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Evaluation of Possible Sediment Contamination in the White Rock Land Transfer Parcel: Reach CDB-4

Los Alamos
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Produced by the Canyons Focus Area

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EXECUTIVE SUMMARY

This report presents the results of an investigation of potentially contaminated sediments in Cañada del Buey, within an area known as the White Rock land transfer parcel (canyon reach CDB-4). Cañada del Buey is a canyon that drains part of Los Alamos National Laboratory (the Laboratory), in Los Alamos County, New Mexico. The proposed transfer would move a parcel of land from Laboratory control to Los Alamos County and San Ildefonso Pueblo control.

The objectives of this work included defining the nature and extent of any contamination within the sediments of reach CDB-4, evaluating potential human health and ecological risk, and providing recommendations concerning potential additional assessments or remedial actions prior to any land transfer.

Cañada del Buey may have received contaminants from multiple potential release sites (PRSs) within the watershed, including PRSs within technical area 46 (TA-46), TA-51, TA-54, and former TA-4. However, this investigation identified no contaminants in young (post-1942) sediments from reach CDB-4. Although a series of inorganic chemicals were detected at levels above Laboratory-wide sediment background levels, these results can be attributed to a local background which differs from that of areas previously sampled for background geochemistry. Therefore, it is recommended that no additional assessment or remedial action is required before land transfer.

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1.0 INTRODUCTION

1.1 Purpose

This report describes an investigation of sediment in the proposed White Rock land transfer parcel (Figure 1.1-1). This investigation was conducted during 1999 by personnel from the Canyons Focus Area as part of the Laboratory's Environmental Restoration (ER) Project. The investigation focused on a single reach of Cañada del Buey, reach CDB-4, following the technical strategy described in the "Core Document for Canyons Investigations" (the "core document") (LANL 1997, 55622; LANL 1998, 57666). Data collected from reach CDB-4 have been used to evaluate possible contamination resulting from Laboratory activities that might pose a risk to human health or ecosystems and affect the proposed land transfer. The subject medium of the investigation was restricted to sediments because there is no alluvial groundwater in this part of Cañada del Buey and there is no surface water, except for occasional stormwater events. In a future report, these data will be combined with additional data from elsewhere in Cañada del Buey to support an assessment of the entire length of the canyon. That assessment will involve a more comprehensive evaluation of the human health and ecological risk related to present-day levels of contamination and the effects of future transport of contaminants.

1.2 Legislative and Regulatory Context

During November 1997, Congress enacted legislation that required the Secretary of Energy to identify land at the Laboratory for potential conveyance and transfer to either Los Alamos County or to the Secretary of the Interior, to be held in trust for the Pueblo of San Ildefonso (Public Law 105-119, the Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriations Act, 1998). The White Rock parcel was one of ten areas identified by the Secretary and the Department of Energy (DOE) for possible land transfer (DOE 1998, 58671). Public Law 105-119 also directed the DOE to identify any environmental restoration or remediation that these parcels would require prior to transfer. As presented in "Environmental Restoration Report to Support Land Conveyance and Transfer under Public Law 105-119" (LANL 1999, 63037), the White Rock parcel had not yet been characterized and the extent of any potential contamination was unknown. The work presented in this report was conducted to evaluate the need for any remediation prior to land transfer.

The work presented in this report was also designed to be consistent with other ER Project investigations, and to help satisfy additional regulatory requirements. The regulatory requirements governing the ER Project canyons investigations are discussed in Section 1.4 of the core document (LANL 1997, 55622; LANL 1998, 57666). In particular, these investigations address requirements of Module VIII of the Laboratory's Hazardous Waste Facility Permit (the "HSWA module") (EPA 1990, 01585) under the Resource Conservation and Recovery Act (RCRA). These requirements include addressing "the existence of contamination and the potential for movement or transport to or within Canyon watersheds." In addition to federal and state regulations, DOE Order 5400.5, "Radiation Protection of the Public and the Environment," provides guidance on evaluating residual radioactivity at DOE facilities.

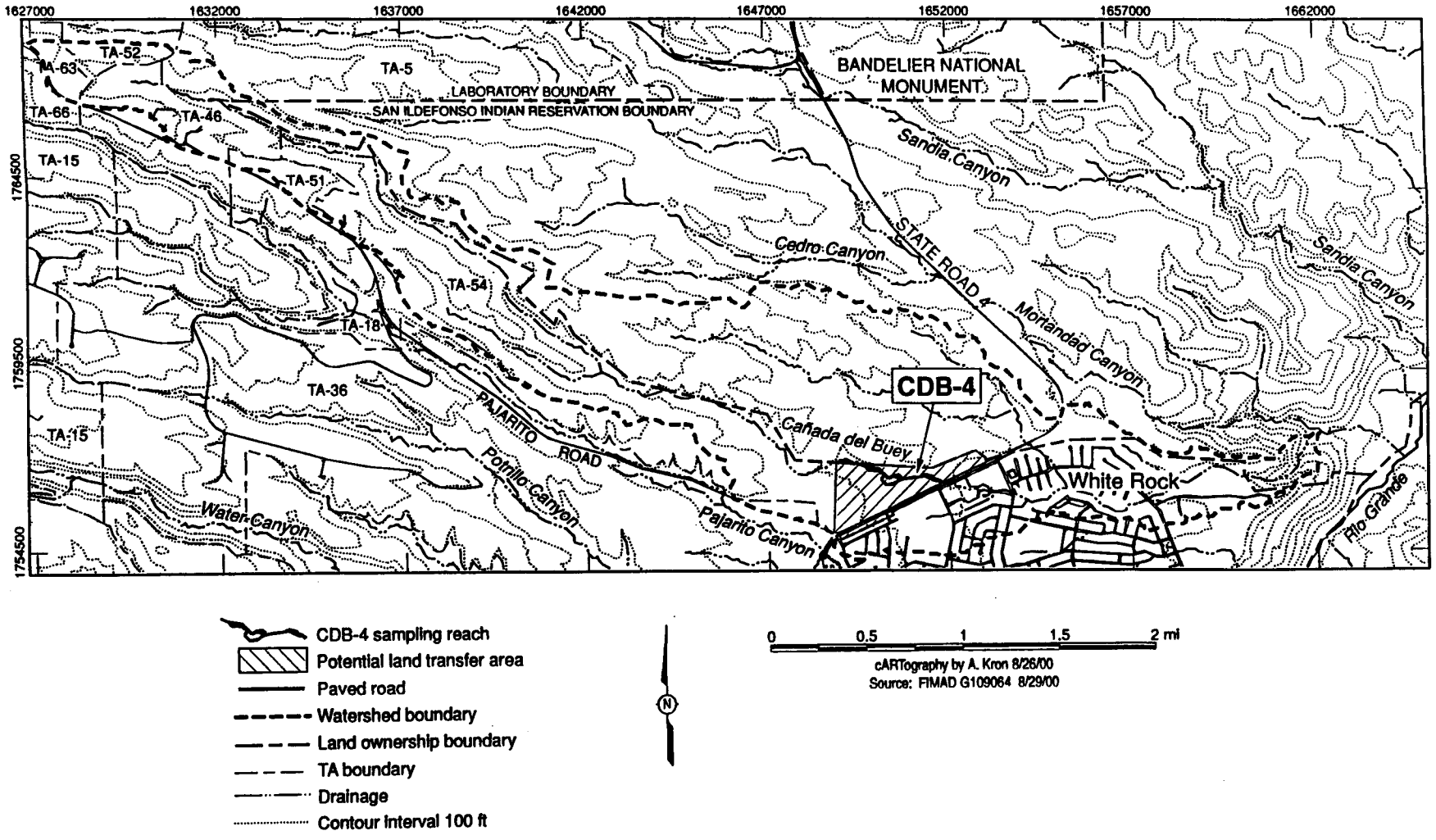


Figure 1.1-1. **Map of the Cañada del Buey watershed, showing property boundaries, Laboratory technical areas, and reach CDB-4**

1.3 Background

1.3.1 Geography, Geology, and Hydrology

Cañada del Buey heads on the Pajarito Plateau (on Laboratory land) and extends eastward through the community of White Rock to its confluence with Mortandad Canyon (on San Ildefonso Pueblo land) (Figure 1.1-1). Reach CDB-4 is that part of Cañada del Buey that lies within the proposed White Rock land transfer parcel, and it extends for 0.8 km west from highway NM 4, immediately west of White Rock. Upstream from NM 4, Cañada del Buey has a drainage area of approximately 5.5 km^2 and a basin length of approximately 9 km. The primary geologic unit that is exposed within the watershed upstream from NM 4 is the Tshirege Member of the Bandelier Tuff, which consists of Quaternary ignimbrites (Griggs 1964, 08795; Smith et al. 1970, 09752; Dethier 1997, 49843). Pliocene basaltic rocks of the Cerros del Rio volcanic field are exposed along the stream channel in reach CDB-4 and on adjacent slopes.

Stream flow in reach CDB-4 consists of infrequent, short-duration runoff from rain storms on the plateau. Bedrock occurs at a shallow depth below the stream channel, and no alluvial groundwater has been observed in hand-dug holes that extended to bedrock or in areas where alluvium pinches out on bedrock.

1.3.2 Laboratory History and Operations

Several Laboratory sites within the Cañada del Buey watershed may have contributed contaminants to the stream channel, as is summarized in the "Work Plan for Sandia Canyon and Cañada del Buey" (LANL 1999, 64617). TAs that might have been sources of contaminants include former TA-4 (currently within the boundaries of TA-52), TA-46, TA-51, and TA-54 (Figure 1.1-1). Summaries of pertinent information about key sites in the Cañada del Buey watershed are presented below.

1.3.2.1 TA-4

Former TA-4 was located on the mesa between Cañada del Buey and Ten Site Canyon and now lies within the boundaries of TA-52. It was occupied from approximately 1944 to 1955. The only known source of contamination at TA-4 that involved releases to Cañada del Buey was an outfall, PRS 4-003(a), from photo-processing facilities (LANL 1999, 64617, p. 2-46). Analytes that have been detected above background levels at this PRS include arsenic; chromium; lead; plutonium-239, -240; and pentachlorophenol.

1.3.2.2 TA-46

TA-46 is located on Mesita del Buey, between Cañada del Buey and Pajarito Canyon, and was established in 1954 as a weapons assembly site. Since that time, laboratories at TA-46 have been used for a variety of programs, including the development of nuclear reactors for propulsion of space rockets, the development of uranium-isotope separation methods, laser research, and solar-energy research. Various outfalls from TA-46 have discharged contaminants into Cañada del Buey. Analytes that have been detected above background levels at TA-46 outfalls include metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc); radionuclides (plutonium-238, uranium-234, uranium-235, and uranium-238); and a variety of organic chemicals (LANL 1996, 54929; LANL 1999, 64617).

1.3.2.3 TA-51

TA-51 is located on Mesita del Buey, between Cañada del Buey and Pajarito Canyon, and was established in 1980 as an experimental engineering test facility. The only known source of potential contaminant releases from TA-51 into Cañada del Buey is an inactive septic system designated PRS 51-001 (LANL 1999, 64617, p. 2-60). No data regarding this PRS have been reported.

1.3.2.4 TA-54

TA-54 is located on Mesita del Buey, between Cañada del Buey and Pajarito Canyon, and was established in 1957 as a disposal area for low-level radioactive waste. It was also the site of a radiation exposure facility and has been used for disposal of administratively controlled wastes and chemical waste, for land farming of petroleum-contaminated soils, and for waste storage. Various analytes have been detected above background levels downgradient from TA-54 PRSs in the Cañada del Buey watershed. These include metals (aluminum, barium, calcium, chromium, copper, iron, lead, and magnesium) and radionuclides (americium-241; cesium-137; cobalt-60; plutonium-238; plutonium-239, -240; polonium-210; strontium-90; technetium-99; tritium; uranium-235; and yttrium-90) (LANL 1996, 54462)

1.4 Land Use

The area of Cañada del Buey that lies within reach CDB-4 is currently owned by the DOE. This area has been left in a natural state and has not been used for any Laboratory activities. The area that includes reach CDB-4 is being considered for transfer to Los Alamos County and/or San Ildefonso Pueblo (DOE 1998, 58671). Los Alamos County and San Ildefonso Pueblo have proposed a combination of residential and commercial use and cultural preservation for this land (LANL 1999, 63067).

1.5 Previous Sediment Investigations

Potential contaminants associated with sediments in reach CDB-4 have been investigated as part of the Laboratory's Environmental Surveillance Program since 1978 (e.g., Environmental Surveillance and Compliance Programs 1997, 56684). This work has included the annual sampling of active channel sediments immediately upstream from NM 4. A compilation of the sediment data through 1997 indicated that several analytes had maximum results at low levels above background levels: barium, cadmium, lead, selenium, americium-241, tritium, and plutonium-238 (LANL 1999, 64617, p. 3-85 to 3-87).

1.6 Preliminary Conceptual Model and Technical Approach

The available data from PRSs in the Cañada del Buey watershed indicate that a variety of metals, radionuclides, and organic compounds could be present as contaminants in canyon bottom sediments, although prior data from Cañada del Buey sediments are insufficient to determine if contaminants are systematically present above background levels. Because of their geochemical characteristics, most of the contaminants are expected to be adsorbed onto sediment particles, and transport downstream from the release sites would be largely controlled by sediment transport processes. Contaminants associated with sediments could have been dispersed, via floods, downstream to reach CDB-4.

The concentrations of any contaminants in the watershed are expected to vary greatly and to be related to such factors as distance from the source, sediment particle size, and age of the deposit. Contaminant concentrations are expected to be generally higher in sediment deposits closer to the source and to be higher in finer-grained sediments than in downstream deposits or in coarser-grained sediments.

Contaminant concentrations are also expected to be higher in sediment deposits that are relatively close to the age of the peak contaminant releases and to be lower in younger sediments.

The technical approach that was used in this investigation includes detailed geomorphic mapping and sediment sampling of the entire length of Cañada del Buey within the White Rock land transfer parcel. The methodology that was followed is presented in the core document (LANL 1997, 55622; LANL 1998, 57666). The work focused on determining the nature and extent of contamination, evaluating risk (if necessary), and testing components of the preliminary conceptual model in a phased approach. Geomorphic mapping and sediment sampling concentrated on identifying and characterizing post-1942 sediments (i.e. those sediments younger than the Laboratory). An evaluation of data from the first sampling phase was used to revise the conceptual model, identify key uncertainties, and focus subsequent data-collection activities. Investigation goals included evaluating present and future potential risk, evaluating sediment transport processes, and providing the data needed to make decisions about possible remedial action alternatives.

1.7 Unit Conventions

This report uses primarily metric units of measure, although English units are used for contours on topographic maps, for references to elevations derived from topographic maps, and for New Mexico State Plane coordinates as shown on some maps. English units are also used for radioactivity (curies [Ci] instead of becquerels [Bq]). Two scales, one with metric units of distance and one with English units of distance, are shown on maps. A table for converting metric to English units is presented in Appendix A.

1.8 Report Organization

Section 2 of this report presents the results of the field investigations of reach CDB-4 sediments. Section 2.1 introduces the reach and its major geographic characteristics. Section 2.2 describes the methods of investigation, including geomorphic mapping, physical characterization of young sediments, radiological field measurements, and sediment sampling activities. Section 2.3 presents the results of these field investigations, including physical characteristics of the geomorphic units and key aspects of the post-1942 geomorphic history.

Section 3 of this report presents analytical results from the sediment samples collected in reach CDB-4. Section 3.1 comprises a data review that evaluates which radionuclides and organic and inorganic chemicals should be retained as chemicals of potential concern (COPCs). Section 3.2 examines each COPC in the contexts of likely sources within the Cañada del Buey watershed and possible collocation with other COPCs.

Section 4 of this report presents a conceptual model of potential contamination in reach CDB-4 sediments that has been revised and refined from the preliminary conceptual model using the results of this investigation. Section 4.1 discusses those analytes that are present above Laboratory-wide background levels. Section 4.2 discusses sediment sources. Section 4.3 discusses potential future contamination.

Section 5 of this report serves as a placeholder for site assessments, although no assessments of potential human health risk or ecological risk were made because no contamination was measured in reach CDB-4 sediments.

Section 6 of this report summarizes the key conclusions of this investigation and provides recommendations concerning possible additional assessments, data collection, and/or remedial action.

Section 7 lists the references cited in this report.

Appendix A presents a list of acronyms used in this report as well as a conversion table of metric units to English units.

Appendix B presents supplemental information about the characterization of geomorphic units found in reach CDB-4. Section B-1.0 presents data regarding the thickness of post-1942 sediment in the different geomorphic units. Section B-2.0 presents data concerning particle-size characteristics, organic matter content, and pH in the sediment samples. Section B-3.0 presents the chronology of sediment-sampling events in reach CDB-4 and the primary goals of each sampling event. Section B-4.0 presents the geomorphic context in which the sediment samples were taken.

Appendix C presents the results of quality assurance (QA) and quality control (QC) activities pertaining to the reach CDB-4 sediment samples. Section C-1.0 summarizes the QA/QC activities. Section C-2.0 addresses inorganic chemical analyses. Section C-3.0 addresses organic chemical analyses. Section C-4.0 addresses radionuclide analyses. Section C-5.0 presents data qualifiers for the samples.

Appendix D presents analytical suites and the results of the sediment analyses performed during this investigation. Section D-1.0 presents target analytes and detection limits. Section D-2.0 presents sample request numbers and analytical suites for each sample. Section D-3.0 presents summaries of analytical results. Section D-4.0 presents analytical results for detected inorganic chemicals and radionuclides.

Appendix E presents supplemental statistical analyses of the analytical results of this investigation. Section E-1.0 presents statistical evaluations of the inorganic chemical data. Section E-2.0 presents statistical evaluations of the radionuclide data.

1.9 Acknowledgments

The authors of this report had the following responsibilities: Paul Drakos was principal investigator for sediment characterization during the fieldwork and was responsible for documenting the field investigations; Randy Ryti was responsible for data review and statistical analyses and was also the lead for statistical analysis during all phases of the field investigation; Steven Reneau provided technical oversight and contributed to data interpretation, technical editing, and report compilation; Keith Greene was responsible for the data validation activities included in this report.

In addition to the authors of this report, numerous individuals contributed to this investigation: Deborah Steven, Jenny Harris, and Mark Van Eeckhout contributed to the geomorphic characterization activities and sediment sampling; Bill Hardesty contributed to the data validation activities; Marcia Jones provided geographic information system (GIS) support; Al Funk was the field team manager; Lisa Levine served as editor for this report; Andi Kron was the graphic artist; and Lisa Levine and Pam Maestas were the compositors. Review comments on this report were provided by Ted Ball, Don Hickmott, Danny Katzman, Rich Mirenda, Paul Schumann, Lars Soholt, and Holly Wheeler-Benson. Finally, as leader of the Canyons Focus Area, Allyn Pratt supported all phases of this investigation.

2.0 FIELD INVESTIGATIONS

2.1 Introduction to Reach CDB-4

Reach CDB-4 is that portion of Cañada del Buey that lies within the proposed White Rock land transfer parcel, and it extends for 0.8 km west from State Road NM 4. The entire canyon bottom within CDB-4 was mapped, including both areas that were affected by post-1942 flooding and adjacent areas. The location of reach CDB-4 within the Cañada del Buey watershed is shown in Figure 1.1-1. The extent of

post-1942 channels and floodplains within CDB-4 is shown in Figure 2.1-1. The inner canyon floor is relatively narrow through CDB-4, and the stream is locally incised into basaltic rocks of the Cerros del Rio volcanic field. For over 150 m, the channel splits around a basalt "island" in the middle of the reach. It is also broken into several braids along the eastern part of the reach. The general nomenclature for the geomorphic units used in this report is discussed in section 2.2.1, and the specific units in the reach are discussed in section 2.3.1.

2.2 Methods of Investigation

2.2.1 Geomorphic Mapping

Field investigations in reach CDB-4 began by preparing a preliminary geomorphic map that focused on identifying young (post-1942), potentially contaminated sediment deposits and subdividing these deposits into geomorphic units with different age and/or sedimentological characteristics. These geomorphic units delineate the horizontal extent of post-1942 sediments in the reach and group areas with similar physical characteristics. Where uncertainties existed about the limits of potentially contaminated sediments, boundaries were drawn conservatively such that the area potentially affected by post-1942 floods was overestimated rather than underestimated.

The mapping of reach CDB-4 was performed at a scale of 1:200. It involved taping the distances along the channel between surveyed control points and frequently measuring unit widths. Aerial photographs were not useful for mapping CDB-4 because of the narrow active canyon floor and the density of vegetation. The boundaries between geomorphic units were typically defined on the basis of topographic breaks, vegetation changes, and/or changes in surface sediments, although, in some areas, boundaries are more approximate.

Geomorphic mapping was iterative, and the map was revised after each phase of the investigation. For example, a relatively high-discharge flood event on June 17, 1999, altered some geomorphic units that had been mapped in May, leading to a revision of map units. In addition, the geodetic surveying of sample locations that followed each sampling event often led to revising the map so that the surveyed sample locations fell within the appropriate geomorphic unit. For example, the surveyed coordinates of a sample site that was located on a stream bank could fall within the active channel on a preliminary geomorphic map because of small inaccuracies in unit boundaries. Refinements to the conceptual model that were made during the investigation also resulted in reexamining and revising the maps.

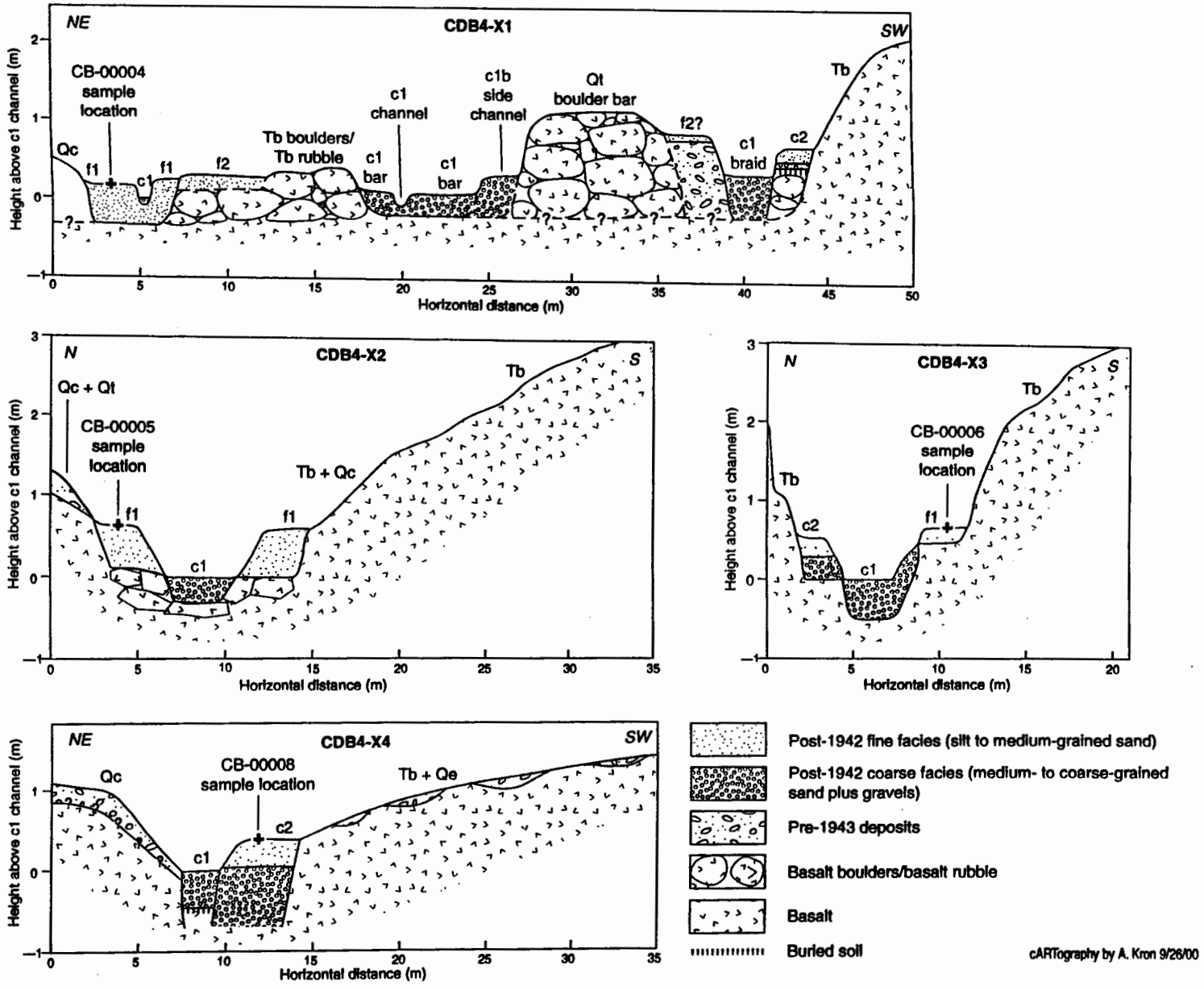


Figure 2.1-1. **Topographic map of reach CDB-4 and vicinity, showing area of post-1942 sediments and index to detailed geomorphic maps**

The following general conventions were used when naming the units in reach CDB-4.

- The designation *c* refers to post-1942 channel units, which are areas that were either occupied by the main stream channel or had experienced significant deposition of coarse-grained channel sediments sometime in the post-1942 period. The active channel was designated *c1;* the abandoned channel units, which were typically vegetated and topographically higher than the active channel, were designated *c2*. The designation *c1b* was used in CDB-4 to distinguish two types of channel segments: (1) recently abandoned channel segments adjacent to the main channel that were unvegetated or poorly vegetated, and (2) channel segments that appeared to receive intermittent stream flows at a lower frequency than the main c1 channels.

- The designation *f* refers to floodplain areas that were, or may have been, inundated by overbank floodwaters since 1942 but that were not occupied by the main stream channel. Areas that had probably been inundated by floods during this period, as shown by geomorphic evidence, were indicated by *f1*. Areas that had possibly been subjected to minor inundation, but where the evidence was generally inconclusive, were indicated by *f2*. If f2 surfaces had been inundated, the thickness of post-1942 sediment would be small. The designation *f1b* refers to areas that were located at a height correlative with f1 surfaces and that had indicators of recent flow such as pine needle mounds or vegetation mats pushed up against standing vegetation, but had no evidence of post-1942 sediment deposits.

Other designations on the geomorphic maps delineate areas that have not been directly affected by post-1942 floods downstream from potential contaminant sources. Following standard geologic nomenclature, *Q* indicates geologic units of the Quaternary period and *T* indicates geologic units of the Tertiary period. *Qal* refers to active channel alluvium in tributary drainages. *Qc* refers to colluvium. *Qt* refers to pre-1943 stream terraces that have not been inundated by post-1942 floods. *Qf* refers to fans from tributary drainages. *Qe* refers to eolian deposits (wind-blown sediment). *Qbt* refers to the Tshirege Member of the Bandelier Tuff. *Tb* refers to basaltic rocks of the Cerros del Rio volcanic field.

2.2.2 Physical Characterization of Young Sediments

Physical characterization of the geomorphic units included measurements of the thickness of post-1942 sediments, general field descriptions of particle size, and laboratory particle-size analysis for samples submitted for standard chemical and/or radiological analyses. The determination of unit thicknesses used a variety of approaches, including identifying the depth to which the bases of trees were buried by sediment, recognizing buried soil horizons, and searching for the presence of "exotic" material that indicated a post-1942 age (e.g., quartzite clasts imported from quarries off Laboratory land). Additional details concerning the methods and results of the physical characterization of post-1942 sediments in reach CDB-4 are presented in Appendix B.

An important distinction within the post-1942 sediments involves general variations in particle size. This is because contaminant concentrations tend to be higher in finer-grained sediments of a given age. The term *facies* is used to describe the observed texture of a deposit (primarily grain size). Two primary facies are described in this report: the fine facies, which generally contains median particle sizes of fine sand (0.125–0.25 mm) or smaller, and the coarse facies, which generally contains median particle sizes of coarse sand (0.5–1.0 mm) or greater. Medium sand (0.25–0.5 mm) can be assigned to either facies, depending on the stratigraphic context. The fine-grained sediments are generally transported as suspended load during floods and are commonly deposited on floodplains by water that overtops stream banks. The coarse-grained sediments are generally transported as bed load and deposited along the main stream channel. However, neither of the two facies are restricted to specific geomorphic units.

Although fine facies sediment typically forms upper layers on floodplains and abandoned channel units, it can also be found in thin layers along active channels. And coarse facies sediment can be deposited on floodplains during large floods. It should also be stressed that these distinctions are somewhat arbitrary, and that gradations commonly occur. Nevertheless, the distinctions form an important basis for differentiating sediment deposits of similar age that may contain highly variable levels of contamination.

2.2.3 Radiological Field Measurements

Field screening for gamma and beta radiation was performed using a sodium iodide probe with a 1- by 1-in. detector and a Ludlum ESP-1 probe. The screening indicated that post-1942 sediments in reach CDB-4 do not exhibit field-measured radiation levels above background levels. Therefore, these measurements were not useful for distinguishing potentially contaminated sediments and are not discussed further in this report.

2.2.4 Sediment Sampling and Preliminary Data Evaluation

Sediment sampling in this investigation followed a phased approach that included sampling for both full-suite and limited-suite analyses. A preliminary evaluation of the data after the first sampling phase helped identify uncertainties and focus subsequent sample collection and analysis. The primary goals of each sampling event, as well as other information about the events, are summarized in Appendix B.

Full-suite analyses were performed on samples collected from reach CDB-4 after the initial field-mapping phase. The goals of this sampling event were to identify all analytes that were present above background levels and to determine the primary risk drivers (if any). The sample sites were selected to include representative fine-grained and coarse-grained sediment deposits from the range of geomorphic units. The full-suite analyses included a variety of inorganic chemicals, organic chemicals, and radionuclides (see section 3.1 and Appendix C).

The evaluation of analytical results from the first round of sampling identified only plutonium-239, -240 and a series of metals as chemicals of potential concern (COPCs), although it was not certain if any of these analytes were actually present at levels greater than background levels. The second sampling phase was designed to collect additional data about these limited-suite analytes from both potentially contaminated sediments and from local background sites. The goal was to determine if any potential contaminants exceeded local background concentrations. It had been hypothesized that the local background concentrations of metals differed from Laboratory-wide background levels due to local differences in parent materials (soils and lithology), specifically the presence and weathering of basalt and/or the reworking of eolian deposits and older soils. In addition, second-phase samples were collected for tritium analyses because such analyses had been inadvertently left out of the first sampling phase.

Sites for local background sediment sampling were selected from tributary drainages and side slopes to cover the range of local sediment sources that were contributing sediments to the reach CDB-4 mapping area. None of these sample sites were downslope from areas affected by Laboratory activities. Runoff from the closest potential release sites (PRSs), which are located at Material Disposal Area G at TA- 54, drain into Cañada del Buey 0.7 km upstream from CDB-4. Local background sediment sampling sites included alluvium (Qal) in side drainages heading in areas underlain by Qbt (Bandelier Tuff), Qal side drainages heading on Tb (Cerros del Rio basalt), Qf (Quaternary alluvial fan) deposits, incipient drainages on colluvial slopes (Qc) bordering the active channel, and shallow side drainages in areas where eolian deposits mantle basalt (Tb+Qe) and contribute sediment to the active channel.

2.3 Results

2.3.1 Physical Characteristics

Reach CDB-4 is located in a part of Cañada del Buey where the stream has incised less than 10 m into the top of the Cerros del Rio basalt. Throughout CDB-4, the active channel and its associated historic and Quaternary (prehistoric) geomorphic units are bordered on the north by slopes and low cliffs of Bandelier Tuff (Qbt) as well as colluvium derived from Qbt. They are bordered on the south by basalt, which is overlain in some areas by eolian deposits. A Quaternary terrace (Qt) is present throughout much of the mapping area and is underlain by a well-developed carbonate soil indicative of a pre-Holocene age.

Approximately one-half of the length of CDB-4 is characterized by a braided stream channel. Two channels and bordering geomorphic units were mapped separately between control stakes CDB-4 + 350 m and CDB-4 + 575 m. Multiple channels and bordering geomorphic units were mapped between CDB-4 + 25 m and CDB-4 + 150 m (distances were measured upstream from the State Road NM 4 box culvert).

Calculations of average unit widths were based on a reach length measured along the north channel, which appears to be the predominant channel for conveying active stream flows, and results in a reach length of 775 m. (Areas of geomorphic units were summed where multiple channels were present.) The area that has been affected by post-1942 floods averages approximately 8 to 13 m wide in CDB-4. The areal distribution of the geomorphic units is shown on Figure 2.1-1 and Figure 2.3-1(a–d), and topographic relations are illustrated in the cross-sections of Figure 2.3-2. Physical characteristics of the geomorphic units in CDB-4 are summarized in Table 2.3-1. Data on particle size and unit thickness are presented in Appendix B, Tables B-1.0-1 through B-1.0-4, B-2.0-1, and B-2.0-2.

Table 2.3-1
Geomorphic Mapping Units in Reach CDB-4

Unit	Estimated Average Unit Height Above Channel (m)	Unit Area (m^2)[a]	Average Unit Width (m)	Sediment Facies	Estimated Average Thickness (m)	Estimated Volume (m^3)	Typical Median Particle Size Class (<2 mm fraction)	Notes
c1	0	2800	3.6	Fine	0.08	224	Fine sand[b]	Active channel and adjacent bars
				Coarse	0.28	784	Coarse sand	
c1b	0.25	474	0.6	Fine	0.14	66	Coarse silt—very fine sand	Recently abandoned channels and point bars, sparsely vegetated; 1980s to 1990s?
				Coarse	0.25	119	Coarse sand	
c2	0.35	1110	1.4	Fine	0.3	333	Very fine sand	Abandoned post-1942 channels
				Coarse	0.28	311	Very coarse sand	

Table 2.3-1 (continued)

Unit	Estimated Average Unit Height Above Channel (m)	Unit Area (m^2)[a]	Average Unit Width (m)	Sediment Facies	Estimated Average Thickness (m)	Estimated Volume (m^3)	Typical Median Particle Size Class (<2 mm fraction)	Notes
f1	0.5	1277	1.6	Fine	0.33	421	Very fine sand	Active floodplains
				Coarse	0.02	26	Medium sand[b]	
f1b	0.5	363	0.5	n/a[c]	0	0	n/a	Active floodplain with no young sediment
f2	0.7	3755	4.8	Fine	<0.05	<188	Fine sand[b]	Potentially active floodplain

[a] Average unit width includes all channel braids and associated geomorphic surfaces, and uses length of 775 m for CDB-4.

[b] Based on field descriptions.

[c] n/a = Not applicable.

The active channel, c1, averages 3.6 m wide in CDB-4. Its bed is composed of coarse sand and gravel with isolated fine-sand lenses. Typically, c1 units lack vegetation. The average thickness of the c1 unit is 36 cm, and it includes an average of approximately 8 cm of fine-grained sediment. Throughout much of reach CDB-4, c1 sediments sit directly on basalt. In areas where older sediments underlie c1 deposits, a buried soil with subangular blocky structure and clay films bridging grains and coating pebbles is usually present. Recently abandoned channels and point bars, c1b, have an average height of 0.25 m above the active channel and an average width of 0.6 m, resulting in a combined average width of approximately 4.2 m for c1 and c1b units. The average c1b thickness of 39 cm includes 25 cm of coarse sand (coarse facies) and 14 cm of coarse silt to very fine sand (fine facies). Unit c1b either rests directly on basalt or welded tuff boulders or is underlain by a buried soil with subangular blocky structure that appears to be the same soil that was observed underlying c1 sediments.

The active channel is bordered intermittently by abandoned post-1942 channel units (c2) that have an average width of 1.4 m and an average height of 0.35 m above the channel. The c2 units include an average of 30 cm of coarse-grained sediments comprising medium sand to very coarse sand. They are capped by an average of approximately 28 cm of fine-grained sediments which are dominated by very fine sand. Unit c2 either rests directly on basalt or welded tuff boulders or is underlain by a buried soil with subangular blocky structure that appears to be the same soil that was observed underlying c1 sediments.

