Data and Statistical Summaries of Background Concentrations of Metals in Soils and Streambed Sediments in Part of Big Soos Creek Drainage Basin, King County, Washington

By E. A. Prych, D. L. Kresch, J. C. Ebbert, and G. L. Turney

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
acre	0.4047	hectare
square mile (mi^2)	2.590	square kilometer
gallon (gal)	3.785	liter
gallon (gal)	0.003785	cubic meter
cubic foot (ft^3)	0.02832	cubic meter
ounce, avoirdupois (oz)	28.35	gram
pound, avoirdupois (lb)	0.4536	kilogram
Other conversions:		
part per million (ppm)	1.000	milligram per kilogram
part per billion (ppb)	1.000	microgram per kilogram
part per billion (ppb)	1.000	microgram per liter

degree Fahrenheit (^oF) $^oC = 5/9\ (^oF-32)$ degree Celsius (^oC)
degree Celsius (^oC) $^oF = 9/5\ ^oC + 32$ degree Fahrenheit (^oF)

Sea Level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

The State of Washington Department of Ecology (Ecology) needs information on background concentrations of metals in soils to determine if soils at specific sites are contaminated and to evaluate the effectiveness of remedial work at sites of known metals contamination. Consequently, the U.S. Geological Survey, in cooperation with Ecology, conducted a pilot study in Soos Creek Basin to obtain data on the magnitude and variability of concentrations of metals in soils that are unaffected by local anthropogenic metal sources. In addition to providing data for an area where such data are needed, the information from the present study will be useful for planning data-collection programs in other areas.

In 1987, 29 soil samples from 14 holes at 9 sites, and 7 streambed-sediment samples and 3 stream-water samples from 3 sites were collected and analyzed for concentrations of metals, organic carbon, and other selected constituents. Soil samples were collected from a cluster of five holes at one site, from two holes at another site, and from one hole at each of the other sites. At least one soil sample was collected from a depth of less than 12 inches in each hole. Four soil samples from depths as great as 5 feet were collected from each of five holes at three sites. All but one of the nine soil-sampling sites were believed to be unaffected by local anthropogenic metal sources.

Concentrations of 43 metals were determined by a total method, and concentrations of 17 metals were determined by a total-recoverable method, the extraction procedure toxicity (EP-TOX) method, and an American Society of Testing Materials (ASTM) method. The 17 metals included those in the U.S. Environmental Protection Agency list of priority pollutants plus a few other metals of interest.

Ranges in concentrations of metals determined by the total method in this study are within ranges of concentrations determined by others in soils from 1,318 sites in the conterminous United States. Concentrations of most metals as determined by the EP-TOX and ASTM methods, and a few metals determined by the other two methods, are less than laboratory minimum reporting levels. Coefficients of variation of metals concentrations range from 10 to 65 percent for the total method, and from 18 to 81 percent for the total-recoverable method. Mean values of ratios of total to total-recoverable concentrations for most metals range from 1.84 to 8.47. Mean values of the ratios of total or total-recoverable to EP-TOX or ASTM concentrations are greater than 100 for most metals. Mean values of the ratios of EP-TOX to ASTM range from less than 0.4 to about 2.

Concentrations of total organic carbon; of mercury, manganese, phosphorous, lead, selenium, antimony, and zinc as determined by the total method; and of some of these plus other metals as determined by other methods are larger in shallow soil (less than 12 inches) than in deep soil (greater than 12 inches). Areal variability of total and total-recoverable metals concentrations in soil samples from shallow but not deep depths, as indicated by coefficients of variation, in subbasins (up to 13 square miles in size) is one and one half to two times that in clusters (1 acre or less).

Concentrations of total chromium and nickel correlated (correlation coefficient greater than 0.5) with concentrations of total titanium in all, shallow, and deep samples, suggesting that chromium and nickel are associated primarily with the mineral matrix rather than with oxide coatings on particles or with organic material. Concentrations of total lead and zinc correlate with concentrations of total organic carbon in all, shallow, and deep samples, suggesting that these metals may be associated with organic material. Concentrations of total copper and antimony are correlated with concentrations of total organic carbon in the shallow, but not the deep, samples.

Concentrations of total and total-recoverable metals, and of total organic carbon in streambed sediments are more typical of shallow than deep soils. However, maximum observed concentrations of total and total-recoverable cadmium, copper, mercury, manganese, lead, and zinc, and of total arsenic, antimony, and selenium in streambed sediments are as much as twice those in shallow soils.

INTRODUCTION

Existing data on background metals concentrations in soils of the State of Washington are not adequate for determining if soils at specific sites have been contaminated, or the effectiveness of clean-up operations at sites known to have been contaminated with metals. Existing data are inadequate because they are available for only a small number of locations, and they were obtained using a variety of laboratory methods. Consequently, in 1987, the State of Washington Department of Ecology (Ecology) and the U.S. Geological Survey (USGS) began a cooperative study to determine background concentrations of metals in major soil types at various locations in Washington.

This report presents the results of the first phase of this study. The goals for this first phase were to obtain data on the magnitudes and variabilities of metals concentrations in soils that will aid in the design of sampling programs for following phases, while at the same time obtaining metals concentrations in one area of the State where there is an immediate need. Big Soos Creek Basin, in the Puget Sound region of western Washington, was chosen as a study area because (1) the surficial geologic material from which the soils have evolved--glacial drift--is typical of that in most of the Puget Sound region, which is one of the most industrialized and densely populated regions in the State, and where there is a need for data on background concentrations of metals; and (2) the area contains sampling sites that apparently are not affected by local anthropogenic sources of metals. In this phase of the study, soils and streambed sediments from the upper part of the Big Soos Creek drainage basin (fig. 1) were collected and analyzed to determine concentrations of as many as 44 metals (see table 1). Of special interest are antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc, which are listed by the U.S. Environmental Protection Agency (1988) as priority pollutants; aluminum, iron, manganese, and titanium, which can be indicators of the metal content of the mineral matrix or oxide coatings; and barium. For convenience, all elements investigated in this study will hereafter be referred to collectively as metals.

Two general types of laboratory methods for determining metal concentrations in soil are in general use and were used in the present study. In the first type, a substantial fraction of the metal in the soil is extracted using a mixture of strong acids, and the liquid extract is analyzed for metal content. Concentrations determined by methods of this type normally are expressed as a mass of metal per unit mass of dry soil. The fraction of the total amount of a metal removed from a soil sample depends on the strength and composition of the extracting solution. If 95 percent or more of a metal is removed from a sample, the result commonly is referred to as a total concentration (Fishman and Friedman, 1985, p. 50). These types of extractions typically are used for geologic and geochemical applications where knowledge of the total amount of a metal present is necessary. If less than 95 percent of the total amount of a metal is removed from a sample, the analytical result commonly is referred to as a total-recoverable concentration. Many of these types of extractions attempt to simulate processes occurring in nature, such as the uptake of metals by biota, and are widely used in environmental investigations. Because extractants of different strengths and compositions are used, data from different studies often are not comparable.

The other type of analysis done on soil samples is one in which a soil sample is leached with water or a weak acid, and the leachate is analyzed for metals. These analyses, which were designed to simulate leaching by water or landfill leachate percolating through soils or wastes, usually extract a small fraction of the total amount of metals in a sample. Results of these analyses normally are reported as a concentration of metal in the leachate. However, for comparability with total and total-recoverable analyses, metals concentrations obtained by the leaching methods in this study are given both as concentration in leachate and per unit mass of dry soil. A number of different leaching procedures are in use and probably yield different results.

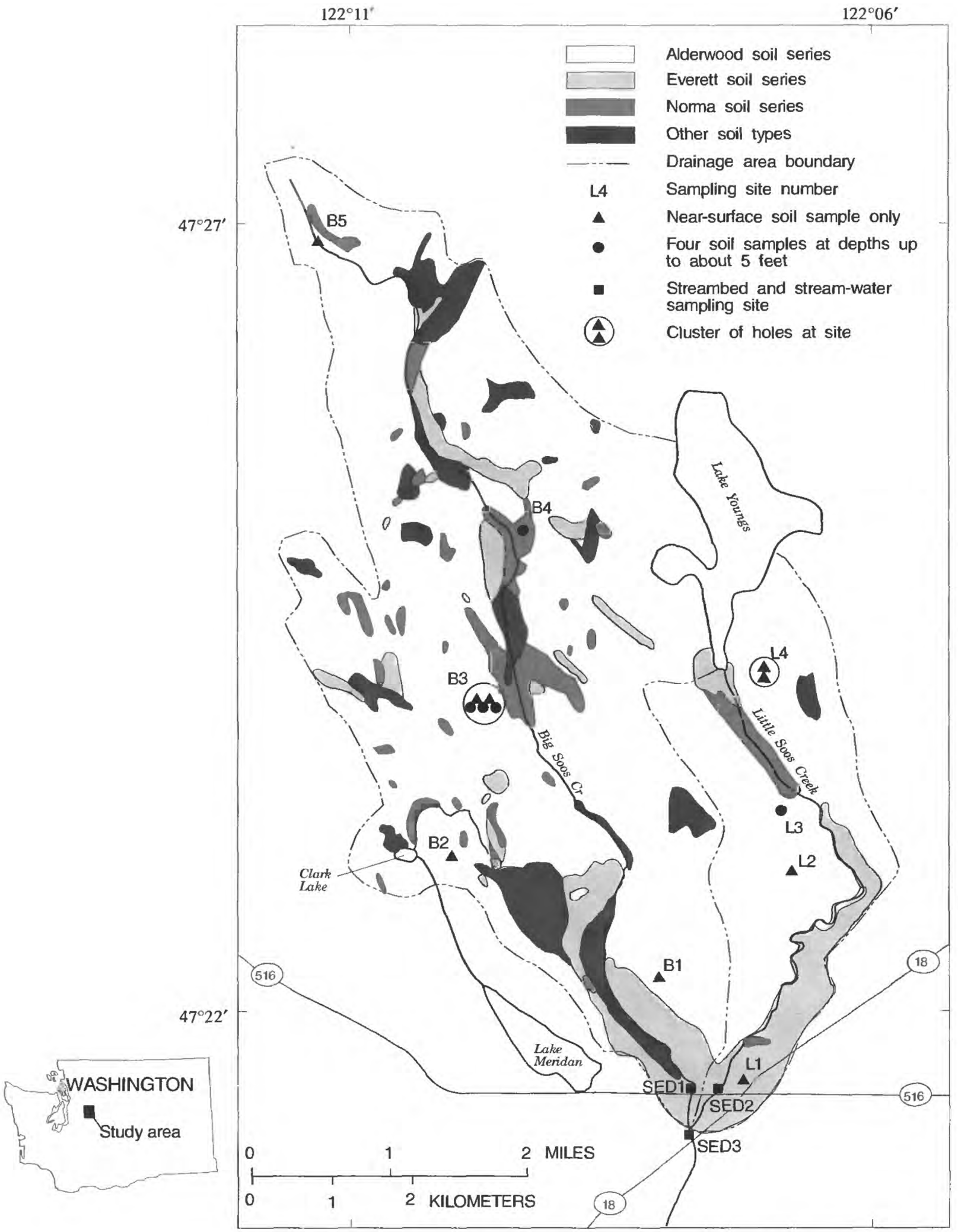

Figure 1.--Study area with drainage-area boundaries, sampling locations, soil types, and distributions of samples collected at each sampling site (adapted from U.S. Department of Agriculture, 1973).

Table 1.--Laboratory minimum reporting levels for concentrations of metals in soils, streambed sediments, and stream water when determined by different methods

[Laboratory minimum reporting levels are in milligrams per kilogram of dry material for soil and for streambed sediment, except numbers in parentheses; and in micrograms per liter for stream water, except as indicated; numbers in parentheses are in micrograms per liter of leachate; --, analysis was not done]

Metal		Laboratory minimum reporting level for indicated media and method						
		Soil and streambed sediment		Soil				Stream water
Symbol	Name	Total	Total recoverable	EP-TOX		ASTM		Dissolved
Ag	Silver	2	4	0.1	(5)	0.1	(5)	1
Al	Aluminum	500	5	.2	(10)	.2	(10)	10
As	Arsenic	10	11 or 12	.02	(1)	.02	(1)	1
Au	Gold	8	--	--		--		--
Ba	Barium	1	--	1 or 2	(50) (100)	.1	(5)	--
Be	Beryllium	1	.5 or .6	.2	(10)	.2	(10)	.5
Bi	Bismuth	10	--	--		--		--
Ca	Calcium	500	--	--		--		.1 mg/L
Cd	Cadmium	2	.8	.02	(1)	.02	(1)	1
Ce	Cerium	4	--	--		--		--
Co	Cobalt	1	--	--		--		--
Cr	Chromium	1	.8	.2	(10)	.2	(10)	1
Cu	Copper	1	2	.02	(1)	.02	(1)	1
Eu	Europium	2	--	--		--		--
Fe	Iron	500	.1	.2	(10)	.2	(10)	10
Ga	Gallium	4	--	--		--		--
Ho	Holmium	4	--	--		--		--
Hg	Mercury	.02	.001	.02	(1)	.002	(.1)	.1
K	Potassium	500	--	--		--		.1 mg/L
La	Lanthanum	2	--	--		--		--
Li	Lithium	2	--	--		--		--
Mg	Magnesium	50	--	--		--		.1 mg/L
Mn	Manganese	4	.1	.2	(10)	.2	(10)	10
Mo	Molybdenum	2	--	--		--		--
Na	Sodium	50	--	--		--		.1 mg/L
Nb	Niobium	4	--	--		--		--
Nd	Neodymium	4	--	--		--		--
Ni	Nickel	2	2	0.02	(1)	0.02	(1)	1
P	Phosphorus	50	--	--		--		--
Pb	Lead	4	4 or 5	.1	(5)	.1	(5)	5
Sb	Antimony	.1	2	.02	(1)	.02	(1)	1
Sc	Scandium	2	--	--		--		--
Se	Selenium	.1	4	.4	(20)	.04	(2)	1
Sn	Tin	10	--	--		--		--
Sr	Strontium	2	--	--		--		--
Ta	Tantalum	40	--	--		--		--
Th	Thorium	4	--	--		--		--
Ti	Titanium	50	.2	--		--		--
Tl	Thallium	--	8 or 9	.02	(1)	.02	(1)	--
U	Uranium	100	--	--		--		--
V	Vanadium	2	--	--		--		--
Y	Yttrium	2	--	--		--		--
Yb	Ytterbium	1	--	--		--		--
Zn	Zinc	4	2	.2	(10)	.2	(10)	0.5

Other factors that may affect the comparability of metals concentrations in soils are properties such as organic carbon content and particle-size distribution. These properties often are not determined, but are known to affect a soil's capacity to sorb and concentrate metals (Horowitz, 1985).

A topic of practical interest is the question of how well concentrations of metals in bed sediments of streams represent concentrations in the soils of the drainage areas. Concentrations of metals in streambed sediments from first- or second-order streams have been determined for all of England and Wales (Applied Geochemistry Research Group, 1978) and for a large part of the Federal Republic of Germany (Fauth and others, 1985). These types of data also were collected during the USGS's water-quality assessment of the Yakima River Basin in south-central Washington, which began in 1986. These studies did not examine the relation between concentrations of metals in streambed sediments and concentrations in soils.

Purpose and Scope

The purposes of this report are (1) to present statistical summaries and the data collected on background concentrations of metals in soils and streambed sediments in Big Soos Creek drainage basin; (2) to describe the variability of the background concentrations of total, total-recoverable, and leachable metals in soils in part of the Big Soos Creek drainage basin; (3) to describe the variability with depth of metals concentrations in soils; (4) to compare the effects of laboratory methodology on reported concentrations of metals in soils; (5) to test the assumption that metals concentrations in streambed sediments are representative of average concentrations in soils; and (6) to examine correlations between the concentrations of different metals in soils, between concentrations of metals and particle size, and between concentrations of metals and organic carbon.

In June 1987, a total of 29 soil samples were collected at 9 sites in the part of the drainage area that is above the confluence of the Big and Little Soos Creeks (fig. 1). Samples from more than one hole were collected at two sampling sites, and in some holes, samples were collected at various depths down to 5 feet below land surface (fig. 1). Most samples were collected at a depth of less than 1 foot. Seven surficial streambed-sediment samples were collected at three sites (fig. 1). A more detailed discussion of sample collection is presented in the section "Sample Collection and Processing".

Four methods were used to determine metals concentrations in soil samples: a total, a total-recoverable, and two leaching methods (an American Society of Testing and Materials method, ASTM, and the extraction procedure toxicity method, EP-TOX). Streambed sediments were analyzed by the total and total-recoverable methods only. In addition to the determination of metals concentrations, particle-size distributions and organic carbon content of soil samples and streambed sediments were determined, and the pH of each soil sample was determined using two different methods. Additional details on all types of analyses are provided in the section "Laboratory Methods".

This report presents all data collected during the investigation in tabular form (mostly in the appendix), and presents metals concentrations graphically as functions of depth. The graphs also are used to compare metals concentrations in streambed sediments with those in soils. Summary statistics are given of metals concentrations in all, shallow (less than 12 inches), and deep (greater than 12 inches) samples, and of all possible ratios of metals concentrations determined by the four different methods. Coefficients of variation of metals concentrations in samples from three different size areas--clusters (less than an acre), subbasins (2.9 and 13 mi^2), and the entire study area (15.9 mi^2) are used to evaluate areal variability. Matrices of correlation coefficients between concentrations of different metals and between metals concentrations and particle size are presented.

Description of the Study Area

The Big Soos Creek drainage basin is located about 15 miles southeast of the city of Seattle in the Puget Sound region of the State of Washington. The study area (fig. 1) is the part of the drainage area that is above the confluence of Little Soos Creek and Big Soos Creek and includes the subbasins drained by both creeks. In this report, the two subbasins are referred to as the Big Soos and Little Soos Creek subbasins, and the entire area as part of the Big Soos Creek Basin. The study area encompasses 15.9 mi^2, of which 2.9 mi^2 are in the Little Soos Creek subbasin.

The study area is a glacial drift plain with small ridges and rounded hills. The altitude ranges from about 320 to 620 feet above sea level. The southern and eastern parts of the study area are somewhat rural in character, while the northern and western parts are more suburban with subdivisions and scattered single-family homes. The

entire area is being rapidly developed. State routes 18 and 515, which are two-lane highways with heavy traffic, cross the southern part of the study area (see fig. 1).

The climate is influenced by incoming maritime air masses originating over the Pacific Ocean. Annual precipitation is about 40 inches, and there is a well-defined rainy season from October to March when about 75 percent of the precipitation occurs. Typically during this season, rainfall is light to moderate in intensity. The dry season occurs in summer; less than 5 percent of the annual precipitation falls in July and August.

Soils

The soils sampled during this study were derived from Vashon till and (or) stratified drift of the Pleistocene age. According to Mullineaux (1970), most of the rocks and materials in the Vashon till in this part of the Puget Sound Lowland are derived from the central Cascade Range, located south of Snoqualmie Pass and drained by the Cedar, Green, and White Rivers. However, 5 to 15 percent of the till can be identified as derived from British Columbia and the northern parts of the Cascade Range, and the origin of some material is unknown. The Vashon Drift is a typical example of sediments derived mostly from British Columbia and the northern parts of the Cascade Range, but the drift also contains numerous andesitic and granodioritic stones that could have been derived from either the northern or central parts of the Cascade Range. The mineralogy of the parent materials from which the sampled soils were formed, therefore, is mixed. Consequently, some variability should be expected in metal concentrations in the soils formed from these materials.

The predominant soil types in the study area (fig. 1) are in the Alderwood series (U.S. Department of Agriculture, 1973). All but two soil-sampling sites were in areas with Alderwood soils (fig. 1). The other two types of soils sampled were in the Everett series and the Norma series. The Alderwood and Everett soils are in the loamy-skeletal, mixed mesic family, and the Norma soil is in the coarse-loamy, mixed, nonacid, mesic family. All three soils are type sm (sands with silt and clay) in the Unified Soil Classification System.

The Alderwood series consists of moderately well-drained soils formed in glacial deposits. In a typical profile, the surface layer and subsoil are a grayish-brown to dark brown, gravelly, sandy loam about 2 feet thick. The substratum is a grayish-brown, weakly consolidated to strongly consolidated glacial till extending to a depth of 5 feet or more.

Soils in the Everett series were formed in gravelly glacial outwash deposits and are well drained. The surface layer and subsoil are typically a black to brown, gravelly sandy loam about 3 feet thick. The substratum is a multicolored black to grey, gravelly sand layer extending to a depth of 5 feet or more.

The Norma series is made up of poorly drained soils formed in alluvium. These soils are found in basins on the glacial uplands and adjacent to stream bottoms. In a typical profile, the surface layer is a black sandy loam about 10 inches thick, and the subsoil is a dark grayish-brown and dark-gray sandy loam extending to a depth of about 5 feet.

Soils are categorized into horizons, which are layers of soil, approximately parallel to the land surface, that have distinct characteristics produced by soil-forming processes (see, for example, U.S. Department of Agriculture, 1973, p. 99). The soil horizons generally are designated A, B, and C, but each may have subhorizons such as BW1 or BW2. The A horizon is the mineral horizon at the surface or just below a layer of organic matter, if present. This horizon is where living organisms are most active, and therefore is marked by the presence of humus. In the study area, the A horizon generally appeared darker than the underlying horizons. The B horizon underlies the A horizon and is the layer of maximum accumulation of materials such as iron and aluminum oxides and silicate clays. This accumulation is caused by weathering and leaching of materials from the overlying A horizon. Combined, the A and B horizons usually are called the solum, or true soil. The C horizon is the weathered, unconsolidated rock material immediately beneath the solum. It may or may not be the same as the parent material from which the soil was formed. In the study area, the A horizon typically is less than 1 foot thick and is not present in some places. The B horizon typically is 1 to 3 feet thick. The C horizon can be 3 feet or more in thickness. Samples representing soil horizons, A, B, and C were collected from all but the Everett soil series (fig. 1).

Acknowledgments

This study was done in cooperation with the Toxics Cleanup Program of the State of Washington Department of Ecology. Mr. Peter Kmet of Ecology initiated the discussions that led to this and a continuing series of projects

that are being conducted to determine background concentrations of metals in soils of Washington. The efforts of Mr. Merley McCall and Mr. Stephen Twiss of Ecology in arranging some of the special laboratory analyses of soil samples are greatly appreciated.

Appreciation is expressed also to Dr. Craig Cogger and Mr. Michael Sukop of Washington State University for accompanying the authors in the field, where they shared with the authors their knowledge of the soils in the Puget Sound area and provided valuable guidance during soil sampling.

DATA COLLECTION

A total of 29 soil samples were collected in this study; 21 were from 5 sites in the Big Soos Creek subbasin and 8 were from 4 sites in the Little Soos Creek subbasin. In addition, seven streambed-sediment samples were collected from three sites. Two sites were on Big Soos Creek, one upstream and the other downstream of the confluence with Little Soos Creek. The third site was on Little Soos Creek.

Sample Identification System

In this report, the term soil-sampling site specifies a small area (always less than 1 acre) where one or more soil samples were collected from one or more holes. Soil-sample identifiers are alphanumeric labels (table 2) that identify the site, hole, and depth. The first letter (B or L) of the sample identifier indicates the subbasin from which the sample was collected, Big Soos Creek or the Little Soos Creek, respectively. The number that follows the first letter identifies the sampling site within the subbasin. Specific holes from which soil samples were collected at sampling sites are identified by a letter (A through E) following the site designation. Following the hole designation is the approximate mean depth of the sample, in feet below land surface. For example, sample B3C4.0 was collected in the Big Soos Creek subbasin (fig. 1) at site 3, from hole C, from a depth of about 4 feet.

Streambed-sediment samples are identified by the letters "SED" followed by a number designating the stream site and a letter designating the location at the site (fig. 1).

Sampling Design

Soil samples were collected to obtain information on the magnitude of metals concentrations in soils and also the variability of concentrations with size of the sampling area and with depth. Consequently, to obtain information on the variability in this relatively large area, samples were collected at five sites in Big Soos Creek subbasin (13.0 mi^2) and at four sites in Little Soos Creek subbasin (2.9 mi^2). To obtain information on variability within smaller areas, samples were collected from five holes distributed over about 1 acre at site B3, and from two holes within 300 feet of each other at site L4 (fig. 1). Because samples taken during many remedial investigations are collected with a shovel and are seldom deeper than 12 inches, at least one shallow sample (less than 12 inches deep) was collected from every hole at every site. At sites L3, B4, and at three of the five holes at site B3 (fig. 1), samples were collected from three different depths in addition to the shallow sample.

All sites, except one, were chosen to be in locations believed to be free of the effects of local anthropogenic sources of metals. Sample L1A0.5 was collected about 500 feet northwest of Highway 18 to test if metals concentrations in soils from a location near a suspected local anthropogenic source of metals would differ from concentrations in samples from the other locations. The sample from site L1 was expected to contain elevated concentrations of some metals derived from motor-vehicle fuels and lubricants, and from the wear of motor-vehicle parts and tires.

Three of the seven streambed-sediment samples that were collected were from site SW1 on Big Soos Creek above the confluence with Little Soos Creek (fig. 1). Two of these samples were from a location about 0.25 mile upstream of the confluence, just above and below Highway 516, and the third from a location approximately 0.5 mile upstream of the confluence. Two samples were collected from site SW2 on Little Soos Creek approximately 0.4 mile upstream from the confluence and 200 feet upstream of Highway 516. The remaining two streambed-sediment samples were collected from site SW3 on Big Soos Creek approximately 0.1 mile downstream of the confluence with Little Soos Creek, where it is crossed by State Highway 18.

Although not directly related to the objectives of this study, streamwater samples were collected at each of the three stream sites at the same time the streambed-sediment samples were collected in order to document water quality at the sites. The water sample from the upper Big Soos

Table 2.--Physical and chemical characteristics of soils and streambed sediments

[Ag, Alderwood; Ev, Everett; No, Norma; Sample depth indices S and D identify shallow and deep samples, respectively; pH 1:1, pH determined after mixing sample with an equal mass of deionized water; pH CaCl , pH determined after adding CaCl to soil water mixture; reference soil consists of a mixture of samples L3A0.5, L3A1.0, B3A3.0, B3A5.0, B3C2.0, B3C4.0, B3C5.0, B3D1.0, and B5A0.5]

Site	Sample	Lat-itude	Long-itude	Soil series	Soil description	Soil horizon	Sample depth top (inches)	Sample depth bottom (inches)	Sample depth index	Total organic carbon[a] (percent)	pH 1:1	pH CaCl
					Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	472129	1220717	Ev	Top soil, near Highway 18	A	2	6	S	9.6	6.0	5.1
L2	L2A0.5	472256	1220642	Ag	Light sandy loam	B	2	10	S	4.0	4.9	4.6
L3	L3A0.1	472317	1220642	Ag	Dark brown	A	0	2	S	8.4	5.9	5.4
L3	L3A0.5	472317	1220642	Ag	Dark brown	A	3	7	S	6.6	6.2	5.3
L3	L5A0.5 (duplicate of sample L3A0.5)									6.0	6.1	5.1
L3	L3A1.0	472317	1220642	Ag	Medium brown sandy loam	BW1	9	16	D	2.0	6.2	5.3
L3	L3A4.0	472317	1220642	Ag	Grey rocky till	C2	34	42	D	.02	6.5	5.0
L4	L4A0.5	472407	1220657	Ag	Top soil	A	2	7	S	7.5	4.7	4.2
L4	L4B0.5	472410	1220657	Ag	Top soil	A	2	6	S	5.3	4.4	4.3
	L6A0.5				Reference soil					1.5	6.0	5.2
					Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	472220	1220800	Ag	Top soil	A	2	7	S	5.8	5.8	4.8
B2	B2A0.5	472308	1221004	Ag	Dark brown, loamy	A	2	10	S	7.4	5.7	5.0
B2	B6A0.5(duplicate of sample B2A0.5)									8.0	5.8	5.0
B3	B3A0.1	472404	1220945	Ag	Top soil	A	0	2	S	9.9	5.3	4.8
B3	B3A1.0	472404	1220945	Ag	Light brown sandy loam	BW1	10	16	D	2.4	5.2	4.9
B3	B3A3.0	472404	1220945	Ag	Sandy loam	BW2	24	36	D	.43	5.8	4.6
B3	B3A5.0	472404	1220945	Ag	Till	C	48	60	D	<.01	5.2	4.5
B3	B3B0.1	472405	1220943	Ag	Top soil	A	0	2	S	9.2	4.8	4.6
B3	B3B1.0	472405	1220943	Ag	Light brown sandy loam	BW1	12	16	D	2.2	5.6	5.1
B3	B3B2.0	472405	1220943	Ag	Sandy loam	BW2	18	27	D	.95	5.3	4.9
B3	B3B4.0	472405	1220943	Ag	Grey compact till	C2	45	52	D	.26	5.8	4.5
B3	B3C0.1	472406	1220941	Ag	Top soil	A	0	2	S	8.4	6.1	5.2
B3	B3C2.0	472406	1220941	Ag	Light brown sandy loam	BW1	22	26	D	1.2	5.9	5.5
B3	B3C4.0	472406	1220941	Ag	Sandy loam	BW2	40	50	D	.61	6.3	5.6
B3	B3C5.0	472406	1220941	Ag	Grey sandy till	C	60	66	D	.10	5.8	5.2
B3	B3D1.0	472405	1220942	Ag	Light brown sandy loam	B	6	10	S	2.5	6.3	5.2
B3	B3E1.0	472404	1220944	Ag	Light brown sandy loam	B	6	10	S	2.9	5.7	4.9
B4	B4A2.0	472508	1220914	No	Grey silt loam	2B6	16	26	D	3.4	5.7	5.1
B4	B7A2.0 (duplicate of sample B4A2.0)									3.7	5.4	5.1
B4	B4A4.0	472508	1220914	No	Silt loam	4C	54	61	D	.62	5.4	4.8
B4	B4A0.1	472508	1220914	No	Loam	1A	0	2	S	5.3	4.8	4.3
B4	B4A0.5	472508	1220914	No	Loam	1A	2	7	S	5.0	4.9	4.3
B5	B5A0.5	472653	1221116	Ag	Brownish grey sandy loam	BW2?	4	10	S	1.2	5.8	5.2
	B8A0.5 (duplicate of sample L6A0.5)				Reference soil					1.8	6.0	5.2
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	472143	1220734							6.7		
SW1	SED1B	472129	1220742							6.8		
SW1	SED1C	472129	1220742							7.9		
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	472131	1220725							10.0		
SW2	SED2B	472131	1220725							9.7		
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	472112	1220742							3.6		
SW3	SED3B	472112	1220742							8.4		

[a] Concentration of inorganic carbon is less than 0.02 percent in every sample.

