferences on other elements in the 10-element, partial extraction ICP-AES method (EP). In these instances, the total extraction ICP-AES method (ET) is preferred for these elements. Analyses of stream sediments for As and Sb by hydride-generation atomic absorption spectrometry (HY) are preferred over the 10-element ICP-AES method (EP).

DESCRIPTION OF DATA FILES

The analytical data files are provided in two formats, as a Microsoft Access 2000 database and as separate Microsoft Excel .XLS files (version 3.0). The data in the Access database are arranged as a series of tables. The tables and their brief descriptions follow below. For those not using Microsoft Access 2000, the tables are saved as separate .XLS files with the same name and fields. The following abbreviations are used in the tables: FeOx, iron oxide; MnOx, manganese oxide; ppt, precipitate.

FIELD NUMBERS

The field number coding scheme is as follows: The first two numbers indicate the year the sample was collected. The next two letters (SA) indicate samples from Salmon National Forest. The next 3 digits indicate the sample site number. Collectively, these three parameters comprise the Site ID. Following the 3-digit number are suffixes indicating sample media type and, if applicable, QA/QC samples. The Site ID and media suffix together comprise the sample field number.

<i>Media</i>	<i>Suffix</i>
Stream sediment	S
Heavy-mineral concentrate	C
Filtered/unacidified water, for anion analysis	FU
Unfiltered/acidified water, for cation analysis	RA
Filtered/acidified water, for cation analysis	FA
Water for ferrous iron analysis, for ferrous iron analysis	FE
Unfiltered/unacidified water, for alkalinity analysis	ALK
Filtered/acidified water, for mercury analysis	HG

For QA/QC samples, a “D” suffix immediately following the 3-digit number indicates a sample site duplicate. These suffixes precede the sample media type suffix. Thus, field number 96SA072S indicates a sediment sample from site 96SA072, while field number 96SA072DS indicates a site duplicate of the same.

COORDINATES

Sample site locations are given in the SampleSiteInfo table as both degrees-minutes-decimal seconds and decimal degrees. Initially in the 1996 study (Eppinger and others, 2001), coordinates were determined by digitizing sample locations as plotted on U.S. Geological Survey 1:24,000-scale topographic maps. However, in the 2001 study, the sites were re-occupied and

sample site coordinates were determined with a Global Positioning System (GPS) unit. The 2001 GPS coordinates are preferred and provided here. The datum and spheroid used are WGS84.

GEOCHEMICAL ANALYSES

All geochemical data are given in the following format. Field identifiers consist of a single line. The first one or two letters give the chemical element symbol, then units of measurement, and finally a code for the analytical method used for the element in that particular column. These three items are separated by underscores. Element symbols and associated names are shown in the appendix. Units of measurement are: PPM, parts per million; PPB, parts per billion; and PCT, percent. The analytical methods and associated code letters are:

- AF atomic fluorescence spectrometry for mercury (water samples)
- CO colorimetric method for ferrous iron (water samples)
- CT coulometric titration for carbonate (solid samples)
- CV cold-vapor atomic absorption spectrometry for mercury (solid samples)
- DI for organic carbon, calculated difference between LE and CT values (solid samples)
- EP inductively coupled plasma-atomic emission spectrometry (partial extraction, solids)
- ET inductively coupled plasma-atomic emission spectrometry (total digestion, solid samples)
- ES semiquantitative emission spectrography (solid samples)
- EW inductively coupled plasma-atomic emission spectrometry (water samples)
- FA fire assay atomic absorption spectrometry (solid samples)
- HY hydride generation atomic absorption spectrometry (solid samples)
- IC ion chromatography (water samples)
- LE LECO analyzer for total carbon and total sulfur (solid samples)
- MW inductively coupled plasma-mass spectrometry (water samples)
- TI titration for alkalinity (water samples)

For example, As_PPM_ET indicates arsenic, in parts per million, determined by total digestion inductively coupled plasma-atomic emission spectrometry. For all geochemical data except heavy mineral concentrates, a negative sign “-“ in front of the value indicates that an element was not observed at the lower limit of determination shown. A blank entry indicates that the sample was not analyzed for that particular element. For heavy mineral concentrate geochemical analyses, the following symbols are used: N (x), not detected at the limit of determination given in parentheses; L (x), detected, but less than the limit of determination given in parentheses; G (x), greater than the upper determination limit given in parentheses. Thus, for the heavy mineral concentrates, values are given as text fields rather than numeric fields in the database tables.