Active floodplains (f1) in CDB-4 are an average of 1.6 m wide. The f1 unit averages 0.5 m above the active channel and is capped by an average of 33 cm of fine-grained sediments dominated by very fine sand. An f1b subunit is distinguished in CDB-4 by indicators of scouring such as organic material caught up in vegetation, vegetation bent over in the downstream direction, and a topographic break creating a small bench, but it is characterized by an absence of post-1942 sediment. Therefore, unit f1b adds to the area of post-1942 geomorphic units but does not contribute to the volume of post-1942 sediments. Unit f1 deposits sit directly on basalt or welded tuff boulders throughout most of the map area, although, in some cases, f1 deposits are also underlain by a buried soil with subangular blocky structure and clay films.

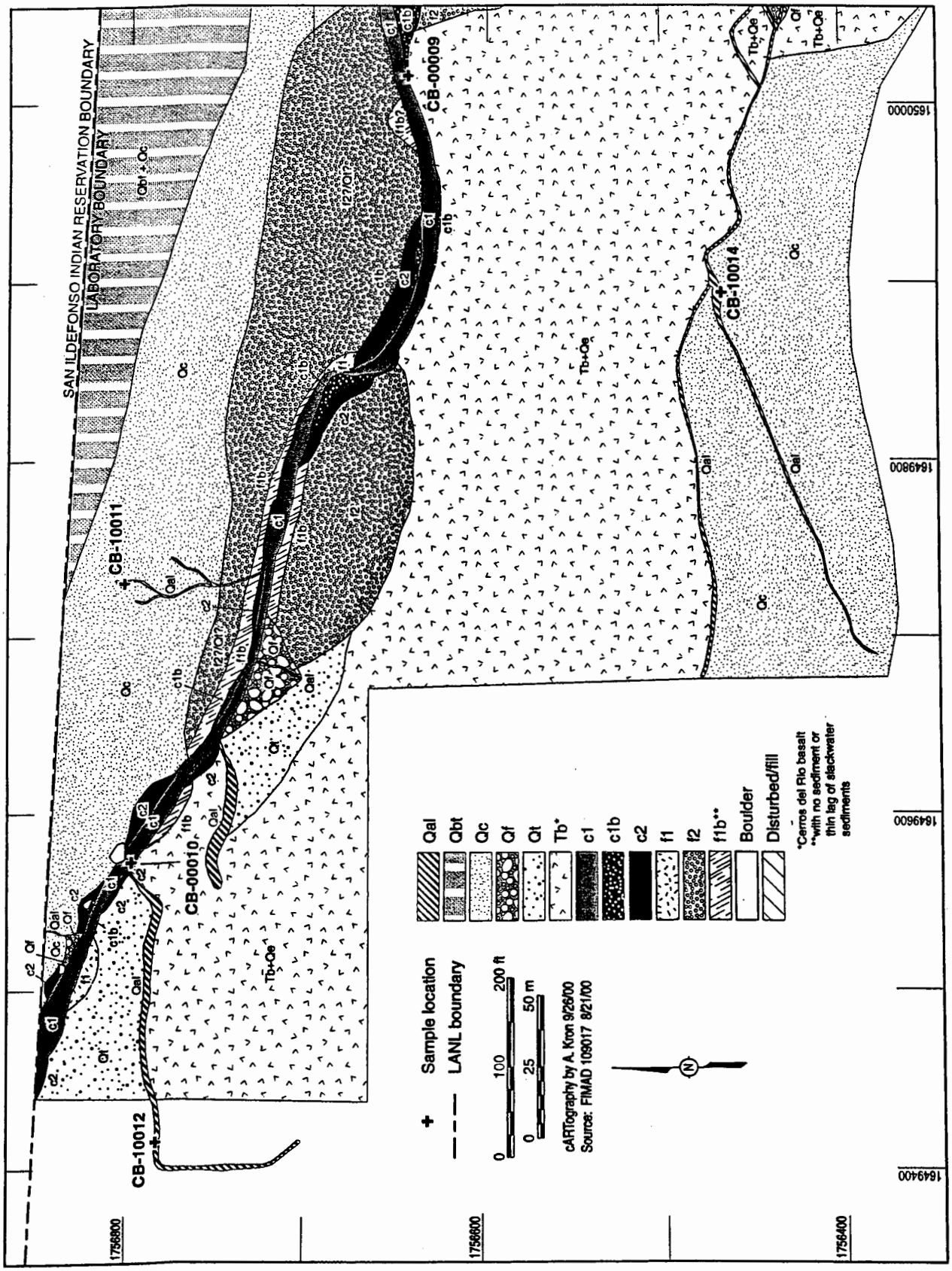


Figure 2.3-1a. Map showing geomorphic units and sample locations in reach CDB-4

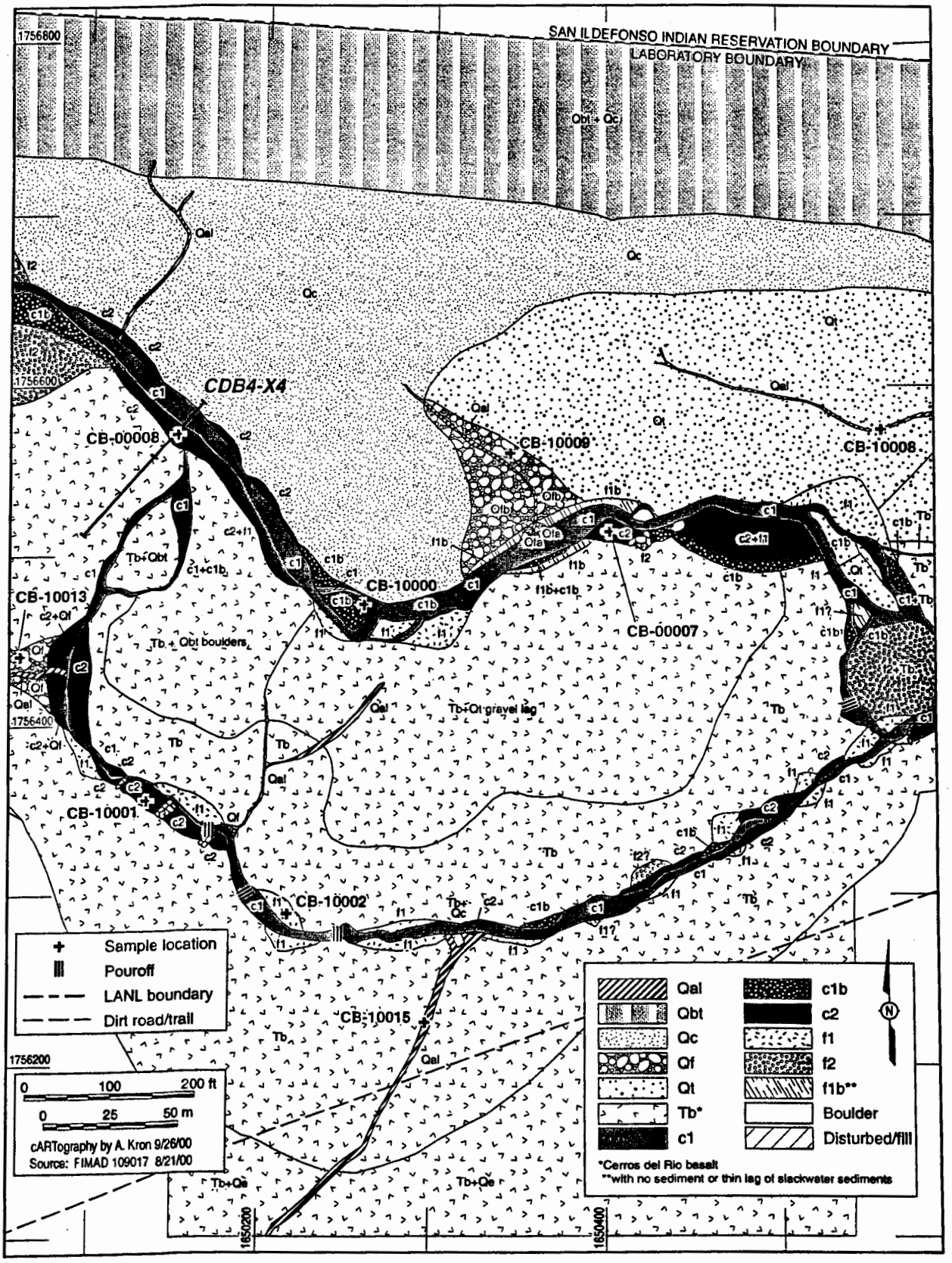


Figure 2.3-1b. Map showing geomorphic units and sample locations in reach CDB-4

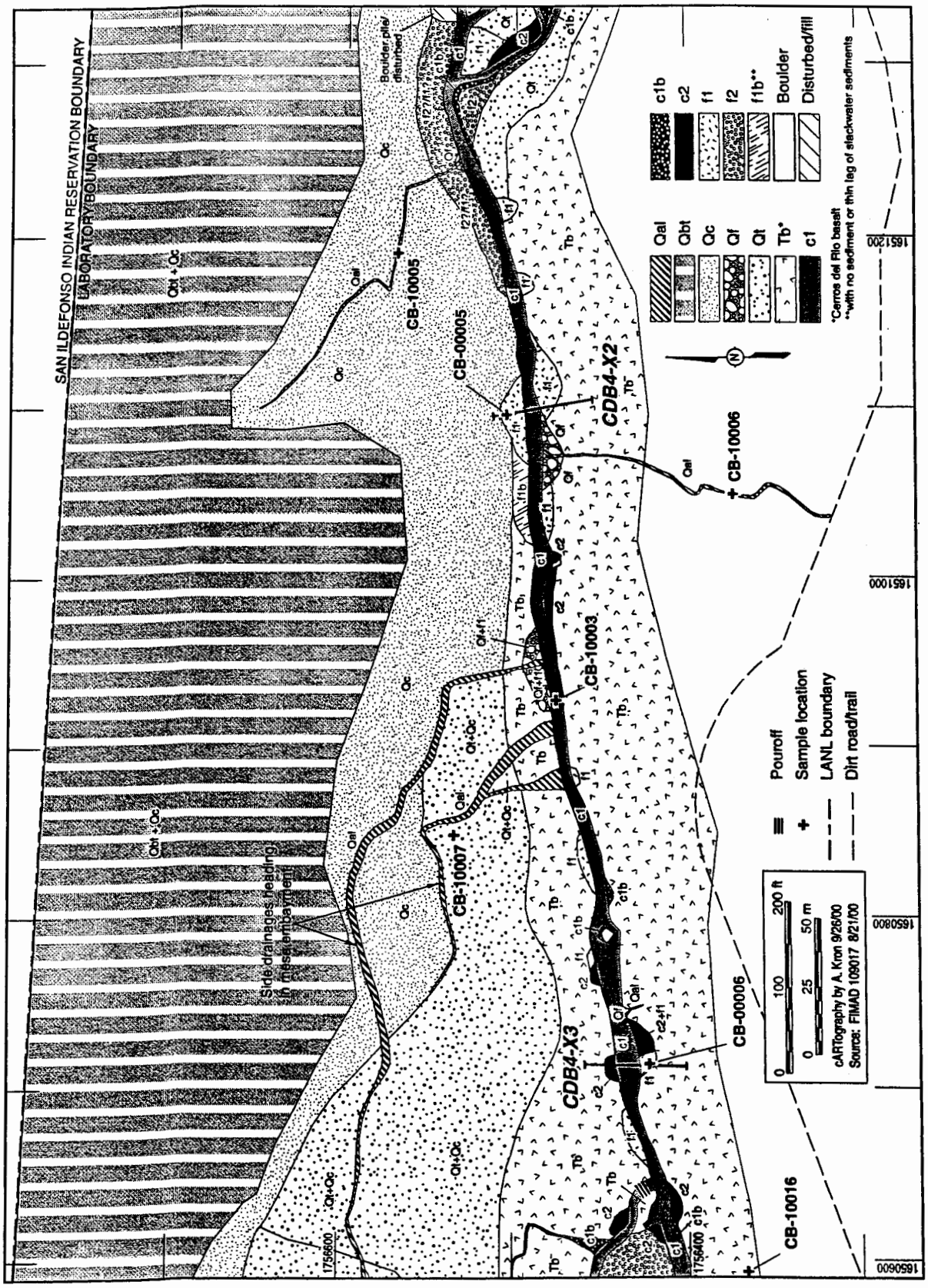


Figure 2.3-1c. Map showing geomorphic units and sample locations in reach CDB-4

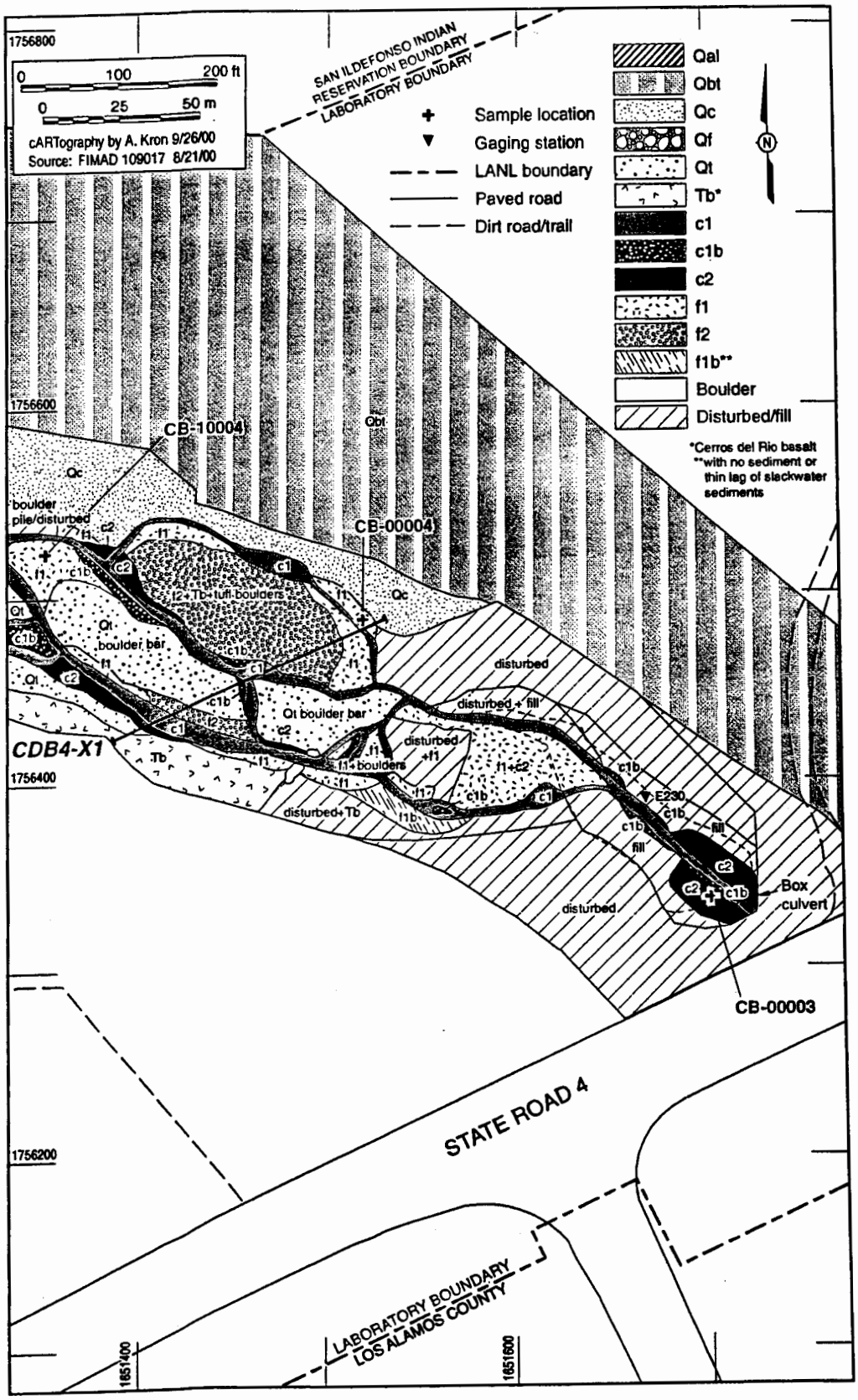


Figure 2.3-1d. Map showing geomorphic units and sample locations in reach CDB-4

Potentially active floodplains (f2) in CDB-4 are slightly higher than f1 and average approximately 5 m in width. It should be noted that the average width of f2 units is somewhat skewed by the presence of several relatively large f2 units, in particular between control stakes CDB-4 + 615 m and CDB-4 + 750 m. These f2 areas either have not been inundated by post-1942 floods or were only briefly inundated, experiencing little or no post-1942 sediment deposition.

An estimated 2300–2500 m^3 of post-1942 sediment are stored in reach CDB-4; this sediment is roughly equally distributed between fine-grained and coarse-grained sediment (Table 2.3-1). The active channel, c1, contains over 60% of the coarse sediment in CDB-4. In contrast, the fine sediment is widely distributed across the f1, c2, and c1 units.

2.3.2 Geomorphic History

Since 1943, the geomorphic processes within reach CDB-4 have included the lateral migration of the active channel over an area that averages 6 m wide (represented by the width of the c1, c1b, and c2 units) and the occasional overtopping of higher pre-1943 surfaces during floods. Vertical changes in the elevation of the stream bed have also apparently occurred in CDB-4, resulting in the presence of young (post-1942) channel sediments up to 0.5 m above the active channel. The largest apparent vertical changes were recorded by coarse-grained c2 sediment occurring above the elevation of nearby f1 surfaces at cross-section CDB4-X1, which is located in an area of braided channels (Figure 2.3-2). The configuration of geomorphic units observed at CDB4-X1 may be the result of post-1942 channel migration from southwest to northeast in this part of CDB-4.

Most of the post-1942 fine-grained sediment within reach CDB-4 is stored within the c1, c2, and f1 units, relatively close to the active channel. Smaller amounts may be stored in the f2 units farther away from the channel. The sediments within the c1, c2, and f1 units are particularly susceptible to remobilization by lateral bank erosion during floods, and the average residence time for sediment at these sites is probably less than 50 years. This conclusion is based, in part, on the observation that many of the post-1942 units occur as pockets of sediments located in small embayments along a bedrock-bordered stream channel.

The inundation of the post-1942 geomorphic units during the June 17, 1999, flood provides additional evidence that remobilization of sediment stored in the c1b, c2, and f1 geomorphic units occurs on a time scale of less than 50 years. The June 1999 flood in CDB-4 deposited new sediment on c2 and f1 units throughout the reach, with some aggradation observed on top of previously mapped post-1942 deposits (e.g., deposition of 10 cm of fine sand on top of a previously mapped c2 unit at sample location CB-00007). Some scouring of post-1942 deposits was also observed, although the flood appears to have resulted in a preponderance of additional sediment deposition in the reach, rather than erosion of young sediments. These observations suggest somewhat longer residence times for the post-1942 sediments. The absence of age control for sediments in CDB-4 (except for the June 1999 deposits), however, makes quantifying residence times for sediments stored in post-1942 geomorphic units problematic.

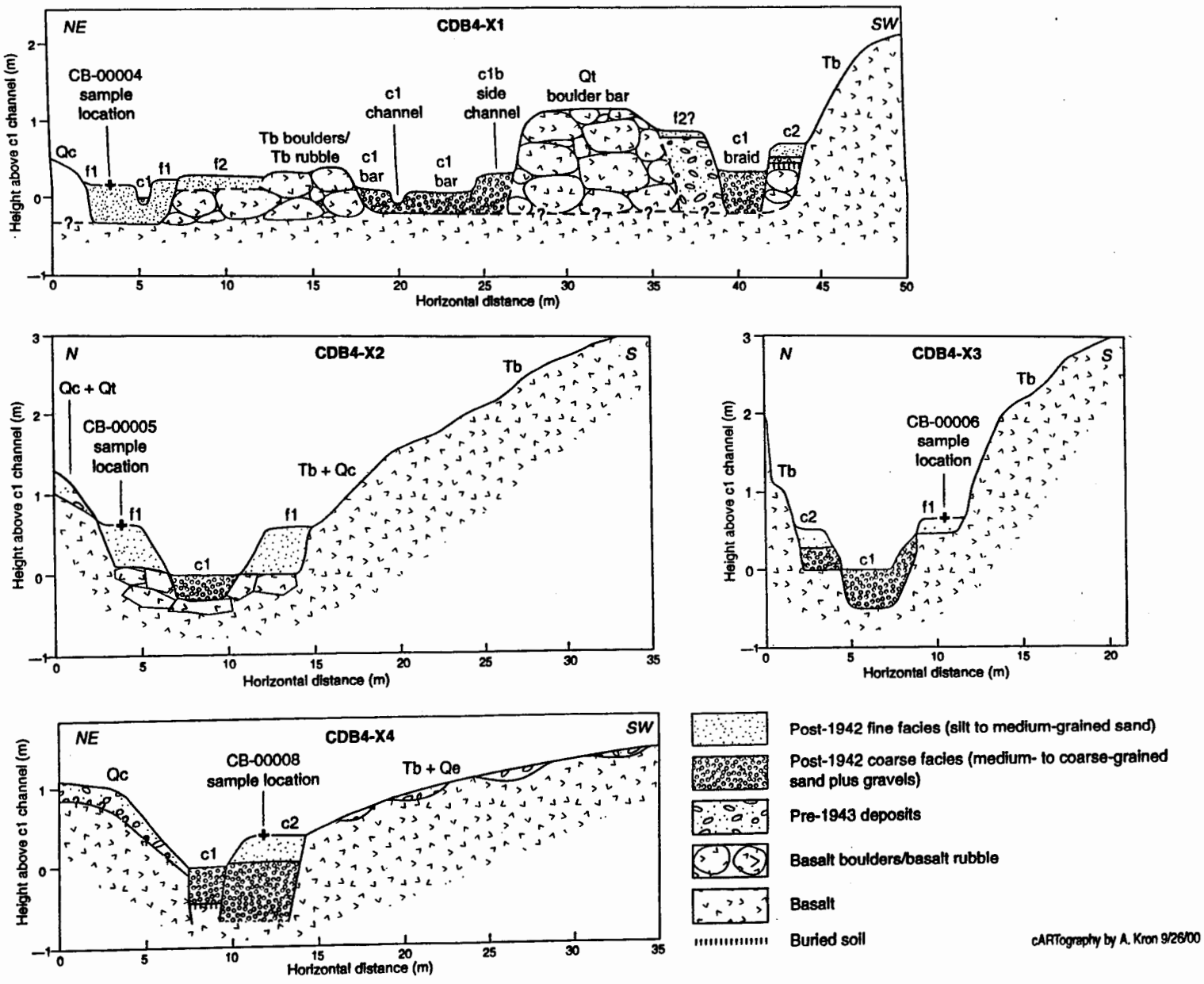


Figure 2.3-2. Schematic cross-sections showing relations between geomorphic units in reach CDB-4

3.0 ANALYTICAL RESULTS AND DATA REVIEW

3.1 Data Review

Sediment samples for site characterization in reach CDB-4 were collected in two phases, one in May 1999 and one in November 1999. During both phases, sample collection followed the technical approach presented in Chapter 5 of the "Core Document for Canyons Investigations" (LANL 1997, 55622; LANL 1998, 57666). Selection of sample locations was based on geomorphic mapping and associated geomorphic characterization. Locations included all potentially contaminated geomorphic units and the full range of sediment grain size. The selection of sample locations and analyte suites for the second sampling phase was based on the results of the first sampling phase.

The second sampling phase included 13 samples from 12 sites which were analyzed for a limited suite in order to characterize local sediment background levels. These sample results were not used to establish the list of chemicals of potential concern (COPCs); however, the validation information for these samples is included in this section. The local sediment background sample results are presented in Appendix D; interpretation of the results is provided in section 3.2 and in Appendix E. The locations of these background samples are discussed in section 2.2.4 and shown on Figures 2.3-1a through 2.3-1d.

The sediment samples from reach CDB-4 included samples for both full-suite and limited-suite analyses. Ten samples from potentially-contaminated sediment deposits were collected for full-suite analysis in the first phase. Seven samples from potentially-contaminated sediment deposits were collected for limited-suite analysis in the second phase. The number of samples analyzed for organic chemicals, inorganic chemicals (target analyte list [TAL] metals), and radionuclides is presented in Table 3.1-1.

Table 3.1-1
Number of Samples in Reach CDB-4, Analyzed by Suite

Analytical Suite	Potentially Contaminated Sediment Samples	Local Background Samples
Pesticides and polychlorinated biphenyls (PCBs)	10	0
Semivolatile organic compounds (SVOCs)	10	0
Inorganic chemicals	17	13
Cyanide, total	10	0
Uranium, total	10	0
Americium-241 (by alpha spectroscopy)	10	0
Gamma spectroscopy radionuclides	10	0
Tritium	17	0
Isotopic plutonium	17	6
Isotopic uranium	10	0
Isotopic thorium	10	0
Strontium-90	10	0

The objective of this data review is to determine which analytes should be retained for further assessment and which analytes should be eliminated before assessing potential human-health and ecological risk. Analytes that are retained will be considered COPCs. When making these assessments, consideration is

given to the magnitude of contaminant concentrations relative to background values (or relative to detection limits in the cases of organic chemicals), the correlation between contaminant concentrations, and any potential QC problems with the laboratory analyses.

3.1.1 Comparison of Inorganic Chemical Data with Sediment Background Data

A total of 17 sediment samples from reach CDB-4 were analyzed for the inorganic chemicals on the TAL. Those sample results were compared with the sediment background data that are presented in "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory" (Ryti et al. 1998, 59730). The methods used to analyze the inorganic chemicals are comparable to those used to generate the Laboratory background data, allowing a direct comparison of the CDB-4 results to the Laboratory background data. A comparison of the inorganic chemical data from CDB-4 to the local background data is presented in section 3.2.

As is detailed in Appendix C, QC problems with this sediment data set were caused by the occurrence of both high and low recoveries in the laboratory control samples or the matrix spike samples. Laboratory control samples and matrix spike samples are used to assess the quality of the sample digestion, extraction, and analysis procedures. A low recovery suggests an incomplete recovery of an analyte. A high recovery indicates an enhancement of the analyte due to contamination or spectral/chemical interference. Matrix spike samples may have inconsistent recoveries due to matrix interference and the heterogeneous nature of many sediment samples.

In request number (RN) 5598, the laboratory control sample recovery for iron was high iron was detected in the 10 sediment samples that were analyzed for this RN. Two of the identified iron concentrations were above the background value. The iron results for all the samples should be regarded as estimated and biased high (J+).

For RN 6217, 20 sediment samples were analyzed for TAL metals. Of these 20, 7 were collected from potentially contaminated geomorphic units, and 13 were collected for characterization of local sediment background levels. Although data qualifiers apply to all 20 samples because QA/QC problems affect the entire RN, the samples summarized below are exclusive of the local background samples. The laboratory control sample met acceptable recoveries for all analytes except aluminum. Aluminum was detected in all seven potentially contaminated samples, and the aluminum results for these samples should be regarded as estimated and biased low (J-). The matrix spike recoveries all met acceptance criteria, with the exception of antimony and lead. The detection limit for these samples should be regarded as estimated and biased low (UJ-), based on the low matrix spike recovery. Antimony was detected in one of the seven sediment samples. Lead was detected in all seven of the sediment samples. All detected antimony and lead sediment sample results are estimated values and are biased low (J-). The results for all detected lead and antimony samples should be regarded as estimated and biased low (J-).

Of the 25 TAL metals, all except cadmium, total cyanide, mercury, and silver were detected in at least one reach CDB-4 sediment sample. Table 3.1-2 presents the concentration range and frequency of the results above background values for the detected and nondetected inorganic chemicals in reach CDB-4.

Table 3.1-2
Frequency of Detected Inorganic Chemicals in Reach CDB-4 Sediment Samples

Analyte	Number of Analyses	Number of Detects	Concentration Range (mg/kg)[a]	Background Value (mg/kg)	Frequency of Detects above Background Value[b]
Aluminum	17	17	1900 to 8870	15400	0/17
Antimony	17	9	[0.29] to 0.71	0.83	0/17, 0/8
Arsenic	17	17	0.88 to 3.1	3.98	0/17
Barium	17	17	26.8 to 130	127	1/17
Beryllium	17	17	0.25 to 0.98	1.31	0/17
Cadmium	17	0	[0.01 to 0.02]	0.4	0/17 DL[c]>BV[d]
Calcium	17	17	503 to 5620	4420	2/17
Chromium	17	17	2.4 to 10.8	10.5	1/17
Cobalt	17	17	2.2 to 9	4.73	12/17
Copper	17	17	1.9 to 9	11.2	0/17
Cyanide, total	10	0	[0.51 to 0.58]	0.82	0/10
Iron	17	17	4500 to 21200	13800	2/17
Lead	17	17	3.7 to 13.9	19.7	0/17
Magnesium	17	17	430 to 2400	2370	1/17
Manganese	17	17	204 to 481	543	0/17
Mercury	17	0	[0.0022 to 0.01]	0.1	0/17
Nickel	17	17	2.3 to 8.7	9.38	0/17
Potassium	17	17	367 to 1450	2690	0/17
Selenium	17	13	[0.11] to 1	0.3	11/17, 1/4 DL>BV
Silver	17	0	[0.025 to 0.03]	1	0/17
Sodium	17	17	30 to 124	1470	0/17
Thallium	17	2	[0.11] to 1.1	0.73	2/17
Uranium, total	10	10	0.29 to 1.22	2.22	0/10
Vanadium	17	17	7.5 to 34.4	19.7	6/17
Zinc	17	17	15 to 54.8	60.2	0/17

[a] Values in square brackets indicate nondetected results.

[b] Value is the ratio of the number of detected values exceeding the background value to the number of analyses.

[c] DL = Detection limit.

[d] BV = Background value.

For reach CDB-4 sediment data, all TAL metals except selenium had reporting limits that were lower than the Laboratory's sediment background values. The reporting limits for selenium ranged from 0.11 to 0.35 mg/kg, compared with the background value of 0.3 mg/kg. Because the reporting limits for cadmium, total cyanide, mercury, and silver were less than the sediment background values, and because these four inorganic chemicals were not detected in any samples, they will not be retained for further assessment.

Twelve of the inorganic chemicals (aluminum, antimony, arsenic, beryllium, copper, lead, manganese, nickel, potassium, sodium, total uranium, and zinc) were measured above their detection limits but below their Laboratory sediment background values. Statistical comparisons to Laboratory background data (see Appendix E) showed that copper and manganese concentrations in reach CDB-4 are greater than

Laboratory-wide background, despite the absence of analytical results above background values. These analytes will be retained as COPCs. (Additional discussion and graphical data presentations of these 12 inorganic chemicals can be found in Appendix E.)

As noted above and discussed in Appendix C, there were indications of negative bias for some aluminum, antimony, and lead sample results. However, careful review of the affected results shows that these negatively biased results are less than one-half of the appropriate background values, with the exception of one lead sample result which measured two-thirds of the background value. Thus, nine of the inorganic chemicals that were measured at levels less than their background values (aluminum, antimony, arsenic, beryllium, lead, nickel, potassium, total uranium, and zinc) will not be retained for further assessment .

Nine of the inorganic chemicals (barium, calcium, chromium, cobalt, iron, magnesium, selenium, thallium, and vanadium) had one or more detected sample results greater than their background values. Statistical and graphical data evaluations led to the elimination of three of these inorganic chemicals because they did not differ statistically from background data. These inorganic chemicals were calcium, chromium, and magnesium, and they will not be retained for further assessment. The remaining six inorganic chemicals (with one or more values greater than the background value) were shown to be greater than background by statistical and graphical comparisons and are retained as COPCs. These inorganic chemicals are barium, cobalt, iron, selenium, thallium, and vanadium. (Additional discussion and graphical data presentations of these nine inorganic chemicals can be found in Appendix E.)

In summary, the inorganic chemical data review yielded eight analytes to be carried forward as COPCs (see Table 3.1-3). A complete presentation of the data for detected inorganic chemicals, which includes inorganic chemicals identified as COPCs, is provided in Appendix D. The concentrations of the chemicals that were eliminated as COPCs were well within the background concentration range, with the exceptions noted above, and those chemicals are justifiably removed from further assessment.

Table 3.1-3
Results of Inorganic Chemical Data Review

Analyte	Result	Rationale
Aluminum	Eliminated	No values exceeded the Laboratory background value
Antimony	Eliminated	No values exceeded the Laboratory background value
Arsenic	Eliminated	No values exceeded the Laboratory background value
Barium	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data
Beryllium	Eliminated	No values exceeded the Laboratory background value
Cadmium	Eliminated	No values exceeded the Laboratory background value
Calcium	Eliminated	Statistical and graphical results presented in Appendix E showed that reach data were not different from Laboratory background data
Chromium, total	Eliminated	Statistical and graphical results presented in Appendix E showed that reach data were not different from Laboratory background data
Cobalt	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data
Copper	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data
Cyanide, total	Eliminated	No values exceeded the Laboratory background value
Iron	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data

Table 3.1-3 (continued)

Analyte	Result	Rationale
Lead	Eliminated	No values exceeded the Laboratory background value
Magnesium	Eliminated	Statistical and graphical results presented in Appendix E showed that reach data were not different from Laboratory background data
Manganese	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data
Mercury	Eliminated	No values exceeded the Laboratory background value
Nickel	Eliminated	No values exceeded the Laboratory background value
Potassium	Eliminated	No values exceeded the Laboratory background value
Selenium	Retained	Detected values were greater than the Laboratory background value
Silver	Eliminated	No values exceeded the Laboratory background value
Sodium	Eliminated	No values exceeded the Laboratory background value
Thallium	Retained	Detected values were greater than the Laboratory background value
Uranium, total	Eliminated	No values exceeded the Laboratory background value
Vanadium	Retained	Statistical and graphical results presented in Appendix E showed that reach data were greater than Laboratory background data
Zinc	Eliminated	No values exceeded the Laboratory background value

3.1.2 Comparison of Radionuclide Data with Background/Fallout Radionuclide Concentrations for Sediments

A total of 17 sediment samples from reach CDB-4 were analyzed for radionuclides; the analytical suites are presented in Table 3.1-1 and the analytical methods are presented in Appendix D. The analytical results were compared with the sediment background data that are presented in "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory" (Ryti et al. 1998, 59730). The methods used to analyze the reach CDB-4 radionuclides are comparable to those used to generate the Laboratory background data, allowing a direct comparison of the CDB-4 results to the Laboratory background data. As it is used in this section, *background* includes radionuclides that are derived from atmospheric fallout, in addition to naturally occurring radionuclides.

As is described more fully in Appendix C, detection status was determined by comparisons either with minimum detectable concentrations that were determined by the analytical laboratories, or with the 1-sigma total propagated uncertainty (TPU). Detection status was used in the preliminary data evaluation step to identify COPCs for the following suites: isotopic uranium, isotopic plutonium, tritium, and strontium-90.

The concentrations of 42 radionuclides were measured by gamma spectroscopy, with varying certainty and applicability to Laboratory releases. A summary of detection frequency and concentration ranges for all gamma spectroscopy–measured radionuclides is provided in Appendix D. According to ER Project guidance (Vanden Plas 2000, 65467), eight gamma spectroscopy radionuclides should be retained and evaluated in data review: americium-241, cesium-134, cesium-137, cobalt-60, europium-152, ruthenium-106, sodium-22, and uranium-235. Each of these radionuclides is a potential historical contaminant, has a half-life greater than one year, and can be reliably measured by gamma spectroscopy. Among these eight radionuclides, cesium-137 and uranium-235 were detected in reach

CDB-4 sediment samples. Because uranium-235 was also measured by alpha spectroscopy, which has lower detection limits than gamma spectroscopy, the alpha spectroscopy results will be evaluated in this data review and shown in Table D-4.0-2 (Appendix D).

As is discussed in Appendix C, no QC problems were associated the reach CDB-4 radionuclide data.

Nine radionuclides were detected in the sediment samples. Table 3.1-4 presents the concentration range and frequency of the results above background values for these radionuclides in reach CDB-4. A complete presentation of the data for these detected radionuclides can be found in Appendix D. Only plutonium-239, -240 had a sample result that was greater than its background value, but this analyte was eliminated as a COPC by statistical analyses (presented in Appendix E). Based on this information, none of the detected radionuclides were retained as COPCs (Table 3.1-5).

