Work Plan
for
Sandia Canyon
and
Cañada del Buey

Environmental
Restoration
Project

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A Department of Energy
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EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan establishes the technical approach and methodology for environmental investigation of Sandia Canyon and Cañada del Buey at Los Alamos National Laboratory (hereafter "the Laboratory"). This work plan is tiered to the "Core Document for Canyons Investigations" (LANL 1997, 55622) (hereafter "the core document") and references the core document for general background information, technical approach, and risk assessment approach.

Potential release sites (PRSs) on adjacent mesas and on the canyon floor have introduced potential contaminants to the canyons (including organic and inorganic chemicals to Sandia Canyon and inorganic chemicals and radionuclides to Cañada del Buey) during the past 50 years. Current data indicate that contaminants are present in some canyon-floor sediments. Based on the release history of PRSs in the drainage areas, the potential exists for additional areas of contamination to occur in sediments, surface waters, and groundwater in other parts of the canyons. Currently some Laboratory employees work at Technical Area (TA) 72 in Sandia Canyon, and the lower part of the canyon is accessible to recreational users east of TA-72. East of the Laboratory boundary, Sandia Canyon passes through Bandelier National Monument and San Ildefonso Pueblo land before emptying into the Rio Grande. East of the Laboratory boundary, Cañada del Buey passes through residential areas in the town of White Rock and on San Ildefonso Pueblo land before emptying into Mortandad Canyon, which in turn empties into the Rio Grande.

Purpose

The purposes of the investigation are to evaluate the present-day human-health and ecological risks from Laboratory-derived contaminants within the canyon systems and to assess future impacts from the transport of these contaminants. To achieve these goals, the investigation will

- *assess present-day risk to human health and to ecological systems and evaluate the potential for transport of contaminants that could cause human-health and ecological risks in the future;*
- *determine the degree to which the stream channel sediments, active floodplain sediments, and underlying groundwater in Sandia Canyon and Cañada del Buey have been affected by Laboratory releases;*
- *refine the conceptual model for contaminant occurrence, transport, and exposure routes and for contaminant transport pathways and mechanisms specific to the canyon systems (hereafter "the conceptual model") as related to risk evaluation;*
- *assess the potential for interconnections between groundwater in alluvium, intermediate perched zones, and the regional zone of saturation as related to risk evaluation;*
- *provide supplemental characterization of groundwater associated with PRSs located in the main canyons and tributaries; and*
- *recommend possible remedial actions for areas on the canyon floor that are found to have unacceptable present-day human-health or ecological risks.*

This work plan presents a technical approach that will be applied to the investigation of the Sandia Canyon and Cañada del Buey systems that are, or may have been, affected by Laboratory operations. This work plan provides information specific to the Sandia Canyon and Cañada del Buey systems' historical land uses and Laboratory operations, environmental setting, the conceptual models, and a detailed sampling

and analysis plan for investigations. Historical background for general Laboratory operations, the regional environmental setting, general technical approach to the investigation, and the general approach to present-day human-health and ecological risk assessment are discussed in the core document.

Response to Regulatory Requirements

The Laboratory Environmental Restoration (ER) Project addresses the requirements of Module VIII of the Laboratory's Hazardous Waste Facility Permit (the Hazardous and Solid Waste Amendments [HSWA] Module) (modification dated May 19, 1994), which was issued by the US Environmental Protection Agency (EPA) to address corrective actions at the Laboratory (EPA 1990, 1585). The New Mexico Environment Department (NMED) is the administrative authority for the HSWA Module. This work plan addresses and satisfies portions of the requirements in Section I.5, Section Q, Tasks I through V, of the HSWA Module.

Because the Sandia Canyon and Cañada del Buey systems are identified as transport pathways for contaminants migrating across and off the Laboratory rather than as sources of contaminants, a distinction is created between the HSWA Module requirements for investigations of the canyon systems and the HSWA Module requirements for investigations of PRSs. The Sandia Canyon pathway crosses Bandelier National Monument and San Ildefonso Pueblo land and eventually contributes sediments, surface water, and possibly groundwater to the Rio Grande. The Cañada del Buey pathway crosses private land and San Ildefonso Pueblo land and eventually contributes sediments, surface water, and possibly groundwater to Mortandad Canyon, which empties into the Rio Grande. Because the Sandia Canyon and Cañada del Buey systems and the associated transport processes are addressed as the focus of the investigations rather than distinct PRSs, the Sandia Canyon and Cañada del Buey investigations are different from PRS-based investigations in both a regulatory and a scientific perspective.

This work plan deals primarily with the investigation of affected media within the canyon systems rather than the investigation of PRSs, although supplemental characterization of groundwater associated with PRSs is included in the planned investigations. The general technical approach presented in the core document and the sampling and analysis plan in Chapter 7 of this work plan are designed to address the broad requirements contained in the HSWA Module, Sections I.5 and Q, as well as to provide data supporting risk-based decisions for the PRSs.

Conceptual Model and Technical Approach

One of the significant distinctions of the canyons investigations compared with a PRS-based RFI is the responsibility to investigate the canyons as an integrated natural system. This integration is accomplished through a process-oriented conceptual model, which guides the technical approach to the investigations and is refined by the findings of each successive investigation through refinements in models of regional stratigraphy, groundwater and contaminant occurrence and movement, sediment transport, and geochemical interactions.

The investigation area is bounded on the west by the upper portion of each canyon, on the east by the Rio Grande, in the canyon floors laterally from the stream channel to the edge of the modern floodplain deposits, and in the stream channel vertically to the deepest groundwater bodies affected by regulatorially defined limits of contaminant concentrations.

The Sandia Canyon and Cañada del Buey characterization activities, summarized in Chapter 1 and presented in Chapter 7 of this work plan, are designed to collect data to support risk assessment based on present-day contaminant levels and to evaluate the potential future impacts of contaminant transport in *the canyon systems. Systematic characterization of the entire Sandia Canyon and Cañada del Buey systems is impractical because of the large surface area of the canyon floor. Therefore, a process-oriented, iterative approach is planned to determine the nature and extent of contamination in Sandia Canyon and Cañada del Buey. The iterative approach allows the investigators to tailor the characterization requirements to observed conditions in the field. This approach relies on frequent regulatory input and will ultimately lead to a well-defined and quantitative understanding of the natural systems involved in canyon contaminant fate and transport and defensible present-day and future risk assessments within the canyons. These investigations are integral to the overall ER Project strategy to identify major sources of contaminants for the canyon systems and to reduce future contributions from those mesa-top sites that have the largest impact on the canyon systems. This approach is discussed in detail in the core document.*

Sampling and Analysis Strategy

Characterization activities in the Sandia Canyon and Cañada del Buey investigations are presented in detail in Chapter 7 of this work plan and will include two complementary investigation paths. These include

- *geomorphic mapping, sampling, and analysis of surface sediments in selected reaches of the canyon floor to evaluate surface exposure pathways and*
- *sampling and analysis of perennial surface water and groundwater to assess potential water exposure pathways as well as transport pathways and potential impacts on the different zones of saturation.*

Sediment Investigations

Representative sections of the canyon floor, called "canyon reaches," will be investigated in detail to evaluate contaminant concentrations and distributions as a function of proximity to PRSs, depositional environments, sediment grain size, and age of sediment deposits. Contaminant data obtained from adjacent reaches are expected to bound the range of contaminant concentrations in the unsampled canyon areas located between the reaches that will be sampled. The data collected will allow the investigation team to evaluate human and ecological risk within and between the reaches, test hypotheses about processes that control contaminant transport and deposition, and provide a means for testing the investigation approach.

The initial step in characterizing surface sediments is to prepare a geomorphic map that defines the distribution of types of surface sediments. Discrete sampling points are identified using the geomorphic map to ensure that each major geomorphic feature is represented in the sampling plan. Initial sampling campaigns usually consist of biased sampling of appropriate geomorphic units for a broad suite of analytes to identify the contaminants that are present in the canyons. If needed, subsequent sampling is generally limited to contaminants of concern identified during the initial sampling and analysis. Data collected for sediment investigations provide information about contaminant distributions, inventories, collocation of multiple contaminant species, and trends in contaminant concentrations over time.

Sediment sampling is largely restricted to post-1942 canyon deposits in both the active channels and the floodplains. Furthermore, the sampling plan uses information from investigations of mesa-top and canyon floor PRSs (e.g., TA-72 and former TA-20), history of activities at PRSs, and the geomorphic map to (1) focus sampling efforts on areas most likely to contain contaminants, (2) determine the geomorphic *settings where the greatest contaminant inventories could occur (post-1942 sediments), and (3) assess the susceptibility of the contaminants to redistribution by wind and water.*

Five canyon reaches in the Sandia Canyon system and five reaches in the Cañada del Buey system have been selected for initial geomorphic mapping and sediment sampling based on location downgradient from PRSs and TAs where contaminants may have been transported to the canyon systems. If contaminants are identified in specific reaches, additional reaches downstream of the contaminants will be investigated. If contaminants are not identified in any of the initial reaches investigated, no further investigations will be planned in adjacent subreaches. Mesa tops, alluvial and colluvial deposits on canyon walls, and drainages of canyon walls may contain contaminants from individual PRSs. For the most part these sites have been characterized as part of RFIs conducted by other ER Project focus areas.

Groundwater Investigations

The investigations undertaken to characterize the nature, extent, and potential surface water and groundwater transport of contaminants were developed in cooperation with other Laboratory entities also responsible for groundwater protection. These investigations are summarized in the "Hydrogeologic Workplan" (LANL 1998, 59599), which was initially developed for the "Groundwater Protection Management Program Plan" (LANL 1995, 50124).

Groundwater investigations focus on areas most likely to contain contaminants, such as the near-surface alluvial groundwater downgradient of known release sites and areas where Laboratory environmental surveillance data indicate that Laboratory-derived contaminants are present. Intermediate-depth perched groundwater zones and the top of the regional zone of saturation are being characterized (1) as potential water exposure pathways, (2) as transport pathways, and (3) for potential impacts on the different zones of saturation. Wells constructed for characterizing groundwater can be used to enhance current Laboratory groundwater monitoring systems, if necessary. In Sandia Canyon, three alluvial groundwater wells are planned to characterize the alluvial groundwater, and three regional aquifer wells are planned to characterize potential intermediate-depth groundwater and the regional aquifer. In Cañada del Buey, sampling existing alluvial groundwater wells is planned to characterize alluvial or shallow perched groundwater and sampling one regional aquifer well is planned to characterize potential intermediate-depth groundwater and the regional aquifer.

Groundwater investigations follow an iterative approach in which information obtained from each borehole will be evaluated in the context of other relevant groundwater studies and the current conceptual model so that future characterization efforts can be redirected to focus on critical data needs. These ongoing evaluations will be made in collaboration with regulators and other investigators implementing the "Hydrogeologic Workplan" (LANL 1998, 59599) and may lead to changes in the locations and numbers of future boreholes. Changes in the scope of groundwater investigations are negotiated periodically with the administrative authority.

Schedule and Reporting

Annex I of the core document contains a preliminary schedule for conducting the Sandia Canyon and Cañada del Buey investigations. The schedule is subject to change based on future US Department of Energy (DOE) funding.

The Laboratory, DOE, NMED, EPA, and the stakeholders have not produced a final definition of the types and schedule of reports needed to execute the investigations described in this work plan. Because Sandia Canyon and Cañada del Buey contain PRSs that may have impacted alluvial groundwater and *possibly deeper groundwater, investigations planned as part of this work plan may provide supplemental characterization of groundwater associated with certain PRSs if deemed necessary.*

Consistent with the technical approach, the Laboratory will notify NMED if any results indicate the need for stabilization.

Structure of the Work Plan

This work plan contains seven chapters and six appendixes as listed below.

Chapters

Chapter 1 introduces the overall regulatory, operational, and environmental setting and summarizes the planned Sandia Canyon and Cañada del Buey investigations.

Chapter 2 provides the historical background for the archaic and modern land uses within the investigation areas, and discusses possible contaminant sources based on archival data.

Chapter 3 describes the environmental setting for Sandia Canyon and Cañada del Buey and summarizes available environmental data germane to the planned investigation.

Chapter 4 develops the conceptual model for the Sandia Canyon and Cañada del Buey and the implications in shaping the overall investigation efforts.

Chapter 5 refers the reader to the core document, which describes the general technical approach that will be followed during execution of this work plan.

Chapter 6 refers the reader to the core document and current ER Project guidance, which explains the human-health and ecological risk assessment considerations and approach for evaluating the data derived from the investigation. (Details on data collection for the present-day human-health risk assessment and the ecological risk assessment are discussed in Chapter 7.)

Chapter 7 contains the sampling and analysis plans for the initial characterization efforts in Sandia Canyon and Cañada del Buey and describes more fully the implementation of the reach concept for sediment investigations. Surface water and groundwater investigations are described in detail, and elements of the quality assurance project plan for each investigation are included.

Appendixes

Appendix A contains the foldout color maps referenced in the text.

Appendix B lists the PRSs in the Sandia Canyon and Cañada del Buey watersheds and their current status.

Appendix C contains drilling and well completion data for wells and boreholes in Sandia Canyon.

Appendix D contains drilling and well completion data for wells, boreholes, and moisture access tubes in Cañada del Buey.

Appendix E contains the stratigraphic information that was used to construct cross sections.

Appendix F lists the individuals who contributed to this work plan.