Creek site was collected at the most upstream location, 0.5 mile above the confluence with Little Soos Creek. Water samples were analyzed to determine concentrations of dissolved metals and major ions. Field determinations were made of temperature, pH, specific conductance, and dissolved-oxygen concentration.

Sample Collection and Processing

All samples were collected in June 1987. Each soil sample consisted of a minimum of 10 pounds of soil that was collected with a stainless steel scoop, and sieved in the field with a stainless steel sieve to remove all particles larger than 19 mm (millimeters). Each sieved sample was placed into a plastic bucket, covered with a tightly fitting lid, and stored in the bucket until processed further. The scoop and sieve were washed with a laboratory detergent and rinsed with deionized water before collecting each sample.

Shallow soil samples were collected after first removing the top 1 to 2 inches, which contained plant debris and litter. Soil from as deep as 10 inches then was removed using the stainless steel scoop. Although depth was of primary concern, the shallowest sample was usually collected from only the top soil horizon, usually the A horizon. Soil samples from deeper zones were collected by first digging a pit 5 to 7 feet deep with a backhoe. Samples then were collected from the exposed B and C soil horizons on the sides of the pit using the scoop. These samples were handled in the same manner as the shallow soil samples.

Streambed-sediment samples were collected from locations where fine sand and silt were deposited. Samples of shallow sediments (approximately the upper 1 inch) were collected using a stainless steel scoop. The scoop had holes in its upper half to permit the slow draining of water, in order to minimize the loss of fine material. Samples were placed in glass jars and kept chilled until processed.

Water samples were collected using a Survey DH-48 depth-integrating hand-held sampler containing an acid-rinsed glass bottle. At each site, several samples, which were collected in the stream cross section using the equal-width increment (EWI) method, were composited into a single sample. This method also is known as the equal transit rate (ETR) method and is further described by Guy and Norman (1976). The composite sample was mixed, filtered through a 0.45-µm (micrometer) filter, and preserved by acidification and chilling where appropriate. All these operations were performed in the field. Field determinations of temperature, pH, specific conductance, and dissolved-oxygen concentration were made using standard methods described by Wood (1981).

Soil and streambed-sediment samples were sieved again prior to most analyses. Different size fractions were used in different laboratory determinations because of standard practices and laboratory requirements. Size fractions of samples for various determinations were: total metals and organic carbon--particle sizes smaller than 0.063 mm (millimeters); total-recoverable metals--particle sizes smaller than 9.5 mm; and leachable metals and pH--particle sizes smaller than 2 mm. Particle-size determinations were performed on a less-than 19.5 mm subsample.

Because of the large range of particle sizes in samples analyzed by the total-recoverable method, selected samples (table 3) were subdivided further to determine variability of concentrations among particle-size classes. Six soil samples were subdivided into three size fractions --less than 0.063 mm, 0.063 mm to 2 mm, and 2 mm to 9.5 mm--prior to analysis. To determine possible effects of sieving, unfractionated samples (all particle sizes less than 9.5 mm) from two of the six locations were also analyzed (table 3).

Representative subsamples used for different analytical determinations and for duplicate samples were obtained by mixing and quartering the sample as described by the ASTM method D3987-85 (American Society for Testing and Materials, 1985). The size fraction smaller than 0.063 mm was obtained by wet-sieving the samples with deionized water through a polyester sieve. The fine sediment was isolated from the resulting slurry by evaporating the water at a temperature of 30° to 40°C. All other size fractions were prepared by dry sieving the samples through plastic or stainless steel sieves.

Laboratory Methods

The four methods for determining metals concentrations in soils and sediments utilize different digestion or extraction procedures. All procedures produce aqueous extracts that are analyzed using wet-chemistry methods, such as atomic absorption or inductively coupled plasma spectroscopy (Fishman and Friedman, 1985; U.S. Environmental Protection Agency, 1983, 1986). Because the type of digestion or extraction utilized governs the concentrations of metals in the aqueous extract, the extraction step is the most significant difference between the

Table 3.--Types of metals analyses performed on soil and streambed sediments

[analysis performed by: a.--U.S. Geological Survey, Geologic Division Laboratory at Arvada, Colorado;
b.--Washington State Department of Ecology Laboratory at Manchester, Washington;
c.--Weyerhaeuser Technology Center Laboratory at Federal Way, Washington; and
d.--U.S. Geological Survey National Water Quality Laboratory at Arvada, Colorado and contract laboratory;
Lack of a letter indicates analysis not done; <, less than; mm, millimeter]

Site		Sample	Type of analysis and particle size class: Total <0.063 mm	Total recoverable <9.5mm	Total recoverable <0.063mm	Total recoverable 0.063-2mm	Total recoverable 2-9.5mm	EP-TOX <2mm	ASTM <2mm
			Soil samples from Little Soos Creek drainage basin						
L1		L1A0.5	a	b,c				d	d
L2		L2A0.5	a		b	b	b	d	d
L3		L3A0.1	a	b,c				d	d
L3		L3A0.5	a	b				d	d
L3	*	L5A0.5	a	b				d	d
L3		L3A1.0	a	b,c				d	d
L3		L3A4.0	a	b				d	d
L4		L4A0.5	a	b				d	d
L4		L4B0.5	a	b				d	d
		L6A0.5	a	b				d	d
			Soil samples from Big Soos Creek drainage basin						
B1		B1A0.5	a	b				d	d
B2		B2A0.5	a	b,c				d	d
B2	*	B6A0.5	a	b				d	d
B3		B3A0.1	a	b	b	b	b	d	d
B3		B3A1.0	a		b	b	b	d	d
B3		B3A3.0	a		b	b	b	d	d
B3		B3A5.0	a	b	b	b	b	d	d
B3		B3B0.1	a	b				d	d
B3		B3B1.0	a	b				d	d
B3		B3B2.0	a	b				d	d
B3		B3B4.0	a	b				d	d
B3		B3C0.1	a	b				d	d
B3		B3C2.0	a	b					
B3		B3C4.0	a	b					
B3		B3C5.0	a	b,c					
B3		B3D1.0	a	b				d	d
B3		B3E1.0	a		b	b	b	d	d
B4		B4A0.1	a	b				d	d
B4		B4A0.5	a	b				d	d
B4		B4A2.0	a	b,c				d	d
B4	*	B7A2.0	a	b				d	d
B4		B4A4.0	a	b				d	d
B5		B5A0.5	a	b				d	d
	**	B8A0.5	a	b				d	d
			Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek						
SW1		SED1A	a	b					
SW1		SED1B	a	b					
SW1		SED1C	a	b					
			Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek						
SW2		SED2A	a	b					
SW2		SED2B	a	b					
			Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek						
SW3		SED3A	a	b					
SW3		SED3B	a	b					

* Sample is a duplicate of the preceding sample in table ** Sample is a duplicate of sample L6A0.5

methods. Laboratory minimum reporting levels (minimum concentration for which there is confidence in the laboratory-determined value) for each method are given in table 1.

The analysis for total metals concentrations utilizes a digestion with hot concentrated nitric, hydrofluoric, and perchloric acids (Fishman and Friedman, 1985) and usually results in the complete dissolution of the solid-phase matrix. Analyses by this method were performed by the Geologic Division Laboratory of the U.S. Geological Survey in Arvada, Colo.

The total-recoverable analysis for metals concentrations that was used in this study utilizes a strong solution of hot nitric and hydrochloric acids to digest samples, as described by USEPA method 3050 (U.S. Environmental Protection Agency, 1986). Although the entire solid-phase matrix is not necessarily dissolved, most of the metals bound to particulate surface coatings do dissolve. The amount of metal dissolved is dependent on many factors, including the mineral composition, particle-size distribution, and organic carbon content of the sample. These analyses were performed at a laboratory jointly operated by Ecology and the USEPA in Manchester, Wash. Six duplicate samples also were analyzed by Weyerhaueser Analytical and Testing Services of Federal Way, Wash.

In the EP-TOX method (U.S. Environmental Protection Agency, 1986) metals are extracted by shaking a soil sample for 24 hours in a dilute acetic acid solution. The volume of acetic acid solution is 20 times the weight of the sample, and the solution is maintained at a pH of 5. The solution then is filtered and analyzed for concentrations of metals. Because the extraction solution is weak and dilute, only loosely bound metals are extracted. The ASTM method is similar to the EP-TOX method, except that distilled water is used in the extraction step, and pH is not adjusted during extraction. The method used is ASTM D3987-85 (American Society for Testing and Materials, 1985). Metals were extracted and analyzed for by, or by a contractor to, the U.S. Geological Survey National Water Quality Laboratory (NWQL) in Arvada, Colo.

Particle-size distributions in samples were determined by dry-sieving at the USGS's sediment laboratory in Vancouver, Wash., using a mechanical agitator with standard size sieves from 0.063 mm to 19 mm. The method is described in more detail by Guy (1977).

Organic-carbon concentrations were determined at the NWQL. First the total-carbon concentration in a sample was determined by complete oxidation, then inorganic carbon was determined using a modified Van Slyke apparatus and treatment with hydrochloric acid (Wershaw and others, 1987). The organic-carbon concentration is calculated as the difference between total and inorganic-carbon concentration.

The pH of each soil sample was determined by two commonly used methods (Beckman Instruments, Incorporated, 1983). Twenty grams of soil that were sieved to remove particles larger than 2 mm were mixed with 20 mL (milliliters) of distilled water, and the mixture was allowed to stand for 30 minutes. This slurry was mixed again, and the pH was measured using standard instruments to give the pH by the first method. Next, one drop of a 1-molar calcium chloride solution was added to the slurry, then the slurry was mixed intermittently for an additional 30 minutes. The pH was measured again to give the pH by the second method. The second method supposedly gives more consistent results than the first, and is not as dependent on the amount of salts present in the soil at the time the sample is taken. All the soil samples collected in this study were acidic, and most pH values ranged between 4.5 and 6.5. The pH determined after adding calcium chloride was about 1 pH unit smaller than the first measurement.

Surface-water samples were analyzed for concentrations of dissolved metals and common ions at the NWQL using techniques described by Fishman and Friedman (1985).

Quality Assurance

Duplicates of soil samples L3A0.5, B2A0.5, and B4A2.0 were prepared by splitting and were submitted to the laboratories as samples from ficticious locations. A reference soil sample also was made by combining fractions of several samples, and portions of it were submitted as samples from other fictitious locations (L6A0.5 and B8A0.5). The reference soil is and will be used to monitor laboratory performance in this and future studies. The duplicate and reference quality-assurance samples were analyzed for concentrations of metals using all four methods. They also were analyzed for particle-size distributions, organic-carbon concentrations, and pH values. As an additional check on quality assurance, the Ecology/EPA laboratory split six soil samples and sent half to another laboratory for the determination of concentrations of total-recoverable metals.

PRESENTATION AND ANALYSES OF DATA

All metal-concentration data for the soil and streambed-sediment samples that were collected during this study are contained in tables 16 through 21 at the end of this report. For ease in comparability, concentrations of all metals determined by all methods are given in units of mg/kg (milligrams of metal per kilogram of dry soil). Because results of analyses by the EP-TOX and ASTM methods normally are given in units of milligrams (or micrograms) of metal per liter of leachate, concentrations in these units for these methods also are given on some of the tables. To convert EP-TOX or ASTM concentrations from milligrams per kilogram of soil to micrograms per liter of leachate, multiply by 50.

Concentrations of the 43 metals that were determined by the total method are listed in table 16, while concentrations of the 18 metals that were determined by either the total-recoverable, EP-TOX, or ASTM methods are in table 17. Concentrations determined by the total method for the metals in table 17 were given also in table 16, but are repeated to assist in making comparisons of concentrations determined by all four methods. Total-recoverable concentrations in duplicates of six soil samples as determined by two laboratories are in table 18.

Total-recoverable concentrations in three size fractions of six soil samples--less than 0.063 mm, between 0.063 mm and 2 mm, and between 2 and 9.5 mm are contained in table 19. Because concentrations determined by the total-recoverable method for all other soil samples were for the size fraction less than 9.5 mm, concentrations for that size fraction were computed from the data in table 20. These were computed by calculating the weighted averages of the concentrations in the three size fractions. Total-recoverable concentrations for the entire fraction less than 9.5 mm also were determined by direct laboratory analysis for two (B3A0.1 and B3A5.0) of the six samples. The means of the laboratory and computed concentrations for these two samples are given in table 17. The computed values are given in the table for the other four samples.

Distributions of particle sizes smaller than 9.5 mm in diameter are given in table 20. This is the largest particle size included in the samples analyzed by the total-recoverable method. The distributions for sizes less than 2 mm, the largest particle size included in analyses by the EP-TOX and ASTM methods, can be deduced from the data in the table. The distribution of particle sizes less than 0.063 mm, the largest size included in analyses by the total method, were not determined. Other chemical and physical characteristics of the soil and streambed-sediment samples were given in table 2, which lists soil types and descriptions, depths, horizons from which samples were collected, pH values, and organic carbon concentrations.

Table 21 contains concentrations of metals and other water-quality constituents and characteristics of streamwater samples that were collected at the mouth of Little Soos Creek and from Big Soos Creek upstream and downstream of the confluence with Little Soos Creek.

Summary Statistics

Summary statistics (mean, standard deviation, and others) were computed for concentrations of metals by each of the four laboratory methods (tables 4 through 7). Because of the variation with depth of concentrations of some of the metals (to be discussed in the next section), separate statistics are given for concentrations in shallow samples (mean depths less than 12 inches) and deep samples (mean depths greater than 12 inches), as well as for all samples. However, any depth between 12 and 24 inches would have served equally well for segregating the data. For convenience, the samples with mean depths less than 12 inches will be referred to as shallow samples, and those with mean depths greater than 12 inches will be referred to as deep samples.

Statistical values in tables 4 through 7 were computed using data for all samples except sample L1A0.5, the one from near Highway 18 that probably contained metals from a local anthropogenic source. Average concentrations of duplicate samples were used in the computations. Data for all other samples were given equal weight in computations of the statistics in these tables. Statistics that were computed for averages of concentrations in all samples collected at a site are given in the later subsection "Areal Variability of Concentrations."

The coefficients of variation (100 percent multiplied by standard deviation divided by mean) of concentrations in samples from all depths for 30 of the 43 metals determined by the total method (table 4) range from 10 to 65 percent and have a median value of 20 percent. The total concentration of mercury was less than the laboratory's reporting level in only one sample (B5A0.5, tables 16 and 17). The statistical values computed for this metal were affected little when the assumed concentration in this sample was varied between zero and the reporting level. Coefficients of variation for the 13 other metals were not computed because concentrations of these metals in most

Table 4.--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the total method

[Concentrations are in milligrams per kilogram of dry soil; tot., total number of samples analyzed; det., number of samples with concentrations equal to or larger than analyzing laboratory's minimum reporting values; --, statistic not computed because concentrations in most samples were less than laboratory's minimum reporting value; <, less than]

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				All samples				
Silver	28/0	<2	<2	--	--	<2	<2	<2
Aluminum	28/28	77,000	76,000	10,000	14	60,000	110,000	87,000
Arsenic	28/14	<13	15	--	--	<10	30	20
Gold	28/0	<8	<8	--	--	<8	<8	<8
Barium	28/28	470	460	56	12	370	580	540
Beryllium	28/7	<1	<1	--	--	<1	1	<1
Bismuth	28/0	<10	<10	--	--	<10	<10	<10
Calcium	28/28	18,000	18,000	2,100	12	13,000	22,000	20,000
Cadmium	28/0	<2	<2	--	--	<2	<2	<2
Cerium	28/28	41	42	8.2	20	28	58	51
Cobalt	28/28	12	12	1.8	15	9	17	14
Chromium	28/28	98	99	19	19	62	150	120
Copper	28/28	22	22	5.6	25	10	34	28
Europium	28/1	<2	22	--	--	<2	2	<2
Iron	28/28	31,000	32,000	4,200	13	21,000	38,000	37,000
Gallium	28/28	16	16	2.5	15	13	24	19
Holmium	28/1	<4	<4	--	--	<4	4	<4
Mercury	28/27	.10	.11	.05	50	<.02	.22	.16
Potassium	28/28	7,500	7,800	770	10	6,100	8,600	8,500
Lanthanum	28/28	20	21	3.2	16	16	31	22
Lithium	28/28	22	20	7.5	34	12	41	31
Magnesium	28/28	7,500	7,100	1,400	18	5,600	9,900	9,300
Manganese	28/28	700	600	420	59	350	2,400	11,000
Molybdenum	28/0	<2	<2	--	--	<2	<2	<2
Sodium	28/28	18,000	18,000	2,100	12	14,500	22,000	21,000
Niobium	28/28	7.1	7	1.7	24	5	13	9
Neodymium	28/28	19	18	4.7	25	13	34	23
Nickel	28/28	50	50	9.5	19	32	74	59
Phosphorus	28/28	1,400	1,600	800	58	300	2,800	2,600
Lead	28/28	18	12	11	65	7	52	21
Antimony	28/28	.64	.5	.36	56	.3	1.7	1.0
Scandium	28/28	12	12	2.9	24	8	22	14
Selenium	28/28	.49	.5	.20	41	.2	.9	.8
Tin	28/1	<10	<10	--	--	<10	10	<10
Strontium	28/28	240	240	31	13	180	310	260
Tantalum	28/0	<40	<40	--	--	<40	<40	<40
Thorium	28/17	<4.5	4	--	--	<4	6	<4
Titanium	28/28	4,200	4,200	540	13	3,100	5,400	4,800
Uranium	28/0	<100	<100	--	--	<100	<100	<100
Vanadium	28/28	91	92	13	15	65	130	100
Yttrium	28/28	16	15	5.0	31	10	31	22
Ytterbium	28/28	1.7	2	.57	33	1	3	2
Zinc	28/28	63	61	22	35	32	120	83

Table 4.--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the total method--Continued

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				Shallow samples (mean depths less than 12 inches)				
Silver	15/0	<2	<2	--	--	<2	<2	<2
Aluminum	15/15	72,000	75,000	8,800	12	60,000	87,000	83,000
Arsenic	15/11	<15	10	--	--	<10	30	<10
Gold	15/0	<8	<8	--	--	<8	<8	<8
Barium	15/15	450	440	62	14	370	580	540
Beryllium	15/3	<1	<1	--	--	<1	1	1
Bismuth	15/0	<10	<10	--	--	<10	<10	<10
Calcium	15/15	17,000	18,000	1,900	11	14,000	21,000	20,000
Cadmium	15/0	<2	<2	--	--	<2	<2	<2
Cerium	15/15	37	34	7.9	21	28	51	47
Cobalt	15/15	12	12	2.1	18	9	17	14
Chromium	15/15	89	82	17	19	62	120	110
Copper	15/15	23	24	5.6	25	10	30	28
Europium	15/0	<2	<2	--	--	<2	<2	<2
Iron	15/15	30,000	30,000	4,600	15	21,000	38,000	36,000
Gallium	15/15	16	16	2.3	14	13	20	20
Holmium	15/1	<4	<4	--	--	<4	4	<4
Mercury	15/14	.13	.12	.05	40	<.02	.22	.16
Potassium	15/15	7,000	7,000	640	9	6,100	8,000	8,000
Lanthanum	15/15	19	17	2.9	15	16	23	22
Lithium	15/15	24	25	5.4	23	15	33	30
Magnesium	15/15	6,700	6,700	900	14	5,600	8,900	7,600
Manganese	15/15	840	730	530	63	350	2,400	1,300
Molybdenum	15/0	<2	<2	--	--	<2	<2	<2
Sodium	15/15	17,000	16,000	1,700	10	14,500	21,000	18,000
Niobium	15/15	7.2	7	1.2	17	6	9	9
Neodymium	15/15	16	14	3.5	21	13	22	22
Nickel	15/15	46	44	11	24	32	74	58
Phosphorus	15/15	1,700	1,800	770	46	300	2,800	2,700
Lead	15/15	25	23	11	46	10	52	38
Antimony	15/15	0.86	0.9	0.38	44	0.4	1.7	1.4
Scandium	15/15	10	11	1.8	17	8	14	13
Selenium	15/15	.58	.5	.20	34	.2	.9	.8
Tin	15/0	<10	<10	--	--	<10	<10	<10
Strontium	15/15	220	220	23	11	185	250	250
Tantalum	15/0	<40	<40	--	--	<40	<40	<40
Thorium	15/6	<4.3	<4	--	--	<4	6	5
Titanium	15/15	4,100	4,200	600	15	3,100	5,100	4,800
Uranium	15/0	<100	<100	--	--	<100	<100	<100
Vanadium	15/15	85	84	12	14	65	100	100
Yttrium	15/15	13	12	3.3	24	10	20	18
Ytterbium	15/15	1.4	1	.51	36	1	2	2
Zinc	15/15	74	70	23	31	32	120	103

Table 4.--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the total method--Continued

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				Deep samples (mean depths greater than 12 inches)				
Silver	13/0	<2	<2	--	--	<2	<2	<2
Aluminum	13/13	82,000	78,000	9,900	12	75,000	110,000	90,000
Arsenic	13/3	<11	<10	--	--	<10	20	10
Gold	13/0	<8	<8	--	--	<8	<8	<8
Barium	13/13	480	470	43	9	420	560	530
Beryllium	13/4	<1	<1	--	--	<1	1	1
Bismuth	13/0	<10	<10	--	--	<10	<10	<10
Calcium	13/13	18,000	18,000	2,100	12	13,500	22,000	21,000
Cadmium	13/0	<2	<2	--	--	<2	<2	<2
Cerium	13/13	45	43	6.5	14	33	58	52
Cobalt	13/13	13	12	1.3	10	11	16	15
Chromium	13/13	109	110	15	14	94	150	110
Copper	13/13	22	20	5.6	26	16	34	30
Europium	13/1	<2	<2	--	--	<2	2	<2
Iron	13/13	33,000	32,000	3,000	9	27,000	38,000	37,000
Gallium	13/13	16	15	2.7	17	14	24	19
Holmium	13/0	<4	<4	--	--	<4	<4	<4
Mercury	13/13	.07	.06	.05	66	.02	.16	.13
Potassium	13/13	8,100	8,200	440	5	7,000	8,600	8,600
Lanthanum	13/13	22	21	3.2	15	18	31	23
Lithium	13/13	20	16	9.2	46	12	41	33
Magnesium	13/13	8,500	9,000	1,200	14	6,400	9,900	9,800
Manganese	13/13	540	530	120	23	350	840	640
Molybdenum	13/0	<2	<2	--	--	<2	<2	<2
Sodium	13/13	19,000	19,000	1,800	10	15,000	22,000	21,000
Niobium	13/13	7	7	2.3	32	5	13	9
Neodymium	13/13	21	20	4.9	23	16	34	25
Nickel	13/13	54	57	5.3	10	44	60	59
Phosphorus	13/13	1,100	800	740	69	300	2,600	2,200
Lead	13/13	9.2	9	1.8	19	7	12	12
Antimony	13/13	0.39	0.4	0.06	16	0.3	0.5	0.6
Scandium	13/13	14	14	2.9	21	10	22	16
Selenium	13/13	.40	.4	.16	41	.2	.8	.6
Tin	13/1	<10	<10	--	--	<10	10	<10
Strontium	13/13	250	260	29	11	200	310	280
Tantalum	13/0	<40	<40	--	--	<40	<40	<40
Thorium	13/10	<4.8	5	--	--	<4	6	5
Titanium	13/13	4,300	4,200	450	10	3,800	5,400	4,800
Uranium	13/0	<100	<100	--	--	<100	<100	<100
Vanadium	13/13	98	95	12	12	82	130	107
Yttrium	13/13	18	16	5.4	29	13	31	24
Ytterbium	13/13	2	2	.43	21	1	3	2
Zinc	13/13	51	46	13	26	33	81	65

Table 5.--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the total-recoverable method

[Concentrations are in milligrams per kilogram of dry soil; tot., total number of samples analyzed; det., number of samples with concentrations equal to or larger than analyzing laboratory's minimum reporting values; --, statistic not computed because concentrations in most samples were less than laboratory's minimum reporting value; <, less than]

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				All samples				
Silver	28/0	<4	<4	--	--	<4	<4	<4
Aluminum	28/28	17,200	16,000	6,500	38	7,390	36,700	25,600
Arsenic	28/10	<13	<11	--	--	<11	24	19
Beryllium	28/9	<.55	<.5	--	--	<.5	.75	.6
Cadmium	28/0	<.8	<.8	--	--	<.8	<.8	<.8
Chromium	28/28	21	22	4.0	19	12	27	25
Copper	28/28	12	12	3.8	31	4	22	14
Iron	27/27	14,200	14,200	2,600	18	5,920	20,100	16,800
Mercury	28/28	.036	.036	.016	43	.011	.058	.054
Manganese	28/28	351	236	290	81	90	1,310	744
Nickel	28/28	22	22	5.2	23	9	34	27
Lead	28/1	<4.4	<4	--	--	<4	15	<4
Antimony[a]	28/28	50	44	16	32	21	93	68
Selenium	28/0	<4	<4	--	--	<4	<4	<4
Titanium	28/28	554	559	170	30	257	893	768
Thallium	28/22	<11	<8	--	--	<8	18	14
Zinc	28/28	35	33	12	35	12	71	50
				Shallow samples (meann depths less than 12 inches)				
Silver	15/0	<4	<4	--	--	<4	<4	<4
Aluminum	15/15	18,700	16,900	7,100	38	7,390	36,700	24,900
Arsenic	15/7	<14	<12	--	--	<11	24	22
Beryllium	15/5	<.57	<.5	--	--	<.5	.8	.6
Cadmium	15/0	<.8	<.8	--	--	<.8	<.8	<.8
Chromium	15/15	20	20	4.4	22	12	26	24
Copper	15/15	13	13	3.8	30	4.0	22	14
Iron	14/14	14,400	14,800	3,300	23	5,920	20,100	16,900
Mercury	15/15	.044	.047	.013	30	.012	.058	.058
Manganese	15/15	460	374	340	74	90	1,310	840
Nickel	15/15	21	21	5.7	27	9	34	25
Lead	15/1	<4.8	<4	--	--	<4	15	<4
Antimony[a]	15/15	53	49	18	34	21	93	72
Selenium	15/0	<4	<4	--	--	<4	<4	<4
Titanium	15/15	508	479	195	38	257	893	781
Thallium	15/9	<10	9	--	--	<8	15	13
Zinc	15/15	39	38	14	36	12	71	56
				Deep samples (mean depths greater than 12 inches)				
Silver	13/0	<4	<4	--	--	<4	<4	<4
Aluminum	13/13	15,400	13,300	5,500	35	10,200	26,600	244,000
Arsenic	13/3	<12	<11	--	--	<11	17	12
Beryllium	13/4	<.52	<.5	--	--	<.5	.6	.6
Cadmium	13/0	<.8	<.8	--	--	<.8	<.8	<.8
Chromium	13/13	23	23	2.6	12	19	27	26
Copper	13/13	11	11	3.8	34	7	22	14
Iron	13/13	14,000	13,900	1,800	13	10,800	17,200	15,600
Mercury	13/13	.027	.027	.013	47	.011	.051	.041
Manganese	13/13	225	184	126	56	130	595	495
Nickel	13/13	24	24	4.1	17	16	29	28
Lead	13/0	<4	<4	--	--	<4	<4	<4
Antimony[a]	13/13	46	41	12	27	34	68	66
Selenium	13/0	<4	<4	--	--	<4	<4	<4
Titanium	13/13	606	585	111	18	385	768	747
Thallium	13/12	<12	<8	--	--	<8	18	<8
Zinc	13/13	29	26	6.1	21	23	41	39

[a] Total-recoverable concentrations of antimony are suspected to be in error.

