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May 2, 2003
Final

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ABSTRACT

Natural background concentrations were determined for inorganic and radionuclide constituents of sediments as part of Environmental Restoration Project Canyons investigations at Los Alamos National Laboratory (LANL). Twenty-four sediment samples were collected from uncontaminated locations within Los Alamos, Pueblo, and Guaje Canyons. Results from these samples are compared with results of inorganic chemical concentrations from sixteen samples collected from Indio and Ancho Canyons that were analyzed as part of an earlier study of background sediment concentrations.

Sediments were sampled from two geomorphic units (channel and floodplain), each subdivided into two age units (historic and prehistoric) resulting in four different types of sampling units: (1) active stream channels, (2) active floodplains, (3) prehistoric channels, and (4) prehistoric floodplains. Active channels and floodplains are considered to be geomorphic units that have received at least some sedimentation since 1943 when LANL operations began. Prehistoric units have not received any sediment since 1943. Laboratory analysis for samples from Pueblo, Los Alamos, and Guaje Canyons consisted of (1) particle-size distribution, (2) leachable elemental concentrations from partial digestion of the sample using nitric acid (Environmental Protection Agency Method 3050A), (3) radionuclide concentrations, and (4) total organic carbon concentration. Natural background alpha, beta, and gamma radiation were measured in situ using hand-held field instruments for sediments sampled from Pueblo, Los Alamos, and Guaje Canyons. Laboratory analysis for samples from Ancho and Indio Canyons consisted of (1) leachable elemental concentrations from partial digestion of the sample using nitric acid at pH 1 and (2) total elemental concentrations obtained after complete digestion of the sample using hydrofluoric acid. Statistical analysis of inorganic and radionuclide constituents, including detection limits, number of samples above and below detection limits, and the minimum, maximum, mean, and upper tolerance limits (UTLs), are reported for background sediment samples. The spatial coverage and population size of background chemistry samples are considered adequate for defining background values for canyon sediments in most areas on the Pajarito Plateau.

Analytical results are compared to LANL-wide soil background concentrations and are compared among canyons, between geomorphic units, and as a function of sediment particle size. Statistical analysis indicates that the background sediment leachable results generally have less variability and lower concentrations than the LANL-wide acid leachable soil background samples. Statistical analysis indicates that differences in constituent concentrations between canyons for nearly all measured analytes are small, which supports combining the background samples from Ancho and Indio Canyons with the samples collected from Los Alamos, Pueblo, and Guaje Canyons into one LANL-wide background data set. Results do imply, however, that sediment particle size may have a potentially large influence on concentrations of inorganic chemicals and radionuclides. Concentrations of nearly all inorganic chemicals and radionuclides are greater in the floodplain deposits relative to the channel deposits, although the difference in concentrations is not statistically significant for most constituents.

Particle-size distribution results indicate that floodplain deposits are mostly finer textured than channel deposits with a higher abundance of clay and silt and a lower abundance of gravel relative to channel deposits. Higher abundances of clay and silt are significant because these particles generally have chemically reactive surfaces that enhance adsorption of contaminants. These results indicate that selection and sampling of sediments should be carefully considered and documented to ensure that major types of geomorphic units and variations in sediment texture are clearly identified when sampling for contaminants.

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INTRODUCTION

Background elemental concentrations were determined for inorganic and radionuclide constituents of sediments as part of Environmental Restoration (ER) Project Canyons investigations at Los Alamos National Laboratory (LANL or the Laboratory). The primary purpose of the Canyons investigations is to evaluate the effects of past and current Laboratory releases into the major canyon systems of the Pajarito Plateau (LANL, 1997). These background investigations also conform to guidelines set forth in Task IV of the Laboratory's Hazardous and Solid Waste and Amendments (HSWA) permit to "describe the extent of contamination (qualitative/quantitative) in relation to the background levels indicative for the area."

This report summarizes results of sediment background chemistry investigations to determine background concentrations as part of the Task/Site investigations conducted in Pueblo and Los Alamos Canyons (LANL, 1995). We use the term sediment to refer to young alluvium occurring within or near stream channels, which would be generally classified as A or C genetic horizons in soil nomenclature. Samples were collected from four primary sample areas: upper Los Alamos Canyon, upper Pueblo Canyon, lower Pueblo Canyon, and Guaje Canyon (Figure 1). Sediment samples were collected to represent a range of depositional settings including (1) active (historic) channels and floodplains and (2) prehistoric channels and floodplains. Here, the term prehistoric refers to the time preceding establishment of Project Y of the Manhattan Engineer District (i.e., pre-1943). Sites were chosen to (1) avoid any known contamination and (2) provide reasonable estimates of background concentrations, including a variety of bedrock source areas and sediment texture, for canyon sediments within areas affected by the Laboratory. Field, analytical, and statistical methods used to describe background element concentrations are described, and geologic factors that control elemental distributions are discussed. Potential differences in sediment background chemistry by canyon, by grain size, and by geomorphic unit are also discussed. The background data supplements information from earlier background sediment investigations in Ancho and Indio Canyons at TA-39 by Reneau et al. (1998). Estimates of the upper limit of background, intended for use in determining if sediments are contaminated, are calculated based on upper tolerance limits (UTLs) or detection limits (hereafter referred to as "background values"). Sediment background values are summarized in Ryti et al. (1998), which also contains information on the sample sites, analytical methods, and results for background soil and tuff samples. Sediment background data are presented in Appendix C and are summarized in tables and figures in this report; the data are also available electronically through the ER Project database. Statistical testing of the distribution of background sediment concentrations for metals and radionuclides is possible using these data; additionally, statistical testing and plots can be used to infer whether investigation sample results are statistically greater than background.

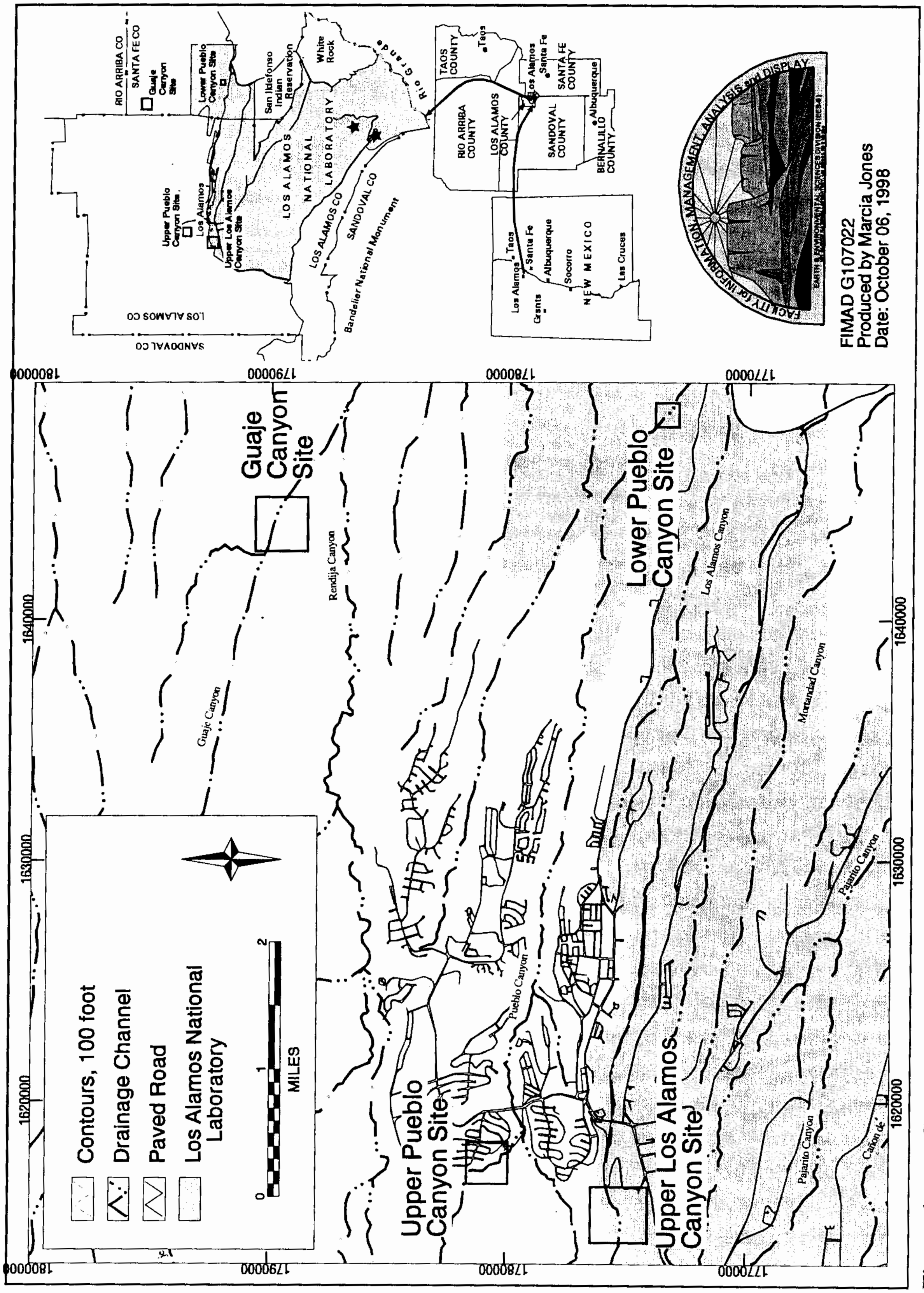


Figure 1. General locations of sediment sample areas in Los Alamos, Pueblo, and Guaje canyons. Stars (inset county map) indicate general sample locations in Ancho and Indio Canyons from Reneau et al. (1998).

This report focuses on data from sediment samples collected in 1996, supplemented by data from samples collected in 1994 during an earlier study. This combined data set was used to propose the sediment background values presented in Ryti et al. (1998), which have been used subsequently in ER Project investigations. Since the time this study was completed, several additional studies have been conducted that have relevance for understanding background concentrations in sediments. Findings from these studies in relation to the work presented here are briefly discussed at the end of this report.

SAMPLING SITES

Twenty-four samples were collected in 1996 among four primary sample areas in upper Los Alamos Canyon, upper Pueblo Canyon, lower Pueblo Canyon, and Guaje Canyon (Figures 1, 2, 3, 4, and 5; Table 1). Sampling strategies for determining background concentrations require selection of sites that (1) avoid any known contamination and (2) provide reasonable estimates of background concentrations for sediments in canyons across the Laboratory. Samples were collected from the upper reaches of Los Alamos and Pueblo Canyons upstream of the Laboratory because these canyons, as well as most canyons across the Laboratory, have received discharge and runoff from Laboratory Technical Areas, increasing the possibility of localized contamination. Sediment background within the narrow parts of upper Los Alamos and Pueblo Canyons, however, may not be entirely comparable with the typical broader reaches of lower Los Alamos and Pueblo Canyons. Thus, three samples were collected from prehistoric (pre-1943) sediments in lower Pueblo Canyon to provide a comparison for sediments from large canyon reaches. Samples were also collected from Guaje Canyon (north of LANL operations) because of differences in source rocks (discussed below) and because Guaje Canyon is a major sediment source for lower Los Alamos Canyon.

GEOLOGIC SETTING

Bedrock Sources

Bedrock source areas for the upper parts of Pueblo and Los Alamos Canyons include Bandelier Tuff and dacitic rocks of the Tschicoma Formation (Smith et al., 1970). Cobbles and gravel largely consisting of tuff, dacite, and pumice in a sandy matrix, rich in quartz and sanidine crystals, dominate the lithology of the Pueblo and Los Alamos Canyon sediments. Guaje Canyon drains areas exposing the Puye Formation, the Bandelier Tuff, and the Tschicoma Formation (Smith et al., 1970). Cobbles and gravel largely consisting of dacitic and andesitic clasts in a sandy matrix dominate the lithology of the Guaje Canyon sediments. Analytical results from this study are also compared with results from a previous study of background sediments in Indio and Ancho Canyons (Reneau et al., 1998), canyons that exclusively drain areas underlain by Bandelier Tuff bedrock.

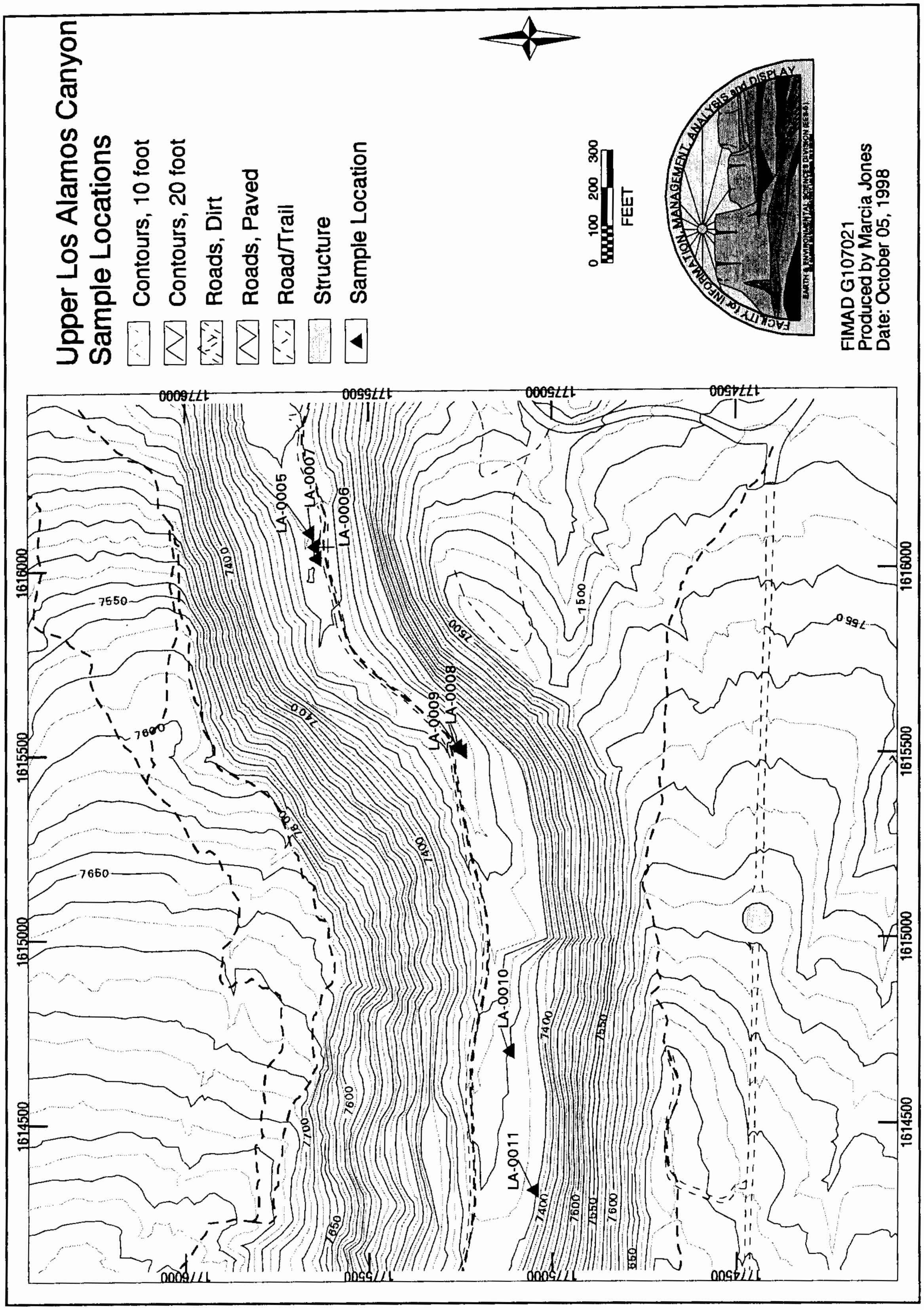


Figure 2. Locations of the seven sample sites in upper Los Alamos Canyon. Sites are located along the stream channel downstream of the Los Alamos Reservoir.

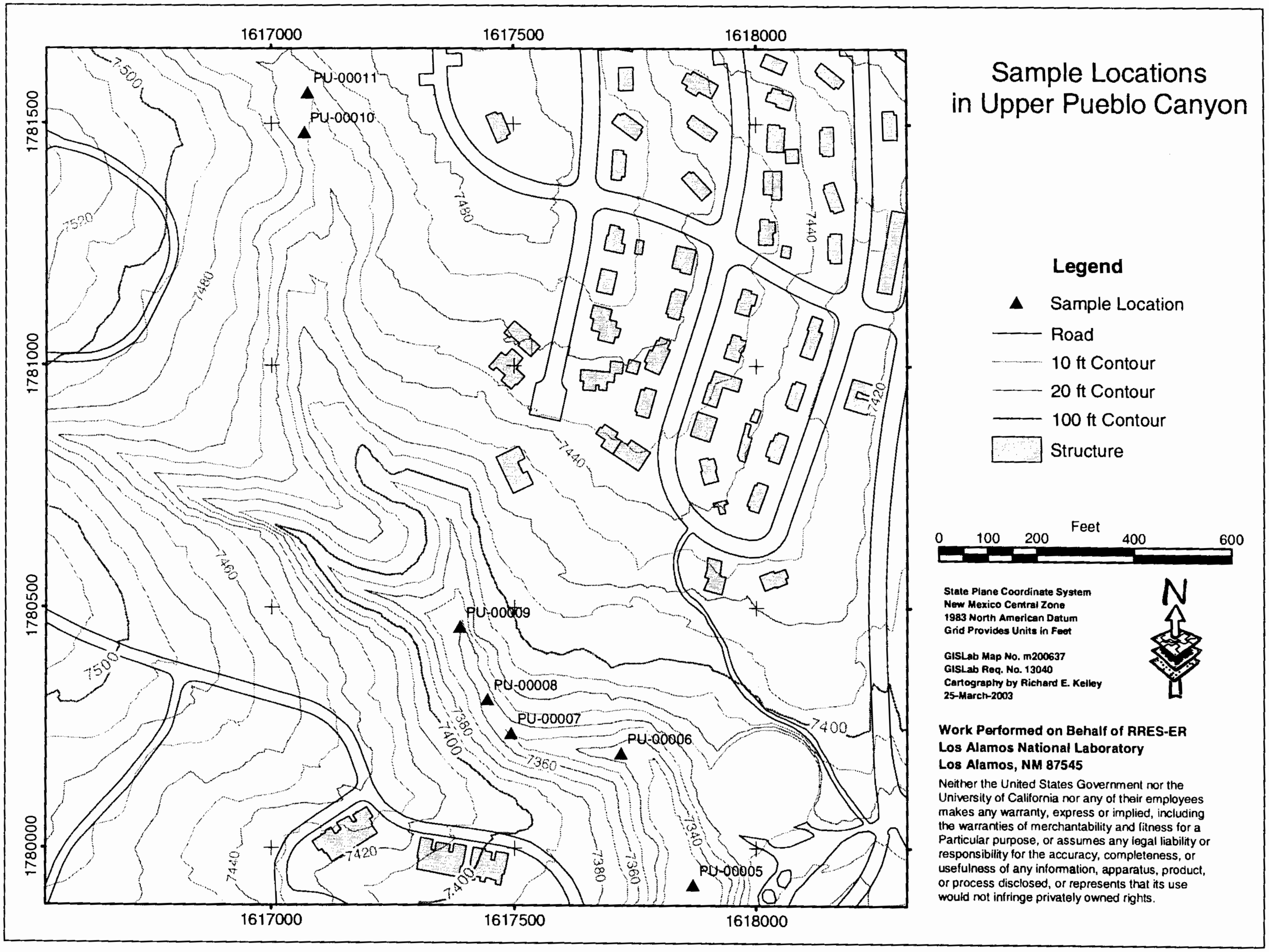


Figure 3. **Locations of the seven sample sites in upper Pueblo Canyon. Sites are located along a stream channel upstream of North Road in Los Alamos.**

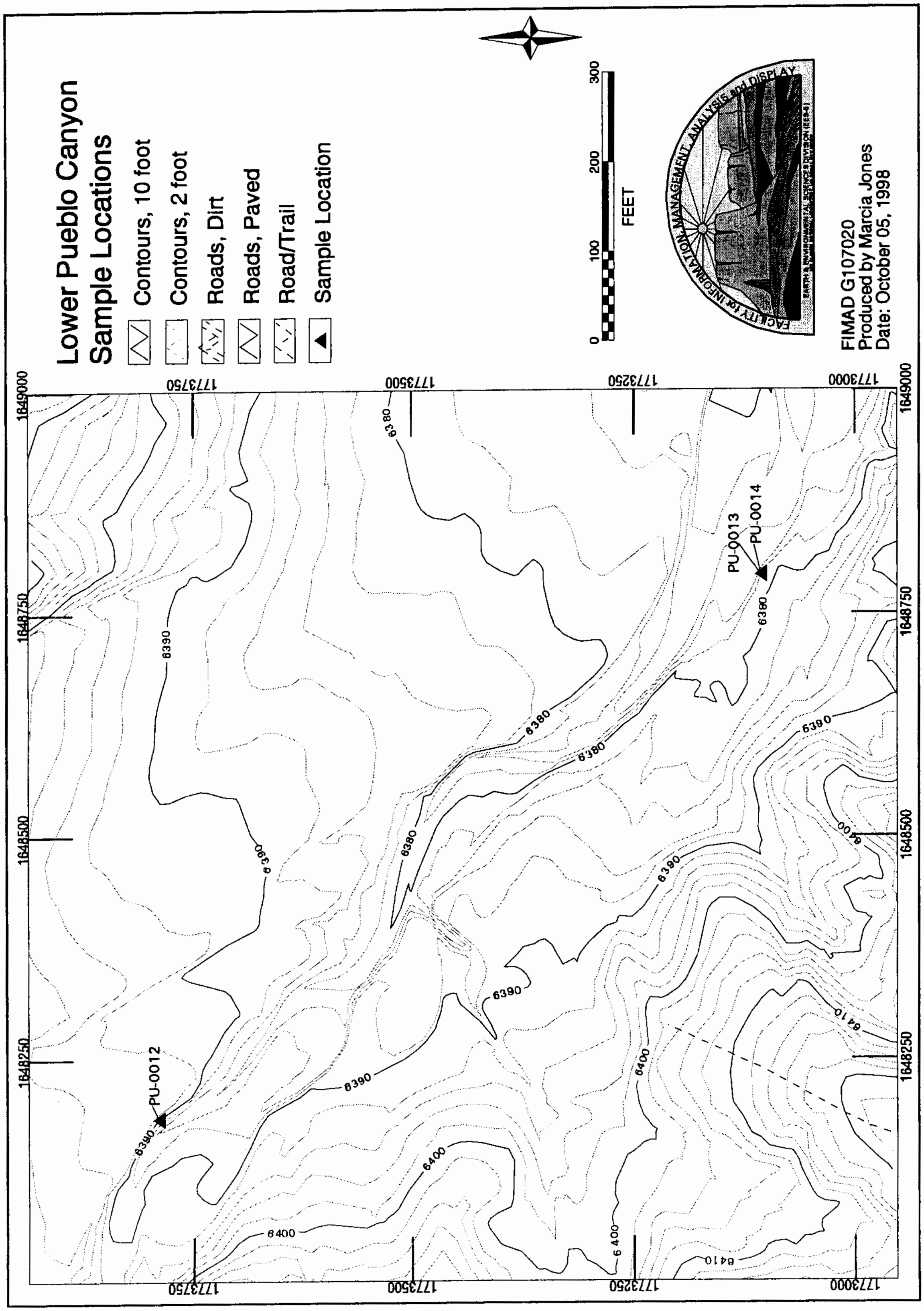


Figure 4. **Locations of the three sample sites in lower Pueblo Canyon. Sites are located upstream of the highway maintenance station on state road 502.**

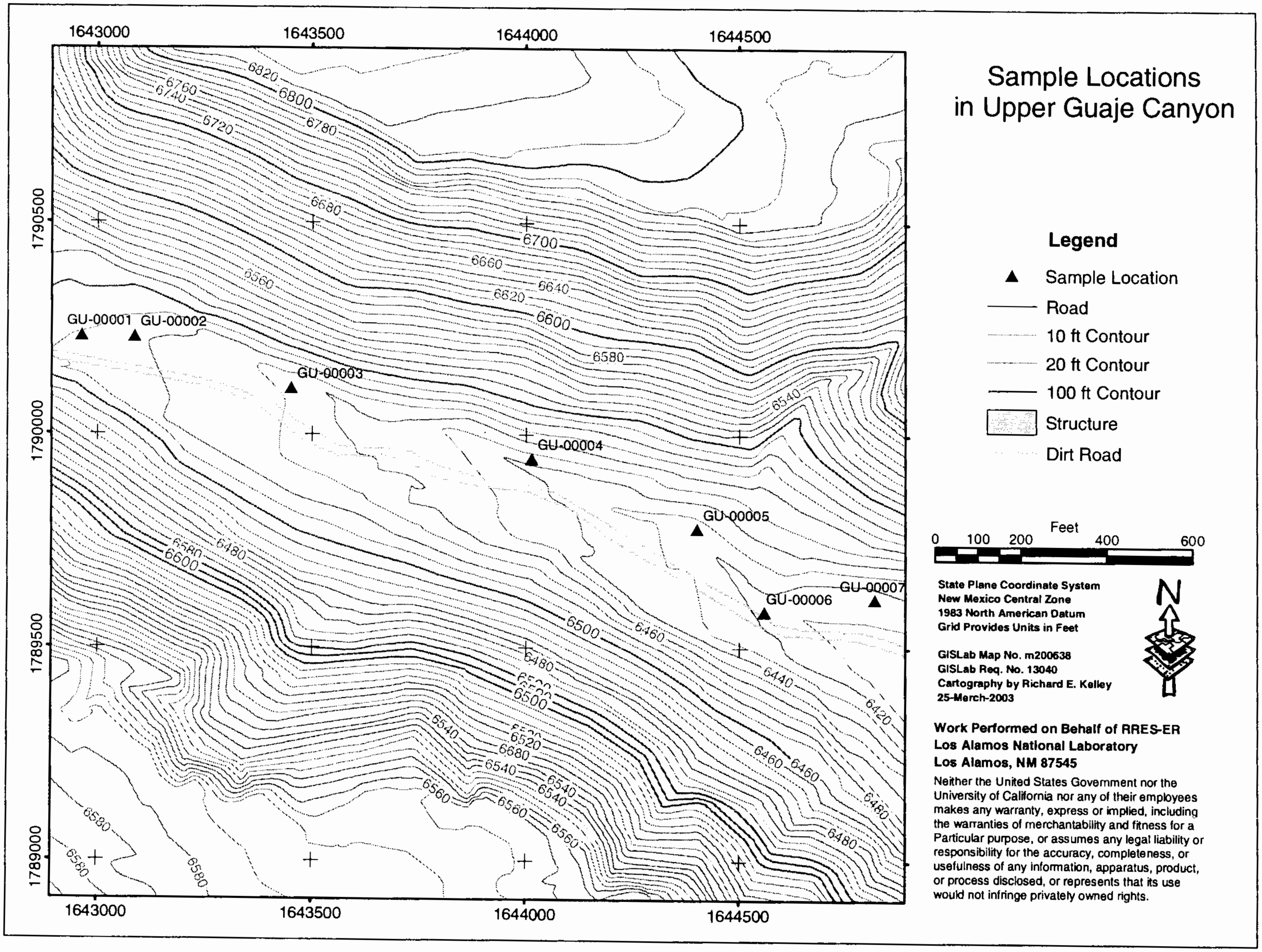


Figure 5. **Locations of the seven sample sites in upper Guaje Canyon. Sites are located along the stream channel upstream of the confluence of Guaje and Rendija Canyons.**

Table 1
Summary of Location, Sample Numbers, and Geomorphic Setting for Canyons Sediment Background Samples

Location ID	Sample ID	Geomorphic Unit	Symbol	Sample Depth (cm)
New Sites, This Report				
Upper Los Alamos Canyon				
LA-0005	04LA-96-0050	active floodplain	FP	3–18
LA-0006	04LA-96-0051	active channel	AC	0–10
LA-0007	04LA-96-0052	prehistoric floodplain	PFP	22–34
LA-0008	04LA-96-0053	active channel	AC	4–13
LA-0009	04LA-96-0054	active channel	AC	10–38
LA-0010	04LA-96-0055	prehistoric floodplain	PFP	22–41
LA-0011	04LA-96-0056	active floodplain	FP	3–28
Upper Pueblo Canyon				
PU-0005	04PU-96-0010	active floodplain	FP	0–10
PU-0006	04PU-96-0011	active floodplain	FP	3–28
PU-0007	04PU-96-0012	prehistoric channel	PC	13–23
PU-0008	04PU-96-0013	active channel	AC	0–25
PU-0009	04PU-96-0014	active channel	AC	0–25
PU-0010	04PU-96-0015	active floodplain	FP	0–25
PU-0011	04PU-96-0016	active floodplain	FP	0–25
Lower Pueblo Canyon				
PU-0012	04PU-96-0017	prehistoric channel	PC	71–102
PU-0013	04PU-96-0018	prehistoric floodplain	PFP	57–76
PU-0014	04PU-96-0019	prehistoric floodplain	PFP	108–114
Upper Guaje Canyon				
GU-0001	04GU-96-0001	active floodplain	FP	0–23
GU-0002	04GU-96-0002	active channel	AC	0–5
GU-0003	04GU-96-0003	active floodplain	FP	1–14
GU-0004	04GU-96-0004	prehistoric floodplain	PFP	160–190
GU-0005	04GU-96-0005	active channel	AC	0–19
GU-0006	04GU-96-0006	prehistoric floodplain	PFP	64–74
GU-0007	04GU-96-0007	active floodplain	FP	0–5

Table 1 (continued)

Location ID	Sample ID	Geomorphic Unit	Symbol	Sample Depth (cm)
Summary of Sites from Reneau et al. (1998)				
Indio Canyon				
	FS2220–FS2223, FS2234[a]	active floodplain	FP	0–46
	FS2224	active channel	AC	0–15
	FS2225[b]	active channel	AC	0–3
	FS2226[c]	active channel	AC	0–3
Ancho				
	FS2227	prehistoric floodplain	PFP	125–140
	FS2228	prehistoric channel	PC	79–94
	FS2229–FS2232, FS2235[a]	active floodplain	FP	20–41
	FS2233	active channel	AC	0–15

[a] Multiple samples from same site analyzed as either sand and silt+clay size subsets or as sample duplicates.

[b] Black (magnetite) sand sample, excluded from calculations of background values.

[c] Clay and silt rich sediment ("mud") sampled from active channel.

Geomorphic Units

Alluvial sediments on the Pajarito Plateau vary greatly in thickness, texture, lithology, and age, resulting from the varied bedrock source areas and the complex physical processes of sediment transport and deposition. Generally, coarser textured sediments (sediments with abundant gravel and coarse sand) require greater stream power for transport and are deposited along axial channels as bedload. By comparison, fine textured sediments (sediments with abundant fine sand, silt, and clay) are commonly transported as suspended load, both within axial channels and over adjacent floodplains during floods. Because of spatial and temporal variations in stream flow frequency, flow volumes, and the migration, incision, and/or aggradation of stream channels, sediment properties can vary greatly both laterally and vertically (stratigraphically). Variations in the particle-size distribution and mineralogy of alluvium are important for understanding the geochemical concentrations of sediments, because it is likely that the transport of many contaminants is related to the transport of fine-grained particles such as silt, clay, and organic matter, which are characterized by larger surface areas and adsorption-site charge densities. To capture the major degrees of sediment variation, we sampled sediments from two main geomorphic units that can be partitioned into two general age groups (Figure 6; Table 1) and that can also have significant particle-size variations within them.

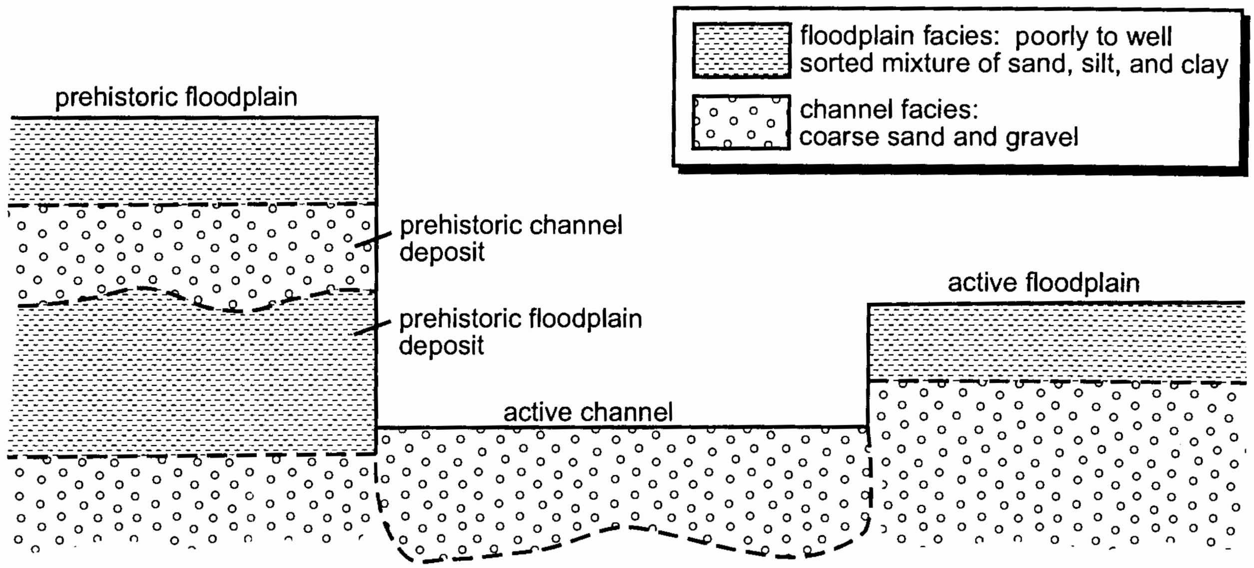


Figure 6. Schematic diagram showing the different geomorphic settings and sediment facies sampled in this study. Note that both channel and floodplain facies may occur below floodplains.

Geomorphic Units

(1) ***Channel.*** Channels include sediments transported as either bedload or suspended load and deposited along the main channels of ephemeral or perennial streams. Channel sediments generally have a coarse texture, often consisting of abundant sand and gravel, indicating deposition by high stream power associated with axial stream channels (channel facies). Channel sediments can also be fine-textured, similar to deposits typically found on floodplains (overbank facies).

(2) ***Floodplain.*** Floodplains include sediments deposited along vegetated benches or surfaces adjacent to stream channels. Floodplains episodically receive sediment during periods of high channel flow. Flood activity is infrequent enough to allow vegetation (shrubs and grasses) to become firmly established on these surfaces. Floodplain sediments generally have a fine texture, often consisting of abundant fine sand and silt, indicating deposition by low stream power associated with flood water overtopping and spreading out away from the stream channels (overbank facies). Floodplains can also locally include coarse sediment (channel facies) deposited during large floods.

Age Units

(1) ***Historic Sediments.*** Historic sediments are sediments that have been deposited along channels or floodplains since 1943. The 1943 time is defined here as the beginning of

historic sedimentation because anthropogenic activities since 1943 have resulted in the greatest potential impact to the geochemistry of canyon sediments. *Active channels* (as used in this report) include both channels currently transporting sediment and channels that have been abandoned since 1943. *Active floodplains* are generally within about 1 m of the lowest point of the active channels, consisting of either recently flooded surfaces or surfaces abandoned since 1943. Floodplains and channels may have become inactive since 1943 resulting from channel incision and/or channel migration.

(2) ***Prehistoric Sediments***. Prehistoric sediments were deposited before 1943. *Prehistoric floodplain* deposits consist of either surface deposits or deposits buried within prehistoric floodplains (Figure 6) or surfaces adjacent to floodplains and active channels that are generally >1 m above the base of the active channel. These surfaces have young to mature stands of trees and in some cases have weakly developed soils at the surface. *Prehistoric channel* sediments are buried within prehistoric floodplains and terraces. Ideally, prehistoric sediments should have no detected results for fallout radionuclides, although it is possible that there has been some subsurface migration of these constituents. It is also possible that false detects could result from problems with instrument calibration at low concentrations.

Using the geomorphic and age criteria listed above, four main units are discussed in the following text: active channel, active floodplain, prehistoric channel, and prehistoric floodplain. For statistical comparisons, historic and prehistoric age units are combined and all channel sediments (i.e., active and prehistoric; Figure 6, Table 1) are compared with all floodplain sediments. For the purpose of determining natural background levels of inorganic chemicals and radionuclides, we consider the geomorphic context to be of particular concern. Further comparisons between only floodplains and channel deposits were evaluated to simplify statistical analysis. The relative age of the deposits may be important when examining particle-size relations because some prehistoric deposits may represent stream conditions (i.e., large flood events) that have not occurred during historic time.

METHODS

Sample Collection

Representative bulk samples were collected at each sample site and packed into 1-gallon high density polyethylene (HDPE) plastic bottles or three 1-liter HDPE plastic bottles. Vegetation and debris were removed from each surface before sampling. Sample depth, thickness, and height relative to base of adjacent active channels were recorded.

Fixed-Point Alpha, Beta, and Gamma Survey

In situ measurements of alpha, beta, and gamma radiation were taken at each sample location using:

(1) *Alpha radiation.* A Ludlum Model 43-1 detector (zinc sulfide scintillation probe) with a Ludlum Model 2221 scaler/ratemeter.

(2) *Beta radiation.* A Ludlum Model 44-116 detector (plastic scintillation probe) with a Ludlum Model 2221 scaler/ratemeter.

(3) *Gamma radiation.* A Ludlum Model 44-10 detector (sodium iodide scintillation probe) encased in a lead- and copper-lined polyethylene shield, with a Ludlum Model 2221 scaler/ratemeter.

The survey was conducted by placing the probe face on the soil surface (horizontal for surface measurements, vertical for depth measurements) and collecting 5-min timed measurements (counts per 5 min). Before and after each day's use, each instrument's response was checked by collecting a 1-minute measurement of a ^{232}Th source (for alpha radiation response) and a ^{137}Cs source (for beta and gamma radiation response) of known activity and compared to the acceptable range (average ± 20%). At the same time, each instrument was used to collect five 1-minute measurements of local background radiation, the average of which was compared to an acceptable range (average ± 3 sigma). These measurements were taken each day at the same place in an area that was not likely to have been radioactively contaminated by Laboratory activities. During these measurements, source-to-detector geometry was kept as consistent as possible. Scaler/ratemeter battery voltage, operating high voltage, threshold setting, and window configuration were also checked twice daily.

Geochemistry Analysis - Sample Preparation and Laboratory Analytical Methods

Standard Environmental Protection Agency (EPA) analytical methods were used to measure concentrations of inorganic chemicals. Radionuclide concentrations were determined by methods required by the Laboratory's analytical services contract. Modified ASTM (American Society for Testing and Materials) methods were used to determine the particle-size distribution of sediment background samples. Use of these methods ensures comparability of these background sample data to data from samples collected in Laboratory Resource Conservation and Recovery Act (RCRA) investigations.

Sample pretreatment. Laboratory pretreatment procedures were designed to ensure that each sample analyzed by the laboratory was representative of the sediment stratum that was collected in the field, and that the pretreatment was consistent for the inorganic chemical and radionuclide analytical suites. All samples were air-dried then sieved through a No. 10 mesh sieve to remove the >2-mm size fraction (gravel). A 50-g subsample was split from the sample for tritium analysis before drying and sieving of the sample. Percent weight of gravel was determined for each sample. All samples were split into representative aliquots for additional geochemical and particle-size analysis. The pretreatment procedure is described in detail in Appendix A.

Laboratory analytical methods. Two sets of samples underwent analysis for inorganic chemicals, radionuclides, and total organic carbon (TOC): (1) the <2-mm size fraction for all 24 sediment samples and (2) the <0.0625-mm size fraction (silt and clay) for a subset of samples. The complete analyte lists, sample preparation and analytical methods are provided in Appendix B. To ensure comparability with other ER Project sample results, all inorganic chemical analyses were performed according to EPA SW-846 methods (EPA, 1986). General procedures for the three geochemical suites are as follows:

(1) *Inorganic* chemicals were extracted with nitric acid (at pH 1) according to EPA method SW-3050 or equivalent. Metal concentrations in these extracts were analyzed by inductively coupled plasma emission spectroscopy (ICPES) according to EPA method SW-6010. Antimony, aluminum, barium, beryllium, calcium, cadmium, chromium, cobalt, iron, magnesium, manganese, nickel, potassium, sodium, silver, titanium, and vanadium were analyzed by ICPES with radial viewing; arsenic, lead, selenium, and thallium were analyzed by ICPES with axial viewing. Mercury was measured by cold vapor atomic absorption spectroscopy according to EPA method SW-7471. Cyanide was measured colorimetrically according to EPA method SW-7471. All results were reported on a dry weight basis.

(2) *Radionuclides* were analyzed using methods approved by LANL. Gamma-emitting radionuclides (see analyte list in Appendix B) were measured by gamma spectroscopy on dried and milled samples, with no further sample extraction. Americium-241, the plutonium isotopes ^{238}Pu and ^{239,240}Pu (unresolved isotopes), and the thorium isotopes ^{228}Th, ^{230}Th, and ^{232}Th were measured by alpha spectrometry following complete fusion of the sediment sample. The uranium isotopes ^{234}U, ^{235}U, and ^{238}U were measured by inductively coupled plasma mass spectrometry (ICPMS) following complete digestion of the sample. For analysis of ^{234}U, the sample extract was preconcentrated on a flow injection analyzer. Tritium in the water fraction distilled from each sediment sample was measured by liquid scintillation counting. The gravimetric moisture content of each sample was also determined, and all tritium results were converted to units of pCi/g of dry sediment. Strontium-90 was measured in complete sample digests by counting the beta particle emission of the ^{90}Y decay product in a gas proportional counter. Gross-alpha and gross-beta radiation were measured by gas proportional counting.

(3) *Total Organic Carbon (TOC).* The concentration of TOC was determined by the loss on ignition method.

Particle-size distribution analysis (PSDA). The texture of the <2-mm size fraction all sediment samples was determined using LANL-specified modifications to general procedures in ASTM D 422 (1990). Specific requirements for PSDA employing dry-sieve and hydrometer methods are described in Appendix A; complete results of PSDA are reported in Appendix D.

Geochemistry Analysis - Statistical Methods

Statistical analysis of the background data consists of the following three steps:

(1) Prepare data for analysis.

(2) Evaluate data heterogeneity:

  (a) Determine if previously collected sediment data (from Indio and Ancho Canyons; Reneau et al., 1998) can be combined with the new data (from Los Alamos, Pueblo and Guaje Canyons) to establish one set of new LANL sediment background data applicable to all canyons.

  (b) Compare data from channel and floodplain geomorphic units to determine if there are significant differences and whether sediment background data should be divided into subsets by geomorphic unit.

  (c) Compare data from fine fractions and total grain size analyses to determine if there are significant differences and whether sediment background data should be divided into subsets by grain size.

(3) Calculate sediment background values.

Prepare data for analysis. Chemical and radionuclide analytical methods used on sediment background samples were compared to those typically used and/or required to be used in the ER Project. The detection frequency of each reported chemical and radionuclide was summarized. The list of detected chemicals and radionuclides was reviewed to ensure that background data would be useful (or help establish a contaminant release from Laboratory operations).

Some of the geochemical results data are reported as less than the inorganic chemical detection level (<DL) or less than the radionuclide minimum detectable activity (<MDA). To facilitate statistical analysis of these data, all values reported as <DL or <MDA were replaced by one-half of the detection limit. This replacement approach is recommended in the EPA risk assessment

guidance (EPA, 1992). In addition, most infrequently detected analytes are excluded from further statistical analyses.

Evaluate data heterogeneity. Both graphical and quantitative lines of evidence were used to help determine if these background data represent a single population or should be viewed as distinct subpopulations. Box plots were used as the main graphical data display to evaluate potential differences between canyons, geomorphic units, and sample grain size. Statistical tests and summary statistics were used as quantitative lines of evidence to support the visual impression provided by the box plots.

Box plots of all inorganic chemicals and detected radionuclides are used to compare (1) background data among canyon source, geomorphic unit, and grain size and (2) background elemental concentrations for Los Alamos, Pueblo, Guaje, Indio, and Ancho Canyons sediment data to LANL soil background data (using the combined data set from all soil horizons; Longmire et al., 1995). In the box plots, actual detected values (as filled circles) are shown for each data source. Values reported as less than the detection limits are shown as open circles. The ends of the box represent the "inter-quartile" range of the data distribution. The inter-quartile range is specified by the 25th percentile and 75th percentile of the data distribution. The line within the box plot is the median (50th percentile) of the data distribution. Thus, the box indicates concentration values for the central half of the data, and concentration shifts can be assessed by comparing the boxes. If the majority of the data is represented by a single concentration value (usually the DL), the box is reduced to a single line.