References for the Executive Summary

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

LANL (Los Alamos National Laboratory), October 25, 1995. "Groundwater Protection Management Program Plan" (draft), Revision 2.0, Los Alamos, New Mexico. (LANL 1995, ER ID 50124)

LANL (Los Alamos National Laboratory), April 1997. "Core Document for Canyons Investigations," Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), May 22, 1998. "Hydrogeologic Workplan," Los Alamos, New Mexico. (LANL 1998, ER ID 59599)

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List of Acronyms

AEC	Atomic Energy Commission
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
ATP	accelerator production of tritium
BRET	Biological Resources Evaluation Team
BV	background value
CA	composite analysis
CEARP	Comprehensive Environmental Assessment and Response Program
CEDE	committed effective dose equivalent
CMR	Chemistry and Metallurgy Research
CMS	corrective measures study
COPC	chemical of potential concern
CVAA	cold vapor atomic absorption
CWA	Clean Water Act
D&D	decontamination and decommissioning
DI	deionized
DOC	dissolved organic carbon
DOE	US Department of Energy
DU	depleted uranium
EA	environmental assessment
EC	expedited cleanup
EDL	estimated detection limit
EETF	Experimental Engineering Test Facility
EPA	US Environmental Protection Agency
EQL	estimated quantitation limit
ER	environmental restoration
ESH	environment, safety and health
ET	evapotranspiration
ETVAA	electrothermal vapor atomic absorption
FIMAD	Facility for Information Management, Analysis, and Display
FSF	Field Support Facility
FWS	US Department of the Interior, Fish and Wildlife Service
G/MAP	gaseous/mixed air activation products
GPC	gas proportional counter
GTA	ground test accelerator
HE	high explosive
HEPA	high-efficiency particulate air
HSWA	Hazardous and Solid Waste Amendment
IA	interim action

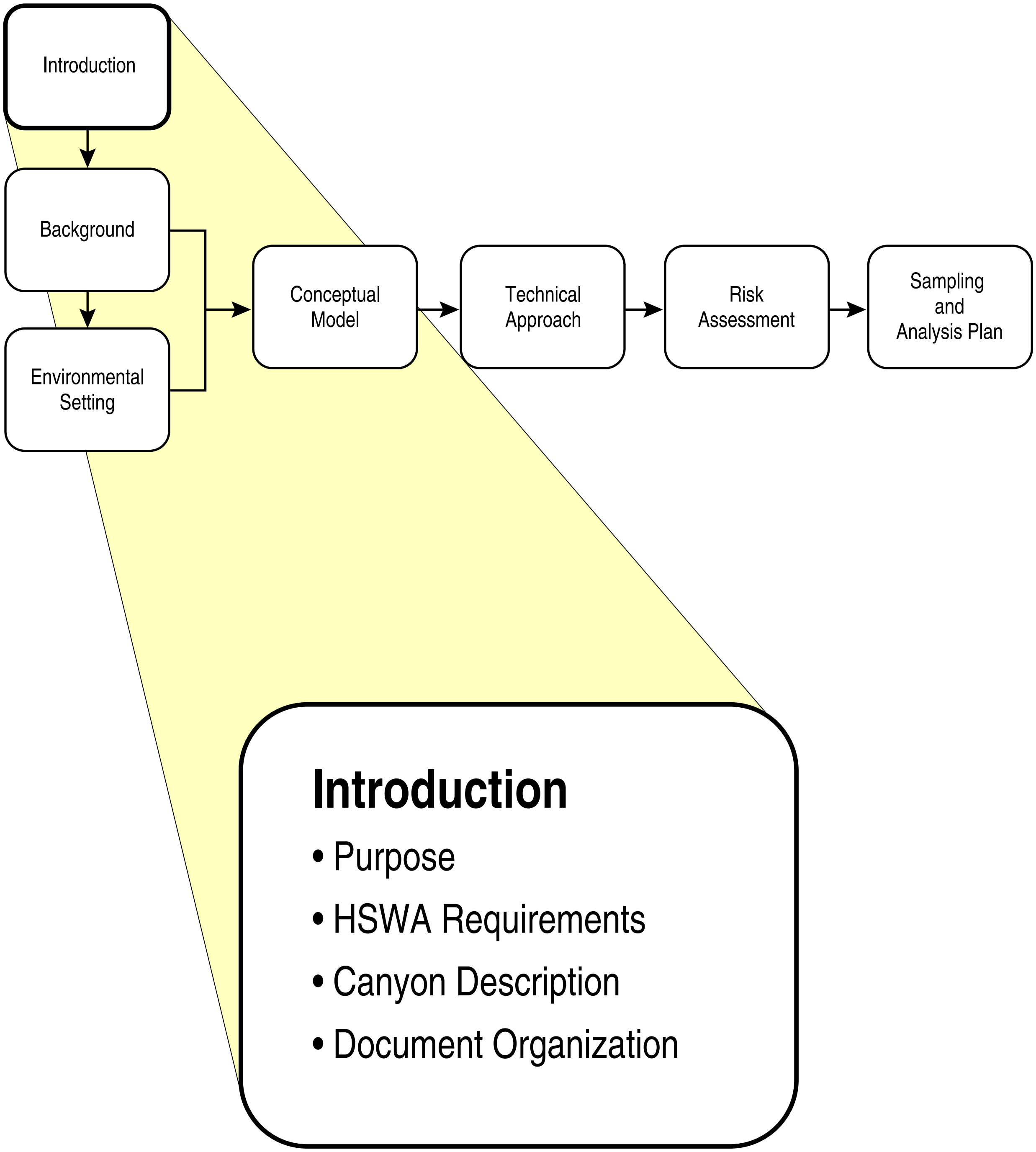
ICPES	inductively coupled plasma emission spectroscopy
ICPMS	inductively coupled plasma mass spectrometry
IDW	investigation-derived waste
LAMPF	Los Alamos Meson Physics Facility
LANSCE	Los Alamos Neutron-Scattering Center
LANSCENET	network of 24 TLD stations
LEDA	low-energy demonstration accelerator
linac	linear accelerator
LSC	liquid scintillation counting
MCL	maximum contaminant level
MDA	material disposal area
NDT	nondestructive testing
NEPA	National Environmental Policy Act
NEWNET	Neighborhood Environmental Watch Network
NFA	no further action
NMED	New Mexico Environment Department
NMEID	New Mexico Environmental Improvement Division
NMWQCC	New Mexico Water Quality Control Commission
NOD	Notice of Deficiency
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
OU	operable unit
PA	performance assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethylene
PEIS	programmatic environmental impact statement
PID	photoionization detector
ppm	parts per million
PRS	potential release site
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation Recovery Act
RECF	risk of excess cancer fatalities
RFI	RCRA facility investigation
RFID	radio frequency identification
ROD	Record of Decision
RSRL	regional statistical reference level
SAL	screening action level

SAP	sampling and analysis plan
SM	South Mesa
SOP	standard operating procedure
START	Strategic Arms Reduction Talks
STP	sewage treatment plant
SVOC	semivolatile organic compound
SWMU	solid waste management unit
SWSC	sanitary wastewater system consolidation
TA	technical area
TCA	trichloroethane
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TLDNET	TLD station
TPH	total petroleum hydrocarbons
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSS	total suspended solids
TWISP	Transuranic Waste Inspectable Storage Project
UHTREX	ultra-high temperature reactor experiment
UST	underground storage tank
UTL	upper tolerance limit
VAP	vaporous activation products
VCA	voluntary corrective action
VOC	volatile organic compound
WIPP	Waste Isolation Pilot Plant
WNR	Weapons Neutron Research Facility
WNR/PSR	Weapons Neutron Research Facility/Proton Storage Ring
WWTP	wastewater treatment plant
XRF	x-ray fluorescence

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)

Chapter 1



Introduction

- Purpose
- HSWA Requirements
- Canyon Description
- Document Organization

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan describes investigations to be conducted in the Sandia Canyon and Cañada del Buey systems as part of the Environmental Restoration (ER) Project at Los Alamos National Laboratory (the Laboratory). These investigations are being conducted by the Canyons Focus Area investigation team. This work plan includes a summary and evaluation of previous hydrogeologic and contaminant studies in the Sandia Canyon and Cañada del Buey systems and a description of new investigations to evaluate present-day human health and ecological risk that have resulted from Laboratory releases to the canyon.

These canyons were selected to be addressed by one work plan in the core document for canyons investigations (LANL 1997, 55622, p. 1-5) because of similarities common to both canyons. Both canyons head in the central part of the Pajarito Plateau near the central part of the Laboratory and neither contains a naturally occurring perennial stream on Laboratory property. Relative to other canyon systems at the Laboratory, these canyons do not contain major quantities of contaminants. Thus, the approach to characterizing these two canyons is expected to be similar.

1.1 Purpose

The purpose of the Sandia Canyon and Cañada del Buey investigations is to evaluate present-day human health and ecological risks from Laboratory-derived contaminants and to assess future impacts from the transport of these contaminants. Specifically, these investigations will

- assess present-day risk to human health and ecological systems and evaluate the potential for transport of contaminants that could cause human health and ecological risks in the future;
- determine the degree to which the stream channel sediments, active floodplain sediments, and underlying groundwater in Sandia Canyon and Cañada del Buey have been affected by Laboratory releases;
- refine the conceptual model for contaminant occurrence, transport, and exposure routes and for contaminant transport pathways and mechanisms specific to the canyon systems (hereafter "the conceptual model") as related to risk evaluation;
- assess the potential for interconnections between groundwater in alluvium, intermediate perched zones, and the regional aquifer as related to risk evaluation;
- provide supplemental characterization of groundwater associated with potential release sites (PRSs) located in the main canyons and tributaries; and
- recommend possible remedial actions for areas on the canyon floor that are found to have unacceptable present-day human health or ecological risks.

The Sandia Canyon and Cañada del Buey investigations will characterize contaminant distributions in surface water of the active stream channels, groundwater beneath the canyon floors, and sediments in those parts of the canyon floors that are affected by Laboratory operations both on-site and potentially off-site. Mesa tops, alluvial and colluvial deposits on canyon walls, and small drainages off canyon walls may contain contaminants from individual PRSs. These sites will be characterized primarily as part of RFIs conducted by other ER Project focus areas. The Canyons Focus Area team will concentrate on contaminants within the active stream channels, adjacent floodplains, and associated surface water and groundwater. Results of field investigations conducted by other focus areas have been included in the planning and implementation of investigations conducted in the Sandia Canyon and Cañada del Buey systems.

1.2 Relationship to Other Documents

This work plan is tiered to the "Core Document for Canyons Investigations" (hereafter "the core document") (LANL 1997, 55622), which provides the general framework for investigations in canyon systems and provides information common to all the investigations. The core document includes a description of the regulatory and programmatic framework for investigations, historical information on area land uses and Laboratory operations, a summary of the regional environmental setting, the generalized conceptual model for the canyon systems, the general technical approach for all canyons investigations, and the present-day human health and ecological risk assessment approach.

This canyon-specific work plan contains only a brief introduction and summary of the planned investigations, a discussion of the canyons' history, summaries of the environmental setting and previous investigations conducted in Sandia Canyon and Cañada del Buey, canyon-specific details on the investigation objectives and technical approach, and a comprehensive sampling and analysis plan. The format of this work plan follows that established by previous canyon-specific work plans and has been authorized by the administrative authority (NMED 1998, 58206).

Table 1.2-1 lists the major RFI tasks and subtasks required in Section Q of Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 1585) and the location in this document and/or the core document (LANL 1997, 55622) where these requirements are addressed.

The groundwater investigations in Sandia Canyon and Cañada del Buey are an integral part of the Laboratory's "Hydrogeologic Workplan" (LANL 1998, 59599), which was developed to implement the "Groundwater Protection Management Program Plan" (LANL 1995, 50124). Groundwater and surface water investigations will follow an iterative approach in which information obtained from each successive borehole, well, and sampling event will be evaluated in the context of the hydrogeological portion of the conceptual model. These ongoing evaluations will be made in collaboration with other investigations implementing the hydrogeologic work plan and may lead to changes in the locations, numbers, and sequence of future sampling events, boreholes, and wells. In accordance with the approach discussed in the hydrogeologic work plan, changes in the scope of groundwater investigations will be negotiated annually with the regulators.

Two sediment reaches and portions of the surface water investigations in upper Sandia Canyon are currently being investigated as part of the sampling and analysis plan (SAP) for Upper Sandia Canyon (LANL 1998, 62340). The upper Sandia Canyon SAP follows the canyons technical approach as outlined in the core document (LANL 1997, 55622) and the results of the investigations will be compatible and fully integrated with the canyon sediment and surface water investigations described in this work plan.

The remainder of this introductory chapter gives a brief physical description of Sandia Canyon and Cañada del Buey and outlines the organization of this work plan.

1.3 Locations and Environmental Settings

The following section describes the Sandia Canyon and Cañada del Buey locations and environmental settings.

Table 1.2-1
Location of Discussions of HSWA[a] Module Requirements

HSWA Module Requirements	Core Document[b]	This Document
RFI Task I: Description of Current Conditions		
Facility Background	Chapters 2 and 3	Chapter 2
Nature and Extent of Contamination	Chapters 2 and 3	Chapter 3
RFI Task II: RFI Workplan		
Data Collection Quality Assurance Plan	Future sampling and analysis plans	Chapter 7
Data Management Plan	Annex III	
Health and Safety Plan	Annex II	
Community Relations Plan	Annex IV	
RFI Task III: Facility Investigation		
Environmental Setting	Chapter 3	Chapter 3
Source Characterization	Chapters 2, 3, 4, and 5	Chapter 2
Contamination Characterization	Chapters 2, 3, 4, and 5	Chapters 2, 3, and 4
Potential Receptor Identification	Chapters 4 and 6	Chapter 7
RFI Task IV: Investigative Analysis		
Data Analysis	Chapters 5 and 6	Chapter 7
Protection Standards	Chapter 6	
RFI Task V: Reports		
Preliminary and Workplan		Entire Document
Progress Draft and Final	Chapter 7 and Annex I	

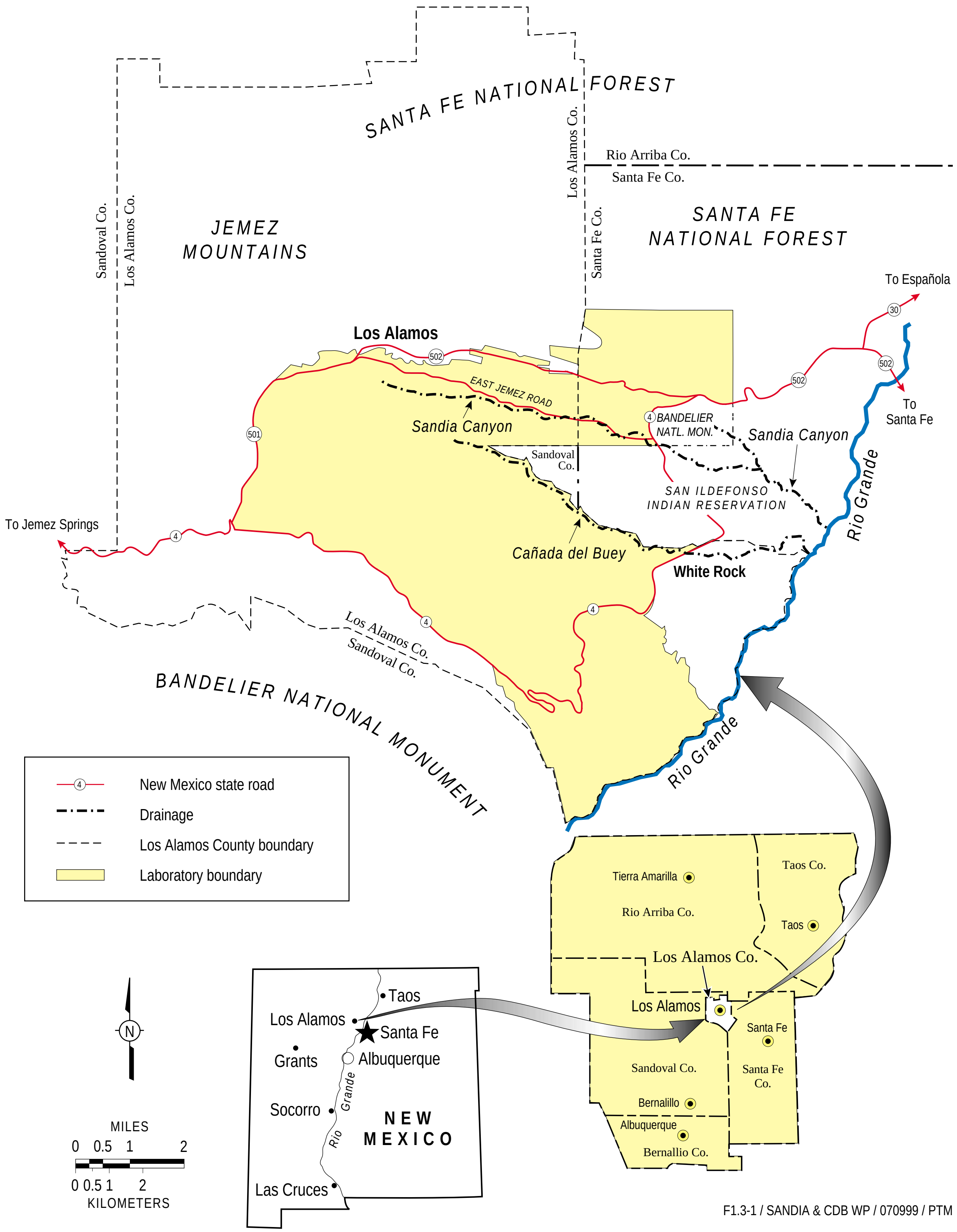
[a] HSWA = Hazardous and Solid Waste Amendments Act.