***Table 6.**--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the EP-TOX method*

[Concentrations are in milligrams per kilogram of dry soil; to convert to concentrations in micrograms per liter of leachate, multiply by 50; tot., total number of samples analyzed; det., number of samples with concentrations equal to or larger than analyzing laboratory's minimum reporting values; --, statistic not computed because concentrations in most samples were less than laboratory's minimum reporting value]

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				All samples				
Silver	25/0	<0.1	<0.1	--	--	<0.1	<0.1	<0.1
Aluminum	25/23	<1.9	1.2	--	--	<.2	8.2	3.9
Arsenic	25/3	<.02	<.02	--	--	<.02	.04	<.02
Barium	25/0	<2	<1	--	--	<1	<2	<1
Beryllium	25/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Chromium	25/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	25/25	.09	.08	0.05	57	.02	.22	.14
Iron	25/11	<.59	<.2	--	--	<.2	2.4	1.4
Mercury	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Manganese	25/9	<.25	<.2	--	--	<.2	1.0	.3
Nickel	25/19	<.05	.04	--	--	<.02	.14	.09
Lead	25/0	<.1	<.1	--	--	<.1	<.1	<.1
Antimony	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Selenium	25/0	<.4	<.4	--	--	<.4	<.4	<.4
Thallium	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	25/1	<.2	<.2	--	--	<.2	.2	<.2
				Shallow samples (mean depths less than 12 inches)				
Silver	15/0	<0.1	<0.1	--	--	<0.1	<0.1	<0.1
Aluminum	15/15	2.5	2.0	2.4	93	.4	8.2	5.9
Arsenic	15/3	<.02	<.02	--	--	<.02	.04	.02
Barium	15/0	<1.1	<1	--	--	<1	<2	<1
Beryllium	15/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Chromium	15/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	15/15	.10	.10	.05	55	.02	.22	.16
Iron	15/10	<.81	.4	--	--	<.2	2.4	1.8
Mercury	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Manganese	15/6	<.23	<.2	--	--	<.2	.4	.3
Nickel	15/11	<.05	.02	--	--	<.02	.14	.09
Lead	15/0	<.1	<.1	--	--	<.1	<.1	<.1
Antimony	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Selenium	15/0	<.4	<.4	--	--	<.4	<.4	<.4
Thallium	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	15/1	<.2	<.2	--	--	<.2	.2	<.2
				Deep samples (mean depths greater than 12 inches)				
Silver	10/0	<0.1	<0.1	--	--	<0.1	<0.1	<0.1
Aluminum	10/8	<.8	.6	--	--	<.2	2.8	1.6
Arsenic	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Barium	10/0	<1.2	<1	--	--	<1	<2	<2
Beryllium	10/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Chromium	10/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	10/10	.07	.06	.04	57	.02	.14	.11
Iron	10/1	<.26	<.2	--	--	<.2	.8	<.2
Mercury	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Manganese	10/3	<.28	<.2	--	--	<.2	1.0	.2
Nickel	10/8	<.05	.05	--	--	<.02	.10	.06
Lead	10/0	<.1	<.1	--	--	<.1	<.1	<.1
Antimony	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Selenium	10/0	<.4	<.4	--	--	<.4	<.4	<.4
Thallium	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	10/0	<.2	<.2	--	--	<.2	.2	<.2

***Table 7.**--Summary statistics for concentrations of metals in all, shallow, and deep soil samples as determined by the ASTM method*

[Concentrations are in milligrams per kilogram of dry soil; to convert to concentrations in micrograms per liter of leachate, multiply by 50; tot., total number of samples analyzed; det., number of samples with concentrations eqnal to or larger than analyzing laboratory's minimum reporting values; --, statistic not computed because concentrations in most samples were less than laboratory's minimum reporting value]

Metal	No. of samples tot./det.	Mean	Median	Standard deviation	Coefficient of variation (percent)	Minimum	Maximum	90th percentile
				All samples				
Silver	25/0	<0.1	<0.01	--	--	<0.1	<0.1	<0.1
Aluminum	25/25	4.7	4.2	2.6	55	.6	11.4	8.1
Arsenic	25/3	<.02	<.02	--	--	<.02	.06	<.02
Barinm	25/10	<.13	<.1	--	--	<.1	.32	.2
Beryllium	25/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Chrominm	25/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	25/25	.06	.06	.04	60	.02	.14	.12
Iron	25/24	<1.7	1.6	--	--	<.2	5.6	3.1
Mercury	25/0	<.002	<.002	--	--	<.002	<.002	<.002
Manganese	25/4	<.2	<.2	--	--	<.2	.4	<.2
Nickel	25/14	<.03	.02	--	--	<.02	.08	.08
Lead	25/1	<.1	<.1	--	--	<.1	.34	<.1
Antimony	25/1	<.02	<.02	--	--	<.02	.02	<.02
Selenium	25/0	<.04	<.04	--	--	<.04	<.04	<.04
Thallium	25/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	25/2	<.2	<.2	--	--	<.2	.2	<.02
				Shallow samples (mean depths less than 12 inches)				
Silver	15/0	<0.1	<0.1	--	--	<0.1	<0.1	<0.1
Aluminum	15/15	5.1	4.0	3.0	59	1.2	11.4	9.0
Arsenic	15/3	<.03	<.02	--	--	<.02	.06	.04
Barium	15/9	<.16	.12	--	--	<.1	.32	.24
Beryllium	15/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Chromium	15/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	15/15	.07	.06	.04	50	.02	.14	.12
Iron	15/14	<1.7	1.6	--	--	<.2	5.6	2.9
Mercury	15/0	<.002	<.002	--	--	<.002	<.002	<.002
Manganese	15/4	<.2	<.2	--	--	<.2	.4	.2
Nickel	15/8	<.03	.02	--	--	<.02	.08	.08
Lead	15/1	<.12	<.1	--	--	<.1	.34	<.1
Antimony	15/1	<.02	<.02	--	--	<.02	.02	<.02
Selenium	15/0	<.04	<.04	--	--	<.04	<.04	<.04
Thallium	15/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	15/1	<.2	<.02	--	--	<.2	.2	<.2
				Deep samples (mean depths greater than 12 inches)				
Silver	10/0	<0.1	<0.1	--	--	<0.1	<0.1	<0.1
Aluminum	10/10	4.1	4.4	1.7	42	.6	5.8	290
Arsenic	10/0	<.02	<.02	--	--	<.02	<.02	<.2
Barium	10/0	<.1	<.1	--	--	<.1	<.1	<.1
Beryllium	10/0	<.2	<.2	--	--	<.2	<.2	<.2
Cadmium	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Chromium	10/0	<.2	<.2	--	--	<.2	<.2	<.2
Copper	10/10	.04	.04	.02	58	.02	.08	.07
Iron	10/10	1.7	2.0	--	--	.4	3.18	155
Mercury	10/0	<.002	<.002	--	--	<.002	<.002	<.002
Manganese	10/0	<.2	<.2	--	--	<.2	<.2	<.2
Nickel	10/6	<.02	.02	--	--	<.02	.04	.03
Lead	10/0	<.1	<.1	--	--	<.1	<.1	<.1
Antimony	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Selenium	10/0	<.04	<.04	--	--	<.04	<.04	<.04
Thallium	10/0	<.02	<.02	--	--	<.02	<.02	<.02
Zinc	10/1	<.2	<.2	--	--	<.2	.2	<.2

of the soil samples were less than the laboratory's reporting level. The coefficients of variation of concentrations in samples from all depths for 10 of the 17 metals determined by the total-recoverable method (table 5) range from 18 to 81 percent and have a median value of 32 percent. A comparison of the coefficients of variation for the 10 metals that have coefficients of variation for concentrations determined by both the total and total-recoverable methods shows that, in most cases, the coefficient for the total method is the same or less than the coefficient for the total-recoverable method.

Only a few coefficients of variation could be computed for concentrations determined by the EP-TOX and ASTM laboratory methods (tables 6 and 7) because most of these concentrations are less than the laboratory's reporting level. These coefficients ranged from 55 to 60 percent for concentrations in samples from all depths.

All the statistical values given in this report were computed with untransformed data. Statistical tests (table 8) show that the data are neither predominantly normally distributed nor log-normally distributed. The method used was the probability plot correlation coefficient test (Looney and Gulledge, 1985). The information in table 8 and the numerical results of the tests (not shown), however, suggest a slightly greater tendancy for the data to be log-normally rather than normally distributed. In many cases neither null hypothesis (data are normally distributed or log-normally distributed) can be rejected because the data sets are rather small and the ranges of concentrations, as indicated by the coefficients of variation, are not large. Also, the small differences between most mean and median concentrations are not large, which suggests that the untransformed data are not highly skewed.

Variations of Concentrations With Depth

Concentrations of selected metals and of total organic carbon are shown as functions of depth below land surface in figures 2 through 5. Graphs of those metals whose concentrations were mostly below the laboratories' reporting levels are not included. Total organic carbon is included because concentrations of total organic carbon correlate with some metals concentrations in the sampled soils. Concentrations of total organic carbon (fig. 2) approach 100 grams per kilogram (equivalent to 10 percent) near the land surface, but decrease rapidly with depth in the upper 10 inches. Concentrations are less than 10 grams per kilogram at depths greater than about 25 inches. The large concentrations near land surface are most likely a product of the local vegetation.

Concentrations of some metals also are higher in shallow than deep soils. This trend is evident for manganese, lead, and antimony as determined by the total method (fig. 3). Concentrations of these metals appear to become uniform with depth at depths greater than about 12 to 24 inches. Although there is more scatter in the data, concentrations also tend to be higher in shallow soils for total mercury, phosphorous, selenium, and zinc (fig. 3) and for total-recoverable aluminum, mercury, manganese, antimony, and zinc (fig. 4). Although the distributions of concentrations of these metals are similar to the distribution of total organic carbon, the similarity does not prove the existence of a cause-and-effect relation. Concentrations of a few metals (for example, magnesium and sodium by the total method) show a slight increase with depth.

The reasons for the elevated total and total-recoverable concentrations of some metals near the surface are unknown, but several reasons can be suggested. One is enrichment of metals in soil on a regional scale by precipitation or dust containing metals from regional anthropogenic sources. Crecelius and others (1975) found that a major source of arsenic and antimony in bed sediments of Puget Sound was atmospheric deposits originating from the smokestack emissions of a copper smelter near the city of Tacoma. The smelter was located about 20 miles southwest and upwind of Big Soos Creek Basin. Concentrations of antimony in shallow samples from the study area are larger than in deep samples (figs. 3 and 4). Most arsenic concentrations are smaller than the laboratories' reporting level. Another possible but unsubstantiated reason for the elevated metals concentrations in shallow soils is that the metals could be residuals from weathered natural geologic material near land surface, or that metals could have been concentrated in growing vegetation and then incorporated into the surficial soil when the vegetation died.

Concentrations of only three metals (aluminum, copper, and iron) determined by the EP-TOX and ASTM methods were larger than the laboratories' reporting levels in a large enough number of samples to permit plotting as a function of depth (fig. 5). EP-TOX concentrations of aluminum and iron, and perhaps ASTM concentrations of aluminum and copper are larger in shallow than in deep soil. Because the EP-TOX and ASTM concentrations are a small fraction of the total concentrations (see table 9), they are a measure (as intended) of the amount of metal

***Table 8.**--Metals for which concentrations determined by total and total-recoverable methods are normally or log-normally distributed*

[N, L, cannot reject with 90 percent confidence the null hypothesis that the data are normally and log-normally distributed, respectively, as determined by the probability plot correlation coefficient method; 0, null hypothesis can be rejected; --, concentrations were not determined or many were less than the laboratory's minimum reporting level]

Metal	Total method			Total-recoverable method		
	Sample depth			Sample depth		
	All	Shallow	Deep	All	Shallow	Deep
Silver	--	--	--	--	--	--
Aluminum	0,0	N,L	0,L	0,L	N,L	0,L
Arsenic	--	--	--	--	--	--
Gold	--	--	--	--	--	--
Barium	N,L	N,L	N,L	--	--	--
Beryllium	--	--	--	--	--	--
Bismuth	--	--	--	--	--	--
Calcium	0,0	0,L	N,L	--	--	--
Cadmium	--	--	--	--	--	--
Cerium	N,L	N,L	N,L	--	--	--
Cobalt	0,0	0,L	0,0	--	--	--
Chromium	N,L	N,L	0,0	N,0	N,L	N,L
Copper	N,L	N,0	0,0	0,0	0,0	0,L
Europium	--	--	--	--	--	--
Iron	N,0	N,L	N,L	0,0	0,0	N,L
Gallium	0,0	0,L	0,0	--	--	--
Holmium	--	--	--	--	--	--
Mercury	N,0	N,0	N,L	N,0	0,0	N,L
Potassium	N,0	N,L	0,0	--	--	--
Lanthanum	0,0	0,0	0,0	--	--	--
Lithium	N,L	N,L	0,0	--	--	--
Magnesium	N,L	N,L	N,L	--	--	--
Manganese	0,0	0,L	N,L	0,L	0,L	0,0
Molybdenum	--	--	--	--	--	--
Sodium	N,L	N,0	N,L	--	--	--
Niobium	0,0	0,0	0,0	--	--	--
Neodymium	0,L	0,0	0,L	--	--	--
Nickel	N,L	N,L	0,0	N,0	N,0	N,L
Phosphorus	0,0	0,0	0,L	--	--	--
Lead	0,0	0,L	0,L	--	--	--
Antimony	0,0	0,L	0,0	0,L	N,L	0,0
Scandium	0,0	0,L	0,0	--	--	--
Selenium	0,0	N,L	N,L	--	--	--
Tin	--	--	--	--	--	--
Strontium	N,L	N,L	N,L	--	--	--
Tantalum	--	--	--	--	--	--
Thorium	--	--	--	--	--	--
Titanium	N,L	N,L	N,L	N,L	N,L	N,L
Thallium	--	--	--	--	--	N,L
Uranium	--	--	--	--	--	--
Vanadium	0,L	N,L	0,0	--	--	--
Yttrium	0,L	N,L	0,L	--	--	--
Ytterbium	0,0	0,0	0,0	--	--	--
Zinc	0,L	N,L	0,L	0,0	N,0	0,0
Carbon	0,0	N,0	0,0	--	--	--

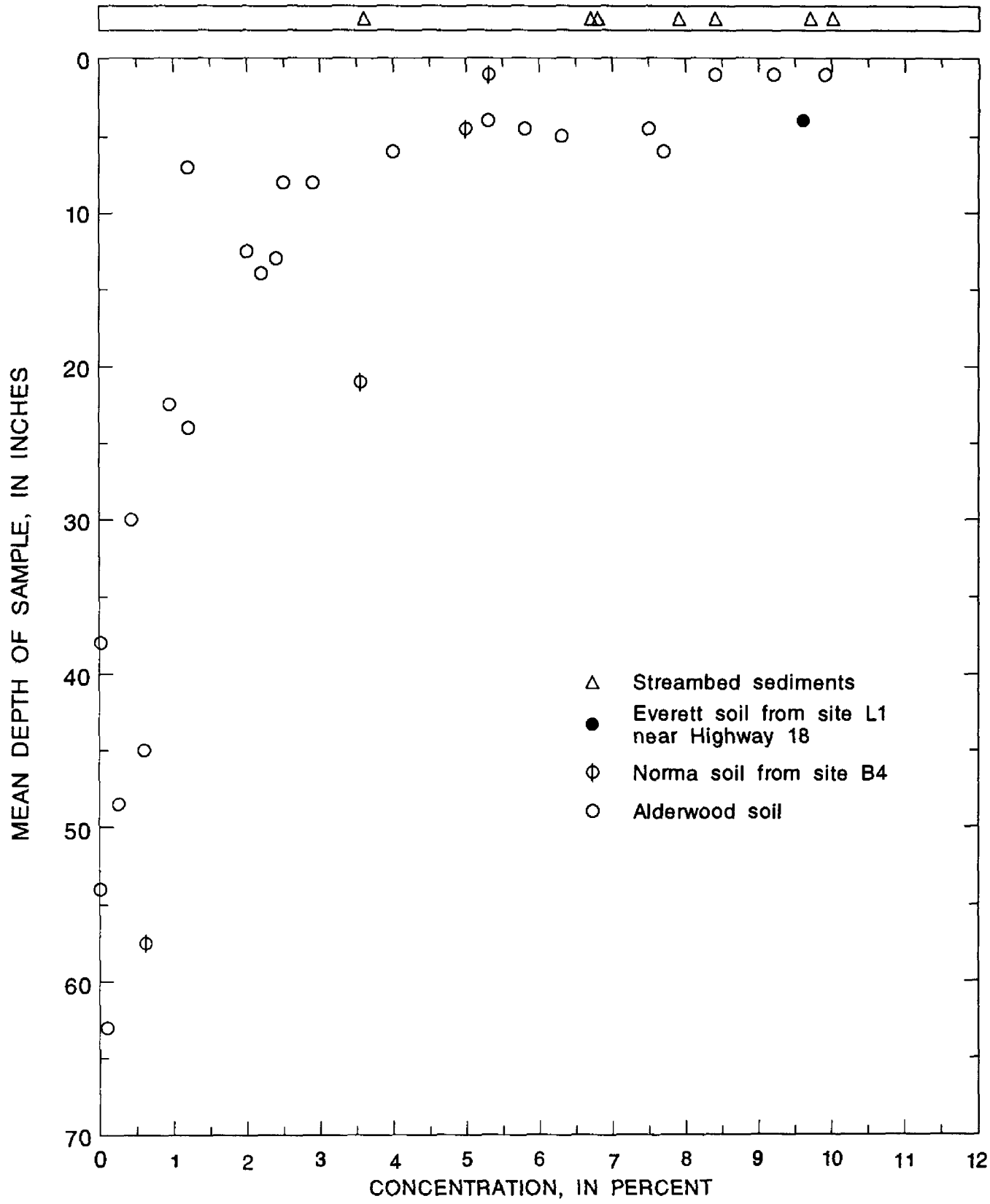

Figure 2.--Concentrations of total organic carbon in soil as a function of depth, and in streambed sediments from Big Soos Creek Basin.

bound only loosely to the soil. Consequently, a larger EP-TOX or ASTM concentration in shallow soil does not indicate necessarily a larger total concentration there. It only indicates a larger amount of loosely bound metal.

The reason for this is unknown, but could be related to the presence of larger concentrations of organic matter, or the metals being in a higher oxidation state near the surface.

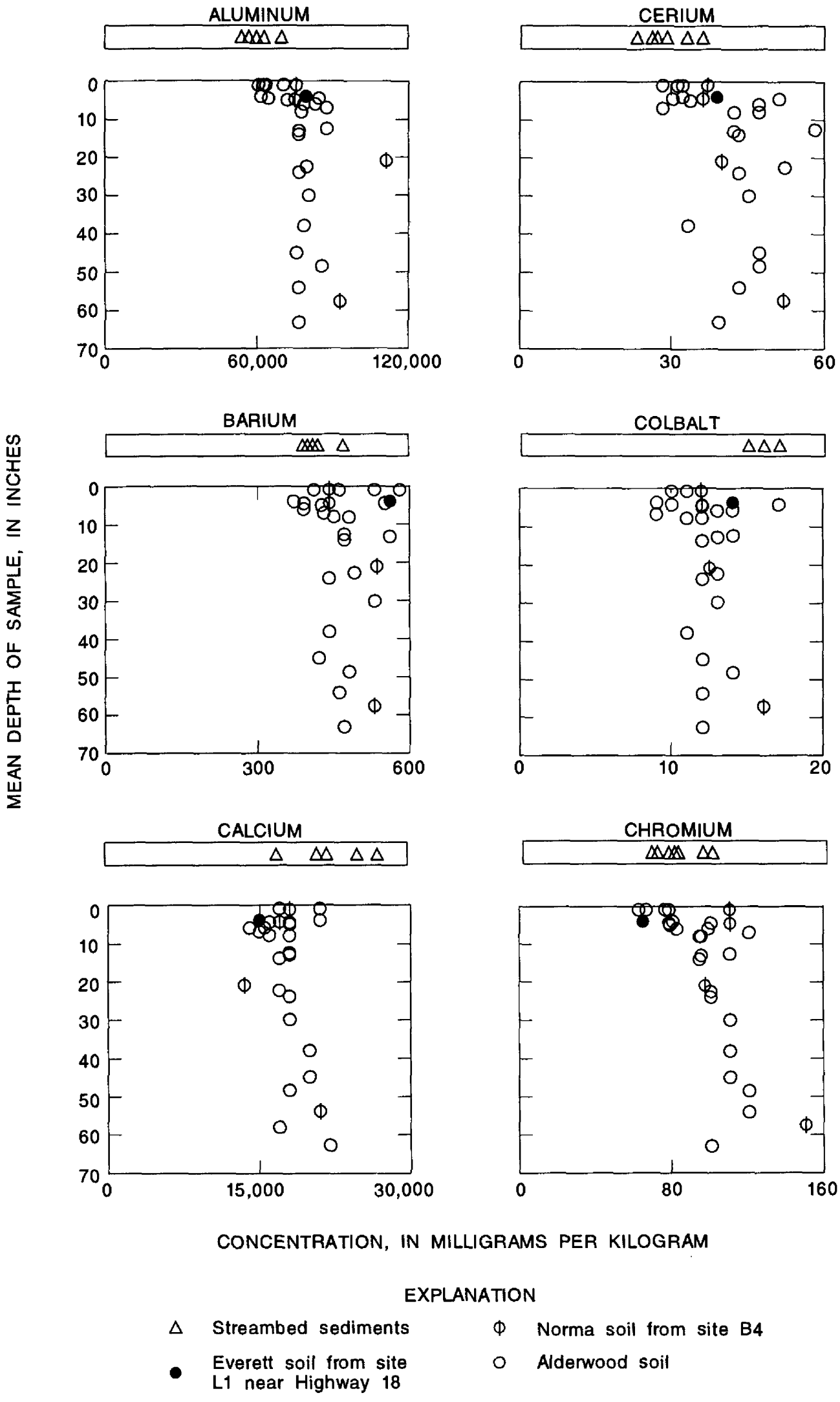

Figure 3.--Total concentrations of metals in soil as functions of depth, and in streambed sediments from Big Soos Creek Basin.