Table 3.1-4
Frequency of Detected Radionuclides in Reach CDB-4 Sediment Samples

Analyte	Number of Analyses	Number of Detects	Concentration Range (pCi/g)[a]	Background Value/Fallout Value (pCi/g)	Frequency of Detects above Background Value[b]
Americium-241[c]	10	5	[0.0086] to 0.0229	0.040	0/10
Cesium-137	10	4	[0.032] to 0.73	0.90	0/10
Plutonium-239, -240	17	5	[-0.001] to 0.076	0.068	1/17
Thorium-228	10	10	0.613 to 1.7	2.28	0/10
Thorium-230	10	10	0.407 to 1.38	2.29	0/10
Thorium-232	10	10	0.539 to 1.7	2.33	0/10
Uranium-234	10	10	0.324 to 1.24	2.59	0/10
Uranium-235	10	3	[0.019] to 0.083	0.20	0/10
Uranium-238	10	10	0.373 to 1.262	2.29	0/10

[a] Values in square brackets indicate nondetected results.

[b] Value is the ratio of the number of detected values exceeding the background value to the number of analyses.

[c] Measured by alpha spectroscopy.

Table 3.1-5
Results of Radionuclide Data Review

Analyte	Result	Rationale
Americium-241	Eliminated	No values exceeded the Laboratory background value.
Cesium-137	Eliminated	No values exceeded the Laboratory background value.
Plutonium-239, -240	Eliminated	Statistical and graphical results presented in Appendix E showed that reach data were not different from Laboratory background data.
Thorium-228	Eliminated	No values exceeded the Laboratory background value.
Thorium-230	Eliminated	No values exceeded the Laboratory background value.
Thorium-232	Eliminated	No values exceeded the Laboratory background value.
Uranium-234	Eliminated	No values exceeded the Laboratory background value.
Uranium-235	Eliminated	No values exceeded the Laboratory background value.
Uranium-238	Eliminated	No values exceeded the Laboratory background value.

3.1.3 Evaluation of Organic Chemicals in Sediments

A total of 10 sediment samples from reach CDB-4 were analyzed for organic chemicals. US Environmental Protection Agency (EPA Method 8270 was used to analyze for SVOCs, EPA Method 8081 was used to analyze for organochlorine pesticides, and EPA Method 8082 was used to analyze for PCBs. No organic chemicals were detected in these samples.

The evaluation of reach CDB-4 sediment data quality is presented in Appendix C. Samples CACB-99-0009 and CACB-99-0010 are qualified because the continuing calibration standard that was used for qualification and quantification of these samples exceeded quality control limits. The internal standard areas were less than 50% of the previous continuing calibration standard. The reporting limits are qualified as estimated (UJ) because of the internal standard failure and because no analytes were detected. Table C-5.0-3 (Appendix C) summarizes the sample-specific qualifiers that were applied to these data. None of the data qualifications affect the usability or defensibility of the data. There are no other QC problems associated with organic chemicals in the remainder of the reach CDB-4 sediment samples.

In summary, based on the lack of positive detections in any samples, no organic chemicals were retained as COPCs .

3.2 Nature and Sources of Potential Contamination in Sediments

Potential contamination in reach CDB-4 sediments was investigated using full-suite and limited-suite analyses, statistical analyses of the analytical data, and detailed geomorphic mapping and physical characterization of post-1942 sediments. The nature, characteristics, and probable sources of the COPCs that were identified in section 3.1 are discussed here. Evidence for the possible collocation of contaminants is also included. Identifying the sources of contaminants is an important part of the conceptual model that describes their distribution; therefore, evidence pertaining to the sources of each COPC is also discussed in this section.

Eight inorganic chemicals were identified as COPCs in reach CDB-4, based on a comparison of the reach CDB-4 results and Laboratory-wide background data: barium, cobalt, copper, iron, manganese, selenium, thallium, and vanadium. In addition, reach data were also compared to data from local background samples. The need to obtain local background data for inorganic chemicals was suggested by the initial

list of COPCs that was developed after the first sampling event. These COPCs included metals that are not typically associated with releases from Resource Conservation and Recovery Act (RCRA) facilities (e.g., cobalt, iron, and manganese).

One possible explanation for the elevated concentrations of these inorganic chemicals is that they are due to differences between the bedrock sources for the sediment in reach CDB-4 and the bedrock sources for the sites that had been previously sampled for Laboratory background data. Specifically, basalt is present in areas adjacent to CDB-4, whereas previously sampled sediment sites drain areas without basalt, including areas of Bandelier Tuff, Tschicoma Formation dacite, and Puye Formation fanglomerate (Ryti et al. 1998, 59730).

Another possible explanation for the elevated concentrations of these inorganic chemicals is that they are due to geochemical differences between local soils which provide a source for reach CDB-4 sediments and soils in other parts of the Laboratory. Specifically, soils adjacent to CDB-4 appear to have a strong eolian component, which could make them geochemically different from the soils in areas that had been previously sampled for sediment background.

Thirteen local background samples were collected from reach CDB-4 (sample ID numbers CACB-99-0018 through CACB-99-0030; location ID numbers CB-10005 through CB-10016; Figures 2.3-1a through 2.3-1d). The same analytical methods that had been used for other samples submitted for inorganic chemical analysis were used here. Data validation information for these samples can be found in Appendix C, and sample results are provided in Appendix D. There are no data validation problems associated with these samples or analytes that would affect the comparison of local background samples to reach samples.

For six inorganic COPCs (barium, cobalt, copper, iron, manganese, and vanadium) that were detected with sufficient frequency in local background samples and in reach samples to undergo statistical testing, there are no differences between reach results and local background results (Appendix E). Statistical plots of detected and nondetected selenium and thallium results also suggest no difference between reach and local background concentrations (Appendix E). Appendix E also provides comparisons between local background concentrations, reach data, and Laboratory background data for other inorganic chemicals which were not identified as COPCs in section 3.1. Among these other analytes, calcium, nickel, and magnesium show similar trends in concentration, where the reach samples have concentrations that are generally between the Laboratory background and the local background. These common concentration trends suggest a mix of two sediment sources, one that is locally derived and another that comes from upgradient background materials with different geochemistry.

An important point to consider when evaluating the concentration trends of reach data against the two sets of background data is the magnitude of the concentration differences. The differences noted between reach CBD-4 data and Laboratory-wide background data are small compared to differences noted in Los Alamos and Pueblo Canyon sediment investigations, where a series of inorganic chemicals are clearly above background levels (Reneau et al. 1998, 59159; Reneau et al. 1998, 59160; Reneau et al. 1998, 59667). Table 3.2-1 provides a summary of the maximum concentration for CDB-4 data versus the background value; the ratio of these values is also provided. For copper and manganese, the maximum value in reach CDB-4 is less than the background value and, for all other COPCs (except selenium), the maximum value is less than twice the background value. Thus, the differences between reach data and Laboratory-wide background data are small and reflect small absolute (mg/kg) differences in concentration as well.

Table 3.2-1
Summary of the Pairwise Correlation Analysis

Analyte	Maximum (mg/kg)	Background Value (mg/kg)	Ratio
Barium	130	127	1.02
Cobalt	9	4.73	1.90
Copper	9	11.2	0.80
Iron	21200	13800	1.54
Manganese	481	543	0.89
Selenium	1	0.3	3.33
Thallium	1.1	0.73	1.51
Vanadium	34.4	19.7	1.75

Correlation analysis of these inorganic COPCs is provided here to further evaluate the hypothesis that variations in background levels account for the distribution of these COPCs. The purpose of this analysis is to determine the degree of association between high and low concentrations across pairs of COPCs. The correlation analysis is supported by a calculation of correlation coefficients from these COPCs (Table 3.2-2) as well as a graphical display of these patterns in a scatterplot matrix (Figure 3.2-1).

Both Pearson correlation and Spearman rank correlation coefficients are presented in Table 3.2-2. The difference between these measures of correlation is that the Pearson correlation is calculated from the original sample results while the Spearman correlation is calculated from sample ranks. Ranks are calculated by ordering the sample results from lowest to highest and assigning a value of 1 to the highest value, a value of 2 to the second highest value, and so on, until all sample results have been assigned ranks.

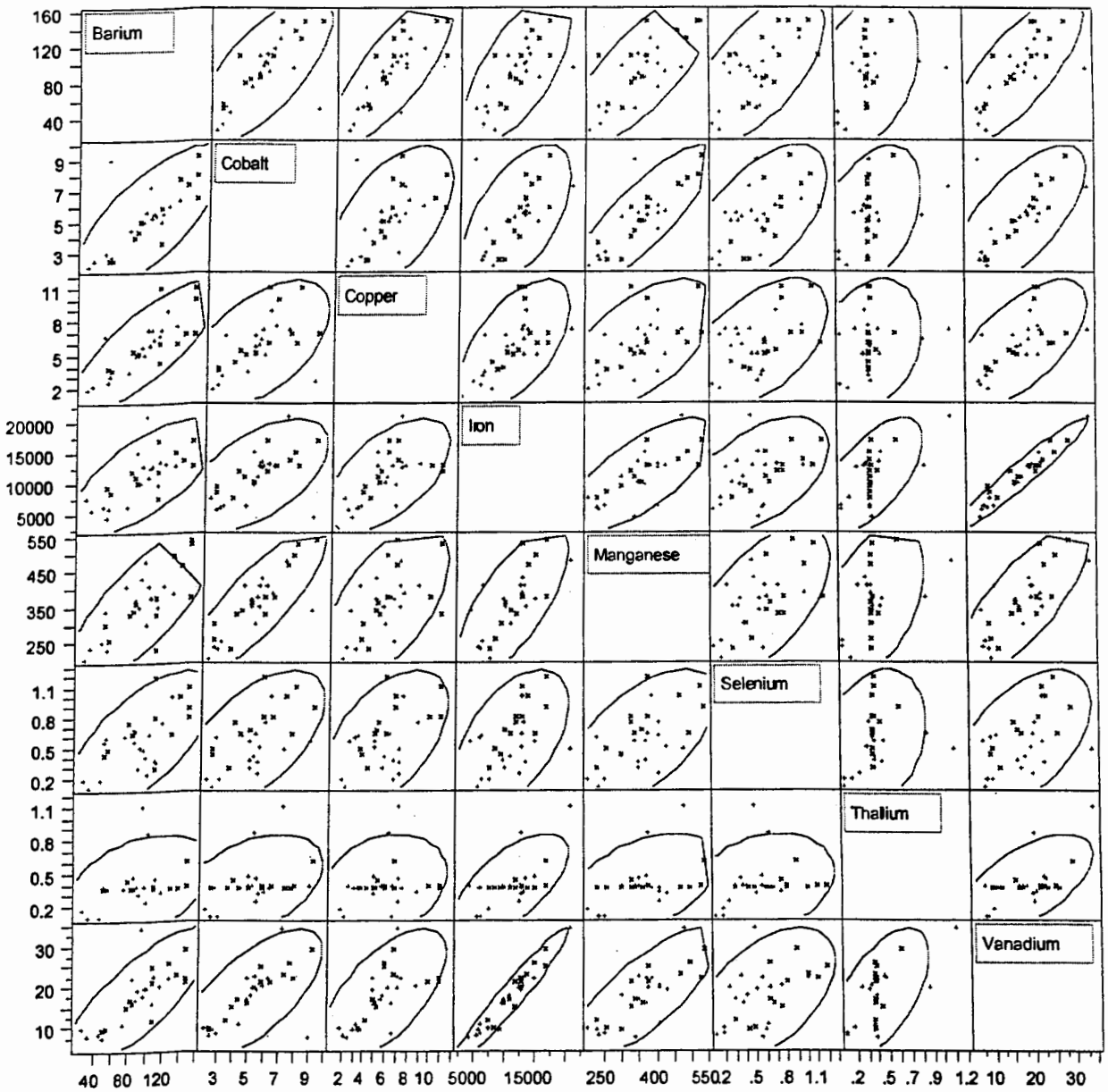
Correlation coefficients range between –1 and +1. A correlation of –1 indicates a perfect negative correlation between COPCs (the highest result for one COPC is associated with the lowest result for the other COPC). A correlation of +1 indicates a perfect positive correlation between COPCs (the highest result for one COPC is associated with the highest result for the other COPC). The statistical significance of these correlation coefficients is also shown to provide a measure of the relevance of the observed correlations. Statistical significance values that are less than 0.05 are assumed to represent correlations greater than one may expect by chance alone. Table 3.2-2 shows that the correlation between most inorganic COPCs is statistically significant (<0.05) with the exception of the correlation of some COPCs with thallium. The poor correlation of thallium with other inorganic chemicals is due to infrequent detection of thallium in these samples (4 detects out of 30 sample results).

The scatterplot matrix corroborates the findings that comes from evaluating the correlation coefficients, and it also shows that the correlation between some COPCs (e.g., iron and vanadium) are exceptionally high (Figure 3.2-1). In particular, note the correlation of other COPCs with iron, which supports the common source for these COPCs. To support the evaluation of selenium and thallium, which were infrequently detected in the reach samples, scatter plots of these COPCs versus iron were also prepared. These plots (Figures 3.2-2 and 3.2-3) distinguish detected sample results from nondetected sample results. Selenium has a significant correlation with iron, and nondetected selenium sample results tend to have low iron concentrations (Figure 3.2-2). It is evident that one reason for the poor correlation of thallium with other COPCs is the lack of detected sample results, but Figure 3.2-3 does show that the detected thallium results are associated with the higher iron results.

Table 3.2-2
Summary of the Pairwise Correlation Analysis

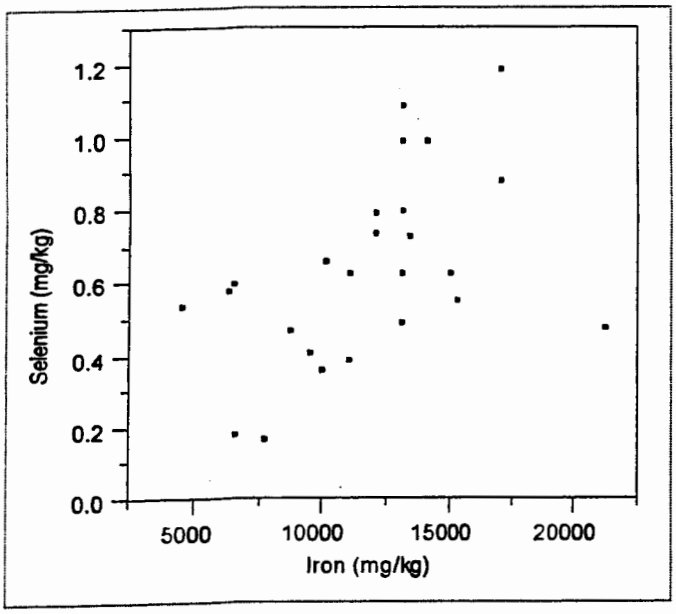
Variable	By Variable	Count	Pearson Correlation	Pearson Statistical Significance	Spearman Rank Correlation	Spearman Statistical Significance
Cobalt	Barium	30	**0.726**	<0.001	**0.749**	<0.001
Copper	Barium	30	**0.787**	<0.001	**0.799**	<0.001
Copper	Cobalt	30	**0.537**	0.002	**0.659**	<0.001
Iron	Barium	30	**0.677**	<0.001	**0.729**	<0.001
Iron	Cobalt	30	**0.566**	0.001	**0.667**	<0.001
Iron	Copper	30	**0.568**	0.001	**0.655**	<0.001
Manganese	Barium	30	**0.757**	<0.001	**0.687**	<0.001
Manganese	Cobalt	30	**0.839**	<0.001	**0.806**	<0.001
Manganese	Copper	30	**0.558**	0.001	**0.580**	<0.001
Manganese	Iron	30	**0.719**	<0.001	**0.744**	<0.001
Selenium	Barium	30	**0.645**	<0.001	**0.596**	<0.001
Selenium	Cobalt	30	**0.577**	<0.001	**0.607**	<0.001
Selenium	Copper	30	**0.513**	0.004	**0.472**	**0.008**
Selenium	Iron	30	**0.494**	0.006	**0.542**	**0.002**
Selenium	Manganese	30	**0.590**	<0.001	**0.565**	**0.001**
Thallium	Barium	30	0.327	0.078	**0.384**	**0.036**
Thallium	Cobalt	30	**0.406**	0.026	**0.404**	**0.027**
Thallium	Copper	30	0.218	0.246	0.291	0.119
Thallium	Iron	30	**0.623**	<0.001	**0.481**	**0.007**
Thallium	Manganese	30	**0.442**	**0.015**	0.316	0.089
Thallium	Selenium	30	0.243	0.195	0.333	0.072
Vanadium	Barium	30	**0.774**	<0.001	**0.824**	<0.001
Vanadium	Cobalt	30	**0.692**	<0.001	**0.741**	<0.001
Vanadium	Copper	30	**0.639**	<0.001	**0.724**	<0.001
Vanadium	Iron	30	**0.963**	<0.001	**0.952**	<0.001
Vanadium	Manganese	30	**0.785**	<0.001	**0.767**	<0.001
Vanadium	Selenium	30	**0.514**	0.004	**0.569**	**0.001**
Vanadium	Thallium	30	**0.617**	<0.001	**0.484**	**0.007**

Note: Values in bold are considered statistically significant.



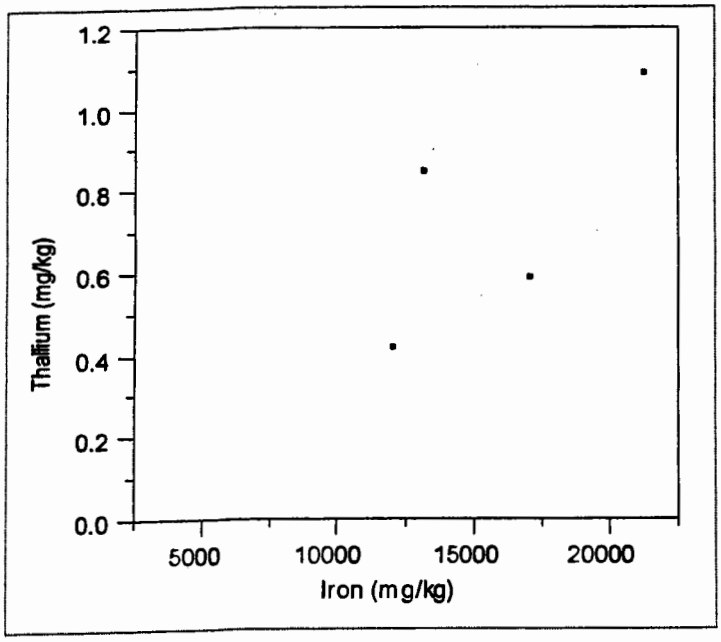
Note: A plus sign represents a reach CDB-4 sample result; an x represents a local background sample result; x and y axes indicate concentrations in mg/kg

Figure 3.2-1. Scatterplot matrix for inorganic COPCs



Note: Open symbols represent nondetected selenium sample results.

Figure 3.2-2. Scatter plot of selenium versus iron



Note: Open symbols represent nondetected thallium sample results.

Figure 3.2-3. Scatter plot of thallium versus iron

Correlation analyses and other statistical evaluations (Appendix E) support a common source for the elevated inorganic COPCs in reach CDB-4. As discussed above, the concentrations of these COPCs in the reach samples are intermediate between the local background and Laboratory background concentrations, which suggests that reach sediments are a mixture of Laboratory background and locally derived materials. These local background materials are either weathered basalts or eolian material. Because a comparison with local background data indicates that the probable source of these elevated levels of chemicals is naturally occurring material local to the reach and not Laboratory releases, no further assessment of the risk associated with these COPCs is warranted.

4.0 REVISED CONCEPTUAL MODEL

A key part of the technical approach to evaluating contamination in canyon bottoms, as presented in Section 5 of the core document (LANL 1997, 55622; LANL 1998, 57666), is the collection of data to test hypotheses concerning the nature, distribution, and transport of contaminants associated with sediment. These hypotheses comprise components of a preliminary conceptual model and were based on the results of investigations in other canyons and the existing knowledge of contaminant sources in the Cañada del Buey watershed. Refinement of this conceptual model is necessary for understanding the analytical results from reach CDB-4, and it will contribute to a future watershed-scale assessment of human-health and ecological risk.

This section presents the current conceptual model of contamination in reach CDB-4 sediments, a model which has been revised and refined from the preliminary conceptual model that was presented in section 1.6 of this report. This section includes discussions of the analytes that were measured above Laboratory-wide background levels within the sediments, the sources of these sediments, and the potential for future contamination in reach CDB-4.

4.1 Analytes Above Laboratory-Wide Background Levels

Within the sediments of reach CDB-4, eight inorganic chemical analytes are present at levels that are statistically higher than Laboratory-wide background levels. These eight analytes were initially retained as COPCs, as discussed in section 3.1. In addition, one radionuclide—plutonium-239, -240—had one result slightly above the background value, but it was eliminated as a COPC after statistical evaluation (Appendix E). No organic chemicals were detected in reach CDB-4; therefore, there are no organic COPCs.

The inorganic chemicals that were initially identified as COPCs in this investigation were barium, cobalt, copper, iron, manganese, selenium, thallium, and vanadium. It was hypothesized that these elevated inorganic chemicals represent local background levels that are different from the Laboratory-wide background levels as presented in Ryti et al. (1998, 59730). To test this hypothesis, fine-grained sediment samples were collected from 12 sites along local tributary drainages to Cañada del Buey during the second sampling phase.

The sample results support the hypothesis that local background levels are elevated relative to Laboratory-wide background levels. The results show very similar average concentrations of these eight metals in both the local background samples and texturally similar sediment samples along Cañada del Buey (Table 4.1-1). Averages for two metals, cobalt and selenium, are higher than the Laboratory-wide background values in both sets of samples. The cobalt and selenium average values from coarse sediments in Cañada del Buey are also greater than the average concentrations of these metals in Laboratory background samples.

The maximum results for three other analytes are higher than the Laboratory-wide background values in both data sets: barium, iron, and vanadium. By comparison, the average concentrations of all eight metals are higher in the fine-grained sediment samples than in the coarse-grained sediment samples collected along Cañada del Buey, which is consistent with background results from investigations in other canyons (McDonald et al. 1996, 55532; Reneau et al. 1998, 62050). Potential sources of elevated local background levels for reach CDB-4 include basalt or soils developed on eolian deposits. Geochemical and geomorphic evidence suggests that the erosion of eolian-derived soils is the most likely explanation.

Table 4.1-1
Summary of Reach CDB-4 COPCs

Data Set	Median Particle-Size Class	Barium (mg/kg)	Cobalt (mg/kg)	Copper (mg/kg)	Iron (mg/kg)	Manganese (mg/kg)	Selenium (mg/kg)	Thallium (mg/kg)	Vanadium (mg/kg)
Laboratory-wide sediment background	n/a[a]								
Average value		60	2.40	4.6	8030	290	n.d.[b]	n/a	10.4
Background value		127	4.73	11.2	13800	543	0.3	0.73	19.7
Reach CDB-4, coarse-grained sediment	Coarse sand								
Average value		42	3.9	3.3	6170	253	0.32	0.23	8.8
Maximum value		53	9.0	6.7	7670	340	0.59	0.38	10.1
Reach CDB-4, fine-grained sediment	Very fine sand								
Average value		102	5.6	6.4	12708	388	0.52	0.47	20.2
Maximum value		130	7.3	9.0	21200	481	1.00	1.10	34.4
Local background, fine-grained sediment	Very fine sand								
Average value		110	5.7	6.7	12400	384	0.75	0.40	19.1
Maximum value		150	9.3	11.0	17000	540	1.20	0.60	29.0

[a] n/a = Not available.
[b] n.d.= Not detected.

In summary, the results from reach CDB-4 indicate that this area has local background levels (for a series of metals) that are elevated above those in areas previously sampled for the Laboratory-wide background data set. Results also indicate that no analytes are present at levels that statistically differ from this local background.

4.2 Sediment Sources

The analytical results from reach CDB-4 and adjacent local background sites suggest that local drainages supply much of the sediment that is deposited in this part of Cañada del Buey. The hypothesis of a local source of sediment is also supported by field observations of a recent flood and by studies of runoff and erosion elsewhere on the Pajarito Plateau.

On June 17, 1999, White Rock experienced a record rainfall of 2.11 in. in one hour, including a record 0.72 in. in two consecutive 15-minute periods (*Los Alamos Monitor*, 1999, 66647). This rain produced a flood in Cañada del Buey, with an estimated discharge of 210 ft^3 per second at State Road NM 4 (Shaull

et al. 2000, 66648). This flood inundated the post-1942 geomorphic units along reach CDB-4 and created new sediment deposits in many areas. Field observations revealed that the runoff did not originate from the headwaters of Cañada del Buey; instead it came from a series of tributary drainages which extend for 3 km to the west of State Road NM 4, and which receive runoff from the mesas on both the north and south sides of the main channel. The largest discharges originated from San Ildefonso Pueblo land to the north.

Previous studies have indicated that piñon-juniper woodlands on the eastern Pajarito Plateau can be major sources of runoff and sediment during thunderstorms (Wilcox et al. 1996, 66646), which is consistent with the observations made after the June 17 flood. Available data and observations therefore support the hypothesis that much of the sediment along reach CDB-4 is derived from local sources.

4.3 Potential Future Contamination

The evidence for a local source of much of the sediment in reach CDB-4, together with the absence of recognized contaminants more than 50 years after Laboratory activities began in the watershed, indicates a low potential for future contamination (in the absence of new contaminant sources). Any contaminants which might be present along Cañada del Buey upstream of the proposed land transfer parcel, and which might be susceptible to transport into reach CDB-4, can be expected to be strongly diluted by locally derived sediment in the lower watershed. The demonstrated downstream dilution of contaminants in other watersheds, combined with strong evidence for dilution over time after peak contaminant releases (e.g., Reneau et al. 1998, 59159; Reneau et al. 1998, 59160; Reneau et al. 1998, 59667), provides support for this conclusion. It is therefore considered very unlikely that future contamination in reach CDB-4 sediments could reach levels that pose unacceptable human-health or ecological risk as a result of Laboratory activities.

5.0 SITE ASSESSMENTS

No human-health or ecological risk assessments were conducted for this investigation because no contaminants were identified.

6.0 CONCLUSIONS AND RECOMMENDATIONS

An investigation of young sediments along Cañada del Buey in the proposed White Rock land transfer parcel (reach CDB-4) found no evidence of contaminants. No organic chemicals were detected. No radionuclides were found at levels statistically higher than the Laboratory-wide sediment background levels. A series of inorganic chemicals were detected at levels above the Laboratory-wide background levels, but these results can be attributed to a local background that differs from areas previously sampled for background geochemistry.

The evidence for a local source of much of the sediment in reach CDB-4, together with the absence of recognized contaminants more than 50 years after Laboratory activities began in the watershed, indicate a low potential for future contamination (in the absence of new contaminant sources). Any contaminants which might be present along Cañada del Buey upstream of the proposed land transfer parcel, and which might be susceptible to transport into reach CDB-4, can be expected to be strongly diluted by locally derived sediment in the lower watershed. It is considered very unlikely that future contamination in reach CDB-4 sediments could reach levels that pose unacceptable human-health or ecological risk as a result of Laboratory activities. Therefore, it is recommended that no additional assessment or remedial action is required before land transfer.

7.0 REFERENCES

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ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with Los Alamos National Laboratory potential release sites. These numbers can be used to locate copies of the documents at the ER Project's Records Processing Facility and, where applicable, within the ER Project reference library. The references cited in this report can be found in the volumes of the reference library titled "Reference Set for Canyons."

Copies of the reference library are maintained at the New Mexico Environment Department Hazardous and Radioactive Materials Bureau, the Los Alamos Area Office of the US Department of Energy, and the ER Project Office. This library is a living document that was developed to ensure that the administrative authority has all the necessary material to review the decisions and actions proposed in this report. However, documents previously submitted to the administrative authority are not included in the reference library.

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Appendix A

Acronyms and Unit Conversion Table

BKG	background data
BV	background value
COPC	chemical of potential concern
CRDL	contract-required detection limit
CRQL	contract-required quantitation limit
CVAA	cold vapor atomic absorption
DOE	US Department of Energy
EPA	US Environmental Protection Agency
EQL	estimated quantitation limit
ER	environmental restoration
FD	field duplicate
FIMAD	Facility for Information Management, Analysis, and Display
HSWA	Hazardous and Solid Waste Amendments (Act)
ICPES	inductively coupled plasma emission spectroscopy
ICPMS	inductively coupled plasma mass spectroscopy
IDL	instrument detection limit
LANL	Los Alamos National Laboratory
LCS	laboratory control sample
MDA	minimum detectable activity
MDC	minimum detectable concentration
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
NFG	national functional guideline
PCB	polychlorinated biphenyl
PRS	potential release site
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RN	request number
SOP	standard operating procedure
SOW	statement of work
SVOC	semivolatile organic compound
TA	technical area

TAL	target analyte list
TPU	total propagated uncertainty
USGS	US Geological Survey

Metric to English Conversions

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (L)	0.26	gallons (gal.)
milligrams per liter (mg/L)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

Appendix B

Characterization of Geomorphic Units

This appendix presents supplemental information about the characteristics of the geomorphic units in reach CDB-4, the goals of each sampling event, and the geomorphic context of the sediment samples.

B-1.0 THICKNESS OF POST-1942 SEDIMENT DEPOSITS

The thickness of post-1942 sediment in reach CDB-4 was measured in order to calculate the volume of sediment in the different geomorphic units and to guide sample allocation. Thickness measurements were focused on the relatively fine-grained facies because these sediments are more likely to contain higher levels of contaminants than the coarser-grained sediment facies (e.g., Reneau et al. 1998, 59159). In addition, the thickness of post-1942 fine facies sediments can be determined with greater confidence than the thickness of associated coarse facies sediments because of the general absence of clear stratigraphic markers in the latter and the difficulty in confidently determining the contact with underlying pre-1943 sediment. Thickness measurements for reach CDB-4 are presented in Tables B-1.0-1 through B-1.0-4.

Table B-1.0-1
Thickness Measurements for Reach CDB-4, c1 Unit

Channel Distance (m)	Side of Channel	Thickness of c1 Fine Facies (cm)	Thickness of c1 Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
00	—[a]	0	35	35	—
25	—	0	34	—	34
50	South	0	21	—	21
50	North	0	25	—	—
75	North	0	13	—	13
75	South	7	23	30	—
100	South	33	20	—	53
100	North	2	0	—	—
125	North	0	22	22	—
125	South	2	0	—	2
150	—	1	65	—	66
175	—	0	50	—	50
225	—	0	34	—	34
250	—	0	36	—	36
275	—	0	40	—	40
300	—	0	12	—	12
325	—	0	50	—	50
350	South	0	22	22	22
350	North	5	22	—	27
375	—	0	7	—	7
400	—	20	12	—	32
425	—	33	0	33?[b]	48
450	—	0	3	—	3
475	—	14	18	32?	34
500	—	0	5	-	—

Table B-1.0-1 (continued)

Channel Distance (m)	Side of Channel	Thickness of c1 Fine Facies (cm)	Thickness of c1 Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
525	—	11	0	11	11
550	—	0	29	29	—
575	—	15	0	—	15
600	—	13	31	44	—
625	—	8	14	22	—
650	—	0	48	48?	—
675	—	0	90	—	—
700	—	58	0	58	—
725	—	45	0	45?	—
750	—	0	88	—	—
775	—	0	48	48	—
800	—	29	93	—	122
825	—	0	92	—	92
25N[c]	—	0	2	—	—
50N	—	8	26	—	34
75N	—	0	28	—	—
100N	—	28	15	—	43
125N	North	0	18	—	18
125N	South	9	—	—	9
150N	—	0	55	55	—
Average	—	**8**	**28**	—	—

[a] — = not applicable or not available.

[b] ? indicates that the presence of a buried soil at this location is uncertain.

[c] N = distance along major northern channel braid.

Table B-1.0-2
Thickness Measurements for Reach CDB-4, c1b Unit

Channel Distance (m)	Side of Channel	Thickness of c1b Fine Facies (cm)	Thickness of c1b Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
00	South	0	52	52	—[a]
25	North	19	20	—	39
200	South	3	6	—	—
302	Middle	29	16	—	45
350	South	18	0	—	18
625	South	0	45	45	—
650	South	31	59	—	—
675	South	15	62	77?[b]	—
802	South	8	10	18	—
830	South	23	81	104	—

Table B-1.0-2 (continued)

Channel Distance (m)	Side of Channel	Thickness of c1b Fine Facies (cm)	Thickness of c1b Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
25N[c]	North	27	9	—	36
50N	South	14	7	—	21?
50N	South[d]	47	0	47?	—
100N	South	0	27	27	30
125N	North	0	18	—	18
125N	South	9	0	—	9
129N	North	0	36	—	—
75FN[e]	—	7	3	—	—
Average	—	**13.9**	**25.1**	—	—

[a] — = not applicable or not available.

[b] ? indicates that the presence of a buried soil at this location is uncertain.

[c] N = distance along major northern channel braid.

[d] Indicates overflow channel.

[e] FN = distance along a far northern channel braid.

Table B-1.0-3
Thickness Measurements for Reach CDB-4, c2 Unit

Channel Distance (m)	Side of Channel	Thickness of c2 Fine Facies (cm)	Thickness of c2 Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
00	South	80	27	—[a]	107
00	North	58	62	—	120
44	North	10	30	40?[b]	61
50	North	36	8	—	44
75	North	19	6	25	32?
125	South	7	10	—	17
250	South	20	6	—	26
325	North	52	13	—	65
400	North	13	12	—	25
402	South	16	8	—	24
425	North	38	16	—	54
525	South	25	15	40	55
525	North	20	46	—	66
548	North	39	—	39	—
600	South	48	66	—	—
700	North	48	61	109	—
710	South	38	23	61	—
725	South	38	42	80	89
750	North	29	33	62	—
775	North	12	37	49	—

Table B-1.0-3 (continued)

Channel Distance (m)	Side of Channel	Thickness of c2 Fine Facies (cm)	Thickness of c2 Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
825	North	21	61	—	82
50N[c]	North	8	25	33	—
80N	South	19	8	—	34
150N	South	22	37	—	59
155N	North	23	7	—	30
average	—	**30**	**27**	—	—

[a] — = not applicable or not available.

[b] ? indicates that the presence of a buried soil at this location is uncertain.

[c] N = distance along major northern channel braid.

Table B-1.0-4
Thickness Measurements for Reach CDB-4, f1 Unit

Channel Distance (m)	Side of Channel	Thickness of f1 Fine Facies (cm)	Thickness of f1 Coarse Facies (cm)	Depth to Buried Soil (cm)	Depth to Bedrock (cm)
75	South	16	0	—[a]	16
100	North	30	0	—	30
125	South	34	0	34	—
170	South	45	0	45	56
200	North	23	13	—	36
206	North	51	0	—	51
225	South	61	0	—	61
275	South	26	25	—	51
325	South	30	0	—	30
375	South	22	0	22	22
375	North	26	0	—	—
475	South	30	0	—	30
492	North	45	0	—	45
45N[b]	North	24	0	—	24
50N	South	31	0	—	31
125N	South	34	0	—	34
116N	South	20	0	—	20
75FN[c]	South	28	7	—	35
75FN	North	47	0	—	47
average	—	**33**	**2**	—	—

[a] — = not applicable or not available.

[b] N = distance along major northern channel braid.

[c] FN = distance along a far northern channel braid.

B-2.0 PARTICLE-SIZE, ORGANIC MATTER, AND pH DATA

Each layer that was sampled for analysis of potential contaminants was also sampled for analysis of particle-size distribution to evaluate possible relations between contaminant levels and size characteristics. All samples were analyzed by the Soil Characterization and Quaternary Pedology Laboratory of the Desert Research Institute, following procedures recommended by the United States Geological Survey (USGS) for geological applications (Janitzky 1986, 57674). To evaluate potential correlations between contaminant concentrations and organic matter, data on organic matter content were obtained for some of the samples. For organic matter analyses, a loss-on-ignition method was used. In this method, after a sample is dried at a low temperature to remove water, the percentage of sample lost by combustion after heating it to 400°C for four hours is calculated. To provide additional data on geochemical characteristics of reach CDB-4 sediment, pH data were obtained for some of the samples.