[b] LANL 1997, 55622.

1.3.1 Sandia Canyon

Sandia Canyon is located on the Pajarito Plateau in the central part of the Laboratory (Figure 1.3.1-1). The canyon heads on Laboratory property within Technical Area (TA)-3 at an elevation of approximately 7300 ft (2190 m) and trends east-southeast across the Laboratory, Bandelier National Park, and San Ildefonso Pueblo land, and empties into the Rio Grande in White Rock Canyon at an elevation of 5450 ft (1635 m). The main channel is approximately 9.4 mi (15 km) long, and the total watershed area is approximately 5.5 mi^2 (14.3 km^2) (LANL 1997, 55622, p. 3-2). Sandia Canyon on Laboratory property extends for a distance of 5.6 mi (9 km) and has a watershed area approximately 2.65 mi^2 (6.9 km^2) (McLin 1992, 12014, p. 19).

PRSs within the Sandia Canyon watershed are located at TAs-3, -60, and -61 (associated with former Operable Unit [OU] 1114); and TAs-53 and -72, and former TA-20 (associated with former OU 1100). Figure A-1 in Appendix A of this work plan shows the locations of the technical areas and PRSs, and Appendix B lists the PRSs and their current status.



F1.3-1 / SANDIA & CDB WP / 070999 / PTM

Figure 1.3.1-1. Location of Sandia Canyon, Cañada del Buey, and selected tributaries.

The Laboratory's primary use of Sandia Canyon has been for liquid waste disposal from industrial and sanitary systems (e.g., Environmental Protection Group 1994, 45363). The canyon also was the location of the brief operation of a small-charge implosion and initiator experiment site in the 1940s, and in recent years has been the location of the Laboratory's security force firing range. Laboratory operations conducted in and adjacent to Sandia Canyon may have possibly discharged to Sandia Canyon and its tributaries since the Laboratory began operation in 1943. Early discharges were associated with outfalls, surface runoff, and firing site activities located at TA-3, which is now the location of the Laboratory administration complex, and former TA-20, which briefly operated in the 1940s as a firing site. Additional discharges began with the continued expansion of Laboratory operations to include accelerator technology research and a firing range in the 1960s, specifically at TAs-53 and -72. Discharges to Sandia Canyon have decreased as many outfalls have either been rendered inactive or rerouted to the Laboratory's Sanitary Wastewater System Consolidation sanitary waste treatment (SWSC) facility at TA-46 during the 1980s and 1990s. Chapter 2 of this work plan contains a more detailed discussion of past and present discharges.

1.3.2 Cañada del Buey

Cañada del Buey is located on the Pajarito Plateau in the central part of the Laboratory (Figure 1.3.1-1). Cañada del Buey is the largest tributary to Mortandad Canyon. The canyon heads on Laboratory property at TA-52 and TA-36 at an elevation of approximately 7200 ft (2195 m) and trends east-southeast across the Laboratory, San Ildefonso Pueblo land, and Los Alamos County and ends at its confluence with Mortandad Canyon at an elevation of 5620 ft (1686 m) approximately 0.5 mi (0.8 km) upstream of the Rio Grande. The main channel is approximately 8.2 mi (13.2 km) long, and the total watershed area is 4.3 mi^2 (11.1 km^2) (LANL 1997, 55622, p. 3-2). On Laboratory property the channel extends for a distance of approximately 5 mi (8 km) and has a watershed area of approximately 2.10 mi^2 (5.4 km^2) (McLin 1992, 12014, p. 19). On Laboratory property, Cañada del Buey has one main tributary, the south fork of Cañada del Buey, and a smaller tributary, referred to as the TA-46 tributary or the SWSC tributary. A larger tributary to Cañada del Buey (the north fork) is entirely on San Ildefonso Pueblo land and joins the main channel in White Rock; no Laboratory activities have occurred within this drainage.

PRSs within the Cañada del Buey watershed are located at TA-52 and former TA-4 (associated with former OU 1129), TA-46 (associated with former OU 1140), TAs-51 and -54 (associated with former OU 1148), and TA-18 (associated with former OU 1093). Figure A-1 in Appendix A of this work plan shows the locations of the technical areas and PRSs, and Appendix B lists the PRSs and their current status.

The primary Laboratory use of Cañada del Buey has been as a buffer zone for surface and subsurface material disposal areas at TA-54 on Mesita del Buey, located just south of the canyon, and to a lesser extent for liquid waste disposal. The earliest discharges were associated with outfalls, surface runoff, and dispersion from firing sites located at former TA-4 (Alpha Site), which is now part of TA-52. Additional discharges began with the expansion of Laboratory operations to new sites from the 1950s through the 1990s, specifically at the following technical areas:

- TA-46, which has housed nuclear propulsion, isotope separation, solar energy experiments, and the Laboratory's sanitary waste treatment facility;
- TA-51, the waste burial technologies laboratory;
- TA-52, which formerly served as the site for reactor experiments; and
- TA-54, the Laboratory's on-site waste treatment, storage, and disposal facility.

Laboratory discharges to Cañada del Buey have decreased because many outfalls have either been rendered inactive or rerouted to the Laboratory's sanitary waste treatment facility at TA-46 during the 1980s and 1990s. Chapter 2 of this work plan contains a more detailed discussion of past and present discharges.

1.4 Summary of the Sandia Canyon and Cañada del Buey Investigations

The following sections summarize the investigations and approaches to problem resolution.

1.4.1 Problem and Approach to Problem Resolution

PRSs on adjacent mesas and on the canyon floors potentially have introduced contaminants to Sandia Canyon and Cañada del Buey during the past 50 years. Current data indicate that contaminants are present in some canyon-floor sediments and in some parts of the alluvial groundwater system. Based on the release history of PRSs in the drainage areas, the potential exists for additional areas of contamination to occur in sediments, surface waters, and groundwater in other parts of the canyons. Currently, a portion of Sandia Canyon is used by Laboratory workers at TA-72, and part of the canyon is accessible for recreational use east of TA-72. East of the Laboratory boundary, Sandia Canyon passes through Bandelier National Monument and San Ildefonso Pueblo lands before emptying into the Rio Grande. East of the Laboratory boundary, Cañada del Buey passes through residential areas in the town of White Rock and San Ildefonso Pueblo land before emptying into Mortandad Canyon near the Rio Grande.

Systematic characterization of the entire Sandia Canyon and Cañada del Buey systems is impractical because of the large surface area of the canyon floors. The main Sandia Canyon channel extends 9.4 mi (15 km) from TA-3 to the Rio Grande. The main Cañada del Buey channel extends 7.4 mi (11.8 km) from TA-52 to its confluence with Mortandad Canyon. Two tributaries, the TA-46 tributary and the south fork of Cañada del Buey, have channel lengths of approximately 0.5 mi (0.8 km) and 2.2 mi (3.5 km), respectively. Therefore, a process-oriented, iterative approach is proposed to determine the nature and extent of contamination in Sandia Canyon and Cañada del Buey. The iterative approach allows the investigators to tune the characterization requirements to observed conditions in the field. This approach relies on frequent regulatory input and ultimately will lead to a well-defined and quantitative understanding of the natural systems involved in canyon contaminant fate and transport and defensible present-day and future risk assessments within the canyons. These investigations are integral to the overall ER Project strategy to identify major sources of contaminants for the canyon systems and to reduce future contributions from those mesa-top sites that have the largest impact on the canyon systems. This approach is discussed in detail in the core document (LANL 1997, 55622), which was approved by the administrative authority (NMED 1998, 58638) and the integrated technical strategy document (LANL 1999, 63491).

Canyons investigations can be conveniently discussed in terms of two complementary investigation paths. These include

- geomorphic mapping, sampling, and analysis of surface sediments in selected reaches of the canyon floor to evaluate surface exposure pathways, and
- sampling and analysis of surface and groundwater to assess potential water exposure pathways as well as transport pathways and potential impacts on the different zones of saturation.

1.4.1.1 Surface Sediment Investigations

Representative sections of the canyon floor, called “canyon reaches,” will be investigated in detail to evaluate contaminant concentrations and distributions as a function of proximity to PRSs, depositional environments, the grain size of sediments, and the age of sediment deposits. Contaminant data obtained from adjacent reaches are expected to bound the range of contaminant concentrations in the unsampled canyon areas located between the sampled reaches. The data collected will allow the investigation team to evaluate human health and ecological risk within and between the reaches, to test hypotheses about processes that control contaminant transport and deposition, and to provide a means for testing the investigation approach.

The initial step in characterizing surface sediments is to prepare a geomorphic map that defines the distribution of types of surface sediments. Discrete sampling points are identified using the geomorphic map to ensure that each major geomorphic feature is represented in the sampling plan. Initial sampling campaigns usually consist of biased sampling of appropriate geomorphic units for a broad suite of analytes to identify the contaminants that are present in the canyon system. If needed, subsequent sampling generally is limited to contaminants of concern identified during the initial sampling and analysis. Data collected for sediment investigations provide information about contaminant distributions, inventories, collocation of multiple contaminant species, and trends in contaminant concentrations over time.

Sediment sampling largely is restricted to post-1942 canyon deposits in both the active channels and the floodplains. Furthermore, the sampling plan uses information from investigations of mesa-top PRSs, history of activities at PRSs, and the geomorphic map to focus sampling efforts on those areas most likely to contain contaminants, to determine the geomorphic settings where the greatest contaminant inventories could occur (post-1942 sediments), and to assess the susceptibility of the contaminants to redistribution by wind and water.

1.4.1.2 Groundwater Investigations

The investigations undertaken to characterize the nature, extent, and potential groundwater transport of contaminants were developed in cooperation with other Laboratory entities also responsible for groundwater protection. These investigations are summarized in the hydrogeologic work plan (LANL 1998, 59599), which initially was developed for the “Groundwater Protection Management Program Plan” (LANL 1995, 50124).

Groundwater investigations focus on areas most likely to contain contaminants, such as the near-surface alluvial groundwater downgradient of known release sites and areas where Laboratory environmental surveillance data indicate that Laboratory-derived contaminants are present. Intermediate-depth perched groundwater zones and the top of the regional aquifer are being characterized (1) as potential water exposure pathways, (2) as transport pathways, and (3) for potential impacts on the different zones of saturation. Wells constructed for characterizing groundwater can be used to enhance current Laboratory groundwater monitoring systems, if necessary.

Groundwater investigations follow an iterative approach in which information obtained from each borehole will be evaluated in the context of other relevant groundwater studies and the current conceptual model so that future characterization efforts can be redirected to focus on critical data needs. These ongoing evaluations will be made in collaboration with regulators and other investigators implementing the hydrogeologic work plan (LANL 1998, 59599) and may lead to changes in the locations and numbers of future boreholes. Changes in the scope of groundwater investigations are negotiated periodically with the regulators.

1.4.2 Decisions

Two primary decisions will be based on the results of the Sandia Canyon and Cañada del Buey investigations.

The first decision deals with present-day risk from contaminants currently distributed in the canyon systems. Is there imminent and substantial endangerment to human health or the environment associated with contaminants in sediments, surface water, or groundwater in any part of Sandia Canyon or Cañada del Buey? If so, work implemented by this plan will identify areas and media in the canyons where corrective measures (for example, removal, stabilization, and institutional control) would reduce present-day risk to an acceptable level. In addition, the data collected will identify PRSs within the canyon drainage areas that continue to have unacceptable impacts on the canyons.

The second decision deals with the future impacts created if natural processes cause remobilization and redistribution of contaminants in the canyon systems. Is there an unacceptable future risk or consequence that results from leaving the current inventory and distribution of contaminants in the canyons? If so, work implemented in this plan will identify areas and media in the canyons where remedial actions could reduce the anticipated future impacts to an acceptable level.

In addition to the primary decisions, data from the Sandia Canyon and Cañada del Buey investigations will support the Hazardous and Solid Waste Amendments (HSWA) Permit requirement to evaluate the hydrogeologic setting, with particular attention to determining whether there are connections between alluvial groundwater, perched intermediate groundwater, and the regional aquifer. The data collected will also satisfy some of the data needs identified in the hydrogeologic work plan (LANL 1998, 59599).

1.4.2.1 Inputs to Decision Making

Information is needed to support risk assessments and the basis for discussion with regulators to determine when characterization of the canyon systems is sufficient. Concentrations of constituents listed in Sections 7.1.2, 7.1.3, 7.1.4, 7.2.2, and 7.2.4 will be estimated in each media. In addition, the process-oriented approach requires that data be gathered to test assumptions and hypotheses about how contaminants are transported through the various media of the canyon system. More specific information about the current conceptual model and data needs are discussed in Chapter 4 of this work plan.

1.4.2.2 Boundaries of the Investigation

This investigation encompasses Sandia Canyon from TA-3 to the Rio Grande, and Cañada del Buey and its tributaries (the TA-46 tributary and the south fork of Cañada del Buey) from TA-52 to its confluence with Mortandad Canyon approximately 0.5 mi (0.8 km) upstream of the Rio Grande. Sediment investigations will extend laterally from the active channel to the toe of the colluvial slope at the base of the canyon walls. Sediment investigations will focus on deposits most likely to be affected by Laboratory operations (i.e., deposits that are post-1942). The vertical extent of Laboratory-derived contaminants is not yet determined, but it is expected to be largely confined to the upper 7 ft to 10 ft (2 m to 3 m) of canyon-floor deposits. Data will be collected within representative reaches in the canyon systems. If appropriate, these data will support decisions (as described below) concerning sediments within intervening unsampled sections of the canyons, as well as each canyon as a whole. The process for selecting and defining reaches is described in the core document (LANL 1997, 55622) and in Chapter 7 of this work plan.

The boundaries of the groundwater investigations generally are similar to those of the sediment investigations with the following exception. The groundwater investigations extend into the upper 100 ft (30 m) of the regional aquifer, the top of which is approximately 800 ft to 1100 ft (245 m to 335 m) below the canyon floor.