DESCRIPTIONS OF TABLES AND FIELDS WITHIN TABLES

Below are brief descriptions of the various tables and fields contained within the tables. First are tables containing sample and site descriptive information, next are tables containing chemical analyses. Following those is a table with fields specific to the wildfire study. Fields common to all or most tables are listed together. Fields unique to specific tables are listed below those tables.

Tables containing sample and site descriptive information

<i>Table</i>	<i>Description</i>
SAMPLOG	table of all sample sites and the sample media collected at each site

<i>Fields:</i>	<i>Field Type:</i>	<i>Contents:</i>
Site_ID	text	sample site identifier (field is common to all tables)
QA/QC_Sample	text	QA/QC sample site duplicate
Water_FU	number	filtered (0.45 micron), unacidified water
Water_RA	number	unfiltered, acidified (HNO ₃) water
Water_FA	number	filtered (0.45 micron), acidified (HNO ₃) water
Water_FE2+	number	filtered (0.45 micron), acidified (HCl) water for Fe ²⁺ analysis performed in the laboratory
Water_HG	number	filtered (0.45 micron), preserved (K ₂ Cr ₇ O ₇ -HNO ₃) water for Hg analysis
Water_ALK	number	unfiltered, unacidified water for alkalinity performed in the laboratory
Stream_Sed	number	stream sediment sample (minus 80 mesh)
Concentrate	number	heavy-mineral concentrate sample (minus 20 mesh)
Notes	text	any additional notes regarding samples collected

Table

SITEINFO

Description

information relevant to all sample sites

<i>Fields:</i>	<i>Field Type:</i>	<i>Contents:</i>
Site_ID	text	sample site identifier (field is common to all tables)
LatDeg	number	latitude, degrees
LatMin	number	latitude, minutes
LatSec	number	latitude, decimal seconds
LongDeg	number	longitude, degrees
LongMin	number	longitude, minutes
LongSec	number	longitude, decimal seconds
LatitudeDD	number	latitude in decimal degrees
LongitudeDD	number	longitude in decimal degrees
XY_Error_ft	number	location error in X and Y directions as given by GPS unit, in feet
Datum	text	datum for latitude/longitude
Spheroid	text	spheroid for latitude/longitude
Elev_ft	number	elevation at sample site, in feet; from 1:24,000 topographic map
7_1/2_Quad	text	7.5' USGS quadrangle on which the site is located
County	text	county that site is located in
Date_Coll	date/time	date of sample collection at site
Time_Coll	date/time	time of sample collection at site
Location_Info	text	brief sample location descriptor
Site_Descript	text	brief sample site descriptor
Deposit_Type	text	brief description of mineral deposit(s) located upstream of sample site
Deposit_Name	text	name of deposit(s) located upstream of site
Mine_District	text	mining district name
Weather	text	weather at time of sample collection
Air_Temp_C	text	air temperature (Celsius) at time of collection

Geol_Bedrock	memo	description of bedrock geology at the site
Contamination	text	description of anthropogenic contamination at site
Other_Info	text	additional information about site

Table

Description

WATSITEI

information relevant specifically to water sample sites

<i>Fields:</i>	<i>Field Type:</i>	<i>Contents:</i>
Site_ID	text	sample site identifier (field is common to all tables)
Temp_C	number	water temperature at collection site, degrees Celsius
Flow_Rate	number	estimated water flow rate (ball-park estimate)
Flow_Units	text	units of measurement for flow (gpm, gallons per minute; cfs, cubic feet per second)
pH	number	water pH at collection site
Conduct_uS/cm	number	water conductivity at collection site, in microsiemens per centimeter
Turbidity_FTU	number	turbidity of sampled water, formazine turbidity units (equivalent to nephelometric turbidity units), collected for 2001 samples only
Turbidity_Qual	text	qualitative estimate of water turbidity
Diss_O2_ppm	number	dissolved oxygen in water at collection site, in ppm
Water_Source	text	source of water samples collected
Type_of_Site	text	water sample site descriptor
Water_Color	text	color of sampled water
Water_Odor	text	odor of sampled water
Channel_Bed	text	brief description of water channel bed
Other_Notes	text	additional descriptive information for sample or site