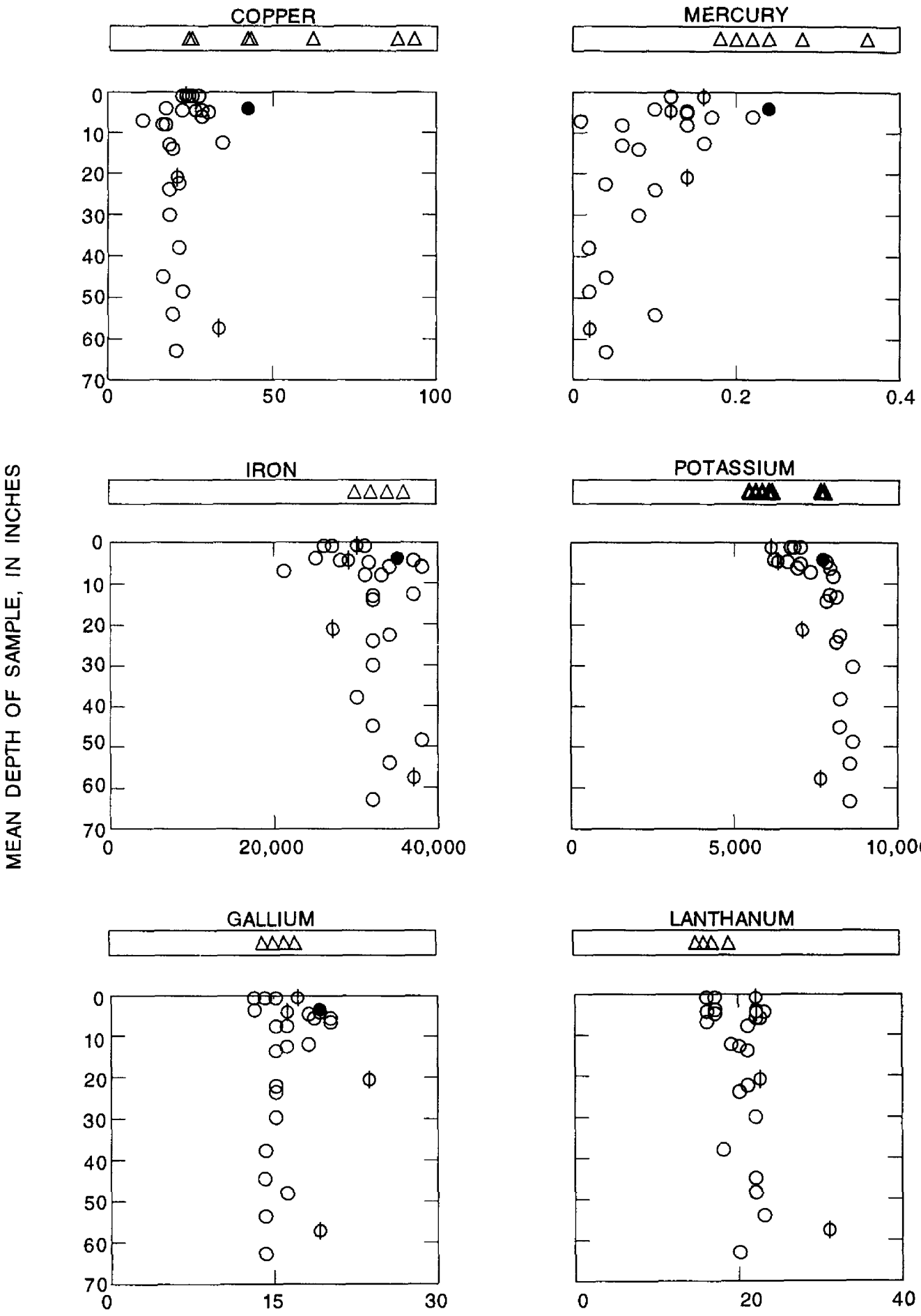

Figure 3.--Continued

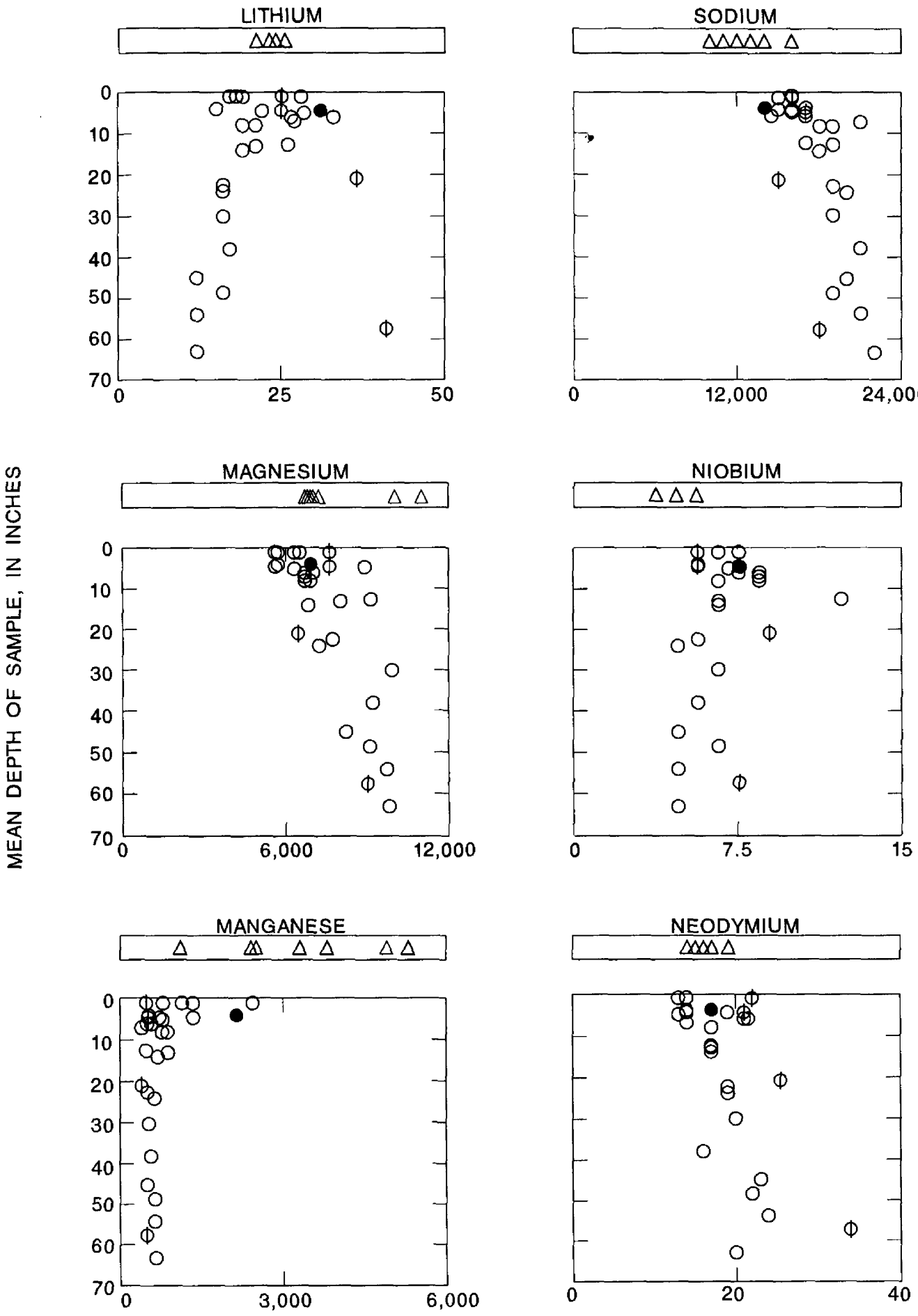

Figure 3.--Continued

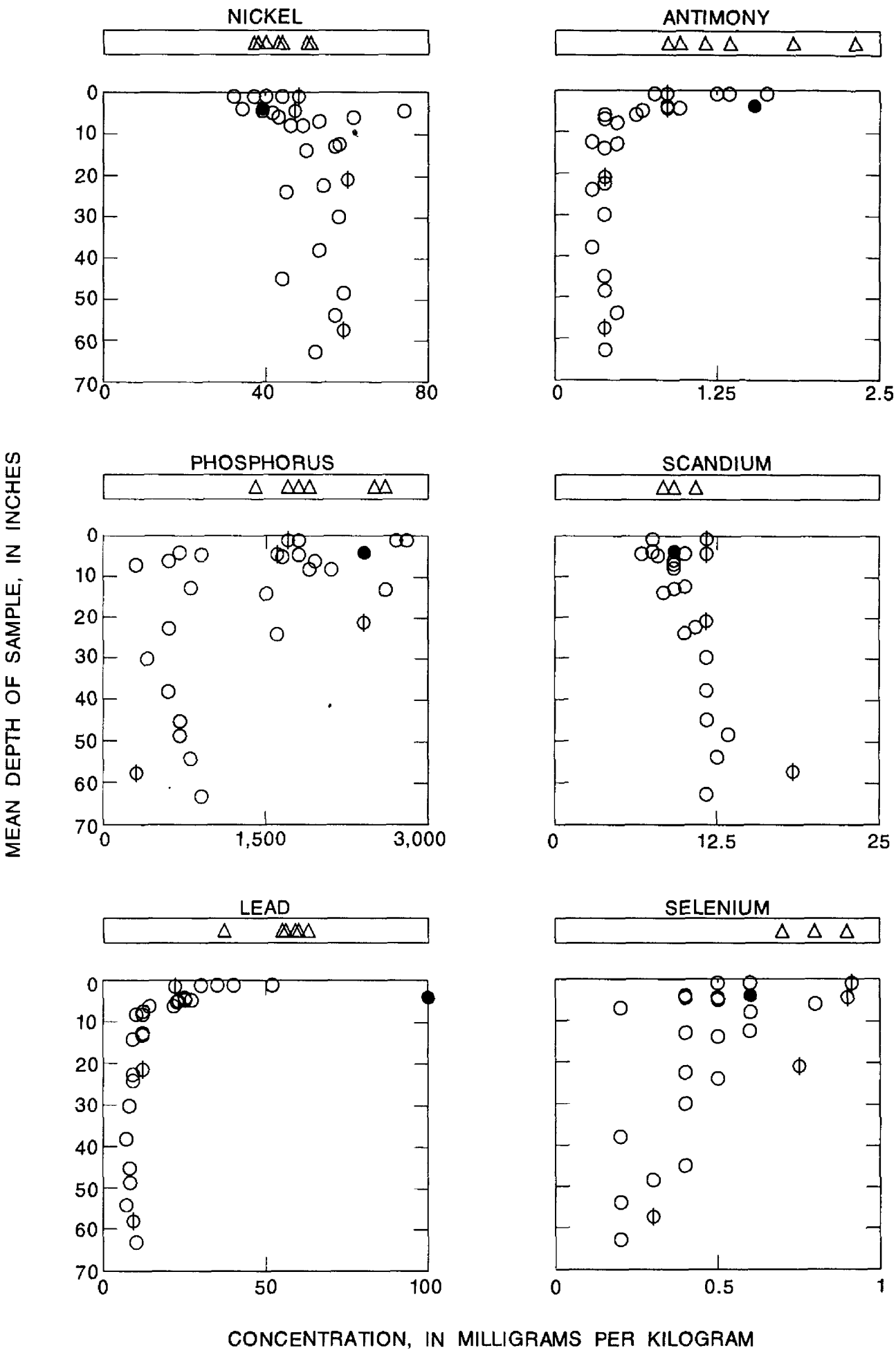

Figure 3.--Continued

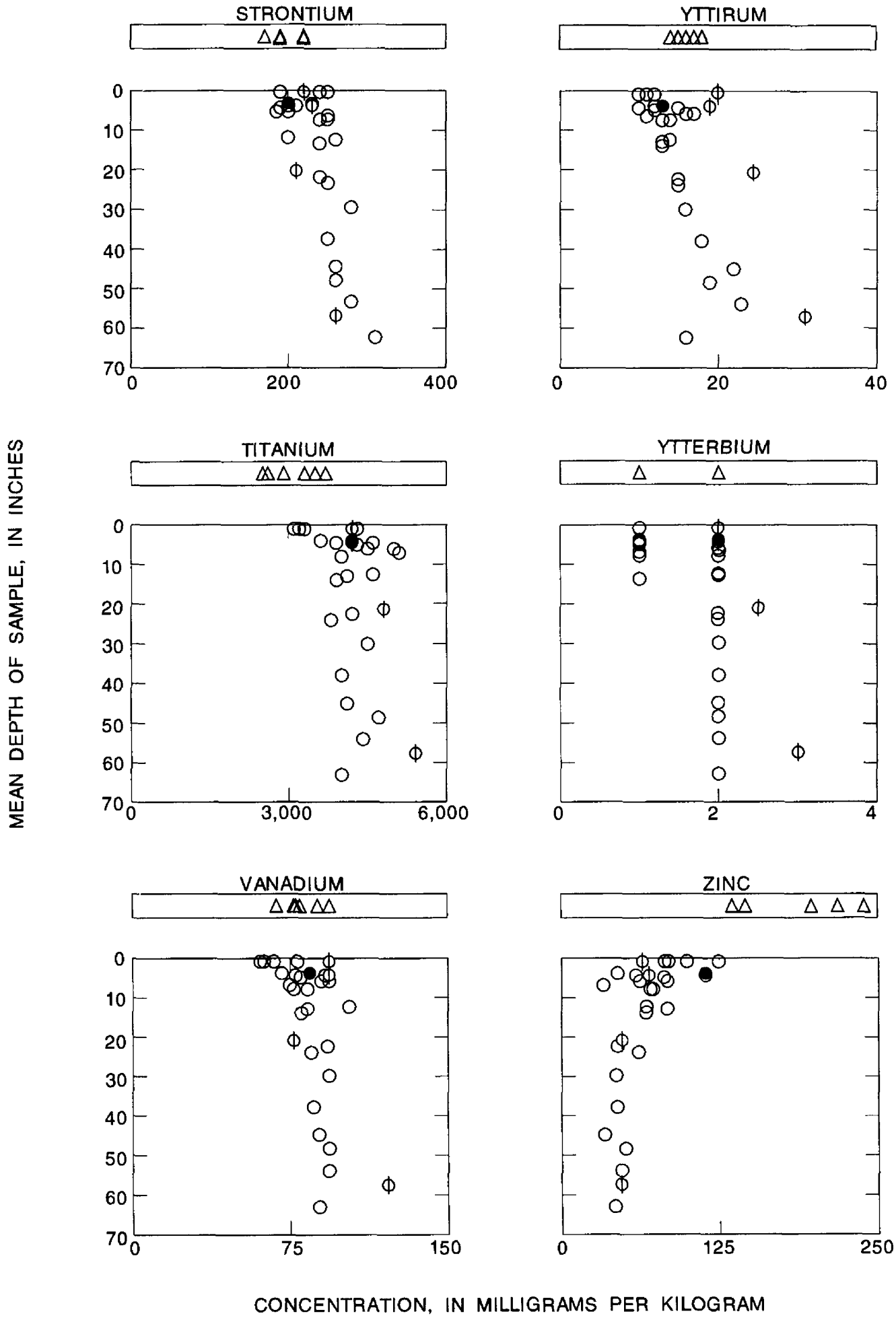

Figure 3.--Continued

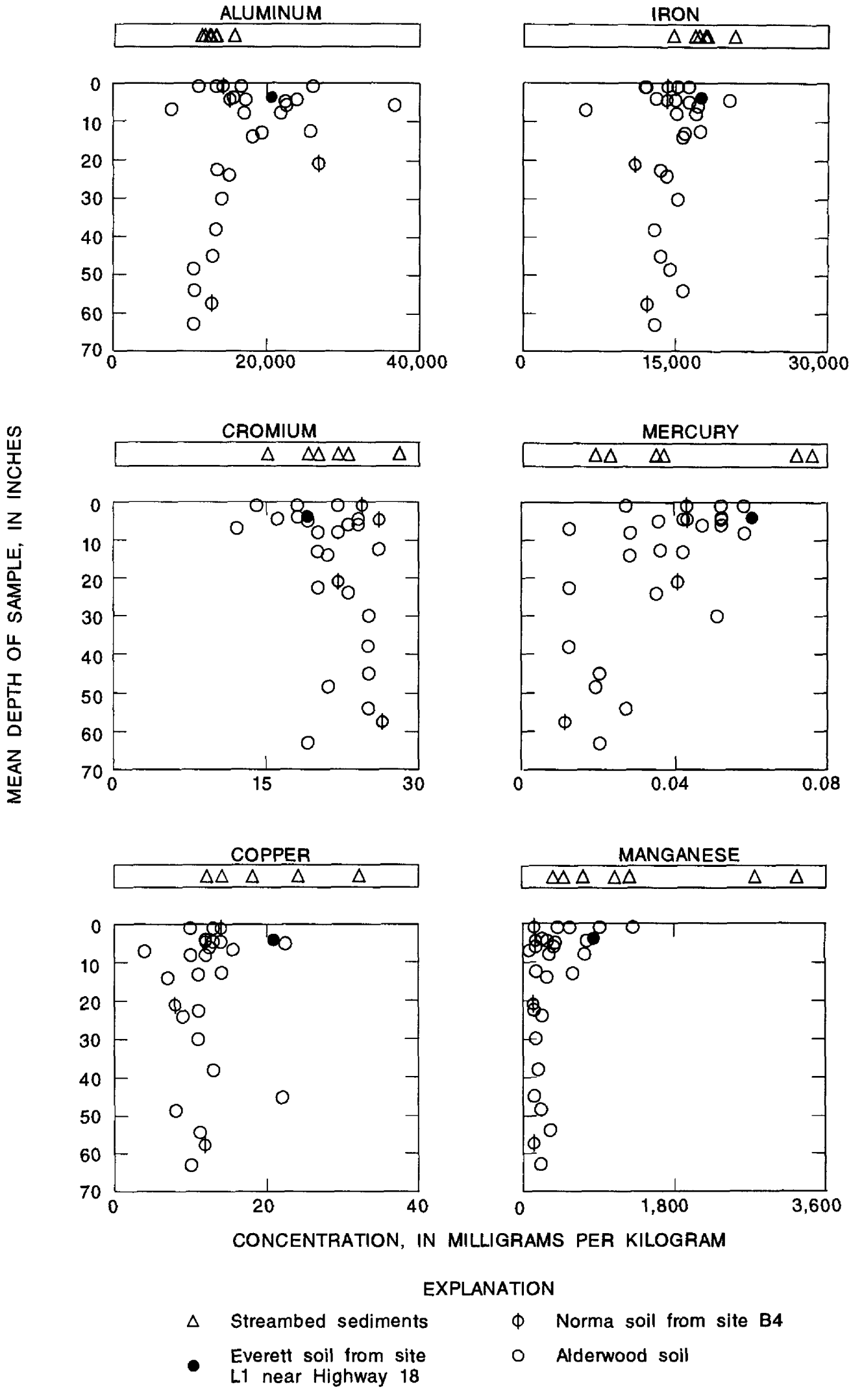

Figure 4.--Total-recoverable concentrations of metals in soil as functions of depth, and in streambed sediments from Big Soos Creek Basin.

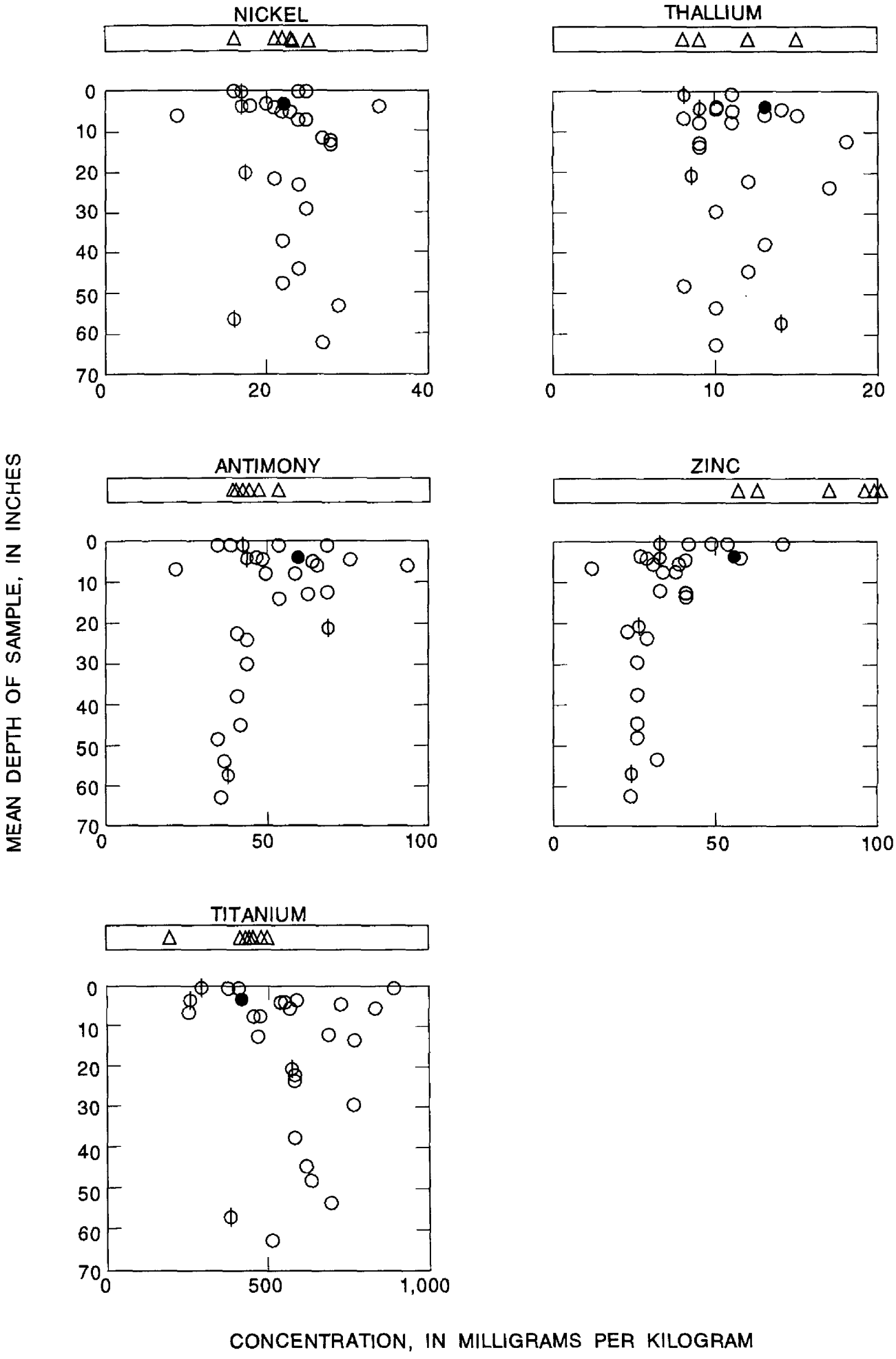

Figure 4.--Continued

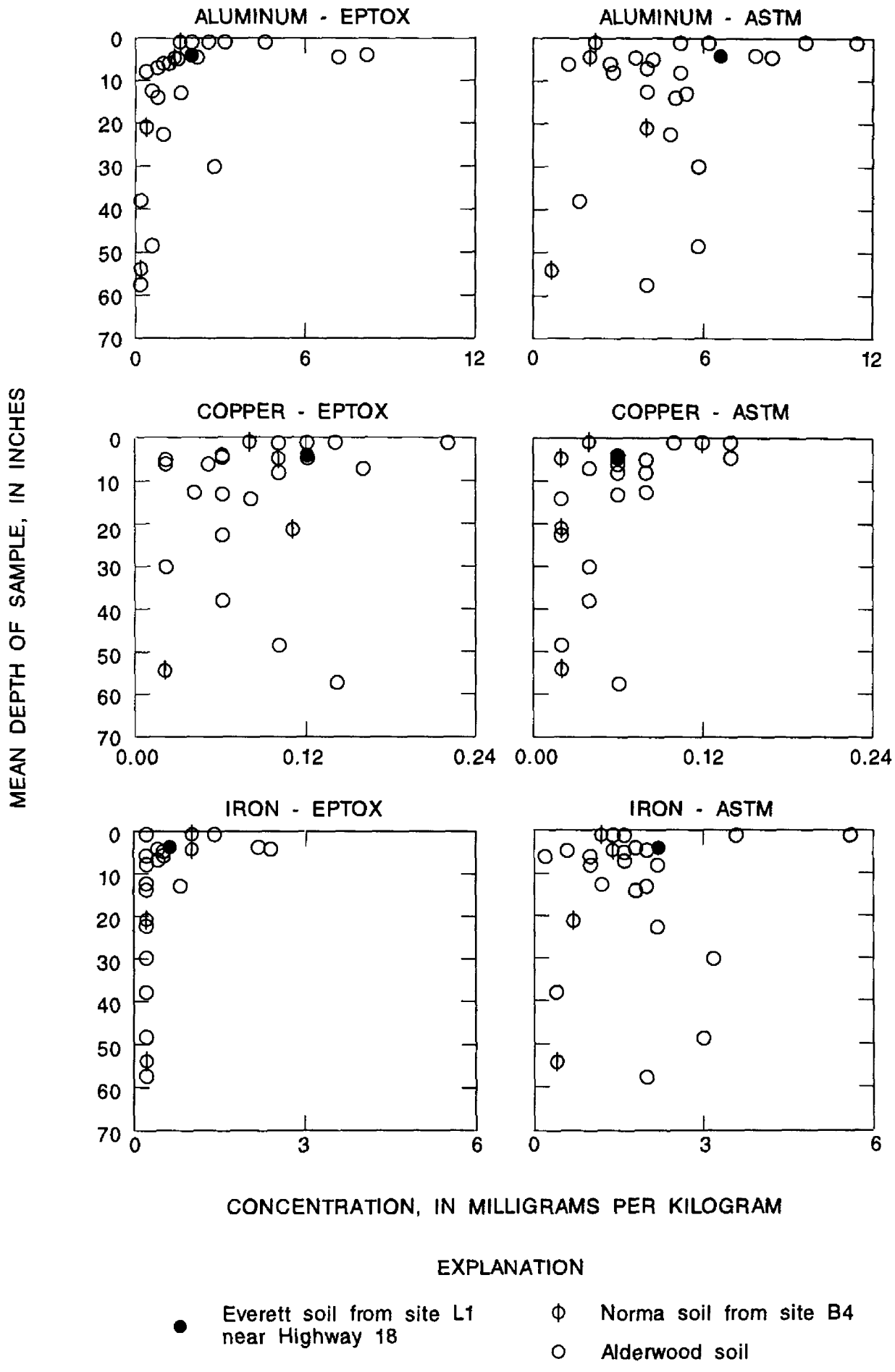

Figure 5.--Concentrations of metals in soil, determined by extraction procedure toxicity method (EP-TOX) and American Society of Testing Materials method (ASTM), as functions of depth in Big Soos Creek Basin. Concentrations of EP-TOX aluminum in two samples, of ASTM iron in one sample, and of EP-TOX iron in numerous samples were less than the detection level of 0.2 milligrams per kilogram.

Table 9.--Statistics for ratios between concentrations of metals determined by different laboratory methods

[TOT, total method; TR, total-recoverable method; S.D., standard deviation; C.V., coefficient of variation, in percent; N, number of ratios used in computing statistics; --, no data; >, greater than]

	TOT/TR	TOT/EPTOX	TOT/ASTM	TR/EPTOX	TR/ASTM	EPTOX/ ASTM
			Aluminum			
Mean	5.02	>116,000	25,200	>23,100	5,730	0.409
S.D.	1.99	>127,000	24,800	>21,400	6,110	.284
C.V.	40	>110	98	>93	107	69
N	29	26	26	26	26	24
			Arsenic			
Mean	>1.30	>770	>61	>840	>770	.6
S.D.	>.65	>320	>230	>295	>340	.1
C.V.	--	--	--	--	--	17
N	14	14	14	9	9	3
			Barium			
Mean	--	>430	>4000	--	--	--
S.D.	--	>100	>1200	--	--	--
C.V.	--	--	--	--	--	--
N	29	26	26	0	0	0
			Beryllium			
Mean	>1.7	>5	>5	>3	>3	--
S.D.	>.3	>0	>0	>.4	>.4	--
C.V.	>16	--	--	--	--	--
N	8	8	8	10	10	0
			Chromium			
Mean	4.7	>480	>480	>110	>110	--
S.D.	1.2	>100	>100	>20	>20	--
C.V.	25	--	--	--	--	--
N	29	26	26	26	26	0
			Copper			
Mean	1.94	422	543	235	271	2.1
S.D.	.47	382	330	250	146	1.8
C.V.	24	90	61	106	54	86
N	29	26	26	26	26	26
			Iron			
Mean	2.23	>107,000	>31,600	>46,000	11,700	.62
S.D.	.39	>65,000	>37,900	>27,900	9,600	.37
C.V.	17	--	>80	--	81	60
N	28	26	26	25	25	10
			Mercury			
Mean	2.77	>5.6	>56	>1.9	>19	--
S.D.	1.00	>2.8	>28	>.8	>8	--
C.V.	36	--	--	--	--	--
N	28	25	25	26	26	--
			Manganese			
Mean	2.40	>3,400	>3,600	>1,700	>1,800	>1.7
S.D.	.69	>2,200	>2,000	1,400	1,200	>1.2
C.V.	29	--	--	--	--	--
N	29	26	26	26	26	10
			Nickel			
Mean	2.35	>1,400	>2,100	>570	>970	>2.9
S.D.	.84	>830	>800	>270	>400	>1.6
C.V.	36	--	--	--	--	--
N	29	26	26	26	26	17

Table 9.--Statistics for ratios between concentrations of metals determined by different laboratory methods--Continued

	TOT/TR	TOT/EPTOX	TOT/ASTM	TR/EPTOX	TR/ASTM	EPTOX/ ASTM
			Lead			
Mean	>3.95	>220	>210	>220	>220	--
S.D.	>2.10	>200	>200	>99	>99	--
C.V.	>--	--	--	--	--	--
N	29	26	26	2	2	0
			Antimony[1]			
Mean	.015	>36	>36	>2,600	>2600	--
S.D.	.010	>20	>20	>800	>800	--
C.V.	69	--	--	--	--	--
N	29	26	26	26	26	0
			Selenium			
Mean	>.13	>1.3	>13	--	--	--
S.D.	>.05	>.5	>5	--	--	--
C.V.	--	--	--	--	--	--
N	29	26	26	0	0	0
			Titanium			
Mean	8.47	--	--	--	--	--
S.D.	3.43	--	--	--	--	--
C.V.	40	--	--	--	--	--
N	29	0	0	0	0	0
			Thallium			
Mean	--	--	--	>570	>570	--
S.D.	--	--	--	>130	>130	--
C.V.	--	--	--	--	--	--
N	0	0	0	18	18	0
			Zinc			
Mean	1.84	>340	>340	>180	>180	1.0
S.D.	.25	>120	>120	>65	>65	--
C.V.	13	--	--	--	--	--
N	29	26	26	26	26	1

[1] Ratios computed using laboratory-reported values of total-recoverable antimony concentrations that are suspected of being high by a factor of more than 10.

Relations Between Metals Concentrations Determined by Different Methods

Ratios between concentrations of metals in soils determined by the different laboratory methods were computed using all six possible combinations of the four methods; the results are summarized in table 9. The numerator in each ratio was the concentration determined by the method using the more rigorous extraction procedure of the two. Consequently, ratios would tend to be greater than unity. Some exceptions can be expected because the classes of particle sizes analyzed by the different methods generally were not the same. Also, the ratio of EP-TOX concentration (dilute acetic acid extraction) to ASTM concentration (distilled water extraction) should not be expected to be less than unity for all metals or samples, because (1) the solubilities of some metals increase or decrease with pH depending on the pH range, and (2) the solubilities of many metals are functions of other variables besides pH, such as oxidation-reduction potential, that are not controlled in the ASTM or EP-TOX procedures.

Means, standard deviations, and coefficients of variation for 16 metals are listed in table 9. Not all the ratios could be computed for all of the metals because not all methods were used to analyze for all metals, and because concentrations of some metals were smaller than laboratory minimum reporting levels for some methods. When the concentration in the numerator of a ratio was smaller than the reporting level, the ratio was not computed. When the concentration in the denominator, but not the numerator, was smaller than the laboratory minimum

reporting level, a lower limit of the ratio was computed by using the reporting level for the concentration in the denominator. Consequently, for some ratios, only lower limits of mean values and standard deviations are given in table 9. In these cases, a coefficient of variation is not given because it is not possible to determine if the computed ratio is or is not a lower limit.

Mean values of the ratios of the total to total-recoverable concentrations for 9 of the 10 metals for which actual values were computed range from 1.84 for zinc to 8.47 for titanium. The mean ratio for antimony is 0.015. Total concentrations were about twice total-recoverable concentrations for copper, iron, mercury, manganese, nickel, and zinc, but were about five to eight times as large for aluminum and titanium. The reason for the larger ratio for the latter two metals may be that they are primarily part of the mineral matrix, and consequently are not extracted as easily by the procedures used in the total-recoverable method as are some of the other metals that may be enriched in surface coatings.

Coefficients of variation for the nine metals range from 13 percent for zinc to 40 percent for aluminum and titanium. The mean values of the total to total-recoverable concentration ratios for all metals are greater than unity, as expected, except for antimony and perhaps selenium. Only a lower limit for the mean of the ratios for selenium, greater than 0.13, can be given because the total-recoverable concentration of selenium in every sample is smaller than the reporting level, and this reporting level is larger than the reported total concentration in every sample. The mean ratio for antimony, 0.015, is less than unity because the reported total-recoverable concentration is larger than the reported total concentration for every sample (see table 17).

The reason for the anomalous ratio for antimony is probably an error in the reported total-recoverable concentrations. Parker (1967, table 17), who summarized the findings of other investigators, reported that the typical total concentration of antimony in a wide variety of different types of rocks from all over the world ranges from 0.1 to 2 mg/kg (milligrams per kilogram). The arithmetic mean concentration of 0.66 mg/kg for antimony in soils and other surficial materials in the United States (Shacklette and Boerngen, 1984) is within the range reported by Parker (1967). The reported total concentrations of antimony in the soil samples collected in this study, 0.3 to 1.7 mg/kg, agree with those reported by Parker (1967). However, the reported total-recoverable concentrations (21 to 93 mg/kg) are more than ten times as large. Also, the total-recoverable concentrations of antimony in the six duplicate samples that were analyzed by the second laboratory (laboratory c in tables 3 and 18) are smaller (all are below the detection limit of 35 mg/kg) than the concentrations reported by the laboratory that analyzed all of the other samples by this method. However, because all antimony concentrations reported by the second laboratory are smaller than the laboratory's reporting level, the absolute values of these concentrations are unknown. Even though the total-recoverable concentrations of antimony are suspect, they are included in the analyses of this report.

Concentrations determined by the total or total-recoverable methods generally are more than 500 times as great as those determined by the EP-TOX or ASTM methods. The large ratios are to be expected because the extraction procedures employed by the EP-TOX and ASTM methods use a dilute solution of a weak acid or water, whereas the total and total-recoverable methods use strong acids. Because concentrations in most samples were less than the reporting levels for the EP-TOX and ASTM methods, only lower bounds for the means of these ratios could be determined for most metals. Exceptions are for aluminum, copper, and iron.

Concentrations of copper, nickel, and perhaps manganese, determined by the EP-TOX method tend to be larger than those determined by the ASTM method (tables 9 and 17). For aluminum and iron, however, the reverse is true.