Table B-2.0-1 shows data on particle-size distribution, organic matter content, and pH for reach CDB-4 sediment samples. Table B-2.0-2 summarizes these data for each geomorphic unit and sediment facies. Percentages of sand, silt, and clay size fractions were calculated from the <2-mm size fraction. For the <2-mm size fraction, the median particle-size class and the median particle size are shown in order to facilitate comparison of the particle-size characteristics of the different samples and the different geomorphic units. Because particle-size distributions are traditionally shown on semilogarithmic plots, the median particle size was calculated for these tables by extrapolating between boundaries of size classes using a logarithmic transformation. Percentages of gravel in these tables may be lower than in the actual sampled layer because only gravel that would fit into the sample bottles was collected (<5 cm). Average gravel percentages for the coarse facies sediment may thus be underestimated, although gravel percentages for fine facies deposits are generally accurate.

Table B-2.0-1
Reach CDB-4 Particle-Size, Organic Matter, and pH Data

Sample ID	Gravel (> 2 mm) (wt %)	Very Coarse Sand (2-1 mm) (wt %)	Coarse Sand (1-0.5 mm) (wt %)	Medium Sand (0.5-0.25 mm) (wt %)	Fine Sand (0.25-0.125 mm) (wt %)	Very Fine Sand (0.125-0.0625 mm) (wt %)	Coarse Silt (62.5-15 µm) (wt %)	Fine Silt (15-2 µm) (wt %)	Clay (<2 µm) (wt %)	Organic Matter (wt %)	pH	Median Particle-Size Class	Median Particle Size (mm)
CACB-99-0001	6.0	6.7	11.7	7.6	6.6	12.6	41.0	7.0	6.7	1.9	8.4	csi[a]	0.053
CACB-99-0002	5.0	6.3	10.7	14.2	14.8	18.4	24.6	5.8	4.9	1.3	8.5	vfs[b]	0.107
CACB-99-0003	0.6	0.8	2.1	5.3	13.0	29.5	38.6	5.5	5.2	2.1	8.5	vfs	0.063
CACB-99-0004	0.9	1.8	5.9	10.3	15.2	23.7	28.4	5.9	8.7	2.7	7.4	vfs	0.076
CACB-99-0005	3.6	8.8	11.3	15.9	16.6	17.8	17.4	5.2	6.9	1.6	8.0	fs[c]	0.140
CACB-99-0006	3.6	5.9	4.8	8.9	13.7	23.2	30.7	5.0	7.7	1.5	7.8	vfs	0.076
CACB-99-0007	26.6	50.3	30.5	8.2	2.4	1.2	2.0	2.5	2.8	0.5	8.5	vcs[d]	1.004
CACB-99-0008	2.4	4.5	7.2	5.8	7.0	17.9	40.8	7.8	8.7	1.9	7.7	csi	0.048
CACB-99-0009	2.2	34.5	45.1	9.6	2.1	1.1	1.5	2.5	3.3	0.5	8.1	cs[e]	0.789
CACB-99-0010	3.4	26.9	40.2	15.9	4.9	2.8	3.3	2.3	3.6	0.6	8.6	cs	0.672
CACB-99-0011	5.1	15.2	12.2	10.5	12.3	17.0	19.4	4.6	8.8	—[f]	—	fs	0.127
CACB-99-0012	5.8	8.3	7.0	8.3	13.8	22.8	25.8	5.5	8.2	—	—	vfs	0.085
CACB-99-0013	6.2	25.1	27.5	11.9	5.3	6.6	11.1	4.6	7.8	—	—	cs	0.533
CACB-99-0014	0.7	1.5	2.7	4.7	8.6	24.6	39.0	8.2	10.7	—	—	csi	0.046
CACB-99-0015	6.0	1.9	3.6	6.0	8.6	21.7	36.7	7.3	14.1	—	—	csi	0.045
CACB-99-0016	10.6	20.7	41.8	17.7	4.8	3.5	3.9	3.0	4.6	—	—	cs	0.615
CACB-99-0017	1.4	4.2	8.2	12.4	11.3	20.1	29.3	6.2	8.1	—	—	vfs	0.077
CACB-99-0018	3.4	4.6	9.2	7.9	5.7	18.2	28.6	10.6	15.8	—	—	csi	0.050
CACB-99-0019	1.8	6.5	10.6	11.0	12.9	22.2	23.7	5.3	7.8	—	—	vfs	0.094
CACB-99-0020	1.9	3.2	10.0	15.5	14.4	16.4	20.5	7.9	12.1	—	—	vfs	0.093
CACB-99-0021	5.5	10.6	20.0	17.6	12.9	12.3	14.8	6.0	7.0	—	—	fs	0.226
CACB-99-0022	2.5	3.7	4.9	4.4	4.9	18.3	36.6	10.3	16.8	—	—	csi	0.036
CACB-99-0023	1.1	1.2	5.6	11.0	10.2	19.3	27.3	10.2	15.3	—	—	csi	0.054

Table B-2.0-1 (continued)

Sample ID	Gravel (> 2 mm) (wt %)	Very Coarse Sand (2-1 mm) (wt %)	Coarse Sand (1-0.5 mm) (wt %)	Medium Sand (0.5-0.25 mm) (wt %)	Fine Sand (0.25-0.125 mm) (wt %)	Very Fine Sand (0.125-0.0625 mm) (wt %)	Coarse Silt (62.5-15 µm) (wt %)	Fine Silt (15-2 µm) (wt %)	Clay (<2 µm) (wt %)	Organic Matter (wt %)	pH	Median Particle-Size Class	Median Particle Size (mm)
CACB-99-0024	7.6	8.4	11.9	12.3	11.5	16.2	22.3	6.5	10.8	—	—	vfs	0.097
CACB-99-0025	4.2	1.2	2.7	2.2	3.5	21.8	49.3	6.8	12.5	—	—	csi	0.036
CACB-99-0026	7.3	6.3	12.3	14.6	12.9	16.6	19.4	9.1	8.8	—	—	vfs	0.106
CACB-99-0027	10.6	14.1	20.2	15.5	11.7	12.4	13.2	5.6	7.1	—	—	fs	0.247
CACB-99-0028	2.2	4.5	9.7	11.1	11.5	21.1	22.8	6.3	12.9	—	—	vfs	0.081
CACB-99-0029	2.0	3.3	9.0	11.4	9.0	15.8	23.3	11.0	17.1	—	—	csi	0.057

[a] csi = coarse silt.

[b] vfs = very fine sand.

[c] fs = fine sand.

[d] vcs = very coarse sand.

[e] cs = coarse sand.

[f] — = not applicable or not available.

Table B-2.0-2
Reach CDB-4 Particle-Size, Organic Matter, and pH Summary

Geomorphic Unit	Sediment Facies	Summary Statistic	Gravel (> 2 mm) (wt %)	Very Coarse Sand (2-1 mm) (wt %)	Coarse Sand (1-0.5 mm) (wt %)	Medium Sand (0.5-0.25 mm) (wt %)	Fine Sand (0.25-0.125 mm) (wt %)	Very Fine Sand (0.125-0.0625 mm) (wt %)	Coarse Silt (62.5-15 µm) (wt %)	Fine Silt (15-2 µm) (wt %)	Clay (<2 µm) (wt %)	Organic Matter (wt %)	pH	Median Particle-Size Class	Median Particle Size (mm)
c1	Coarse	Average	7.0	23.8	41.0	16.8	4.9	3.1	3.6	2.7	4.1	0.6	8.6	cs[a]	0.642
		Number of samples	2	2	2	2	2	2	2	2	2	1	1	—[b]	—
c1b	Fine	Average	2.4	4.5	7.2	5.8	7.0	17.9	40.8	7.8	8.7	1.9	7.7	csi[c]	0.048
		Number of samples	1	1	1	1	1	1	1	1	1	1	1	—	—
c1b	Coarse	Average	4.2	29.8	36.3	10.8	3.7	3.8	6.3	3.5	5.6	0.5	8.1	cs	0.680
		Number of samples	2	2	2	2	2	2	2	2	2	1	1	—	—
c2	Fine	Average	4.1	7.7	8.3	9.3	11.9	19.7	28.9	5.9	8.2	1.7	8.1	vfs[d]	0.080
		Number of samples	6	6	6	6	6	6	6	6	6	3	3	—	—
c2	Coarse	Average	26.6	50.3	30.5	8.2	2.4	1.2	2.0	2.5	2.8	0.5	8.5	vcs[e]	1.004
		Number of samples	1	1	1	1	1	1	1	1	1	1	1	—	—
f1	Fine	Average	2.8	3.0	6.1	9.6	12.6	22.7	31.5	6.2	8.2	2.0	8.1	vfs	0.071
		Number of samples	5	5	5	5	5	5	5	5	5	3	3	—	—
Qal	Fine	Average	4.2	5.6	10.5	11.2	10.1	17.5	25.1	8.0	12.0	—	—	vfs	0.076
		Number of samples	12	12	12	12	12	12	12	12	12	0	0	—	—

[a] cs = coarse sand.
[b] — = not applicable.
[c] csi = coarse silt.
[d] vfs = very fine sand.
[e] vcs = very coarse sand.

B-3.0 SEDIMENT SAMPLING EVENTS

Sediment sampling in this investigation followed a phased approach, which focused on sequentially reducing uncertainties about potential contamination in reach CDB-4. Table B-3.0-1 shows the chronology of sediment sampling events in reach CDB-4 and the primary goals of each sampling event.

Table B-3.0-1
Summary of Sediment Sampling Events in Reach CDB-4

Sampling Event	Sampling Dates	Number of Samples Collected	Type of Analyses and Primary Goals
1	5/17/99	10	Full-suite analyses; determine if any analytes are present above Laboratory-wide background values and determine any possible risk drivers; examine general variations in possible contaminants between geomorphic units.
2	11/24/99 and 11/29/99	20	Limited-suite analyses for metals and isotopic plutonium in potentially contaminated sediments and local background sediments; tritium analyses in potentially contaminated sediments; determine if any analytes are present above local background levels.

B-4.0 GEOMORPHIC CONTEXT OF SEDIMENT SAMPLES

Table B-4.0-1 presents information about the geomorphic context of each sediment sample, including the geomorphic unit, sample depth, sediment facies, and median particle-size class. Samples are ordered by Location ID and by sample depth.

Table B-4.0-1
Geomorphic Context of Sediment Samples in Reach CDB-4

Location ID	Sample ID	Channel Distance (m)[a]	Side of Channel	Geomorphic Unit	Depth (cm)	Sediment Facies	Median Particle-Size Class	Notes
CB-00003	CACB-99-0001	0	South	c2	35–66	Fine	csi[b]	
CB-00003	CACB-99-0031	0	South	c2	35–66	Fine	—[c]	Layer resampled for tritium
CB-00004	CACB-99-0002	75	North	f1	0–33	Fine	vfs[d]	
CB-00004	CACB-99-0032	75	North	f1	0–33	Fine	—	Layer resampled for tritium
CB-00005	CACB-99-0003	206	North	f1	12–28	Fine	vfs	
CB-00005	CACB-99-0033	206	North	f1	12–28	Fine	—	Layer resampled for tritium
CB-00006	CACB-99-0004	325	South	f1	0–19	Fine	vfs	
CB-00006	CACB-99-0034	325	South	f1	0–19	Fine	—	Layer resampled for tritium
CB-00007	CACB-99-0011	80N[e]	South	c2	(-10)–0	Fine	fs[f]	June 1999 flood layer

Table B-4.0-1 (continued)

Location ID	Sample ID	Channel Distance (m)[a]	Side of Channel	Geomorphic Unit	Depth (cm)	Sediment Facies	Median Particle-Size Class	Notes
CB-00007	CACB-99-0005	80N	South	c2	0–11	Fine	fs	
CB-00007	CACB-99-0035	80N	South	c2	0–11	Fine	—	Layer resampled for tritium
CB-00007	CACB-99-0012	80N	South	c2	19–27	Fine	vfs	
CB-00008	CACB-99-0006	600	South	c2	0–12	Fine	vfs	
CB-00008	CACB-99-0036	600	South	c2	0–12	Fine	—	Layer resampled for tritium
CB-00008	CACB-99-0007	600	South	c2	32–79	Coarse	vcs[g]	
CB-00008	CACB-99-0038	600	South	c2	32–79	Coarse	—	Layer resampled for tritium
CB-00009	CACB-99-0008	650	South	c1b	0–17	Fine	csi	
CB-00009	CACB-99-0037	650	South	c1b	0–17	Fine	—	Layer resampled for tritium
CB-00009	CACB-99-0009	650	South	c1b	31–90	Coarse	cs[h]	
CB-00009	CACB-99-0039	650	South	c1b	31–90	Coarse	—	Layer resampled for tritium
CB-00010	CACB-99-0010	800	—	c1	0–40	Coarse	cs	
CB-00010	CACB-99-0040	800	—	c1	0–40	Coarse	—	Layer resampled for tritium
CB-10000	CACB-99-0013	129N	North	c1b	17–30	Fine	csi	
CB-10001	CACB-99-0014	525	South	c2	0–25	Fine	csi	
CB-10002	CACB-99-0015	492	North	f1	28–45	Fine	csi	
CB-10003	CACB-99-0016	260	—	c1	0–10	Coarse	cs	
CB-10004	CACB-99-0017	125	Middle	f1	0–23	Fine	vfs	
CB-10005	CACB-99-0024	160	—	Qal	0–5	Fine	vfs	Local background sediment sample
CB-10006	CACB-99-0018	215	—	Qal	0–11	Fine	csi	Local background sediment sample
CB-10007	CACB-99-0019	275	—	Qal	0–15	Fine	vfs	Local background sediment sample
CB-10007	CACB-99-0030	275	—	Qal	0–15	Fine	—	Field duplicate sample
CB-10008	CACB-99-0020	50N	—	Qal/Qt	0–12	Fine	vfs	Local background sediment sample
CB-10009	CACB-99-0026	100N	—	Qfb	0–9	Fine	vfs	Local background sediment sample
CB-10010	CACB-99-0021	620	—	Qal/Qc	0–9	Fine	fs	Local background sediment sample
CB-10011	CACB-99-0027	750	—	Qc	0–13	Fine	fs	Local background sediment sample
CB-10012	CACB-99-0022	840	—	Qal	0–12	Fine	csi	Local background sediment sample

Table B-4.0-1 (continued)

Location ID	Sample ID	Channel Distance (m)[a]	Side of Channel	Geomorphic Unit	Depth (cm)	Sediment Facies	Median Particle-Size Class	Notes
CB-10013	CACB-99-0028	550	—	Qal	0–13	Fine	vfs	Local background sediment sample
CB-10014	CACB-99-0023	550	—	Qal	0–13	Fine	csi	Local background sediment sample
CB-10015	CACB-99-0029	460	—	Qal	0–6	Fine	csi	Local background sediment sample
CB-10016	CACB-99-0025	365	—	Tb + Qe	0–6	Fine	csi	Local background sediment sample

[a] 0 m point is box culvert at NM State Road 4; distances increase upstream to approximately 830 m at San Ildefonso Pueblo boundary.

[b] csi = coarse silt.

[c] — = not applicable.

[d] vfs = very fine sand.

[e] N = distance along major northern channel braid.

[f] fs = fine sand.

[g] vcs = very coarse sand.

[h] cs = coarse sand.

Appendix C

Results of Quality Assurance/Quality Control Activities

C-1.0 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL ACTIVITIES

This appendix consists of an assessment of the quality of analytical results obtained from sediment samples collected in 1999 from reach CDB-4. Table C-1.0-1 presents the analytical suites for all the samples collected during this investigation.

Table C-1.0-1
Analytical Suites

Chemical Category	Analytical Suite
Radionuclides	Gamma-emitting radionuclides
	Isotopic thorium
	Isotopic uranium
	Isotopic plutonium
	Americium-241
	Strontium-90
	Tritium
Inorganic Chemicals	Target analyte list (TAL) metals
	Mercury
	Cyanide
	Uranium
Organic Chemicals	Organochlorine pesticides
	Polychlorinated biphenyls (PCBs)
	Semivolatile organic compounds (SVOCs)

Quality assurance (QA), quality control (QC), and data validation procedures were implemented in accordance with the requirements of the "Quality Assurance Project Plan Requirements for Sampling and Analysis" (LANL 1996, 54609), and the Laboratory Environmental Restoration (ER) Project analytical services statement of work (SOW) for contract laboratories (LANL 1995, 49738). The results of the QA/QC activities were used to estimate accuracy, bias, and precision of the analytical measurements. QC samples used to assess accuracy and bias included method blanks, blank spikes, matrix spikes, interference check samples, and laboratory control samples. Internal standards, external standards, surrogates, and tracers were also used to assess accuracy. Matrix spike duplicates and laboratory control sample duplicates are used to assess precision. The type and frequency of QC analyses are described in the ER Project analytical services SOW (LANL 1995, 49738). Other QC factors, such as sample preservation and holding times, were also assessed. The requirements for sample preservation and holding times are given in an ER Project standard operating procedure (SOP): ER-SOP-1.02, Rev. 0, "Sample Containers and Preservation."

C-1.1 Baseline Data Validation

Sample results were qualified using the ER Project baseline data validation qualifiers. The ER Project's baseline data validation process adheres to two guidance documents written by the EPA: "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (EPA 1994, 48639) and "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review" (EPA 1999, 66649). The validation process also incorporates Laboratory-specific reason codes

for qualifying data. Data packages received from the analytical laboratory were reviewed with respect to the NFG as well as Laboratory quality procedures for data validation. Data validation results, including RNs, sample identification numbers, and their associated qualifiers, are presented in section C-5.0.

C-1.2 Focused Data Validation

A focused data validation was also performed for all the data packages. The focused validation followed the same procedure discussed above and included a more detailed review of the raw data results generated by the analytical laboratory. Data validation results for the focused validation, including RNs, sample identification numbers, and their associated qualifiers, are presented in section C-5.0. Qualifiers assigned by the laboratory as not detected (U) because the results were either less than instrument detection limit (IDL) (for inorganic chemicals), or less than the method detection limit (MDL) (for organic chemicals), are not mentioned in this appendix.

For radionuclides, those samples qualified by the laboratory as not detected (U) because the results were either less than the minimum detectable concentration (MDC) ,or less than the minimum detectable activity (MDA) without further qualification (R9a or R9b), are also not mentioned in this appendix. Radionuclide results qualified as not detected (U) with an additional qualification (R9b) were examined to see if the result was greater than three times the total propagated uncertainty (TPU). If the result was less than three times the TPU, it is mentioned in Table C-5.0-4.

All data, including the qualified data, are usable for evaluation and interpretive purposes. The entire data set meets the standards set for use in this report, with no exceptions.

C-1.3 Samples Collected

A summary of the samples collected in reach CDB-4 for analyses is presented in Table C-1.3-1. Summaries of the analytical methods for inorganic chemicals, radionuclides, and organic analytes are provided in the following sections. The contract-required detection limit (CRDL) for each analyte listed is provided in Appendix D-1.0. These limits are also detailed in the ER Project analytical services SOW (LANL 1995, 49738).

Table C-1.3-1
Summary of Reach CDB-4 Samples

Request No.	Collection Date	Sample ID	Analytical Suite	Laboratory
Inorganic Chemicals				
5598	17-May-99	CACB-99-0001 CACB-99-0002 CACB-99-0003 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	TAL Metals and Cyanide	Paragon

Table C-1.3-1 (continued)

Request No.	Collection Date	Sample ID	Analytical Suite	Laboratory
Inorganic Chemicals				
5601	17-May-99	CACB-99-0001 CACB-99-0002 CACB-99-0003 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	Uranium	Huffman
6217	29-Nov-99	CACB-99-0011 CACB-99-0012 CACB-99-0013 CACB-99-0014 CACB-99-0015 CACB-99-0016 CACB-99-0017 CACB-99-0018 CACB-99-0019 CACB-99-0020 CACB-99-0021 CACB-99-0022 CACB-99-0023 CACB-99-0024 CACB-99-0025 CACB-99-0026 CACB-99-0027 CACB-99-0028 CACB-99-0029 CACB-99-0030	TAL Metals	Paragon
Organic Chemicals				
5597	17-May-99	CACB-99-0001 CACB-99-0002 CACB-99-0003 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	SVOCs Pesticide/PCBs	Paragon

Table C-1.3-1 (continued)

Request No.	Collection Date	Sample ID	Analytical Suite	Laboratory
Radionuclides				
5599	17-May-99	CACB-99-0001 CACB-99-0002 CACB-99-0003 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	Gamma-emitting radionuclides Americium-241 Isotopic thorium Isotopic uranium Isotopic plutonium Strontium-90	Paragon
6218	24-Nov-99	CACB-99-0011 CACB-99-0012 CACB-99-0013 CACB-99-0014 CACB-99-0015 CACB-99-0016 CACB-99-0017	Isotopic plutonium/tritium	Paragon
	29-Nov-99	CACB-99-0018 CACB-99-0019 CACB-99-0020 CACB-99-0021 CACB-99-0022 CACB-99-0023	Isotopic plutonium	
	24-Nov-99	CACB-99-0031 CACB-99-0032 CACB-99-0033 CACB-99-0034 CACB-99-0035 CACB-99-0036 CACB-99-0037 CACB-99-0038 CACB-99-0039 CACB-99-0040	Tritium	

C-2.0 INORGANIC CHEMICAL METHODS

Thirty samples were analyzed for target analyte list (TAL) metals. Ten samples were analyzed for cyanide and uranium. The analytical methods for this data set are shown in Table C-2.0-1. The analytical laboratories that analyzed the samples are shown in Table C-1.3-1. The qualifiers for the inorganic chemical analytes are provided in section C-5.1. Holding times were met for all inorganic chemical digestions and analyses.

Table C-2.0-1
Analytical Methods for Inorganic Chemical Analyses

Analytical Method	Analytical Description	Analytical Suite
EPA SW-846 Method 6010B	Inductively coupled plasma emission spectroscopy (ICPES)	Aluminum, antimony, arsenic, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, sodium, silver, thallium, vanadium and zinc. (TAL metals)
EPA SW-846 Method 9012	Colorimetric	Cyanide
EPA SW-846 Method 6020	Inductively coupled plasma mass spectroscopy (ICPMS)	Uranium
EPA SW-846 Method 7471A	Cold vapor atomic absorption (CVAA)	Mercury (TAL metal)

C-2.1 Inorganic Quality Assurance/Quality Control Samples

Laboratory control samples (LCSs), method blanks, matrix spike samples, and interference check samples were analyzed to assess accuracy, precision, and potential bias for inorganic chemical analyses. Each of these QA/QC sample types is defined in the ER Project analytical services SOW (LANL 1995, 49738) and described briefly in the sections below.

The LCS serves as a monitor of the overall performance of each step during the analysis, including sample digestion. The analytical results for the samples were qualified according to NFG (EPA 1994, 48639) if the individual LCS recovery indicated an unacceptable bias in the measurement of individual analytes. The LCS recoveries should fall within the control limits of 80% to 120%.

Table C-2.1-1 summarizes the samples analyzed for inorganic chemicals.

Table C-2.1-1
Summary of Samples Analyzed for Inorganic Chemicals

Request No.	Collection Date	Cyanide	TAL Metals	Uranium
5598	May 1999	10	10	—*
5601	May 1999	—	—	10
6217	November 1999	—	20	—
	Total	10	30	10

* Samples in this request number were not analyzed for this chemical.

Preparation blanks are used as a measurement of bias and potential cross contamination. All target analytes should be below the CRDL in the preparation blank.

Accuracy for inorganic chemical analyses is also assessed using matrix spike samples. A matrix spike sample is designed to provide information about the effect of each sample matrix on the sample preparation procedures and analytical technique. The spike sample recoveries should be within the acceptance range of 75% to 125%.

C-2.2 Inorganic Chemical Background Values

It is important to note that the currently used ER Project analytical services SOW (LANL 1995, 49738) was issued before the widespread use of axial view inductively coupled plasma emission spectroscopy (ICPES) (also known as *trace* ICPES), and before the development of the ER Project inorganic chemical background data set. With the advent of axial view ICPES, detection limits for inorganic chemicals have greatly improved. As an example, while antimony detection limits for the older radial view ICPES are typically on the order of 12 mg/kg, the trace ICPES detection limits are as low as 0.5 mg/kg. Table C-2.2-1 summarizes the single nondetected inorganic chemical with reporting limits that exceeded its Laboratory background value.

Table C-2.2-1
Summary of Nondetected Inorganic Chemical Results Where Detection Limits Exceeded Background Values

Analyte	Background Value (mg/kg)	Number of Samples	Number of Detects	Nondetects Above BV
Selenium	0.3	17	13	1

C-3.0 ORGANIC CHEMICAL ANALYSES

A total of 10samples were collected and then analyzed for SVOCs using EPA SW-846 Method 8270, for pesticides using EPA SW-846 Method 8081, and for PCBs using EPA SW-846 Method 8082. The analytical methods used for this data set are shown in Table C-3.0-1. All QC procedures were followed as required in the ER Project analytical services SOW (LANL 1995, 49738). The analytical laboratories that analyzed these samples are shown in Table C-1.3-1. The qualifiers for organic analytes are provided in Section C-5.2. All extraction and analysis holding times were met.

Table C-3.0-1
Analytical Methods for Organic Chemical Analyses

Analytical Method	Analytical Description	Target Compound List
EPA SW-846 Method 3540—Extraction EPA SW-846 Method 8270—Analysis	SVOCs	ER Project analytical services SOW (LANL 1995, 49738). Also in Appendix D of this report.
EPA SW-846 Method 3540—Extraction EPA SW-846 Method 8081—Analysis	Pesticides	ER Project analytical services SOW (LANL 1995, 49738). Also in Appendix D of this report.
EPA SW-846 Method 3540—Extraction EPA SW-846 Method 8082—Analysis	PCBs	ER Project analytical services SOW (LANL 1995, 49738). Also in Appendix D of this report.

Table C-3.0-2 summarizes the samples analyzed for organic chemicals.

Table C-3.0-2
Summary of Samples Analyzed for Organic Chemicals

Request No.	Collection Date	SVOCs	Pesticides/PCBs
5597	May 1999	10	10
	Total	10	10

C-3.1 Quality Assurance/Quality Control Samples for Organic Chemical Analysis

LCSs, method blanks, matrix spike samples, internal standards, and surrogates were analyzed to assess the accuracy, precision, and potential bias of the organic chemical analyses. Each of these QA/QC sample types is defined in the ER Project analytical services SOW (LANL 1995, 49738) and described briefly in the sections below.

The LCS serves as a monitor of the overall performance of each step during the analysis, including sample extraction. The analytical results for the samples were qualified according to NFG if the individual LCS recovery indicated an unacceptable bias in the measurement of individual analytes. The LCS recoveries should fall within the laboratory- and method-specified control limits.

Method blanks are used to measure bias and potential cross-contamination. The blank results for organic chemical analyses were within acceptable limits for all the analyses. All target analytes should be below the contract-required quantitation limits (CRQLs) in the method blank.

Accuracy, precision, and potential bias of organic chemical analyses are also assessed using matrix spike (MS) and matrix spike duplicate (MSD) samples. MS/MSD samples are designed to provide information about the effect of each sample matrix on the sample extraction procedures and analytical technique. The MS/MSD recoveries should fall within the laboratory- and method-specified control limits.

C-3.2 SVOC Analysis

Ten samples were analyzed for SVOCs, using EPA SW-846 Method 3540 for extraction and EPA SW-846 Method 8270B for analysis. The analytical laboratories that performed the analyses are listed in Table C-1.3-1. The SVOC target analyte list, including the required estimated quantitation limits (EQLs), is provided in Appendix D. For SVOCs, the extraction holding time is 14 days, and the analysis of the extract must occur within 40 days. Holding times for extraction and analysis were met for all samples. The qualifiers that were applied to these samples, due to internal standard and surrogate recoveries, are presented in section C-5.0 of this appendix.

C-3.3 Pesticide and PCB Chemical Analysis

Ten samples were analyzed for organochlorine pesticides and PCBs. Sample extraction was accomplished using EPA SW-846 Method 3540. Sample analysis for pesticides and PCBs was performed using EPA SW-846 Methods 8081 and 8082, respectively. The analytical laboratories that performed the analyses are listed in Table C-1.3-1. The pesticide/PCB target analyte list, including the required EQLs, is provided in Appendix D. For pesticides and PCBs, the extraction holding time is 14 days, and the analysis of the extract must occur within 40 days Holding times for extraction and analysis were met for all

samples. The qualifiers that were applied to these samples, due to breakdown criteria and surrogate recoveries, are presented in section C-5.0 of this appendix.

C-4.0 RADIONUCLIDE ANALYSES

Samples were analyzed for radionuclides by the methods listed in Table C-4.0-1. Twenty-three samples were analyzed for isotopic plutonium. Ten samples were analyzed for gamma-emitting radionuclides, isotopic uranium, isotopic thorium, americium-241, and strontium-90. Seventeen samples were analyzed for tritium. The maximum allowable reporting limits, as defined in the ER Project analytical services SOW, for radionuclides are provided in Appendix D.

Table C-4.0-1
Analytical Methods for Radionuclide Analyses

Radionuclides	Analytical Technique
Gamma-emitting radionuclides	Gamma spectroscopy
Strontium-90	Proportional counting
Isotopic plutonium	Chemical separation/alpha spectroscopy
Isotopic thorium	Chemical separation/alpha spectroscopy
Isotopic uranium	Chemical separation/alpha spectroscopy
Americium-241	Chemical separation/alpha spectroscopy
Tritium	Liquid scintillation

Radionuclides with reported values less than the MDC were qualified as not detected (U). The radionuclides qualified as not detected based on the MDC are summarized in Table C-5.0-4. Each radionuclide result was also compared with the corresponding 1-sigma TPU. If the result was not greater than three times the TPU, it was qualified as not detected. Radionuclides qualified as not detected based on the 1-sigma TPU are also presented in section C-5.0.

Table C-4.0-2 summarizes the samples analyzed for radionuclides.

Table C-4.0-2
Summary of Samples Analyzed for Radionuclides

Request No.	Collection Date	Isotopic Plutonium	Isotopic Uranium	Strontium-90	Isotopic Thorium	Americium-241	Tritium	Gamma-Emitting Radionuclides
5599R	May 1999	10	10	10	10	10	—*	10
6218R	November 1999	13	—	—	—	—	17	—
	Total	23	10	10	10	10	17	10

* Samples in this request number were not analyzed for this radionuclide.

Accuracy, precision, and potential bias of radionuclide analyses performed at off-site fixed laboratories were assessed using matrix spike samples, LCSs, method blanks, duplicates, and tracers.

The ER Project analytical services SOW (LANL 1995, 49738) specifies that spike sample recoveries should be within ± 25% of the certified value. All spike sample recoveries met this acceptance criteria.

LCSs were analyzed to assess accuracy for radionuclide analyses. The LCS serves as a monitor of the overall performance of each step during the analysis, including the radionuclide separation preparation. The ER Project analytical services SOW (LANL 1995, 49738) specifies that LCS recoveries should be within ± 25% of the certified value. The analytical results for individual LCSs were all within the ± 25% recovery control limit.

Method blanks are also used to assess bias. The ER Project analytical services SOW (LANL 1995, 49738) specifies that the method blank concentration should not exceed the required EQL. All method blanks met these criteria.

C-5.0 DATA VALIDATION

Data qualifiers are defined in Table C-5.0-1. The remaining tables present the data qualifiers applied to each analyte, as appropriate, for a given sample. Table C-5.0-2 (inorganic chemical data quality), Table C-5.0-3 (organic chemical data quality), and Table C-5.0-4 (radionuclide data quality) summarize the qualifiers for this data set.

Table C-5.0-1
Explanation of Data Qualifiers Used in the Data Validation Procedure

Qualifier	Explanation
U	The analyte was analyzed for, but not detected. Reported value is the sample-specific estimated quantitation limit or detection limit.*
J	The reported value should be regarded as estimated.
J+	The reported value should be regarded as estimated and biased high.
J-	The reported value should be regarded as estimated and biased low.
UJ	The analyte was analyzed for, but not detected. Reported value is an estimate of the sample-specific quantitation limit or detection limit.
UJ+	The analyte was analyzed for, but not detected. Reported value is an estimate of the sample-specific quantitation limit or reporting limit with a high bias.
UJ-	The analyte was analyzed for, but not detected. Reported value is an estimate of the sample-specific quantitation limit or reporting limit with a low bias.
R	The sample results were rejected because of serious deficiencies in the ability to analyze the sample and meet quality control criteria; presence or absence cannot be verified.

* For radionuclide analyses, the reported value is the best estimate of the analyte concentration, even when that estimate is less than the detection limit. For statistical reasons, the estimates may sometimes be given as negative results.

C-5.1 Inorganic Data Review

For RN 5598, Paragon analyzed 10 samples for TAL metals and cyanide. Cyanide was analyzed by EPA SW-846 Method 9012, colorimetric titration. Mercury was analyzed by EPA SW-846 Method 7471A, CVAA. The other TAL metals were analyzed by EPA SW-846 Method 6010B, ICPES.

- The holding times for these samples were met. The preparation blank results were below detection limits for all analytes. The recoveries for the LCSs met acceptance criteria of 80% to 120%, with the exception of iron. The results for this analyte should be regarded as estimated

and biased high (J+) because the associated LCS recovery was high (148%). All initial and continuing calibration verifications were within acceptance criteria. The interference check sample met acceptance criteria. The matrix spike recoveries all met acceptance criteria (75% to 125%). The sample-specific analytes that were qualified as estimated (J) because the results were less than the practical quantitation limit but greater than the IDL are also shown in Table C-5.0-2.

Table C-5.0-2
Data Quality Evaluation for Inorganic Sample Analyses

Request No.	Location ID	Sample ID	Analyte	Explanation
5598R	CB-00003	CACB-99-0001	Beryllium Cobalt Sodium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00004	CACB-99-0002	Beryllium Cobalt Nickel Selenium Sodium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00005	CACB-99-0003	Antimony Beryllium Cobalt Sodium Thallium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00006	CACB-99-0004	Beryllium Cobalt Selenium Sodium Thallium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00007	CACB-99-0005	Antimony Beryllium Cobalt Selenium Sodium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00008	CACB-99-0006	Antimony Beryllium Cobalt Nickel Sodium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00008	CACB-99-0007	Antimony Arsenic Barium Beryllium Calcium Cobalt Copper Magnesium Nickel Potassium Selenium Sodium Vanadium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.

Table C-5.0-2 (continued)

Request No.	Location ID	Sample ID	Analyte	Explanation
5598R	CB-00009	CACB-99-0008	Antimony Beryllium Cobalt Sodium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00009	CACB-99-0009	Arsenic Barium Beryllium Calcium Cobalt Copper Magnesium Nickel Potassium Sodium Vanadium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00010	CACB-99-0010	Arsenic Beryllium Calcium Cobalt Magnesium Nickel Potassium Selenium Sodium Vanadium	The results for these analytes should be regarded as estimated (J) because the results were less than the practical quantitation limit but above the IDL.
5598R	CB-00003 CB-00004 CB-00005 CB-00006 CB-00007 CB-00008 CB-00008 CB-00009 CB-00009 CB-00010	CACB-99-0001 CACB-99-0002 CACB-99-0003 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	Iron	The results for this analyte should be regarded as estimated and biased high (J+) because the associated LCS recovery was high.
6217R	CB-00007 CB-10000 CB-10003	CACB-99-0011 CACB-99-0013 CACB-99-0016	Beryllium Sodium	The results for these analytes should be regarded as estimated (J) because these analytes were detected below the reporting limit but above the IDL.
6217R	CB-00007 CB-10002 CB-00010 CB-10011	CACB-99-0012 CACB-99-0015 CACB-99-0021 CACB-99-0027	Selenium Sodium	The results for these analytes should be regarded as estimated (J) because these analytes were detected below the reporting limit but above the IDL.