Tables containing geochemical analyses

The following fields are common to all or most tables containing geochemical analyses:

<i>Fields:</i>	<i>Field Type:</i>	<i>Contents:</i>
Site_ID	text	sample site identifier (field is common to all tables)
Field_No	text	sample field number; this is the site identifier with applicable QA/QC suffix and sample media suffix; for example 96SA072DFA
Lab_No	text	laboratory-assigned sample number; this is the sample record ID in the USGS National Geochemical Database
Actual_Sample	text	description of actual sample analyzed, following sample preparation
QA/QC_Info	text	quality assurance/quality control information

For the following tables, geochemical analyses follow the common fields described above. Format for the geochemical analyses are as described above in the **GEOCHEMICAL ANALYSES** section. Except for the heavy mineral concentrate data, all geochemical analyses are given as **numeric fields** with a negative sign (“-“) replacing “less than” (“<“) qualifiers. For heavy

mineral concentrates, the geochemical analyses are given as **text fields** because of the qualifiers N, L, and G.

<i>Table</i>	<i>Description</i>
WATANI	anion analyses, filtered/unacidified, refrigerated water
WATCATFA	cation analyses, filtered/acidified water
WATCATRA	cation analyses, unfiltered/acidified water
WATHG	mercury analyses, filtered/preserved water

The following fields are unique to specific tables:

<i>Table</i>	<i>Description</i>
WATFE2+	Fe ²⁺ analyses, filtered/acidified water
<i>Fields:</i>	<i>Field Type: Contents:</i>
Fe2+_PPM_CO	number ferrous iron by colorimetric method, analyzed in laboratory, parts per million, done on 1996 hot springs samples and Blackbird Creek only
Fe2+_PPM_FLD	number ferrous iron analyzed in field at collection site with CHEMetrics, Inc. colorimetric test kit, parts per million, done on all 2001 samples only

<i>Table</i>	<i>Description</i>
WATALK	alkalinity analyses, unfiltered/unacidified, refrigerated water
<i>Fields:</i>	<i>Field Type: Contents:</i>
Alk_PPM_TI	number alkalinity by titration, analyzed in laboratory; parts per million as CaCO ₃ , done on 2001 samples having field kit alkalinities of 25 ppm or less
Alk_PPM_FLD	number alkalinity analyzed in field at collection site with CHEMetrics, Inc. titration kit, as parts per million equivalent CaCO ₃ ; done on all 1996 and 2001 samples

<i>Table</i>	<i>Description</i>
HMCONC	heavy-mineral concentrate descriptive and analytical data
<i>Fields:</i>	<i>Field Type: Contents:</i>
Sieve_Size	text sample sieve size as prepared in laboratory
Sample_Descr	text brief sample description
Character	text character of sample: single grab or composite of several increments
Source	text sample collected from outcrop, float, alluvium, etc.
Mineral_Scan	text on-site hand lens examination of panned concentrate

Geochemical analyses follow at this point.

<i>Table</i>	<i>Description</i>
SEDIMENT	sediment descriptive and analytical data
<i>Fields:</i>	<i>Field Type: Contents:</i>

Sample_Descr	text	brief sample description
Character	text	character of sample: single grab or composite of several increments
Source	text	sample collected from outcrop, float, alluvium, etc.
Organic_Cont	text	relative organic content in sample collected
Sieve_Size	text	sample sieve size as prepared in laboratory
Stain_Alluv	text	iron oxide or manganese oxide staining observed on alluvium
Geology_Alluv	text	geologic description of alluvium at sample site

Geochemical analyses follow at this point.

Table containing wildfire study fields

<i>Table</i>	<i>Description</i>	
WILDFIRE	fields containing wildfire information and sorting codes	
<i>Fields:</i>	<i>Field Type:</i>	<i>Contents:</i>
Site_ID	text	sample site identifier (field is common to all tables)
2ndSite_ID	text	secondary descriptive sample site ID, for Middle Fork (MF), Main Salmon (SA), and Panther Creek (PC), with creek name and year collected; DUPE indicates sample site duplicate
Sort_Top_to_Bottom	number	sorting code for grouping 1996 samples together (values 1-83) and equivalent 2001 samples (values as above + 100) together, starting from the upper end of the river and working downstream; order is Middle Fork, then Salmon River, then Panther Creek; example: 2 is Sulphur Creek on the Middle Fork in 1996, 102 is same site in 2001; no entry for sample site duplicates or unique samples
Sort_Sites_Together	number	sort code for grouping 1996 and 2001 samples together next to one-another (1996 sample followed by equivalent 2001 sample); Middle Fork (values < 100), Main Salmon (values 101 to 122), and Panther Creek (values > 200); includes sample site duplicates and unique samples
Potential_Fire_Effects	text	qualitative estimate of 2000 wildfire effects in drainage basin above site, from B. Rieffenberger; Sig, significant; Min, minimal; Dnb, did not burn; ?, unknown