Background sediment data for Los Alamos, Pueblo, Guaje, Indio, and Ancho canyons were statistically compared by the Wilcoxon rank sum (WRS) test or the Kruskal-Wallis (K-W) test. The K-W test is applied where we are testing to see if there are differences between three or more data groups. The basic methods of both the K-W and the WRS tests involve computing differences between ranked groups of data. The WRS test is one of the "distribution shift" methods discussed in the LANL ER Project Policy Paper on background comparisons (Ryti et al., 1996). The WRS test was also used to determine if there are significant chemical differences between geomorphic units (floodplain versus channel) and grain sizes (<2-mm size fraction versus fine size fraction background data. (Note: the fine size fraction was <0.075 mm for the Indio Canyon and Ancho Canyon samples.)

Calculation of sediment background values. In preparation for calculating UTL values, data were first inspected for suspect values that are exceptionally high or low relative to the rest of the data. Next, the background data were evaluated to determine if they are derived from a single statistical population, which involves fitting the data to a standard statistical distribution (e.g., normal or lognormal).

The UTL values were calculated for all inorganic chemicals and radionuclides with detection frequencies of at least 50%. The background value for less frequently detected analytes was based on the expected analytical laboratory detection limit. The UTL values were calculated in three ways, depending on whether the analyte fit a normal, square-root normal, or lognormal statistical distribution. Additional information on data transformations used for statistical distribution analysis are contained in Box and Cox (1964) and Wolter (1985). The appropriate statistical distribution for each analyte was selected based on reviewing probability plots (Appendix E).

The probability plots show each background analytical result ordered from lowest to highest. Detected values are shown as solid circles, and nondetects, plotted as one-half of the detection limit, are shown as open circles. The x-axis is the standard normal quantile scale. The units of the standard normal quantile are in standard deviations, where 1 represents one sigma or standard deviation. The y-axis of the probability plot is the concentration of the inorganic chemicals (in mg/kg). The purpose of these plots is twofold. First, they provide a succinct way to present all of the data for each analyte. Second, they provide a way to assess the statistical distribution of each analyte. Specifically, if the data for an analyte follow a straight line when plotted on a standard normal scale, these data are considered to originate from a normal statistical distribution. One can assess the fit to other statistical distributions by transforming the y-axis to another scale. For example, chemical data are frequently derived from a lognormal distribution, and transforming the y-axis into a logarithmic scale assesses the fit to a lognormal distribution.

For analytes that are normally distributed without any data transformation (1), we calculated parametric tolerance limits by using the following equation:

$$\text{UTL} = \text{mean} + (\text{standard deviation} * k_{0.95,0.95}) \qquad (1)$$

The k-factor depends on the number of background samples; complete tables of k-factors are published in the RCRA groundwater statistical analysis document (EPA, 1989) and Gilbert (1987). Example k-factors are presented in Ryti et al. (1996). For analytes that are normally distributed after a square root transformation, the mean and standard deviation of the square root transformed data are used in the following equation:

$$\text{UTL}_{0.95,0.95} = (\text{mean} + [\text{standard deviation} * k_{0.95,\,0.95}])^2 \qquad (2)$$

The UTL values for lognormally distributed analytes are estimated by a first-order Monte Carlo simulation process, which uses the lognormal distribution function in the S-plus statistical programming language (see Appendix F for the S-plus program code). These simulations were run for 10,000 trials, which were sufficient to estimate the lognormal UTLs to two to three significant digits. Inputs to this function are the lognormal mean (E) and the lognormal standard deviation (V). Definitions of E and V, as well as methods for calculating these statistics are presented in Gilbert (1987, p. 164).

RESULTS AND DISCUSSION

Particle-Size Distribution of Sediments

A summary of particle-size analyses is presented in Table 2, and complete results are presented in Appendix D. Particle-size distribution data are not available for the samples from Indio and Ancho Canyons. Sediments from Pueblo, Los Alamos, and Guaje Canyons are largely dominated by the sand size fraction (2 to 0.0625 mm) with sand contents ranging from 46.2% to 98.0% by weight. Graphic mean particle size (of the <2-mm fraction) is 0.22 mm, and the graphic mean texture ranges from coarse sand to very fine sand. Clay contents (<0.002 mm) are low in all samples and range from 0.2% to 11.4% by weight. Sediment textures, based on the proportion of weight percent sand, silt, and clay, range from sand to loam. Gravel content (>2 mm) varies greatly, ranging from 3.4% to 66.3% by weight. Most of the samples are poorly sorted, indicating variable mixture of sand, silt, and clay-sized particles.

Cumulative frequency plots of the particle-size data indicate that the texture of the background sediments falls between two types of generalized deposits (Figures 7 to 12). Channel deposits (active and prehistoric) largely consist of gravel and sand, whereas floodplain deposits (active and prehistoric) have relatively higher silt and clay contents and lower gravel content (Figure 7). Mean weight values for gravel, sand, silt, and clay and graphic mean indicate that the channel sediments are primarily coarser in texture than floodplain sediments (Table 3). Graphic skewness (Table 2) also reflects this relative mixture of coarse and fine particles. Channel deposits are largely fine skewed (low percentages of silt- and clay-sized particles) whereas floodplain deposits are largely coarse skewed (high percentages of silt- and clay-sized particles).

The variations in texture primarily reflect variations in water velocity and turbulence with higher velocities and turbulence enhancing the transport and deposition of coarser sediment. As a result, sediment with high gravel and sand contents reflect high flow conditions that are characteristic of flow along active channels or along low-lying floodplains during flood events. By comparison, high silt and clay and low gravel contents reflect low flow conditions that are characteristic of low water conditions (low water levels along active channels) and slow water during floods when water overtops stream banks and flows onto adjacent floodplains. It should be noted, however, that because large temporal and spatial variations occur in stream flow, there may be many exceptions to the above relation between geomorphic setting and particle size.

Table 2
Summary of Particle-Size Distribution Analysis for Background Sediments

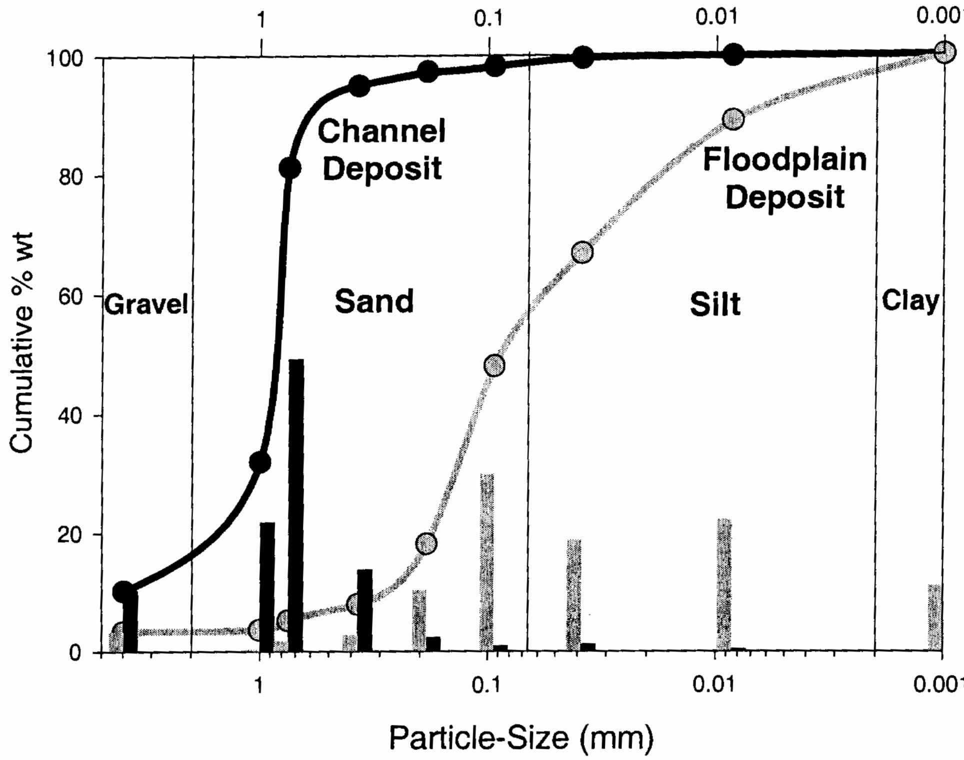
Sample ID	Geomorphic Unit	Sample Depth (cm)	>2 mm % wt	Sand % wt	Silt % wt	Clay % wt	Texture[a]	<2-mm Size Fraction					
								Graphic Mean	Graphic Mean Texture[b]	Inclusive Graphic Std Dev	Sorting	Inclusive Graphic Skewness	Skewness
Upper Los Alamos Canyon													
04LA-96-0050	FP	3–18	14.6	53.9	41.2	4.9	sl	0.84	vfs	1.3	poorly sorted	-0.37	strongly coarse skewed
04LA-96-0051	AC	0–10	66.3	92.8	5.8	1.4	s	0.38	ms	1.28	poorly sorted	0.39	strongly fine skewed
04LA-96-0052	PFP	22–34	6.1	67.4	27.5	5.1	sl	0.12	vfs	1.56	poorly sorted	-0.19	coarse skewed
04LA-96-0053	AC	4–13	47.8	89.2	8.0	2.8	s	0.28	ms	1.37	poorly sorted	0.32	strongly fine skewed
04LA-96-0054	AC	10–38	56.6	85.1	11.6	3.3	ls	0.26	ms	1.54	poorly sorted	0.3	strongly fine to fine skewed
04LA-96-0055	PFP	22–41	9.7	80.2	17.4	2.4	ls	0.17	fs	1.45	poorly sorted	0.18	fine skewed
04LA-96-0056	FP	3–28	54.1	79.8	17.0	3.3	ls	0.18	fs	1.67	poorly sorted	-0.03	near symmetrical
Upper Pueblo Canyon													
04PU-96-0010	FP	0–10	5.0	71.1	27.5	1.4	sl	0.24	fs	1.79	poorly sorted	0.46	strongly fine skewed
04PU-96-0011	FP	3–28	22.3	77.7	21.6	0.7	ls	0.23	fs	1.8	poorly sorted	0.28	fine skewed
04PU-96-0012	PC	13–23	63.2	68.4	23.9	7.7	sl	0.14	fs	1.58	poorly sorted	0.02	near symmetrical
04PU-96-0013	AC	0–25	32.9	74.6	22.5	2.9	ls	0.17	fs	1.57	poorly sorted	0.22	fine skewed
04PU-96-0014	AC	0–25	25.1	71.5	24.8	3.7	sl	0.15	fs	1.62	poorly sorted	-0.02	near symmetrical
04PU-96-0015	FP	0–25	35.9	64.1	31.3	4.6	sl	0.14	fs	1.55	poorly sorted	0.14	fine skewed
04PU-96-0016	FP	0–25	21.2	75.3	19.7	5.1	ls	0.24	fs	1.93	poorly sorted	0.28	fine skewed

Table 2 (continued)

Sample ID	Geomorphic Unit	Sample Depth (cm)	>2 mm % wt	Sand % wt	Silt % wt	Clay % wt	Texture[a]	<2-mm Size Fraction					
								Graphic Mean	Graphic Mean Texture[b]	Inclusive Graphic Std Dev	Sorting	Inclusive Graphic Skewness	Skewness
Lower Pueblo Canyon													
04PU-96-0017	PC	71–102	11.4	98.0	1.8	0.2	s	0.36	ms	0.7	moderately-well sorted	0.46	strongly fine skewed
04PU-96-0018	PFP	57–76	7.8	47.3	46.9	5.8	sl	0.10	vfs	1.77	poorly sorted	-0.64	strongly coarse skewed
04PU-96-0019	PFP	108–114	3.4	46.2	42.4	11.4	l	0.63	vfs	0.89	moderately sorted	-0.31	strongly coarse skewed
Upper Guaje Canyon													
04GU-96-0001	FP	0–23	16.8	85.6	12.7	1.7	ls	0.28	ms	1.54	poorly sorted	0.24	fine skewed
04GU-96-0002	AC	0–5	11.2	56.6	38.8	4.6	sl	0.16	fs	1.57	poorly sorted	-0.46	strongly coarse skewed
04GU-96-0003	FP	1–14	38.9	93.4	5.7	0.9	s	0.38	ms	1.3	poorly sorted	0.37	strongly fine skewed
04GU-96-0004	PFP	160–190	19.0	71.4	24.9	3.7	sl	0.17	fs	1.69	poorly sorted	0.08	near symmetrical
04GU-96-0005	PC	0–19	28.4	96.1	3.7	0.2	s	0.57	cs	1.09	poorly sorted	0.4	strongly fine skewed
04GU-96-0006	PFP	64–74	11.7	70.8	24.8	4.4	sl	0.13	fs	1.43	poorly sorted	-0.05	near symmetrical
04GU-96-0007	FP	0–5	30.7	93.5	6.0	0.5	s	0.39	ms	1.25	poorly sorted	0.33	strongly fine skewed
							Mean	**0.28**					
							Std	**0.18**					

[a] Texture based on proportion of weight percent sand, silt, and clay. Sand (s), sandy loam (sl), loamy sand (ls), loam (l).

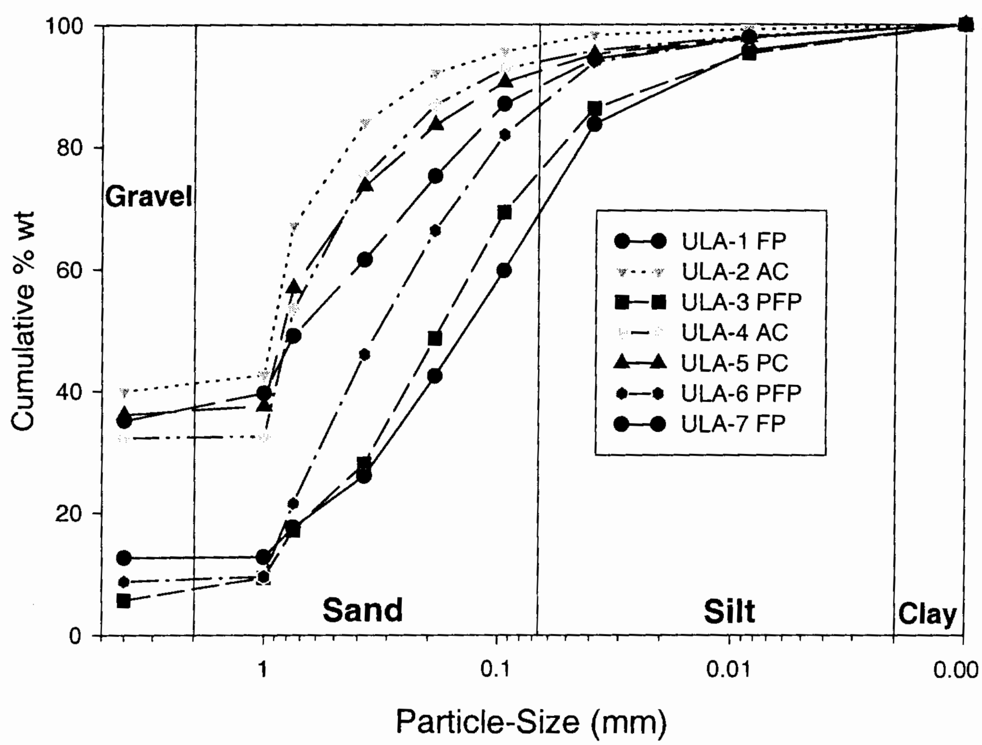
[b] Texture based on mean grain size determined from cumulative frequency graph. Coarse sand (cs), medium sand (ms), fine sand (fs), very fine sand (vfs).



Notes:

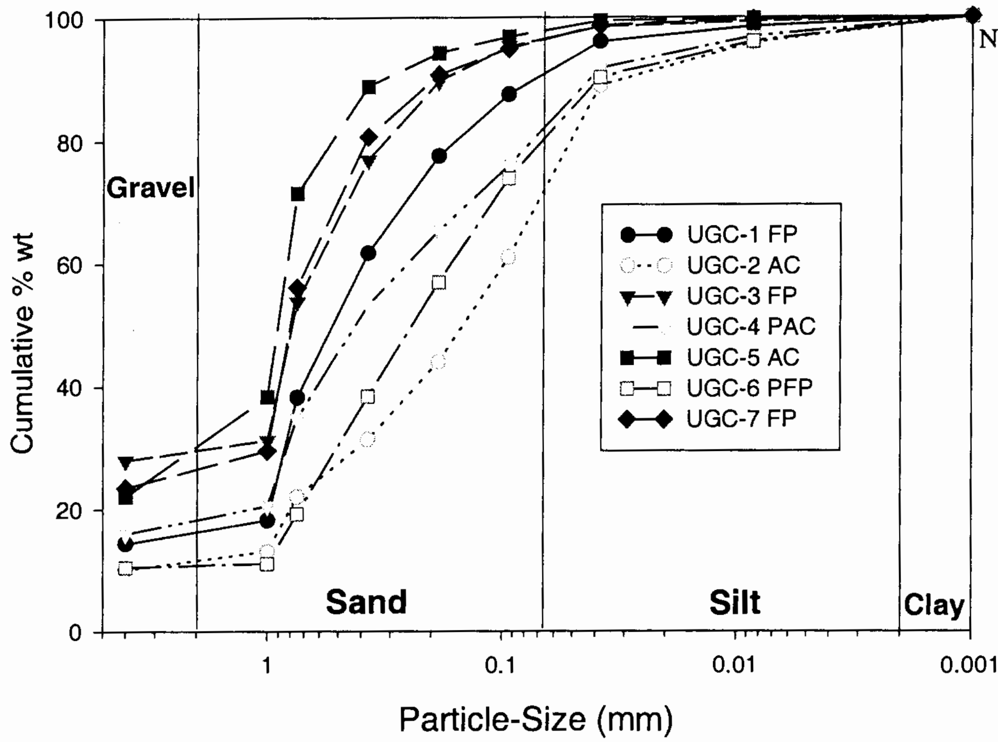
1. Bar graph shows weight percent for each particle size class.
2. Channel sediments typically have a greater abundance of gravel and sand relative to floodplain deposits that have greater amounts of silt and clay.
3. Samples shown are 04PU-96-0017 (channel) and 04PU-96-0019 (floodplain).
4. All percent weight gravel is plotted as 4-mm size particles for simplicity.

Figure 7. Cumulative frequency plots for particle-size distribution for channel and floodplain deposits



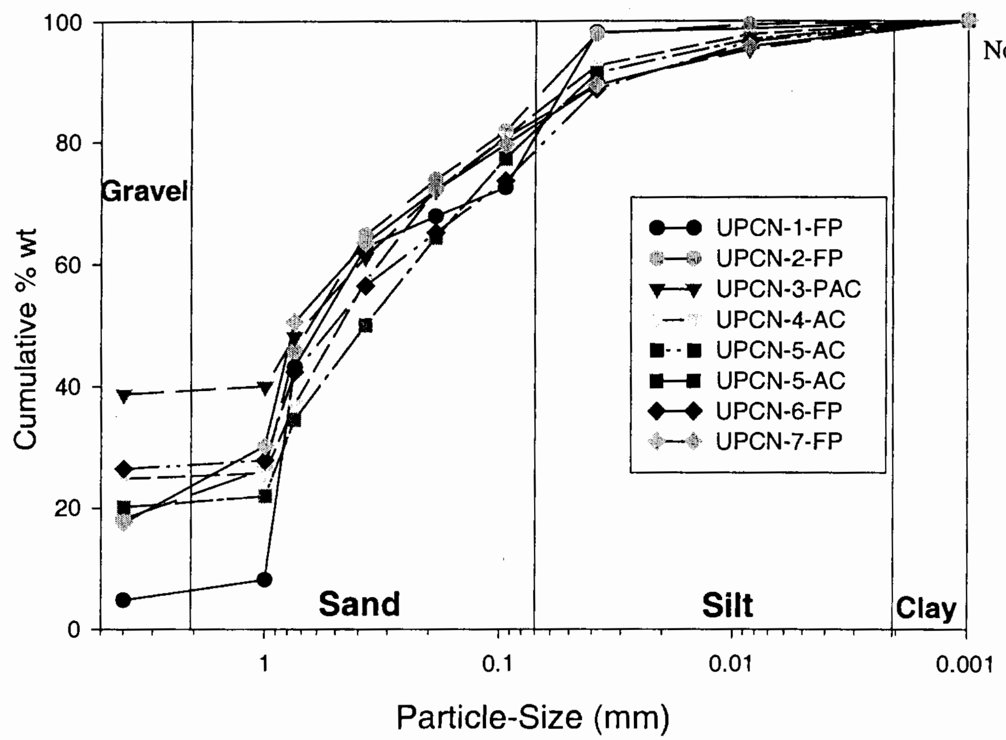
Note: All percent weight gravel is plotted as 4-mm size particles for simplicity

Figure 8. Cumulative frequency plots for particle-size distribution for the seven sediment samples from upper Los Alamos Canyon



Note: All percent weight gravel is plotted as 4-mm size particles for simplicity

Figure 9. **Cumulative frequency plots for particle-size distribution for the seven sediment samples from upper Guaje Canyon**



Note: All percent weight gravel is plotted as 4-mm size particles for simplicity

Figure 10. **Cumulative frequency plots for particle-size distribution for the seven sediment samples from upper Pueblo Canyon**

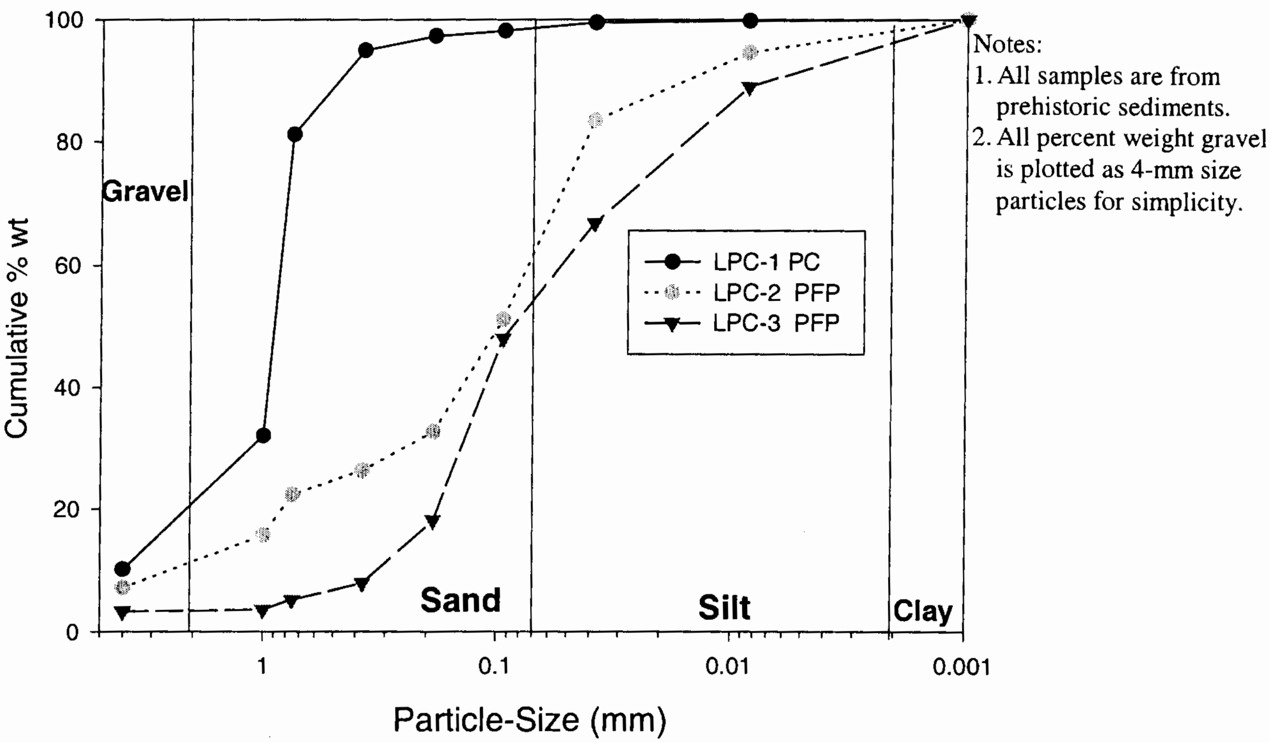


Figure 11. Cumulative frequency plots for particle-size distribution for the three sediment samples from lower Pueblo Canyon

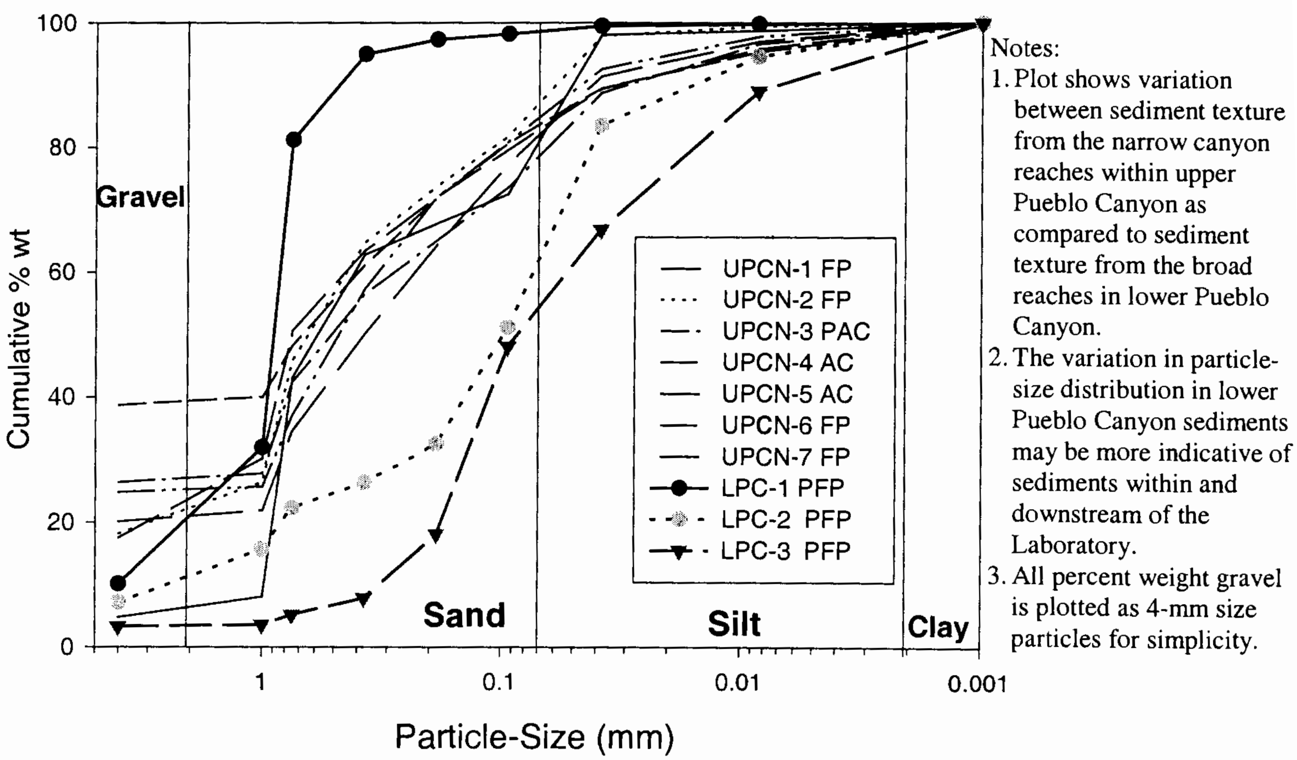


Figure 12. Cumulative frequency plots for particle-size distribution for the 10 sediment samples from lower and upper Pueblo Canyon

Table 3
Comparison of Particle-Size Distributions for Channel and Floodplain Sediments

Sample ID	>2 mm % wt	Silt + Clay % wt	Sand % wt	Silt % wt	Clay % wt	Graphic Mean (mm)
Channel						
04LA-96-0051	66.3	7.2	92.8	5.8	1.4	0.38
04LA-96-0053	47.8	10.8	89.2	8.0	2.8	0.28
04LA-96-0054	56.6	14.9	85.1	11.6	3.3	0.26
04GU-96-0002	11.2	43.4	56.6	38.8	4.6	0.16
04GU-96-0005	28.4	3.9	96.1	3.7	0.2	0.57
04PU-96-0012	63.2	31.6	68.4	23.9	7.7	0.14
04PU-96-0013	32.9	25.4	74.6	22.5	2.9	0.17
04PU-96-0014	25.1	28.5	71.5	24.8	3.7	0.15
04PU-96-0017	11.4	2.0	98.0	1.8	0.2	0.36
Mean	38.1	18.6	81.4	15.6	3.0	0.26
Std Dev	21.2	14.2	14.2	12.4	2.3	0.14
Floodplain						
04LA-96-0050	14.6	46.1	53.9	41.2	4.9	0.08
04LA-96-0052	6.1	32.6	67.4	27.5	5.1	0.12
04LA-96-0055	9.7	19.8	80.2	17.4	2.4	0.17
04LA-96-0056	54.1	20.3	79.8	17.0	3.3	0.18
04GU-96-0001	16.8	14.4	85.6	12.7	1.7	0.28
04GU-96-0003	38.9	6.6	93.4	5.7	0.9	0.38
04GU-96-0004	19.0	28.6	71.4	24.9	3.7	0.17
04GU-96-0006	11.7	29.2	70.8	24.8	4.4	0.13
04GU-96-0007	30.7	6.5	93.5	6.0	0.5	0.39
04PU-96-0010	5.0	28.9	71.1	27.5	1.4	0.24
04PU-96-0011	22.3	22.3	77.7	21.6	0.7	0.23
04PU-96-0015	35.9	35.9	64.1	31.3	4.6	0.14
04PU-96-0016	21.2	24.8	75.3	19.7	5.1	0.24
04PU-96-0018	7.8	52.7	47.3	46.9	5.8	0.10
04PU-96-0019	3.4	53.8	46.2	42.4	11.4	0.06
Mean	19.8	28.2	71.8	24.4	3.7	0.20
Std Dev	14.5	14.6	14.5	12.4	2.8	0.10

Textural analysis indicates that most of the floodplain deposits and all of the channels deposits have sand content that is higher than the total silt and clay content. The generally sandy character of these samples primarily reflects two conditions. First, clay and silt content is generally low in the bedrock sources (discussed above) that these sediments are originally derived from. Second, most of these samples are from narrow, low-lying floodplains (usually less than a meter above the lowest point of the active channel) that characterize the narrow reaches along the upper watershed of each canyon. Sand and gravel can be readily deposited on low-lying floodplains during large floods when flow depths exceed floodplain heights and flood water is confined to narrow areas by canyon walls.

Cumulative frequency plots indicate that textural variations are similar between upper Los Alamos Canyon and Guaje Canyon sediments, showing a range of particle size distribution between floodplain and channel deposits (Figures 8 and 9). By comparison, sediments in upper Pueblo Canyon display little variation in particle distribution between floodplain and channel (Figure 10). The reach sampled in upper Pueblo Canyon is a narrow reach incised into bedrock. Floodplains are low and are probably flooded during frequent ephemeral stream events. By comparison, sediments in lower Pueblo Canyon display considerable variation in particle distribution between floodplain and channel (Figures 11 and 12). This variation reflects in part the larger size of the fluvial system, with wider, more extensive channels and floodplains in lower Pueblo Canyon relative to upper Pueblo Canyon.

Sediment in lower Pueblo Canyon is probably more indicative of the particle-size distribution found throughout most of the larger reaches that run through the Laboratory. These results indicate that silt and clay content will likely be higher in floodplain deposits in canyon reaches that are within or downstream of the Laboratory relative to sediments upstream of the Laboratory that were sampled as part of this background study. This last point is important because statistical comparisons between floodplain and channel deposits (discussed below) indicate the background chemistry is similar between channels and floodplains. If floodplain deposits are largely finer grained in downstream reaches relative to the upstream reaches characterized in this study, statistical differences between background geochemistry of floodplain and channel deposits are possible.

Fixed-Point Alpha, Beta, and Gamma Survey

Results of in situ measurements of alpha, beta, and gamma radiation also indicate that only minimal differences in background radiation occur among the three canyons measured (Table 4). Alpha background radiation has the highest variation among canyons and may partially reflect variations in sediment source rock type, or this variation could also reflect the high measurement error associated with alpha particle counting.

Table 4
Summary of Results from Fixed-Point Alpha, Beta, and Gamma Survey by Canyon and Geomorphic Unit

Sample ID	Unit	Depth (cm)	Alpha (cpm)	Beta (cpm)	Gamma (cpm)
Counts per Minute (cpm) by Canyon					
Los Alamos					
04LA-96-0050	FP	3–18	11.8	372	6305
04LA-96-0051	AC	0–10	10.6	344	6220
04LA-96-0052	PFP	22–34	16.2	410	6945
04LA-96-0052			22.0		
04LA-96-0053	AC	4–13	13.2	424	7180
04LA-96-0054	AC	10–38	6.4	414	7055
04LA-96-0055	PFP	22–41	13.4	419	6560
04LA-96-0056	FP	3–28	11.4	424	6392
		Mean	13.1	401	6665
		Std Dev	4.5	31	389
Pueblo					
04PU-96-0010	FP	0–10	8.2	323	5440
04PU-96-0011	FP	3–28	6.0	361	5772
04PU-96-0012	PC	13–23	7.6	382	6213
04PU-96-0013	AC	0–25	9.0	355	6356
04PU-96-0014	AC	0–25	5.0	362	7389
04PU-96-0015	FP	0–25	11.0	383	6362
04PU-96-0016	FP	0–25	14.8	339	5603
04PU-96-0016			12.6		
		Mean	9.3	358	6162
		Std Dev	3.3	22	655
Guaje					
04GU-96-0001	FP	0–23	12.0	409	5730
04GU-96-0002	AC	0–5	3.6	403	5601
04GU-96-0003	FP	1–14	8.8	389	5785
04GU-96-0004	PFP	160–190	7.2	456	6852
04GU-96-0005	AC	0–19	4.2	385	5073

Table 4 (continued)

Sample ID	Unit	Depth (cm)	Alpha (cpm)	Beta (cpm)	Gamma (cpm)
04GU-96-0006	PFP	64–74	3.4	436	6513
04GU-96-0007	FP	0–5	8.6	457	6101
		Mean	6.8	419	5951
		Std Dev	3.2	30	594
Counts per Minute by Geomorphic Unit					
Channel					
		Mean	7.5	384	6386
		Std Dev	3.3	29	800
Floodplain					
		Mean	10.2	398	6182
		Std Dev	3.6	42	483

Geochemistry Results

(1) Prepare data for analysis

One background sample was dominated by black magnetite sands, which is an unusual, naturally occurring sediment deposit. This sample was collected from Indio Canyon (sample FS2225, Reneau et al., 1998), and because of its unique mineralogy and chemistry, this sample has been excluded from all statistical summaries and plots presented in this document. However, this sample may be useful in evaluating other samples containing black sands.

A summary of the detection limits, number of samples above and below detection limits, and the minimum, maximum, median, mean, and standard deviation of concentrations for inorganic analytes in the <2-mm and fine size fractions are reported in Tables 5 and 6. A complete listing of inorganic analytical results is reported in Appendix C. Two inorganic analytes (selenium and tantalum) were not detected in any background sample, and 31 inorganic analytes were detected in at least one sample. Concentrations below detection limits commonly occurred for antimony, cadmium, mercury, selenium, silver, tantalum, and thallium. These analytes are excluded from further statistical analyses.

Table 5
Summary of Concentration Range (mg/kg)
of Detects and Nondetects for Inorganic Analytes in the <2-mm Size Fraction

Analyte	Nondetects			Detects			Median	Mean	Standard Deviation
	Count	Min	Max	Count	Min	Max			
Ag	16	0.1	0.1	2	0.11	0.28	0.050	0.066	0.055
Al	0			25	740	13300	5510	5840	3240
As	2	0.5	0.5	29	0.3	3.6	1.80	1.84	0.967
B	10	1.2	1.2	10	1.2	4.1	0.900	1.40	0.994
Ba	0			31	8	127	64.6	60.4	30.1
Be	2	0.08	0.08	29	0.17	1.3	0.545	0.590	0.324
Ca	0			31	180	4240	1640	1680	980
Cd	18	0.1	0.2	6	0.1	0.18	0.100	0.093	0.037
Cl	5	2.5	2.5	2	8.4	10.3	1.25	3.56	3.99
CN	4	0.15	0.15	20	0.16	0.63	0.250	0.295	0.186
Co	0			31	0.6	4.2	2.20	2.35	1.08
Cr	0			31	0.8	9.2	5.40	5.62	2.20
Cu	0			31	0.77	12	4.30	4.57	2.45
Fe	0			31	1400	13000	8400	8030	2610
Hg	21	0.02	0.02	3	0.02	0.03	0.010	0.012	0.005
K	0			31	180	2600	1120	1300	628
Mg	0			31	170	2370	826	977	521
Mn	0			31	46	517	302	290	115
Na	0			31	34	1970	458	551	414
Ni	2	2	2	29	2.5	8.9	4.60	4.98	1.99
Pb	1	4	4	30	3.5	25.6	8.90	9.25	4.72
Sb	30	4.9	5	1	5	5	2.45	2.54	0.457
Se	24	0.2	0.2	0					
SO_4	5	5	5	2	26.5	35	2.50	10.6	14.0
Ta	7	0.3	0.3	0					
Th	0			7	0.9	7	5.50	4.20	2.60
Th-total	0			7	3.3	18	13.0	11.1	5.73
Ti	0			24	102	400	226	242	85.3
Tl	7	0.3	0.4	24	0.56	3.2	1.20	1.24	0.862
U	3	0.3	0.3	28	0.14	2	0.660	0.685	0.423
U-total	0			31	0.7	7.2	4.00	3.76	1.46
V	0			31	1	20	10.0	10.4	4.19
Zn	0			31	9	56.2	34.0	33.9	11.9

Table 6
Summary of the Concentration Range (mg/kg) of Detects and Nondetects for Inorganic Analytes in the Fine Size Fraction (<0.0625 or <0.075 mm)

Analyte	Nondetects Count	Nondetects Min	Nondetects Max	Detects Count	Detects Min	Detects Max	Median	Mean	Standard Deviation
Ag	4	0.1	0.1	0					
Al	0			6	6800	13200	8870	9560	2630
As	0			7	1.1	4.2	2.5	2.56	0.947
B	1	1.2	1.2	4	1.4	3.9	2.7	2.36	1.34
Ba	0			7	90	123	115	111	12.7
Be	0			7	0.82	1.6	1	1.07	0.255
Ca	0			7	1900	5860	2500	3020	1380
Cd	3	0.1	0.2	2	0.2	0.22	0.1	0.134	0.073
Cl	0			0					
CN	5	0.15	0.15	0					
Co	0			7	2.6	4.8	3.4	3.59	0.790
Cr	0			7	5.8	12.6	8.8	8.43	2.48
Cu	0			7	5.8	10.1	7.3	7.63	1.39
Fe	0			7	8400	12000	9510	9850	1210
Hg	2	0.02	0.02	3	0.03	0.04	0.03	0.024	0.013
K	0			7	1270	2070	1830	1720	321
Mg	0			7	1230	2070	1500	1600	324
Mn	0			7	230	784	376	430	194
Na	0			7	76	845	307	412	290
Ni	0			7	5	11.9	7.4	7.76	2.14
Pb	0			7	7	20.4	12.6	13.9	5.19
Sb	7	4.9	5	0					
Se	5	0.2	0.2	0					
SO_4	0			0					
Ta	2	0.3	0.3	0					
Th	0			2	6.9	7.7	7.3	7.30	0.566
Th-total	0			2	16	17	16.5	16.5	0.707
Ti	0			5	61.5	329	203	186	115
Tl	3	0.3	0.3	4	1	2.6	1	1.05	0.983
U	0			7	0.6	1.9	1.2	1.21	0.454
U-total	0			7	4.4	7.7	4.9	5.51	1.21
V	0			7	11.3	19.1	12.9	13.5	2.60
Zn	0			7	29.2	74.2	38	43.6	16.4

It is important to note that the detection limits for antimony and thallium in the sediment background samples are greater than those reported in soil background samples because concentrations of antimony and thallium in sediment samples were measured by a different analytical method (ICPES) than was used for the majority of the soil background data (ICPMS). ICPMS is considered to be a better analytical method to quantify the abundance of these metals because of its lower detection limits and method performance. Reported sediment concentrations of Sb are 2 to 5 times higher than concentrations of Sb in background soils. These higher concentrations are a result of the lower precision of ICPES analysis, relative to the ICPMS analysis, and we do not use these sediment data for calculating background values.

A summary of the detection limits, number of samples above and below detection limits, and the minimum, maximum, median, mean, and standard deviation of concentrations for radionuclides in the <2-mm and fine size fractions are reported in Tables 7 and 8. Some radionuclide results are reported whether or not the value is greater than the MDA. Sample results for the following radionuclides are not censored: ^{3}H, ^{238}Pu, ^{239,240}Pu, and ^{90}Sr. Sample results for all other radionuclides have been censored at the MDA. The following radionuclides were not detected and are excluded from further statistical analyses: ^{140}Ba, ^{211}Bi, ^{212}Bi, ^{109}Cd, ^{139}Ce, ^{144}Ce, ^{134}Cs, ^{57}Co, ^{60}Co, ^{152}Eu, ^{129}I, ^{140}La, ^{54}Mn, ^{203}Hg, ^{237}Np, ^{231}Pa, ^{233}Pa, ^{234}Pa, ^{210}Pb, ^{211}Pb, ^{223}Ra, ^{224}Ra, ^{219}Rn, ^{106}Ru, ^{75}Se, ^{22}Na, ^{85}Sr, ^{234}Th, ^{113}Sn, ^{88}Y, and ^{65}Zn. A complete list of radionuclide analytical results is reported in Appendix C.

Two radionuclides were eliminated from statistical analysis because of inadequate analytical methods. The ^{226}Ra data are from gamma spectroscopy, which is not an acceptable method for quantifying this radionuclide. Thus, we will not use the ^{226}Ra data to calculate a UTL value. Uranium-235 can also be detected with gamma spectroscopy, although not at the activities expected for the natural uranium background. Thus, ^{235}U data by gamma spectroscopy are also excluded from the sediment background data. Alpha spectroscopy is the more appropriate method to measure background concentrations for both of these analytes.

The detected radionuclides fall into two broad categories: fallout radionuclides and naturally occurring radionuclides. The fallout radionuclides include ^{241}Am, ^{137}Cs, ^{90}Sr, ^{3}H, ^{238}Pu, and ^{239,240}Pu. The naturally occurring radionuclides include uranium and thorium isotopes and their daughters (Table 9). Because of the short half-life associated with many of the naturally occurring isotopes they are not of interest for risk or dose assessment purposes (Table 9). Thus, there is no need for further statistical evaluation of the short-lived uranium and thorium daughters. Thus, ^{228}Ac, ^{214}Bi, ^{212}Pb, ^{214}Pb, ^{208}Tl, and ^{234}Th are excluded from further statistical analyses.