Table C-5.0-2 (continued)

Request No.	Location ID	Sample ID	Analyte	Explanation
6217R	CB-10001 CB-10004 CB-10007 CB-10008 CB-10012 CB-10009 CB-10013 CB-10015 CB-10007	CACB-99-0014 CACB-99-0017 CACB-99-0019 CACB-99-0020 CACB-99-0022 CACB-99-0026 CACB-99-0028 CACB-99-0029 CACB-99-0030	Sodium	The results for this analyte should be regarded as estimated (J) because this analyte was detected below the reporting limit but above the IDL.
6217R	CB-10006	CACB-99-0018	Mercury Silver Sodium	The results for these analytes should be regarded as estimated (J) because these analytes were detected below the reporting limit but above the IDL.
6217R	CB-10014 CB-10005	CACB-99-0023 CACB-99-0024	Sodium Thallium	The results for these analytes should be regarded as estimated (J) because these analytes were detected below the reporting limit but above the IDL.
6217R	CB-10016	CACB-99-0025	Mercury Sodium	The results for these analytes should be regarded as estimated (J) because these analytes were detected below the reporting limit but above the IDL.
6217R	CB-00007 CB-00007 CB-10000 CB-10001 CB-10002 CB-10003 CB-10004 CB-10006 CB-10007 CB-10008 CB-00010 CB-10012 CB-10014 CB-10005 CB-10016 CB-10009 CB-10011 CB-10013 CB-10015 CB-10007	CACB-99-0011 CACB-99-0012 CACB-99-0013 CACB-99-0014 CACB-99-0015 CACB-99-0016 CACB-99-0017 CACB-99-0018 CACB-99-0019 CACB-99-0020 CACB-99-0021 CACB-99-0022 CACB-99-0023 CACB-99-0024 CACB-99-0025 CACB-99-0026 CACB-99-0027 CACB-99-0028 CACB-99-0029 CACB-99-0030	Lead	The results for this analyte should be regarded as estimated and biased low (J-) because the associated matrix spike recovery was low.

Table C-5.0-2 (continued)

Request No.	Location ID	Sample ID	Analyte	Explanation
6217R	CB-00007 CB-00007 CB-10000 CB-10001 CB-10002 CB-10003 CB-10004 CB-10006 CB-10007 CB-10008 CB-00010 CB-10012 CB-10014 CB-10005 CB-10016 CB-10009 CB-10011 CB-10013 CB-10015 CB-10007	CACB-99-0011 CACB-99-0012 CACB-99-0013 CACB-99-0014 CACB-99-0015 CACB-99-0016 CACB-99-0017 CACB-99-0018 CACB-99-0019 CACB-99-0020 CACB-99-0021 CACB-99-0022 CACB-99-0023 CACB-99-0024 CACB-99-0025 CACB-99-0026 CACB-99-0027 CACB-99-0028 CACB-99-0029 CACB-99-0030	Aluminum	The results for this analyte should be regarded as estimated and biased low (J-) because the associated LCS recovery was low.
6217R	CB-10002 CB-10006 CB-10014 CB-10011 CB-10007	CACB-99-0015 CACB-99-0018 CACB-99-0023 CACB-99-0027 CACB-99-0030	Antimony	The results for this analyte should be regarded as estimated and biased low (J-) because the associated matrix spike recovery was low.
6217R	CB-00007 CB-00007 CB-10000 CB-10001 CB-10003 CB-10004 CB-10007 CB-10008 CB-00010 CB-10012 CB-10005 CB-10016 CB-10009 CB-10013 CB-10015	CACB-99-0011 CACB-99-0012 CACB-99-0013 CACB-99-0014 CACB-99-0016 CACB-99-0017 CACB-99-0019 CACB-99-0020 CACB-99-0021 CACB-99-0022 CACB-99-0024 CACB-99-0025 CACB-99-0026 CACB-99-0028 CACB-99-0029	Antimony	The reporting limits for this analyte should be regarded as estimated and biased low (UJ-) because the associated matrix spike recovery was low.

Table C-5.0-3
Data Quality Evaluation for Organic Sample Analyses

Request No.	Location ID	Sample ID	Analytical Suite	Analyte	Explanation
5597	CB-00009 CB-00010	CACB-99-0009 CACB-99-0010	SVOCs	All target analytes	The reporting limits for these analytes should be regarded as estimated (UJ) because the associated internal standard recoveries did not pass acceptance criteria.

Table C-5.0-4
Data Quality Evaluation for Radionuclide Sample Analyses

Request No.	Location ID	Sample ID	Analytical Suite	Analyte	Explanation
5599	CB-00003	CACB-99-0001	Isotopic plutonium	Plutonium-238	The result for this analyte should be regarded as not detected (U) because the result was less than three times the 1-sigma TPU.
5599	CB-00006	CACB-99-0004	Isotopic plutonium	Plutonium-239,240	The result for this analyte should be regarded as not detected (U) because the result was less than the MDC.
5599	CB-00004	CACB-99-0002	Isotopic plutonium	Plutonium-239,240	The result for this analyte should be regarded as not detected (U) because the result was less than three times the 1-sigma TPU.
5599	CB-00003 CB-00009 CB-00010	CACB-99-0001 CACB-99-0009 CACB-99-0010	Gamma-emitting radionuclides	Cesium-137	The results for this analyte should be regarded as not detected (U) because the results were less than three times the 1-sigma TPU.
5599	CB-00004 CB-00005 CB-00009 CB-00009	CACB-99-0002 CACB-99-0003 CACB-99-0008 CACB-99-0009	Gamma-emitting radionuclides	Uranium-235	The results for this analyte should be regarded as not detected (U) because the results were less than three times the 1-sigma TPU.
5599	CB-00003 CB-00007 CB-00008	CACB-99-0001 CACB-99-0005 CACB-99-0006	Gamma-emitting radionuclides	Uranium-235	The results for this analyte should be regarded as not detected (U) because of spectral interference.

Table C-5.0-4 (continued)

Request No.	Location ID	Sample ID	Analytical Suite	Analyte	Explanation
5599	CB-00006	CACB-99-0004	Gamma-emitting radionuclides	Europium-152	The result for this analyte should be regarded as not detected (U) because the result was less than three times the 1-sigma TPU.
5599	CB-00004 CB-00008	CACB-99-0002 CACB-99-0007	Americium-241	Americium-241	The results for this analyte should be regarded as not detected (U) because the results were less than three times the 1-sigma TPU.
5599	CB-00009	CACB-99-0008	Gamma-emitting radionuclides	Cesium-137 Cobalt-60	The results for these analytes should be regarded as not detected (U) because the results were less than three times the 1-sigma TPU.
5599	CB-00005	CACB-99-0003	Strontium-90	Strontium-90	The result for this analyte should be regarded as not detected (U) because the result was less than three times the 1-sigma TPU.
5599	CB-00003 CB-00004 CB-00006 CB-00007 CB-00008 CB-00008 CB-00009 CB-00009 CB-00010	CACB-99-0001 CACB-99-0002 CACB-99-0004 CACB-99-0005 CACB-99-0006 CACB-99-0007 CACB-99-0008 CACB-99-0009 CACB-99-0010	Strontium-90	Strontium-90	The results for this analyte should be regarded as not detected (U) because the results were less than the MDC.
6218	CB-10004 CB-10008 CB-10012	CACB-99-0017 CACB-99-0020 CACB-99-0022	Isotopic plutonium	Plutonium-239,240	The results for this analyte should be regarded as not detected (U) because the results were less than three times the 1-sigma TPU.

For RN 5601, Huffman analyzed 10 samples for uranium by EPA SW-846 Method 6020, ICPMS. The results are reported as 100% uranium-238.

- The holding times for these samples were met. The preparation blank results were below detection limits for all analytes. The recoveries for the LCS met acceptance criteria of 80% to 120%. All initial and continuing calibration verifications were within acceptance criteria. The matrix spike recoveries all met acceptance criteria (75% to 125%).

For RN 6217, Paragon analyzed 20 samples for TAL metals. Mercury was analyzed by EPA SW-846 Method 7471A, CVAA. The other TAL metals were analyzed by EPA SW-846 Method 6010B, ICPES.

- The holding times for these samples were met. The preparation blank results were below detection limits for all analytes. The recoveries for the LCS met acceptance criteria of 80% to 120%, with the exception of aluminum. The results for this analyte should be regarded as estimated and biased low (J-) because the associated LCS recovery was low. All initial and continuing calibration verifications were within acceptance criteria. The interference check sample met acceptance criteria. The matrix spike recoveries all met acceptance criteria (75% to 125%), with the exception of antimony and lead. The results for these analytes are regarded as estimated

and biased low (J-), because the associated matrix spike recoveries were low. The not-detected antimony results are qualified as estimated and biased low (UJ-) because the matrix spike recovery was low. The results are therefore qualified as shown in Table C-5.0-2. The sample-specific analytes that were qualified as estimated (J) because the results were less than the limit but greater than the IDL are also shown in Table C-5.0-2.

C-5.2 Organic Data Review

For RN 5597, Paragon analyzed 10 samples for SVOCs and pesticides/PCBs. SVOCs were analyzed by EPA SW-846 Method 8270; pesticides and PCBs were analyzed by EPA SW-846 Methods 8081 and 8082, respectively.

- For SVOC analyses, the method blank was below the reporting limits for all target analytes. The initial and continuing calibration verifications passed acceptance criteria, with the exception of the continuing calibration standard that was used for qualification and quantification of CACB-99-0009 and CACB-99-0010. The internal standard areas were less than 50% from the previous continuing calibration standard. The reporting limits for both of these samples are qualified as estimated (UJ), as shown in Table C-5.0-3. The batch quality control samples (LCS and/or matrix spike samples) recoveries met acceptance criteria. The internal standard and surrogate recoveries met acceptance criteria. The extraction and analysis holding times were met.

- For pesticides/PCBs, the method blank was below the reporting limits for all target analytes. The initial and continuing calibration verifications passed acceptance criteria, with the exception of the closing standard for 4,4'-DDT. The percent difference was low on both columns for this analyte. There were no target analytes qualified or quantified in this data set, therefore no qualifiers were applied. The surrogate recoveries all passed acceptance criteria. The retention time window criteria and breakdown criteria were within the specified ranges. The batch quality control samples (LCS and/or MS/MSD) recoveries met acceptance criteria. The extraction and analysis holding times were met.

C-5.3 Radionuclide Data Review

The radionuclides that were qualified as not detected (U) because the result was less than the MDC or because the result was less than three times the 1-sigma TPU are summarized in Table C-5.0-4. These radionuclides are not repeated in the text below.

For RN 5599, Paragon analyzed 10 samples for isotopic plutonium, isotopic uranium, isotopic thorium and americium-241 by chemical separation followed by alpha spectroscopy. The samples were also analyzed for strontium-90 (by proportional counting) and for gamma-emitting radionuclides (by gamma spectroscopy).

- For isotopic uranium, the samples were analyzed using PAI SOP714R4. The method blank results were below the MDCs. The tracer yields and LCS recoveries all met acceptance criteria. No matrix spike sample analysis was performed for this RN.

- For isotopic thorium, the samples were analyzed using PAI SOP714R4. The method blank results were below the MDCs. The tracer yields and LCS recoveries all met acceptance criteria. No matrix spike sample analysis was performed for this RN.

- For isotopic plutonium, the samples were analyzed using PAI SOP714R4. The method blank results were below the MDCs. The tracer yields and LCS recoveries all met acceptance criteria. No matrix spike sample analysis was performed for this RN.
- For americium-241, the samples were analyzed using PAI SOP714R4. The method blank results were below the MDCs. The tracer yields and LCS recoveries all met acceptance criteria. No matrix spike sample analysis was performed for this RN.
- For strontium-90, the samples were analyzed using PAI SOP724R5. The method blank results were below the MDCs. The LCS and matrix spike recoveries met acceptance criteria.
- For gamma-emitting radionuclides, the samples were analyzed by PAI SOP713R4. The method blank results were below the MDCs. The LCS recoveries all met acceptance criteria.

For RN 6218, 13 samples were analyzed by Paragon for isotopic plutonium. The method was chemical separation followed by alpha spectroscopy. The samples were also analyzed for tritium by liquid scintillation.

- For isotopic plutonium, the samples were analyzed using PAI SOP714R4. The method blank results were below the MDCs. The tracer yields and LCS recoveries all met acceptance criteria. No matrix spike sample analysis was performed on this RN.
- For tritium, the samples were analyzed using PAI SOP704R5. The method blank results were below the MDCs. The LCS and matrix spike recoveries met acceptance criteria.

Appendix D

Analytical Suites and Results

D-1.0 TARGET ANALYTES AND DETECTION LIMITS

This section summarizes the target analytes and detection limits for all analyses conducted during this investigation. Table D-1.0-1 lists the analytical suite and the contract-required detection limits (CRDLs) for inorganic chemicals, in accordance with the ER Project analytical services statement of work (SOW) for contract laboratories (LANL 1995, 49738) and the Quality Assurance Project Plan (LANL 1996, 54609). In many cases, a laboratory's reporting limits for the target analytes were significantly lower than the CRDLs. Tables D-1.0-2 through D-1.0-4 list the analytical suites and EQLs for radionuclides and organic chemicals. The sample-specific reporting limit for each analyte that is reported as not detected (U) is available in section D-4.0 of this appendix. The Laboratory's FIMAD database also contains the sample-specific reporting limits for each analyte.

D-1.1 Inorganic Chemical Analyses

Table D-1.0-1 shows target analytes for inorganic chemical analyses and associated detection limits, which are CRDLs. Some of the CRDLs listed in Table 1.0-1 are not adequate to meet Laboratory background levels. For these analytes, the contract laboratories were contacted and, whenever possible, reporting limits and analytical techniques (use of axial view ICPES instead of radial view ICPES) were changed to meet the Laboratory background values.

Table D-1.0-1
Laboratory CRDLs for Inorganic Chemical Analytes

Analyte	EPA Sample Preparation Method	Analytical Technique	CRDLs (mg/kg)
Aluminum	3050A	ICPES	40
Antimony	3050A	ICPES	12
Arsenic	7060/3050A	ICPES	2
Barium	3050A	ICPES	40
Beryllium	3050A	ICPES	1
Cadmium	3050A	ICPES	1
Calcium	3050A	ICPES	1000
Chromium	3050A	ICPES	2
Cobalt	3050A	ICPES	10
Copper	3050A	ICPES	5
Cyanide	9012	Colorimetric	0.05
Iron	3050A	ICPES	20
Lead	7421/3050A	ICPES	0.6
Magnesium	3050A	ICPES	1000
Manganese	3050A	ICPES	3
Mercury	7471	CVAA	0.1
Nickel	3050A	ICPES	8
Potassium	3050A	ICPES	1000
Selenium	7740/3050A	ICPES	1

Table D-1.0-1 (continued)

Analyte	EPA Sample Preparation Method	Analytical Technique	CRDLs (mg/kg)
Silver	3050A	ICPES	2
Sodium	3050A	ICPES	1000
Thallium	7841/3050A	ICPES	2
Uranium	3050A	ICPMS	0.5
Vanadium	3050A	ICPES	10
Zinc	3050A	ICPES	4

D-1.2 Radionuclide Analyses

The EQLs for radionuclides are summarized in Table D-1.0-2. The Laboratory methods for these analytes are contained in "Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance" (LANL 1993, 31793).

Table D-1.0-2
EQLs for Radionuclides

Analyte	Analytical Technique	EQLs (pCi/g)
Americium-241	Alpha spectroscopy	0.1
Americium-241	Gamma spectroscopy	1.0
Cesium-137	Gamma spectroscopy	1.0
Cobalt-60	Gamma spectroscopy	0.5
Plutonium-238	Alpha spectroscopy	0.1
Plutonium-239, -240	Alpha spectroscopy	0.1
Strontium-90	Proportional counting	2.0
Thorium-228	Alpha spectroscopy	0.1
Thorium-230	Alpha spectroscopy	0.1
Thorium-232	Alpha spectroscopy	0.1
Tritium	Liquid scintillation	300 (pCi/L)
Uranium-234	Alpha spectroscopy	0.1
Uranium-235	Alpha spectroscopy	0.1
Uranium-238	Alpha spectroscopy	0.1

D-1.3 Organic Chemical Analyses

Table D-1.0-3 summarizes the SVOC target analytes and the associated EQLs. Samples were analyzed using either EPA SW-846 Method 8270 or Contract Laboratory Method OLM04.2. These methods use solvent extraction. The sample extracts are analyzed using gas chromatography/mass spectroscopy.

Table D-1.0-4 summarizes the pesticide/PCB analytes and the associated EQLs. Samples were analyzed using either EPA SW-846 Method 8081/8082 or Contract Laboratory Program Method OLM04.2. These methods use solvent extraction. The sample extracts are analyzed using gas chromatography.

Table D-1.0-3
EQLs for SVOCs

Analyte	EQLs (µg/kg)
Acenaphthene	330
Acenaphthylene	330
Aniline	660
Anthracene	330
Azobenzene	660
Benz(a)anthracene	330
Benzoic acid	1650
Benzo(b)fluoranthene	330
Benzo(k)fluoranthene	330
Benzo(g,h,i)perylene	330
Benzo(a)pyrene	330
Benzyl alcohol	660
Bis(2-chloroethoxy)methane	330
Bis(2-chloroethyl)ether	330
4-Bromophenyl phenylether	330
Butylbenzyl phthalate	330
Carbazole	330
4-Chloroaniline	660
4-Chloro-3-methylphenol	660
2-Chloronaphthalene	330
2-Chlorophenol	330
4-Chlorophenyl phenylether	330
Chrysene	330
Dibenz(a,h)anthracene	330
Dibenzofuran	330
1,2-Dichlorobenzene	330
1,3-Dichlorobenzene	330
1,4-Dichlorobenzene	330
3,3'-Dichlorobenzidine	660
2,4-Dichlorophenol	330

Table D-1.0-3 (continued)

Analyte	EQLs (µg/kg)
Diethyl phthalate	330
Dimethyl phthalate	330
2,4-Dimethylphenol	330
2,4-Dinitrophenol	1650
Di-n-butylphthalate	330
4,6-Dinitro-2-methylphenol	1650
2,4-Dinitrotoluene	330
2,6-Dinitrotoluene	330
Di-n-octyl phthalate	330
Bis(2-ethylhexyl) phthalate	330
Fluoranthene	330
Fluorene	330
Hexachlorobenzene	330
Hexachlorobutadiene	330
Hexachlorocyclopentadiene	330
Hexachloroethane	330
Indeno(1,2,3-cd)pyrene	330
Isophorone	330
2-Methylnaphthalene	330
2-Methylphenol	330
4-Methylphenol	330
Naphthalene	330
2-Nitroaniline	1650
3-Nitroaniline	1650
4-Nitroaniline	660
Nitrobenzene	330
2-Nitrophenol	330
4-Nitrophenol	1650
N-Nitrosodimethylamine	330
N-Nitrosodiphenylamine	330
N-Nitroso-di-n-propylamine	330
2,2'-oxybis(1-Chloropropane)	330
Pentachlorophenol	1650
Phenanthrene	330
Phenol	330
Pyrene	330
1,2,4-Trichlorobenzene	330
2,4,5-Trichlorophenol	1650
2,4,6-Trichlorophenol	330

Table D-1.0-4
EQLs for Pesticides and PCBs

Analyte	EQLs (µg/kg)
Aldrin	1.7
α-BHC	1.7
β-BHC	1.7
δ-BHC	1.7
γ-BHC (lindane)	1.7
α-Chlordane	1.7
γ-Chlordane	1.7
4,4'-DDD	3.3
4,4'-DDE	3.3
4,4'-DDT	3.3
Dieldrin	3.3
Endosulfan I	1.7
Endosulfan II	3.3
Endosulfan sulfate	3.3
Endrin	3.3
Endrin ketone	3.3
Endrin aldehyde	3.3
Heptachlor	1.7
Heptachlor epoxide	1.7
Methoxychlor	17
Toxaphene	170
Aroclor-1016	33
Aroclor-1221	66
Aroclor-1232	33
Aroclor-1242	33
Aroclor-1248	33
Aroclor-1254	33
Aroclor-1260	33

D-2.0 ANALYTE SUITES AND RNs

Table D-2.0-1 presents the analytical suites and RNs for each sediment sample (including local background samples) collected in reach CDB-4. The RN identifies a batch of samples that have been sent to a specific off-site analytical laboratory for a specific suite of analyses. RNs can be used to track the original data packages from the off-site analytical laboratories. Table D-2.0-1 also presents some field information (e.g., location ID and sample collection depth). Table D-2.0-2 presents the analytical laboratory that analyzed each request number.

Table D-2.0-1
Reach CDB-4 Sediment Samples, Analytical Suites, and RNs

Sample ID	Location ID	Depth (cm)	Date Collected	Americium-241	Cyanide	Gamma-emitting Radionuclides	Tritium	Isotopic Plutonium	Isotopic Thorium	Isotopic Uranium	Pesticides and PCBs	Strontium-90	SVOCs	Metals	Uranium, Total	Sample Notes
CACB-99-0001	CB-00003	35–66	5/17/99	5599R	5598R	5599R	NA[a]	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—[b]
CACB-99-0002	CB-00004	0–33	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0003	CB-00005	12–28	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0004	CB-00006	0–19	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0005	CB-00007	0–11	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0006	CB-00008	0–12	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0007	CB-00008	32–79	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0008	CB-00009	0–17	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0009	CB-00009	31–90	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0010	CB-00010	0–40	5/17/99	5599R	5598R	5599R	NA	5599R	5599R	5599R	5597R	5599R	5597R	5598R	5601R	—
CACB-99-0011	CB-00007	(-10)–0	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0012	CB-00007	19–27	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0013	CB-10000	17–30	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0014	CB-10001	0–25	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0015	CB-10002	28–45	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0016	CB-10003	0–10	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0017	CB-10004	0–23	11/24/99	NA	NA	NA	6218R	6218R	NA	NA	NA	NA	NA	6217R	NA	—
CACB-99-0018	CB-10006	0–11	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB[c]
CACB-99-0019	CB-10007	0–15	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0020	CB-10008	0–12	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0021	CB-00010	0–9	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0022	CB-10012	0–12	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0023	CB-10014	0–13	11/29/99	NA	NA	NA	NA	6218R	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0024	CB-10005	0–5	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0025	CB-10016	0–6	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0026	CB-10009	0–9	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0027	CB-10011	0–13	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0028	CB-10013	0–13	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB

Table D-2.0-1 (continued)

Sample ID	Location ID	Depth (cm)	Date Collected	Americium-241	Cyanide	Gamma-emitting Radionuclides	Tritium	Isotopic Plutonium	Isotopic Thorium	Isotopic Uranium	Pesticides and PCBs	Strontium-90	SVOCs	Metals	Uranium, Total	Sample Notes
CACB-99-0029	CB-10015	0–6	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	LB
CACB-99-0030	CB-10007	0–15	11/29/99	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	6217R	NA	FD[d]
CACB-99-0031	CB-00003	35–66	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R[e]
CACB-99-0032	CB-00004	0–33	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0033	CB-00005	12–28	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0034	CB-00006	0–19	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0035	CB-00007	0–11	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0036	CB-00008	0–12	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0037	CB-00009	0–17	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0038	CB-00008	32–79	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0039	CB-00009	31–90	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R
CACB-99-0040	CB-00010	0–40	11/24/99	NA	NA	NA	6218R	NA	NA	NA	NA	NA	NA	NA	NA	R

[a] NA = not analyzed.

[b] — = no notes

[c] LB = local background sample.

[d] FD = field duplicate.

[e] R = resample of layer.

Table D-2.0-2
Reach CDB-4 RNs, Analytical Suites, and Analytical Laboratories

RN	Number of Samples	Analytical Suite	Analytical Laboratory
5597	10 sediment samples	SVOCs[a] Pesticides/PCBs[c]	Paragon Analytics[b]
5598	10 sediment samples	TAL metals[d] Cyanide[e]	Paragon Analytics
5599	10 sediment samples	Gamma-emitting radionuclides[f] Americium-241[g] Isotopic thorium[h] Isotopic uranium[i] Isotopic plutonium[j] Strontium-90[k]	Paragon Analytics
5601	10 sediment samples	Total uranium[l]	Huffman[m]
6217	20 sediment samples	TAL metals	Paragon Analytics
6218	20 sediment samples	Isotopic plutonium (13 samples) Tritium[n] (17 samples)	Paragon Analytics

[a] SVOCs analyzed by EPA SW-846 Method 8270.

[b] Paragon Analytics (formerly ATI) is located in Fort Collins, Colorado.

[c] Pesticides/PCBs analyzed by EPA SW-846 Method 8081/8082.

[d] 23 metals from the EPA Contract Laboratory Program list.

[e] Cyanide was analyzed by EPA SW-846 Method 9012.

[f] Americium-241, cobalt-60, cesium-134, cesium-137, europium-152, sodium-22, ruthenium-106, and uranium-235 analyzed by gamma spectroscopy.

[g] Americium-241 analyzed by chemical separation/alpha spectroscopy.

[h] Thorium isotopes analyzed by chemical separation/alpha spectroscopy.

[i] Uranium isotopes analyzed by chemical separation/alpha spectroscopy.

[j] Plutonium isotopes analyzed by chemical separation/alpha spectroscopy.

[k] Strontium-90 analyzed by proportional counting.

[l] Total uranium analyzed by ICPMS.

[m] Huffman is located in Golden, Colorado.

[n] Tritium analyzed by liquid scintillation.

D-3.0 SUMMARY OF REACH CDB-4 ANALYSES

Tables D-3.0-1 through D-3.0-3 present summaries of the inorganic chemical, radionuclide, and organic chemical analyses for sediment samples (including local background samples) from reach CDB-4. These tables show the number of samples, detection frequency, and concentration range for each analyte.

Table D-3.0-1
Summary of Inorganic Chemical Analyses in Reach CDB-4

Analyte	Total Count	Nondetects			Detects		
		Count	Min.	Max.	Count	Min.	Max.
Target Analyte List Metals Analyzed by EPA Method 6010 (mg/kg)							
Aluminum	30	0	n/a*	n/a	30	1900	8870
Antimony	30	17	0.29	0.32	13	0.33	0.71
Arsenic	30	0	n/a	n/a	30	0.88	3.9
Barium	30	0	n/a	n/a	30	26.8	150
Beryllium	30	0	n/a	n/a	30	0.25	1.1
Cadmium	30	30	0.01	0.02	0	n/a	n/a
Calcium	30	0	n/a	n/a	30	503	16000
Chromium, total	30	0	n/a	n/a	30	2.4	10.8
Cobalt	30	0	n/a	n/a	30	2.2	9.3
Copper	30	0	n/a	n/a	30	1.9	11
Cyanide	10	10	0.51	0.58	0	n/a	n/a
Iron	30	0	n/a	n/a	30	4500	21200
Lead	30	0	n/a	n/a	30	3.7	18
Magnesium	30	0	n/a	n/a	30	430	2400
Manganese	30	0	n/a	n/a	30	204	540
Mercury	30	28	0.0022	0.01	2	0.0058	0.063
Nickel	30	0	n/a	n/a	30	2.3	12
Potassium	30	0	n/a	n/a	30	367	1500
Selenium	30	5	0.11	0.35	25	0.18	1.2
Silver	30	29	0.024	0.029	1	0.35	0.35
Sodium	30	0	n/a	n/a	30	30	124
Thallium	30	26	0.11	0.47	4	0.43	1.1
Uranium	10	0	n/a	n/a	10	0.29	1.22
Vanadium	30	0	n/a	n/a	30	7.5	34.4
Zinc	30	0	n/a	n/a	30	15	55

* n/a = not applicable.

Table D-3.0-2
Summary of Radionuclide Analyses in Reach CDB-4

Analyte	Total Count	Nondetects			Detects		
		Count	Min. (pCi/g)	Max. (pCi/g)	Count	Min. (pCi/g)	Max. (pCi/g)
Radionuclides Analyzed by Gamma Spectroscopy							
Americium-241	10	10	-0.68	0.16	0	n/a	n/a
Cesium-134	10	10	-0.035	0.057	0	n/a	n/a
Cesium-137	10	6	0.032	0.14	4	0.24	0.73
Cobalt-60	10	10	-0.067	0.092	0	n/a	n/a
Europium-152	10	10	-0.17	0.26	0	n/a	n/a
Ruthenium-106	10	10	-0.42	0.32	0	n/a	n/a
Sodium-22	10	10	-0.072	0.067	0	n/a	n/a
Uranium-235	10	10	0.038	0.18	0	n/a	n/a
Americium-241 Analyzed by Chemical Separation/Alpha Spectroscopy							
Americium-241	10	5	0.0086	0.0114	5	0.0128	0.0229
Tritium Analyzed by Liquid Scintillation							
Tritium	17	17	-0.002	0.046	0	n/a	n/a
Isotopic Uranium Analyzed by Chemical Separation/Alpha Spectroscopy							
Uranium-234	10	0	n/a	n/a	10	0.324	1.24
Uranium-235	10	2	0.0189	0.023	8	0.044	0.083
Uranium-238	10	0	n/a	n/a	10	0.373	1.26
Isotopic Plutonium Analyzed by Chemical Separation/Alpha Spectroscopy							
Plutonium-238	23	23	-0.029	0.017	0	n/a	n/a
Plutonium-239	23	16	-0.0011	0.033	7	0.020	0.076
Isotopic Thorium Analyzed by Chemical Separation/Alpha Spectroscopy							
Thorium-228	10	0	n/a	n/a	10	0.613	1.7
Thorium-230	10	0	n/a	n/a	10	0.41	1.38
Thorium-232	10	0	n/a	n/a	10	0.539	1.7
Strontium-90 Analyzed by Proportional Counting							
Strontium-90	10	10	0.05	0.74	0	n/a	n/a

* n/a = not applicable.

Table D-3.0-3
Summary of Organic Chemical Analyses in Reach CDB-4

Analyte	Total Count	Nondetects			Detects		
		Count	Min. (mg/kg)	Max. (mg/kg)	Count	Min. (mg/kg)	Max. (mg/kg)
Pesticides/PCBs Analyzed by EPA Method 8081/8082							
Aroclor-1016	10	10	0.034	0.039	0	n/a*	n/a
Aroclor-1221	10	10	0.068	0.078	0	n/a	n/a
Aroclor-1232	10	10	0.034	0.039	0	n/a	n/a
Aroclor-1242	10	10	0.034	0.039	0	n/a	n/a
Aroclor-1248	10	10	0.034	0.039	0	n/a	n/a
Aroclor-1254	10	10	0.034	0.039	0	n/a	n/a
Aroclor-1260	10	10	0.034	0.039	0	n/a	n/a
Toxaphene (technical)	10	10	0.17	0.2	0	n/a	n/a
Aldrin	10	10	0.0017	0.002	0	n/a	n/a
α-BHC	10	10	0.0017	0.002	0	n/a	n/a
β-BHC	10	10	0.0017	0.002	0	n/a	n/a
δ-BHC	10	10	0.0017	0.002	0	n/a	n/a
γ-BHC	10	10	0.0017	0.002	0	n/a	n/a
α-Chlordane	10	10	0.0017	0.002	0	n/a	n/a
γ-Chlordane	10	10	0.0017	0.002	0	n/a	n/a
4,4'-DDD	10	10	0.0034	0.0039	0	n/a	n/a
4,4'-DDE	10	10	0.0034	0.0039	0	n/a	n/a
4,4'-DDT	10	10	0.0034	0.0039	0	n/a	n/a
Dieldrin	10	10	0.0034	0.0039	0	n/a	n/a
Endosulfan I	10	10	0.0017	0.002	0	n/a	n/a
Endosulfan II	10	10	0.0034	0.0039	0	n/a	n/a
Endosulfan sulfate	10	10	0.0034	0.0039	0	n/a	n/a
Endrin	10	10	0.0034	0.0039	0	n/a	n/a
Endrin aldehyde	10	10	0.0034	0.0039	0	n/a	n/a
Endrin ketone	10	10	0.0034	0.0039	0	n/a	n/a
Heptachlor	10	10	0.0017	0.002	0	n/a	n/a
Heptachlor epoxide	10	10	0.0017	0.002	0	n/a	n/a
4,4'-Methoxychlor	10	10	0.017	0.02	0	n/a	n/a
Semivolatile Organic Compounds Analyzed by EPA Method 8270							
Acenaphthene	10	10	0.34	0.39	0	n/a	n/a
Acenaphthylene	10	10	0.34	0.39	0	n/a	n/a
Aniline	10	10	0.68	0.78	0	n/a	n/a
Anthracene	10	10	0.34	0.39	0	n/a	n/a
Azobenzene	10	10	0.68	0.78	0	n/a	n/a
Benzidine	10	10	0.34	0.39	0	n/a	n/a
Benz(a)anthracene	10	10	0.34	0.39	0	n/a	n/a

Table D-3.0-3 (continued)

Analyte	Total Count	Nondetects			Detects		
		Count	Min. (mg/kg)	Max. (mg/kg)	Count	Min. (mg/kg)	Max. (mg/kg)
Semivolatile Organic Compounds Analyzed by EPA Method 8270 (continued)							
Benzo(a)pyrene	10	10	0.34	0.39	0	n/a	n/a
Benzo(b)fluoranthene	10	10	0.34	0.39	0	n/a	n/a
Benzo(g,h,i)perylene	10	10	0.34	0.39	0	n/a	n/a
Benzo(k)fluoranthene	10	10	0.34	0.39	0	n/a	n/a
Benzoic acid	10	10	1.7	2.0	0	n/a	n/a
Benzyl alcohol	10	10	0.68	0.78	0	n/a	n/a
Bis(2-chloroethoxy)methane	10	10	0.34	0.39	0	n/a	n/a
Bis(2-chloroethyl)ether	10	10	0.34	0.39	0	n/a	n/a
Bis(2-ethylhexyl) phthalate	10	10	0.34	0.39	0	n/a	n/a
4-Bromophenyl-phenylether	10	10	0.34	0.39	0	n/a	n/a
Butylbenzyl phthalate	10	10	0.34	0.39	0	n/a	n/a
Carbazole	10	10	0.34	0.39	0	n/a	n/a
4-Chloro-3-methylphenol	10	10	0.68	0.78	0	n/a	n/a
4-Chloroaniline	10	10	0.68	0.78	0	n/a	n/a
2-Chloronaphthalene	10	10	0.34	0.39	0	n/a	n/a
2-Chlorophenol	10	10	0.34	0.39	0	n/a	n/a
4-Chlorophenyl-phenyl ether	10	10	0.34	0.39	0	n/a	n/a
Chrysene	10	10	0.34	0.39	0	n/a	n/a
Dibenz(a,h)anthracene	10	10	0.34	0.39	0	n/a	n/a
Dibenzofuran	10	10	0.34	0.39	0	n/a	n/a
1,3-Dichlorobenzene	10	10	0.34	0.39	0	n/a	n/a
3,3'-Dichlorobenzidine	10	10	0.68	0.78	0	n/a	n/a
2,4-Dichlorophenol	10	10	0.34	0.39	0	n/a	n/a
Diethylphthalate	10	10	0.34	0.39	0	n/a	n/a
Dimethyl phthalate	10	10	0.34	0.39	0	n/a	n/a
2,4-Dimethylphenol	10	10	0.34	0.39	0	n/a	n/a
Di-n-butyl phthalate	10	10	0.34	0.39	0	n/a	n/a
4,6-Dinitro-2-methylphenol	10	10	1.7	2.0	0	n/a	n/a
2,4-Dinitrophenol	10	10	1.7	2.0	0	n/a	n/a
2,4-Dinitrotoluene	10	10	0.34	0.39	0	n/a	n/a
2,6-Dinitrotoluene	10	10	0.34	0.39	0	n/a	n/a
Di-n-octyl phthalate	10	10	0.34	0.39	0	n/a	n/a
Fluoranthene	10	10	0.34	0.39	0	n/a	n/a
Fluorene	10	10	0.34	0.39	0	n/a	n/a
Hexachlorobenzene	10	10	0.34	0.39	0	n/a	n/a
Hexachlorobutadiene	10	10	0.34	0.39	0	n/a	n/a

Table D-3.0-3 (continued)

Analyte	Total Count	Nondetects			Detects		
		Count	Min. (mg/kg)	Max. (mg/kg)	Count	Min. (mg/kg)	Max. (mg/kg)
Semivolatile Organic Compounds Analyzed by EPA Method 8270 (continued)							
Hexachlorocyclopentadiene	10	10	0.34	0.39	0	n/a	n/a
Hexachloroethane	10	10	0.34	0.39	0	n/a	n/a
Indeno(1,2,3-cd)pyrene	10	10	0.34	0.39	0	n/a	n/a
Isophorone	10	10	0.34	0.39	0	n/a	n/a
2-Methylnaphthalene	10	10	0.34	0.39	0	n/a	n/a
2-Methylphenol	10	10	0.34	0.39	0	n/a	n/a
4-Methylphenol	10	10	0.34	0.39	0	n/a	n/a
Naphthalene	10	10	0.34	0.39	0	n/a	n/a
2-Nitroaniline	10	10	1.7	2.0	0	n/a	n/a
3-Nitroaniline	10	10	1.7	2.0	0	n/a	n/a
4-Nitroaniline	10	10	0.68	0.78	0	n/a	n/a
Nitrobenzene	10	10	0.34	0.39	0	n/a	n/a
2-Nitrophenol	10	10	0.34	0.39	0	n/a	n/a
4-Nitrophenol	10	10	1.7	2.0	0	n/a	n/a
N-Nitrosodimethylamine	10	10	0.34	0.39	0	n/a	n/a
N-Nitroso-di-n-propylamine	10	10	0.34	0.39	0	n/a	n/a
N-Nitrosodiphenylamine	10	10	0.34	0.39	0	n/a	n/a
2,2'-Oxybis(1-chloropropane)	10	10	0.34	0.39	0	n/a	n/a
Pentachlorophenol	10	10	1.7	2.0	0	n/a	n/a
Phenanthrene	10	10	0.34	0.39	0	n/a	n/a
Phenol	10	10	0.34	0.39	0	n/a	n/a
Pyrene	10	10	0.34	0.39	0	n/a	n/a
Pyridine	10	10	0.34	0.39	0	n/a	n/a
Toxaphene (technical grade)	10	10	0.34	0.39	0	n/a	n/a
1,2,4-Trichlorobenzene	10	10	0.34	0.39	0	n/a	n/a
2,4,5-Trichlorophenol	10	10	1.7	2.0	0	n/a	n/a
2,4,6-Trichlorophenol	10	10	0.34	0.39	0	n/a	n/a

* n/a = not applicable.