PHOTOGRAPHS

Digital photographs were taken by R.G. Eppinger at each sample site in the 2001 study. Unfortunately, photographs were not taken at these sites in the initial 1996 study. The 2001 photographs are listed in Table 3 and provided as .PDF files. The filenames are the same as the sample site ID number. Multiple photographs from a given site are listed with a numeric suffix. For example, filename 01SA240.PDF is a photograph of the sample collection locality at site 01SA240, while filename 01SA254-2.PDF is the second of a series of photographs from site

01SA254. Photographs were formatted as 3.75 in X 5 in, 150 dpi. All photograph files are located in the PHOTOS folder.

Table 3. List of sample site photographs. [photographs are in the PHOTOS folder].

Sample Site Number	Description	Sample Site Number	Description
	Middle Fork Drainage		
01SA240	Middle Fork above Sulphur Creek	01SA272	Middle Fork above Waterfall Creek
01SA241	Sulphur Creek near mouth	01SA273-1	Waterfall Creek near mouth
01SA242	Elkhorn Creek near mouth	01SA273-2	Waterfall Creek near mouth
01SA243	Soldier Creek near mouth	01SA274	Big Creek near mouth
01SA244	Fire Island hot spring	01SA275	Middle Fork above Papoose Creek
01SA245	Middle Fork above Greyhound Creek	01SA276-1	Papoose Creek near mouth
01SA246	Greyhound Creek near mouth	01SA276-2	Papoose Creek near mouth
01SA247	Middle Fork above Rapid River	01SA276-3	Papoose Creek near mouth
01SA248	Rapid River near mouth	01SA277	Ship Island Creek near mouth
01SA249	Middle Fork above Lake Creek	01SA278	Parrot Creek at mouth
01SA250-1	Pistol Creek looking downstream from pack bridge near mouth	01SA279	Middle Fork above Stoddard Creek
01SA250-2	Pistol Creek looking upstream from pack bridge near mouth	01SA280	Stoddard Creek near mouth
01SA250-3	Pistol Creek pack bridge	01SA281	Roaring Creek near mouth
01SA250-4	Pistol Creek campsite	01SA282-1	Color Creek near mouth
01SA251	Middle Fork above Indian Creek	01SA282-2	Color Creek near mouth
01SA252	Indian Creek near mouth	01SA283	Goat Creek near mouth
01SA254-1	Little Soldier Creek at mouth	01SA284	Middle Fork above Main Salmon River
01SA254-2	Little Soldier Creek at mouth		Main Salmon Drainage
01SA255	Marble Creek near mouth	01SA285	Kitchen Creek near mouth
01SA256	Middle Fork above Little Loon Creek	01SA286	Butts Creek near mouth
01SA257-1	Little Loon Creek at mouth	01SA315	Corn Creek near mouth
01SA257-2	Little Loon Creek at mouth	01SA316	Colson Creek about 1/2 mi above mouth
01SA258	Middle Fork above White Creek	01SA317	Lake Creek at confluence with Main Salmon
01SA259	White Creek near mouth	01SA318	Owl Creek about 1/4 mi above mouth
01SA260	Loon Creek near mouth	01SA319	Main Salmon below Cove Creek bridge
01SA261	Loon Creek hot springs	01SA320-1	Looking upstream, Main Salmon about 1/4 mi above Panther Creek
01SA262	Middle Fork above Norton Creek	01SA320-2	Looking downstream, Main Salmon about 1/4 mi above Panther Creek
01SA263	Norton Creek at mouth from across Middle Fork	01SA321	Pine Creek near mouth
01SA264	Grouse Creek near mouth	01SA322	Big Sheepeater Creek near mouth
01SA265	Middle Fork above Camas Creek	01SA323	Boulder Creek near mouth
01SA266	Camas Creek near mouth	01SA324	Spring Creek near mouth
01SA267	Middle Fork above Sheep Creek	01SA325	East Boulder Creek near mouth
01SA268	Sheep Creek at mouth	01SA326	Squaw Creek near mouth
01SA269	Brush Creek at mouth	01SA327	Indian Creek near mouth, along Main Salmon River
01SA270	Middle Fork above Wilson Creek	01SA328	Sage Creek near mouth
01SA271	Wilson Creek near mouth	01SA329	Moose Creek near mouth

Table 3. continued.