Table 7
Summary of Concentration Range (pCi/g) of
Detects and Nondetects for Radionuclides in the <2-mm Size Fraction

Analyte	Nondetects			Detects			Median	Mean	Standard Deviation
	Count	Min	Max	Count	Min	Max			
Gross Alpha	0			24	8.47	49.28	30.7	30.8	12.1
Gross Beta	0			24	22.7	41.12	34.8	34.6	4.98
Ac-228	3	0.31	0.55	21	1.14	3.07	1.72	1.66	0.710
Am-241	0			24	0.009	0.139	0.019	0.026	0.025
Ba-140	24	0.11	0.44	0					
Bi-211	24	0.84	1.38	0					
Bi-212	24	1.11	4.61	0					
Bi-214	8	0.25	0.46	16	0.49	1.4	0.740	0.669	0.408
Cd-109	24	2.6	4.65	0			1.67	1.73	0.244
Ce-139	24	0.03	0.12	0					
Ce-144	24	0.47	1.31	0					
Co-57	24	0.03	0.1	0					
Co-60	24	0.05	0.14	0					
Cs-134	24	0.07	0.17	0					
Cs-137	17	0.06	0.13	7	0.21	1.28	0.060	0.211	0.307
Eu-152	24	0.09	0.6	0					
H-3	0			23	0.003	0.0856	0.018	0.024	0.019
Hg-203	24	0.06	0.15	0					
I-129	24	0.13	0.36	0					
K-40	0			24	24.21	35.1	30.1	29.8	3.03
La-140	24	0.02	0.08	0					
Mn-54	24	0.04	0.12	0					
Na-22	24	0.02	0.1	0					
Np-237	24	0.78	1.4	0					
Pa-231	24	2.34	4.46	0					
Pa-233	24	0.08	0.25	0					
Pa-234M	24	7.93	21.2	0					
Pb-210	24	1.41	2.66	0					
Pb-211	24	2.12	4.69	0					

Table 7 (continued)

Analyte	Nondetects			Detects			Median	Mean	Standard Deviation
	Count	Min	Max	Count	Min	Max			
Pb-212	0			24	0.66	2.22	1.54	1.47	0.386
Pb-214	0	0	0.002	24	0.58	2.13	1.19	1.16	0.350
Pu-238	24	-0.002	0.006	0			0.002	0.002	0.002
Pu-239,240	10	0.002	0.009	14	0.010	0.197	0.012	0.025	0.040
Ra-223	24	0.7	1.7	0					
Ra-224	24	1.85	3.4	0					
Ra-226	23	1.91	3.55	1	2.24	2.24	1.39	1.42	0.268
Rn-219	24	0.96	2.45	0					
Ru-106	24	0.35	1.31	0					
Se-75	24	0.05	0.23	0					
Sn-113	24	0.04	0.35	0					
Sr-85	24	0.09	0.15	0					
Sr-90	24	-0.3	1	0			0.2	0.229	0.352
Th-227	24	1.04	1.93	0					
Th-228	0			24	0.7	2.12	1.40	1.44	0.365
Th-230	0			24	0.69	2.12	1.33	1.38	0.396
Th-232	0			24	0.66	2.03	1.40	1.43	0.390
Th-234	24	2.64	4.46	0					
Tl-208	0			24	0.28	0.81	0.560	0.562	0.149
U-234	0			24	0.59	2.5	1.30	1.40	0.429
U-235	9	0.06	0.06	15	0.06	0.16	0.105	0.087	0.050
U-238	2	0.06	1.5	22	0.51	2.1	1.30	1.22	0.461
Y-88	24	0.02	0.06	0					
Zn-65	23	0.1	0.35	0					

Table 8
Summary of Concentration Range (pCi/g) of Detects and Nondetects for Radionuclides in the Fine Size Fraction (<0.0625 or <0.075 mm)

Analyte	Nondetects			Detects			Median	Mean	Standard Deviation
	Count	Min	Max	Count	Min	Max			
Gross Alpha	0			4	45.94	60.31	49.7	51.4	6.72
Gross Beta	0			4	27.61	45.32	38.2	37.3	8.82
Ac-228	2	0.7	0.7	3	1.65	3.08	1.65	1.65	1.30
Am-241	0			5	0.014	0.046	0.022	0.029	0.015
Ba-140	5	0.42	0.59	0					
Bi-211	1	1.4	1.4	4	2.33	3.68	3.34	2.69	1.23
Bi-212	5	2.8	5.02	0					
Bi-214	4	0.57	1.82	1	2.97	2.97	0.810	1.06	1.11
Cd-109	5	4.15	5.48	0					
Ce-139	5	0.09	0.2	0					
Ce-144	5	0.57	1.43	0					
Co-57	5	0.09	0.14	0					
Co-60	5	0.2	0.25	0					
Cs-134	5	0.12	0.33	0					
Cs-137	2	0.19	0.23	3	0.38	1.09	0.380	0.504	0.444
Eu-152	5	0.75	1.27	0					
H-3	0			0					
Hg-203	5	0.13	0.27	0					
I-129	5	0.02	0.04	0					
K-40	1	5.49	5.49	4	31.06	38.13	34.0	28.7	14.8
La-140	4	0.06	0.18	1	0.12	0.12	0.045	0.065	0.038
Mn-54	4	0.14	0.26	1	0.15	0.15	0.120	0.110	0.034
Na-22	5	0.05	0.15	0					
Np-237	5	1.25	1.66	0					
Pa-231	5	4.92	10.6	0					
Pa-233	5	0.24	0.38	0					
Pa-234M	5	14.1	20.3	0					
Pb-210	4	2.82	4.11	1	3.22	3.22	1.95	2.04	0.711
Pb-211	5	4.1	6.89	0					

Table 8 (continued)

Analyte	Nondetects			Detects			Median	Mean	Standard Deviation
	Count	Min	Max	Count	Min	Max			
Pb-212	0			5	1.18	2.27	1.68	1.74	0.431
Pb-214	3	0.45	0.62	2	0.4	0.87	0.310	0.413	0.264
Pu-238	4	0.002	0.005	0			0.004	0.004	0.001
Pu-239,240	0			4	0.026	0.277	0.064	0.108	0.116
Ra-223	5	1.83	2.3	0					
Ra-224	4	3.9	4.93	1	3.36	3.36	2.39	2.49	0.524
Ra-226	4	3.74	4.91	1	4.75	4.75	2.34	2.70	1.17
Rn-219	5	2.01	3.43	0					
Ru-106	5	1.4	2.91	0					
Se-75	5	0.15	0.25	0					
Sn-113	5	0.09	0.28	0					
Sr-85	5	0.18	0.24	0					
Sr-90	4	0.1	0.2	0			0.1	0.088	0.025
Th-227	5	1.88	2.44	0					
Th-228	0			4	1.59	2.76	2.05	2.11	0.556
Th-230	0			4	1.77	2.53	1.93	2.04	0.347
Th-232	0			4	1.58	2.63	2.00	2.05	0.484
Th-234	5	4.51	5.95	0					
Tl-208	0			5	0.82	1.2	0.850	0.934	0.163
U-234	0			4	1.5	2.6	2.20	2.13	0.486
U-235	2	0.06	0.06	2	0.18	0.18	0.180	0.266	0.205
U-238	0			4	1.5	2.5	1.90	1.95	0.480
Y-88	5	0.19	0.24	0					
Zn-65	5	0.18	0.45	0					

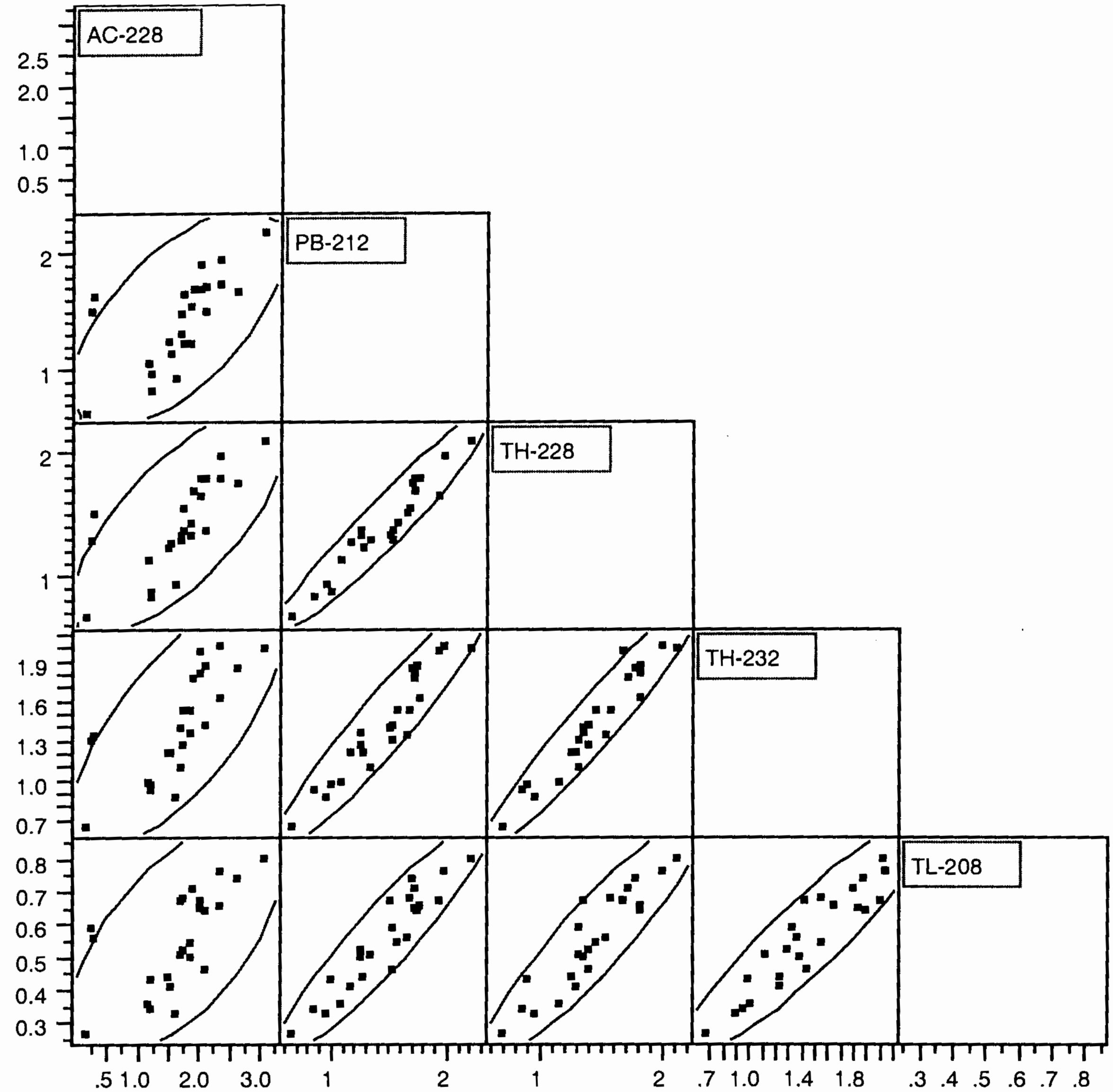
Table 9
Summary of Naturally Occurring Uranium and Thorium Isotopes and Daughters Detected in Sediment Samples

Group	Radionuclide	Half-Life[a]
Thorium series	Thorium-232[b]	14,000,000,000 years
	Thorium-228[b]	1.9 years
	Actinium-228	6.2 hours
	Lead-212	11 hours
	Thallium-208	3.1 minutes
Actinium series	Uranium-235[b]	700,000,000 years
Uranium series	Uranium-238[b]	4,500,000,000 years
	Uranium-234[b]	250,000 years
	Thorium-234	24 days
	Thorium-230[b]	75,000 years
	Radium-226[b]	1600 years
	Lead-214	27 minutes
	Bismuth-214	20 minutes

[a] Values are rounded to two significant figures from information presented in Nuclides and Isotopes, Chart of the Nuclides, 15th Ed. (Parrington et al., 1996).

[b] Radionuclides of interest for risk or dose assessment purposes (that is, radionuclides with half-lives that exceed one-half year [Yu et al., 1993, p. 62]).

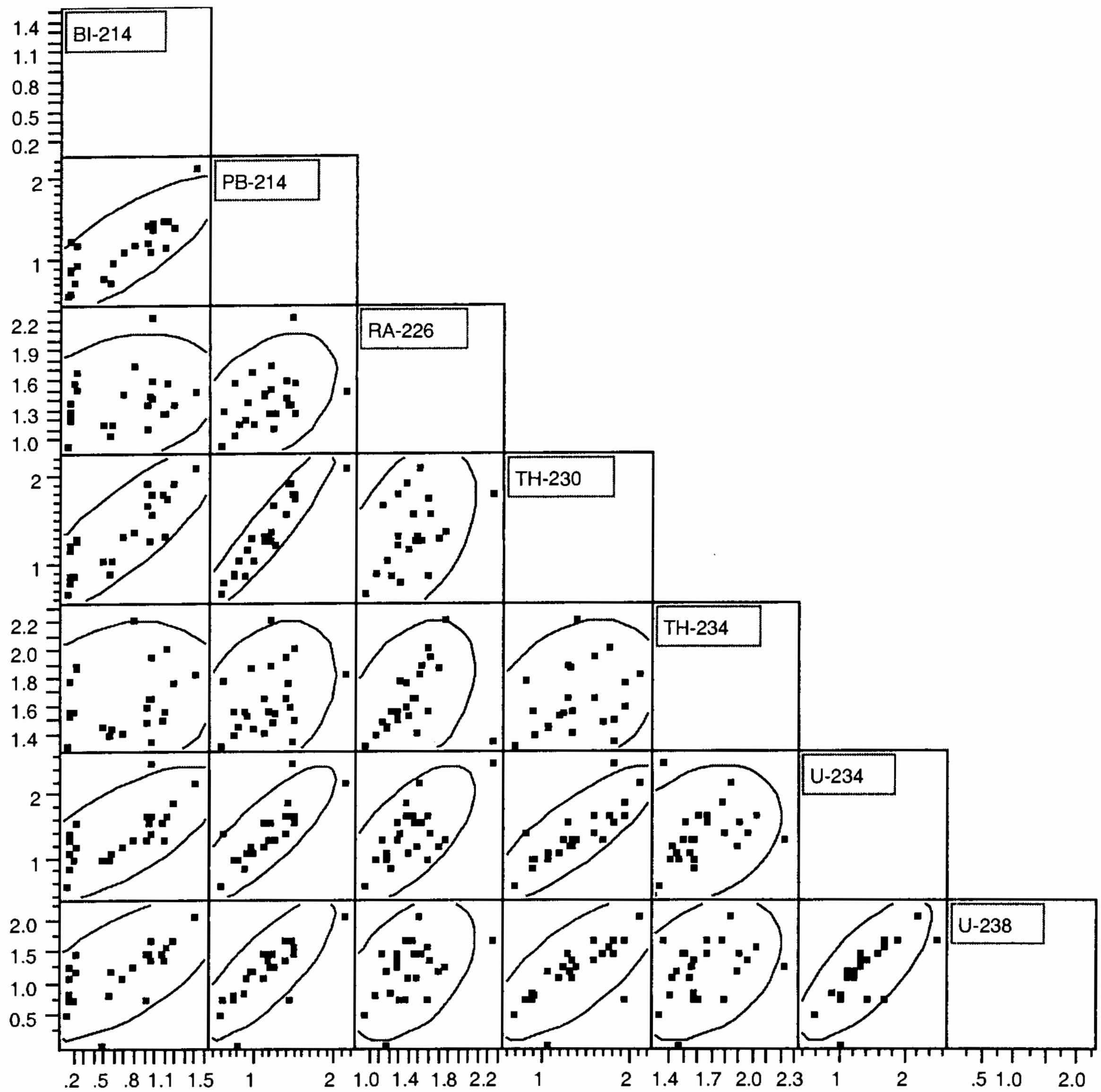
However, an evaluation of the results for naturally occurring radionuclides can be used to determine if these radionuclides have achieved "secular equilibrium." Secular equilibrium occurs when a long-lived parent radionuclide has daughter radionuclides that are relatively short-lived. Over time, the activity of the radionuclides in the chain reach a steady-state equilibrium. Thus, secular equilibrium would suggest that the activity of ^{232}Th would be equal to the activity of ^{228}Th. The presence of a strong correlation between radionuclides in the thorium and uranium decay series demonstrates that a steady-state equilibrium has been established for these radionuclides in sediment samples (Figures 13 and 14). This high, positive correlation also confirms the natural origin of these radionuclides. Thus, an assessment of the concentration of radionuclides for secular equilibrium can be used as evidence that samples were collected from natural background materials. These correlation analyses should be interpreted carefully as low correlations between radionuclides could result from analytical error. For example, in the thorium decay series, ^{228}Ac exhibits a relatively low correlation with the other radionuclides because of the high analytical error associated with quantifying ^{228}Ac activity using gamma spectroscopy. A similar phenomenon can be observed in the uranium decay chain, where ^{214}Bi, ^{226}Ra, and ^{234}Th are poorly quantified by gamma spectroscopy.



The correlation coefficients (r) of progeny radionuclides with thorium-232, the numbers of samples (n), and the statistical significance values (p) for each analyte are as follows:

Actinium-228 (AC-228):	r = 0.72, n = 24, p = <0.001
Lead-212 (PB-212):	r = 0.95, n = 24, p = <0.001
Thorium-228 (TH-228):	r = 0.96, n = 24, p = <0.001
Thallium-208 (TL-208):	r = 0.92, n = 24, p = <0.001

Figure 13. Cross-correlation between radionuclides in the thorium decay series



The correlation coefficients (r) of progeny radionuclides with uranium-238, the numbers of samples (n), and the statistical significance values (p) for each analyte are as follows:

Bismuth-214 (BI-214):	r = 0.65, n = 24,	p = <0.001
Lead-214 (PB-214):	r = 0.80, n = 24,	p = <0.001
Radium-226 (RA-226):	r = 0.45, n = 24,	p = 0.028
Thorium-230 (TH-230):	r = 0.72, n = 24,	p = <0.001
Thorium-234 (TH-234):	r = 0.38, n = 24,	p = 0.071
Uranium-234 (U-234):	r = 0.74, n = 24,	p = <0.001

Figure 14. Cross-correlation between radionuclides in the uranium decay series

(2) Evaluate data heterogeneity

Comparisons Among Canyons. Box plot summaries by canyon of inorganic chemicals and radionuclides are presented in Figures 15 through 23 and comparisons among mean concentrations of all five canyons (including Indio and Ancho Canyons) are presented in Tables 10 and 11. The box plots and mean concentrations show minimal differences between canyons in nearly all background analytes.

Results of the K-W test indicate that concentrations of most analytes are similar among all canyons, with concentrations of As, Mn, Pb, Na, U, Zn, gross beta radiation, ^{241}Am, ^{239,240}Pu, and ^{235}U showing statistically significant differences among canyons (Tables 12 and 13). Of these analytes, As, Na, Zn, and ^{235}U exhibit highly significant differences between canyons (probability values in Tables 12 and 13 less than 1%). The other six analytes only show statistical differences at the 5% significance level and represent lesser differences in concentration among canyons. Some of these analytes may represent false positive statistical errors, although the frequency of analytes (6/47 = 13%) with only a 5% significance level is more twice the frequency expected for a 5% significance level. Here we discuss the importance and potential causes for the observed between canyon differences for the four analytes that exhibit highly significant differences between canyons.

The mean concentration of As is slightly higher in Pueblo Canyon and is slightly lower in Guaje Canyon than in the other three canyons (Table 10). This 0.5 mg/kg difference in canyon mean As concentrations from the pooled mean makes little practical difference in the estimated As sediment concentrations. Mean concentrations of Na in Ancho and Indio Canyons are considerably lower than the mean concentrations of Na in the other four canyons (Table 10). It is not certain why such large differences in Na would occur among canyons. Variations in cation exchange capacity related to variations in clay content or organic matter content could be partly responsible, although no data on clay or organic matter content are available from the Ancho Canyon and Indio Canyon samples to test this hypothesis. Concentrations of Zn are higher in Los Alamos and Pueblo Canyons compared to the other three canyons (Figure 20). The Zn mean concentrations differ by less than one pooled standard deviation from the pooled mean. Thus, differences in mean Zn make little practical difference. The ^{235}U data are relatively low in Pueblo Canyon, but this difference is not observed for the ^{234}U and ^{238}U data. It is important to note that all ^{235}U measurements are within a factor of three of the MDA. Thus, differences in ^{235}U between canyons could be related to laboratory measurement error for this radionuclide. Measured levels of Cl^- and SO_4^{2-} are also considerably different between Ancho and Indio Canyons (Table 10). Large variation between both Cl^- and SO_4^{2-} is not surprising because these anions are highly mobile in soil and stream environments.

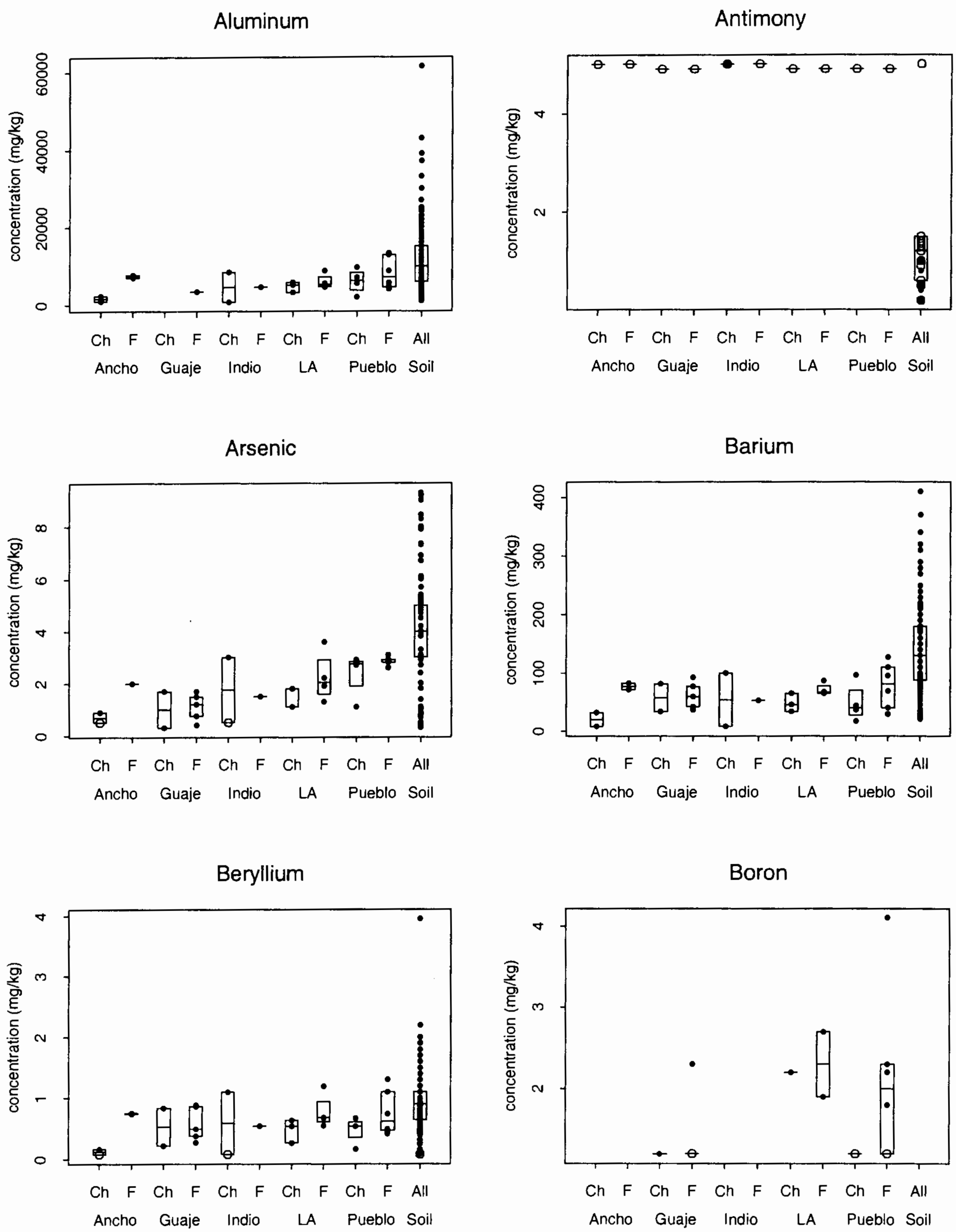


Figure 15. **Al, Sb, As, Ba, Be, and B by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background**

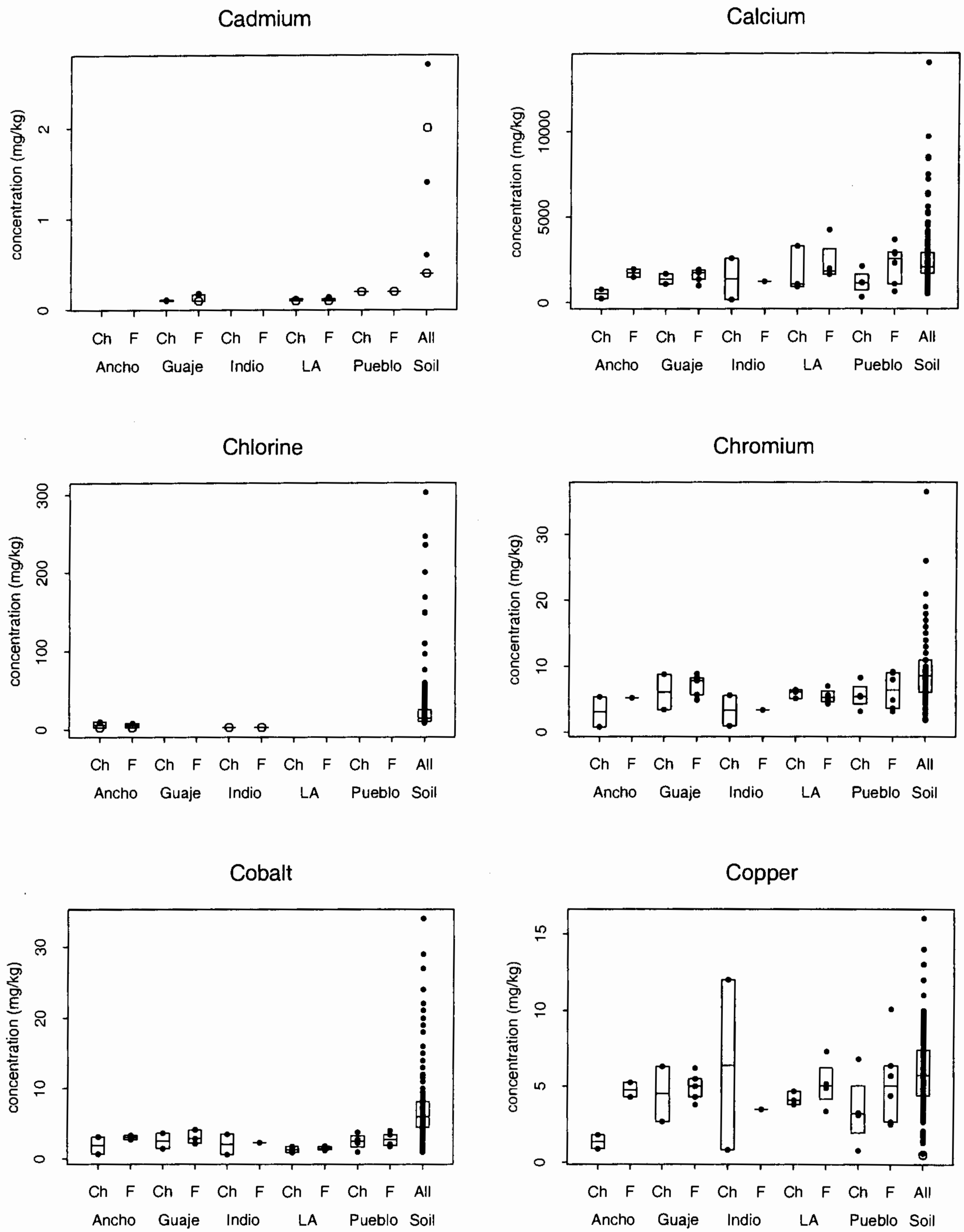


Figure 16. Cd, Ca, Cl, Cr, Co, and Cu by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background

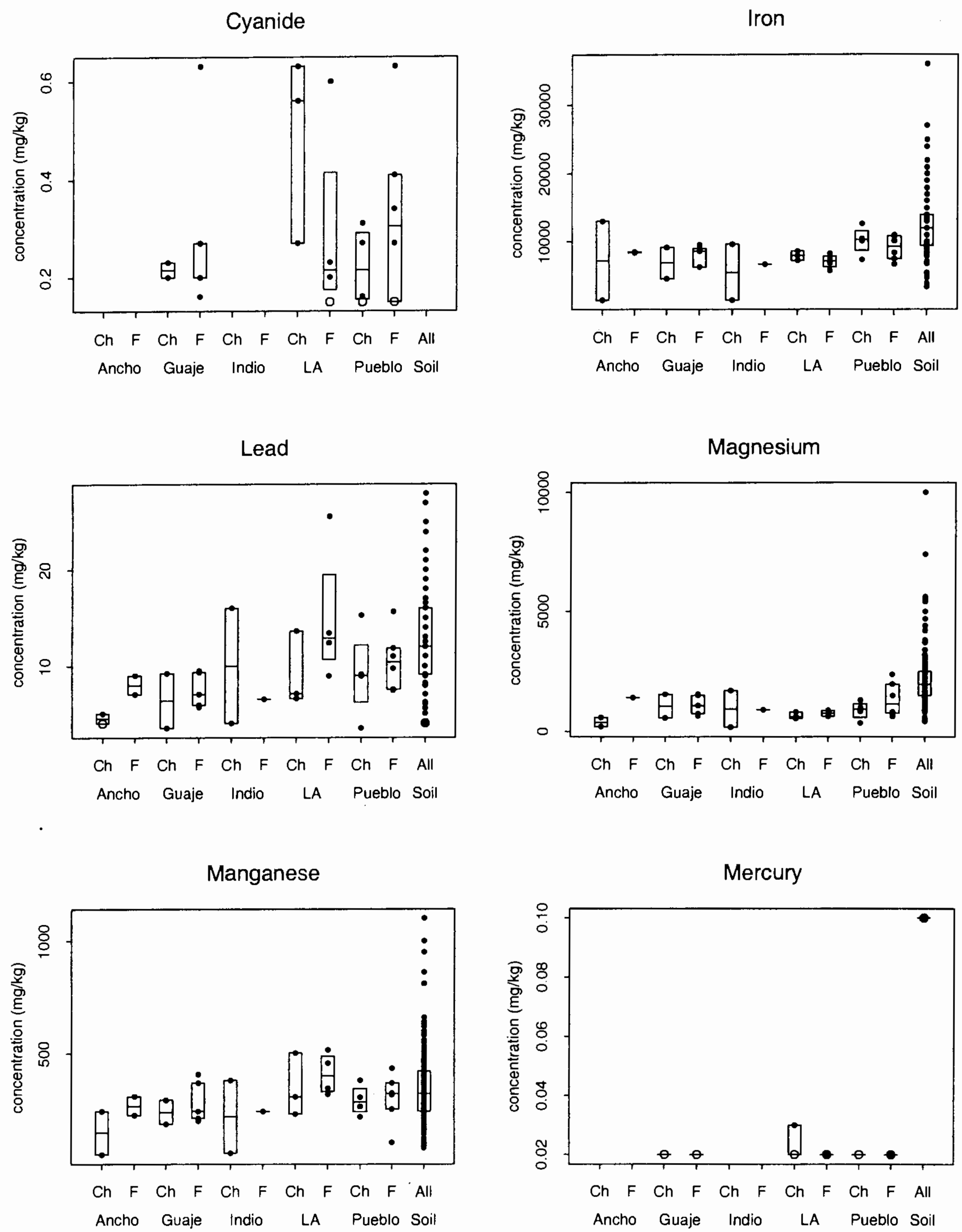


Figure 17. CN, Fe, Pb, Mg, Mn, and Hg by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background

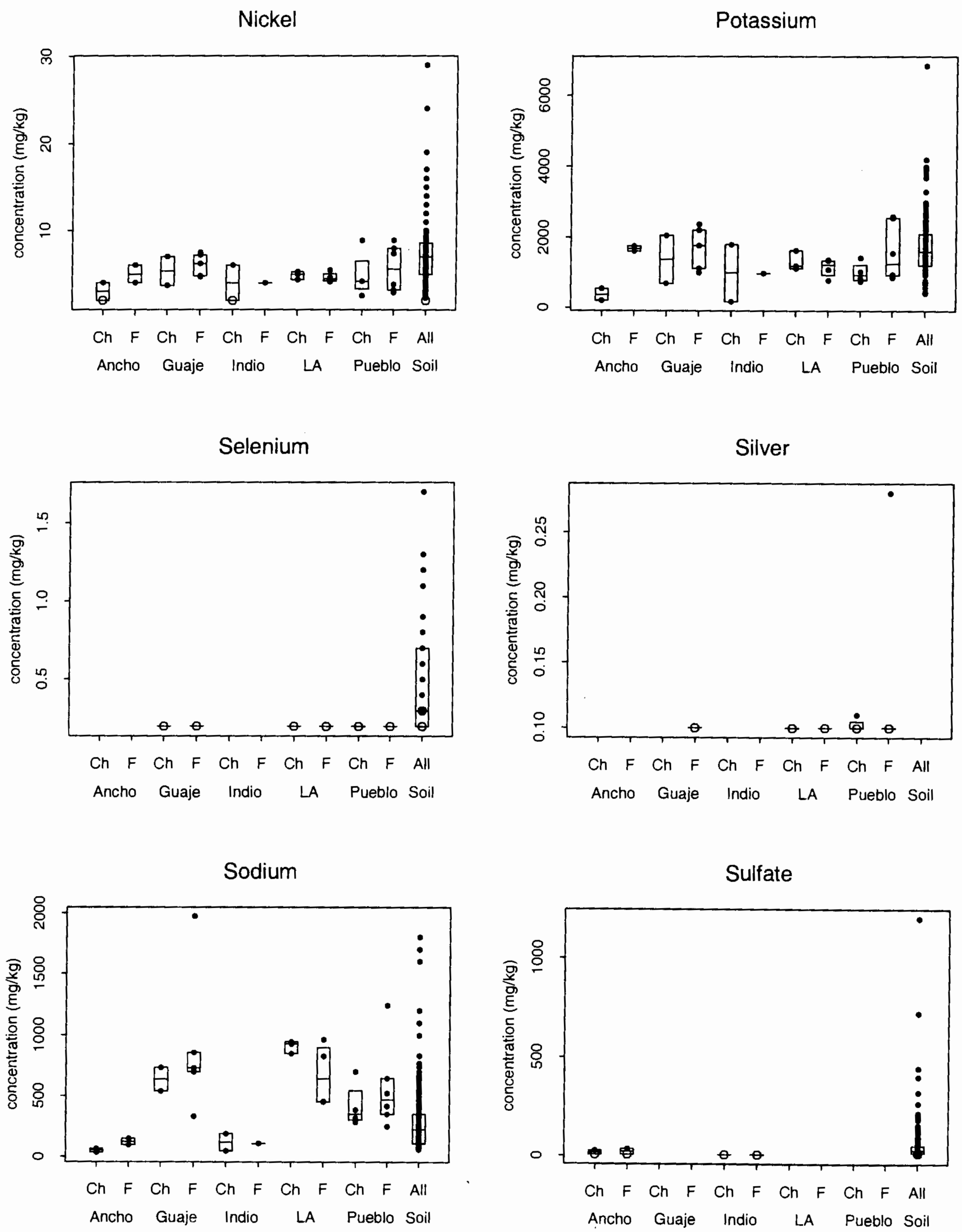


Figure 18. **Ni, K, Se, Ag, Na, and SO_4 by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background**

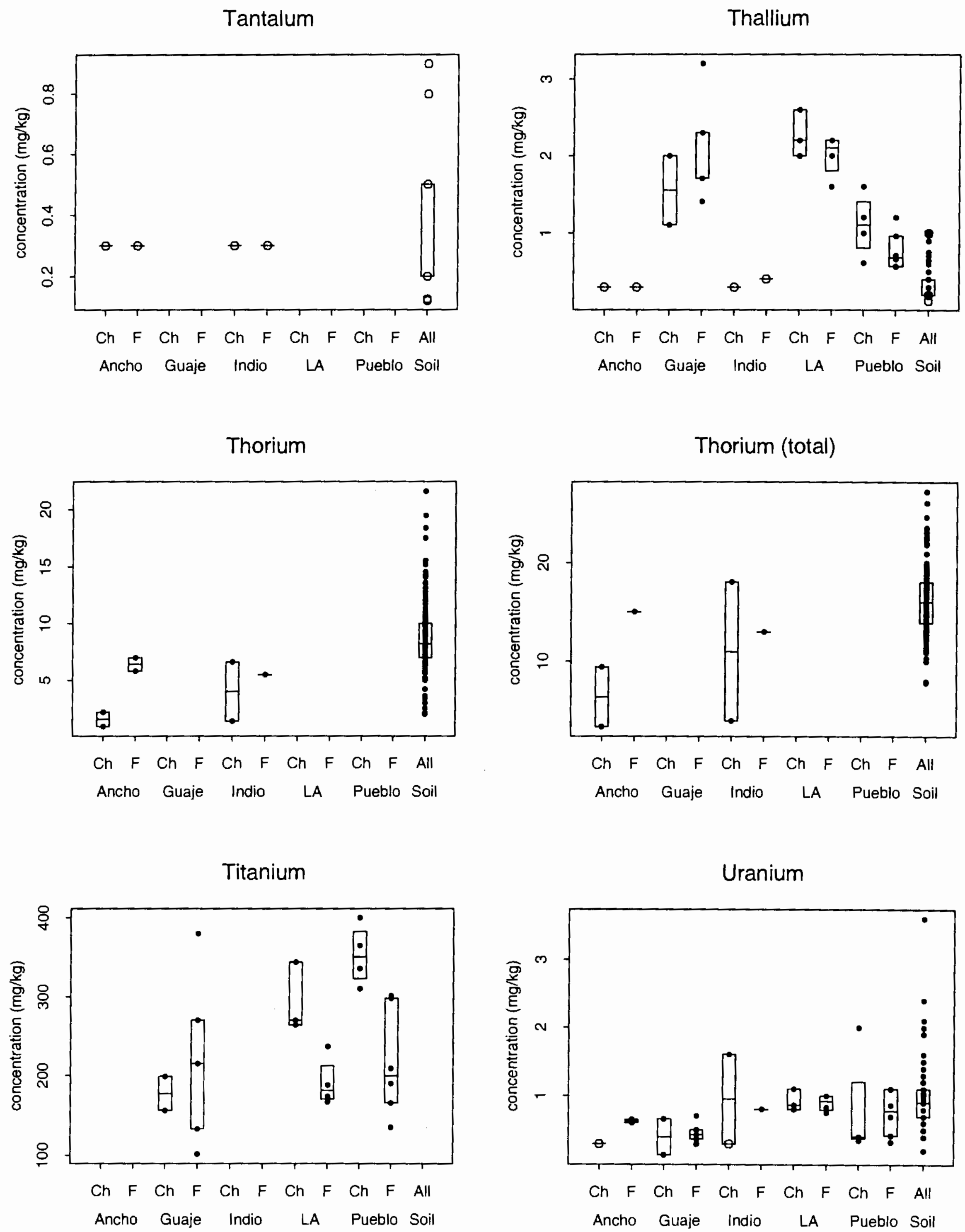


Figure 19. Ta, Tl, Th, Th (total), Ti, and U by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background

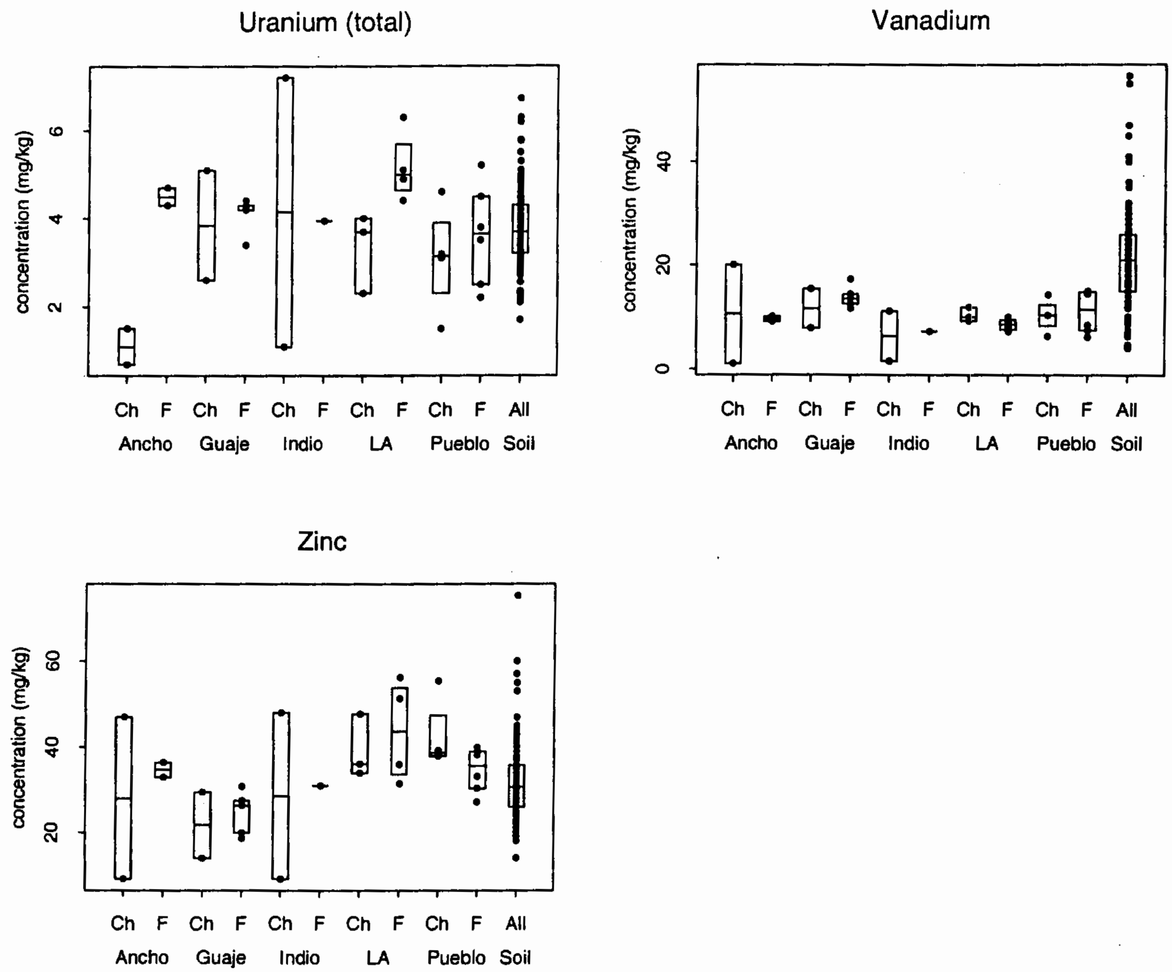


Figure 20. **U (total), V, and Zn by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background**

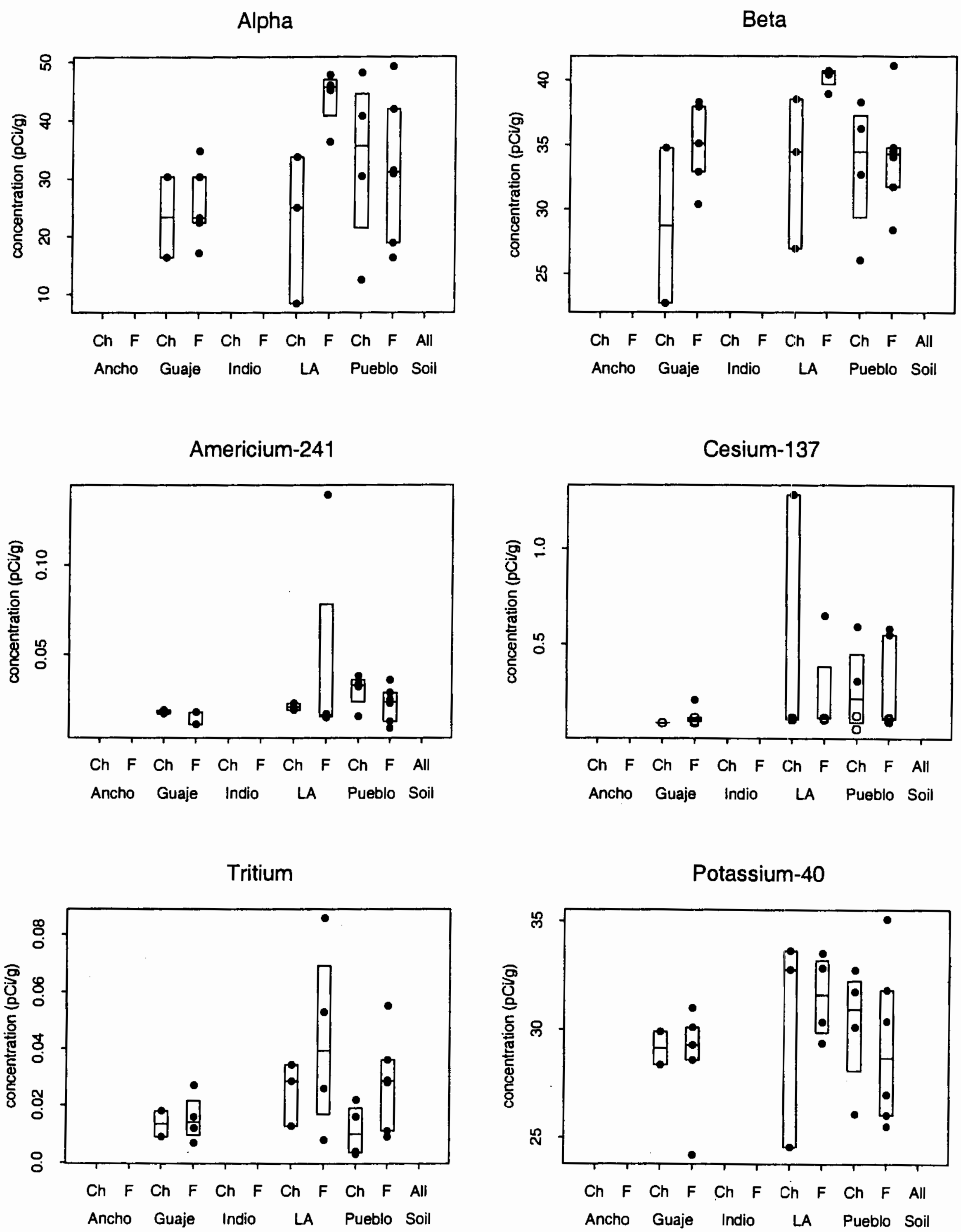


Figure 21. Alpha, Beta, Am-241, Cs-137, H-3, and K-40 by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background