Areal Variability of Concentrations

To investigate whether the variability in observed concentrations changes with the size of a sampled area, average coefficients of variation (table 10) of concentrations were computed for groups of sample sets representing three different size areas--clusters, subbasins, and the basin. Clusters, which are less than 1 acre in size, are sites where more than one sample was collected from one or more holes; the two subbasins are the two parts of the study area that drain to the Big and Little Soos Creeks before their confluence; and the basin is the entire study area. Coefficients were computed for total and total-recoverable metals concentrations, and computations were made separately for shallow and deep samples; concentrations in sample L1A0.5 (near Highway 18) were not included. Each coefficient of variation in table 10 is the square root of the weighted average of the squares of coefficients of variation for sample sets in a group. The weighting factor for a set is the number of samples in a set minus one.

***Table 10.**--Average coefficients of variation (in percent) of concentrations of metals as determined by total and total-recoverable methods and of total organic carbon in deep and shallow samples, when data are grouped by cluster (CL), subbasin (SB) and basin (BN)*

[--, coefficients not computed because concentrations not determined or many concentrations less than laboratory's lower reporting limit]

	Total method						Total-recoverable method					
	Shallow			Deep			Shallow			Deep		
Metal	CL	SB	BN	CL	SB	BN	CL	SB	BN	CL	SB	BN
Silver	--	--	--	--	--	--	--	--	--	--	--	--
Aluminum	10	12	12	6	13	12	20	33	38	30	34	35
Arsenic	--	--	--	--	--	--	--	--	--	--	--	--
Gold	--	--	--	--	--	--	--	--	--	--	--	--
Barium	8	11	14	8	9	9	--	--	--	--	--	--
	--	--	--	--	--	--	--	--	--	--	--	--
Bismuth	--	--	--	--	--	--	--	--	--	--	--	--
Calcium	11	12	11	10	12	11	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	--	--	--	--	--
Cerium	18	22	21	16	15	14	--	--	--	--	--	--
Cobalt	6	18	18	10	11	10	--	--	--	--	--	--
Chromium	15	17	19	13	14	14	16	23	22	11	11	12
Copper	20	26	25	17	23	26	19	27	34	36	35	34
Europium	--	--	--	--	--	--	--	--	--	--	--	--
Iron	9	16	15	10	10	9	12	23	23	10	13	13
Gallium	8	14	14	9	18	18	--	--	--	--	--	--
Holmium	--	--	--	--	--	--	--	--	--	--	--	--
Mercury	23	37	36	64	65	66	22	30	30	52	48	47
Potassium	7	9	9	4	6	6	--	--	--	--	--	--
Lanthanum	11	15	15	9	13	15	--	--	--	--	--	--
Lithium	12	29	23	37	48	46	--	--	--	--	--	--
Magnesium	7	13	14	14	14	14	--	--	--	--	--	--
Manganese	41	56	63	19	23	23	37	64	74	50	55	56
Molybdenum	--	--	--	--	--	--	--	--	--	--	--	--
Sodium	8	11	10	8	10	10	--	--	--	--	--	--
Niobium	13	17	17	23	28	33	--	--	--	--	--	--
Neodymium	11	21	21	13	21	23	--	--	--	--	--	--
Nickel	13	21	24	10	10	10	16	28	27	11	18	17
Phosphorus	15	41	46	67	66	69	--	--	--	--	--	--
Lead	47	47	46	20	20	19	--	--	--	--	--	--
Antimony	6	43	44	13	12	16	17	32	34	26	27	27
Scandium	10	15	17	17	22	21	--	--	--	--	--	--
Selenium	9	34	34	41	45	43	--	--	--	--	--	--
Tin	--	--	--	--	--	--	--	--	--	--	--	--
Strontium	6	9	11	10	11	11	--	--	--	--	--	--
Tantalum	--	--	--	--	--	--	--	--	--	--	--	--
Thorium	--	--	--	--	--	--	--	--	--	--	--	--
Titanium	10	15	15	8	10	10	11	26	38	18	19	18
Thallium	--	--	--	--	--	--	--	--	--	--	--	--
Uranium	--	--	--	--	--	--	--	--	--	--	--	--
Vanadium	11	14	14	12	13	13	--	--	--	--	--	--
Yttrium	13	24	24	21	29	29	--	--	--	--	--	--
Ytterbium	28	36	36	18	21	20	24	36	36	21	22	21
Zinc	20	30	31	28	27	26	--	--	--	--	--	--
Median	11	16	18	13	14	16	18	29	34	24	24	24
Carbon	43	46	43	102	105	101	--	--	--	--	--	--
No. of groups	4	2	1	4	2	1	4	2	1	4	2	1

The average coefficients of variation for most of the individual metals and the median values of the coefficients (table 10) are about one and one half to two times as large for subbasins as for clusters for both total and total-recoverable metals in shallow but not deep samples. For most metals there is little difference between coefficients of variation for subbasins and basins for either deep or shallow samples. The differences between the coefficients for clusters and subbasins for the shallow samples indicates that the variability of concentrations increases with increasing sampling area over all or part of the range less-than-1-acre (cluster) to 13 mi^2 (subbasins). The lack of differences in the coefficients of variation between subbasins and basin may be a result of the small difference in size between Big Soos Creek subbasin (13.0 mi^2) and the entire basin (15.9 mi^2).

Relations Between Metals Concentrations and Particle Size

Some of the data collected in this study provide information on relations between metals concentrations determined by the total-recoverable method and particle sizes. No information is provided for relations between particle size and concentrations determined by the total method, because all concentrations determined by this method were for only the size fraction smaller than 0.063 mm, and distributions of particle sizes within this size fraction were not determined.

As mentioned earlier, some investigators have found that in streambed sediments, concentrations of metals tend to be larger in sediments with smaller particle sizes than in sediments with larger particle sizes (Horowitz, 1985). Median concentrations of all metals determined by the total-recoverable method in three different size classes of six samples are larger in the silt-plus-clay size class (less than 0.063 mm) than in the sand class (0.063 to 2 mm) of nearly all samples (fig. 6 and table 19). Median concentrations in the gravel size class (2 to 9.5 mm), however, are also larger than in the sand size class in most samples for most metals except for perhaps mercury and titanium. Median concentrations of copper, mercury, titanium, and zinc are larger in the silt-plus-clay size class than in the gravel size class in at least five of the six samples, but concentrations of manganese and perhaps iron tend to be larger in the gravel size class than in the silt-plus-clay size class. The reason for the relatively large concentrations in the gravel size class is unknown.

The finding that concentrations in the sand size class are smaller than in either the silt-plus-clay or gravel size classes is supported by the fact that correlation coefficients between metals concentrations (as determined by the total-recoverable method) in the entire less-than-9.5 mm size fraction in all soil samples (except L1A0.5) and the weight fractions in three different classes (table 11) are lower (more negative) for the sand size class than for the other two size classes for all metals except manganese.

Correlations Between Concentrations

In their discussions of trace elements in streambed sediments, Horowitz and others (1989) state that metals are present in sediments as constituents of the mineral matrix, as parts of surface coatings on particles, and incorporated with organic matter. They state that total concentrations of aluminum, iron, manganese, and titanium are relatively high and are potentially capable of representing the fraction in the mineral matrix. Because titanium minerals are stable, concentrations of titanium minerals in soils often are used as an indicator of the amount of parent, or rock, material present (Bohn and others, 1985). Characteristics potentially capable of representing the surface-coating fraction are the amounts of iron- and manganese-oxide coatings on particles, and particle surface area. Particle size often is used as a surrogate for surface area, because the two are inversely related, and the former is determined more often than the latter. The organic component can be represented by the concentration of total organic carbon.

The relations between concentrations of total-recoverable metals in sampled soils and particle size were discussed in the previous section. Here, relations among concentrations of different metals and organic carbon are discussed. Correlation coefficients between concentrations of different metals in soils and between concentrations of metals and of organic carbon were computed (tables 12 and 13) for all samples, for shallow samples, and for deep samples. Concentrations of total organic carbon were determined for only the size fraction smaller than 0.063 mm, which was the fraction analyzed for total metals concentrations. However, correlation coefficients between this total organic carbon concentration and total-recoverable, as well as total metal concentrations, were computed.

Correlation coefficients were computed using both untransformed and log-transformed data. (The logarithmic transformation is often used so that the data better approximate a normal distribution.) Because conclusions

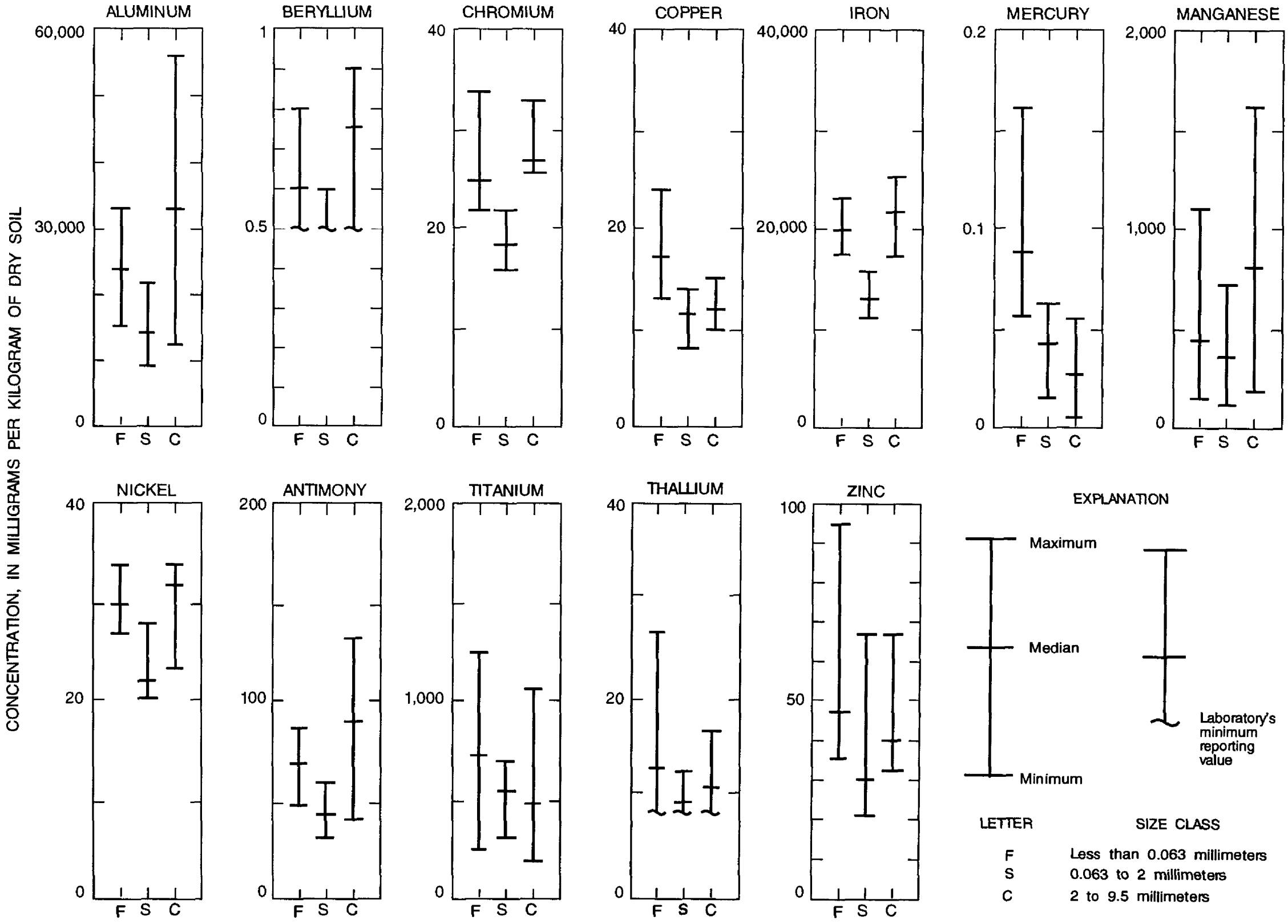

Figure 6.--Concentrations of metals, as determined by the total-recoverable method, in three size classes of six soil samples from Big Soos Creek Basin. See Table 21 for sample numbers and data for individual samples.

***Table 11.**--Correlation coefficients between concentrations of metals in soils determined by the total-recoverable method and weight fractions in different particle-size classes*

[--, no data]

Metal	Size class (in millimeters)		
	less than 0.063	0.063 to 2.0	2.0 to 9.5
Silver	--	--	--
Aluminum	-0.19	-0.64	0.50
Arsenic	--	--	--
Beryllium	--	--	--
Cadmium	--	--	--
Chromium	.37	-.22	-.09
Copper	-.19	-.43	.37
Iron	-.12	-.59	.43
Mercury	-.02	-.28	.18
Manganese	-.15	-.05	.12
Nickel	-.13	-.49	.37
Lead	--	--	--
Antimony	-.20	-.68	.53
Selenium	--	--	--
Titanium	-.47	-.64	.66
Thallium	-.10	-.30	.24
Zinc	-.11	-.32	.26

about the degree of correlation between variables were nearly the same for transformed data and untransformed data, only those computed from untransformed data are shown (tables 12 and 13). A correlation coefficient of 0.50 (0.25 when squared) is used in the following discussion as a criteria for determining whether two variables are correlated. Although this value was selected for convenience somewhat arbitrarily and may appear to be low, the probability that two uncorrelated variables would have a correlation coefficient of 0.5 or larger by chance is less than 5 percent for the number of samples used in the computations. The following evaluation of the correlation data is not exhaustive, but rather is intended to demonstrate how these data may be used to examine variations of metals concentrations in soils.

Concentrations of chromium and nickel determined by the total method are correlated with concentrations of titanium and also with concentrations of aluminum (table 12), regardless if all data, data for only shallow, or data for only deep samples are used. An exception is that there is little correlation between chromium and aluminum for deep samples. These correlations suggest that chromium and nickel are associated mostly with the mineral phase of the soils sampled. Concentrations of these metals obtained by the total-recoverable method do not correlate as well as those obtained by the total method, perhaps because the total-recoverable method is inefficient for extracting titanium. The average ratio of total to total-recoverable concentrations for titanium is higher than for any other metal (table 9).

In the upper layers of soils, organic matter may contribute appreciably to the capacity of the soil to fix metals by adsorption or complexation. The ability of organic matter to concentrate metals varies with the metal and the composition of the organic matter. Properties of organic matter that govern its affinity for metals include surface area, cation-exchange capacity, surface charge, and the stability of the organic-metal complex. The stability of the organic-metal complex in soils decreases according to the following sequence: lead, copper, nickel, cobalt, zinc, cadmium, iron, manganese, and magnesium (Horowitz, 1985).

***Table 12.**--Correlation coefficients between total concentrations of selected metals in soils and between concentrations of the metals and concentrations of total organic carbon*

[All concentrations determined for the size class less than 0.063 millimeters; TOC, total organic carbon; --, no data]

		Al	Fe	Mn	Ti	TOC	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn	
							All samples									
Cr	Chromium	0.65	0.40	-0.51	0.79	-0.75	1.00	-0.02	-0.49	0.66	-0.71	-0.66	-0.27	--	-0.55	Cr
Cu	Copper	.06	.48	.20	.19	.36		1.00	.47	.13	.33	.24	.36	--	.45	Cu
Hg	Mercury	-.12	.09	.16	-.07	.61			1.00	-.17	.42	.34	.77	--	.51	Hg
Ni	Nickel	.76	.53	-.30	.64	-.46				1.00	-.53	-.52	-.11	--	-.08	Ni
Pb	Lead	-.61	-.45	.77	-.58	.91					1.00	.96	.28	--	.71	Pb
Sb	Antimony	-.58	-.35	.82	-.58	.87						1.00	.22	--	.65	Sb
Se	Selenium	.08	.06	-.02	.01	.48							1.00	--	.38	Se
Tl	Thallium	--	--	--	--	--								--	--	Tl
Zn	Zinc	-.36	.01	.71	-.40	.75									1.00	Zn
Al	Aluminum	1.00	.34	-.51	.79	-.52										
Fe	Iron		1.00	-.21	.47	-.37										
Mn	Manganese			1.00	-.60	.55										
Ti	Titanium				1.00	-.47										
							Samples with mean depths of less than 12 inches									
Cr	Chromium	.82	.05	-.59	.68	-.69	1.00	-.36	-.25	.66	-.68	-.62	.23	--	-.40	Cr
Cu	Copper	-.14	.58	.32	-.05	.59		1.00	.74	.10	.43	.33	.50	--	.63	Cu
Hg	Mercury	-.03	.70	.01	-.08	.32			1.00	.05	.06	.03	.67	--	.32	Hg
Ni	Nickel	.82	.49	-.18	.59	-.28				1.00	-.40	-.40	.15	--	.23	Ni
Pb	Lead	-.74	-.32	.79	-.74	.84					1.00	.95	-.15	--	.60	Pb
Sb	Antimony	-.77	-.38	.77	-.83	.78						1.00	-.13	--	.54	Sb
Se	Selenium	.21	.58	-.23	.15	.03							1.00	--	.12	Se
Tl	Thallium	--	--	--	--	--								--	--	Tl
Zn	Zinc	-.20	.33	.69	-.39	.66									1.00	Zn
Al	Aluminum	1.00	.42	-.47	.87	-.66										
Fe	Iron		1.00	-.11	.42	-.07										
Mn	Manganese			1.00	-.63	.51										
Ti	Titanium				1.00											
							Samples with mean depths of greater than 12 inches									
Cr	Chromium	.19	.62	-.29	.76	-.48	1.00	.60	-.34	.35	-.37	.03	-.41	--	-.33	Cr
Cu	Copper	.43	.61	-.38	.68	.07		1.00	.16	.49	.31	-.34	.11	--	.14	Cu
Hg	Mercury	.38	-.20	-.25	.03	.63			1.00	.17	.54	-.14	.74	--	.36	Hg
Ni	Nickel	.59	.26	-.13	.74	.18				1.00	.29	.30	.06	--	.14	Ni
Pb	Lead	.48	-.14	.03	.14	.81					1.00	.02	.67	--	.59	Pb
Sb	Antimony	-.09	.00	.44	.13	.03						1.00	-.24	--	.11	Sb
Se	Selenium	.59	-.30	-.38	.11	.88							1.00	--	.34	Se
Tl	Thallium	--	--	--	--	--								--	1.00	Tl
Zn	Zinc	-.09	.10	.62	-.17	.50										Zn
Al	Aluminum	1.00	-.16	-.62	.71	-.55										
Fe	Iron		1.00	.06	.42	-.38										
Mn	Manganese			1.00	-.50	-.06										
Ti	Titanium				1.00	.06										

***Table 13.**--Correlation coefficients between total-recoverable concentrations of selected metals in soils and between concentrations of the metals and concentrations of total organic carbon*

[Concentrations of all metals determined for the size class less than 9.5 millimeters. Concentrations of total organic carbon (TOC) determined for the size class less than 0.063 millimeters; --, no data]

		Al	Fe	Mn	Ti	TOC	Cr	Cu	Hg	Ni	Pb	Sb	Se	Tl	Zn	
							All samples									
Cr	Chromium	0.27	0.45	-0.43	0.30	-0.41	1.00	0.26	-0.18	0.42	--	0.30	--	0.35	-0.13	Cr
Cu	Copper	.29	.41	.17	.22	.27		1.00	.19	.17	--	.34	--	.22	.30	Cu
Hg	Mercury	.39	.40	.60	-.10	.67			1.00	.12	--	.42	--	-.14	.61	Hg
Ni	Nickel	.30	.82	.17	.54	-.17				1.00	--	.44	--	.11	.38	Ni
Pb	Lead	--	--	--	--	--					--	--	--	--	--	Pb
Sb	Antimony	.98	.62	.11	.51	.32						1.00	--	.24	.40	Sb
Se	Selenium	--	--	--	--	--							--	--	--	Se
Tl	Thallium	.27	.17	-.34	.28	-.21								1.00	-.27	Tl
Zn	Zinc	.30	.56	.82	-.00	.72									1.00	Zn
Al	Aluminum	1.00	.50	.03	.49	.32										
Fe	Iron		1.00	.28	.44	.20										
Mn	Manganese			1.00	-.22	.59										
Ti	Titanium				1.00	-.15										
							Samples with mean depths of less than 12 inches									
Cr	Chromium	.59	.68	-.31	.25	-.15	1.00	.33	.11	.54	--	.61	--	.15	.11	Cr
Cu	Copper	.50	.63	.21	.50	.38		1.00	.35	.40	--	.55	--	.22	.44	Cu
Hg	Mercury	.16	.46	.60	-.06	.49			1.00	.37	--	.24	--	.11	.56	Hg
Ni	Nickel	.63	.94	.31	.49	.16				1.00	--	.75	--	.15	.60	Ni
Pb	Lead	--	--	--	--	--					1.00	--	--	--	--	Pb
Sb	Antimony	.98	.77	-.03	.79	.08						1.00	--	.53	.30	Sb
Se	Selenium	--	--	--	--	--							--	--	--	Se
Tl	Thallium	.56	.26	-.33	.48	-.01								1.00	-.27	Tl
Zn	Zinc	.17	.57	.79	.12	.70									1.00	Zn
Al	Aluminum	1.00	.66	-.13	.82	.00										
Fe	Iron		1.00	.24	.49	.27										
Mn	Manganese			1.00	-.10	.51										
Ti	Titanium				1.00	.16										
							Samples with mean depths of greater than 12 inches									
Cr	Chromium	.03	.08	-.38	.10	-.24	1.00	.50	-.01	-.21	--	-.04	--	.54	-.17	Cr
Cu	Copper	-.12	.02	-.22	-.07	-.27		1.00	-.22	.02	--	-.09	--	.35	-.21	Cu
Hg	Mercury	.56	.40	.32	.39	.52			1.00	.36	--	.62	--	-.10	.44	Hg
Ni	Nickel	-.06	.79	.58	.50	-.09				1.00	--	.09	--	-.08	.65	Ni
Pb	Lead	--	--	--	--	--					1.00	--	--	--	--	Pb
Sb	Antimony	.98	.25	.23	.10	.91						1.00	--	.09	.55	Sb
Se	Selenium	--	--	--	--	--							--	--	--	Se
Tl	Thallium	.17	.17	-.32	-.11	-.07								1.00	-.13	Tl
Zn	Zinc	.41	.68	.77	.27	.50									1.00	Zn
Al	Aluminum	1.00	.13	.04	.10	.91										
Fe	Iron		1.00	.48	.55	.02										
Mn	Manganese			1.00	-.13	.21										
Ti	Titanium				1.00	-.01										

As expected, the concentration of a metal correlates with the concentration of total organic carbon if the distribution of the metal with depth is similar to the distribution of organic carbon (see figs. 2 and 3). Total concentrations of lead and zinc correlate with concentrations of total organic carbon in all the shallow and the deep samples (table 12), suggesting that the lead and zinc present in the soils are associated with the organic matter. Concentrations of total copper and antimony are correlated with concentrations of total organic carbon only in the shallow, but not the deep, samples. A possible explanation for the difference between correlations of copper and organic carbon in the shallow and deep samples may be that minerals containing copper are more weathered, or degraded, in the shallow soils, thereby releasing copper for complexation with the organic matter present. Copper concentrations in the shallow soil samples are not larger than concentrations in the deep samples, indicating that the association between copper and organic matter in the shallow samples is not simply a result of the deposition of copper at the land surface. In contrast, the correlation between concentrations of antimony and organic carbon in the shallow samples only, as well as larger concentrations of antimony in the shallow samples, may be a result of airborne deposition from the smelter that operated upwind of the study area.

Metals Concentrations in Streambed Sediments

Concentrations of most metals and total organic carbon in streambed-sediment samples collected in this study are typical of or slightly larger than those in soils (figs. 2-4 and table 14). For total organic carbon and those metals that have larger concentrations in shallow soils than in deep soils, concentrations in streambed sediments are more similar to concentrations in shallow than in deep soils. The maximum observed concentrations of some metals in the streambed sediments are as much as twice those in the shallow soils. This is true for cadmium, copper, mercury, manganese, lead, and zinc determined by both the total and total-recoverable methods, and for arsenic, antimony, and selenium determined by the total method. Concentrations of total and total-recoverable lead in streambed-sediment sample SED1B were a factor of 10 or more larger than concentrations in soil samples.

***Table 14.**--Comparison of mean concentrations of metals in streambed sediments with mean concentrations in soil samples from depths of less than 12 inches*

[All concentrations are in milligrams per kilogram; <, less than; --, no data; S.D., standard deviation]

	Total concentrations				Total-recoverable concentrations			
	Soil		Streambed		Soil		Streambed	
Metal	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Silver	<2	--	<2	--	<4	--	<4	--
Aluminum	73,000	8,700	62,000	6,100	19,000	6,900	13,000	1,400
Arsenic	<14	--	23	4.9	<14	--	<11	--
Barium	460	66	410	26	--	--	--	--
Beryllium	<1	--	<1	--	<.57	--	<.5	--
Cadmium	<2	--	16	8	<.8	--	<1.6	--
Chromium	87	17	82	12	20	4.3	21	4.1
Copper	24	7.3	54	28	13	4.2	20	6.9
Iron	30,000	4,600	32,000	2,100	15,000	3,200	18,000	1,800
Mercury	.13	.05	.24	.06	.05	.01	.04	.02
Manganese	920	600	3,300	1,500	480	340	1,400	1,100
Nickel	45	11	43	5.5	21	5.5	22	3.1
Lead	29	22	55 [a]	9 [a]	<4	--	<6 [b]	--
Antimony	.91	.41	1.4	.56	53	17	44	4.7
Selenium	.58	.19	.77	.10	<4	--	<4	--
Titanium	4,100	580	3,100	460	500	190	420	100
Thallium	--	--	--	--	<11	--	<10	--
Zinc	76	24	180	43	40	14	84	17

[a] The total concentration of 1,100 in sample SED1B was omitted from this calculation.
[b] The total-recoverable concentration of 397 in sample SED1B was omitted from this calculation.

The reasons why concentrations in streambed sediments are more similar to those in shallow than in deep soils are unknown; however, several possibilities are suggested. (1) Natural geochemical processes acting on surficial streambed sediments are more likely to be similar to those acting on shallow than to those acting on deep soils. (2) Anthropogenic effects on surficial streambed sediments would tend to be more similar to effects on shallow than on deep soils. (3) Sources of streambed sediments would more likely be shallow rather than deep soils. The reasons that concentrations of some metals are larger in streambed sediments than those in shallow soils also are unknown. Possible reasons are (1) the presence of one or more localized anthropogenic metal sources in the drainage area, and (2) geochemical processes that leach metals from soil but reprecipitate them on streambed sediments.

Concentrations in a Sample From Near Highway 18

Sample L1A05 was collected near Highway 18 to test if concentrations in soil from a location with suspected local anthropogenic effects differed from concentrations in samples from locations believed to be free of these effects. Elevated concentrations of copper, chromium, iron, lead, and zinc have been reported to be associated with motor-vehicle traffic (Asplund and others, 1980). In most of the analyses discussed so far, the data for this sample were omitted; however, they are included in figures 2 through 5. This sample had larger total concentrations of copper, mercury, and lead (fig. 3) and total-recoverable concentrations of mercury and lead (fig. 4) than any of the other samples. (Total-recoverable lead concentrations are not included in figure 4 because total-recoverable lead concentrations in nearly all samples are less than the laboratory's reporting level.) In addition, total concentrations of manganese, antimony, zinc, and other metals; and total-recoverable concentrations of copper and zinc are near the upper end of the range of observed concentrations.

Although the proximity of the sampling site to Highway 18 is the most obvious reason for the elevated concentrations of some metals in sample L1A0.5, other possibilities exist. One is that the concentration of total organic carbon in sample L1A0.5 is larger than in most other samples (see fig. 2 and table 2). As discussed previously, the concentrations of some metals, including lead, correlate with concentration of total organic carbon. Another possibility is that the soil type at site L1 (Everett) is different from that of the other sites (see fig. 1 and table 2). It is possible that concentrations of metals in the Everett soil series are naturally large.

Comparison of Metals Concentrations in Big Soos Creek Basin With Those in the Conterminus United States

Shacklette and Boerngen (1984) present the results of a study designed to give estimates of the range of elemental abundance in soils and surficial materials in the conterminous United States that were unaltered or little altered from their natural condition. Sample collection started in 1961 and continued until 1975 when soils and surficial materials from 1,318 sites had been collected. These samples were analyzed for 46 different elements. The samples were collected from a depth of 20 cm (about 8 inches), and were sieved to remove particles larger than 2 mm.

A comparison of total metals concentrations in soils from this study with data published by Shacklette and Boerngen (1984) shows that ranges of concentrations of metals in soil samples from Big Soos Creek Basin are generally within the ranges of concentrations in samples collected throughout the United States (table 15). Notable exceptions are chromium and nickel, which, on the basis of the mean concentrations, are about twice as abundant in the soils of Big Soos Creek Basin. This is probably indicative of the composition of the parent geologic material from which the soils of the Big Soos Creek Basin were formed.

CONCLUSIONS

The findings from this study suggest the following concerning the comparisons of metals concentrations in soil samples from one site with concentrations in samples from other sites or with regulatory requirements.

(1) Because concentrations of some metals are functions of depth, consideration needs to be given to the depths from which samples are collected.