Sample Site Number	Description	Sample Site Number	Description
	Panther Creek Drainage		
01SA287	Fourth of July Creek near mouth	01SA304-2	Looking downstream, Panther Creek above Beaver Creek
01SA288	Panther Cr. above Fourth of July Cr.	01SA305	Beaver Creek near mouth
01SA289	Porphyry Creek near mouth	01SA306-1	Clear Creek near mouth
01SA290	Musgrove Creek near mouth	01SA306-2	Clear Creek near mouth
01SA291	Moyer Creek near mouth	01SA306-3	New fine sediment with ash, Clear Creek near mouth
01SA292	Panther Creek at McDonald Flat Campground	01SA307-1	Looking upstream, Panther Creek above Garden Creek
01SA293	Woodtick Creek near mouth	01SA307-2	Looking downstream, Panther Creek above Garden Creek
01SA294	Copper Creek near mouth	01SA308	Garden Creek at mouth
01SA295	Panther Creek above Blackbird Creek	01SA309-1	Big Creek hot springs, near mouth of Panther Creek
01SA296-1	Blackbird Creek near mouth	01SA309-2	Big Creek hot springs, near mouth of Panther Creek
01SA296-2	Blackbird Creek near mouth	01SA309-3	Big Creek hot springs, near mouth of Panther Creek
01SA296-3	Blackbird Creek near mouth	01SA310-1	Blackbird Creek above mine and freshwater impoundment pond
01SA296-4	Blackbird Creek near mouth	01SA310-2	Deer skeleton in ash-laden sediment, Blackbird Creek above mine and freshwater impoundment pond
01SA296-5	Blackbird Creek near mouth	01SA311	Big Deer Creek above confluence with South Fork
01SA297-1	Panther Creek above Deep Creek campground	01SA312	South Fork above confluence with Big Deer Creek
01SA297-2	Ash & charcoal in sediment, Panther Creek above Deep Creek campgrnd	01SA313	South Fork above confluence with Bucktail Creek
01SA298	Deep Creek near mouth	01SA314-1	Bucktail Creek above confluence with South Fork
01SA299	Napias Creek above mouth	01SA314-2	Bucktail Creek above confluence with South Fork
01SA300	Big Jureano Creek near mouth	01SA331-1	Panther Creek above Garden Creek, after July 2001 Clear Creek storm event
01SA301-1	Big Deer Creek near mouth	01SA331-2	Ash-laden fine sediment, Panther Creek above Garden Creek, after July 2001 Clear Creek storm event.
01SA301-2	Big Deer Creek near mouth	01SA332-1	Clear Creek near mouth, after July 2001 Clear Creek storm event, compare with photo 01SA306-2.
01SA302	Panther Creek above Big Deer Creek	01SA332-2	Clear Creek near mouth, after July 2001 Clear Creek storm event
01SA303	Trail Creek near mouth	01SA332-3	Clear Creek near mouth, after July 2001 Clear Creek storm event, compare with photo 01SA306-3
01SA304-1	Looking upstream, Panther Creek above Beaver Creek	01SA332-4	Clear Creek near mouth, after July 2001 Clear Creek storm event, compare with photo 01SA306-1

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APPENDIX

Table A1. Limits of determination for stream sediment samples analyzed by 40-element inductively coupled plasma-atomic emission spectrometry, total extraction (ET).