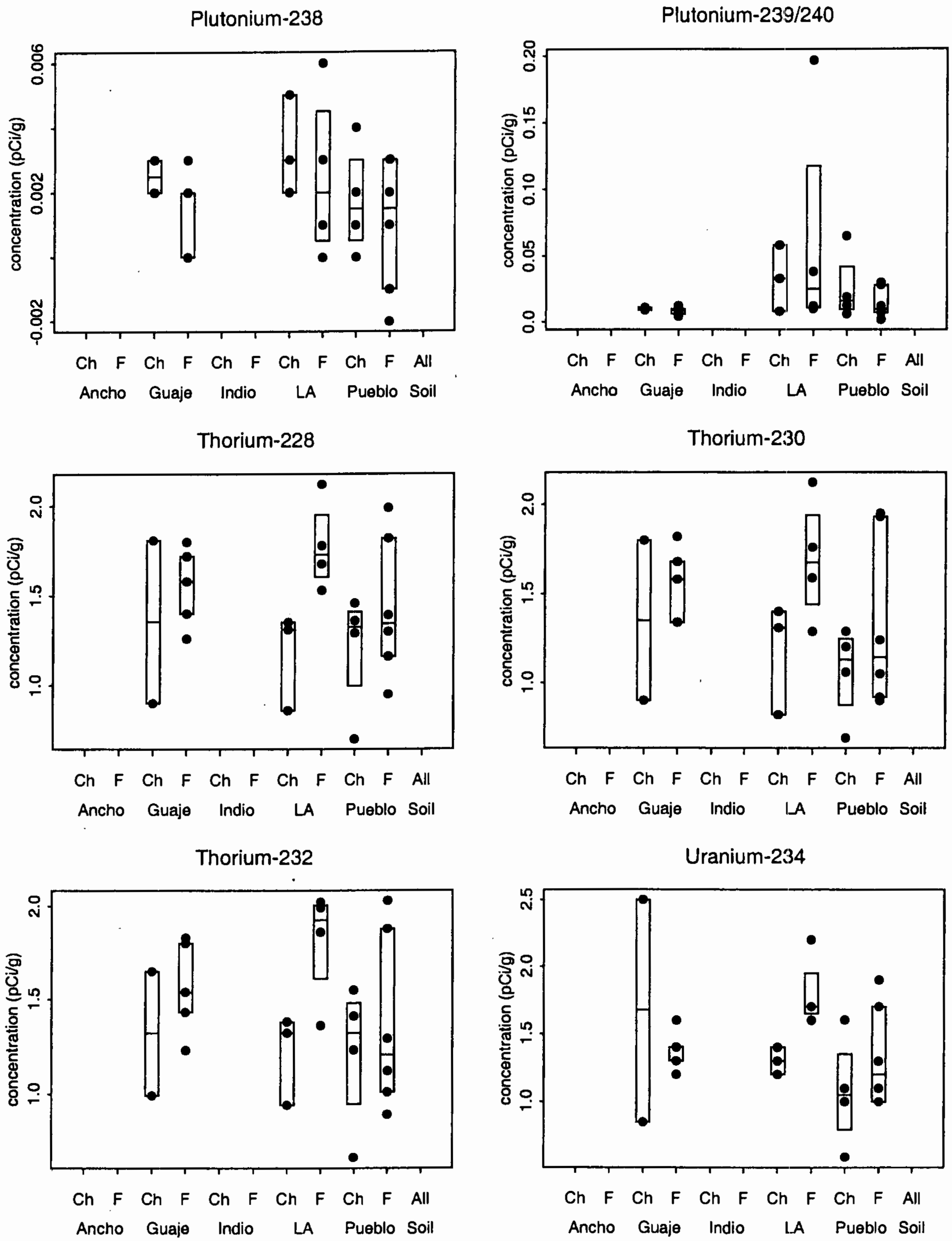


Figure 22. **Pu-238, Pu-239,240, Th-228, Th-230, Th-232, and U-234 by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background**

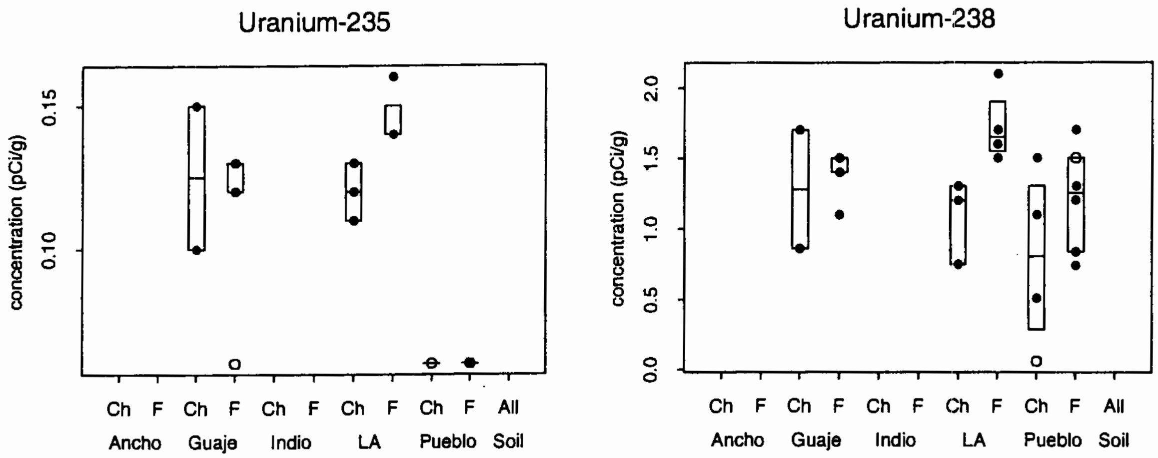


Figure 23. U-235 and U-238 by canyon source and geomorphic unit (no fines) compared to Laboratory all-soil background

Table 10
Mean and Standard Deviations by Canyon for Inorganic and Organic Analytes

Analyte (mg/kg)	Ancho		Indio		Guaje		Los Alamos		Pueblo		All Canyons	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Inorganics												
Ag							0.05	0.00	0.08	0.07	0.07	0.06
Al	4483	3370	4547	3830			5393	1734	7328	3773	5838	3238
As	1.29	0.86	1.58	1.38	1.19	0.56	1.86	0.88	2.67	0.57	1.84	0.97
B					1.08	0.66	2.27	0.40	1.40	1.19	1.40	0.99
Ba	48.5	34.4	53.8	46.0	64.6	23.1	61.4	17.2	66.4	38.2	60.4	30.1
Be	0.43	0.38	0.56	0.53	0.61	0.29	0.65	0.28	0.64	0.33	0.59	0.32
Ca	1113	763	1343	1213	1612	333	2122	1215	1820	1107	1683	980
Cd					0.09	0.05	0.07	0.04	0.10	0.00	0.09	0.04
Cl	5.30	4.74	1.25	0.00							3.56	3.99
CN					0.27	0.18	0.37	0.22	0.26	0.18	0.29	0.19
Co	2.46	1.21	2.12	1.45	3.07	1.11	1.40	0.32	2.63	0.99	2.35	1.08
Cr	4.2	2.2	3.3	2.3	7.0	2.3	5.6	0.9	6.0	2.4	5.6	2.2
Cu	3.1	2.0	5.4	5.8	5.0	1.4	4.8	1.3	4.6	2.7	4.6	2.4
Fe	7838	4793	5883	4153	7857	2007	7406	989	9480	1928	8034	2607
Hg					0.01	0	0.01	0.01	0.011	0.00	0.01	0.00
K	1023	769	987	810	1703	665	1215	263	1349	697	1299	628
Mg	893	605	922	765	1157	440	708	138	1142	638	977	521
Mn	203	111	224	164	282	89	381	110	294	94	290	115
Na	86	49	115	72	856	575	774	224	512	296	551	414
Ni	3.8	2.1	3.7	2.5	6.1	1.5	4.8	0.5	5.4	2.6	5.0	2.0
Pb	5.8	3.0	8.8	6.3	7.4	2.4	12.5	6.5	10.0	3.7	9.3	4.7
Sb	2.50	0.00	3.33	1.44	2.45	0.00	2.45	0.00	2.45	0.00	2.54	0.46
Se					*0.10*	*0.00*	*0.10*	*0.00*	*0.10*	*0.00*	*0.10*	*0.00*
SO_4	16.63	16.68	2.50	0.00							10.57	14.00
Ta	*0.15*	*0.00*	*0.15*	*0.00*							0.15	0.00
Th	4.0	2.9	4.5	2.7							4.2	2.6
Th-total	10.68	5.58	11.63	7.15							11.09	5.73
Tl					198	99	235	64	271	90	242	85
Ti	0.15	0.00	0.17	0.03	1.85	0.73	2.11	0.30	0.91	0.35	1.24	0.86

Table 10 (continued)

Analyte (mg/kg)	Ancho		Indio		Guaje		Los Alamos		Pueblo		All Canyons	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
U	0.39	0.28	0.85	0.73	4.13	0.82	4.39	1.25	3.41	1.16	3.13	1.73
U-total	2.80	2.00	4.08	3.05							3.35	2.36
V	10.0	7.8	6.5	4.8	13.3	3.3	9.3	1.5	10.7	3.7	10.4	4.2
Zn	31.4	16.1	29.3	19.6	24.7	6.5	41.8	9.8	37.9	7.5	33.9	11.9
Organics												
TOC					3394	1624	11506	3887	8712	8100	7885	6456

Notes: 1. Nondetect (*italics*) values shown at 1/2 of absolute value.
2. Empty cells indicate no data.

Table 11
Mean and Standard Deviations by Canyon for Radionuclides (Excluding Nondetects)

Analyte (pCi/g)	Guaje		Los Alamos		Pueblo		All Canyons	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Gross Alpha	26.3	6.7	34.7	14.1	32.1	13.1	30.8	12.1
Gross Beta	32.4	5.4	37.2	5.0	33.8	4.4	34.6	5.0
Am-241	0.02	0.00	0.04	0.05	0.03	0.01	0.03	0.03
Cs-137	0.05	0.01	0.32	0.48	0.24	0.25	0.21	0.31
H-3	0.02	0.01	0.04	0.03	0.02	0.02	0.02	0.02
K-40	29.5	1.0	31.0	3.3	29.7	3.3	29.8	3.0
Pu-238	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pu-239,240	0.01	0.00	0.05	0.07	0.02	0.02	0.03	0.04
Th-228	1.54	0.35	1.52	0.40	1.34	0.38	1.44	0.36
Th-230	1.52	0.35	1.47	0.41	1.22	0.42	1.37	0.40
Th-232	1.54	0.31	1.55	0.41	1.31	0.43	1.43	0.39
U-234	1.49	0.55	1.59	0.33	1.23	0.40	1.40	0.43
U-235	0.13	0.02	0.13	0.02	0.06	0.09	0.10	0.07
U-238	1.39	0.28	1.45	0.43	0.97	0.50	1.22	0.46

Note: Radionuclides not measured for Indio and Ancho Canyons.

Table 12
Summary of Statistical Distribution Shift Tests for Inorganic Analytes

Chemical	Kruskal-Wallis Comparison of 5 Canyons	Wilcoxon Rank Sum Comparison of Channel Versus Floodplain Data	Wilcoxon Rank Sum Comparison of Fine Grain Versus <2-mm Size Fraction
Al	0.365	0.155	**0.014**
As	**0.004**	0.104	0.152
Ba	0.925	**0.034**	**<0.001**
Be	0.840	**0.031**	**0.002**
Ca	0.528	**0.034**	**0.008**
CN	0.904	0.787	**0.003**
Co	0.063	0.193	**0.016**
Cr	0.075	0.435	**0.006**
Cu	0.949	0.072	**0.001**
Fe	0.215	0.617	**0.046**
K	0.545	0.078	**0.048**
Mg	0.455	**0.045**	**0.006**
Mn	**0.026**	0.238	0.060
Na	**<0.001**	0.389	0.418
Ni	0.421	0.222	**0.005**
Pb	**0.026**	0.167	**0.023**
Th	0.721	0.157	0.079
Th-total	0.472	0.285	0.142
Ti	0.253	**0.027**	0.299
U	**0.018**	0.357	**0.009**
U-total	0.353	**0.032**	**0.004**
V	0.113	0.795	0.062
Zn	**0.002**	0.496	0.194

Note: Values less than 0.05 (in bold) represent statistically significant results.

Table 13
Summary of Statistical Distribution Shift Tests for Radionuclides

Radionuclide	Kruskal-Wallis Comparison of 3 Canyons	Wilcoxon Rank Sum Comparison of Channel Versus Floodplain data	Wilcoxon Rank Sum Comparison of Fine Grain Versus <2-mm Size Fraction
Gross Alpha	0.090	0.270	**0.007**
Gross Alpha	**0.027**	0.121	0.555
Am-241	**0.038**	0.135	0.370
Cs-137	0.064	0.952	**0.024**
H-3	0.238	0.231	**<0.001**
K-40	0.083	0.788	0.119
Pu-238	0.385	0.301	**0.049**
Pu-239,240	**0.027**	0.339	**0.015**
Th-228	0.373	**0.040**	**0.030**
Th-230	0.286	**0.046**	**0.011**
Th-232	0.258	0.084	**0.030**
U-234	0.096	0.159	**0.018**
U-235	**<0.001**	0.480	0.190
U-238	0.070	0.106	**0.016**

Note: Values less than 0.05 (in bold) represent statistically significant results.

The concentration of TOC shows considerable variation among canyons (Table 10). Variation among TOC measurements primarily reflects differences in the accumulation of disseminated organic matter among Los Alamos, Pueblo, and Guaje Canyons. Vegetative cover and development of soil organic matter in surface horizons are generally highest at the Los Alamos Canyon sample sites relative to sample sites in Guaje and Pueblo Canyons.

Similar concentrations of most analytes among all five canyons provide justification for consolidating all sediment background data. As discussed above, the differences in the means between canyons is small relative to the within-canyon or pooled-canyon estimates of variability. An advantage in combining all canyons into one data set is that this larger data set will provide better statistics and can be used to detect smaller differences when used in statistical distribution shift tests. The presence of similar concentrations of nearly all analytes among all five canyons is also notable because there are variations among bedrock sources of sediment.

Channel and Floodplain Comparisons. Mean concentrations of most inorganic and radionuclide analytes are greater in floodplain sediments relative to channel sediments (Figures 24 through 32; Tables 14 and 15). Only Fe, Ti, Zn, and ^{137}Cs have higher concentrations in channel sediments relative to the floodplain sediments. The WRS test (Tables 12 and 13) indicates that concentrations of Ba, Be, Ca, K, Ti, U total, ^{228}Th, and ^{230}Th are statistically different between floodplain and channel sediments. None of these analytes, however, exhibit highly significant differences (p-values in Tables 12 and 13 are between 2% and 5%). It should also be noted that the differences among mean concentrations of nearly all analytes are relatively small between floodplain and channel sediments. Because of the small difference between mean concentrations, the difference between geomorphic units is viewed as not significant, and the channel and floodplain geomorphic unit background samples will be pooled to form a single sediment background data set. Pooling the data has the advantage of reducing uncertainty in summary statistics, and this larger sediment background data set can be used to detect smaller differences when used in statistical distribution shift tests.

Influence of Particle-Size and Sediment Depositional Processes on Geochemistry. The presence of generally higher concentrations of most analytes in floodplain sediments relative to channel sediments suggests a control of sediment particle-size on analyte concentrations. Analyte concentrations of the combined silt- and clay-sized fractions (<0.0625 or <0.075 mm) were measured on a subset of samples. Mean concentrations of most analytes from these samples are higher than the mean concentrations of the <2-mm size fraction (Tables 15). Only Na, Ti, and U have higher concentrations in the <2-mm size fraction.

Generally higher concentrations of analytes in the floodplain sediments and fine size fractions indicate that many inorganic and radionuclide analytes may be preferentially adsorbed onto clay- and silt-sized particles. Silt and clay generally have more chemically reactive surfaces relative to sand because they have larger surface areas and higher site-charge densities. As discussed above, the floodplain sediments generally have a greater abundance of silt and clay relative to the channel deposits. As a result, the transport and deposition of many metals and radionuclides may be strongly influenced by fluvial processes that enhance the deposition of clay and silt. Therefore, sediment sampling strategies for monitoring or estimating contaminant transport should pay particular attention to particle size characteristics of the samples, with maximum concentrations possibly found at sites with preferential deposition of silt and clay such as floodplain settings.

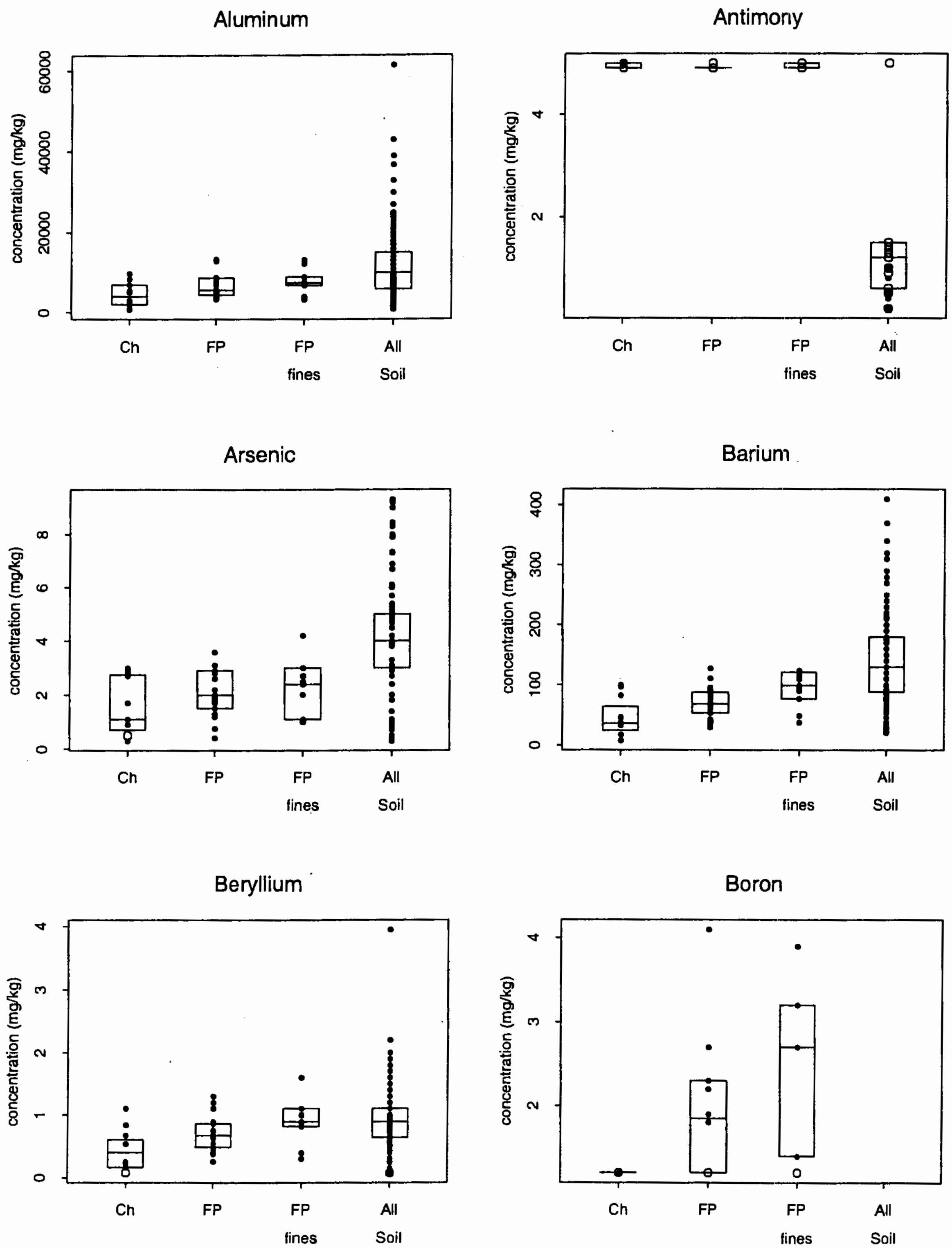


Figure 24. **Al, Sb, As, Ba, Be, and B by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

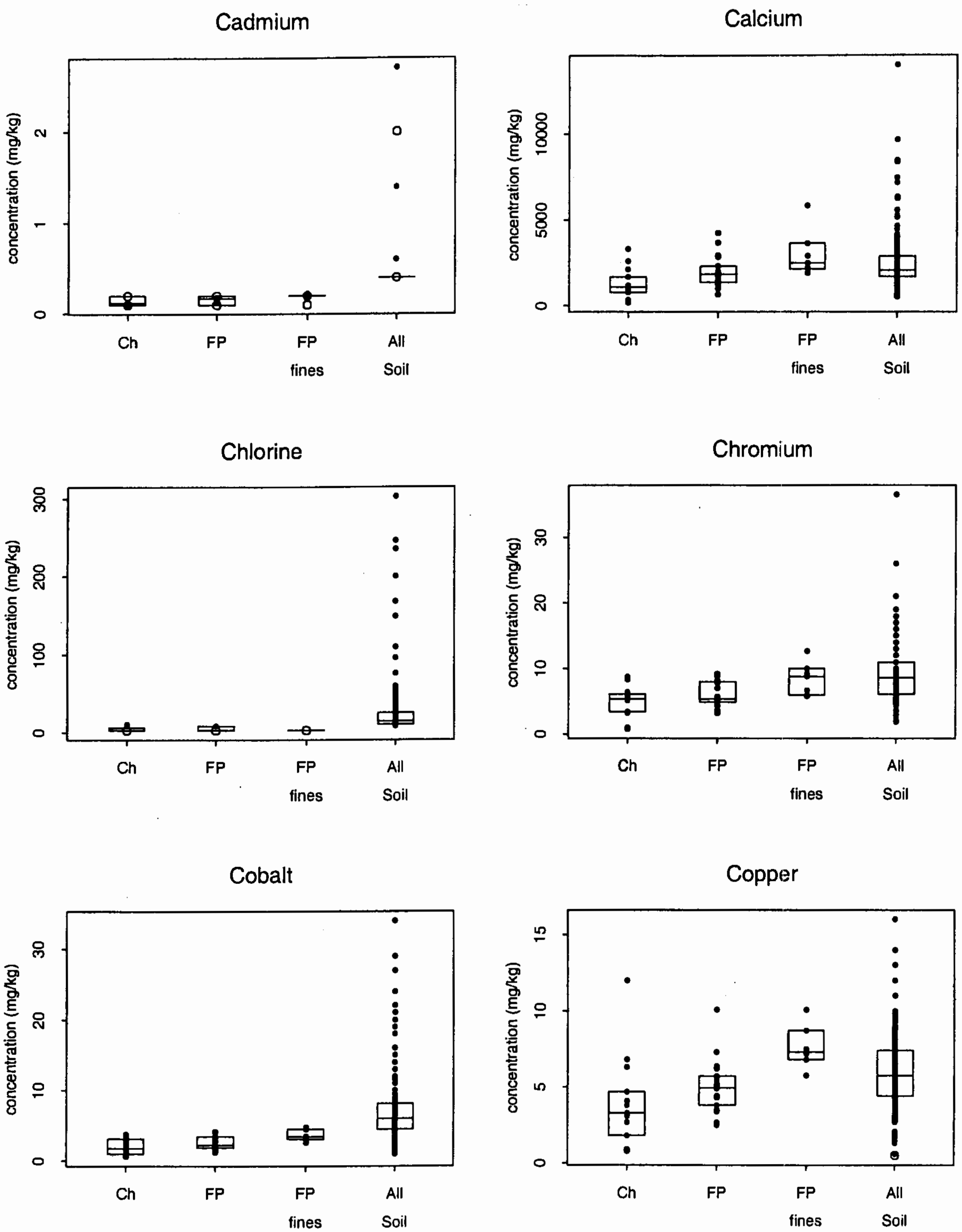


Figure 25. **Cd, Ca, Cl, Cr, Co, and Cu by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

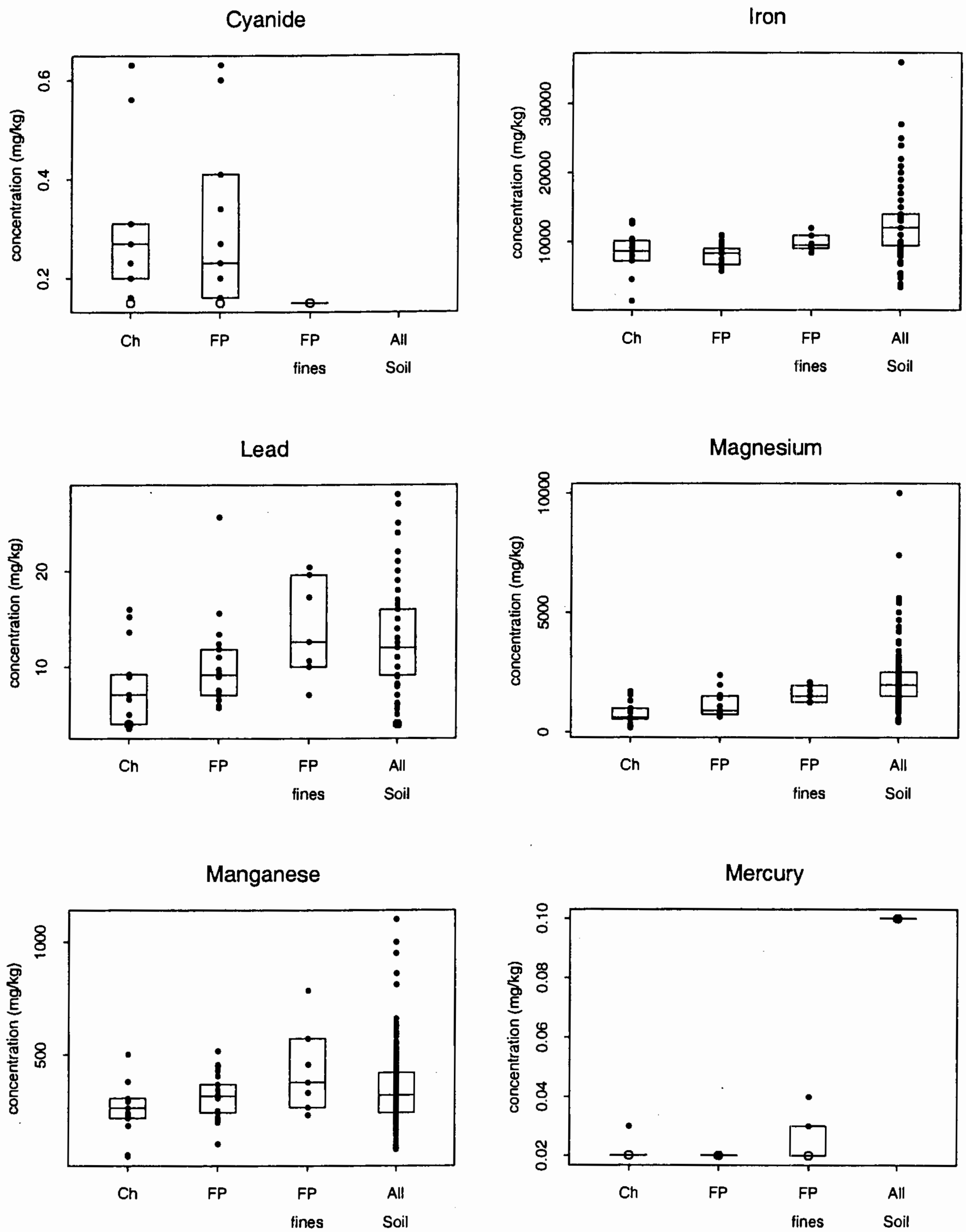


Figure 26. CN, Fe, Pb, Mg, Mn, and Hg by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background

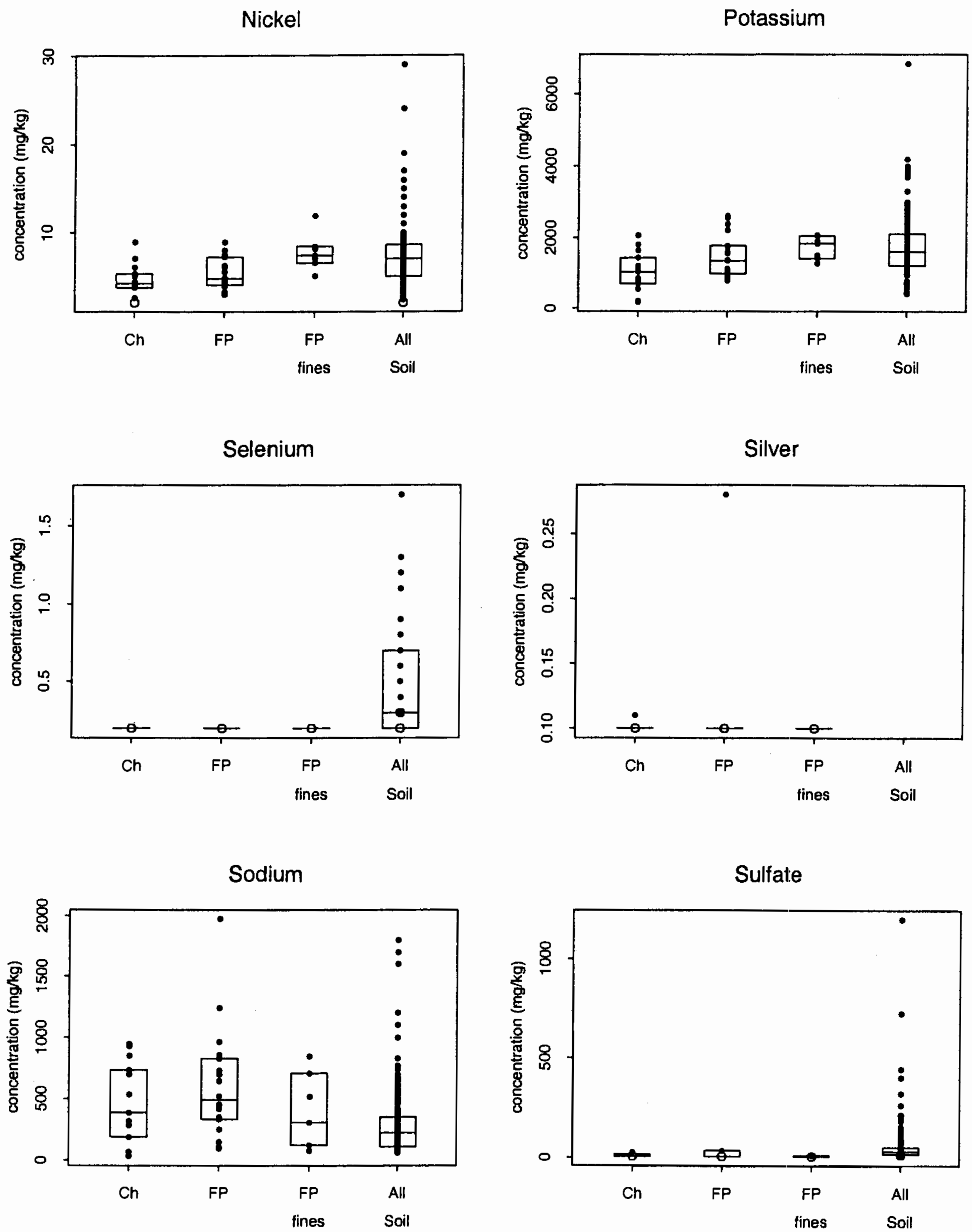


Figure 27. **Ni, K, Se, Ag, Na, and SO_4 by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

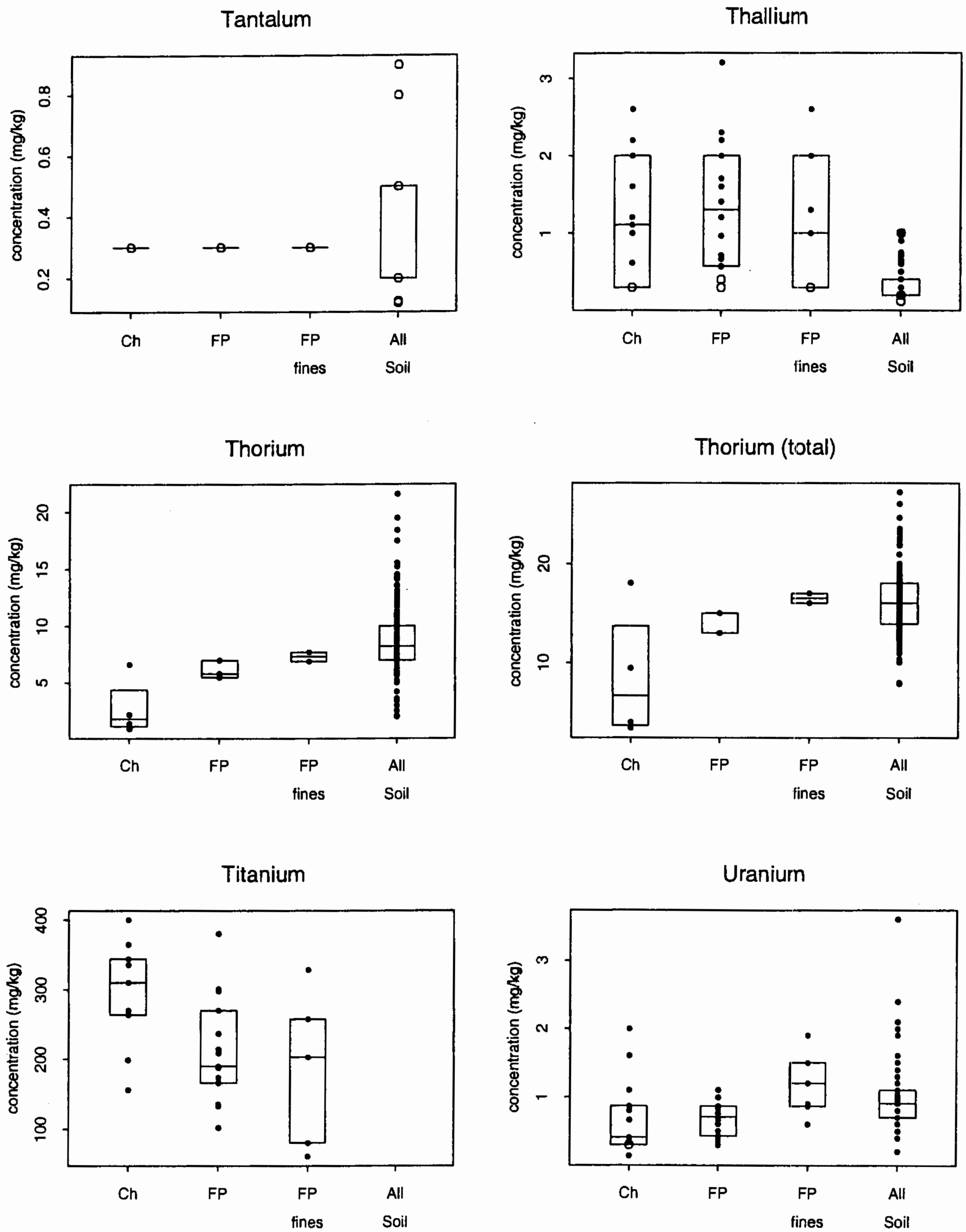


Figure 28. Ta, Tl, Th, Th (total), Ti, and U by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background

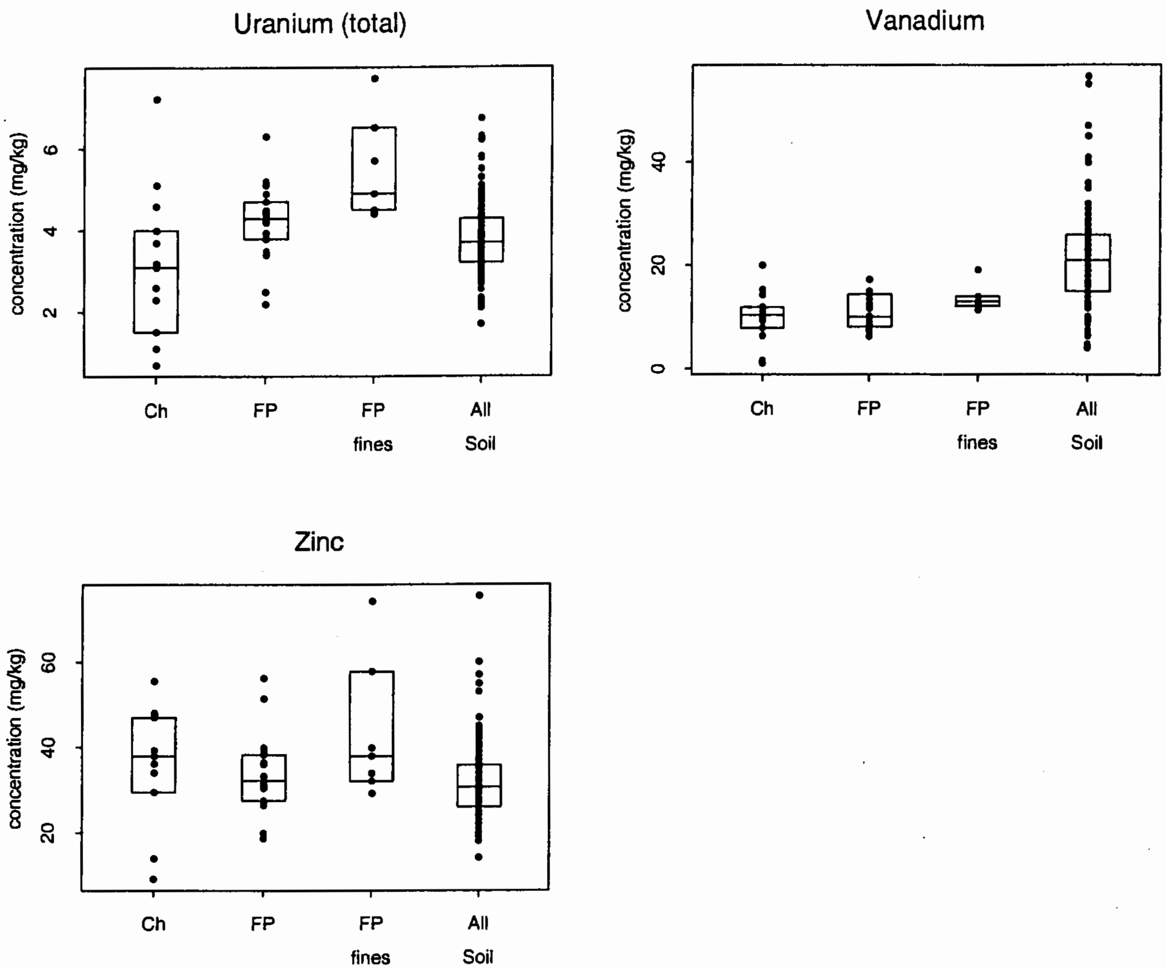


Figure 29. **U (total), V, and Zn by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

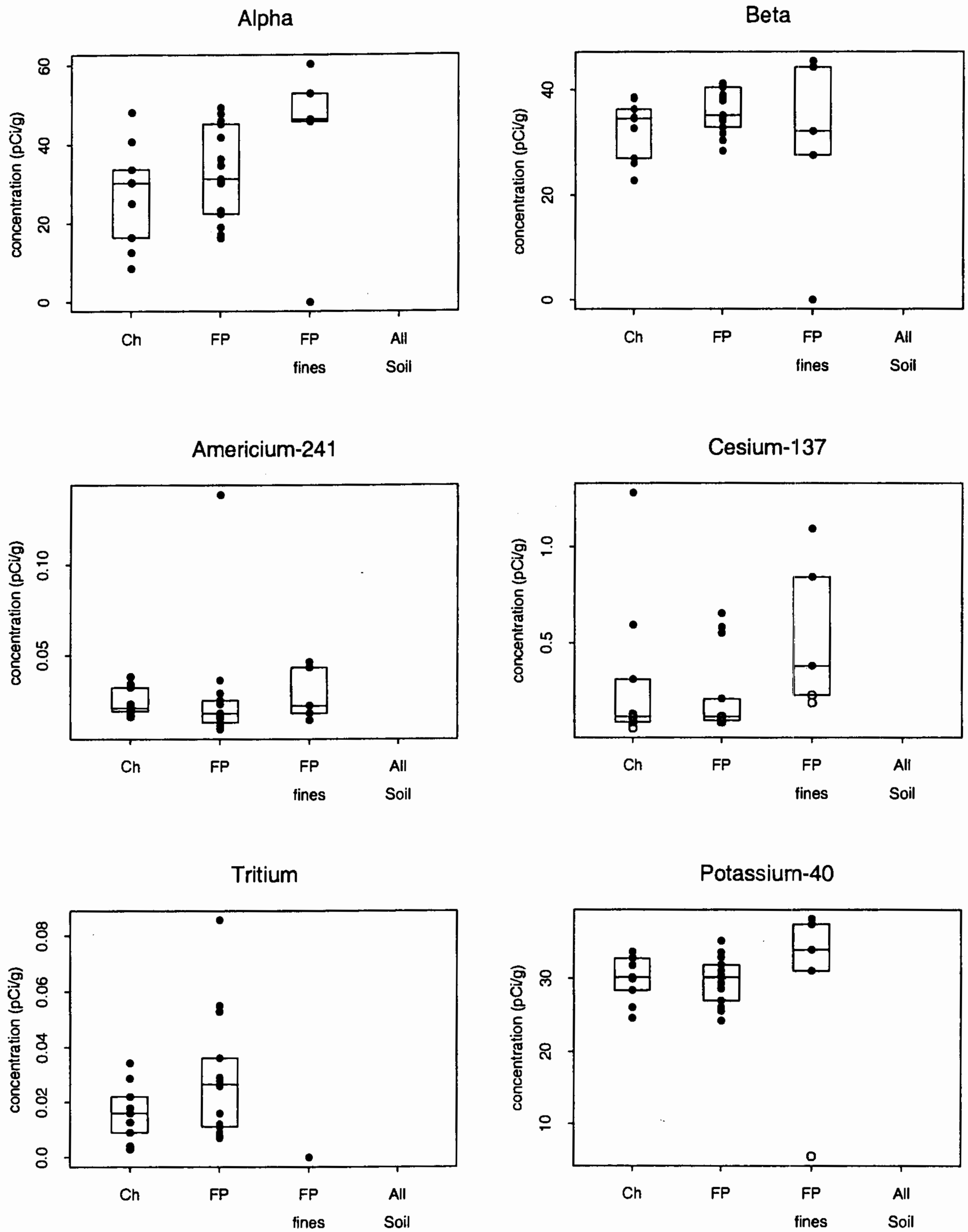


Figure 30. Alpha, Beta, Am-241, Cs-137, H-3, and K-40 by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background

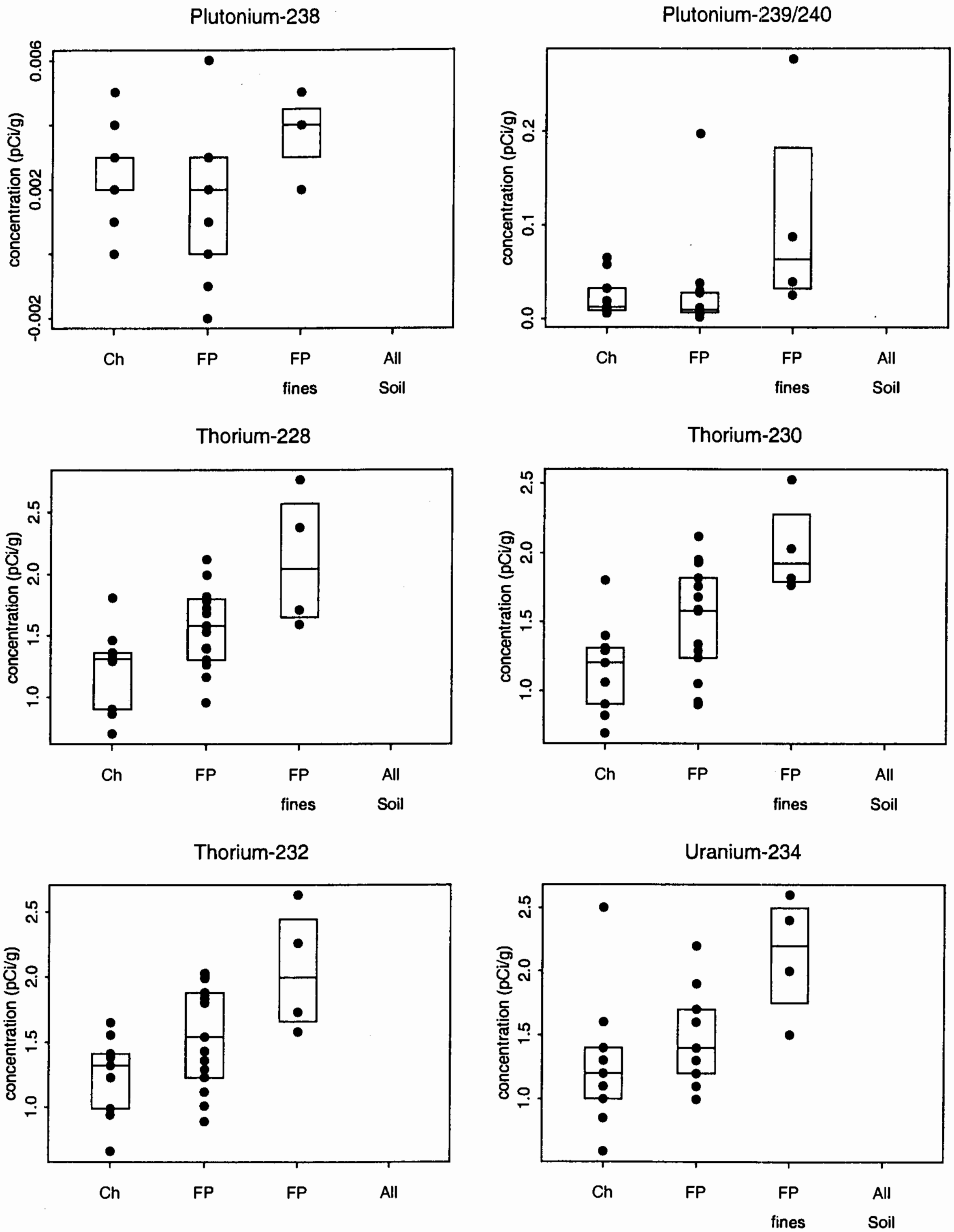


Figure 31. **Pu-238, Pu-239,240, Th-228, Th-230, Th-232, and U-234 by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