The sediment investigations focus primarily on post-1942 sediment and groundwater pathways. Some potential contaminants have relatively short half-lives (for example, the half-life of tritium is 12.3 years), and their concentrations will decrease over time. Other contaminants (for example, metals and isotopic uranium) do not decay significantly over relevant time periods. The time frame for projection of contaminant trends into the future is not yet defined, but data are being gathered to evaluate a range of different time frames.

1.4.2.3 Sandia Canyon and Cañada del Buey Decision Rules

For each of the decisions discussed earlier (that is, imminent present-day risk and potential future risk), risk will be assessed under a set of assumptions and exposure scenarios considered to be reasonable and appropriate by risk managers. The specific rules applied to each risk-based decision are consistent with the general technical approach flow diagram (Figure 5-1) in the core document (LANL 1997, 55622, p. 5-4). The following decision rules will be applied.

What contaminants must be considered to support risk-based decisions?

To establish the chemicals of potential concern (COPCs) for each system, analytical results from each reach in Sandia Canyon and Cañada del Buey will be compared to comparable background values and other relevant standards, according to the most recent methodologies and procedures provided by the ER Project Analysis and Assessment Team. A weight-of-evidence approach will be used to determine COPCs. The weight of evidence will rely heavily on quantitative (statistical and graphical) approaches to evaluate reach data but also will benefit from known PRS sources and sampling of upstream reaches. This latter “process knowledge” evidence may lead to adding or subtracting COPCs identified from the quantitative data review. Constituents identified as COPCs will be carried forward to evaluate present-day human-health and ecological risks.

Are the data adequate to revise the physical process model?

If the major assumptions upon which estimates of contaminant distributions are based are confirmed by the data collected in this investigation, through exploratory data analysis and tests of statistical hypotheses, the investigators will evaluate risk. Otherwise, the investigators will define additional data needs and plan additional data collection efforts to support decision-making. This step is equivalent to the scoping or site conceptual model phase of the screening-level ecological risk assessment.

Are the data adequate to support risk-based decisions?

If the uncertainty in estimated risk values is likely to influence the decision based on the risk assessment, the investigators will consider whether additional data are needed before completing the risk assessment and uncertainty analysis.

Is an unacceptable present-day risk associated with contaminants in specific reaches of Sandia Canyon or Cañada del Buey?

Present-day risk will be evaluated by calculating action levels for present-day use scenarios. The action levels will be calculated in accordance with general US Environmental Protection Agency guidance on development of risk-based preliminary remediation goals (EPA 1991, 58234). If action levels are exceeded, appropriate interim measures, best management practices, or corrective measures may be implemented to mitigate the present-day risk at each specific reach.

Are data sufficient to evaluate the final remedy selection based on both present-day and future risk in the canyons?

Risk assessment to support final remedy selection will consider both present and future land-use scenarios and will incorporate fate and transport calculations for surface and subsurface groundwater pathways and wind resuspension and transport of sediments. Additional data needs will be identified to ensure that necessary and sufficient data are available to project future risk for all potential transport and exposure pathways within an acceptable statistical confidence interval. If data are adequate to estimate an acceptable future risk within an acceptable confidence interval, no further action will be proposed. Estimated future risk will be only one input necessary to provide information for the final remediation decision.

1.5 Organization of this Work Plan

Following this introductory chapter, Chapter 2 provides background information on Sandia Canyon and Cañada del Buey, including a description and history of the areas and the potential sources of contamination. Chapter 3 provides details on the canyon-specific environmental settings. Chapter 4 contains the conceptual model specific to the canyon systems as an expansion in detail of the conceptual model in the core document (LANL 1997, 55622). Chapter 5, the technical approach, incorporates the core document technical approach by reference (LANL 1997, 55622). Chapter 6, the present-day human health and ecological risk assessment approach, also incorporates the core document risk assessment approach by reference. Chapter 7 contains the detailed sampling and analysis plans for addressing the objectives discussed in Section 1.1.

A list of acronyms precedes Chapter 1. Definitions of unfamiliar terms can be found in the installation work plan for the ER Project (LANL 1996, 55574, p. V-1; LANL 1998, 62060, p. 3-1) and in the *Glossary of Geology* (Bates and Jackson 1987, 50287).

1.6 Units of Measurement

The units of measurement used in this document are expressed in both English and metric units, depending on which unit is commonly used in the field being discussed. For example, English units are used in text pertaining to engineering, and metric units are often used in discussions of geology, geochemistry, and hydrology. When information is derived from some other published report, the units are consistent with those used in that report. However, both English and metric units are provided for measurements of length, area, and volume.

References for Chapter 1

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

Bates, R. L., and J. A. Jackson (Eds.), 1987. *Glossary of Geology*, Third Edition, American Geological Institute, Alexandria, Virginia. (Bates and Jackson 1987, ER ID 50287)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

EPA (US Environmental Protection Agency), December 1991. "Risk Assessment Guidance for Superfund: Volume I–Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)," Interim, EPA/540/R-92/003, Publication 9285.7-01B, Office of Emergency and Remedial Response, Washington, DC. (EPA 1991, ER ID 58234)

Environmental Protection Group, July 1994. "Environmental Surveillance at Los Alamos During 1992," Los Alamos National Laboratory Report LA-12764-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1994, ER ID 45363)

LANL (Los Alamos National Laboratory), October 25, 1995. "Groundwater Protection Management Program Plan" (draft), Revision 2.0, Los Alamos, New Mexico. (LANL 1995, ER ID 50124)

LANL (Los Alamos National Laboratory), December 1996. "Installation Work Plan for Environmental Restoration Program," Revision 6, Los Alamos National Laboratory Report LA-UR-96-4629, Los Alamos, New Mexico. (LANL 1996, ER ID 55574)

LANL (Los Alamos National Laboratory), April 1997. "Core Document for Canyons Investigations," Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), March 27, 1998. "Sampling and Analysis Plan for Upper Sandia Canyon," Los Alamos National Laboratory Report LA-UR-98-4893, Los Alamos, New Mexico. (LANL 1998, ER ID 62340)

LANL (Los Alamos National Laboratory), May 22, 1998. “Hydrogeologic Workplan,” Los Alamos, New Mexico. (LANL 1998, ER ID 59599)

LANL (Los Alamos National Laboratory), December 1998. “Installation Work Plan for Environmental Restoration Project,” Revision 7, Los Alamos National Laboratory Report LA-UR-98-4652, Los Alamos, New Mexico. (LANL 1998, ER ID 62060)

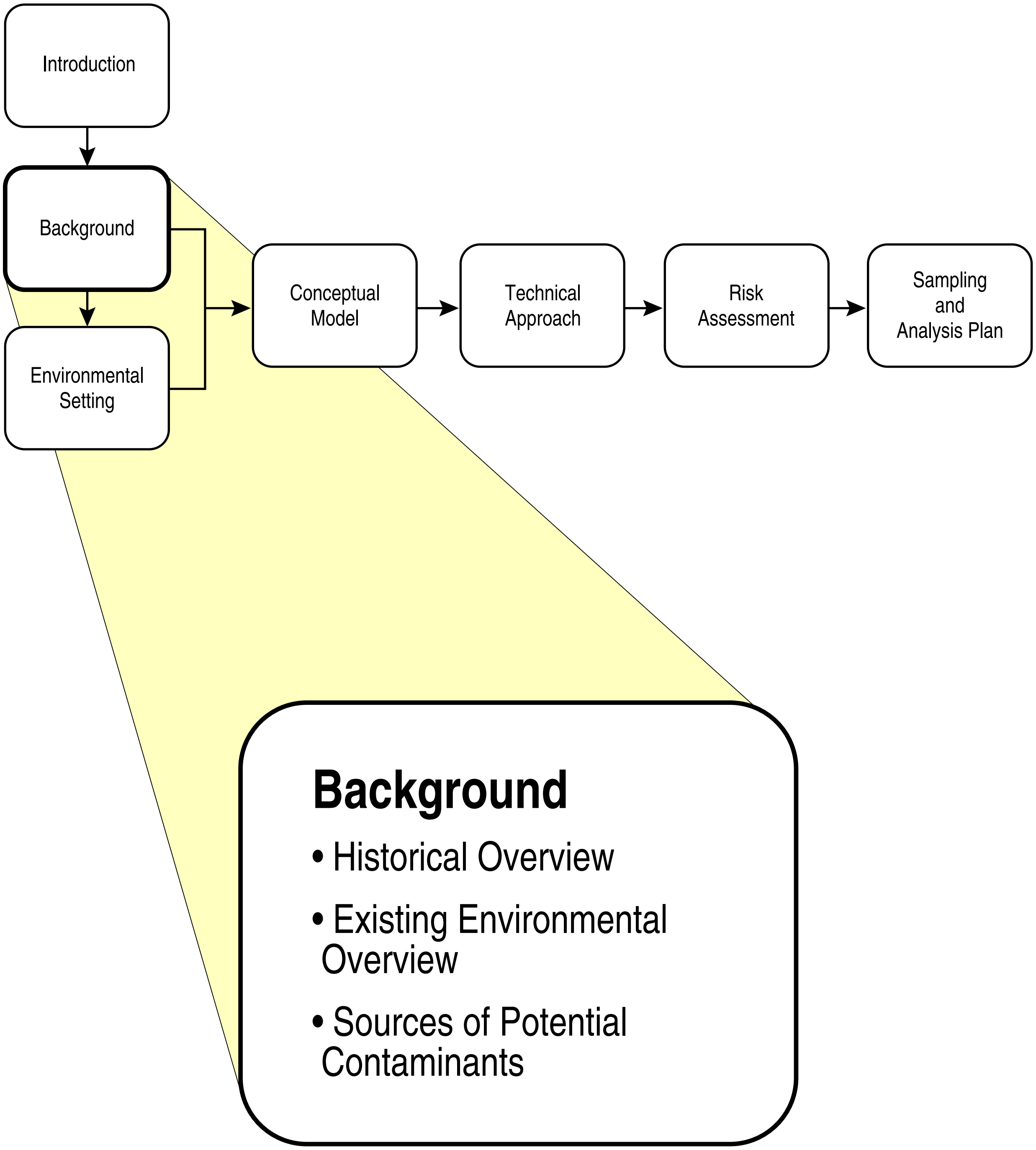
LANL (Los Alamos National Laboratory), 1999, “Integrated Technical Strategy,” Los Alamos National Laboratory Report LA-UR-99-3506, Los Alamos, New Mexico. (LANL 1999, ER ID 63491)

McLin, S. G., August 1992. “Determination of 100-Year Floodplain Elevations at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-12195-MS, Los Alamos, New Mexico. (McLin 1992, ER ID 12014)

NMED (New Mexico Environment Department), March 17, 1998. “Approval of the Canyons Investigation Core Work Plan, Los Alamos National Laboratory, NM0890010515,” Letter to Mr. Theodore Taylor (Project Manager, Los Alamos Area Office, US Department of Energy) and Mr. John Browne (Director, Los Alamos National Laboratory) from Robert S. (“Stu”) Dinwiddie (Manager, RCRA Permits Management Program, Hazardous and Radioactive Materials Bureau), Santa Fe, New Mexico. (NMED 1998, ER ID 58638)

NMED (New Mexico Environment Department), March 27, 1998. “Approval of the Sampling and Analysis Plans, Canyons Investigations, Los Alamos National Laboratory, NM0890010515,” Letter to Mr. Theodore Taylor (Project Manager, Los Alamos Area Office, Department of Energy) and Mr. John Browne (Director, Los Alamos National Laboratory) from Robert S. (“Stu”) Dinwiddie, Manager, RCRA Permits Management Program, Hazardous and Radioactive Materials Bureau), Santa Fe, New Mexico. (NMED 1998, ER ID 58206)

Chapter 2



Background

- Historical Overview
- Existing Environmental Overview
- Sources of Potential Contaminants

2.0 BACKGROUND

Chapter 2 of the “Core Document for Canyons Investigations” (hereafter referred to as “the core document”) (LANL 1997, 55622) discusses the location, prehistoric and historic use, and potential sources of contaminants in the canyons as well as environmental protection and monitoring programs relevant to the canyons. This chapter focuses on San.dia Canyon and Cañada del Buey and their tributaries and discusses the topics in appropriate detail for a canyon-specific work plan.

In this document reference to the “Sandia Canyon watershed” or “Cañada del Buey watershed” comprises the entire drainage area of the canyon and its tributaries, including appropriate portions of mesa tops and canyon walls. Reference to the “Sandia Canyon system” or “Cañada del Buey system” includes only the floor of the canyon and its tributaries, which essentially comprises the flood plain, canyon-floor sediments, stream channel, and associated deposits on the canyon floor. Investigations planned as part of the Sandia Canyon and Cañada del Buey work plan primarily are located within the Sandia Canyon and Cañada del Buey systems.

2.1 History of Sandia Canyon and Cañada del Buey

This section describes prehistoric, pre-Laboratory, and current Laboratory usages, as well as current recreational usage of Sandia Canyon and Cañada del Buey.

2.1.1 Prehistoric Use

Hundreds of American Indian sites from the thirteenth and fourteenth centuries, and possibly earlier, have been found on the Pajarito Plateau. Many are within Sandia Canyon and Cañada del Buey (Steen 1977, 7148). These sites may be identified by ruins, artifacts, pottery, or petroglyphs. The earliest structures on the Pajarito Plateau probably appeared during the late thirteenth century when pueblo Indians first occupied the Pajarito Plateau. These settlements were small farmsteads of from two to ten rooms that were almost always constructed of puddled adobe. These sites typically were occupied for short periods, usually for a generation or less. Nearly all the structures from this period that were surveyed were “cannibalized”; roofing timbers and most of the stone had been removed for reuse at another location (Steen 1977, 7148, pp. 7 and 10). A seven-room structure typical of a farmstead settlement formerly occupied the location of present-day Technical Area (TA) 53 on Mesita de los Alamos. The site was excavated in 1974 before it was destroyed during construction of the Meson Physics Facility (TA-53). The site consisted of a network of low walls approximately 16 in. (40 cm) high, with evidence of fire pits in two rooms; a cairn, midden, pottery shards, tools constructed of stone and bone, and a shell were found within and adjacent to the ruin. Apparently, when they abandoned the site the Indians stripped the building of roofing materials and stones from the walls. The structure was built, occupied, and then dismantled, all probably during the early fourteenth century (Steen 1977, 7148, pp. 54 and 57). Eleven other similar sites were excavated at the TA-53 location before construction of the Meson Physics Facility (Steen 1977, 7148, p. 5). In 1965, another excavation on Mesita de los Alamos revealed a site consisting of two contiguous kivas surrounded by five rooms. This site was accompanied by ceramics, bone tools and beads, and stone artifacts (Steen 1982, 6056, pp. 30 through 33).

Two small close-coil woven baskets of an unusual style were found in a pocket in the tuff at the lower end of Sandia Canyon. The baskets were flat-bottomed with straight, short sides. One bore a simple zigzag pattern. Although these types of baskets were common features of the first century of Puebloan occupation of the Pajarito Plateau, the artifacts found with these baskets included only corrugated pottery sherds and two desiccated corn cobs, which were of little use for dating (Steen 1982, 6056, p. 46).