D-4.0 ANALYTICAL RESULTS FOR REACH CDB-4 DETECTED INORGANIC CHEMICALS AND RADIONUCLIDES

Tables D-4.0-1 and D-4.02 present analytical results for detected inorganic chemicals and radionuclides for reach CDB-4 sediment samples.

Table D-4.0-1
Analytical Results for Detected Inorganic Chemicals in Sediment in Reach CDB-4

Sample ID	Location ID	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Cyanide, total	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Uranium, total	Vanadium	Zinc
CACB-99-0001	CB-00003	8870	0.7	2.6	119	0.86 (J)[a]	0.02 (U)[b]	3120	8.2	6 (J)	9	0.58 (U)	13300 (J+)[c]	13.9	1750	410	0.01 (U)	7.3	1300	0.74	0.03 (U)	124 (J)	0.33 (U)	0.79	20.1	36.3
CACB-99-0002	CB-00004	7070	0.71	2.4	87.4	0.75 (J)	0.02 (U)	5620	7.3	5 (J)	5	0.54 (U)	15300 (J+)	8.6	1530	374	0.01 (U)	6.1 (J)	1150	0.56 (J)	0.03 (U)	84 (J)	0.47 (U)	0.63	21.9	44.3
CACB-99-0003	CB-00005	8230	0.52 (J)	2.6	104	0.82 (J)	0.02 (U)	3340	7.7	5.4 (J)	6.4	0.52 (U)	13000 (J+)	10.6	1740	375	0.01 (U)	6.9	1330	0.64	0.03 (U)	100 (J)	0.86 (J)	0.94	19.9	36.6
CACB-99-0004	CB-00006	7550	0.7	2.5	98.6	0.69 (J)	0.02 (U)	2170	10.8	7.3 (J)	7.3	0.55 (U)	21200 (J+)	11.1	1550	481	0.01 (U)	8.1	1200	0.49 (J)	0.03 (U)	73.5 (J)	1.1 (J)	1.22	34.4	54.8
CACB-99-0005	CB-00007	7780	0.52 (J)	2.8	94	0.76 (J)	0.02 (U)	1840	7	5.7 (J)	5	0.52 (U)	13000 (J+)	10.3	1380	433	0.01 (U)	6.4	1110	0.5 (J)	0.03 (U)	87.6 (J)	0.31 (U)	0.69	19.2	38.8
CACB-99-0006	CB-00008	7550	0.48 (J)	2.6	101	0.78 (J)	0.02 (U)	1860	7.4	5.6 (J)	7.2	0.55 (U)	12800 (J+)	10.8	1520	410	0.01 (U)	6.5 (J)	1220	0.24 (U)	0.03 (U)	89.3 (J)	0.24 (U)	0.83	19.7	38.3
CACB-99-0007	CB-00008	2290	0.46 (J)	0.88 (J)	26.8 (J)	0.25 (J)	0.01 (U)	543 (J)	2.9	2.2 (J)	1.9 (J)	0.51 (U)	7670 (J+)	3.7	437 (J)	204	0.01 (U)	2.3 (J)	384 (J)	0.18 (J)	0.03 (U)	33.1 (J)	0.18 (U)	0.31	10.1 (J)	28.5
CACB-99-0008	CB-00009	8850	0.55 (J)	2.7	112	0.79 (J)	0.02 (U)	2440	8.7	5.5 (J)	7.2	0.58 (U)	13600 (J+)	9.6	1780	350	0.01 (U)	7.2	1450	0.35 (U)	0.03 (U)	91.6 (J)	0.45 (U)	0.81	22.8	36.7
CACB-99-0009	CB-00009	2340	0.29 (U)	0.97 (J)	34 (J)	0.26 (J)	0.01 (U)	503 (J)	2.7	2.6 (J)	2.3 (J)	0.51 (U)	5920 (J+)	4.5	436 (J)	237	0.01 (U)	2.5 (J)	367 (J)	0.11 (U)	0.03 (U)	33 (J)	0.11 (U)	0.29	8.2 (J)	21.6
CACB-99-0010	CB-00010	3540	0.31 (U)	1.2 (J)	46.5	0.39 (J)	0.01 (U)	864 (J)	2.8	3.1 (J)	6.7	0.52 (U)	6560 (J+)	6.5	685 (J)	253	0.01 (U)	3.4 (J)	553 (J)	0.19 (J)	0.03 (U)	54.6 (J)	0.11 (U)	0.45	8.7 (J)	24.1
CACB-99-0011	CB-00007	2800 (J-)[d]	0.31 (UJ)[e]	1.4	76	0.49 (J)	0.018 (U)	940	3.4	4.5	3.5	NA[f]	6400	7.4 (J-)	640	410	0.0022 (U)	4.3	600	0.61	0.025 (U)	39 (J)	0.37 (U)	NA	11	20
CACB-99-0012	CB-00007	6000 (J-)	0.32 (UJ)	2.2	110	0.84	0.019 (U)	5500	5.7	5	6.8	NA	9900	9.9 (J-)	2400	370	0.0023 (U)	7.2	1200	0.37 (J)	0.026 (U)	87 (J)	0.39 (U)	NA	16	30
CACB-99-0013	CB-10000	2900 (J-)	0.31 (UJ)	1.1	53	0.51 (J)	0.018 (U)	890	3.2	2.8	3.1	NA	6200	6.1 (J-)	640	230	0.0022 (U)	3.7	600	0.59	0.025 (U)	43 (J)	0.37 (U)	NA	9.6	22
CACB-99-0014	CB-10001	7100 (J-)	0.31 (UJ)	3.1	130	0.98	0.019 (U)	3200	8	6.4	7.7	NA	13000	13 (J-)	1800	390	0.0022 (U)	8.7	1400	1	0.025 (U)	71 (J)	0.37 (U)	NA	22	31
CACB-99-0015	CB-10002	6300 (J-)	0.33 (J)	2.5	100	0.92	0.019 (U)	1600	6.9	5.3	5.9	NA	11000	9.7 (J-)	1500	300	0.0023 (U)	7.1	1400	0.4 (J)	0.025 (U)	59 (J)	0.38 (U)	NA	18	33
CACB-99-0016	CB-10003	1900 (J-)	0.32 (UJ)	1.2	51	0.38 (J)	0.019 (U)	770	2.4	9	2.7	NA	4500	7.7 (J-)	430	340	0.0023 (U)	3.8	410	0.55	0.025 (U)	30 (J)	0.38 (U)	NA	7.5	15
CACB-99-0017	CB-10004	4800 (J-)	0.31 (UJ)	2.4	92	0.78	0.019 (U)	2600	5.7	5	5.8	NA	10000	10 (J-)	1200	350	0.0022 (U)	6.4	990	0.29 (U)	0.025 (U)	60 (J)	0.38 (U)	NA	17	30
CACB-99-0018	CB-10006	7800 (J-)	0.39 (J)	3.3	150	1	0.019 (U)	3100	9.5	8	11	NA	13000	16 (J-)	1900	530	0.063 (J)	10	1500	1.1	0.35 (J)	52 (J)	0.38 (U)	NA	22	35

Table D-4.0-1 (continued)

Sample ID	Location ID	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Cyanide, total	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Uranium, total	Vanadium	Zinc
CACB-99-0019	CB-10007	4500 (J-)	0.31 (UJ)	2.2	86	0.78	0.018 (U)	2100	5.7	5	5.2	NA	10000	11 (J-)	1200	360	0.0022 (U)	6.2	980	0.67	0.024 (U)	63 (J)	0.37 (U)	NA	16	31
CACB-99-0020	CB-10008	6700 (J-)	0.31 (UJ)	2.5	110	1	0.019 (U)	3900	8.6	5.9	6.1	NA	17000	11 (J-)	1700	380	0.0022 (U)	9.1	1400	1.2	0.025 (U)	57 (J)	0.38 (U)	NA	25	44
CACB-99-0021	CB-10010	3300 (J-)	0.3 (UJ)	1.6	52	0.76	0.018 (U)	1300	3.4	2.6	3.8	NA	9400	9 (J-)	840	300	0.0022 (U)	3.4	790	0.42 (J)	0.024 (U)	57 (J)	0.36 (U)	NA	9.5	35
CACB-99-0022	CB-10012	8600 (J-)	0.31 (UJ)	3.9	150	1.1	0.019 (U)	2600	8.1	6.5	10	NA	13000	15 (J-)	2000	380	0.0022 (U)	9.6	1400	0.81	0.025 (U)	64 (J)	0.38 (U)	NA	21	33
CACB-99-0023	CB-10014	8100 (J-)	0.67 (J)	3.3	150	1.1	0.019 (U)	3600	10	9.3	6.9	NA	17000	14 (J-)	2100	540	0.0023 (U)	12	1500	0.89	0.025 (U)	60 (J)	0.6 (J)	NA	29	35
CACB-99-0024	CB-10005	5700 (J-)	0.31 (UJ)	2.1	81	0.98	0.019 (U)	6900	6	4	5.4	NA	12000	12 (J-)	1600	330	0.0022 (U)	6.5	1200	0.75	0.025 (U)	64 (J)	0.43 (J)	NA	15	37
CACB-99-0025	CB-10016	6400 (J-)	0.31 (UJ)	2.9	110	0.82	0.018 (U)	2000	8.6	5.9	11	NA	12000	18 (J-)	1600	330	0.0058 (J)	7.7	1200	0.8	0.024 (U)	51 (J)	0.37 (U)	NA	21	33
CACB-99-0026	CB-10009	4800 (J-)	0.31 (UJ)	2.3	110	0.85	0.018 (U)	16000	5	3.7	4.4	NA	7700	8 (J-)	1800	230	0.0022 (U)	6.8	1300	0.29 (U)	0.025 (U)	65 (J)	0.37 (U)	NA	12	23
CACB-99-0027	CB-10011	3500 (J-)	0.42 (J)	1.5	56	0.7	0.018 (U)	3200	3.7	2.5	3.6	NA	8700	7.8 (J-)	960	260	0.0022 (U)	3.8	880	0.48 (J)	0.024 (U)	65 (J)	0.37 (U)	NA	10	32
CACB-99-0028	CB-10013	6300 (J-)	0.31 (UJ)	2.9	130	0.9	0.018 (U)	2200	8.5	7.8	6	NA	15000	13 (J-)	1600	500	0.0022 (U)	9.2	1200	0.64	0.025 (U)	53 (J)	0.37 (U)	NA	26	33
CACB-99-0029	CB-10015	7500 (J-)	0.31 (UJ)	3.2	140	1.1	0.018 (U)	3600	8.1	7.4	7	NA	14000	14 (J-)	1900	470	0.0022 (U)	10	1500	1	0.025 (U)	57 (J)	0.37 (U)	NA	23	32
CACB-99-0030	CB-10007	4700 (J-)	0.5 (J)	2.4	84	0.82	0.018 (U)	2200	6	4.4	5.1	NA	11000	11 (J-)	1200	340	0.0022 (U)	6.2	1000	0.64	0.024 (U)	66 (J)	0.37 (U)	NA	17	36

Note: Results are in mg/kg.

[a] J = The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis.

[b] U = The analyte was analyzed for but not detected. Reported value is the sample-specific estimated quantitation limit or detection limit.

[c] J+ = The analyte was positively identified, and the associated numerical value is an estimate and likely biased high.

[d] J- = The analyte was positively identified, and the associated numerical value is an estimate and likely biased low.

[e] UJ = The analyte was analyzed for but not detected. Reported value is an estimate of the sample-specific quantitation limit or detection limit.

[f] NA = not analyzed.

Table D-4.0-2
Analytical Results for Detected Radionuclides in Sediment in Reach CDB-4

Sample ID	Location ID	Americium-241	Cesium-137	Plutonium-239,240	Thorium-228	Thorium-230	Thorium-232	Uranium-234	Uranium-235	Uranium-238
CACB-99-0001	CB-00003	0.0167	0.14 (U)[a]	0.002 (U)	1.38	1.08	1.40	1.079	0.067	0.990
CACB-99-0002	CB-00004	0.0086 (U)	0.07 (U)	0.008 (U)	1.51	1.23	1.52	0.994	0.058	0.956
CACB-99-0003	CB-00005	0.0141	0.73	0.05	1.47	1.38	1.47	1.240	0.083	1.262
CACB-99-0004	CB-00006	0.0229	0.42	0.033 (U)	1.70	1.26	1.70	0.899	0.054	1.162
CACB-99-0005	CB-00007	0.0225	0.32	0.076	1.57	1.17	1.48	0.942	0.049	0.920
CACB-99-0006	CB-00008	0.0098 (U)	0.24	0.012 (U)	1.38	1.20	1.57	1.077	0.072	1.101
CACB-99-0007	CB-00008	0.0100 (U)	0.03 (U)	0.001 (U)	0.858	0.466	0.801	0.366	0.019 (U)	0.424
CACB-99-0008	CB-00009	0.0114 (U)	0.14 (U)	0.013 (U)	1.37	1.13	1.47	0.897	0.045	0.991
CACB-99-0009	CB-00009	0.0099 (U)	0.09 (U)	0.012 (U)	0.613	0.407	0.539	0.324	0.023 (U)	0.373
CACB-99-0010	CB-00010	0.0128	0.09 (U)	0.0319	0.861	0.731	0.809	0.602	0.044	0.657
CACB-99-0011	CB-00007	NA[b]	NA	0.006 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0012	CB-00007	NA	NA	0.0202	NA	NA	NA	NA	NA	NA
CACB-99-0013	CB-10000	NA	NA	0.005 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0014	CB-10001	NA	NA	0.0414	NA	NA	NA	NA	NA	NA
CACB-99-0015	CB-10002	NA	NA	0.002 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0016	CB-10003	NA	NA	-0.001 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0017	CB-10004	NA	NA	0.009 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0018	CB-10006	NA	NA	0.0249	NA	NA	NA	NA	NA	NA
CACB-99-0019	CB-10007	NA	NA	0.0287	NA	NA	NA	NA	NA	NA
CACB-99-0020	CB-10008	NA	NA	0.0079 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0021	CB-00010	NA	NA	0.0025 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0022	CB-10012	NA	NA	0.0122 (U)	NA	NA	NA	NA	NA	NA
CACB-99-0023	CB-10014	NA	NA	0.0068 (U)	NA	NA	NA	NA	NA	NA

Note: Results are in pCi/g.

[a] U = The analyte was analyzed for, but not detected. Reported value is the sample-specific EQL or detection limit.

[b] NA = not analyzed.

Appendix E

Statistical Analyses

E-1.0 STATISTICAL EVALUATIONS OF INORGANIC CHEMICAL DATA

The objective of this section is to present detailed statistical and graphical analyses that compare inorganic chemical data from reach CDB-4 with Laboratory-wide and local sediment background data. Laboratory-wide sediment background data are presented in "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory" (Ryti et al. 1998, 59730). Local sediment background samples were collected for analysis of inorganic chemicals and isotopic plutonium to provide information about the likely source of some sample results which were elevated when compared with the Laboratory-wide sediment background data set. It was hypothesized that sediments in reach CDB-4 could have been influenced by local parent material (including basalts and local soils) that differed geochemically from the Laboratory-wide sediment background samples that had been collected in other areas. Results from the analysis of the local sediment background samples are presented in Appendix D. Note that the phrase *background values* refers to estimates of the upper limit of Laboratory-wide background levels, as presented in Ryti et al. (1998, 59730). These analyses were used to determine if the reach data show evidence of contaminant releases through a systematic increase in the concentration of one or more analytes to levels greater than the concentrations observed in either the Laboratory-wide background data or local background data. (Note: The figures for this section have been placed at the end of the section.)

E-1.1 Data Analysis Methods

Two types of data analyses were used to evaluate the concentrations of inorganic chemicals in the reach sample data as compared with background data. In the first type, a graphical comparison is made between reach sample data and background sample data. In the second type, the results of formal statistical testing are presented. Each of these methods is discussed below in more detail.

E-1.1.1 Comparisons of Inorganic Chemical Data

These comparisons use graphical displays called box plots, which show the actual values for each inorganic chemical (Figures E-1.2-1 through E-1.2-25). The ends of each box represent the "interquartile" range of the data distribution, which is specified by the 25th percentile and 75th percentile of the data distribution. The horizontal line above each box represents the 90th percentile, and the line beneath the box represents the 10th percentile of the sample results. The horizontal line within each box is the median (the 50th percentile) of the data distribution (if the number of samples is four or fewer, the horizontal line is not displayed). Thus, each box indicates concentration values for the central half of the data, and concentration shifts can be readily assessed by comparing the boxes. If most of the data are represented by a single concentration value (usually the detection limit), the box is reduced to a single line. These plots also contain a horizontal line across the entire plot which represents the overall average concentration of all data groups.

In these statistical plots, one symbol is used for the analytical laboratory results for the potentially contaminated sediment samples from reach CDB-4 (CDB-4), another is used for the Laboratory-wide sediment background data (BKG), and another is used for local sediment background samples (local). The symbols are used consistently in all statistical plots in this section. Laboratory-wide background data are represented by a square; reach CDB-4 data, by a plus symbol; and local background data, by an x. Also note that nondetected sample results are plotted as the detection limit value.

E-1.1.2 Statistical Testing

Because the data for these inorganic chemicals do not typically satisfy conditions of statistical normality, nonparametric statistical tests are preferred for background comparisons. Thus, the nonparametric Gehan test was used for statistical testing. The purpose of this test was to detect if the reach data show evidence of a release of any analyte through a systematic increase in that analyte's concentration, relative to concentrations observed in the background data. The Gehan test pools site and background data into one aggregate set and determines whether the average rank of site data is greater than that of the background data. The Gehan test is most sensitive to detecting cases where most of the reach data are greater than the average or median value observed in the background data. The Gehan test is a variation on the Wilcoxon rank sum test which handles nondetected sample results in a statistically valid manner. More discussion of this test is contained in Ryti et al. (1996, 53953).

The metrics used to determine if a statistically significant difference between reach data and background data exists are the calculated significance levels (p-values) for the tests. The results of these tests are shown in Table E-1.2-1. A low p-value (near 0) indicates that reach data are greater than background data; a p-value approaching 1 indicates no difference between reach data and background data. If a p-value is less than some small probability (0.05), there is some reason to suspect that the reach statistical distribution may be elevated above the background distribution; otherwise, no difference is indicated.

E-1.2 Results

The results of the statistical analyses are presented for each inorganic chemical and include a discussion of statistical tests that compare sample results from reach CDB-4 with Laboratory-wide and local sediment background data. As will be discussed for each individual inorganic chemical, none of the analytes that are greater than Laboratory-wide sediment background levels are also greater than local sediment background levels.

These inorganic chemicals can be divided into five groups that depict different trends between the reach and background concentrations. Nearly all of these inorganic chemicals fall into two categories: (1) analytes with no difference among the reach concentrations, Laboratory-wide background concentrations, and local background concentrations (aluminum, antimony, cadmium, mercury, silver, thallium, uranium, and zinc); and (2) analytes whose reach concentrations are intermediate between the local background and Laboratory-wide background data, with local background data being highest (barium, calcium, cobalt, copper, iron, magnesium, manganese, nickel, selenium, and vanadium). Four inorganic chemicals (arsenic, beryllium, chromium, and lead) exhibit a trend in which reach data are similar to Laboratory-wide background levels, but local background concentrations are greater than other data groups. For potassium, both reach and local background concentrations are less than Laboratory-wide background levels. Lastly, sodium concentrations in Laboratory-wide background samples are greater than in reach samples, which are greater than local background sample results.

Table E-1.2-1
Summary of the P-Values from the Gehan Statistical Testing

Analyte	Laboratory-Wide Background	Local Background
Aluminum	0.439	0.599
Antimony	ND[a]	ND
Arsenic	0.337	0.951
Barium	**0.006**	0.961
Beryllium	0.129	0.999
Cadmium	—[b]	—
Calcium	0.213	0.982
Chromium, total	0.394	0.932
Cobalt	**<0.001**	0.762
Copper	**0.045**	0.787
Cyanide, total	—	ND
Iron	**0.023**	0.872
Lead	0.295	0.997
Magnesium	0.062	0.963
Manganese	**0.030**	0.700
Mercury	—	—
Nickel	0.143	0.977
Potassium	0.918	0.947
Selenium	—	—
Silver	—	—
Sodium	1	0.184
Thallium	ND	ND
Uranium, total	0.398	ND
Vanadium	**0.001**	0.875
Zinc	0.784	0.762

Note: Bolded values indicate that reach sample results are significantly greater than Laboratory-wide sediment background values.

[a] ND = no background data.

[b] — = not applicable (statistical tests are not appropriate because of the high frequency of nondetected values).

E-1.2.1 Aluminum

Statistical testing results (Table E-1.2-1) suggest that reach data are not greater than the Laboratory-wide or local sediment background data. A review of the box plot (Figure E-1.2-1) shows that aluminum concentrations are similar among the reach CDB-4(CDB-4), Laboratory-wide background (BKG), and local background (local) data groups. Thus, aluminum is not retained as a COPC.

E-1.2.2 Antimony

Antimony was detected in less than half of the reach CDB-4 sediment samples; thus, statistical testing is not appropriate. The box plot shows the range of the nondetected and detected values for reach CDB-4

and background (Figure E-1.2-2). Note that the Laboratory-wide sediment background data (BKG group) presented in Figure E-1.2-2 were analyzed by inductively coupled plasma emission spectroscopy (ICPES), which has detection limits above the soil background value. The soil background value of 0.83 mg/kg for antimony is used as a surrogate sediment background value (Ryti et al. 1998, 59730). Because no values of antimony are greater than this background value, antimony is not retained as a COPC.

E-1.2.3 Arsenic

Statistical testing results (Table E-1.2-1) suggest that reach CDB-4 arsenic sample results do not exceed the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-3) confirms these results and also shows that arsenic concentrations from the local sediment background samples are slightly greater than either the reach CDB-4 or Laboratory-wide background results (compare lower quartile and maximum concentrations on Figure E-1.2-3). Thus, arsenic is not retained as a COPC. The reason that local background concentrations of arsenic are somewhat greater than reach or Laboratory-wide background levels is unknown, although the difference is not statistically significant.

E-1.2.4 Barium

Although only a single barium sample result is marginally greater than the Laboratory-wide sediment background value (130 mg/kg versus 127 mg/kg), statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 concentrations exceed the Laboratory-wide sediment background concentrations. A review of the data comparing reach CDB-4 with the background data sets (Figure E-1.2-4) confirms this result. The box plot also shows that reach CDB-4 barium concentrations are intermediate between Laboratory-wide and local sediment background concentrations. The somewhat elevated barium concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, barium is not retained as a COPC for risk assessment calculations.

E-1.2.5 Beryllium

Statistical testing results (Table E-1.2-1) suggest that reach CDB-4 beryllium sample results are not greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-5) confirms these results and shows that beryllium concentrations from the local sediment background samples are slightly greater than either the reach CDB-4 or Laboratory-wide sediment background results. Thus, beryllium is not retained as a COPC.

E-1.2.6 Cadmium

Cadmium was not detected in the reach samples or in the sediment background samples, thus statistical testing is not appropriate. The box plot shows the range of nondetected values for reach CDB-4 and sediment background (Figure E-1.2-6). None of the detection limits are greater than the Laboratory-wide sediment background value. Thus, cadmium is not retained as a COPC.

E-1.2.7 Calcium

One calcium sample result is greater than the Laboratory-wide sediment background value (5620 mg/kg versus 4420 mg/kg). Statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 sample results for calcium are not significantly greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-7) confirms these results and shows that calcium concentrations from

the reach samples are intermediate between the local and Laboratory-wide sediment background results. Thus, calcium is not retained as a COPC.

E-1.2.8 Total Chromium

Statistical testing results (Table E-1.2-1) suggest that the reach data are not greater than the Laboratory-wide or local sediment background data. A review of the box plot (Figure E-1.2-8) shows that total chromium concentrations from the local sediment background samples are slightly greater than either the reach CDB-4 or Laboratory-wide sediment background results (compare lower quartile values on Figure E-1.2-8). Thus, total chromium is not retained as a COPC. The reason that local background concentrations of total chromium are somewhat greater than the reach or Laboratory-wide background concentrations is unknown, although it is worth noting that the difference is not statistically significant and is also small (approximately 3 mg/kg).

E-1.2.9 Cobalt

Twelve cobalt sample results are greater than the Laboratory-wide sediment background value. Statistical testing results (Table E-1.2-1) also suggest that the reach CDB-4 data are greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-9) confirms this result. The box plot also shows that cobalt concentrations from the local sediment background samples are somewhat lower than reach CDB-4 results. Thus, reach cobalt concentrations are intermediate between Laboratory-wide and local background data. However, statistical testing shows that reach CDB-4 cobalt concentrations are not greater than local background concentrations. The somewhat elevated cobalt concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, cobalt is not retained as a COPC for risk assessment calculations.

E-1.2.10 Copper

Although no copper sample results are greater than the Laboratory-wide sediment background value, statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 data are greater than the Laboratory sediment background data. A review of the box plot (Figure E-1.2-10) confirms this result. The box plot also shows that reach CDB-4 copper concentrations are intermediate between Laboratory-wide and local background concentrations. The somewhat elevated copper concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, copper is not retained as a COPC for risk assessment calculations.

E-1.2.11 Total Cyanide

Statistical testing is not appropriate because there are no detected reach CDB-4 total cyanide sample results. None of the total cyanide detection limits are greater than the Laboratory-wide sediment background value, as shown in the box plot (Figure E-1.2-11). (Note that no total cyanide analyses were requested for the local sediment background samples.) Thus, total cyanide is not retained as a COPC.

E-1.2.12 Iron

Two iron sample results are greater than the Laboratory-wide sediment background value, and statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 data are greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-12) confirms this result. The box plot also shows that iron concentrations from the local sediment background samples are greater than reach

CDB-4 results. Statistical testing also shows that reach CDB-4 iron concentrations are intermediate between Laboratory-wide and local sediment background concentrations. The somewhat elevated iron concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, iron is not retained as a COPC for risk assessment calculations.

E-1.2.13 Lead

Statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 lead concentrations are not greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-13) confirms this and also shows that lead concentrations from the local sediment background samples are slightly greater than either the reach CDB-4 or Laboratory-wide sediment background concentrations (compare the interquartile ranges on Figure E-1.2-13). Thus, lead is not retained as a COPC. The reason that local background concentrations of lead are somewhat greater than reach or Laboratory-wide background concentrations is unknown, although the difference is not statistically significant.

E-1.2.14 Magnesium

One magnesium sample result is marginally greater than the Laboratory-wide sediment background value (2400 mg/kg versus 2370 mg/kg). Statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 magnesium sample results are not significantly greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-14) confirms these results and also shows that magnesium concentrations from the reach samples are intermediate between the local sediment background and Laboratory-wide sediment background results. Thus, magnesium is not retained as a COPC.

E-1.2.15 Manganese

Although no manganese sample results exceed the Laboratory-wide sediment background value, statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 data are elevated relative to the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-15) confirms this result. The box plot also shows that manganese concentrations from the local sediment background samples are greater than the reach CDB-4 results. Thus, reach CDB-4 manganese concentrations are intermediate between Laboratory-wide and local sediment background concentrations. The somewhat elevated manganese concentrations measured in reach CDB-4 are thought to be derived from local parent material (soils or bedrock) and to not represent releases from Laboratory operations. Thus, manganese is not retained as a COPC for risk assessment calculations.

E-1.2.16 Mercury

Mercury was not usually detected in the reach or background samples, thus statistical testing is not appropriate. The box plot shows the range of detected and nondetected values for reach CDB-4 and background samples (Figure E-1.2-16). The two detected sample results from the local sediment background samples are less than the Laboratory-wide sediment background value. None of the detection limits exceed the background value. Thus, mercury is not retained as a COPC.

E-1.2.17 Nickel

Statistical testing results (Table E-1.2-1) suggest that the reach CDB-4 nickel sample results are not significantly greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-17) confirms these results and also shows that nickel concentrations from the reach samples are intermediate between the local sediment background and the Laboratory-wide sediment background results. Thus, nickel is not retained as a COPC.

E-1.2.18 Potassium

Statistical testing results (Table E-1.2-1) suggest that the reach potassium data are not greater than the Laboratory-wide or local sediment background data. A review of the box plot (Figure E-1.2-18) shows that reach CDB-4 potassium concentrations are less than Laboratory-wide and local sediment background data groups (compare lower quartiles on Figure E-1.2-18). Thus, potassium is not retained as a COPC. The reason that reach background concentrations of potassium are somewhat less than Laboratory-wide or local background levels is unknown, although it is worth noting that the difference is not statistically significant.

E-1.2.19 Selenium

Selenium was not usually detected in the Laboratory-wide sediment background samples, thus statistical testing is not appropriate. Eleven detected selenium sample results from reach CDB-4 are greater than the Laboratory-wide sediment background value, and one nondetected sample from reach CDB-4 is greater than the background value. A review of the box plot (Figure E-1.2-19) confirms this result. The box plot also shows that selenium concentrations from the local sediment background samples are greater than reach CDB-4 results (Figure E-1.2-19). The elevated selenium concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, selenium is not retained as a COPC for risk assessment calculations.

E-1.2.20 Silver

Silver was not usually detected in the reach or background samples, thus statistical testing is not appropriate. The box plot shows the range of detected and nondetected values for reach CDB-4 and background samples (Figure E-1.2-20). The one detected sample result for the local sediment background samples is less than the Laboratory-wide sediment background value. None of the detection limits or detected sample results are greater than the Laboratory-wide sediment background value. Thus, silver is not retained as a COPC.

E-1.2.21 Sodium

Results of the statistical testing (Table E-1.2-1) suggest that the reach sodium sample results are not significantly greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-21) confirms these results and also shows that Laboratory-wide sediment background concentrations of sodium are greater than either the reach CDB-4 or local sediment background results. Thus, sodium is not retained as a COPC. The reason that reach and local sediment background concentrations of sodium are less than Laboratory-wide sediment background concentrations is not known.

E-1.2.22 Thallium

Two thallium sample results from reach CDB-4 are greater than the Laboratory-wide sediment background value. The box plot shows the thallium Laboratory-wide sediment background sample results, the results from reach CDB-4, and the local sediment background samples (Figure E-1.2-22). Note that the Laboratory-wide sediment background data (BKG group) for thallium were analyzed by ICPES, which produces biased results greater than the soil background value. Thus, comparisons of reach data with Laboratory-wide sediment background results are not appropriate.

Thallium was infrequently detected in reach CDB-4 and local sediment background samples, which means that statistical testing is not appropriate for these data groups. Thallium was detected in two reach CDB-4 samples and in two local sediment background samples. The two detected sample results from reach CDB-4 were both greater than the background value. The highest detected thallium result (1.1 mg/kg) is from the sample with the highest iron concentration (21,200 mg/kg), which suggests a common source for both metals. Because elevated iron concentrations in reach CDB-4 are hypothesized to be derived from local parent material, it is suspected that elevated thallium results in reach CDB-4 are also derived from local parent material and do not represent releases from Laboratory operations. Thus, thallium is not retained as a COPC for risk assessment calculations.

E-1.2.23 Total Uranium

Statistical testing results (Table E-1.2-1) suggest that the reach total uranium sample results are not greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-23) confirms these results. (Note that no total uranium analyses were requested for the local sediment background samples.) Thus, total uranium is not retained as a COPC.

E-1.2.24 Vanadium

Six vanadium sample results are greater than the Laboratory-wide sediment background value, and statistical testing results (Table E-1.2-1) suggest that the reach data are greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-1.2-24) confirms this result. The box plot also shows that vanadium concentrations from the reach samples are intermediate between the local and Laboratory-wide sediment background results (Figure E-1.2-24). Statistical testing also shows that reach vanadium concentrations are not greater than local sediment background concentrations (Table E-1.2-1). The somewhat elevated vanadium concentrations measured in reach CDB-4 are thought to be derived from local parent material and to not represent releases from Laboratory operations. Thus, vanadium is not retained as a COPC for risk assessment calculations.

E-1.2.25 Zinc

Statistical testing results (Table E-1.2-1) suggest that the reach data are not greater than the Laboratory-wide or local sediment background data. A review of the box plot (Figure E-1.2-25) shows that zinc concentrations are similar among reach, Laboratory-wide sediment background, and local sediment background data groups. Thus, zinc is not retained as a COPC.