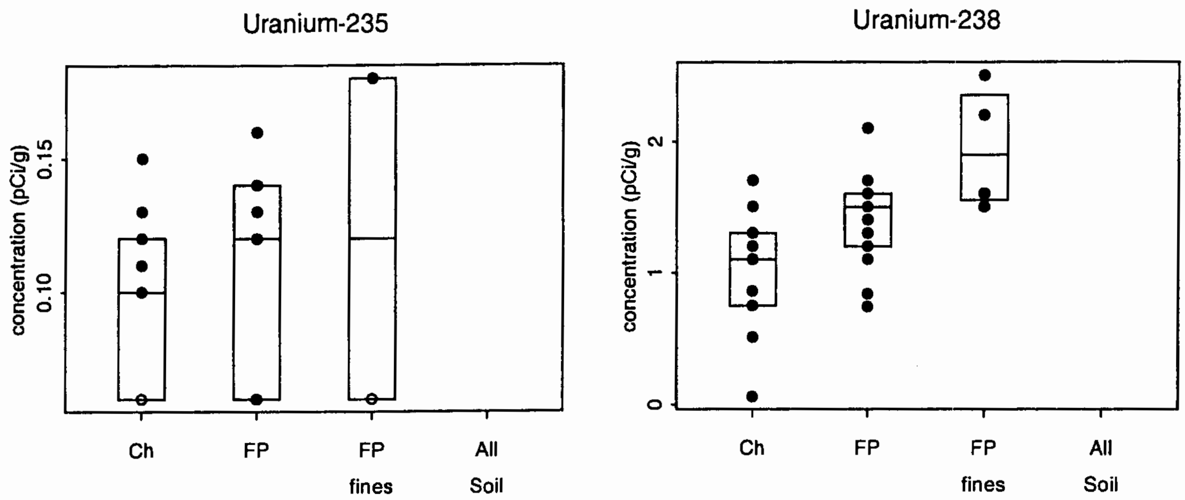


Figure 32. **U-235 and U-238 by channel, floodplain, and floodplain-fine groupings compared to Laboratory all-soil background**

Table 14
Comparison of Channel and Floodplain
(Historic and Prehistoric) Inorganic, Organic, and Radionuclide Analytes

Analyte	Channel		Floodplain	
	Mean	Std Dev	Mean	Std Dev
Inorganic and Organic Analytes (mg/kg)				
Ag	0.06	0.02	0.07	0.07
Al	4555	3185	6693	3082
As	1.56	1.03	2.05	0.89
B	1.16	0.72	1.55	1.14
Ba	48.8	31.9	68.8	26.4
Be	0.47	0.34	0.68	0.29
Ca	1342	945	1930	956
Cd	0.10	0.04	0.09	0.04
Cl	3.51	4.53	3.63	4.13
CN	0.25	0.14	0.32	0.21
Co	2.26	1.28	2.41	0.94
Cr	5.2	2.6	5.9	1.9
Cu	4.1	3.2	4.9	1.8
Fe	8125	3681	7968	1555
Hg	0.01	0.01	0.01	0.00
K	1078	616	1458	603
Mg	849	523	1070	514
Mn	268	132	306	102
Na	464	340	615	460
Ni	4.6	2.3	5.3	1.7
Pb	8.2	4.6	10.0	4.8
Sb	2.66	0.70	2.46	0.02
Se	0.10	0.00	0.10	0.00
SO_4	8.50	12.00	13.33	18.76
Ta	0.15	0.00	0.15	0.00
Th	2.8	2.6	6.1	0.8
Th-total	8.65	6.81	14.33	1.15
Tl	279	96	220	73

Table 14 (continued)

Analyte	Channel		Floodplain	
	Mean	Std Dev	Mean	Std Dev
Ti	1.08	0.78	1.35	0.92
U	2.53	1.74	3.57	1.63
U-total	2.63	3.07	4.32	0.38
V	10.3	5.3	10.6	3.3
Zn	34.0	15.2	33.9	9.4
TOC	6306	5730	8832	6866
Radionuclide Analytes (pCi/g)				
Gross Alpha	27.0	13.2	33.0	11.3
Gross Beta	32.7	6.0	35.7	4.0
Am-241	0.02	0.01	0.03	0.03
Cs-137	0.27	0.42	0.17	0.22
H-3	0.02	0.01	0.03	0.02
K-40	29.44	2.85	30.02	3.21
Pu-238	0.00	0.00	0.00	0.00
Pu-239,240	0.02	0.02	0.03	0.05
Th-228	1.28	0.40	1.54	0.32
Th-230	1.22	0.40	1.47	0.37
Th-232	1.29	0.37	1.52	0.38
U-234	1.33	0.55	1.44	0.35
U-235	0.08	0.05	0.11	0.07
U-238	1.03	0.54	1.34	0.38

Table 15
Comparison of <2 mm and Fine Fraction
(Historic and Prehistoric) Inorganic, Organic, and Radionuclide Analytes

Analyte	<2 mm		Fine Fraction	
	Mean	Std Dev	Mean	Std Dev
Inorganic and Organic Analytes (mg/kg)				
Ag	0.07	0.06	0.05	0.00
Al	5838	3238	7914	2976
As	1.84	0.97	2.26	0.94
B	1.40	0.99	2.36	1.20
Ba	60.4	30.1	94.3	28.0
Be	0.59	0.32	0.90	0.33
Ca	1683	980	2485	1291
Cd	0.09	0.04	0.13	0.06
Cl	3.51	4.53	1.25	0.00
CN	0.29	0.19	0.08	0.00
Co	2.35	1.08	3.22	0.93
Cr	5.6	2.2	6.8	3.0
Cu	4.6	2.4	6.5	2.1
Fe	8034	2607	8869	2084
Hg	0.01	0.00	0.02	0.01
K	1299	628	1579	453
Mg	977	521	1410	421
Mn	290	115	366	172
Na	551	414	297	263
Ni	5.0	2.0	6.8	2.2
Pb	9.3	4.7	11.6	5.1
Sb	2.54	0.46	2.48	0.02
Se	0.10	0.00	0.10	0.00
SO_4	8.50	12.00	4.32	2.83
Ta	0.15	0.00	0.15	0.00
Th	4.2	2.6	6.1	1.6
Th-total	11.09	5.73	14.13	3.49

Table 15 (continued)

Analyte	<2 mm		Fine Fraction	
	Mean	**Std Dev**	**Mean**	**Std Dev**
Tl	242	85	186	102
Ti	1.24	0.86	0.85	0.85
U	3.13	1.73	2.91	2.61
U-total	3.35	2.36	4.33	1.22
V	10.4	4.2	11.5	3.8
Zn	33.9	11.9	39.5	14.3
TOC	7885	6456		
Radionuclide Analytes (pCi/g)				
Gross Alpha	30.8	12.1	51.4	5.8
Gross Beta	34.6	5.0	37.3	7.6
Am-241	0.03	0.03	0.03	0.01
Cs-137	0.21	0.31	0.50	0.40
H-3	0.02	0.02	ND*	ND
K-40	29.80	3.03	28.66	13.20
Pu-238	0.00	0.00	0.00	0.00
Pu-239,240	0.03	0.04	0.11	0.10
Th-228	1.44	0.36	2.11	0.48
Th-230	1.37	0.40	2.04	0.30
Th-232	1.43	0.39	2.05	0.42
U-234	1.40	0.43	2.13	0.42
U-235	0.10	0.07	0.27	0.18
U-238	1.22	0.46	1.95	0.42

*ND = Not detected.

Statistical comparisons between fine fraction (<0.0625 or <0.075 mm) and the whole sample (<2-mm size fraction) show many differences for inorganic chemicals and radionuclides. There are statistically significant differences between concentrations of Al, Ba, Be, Ca, CN, Co, Cr, Cu, Fe, K, Mg, Ni, Pb, U, U-total, gross alpha radiation, ^{137}Cs, ^{3}H, ^{238}Pu, ^{239,240}Pu, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U, and ^{238}U (Tables 12 and 13). Twelve of these analytes exhibit highly significant differences (p-values in Tables 12 and 13 are less than 1%). These analytes include: Ba, Be, Ca, CN, Cr, Cu, Mg, Ni, U, U-total, gross alpha radiation, and ^{3}H. The statistical differences resulting from particle grain size variations suggest that background sediment UTLs should not calculated for the fine fraction samples, although these samples may be useful for comparison with sediment samples that are finer than those sampled in this background study.

(3) Calculate sediment background values

The proposed inorganic chemical background values for sediment are summarized in Table 16, and the proposed radionuclide background values for sediment are summarized in Table 17. Each inorganic chemical and radionuclide is discussed in detail in the following sections, including a comparison of sediment background values with soil background values that are presented in Ryti et al. (1998). The soil background values for fallout radionuclides were derived by Campbell (1998) using data from LANL's Environmental Surveillance Program. Background values for inorganic chemicals in soils are typically higher than that for sediment, and these differences are associated with chemical and mineralogical changes accompanying soil development. The sediment background values for naturally occurring radionuclides may be used as surrogate values for these radionuclides in soil, because there are no directly measured values for naturally occurring radionuclides in soil. We also compared the concentrations reported for fallout radionuclides from prehistoric sediments to post-1943. Ideally, prehistoric deposits should have no detected results for fallout radionuclides, although this was not always the case (as discussed below).

Inorganic Chemical Analytes

Aluminum

All Al results were detects, and the concentration range is from 740 to 13,300 mg/kg. No suspect values were identified in the Al probability plots. These data appear to originate from a square-root normal statistical distribution (see probability plots in Appendix E). The UTL value is 15,400 mg/kg, which is roughly 20% greater than the maximum value. The UTL will be used as the Al sediment background value. The Al soil background value is 29,200 mg/kg or about 1.9 times the sediment value.

Antimony

All of the sediment Sb data were produced by ICPES, which has a higher detection limit than the method used for Sb in soils (ICPMS). Because a more appropriate chemical analysis method was used for the soils background data, we will use the soil UTL value for this chemical as the background value for sediments. Thus, the Sb sediment background value will be 0.83 mg/kg.

Table 16
Summary of Background Values for Inorganic Analytes (mg/kg)

Analyte	UTL:95,95	Maximum Value	Maximum Detection Limit	Background Value
Ag	n/a[a]	0.28	<0.1	NC[b] (1.0)
Al	15400	13300	n/a	15400
As	3.98	3.6	<0.5	3.98
Ba	127	127	n/a	127
Be	1.31	1.3	<0.08	1.31
Ca	4420	4240	n/a	4420
Cd	n/a	0.18	<0.2	NC (0.4)
Cl	17.1	10.3	<2.5	17.1
CN	0.82	0.63	<0.15	0.82
Co	4.73	4.2	n/a	4.73
Cr	10.5	9.2	n/a	10.5
Cu	11.2	12	n/a	11.2
Fe	13800	13000	n/a	13800
Hg	n/a	0.03	<0.02	NC (0.1)
K	2690	2600	n/a	2690
Mg	2370	2370	n/a	2370
Mn	543	517	n/a	543
Na	1470	1970	n/a	1470
Ni	9.38	8.9	<2	9.38
Pb	19.7	25.6	<4	19.7
Sb[c]	n/a	n/a	n/a	0.83
Se	n/a	n/a	<0.2	NC (0.3)
SO_4	58.2	35	<5	58.2
Ta	n/a	n/a	<0.3	NC (0.3)
Th[d]	n/a	n/a	n/a	14.6
Th-total[d]	n/a	n/a	n/a	22.4
Ti	439	400	n/a	439
Tl[a]	n/a	n/a	n/a	0.73
U	2.22	2	<0.3	2.22
U-total	6.99	7.2	n/a	6.99

Arsenic

Twenty nine of the 31 As results were detects, and the concentration range of detects was 0.3 to 3.6 mg/kg. No suspect values were identified in the As probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 3.98 mg/kg, which is roughly 10% greater than the maximum value. The UTL will be used as the As sediment background value. The As soil background value is 8.17 mg/kg or about two times the sediment value.

Barium

All Ba results were detects, and the concentration range is from 8 to 127 mg/kg. No suspect values were identified in the Ba box plots or probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 127 mg/kg, which is equal to the maximum value. The UTL will be used as the Ba sediment background value. The Ba soil background value is 295 mg/kg or about 2.3 times the sediment value.

Beryllium

Twenty nine of the 31 Be results were detects, and the concentration range of detects was 0.17 to 1.3 mg/kg. No suspect values were identified in the Be probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 1.31 mg/kg, which is roughly equal to the maximum value. The UTL will be used as the Be sediment background value. The Be soil background value is 1.83 mg/kg or about 1.4 times the sediment value.

Cadmium

Six of 24 Cd results were detects, which is not a sufficient detection frequency to permit calculation of a UTL value. The contract required quantitation limit, 0.4 mg/kg, is proposed as a background value for Cd, which is higher than the maximum reported value of 0.18 mg/kg. The Cd soil background value is also 0.4 mg/kg, and is also based on the contract required quantitation limit.

Calcium

All Ca results were detects, and the concentration range is from 180 to 4240 mg/kg. No suspect values were identified in the Ca probability plots. These data appear to originate from a square-

Table 16 (continued)

Analyte	UTL:95,95	Maximum Value	Maximum Detection Limit	Background Value
V	19.7	20	n/a	19.7
Zn	60.2	56.2	n/a	60.2

[a] n/a = Not applicable.

[b] NC = Not calculated. The detection limit noted parenthetically is used as a background value.

[c] UTL from LANL soil background was used because a less sensitive analytical method was used for sediment samples.

[d] UTL was not calculated for thorium because of the small number of sediment samples. The soil UTL is used as a surrogate value for this analyte.

Table 17
Summary of Background Values for Radionuclides (pCi/g)

Radionuclide	UTL	Maximum Value	Maximum MDA	Background Value
Gross Alpha	58.8	49.28	n/a[a]	58.8
Gross Beta	46.1	41.12	n/a	46.1
Am-241	0.04	0.038	n/a	0.04
Cs-137	0.90	1.28	<0.13	0.90
H-3	0.093	0.0856	n/a	0.093
K-40	36.8	35.1	n/a	36.8
Pu-238	0.006	0.006	n/a	0.006
Pu-239,240	0.068	0.065	n/a	0.068
Ra-226[b]	n/a	n/a	n/a	2.59
Ra-228[c]	n/a	n/a	n/a	2.33
Sr-90	1.04	1	n/a	1.04
Th-228	2.28	2.12	n/a	2.28
Th-230	2.29	2.12	n/a	2.29
Th-232	2.33	2.03	n/a	2.33
U-234	2.59	2.5	n/a	2.59
U-235	0.20	0.16	<0.006	0.20
U-238	2.29	2.1	<1.5	2.29

[a] n/a = Not applicable.

[b] UTL is based on U-234 activity, instead of using gamma spectroscopy results for this radionuclide.

[c] This radionuclide was not measured in sediment; the UTL was estimated from thorium-232.

root normal statistical distribution (see probability plots in Appendix E). The UTL value is 4420 mg/kg, which is roughly 5% greater than the maximum value. The UTL will be used as the Ca sediment background value. The Ca soil background value is 6120 mg/kg or about 1.4 times the sediment value.

Chloride

Two of the seven Cl^- results were detects, and the concentration range of detects was 8.4 to 10.3 mg/kg. This low detection frequency and number of samples should preclude calculating a UTL value for this chemical. However, chloride is not a typical RCRA-contaminant, and a sediment UTL value is calculated for comparison purposes to other media. Because of the limited number of samples, it was assumed that Cl^- data were derived from a normal statistical distribution. The calculated UTL value is 17.1 mg/kg, which is 70% greater than the maximum Cl^- result. The UTL will be used as the Cl^- sediment background value. The Cl^- soil background value is 231 mg/kg or about 10 times the sediment value.

Chromium

All of the 31 Cr results were detects, and the concentration range is from 0.8 to 9.2 mg/kg. No suspect values were identified in the Cr probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 10.5 mg/kg, which is roughly 15% greater than the maximum value. The UTL will be used as the Cr sediment background value. The Cr soil background value is 19.3 mg/kg or about 1.8 times the sediment value.

Cobalt

All Co results were detects, and the concentration range is from 0.6 to 4.2 mg/kg. No suspect values were identified in the Co probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 4.73 mg/kg, which is roughly 10% greater than the maximum value. The UTL will be used as the Co sediment background value. The Co soil background value is 8.64 mg/kg or about 1.8 times the sediment value.

Copper

All Cu results were detects, and the concentration range is from 0.77 to 12 mg/kg. No suspect values were identified in the Cu probability plots. These data appear to originate from a square-root normal statistical distribution (see probability plots in Appendix E). The UTL value is

11.2 mg/kg, which is within the background copper concentration range. The UTL will be used as the Cu sediment background value. The Cu soil background value is 14.5 mg/kg or about 1.3 times the sediment value.

Iron

All Fe results were detects, and the concentration range is from 1400 to 13,000 mg/kg. No suspect values were identified in the Fe probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 13,800 mg/kg, which is 6% greater than the maximum value. The UTL will be used as the Fe sediment background value. The Fe soil background value is 21,500 mg/kg or about 1.5 times the sediment value.

Lead

Thirty of the 31 Pb results were detects, and the concentration range of detects was 3.5 to 25.6 mg/kg. One high value was noted in the Pb probability plots, but this value did not skew the estimated mean or standard deviation and was not omitted from the lead background data. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 19.7 mg/kg, which is within the background Pb concentration range. The UTL will be used as the Pb sediment background value. The Pb soil background value is 22.3 mg/kg or about equal to the sediment value.

Magnesium

All Mg results were detects, and the concentration range is from 170 to 2370 mg/kg. No suspect values were identified in the Mg probability plots. These data appear to originate from a square-root normal statistical distribution (see probability plots in Appendix E). The UTL value is 2370 mg/kg, which is equal to the maximum value. The UTL will be used as the Mg sediment background value. The Mg soil background value is 4610 mg/kg or about two times the sediment value.

Manganese

All Mn results were detects, and the concentration range is from 46 to 517 mg/kg. No suspect values were identified in the Mn box plots or probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 543 mg/kg, which is roughly 5% greater than the maximum value. The UTL will be used as the

Mn sediment background value. The Mn soil background value is 671 mg/kg or about 1.2 times the sediment value.

Mercury

Three of 24 Hg results were detects, which is not a sufficient detection frequency to permit calculation of a UTL value. The contract required quantitation limit, 0.1 mg/kg, is proposed as a background value for Hg. This value is higher than the maximum detected sample result of 0.03 mg/kg. The Hg soil background value is also 0.1 mg/kg, and is also based on the contract required quantitation limit.

Nickel

Twenty of the 31 Ni results were detects, and the concentration range of detects was 2.5 to 8.9 mg/kg. No suspect values were identified in the Ni probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 9.38 mg/kg, which is roughly 5% greater than the maximum value. The UTL will be used as the Ni sediment background value. The Ni soil background value is 15.4 mg/kg or about 1.6 times the sediment value.

Potassium

All K results were detects, and the concentration range is from 180 to 2600 mg/kg. No suspect values were identified in the K probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 2690 mg/kg, which is roughly 3% greater than the maximum value. The UTL will be used as the K sediment background value. The K soil background value is 3460 mg/kg or about 1.3 times the sediment value.

Selenium

None of 24 Se results were detects, which does not allow calculation of a UTL value. The contract required quantitation limit, 0.3 mg/kg, is proposed as a background value for Se. The Se soil background value is 1.52 mg/kg.

Silver

Two of 18 Ag results were detects, which is not a sufficient detection frequency to permit calculation of a UTL value. The contract required quantitation limit, 1 mg/kg, is proposed as a background value for Ag. The Ag soil background value is also 1 mg/kg, and is also based on the contract required quantitation limit.

Sodium

All Na results were detects, and the concentration range of detects was 34 to 1970 mg/kg. One high value was noted in the Na probability plots, but this value did not skew the estimated mean or standard deviation and was not omitted from the Na background data. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 1470 mg/kg, which is within the background Na concentration range. The UTL will be used as the Na sediment background value. The Na soil background value is 915 mg/kg or about two-thirds of the sediment value. Na is one of three metals (uranium and zinc are the others) where the sediment background value is greater than the soil background value.

Sulfate

Two of the seven SO_4^{2-} results were detects, and the concentration range of detects was 26.5 to 35 mg/kg. This low detection frequency and number of samples should preclude calculation of a UTL value for this chemical. However, sulfate is not a typical RCRA-contaminant, and a sediment UTL value is calculated for comparison purposes to other media. Because of the limited number of samples, it was assumed that SO_4^{2-} data were derived from a normal statistical distribution. The calculated UTL value is 58.2 mg/kg, which is 70% greater than the maximum SO_4^{2-} result. The UTL will be used as the SO_4^{2-} sediment background value. The SO_4^{2-} soil background value is 293 mg/kg or about five times the sediment value.

Tantalum

None of seven Ta results were detects, which does not allow calculation of a UTL value. The soils contract required quantitation limit, 0.3 mg/kg, is proposed as a background value for Ta. The Ta soil background value is also 0.3 mg/kg, and is also based on the contract required quantitation limit.

Thallium

Most of the sediment Tl data were produced by ICPES, which has a higher detection limit than the method used for Tl in soils (ICPMS). Because a more appropriate chemical analysis method was used for the soils background data, we will use the soil UTL value for this element as the background value for sediments. Thus, the Tl sediment background value will be 0.73 mg/kg.

Thorium

Seven of the 24 Th results were detects, which is not a sufficient number of samples to permit calculation of a UTL value. The concentration range for Th of the seven detects was from 0.9 to 7 mg/kg. Because the Th concentrations are expected to be similar between soil and sediment, the soil background will be used as a surrogate for sediment. The soils UTL value, 14.6 mg/kg, is proposed as a background value for Th.

Total Thorium

There are also results for total Th, and the primary use of such data is to establish isotopic abundance of naturally occurring isotopes of thorium and its daughters. Total Th has a unique analyte code in the ER database to avoid confusion with the leachable Th results discussed above. All of the seven total Th results were detects, and the concentration range for total Th was from 3.3 to 18 mg/kg. Because the total Th concentrations are expected to be similar between soil and sediment, the soil background will be used as a surrogate for sediment. The soil UTL value, 22.4 mg/kg, is proposed as a background value for total Th.

Titanium

All of the 24 Ti sample results were detects, and the concentration range for titanium was from 102 to 400 mg/kg. No suspect values were identified in the Ti probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The Ti UTL value is 439 mg/kg, which is roughly 10% greater than the maximum value. The UTL will be used as the Ti sediment background value. There are no soil background data for Ti, thus data analysts may want to use the Ti sediment background value as a surrogate background value for Ti in soils.

Uranium

Twenty-eight of the 31 U results were detects, and the concentration range for uranium was from 0.14 to 2 mg/kg. No suspect values were identified in the U probability plots. These data appear to originate from a lognormal statistical distribution (see probability plots in Appendix E). The U UTL value is 2.22 mg/kg, which is roughly 10% greater than the maximum value. The UTL will be used as the U sediment background value. The U soil background value is 1.82 mg/kg or about 80% of the sediment value. U is one of three metals (sodium and zinc are the others) where the sediment background value is greater than the soil background value.

Total Uranium

There are also results for total U, and the primary use of such data is to establish isotopic abundance of naturally occurring isotopes of uranium and its daughters. Total U has a unique analyte code in the ER database to avoid confusion with the leachable U results discussed above. All of the 31 total uranium results were detects, and the concentration range for total U was from 0.7 to 7.2 mg/kg. No suspect values were identified in the total U probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The total uranium UTL value is 6.99 mg/kg, which is within the total uranium concentration range. The UTL will be used as the total U sediment background value. The total U soil background value is 5.4 mg/kg or about 80% of the sediment value. U is one of three metals (sodium and zinc are the others) where the sediment background value is greater than the soil background value.

Vanadium

All of the 31 V results were detects, and the concentration range is from 1 to 20 mg/kg. No suspect values were identified in the V probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 19.7 mg/kg, which is within the background V concentration range. The UTL will be used as the V sediment background value. The V soil background value is 39.6 mg/kg or two times the sediment value.

Zinc

All of the 31 Zn results were detects, and the concentration range is from 9 to 56.2 mg/kg. No suspect values were identified in the Zn probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 60.2 mg/kg, which is roughly 7% greater than the maximum value. The UTL will be used as the Zn sediment background value. The Zn soil background value is 48.8 mg/kg or about 80% of the sediment value. Zn is one of three metals (uranium and zinc are the others) where the sediment background value is greater than the soil background value.

<u>Radionuclides</u>

Americium-241

All of the 24 ^{241}Am results were detects, and the concentration range is from 0.009 to 0.139 pCi/g. The box plots suggest one value for ^{241}Am (sample 04LA-96-0050) was elevated, and this sample was excluded because of its large influence on summary statistics for this radionuclide. After excluding this result, the remaining data range from 0.009 to 0.038 pCi/g and appear to originate from a normal statistical distribution (see probability plots in Appendix E). With this outlier excluded there are no differences between the prehistoric (pre-1943) sample results and the post-1943 (or fallout affected) sample layers (see Appendix C). Because the ranges of concentrations were similar for the prehistoric and post-1943 sample layers, these data were included in one data group to improve the statistics for calculating a UTL. The UTL value is 0.040 pCi/g, which is roughly 5% greater than the maximum value. The UTL will be used as the ^{241}Am sediment background value. The ^{241}Am soil background value is 0.013 pCi/g, or about 1/3rd of the sediment value. Differences between these background values most likely result from slight differences in the sensitivity and calibration of the ^{241}Am alpha spectroscopy analyses for soils compared to sediments, with poorer sensitivity for the sediments. The fact that all results from the sediment samples were detects, including samples from prehistoric deposits and that they appear to represent a normal statistical distribution further suggests an instrument calibration problem with these analyses.

Cesium-137

Seven of the 24 ^{137}Cs results were detects, and the concentration range of detects was 0.21 to 1.28 pCi/g. No suspect values were identified in the ^{137}Cs box plots or probability plots. Most of the ^{137}Cs prehistoric (pre-1943) sample results were nondetects, except for a single detected result for sample 04PU-96-0012 from upper Pueblo Canyon. This anomalous detected value was from a coarse-grained deposit at depth and might have resulted from subsurface migration of fallout radionuclides or may instead represent a false detect. Because the ranges of concentrations were similar for the prehistoric and post-1943 sample layers, these data were included in one data group to improve the statistics for calculating a UTL. These data are best fit by a lognormal statistical distribution (see probability plots in Appendix E). The UTL value is 0.90 pCi/g, which is within the background ^{137}Cs concentration range. The UTL will be used as the ^{137}Cs sediment background value. The ^{137}Cs soil background value is 1.65 pCi/g, or about 1.8 times the sediment background value. This difference is considered to be small compared to sampling and measurement uncertainties associated with establishing background concentrations of fallout radionuclides.

Plutonium-238

None of the 24 ^{238}Pu results were detects, but the ^{238}Pu data were not censored and four values were reported as negative values. Negative values can occur after instrument background values are subtracted. The ^{238}Pu concentration range was -0.002 to 0.006 pCi/g. No suspect values were identified in the ^{238}Pu box plots or probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 0.006 pCi/g, which is equal to the maximum value. The UTL will be used as the ^{238}Pu sediment background value. The ^{238}Pu soil background value is 0.023 pCi/g, or about four times the sediment background value. It is unclear why ^{238}Pu concentrations are greater in background soils compared to background sediments, although this disparity may in part result from differences in instrument sensitivity and calibration.

Plutonium-239,240

The $^{239,240}Pu$ results were not censored, and the concentration range is from 0.002 to 0.197 pCi/g. The box plots suggest that one value for $^{239,240}Pu$ (sample 04LA-96-0050) was elevated, and this sample was excluded because of its large influence on summary statistics for this radionuclide. After excluding this result, the remaining data range from 0.009 to 0.065 pCi/g and appear to originate from a lognormal statistical distribution (see probability plots in Appendix E). Most of the $^{239,240}Pu$ prehistoric (pre-1943) sample results were nondetects or low concentrations, except for a single larger value for sample 04PU-96-0017 from lower Pueblo Canyon. This anomalous result was from a coarse-grained deposit and possibly represents the subsurface migration of plutonium in alluvial groundwater. Because the ranges of concentrations were similar for the prehistoric and post-1943 sample layers, these data were included in one data group to improve the statistics for calculating a UTL. The UTL value is 0.068 pCi/g, which is roughly 5% greater than the maximum value. The UTL will be used as the $^{239,240}Pu$ sediment background value. The $^{239,240}Pu$ soil background value is 0.054 pCi/g, or about 80% of the sediment background value. This difference is considered to be small compared to sampling and measurement uncertainties associated with establishing background concentrations of fallout radionuclides.

Potassium-40

All of the 24 ^{40}K results were detects, and the concentration range of detects was 24.2 to 35.1 pCi/g. No suspect values were identified in the ^{40}K box plots or probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 36.8 pCi/g, which is roughly 5% greater than the maximum value. The UTL will be used as the ^{40}K sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Radium-226

One radionuclide, ^{226}Ra, was measured by gamma spectroscopy, which is not an acceptable method for detecting background activity of ^{226}Ra. Because activity of ^{226}Ra can be estimated from the activity of its parent radionuclide (^{234}U), we will use the ^{234}U UTL (2.59 pCi/g) as a background value for ^{226}Ra. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Radium-228

Radium-228 was not measured in any sediment background samples, but it is important when evaluating human health and ecological effects. The activity of ^{228}Ra can be estimated from the activity of its parent radionuclide (^{232}Th). Thus, we will use the ^{232}Th UTL (2.33 pCi/g) as a background value for ^{228}Ra. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Strontium-90

None of the 24 ^{90}Sr results were detects, and the concentration range of nondetects was -0.3 to 1 pCi/g. The ^{90}Sr data were not censored and were used without replacement in the probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The calculated UTL value is 1.04 pCi/g, which is 4% greater than the maximum value. The UTL will be used as the ^{90}Sr sediment background value. The ^{90}Sr soil background value is 1.31 pCi/g or about 1.2 times the sediment background value. This difference is considered to be small compared to sampling and measurement uncertainties associated with establishing background concentrations of fallout radionuclides.

Thorium-228

All of the 24 ^{228}Th results were detects, and the concentration range of detects was 0.7 to 2.12 pCi/g. No suspect values were identified in the ^{228}Th probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 2.28 pCi/g, which is roughly 8% greater than the maximum value. The UTL will be used as the ^{228}Th sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Thorium-230

All of the 24 ^{230}Th results were detects, and the concentration range of detects was 0.69 to 2.12 pCi/g. No suspect values were identified in the ^{230}Th probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 2.29 pCi/g, which is roughly 8% greater than the maximum value. The UTL will be used as the ^{230}Th sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Thorium-232

All of the 24 ^{232}Th results were detects, and the concentration range of detects was 0.66 to 2.03 pCi/g. No suspect values were identified in the ^{232}Th probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 2.33 pCi/g, which is roughly 15% greater than the maximum value. The UTL will be used as the ^{232}Th sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Tritium

The ^{3}H results were not censored, and the concentration range was 0.003 to 0.0856 pCi/g (dry weight). No suspect values were identified in the ^{3}H probability plots. Most of the ^{3}H prehistoric (pre-1943) sample results were nondetects or low concentrations, except for a single larger value for sample 04LA-96-0052. Because the ranges of concentrations were similar for the prehistoric and post-1943 sample layers, these data were included in one data group to improve the statistics for calculating a UTL. These data appear to originate from a lognormal statistical distribution (see probability plots in Appendix E). The UTL value is 0.093 pCi/g, which is roughly 9% greater than the maximum value. The UTL will be used as the ^{3}H sediment background value. The ^{3}H soil background value is 0.76 pCi/ml of soil moisture, which is a different unit than the sediment background value. The soil moisture of the background samples must be known to convert the soil background number to the same units as the sediment background value.

Uranium-234

All of the 24 ^{234}U results were detects, and the concentration range of detects was 0.59 to 2.5 pCi/g. No suspect values were identified in the ^{234}U probability plots. These data appear to originate from a lognormal statistical distribution (see probability plots in Appendix E). The UTL value is 2.59 pCi/g, which is roughly 4% greater than the maximum value. The will be used as the ^{234}U sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Uranium-235

Fifteen of the 24 ^{235}U results were detects, and the concentration range of detects was 0.06 to 0.16 pCi/g. No suspect values were identified in the ^{235}U probability plots. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 0.20 pCi/g, which is 25% greater than the maximum value. The UTL will be used as the

^{235}U sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

Uranium-238

Twenty-two of the 24 ^{238}U results were detects, and the concentration range of detects was 0.51 to 2.1 pCi/g. One suspect nondetect value was noted with a concentration of 0.06 pCi/g, but this value was judged not to interfere with estimating the mean and standard deviation of the ^{238}U sample data. These data appear to originate from a normal statistical distribution (see probability plots in Appendix E). The UTL value is 2.29 pCi/g, which is roughly 9% greater than the maximum value. The UTL will be used as the ^{238}U sediment background value. This radionuclide was not measured in soil background samples, and the sediment background value can be used as a surrogate soil background value.

IMPLICATIONS FOR SEDIMENT SAMPLING AND STATISTICS

The UTLs calculated from these samples will be useful in making initial background comparisons. Statistical analysis indicates that (1) leachable elemental concentrations have lower concentrations and less variability than LANL-wide background soil leachable elemental concentrations and (2) minimal variation occurs among the five canyons sampled. Minimal variation among concentrations of inorganic, organic, and radionuclide constituents indicates that the current background sediment sample set may be adequate for determining LANL-wide UTLs for most additional Canyons investigation activities. Other statistical tests may also be used, as needed, to support the Canyons investigations.

Results also indicate that the particle-size distribution and geomorphic setting may have a potentially strong influence on contaminant concentrations downstream or downwind from release sites. Analytical results indicate that concentrations of most analytes increase as silt and clay contents increase. This increase occurs because silt- and clay-size particles have higher surface areas that are largely more chemically active than sand- and gravel-size particles. Results of textural analysis indicate that sediments deposited on floodplains generally have more silt and clay; therefore, it is likely that these geomorphic units may have a greater potential for storing contaminants relative to stream channels. Fine-grained sediment, however, can also be deposited in channels and within coarse sediments on floodplains.

The overall results from this background investigation strongly indicate that sample sites should be carefully selected when evaluating contaminant concentrations, location, and inventory. Detailed documentation of the geomorphic setting and recognition of the history of sedimentation will also be important. Sediments samples should represent both channel and floodplain depositional environments, especially identification of areas away from marginal floodplains that may have received sediment during large floods. Understanding geomorphic setting and sediment texture will enhance identification of dispersal of potential contaminants.

MORE RECENT BACKGROUND STUDIES

Since the time this study was completed and the resultant background values were proposed in Ryti et al. (1998), several additional studies have been conducted that are relevant to understanding background concentrations in sediments in this area. These studies are briefly discussed below.

During an investigation of potential contamination in sediments in Cañada del Buey near White Rock (Drakos et al., 2000), a series of inorganic chemicals were detected at levels above the background values proposed in this study. To test the hypothesis that these samples represented a local background that was naturally different from previously sampled areas, samples were collected from 12 sites along local drainages that were supplying sediment to Cañada del Buey from adjacent eroding slopes. These samples confirmed that locally derived sediments had elevated concentrations of the following metals: Ba, Co, Cu, Fe, Mn, Se, Tl, and V. It is believed that these geochemical differences probably reflect erosion of relatively old, eolian-derived soils on this part of the Pajarito Plateau, although the presence of basalt (absent from previously sampled areas) may also contribute to these geochemical differences. Importantly, these findings indicate that local variations in background geochemistry exist that should be considered in evaluations of potential contamination.

The Cerro Grande fire of May 2000 had a major impact on many watersheds that drain the eastern Jemez Mountains and the Pajarito Plateau. After the fire, samples of ash, reworked ash (muck), and sediments containing components of ash were collected in part to understand the impact of the fire on concentrations of various analytes that were independent of possible effects of remobilizing contaminants released from LANL sources (e.g., Katzman et al., 2001; Kraig et al., 2002). This work has shown that the concentrations of fallout radionuclides (e.g., ^{137}Cs, ^{239,240}Pu, and ^{90}Sr) and many metals (Al, As, Ba, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, V, and Zn) are elevated in ash, muck, and post-fire sediments containing ash as compared to pre-fire background levels. Evaluations of potential contamination in sediments downstream of burned areas should, therefore, take into account the possibility that certain analytes may have elevated values compared to the background values developed in this study.

A statistical evaluation of radionuclide concentrations in sediment samples collected from rivers and reservoirs in northern New Mexico and southern Colorado from 1974 to 1997 was used to estimate upper levels of background in these settings (McLin and Lyons, 2002). This work indicates that estimated background levels vary between river and reservoir sediments and between these settings and sediments collected from smaller drainages on the Pajarito Plateau.

This work also indicates that the estimated upper levels of background can vary with the method of calculation. The largest difference between the study of McLin and Lyons (2002) and this study of sediments from the Pajarito Plateau is the estimated upper background level for $^{239,240}Pu$, which is larger for the Pajarito Plateau sediments. Although it was suggested that this difference is most likely caused by elevated detection limits in the samples collected from the Pajarito Plateau (cited to be 0.1 pCi/g, McLin and Lyons, 2002, p. 26), the typical detection limit for $^{239,240}Pu$ in this Pajarito Plateau data set, ~0.01 pCi/g, is significantly below the calculated background value and is adequate for the purposes of this study. We feel that these differences in estimates of the upper limit of background more likely relate to other factors, including higher local input of fallout radionuclides associated with higher annual precipitation near LANL, or contributions from LANL stack emissions and/or fugitive dust from LANL, as proposed by Fresquez et al. (1998). Additional factors may include variable dilution of fallout radionuclides between large and small drainage basins or statistics related to the random sampling of relatively high values in a non-normally distributed data set.

ACKNOWLEDGMENTS

This work was supported by the Los Alamos National Laboratory Environmental Restoration Project through the Canyons Focus Area. The authors thank Allyn Pratt and Dave Broxton for their support throughout this work; Jenny Kofoed for assistance in sediment sampling; Dave Hunter, Darrio Rocha, and John Taylor for field radiation measurements; Anthony Garcia, Marcia Jones, Rick Kelley, Pam Maestas, and Meena Sachdeva for support with graphics, compositing, and editing; and Pat Longmire, Steve McLin, and Lars Soholt for helpful review comments.

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APPENDIX A SEDIMENT SAMPLE PRETREATMENT AND PARTICLE-SIZE DISTRIBUTION ANALYSIS FOR CANYONS BACKGROUND SEDIMENTS

This appendix addresses sample pretreatment and particle-size distribution analysis (PSDA) data requirements for background sediment samples sent to Rust-Geotech from Los Alamos National Laboratory (LANL). Samples required (1) sample preparation consisting of drying sample, sieving to remove >2-mm size fraction, sample splitting into smaller portions for additional physical and chemical analysis, and (2) PSDA.

1.0 OVERVIEW OF SAMPLE PRETREATMENT

Samples had an initial pretreatment consisting of preparation of four sample splits for the following analyses: (1) tritium, (2) PSDA, (3) X-ray fluorescence (XRF), and (4) radiochemical plus chemical analyses. The sample split for tritium analysis was removed first before drying and sieving of sample. The other splits were removed following sample drying and sieving to remove the >2-mm size fraction. A few of the samples also received *additional* rad and chemical analyses on the silt + clay (<0.0625 mm) size fraction.

2.0 SAMPLE MIXING

In some cases, sediment samples were shipped in more than one sample container (i.e., two or three 2-L plastic bottles per sample). For samples shipped in more than one container, samples were first mixed before any sample splits were removed or before samples were dried and sieved.

3.0 SAMPLES FOR TRITIUM ANALYSIS

A sample split of about 500 g was removed from samples for tritium analysis. This sample split was removed after all sample was combined (if shipped in more than one container) and before sample drying and sieving. The sample was then analyzed for tritium according to procedures previously specified by LANL. If the sample was very dry, a determination of moisture content was performed and the amount needed for tritium analysis was calculated. If there was insufficient sample for all four splits, the split for tritium analysis was eliminated.

3.1 Determining Percent >2-mm Size Fraction

After tritium analysis, samples were sieved to remove and determine the percent weight abundance of the >2-mm size fraction.

4.0 SAMPLE DRYING

Sediment samples were spread across a clean sheet of plastic or butcher paper, or across a clean plastic or metal tray. Samples were spread to a depth of less than about 2 cm and allowed to air dry at about 20°C or higher for about 24 hours. The air-dried sample was weighed to the nearest 1 g after air drying.

5.0 SAMPLE SIEVING TO REMOVE THE >2-MM SIZE FRACTION

Samples were sieved to remove the >2-mm size fraction (gravel and stones) and large pieces of nonmineral debris (roots, inorganic trash, etc.). All samples were sieved using a sieve with a mesh size of 2-mm (US standard sieve mesh No. 10). The <2-mm (fine earth) fraction was weighed to the nearest 1.0 g and the weight recorded. The >2-mm (coarse) size fraction was stored in a labeled plastic bag for return to LANL. Sieves were thoroughly cleaned between each sample (using the best combination of brushing, compressed air, and/or washing with deionized water) to remove trapped particles.

5.1 Homogenize Sample

The <2-mm sample was mixed together using appropriate methods to homogenize sample. The technique used to homogenize sample minimized physical disintegration of samples. Implements used to homogenize samples were thoroughly cleaned between each sample.

6.0 SAMPLE SPLITTING

Samples were split into representative portions using a standard soil/sediment splitter. The splitter was thoroughly cleaned between each sample (using the best combination of brushing, compressed air, and/or washing with deionized water) to remove trapped particles. Samples were split into representative fractions for each set of chemical and rad analyses so that sample splits adequately represented the chemical and physical composition of the original sample. Weights required for each analysis were determined.

6.1 XRF Sample Split for LANL

In addition to sample splits for analyses, a separate sample split of about 25 g was removed and sent back to LANL for XRF analysis.

7.0 SEDIMENT PARTICLE-SIZE DISTRIBUTION ANALYSIS

General procedures for sediment size analysis as specified under general American Society for Testing and Materials (ASTM) procedures were used for determining PSDA of sediment samples.

7.1 Sand-Size Analysis

Sand-size analysis was determined using standard ASTM dry-sieving procedures specified. Sands were sieved using a set of sieves at **one-phi** intervals consisting of

phi range	**size range (mm)**
0	1.0
1	0.5
2	0.25
3	0.125
4	0.0625

Weight percent and sample weights for each sieved fraction, including the <0.0625 fraction caught in bottom sieve pan, were reported.

7.2 Silt- and Clay-Size Analysis

Silt- and clay-size analysis was determined using standard hydrometer procedures. Distribution of the following size fractions were determined:

particle range	**phi range**	**size range (mm)**
Coarse and medium silt	4–6	0.0625–0.015
Fine and very fine silt	6–9	0.015–0.002
Clay	<9	<0.002

8.0 DOCUMENTATION

Laboratory data for particle-size distribution included the following:

(1) Percentage of sample passing (or retained on) each sieve, or determined from hydrometer readings. Data were reported in both tabular and graphical form. Data included

Total Sample

- Total weight of air dry sample
- Weight of air dry sample fine earth fraction (<2 mm)
- Percent weight gravel (>2-mm fraction)
- Percent weight of all sand-size fractions and remaining silt fraction from dry sieving
- Percent weight of clay- and silt-sized fractions from hydrometer analysis

Tritium Sample

- Percent weight gravel (>2-mm fraction)

(2) Statistical and graphical interpretation including graphic mean, standard deviation, skewness, and kurtosis following data interpretation.

9.0 SEDIMENT SAMPLE PRETREATMENT FOR *SELECTED SAMPLES* FOR DETERMINING CHEMISTRY IN <0.0625-MM FRACTION

This section addresses additional sample pretreatment of a selected subset of sediment and soil samples sent from LANL. This additional pretreatment consisted of additional sample sieving to remove the >0.0625-mm fraction. These samples were split from the sample that remained following the sample splitting and sieving discussed above. Additional chemical and rad analyses were conducted on the <0.0625-mm fraction. The purpose of these analyses was to compare the concentrations of important constituents associated with the silt- and clay-sized particles.