Element	Lower Determination Limit	Upper Determination Limit	Element	Lower Determination Limit	Upper Determination Limit
Percent			Parts Per Million		
Al, aluminum	0.005	50	Ga, gallium	4	50,000
Ca, calcium	0.005	50	Ho, holmium	4	5,000
Fe, iron	0.02	25	La, lanthanum	2	50,000
K, potassium	0.01	50	Li, lithium	2	50,000
Mg, magnesium	0.005	5	Mn, manganese	4	50,000
Na, sodium	0.005	50	Mo, molybdenum	2	50,000
P, phosphorus	0.005	50	Nb, niobium	4	50,000
Ti, titanium	0.005	25	Nd, neodymium	9	50,000
Parts Per Million			Parts Per Million		
Ag, silver	2	10,000	Ni, nickel	3	50,000
As, arsenic	10	50,000	Pb, lead	4	50,000
Au, gold	8	50,000	Sc, scandium	2	50,000
Ba, barium	1	35,000	Sn, tin	50	50,000
Be, beryllium	1	5,000	Sr, strontium	2	15,000
Bi, bismuth	50	50,000	Ta, tantalum	40	50,000
Cd, cadmium	2	25,000	Th, thorium	6	50,000
Ce, cerium	5	50,000	U, uranium	100	100,000
Co, cobalt	2	25,000	V, vanadium	2	30,000
Cr, chromium	2	25,000	Y, yttrium	2	25,000
Cu, copper	2	15,000	Yb, ytterbium	1	5,000
Eu, europium	2	5,000	Zn, zinc	2	15,000

APPENDIX (cont.)

Table A2. Limits of determination for selected elements in stream sediment samples analyzed by other methods. [values are in parts per million unless noted otherwise; EP, partial extraction 10-element inductively coupled plasma-atomic emission spectrometry; FA, fire assay atomic absorption spectrometry; CV, cold-vapor atomic absorption spectrometry; HY, hydride generation atomic absorption spectrometry; LE, Leco analyzer; CT, coulometric titration; TI, titration]

Element	Method	Lower Determination Limit ¹	Upper Determination Limit ^{1,2}
Ag, silver	EP	0.08	400
As, arsenic	EP	1	6,000
Au, gold	EP	0.1	1,500
Bi, bismuth	EP	1	6,000
Cd, cadmium	EP	0.05	500
Cu, copper	EP	0.05	500
Mo, molybdenum	EP	0.1	900
Pb, lead	EP	1	6,000
Sb, antimony	EP	1	6,000
Zn, zinc	EP	0.05	500
Au, gold	FA	0.005	10,000
Hg, mercury	CV	0.02	
As, arsenic	HY	0.6	20
Sb, antimony	HY	0.6	20
Se, selenium	HY	0.2	4
Te, tellurium	HY	0.1	
Tl, thallium	HY	0.1	
CTo, total carbon	LE	0.05 %	30 %
CO ₂ , carbonate	CT	0.01 %	50 %
STo, total sulfur	LE	0.05 %	35 %
FeO, ferrous oxide	TI	0.01 %	

¹ Limits of determination shown here are nominal and limits may vary in the data files. The variability in limits of determination is due to variable sample weight used, dilution of the sample solution, instrumental interference correction, and slight changes in methodology over time.

² Samples containing concentrations greater than the upper limits of determination listed here were diluted and reanalyzed.

APPENDIX (cont.)

Table A3. Limits of determination for nonmagnetic heavy-mineral concentrate samples analyzed by semiquantitative emission spectrography (ES).

Element	Lower Determination Limit	Upper Determination Limit	Element	Lower Determination Limit	Upper Determination Limit
Percent			Parts Per Million		
Ca, calcium	0.1	50	Ge, germanium	20	200
Fe, iron	0.1	50	La, lanthanum	100	2,000
Mg, magnesium	0.05	20	Mn, manganese	20	10,000
Na, sodium	0.5	10	Mo, molybdenum	10	5,000
P, phosphorus	0.5	20	Nb, niobium	50	5,000
Ti, titanium	0.005	2	Ni, nickel	10	10,000
Parts Per Million			Pb, lead	20	50,000
Ag, silver	1	10,000	Pd, palladium	10	2,000
As, arsenic	500	20,000	Pt, platinum	50	2,000
Au, gold	20	1,000	Sb, antimony	200	20,000
B, boron	20	5,000	Sc, scandium	10	200
Ba, barium	50	10,000	Sn, tin	20	2,000
Be, beryllium	2	2,000	Sr, strontium	200	10,000
Bi, bismuth	20	2,000	Th, thorium	200	5,000
Cd, cadmium	50	1,000	V, vanadium	20	20,000
Co, cobalt	20	5,000	W, tungsten	50	20,000
Cr, chromium	20	10,000	Y, yttrium	20	5,000
Cu, copper	10	50,000	Zn, zinc	500	20,000
Ga, gallium	10	10,000	Zr, zirconium	20	2,000

Table A4. Limits of determination for acidified water samples analyzed by inductively coupled plasma-atomic emission spectrometry (EW).