Cavate rooms are features associated with the late fourteenth century, and are believed to be contemporaneous with the plaza and to some degree the larger sites, such as the Tshirege ruin located on Mesita del Buey. Cavate rooms are thought to have served as storage rooms or ceremonial chambers. Evidence of the degree and type of use varies; many are roughly finished and unsmoked and may have been used for storage, while many are well finished, equipped with niches and firepits, and heavily smoked. One somewhat unusual example of a cavate room is located in Cañada del Buey. The inner cavate room has a large natural opening that gives access to two surface rooms; access to one room is typical (Steen 1977, 7148, pp. 14 through 17). Another example is a small well-preserved cavate room located at the head of Cañada del Buey (Steen 1982, 6056, p. 4). Two cavate-room sites are located on the north side of Sandia Canyon. One consists of 7 cavate rooms and 12 surface rooms and contains outstanding rock art. The other site consists of over 20 cavate rooms and features talus houses three stories high (Steen 1982, 6056, p. 3).

Segments of one of the best-preserved series of trails are located in the Sandia Canyon watershed. A series of trails that extends for more than 150 m (165 yd) is present on the long ridge north of Sandia Canyon. The trail apparently was part of the route from Tsankawi to Mesita de Los Alamos (Steen 1977, 7148, p. 30).

Mesita del Buey contains numerous archaeological sites. One site was excavated in 1957 to accommodate construction of the TA-54 service road. This early ruin consisted of 11 adobe rooms typical of late thirteenth- to fourteenth-century construction. As in other ruins from this period, the roof materials had been removed for use elsewhere (Steen 1982, 6056, p. 16). Other sites were excavated during the late 1970s and early 1980s to accommodate expansion of operations at TA-54 (Steen 1977, 7148, p. 5; Steen 1982, 6056, pp. 9 and 20). Each site typically consists of a double row of rooms with the principal axis running north/south accompanied by pottery and various stone tools. Two projectile points representative of the Archaic Period (4000 B.C. to A.D. 600) were found on the surface of Mesita del Buey near Rex Drive (Steen 1977, 7148, p. 7).

Many archaeological sites in this area are eligible for inclusion on the National Register of Historic Places: 23 are located within Operable Unit (OU) 1100, 17 are located within OU 1114, 1 is located within OU 1129, 14 are located within OU 1140, and 56 are located within OU 1148 (LANL 1994, 34756, p. 3-7; LANL 1993, 51977, p. A-1; LANL 1992, 7666, p. 2-23; LANL 1993, 20952, p. 3-3; LANL 1992, 7669, p. 3-31). Numerous surveys and publications dating from the 1880s describe the wealth of archaeological sites on the Pajarito Plateau. A comprehensive bibliography of archeological publications is available in Mathien et al. (1993, 57520).

2.1.2 Pre-Laboratory and Early Laboratory Historic Use

Much of the Pajarito Plateau was part of the Ramon Vigil land grant, which comprised approximately 32,000 ac (128 km^2) (Foxx and Tierney 1984, 5950, p. 4). During the Spanish Colonial and Territorial periods (A.D. 1600 to A.D. 1900) grazing and seasonal utilization of the plateau by non-Indian groups is highly probable but has not been thoroughly documented. During the Homesteading Period (A.D. 1890 to A.D. 1943) the Pajarito Plateau was used for ranching, farming, and/or timber production. Homestead-era sites are characterized by wooden cabin and corral structures, rock or cement cisterns, and a scattering of debris associated with household, farming, and grazing activities (LANL 1997, 55622, p. 2-5).

In 1911, José Albino Montoya filed for 90 ac (0.36 km^2) of the Ramon Vigil land grant and took up permanent residency. The Montoya Field homestead is located on Sigma Mesa in the heart of Laboratory property. Montoya built several structures on the land, including a log-and-frame house, a cement cistern, a corral, a hen house, a reservoir, and a wire fence (Foxx et al. 1997, 57580, p. 10; Cross 1994, 26071,

p. 17). Portions of the Montoya Field ranging from 5 ac to 25 ac (0.01 km^2 to 0.07 km^2) were farmed for beans, corn, and oats, and the site was ranched with chickens and large livestock (Foxx et al. 1997, 57580, pp. 10 and 35). Other portions of the Ramon Vigil grant were bought in 1914 by Ashley Pond and other executives who hoped to turn the area into a recreational ranch called The Pajarito Club. The venture failed, and subsequently the grant was purchased by Frank Bond and used as a line camp. In 1917, the Brook Ranch, one of the more extensive homesteads in the area and situated on Los Alamos Mesa, was purchased by Ashley Pond, who established the Los Alamos Ranch School (Foxx and Tierney 1984, 5950, p. 4).

In 1942, Dr. J. Robert Oppenheimer and General Leslie R. Groves (commanding officer of the Manhattan Project) decided that the Pajarito Plateau was ideal for the research, design, and assembly of the Manhattan Project, and 54,000 ac (216 km^2) of the Plateau were obtained through condemnation or purchase (Foxx and Tierney, 1984, 5950, p. 5). Condemnation proceedings for the Los Alamos Ranch School began in November 1942; in February 1943 the school closed (LANL 1997, 55622, p. 2-6). At the time the area was condemned for the Manhattan Project, approximately 35 homesteads amounting to 3600 ac (14 km^2) were in private ownership. The Laboratory was established in 1943 as Project Y of the Manhattan Engineer District—the secret World War II effort to develop the world's first nuclear weapons (LANL 1997, 55622, p. 2-6). The Los Alamos Ranch School and Anchor Ranch (present-day TA-8) became technical areas, and 25 other outlying sites were developed. More than 50 mi (80 km) of dirt, gravel, and paved roads were built, and housing areas were constructed to support civilian and army personnel. By 1946, activities and population growth necessitated building power lines and diverting water in Water, Los Alamos, and Guaje Canyons. In the following few years, a natural gas pipeline was constructed across the Jemez Mountains to connect with a pipeline from Farmington, New Mexico (Foxx and Tierney 1984, 5950, p. 4-5). Operations initially located at the ranch school shifted to TA-3 beginning in 1950. The earliest Laboratory activities conducted within the Sandia Canyon and Cañada del Buey watersheds during the 1940s include the following:

- a former firing site at the location of present day TA-3 at the head of Sandia Canyon,
- a testing ground for initiators and implosion experiments at the location of former TA-20 in middle Sandia Canyon, and
- a small-charge firing site at former TA-4, located at the head of Cañada del Buey (LANL 1993, 51977, p. 2-6; LANL 1994, 34756, p. 2-1; LANL 1992, 7666, p. 3-5).

Extensive development of the lower portion of the old Ramon Vigil Grant did not begin until the US Atomic Energy Commission (AEC) developed the town of White Rock as a temporary construction camp in 1950. By 1950, approximately 1500 residents had moved into the area. However, by the mid-1950s the area was abandoned and not used again until 1960. At that time the AEC released land to private development; these developments became known as White Rock and Pajarito Acres. In 1970, an additional 318 ac (1.3 km^2) were developed in the subdivision presently known as La Senda (Foxx and Tierney 1984, 5950, p. 5).

2.1.3 Laboratory Operational Use

The primary Laboratory use of Sandia Canyon has been disposal of liquid waste from industrial and sanitary systems (e.g., Environmental Protection Group 1994, 45363, p. IV-28) The canyon also was the location of a brief operation of a small-charge implosion and initiator experiment site in the 1940s, and in recent years has served as the location of the Laboratory's security force firing range. These operations, conducted in and adjacent to Sandia Canyon, might have discharged to Sandia Canyon and its tributaries since the Laboratory began operation in 1943. These early discharges were associated with outfalls, surface runoff, and firing site activities located at TA-3, which is the current location of the Laboratory administration complex, and former TA-20, which briefly operated in the 1940s as a firing site. Additional discharges began with the continued expansion of Laboratory operations to include accelerator technology research and a firing range in the 1960s, specifically at TAs-53 and -72.

The Laboratory has used Cañada del Buey primarily as a buffer zone for surface and subsurface material disposal areas (MDAs) at TA-54 on Mesita del Buey, just south of the Canyon, and to a lesser extent for liquid waste disposal. The earliest discharges were associated with outfalls, surface runoff, and dispersion from firing sites located at former TA-4 (Alpha Site), which is now part of TA-52. Additional discharges began with the expansion of Laboratory operations to new sites in the 1950s through the 1990s, specifically at the following technical areas:

- TA-46, which housed nuclear propulsion, isotope separation, and solar energy experiments, and the Laboratory's sanitary waste treatment facility;
- TA-51, the waste-burial technologies laboratory;
- TA -52, which formerly served as the site for reactor experiments; and
- TA-54, the Laboratory's on-site waste treatment, storage, and disposal facility.

Environmental Restoration (ER) Project personnel have identified as potential release sites (PRSs) various industrial and sanitary waste outfalls that currently discharge, or have discharged in the past, to Sandia Canyon and Cañada del Buey and associated tributaries. Other major categories of PRSs identified within the Sandia Canyon and Cañada del Buey watersheds include landfills, MDAs, firing sites, surface impoundments, and waste storage areas. The PRSs are documented in the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plans for OUs 1093 (LANL 1993, 15310), 1100 (LANL 1994, 34756), 1114 (LANL 1993, 51977; LANL 1995, 51981), 1129 (LANL 1992, 7666; Pratt 1994, 39932), 1140 (LANL 1993, 20952), and 1148 (LANL 1992, 7669). These PRSs are shown in Figure A-1 in Appendix A and are listed with current status in Appendix B of this work plan; the significant PRSs are discussed further in this chapter.

2.1.4 Current Recreational and Residential Use

The Sandia Canyon watershed encompasses land managed by the Laboratory, land owned by the National Park Service, and land owned by the San Ildefonso Pueblo. East Jemez Road, which connects state road New Mexico (NM) 4 and Diamond Drive, is located in Sandia Canyon. This road provides unrestricted access to motorists, pedestrians, and bicyclists through most of the canyon. The Los Alamos County-municipal landfill is located adjacent to Sandia Canyon near the head of the canyon. A residential mobile home park is located on East Jemez Road east of the Los Alamos County-municipal landfill and north of Sandia Canyon. A private concrete batch plant is located on East Jemez Road north of the landfill and west of the trailer park. Remnants of an old hiking trail extend from TA-3 to approximately south of TA-53. This trail has been terminated south of TA-53 by erosion resulting from down-cutting of the main canyon channel by road building and straightening the channel. The trail may have last been used regularly during the homestead period or during the very early days of Laboratory operation; the trail is not believed to provide present recreational use. West of state road NM4, hiking trails used by the public extend south from East Jemez Road on Laboratory property into Mortandad Canyon. The Tsankawi Ruins, part of Bandelier National Park and located northeast of the intersection of East Jemez Road and state road NM4, are a tourist attraction.

The Cañada del Buey watershed encompasses land managed by the Laboratory, land owned by the San Ildefonso Pueblo and by Los Alamos County, and privately owned land. A portion of the Cañada del Buey watershed located downstream of the Laboratory boundary extends through the residential community of White Rock; this portion of the canyon receives periodic stormwater runoff from Laboratory property. Private properties are located adjacent to the main channel; residents and the public have unrestricted access to the channel. The White Rock sewage treatment plant is located in the Cañada del Buey watershed and discharges treated sanitary waste to lower Cañada del Buey northeast of White Rock. Overlook Park is located at the northeastern extent of the Cañada del Buey watershed and contains a sport complex and recreational facilities for picnickers, hikers, and climbers.

Access to the western portion of Mesita del Buey at TA-54 is restricted; however, Laboratory employees use this area for activities such as walking and jogging. There is no evidence that the general public uses the Cañada del Buey watershed area on Laboratory land for recreational purposes (LANL 1992, 7669).

2.2 Environmental Monitoring and Regulatory Compliance

Chapter 2 of the core document (LANL 1997, 55622) summarizes environmental protection programs and environmental monitoring programs operated by the Laboratory for chemical and radiological quality of surface water, groundwater, and sediments at the Laboratory. Section 2.1 of this work plan summarizes environmental monitoring in Sandia Canyon and Cañada del Buey. Chapter 3 of this work plan discusses the results of the environmental monitoring.

2.2.1 Current and Proposed Environmental Monitoring

Groundwater monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the US Geological Survey to present efforts that include the ER Project, the “Groundwater Protection Management Program Plan” (LANL 1995, 50124), the Watershed Protection Management Program, the Environmental Surveillance Program, the Decommissioning Project, and emergency management and response programs. Other protection efforts include those required by various New Mexico state regulations, the Clean Water Act (CWA), the National Pollutant Discharge Elimination System (NPDES), and the Hazardous and Solid Waste Amendments (HSWA) Module of the RCRA Part B permit. Table 2.2.1-1 summarizes some of the existing environmental monitoring and surveillance programs that are being implemented in Sandia Canyon and Cañada del Buey.

Tables 2.2.1-2 and 2.2.1-3 list the NPDES-permitted outfalls in Sandia Canyon and Cañada del Buey and describe outfalls, locations, and operational status. In recent years, many of the NPDES outfalls have been directed to the TA-46 sanitary waste-consolidation station.

The Laboratory conducts various other surface water and groundwater quality protection programs in compliance with the CWA, the Safe Drinking Water Act, the Oil Pollution Prevention Act, and New Mexico Water Quality Control Commission (NMWQCC) regulations. The programs include the sanitary wastewater system consolidation (SWSC) that provides sanitary wastewater treatment at TA-46; the Stormwater Pollution Prevention Program; the Spill Prevention, Control, and Countermeasures Program; and the Waste Stream Identification and Characterization Program. These programs are thoroughly discussed in Chapter 2 of the core document (LANL 1997, 55622) and in the “Groundwater Protection Management Program Plan” (LANL 1995, 50124).

Table 2.2.1-1
Summary of Laboratory Environmental Programs Related to Sandia Canyon and Cañada del Buey

Environmental Program	Date Implemented	Approved Activity	Regulatory Agency	Comment
RCRA Permit	November 1989	Hazardous waste storage, treatment, and disposal	EPA[a] NMED[b]	Compliance addressed by ESH-19[c] oversight
HSWA Module of RCRA Permit	May 23, 1990 (new requirements effective May 19, 1994)	RCRA corrective actions	EPA NMED	RFI currently ongoing by ER Project
NPDES Program, CWA	September 13, 1978 (current permit January 30, 1990, revised August 1994)	Discharge of industrial and sanitary liquid effluents	EPA NMED	Compliance addressed by ESH-18 oversight
NPDES Stormwater Permit, CWA	General permit August 25, 1993	Stormwater associated with industrial activities	EPA NMED	Compliance addressed by ESH-18 oversight
Groundwater Protection Management Program	January 1996	Groundwater monitoring	NMED	Hydrogeologic Work Plan approved by NMED on March 25, 1998
Watershed Protection Management Program	Pending	DOE orders compliance	DOE	Watershed Management Plan (draft)
Annual Environmental Surveillance	Circa 1970	DOE orders compliance	DOE	Annual surveillance reports

[a] EPA = US Environmental Protection Agency.