(2) The natural variability of concentrations of metals in soils is such that the coefficient of variation can range from about 10 to 80 percent within a relatively small area. Consequently, the statistics of sampling need to be considered before concluding that concentrations in two areas are different.

(3) The extraction methods used in the laboratory to extract metals from soil samples have an effect on concentrations. Consequently, the extraction methods employed

Table 15.--Comparison of total metals concentrations in soils of Big Soos Creek Basin with those in soils of the conterminous United States

[Concentrations are in milligrams per kilogram; --, no data; <, less than; >, greater than]

Metal	Big Soos Creek basin[1]		Conterminous United States[2]	
	Mean[3]	Range	Mean	Range
Silver	<2	<2 - <2	--	--
Aluminum	72,000	60,000 - 87,000	72,000	700 - >100,000
Arsenic	<15	<10 - 30	7.2	<.1 - 97
Barium	450	370 - 560	580	10 - 5,000
Beryllium	<1	<1 - 1	.92	<1 - 15
Cadmium	<2	<2 - <2	--	--
Chromium	89	62 - 120	54	1 - 2,000
Copper	23	10 - 30	25	<1 - 700
Iron	30,000	21,000 - 38,000	26,000	100 - >100,000
Mercury	.12	<.02 - .22	.09	<.01 - 4.6
Manganese	840	350 - 2,400	550	<2 - 7,000
Nickel	46	32 - 74	19	<5 - 700
Lead	25	10 - 52	19	<10 - 700
Antimony	.86	.4 - 1.7	.66	<1 - 8.8
Selenium	.58	.2 - .9	.39	<.1 - 4.3
Titanium	4,100	3,100 - 5,100	2,900	70 - 20,000
Thallium	--	--	--	--
Zinc	74	32 - 120	60	<5 - 2,900

[1] Shallow samples this study but not including sample L1A0.5.
[2] From Shacklette and Boerngen (1984).
[3] Mean represents an arithmetic mean.

in the laboratory need to be taken into consideration when data from different investigations or laboratories are being compared.

(4) Because metals concentrations can vary among size fractions of a soil sample, care must be taken that the size fractions analyzed are the same when data are compared.

SUMMARY

In 1987, the U.S. Geological Survey, in cooperation with the State of Washington Department of Ecology began a series of studies to determine background concentrations of metals in soils of the State. In this, the first of these studies, 29 soil samples from 14 holes at 9 sites in part of the Big Soos Creek drainage basin in southwest King County, Wash., were collected and analyzed for concentrations of metals and organic carbon, and for other characteristics. Five of the sites were in the Big Soos Creek subbasin and the other four were in the Little Soos Creek subbasin. Samples were collected from single holes and clusters of holes. At least one sample was collected from a depth of less than 12 inches in each hole. Four samples from depths as great as 5 feet were collected from each of five holes. Seven samples of streambed sediments were collected from three sites on Big and Little Soos Creeks.

Metals concentrations in each of the soil samples were determined by four methods: a total method, which uses a strong acid to dissolve nearly the entire mineral matrix; a total-recoverable method, which also uses a stong acid that probably dissolves most metals bound in coatings on particles, but not in the entire mineral matrix; and the extraction procedure toxicity (EP-TOX) and American Society of Testing Materials (ASTM) methods, which use a dilute weak acid or distilled water, respectively, to leach metals from the soil sample.

Concentrations of 43 different metals were determined by the total method, and concentrations of most of the following 18 metals were determined by all four methods:

silver barium chromium mercury lead titanium aluminum beryllium copper manganese antimony thallium arsenic cadmium iron nickel selenium zinc

Exceptions were barium determined by the total-recoverable method, titanium determined by the EP-TOX and ASTM methods, and thallium determined by the total method.

Ranges in total concentrations of most metals are within ranges of concentrations in soils from 1,318 sites in the conterminous United States. Means of concentrations in samples from Big Soos Creek Basin are typically larger but less than twice the means for the conterminous United States. Coefficients of variation of concentrations for all samples ranged from 10 to 65 percent for the total method, from 18 to 81 percent for the total-recoverable method, and from 55 to 60 percent for the EP-TOX and ASTM methods.

As expected, laboratory methods using the more rigorous extraction solutions yielded larger concentrations. Mean values of ratios of total to total-recoverable concentrations for 9 of the 10 metals for which concentrations were larger than laboratory minimum reporting levels ranged from 1.84 for zinc to 8.47 for titanium. Coefficients of variation for the ratios ranged from 13 to 69 percent. Mean values of the ratios of total or total-recoverable to EP-TOX or ASTM concentrations were greater than 500 for most metals. Mean values of the ratios of EP-TOX to ASTM concentrations ranged from about 0.4 to 2.

Concentrations of the following are larger in shallow soil (less than 12 inches) than in deep soil (greater than 12 inches): total organic carbon, mercury, manganese, phosphorous, lead, selenium, antimony, and zinc as determined by the total method; aluminum, mercury, manganese, antimony, and zinc by the total-recoverable method; aluminum and iron as determined by the EP-TOX method; and aluminum and copper by the ASTM method. Possible reasons for the elevated concentrations of some of the metals in shallow soils include regional contamination by precipitation and dust with elevated concentrations of some metals, and complexation and retention of some metals by organic compounds.

The average variability of most total and total-recoverable metals concentrations in soil samples from shallow but not deep depths, as indicated by coefficients of variation, in subbasins (up to 13 mi^2) was one and one half to two times that in clusters (less than 1 acre).

Total-recoverable concentrations of all metals were larger in the silt-plus-clay and gravel size fractions than in the sand size fraction for most of the six samples for which these types of data were obtained. Correlation coefficients between metals concentrations in entire samples and the fractions in different size classes are consistent with concentrations being smallest in the sand size class.

Concentrations of total chromium and nickel correlated with concentrations of total titanium in all samples, shallow samples, and deep samples, suggesting that chromium and nickel are associated primarily with the mineral matrix rather than with oxide coatings on particles or with organic material. Concentrations of total lead and zinc correlate with concentrations of total organic carbon in all samples, shallow samples, and deep samples, suggesting that these metals may be associated with organic material.

Concentrations of total and total-recoverable metals and of total organic carbon in streambed sediments were typical or slightly larger than concentrations in samples of soil from shallow depths. Concentrations were more typical of shallow than deep soils. Maximum observed concentrations of total and total-recoverable cadmium, copper, mercury, manganese, lead, and zinc, and of total arsenic, antimony, and selenium in streambed sediments are as much as twice those in shallow soils.

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DATA TABLES

The following tables list the results of all analyses performed during this study. Note that sample L5A0.5 is a duplicate of sample L3A0.5; B6A0.5 is a duplicate of B2A0.5; B7A2.0 is a duplicate of B4A2.0; and samples L6A0.5 and B8A0.5 are duplicates of the constructed reference soil sample.

Symbols used for metals and elements in table 16

Ag -- silver
Al -- aluminum
As -- arsenic
Au -- gold
Ba -- barium
Be -- beryllium
Bi -- bismuth
Ca -- calcium
Cd -- cadmium
Ce -- cerium
Co -- cobalt
Cr -- chromium
Cu -- copper
Eu -- europium
Fe -- iron
Ga -- gallium
Ho -- holmium
Hg -- mercury
K -- potassium
La -- lanthanum
Li -- lithium
Mg -- magnesium
Mn -- manganese
Mo -- molybdenum
Nd -- neodymium
Ni -- nickel
P -- phosphorus
Pb -- lead
Sb -- antimony
Sc -- scandium
Se -- selenium
Sn -- tin
Sr -- strontium
Ta -- tantalum
Th -- thorium
Ti -- titanium
U -- uranium
Yb -- ytterbium
Zn -- zinc

***Table 16.**--Concentrations of metals determined by the total method in soils and streambed sediments*
[Concentrations are in milligrams per kilogram of dry soil or sediment; <, less than]

Site	Sample	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co
					Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	<2	79,000	20	<8	560	1	<10	15,000	<2	39	14
L2	L2A0.5	<2	78,000	<10	<8	390	1	<10	14,000	<2	47	14
L3	L3A0.1	<2	70,000	10	<8	410	<1	<10	17,000	<2	32	12
L3	L3A0.5	<2	72,000	<10	<8	430	<1	<10	17,000	<2	33	12
L3	* L5A0.5	<2	71,000	10	<8	420	<1	<10	19,000	<2	34	12
L3	L3A1.0	<2	87,000	<10	<8	470	1	<10	18,000	<2	58	14
L3	L3A4.0	<2	78,000	<10	<8	440	<1	<10	20,000	<2	33	11
L4	L4A0.5	<2	64,000	20	<8	390	<1	<10	16,000	<2	30	10
L4	L4B0.5	<2	61,000	10	<8	370	<1	<10	21,000	<2	32	9
	** L6A0.5	<2	82,000	<10	<8	500	<1	<10	17,000	<2	45	13
					Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	<2	84,000	10	<8	550	1	<10	18,000	<2	51	17
B2	B2A0.5	<2	82,000	10	<8	380	1	<10	17,000	<2	46	13
B2	* B6A0.5	<2	83,000	10	<8	400	1	<10	14,000	<2	48	13
B3	B3A0.1	<2	63,000	20	<8	530	<1	<10	17,000	<2	31	11
B3	B3A1.0	<2	76,000	<10	<8	560	<1	<10	18,000	<2	42	13
B3	B3A3.0	<2	80,000	<10	<8	530	<1	<10	18,000	<2	45	13
B3	B3A5.0	<2	76,000	<10	<8	460	<1	<10	21,000	<2	43	12
B3	B3B0.1	<2	62,000	30	<8	460	<1	<10	18,000	<2	31	10
B3	B3B1.0	<2	76,000	<10	<8	470	<1	<10	17,000	<2	43	12
B3	B3B2.0	<2	79,000	<10	<8	490	<1	<10	17,000	<2	52	13
B3	B3B4.0	<2	85,000	10	<8	480	1	<10	18,000	<2	47	14
B3	B3C0.1	<2	60,000	30	<8	580	<1	<10	21,000	<2	28	10
B3	B3C2.0	<2	76,000	<10	<8	440	<1	<10	18,000	<2	43	12
B3	B3C4.0	<2	75,000	<10	<8	420	<1	<10	20,000	<2	47	12
B3	B3C5.0	<2	76,000	<10	<8	470	<1	<10	22,000	<2	39	12
B3	B3D1.0	<2	77,000	<10	<8	480	<1	<10	18,000	<2	47	12
B3	B3E1.0	<2	77,000	<10	<8	450	<1	<10	16,000	<2	42	11

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co
					Soil samples from Big Soos Creek drainage basin--cont.							
B4	B4A0.1	<2	75,000	20	<8	440	<1	<10	18,000	<2	37	12
B4	B4A0.5	<2	75,000	10	<8	440	<1	<10	17,000	<2	36	12
B4	B4A2.0	<2	110,000	20	<8	530	1	<10	14,000	<2	38	12
B4	* B7A2.0	<2	110,000	20	<8	540	1	<10	13,000	<2	41	13
B4	B4A4.0	<2	92,000	10	<8	530	1	<10	17,000	<2	52	16
B5	B5A0.5	<2	87,000	<10	<8	430	<1	<10	15,000	<2	28	9
	** B8A0.5	<2	81,000	<10	<8	490	<1	<10	17,000	<2	46	13
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	<2	57,000	30	<8	420	<1	<10	17,000	24	26	15
SW1	SED1B	<2	70,000	20	<8	410	<1	<10	22,000	7	29	15
SW1	SED1C	<2	54,000	30	<8	390	<1	<10	25,000	11	23	15
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	<2	63,000	20	<8	410	<1	<10	21,000	21	33	15
SW2	SED2B	<2	63,000	20	<8	400	<1	<10	22,000	8	33	15
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	<2	70,000	20	<8	470	<1	<10	27,000	14	36	16
SW3	SED3B	<2	60,000	20	<8	400	<1	<10	22,000	27	27	17

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Cr	Cu	Eu	Fe	Ga	Ho	Hg	K	La	Li	Mg
					Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	64	42	<2	35,000	19	<4	0.24	7,700	22	31	6,900
L2	L2A0.5	82	28	<2	38,000	20	4	.22	7,900	22	33	7,000
L3	L3A0.1	78	24	<2	31,000	17	<4	.12	6,800	17	28	6,300
L3	L3A0.5	79	32	<2	32,000	18	<4	.18	7,000	17	29	6,300
L3	* L5A0.5	78	28	<2	31,000	18	<4	.10	7,000	17	28	6,300
L3	L3A1.0	110	34	<2	37,000	18	<4	.16	7,900	19	26	9,100
L3	L3A4.0	110	21	<2	30,000	14	<4	.02	8,200	18	17	9,200
L4	L4A0.5	78	22	<2	28,000	16	<4	.12	6,600	16	22	5,600
L4	L4B0.5	80	17	<2	25,000	13	<4	.10	6,200	17	15	5,700
	** L6A0.5	110	22	<2	33,000	16	<4	.06	8,300	21	20	8,200
					Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	100	28	<2	37,000	19	<4	.14	7,800	23	31	8,900
B2	B2A0.5	97	28	<2	34,000	18	<4	.18	6,600	22	27	6,500
B2	* B6A0.5	100	28	<2	34,000	19	<4	.16	7,200	23	26	6,900
B3	B3A0.1	76	25	<2	27,000	14	<4	.12	7,000	16	19	6,500
B3	B3A1.0	95	18	<2	32,000	16	<4	.06	8,100	20	21	8,000
B3	B3A3.0	110	18	<2	32,000	15	<4	.08	8,600	22	16	9,900
B3	B3A5.0	120	19	<2	34,000	14	<4	.10	8,500	23	12	9,700
B3	B3B0.1	66	22	<2	26,000	13	<4	.12	6,700	16	18	5,600
B3	B3B1.0	94	19	<2	32,000	15	<4	.08	7,800	21	19	6,800
B3	B3B2.0	100	21	<2	34,000	15	<4	.04	8,200	21	16	7,700
B3	B3B4.0	120	22	<2	38,000	16	<4	.02	8,600	22	16	9,100
B3	B3C0.1	62	27	<2	26,000	15	<4	.12	7,000	17	17	5,700
B3	B3C2.0	100	18	<2	32,000	15	<4	.10	8,100	20	16	7,200
B3	B3C4.0	110	16	<2	32,000	14	<4	.04	8,200	22	12	8,200
B3	B3C5.0	100	20	<2	32,000	14	<4	.04	8,500	20	12	9,800
B3	B3D1.0	94	17	<2	33,000	15	<4	.06	8,000	21	19	6,700
B3	B3E1.0	95	16	<2	31,000	16	<4	.14	8,000	21	21	6,900

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Cr	Cu	Eu	Fe	Ga	Ho	Hg	K	La	Li	Mg
					Soil samples from Big Soos Creek drainage basin--cont.							
B4	B4A0.1	110	23	<2	30,000	17	<4	0.16	6,100	22	25	7,600
B4	B4A0.5	110	26	<2	29,000	16	<4	.12	6,300	22	25	7,600
B4	B4A2.0	96	21	<2	27,000	23	<4	.14	7,000	22	36	6,500
B4	* B7A2.0	98	20	<2	27,000	24	<4	.14	7,100	23	37	6,400
B4	B4A4.0	150	33	2	37,000	19	<4	.02	7,600	31	41	9,000
B5	B5A0.5	120	10	<2	21,000	20	<4	<.02	7,300	16	27	6,700
	** B8A0.5	100	21	<2	33,000	16	<4	.08	8,100	21	19	8,000
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	71	24	<2	30,000	14	<4	.22	6,100	15	21	6,700
SW1	SED1B	100	62	<2	34,000	15	<4	.22	7,600	17	21	11,000
SW1	SED1C	68	25	<2	30,000	15	<4	.20	5,400	15	20	6,800
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	82	93	<2	32,000	16	<4	.28	5,800	17	24	7,000
SW2	SED2B	80	88	<2	32,000	15	<4	.36	5,600	17	23	6,900
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	95	42	<2	36,000	17	<4	.18	7,700	19	23	10,000
SW3	SED3B	77	43	<2	32,000	16	<4	.24	6,000	16	21	7,200

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Mn	Mo	Na	Nb	Nd	Ni	P	Pb	Sb	Sc	Se
					Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	2,100	<2	14,000	8	17	39	2,400	100	1.6	11	0.6
L2	L2A0.5	450	<2	17,000	9	21	43	600	14	.4	11	.8
L3	L3A0.1	750	<2	16,000	8	14	40	1,800	30	.8	9	.6
L3	L3A0.5	760	<2	16,000	7	13	42	1,700	24	.7	9	.5
L3	* L5A0.5	720	<2	16,000	8	13	41	1,600	21	.7	10	.5
L3	L3A1.0	440	<2	17,000	13	17	58	800	12	.3	12	.6
L3	L3A4.0	530	<2	21,000	6	16	53	600	7	.3	14	.2
L4	L4A0.5	680	<2	16,000	6	14	39	900	27	1.0	8	.4
L4	L4B0.5	490	<2	17,000	6	14	34	700	25	.9	9	.4
	** L6A0.5	580	<2	19,000	7	20	54	1,200	12	.4	13	.4
					Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	1,300	<2	15,000	8	19	74	1,800	25	.9	12	.5
B2	B2A0.5	520	<2	14,000	8	21	62	2,000	22	.6	11	.8
B2	* B6A0.5	540	<2	15,000	8	22	61	1,900	21	.7	11	.8
B3	B3A0.1	1,300	<2	16,000	7	14	44	2,700	40	1.3	9	.5
B3	B3A1.0	840	<2	19,000	7	17	57	2,600	12	.5	11	.4
B3	B3A3.0	490	<2	19,000	7	20	58	400	8	.4	14	.4
B3	B3A5.0	600	<2	21,000	5	24	57	800	7	.5	15	.2
B3	B3B0.1	1,100	<2	15,000	6	13	37	2,700	35	1.4	9	.5
B3	B3B1.0	650	<2	18,000	7	17	50	1,500	9	.4	10	.5
B3	B3B2.0	460	<2	19,000	6	19	54	600	9	.4	13	.4
B3	B3B4.0	600	<2	19,000	7	22	59	700	8	.4	16	.3
B3	B3C0.1	2,400	<2	16,000	6	13	32	2,800	52	1.7	9	.5
B3	B3C2.0	590	<2	20,000	5	19	45	1,600	9	.3	12	.5
B3	B3C4.0	460	<2	20,000	5	23	44	700	8	.4	14	.4
B3	B3C5.0	620	<2	22,000	5	20	52	900	10	.4	14	.2
B3	B3D1.0	730	<2	19,000	9	17	49	2,100	12	.5	11	.6
B3	B3E1.0	830	<2	18,000	7	17	46	1,900	10	.5	11	.6

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Mn	Mo	Na	Nb	Nd	Ni	P	Pb	Sb	Sc	Se
					Soil samples from Big Soos Creek drainage basin--cont.							
B4	B4A0.1	440	<2	16,000	6	22	48	1,700	22	0.9	14	0.9
B4	B4A0.5	470	<2	17,000	6	21	47	1,600	23	.9	14	.9
B4	B4A2.0	350	<2	15,000	10	24	59	2,300	12	.4	14	.7
B4	* B7A2.0	350	<2	15,000	9	27	61	2,500	12	.4	14	.8
B4	B4A4.0	450	<2	18,000	8	34	59	300	9	.4	22	.3
B5	B5A0.5	350	<2	21,000	9	14	53	300	12	.4	11	.2
	** B8A0.5	570	<2	19,000	9	20	54	1,200	12	.4	13	.5
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	3,800	<2	11,000	4	15	38	1,800	37	.9	10	.7
SW1	SED1B	1,100	<2	16,000	6	17	50	1,400	1,100	2.4	13	.7
SW1	SED1C	4,900	<2	10,000	5	14	37	1,700	56	1.4	10	.9
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	2,500	<2	13,000	6	17	44	2,500	60	1.9	11	.8
SW2	SED2B	2,400	<2	12,000	6	16	43	2,600	63	1.2	11	.7
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	3,300	<2	14,000	6	19	51	1,800	55	1.0	13	.7
SW3	SED3B	5,300	<2	12,000	4	16	40	1,900	59	1.0	11	.9

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Sn	Sr	Ta	Th	Ti	U	V	Y	Yb	Zn
					Soil samples from Little Soos Creek drainage basin						
L1	L1A0.5	<10	200	<40	6	4,200	<100	90	13	2	110
L2	L2A0.5	<10	200	<40	6	5,000	<100	100	16	2	60
L3	L3A0.1	<10	190	<40	<4	4,300	<100	84	12	1	82
L3	L3A0.5	<10	190	<40	4	4,300	<100	86	12	1	79
L3	* L5A0.5	<10	190	<40	<4	4,300	<100	85	12	1	78
L3	L3A1.0	<10	200	<40	5	4,600	<100	110	14	2	65
L3	L3A4.0	<10	250	<40	<4	4,000	<100	92	18	2	43
L4	L4A0.5	<10	200	<40	4	3,900	<100	83	10	1	57
L4	L4B0.5	<10	230	<40	<4	3,600	<100	76	12	1	43
	** L6A0.5	<10	250	<40	5	4,400	<100	98	17	2	56
					Soil samples from Big Soos Creek drainage basin						
B1	B1A0.5	<10	210	<40	5	4,600	<100	98	15	2	110
B2	B2A0.5	<10	180	<40	5	4,400	<100	95	17	2	81
B2	* B6A0.5	<10	190	<40	5	4,600	<100	97	17	2	81
B3	B3A0.1	<10	240	<40	<4	3,300	<100	72	11	1	120
B3	B3A1.0	<10	260	<40	5	4,100	<100	89	13	2	81
B3	B3A3.0	<10	280	<40	<4	4,500	<100	100	16	2	42
B3	B3A5.0	<10	280	<40	<4	4,400	<100	100	23	2	46
B3	B3B0.1	<10	220	<40	<4	3,200	<100	67	10	1	79
B3	B3B1.0	<10	240	<40	5	3,900	<100	86	13	1	65
B3	B3B2.0	<10	240	<40	5	4,200	<100	99	15	2	43
B3	B3B4.0	<10	260	<40	5	4,700	<100	100	19	2	49
B3	B3C0.1	<10	250	<40	<4	3,100	<100	65	10	1	96
B3	B3C2.0	10	250	<40	5	3,800	<100	91	15	2	59
B3	B3C4.0	<10	260	<40	5	4,100	<100	95	22	2	33
B3	B3C5.0	<10	310	<40	5	4,000	<100	95	16	2	41
B3	B3D1.0	<10	250	<40	<4	4,000	<100	89	13	1	68
B3	B3E1.0	<10	240	<40	4	4,000	<100	82	14	2	70

Table 16.--Concentrations of metals determined by the total method in soils and streambed sediments--Continued

Site	Sample	Sn	Sr	Ta	Th	Ti	U	V	Y	Yb	Zn
					Soil samples from Big Soos Creek drainage basin--cont.						
B4	B4A0.1	<10	220	<40	<4	4,200	<100	100	20	2	62
B4	B4A0.5	<10	230	<40	<4	4,200	<100	100	19	2	67
B4	B4A2.0	<10	210	<40	5	4,700	<100	81	25	3	46
B4	* B7A2.0	<10	210	<40	7	4,900	<100	83	24	2	47
B4	B4A4.0	<10	260	<40	5	5,400	<100	130	31	3	46
B5	B5A0.5	<10	250	<40	<4	5,100	<100	80	11	1	32
	** B8A0.5	<10	250	<40	<4	4,200	<100	96	16	2	58
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek						
SW1	SED1A	<10	170	<40	4	2,600	<100	73	14	1	140
SW1	SED1B	<10	220	<40	<4	3,700	<100	100	17	2	230
SW1	SED1C	<10	170	<40	<4	2,500	<100	73	15	1	130
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek						
SW2	SED2A	<10	190	<40	<4	3,300	<100	85	17	2	210
SW2	SED2B	<10	190	<40	<4	3,300	<100	83	16	2	210
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek						
SW3	SED3A	<10	220	<40	4	3,500	<100	94	18	2	130
SW3	SED3B	<10	190	<40	4	2,900	<100	82	16	2	190

* Sample is a duplicate of the preceding sample in table

** Sample L6A0.5 and B8A0.5 are duplicates of a reference soil sample

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods

[Concentrations are in milligrams per kilogram of dry soil or sediment, except for those in parentheses, which are in micrograms per liter of leachate; <, less than; --, no data]

Site	Sample	Silver				Aluminum					
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX		ASTM	
		Soil samples from Little Soos Creek drainage basin									
L1	L1A0.5	<2	<4	<0.1 (<5)	<0.1 (<5)	79,000	20,500	2.0	(100)	6.6	(330)
L2	L2A0.5	<2	<4	<.1 (<5)	<.1 (<5)	78,000	36,700	1.2	(60)	1.2	(60)
L3	L3A0.1	<2	<4	<.1 (<5)	<.1 (<5)	70,000	25,900	3.18	(160)	11.4	(570)
L3	L3A0.5	<2	<4	<.1 (<5)	<.1 (<5)	72,000	22,800	2.4	(120)	4.2	(210)
L3	*L5A0.5	<2	<4	<.1 (<5)	<.1 (<5)	71,000	21,800	.6	(30)	4.2	(210)
L3	L3A1.0	<2	<4	<.1 (<5)	<.1 (<5)	87,000	25,500	.6	(30)	4.0	(200)
L3	L3A4.0	<2	<4	<.1 (<5)	<.1 (<5)	78,000	13,100	<.2	(<10)	1.6	(80)
L4	L4A0.5	<2	<4	<.1 (<5)	<.1 (<5)	64,000	17,100	7.18	(360)	8.4	(420)
L4	L4B0.5	<2	<4	<.1 (<5)	<.1 (<5)	61,000	15,500	8.2	(410)	7.8	(390)
	**L6A0.5	<2	<4	<.1 (<5)	<.1 (<5)	82,000	15,700	.2	(10)	1.8	(90)
		Soil samples from Big Soos Creek drainage basin									
B1	B1A0.5	<2	<4	<.1 (<5)	<.1 (<5)	84,000	23,800	2.18	(110)	3.58	(180)
B2	B2A0.5	<2	<4	<.1 (<5)	<.1 (<5)	82,000	21,900	.4	(20)	2.58	(130)
B2	*B6A0.5	<2	<4	<.1 (<5)	<.1 (<5)	83,000	23,000	1.6	(80)	2.8	(140)
B3	B3A0.1	<2	<4	<.1 (<5)	<.1 (<5)	63,000	16,500	4.6	(230)	9.6	(480)
B3	B3A1.0	<2	<4	<.1 (<5)	<.1 (<5)	76,000	19,200	1.6	(80)	5.38	(270)
B3	B3A3.0	<2	<4	<.1 (<5)	<.1 (<5)	80,000	13,900	2.8	(140)	5.8	(290)
B3	B3A5.0	<2	<4	<.1 (<5)	<.1 (<5)	76,000	10,300	.2	(10)	.6	(30)
B3	B3B0.1	<2	<4	<.1 (<5)	<.1 (<5)	62,000	13,200	2.0	(100)	6.18	(310)
B3	B3B1.0	<2	<4	<.1 (<5)	<.1 (<5)	76,000	18,000	.8	(40)	5.0	(250)
B3	B3B2.0	<2	<4	<.1 (<5)	<.1 (<5)	79,000	13,300	1.0	(50)	4.8	(240)
B3	B3B4.0	<2	<4	<.1 (<5)	<.1 (<5)	85,000	10,200	.6	(30)	5.8	(290)
B3	B3C0.1	<2	<4	<.1 (<5)	<.1 (<5)	60,000	10,900	2.6	(130)	5.18	(260)
B3	B3C2.0	<2	<4	--	--	76,000	14,900	--	--		
B3	B3C4.0	<2	<4	--	--	75,000	12,700	--	--		
B3	B3C5.0	<2	<4	--	--	76,000	10,200	--	--		
B3	B3D1.0	<2	<4	<.1 (<5)	<.1 (<5)	77,000	16,900	.4	(20)	5.18	(260)
B3	B3E1.0	<2	<4	<.1 (<5)	<.1 (<5)	77,000	21,700	.4	(20)	2.8	(140)

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Silver				Aluminum					
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX		ASTM	
		Soil samples from Big Soos Creek drainage basin--cont.									
B4	B4A0.1	<2	<4	<.1 (<5)	<.1 (<5)	75,000	14,900	1.6	(80)	2.18	(110)
B4	B4A0.5	<2	<4	<.1 (<5)	<.1 (<5)	75,000	15,000	1.4	(70)	2.0	(100)
B4	B4A2.0	<2	<4	<.1 (<5)	<.1 (<5)	110,000	28,300	.4	(20)	4.18	(210)
B4	*B7A2.0	<2	<4	<.1 (<5)	<.1 (<5)	110,000	25,000	.4	(20)	3.8	(190)
B4	B4A4.0	<2	<4	<.1 (<5)	<.1 (<5)	92,000	12,600	<.2	(<10)	4.0	(200)
B5	B5A0.5	<2	<4	<0.1 (<5)	<0.1 (<5)	87,000	7,390	0.8	(40)	4.0	(200)
	**B8A0.5	<2	<4	<.1 (<5)	<.1 (<5)	81,000	14,500	<.2	(<10)	3.18	(160)
	Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek										
SW1	SED1A	<2	<4	--	--	57,000	13,200	--		--	
SW1	SED1B	<2	<4	--	--	70,000	11,800	--		--	
SW1	SED1C	<2	<4	--	--	54,000	11,400	--		--	
	Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek										
SW2	SED2A	<2	<4	--	--	63,000	13,300	--		--	
SW2	SED2B	<2	<4	--	--	63,000	12,400	--		--	
	Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek										
SW3	SED3A	<2	<4	--	--	70,000	12,600	--		--	
SW3	SED3B	<2	<4	--	--	60,000	15,700	--		--	