Element	Lower Determination Limit ¹	Upper Determination Limit	Element	Lower Determination Limit ¹	Upper Determination Limit
Parts Per Million			Parts Per Billion		
Al, aluminum	0.01	1,000	Cr, chromium	1	10,000
Ca, calcium	0.1	1,000	Cu, copper	1	10,000
K, potassium	0.1	1,000	Fe, iron	20	10,000
Mg, magnesium	0.1	1,000	Li, lithium	1	10,000
Na, sodium	0.1	1,000	Mn, manganese	1	10,000
Si, silicon	0.1	1,000	Mo, molybdenum	20	10,000
			Ni, nickel	1	10,000
Parts Per Billion			P, phosphorus	100	10,000
Ag, silver	1	10,000	Pb, lead	20	10,000
As, arsenic	100	10,000	Sb, antimony	50	10,000
B, boron	5	10,000	Sr, strontium	1	10,000
Ba, barium	1	10,000	Ti, titanium	50	10,000
Be, beryllium	1	10,000	V, vanadium	1	10,000
Cd, cadmium	1	10,000	Zn, zinc	1	10,000
Co, cobalt	1	10,000			

¹ Limits of determination shown here are nominal and limits may vary in the data files. The variability in limits of determination is due to variable sample weight used, dilution of the sample solution, and instrumental interference correction.

APPENDIX (cont.)

Table A5. Limits of determination for anions in water samples determined by ion chromatography (IC).

Anion	Lower Determination Limit	Upper Determination Limit¹
Parts Per Million		
Cl⁻, chloride	0.08	4
F⁻, fluoride	0.08	2
NO₃⁻, nitrate	0.08	10
SO₄²⁻, sulfate	0.1	20

¹ Samples containing concentrations greater than the upper limits of determination listed here were diluted and re-analyzed.

Table A6. Limits of determination for water samples analyzed by inductively coupled plasma-mass spectrometry (MW).

Element	Lower Determination Limit ¹	Element	Lower Determination Limit ¹
Parts per million (ppm)		Parts per billion (ppb)	
Al, aluminum	0.2	La, lanthanum	0.01
Ca, calcium	0.05	Li, lithium	0.1
K, potassium	0.0005	Mn, manganese	0.01
Mg, magnesium	0.01	Mo, molybdenum	0.02
Na, sodium	0.01	Nb, niobium	0.02
Si, silicon	0.23	Nd, neodymium	0.01
SO ₄ ²⁻ , sulfate	0.3	Ni, nickel	0.1
Parts per billion (ppb)		P, phosphorus	1
Ag, silver	0.01	Pb, lead	0.05
As, arsenic	0.2	Pr, praseodymium	0.01
Au, gold	0.01	Rb, rubidium	0.01
Ba, barium	0.1	Re, rhenium	0.02
Be, beryllium	0.05	Sb, antimony	0.02
Bi, bismuth	0.01	Se, selenium	0.2
Cd, cadmium	0.02	Sm, samarium	0.01
Ce, cerium	0.01	Sn, tin	0.05
Co, cobalt	0.02	Sr, strontium	0.02
Cr, chromium	0.1	Ta, tantalum	0.02
Cs, cesium	0.01	Tb, terbium	0.005
Cu, copper	0.2	Te, tellurium	0.1
Dy, dysprosium	0.005	Th, thorium	0.03
Er, erbium	0.005	Tl, thallium	0.05
Eu, europium	0.005	Tm, thulium	0.005
Fe, iron	1	U, uranium	0.005
Ga, gallium	0.02	V, vanadium	0.1
Gd, gadolinium	0.005	W, tungsten	0.02
Ge, germanium	0.02	Y, yttrium	0.01
Hf, hafnium	0.05	Yb, ytterbium	0.01
Ho, holmium	0.005	Zn, zinc	0.5
In, indium	0.01	Zr, zirconium	0.05

¹ Limits of determination shown here are nominal and limits may vary in the data files. The variability in limits of determination is due to variable sample weight used, dilution of the sample solution, and instrumental interference correction. Upper limits of determination are not shown because samples with high concentrations were diluted and re-analyzed.