[b] NMED = New Mexico Environment Department.

[c] ESH = Environment, Safety and Health.

Two municipal supply wells located in Sandia Canyon (PM-1 and PM-3) provide water level and water quality information on the regional aquifer. The alluvial groundwater wells used for environmental surveillance in Sandia Canyon are listed in Table 2.2.1-4. These two shallow alluvial groundwater wells (SCO-1 and SCO-2), also called observation wells, are checked annually for water but are usually dry. These wells are located in lower Sandia Canyon east of TA-72. Several other wells have been installed in Sandia Canyon for various purposes. These wells are discussed further in Chapter 3 of this work plan, and in Appendix C. Sandia Spring, which is located in lower off-site Sandia Canyon near the confluence with the Rio Grande, also provides groundwater data used for environmental surveillance.

Two municipal supply wells located in or near Cañada del Buey (PM-4 and PM-5) provide water level and water quality information on the regional aquifer. The alluvial groundwater wells used for environmental surveillance in Cañada del Buey are listed in Table 2.2.1-5. These nine shallow alluvial groundwater wells (CDBO-1 through and CDBO-9), also called observation wells, are monitored and/or sampled annually; water has been observed only in CDBO-6 and CDBO-7. These wells are located in the main Cañada del Buey channel along approximately a 2.6 mi (4.2 km) section that extends from northeast of TA-46 to north-northeast of MDA G at TA-54. Several other wells have been installed in Cañada del Buey for various purposes. These wells are discussed further in Chapter 3 of this work plan, and in Appendix D.

Table 2.2.1-2
NPDES Outfalls in Sandia Canyon

NPDES No.	Description	Discharge Location	Active	Discharge Volume	Comment
01A-001	TA-3 power plant outfall	TA-3-22	Yes	300,000 gpd[a]	Outfall also currently handles sanitary reuse effluent discharged from TA-46 SWSC[b]
03A-023	Cooling tower outfall	TA-3-156	No	Infrequent	Deleted 7/11/95
03A-024	Cooling tower outfall	TA-3-187	Yes	5,700 gpd	Seasonal discharge
03A-027	Cooling tower outfall	TA-3-285	Yes	16,000 gpd	Seasonal discharge
03A-047	Cooling tower outfall	TA-53-60	Yes	16,400 gpd	Seasonal discharge
03A-113	Cooling tower outfall	TA-53-293, 1032	Yes	184,728 gpd	Seasonal discharge
03A-114	Cooling tower outfall	TA-53-2	No	Infrequent	Deleted 7/11/95
03A-125	Cooling tower outfall	TA-53-28	No	Infrequent	Deleted 7/20/98
03A-145	Cooling tower outfall	TA-53-6	No	Infrequent	Deleted 1/14/98
03A-146	Cooling tower outfall	TA-53-14	No	Infrequent	Deleted 9/19/97
03A-148	Cooling tower outfall	TA-3-1498, 1807	No	Infrequent	Deleted 9/19/97
03A-184	Cooling tower outfall	TA-53-17	No	Infrequent	Deleted 8/16/95
04A-094	Non-contact cooling water outfall	TA-3-170	No	Infrequent	Deleted 9/19/97
04A-109	Noncontact cooling water outfall	South of TA-3-73	No	Infrequent	Deleted prior to 1994
04A-133	Noncontact cooling water outfall	TA-53-14	No	Infrequent	Deleted prior to 1994
04A-135	Noncontact cooling water outfall	TA-53-18	No	Infrequent	Deleted 8/16/95
04A-140	Noncontact cooling water outfall	TA-3-141	No	Infrequent	Deleted 8/16/95
04A-151	Once-through cooling water outfall	South of TA-3-22	No	Infrequent	Deleted 8/16/95
04A-163	Municipal supply well	PM 1	Yes	400 gpd	Operated by Los Alamos County
04A-165	Municipal supply well	PM 3	Yes	4844 gpd	Operated by Los Alamos County
06A-183	Photo rinse water outfall	TA-3-510	No	Infrequent	Deleted 8/16/95
SSS-01S	Former TA-46 WWTP[c] outfall at TA-3	Southeast of TA-3-22	No	None	Deleted prior to 1994
NM0024210	Former TA-3 WWTP outfall	Southeast of TA-3-22	No	None	Predecessor to SSS-01S

Source: Dale 1998, 62337.

[a] gpd = gallons per day

[b] SWSC = sanitary wastewater system consolidation.

[c] WWTP = wastewater treatment plant.

Table 2.2.1-3
NPDES Outfalls in Cañada del Buey

NPDES No.	Description	Discharge Location	Active	Discharge Volume	Comment
03A-042	Cooling tower outfall	TA-46-1	No	864 gpd[a]	Deleted 3/10/98
03A-043	Cooling tower outfall	TA-46-31	No	144 gpd	Deleted 7/31/96
03A-124	Cooling tower outfall	TA-46-169	No	<144 gpd	Deleted 12/6/95
03A-136	Cooling tower outfall	TA-46-200	No	<144 gpd	Deleted 12/6/95
04A-013	Noncontact cooling water outfall	TA-46-30	No	<144 gpd	Deleted 12/6/95
04A-014	Noncontact cooling water outfall	TA-46-88	No	9936 gpd	Deleted 7/11/95
04A-018	Noncontact cooling water outfall	TA-46-2	No	432 gpd	Deleted 12/6/95
04A-118	Municipal supply well	PM-4	Yes	1700 gpd	Operated by Los Alamos County
SSS-07S	Sanitary wastewater	TA-46	No	1728 gpd	Deleted before 1994
SSS-012S	Sanitary wastewater	TA-46	No	<144 gpd	Deleted before 1994
SSS-013S	Sanitary wastewater	TA-46 SWSC[b]	Yes	None	No discharge to Cañada del Buey; discharge is routed to 01A-001 outfall at TA-3 (see Table 2.2.1-2)

Source: Dale 1998, 62337; Biggs and Cross 1995, 52028, p. 5.

[a] gpd = gallons per day

[b] SWSC = sanitary wastewater system consolidation.

Table 2.2.1-4
Groundwater Monitoring Wells in Sandia Canyon

Well	Date Installed	Ground Elevation (ft)	Depth of Casing (ft)	Screened Interval (ft)	Purpose
SCO-1- old	1966	6620	20	10–20	Alluvial observation-abandoned (SCO-3)
SCO-1	1989	6618.7	19.3	9.3–19.3	Alluvial observation
SCO-2- old	1966	6500	20	10–20	Alluvial observation- abandoned (SCO-4)
SCO-2	1989	6500.7	19.4	8.4–18.4	Alluvial observation
SCOI-3	1996	6499	25	None	Intermediate observation - abandoned
R-12	1998	6500.78	847	800–820	Regional aquifer monitor well
PM-1	1965	6520	2499	945–2479	Municipal supply well
PM-3	1966	6640	2552	956–2532	Municipal supply well

Source: Environmental Protection Group 1994, 45363, p. vii-6.

Table 2.2.1-5
Groundwater Monitoring Wells in Cañada del Buey

Well	Date Installed	Ground Elevation (ft)	Depth of Casing (ft)	Screened Interval (ft)	Purpose
CDBO-1	1985	5757.6	13.1	5.1–13.1	Alluvial observation
CDBO-2	1985	6748.2	17.9	5.9–17.9	Alluvial observation
CDBO-3	1985	6670.2	12.4	2.4–12.4	Alluvial observation
CDBO-4	1985	6564.5	12.1	8.1–12.1	Alluvial observation
CDBO-5	1992	6879.01	17.5	7–17	Alluvial observation
CDBO-6	1992	6817.2	49	34–44	Alluvial observation
CDBO-7	1992	6771.81	44	29–39	Alluvial observation
CDBO-8	1992	6722.47	23	3–13	Alluvial observation
CDBO-9	1992	6633.71	34	19–29	Alluvial observation
PM-4	1981	6920	2920	1260–2854	Municipal supply well
PM-5	1982	7095	3110	1440–3072	Municipal supply well

Source: Environmental Protection Group 1994, 45363, p. vii-26.

Environmental surveillance stations for monitoring and sampling surface water and sediment are listed in Tables 2.2.1-6 and 2.2.1-7. One gaging station, E125, was installed to monitor streamflow in Sandia Canyon, and two gaging stations, E225 and E230, were installed to monitor streamflow in Cañada del Buey. Additional information regarding these gaging stations is presented in Chapter 3 of this work plan. Surface water sampling in Sandia Canyon is conducted at a collection site in the wetland area in upper Sandia Canyon, and at one site just west and one site south of TA-53. Surface water sampling in Cañada del Buey is conducted at one collection site near TA-46, and runoff samples are collected at a site at the intersection of Cañada del Buey and state road NM4. Sediment samples are collected annually in Sandia Canyon from one site located at state road NM4, and one site near the intersection of Sandia Canyon and the Rio Grande. Sediment samples are collected annually in Cañada del Buey from three sites (G-7 through G-9), which are located in a tributary to Cañada del Buey and at the intersections of drainages below Mesita del Buey, and on the floor of Cañada del Buey, and at one site located in Cañada del Buey at state road NM4.

In addition to annual environmental surveillance monitoring, a supplemental environmental surveillance study was initiated in 1993 at MDA G at TA-54, located on Mesita del Buey south of Cañada del Buey. MDA G has been the principal area at the Laboratory for the storage and disposal of low-level and transuranic (TRU) radioactive waste since 1957. The study has focused on the possibility of contaminated sediment moving out of the MDA G perimeter via surface-water runoff. Since 1993 soil and single-stage water samples from the perimeter of MDA G have been analyzed annually for a limited suite of radionuclides and metals. Reports currently are available for the results of surveillance conducted from 1993 through 1995 (Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518). The results of the investigations are summarized in Chapter 3 of this work plan.

Table 2.2.1-6
Routine Environmental Surveillance Monitoring Stations in Sandia Canyon

Station Name	Media	Attribute	Location
E121	Surface water	Flow volume and water quality	Upper Sandia Canyon in north tributary of reach S-1
E122	Surface water	Flow volume and water quality	Upper Sandia Canyon in south tributary of reach S-1
E123	Surface water	Flow volume and water quality	Near eastern margin of the wetland area in upper Sandia Canyon
E124	Surface water	Flow volume and water quality	Middle Sandia Canyon south of TA-53
E125	Surface water	Flow volume and water quality	Lower Sandia Canyon west of Laboratory boundary at state road NM4
SCS-1	Surface water	Quality	Upper Sandia Canyon wetland east of TA-3
SCS-2	Surface water	Quality	Middle Sandia Canyon west of TA-53
SCS-3	Surface water	Quality	Middle Sandia Canyon south of TA-53
Sandia Canyon at state road NM4	Surface water, sediment	Quality	Intersection of Sandia Canyon and state road NM4
Sandia Spring	Groundwater	Discharge and quality	Lower Sandia Canyon approximately 0.5 mi (0.85 km) above point of discharge into the Rio Grande

Table 2.2.1-7
Routine Environmental Surveillance Monitoring Stations in Cañada del Buey

Station	Media	Attribute	Location
E218	Surface water	Flow volume and water quality	Upper Cañada del Buey north of TA-46
E225	Surface water	Flow volume and water quality	Lower Cañada del Buey north of MDA G and approximately 1.85 mi (2.9 km) west of the Laboratory boundary
E230	Surface water	Flow volume and water quality	Lower Cañada del Buey west of state road NM4 at Laboratory boundary
Cañada del Buey	Surface water	Quality	Upper Cañada del Buey north of TA-46
Cañada del Buey at state road NM4	Sediment	Quality	Lower Cañada del Buey west of state road NM4 at Laboratory boundary
Cañada del Buey at White Rock	Runoff	Quality	Lower Cañada del Buey west of state road NM4 at Laboratory boundary
G-SWMS-6	Surface water	Flow volume and water quality	Drainage from Mesita del Buey north of MDA G
G-7 through G-9	Sediment	Quality	Toe and confluence of drainages from Mesita del Buey and in Cañada del Buey north of MDA G

2.2.2 HSWA Module Requirements

Section C of the HSWA Module (EPA 1990, 1585) includes no requirements for special monitoring of the saturated alluvium, unsaturated zone, or surface water in Sandia Canyon or Cañada del Buey beyond that conducted within the current Environmental Surveillance Program by Laboratory group Environment, Safety, and Health (ESH)-18 in accordance with US Department of Energy (DOE) orders. Section C of the HSWA Module includes no requirements for special monitoring of perched zones in Cañada del Buey.

Section C of the HSWA Module requires perched zone monitoring in Sandia Canyon by one monitoring well near PM-1 and one monitoring well near PM-3. Wells that satisfy the Section C requirements are SCO-1 and SCO-2, which were installed in 1989 and are checked annually as part of the Environmental Surveillance Program monitoring activities.

2.3 Sources of Potential Contaminants Within Sandia Canyon

Potential contaminant sources (as PRSs) on the mesa tops and within the Sandia Canyon watershed and their current regulatory status are listed in Appendix B of this work plan. The sequence of technical area descriptions, histories, and discussions of their associated PRSs are presented with respect to their approximate geographic locations from west to east within the Sandia Canyon watershed. The technical areas and PRSs that are discussed in this section are shown in detail on Figure A-1 in Appendix A of this work plan. Technical areas located in the Sandia Canyon watershed that do not contain PRSs within the watershed are not described or included in this section.

The information compiled in this section is based on available reports and data as of circa November 1998. Additional and updated information about the status of PRSs can be obtained from the Laboratory's ER Project Office and/or the Laboratory's Public Reading Room in Los Alamos, New Mexico, as described in Section 7.2.2 of "Installation Work Plan for Environmental Restoration Project" (LANL 1998, 62060, p. 7-3).

2.3.1 Technical Area 3

TA-3, known as South Mesa (SM) Site, is the location of the main administration building and research laboratories at the Laboratory, and occupies a large area located near the western end of South Mesa between Los Alamos Canyon to the north and Twomile Canyon to the south. Sandia and Mortandad Canyons originate within TA-3, dividing the eastern two thirds of South Mesa into finger-like projections. The middle mesa has been named Sigma Mesa (LANL 1993, 51977, p. 2-1).

TA-3 originally was built as a firing site before 1945. It contained several wooden structures that served as an administration building, a shop, hutments, and magazines. The area also contained a burn pit for destroying explosives. The site was decommissioned and cleared in 1949 (LANL 1993, 51977, p. 2-5).

Operational facilities were shifted to TA-3 from the Los Alamos townsite beginning in 1950. Construction during the early 1950s resulted in the Van de Graaff accelerator building (TA-3-18), laboratory (TA-3-16), and support structures; the Communications Building (TA-3-28); the Chemistry and Metallurgy Research Building; the general and chemical warehouses (TA-3-30 and TA-3-31); the cryogenics laboratory (TA-3-33); the Administration Building; the Sigma Building (TA-3-66), a fire house (TA-3-41), and the Physics Building. Construction of new buildings continued through the 1960s and 1970s as office buildings, shops, storage areas, an addition to the wastewater treatment plant (WWTP), a cement batch plant, and numerous transportable structures filled areas between the initial buildings. Construction continued with the Oppenheimer Study Center in 1977, an annex to the Administration Building in 1981, and a computer laboratory and several centers for various scientific activities in the 1990s (LANL 1993, 51977, p. 2-6). The northeastern portion of TA-3, primarily located east of Diamond Drive and north of Eniwetok Road, is located at the head of Sandia Canyon.