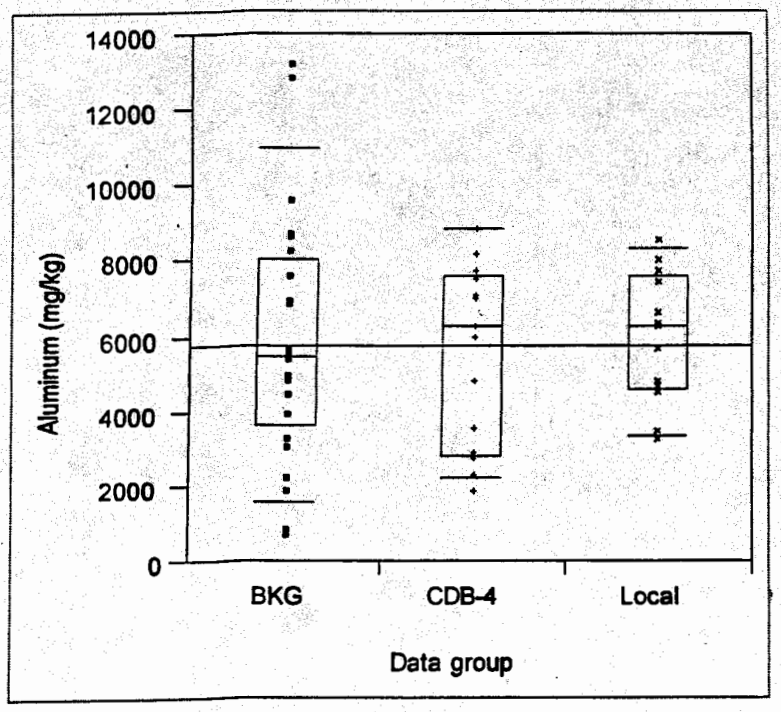

Figure E-1.2-1. Box plot for aluminum

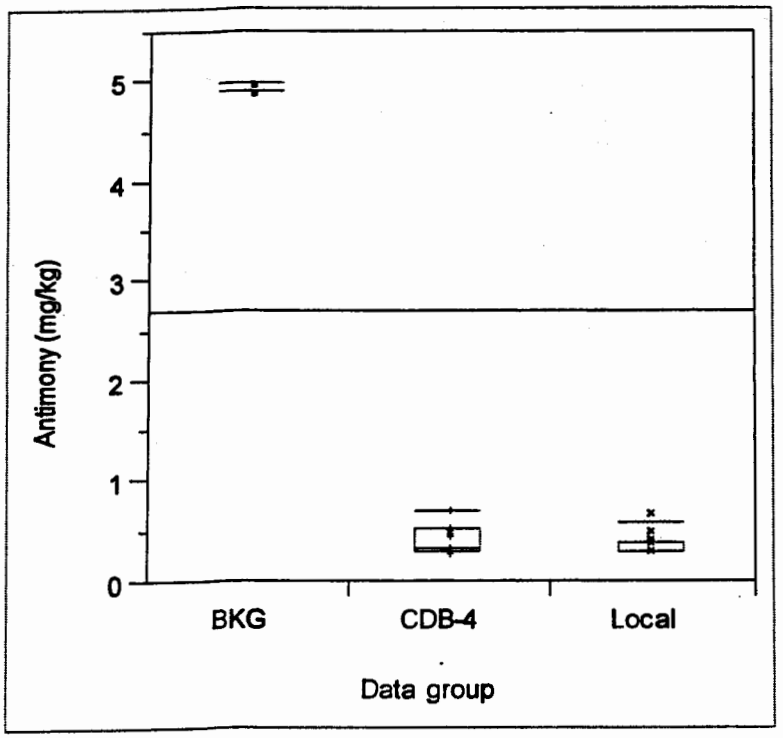

Figure E-1.2-2. Box plot for antimony

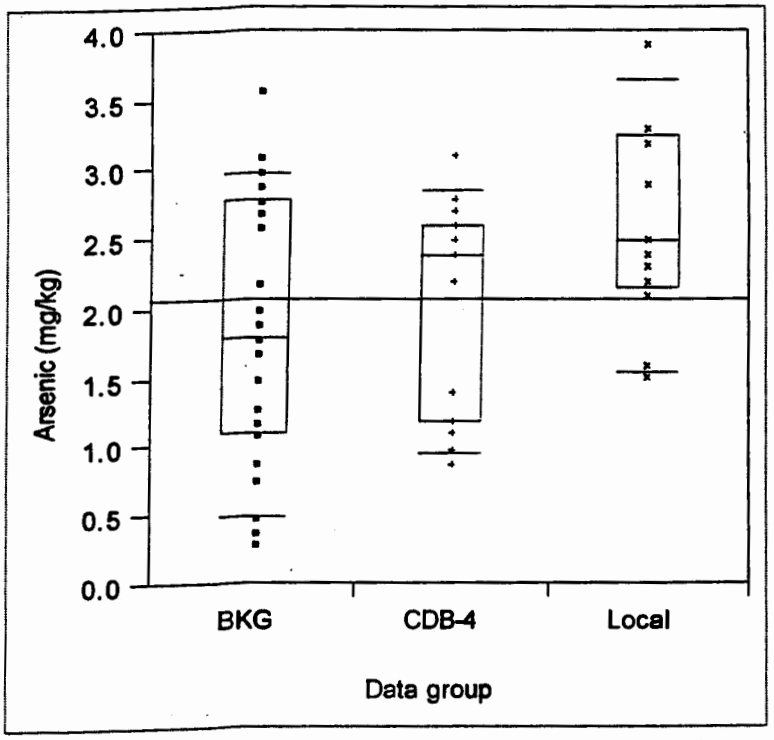

Figure E-1.2-3. Box plot for arsenic

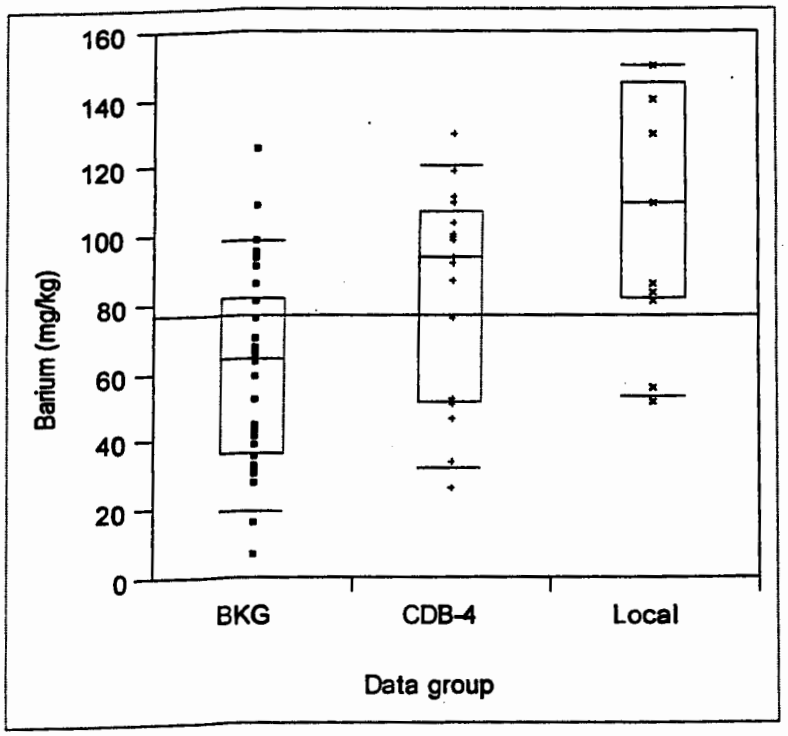

Figure E-1.2-4. Box plot for barium

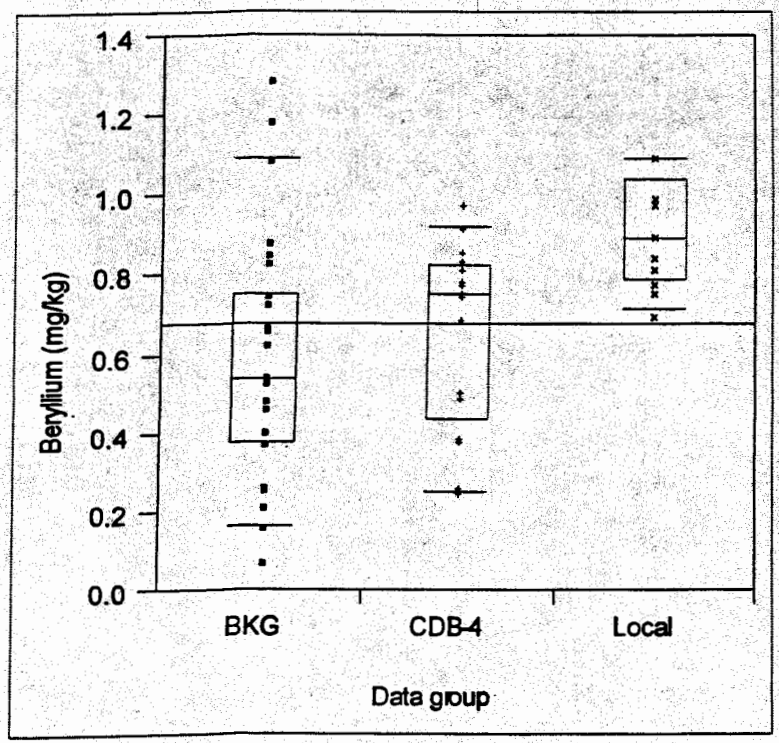

Figure E-1.2-5. Box plot for beryllium

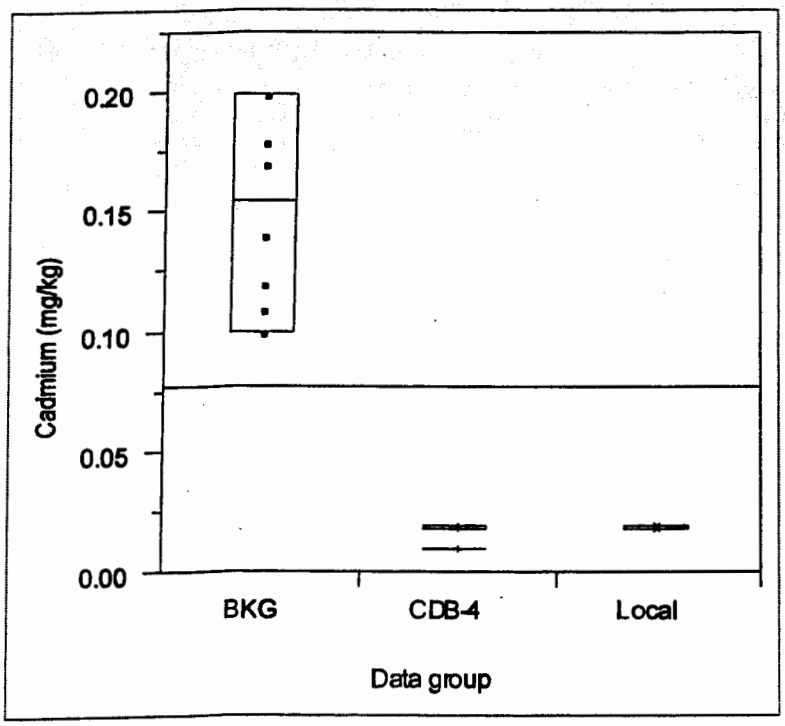

Figure E-1.2-6. Box plot for cadmium

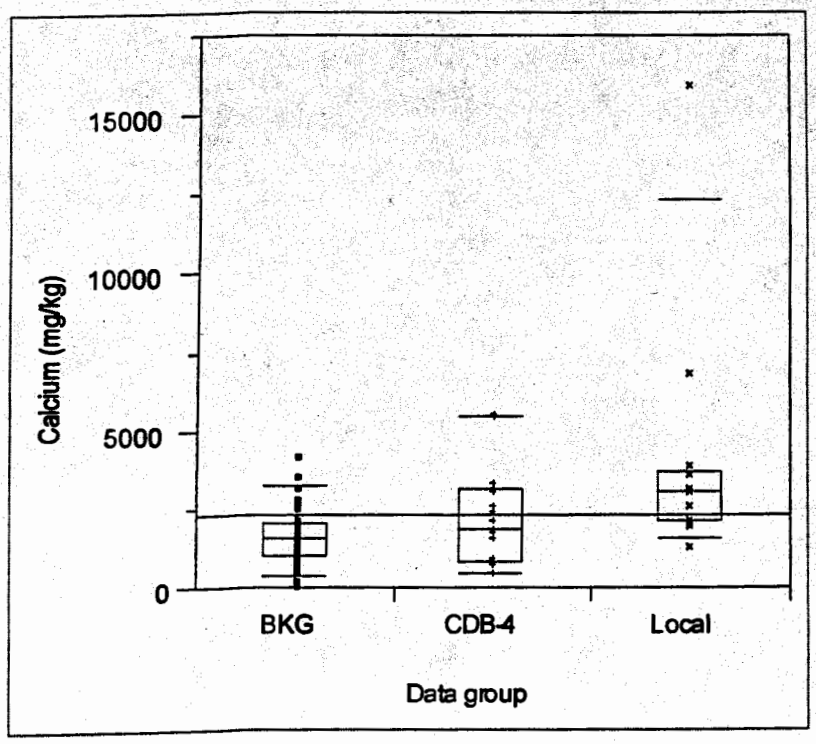

Figure E-1.2-7. Box plot for calcium

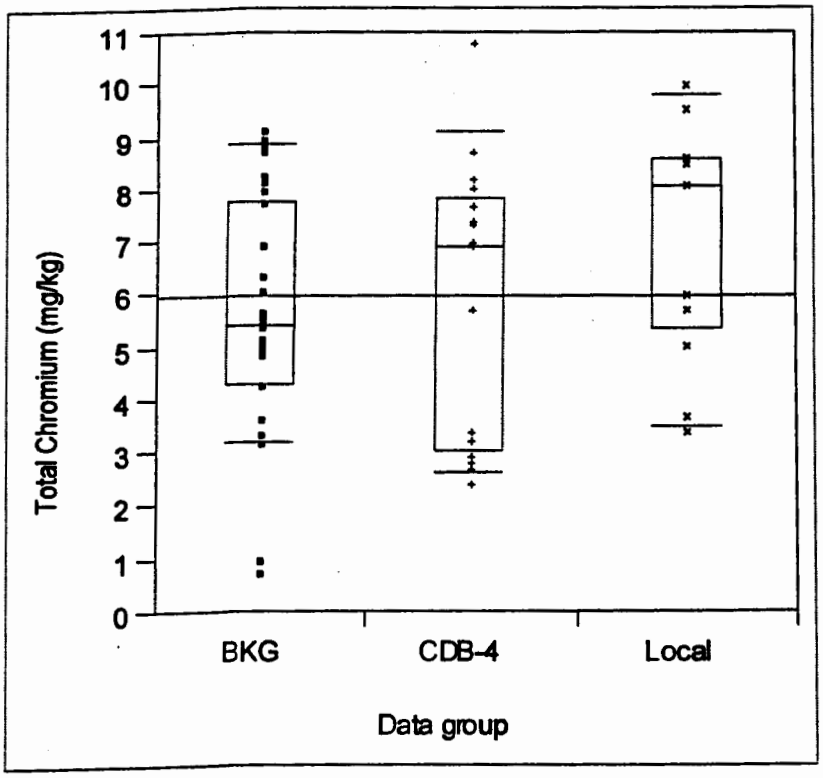

Figure E-1.2-8. Box plot for total chromium

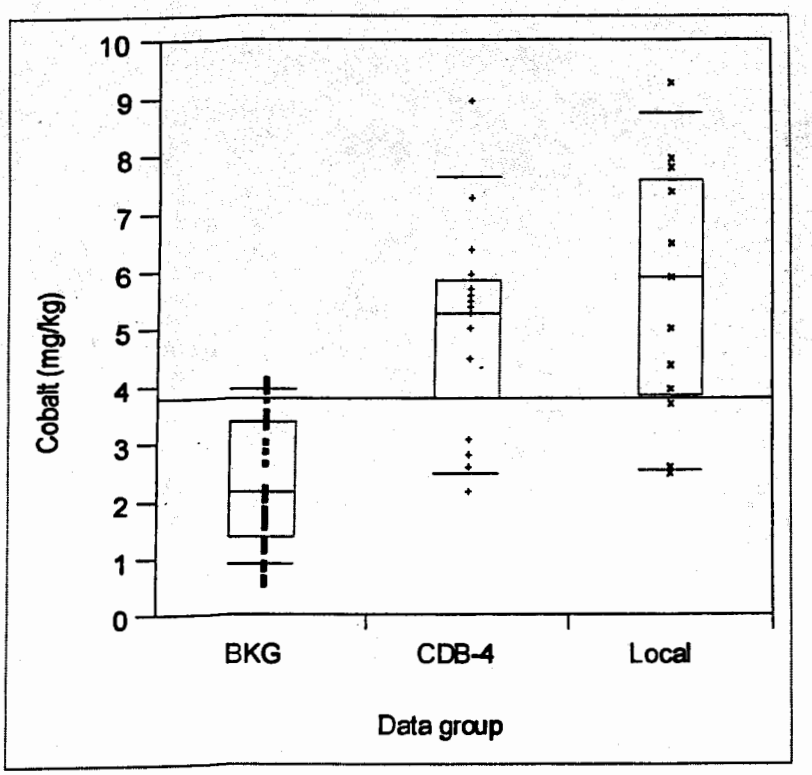

Figure E-1.2-9. Box plot for cobalt

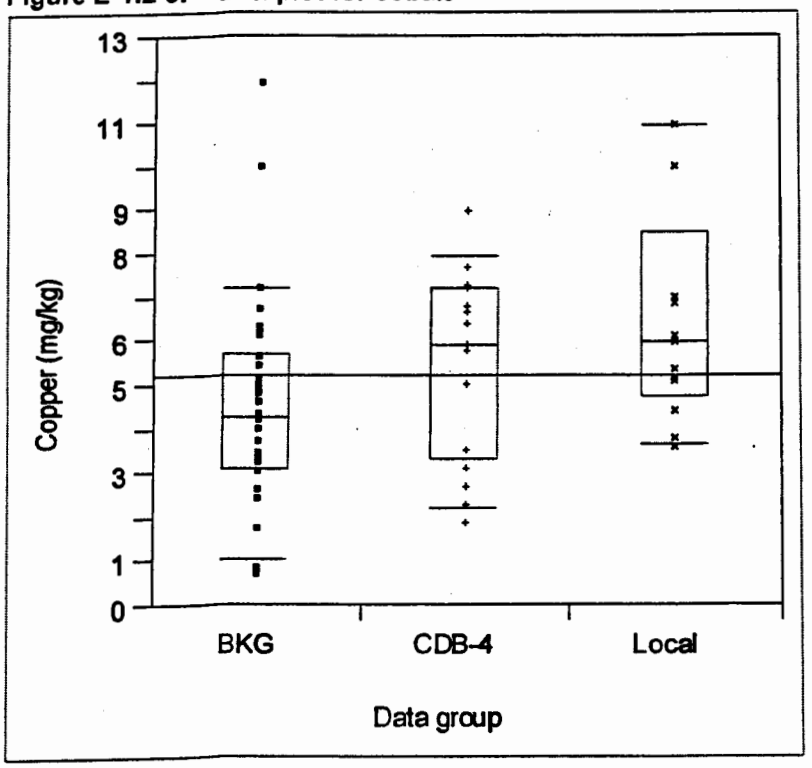

Figure E-1.2-10. Box plot for copper

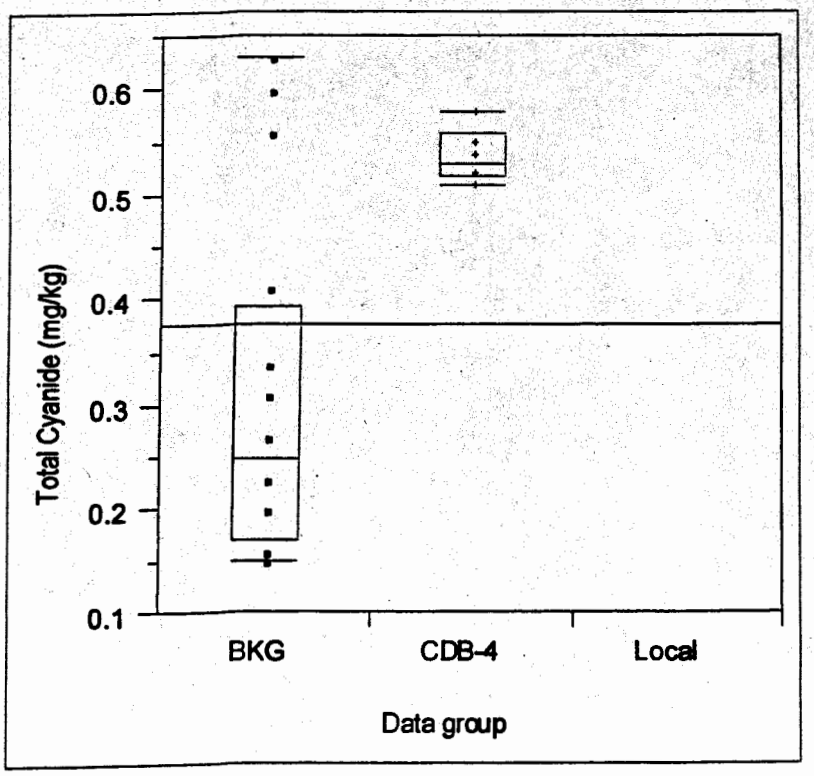

Figure E-1.2-11. Box plot for total cyanide

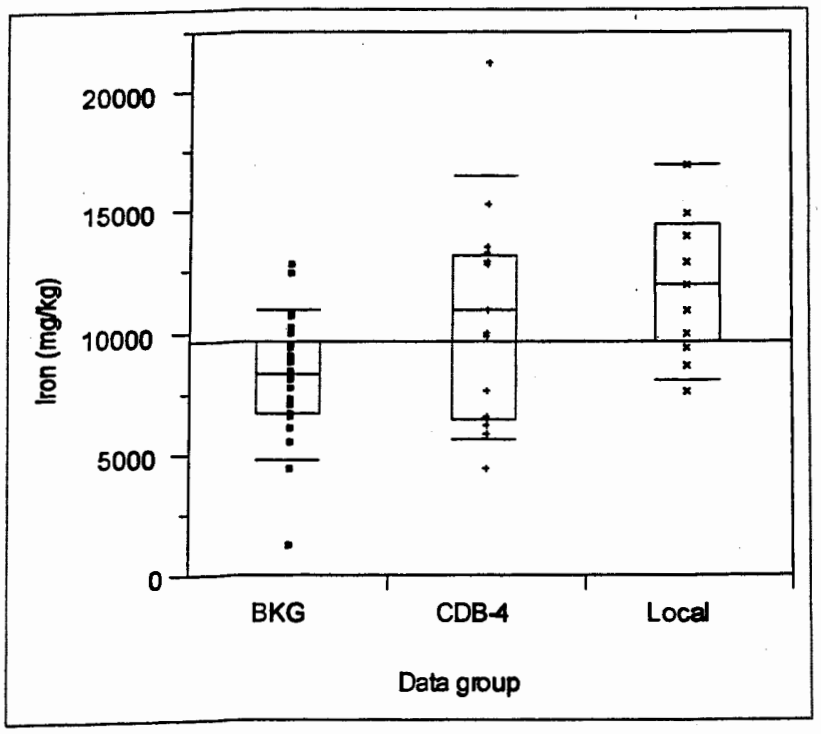

Figure E-1.2-12. Box plot for iron

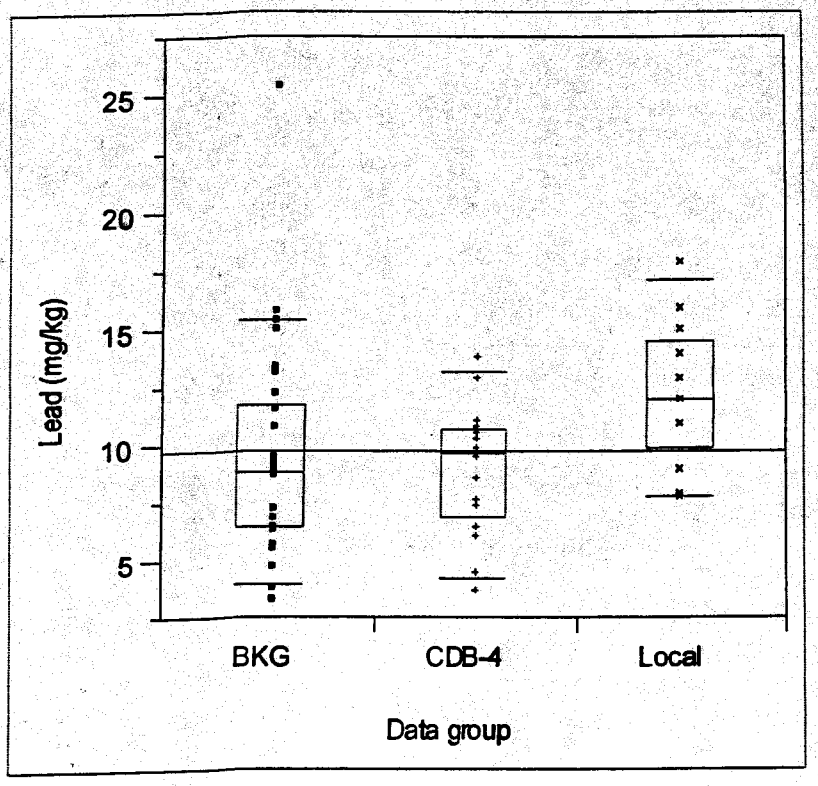

Figure E-1.2-13. Box plot for lead

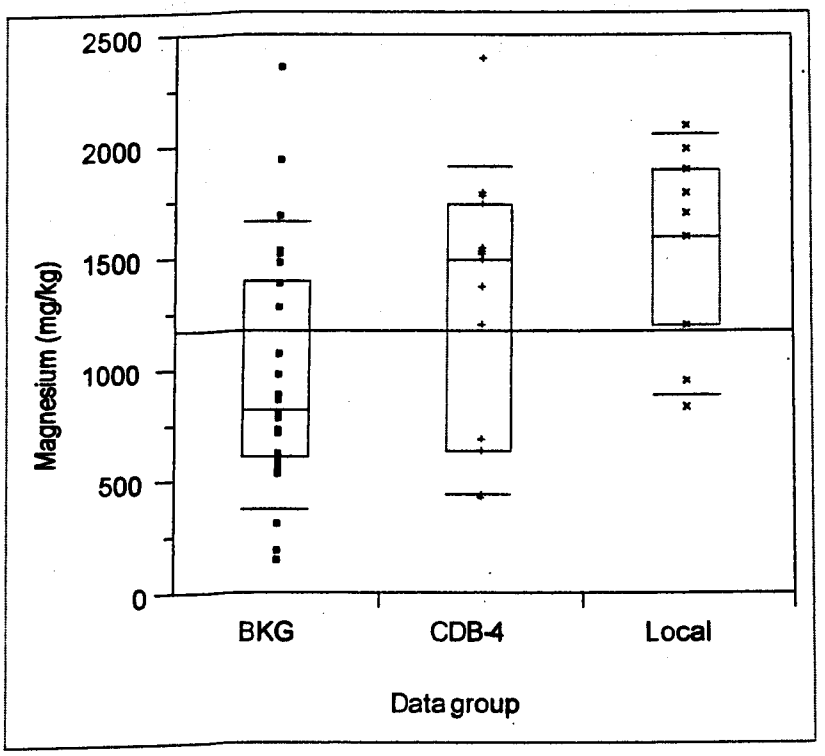

Figure E-1.2-14. Box plot for magnesium

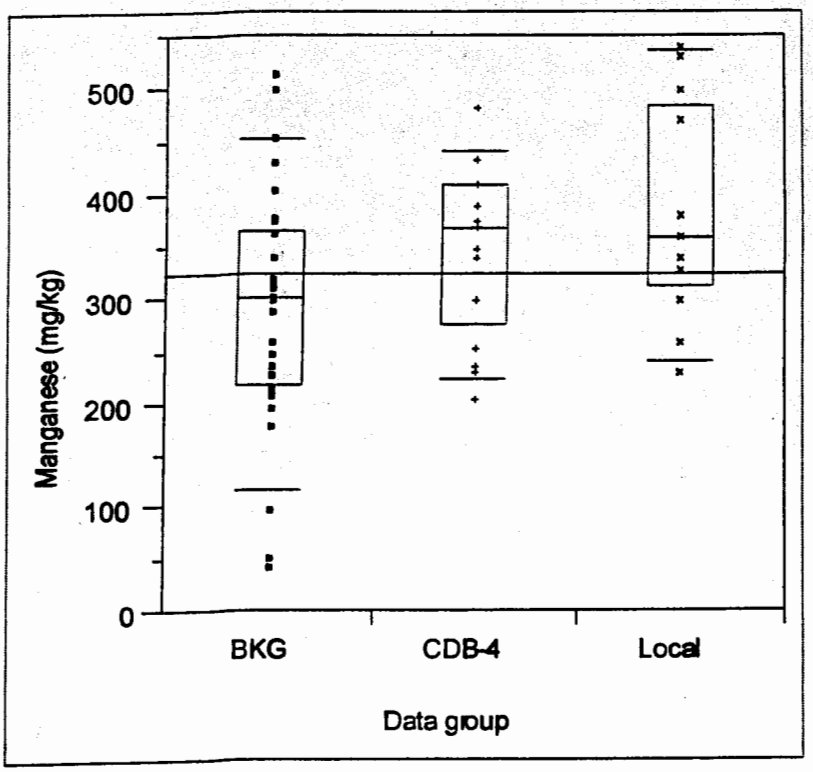

Figure E-1.2-15. Box plot for manganese

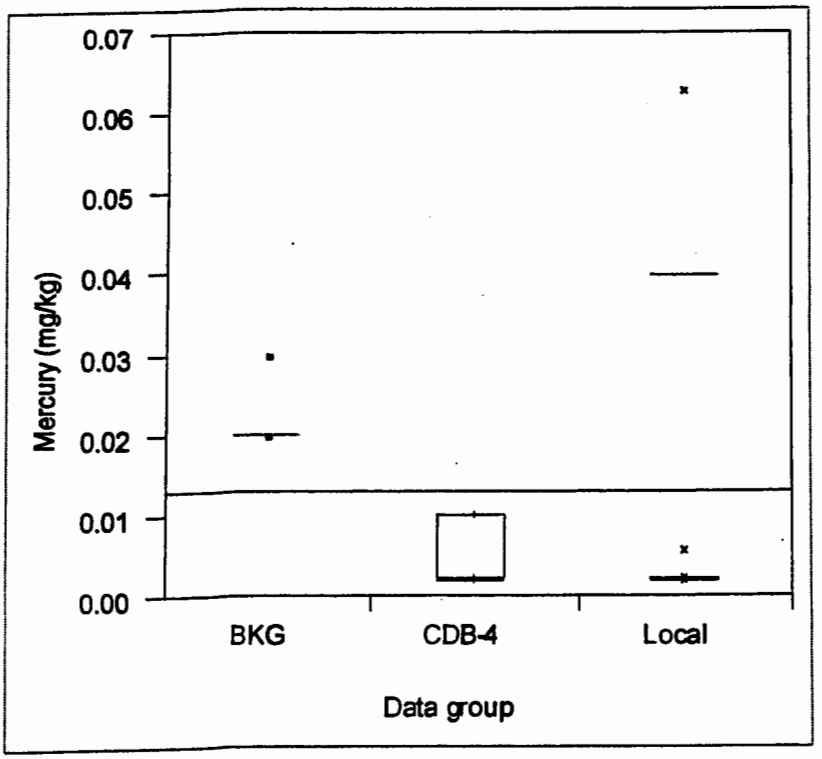

Figure E-1.2-16. Box plot for mercury

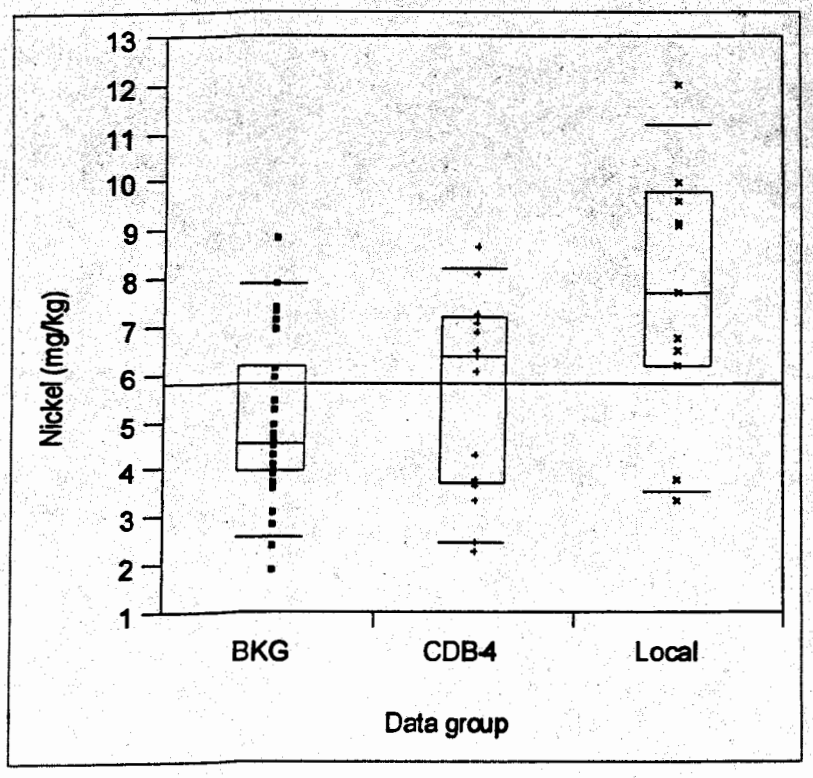

Figure E-1.2-17. Box plot for nickel

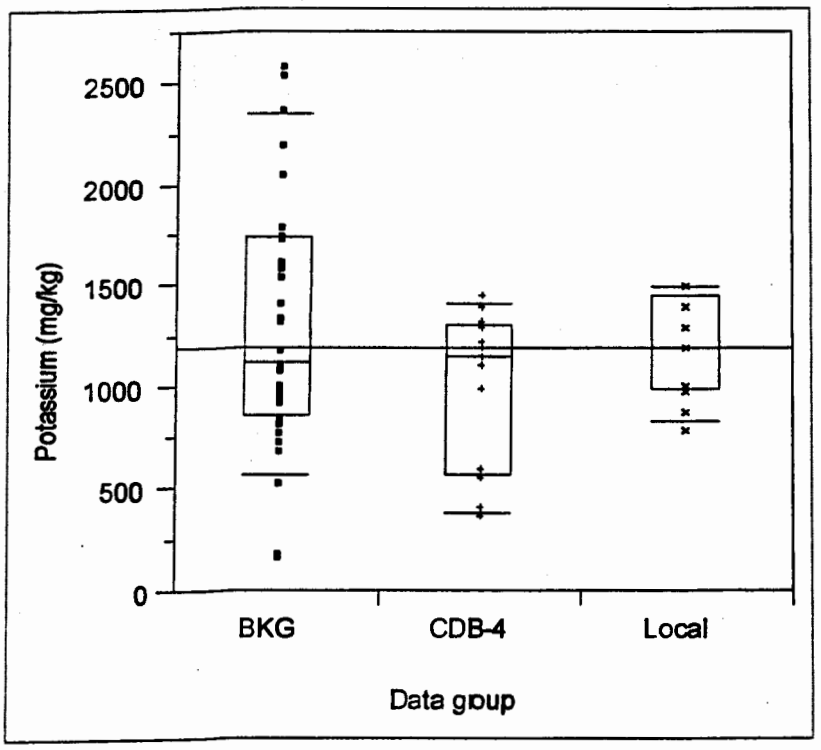

Figure E-1.2-18. Box plot for potassium

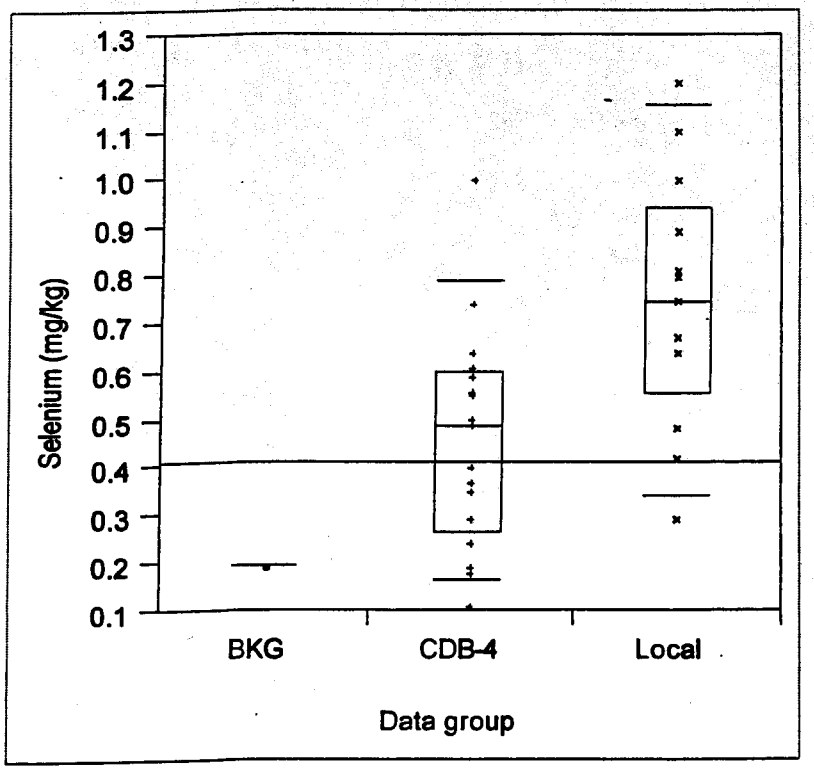

Figure E-1.2-19. Box plot for selenium

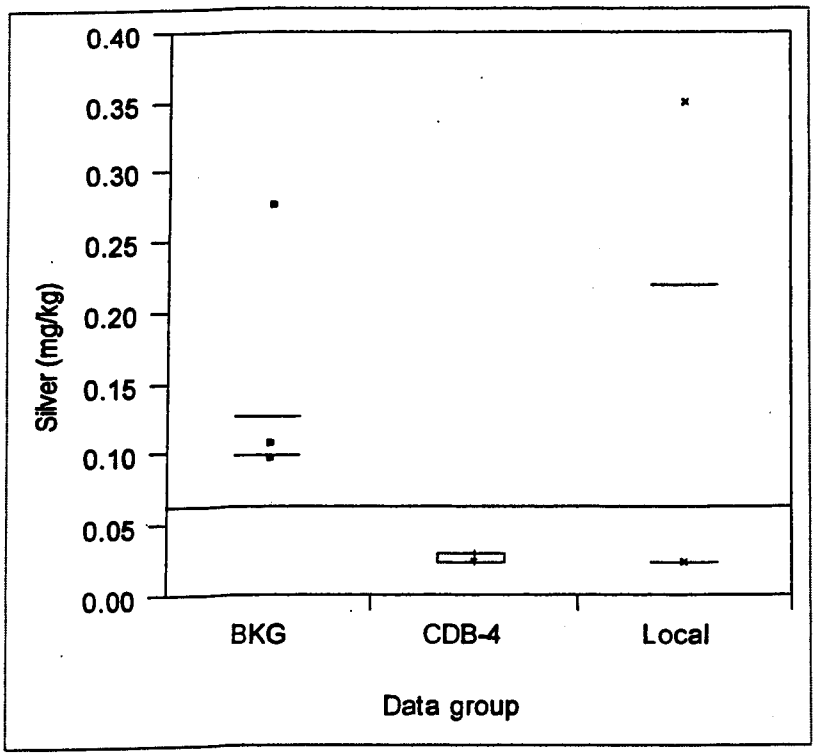

Figure E-1.2-20. Box plot for silver

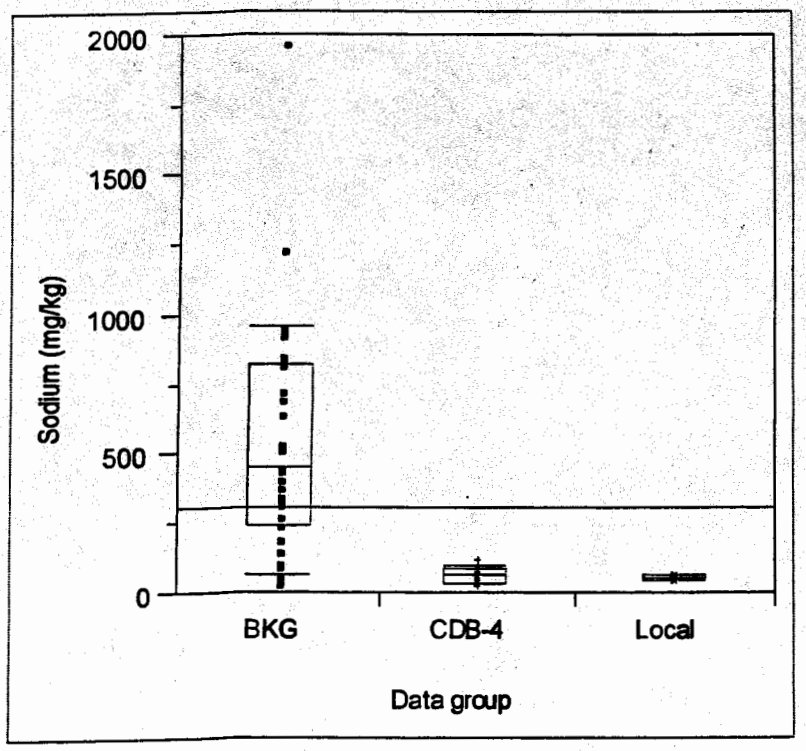

Figure E-1.2-21. Box plot for sodium

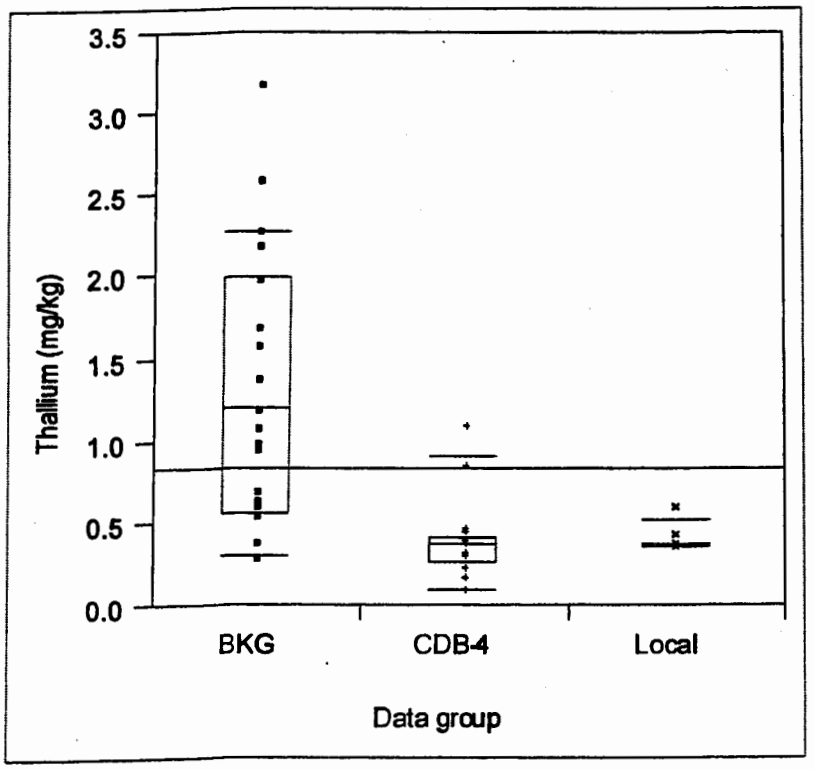

Figure E-1.2-22. Box plot for thallium

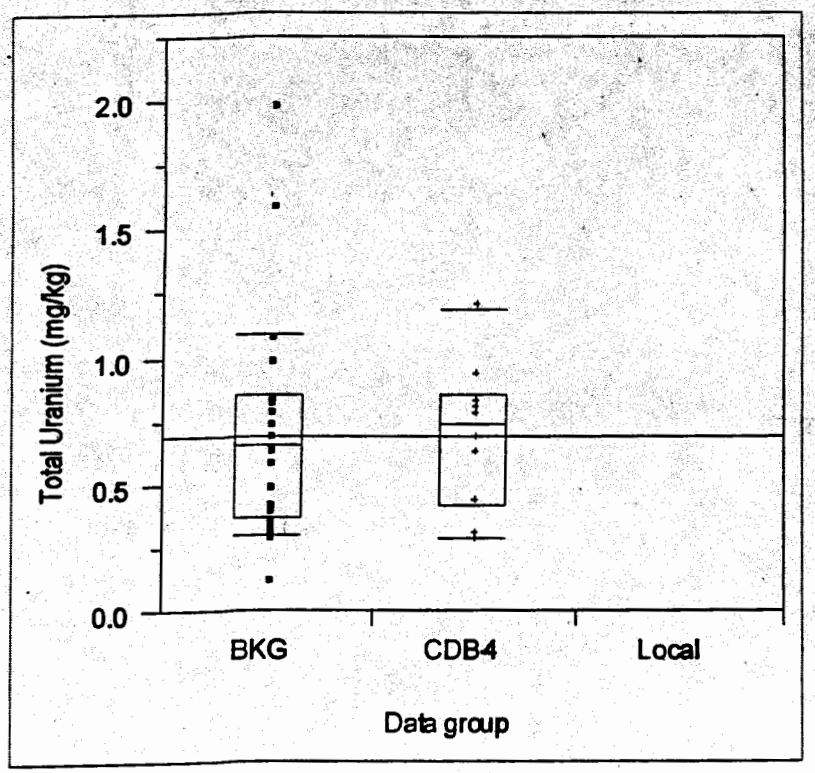

Figure E-1.2-23. Box plot for total uranium

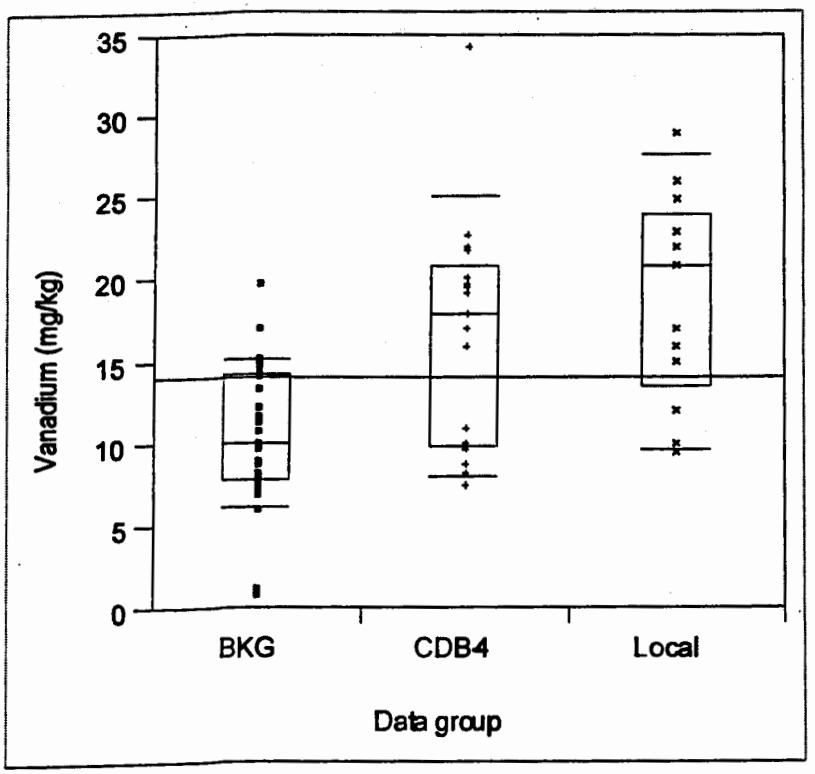

Figure E-1.2-24. Box plot for vanadium

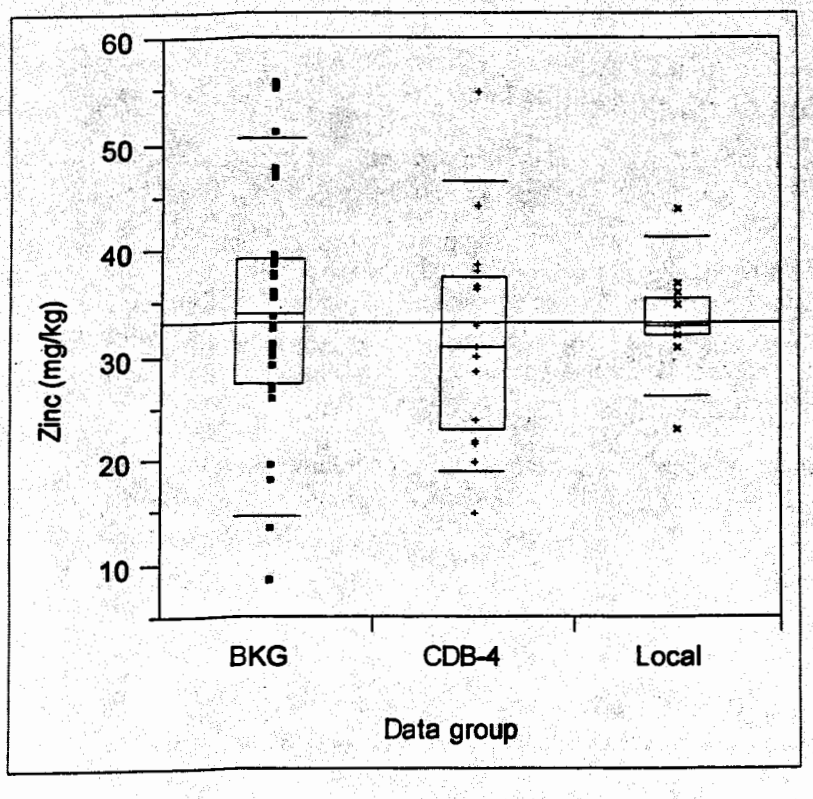

Figure E-1.2-25. Box plot for zinc

E-2.0 STATISTICAL EVALUATIONS OF RADIONUCLIDE DATA

The objective of this section is to present detailed statistical and graphical analyses that compare radionuclide data from reach CDB-4 with Laboratory-wide and local sediment background data. Laboratory-wide sediment background data are presented in "Inorganic and Radionuclide Background Data for Soils, Canyon Sediments, and Bandelier Tuff at Los Alamos National Laboratory" (Ryti et al. 1998, 59730). As used in this section, *background* includes radionuclides that are derived from atmospheric fallout, in addition to naturally occurring radionuclides. Local background samples were collected for isotopic plutonium to provide additional information on fallout concentrations in this area. Sample results for the local background samples are presented in Appendix D.

These analyses were used to determine if the reach data show evidence of contaminant releases through a systematic increase in the concentration of one or more analytes to levels greater than the concentrations observed in the background data. (Note: The figures for this section have been placed at the end of the section.)

E-2.1 Data Analysis Methods

Two types of data analyses were used to evaluate the concentrations of radionuclides in the reach sample data as compared with background data. In the first type, a graphical comparison is made between reach sample data and background sample data. In the second type, the results of formal statistical testing are presented. Each of these methods is discussed below in more detail.

E-2.1.1 Comparisons of Radionuclide Data

These comparisons use graphical displays called box plots, which show the actual values for each radionuclide (Figures E-2.2-1 through E-2.2-9). The ends of each box represent the "interquartile" range of the data distribution, which is specified by the 25th percentile and 75th percentile of the data distribution. The horizontal line within each box is the median (the 50th percentile) of the data distribution (if the number of samples is four or fewer, the horizontal line is not displayed). Thus, each box indicates concentration values for the central half of the data, and concentration shifts can be readily assessed by comparing the boxes. If most of the data are represented by a single concentration value (usually the detection limit), the box is reduced to a single line. These plots also depict a line going across the entire plot that represents the overall average concentration of all data groups.

In these statistical plots, one symbol is used for the analytical laboratory results for the potentially contaminated sediment samples from reach CDB-4 (CDB-4), another is used for the Laboratory-wide sediment background data (BKG), and yet another is used for the local sediment background samples (local). (Note that local sediment background data were only obtained for plutonium-239, -240.) The symbols are used consistently in all statistical plots in this section. Laboratory-wide background data are represented by a square; reach CDB-4 data, by a plus symbol: and local background data, by an *x*. Also note that nondetected sample results are plotted as the detection limit value.

E-2.1.2 Statistical Testing

Because the data for these radionuclides do not appear to typically satisfy conditions of statistical normality, nonparametric statistical tests are preferred for background comparisons. The Wilcoxon rank sum test was used for statistical testing. The purpose of this test is to detect whether the reach data show evidence of a release of any analyte through a systematic increase in concentration greater than that observed in the background data. The Wilcoxon rank sum test pools site and background data into one