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Arsenic				Barium					
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX		ASTM	
					Soil samples from Little Soos Creek drainage basin						
L1	L1A0.5	20	19	<0.02 (<1)	<0.02 (<1)	560	--	<1	(<50)	0.14	(7)
L2	L2A0.5	<10	24	<.02 (<1)	<.02 (<1)	390	--	<1	(<50)	.12	(6)
L3	L3A0.1	10	24	<.02 (<1)	<.02 (<1)	410	--	<1	(<50)	.16	(8)
L3	L3A0.5	<10	18	<.02 (<1)	<.02 (<1)	430	--	<1	(<50)	<.1	(<5)
L3	* L5A0.5	10	19	<.02 (<1)	<.02 (<1)	420	--	<1	(<50)	<.1	(<5)
L3	L3A1.0	<10	12	<.02 (<1)	<.02 (<1)	470	--	<2	(<100)	<.1	(<5)
L3	L3A4.0	<10	17	<.02 (<1)	<.02 (<1)	440	--	<1	(<50)	<.1	(<5)
L4	L4A0.5	20	<11	<.02 (<1)	<.02 (<1)	390	--	<1	(<50)	.14	(7)
L4	L4B0.5	10	11	<.02 (<1)	<.02 (<1)	370	--	<1	(<50)	.22	(11)
	** L6A0.5	<10	<11	<.02 (<1)	<.02 (<1)	500	--	<1	(<50)	<.1	(<5)
					Soil samples from Big Soos Creek drainage basin						
B1	B1A0.5	10	<11	<.02 (<1)	<.02 (<1)	550	--	<2	(<100)	<.1	(<5)
B2	B2A0.5	10	12	<.02 (<1)	<.02 (<1)	380	--	<1	(<50)	<.1	(<5)
B2	* B6A0.5	10	<11	<.02 (<1)	<.02 (<1)	400	--	<1	(<50)	<.1	(<5)
B3	B3A0.1	20	19	.02 (1)	.04 (2)	530	--	<1	(<50)	.20	(10)
B3	B3A1.0	<10	<12	<.02 (<1)	<.02 (<1)	560	--	<1	(<50)	<.1	(<5)
B3	B3A3.0	<10	<11	<.02 (<1)	<.02 (<1)	530	--	<1	(<50)	<.1	(<5)
B3	B3A5.0	<10	<11	<.02 (<1)	<.02 (<1)	460	--	<1	(<50)	<.1	(<5)
B3	B3B0.1	30	<11	.02 (1)	.04 (2)	460	--	<1	(<50)	.14	(7)
B3	B3B1.0	<10	<11	<.02 (<1)	<.02 (<1)	470	--	<2	(<100)	<.1	(<5)
B3	B3B2.0	<10	<11	<.02 (<1)	<.02 (<1)	490	--	<1	(<50)	<.1	(<5)
B3	B3B4.0	10	<11	<.02 (<1)	<.02 (<1)	480	--	<1	(<50)	<.1	(<5)
B3	B3C0.1	30	13	.04 (2)	.06 (3)	580	--	<1	(<50)	.28	(14)
B3	B3C2.0	<10	<11	--	--	440	--	--		--	
B3	B3C4.0	<10	<11	--	--	420	--	--		--	
B3	B3C5.0	<10	<11	--	--	470	--	--		--	
B3	B3D1.0	<10	<11	<.02 (<1)	<.02 (<1)	480	--	<2	(<100)	.32	(16)
B3	B3E1.0	<10	<11	<.02 (<1)	<.02 (<1)	450	--	<1	(<50)	<.1	(<5)
B4	B4A0.1	20	<11	<.02 (<1)	<.02 (<1)	440	--	<1	(<50)	.14	(7)
B4	B4A0.5	10	<11	<.02 (<1)	<.02 (<1)	440	--	<1	(<50)	.12	(6)
B4	B4A2.0	20	15	<.02 (<1)	<.02 (<1)	530	--	<1	(<50)	<.1	(<5)
B4	* B7A2.0	20	<11	<.02 (<1)	<.02 (<1)	540	--	<1	(<50)	<.1	(<5)
B4	B4A4.0	10	<11	<.02 (<1)	<.02 (<1)	530	--	<1	(<50)	<.1	(<5)

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Arsenic				Barium					
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX		ASTM	
		Soil samples from Big Soos Creek drainage basin--cont.									
B5	B5A0.5	<10	<11	<0.02 (<1)	<0.02 (<1)	430	--	<1	(<50)	<0.1	(<5)
	** B8A0.5	<10	<11	<.02 (<1)	<.02 (<1)	490	--	<1	(<50)	<.1	(<5)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek									
SW1	SED1A	30	<11	--	--	420	--	--		--	
SW1	SED1B	20	11	--	--	410	--	--		--	
SW1	SED1C	30	<11	--	--	390	--	--		--	
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek									
SW2	SED2A	20	<11	--	--	410	--	--		--	
SW2	SED2B	20	<11	--	--	400	--	--		--	
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek									
SW3	SED3A	20	<11	--	--	470	--	--		--	
SW3	SED3B	20	11	--	--	400	--	--		--	

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site		Sample	Beryllium				Cadmium			
			Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
Soil samples from Little Soos Creek drainage basin										
L1		L1A0.5	1	0.6	<0.2 (<10)	<0.2 (<10)	<2	<0.8	<0.02 (<1)	<0.02 (<1)
L2		L2A0.5	1	.7	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L3		L3A0.1	<1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L3		L3A0.5	<1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L3	*	L5A0.5	<1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L3		L3A1.0	1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L3		L3A4.0	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L4		L4A0.5	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
L4		L4B0.5	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
	**	L6A0.5	<1	.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
Soil samples from Big Soos Creek drainage basin										
B1		B1A0.5	1	.7	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B2		B2A0.5	1	.7	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B2	*	B6A0.5	1	.8	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3A0.1	<1	<.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3A1.0	<1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3A3.0	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3A5.0	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3B0.1	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3B1.0	<1	.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3B2.0	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3B4.0	1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3C0.1	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3C2.0	<1	<.5	--	--	<2	<.8	--	--
B3		B3C4.0	<1	<.5	--	--	<2	<.8	--	--
B3		B3C5.0	<1	<.5	--	--	<2	<.8	--	--
B3		B3D1.0	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B3		B3E1.0	<1	<.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B4		B4A0.1	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B4		B4A0.5	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B4		B4A2.0	1	.6	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B4	*	B7A2.0	1	.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)
B4		B4A4.0	1	<.5	<.2 (<10)	<.2 (<10)	<2	<.8	<.02 (<1)	<.02 (<1)

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Beryllium				Cadmium			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont.							
B5	B5A0.5	<1	<0.5	<0.2 (<10)	<0.2 (<10)	<2	<0.8	<0.02 (<1)	<0.02 (<1)
**	B8A0.5	<1	<.5	<.2 (<10)	<.2 (<10)	<2	<8	<.02 (<1)	<.02 (<1)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	<1	<.5	--	--	24	5	--	--
SW1	SED1B	<1	<.5	--	--	7	<.8	--	--
SW1	SED1C	<1	<.5	--	--	11	<.8	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	<1	<.5	--	--	21	2	--	--
SW2	SED2B	<1	<.5	--	--	8	<.8	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	<1	<.5	--	--	14	<.8	--	--
SW3	SED3B	<1	.5	--	--	27	1	--	--

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Chromium				Copper				
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX		ASTM
		Soil samples from Little Soos Creek drainage basin								
L1	L1A0.5	64	19	<0.2 (<10)	<0.2 (<10)	42	21	0.12	(6)	0.06 (3)
L2	L2A0.5	82	24	<.2 (<10)	<.2 (<10)	28	15	.02	(1)	.06 (3)
L3	L3A0.1	78	22	<.2 (<10)	<.2 (<10)	24	13	.08	(4)	.12 (6)
L3	L3A0.5	79	19	<.2 (<10)	<.2 (<10)	32	18	.02	(1)	.10 (5)
L3	* L5A0.5	78	19	<.2 (<10)	<.2 (<10)	28	27	.02	(1)	.06 (3)
L3	L3A1.0	110	26	<.2 (<10)	<.2 (<10)	34	14	.04	(2)	.08 (4)
L3	L3A4.0	110	25	<.2 (<10)	<.2 (<10)	21	13	.06	(3)	.04 (2)
L4	L4A0.5	78	16	<.2 (<10)	<.2 (<10)	22	13	.10	(5)	.14 (7)
L4	L4B0.5	80	18	<.2 (<10)	<.2 (<10)	17	12	.06	(3)	.06 (3)
	** L6A0.5	110	26	<.2 (<10)	<.2 (<10)	22	13	.04	(2)	.10 (5)
		Soil samples from Big Soos Creek drainage basin								
B1	B1A0.5	100	24	<.2 (<10)	<.2 (<10)	28	14	.06	(3)	.06 (3)
B2	B2A0.5	97	24	<.2 (<10)	<.2 (<10)	28	13	.04	(2)	.06 (3)
B2	* B6A0.5	100	22	<.2 (<10)	<.2 (<10)	28	12	.06	(3)	.06 (3)
B3	B3A0.1	76	18	<.2 (<10)	<.2 (<10)	25	14	.14	(7)	.14 (7)
B3	B3A1.0	95	20	<.2 (<10)	<.2 (<10)	18	11	.06	(3)	.06 (3)
B3	B3A3.0	110	25	<.2 (<10)	<.2 (<10)	18	11	.02	(1)	.04 (2)
B3	B3A5.0	120	25	<.2 (<10)	<.2 (<10)	19	11	.02	(1)	.02 (1)
B3	B3B0.1	66	14	<.2 (<10)	<.2 (<10)	22	10	.12	(6)	.10 (5)
B3	B3B1.0	94	21	<.2 (<10)	<.2 (<10)	19	7	.08	(4)	.02 (1)
B3	B3B2.0	100	20	<.2 (<10)	<.2 (<10)	21	11	.06	(3)	.02 (1)
B3	B3B4.0	120	21	<.2 (<10)	<.2 (<10)	22	8	.10	(5)	.02 (1)
B3	B3C0.1	62	14	<.2 (<10)	<.2 (<10)	27	14	.22	(11)	.04 (2)
B3	B3C2.0	100	23	--	--	18	9	--	--	
B3	B3C4.0	110	25	--	--	16	22	--	--	
B3	B3C5.0	100	19	--	--	20	10	--	--	
B3	B3D1.0	94	22	<.2 (<10)	<.2 (<10)	17	10	.10	(5)	.08 (4)
B3	B3E1.0	95	20	<.2 (<10)	<.2 (<10)	16	12	.10	(5)	.06 (3)
B4	B4A0.1	110	25	<.2 (<10)	<.2 (<10)	23	14	.10	(5)	.04 (2)
B4	B4A0.5	110	26	<.2 (<10)	<.2 (<10)	26	12	.12	(6)	.02 (1)
B4	B4A2.0	96	24	<.2 (<10)	<.2 (<10)	21	8	.14	(7)	.02 (1)
B4	* B7A2.0	98	20	<.2 (<10)	<.2 (<10)	20	8	.08	(4)	.02 (1)
B4	B4A4.0	150	27	<.2 (<10)	<.2 (<10)	33	12	.14	(7)	.06 (3)

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Chromium				Copper			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont.							
B5	B5A0.5	120	12	<0.2 (<10)	<0.2 (<10)	10	4	0.16 (8)	0.04 (2)
**	B8A0.5	100	18	<.2 (<10)	<.2 (<10)	21	10	.08 (4)	.02 (1)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	71	19	--	--	24	14	--	--
SW1	SED1B	100	20	--	--	62	24	--	--
SW1	SED1C	68	19	--	--	25	12	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	82	28	--	--	93	24	--	--
SW2	SED2B	80	15	--	--	88	18	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	95	23	--	--	42	18	--	--
SW3	SED3B	77	22	--	--	43	32	--	--

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Iron						Mercury			
		Total	Total recoverable	EP-TOX		ASTM		Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Little Soos Creek drainage basin									
L1	L1A0.5	35,000	17,300	0.6	(30)	2.2	(110)	0.24	0.060	<0.02 (<1)	<0.002 (<0.1)
L2	L2A0.5	38,000	--	<.2	(<10)	<.2	(<10)	.22	.047	<.02 (<1)	<.002 (<0.1)
L3	L3A0.1	31,000	16,100	1.4	(70)	5.6	(280)	.12	.027	<.02 (<1)	<.002 (<0.1)
L3	L3A0.5	32,000	15,300	.8	(40)	1.6	(80)	.18	.036	<.02 (<1)	<.002 (<0.1)
L3	* L5A0.5	31,000	17,000	<.2	(<10)	1.6	(80)	.10	.035	<.02 (<1)	<.002 (<0.1)
L3	L3A1.0	37,000	17,200	<.2	(<10)	1.2	(60)	.16	.036	<.02 (<1)	<.002 (<0.1)
L3	L3A4.0	30,000	12,700	<.2	(<10)	.4	(20)	.02	.012	<.02 (<1)	<.002 (<0.1)
L4	L4A0.5	28,000	14,800	2.4	(120)	2.0	(100)	.12	.042	<.02 (<1)	<.002 (<0.1)
L4	L4B0.5	25,000	12,900	2.18	(110)	1.8	(90)	.10	.052	<.02 (<1)	<.002 (<0.1)
	** L6A0.5	33,000	14,200	<.2	(<10)	.6	(30)	.06	.020	<.02 (<1)	<.002 (<0.1)
		Soil samples from Big Soos Creek drainage basin									
B1	B1A0.5	37,000	20,100	.4	(20)	.6	(30)	.14	.052	<.02 (<1)	<.002 (<0.1)
B2	B2A0.5	34,000	17,000	<.2	(<10)	.8	(40)	.18	.058	<.02 (<1)	<.002 (<0.1)
B2	* B6A0.5	34,000	17,000	.8	(40)	1.2	(60)	.16	.046	<.02 (<1)	<.002 (<0.1)
B3	B3A0.1	27,000	15,000	1.4	(70)	3.58	(180)	.12	.058	<.02 (<1)	<.002 (<0.1)
B3	B3A1.0	32,000	15,700	.8	(40)	2.0	(100)	.06	.042	<.02 (<1)	<.002 (<0.1)
B3	B3A3.0	32,000	15,000	<.2	(<10)	3.18	(160)	.08	.051	<.02 (<1)	<.002 (<0.1)
B3	B3A5.0	34,000	15,500	<.2	(<10)	.4	(20)	.10	.027	<.02 (<1)	<.002 (<0.1)
B3	B3B0.1	26,000	11,800	<.2	(<10)	1.4	(70)	.12	.052	<.02 (<1)	<.002 (<0.1)
B3	B3B1.0	32,000	15,500	<.2	(<10)	1.8	(90)	.08	.028	<.02 (<1)	<.002 (<0.1)
B3	B3B2.0	34,000	13,300	<.2	(<10)	2.18	(110)	.04	.012	<.02 (<1)	<.002 (<0.1)
B3	B3B4.0	38,000	14,200	<.2	(<10)	3.0	(150)	.02	.019	<.02 (<1)	<.002 (<0.1)
B3	B3C0.1	26,000	11,900	<.2	(<10)	1.6	(80)	.12	.058	<.02 (<1)	<.002 (<0.1)
B3	B3C2.0	32,000	13,900	--	--			.10	.035	--	--
B3	B3C4.0	32,000	13,300	--	--			.04	.020	--	--
B3	B3C5.0	32,000	12,700	--	--			.04	.020	--	--
B3	B3D1.0	33,000	14,900	<.2	(<10)	2.18	(110)	.06	.028	<.02 (<1)	<.002 (<0.1)
B3	B3E1.0	31,000	16,800	<.2	(<10)	1.0	(50)	.14	.058	<.02 (<1)	<.002 (<0.1)
B4	B4A0.1	30,000	14,000	1.0	(50)	1.2	(60)	.16	.043	<.02 (<1)	<.002 (<0.1)
B4	B4A0.5	29,000	14,000	1.0	(50)	1.4	(70)	.12	.043	<.02 (<1)	<.002 (<0.1)
B4	B4A2.0	27,000	11,300	<.2	(<10)	.8	(40)	.14	.040	<.02 (<1)	<.002 (<0.1)
B4	* B7A2.0	27,000	10,300	<.2	(<10)	.6	(30)	.14	.041	<.02 (<1)	<.002 (<0.1)
B4	B4A4.0	37,000	12,000	<.2	(<10)	2.0	(100)	.02	.011	<.02 (<1)	<.002 (<0.1)

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Iron						Mercury			
		Total	Total recoverable	EP-TOX		ASTM		Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont.									
B5	B5A0.5	21,000	5,920	0.4	(20)	1.6	(80)	<0.02	0.012	<0.02 (<1)	<0.002 (<0.1)
**	B8A0.5	33,000	13,500	<.2	(<10)	1.0	(50)	.08	.027	<.02 (<1)	<.002 (<.1)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek									
SW1	SED1A	30,000	17,900	--		--		.22	.076	--	--
SW1	SED1B	34,000	14,800	--		--		.22	.037	--	--
SW1	SED1C	30,000	17,900	--		--		.20	.035	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek									
SW2	SED2A	32,000	17,300	--		--		.28	.035	--	--
SW2	SED2B	32,000	16,900	--		--		.36	.019	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek									
SW3	SED3A	36,000	18,100	--		--		.18	.023	--	--
SW3	SED3B	32,000	20,800	--		--		.24	.072	--	--

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Manganese						Nickel			
		Total	Total recoverable	EP-TOX		ASTM		Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Little Soos Creek drainage basin									
L1	L1A0.5	2,100	846	0.4	(20)	0.2	(10)	39	22	<0.02 (<1)	<0.02 (<1)
L2	L2A0.5	450	163	<.2	(<10)	<.2	(<10)	43	22	.04 (2)	.02 (1)
L3	L3A0.1	750	420	.4	(20)	.2	(10)	40	25	.10 (5)	<.02 (<1)
L3	L3A0.5	760	373	<.2	(<10)	<.2	(<10)	42	21	<.02 (<1)	.02 (1)
L3	* L5A0.5	720	412	<.2	(<10)	<.2	(<10)	41	21	.06 (3)	<.02 (<1)
L3	L3A1.0	440	163	<.2	(<10)	<.2	(<10)	58	27	.06 (3)	<.02 (<1)
L3	L3A4.0	530	184	<.2	(<10)	<.2	(<10)	53	22	.10 (5)	<.02 (<1)
L4	L4A0.5	680	299	.2	(10)	<.2	(<10)	39	18	.04 (2)	<.02 (<1)
L4	L4B0.5	490	239	.2	(10)	.2	(10)	34	20	.04 (2)	<.02 (<1)
	** L6A0.5	580	231	<.2	(<10)	<.2	(<10)	54	25	.04 (2)	<.02 (<1)
		Soil samples from Big Soos Creek drainage basin									
B1	B1A0.5	1,300	763	.2	(10)	<.2	(<10)	74	34	.04 (2)	<.02 (<1)
B2	B2A0.5	520	494	<.2	(<10)	<.2	(<10)	62	23	.04 (2)	<.02 (<1)
B2	* B6A0.5	540	255	<.2	(<10)	<.2	(<10)	61	23	<.02 (<1)	.12 (6)
B3	B3A0.1	1,300	916	.4	(20)	.2	(10)	44	24	.06 (3)	<.02 (<1)
B3	B3A1.0	840	595	.2	(10)	<.2	(<10)	57	28	.06 (3)	.04 (2)
B3	B3A3.0	490	161	<.2	(<10)	<.2	(<10)	58	25	.06 (3)	.02 (1)
B3	B3A5.0	600	324	.2	(10)	<.2	(<10)	57	29	.04 (2)	<.02 (<1)
B3	B3B0.1	1,100	562	.2	(10)	<.2	(<10)	37	17	.08 (4)	<.02 (<1)
B3	B3B1.0	650	291	<.2	(<10)	<.2	(<10)	50	28	.06 (3)	<.02 (<1)
B3	B3B2.0	460	138	<.2	(<10)	<.2	(<10)	54	21	.04 (2)	.02 (1)
B3	B3B4.0	600	218	<.2	(<10)	<.2	(<10)	59	22	.04 (2)	.02 (1)
B3	B3C0.1	2,400	1,310	<.2	(<10)	.4	(20)	32	16	.06 (3)	.08 (4)
B3	B3C2.0	590	232	--		--		45	24	--	--
B3	B3C4.0	460	141	--		--		44	24	--	--
B3	B3C5.0	620	212	--		--		52	27	--	--
B3	B3D1.0	730	321	<.2	(<10)	<.2	(<10)	49	24	<.02 (<1)	.02 (1)
B3	B3E1.0	830	738	<.2	(<10)	<.2	(<10)	46	25	.14 (7)	<.02 (<1)
B4	B4A0.1	440	143	<.2	(<10)	<.2	(<10)	48	17	<.02 (<1)	.02 (1)
B4	B4A0.5	470	164	<.2	(<10)	<.2	(<10)	47	17	<.02 (<1)	.08 (4)
B4	B4A2.0	350	137	<.2	(<10)	<.2	(<10)	59	19	<.02 (<1)	.04 (2)
B4	* B7A2.0	350	122	<.2	(<10)	<.2	(<10)	61	16	<.02 (<1)	<.02 (<1)
B4	B4A4.0	450	141	1.0	(50)	<.2	(<10)	59	16	<.02 (<1)	.02 (1)

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site		Sample	Manganese						Nickel			
			Total	Total recoverable	EP-TOX		ASTM		Total	Total recoverable	EP-TOX	ASTM
Soil samples from Big Soos Creek drainage basin--cont.												
B5		B5A0.5	350	90	<0.2	(<10)	<0.2	(<10)	53	9	<0.02 (<1)	0.06 (3)
	**	B8A0.5	570	215	<.2	(<10)	<.2	(<10)	54	22	<.02 (<1)	.02 (1)
Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek												
SW1		SED1A	3,800	2,750	--		--		38	16	--	--
SW1		SED1B	1,100	367	--		--		50	22	--	--
SW1		SED1C	4,900	1,270	--		--		37	21	--	--
Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek												
SW2		SED2A	2,500	721	--		--		44	23	--	--
SW2		SED2B	2,400	493	--		--		43	23	--	--
Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek												
SW3		SED3A	3,300	1,090	--		--		51	25	--	--
SW3		SED3B	5,300	3,250	--		--		40	25	--	--

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Lead				Antimony			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable [a]	EP-TOX	ASTM
		Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	100	29	<0.1 (<5)	<0.1 (<5)	1.6	59	<0.02 (<1)	<0.02 (<1)
L2	L2A0.5	14	<4	<.1 (<5)	<.1 (<5)	0.4	93	<.02 (<1)	<.02 (<1)
L3	L3A0.1	30	<4	<.1 (<5)	.34 (17)	.8	68	<.02 (<1)	<.02 (<1)
L3	L3A0.5	24	<4	<.1 (<5)	<.1 (<5)	.7	60	<.02 (<1)	<.02 (<1)
L3	* L5A0.5	21	<4	<.1 (<5)	<.1 (<5)	.7	67	<.02 (<1)	<.02 (<1)
L3	L3A1.0	12	<4	<.1 (<5)	<.1 (<5)	.3	68	<.02 (<1)	<.02 (<1)
L3	L3A4.0	7	<4	<.1 (<5)	<.1 (<5)	.3	40	<.02 (<1)	<.02 (<1)
L4	L4A0.5	27	<4	<.1 (<5)	<.1 (<5)	1.0	48	<.02 (<1)	.02(1)
L4	L4B0.5	25	<4	<.1 (<5)	<.1 (<5)	.9	46	<.02 (<1)	<.02 (<1)
	** L6A0.5	12	<4	<.1 (<5)	<.1 (<5)	.4	51	<.02 (<1)	<.02 (<1)
		Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	25	<4	<.1 (<5)	<.1 (<5)	.9	75	<.02 (<1)	<.02 (<1)
B2	B2A0.5	22	<4	<.1 (<5)	<.1 (<5)	.6	67	<.02 (<1)	<.02 (<1)
B2	* B6A0.5	21	<4	<.1 (<5)	<.1 (<5)	.7	63	<.02 (<1)	<.02 (<1)
B3	B3A0.1	40	<5	<.1 (<5)	<.1 (<5)	1.3	53	<.02 (<1)	<.02 (<1)
B3	B3A1.0	12	<4	<.1 (<5)	<.1 (<5)	.5	62	<.02 (<1)	<.02 (<1)
B3	B3A3.0	8	<4	<.1 (<5)	<.1 (<5)	.4	43	<.02 (<1)	<.02 (<1)
B3	B3A5.0	7	<4	<.1 (<5)	<.1 (<5)	.5	36	<.02 (<1)	<.02 (<1)
B3	B3B0.1	35	<4	<.1 (<5)	<.1 (<5)	1.4	38	<.02 (<1)	<.02 (<1)
B3	B3B1.0	9	<4	<.1 (<5)	<.1 (<5)	.4	53	<.02 (<1)	<.02 (<1)
B3	B3B2.0	9	<4	<.1 (<5)	<.1 (<5)	.4	40	<.02 (<1)	<.02 (<1)
B3	B3B4.0	8	<4	<.1 (<5)	<.1 (<5)	.4	34	<.02 (<1)	<.02 (<1)
B3	B3C0.1	52	15	<.1 (<5)	<.1 (<5)	1.7	34	<.02 (<1)	<.02 (<1)
B3	B3C2.0	9	<4	--	--	.3	43	--	--
B3	B3C4.0	8	<4	--	--	.4	41	--	--
B3	B3C5.0	10	<4	--	--	.4	35	--	--
B3	B3D1.0	12	<4	<.1 (<5)	<.1 (<5)	.5	49	<.02 (<1)	<.02 (<1)
B3	B3E1.0	10	<4	<.1 (<5)	<.1 (<5)	.5	58	<.02 (<1)	<.02 (<1)
B4	B4A0.1	22	<4	<.1 (<5)	<.1 (<5)	.9	42	<.02 (<1)	<.02 (<1)
B4	B4A0.5	23	<4	<.1 (<5)	<.1 (<5)	.9	43	<.02 (<1)	<.02 (<1)
B4	B4A2.0	12	<4	<.1 (<5)	<.1 (<5)	.4	72	<.02 (<1)	<.02 (<1)
B4	* B7A2.0	12	<4	<.1 (<5)	<.1 (<5)	.4	64	<.02 (<1)	<.02 (<1)
B4	B4A4.0	9	<4	<.1 (<5)	<.1 (<5)	.4	37	<.02 (<1)	<.02 (<1)

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Lead				Antimony			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont							
B5	B5A0.5	12	<4	<0.1 (<5)	<0.1 (<5)	0.4	21	<0.02 (<1)	<0.02 (<1)
**	B8A0.5	12	<4	<.1 (<5)	<.1 (<5)	.4	43	<.02 (<1)	<.02 (<1)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	37	<4	--	--	.9	47	--	--
SW1	SED1B	1,100	397	--	--	2.4	39	--	--
SW1	SED1C	56	18	--	--	1.4	40	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	60	<4	--	--	1.9	44	--	--
SW2	SED2B	63	<4	--	--	1.2	42	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	55	<4	--	--	1.0	44	--	--
SW3	SED3B	59	<4	--	--	1.0	53	--	--