PRSs located within the Sandia Canyon watershed at TA-3 have been addressed in the “RFI Work Plan for Operable Unit 1114” (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). The New Mexico Environment Department (NMED) issued a notice of deficiency (NOD) for the work plan and the addendum to the work plan; the NODs and the Laboratory’s responses are presented in the “Notice of Deficiency (NOD) Response for Operable Unit 1114” (LANL 1995, 45976), and the response to the NOD for the RFI work plan for OU 1114, Addendum 1 (LANL 1996, 54088). Most TA-3 PRSs were recommended for no further action (NFA) in the work plan and in the addendum to the work plan. PRSs 3-002(c); 3-003(a and b); 3-013(a and b); 3-014(a through j, p through z, a_2, and b_2); 3-015; 3-033; 3-042; 3-052(f); and 3-053 were investigated and subsequently recommended for NFA in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467). PRSs 3-014(k, l, and o), 3-021, 3-052(b), 3-056(k), and C-3-014 were investigated and subsequently recommended for NFA in the RFI report for PRSs 3-004(c and d), 3-007, 3-014(k, l, and o), 3-021, 3-049(a), 3-052(b), 3-056(k), and C-3-014 (LANL 1997, 56660). PRSs that were the subject of additional investigation, remedial action, or deferred action are summarized below. Investigations at some PRSs are currently in progress.

PRS 3-001(i)—Former Equipment Storage Area

PRS 3-001(i) has been proposed for voluntary corrective action (VCA) as described in the VCA plan for PRS 3-001(i) (LANL 1995, 46198). PRS 3-001(i) consists of two former material and equipment storage areas located near TA-3-70, the roads and grounds office building. Both areas are inactive. Storage area #1 was proposed for NFA in Addendum 1 to “RFI Work Plan for Operable Unit 1114,” (LANL 1995, 51981, p. 5-20-1). Storage area #2, located directly northeast of TA-3-70, measures approximately 50 ft by 150 ft (15 m by 45 m) on level, unpaved ground. It was used by Laboratory support contractors from the early 1970s until approximately 1989 as a staging area for old transformers, roofing compound, tars, and roofing adhesives. Bagged and labeled asbestos materials also were stored in dumpsters before disposal at the Los Alamos County-municipal landfill. There is no staining or documented releases for the area; however workers from the adjacent salvage yard confirm that the salvaged transformers often contained polychlorinated biphenyls (PCBs), and small spills or leaks from the loading and unloading process may have not been documented (LANL 1995, 46198, p. 2).

No sampling had been conducted before the development of the VCA plan. The plan states that the presence and nature of potential contamination at the site would be confirmed using a mobile field laboratory for real-time analyses of PCBs, semivolatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPH). The presence of constituents above their respective screening action levels (SALs) would drive excavation of contaminated soil. The potentially contaminated material associated with this area is expected to be approximately 12 yd^3 (9 m^3) of soil and be restricted to a well-defined area. Upon the removal of contaminated soil, the area would be backfilled and the area reseeded (LANL 1995, 46198, p. 1). VCA activities have not yet been conducted and a schedule for VCA implementation has not been established.

PRS 3-003(n)—One-Time Transformer Spill, and PRS 3-059 – Former Salvage Yard

PRS 3-059 is a former salvage yard and PRS 3-003(n) is a one-time transformer spill from equipment stored in the salvage yard. Both PRSs are located adjacent to TA-3-271. TA-3-271 is now used as a sample-management and core-logging facility, and the location of the adjacent former salvage yard is used as a parking lot and a storage area for empty drums and drilling equipment. Runoff from the surface of the PRSs drains southeast toward Sandia Canyon.

Laboratory support contractors used the salvage yard from the early 1960s through May 1993, when the salvage operation and materials were moved to TA-60-2. The site was used to store transformers, electrical equipment, batteries, and scrap metal. The area comprising PRS 3-003(n) was affected by a spill from a transformer that occurred in 1977; the spill area is located near the northwest corner of TA-3-271. The transformer was labeled as containing between 50 and 500 ppm PCBs. Based on the size of the transformer, the volume of the spill is estimated to be less than 10 gal. (38 L) (LANL 1995, 51981, pp. 5-19-1 through 5-19-3).

In 1993, stormwater runoff samples were collected from two locations downgradient and southeast of PRSs 3-003(n) and 3-059 and analyzed for radionuclides, metals, cyanide, total phenols, volatile organic compounds (VOCs) and SVOCs. A review of the analytical data suggests there were no chemicals of potential concern (COPCs) in the stormwater samples (LANL 1995, 51981, pp. 5-19-3 through 5-19-4). Twelve asphalt and soil samples were collected during late 1984 and early 1995 to determine PCB concentrations for workers at the PRS. No PCB concentrations were detected in any of the samples (LANL 1998, 62340, p. B-8).

The Phase I sampling and analysis plan (SAP) for PRSs 3-003(n) and 3-059 is presented in Addendum 1 to “RFI Work Plan for Operable Unit 1114” (LANL 1995, 51981, pp. 5-19-4 through 5-19-12); however, the samples proposed in the SAP have not been collected (LANL 1998, 62340, p. B-8). The COPCs include PCBs, SVOCs, TPH, and metals.

PRSs 3-012(b) and 3-045(b and c)—Power Plant Outfalls

PRSs 3-012(b) is an outfall that from 1951 to 1985 discharged cooling water originating from treated effluent generated by the TA-3 WWTP. In the past, the water from the WWTP was treated with chromates before being used as cooling water at the power plant, which resulted in the release of hexavalent chromate. The use of chromate in the treatment of water used for cooling at the power plant was discontinued in April 1972 (Purtymun 1975, 11787, p. 115). The NPDES permit number of the outfall is EPA 01A-001, permitted for release of cooling tower water and treated sanitary effluent.

PRS 3-045(b) is the outfall from cooling towers TA-3-25 and TA-3-58, which serve the power plant, TA-3-22. This discharge point is also identified as NPDES outfall EPA 01A-001, and is identical to PRS 3-012(b). Cooling tower TA-3-25 was demolished in 1990 and only the concrete basin remains. Cooling tower TA-3-58 remains in operation. The outfall receives effluent from the neutralization tank, the chlorine building, and cooling tower TA-3-58. The neutralization tank receives blowdown from the boilers and wastewater from the water treatment area. The pH of the wastewater in the neutralization tank is maintained at between 6 and 9 by adding either sulfuric acid or sodium hydroxide, as appropriate, before it is released to the outfall.

Stormwater that collects in the concrete foundation of TA-3-25 also flows to this outfall from leaking pipe valves that previously were connected to the cooling system. A one-time release was discharged to this outfall on May 20, 1990. Low pH values were observed in a 2.5-mi (4-km) section of the watercourse below the outfall. Soda ash was added manually to the entire 2.5-mi (4-km) watercourse, and a May 23, 1990, pH survey detected no pH measurements below 6.9.

PRS 3-045(c) is an outfall that received effluent from cooling tower TA-3-285, which serves the generators powering the Laboratory computer system. PRS 3-045(c) is located approximately 55 ft (16.5 m) east of PRSs 3-012(b) and 3-045(b) and is identified by NPDES permit number EPA 03A-027. Both outfalls discharge to a small tributary of Sandia Canyon south of the power plant and both may have received water that had been treated with chromates.

No previous investigations were conducted at the site before the Phase I RFI investigation; however, effluent at the outfall points is monitored periodically in compliance with the NPDES permits. The monitored parameters include total suspended solids, pH, and total chlorine. Surface water data collected from Environmental Surveillance Program surface water sampling stations SCS-1 and SCS-2 between 1969 and 1972 indicate the presence of hexavalent chromate probably is the result of treatment of the water used in the power plant cooling process (Purtymun 1975, 11787, p. 115).

The Phase I investigation was conducted in July 1994. Five surface samples (0 in. to 6 in. [0 cm to 15 cm] interval) were collected and submitted for analysis of VOCs, SVOCs, organochlorine pesticides and PCBs, herbicides, metals, and radionuclides. The thin veneer of soil adjacent to and within the outfall channel prevented the collection of deeper samples. The volume of three samples was insufficient for analysis of all organics; therefore three additional samples were collected in September 1994 and submitted for analysis of PCBs and herbicides.

Ten chemicals (PCBs; benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; dibenz(a,h)anthracene; indeno(1,2,3-cd)pyrene; chromium; cadmium; lead; and silver) were retained as COPCs by the screening assessment process for PRS 3-012(b) and collocated PRS 3-045(b). Chromium was detected in one sample at a concentration of 2080 mg/kg, which is approximately 10 times its SAL value of 210 mg/kg, and over 100 times its background upper tolerance limit (UTL) value of 19.5 mg/kg. As a result of the Phase I investigation, a Phase II investigation was proposed to determine the extent of contamination. The discussion of the Phase I investigation and the Phase II SAP are presented in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467, pp. 56 through 73). The Phase II investigation has not been conducted and a schedule for the investigation has not been established.

PRS 3-014(c_2)—Wastewater Treatment Plant Pump House Overflow Outfall, and PRSs 3-014(k, l, m, n, and o)—Sludge Drying Beds

PRS 3-014(c_2) is an abandoned overflow outfall (former NPDES permit number NM0024210) associated with the TA-3 WWTP and located north of TA-3-166, the pump building. The WWTP was decommissioned in the autumn of 1992 when the SWSC came on line at TA-46. However, the treated effluent still is routed from the SWSC plant to the TA-3 WWTP outfall because of NPDES permit issues. The overflow outflow pipe discharged as sheet flow onto a steep slope that contains an erosion channel caused by stormwater runoff. The channel eventually trends northeast toward Sandia Canyon. On occasion, soils in the stormwater channel were cleaned out with a backhoe and the removed soil was piled onto the upslope channel bank.

PRS 3-014(c_2) was one of four PRSs sampled to identify any COPCs that might represent contaminants present at all of the PRSs associated with the TA-3 WWTP. Thirty PRSs are associated with the WWTP, which are described in Table 2.3.1-1. Four of these PRSs were sampled because they were believed to be the areas most likely to have received and retained any COPCs associated with the WWTP. PRSs 3-014(a and e) (Imhoff tanks) were selected for sampling because treated sludge was applied directly to the soil in the grassy area around the tanks. PRS 3-014(b_2) was selected because it is a current NPDES-permitted outfall for treated effluent. PRS 3-014(c_2) was selected because it is a storm drain trench and overflow outlet pipe outfall. PRSs 3-014(a and e) and 3-014(b_2) were investigated and subsequently recommended for NFA in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467, pp. 94 and 102).

Table 2.3.1-1
Components of the TA-3 Wastewater Treatment Plant

PRS	Structure	Year Built	Description	Function
3-014(a)	TA-3-49	1951	Imhoff tank	Settling/digestion
3-014(e)	TA-3-192	1965	Imhoff tank	Settling/digestion
3-014(b)	TA-3-48	1951	Dosing siphon	Holding/dispersing
3-014(f)	TA-3-193	1965	Dosing siphon	Holding/dispersing
3-014(c)	TA-3-47	1951	Trickling filter	Microbial digestion
3-014(g)	TA-3-194	1965	Trickling filter	Microbial digestion
3-014(d)	TA-3-46	1951	Secondary clarifier	Settling/clarifying
3-014(h)	TA-3-195	1965	Secondary clarifier	Settling/clarifying
3-014(i)	TA-3-677	1951	Splitter box, comminutor, bar rack	Divert flow, cutter/shredder, filters large debris
3-014(j)	TA-3-166	1957	Effluent pump pit, chlorinator, contact chamber	Final effluent pump, chlorine injector pump, chlorine contact basin
3-014(k)	TA-3-196	1965	Drying bed	Sludge drying
3-014(l)	TA-3-197	1965	Drying bed	Sludge drying
3-014(m)	TA-3-198	1965	Drying bed	Sludge drying
3-014(n)	TA-3-199	1965	Drying bed	Skimmer bed
3-014(o)	TA-3-1871	1987	Drying beds (3)	Sludge drying
3-014(p)	TA-3-265	1966	Sewage lift station	Pump sewage
3-014(q)	TA-3-336	1967	Effluent tank	Holding tank for cooling tower
3-014(r)	TA-3-693	1970s	Sewage pump station	Pump sewage
3-014(s)	TA-3-1639	1970s	Sewage lift station	Pump sewage
3-014(t)	TA-3-1869	1987	Sewage lift station	Pump sewage
3-014(u)	TA-3-1901	1988	Holding tank	Temporary storage
3-014(v)	TA-3-36	1953	Floor drain	Drain to sewer
3-014(w)	TA-3-29	1953	Floor drain	Inactive drain (1991)
3-014(x)	TA-3-66	1959	Floor drain	Drain to sewer
3-014(y)	TA-3-35	1954	Floor drain	Inactive drain (1981)
3-014(z)	TA-3-40	1950s	Floor drain	Inactive drain (1989)
3-014(a_2)	TA-3-316	1969	Floor drain	Drain to sewer
3-014(b_2)	TA-3-166	1988	Permitted outfall	Sanitary outfall
3-014(c_2)	TA-3-166	1985	Abandoned outfall	Sanitary outfall
3-012(b)	TA-3-22	1989	Permitted outfall	Power plant outfall

Source: LANL 1996, 54467, p. 84.

During the Phase I investigation at PRS 3-014(c_2), 18 samples (not including quality assurance/quality control (QA/QC) duplicate samples) were collected from 9 locations. Two samples were collected from a shallow hole at each location, one from the 0-in. to 12-in. (0-cm to 30-cm) interval and one from the 12-in. to 18-in. (30-cm to 46-cm) interval. Samples from the 0-in. to 12-in. (0-cm to 30 cm) interval were submitted for the analysis of SVOCs, organochlorine pesticides, PCBs, herbicides, metals, and radionuclides. Samples from the 12-in. to 18-in. (30-cm to 46-cm) interval were submitted for analysis of cyanide and VOCs.

Seven chemicals (lead, cadmium, chromium, silver, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene) were retained as COPCs by the screening assessment process for PRS 3-014(c_2). As a result of the Phase I investigation, a Phase II investigation was proposed to determine the extent of contamination. The Phase II characterization is planned to include investigation of an additional historical outfall location from PRS 3-014(c_2) that was discovered after the Phase I sampling event, and the WWTP sludge-drying beds [PRSs 3-014(k, l, m, n, and o)], which are located approximately 100 ft (30 m) east of PRS 3-014(c_2). The beds are not lined, and therefore are in direct contact with the underlying soil. One objective of the Phase II investigation was to determine if contaminants identified as a result of the Phase I sampling event were associated with the sludge-drying beds. The discussion of the Phase I investigation and the Phase II SAP are presented in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467, pp. 102 through 121). The Phase II investigation has not been conducted and a schedule for the investigation has not been established.