9.1 Sieving of Selected Samples to Remove >0.0625-mm Fraction

Samples sieved to remove the >0.0625-mm fraction were split from surplus sample that was leftover from initial sample pretreatment and splitting (sample that had been previously air-dried and sieved through a 2-mm sieve). Samples were dry-sieved. Both fractions (>0.0625 mm and

<0.0625 mm) were weighed to the nearest 0.1 g after sieving and sample weights were recorded. Sieves were thoroughly cleaned between each sample (using the best combination of brushing, compressed air, and/or washing with deionized water) to remove trapped particles.

9.2 Sample Splitting

Samples sieved to remove the >0.0625-mm fraction were split into representative portions using a standard soil/sediment splitter. Splitter was thoroughly cleaned between each sample (using the best combination of brushing, compressed air, and/or washing with deionized water) to remove trapped particles. Samples were split into representative fractions for each set of chemical and rad analyses so that sample splits adequately represented the chemical and physical composition of the original sample. Weights were obtained for each analysis.

10.0 REMAINING SAMPLE

Any remaining sample sieved to remove the >2-mm size fraction, excluding sample splits used for tritium and hydrometer analyses, were shipped back to LANL.

11.0 QUALITY ASSURANCE

A preparation blank sample consisting of high purity quartz sand (or equivalent) was prepared with each batch of LANL samples. The blank sample was air-dried, sieved through a 2-mm sieve, and split for analysis of radionuclides (isotopic plutonium, isotopic uranium, gamma spectroscopy) and trace metals. The preparation blank sample results were reported with the data for each analytical suite.

APPENDIX B SUMMARY OF ANALYTES AND METHODS

Analyte	Analytical Code	Analytical Method	Analytical Method Code	Preparation Method
Los Alamos, Pueblo, and Guaje Canyons				
Inorganic Analytes				
Aluminum	Al	ICPES	METTAL	SW-3050A
Antimony	Sb	ICPES	METTAL	SW-3050A
Arsenic	As	ICPES (axial view)	METTAL	SW-3050A
Barium	Ba	ICPES	METTAL	SW-3050A
Beryllium	Be	ICPES	METTAL	SW-3050A
Boron	B	ICPES	METTAL	SW-3050A
Cadmium	Cd	ICPES	METTAL	SW-3050A
Calcium	Ca	ICPES	METTAL	SW-3050A
Chromium	Cr	ICPES	METTAL	SW-3050A
Cobalt	Co	ICPES	METTAL	SW-3050A
Copper	Cu	ICPES	METTAL	SW-3050A
Cyanide	CN	Distillation/ spectrophotometry (equivalent to SW-9012)	METTAL	SW-9012 equivalent
Iron	Fe	ICPES	METTAL	SW-3050A
Lead	Pb	ICPES (axial view)	METTAL	SW-3050A
Magnesium	Mg	ICPES	METTAL	SW-3050A
Manganese	Mn	ICPES	METTAL	SW-3050A
Mercury	Hg	Cold Vapor Atomic Absorption (equivalent to SW-7471)	METTAL	SW-7471 equivalent
Nickel	Ni	ICPES	METTAL	SW-3050A
Potassium	K	ICPES	METTAL	SW-3050A
Selenium	Se	ICPES (axial view)	METTAL	SW-3050A
Silver	Ag	ICPES	METTAL	SW-3050A
Sodium	Na	ICPES	METTAL	SW-3050A
Thallium	Tl	ICPES (axial view)	METTAL	SW-3050A
Titanium	Ti	ICPES	METTAL	SW-3050A
Uranium and Total Uranium	U	ICPMS (as U-238)	ICPMS	SW-3050A and complete digest (splits)
Vanadium	V	ICPES	METTAL	SW-3050A
Zinc	Zn	ICPES	METTAL	SW-3050A

Analyte	Analytical Code	Analytical Method	Analytical Method Code	Preparation Method
Radionuclides				
Gross Alpha	ALPHA	Gas Proportional Counting	GROSSAB	None
Gross Beta	BETA	Gas Proportional Counting	GROSSAB	None
Tritium	H-3	Liquid Scintillation Counting	H3	Distillation
Actinium-228	Ac-228	Gamma spectroscopy	GSCAN	None
Americium-241	Am-241	Alpha spectrometry	AM241	Complete digest
Americium-241	Am-241	Gamma spectroscopy	GSCAN	None
Barium-140	Ba-140	Gamma spectroscopy	GSCAN	None
Bismuth-211	Bi-211	Gamma spectroscopy	GSCAN	None
Bismuth-212	Bi-212	Gamma spectroscopy	GSCAN	None
Bismuth-214	Bi-214	Gamma spectroscopy	GSCAN	None
Cadmium-109	Cd-109	Gamma spectroscopy	GSCAN	None
Cerium-139	Ce-139	Gamma spectroscopy	GSCAN	None
Cesium-134	Cs-134	Gamma spectroscopy	GSCAN	None
Cesium-137	Cs-137	Gamma spectroscopy	GSCAN	None
Cobalt-57	Co-57	Gamma spectroscopy	GSCAN	None
Cobalt-60	Co-60	Gamma spectroscopy	GSCAN	None
Europium-152	Eu-152	Gamma spectroscopy	GSCAN	None
Iodine-129	I-129	Gamma spectroscopy	GSCAN	None
Lanthanium-140	La-140	Gamma spectroscopy	GSCAN	None
Lead-210	Pb-210	Gamma spectroscopy	GSCAN	None
Lead-211	Pb-211	Gamma spectroscopy	GSCAN	None
Lead-212	Pb-212	Gamma spectroscopy	GSCAN	None
Lead-214	Pb-214	Gamma spectroscopy	GSCAN	None
Manganese-54	Mn-54	Gamma spectroscopy	GSCAN	None
Mercury-203	Hg-203	Gamma spectroscopy	GSCAN	None
Neptunium-237	Np-237	Gamma spectroscopy	GSCAN	None
Plutonium-238	Pu-238	Alpha spectrometry	ISOPU	Complete digest
Plutonium-239,240	Pu-239/240	Alpha spectrometry	ISOPU	Complete digest
Potassium-40	K-40	Gamma spectroscopy	GSCAN	None
Protactinium-231	Pa-231	Gamma spectroscopy	GSCAN	None
Protactinium-233	Pa-233	Gamma spectroscopy	GSCAN	None
Protactinium-234M	Pa-234M	Gamma spectroscopy	GSCAN	None
Radium-223	Ra-223	Gamma spectroscopy	GSCAN	None
Radium-224	Ra-224	Gamma spectroscopy	GSCAN	None

Analyte	Analytical Code	Analytical Method	Analytical Method Code	Preparation Method
Radium-226	Ra-226	Gamma spectroscopy	GSCAN	None
Radon-219	Rn-219	Gamma spectroscopy	GSCAN	None
Ruthenium-106	Ru-106	Gamma spectroscopy	GSCAN	None
Selenium-75	Se-75	Gamma spectroscopy	GSCAN	None
Sodium-22	Na-22	Gamma spectroscopy	GSCAN	None
Strontium-85	Sr-85	Gamma spectroscopy	GSCAN	None
Strontium-90	Sr-90	Gas Proportional Counting	SR90	Conc. HNO3 digest
Thallium-208	Tl-208	Gamma spectroscopy	GSCAN	None
Thorium-227	Th-227	Gamma spectroscopy	GSCAN	None
Thorium-228	Th-228	Alpha spectrometry	ISOTH	Complete digest
Thorium-230	Th-230	Alpha spectrometry	ISOTH	Complete digest
Thorium-232	Th-232	Alpha spectrometry	ISOTH	Complete digest
Thorium-234	Th-234	Gamma spectroscopy	GSCAN	None
Tin-113	Sn-113	Gamma spectroscopy	GSCAN	None
Uranium-234	U-234	ICPMS (with Flow Injection Analysis)	ICPMS	Complete digest
Uranium-235	U-235	ICPMS	ICPMS	Complete digest
Uranium-235	U-235	Gamma spectroscopy	GSCAN	None
Uranium-238	U-238	ICPMS	ICPMS	Complete digest
Yttrium-88	Y-88	Gamma spectroscopy	GSCAN	None
Zinc-65	Zn-65	Gamma spectroscopy	GSCAN	None
Ancho and Indio Canyons				
Inorganic Analytes				
Aluminum	Al	ICPES		SW-3050A and HF (splits)
Antimony	Sb	ICPES		SW-3050A and HF (splits)
Arsenic	As	Graphite Furnace Atomic Absorption		SW-3050A and HF (splits)
Barium	Ba	ICPES		SW-3050A and HF (splits)
Beryllium	Be	ICPES		SW-3050A and HF (splits)
Calcium	Ca	ICPES		SW-3050A and HF (splits)
Chloride	Cl	Ion Chromatography		Deionized water leach
Chromium	Cr	ICPES		SW-3050A and HF (splits)
Cobalt	Co	ICPES		SW-3050A and HF (splits)
Copper	Cu	ICPES		SW-3050A and HF (splits)
Iron	Fe	ICPES		SW-3050A and HF (splits)
Lead	Pb	ICPES		SW-3050A and HF (splits)
Magnesium	Mg	ICPES		SW-3050A and HF (splits)

Analyte	Analytical Code	Analytical Method	Analytical Method Code	Preparation Method
Manganese	Mn	ICPES		SW-3050A and HF (splits)
Nickel	Ni	ICPES		SW-3050A and HF (splits)
Potassium	K	ICPES		SW-3050A and HF (splits)
Sodium	Na	ICPES		SW-3050A and HF (splits)
Sulfate	SO4	Ion Chromatography		Deionized water leach
Tantalum	Ta	ICPMS		SW-3050A and HF (splits)
Thallium	Tl	ICPMS		SW-3050A and HF (splits)
Thorium and Total Thorium	Th	ICPMS		SW-3050A and HF (splits)
Uranium and Total Uranium	U	ICPMS		SW-3050A and HF (splits)
Vanadium	V	ICPES		SW-3050A and HF (splits)
Zinc	Zn	ICPES		SW-3050A and HF (splits)

APPENDIX C ALL ANALYTICAL RESULTS

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Ag	Qualifier	Al	As	Qualifier	B	Qualifier	Ba	Be	Qualifier	Ca	Cd	Qualifier	Cl	Qualifier
FS2220	I6425	FP	<2	NA		4500	1.5		NA		53.5	0.545		1250	NA		2.5	U
FS2221	I6425	FP	<0.075	NA		7300	3		NA		99	0.89		1900	NA		2.5	U
FS2222	I6425	FP	0.075–0.25	NA		6900	2		NA		77	0.82		1700	NA		2.5	U
FS2224	I6425	AC	<2	NA		740	0.5	U	NA		8	0.08	U	180	NA		2.5	U
FS2225 (x)	I6400	AC	<2	NA		1400	1		NA		14	0.7		990	NA		2.5	
FS2226	I6387	FP	<2	NA		8400	3		NA		100	1.1		2600	NA		2.5	U
FS2227	A6228	PFP	<2	NA		7700	2		NA		71	0.74		1500	NA		8.4	
FS2228	A6228	PC	<2	NA		2300	0.9		NA		32	0.17		770	NA		10.3	
FS2229	A6295	FP	<2	NA		7000	2		NA		82.5	0.76		1950	NA		2.5	U
FS2230	A6295	FP	<0.075	NA		6800	2		NA		90	0.82		2500	NA		2.5	U
FS2231	A6295	FP	0.075–0.25	NA		7600	3		NA		95	0.87		2400	NA		2.5	U
FS2233	A6295	AC	<2	NA		930	0.5	U	NA		8.3	0.08	U	230	NA		2.5	U
FS2234	I6425	FP	0.25–2	NA		3200	1		NA		37	0.3		960	NA		2.5	U
FS2235	A6295	FP	0.25–2	NA		4100	1		NA		49	0.39		1100	NA		2.5	U
04GU-96-0001	GU-0001	FP	<2	NA		NA	1.2		1.2	U	59.9	0.49		1740	0.1	U	NA	
04GU-96-0002	GU-0002	AC	<2	NA		NA	1.7		1.2		81.8	0.84		1670	0.1		NA	
04GU-96-0003	GU-0003	FP	<2	NA		NA	0.76		1.2	U	42.3	0.38		1350	0.1	U	NA	
04GU-96-0004	GU-0004	PFP	<2	NA		NA	1.5		2.3		77	0.86		1910	0.18		NA	
04GU-96-0004	GU-0004	PFP	<0.0625	NA		NA	1.1		1.2	U	115	1.1		2200	0.22		NA	
04GU-96-0005	GU-0005	AC	<2	NA		NA	0.3		1.2		34.1	0.22		1080	0.11		NA	
04GU-96-0006	GU-0006	PFP	<2	NA		NA	1.7		1.2	U	92.2	0.89		1920	0.1	U	NA	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Ag	Qualifier	Al	As	Qualifier	B	Qualifier	Ba	Be	Qualifier	Ca	Cd	Qualifier	Cl	Qualifier
04GU-96-0007	GU-0007	FP	<2	0.1	U	3350	0.4		1.2	U	36.9	0.27		977	0.17		NA	
04LA-96-0050	LA-0005	FP	<2	0.1	U	5510	3.6		NA		65.8	0.67		2000	0.14		NA	
04LA-96-0051	LA-0006	AC	<2	0.1	U	3140	1.1		NA		33.4	0.26		934	0.1	U	NA	
04LA-96-0052	LA-0007	PFP	<2	0.1	U	8810	2.2		NA		87.1	1.2		1640	0.1	U	NA	
04LA-96-0052	LA-0007	PFP	<0.0625	0.1	U	12300	2.4		1.4		122	1.6		2150	0.1	U	NA	
04LA-96-0053	LA-0008	AC	<2	0.1	U	5800	1.8		2.2		65	0.63		3310	0.1	U	NA	
04LA-96-0054	LA-0009	AC	<2	0.1	U	5060	1.1		NA		45.9	0.54		1080	0.12		NA	
04LA-96-0055	LA-0010	PFP	<2	0.1	U	4910	1.3		2.7		64.6	0.68		1650	0.1	U	NA	
04LA-96-0056	LA-0011	FP	<2	0.1	U	4520	1.9		1.9		67.7	0.55		4240	0.1	U	NA	
04LA-96-0056	LA-0011	FP	<0.0625	0.1	U	8990	2.5		3.2		123	1		5860	0.2		NA	
04PU-96-0010	PU-0005	FP	<2	0.28		4500	2.8		1.2	U	29.1	0.41		641	0.2	U	NA	
04PU-96-0011	PU-0006	FP	<2	0.1	U	5620	2.9		1.2	U	40	0.47		1080	0.2	U	NA	
04PU-96-0012	PU-0007	PC	<2	0.1	U	9720	2.9		1.2	U	96.3	0.67		2110	0.2	U	NA	
04PU-96-0013	PU-0008	AC	<2	0.11		5560	2.7		1.2	U	37	0.54		1150	0.2	U	NA	
04PU-96-0014	PU-0009	AC	<2	0.1	U	6980	2.8		1.2	U	44	0.54		1160	0.2	U	NA	
04PU-96-0015	PU-0010	FP	<2	0.1	U	4010	2.6		2.2		68.4	0.49		2290	0.2	U	NA	
04PU-96-0016	PU-0011	FP	<2	0.1	U	8710	3.1		1.8		95	0.74		2920	0.2	U	NA	
04PU-96-0016	PU-0011	FP	<0.0625	0.1	U	13200	4.2		2.7		121	0.99		3660	0.2	U	NA	
04PU-96-0017	PU-0012	PC	<2	0.1	U	1980	1.1		1.2	U	17.2	0.17		336	0.2	U	NA	
04PU-96-0018	PU-0013	PFP	<2	0.1	U	12900	2.9		4.1		110	1.1		2830	0.2	U	NA	
04PU-96-0018	PU-0013	PFP	<0.0625	0.1	U	8750	2.7		3.9		109	1.1		2900	0.2	U	NA	
04PU-96-0019	PU-0014	PFP	<2	0.1	U	13300	2.9		2.3		127	1.3		3680	0.2	U	NA	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	CN	Qualifier	Co	Cr	Cu	Fe	Hg	Qualifier	K	Mg	Mn	Na	Ni	Qualifier
FS2220	I6425	FP	<2	NA		2.25	3.4	3.5	6650	NA		980	895	240	107.5	4	
FS2221	I6425	FP	<0.075	NA		3.5	5.8	7.3	9400	NA		1500	1500	330	120	7	
FS2222	I6425	FP	0.075–0.25	NA		3	4.7	5.6	9600	NA		1400	1300	350	120	5	
FS2224	I6425	AC	<2	NA		0.6	1	0.8	1400	NA		180	170	53	46	2	U
FS2225 (x)	I6400	AC	<2	NA		6	12	4.4	57000	NA		220	530	1200	68	9	
FS2226	I6387	FP	<2	NA		3.5	5.6	12	9600	NA		1800	1700	380	190	6	
FS2227	A6228	PFP	<2	NA		2.7	5.2	4.3	8400	NA		1600	1400	220	150	4	
FS2228	A6228	PC	<2	NA		3.1	5.4	1.8	13000	NA		540	570	240	66	4	
FS2229	A6295	FP	<2	NA		3.35	5.2	5.25	8550	NA		1750	1400	305	95.5	6	
FS2230	A6295	FP	<0.075	NA		3	5.9	7.5	8400	NA		1900	1500	230	76	5	
FS2231	A6295	FP	0.075–0.25	NA		3.8	5.9	7.3	9200	NA		2200	1600	300	110	7	
FS2233	A6295	AC	<2	NA		0.7	0.8	0.9	1400	NA		200	200	46	34	2	U
FS2234	I6425	FP	0.25–2	NA		1.5	2.2	2.7	4800	NA		650	590	180	75	4	
FS2235	A6295	FP	0.25–2	NA		2	2.5	3	5000	NA		1100	820	190	80	4	
04GU-96-0001	GU-0001	FP	<2	0.63		2.9	8.9	5	8600	0.02	U	2210	1080	239	1970	6.2	
04GU-96-0002	GU-0002	AC	<2	0.2		3.6	8.8	6.3	9160	0.02	U	2060	1550	290	733	7	
04GU-96-0003	GU-0003	FP	<2	0.2		2.2	4.9	4.3	6250	0.02	U	1110	727	209	699	4.8	
04GU-96-0004	GU-0004	PFP	<2	0.16		4.1	8.2	6.2	9590	0.02	U	1760	1500	406	857	7.2	
04GU-96-0004	GU-0004	PFP	<0.0625	0.15	U	4.8	8.8	7.2	9510	0.02	U	2070	1940	457	845	8.1	
04GU-96-0005	GU-0005	AC	<2	0.23		1.4	3.4	2.7	4540	0.02	U	696	552	182	541	3.7	
04GU-96-0006	GU-0006	PFP	<2	0.2		4.2	7.8	5.5	9000	0.02	U	2380	1530	367	333	7.5	
04GU-96-0007	GU-0007	FP	<2	0.27		2.1	5.7	3.8	6270	0.02	U	1000	643	197	731	4.7	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	CN	Qualifier	Co	Cr	Cu	Fe	Hg	Qualifier	K	Mg	Mn	Na	Ni	Qualifier
04LA-96-0050	LA-0005	FP	<2	0.15	U	1.6	5.6	7.3	7450	0.02		1090	870	342	458	4.6	
04LA-96-0051	LA-0006	AC	<2	0.56		0.89	6.1	4.1	8630	0.02	U	1120	544	229	930	4.4	
04LA-96-0052	LA-0007	PFP	<2	0.2		1.8	7	4.9	8210	0.02	U	1350	876	457	826	5.5	
04LA-96-0052	LA-0007	PFP	<0.0625	0.15	U	2.6	9.2	6.8	10900	0.03		1410	1230	570	520	7.4	
04LA-96-0053	LA-0008	AC	<2	0.27		1.7	6.4	4.7	7910	0.03		1630	803	501	944	5.3	
04LA-96-0054	LA-0009	AC	<2	0.63		1.3	5.1	3.8	7180	0.02	U	1190	604	306	847	5	
04LA-96-0055	LA-0010	PFP	<2	0.6		1.2	4.3	3.4	5660	0.02	U	1340	624	317	964	4.1	
04LA-96-0056	LA-0011	FP	<2	0.23		1.3	5	5.2	6800	0.02	U	788	635	517	450	4.4	
04LA-96-0056	LA-0011	FP	<0.0625	0.15	U	3.3	10	8.7	9730	0.04		1270	1250	784	307	8.4	
04PU-96-0010	PU-0005	FP	<2	0.63		1.7	3.7	2.5	7430	0.02	U	939	612	100	522	2.9	
04PU-96-0011	PU-0006	FP	<2	0.27		2.1	4.9	2.7	8410	0.02	U	945	793	249	419	3.8	
04PU-96-0012	PU-0007	PC	<2	0.31		3.8	8.3	6.8	10400	0.02	U	1420	1300	379	386	8.9	
04PU-96-0013	PU-0008	AC	<2	0.15	U	2.3	5.4	3.1	12600	0.02	U	838	826	302	284	4.2	
04PU-96-0014	PU-0009	AC	<2	0.27		2.7	5.5	3.3	10100	0.02	U	1020	990	261	319	4.2	
04PU-96-0015	PU-0010	FP	<2	0.15	U	1.9	3.2	4.4	6670	0.02	U	859	749	433	250	3.2	
04PU-96-0016	PU-0011	FP	<2	0.34		3.4	8	10.1	10800	0.02		1560	1490	367	353	8.9	
04PU-96-0016	PU-0011	FP	<0.0625	0.15	U	4.5	12.6	10.1	12000	0.03		2040	2070	376	307	11.9	
04PU-96-0017	PU-0012	PC	<2	0.16		1	3.2	0.77	7290	0.02	U	753	328	215	699	2.5	
04PU-96-0018	PU-0013	PFP	<2	0.41		3.4	9	5.7	10100	0.02	U	2560	1960	322	1240	7.4	
04PU-96-0018	PU-0013	PFP	<0.0625	0.15	U	3.4	6.7	5.8	9020	0.02	U	1830	1710	263	706	6.5	
04PU-96-0019	PU-0014	PFP	<2	0.15	U	4	9.2	6.4	11000	0.02	U	2600	2370	314	646	8	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Pb	Qualifier	Sb	Qualifier	Se	Qualifier	SO4	Qualifier	Ta	Qualifier	Th	Th-total	Ti	Tl	Qualifier
FS2220	I6425	FP	<2	6.5		5	U	NA		5	U	0.3	U	5.5	13	NA	0.4	U
FS2221	I6425	FP	<0.075	10		5	U	NA		10		0.3	U	7.7	17	NA	0.3	U
FS2222	I6425	FP	0.075–0.25	10		5	U	NA		5.9		0.3	U	7.1	18	NA	0.3	U
FS2224	I6425	AC	<2	4		5	U	NA		5	U	0.3	U	1.4	3.9	NA	0.3	U
FS2225 (x)	I6400	AC	<2	11		5		NA		5		0.3		14	130	NA	0.3	
FS2226	I6387	FP	<2	16		5		NA		5	U	0.3	U	6.6	18	NA	0.3	U
FS2227	A6228	PFP	<2	7		5	U	NA		35		0.3	U	5.8	15	NA	0.3	U
FS2228	A6228	PC	<2	5		5	U	NA		26.5		0.3	U	2.2	9.4	NA	0.3	U
FS2229	A6295	FP	<2	9		5	U	NA		5	U	0.3	U	7	15	NA	0.3	U
FS2230	A6295	FP	<0.075	7		5	U	NA		5	U	0.3	U	6.9	16	NA	0.3	U
FS2231	A6295	FP	0.075–0.25	9		5	U	NA		5	U	0.3	U	7.1	15	NA	0.3	U
FS2233	A6295	AC	<2	4	U	5	U	NA		5	U	0.3	U	0.9	3.3	NA	0.3	U
FS2234	I6425	FP	0.25–2	5		5	U	NA		5	U	0.3	U	3.6	8.8	NA	0.3	U
FS2235	A6295	FP	0.25–2	6		5	U	NA		5	U	0.3	U	4.3	10	NA	1.5	
04GU-96-0001	GU-0001	FP	<2	7		4.9	U	0.2	U	NA		NA		NA	NA	380	3.2	
04GU-96-0002	GU-0002	AC	<2	9.2		4.9	U	0.2	U	NA		NA		NA	NA	199	2	
04GU-96-0003	GU-0003	FP	<2	5.7		4.9	U	0.2	U	NA		NA		NA	NA	215	1.4	
04GU-96-0004	GU-0004	PFP	<2	9.5		4.9	U	0.2	U	NA		NA		NA	NA	133	1.7	
04GU-96-0004	GU-0004	PFP	<0.0625	12.6		4.9	U	0.2	U	NA		NA		NA	NA	61.5	1.3	
04GU-96-0005	GU-0005	AC	<2	3.5		4.9	U	0.2	U	NA		NA		NA	NA	156	1.1	
04GU-96-0006	GU-0006	PFP	<2	9.3		4.9	U	0.2	U	NA		NA		NA	NA	102	1.7	
04GU-96-0007	GU-0007	FP	<2	5.9		4.9	U	0.2	U	NA		NA		NA	NA	270	2.3	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Pb	Qualifier	Sb	Qualifier	Se	Qualifier	SO4	Qualifier	Ta	Qualifier	Th	Th-total	Ti	Tl	Qualifier
04LA-96-0050	LA-0005	FP	<2	25.6		4.9	U	0.2	U	NA		NA		NA	NA	188	2.2	
04LA-96-0051	LA-0006	AC	<2	6.6		4.9	U	0.2	U	NA		NA		NA	NA	344	2.2	
04LA-96-0052	LA-0007	PFP	<2	13.4		4.9	U	0.2	U	NA		NA		NA	NA	237	2.2	
04LA-96-0052	LA-0007	PFP	<0.0625	17.3		4.9	U	0.2	U	NA		NA		NA	NA	258	2.6	
04LA-96-0053	LA-0008	AC	<2	13.6		4.9	U	0.2	U	NA		NA		NA	NA	270	2	
04LA-96-0054	LA-0009	AC	<2	7.1		4.9	U	0.2	U	NA		NA		NA	NA	264	2.6	
04LA-96-0055	LA-0010	PFP	<2	8.9		4.9	U	0.2	U	NA		NA		NA	NA	174	1.6	
04LA-96-0056	LA-0011	FP	<2	12.4		4.9	U	0.2	U	NA		NA		NA	NA	167	2	
04LA-96-0056	LA-0011	FP	<0.0625	20.4		4.9	U	0.2	U	NA		NA		NA	NA	203	2	
04PU-96-0010	PU-0005	FP	<2	7.4		4.9	U	0.2	U	NA		NA		NA	NA	209	0.57	
04PU-96-0011	PU-0006	FP	<2	7.5		4.9	U	0.2	U	NA		NA		NA	NA	298	1.2	
04PU-96-0012	PU-0007	PC	<2	15.2		4.9	U	0.2	U	NA		NA		NA	NA	365	1.2	
04PU-96-0013	PU-0008	AC	<2	8.9		4.9	U	0.2	U	NA		NA		NA	NA	400	1.6	
04PU-96-0014	PU-0009	AC	<2	9.1		4.9	U	0.2	U	NA		NA		NA	NA	310	1	
04PU-96-0015	PU-0010	FP	<2	9.7		4.9	U	0.2	U	NA		NA		NA	NA	166	0.71	
04PU-96-0016	PU-0011	FP	<2	15.6		4.9	U	0.2	U	NA		NA		NA	NA	301	0.66	
04PU-96-0016	PU-0011	FP	<0.0625	19.6		4.9	U	0.2	U	NA		NA		NA	NA	329	1	
04PU-96-0017	PU-0012	PC	<2	3.5		4.9	U	0.2	U	NA		NA		NA	NA	336	0.61	
04PU-96-0018	PU-0013	PFP	<2	11		4.9	U	0.2	U	NA		NA		NA	NA	190	0.56	
04PU-96-0018	PU-0013	PFP	<0.0625	10.6		4.9	U	0.2	U	NA		NA		NA	NA	80.7	0.3	U
04PU-96-0019	PU-0014	PFP	<2	11.8		4.9	U	0.2	U	NA		NA		NA	NA	135	0.96	

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	U	Qualifier	U-total	V	Zn	TOC	ALPHA	BETA	Ac-228	Qualifier	Am-241	Qualifier	Ba-140	Qualifier
FS2220	I6425	FP	<2	0.8		3.95	7.1	31	NA	NA	NA	NA		NA		NA	
FS2221	I6425	FP	<0.075	0.9		5.7	12	38	NA	NA	NA	NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	1		5.6	10	44	NA	NA	NA	NA		NA		NA	
FS2224	I6425	AC	<2	0.3	U	1.1	1.4	9	NA	NA	NA	NA		NA		NA	
FS2225 (x)	I6400	AC	<2	0.8		4	66	300	NA	NA	NA	NA		NA		NA	
FS2226	I6387	FP	<2	1.6		7.2	11	48	NA	NA	NA	NA		NA		NA	
FS2227	A6228	PFP	<2	0.6		4.7	9	33	NA	NA	NA	NA		NA		NA	
FS2228	A6228	PC	<2	0.3	U	1.5	20	47	NA	NA	NA	NA		NA		NA	
FS2229	A6295	FP	<2	0.65		4.3	10	36.5	NA	NA	NA	NA		NA		NA	
FS2230	A6295	FP	<0.075	0.6		4.9	13	32	NA	NA	NA	NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	0.6		4.3	12	37	NA	NA	NA	NA		NA		NA	
FS2233	A6295	AC	<2	0.3	U	0.7	1	9	NA	NA	NA	NA		NA		NA	
FS2234	I6425	FP	0.25–2	0.5		2.5	5	24	NA	NA	NA	NA		NA		NA	
FS2235	A6295	FP	0.25–2	0.4		3	5	24	NA	NA	NA	NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	0.43		4.2	17.2	26.3	5340	30.33	32.89	1.72		0.018		0.21	U
04GU-96-0002	GU-0002	AC	<2	0.66		5.1	15.3	29.5	4380	30.31	34.74	2.34		0.017		0.12	U
04GU-96-0003	GU-0003	FP	<2	0.37		4.2	11.6	20	4030	23.29	35.09	2.1		0.018		0.22	U
04GU-96-0004	GU-0004	PFP	<2	0.71		4.4	14.3	30.8	3110	22.44	38.29	2		0.018		0.13	U
04GU-96-0004	GU-0004	PFP	<0.0625	1.2		4.5	12.9	29.2	NA	NA	NA	1.65		0.014	U	0.42	U
04GU-96-0005	GU-0005	AC	<2	0.14		2.6	7.8	13.9	624	16.43	22.7	1.18		0.019		0.25	U
04GU-96-0006	GU-0006	PFP	<2	0.5		4.3	13.5	27.5	2880	34.78	30.4	1.89		0.011		0.15	U
04GU-96-0007	GU-0007	FP	<2	0.3		3.4	12.5	18.6	1210	17.15	37.93	1.5		0.011		0.11	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	U	Qualifier	U-total	V	Zn	TOC	ALPHA	BETA	Ac-228	Qualifier	Am-241	Qualifier	Ba-140	Qualifier
04LA-96-0050	LA-0005	FP	<2	0.75		4.4	9.9	51.4	15000	46.04	40.39	0.55	U	0.139		0.26	U
04LA-96-0051	LA-0006	AC	<2	1.1		2.3	11.8	36.1	7540	8.47	26.96	1.18		0.019		0.28	U
04LA-96-0052	LA-0007	PFP	<2	1		6.3	9	56.2	10700	47.8	40.67	3.07		0.015		0.32	U
04LA-96-0052	LA-0007	PFP	<0.0625	1.5		7.7	12.3	74.2	NA	52.93	45.32	3.08		0.022		0.58	U
04LA-96-0053	LA-0008	AC	<2	0.86		4	9.9	47.7	15600	33.76	38.51	0.47	U	0.023		0.44	U
04LA-96-0054	LA-0009	AC	<2	0.8		3.7	9.1	34	9250	25.04	34.46	1.86		0.021		0.24	U
04LA-96-0055	LA-0010	PFP	<2	0.83		4.9	7.1	31.4	6750	45.23	38.95	2.03		0.016		0.41	U
04LA-96-0056	LA-0011	FP	<2	1		5.1	8	35.9	15700	36.41	40.72	2.63		0.017		0.42	U
04LA-96-0056	LA-0011	FP	<0.0625	1.5		6.5	13.9	57.8	NA	45.94	44.24	2.81		0.018		0.56	U
04PU-96-0010	PU-0005	FP	<2	0.33		2.2	7.4	27.2	3690	18.96	31.76	1.6		0.009		0.24	U
04PU-96-0011	PU-0006	FP	<2	0.42		2.5	8.4	33.2	5990	16.3	34.51	1.14		0.023		0.23	U
04PU-96-0012	PU-0007	PC	<2	2		4.6	14.2	38	15600	48.16	32.68	1.85		0.034		0.32	U
04PU-96-0013	PU-0008	AC	<2	0.41		3.2	10.3	55.5	3090	30.44	36.25	1.68		0.038		0.29	U
04PU-96-0014	PU-0009	AC	<2	0.41		3.1	10.3	39.3	6140	40.87	38.29	1.52		0.032		0.29	U
04PU-96-0015	PU-0010	FP	<2	0.7		3.5	6.1	30.4	18700	30.9	34.81	1.67		0.013		0.21	U
04PU-96-0016	PU-0011	FP	<2	1.1		3.8	14.9	39.9	25000	41.94	34.09	1.71		0.036		0.24	U
04PU-96-0016	PU-0011	FP	<0.0625	1.9		4.9	19.1	39.9	NA	60.31	32.13	0.7	U	0.046		0.51	U
04PU-96-0017	PU-0012	PC	<2	0.35		1.5	6.2	37.9	670	12.56	26.06	0.31	U	0.016		0.19	U
04PU-96-0018	PU-0013	PFP	<2	0.86		5.2	14.4	38.2	4510	49.28	41.12	2.33		0.029		0.23	U
04PU-96-0018	PU-0013	PFP	<0.0625	0.86		4.4	11.3	33.9	NA	46.5	27.61	0.7	U	0.043		0.59	U
04PU-96-0019	PU-0014	PFP	<2	1.1		4.5	15	39	3730	31.43	28.44	2.1		0.025		0.26	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Bi-211	Qualifier	Bi-212	Qualifier	Bi-214	Qualifier	Cd-109	Qualifier	Ce-139	Qualifier	Ce-144	Qualifier	Co-57	Qualifier	Co-60	Qualifier
FS2220	I6425	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2221	I6425	FP	<0.075	NA		NA		NA		NA		NA		NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA		NA	
FS2224	I6425	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2225 (x)	I6400	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2226	I6387	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2227	A6228	PFP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2228	A6228	PC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2229	A6295	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2230	A6295	FP	<0.075	NA		NA		NA		NA		NA		NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA		NA	
FS2233	A6295	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2234	I6425	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2235	A6295	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	1.28	U	1.56	U	0.96		4.08	U	0.08	U	1.31	U	0.09	U	0.09	U
04GU-96-0002	GU-0002	AC	<2	1.01	U	1.61	U	0.97		3.02	U	0.06	U	0.76	U	0.06	U	0.05	U
04GU-96-0003	GU-0003	FP	<2	1.01	U	3.02	U	1.09		3.3	U	0.04	U	0.98	U	0.07	U	0.1	U
04GU-96-0004	GU-0004	PFP	<2	1.07	U	1.72	U	1.07		3.23	U	0.03	U	0.63	U	0.07	U	0.11	U
04GU-96-0004	GU-0004	PFP	<0.0625	2.33		2.8	U	2.97		4.19	U	0.15	U	1.15	U	0.12	U	0.2	U
04GU-96-0005	GU-0005	AC	<2	0.96	U	1.84	U	0.33	U	3.27	U	0.04	U	0.54	U	0.07	U	0.13	U
04GU-96-0006	GU-0006	PFP	<2	1	U	1.77	U	0.92		3.18	U	0.05	U	0.74	U	0.06	U	0.08	U
04GU-96-0007	GU-0007	FP	<2	0.91	U	1.74	U	0.69		2.97	U	0.06	U	0.7	U	0.05	U	0.08	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Bi-211	Qualifier	Bi-212	Qualifier	Bi-214	Qualifier	Cd-109	Qualifier	Ce-139	Qualifier	Ce-144	Qualifier	Co-57	Qualifier	Co-60	Qualifier
04LA-96-0050	LA-0005	FP	<2	1.19	U	4.61	U	0.42	U	3.98	U	0.12	U	0.84	U	0.09	U	0.08	U
04LA-96-0051	LA-0006	AC	<2	0.85	U	3.67	U	0.31	U	3.36	U	0.07	U	0.6	U	0.06	U	0.08	U
04LA-96-0052	LA-0007	PFP	<2	1.35	U	1.42	U	1.4		3.97	U	0.08	U	1.11	U	0.08	U	0.12	U
04LA-96-0052	LA-0007	PFP	<0.0625	3.68		4.93	U	1.82	U	4.86	U	0.2	U	1.09	U	0.1	U	0.25	U
04LA-96-0053	LA-0008	AC	<2	1.38	U	2.34	U	0.79		4.65	U	0.08	U	0.87	U	0.09	U	0.14	U
04LA-96-0054	LA-0009	AC	<2	1.19	U	2.3	U	0.46	U	3.88	U	0.09	U	0.87	U	0.08	U	0.12	U
04LA-96-0055	LA-0010	PFP	<2	1.3	U	3.09	U	1.12		4.26	U	0.08	U	1.03	U	0.09	U	0.1	U
04LA-96-0056	LA-0011	FP	<2	1.14	U	1.31	U	0.97		3.62	U	0.04	U	0.84	U	0.07	U	0.1	U
04LA-96-0056	LA-0011	FP	<0.0625	3.34		5.02	U	1.62	U	5.48	U	0.18	U	1.43	U	0.12	U	0.23	U
04PU-96-0010	PU-0005	FP	<2	0.95	U	1.4	U	0.4	U	3.19	U	0.06	U	0.84	U	0.09	U	0.09	U
04PU-96-0011	PU-0006	FP	<2	0.85	U	1.84	U	0.54		2.98	U	0.06	U	0.86	U	0.03	U	0.09	U
04PU-96-0012	PU-0007	PC	<2	1.12	U	2.32	U	0.94		3.59	U	0.08	U	0.47	U	0.04	U	0.14	U
04PU-96-0013	PU-0008	AC	<2	0.98	U	1.7	U	0.33	U	3.37	U	0.04	U	1.11	U	0.06	U	0.1	U
04PU-96-0014	PU-0009	AC	<2	0.9	U	1.76	U	0.49		2.9	U	0.06	U	0.49	U	0.04	U	0.09	U
04PU-96-0015	PU-0010	FP	<2	0.99	U	1.16	U	0.58		3.08	U	0.07	U	0.84	U	0.1	U	0.13	U
04PU-96-0016	PU-0011	FP	<2	1	U	2.17	U	0.33	U	3.16	U	0.08	U	0.95	U	0.08	U	0.1	U
04PU-96-0016	PU-0011	FP	<0.0625	1.4	U	4.1	U	0.62	U	4.59	U	0.13	U	0.57	U	0.14	U	0.22	U
04PU-96-0017	PU-0012	PC	<2	0.84	U	1.11	U	0.25	U	2.6	U	0.03	U	0.55	U	0.06	U	0.08	U
04PU-96-0018	PU-0013	PFP	<2	1.2	U	1.9	U	1.18		3.68	U	0.08	U	0.74	U	0.08	U	0.12	U
04PU-96-0018	PU-0013	PFP	<0.0625	3.42		2.95	U	0.57	U	4.15	U	0.09	U	0.94	U	0.09	U	0.2	U
04PU-96-0019	PU-0014	PFP	<2	1.24	U	3	U	0.92		3.59	U	0.08	U	0.85	U	0.08	U	0.08	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Cs-134	Qualifier	Cs-137	Qualifier	Eu-152	Qualifier	H-3	Hg-203	Qualifier	I-129	Qualifier	K-40	Qualifier	La-140	Qualifier
FS2220	I6425	FP	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2221	I6425	FP	<0.075	NA		NA		NA		NA	NA		NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	NA		NA		NA		NA	NA		NA		NA		NA	
FS2224	I6425	AC	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2225 (x)	I6400	AC	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2226	I6387	FP	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2227	A6228	PFP	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2228	A6228	PC	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2229	A6295	FP	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2230	A6295	FP	<0.075	NA		NA		NA		NA	NA		NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	NA		NA		NA		NA	NA		NA		NA		NA	
FS2233	A6295	AC	<2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2234	I6425	FP	0.25–2	NA		NA		NA		NA	NA		NA		NA		NA	
FS2235	A6295	FP	0.25–2	NA		NA		NA		NA	NA		NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	0.08	U	0.12	U	0.38	U	0.027	0.11	U	0.36	U	31		0.04	U
04GU-96-0002	GU-0002	AC	<2	0.11	U	0.09	U	0.16	U	0.018	0.08	U	0.25	U	28.38		0.04	U
04GU-96-0003	GU-0003	FP	<2	0.09	U	0.09	U	0.3	U	0.016	0.07	U	0.2	U	30.11		0.04	U
04GU-96-0004	GU-0004	PFP	<2	0.07	U	0.1	U	0.4	U	NA	0.09	U	0.21	U	28.59		0.02	U
04GU-96-0004	GU-0004	PFP	<0.0625	0.12	U	0.19	U	0.85	U	NA	0.13	U	0.02	U	31.06		0.09	U
04GU-96-0005	GU-0005	AC	<2	0.11	U	0.09	U	0.29	U	0.009	0.09	U	0.2	U	29.91		0.03	U
04GU-96-0006	GU-0006	PFP	<2	0.1	U	0.1	U	0.31	U	0.012	0.09	U	0.18	U	29.28		0.05	U
04GU-96-0007	GU-0007	FP	<2	0.1	U	0.21		0.35	U	0.007	0.07	U	0.15	U	24.21		0.02	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Cs-134	Qualifier	Cs-137	Qualifier	Eu-152	Qualifier	H-3	Hg-203	Qualifier	I-129	Qualifier	K-40	Qualifier	La-140	Qualifier
04LA-96-0050	LA-0005	FP	<2	0.12	U	0.12	U	0.45	U	0.0856	0.13	U	0.15	U	30.37		0.05	U
04LA-96-0051	LA-0006	AC	<2	0.1	U	0.11	U	0.24	U	0.0286	0.06	U	0.17	U	24.57		0.02	U
04LA-96-0052	LA-0007	PFP	<2	0.11	U	0.11	U	0.6	U	0.0527	0.11	U	0.18	U	32.86		0.04	U
04LA-96-0052	LA-0007	PFP	<0.0625	0.24	U	0.23	U	0.75	U	NA	0.17	U	0.03	U	37.39		0.08	U
04LA-96-0053	LA-0008	AC	<2	0.15	U	1.28		0.46	U	0.0343	0.12	U	0.36	U	32.79		0.06	U
04LA-96-0054	LA-0009	AC	<2	0.12	U	0.12	U	0.34	U	0.0127	0.11	U	0.27	U	33.65		0.05	U
04LA-96-0055	LA-0010	PFP	<2	0.17	U	0.12	U	0.42	U	0.0259	0.11	U	0.24	U	33.53		0.04	U
04LA-96-0056	LA-0011	FP	<2	0.12	U	0.65		0.19	U	0.0078	0.08	U	0.19	U	29.39		0.03	U
04LA-96-0056	LA-0011	FP	<0.0625	0.33	U	1.09		0.85	U	NA	0.27	U	0.04	U	38.13		0.18	U
04PU-96-0010	PU-0005	FP	<2	0.1	U	0.12	U	0.29	U	0.028	0.1	U	0.21	U	35.1		0.03	U
04PU-96-0011	PU-0006	FP	<2	0.08	U	0.1	U	0.38	U	0.055	0.06	U	0.18	U	31.85		0.03	U
04PU-96-0012	PU-0007	PC	<2	0.13	U	0.59		0.28	U	0.022	0.1	U	0.23	U	30.12		0.07	U
04PU-96-0013	PU-0008	AC	<2	0.08	U	0.13	U	0.09	U	0.004	0.09	U	0.21	U	32.75		0.08	U
04PU-96-0014	PU-0009	AC	<2	0.11	U	0.31		0.18	U	0.016	0.07	U	0.13	U	31.76		0.03	U
04PU-96-0015	PU-0010	FP	<2	0.09	U	0.55		0.33	U	0.029	0.07	U	0.14	U	30.41		0.02	U
04PU-96-0016	PU-0011	FP	<2	0.1	U	0.58		0.3	U	0.036	0.06	U	0.2	U	26.98		0.05	U
04PU-96-0016	PU-0011	FP	<0.0625	0.15	U	0.84		1.27	U	NA	0.22	U	0.02	U	33.95		0.06	U
04PU-96-0017	PU-0012	PC	<2	0.07	U	0.06	U	0.43	U	0.003	0.06	U	0.16	U	26.08		0.04	U
04PU-96-0018	PU-0013	PFP	<2	0.11	U	0.12	U	0.41	U	0.009	0.09	U	0.23	U	26.03		0.03	U
04PU-96-0018	PU-0013	PFP	<0.0625	0.31	U	0.38		0.82	U	NA	0.15	U	0.03	U	5.49	U	0.12	
04PU-96-0019	PU-0014	PFP	<2	0.14	U	0.11	U	0.2	U	0.011	0.15	U	0.28	U	25.53		0.04	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Mn-54	Qualifier	Na-22	Qualifier	Np-237	Qualifier	Pa-231	Qualifier	Pa-233	Qualifier	Pa-234M	Qualifier	Pb-210	Qualifier	Pb-211	Qualifier
FS2220	I6425	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2221	I6425	FP	<0.075	NA		NA		NA		NA		NA		NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA		NA	
FS2224	I6425	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2225 (x)	I6400	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2226	I6387	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2227	A6228	PFP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2228	A6228	PC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2229	A6295	FP	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2230	A6295	FP	<0.075	NA		NA		NA		NA		NA		NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA		NA	
FS2233	A6295	AC	<2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2234	I6425	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA		NA	
FS2235	A6295	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	0.04	U	0.04	U	1.22	U	3.89	U	0.17	U	12.5	U	2.37	U	4.69	U
04GU-96-0002	GU-0002	AC	<2	0.09	U	0.06	U	0.89	U	2.8	U	0.16	U	8.27	U	1.44	U	2.28	U
04GU-96-0003	GU-0003	FP	<2	0.08	U	0.05	U	0.98	U	2.99	U	0.18	U	10.9	U	1.7	U	2.72	U
04GU-96-0004	GU-0004	PFP	<2	0.1	U	0.07	U	0.97	U	2.94	U	0.08	U	9.19	U	1.6	U	2.59	U
04GU-96-0004	GU-0004	PFP	<0.0625	0.16	U	0.05	U	1.27	U	4.92	U	0.36	U	14.7	U	2.82	U	4.1	U
04GU-96-0005	GU-0005	AC	<2	0.08	U	0.02	U	0.98	U	3.18	U	0.18	U	13.4	U	1.73	U	2.55	U
04GU-96-0006	GU-0006	PFP	<2	0.09	U	0.07	U	0.95	U	3.23	U	0.22	U	15.3	U	2.21	U	2.4	U
04GU-96-0007	GU-0007	FP	<2	0.06	U	0.05	U	0.88	U	2.86	U	0.2	U	10	U	1.46	U	2.18	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Mn-54	Qualifier	Na-22	Qualifier	Np-237	Qualifier	Pa-231	Qualifier	Pa-233	Qualifier	Pa-234M	Qualifier	Pb-210	Qualifier	Pb-211	Qualifier
04LA-96-0050	LA-0005	FP	<2	0.11	U	0.07	U	1.19	U	3.67	U	0.21	U	12.2	U	2.25	U	3.09	U
04LA-96-0051	LA-0006	AC	<2	0.08	U	0.05	U	1	U	2.8	U	0.16	U	13	U	1.53	U	2.52	U
04LA-96-0052	LA-0007	PFP	<2	0.07	U	0.07	U	1.19	U	3.71	U	0.22	U	12.4	U	1.9	U	3.17	U
04LA-96-0052	LA-0007	PFP	<0.0625	0.24	U	0.15	U	1.48	U	5.76	U	0.31	U	20.3	U	4.11	U	6.89	U
04LA-96-0053	LA-0008	AC	<2	0.12	U	0.1	U	1.4	U	4.46	U	0.25	U	15	U	2.28	U	3.63	U
04LA-96-0054	LA-0009	AC	<2	0.08	U	0.04	U	1.17	U	3.51	U	0.21	U	16.7	U	2.66	U	3.27	U
04LA-96-0055	LA-0010	PFP	<2	0.1	U	0.04	U	1.27	U	3.82	U	0.15	U	11.2	U	2.21	U	3.54	U
04LA-96-0056	LA-0011	FP	<2	0.11	U	0.07	U	1.07	U	3.39	U	0.15	U	14.3	U	2.04	U	2.62	U
04LA-96-0056	LA-0011	FP	<0.0625	0.26	U	0.05	U	1.66	U	10.6	U	0.38	U	18	U	3.89	U	5.36	U
04PU-96-0010	PU-0005	FP	<2	0.1	U	0.09	U	0.95	U	2.97	U	0.15	U	12.1	U	1.64	U	2.52	U
04PU-96-0011	PU-0006	FP	<2	0.07	U	0.06	U	0.89	U	2.9	U	0.12	U	10.4	U	1.52	U	2.44	U
04PU-96-0012	PU-0007	PC	<2	0.09	U	0.06	U	1.07	U	3.77	U	0.17	U	21.2	U	1.88	U	3.08	U
04PU-96-0013	PU-0008	AC	<2	0.09	U	0.04	U	1.02	U	3.04	U	0.19	U	12.5	U	1.77	U	2.67	U
04PU-96-0014	PU-0009	AC	<2	0.1	U	0.06	U	0.87	U	2.78	U	0.13	U	10.8	U	1.57	U	2.51	U
04PU-96-0015	PU-0010	FP	<2	0.06	U	0.1	U	0.92	U	2.9	U	0.08	U	8.87	U	1.68	U	2.33	U
04PU-96-0016	PU-0011	FP	<2	0.07	U	0.08	U	0.95	U	3.26	U	0.21	U	9.56	U	1.62	U	3.37	U
04PU-96-0016	PU-0011	FP	<0.0625	0.14	U	0.09	U	1.38	U	5.27	U	0.26	U	19.4	U	3.14	U	4.45	U
04PU-96-0017	PU-0012	PC	<2	0.05	U	0.02	U	0.78	U	2.34	U	0.13	U	7.93	U	1.41	U	2.12	U
04PU-96-0018	PU-0013	PFP	<2	0.12	U	0.1	U	1.1	U	3.44	U	0.14	U	15.7	U	1.91	U	2.75	U
04PU-96-0018	PU-0013	PFP	<0.0625	0.15		0.12	U	1.25	U	5.47	U	0.24	U	14.1	U	3.22		4.21	U
04PU-96-0019	PU-0014	PFP	<2	0.11	U	0.05	U	1.08	U	3.55	U	0.16	U	15.7	U	1.87	U	2.6	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Pb-212	Pb-214	Qualifier	Pu-238	Qualifier	Pu-239/240	Qualifier	Ra-223	Qualifier	Ra-224	Qualifier	Ra-226	Qualifier	Rn-219	Qualifier
FS2220	I6425	FP	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2221	I6425	FP	<0.075	NA	NA		NA		NA		NA		NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	NA	NA		NA		NA		NA		NA		NA		NA	
FS2224	I6425	AC	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2225 (x)	I6400	AC	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2226	I6387	FP	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2227	A6228	PFP	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2228	A6228	PC	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2229	A6295	FP	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2230	A6295	FP	<0.075	NA	NA		NA		NA		NA		NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	NA	NA		NA		NA		NA		NA		NA		NA	
FS2233	A6295	AC	<2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2234	I6425	FP	0.25–2	NA	NA		NA		NA		NA		NA		NA		NA	
FS2235	A6295	FP	0.25–2	NA	NA		NA		NA		NA		NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	1.68	1.4		0	U	0.010	U	1.38	U	3.16	U	3.24	U	2.45	U
04GU-96-0002	GU-0002	AC	<2	1.77	1.46		0.003	U	0.011		1.05	U	2.28	U	2.24		0.97	U
04GU-96-0003	GU-0003	FP	<2	1.54	1.18		0.002	U	0.009	U	1.02	U	2.4	U	2.58	U	1.55	U
04GU-96-0004	GU-0004	PFP	<2	1.72	1.49		0.002	U	0.004	U	1.18	U	2.56	U	2.57	U	1.01	U
04GU-96-0004	GU-0004	PFP	<0.0625	1.68	0.87		NA		NA		2.08	U	4.6	U	4.75		2.03	U
04GU-96-0005	GU-0005	AC	<2	1	0.89		0.002	U	0.009	U	1.16	U	2.39	U	2.42	U	1.08	U
04GU-96-0006	GU-0006	PFP	<2	1.72	1.24		0	U	0.012		1.13	U	2.35	U	2.25	U	1.45	U
04GU-96-0007	GU-0007	FP	<2	1.28	1.13		0.003	U	0.006	U	1.07	U	2.31	U	2.98	U	1.2	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Pb-212	Pb-214	Qualifier	Pu-238	Qualifier	Pu-239/240	Qualifier	Ra-223	Qualifier	Ra-224	Qualifier	Ra-226	Qualifier	Rn-219	Qualifier
04LA-96-0050	LA-0005	FP	<2	1.66	1.2		0.003	U	0.197		1.38	U	3	U	3.05	U	1.6	U
04LA-96-0051	LA-0006	AC	<2	0.84	0.62		0.003	U	0.033		1.18	U	2.24	U	2.62	U	1.38	U
04LA-96-0052	LA-0007	PFP	<2	2.22	2.13		0	U	0.012		1.38	U	2.91	U	3.01	U	1.83	U
04LA-96-0052	LA-0007	PFP	<0.0625	2.27	0.62	U	0.002	U	0.277		2.3	U	4.93	U	4.67	U	3.43	U
04LA-96-0053	LA-0008	AC	<2	1.53	1.21		0.005	U	0.058		1.62	U	3.4	U	3.55	U	1.83	U
04LA-96-0054	LA-0009	AC	<2	1.26	0.97		0.002	U	0.008	U	1.13	U	3.22	U	3.4	U	1.38	U
04LA-96-0055	LA-0010	PFP	<2	1.95	1.5		0.001	U	0.010		1.7	U	3.07	U	3.18	U	0.96	U
04LA-96-0056	LA-0011	FP	<2	1.7	1.38		0.006	U	0.038		1.11	U	2.49	U	2.87	U	1.34	U
04LA-96-0056	LA-0011	FP	<0.0625	2.05	0.52	U	0.005	U	0.040		1.83	U	4.77	U	4.91	U	2.49	U
04PU-96-0010	PU-0005	FP	<2	0.96	0.74		0.001	U	0.007	U	1.32	U	2.31	U	3.19	U	1.22	U
04PU-96-0011	PU-0006	FP	<2	1.08	0.76		-0.001	U	0.008	U	0.95	U	2.33	U	2.15	U	1.27	U
04PU-96-0012	PU-0007	PC	<2	1.58	1.12		0.002	U	0.019		1.13	U	2.58	U	2.91	U	1.58	U
04PU-96-0013	PU-0008	AC	<2	1.51	0.92		0.004	U	0.006	U	0.91	U	2.39	U	2.79	U	1.56	U
04PU-96-0014	PU-0009	AC	<2	1.16	0.81		0	U	0.013		1.05	U	2.19	U	2.36	U	1.46	U
04PU-96-0015	PU-0010	FP	<2	1.35	0.99		0.003	U	0.030		0.76	U	2.28	U	2.36	U	1.39	U
04PU-96-0016	PU-0011	FP	<2	1.25	1.25		0.002	U	0.028		1.17	U	2.38	U	2.57	U	1.85	U
04PU-96-0016	PU-0011	FP	<0.0625	1.18	0.45	U	0.004	U	0.088		2.16	U	3.9	U	4.13	U	2.01	U
04PU-96-0017	PU-0012	PC	<2	0.66	0.58		0.001	U	0.065		0.88	U	1.85	U	1.91	U	1.24	U
04PU-96-0018	PU-0013	PFP	<2	1.98	1.42		0.003	U	0.012		1.22	U	2.91	U	2.76	U	1.46	U
04PU-96-0018	PU-0013	PFP	<0.0625	1.52	0.4		0.004	U	0.026		1.86	U	3.36		3.74	U	2.12	U
04PU-96-0019	PU-0014	PFP	<2	1.76	1.45		-0.002	U	0.002	U	0.7	U	2.98	U	2.75	U	1.68	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Ru-106	Qualifier	Se-75	Qualifier	Sn-113	Qualifier	Sr-85	Qualifier	Sr-90	Qualifier	Th-227	Qualifier	Th-228	Th-230
FS2220	I6425	FP	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2221	I6425	FP	<0.075	NA		NA		NA		NA		NA		NA		NA	NA
FS2222	I6425	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA	NA
FS2224	I6425	AC	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2225 (x)	I6400	AC	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2226	I6387	FP	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2227	A6228	PFP	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2228	A6228	PC	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2229	A6295	FP	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2230	A6295	FP	<0.075	NA		NA		NA		NA		NA		NA		NA	NA
FS2231	A6295	FP	0.075–0.25	NA		NA		NA		NA		NA		NA		NA	NA
FS2233	A6295	AC	<2	NA		NA		NA		NA		NA		NA		NA	NA
FS2234	I6425	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA	NA
FS2235	A6295	FP	0.25–2	NA		NA		NA		NA		NA		NA		NA	NA
04GU-96-0001	GU-0001	FP	<2	0.44	U	0.14	U	0.35	U	0.14	U	0.1	U	1.77	U	1.58	1.58
04GU-96-0002	GU-0002	AC	<2	0.47	U	0.1	U	0.09	U	0.11	U	0.4	U	1.38	U	1.81	1.8
04GU-96-0003	GU-0003	FP	<2	1.09	U	0.05	U	0.1	U	0.1	U	0.6	U	1.41	U	1.4	1.34
04GU-96-0004	GU-0004	PFP	<2	0.81	U	0.09	U	0.11	U	0.09	U	-0.1	U	1.5	U	1.8	1.82
04GU-96-0004	GU-0004	PFP	<0.0625	1.45	U	0.15	U	0.09	U	0.19	U	NA		2.03	U	NA	NA
04GU-96-0005	GU-0005	AC	<2	0.99	U	0.12	U	0.05	U	0.12	U	0.5	U	1.36	U	0.9	0.9
04GU-96-0006	GU-0006	PFP	<2	0.93	U	0.05	U	0.04	U	0.12	U	0.2	U	1.43	U	1.72	1.68
04GU-96-0007	GU-0007	FP	<2	0.42	U	0.08	U	0.08	U	0.1	U	0.1	U	1.28	U	1.26	1.34