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Selenium				Titanium			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Little Soos Creek drainage basin							
L1	L1A0.5	0.6	<4	<0.4 (<20)	<0.04 (<20)	4,200	418	--	--
L2	L2A0.5	.8	<4	<.4 (<20)	<.04 (<20)	5,000	835	--	--
L3	L3A0.1	.6	<4	<.4 (<20)	<.04 (<20)	4,300	893	--	--
L3	L3A0.5	.5	<4	<.4 (<20)	<.04 (<20)	4,300	738	--	--
L3	* L5A0.5	.5	<4	<.4 (<20)	<.04 (<20)	4,300	716	--	--
L3	L3A1.0	.6	<4	<.4 (<20)	<.04 (<20)	4,600	689	--	--
L3	L3A4.0	.2	<4	<.4 (<20)	<.04 (<20)	4,000	584	--	--
L4	L4A0.5	.4	<4	<.4 (<20)	<.04 (<20)	3,900	541	--	--
L4	L4B0.5	.4	<4	<.4 (<20)	<.04 (<20)	3,600	591	--	--
	** L6A0.5	.4	<4	<.4 (<20)	<.04 (<20)	4,400	736	--	--
		Soil samples from Big Soos Creek drainage basin							
B1	B1A0.5	.5	<4	<.4 (<20)	<.04 (<20)	4,600	555	--	--
B2	B2A0.5	.8	<4	<.4 (<20)	<.04 (<20)	4,400	641	--	--
B2	* B6A0.5	.8	<4	<.4 (<20)	<.04 (<20)	4,600	500	--	--
B3	B3A0.1	.5	<4	<.4 (<20)	<.04 (<20)	3,300	378	--	--
B3	B3A1.0	.4	<4	<.4 (<20)	<.04 (<20)	4,100	470	--	--
B3	B3A3.0	.4	<4	<.4 (<20)	<.04 (<20)	4,500	768	--	--
B3	B3A5.0	.2	<4	<.4 (<20)	<.04 (<20)	4,400	697	--	--
B3	B3B0.1	.5	<4	<.4 (<20)	<.04 (<20)	3,200	411	--	--
B3	B3B1.0	.5	<4	<.4 (<20)	<.04 (<20)	3,900	768	--	--
B3	B3B2.0	.4	<4	<.4 (<20)	<.04 (<20)	4,200	585	--	--
B3	B3B4.0	.3	<4	<.4 (<20)	<.04 (<20)	4,700	635	--	--
B3	B3C0.1	.5	<4	<.4 (<20)	<.04 (<20)	3,100	378	--	--
B3	B3C2.0	.5	<4	--	--	3,800	584	--	--
B3	B3C4.0	.4	<4	--	--	4,100	620	--	--
B3	B3C5.0	.2	<4	--	--	4,000	514	--	--
B3	B3D1.0	.6	<4	<.4 (<20)	<.04 (<20)	4,000	479	--	--
B3	B3E1.0	.6	<4	<.4 (<20)	<.04 (<20)	4,000	458	--	--

Table 17.--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued

Site	Sample	Selenium				Titanium			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont							
B4	B4A0.1	0.9	<4	<0.4 (<20)	<0.04 (<20)	4,200	293	--	--
B4	B4A0.5	.9	<4	<.4 (<20)	<.04 (<20)	4,200	261	--	--
B4	B4A2.0	.7	<4	<.4 (<20)	<.04 (<20)	4,700	587	--	--
B4	* B7A2.0	.8	<4	<.4 (<20)	<.04 (<20)	4,900	562	--	--
B4	B4A4.0	.3	<4	<.4 (<20)	<.04 (<20)	5,400	385	--	--
B5	B5A0.5	.2	<4	<.4 (<20)	<.04 (<20)	5,100	257	--	--
	** B8A0.5	.5	<4	<.4 (<20)	<.04 (<20)	4,200	465	--	--
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	.7	<4	--	--	2,600	196	--	--
SW1	SED1B	.7	<4	--	--	3,700	482	--	--
SW1	SED1C	.9	<4	--	--	2,500	415	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	.8	<4	--	--	3,300	433	--	--
SW2	SED2B	.7	<4	--	--	3,300	444	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	.7	<4	--	--	3,500	456	--	--
SW3	SED3B	.9	<4	--	--	2,900	501	--	--

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Thallium				Zinc			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
				Soil samples from Little Soos Creek drainage basin					
L1	L1A0.5	--	13	<0.02 (<1)	<0.02 (<1)	110	56	<0.2 (<10)	<0.2 (<10)
L2	L2A0.5	--	15	<.02 (<1)	<.02 (<1)	60	31	<.2 (<10)	<.2 (<10)
L3	L3A0.1	--	8	<.02 (<1)	<.02 (<1)	82	49	<.2 (<10)	<.2 (<10)
L3	L3A0.5	--	10	<.02 (<1)	<.02 (<1)	79	40	<.2 (<10)	<.2 (<10)
L3	* L5A0.5	--	12	<.02 (<1)	<.02 (<1)	78	42	<.2 (<10)	<.2 (<10)
L3	L3A1.0	--	18	<.02 (<1)	<.02 (<1)	65	33	<.2 (<10)	<.2 (<10)
L3	L3A4.0	--	13	<.02 (<1)	<.02 (<1)	43	26	<.2 (<10)	<.2 (<10)
L4	L4A0.5	--	14	<.02 (<1)	<.02 (<1)	57	29	<.2 (<10)	<.2 (<10)
L4	L4B0.5	--	10	<.02 (<1)	<.02 (<1)	43	27	<.2 (<10)	<.2 (<10)
	** L6A0.5	--	13	<.02 (<1)	<.02 (<1)	56	31	<.2 (<10)	<.2 (<10)
				Soil samples from Big Soos Creek drainage basin					
B1	B1A0.5	--	10	<.02 (<1)	<.02 (<1)	110	58	<.2 (<10)	<.2 (<10)
B2	B2A0.5	--	<8	<.02 (<1)	<.02 (<1)	81	39	<.2 (<10)	<.2 (<10)
B2	* B6A0.5	--	18	<.02 (<1)	<.02 (<1)	81	39	<.2 (<10)	<.2 (<10)
B3	B3A0.1	--	<8	<.02 (<1)	<.02 (<1)	120	71	.2 (10)	.2 (10)
B3	B3A1.0	--	<9	<.02 (<1)	<.02 (<1)	81	41	<.2 (<10)	<.2 (<10)
B3	B3A3.0	--	10	<.02 (<1)	<.02 (<1)	42	26	<.2 (<10)	<.2 (<10)
B3	B3A5.0	--	10	<.02 (<1)	<.02 (<1)	46	32	<.2 (<10)	<.2 (<10)
B3	B3B0.1	--	11	<.02 (<1)	<.02 (<1)	79	42	<.2 (<10)	<.2 (<10)
B3	B3B1.0	--	9	<.02 (<1)	<.02 (<1)	65	41	<.2 (<10)	<.2 (<10)
B3	B3B2.0	--	12	<.02 (<1)	<.02 (<1)	43	23	<.2 (<10)	<.2 (<10)
B3	B3B4.0	--	8	<.02 (<1)	<.02 (<1)	49	26	<.2 (<10)	<.2 (<10)
B3	B3C0.1	--	<8	<.02 (<1)	<.02 (<1)	96	54	<.2 (<10)	<.2 (<10)
B3	B3C2.0	--	17	--	--	59	29	--	--
B3	B3C4.0	--	12	--	--	33	26	--	--
B3	B3C5.0	--	10	--	--	41	24	--	--
B3	B3D1.0	--	11	<.02 (<1)	<.02 (<1)	68	34	<.2 (<10)	.2 (<10)
B3	B3E1.0	--	<9	<.02 (<1)	<.02 (<1)	70	38	<.2 (<10)	<.2 (<10)

***Table 17.**--Concentrations of metals in soils and streambed sediments as determined by different laboratory methods--Continued*

Site	Sample	Thallium				Zinc			
		Total	Total recoverable	EP-TOX	ASTM	Total	Total recoverable	EP-TOX	ASTM
		Soil samples from Big Soos Creek drainage basin--cont							
B4	B4A0.1	--	<8	<0.02 (<1)	<0.02 (<1)	62	33	<0.2 (<10)	<0.2 (<10)
B4	B4A0.5	--	9	<.02 (<1)	<.02 (<1)	67	33	<.2 (<10)	<.2 (<10)
B4	B4A2.0	--	9	<.02 (<1)	<.02 (<1)	46	27	<.2 (<10)	<.2 (<10)
B4	* B7A2.0	--	<8	<.02 (<1)	<.02 (<1)	47	26	<.2 (<10)	<.2 (<10)
B4	B4A4.0	--	14	<.02 (<1)	<.02 (<1)	46	24	<.2 (<10)	<.2 (<10)
B5	B5A0.5	--	<8	<.02 (<1)	<.02 (<1)	32	12	<.2 (<10)	<.2 (<10)
	** B8A0.5	--	<8	<.02 (<1)	<.02 (<1)	58	28	<.2 (<10)	<.2 (<10)
		Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek							
SW1	SED1A	--	<8	--	--	140	99	--	--
SW1	SED1B	--	15	--	--	230	101	--	--
SW1	SED1C	--	<8	--	--	130	63	--	--
		Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek							
SW2	SED2A	--	9	--	--	210	96	--	--
SW2	SED2B	--	12	--	--	210	85	--	--
		Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek							
SW3	SED3A	--	<8	--	--	130	57	--	--
SW3	SED3B	--	<8	--	--	190	85	--	--

* Sample is a duplicate of the preceding sample in table.

** Sample L6A0.5 and B8A0.5 are duplicates of a reference soil sample.

[a] Laboratory reported concentrations of antimony determined by the total-recoverable method are suspected to be high (see text).

***Table 18.**--Concentrations of metals determined by the total-recoverable method in duplicates of six soil samples determined by two laboratories*

[Concentrations in milligrams per kilogram of dry soil; b, Washington State Department of Ecology laboratory at Manchester, Washington; c, Weyerhaeuser Technology Center laboratory at Federal Way, Washington]

Metal	Analyzing laboratory	Sample					
		L1A0.5	L3A0.1	L3A1.0	B2A0.5	B3C5.0	B4A2.0
Silver	b	<4	<4	<4	<4	<4	<4
	c	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Aluminum	b	20,500	25,900	25,500	21,900	10,200	28,300
	c	23,600	18,800	25,400	27,100	12,500	36,800
Arsenic	b	19	24	12	12	<11	15
	c	9.7	7.5	2.9	7.2	3.8	5.5
Beryllium	b	.6	.6	.6	.7	<.5	.6
	c	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
Cadmium	b	<.8	<.8	<.8	<.8	<.8	<.8
	c	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chromium	b	19	22	26	24	19	24
	c	38	22	30	29	19	31
Copper	b	21	13	14	13	10	8
	c	17	13	14	13	9.9	8.3
Iron	b	17,300	16,100	17,200	17,000	12,700	11,300
	c	20,200	14,200	19,400	18,700	12,800	13,500
Mercury	b	.060	.027	.036	.058	.020	.040
	c	.063	<.05	.068	.082	<.04	.075
Manganese	b	846	420	163	494	212	137
	c	897	379	201	207	218	128
Nickel	b	22	25	27	23	27	19
	c	19	18	31	29	27	27
Lead	b	29	<4	<4	<4	<4	<4
	c	30	15	3.1	11	1.8	4 9

***Table 18.**--Concentrations of metals determined by the total-recoverable method in duplicates of six soil samples determined by two laboratories--Continued*

Metal	Analyzing laboratory	Sample					
		L1A0.5	L3A0.1	L3A1.0	B2A0.5	B3C5.0	B4A2.0
Antimony [a]	b	59	68	68	67	35	72
	c	<35	<35	<35	<35	<35	<35
Selenium	b	<4	<4	<4	<4	<4	<4
	c	<2	<2	<2	<2	<2	<2
Titanium	b	418	893	689	641	514	587
	c	824	923	1,180	1,150	714	1,450
Thallium	b	13	8	18	<8	10	9
	c	<6	<6	<6	<6	<6	<6
Zinc	b	56	49	33	39	24	27
	c	49	35	32	42	24	26

[a] Laboratory reported values of antimony concentrations determined by the total-recoverable method are suspected to be high (see text).

***Table 19.**--Concentrations of metals determined by the total-recoverable method in three size fractions of six soil samples*

[Concentrations of metals, in milligrams per kilogram of dry soil for indicated site class; silt plus clay (<0.063 mm), sand (0.063 to 2 mm), and gravel (2 to 9.5 mm); --, no data]

Sample	<0.063 mm	0.063-2 mm	2-9.5 mm	<0.063 mm	0.063-2 mm	2-9.5 mm	<0.063 mm	0.063-2 mm	2-9.5 mm
	Silver			Aluminum			Arsenic		
L2A0.5	<4	<4	<4	32,800	21,800	54,700	32	15	34
B3A0.1	<4	<4	<4	19,500	13,200	30,500	31	16	28
B3A1.0	<4	<4	<4	22,500	14,000	32,300	<11	<11	14
B3A3.0	<4	<4	<4	24,500	10,100	17,900	<11	<11	<11
B3A5.0	<4	<4	<4	14,900	9,120	12,400	<11	<11	<11
B3E1.0	<4	<4	<4	32,600	16,200	32,600	<11	<11	<11
	Beryllium			Cadmium			Chromium		
L2A0.5	.8	.6	.8	<.8	<.8	<.8	23	19	29
B3A0.1	.6	<.5	.8	<.8	<.8	<.8	22	16	27
B3A1.0	.6	.5	.9	<.8	<.8	<.8	23	18	26
B3A3.0	<.5	<.5	<.5	<.8	<.8	<.8	34	19	34
B3A5.0	.6	<.5	<.5	<.8	<.8	<.8	33	22	27
B3E1.0	.8	<.5	.7	<.8	<.8	<.8	28	17	26
	Copper			Iron			Mercury		
L2A0.5	22	14	15	--	15,500	22,100	.057	.063	.026
B3A0.1	23	13	12	17,600	13,000	25,300	.162	.043	.004
B3A1.0	13	11	10	19,300	13,300	20,300	.085	.035	.028
B3A3.0	18	8	13	19,800	11,300	21,300	.089	.042	.056
B3A5.0	17	9	12	21,200	14,000	17,100	.085	.015	.025
B3E1.0	15	12	10	22,800	13,700	22,800	.155	.043	.028
	Manganese			Nickel			Lead		
L2A0.5	167	141	187	27	20	24	<4	<4	<4
B3A0.1	1,110	721	1,620	27	22	34	12	<4	<4
B3A1.0	588	381	1,250	31	26	33	<4	<4	<4
B3A3.0	186	129	225	29	20	35	<4	<4	<4
B3A5.0	326	338	367	34	28	31	<4	<4	<4
B3E1.0	642	469	1,820	33	22	28	<4	<4	<4

***Table 19.**--Concentrations of metals determined by the total-recoverable method in three size fractions of six soil samples--Continued*

Sample	<0.063 mm	0.063-2 mm	2-9.5 mm	<0.063 mm	0.063-2 mm	2-9.5 mm	<0.063 mm	0.063-2 mm	2-9.5 mm
	Antimony [a]			Selenium			Titanium		
L2A0.5	86	60	132	<4	<4	<4	1,260	708	901
B3A0.1	63	44	93	<4	<4	<4	241	312	375
B3A1.0	70	48	96	<4	<4	<4	624	521	194
B3A3.0	70	32	57	<4	<4	<4	1,260	556	1,040
B3A5.0	49	33	42	<4	<4	<4	972	661	602
B3E1.0	85	44	87	<4	<4	<4	607	453	346

	Thallium			Zinc		
L2A0.5	26	12	17	40	28	33
B3A0.1	12	<8	11	95	66	66
B3A1.0	<8	10	9	51	36	50
B3A3.0	10	9	11	35	21	35
B3A5.0	13	9	10	42	28	39
B3E1.0	14	<8	<8	56	33	39

[a] Laboratory reported values of antimony determined by the total-recoverable method are suspected to be high (see text).

***Table 20.**--Particle-size distribution of the part of each soil and streambed-sediment sample that is finer than 9.5 millimeters*

[Percent of particles finer than indicated size, in millimeters]

Site	Sample	9.5	8.0	4.0	2.0	1.0	0.5	0.25	0.125	0.063
					Soil samples from Little Soos Creek drainage basin					
L1	L1A0.5	100.0	94.9	83.1	73.8	57.6	37.4	19.8	12.7	7.8
L2	L2A0.5	100.0	93.3	75.0	57.5	43.8	33.7	23.1	14.7	8.2
L3	L3A0.1	100.0	94.5	79.8	66.8	55.9	42.9	27.8	16.1	10.2
L3	L3A0.5	100.0	95.5	83.0	71.4	60.8	48.5	32.5	20.3	11.4
L3*	L5A0.5	100.0	95.0	77.4	66.5	55.2	43.6	29.0	18.4	10.5
L3	L3A1.0	100.0	96.9	86.7	76.7	63.6	51.7	36.6	24.4	13.8
L3	L3A4.0	100.0	96.0	86.1	72.5	61.5	50.5	32.6	20.8	15.0
L4	L4A0.5	100.0	96.9	85.0	74.3	63.3	51.3	36.3	24.0	12.2
L4	L4B0.5	100.0	94.0	82.5	72.9	63.1	53.6	40.9	27.9	16.3
	** L6A0.5	100.0	100.0	100.0	100.0	93.7	81.0	56.6	33.8	16.7
					Soil samples from Big Soos Creek drainage basin					
B1	B1A0.5	100.0	97.9	86.2	76.5	63.6	52.6	40.9	30.0	18.7
B2	B2A0.5	100.0	98.8	92.5	88.4	82.2	72.4	55.3	38.4	23.7
B2	* B6A0.5	100.0	99.0	93.3	90.5	84.6	75.3	57.7	40.0	24.6
B3	B3A0.1	100.0	98.8	87.9	77.7	68.1	56.5	40.1	25.9	17.3
B3	B3A1.0	100.0	98.0	88.6	79.4	71.2	63.5	47.4	30.9	16.5
B3	B3A3.0	100.0	97.7	82.6	73.2	65.0	56.2	39.4	22.8	11.7
B3	B3A5.0	100.0	98.0	93.8	90.8	87.6	80.8	62.4	42.6	27.3
B3	B3B0.1	100.0	96.8	88.4	80.4	70.8	59.7	41.8	25.6	13.0
B3	B3B1.0	100.0	96.8	88.7	78.8	71.1	62.1	45.8	28.9	14.5
B3	B3B2.0	100.0	96.8	88.9	81.1	73.7	64.2	45.8	27.4	13.9
B3	B3B4.0	100.0	98.9	95.7	87.3	73.8	58.6	38.7	23.2	14.2
B3	B3C0.1	100.0	97.7	92.7	88.5	82.7	70.9	51.2	32.6	16.6
B3	B3C2.0	100.0	98.8	93.4	87.0	81.2	73.0	53.9	35.5	24.3
B3	B3C4.0	100.0	98.8	88.9	82.6	73.9	64.9	47.2	29.4	18.2
B3	B3C5.0	100.0	97.4	93.4	88.8	81.3	69.4	48.6	30.0	17.2
B3	B3D1.0	100.0	98.8	89.1	83.1	77.5	69.7	52.5	35.3	23.2
B3	B3E1.0	100.0	97.8	89.6	82.1	72.2	63.0	45.5	29.1	15.8

***Table 20.**--Particle-size distribution of the part of each soil and streambed-sediment sample that is finer than 9.5 millimeters--Continued*

Site	Sample	9.5	8.0	4.0	2.0	1.0	0.5	0.25	0.125	0.063
					Soil samples from Big Soos Creek drainage basin--cont					
B4	B4A0.1	100.0	100.0	99.2	98.1	95.5	88.9	73.1	52.2	30.0
B4	B4A0.5	100.0	100.0	99.4	98.5	95.8	87.3	69.4	47.6	26.0
B4	B4A2.0	100.0	100.0	100.0	99.8	98.0	91.3	72.2	53.1	39.4
B4*	B7A2.0	100.0	100.0	100.0	99.8	97.3	84.5	62.0	40.3	23.1
B4	B4A4.0	100.0	100.0	100.0	99.9	97.6	84.1	65.2	46.3	25.8
B5	B5A0.5	100.0	98.4	94.0	91.7	88.3	79.6	54.4	30.3	15.8
	** B8A0.5	100.0	100.0	100.0	100.0	92.2	78.1	53.9	31.3	14.1
					Streambed-sediment samples from Big Soos Creek upstream of confluence with Little Soos Creek					
SW1	SED1A	100.0	86.5	65.4	55.9	45.2	31.7	20.6	13.4	7.6
SW1	SED1B	100.0	93.4	76.2	62.2	44.6	29.6	18.3	9.4	3.2
SW1	SED1C	100.0	85.6	52.0	36.9	27.6	17.0	7.2	3.4	1.9
					Streambed-sediment samples from Little Soos Creek upstream of confluence with Big Soos Creek					
SW2	SED2A	100.0	91.4	80.2	72.9	61.4	38.5	10.9	4.4	2.1
SW2	SED2B	100.0	96.8	93.2	85.5	58.3	26.4	10.2	3.3	1.8
					Streambed-sediment samples from Big Soos Creek downstream of confluence with Little Soos Creek					
SW3	SED3A	100.0	85.2	61.9	47.8	31.4	17.6	6.4	2.1	.9
SW3	SED3B	100.0	89.6	67.7	56.3	42.2	25.4	13.8	8.0	5.1

* Sample is a duplicate of the preceding sample in table

** Sample L6A0.5 and B8A0.5 are duplicates of a reference soil sample

Table 21.--Chemical and physical data for stream-water samples collected from Big and Little Soos Creeks on June 9, 1987

[All concentrations are in micrograms per liter unless otherwise specified]

	Dissolved metals			Other constituents and characteristics			
	Sample [1]				Sample [1]		
Metal	SW1	SW2	SW3		SW1	SW2	SW3
Silver	<1	<1	<1	Nitrate plus nitrite (as N) (mg/L)	0.36	<0.10	0.93
Aluminum	<10	20	<10	Chloride (mg/L)	4.3	2.3	3.8
Arsenic	2	<.1	2	Sulfate (mg/L)	11	4.0	9.6
Beryllium	<.5	<.5	<.5	Fluoride (mg/L)	.1	.7	.1
Calcium (mg/L)	15	6.3	11	Silica (mg/L)	20	9.4	16
Cadmium	<1	<.1	<.1	Alkalinity (as CaCO3) (mg/L)	66	19	44
Chromium	<1	<.1	<.1	Dissolved oxygen (mg/L)	8.6	9.9	8.7
Copper	3	3	3	Temperature (degrees celsius)	13.0	14.5	12.0
Iron	240	160	140	pH (standard units)	7.5	7.3	6.9
Mercury	<.1	<.1	<.1	Specific conductance	148	52	115
Potassium (mg/L)	1.6	.50	1.2	(microsiemens per centimeter)			
Magnesium	6,400	1,200	440				
Manganese	110	4	54				
Sodium (mg/L)	5.9	2.1	5.1				
Nickel	<1	<1	<1				
Lead	<5	<5	<5				
Antimony	<1	<1	<1				
Selenium	<1	<1	10				
Zinc	9	4	.010				

[1] Sample SW1, Big Soos Creek upstream of the confluence with Little Soos Creek. U.S. Geological Survey station identification number 472143122075400.

Sample SW2, Little Soos Creek upstream of confluence with Big Soos Creek. U.S. Geological Survey station identification number 472131122072500.

Sample SW3, Big Soos Creek downstream of confluence with Little Soos Creek. U.S. Geological Survey station identification number 472112122074200.

APPENDIX--PRECISION AND VARIATIONS OF INTERLABORATORY ANALYSES

Precision of laboratory determinations of metal concentrations and other soil characteristics were estimated by comparing concentrations determined in duplicate samples. Concentrations in duplicates of three actual soil samples and one constructed reference sample (see table 2 in text), were determined by the laboratories. In addition, duplicate parts of six soil samples were analyzed for only total-recoverable concentrations (see table 2 in text) by two different laboratories. These data were used to obtain a rough estimate of interlaboratory variations in concentrations determined by the total-recoverable method of analyses, and can be an indication of the accuracy of the analyses. No data were collected for estimating interlaboratory variations in concentrations determined by the other three methods of analyses.

The difference, in percent, between the concentrations in each pair of duplicate samples was calculated as the absolute value of the difference between the concentrations divided by the mean of the concentrations. The average difference for each metal and laboratory method is given in table A1. The footnotes in the table explain the computational procedures followed when a concentration was less than a laboratory's minimum reporting level.

The average differences between total-recoverable concentrations are measures of possible interlaboratory variation. Average differences range from 4 to 11 percent for three metals, from 19 to 21 percent for four metals, and are greater than 27 percent for six metals. Concentrations of arsenic, antimony, and thallium reported by laboratory "b" (see table 18) are consistently larger than those reported by laboratory "c". The reverse is true for titanium.

Other Chemical and Physical Characteristics

The precision of the determinations of other chemical and physical characteristics of soil (appendix table 2) was estimated by following the same procedure that was used for estimating the precision of the metal-concentration determinations. However, the average differences are expressed in units of the characteristics rather than in percent. The precision of particle-size determinations was quantified for three size classes; silt-plus-clay (less than 0.063 mm), sand (0.063 mm to 2.0 mm), and gravel (2.0 mm to 9.5 mm).

Metals

The precision of the total method is generally better than the precision of the total-recoverable, EP-TOX, or ASTM methods (table A1). Only for mercury is the precision of the total-recoverable method better than the precision of the total method. In all cases the precision of the total-recoverable method is better than the precision of the EP-TOX and ASTM methods. The precision of the total method is 6 percent or better for 25 of the 30 metals for which all concentrations are above the laboratory's minimum reporting level. The precision is between 9 and 12 percent for four of the metals, and for one metal, mercury, is 24 percent. The precision of concentrations determined by the total-recoverable method ranges from 5 to 8 percent for 4 of the 10 metals for which all concentrations are larger than the laboratory's minimum reporting level. The precision for the other six metals ranges from 12 to 23 percent. Precision of the EP-TOX and ASTM methods is greater than 40 percent and greater than 18 percent, respectively, for those few metals for which some concentrations are larger than detection levels.

***Table A1.**--Average differences between metals concentrations in duplicate soil samples*

[a, concentrations in one or both parts of all duplicate pairs are less than the detection level and the concentrations are consistent; >, greater than; --, no data]

	Average difference,[1] in percent, for indicated method of analysis				
	Precision [2]				Interlaboratory variation [3]
Metal	Total	Total recoverable	EP-TOX	ASTM	Total recoverable
Silver	a	a	a	a	a
Aluminum	1	7	>60	18	19
Arsenic	>0	>11	a	a	>72
Gold	a	--	--	--	--
Barium	3	--	a	a	--
Beryllium	>0	>8	a	a	a
Bismuth	a	--	--	--	--
Calcium	10	--	--	--	--
Cadmium	a	a	a	a	a
Cerium	4	--	--	--	--
Cobalt	2	--	--	--	--
Chromium	4	16	a	a	21
Copper	6	18	40	46	4
Europium	a	--	--	--	--
Iron	1	6	>60	30	11
Gallium	2	--	--	--	--
Holmium	a	--	--	--	--
Mercury	24	14	a	a	>27
Potassium	3	--	--	--	--
Lanthanum	2	--	--	--	--
Lithium	4	--	--	--	--
Magnesium	2	--	--	--	--
Manganese	3	23	a	a	21
Molybdenum	a	--	--	--	--
Sodium	2	--	--	--	--
Niobium	12	--	--	--	--
Neodymium	4	--	--	--	--
Nickel	2	8	>58	>52	20
Phosphorus	5	--	--	--	--
Lead	4	a	a	a	>39
Antimony	4	12	a	a	>52
Scandium	3	--	--	--	--
Selenium	9	a	a	a	a
Tin	a	--	--	--	--

Table A1.--Average differences between metals concentrations in duplicate soil samples--Continued

Metal	Average difference,[1] in percent, for indicated method of analysis				
	Precision [2]				Interlaboratory variation [3]
	Total	Total recoverable	EP-TOX	ASTM	Total recoverable
Strontium	1	--	--	--	--
Tantalum	a	--	--	--	--
Thorium	>14	--	--	--	--
Titanium	3	19	--	--	49
Thallium	--	>39	a	a	>49
Uranium	a	--	--	--	--
Vanadium	2	--	--	--	--
Yttrium	2	--	--	--	--
Ytterbium	10	--	--	--	--
Zinc	2	5	a	a	10

[1] Average of absolute values of differences, in percent, between concentrations in duplicate samples.

When only one of the two laboratory determinations for a duplicate sample was less than the detection level and the determinations were consistent, or when both determinations were less than the detection level, the difference used in the computation of the average difference was ">0".

When only one of the two laboratory determinations for a duplicate sample was less than the detection level and the determinations were inconsistent, the difference used in the computation of the average difference was ">d", where d is the absolute value of the difference, in percent, between the determined concentration and the detection level.

[2] Average difference between concentrations in duplicates of three actual soil samples and one standard soil sample. Both parts of each duplicate sample analyzed by the same laboratory (see table 2).

[3] Average difference between concentrations in duplicates of six soil samples analyzed by two different laboratories (see table 18).

***Table A2.**--Averages of absolute values of differences between chemical and physical characteristics of duplicate soil samples*

Characteristic	Sample numbers				Average difference
	L3A0.5 L5A0.5	B2A0.5 B6A0.5	B4A2.0 B7A2.0	L6A0.5 B8A0.5	
Total organic carbon, in grams per kilogram	66 60	74 80	34 37	15 18	4
pH 1:1, in units	6.19 6.07	5.70 5.81	5.70 5.41	5.96 5.95	.13
pH $CaCl_2$, in units	5.26 5.13	5.00 4.98	5.14 5.15	5.20 5.17	.05
Percent in size class:					
less than 0.063 mm	11.4 10.5	23.7 24.6	39.4 23.1	16.7 14.1	5.2
0.063 mm to 2.0 mm	60.0 56.0	64.7 65.9	60.4 76.7	83.3 85.9	6.0
2.0 mm to 9.5 mm	28.6 33.5	11.6 9.5	.2 .2	.0 .0	1.8