aggregate set and determines whether the average rank of site data is greater than that of the background data. The Wilcoxon rank sum test is most sensitive to detecting cases where most of the reach data are greater than the average or median value observed in the background data. More discussion of this test is contained in Ryti et al. (1996, 53953).

The metrics used to determine if a statistically significant difference between reach data and background data exists are the calculated significance levels (p-values) for the tests, and the results of these tests are shown in Table E-2.2-1. A low p-value (near 0) indicates that reach data are greater than background data; a p-value approaching 1 indicates no difference between reach data and background data. If a p-value is less than some small probability (0.05), there is some reason to suspect that the reach statistical distribution may be elevated above the background distribution; otherwise, no difference is indicated.

E-2.2 Results

The results of the statistical analyses are presented for each radionuclide and include a discussion of statistical tests that compare sample results from reach CDB-4 with Laboratory-wide and local sediment background data.

Table E-2.2-1
Summary of the P-Values
from the Wilcoxon Rank Sum Statistical Testing

Analyte	Laboratory (LANL) Background Data
Americium-241	0.996
Cesium-137	0.477
Plutonium-239, -240	0.693*
Thorium-228	0.823
Thorium-230	0.989
Thorium-232	0.746
Uranium-234	>0.999
Uranium-235	>0.999
Uranium-238	0.997

* Note that the p-value for the comparison of reach to local background levels is 0.486.

E-2.2.1 Americium-241

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide sediment background data. A review of the box plot (Figure E-2.2-1) confirms these results. Thus, americium-241 is not retained as a COPC.

E-2.2.2 Cesium-137

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-2) shows that cesium-137 concentrations in the reach and Laboratory-wide background data groups are similar. Thus, cesium-137 is not retained as a COPC.

E-2.2.3 Plutonium-239, -240

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than either the Laboratory-wide or local sediment background data. A review of the box plot (Figure E-2.2-3) shows that the interquartile plutonium-239, -240 concentrations are similar among the reach, the Laboratory-wide background, and the local background data groups. When interpreting the box plot for plutonium-239, -240, it is important to consider the number of samples in each group. For example, there are only seven local background samples, which means that the upper and lower quartiles of the local background distribution are most likely to be understated or overstated with such a small number of samples. It is also significant that most of the reach CDB-4 and local background sample results are nondetects, so Figure E-2.2-3 primarily compares nondetected sample results for these data groups. Thus, plutonium-239, -240 is not retained as a COPC, based on the absence of significant difference between reach data and background data and on its infrequent detection (only 7 detects out of 23 total samples).

E-2.2.4 Thorium-228

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-4) shows that thorium-228 concentrations in the reach and Laboratory-wide background data groups are similar. Thus, thorium-228 is not retained as COPC.

E-2.2.5 Thorium-230

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-5) shows that thorium-230 concentrations in the reach and the Laboratory-wide background data groups are similar. Thus, thorium-230 is not retained as a COPC.

E-2.2.6 Thorium-232

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-6) shows that thorium-232 concentrations in the reach and the Laboratory-wide background data groups are similar. Thus, thorium-232 is not retained as a COPC.

E-2.2.7 Uranium-234

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-7) shows that uranium-234 concentrations in the reach and the Laboratory-wide background data groups are similar. Thus, uranium-234 is not retained as a COPC.

E-2.2.8 Uranium-235

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-8) shows that uranium-235 concentrations in the reach and the Laboratory-wide background data groups are similar. Thus, uranium-235 is not retained as a COPC.

E-2.2.9 Uranium-238

Statistical testing results (Table E-2.2-1) suggest that the reach data are not greater than the Laboratory-wide background data. A review of the box plot (Figure E-2.2-9) shows that uranium-238 concentrations in the reach and the Laboratory-wide background data groups are similar. Thus, uranium-238 is not retained as a COPC.

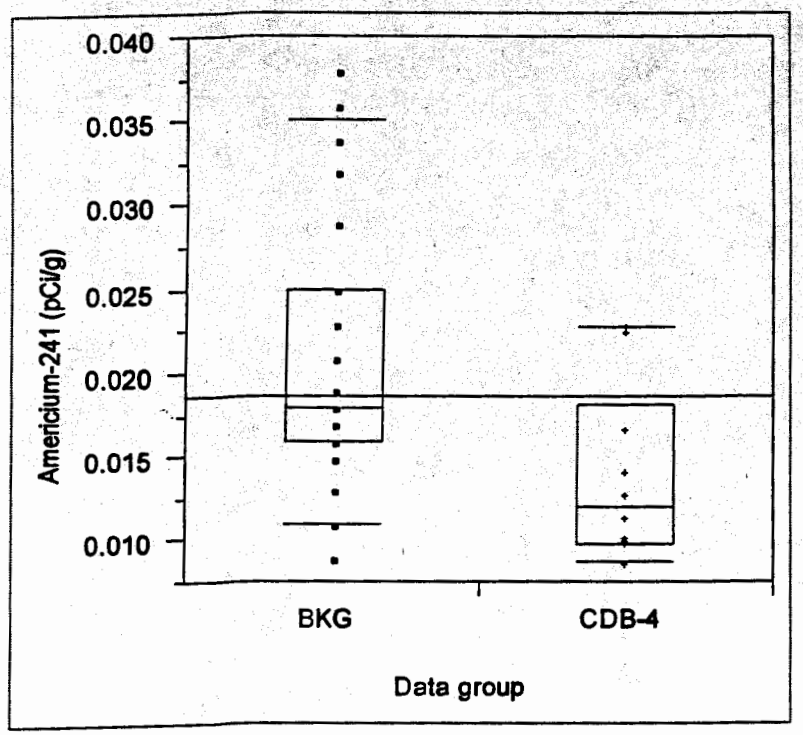

Figure E-2.2-1. Box plot for americium-241

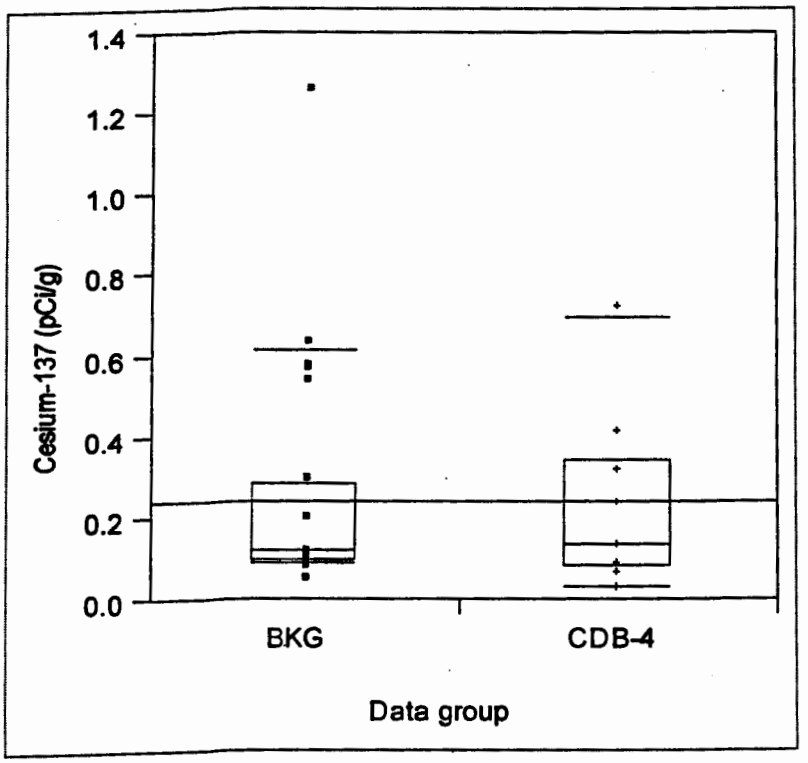

Figure E-2.2-2. Box plot for cesium-137

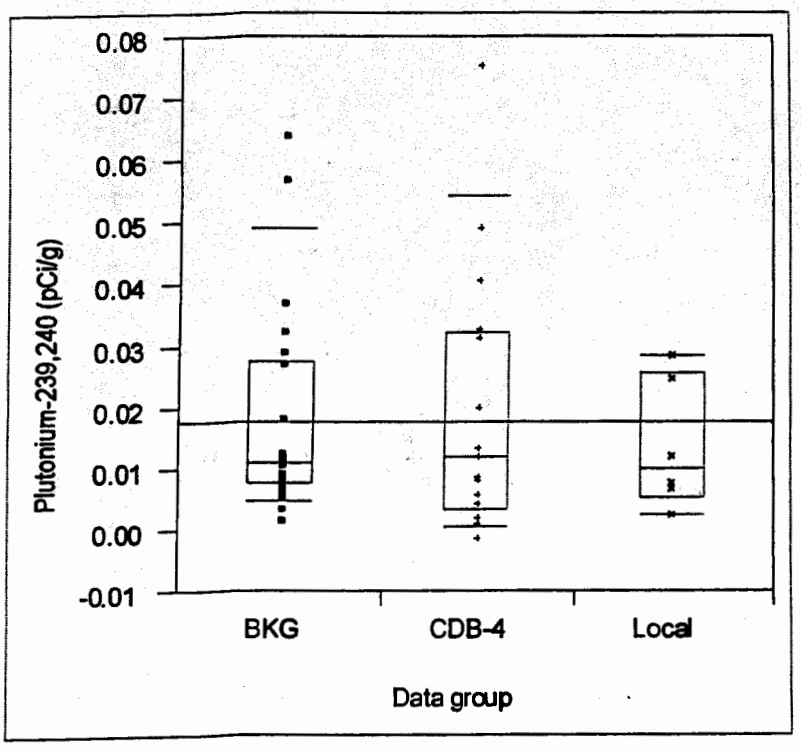

Figure E-2.2-3. Box plot for plutonium-239, -240

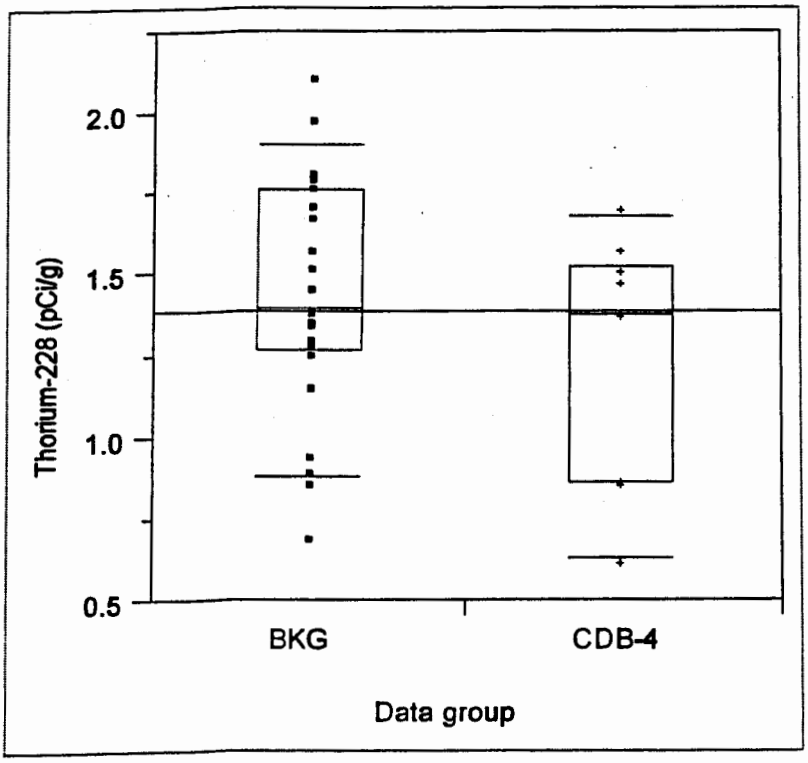

Figure E-2.2-4. Box plot for thorium-228

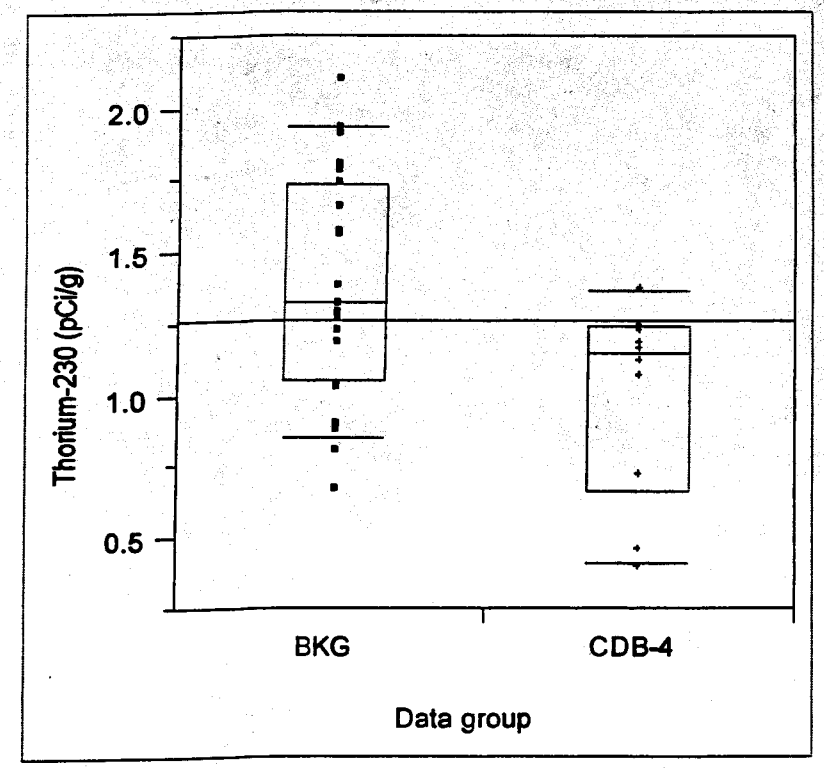

Figure E-2.2-5. Box plot for thorium-230

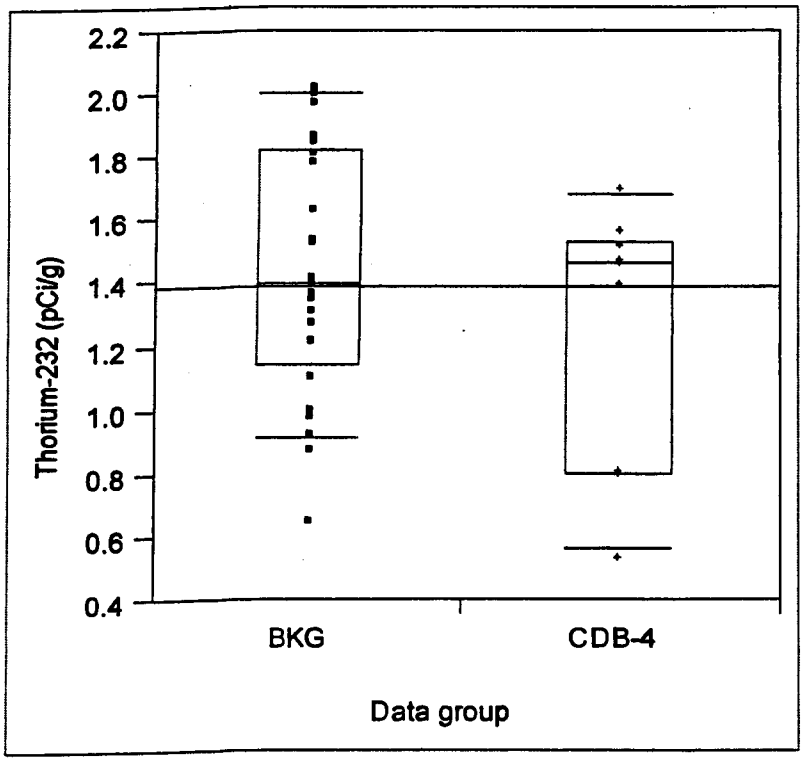

Figure E-2.2-6. Box plot for thorium-232

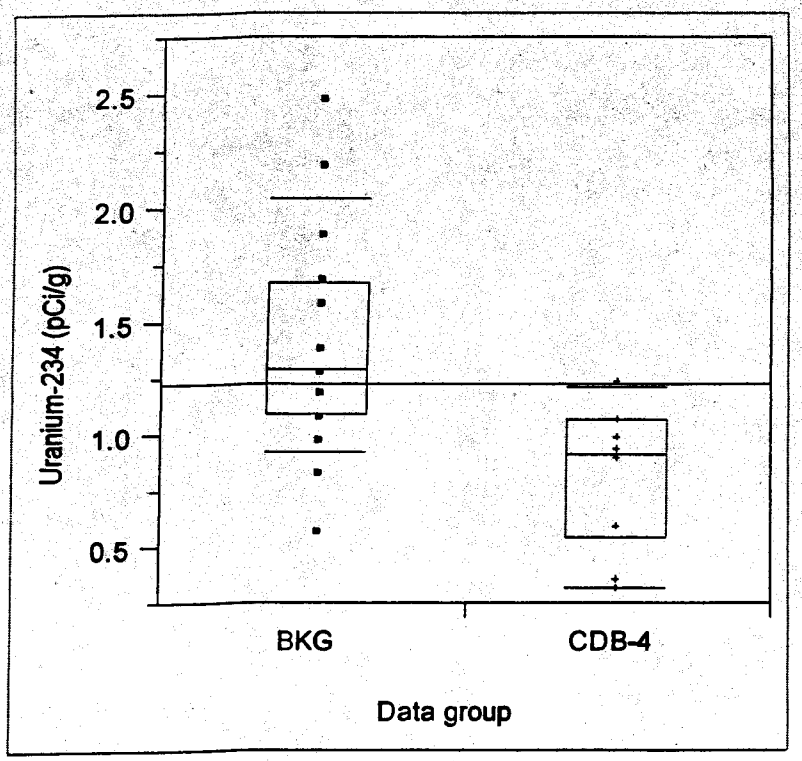

Figure E-2.2-7. Box plot for uranium-234

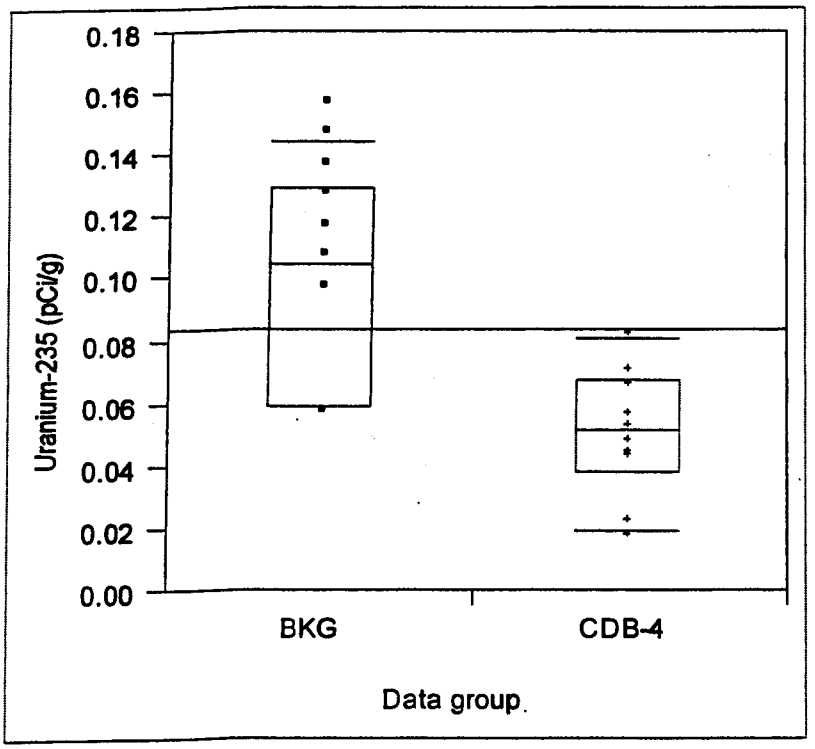

Figure E-2.2-8. Box plot for uranium-235

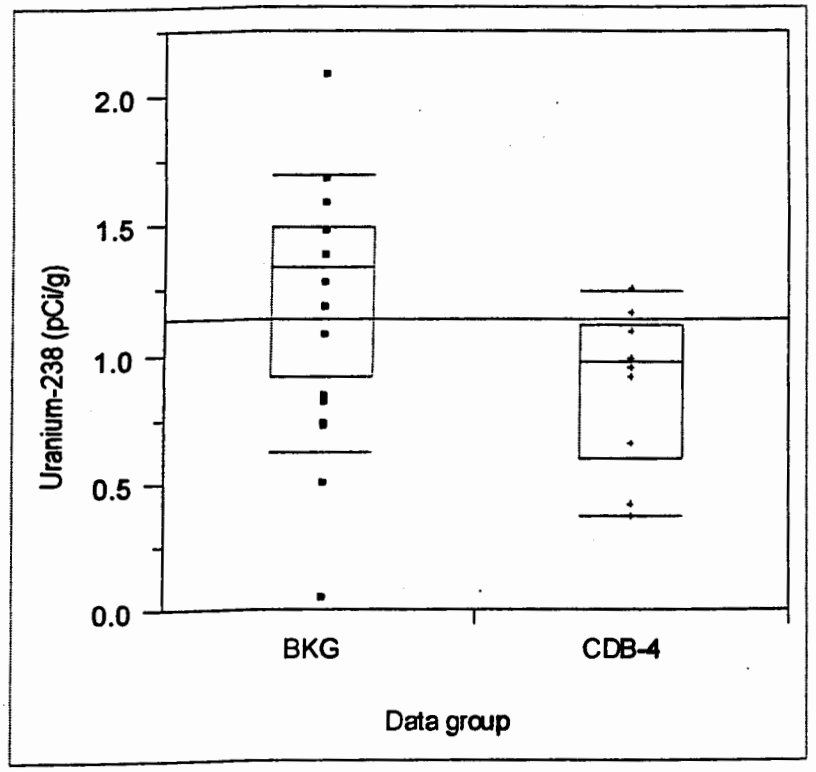

Figure E-2.2-9. Box plot for uranium-238