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Ru-106	Qualifier	Se-75	Qualifier	Sn-113	Qualifier	Sr-85	Qualifier	Sr-90	Qualifier	Th-227	Qualifier	Th-228	Th-230
04LA-96-0050	LA-0005	FP	<2	1.31	U	0.12	U	0.15	U	0.14	U	1	U	1.72	U	1.53	1.29
04LA-96-0051	LA-0006	AC	<2	0.62	U	0.1	U	0.04	U	0.1	U	-0.2	U	1.25	U	0.86	0.82
04LA-96-0052	LA-0007	PFP	<2	1.15	U	0.09	U	0.08	U	0.13	U	0.2	U	1.79	U	2.12	2.12
04LA-96-0052	LA-0007	PFP	<0.0625	1.4	U	0.24	U	0.22	U	0.21	U	0.2	U	2.32	U	2.76	2.53
04LA-96-0053	LA-0008	AC	<2	1.27	U	0.17	U	0.17	U	0.15	U	0	U	1.93	U	1.31	1.4
04LA-96-0054	LA-0009	AC	<2	0.83	U	0.23	U	0.14	U	0.14	U	0.7	U	1.74	U	1.35	1.31
04LA-96-0055	LA-0010	PFP	<2	1.24	U	0.14	U	0.17	U	0.14	U	0.5	U	1.85	U	1.68	1.76
04LA-96-0056	LA-0011	FP	<2	0.81	U	0.12	U	0.05	U	0.11	U	1	U	1.57	U	1.78	1.59
04LA-96-0056	LA-0011	FP	<0.0625	2.91	U	0.23	U	0.28	U	0.24	U	0.2	U	2.44	U	2.38	2.03
04PU-96-0010	PU-0005	FP	<2	0.86	U	0.1	U	0.11	U	0.12	U	0.2	U	1.32	U	0.95	0.9
04PU-96-0011	PU-0006	FP	<2	0.75	U	0.05	U	0.11	U	0.09	U	-0.3	U	1.32	U	1.16	0.92
04PU-96-0012	PU-0007	PC	<2	0.67	U	0.13	U	0.12	U	0.12	U	0.2	U	1.55	U	1.46	1.29
04PU-96-0013	PU-0008	AC	<2	0.9	U	0.06	U	0.1	U	0.13	U	-0.2	U	1.48	U	1.36	1.2
04PU-96-0014	PU-0009	AC	<2	0.64	U	0.12	U	0.09	U	0.11	U	-0.1	U	1.25	U	1.29	1.06
04PU-96-0015	PU-0010	FP	<2	0.37	U	0.12	U	0.12	U	0.11	U	-0.1	U	1.36	U	1.3	1.05
04PU-96-0016	PU-0011	FP	<2	0.35	U	0.09	U	0.08	U	0.11	U	0.2	U	1.41	U	1.39	1.24
04PU-96-0016	PU-0011	FP	<0.0625	2.55	U	0.25	U	0.09	U	0.21	U	0.1	U	1.88	U	1.59	1.77
04PU-96-0017	PU-0012	PC	<2	0.45	U	0.09	U	0.07	U	0.09	U	0.4	U	1.04	U	0.7	0.69
04PU-96-0018	PU-0013	PFP	<2	1.07	U	0.21	U	0.19	U	0.13	U	0.1	U	1.68	U	1.99	1.95
04PU-96-0018	PU-0013	PFP	<0.0625	1.66	U	0.17	U	0.11	U	0.18	U	0.2	U	1.92	U	1.71	1.82
04PU-96-0019	PU-0014	PFP	<2	0.82	U	0.07	U	0.09	U	0.13	U	0.1	U	1.66	U	1.82	1.93

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Th-232	Th-234	Qualifier	Tl-208	U-234	U-235	Qualifier	U-238	Qualifier	Y-88	Qualifier	Zn-65	Qualifier
FS2220	I6425	FP	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2221	I6425	FP	<0.075	NA	NA		NA	NA	NA		NA		NA		NA	
FS2222	I6425	FP	0.075–0.25	NA	NA		NA	NA	NA		NA		NA		NA	
FS2224	I6425	AC	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2225 (x)	I6400	AC	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2226	I6387	FP	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2227	A6228	PFP	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2228	A6228	PC	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2229	A6295	FP	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2230	A6295	FP	<0.075	NA	NA		NA	NA	NA		NA		NA		NA	
FS2231	A6295	FP	0.075–0.25	NA	NA		NA	NA	NA		NA		NA		NA	
FS2233	A6295	AC	<2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2234	I6425	FP	0.25–2	NA	NA		NA	NA	NA		NA		NA		NA	
FS2235	A6295	FP	0.25–2	NA	NA		NA	NA	NA		NA		NA		NA	
04GU-96-0001	GU-0001	FP	<2	1.54	3.92	U	0.69	1.4	0.12		1.4		0.06	U	0.21	U
04GU-96-0002	GU-0002	AC	<2	1.65	2.7	U	0.67	2.5	0.15		1.7		0.03	U	0.34	U
04GU-96-0003	GU-0003	FP	<2	1.43	3.15	U	0.47	1.3	0.12		1.4		0.03	U	0.11	U
04GU-96-0004	GU-0004	PFP	<2	1.83	3.03	U	0.66	1.6	0.13		1.5		0.05	U	0.12	U
04GU-96-0004	GU-0004	PFP	<0.0625	NA	4.59	U	0.85	NA	NA		NA		0.2	U	0.33	U
04GU-96-0005	GU-0005	AC	<2	0.99	3.16	U	0.44	0.85	0.1		0.86		0.02	U	0.12	U
04GU-96-0006	GU-0006	PFP	<2	1.8	3	U	0.72	1.3	0.13		1.5		0.03	U	0.13	U
04GU-96-0007	GU-0007	FP	<2	1.23	2.84	U	0.45	1.2	0.06	U	1.1		0.04	U	0.12	U

Sample ID	Location ID	Geomorphic Unit	Sieve Size (mm)	Th-232	Th-234	Qualifier	Tl-208	U-234	U-235	Qualifier	U-238	Qualifier	Y-88	Qualifier	Zn-65	Qualifier
04LA-96-0050	LA-0005	FP	<2	1.36	3.8	U	0.57	1.6	0.14		1.5		0.04	U	0.17	U
04LA-96-0051	LA-0006	AC	<2	0.94	3.57	U	0.35	1.4	0.11		0.75		0.03	U	0.35	U
04LA-96-0052	LA-0007	PFP	<2	2.02	3.68	U	0.81	2.2	0.16		2.1		0.06	U	0.21	U
04LA-96-0052	LA-0007	PFP	<0.0625	2.63	4.9	U	1.2	2.4	0.18		2.5		0.2	U	0.18	U
04LA-96-0053	LA-0008	AC	<2	1.32	4.46	U	0.6	1.3	0.13		1.3		0.06	U	0.27	U
04LA-96-0054	LA-0009	AC	<2	1.38	3.78	U	0.51	1.2	0.12		1.2		0.06	U	0.11	U
04LA-96-0055	LA-0010	PFP	<2	1.99	4.04	U	0.68	1.7	0.14		1.6		0.05	U	0.28	U
04LA-96-0056	LA-0011	FP	<2	1.86	3.33	U	0.75	1.7	0.14		1.7		0.03	U	0.13	U
04LA-96-0056	LA-0011	FP	<0.0625	2.26	5.95	U	0.82	2.6	0.18		2.2		0.24	U	0.45	U
04PU-96-0010	PU-0005	FP	<2	0.89	3.16	U	0.34	1	0.06	U	0.74		0.04	U	NA	
04PU-96-0011	PU-0006	FP	<2	1.01	2.8	U	0.37	1	0.06		0.84		0.04	U	0.15	U
04PU-96-0012	PU-0007	PC	<2	1.55	3.35	U	0.55	1.6	0.06	U	1.5		0.02	U	0.15	U
04PU-96-0013	PU-0008	AC	<2	1.41	3.1	U	0.68	1.1	0.06	U	1.1		0.02	U	0.1	U
04PU-96-0014	PU-0009	AC	<2	1.23	2.92	U	0.42	1	0.06	U	0.06	U	0.04	U	0.13	U
04PU-96-0015	PU-0010	FP	<2	1.12	2.9	U	0.52	1.1	0.06	U	1.2		0.02	U	0.13	U
04PU-96-0016	PU-0011	FP	<2	1.29	3.11	U	0.53	1.3	0.06		1.3		0.02	U	0.19	U
04PU-96-0016	PU-0011	FP	<0.0625	1.58	5.09	U	0.98	1.5	0.06	U	1.6		0.22	U	0.33	U
04PU-96-0017	PU-0012	PC	<2	0.66	2.64	U	0.28	0.59	0.06	U	0.51		0.03	U	0.24	U
04PU-96-0018	PU-0013	PFP	<2	2.03	3.56	U	0.77	1.9	0.06	U	1.7		0.03	U	0.16	U
04PU-96-0018	PU-0013	PFP	<0.0625	1.73	4.51	U	0.82	2	0.06	U	1.5		0.19	U	0.43	U
04PU-96-0019	PU-0014	PFP	<2	1.88	3.22	U	0.65	1.7	0.06	U	1.5	U	0.05	U	0.26	U

Note: (x) = black magnetite sand sample, U = not detected, NA = not analyzed; FP = active floodplain, AC = active channel, PFP = prehistoric floodplain, PC = prehistoric channel.

APPENDIX D RESULTS OF PARTICLE-SIZE DISTRIBUTION ANALYSIS

Field Site #	Sample ID	Geomorphic Unit	Sample Depth (cm)	Size Interval (mm) as % wt.									Sand % wt.	Silt % wt.	Clay % wt.	>2 mm % wt.
				1.0–2.0	1.0–0.05	0.05–0.25	0.25–0.125	0.125–0.0625	0.0625–0.015	0.015–0.002	<0.002	Total				
Upper Los Alamos Canyon																
ULA-1	04LA-96-0050	FP	3–18	0.03	5.53	9.59	18.81	19.91	27.33	13.9	4.9	100	53.87	41.23	4.9	14.6
ULA-2	04LA-96-0051	AC	0–10	4.47	40.75	28.05	13.38	6.11	4.33	1.5	1.4	99.99	92.76	5.83	1.4	66.3
ULA-3	04LA-96-0052	PFP	22–34	3.85	8.33	11.48	21.8	21.94	17.91	9.6	5.1	100.01	67.4	27.51	5.1	6.1
ULA-4	04LA-96-0053	AC	4–13	0.25	30.66	32.34	17.28	8.64	4.43	3.6	2.8	100	89.17	8.03	2.8	47.8
ULA-5	04LA-96-0054	PC	10–38	2.07	30.4	26.11	15.63	10.93	7.15	4.4	3.3	99.99	85.14	11.55	3.3	56.6
ULA-6	04LA-96-0055	PFP	22–41	0.85	13.08	26.84	22.23	17.15	13.04	4.4	2.4	99.99	80.15	17.44	2.4	9.7
ULA-7	04LA-96-0056	FP	3–28	6.91	14.57	19.12	21.26	17.9	11.45	5.5	3.3	100.01	79.76	16.95	3.3	54.1
Upper Guaje Canyon																
UGC-1	04GU-96-0001	FP	0–23	4.45	23.37	27.39	18.59	11.76	9.83	2.9	1.7	99.99	85.56	12.73	1.7	16.8
UGC-2	04GU-96-0002	AC	0–5	3.36	9.9	10.29	14.16	18.92	31.16	7.6	4.6	99.99	56.63	38.76	4.6	11.2
UGC-3	04GU-96-0003	FP	1–14	4.48	31.37	32.05	17.75	7.76	4.48	1.2	0.9	99.99	93.41	5.68	0.9	38.9
UGC-4	04GU-96-0004	PFP	160–190	5.38	17.05	21.92	14.33	12.73	18.89	6	3.7	100	71.41	24.89	3.7	19
UGC-5	04GU-96-0005	AC	0–19	20.81	42.65	22.25	7	3.36	3.13	0.6	0.2	100	96.07	3.73	0.2	28.4
UGC-6	04GU-96-0006	PFP	64–74	0.7	9.09	21.4	20.69	18.94	18.29	6.5	4.4	100.01	70.82	24.79	4.4	11.7
UGC-7	04GU-96-0007	FP	0–5	7.87	34.81	32.08	13.26	5.46	4.82	1.2	0.5	100	93.48	6.02	0.5	30.7

Field Site #	Sample ID	Geomorphic Unit	Sample Depth (cm)	Size Interval (mm) as % wt.									Sand % wt.	Silt % wt.	Clay % wt.	>2 mm % wt.
				1.0–2.0	1.0–0.05	0.05–0.25	0.25–0.125	0.125–0.0625	0.0625–0.015	0.015–0.002	<0.002	Total				
Upper Pueblo Canyon																
UPCN-1	04PU-96-0010	FP	0–10	3.53	36.76	20.69	5.16	4.99	26.87	0.6	1.4	100	71.13	27.47	1.4	5
UPCN-2	04PU-96-0011	FP	3–28	10	23.77	23	11.21	9.75	19.67	1.9	0.7	100	77.73	21.57	0.7	22.3
UPCN-3	04PU-96-0012	PC	13–23	2.15	13.14	21.23	17.54	14.38	14.46	9.4	7.7	100	68.44	23.86	7.7	63.2
UPCN-4	04PU-96-0013	AC	0–25	1.22	15.02	26.9	19.75	11.73	15.58	6.9	2.9	100	74.62	22.48	2.9	32.9
UPCN-5	04PU-96-0014	AC	0–25	2.32	15.7	19.45	17.81	16.26	17.65	7.1	3.7	99.99	71.54	24.75	3.7	25.1
UPCN-6	04PU-96-0015	FP	0–25	1.82	19.74	19.12	11.89	11.52	20.51	10.8	4.6	100	64.09	31.31	4.6	35.9
UPCN-7	04PU-96-0016	FP	0–25	15.44	24.55	15.63	10.62	9.01	11.85	7.8	5.1	100	75.25	19.65	5.1	21.2
Lower Pueblo Canyon																
LPC-1	04PU-96-0017	PC	71–102	24.25	54.8	15.38	2.59	1.02	1.36	0.4	0.2	100	98.04	1.76	0.2	11.4
LPC-2	04PU-96-0018	PFP	57–76	9.09	7.18	4.3	6.73	19.99	34.91	12	5.8	100	47.29	46.91	5.8	7.8
LPC-3	04PU-96-0019	PFP	108–114	0.29	1.73	2.74	10.56	30.91	19.39	23	11.4	100.02	46.23	42.39	11.4	3.4

Note: FP = Active floodplain, AC = active channel, PFP = prehistoric floodplain, PC = prehistoric active channel.

APPENDIX E PROBABILITY PLOTS

The probability plots show each background analytical result ordered from lowest to highest. Detected values are shown as solid circles, and nondetects, plotted as one-half of the detection limit, are shown as open circles. The x-axis is the standard normal quantile scale. The units of the standard normal quintile are in standard deviation, where I represents one sigma or standard deviation. The y-axis of the probability plot is the concentration of the inorganic chemicals (in mg/kg) or radionuclides (in pCi/g). The purpose of these plots is twofold. First, they are a succinct way to present all data for each analyte. Second, they provide a way to assess the statistical distribution of each analyte. Specifically, if the data for an analyte follow a straight line when plotted on an untransformed or standard normal scale, these data are considered to originate from a normal statistical distribution. One can assess the fit to other statistical distributions by transforming the y-axis to another scale. For example, chemicals frequently follow a lognormal distribution, and transforming the y-axis into a logarithmic scale assesses the fit to a lognormal distribution.

This appendix contains probability plots for each analyte on three scales: (1) untransformed, (2) square root transformation, and (3) natural logarithmic transformation. Probability plots for inorganics are provided in Figure E-1, and probability plots for radionuclides are provided in Figure E-2.

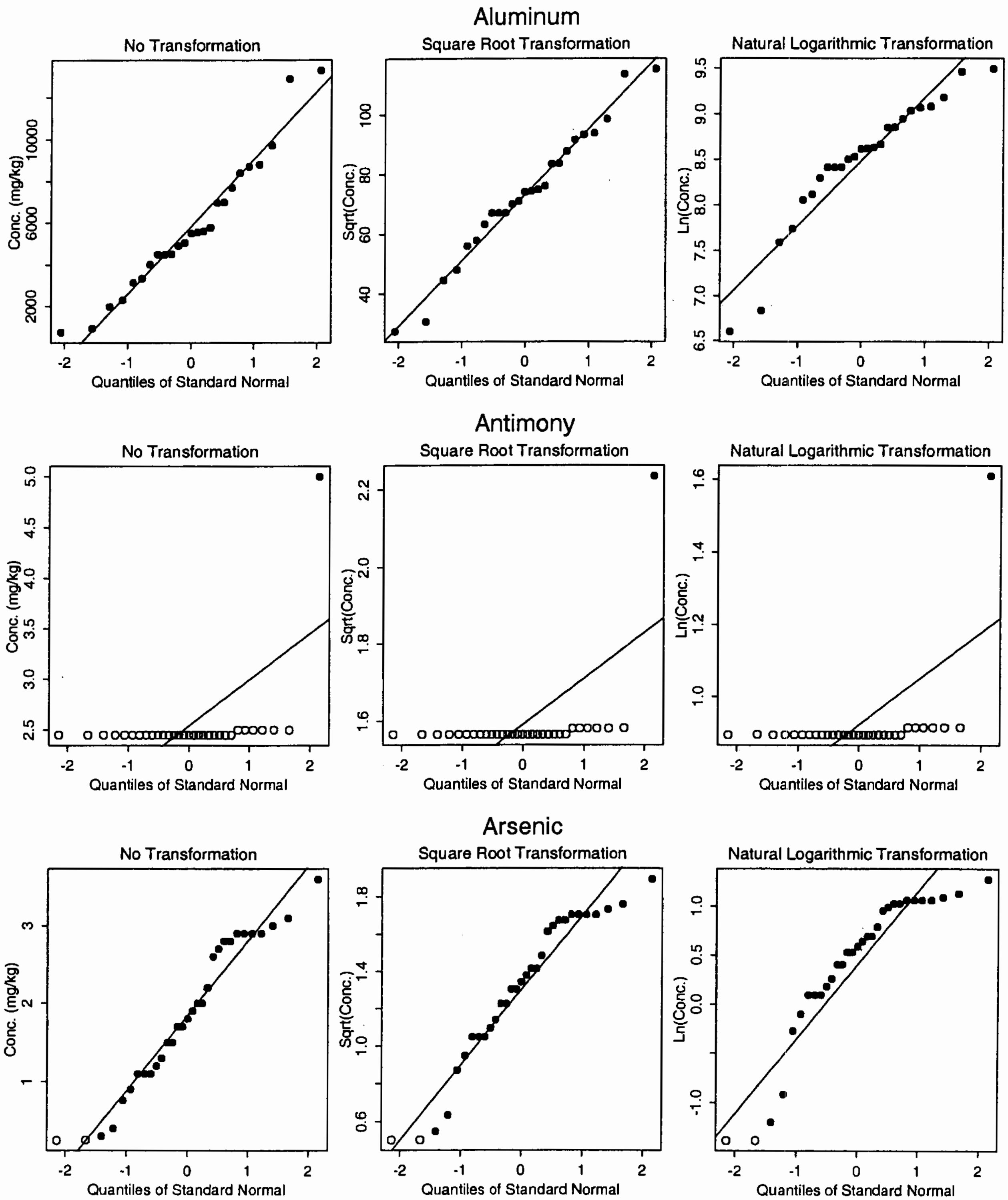

Figure E-1. Probability plots for inorganic sediment data

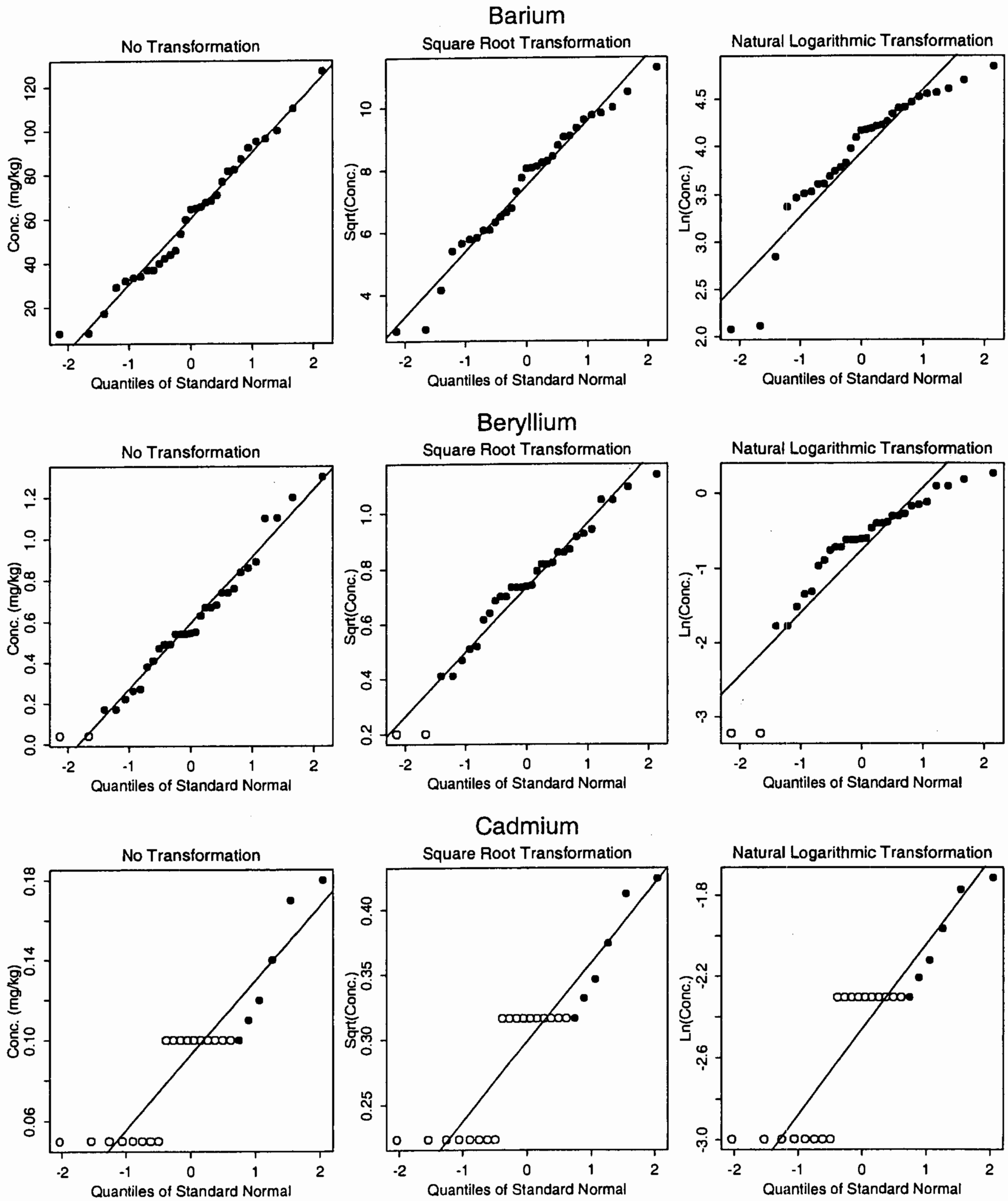

Figure E-1 (continued). Probability plots for inorganic sediment data

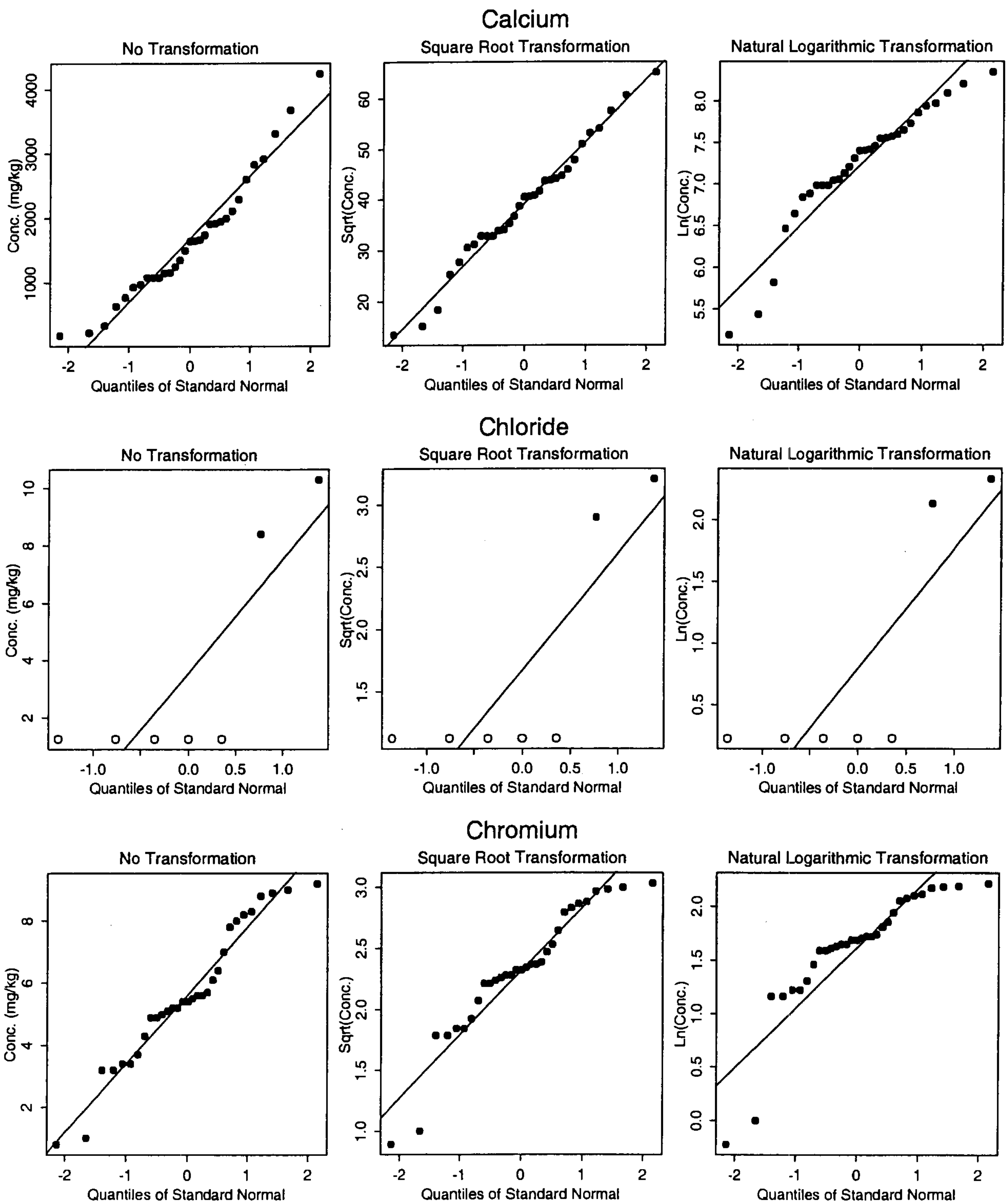

Figure E-1 (continued). Probability plots for inorganic sediment data

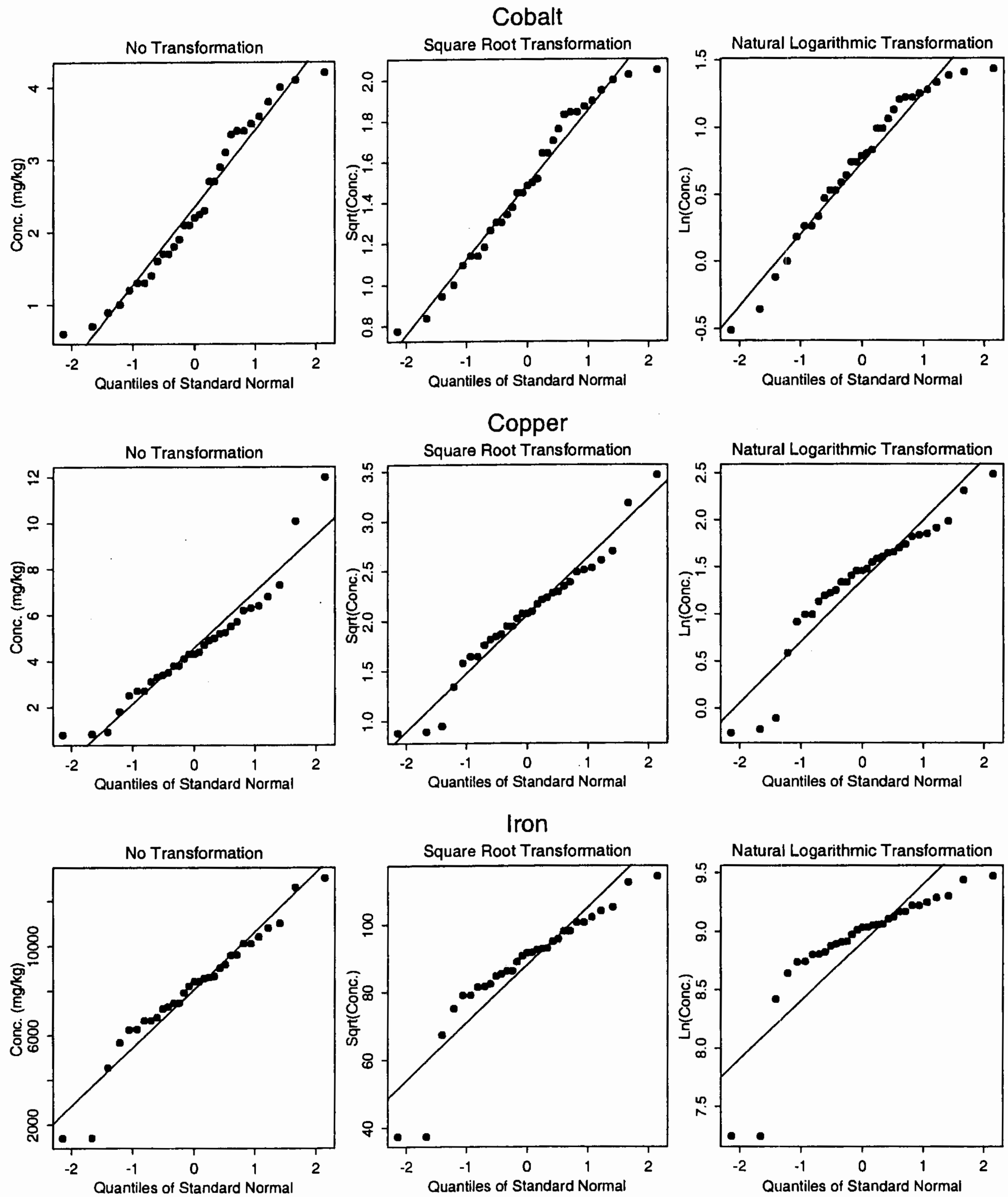

Figure E-1 (continued). Probability plots for inorganic sediment data

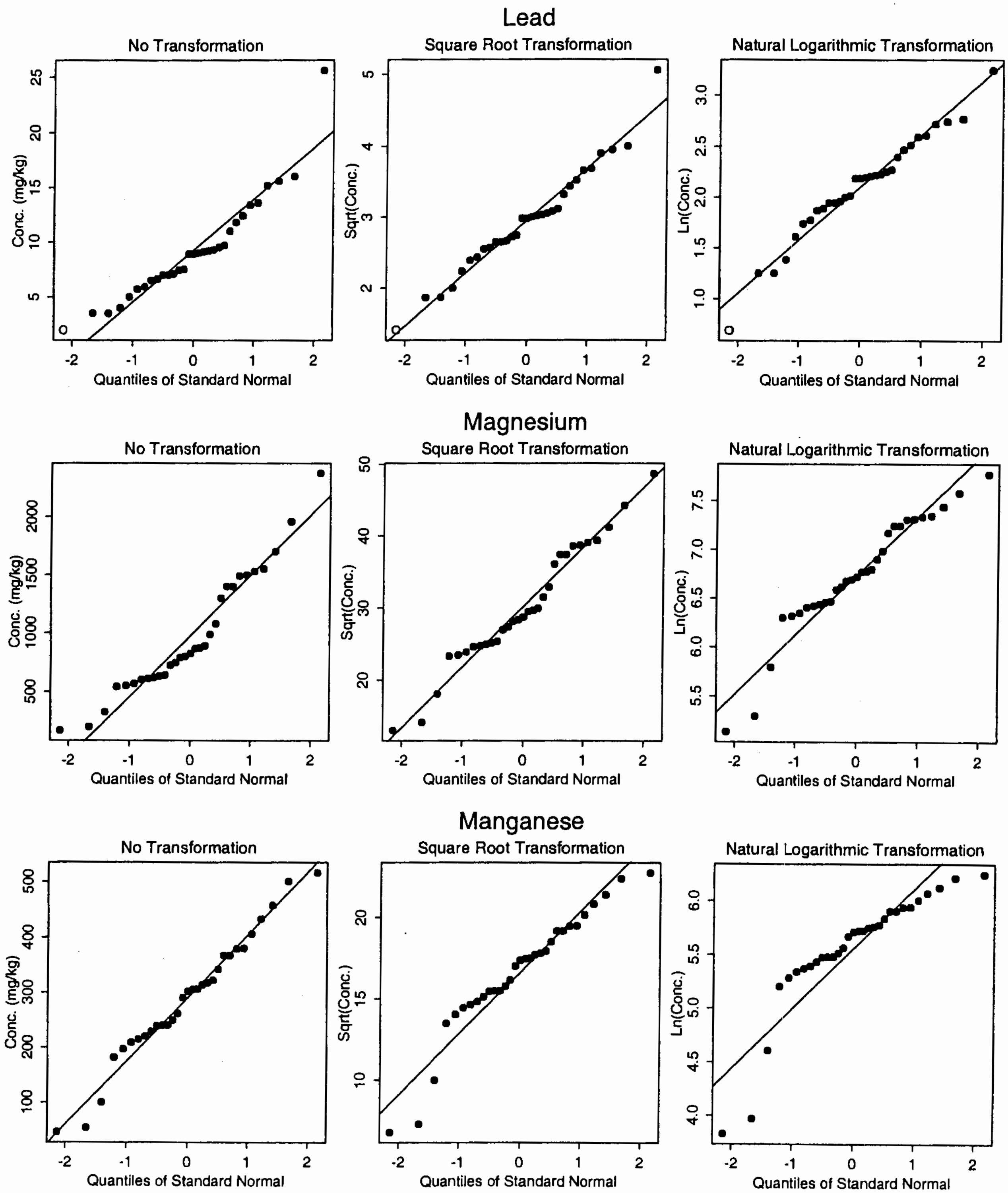

Figure E-1 (continued). Probability plots for inorganic sediment data

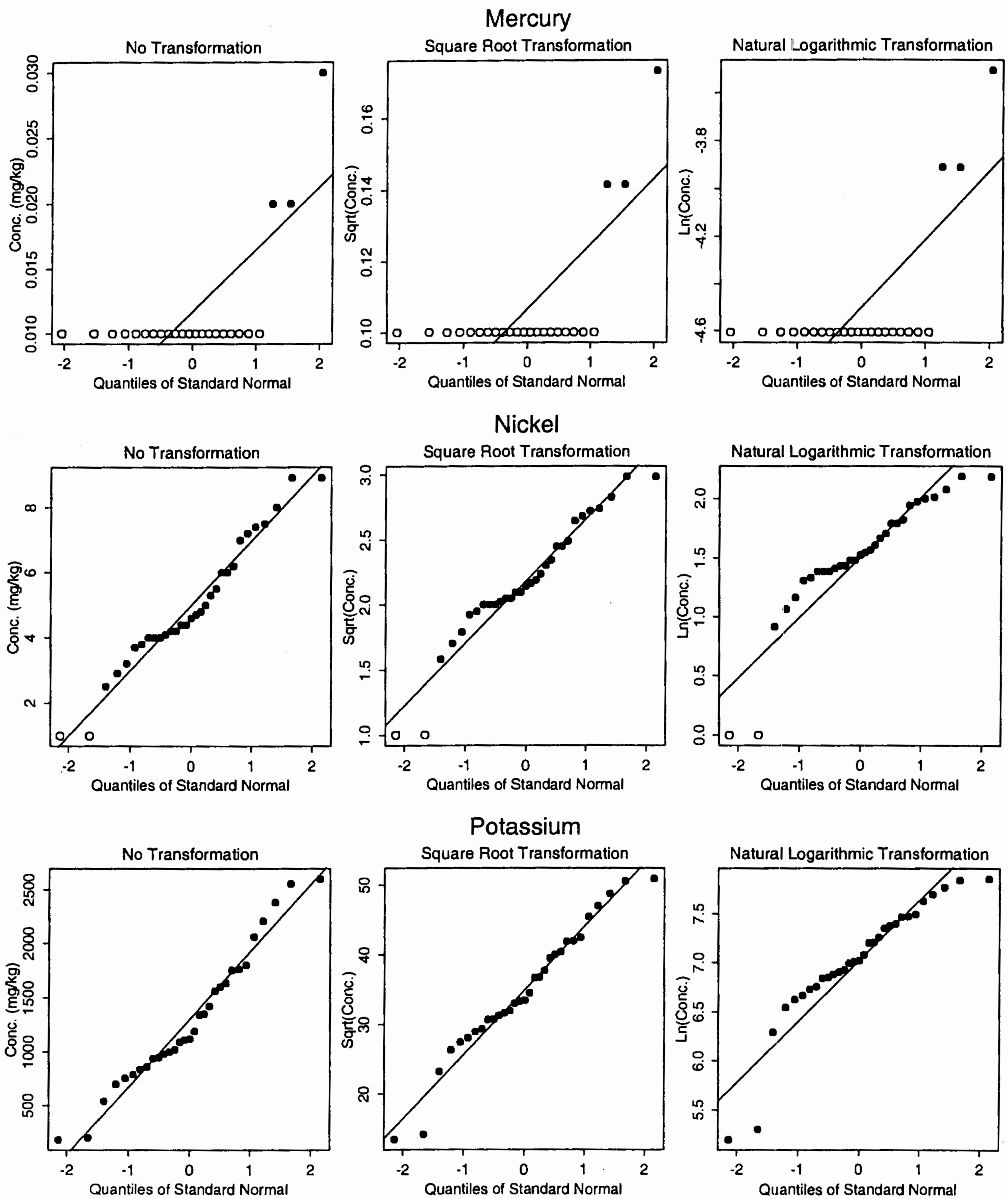

Figure E-1 (continued). Probability plots for inorganic sediment data

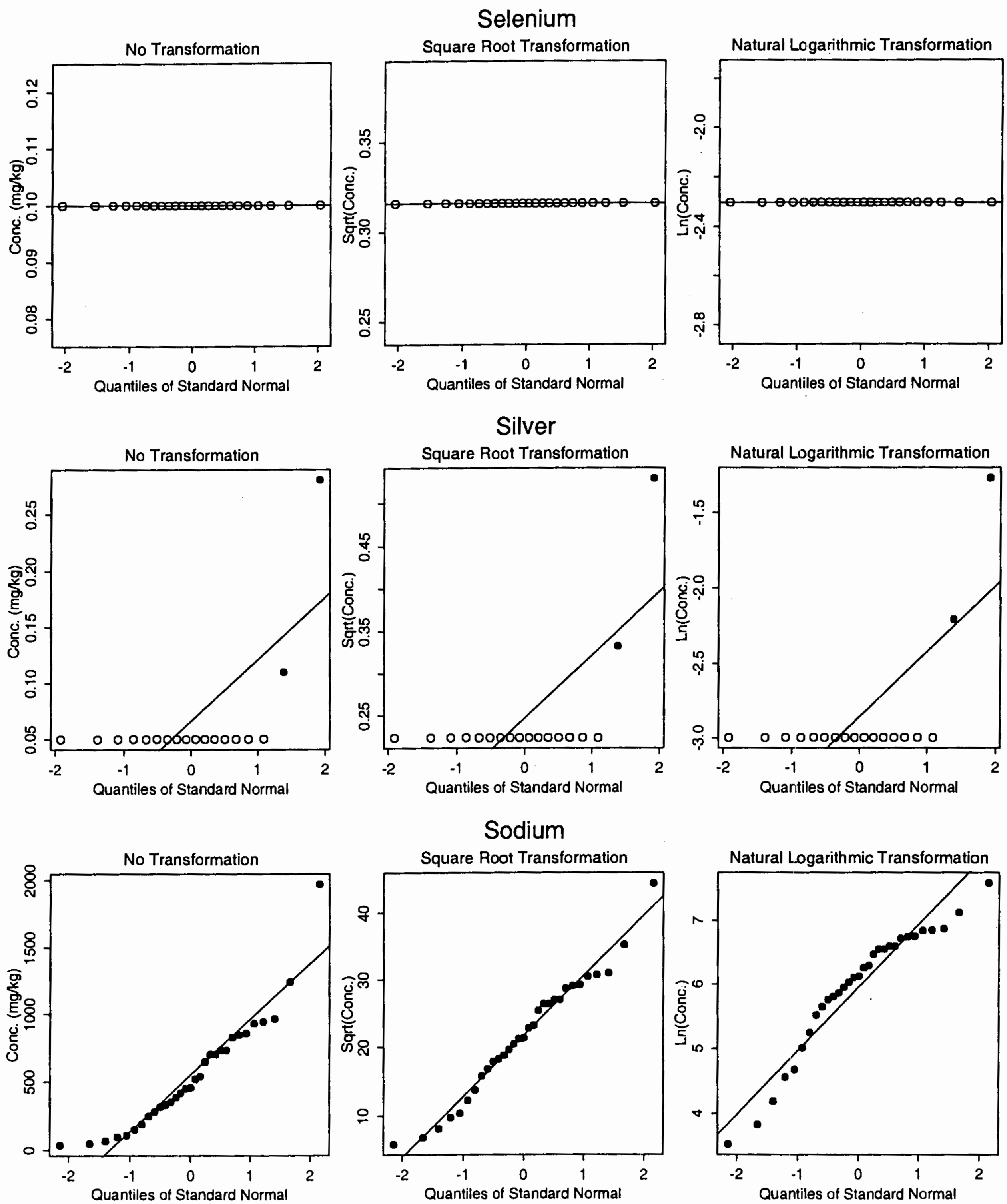

Figure E-1 (continued). Probability plots for inorganic sediment data

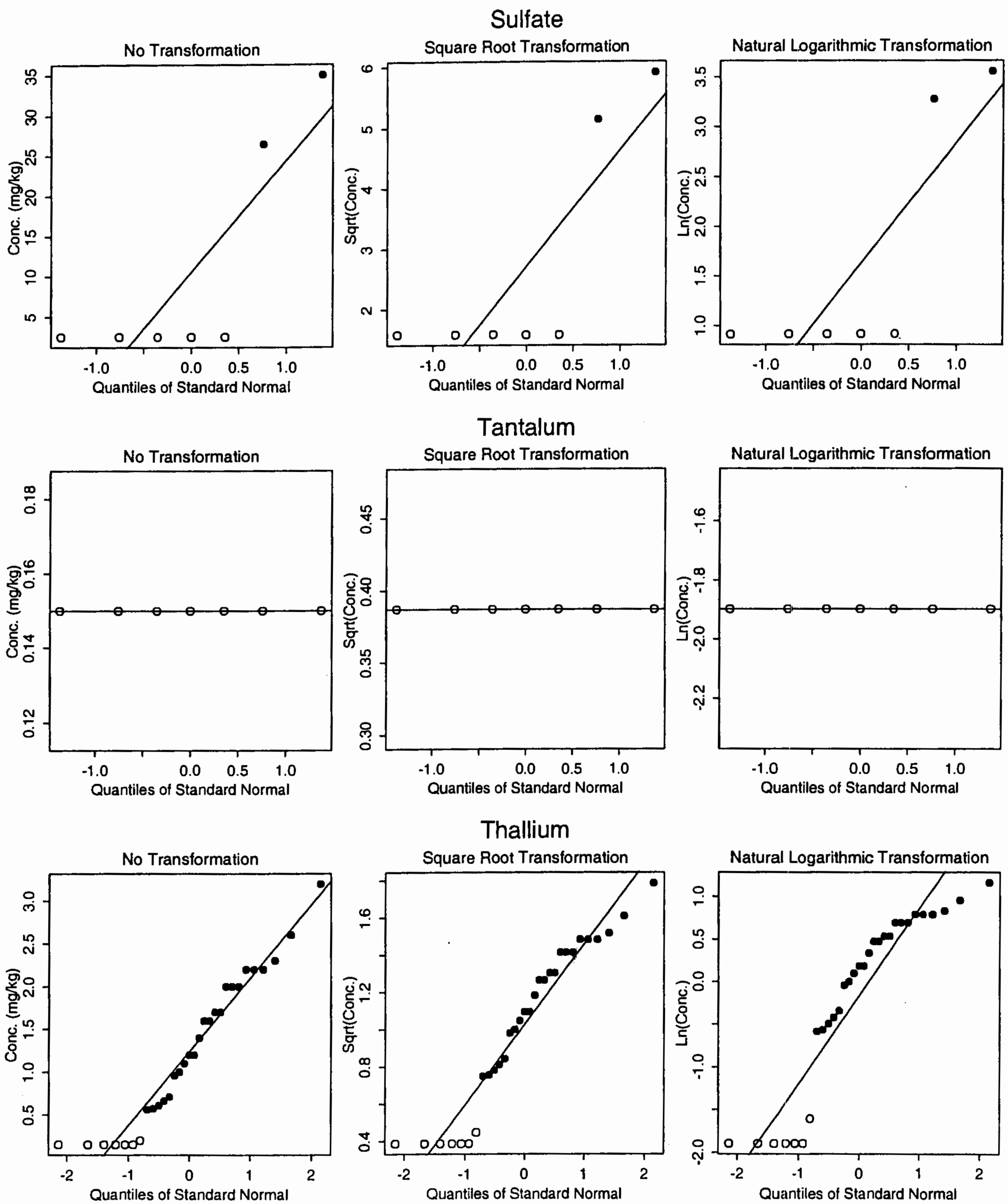

Figure E-1 (continued). Probability plots for inorganic sediment data

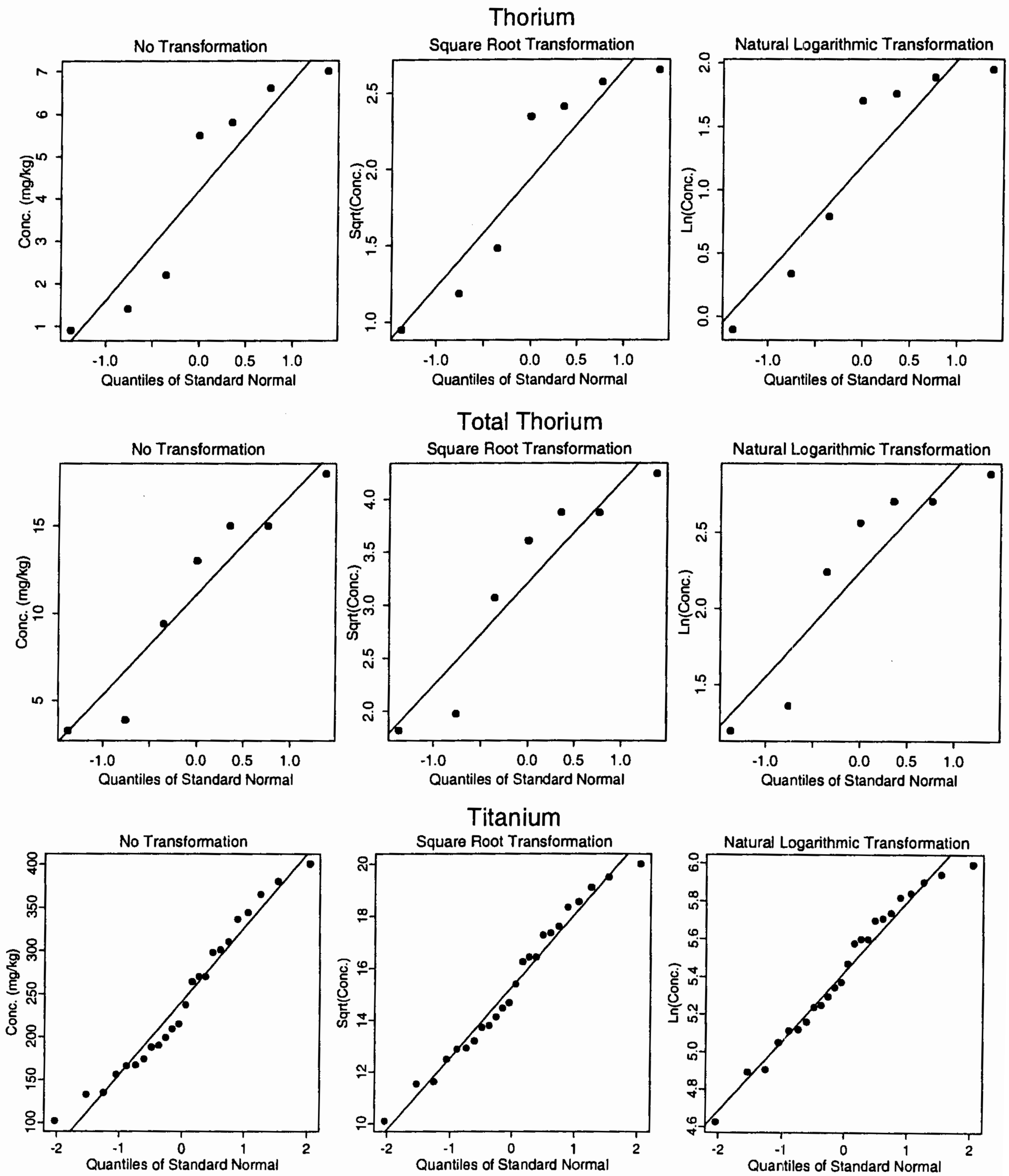

Figure E-1 (continued). Probability plots for inorganic sediment data

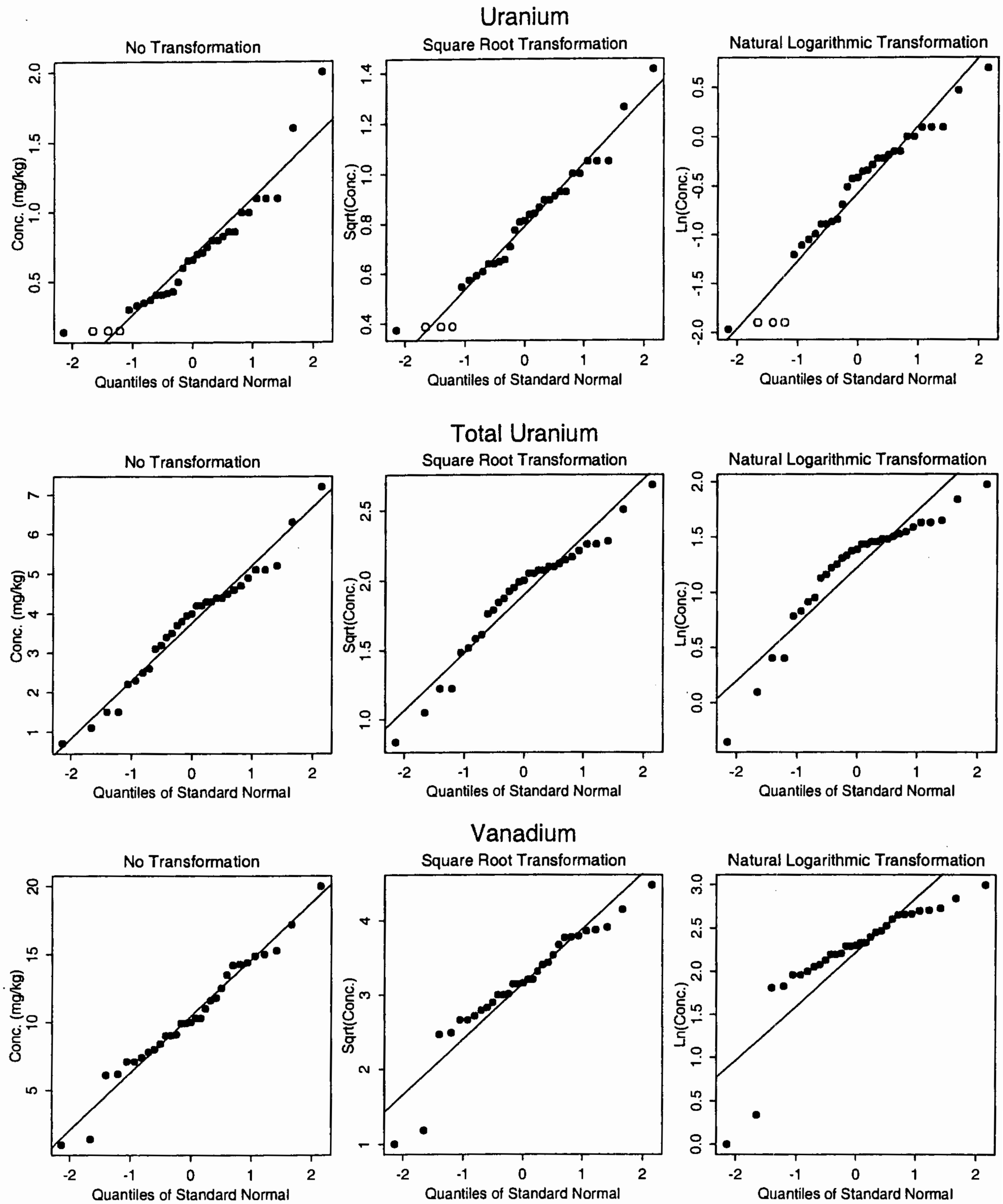

Figure E-1 (continued). Probability plots for inorganic sediment data

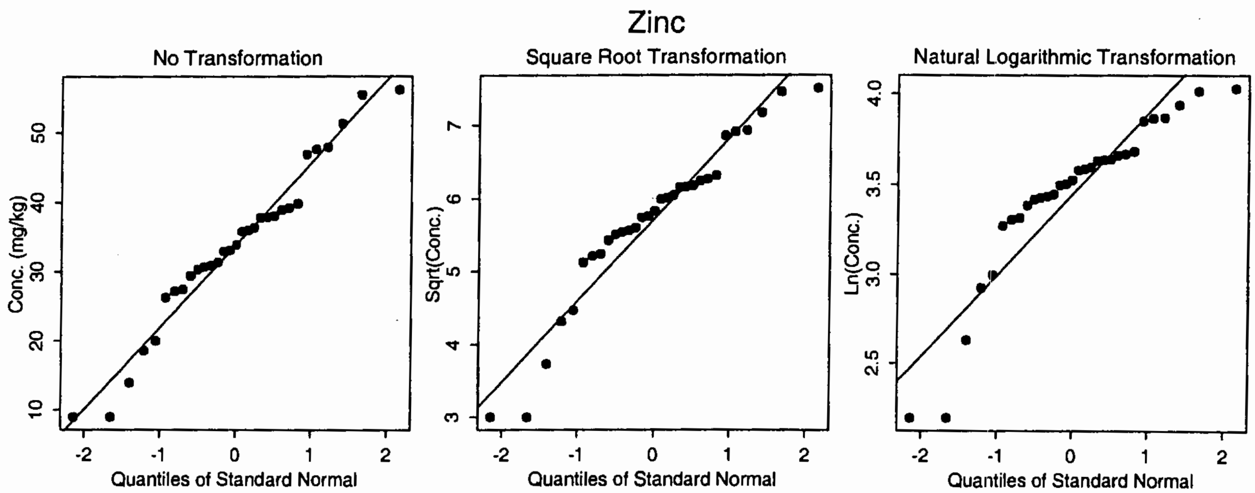

Figure E-1 (continued). Probability plots for inorganic sediment data

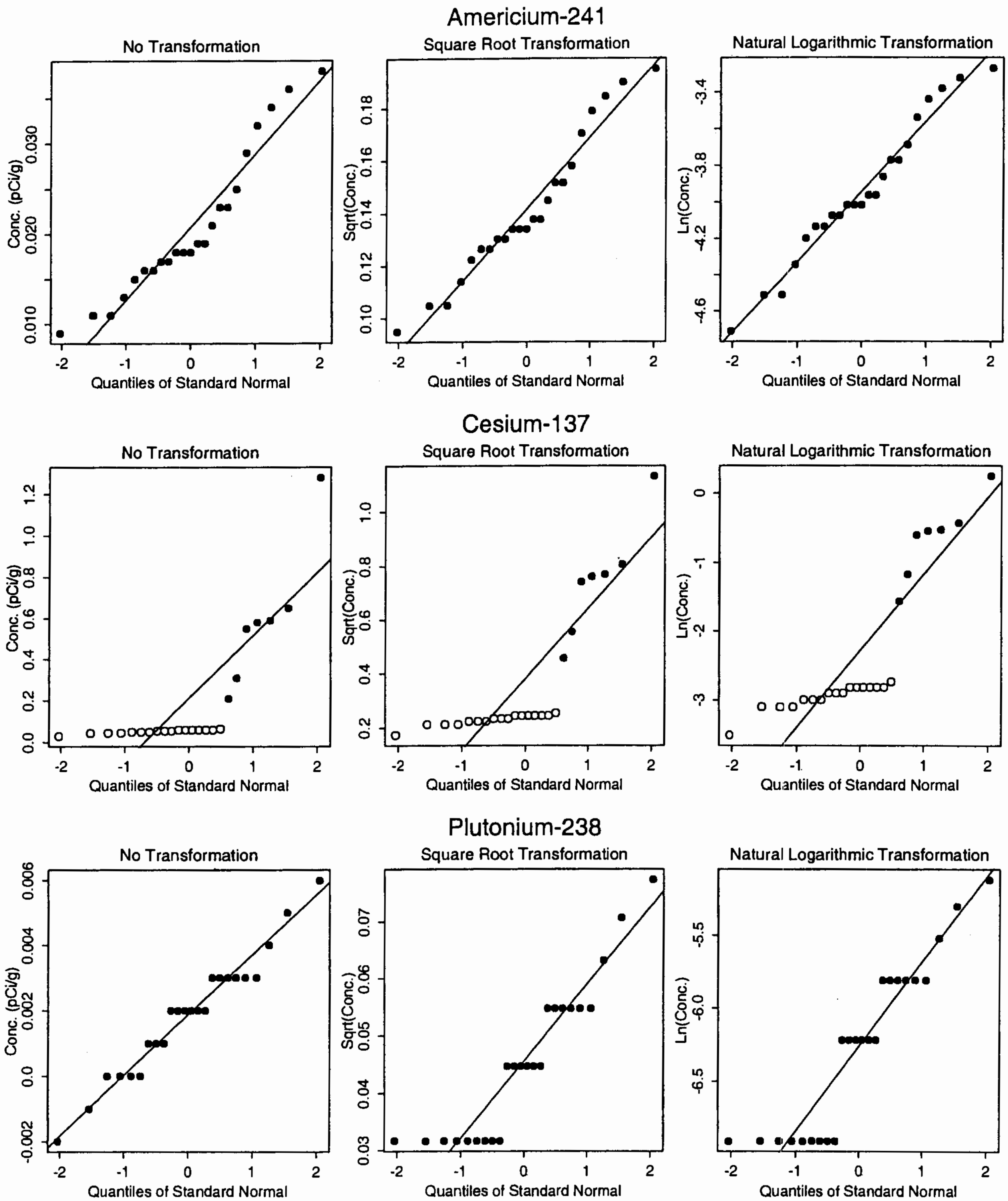

Figure E-2. Probability plots for radionuclide sediment data

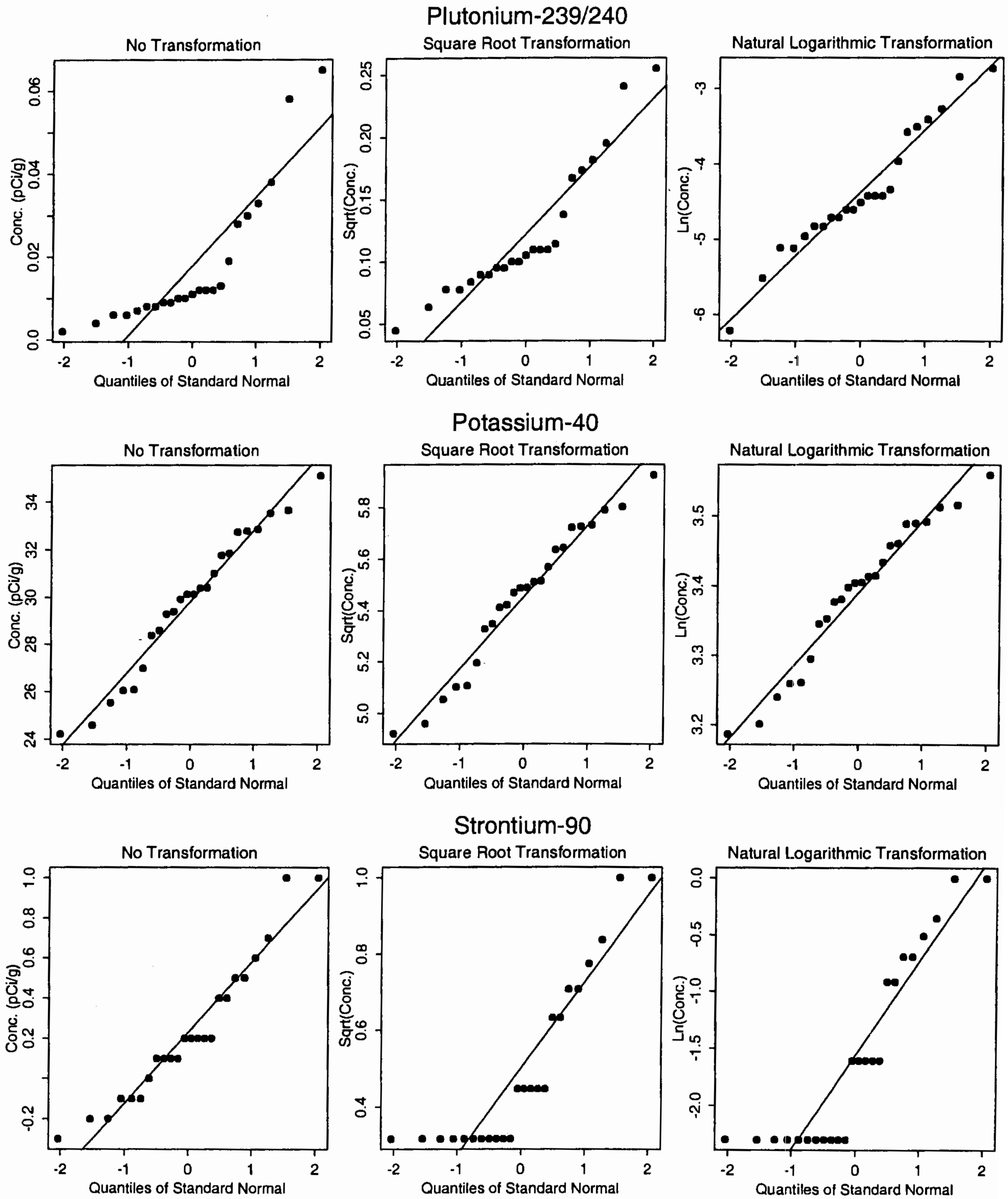

Figure E-2 (continued). Probability plots for radionuclide sediment data

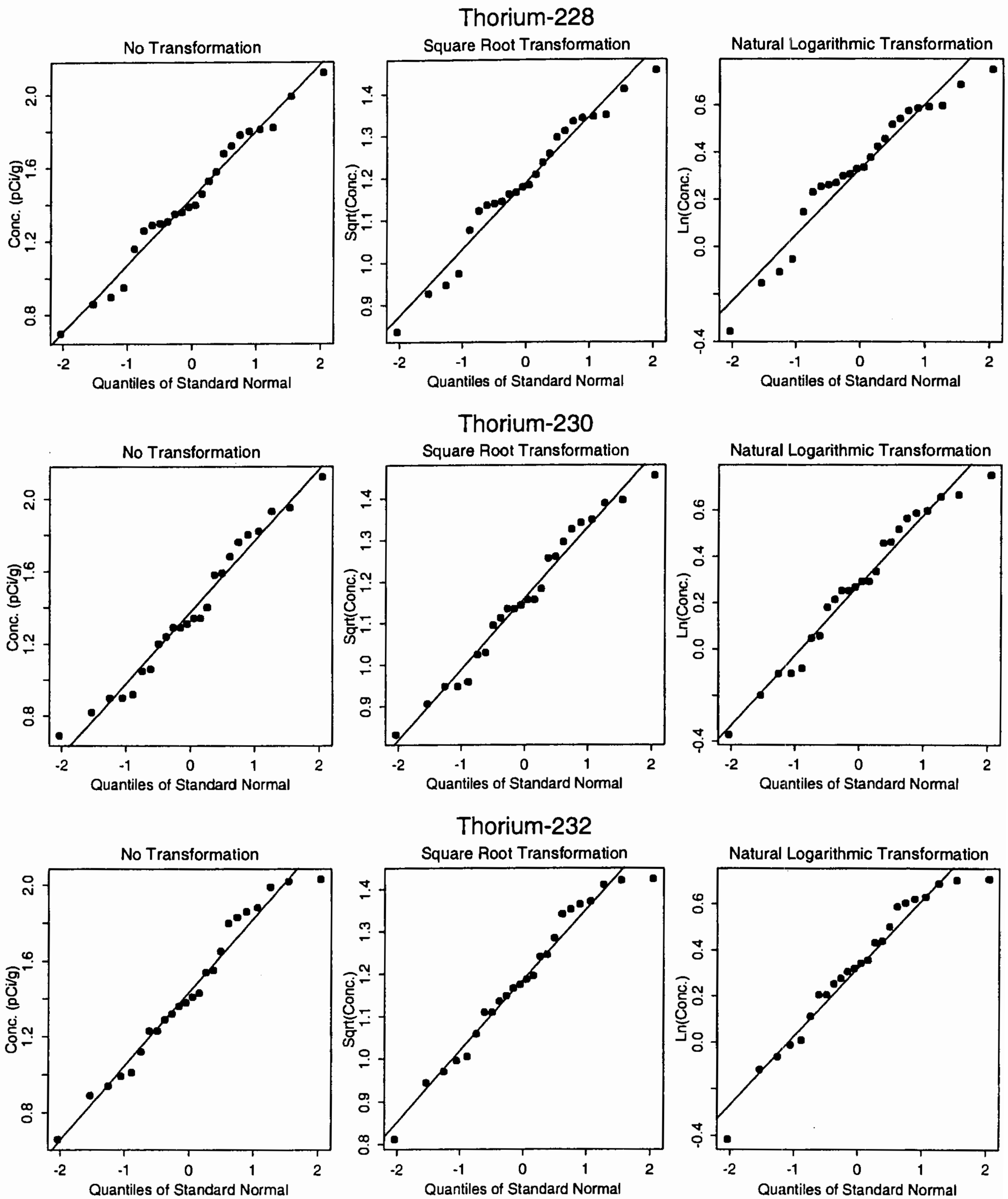

Figure E-2 (continued). Probability plots for radionuclide sediment data

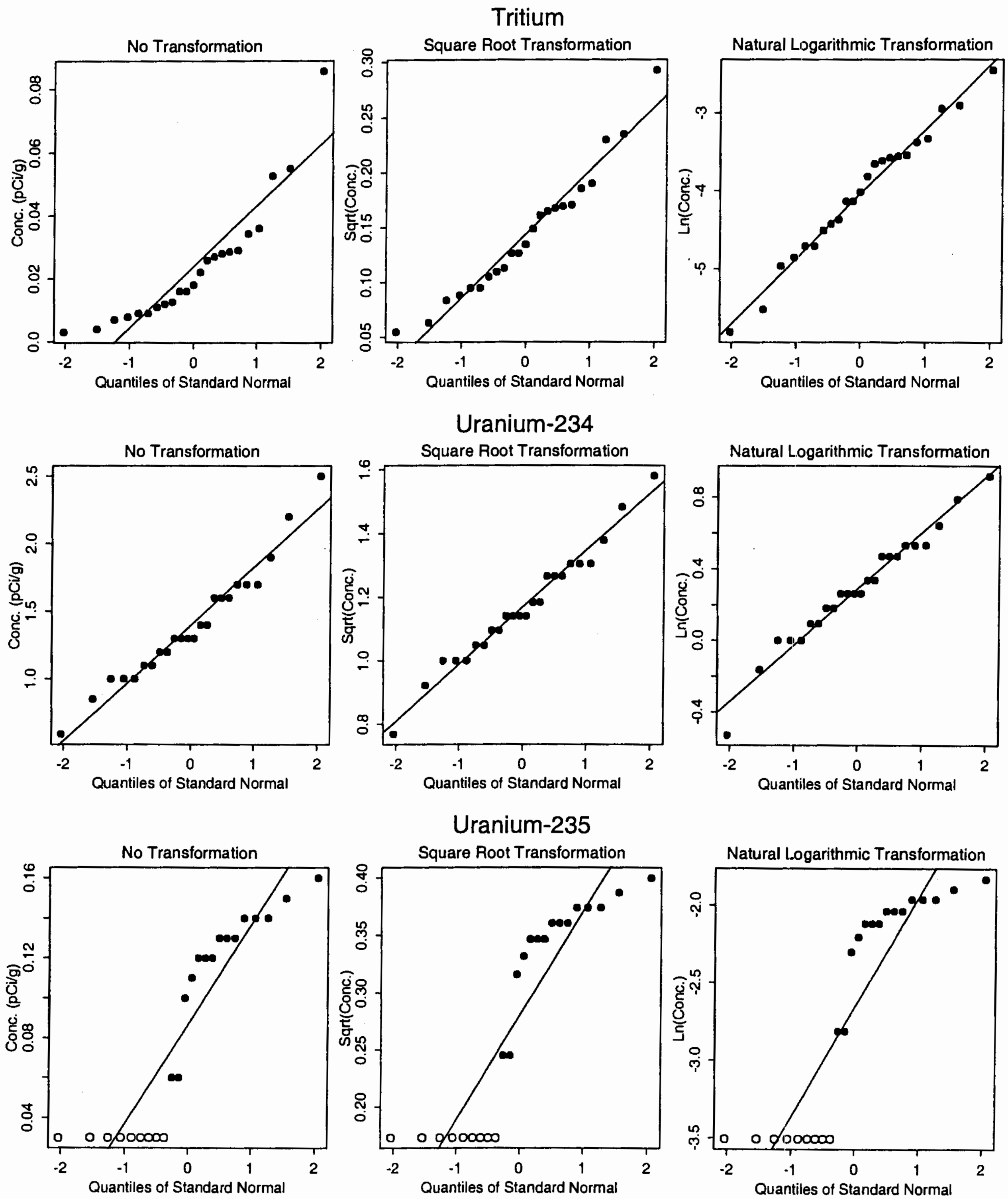

Figure E-2 (continued). Probability plots for radionuclide sediment data

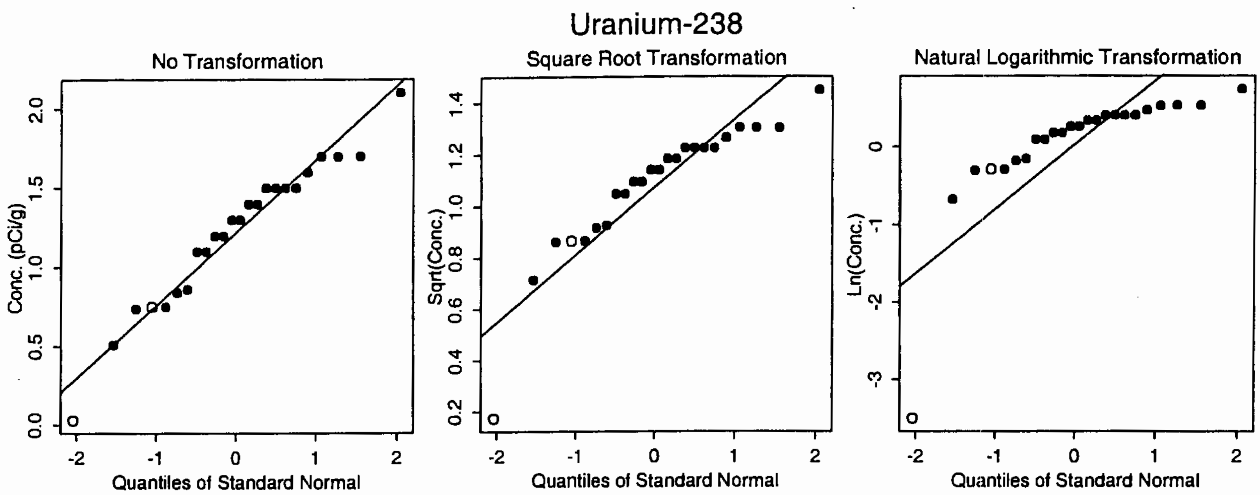

Figure E-2 (continued). Probability plots for radionuclide sediment data

APPENDIX F S-PLUS CODE USED TO CALCULATE LOGNORMAL UTLS

File: lnorm_utl1.s

```
function(q,p,n,ave,sd,nt)
{
# lnorm_utl1.s is used as function LUTL1 in Splus
# This function is used to estimate the upper p% CI of the qth percentile
# percentile for a lognormal distribution.  Uses Gilbert's MBE (minimum unbiased estimator) of
LN.
#    q = the quantile to estimate
#    p = the confidence limit of q
#    n = number of values sampled
#  ave = mean of logtranformed data
#   sd = st. dev. of logtranformed data
#   nt = number of simulation trials
#.............................................................

# Calculate the qth quantile of the normal distribution
q1 <- qnorm(q)

# Initialize arrays
t1 <- rep(-1,n)
t2 <- rep(-1,nt)

i <- 0

repeat

  { i <- i+1

# Get the "n" lognormal samples
    t1 <- rlnorm(n,ave,sd)

# Calculate the mean and sd the hard way
    dummy <- lnormUMV.s(t1)
    ave1 <- dummy$mu
    sd1 <- sqrt(dummy$s2)

# Calculate an estimate of the qth percentile
    t2[i] <- exp(ave1+q1*sd1)
    if(i>=nt) break
  }

# Find the upper p*100% of the qth percentile
quantile(t2,p)
}
```

File: lnormUMV.s

```
function(x)
{
# lnormUMV.s (Splus function)
# Calls: psi.s
# Min Variance Unbiased ests of parameters of lognormal(mu,var=s2) distn
# for X~lognorm(mu,s2), Y=log(X)~normal(mu,s2)
# returns:E=mean(X), V=var(X)
#       mu=mean(Y),s2=var(Y)
# ref:Gilbert('87),Stat Methods for Env Pollution Mon, pp165-166
        n <- length(x)
        y <- log(x)
        ymu <- mean(y)
        vy <- var(y)
        psi1 <- psi.s(vy/2, n)
        psi2 <- psi.s(2 * vy, n)
        psi3 <- psi.s((vy * (n - 2))/(n - 1), n)
        E <- exp(ymu) * psi1
        V <- exp(2 * ymu) * (psi2 - psi3)
        mu <- log(E^2/(V + E^2)^0.5)
        s2 <- log(V/E^2 + 1)
        return(E, V, mu, s2)
}
```

File: psi.s

```
function(t, n)
{
# psi.s (Splus function)
# called by lnormUMV.s
# psi function in Gilbert('87) Stat. Meth. Env. Pollution. Mon, pp 165
# for Min Variance Unbiased ests of parameters of lognormal(mu,var=s2) distn
        psi <- 0
        psi[1] <- ((n - 1) * t)/n
        for(i in 1:25) {
                psi[i + 1] <- (psi[i] * (n - 1)^2 * t)/((i + 1) * n * (n + (2 *
                        i - 1)))
                if(abs((psi[i + 1] - psi[i])/psi[i]) < 1e-09)
                        break
        }
        psi <- 1 + sum(psi)
        psi
}
```

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Document Catalog Number: ER2003-0205
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Document Title /Subject: NATURAL BACKGROUND GEOCHEMISTRY AND STATISTICAL ANALYSIS OF SEDIMENTS, LOS ALAMOS NATIONAL LABORATORY

PRSs: None **Privileged Information: Y / N**

Associated Document Catalog Number(s): None

Author: ~~Reneau, Steve~~ ~~665-3151~~ ~~sreneau~~@lanl.gov RYTI, RANDALL 662 0707, x12 rryti

Author Organization: Canyons

Document Team: None

Document Type: Technical Papers/Report **Former OU:** N/A

RECEIVED OCT 30 2003 BY EK

Date Due: Unknown **Date Final Complete:** Unknown

Date Sent to DOE: Unknown **Date Sent to NMED:** Unknown

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