PRS 3-014(k, l, and o) were investigated in July 1997 and subsequently recommended for NFA in the RFI report for PRSs 3-004(c and d), 3-007, 3-014(k, l, and o), 3-021, 3-049 (a), 3-052(b), 3-056(k), and C-3-014 (LANL 1997, 56660). PRS 3-014(m) was sampled as part of this investigation; however analyses indicate that further action will be necessary at this site. The ER Project plans to include analytical results from the RFI effort for PRS 3-014(m) in a future VCA report (LANL 1997, 56660, p. 60). PRS 3-014(n) was also scheduled for sampling under this RFI; however oil was discovered in the bed. The oil spill was reported to the Laboratory ESH Division. ESH reported the spill to the appropriate Laboratory groups and regulatory agencies. The user group was responsible for sampling and clean up of the PRS. PRS 3-014(n) was remediated in early September 1997. The ER Project plans to include confirmatory sample analytical results in a future RFI report (LANL 1997, 56660, p. 60).

PRS 3-028—Surface Impoundment

PRS 3-028 has been recommended for deferred action as described in “RFI Work Plan for Operable Unit 1114” (LANL 1993, 51977, p. 6-12). PRS 3-028 is an active concrete holding pond located at the northeast corner of the asphalt batch plant at the head of Sandia Canyon. This PRS serves as a settling pond for mineral dust and particulates captured by scrubber water from the asphalt batch plant. The dimensions of the pond are 12 ft by 15 ft by 6 ft (3.6 m by 4.5 m by 1.8 m) deep. Water from the pond is recycled to the scrubber system. Discharge is intermittent and averages about 300 gpd (1140 L/day). The pond is replenished with potable make-up water. The outfall from the pond shares NPDES permit number EPA 04A-109 with PRS 3-045(g). PRS 3-045(g) is an inactive stormwater outfall that was proposed for NFA in Addendum 1 to “RFI Work Plan for Operable Unit 1114” (LANL 1995, 51981, p. 6-25).

The area around the plant and pond is unpaved. In the past, some water from the pond was diverted to wash vehicles and equipment. The wash water discharged to a ditch that led to the edge of Sandia Canyon.

The asphalt batch plant (TA-3-73) associated with PRS 3-028 is active. Water in the pond is no longer dispersed. Deferred characterization has been proposed until the asphalt batch plant is decommissioned (LANL 1993, 51977, p. 6-12).

PRS 3-029—Asphalt Emulsion and Road Construction Debris as Landfill

PRS 3-029 was the subject of a corrective action and subsequently recommended for NFA as described in Addendum 1 to “RFI Work Plan for Operable Unit 1114” (LANL 1995, 51981, pp. 6-23 through 6-25). PRS 3-029 is a 30-ft by 70-ft (9-m by 21-m) inactive landfill located approximately 300 ft (90 m) south of TA-3-271 near the rim of Sandia Canyon. Pits of this type received excess asphalt and clean-out from the asphalt plant and later were covered with sand. This disposal practice continued for some time; similar pits line the edge of Sandia Canyon. When one pit was full, a new pit was constructed. These fills raised and leveled the surface areas at the edge of the mesa.

On November 2, 1990, the New Mexico Environmental Improvement Division (NMEID) issued to the Laboratory a Notice of Violation (NOV) concerning pieces of asphalt and an oily sheen found in the Sandia Canyon watercourse below TA-3-73, the asphalt batch plant. These items meet the definition of refuse and the NMWQCC regulations prohibit disposal of refuse into a watercourse. The pieces of asphalt and oil sheen resulted from disposal of residual asphalt, oil emulsion, and kerosene in the pits as described above (LANL 1995, 51981, p. 6-23).

On November 27, 1990, the Laboratory submitted a corrective action plan to NMEID that subsequently was approved on December 12, 1990. Cleanup of the drainage and outfall and stabilization of the landfill area was initiated in early 1991 and continued through early 1993. The corrective action included removing old pieces of asphalt within the drainage and on the adjacent slope, regrading the entire watercourse and slope to support vegetation, extending the culvert from the storm drain [PRS 3-045(g)] approximately 50 ft (15 m) down the drainage, constructing a concrete berm to prevent additional exposure of asphalt buried in the fill, and seeding and maintaining dense grass cover on all fill slopes and disturbed areas (LANL 1995, 51981, p. 6-24).

On June 12, 1992, the NMED (formerly NMEID) issued a letter to the Laboratory stating that the Laboratory’s corrective action for the cleanup of the asphalt in Sandia Canyon outfall was unsatisfactory. The Laboratory further discussed the general concept for the cleanup, reengineering, and construction of the outfall and downstream area with NMED, and the time schedule to complete the tasks. The tasks were completed in 1993 (LANL 1995, 51981, p. 6-24).

Additionally, water samples were collected from the storm drain and the results indicate that oil, grease, or other compounds typically associated with asphalt plant operations were not present (LANL 1995, 51981, p. 6-24).

On September 18, 1992, a memorandum from David Vackar, Director of the NMED Environmental Protection Division, was sent to the NMED Solid Waste Bureau stating the division’s policy on the use of clean concrete and asphalt for fill. NMED has taken the position that under certain conditions, concrete and asphalt used for fill constitute beneficial reuse of the materials and can be exempted from the definition of a solid waste facility and are not subject to solid waste permitting and operational requirements. Allowing the use of concrete and asphalt for fill purposes appears to be more beneficial than requiring disposal at a landfill (LANL 1995, 51981, p. 6-24).

Because excess asphalt emulsion from road resurfacing operations have been placed in the pits along with other road construction/demolition debris (such as concrete, concrete with rebar, and culvert pieces) and the corrective action required by NMED was completed, this PRS was proposed for NFA. NMED closed out this site on October 20, 1993, with a conditional approval for water monitoring if erosion or tar reappear in the outfall (LANL 1995, 51981, p. 6-25).

PRS 3-035(b)—Underground Storage Tank

PRS 3-035(b) has been recommended for deferred action as described in “RFI Work Plan for Operable Unit 1114” (LANL 1993, 51977, pp. 6-10 through 6-11). PRS 3-035(b) is structure TA-3-1255, an 800-gal. (3040-L) diesel underground storage tank (UST) located near the Central Intrusion Detection Alarm Station (TA-3-440). This tank supplies the emergency electrical generator for the station and has never leaked. At the time of the work plan completion in 1993, the tank was scheduled for replacement under UST guidelines. The tank is regulated and monitored as required under RCRA, Subtitle I. Deferred characterization has been proposed until operations cease at PRS 3-035(b) (LANL 1993, 51977, pp. 6-10 through 6-11).

PRS 3-038(f)—Industrial Waste Line

PRS 3-038(f) has been recommended for deferred action as described in Addendum 1 to “RFI Work Plan for Operable Unit 1114” (LANL 1995, 51981, pp. 6-84 through 6-85). PRS 3-038(f) is an active industrial waste line that connected former transportable structure TA-3-1502 to the new industrial waste line installed in 1984. TA-3-1502 was a transportable used as a hot change house for the radioactive liquid-waste-line-removal project that was conducted at the Laboratory between 1981 and 1986 (Elder et al. 1986, 3089; LANL 1995, 51981, p. 84). The transportable was connected to the old industrial waste line by a manhole, TA-3-278. When the removal project reached the lines that serviced TA-35-1502, new lines were installed to connect the transportable to the new industrial waste line by way of manhole TA-3-759. Manhole TA-3-278 was removed along with the old lines. The industrial-waste-line removal project ended in 1986 and TA-3-1502 was vacated by the workers at that time. In 1987 the transportable was removed; however the lines connecting it to manhole TA-3-759 were left in place. The waste line for transportable office building TA-3-2009 has since been connected to the abandoned waste line of TA-3-1502 and currently is active. Because PRS 3-038(f) remains active, deferred characterization has been proposed until the line is decommissioned (LANL 1995, 51981, p. 6-85).

PRS 3-047(d)—Drum Storage Area

In August and September 1995 a VCA was conducted at PRS 3-047(d) as described in the VCA completion report for PRSs 03-003(p), 03-047(d), and 03-051(c) (LANL 1996, 53780, p. 7-13). PRS 3-047(d) is a former drum-storage area for TA-3-22, the steam plant. The steam plant consisted of an area occupied by a 6-ft by 15-ft (1.8-m by 4.5-m) asphalt pad located adjacent to the east side of TA-3-22. Various materials such as 30-weight motor oil, Stoddard solvent, and waste oil were stored in drums at PRS 3-047(d) from approximately 1954 to 1989. In 1987, a 6-in. (15-cm) asphalt berm was added to the asphalt pad to provide secondary containment. There were no documented spills or releases of product in this area. However, accidental spills may have discharged unknown quantities of drum contents to the environment over time. In 1989, a new location was selected for an upgraded materials storage area. The original drum-storage area asphalt pad was removed and disposed of at the Los Alamos County landfill. The potentially contaminated area is on the eastern edge of the former storage pad. The soils beneath the pad also may be contaminated if these products penetrated the asphalt (LANL 1995, 51981, p. 6-83).

Cleanup activities were guided by three surface screening samples that were analyzed for TPH, VOCs, and polycyclic aromatic hydrocarbons (PAHs), and four subsurface screening samples that were analyzed for VOCs and metals. All screening analyses were performed by mobile chemistry laboratories. Guided by the screening data, a single, square-shaped area measuring approximately 20 ft by 20 ft (6 m by 6 m) was excavated to depths ranging from 4 to 6 in. (10 to 15 cm); approximately 6 yd^3 (4.5 m^3) of soil was removed. Three confirmatory samples were collected and analyzed for PCBs, metals, VOCs, and

SVOCs by SW-846 methods. After the determination that confirmatory sample results met the established cleanup goals, the site was backfilled, compacted, and reseeded with native grasses. PRS 3-047(d) was subsequently recommended for NFA in the VCA completion report (LANL 1996, 53780, p. 7-13).

PRS 3-049(b)—Exhaust Outlet

PRS 3-049(b) is a discharge area, approximately 50 ft by 20 ft (15 m by 6 m) wide, associated with the exhaust outlet from an inactive vacuum pump that served the furnaces in the press building, TA-3-35. The vacuum pump evacuated oil from the furnaces used for experiments in TA-3-35. The vacuum pump exhaust outlet is located 8 ft (2.4 m) above the ground on the south wall of TA-3-35. No oil stains were observed on the exhaust outlet pipe, wall, or ground below the pipe during a 1993 reconnaissance survey. Additionally, a sign on the vacuum pump indicated that the pump contained non-PCB oil. A 10-ft by 8-ft (3-m by 2.4-m) area under the exhaust outlet pipe, described in the solid waste management unit (SWMU) report as stained with oil, is now paved with asphalt (LANL 1990, 7511). This area was paved at approximately the same time that the vacuum pump was deactivated (in the late 1980s). The pavement is graded away from the exhaust outlet, predominantly to the west and southwest. Runoff from this area drains toward low-lying areas and to the southwest. It is assumed that regrading did not alter the preexisting drainage pattern significantly because the stormwater collection system continues to collect runoff as designed (LANL 1995, 51981, p. 5-18-1).

Constructed in 1953, TA-3-35 housed operations to fabricate enriched uranium-loaded graphite and carbide fuel elements. Additionally, enriched uranium (uranium-235) was processed in an area located in the northern portion of the first floor of the building. As a result of the processing operation and the obsolete ventilation/exhaust system, the northern portion of the first floor is contaminated with uranium-235 and does not comply with current ESH requirements. In November 1991, TA-3-35 was declared surplus or inactive due to the lack of funding for facilities, equipment, and security updates. Because of new shop work orders, the press resumed operations in 1995. However, no new operations are taking place in the contaminated area of the building (LANL 1995, 51981, p. 5-18-4).

The Phase I SAP for PRS 3-049(b) is presented in Addendum 1 to “RFI Work Plan for Operable Unit 1114” (LANL 1995, 51981, pp. 5-18-1 through 5-118-8). The COPCs identified in the Phase I SAP include uranium, PCBs, VOCs, TPH, and metals. The Phase I investigation was conducted during the summer of 1997. Based on the results of the Phase I investigation, PRS 3-049(b) is proposed for a Phase II investigation and VCA; a schedule for these activities has not been established.

PRS 3-051(c)—Vacuum Pump Exhaust Area

In August and September 1995 a VCA was conducted at PRS 3-051(c), as described in VCA completion report for PRSs 03-003(p), 03-047(d), and 03-051(c) (LANL 1996, 53780, pp. 14 through 23). PRS 3-051(c) is a vacuum pump exhaust area that served Building TA-3-141. The PRS represents two distinct 3-to-5-ft (0.9-to-1.5-m)-diameter stains of vacuum pump oil and/or exhaust, located on the east site of TA-3-141. Vacuum pump oil may contain contaminants associated with the former vacuum pump processes, including small amounts of heavy metals from equipment wear (LANL 1995, 51981, p. 6-84).

Cleanup activities were guided by surface screening samples that were analyzed for VOCs, PAHs, TPH, and metals by a mobile chemistry laboratory. Guided by the screening data, asphalt and soil were excavated at both stained areas. One area adjacent to the east side of TA-3-141 and north of a concrete pad measured approximately 6 ft by 6 ft (1.8 m by 1.8 m) and was excavated to a depth of 18 in. to 24 in. (46 cm to 61 cm). The second area, at the northeast corner of TA-3-141, measured approximately 10 ft by 15 ft (3 m to 4.5 m) and was excavated to a depth of 12 in. (30 cm). Asphalt and soil were removed from both areas until nonstained soil was reached. Verification samples were collected that indicated the presence of residual thallium at both locations. Excavation was resumed to remove an additional 2 in. to 3 in. (5 cm to 8 cm) from both areas. Two confirmatory samples were collected from each area and analyzed for pesticides, metals, and SVOCs by SW-846 methods. After the determination that confirmatory sample results met the established cleanup goals, the site was backfilled and compacted in preparation for repaving. PRS 3-051(c) subsequently was recommended for NFA in the VCA completion report (LANL 1996, 53780, pp. 14 through 23).

PRS 3-056(c)—Material Storage Area

PRS 3-056(c) was the subject of an expedited cleanup (EC) as described in the "Expedited Cleanup Plan for Solid Waste Management Unit 3-056(c)" (LANL 1995, 47257). PRS 3-056(c) is an inactive storage area located on the north side of a utilities shop, TA-2-223, on Sigma Mesa. PRS 3-056(c) was used as a storage area for electrical equipment, new and used dielectric fluids, and waste solvent from 1967 until it was decommissioned in 1992. Solvents were used to clean electrical equipment; the types of cleaning solvents potentially used and stored at the site included an unknown solvent from 1967 to approximately 1981, and Viking R30® (trichloroethane) from 1981 to 1990. Since 1990, a nonhazardous citrus-based solvent has been used to clean electrical equipment. Transclene® (tetrachloroethylene) may have been stored at the site. Transclene® was used by an electrical equipment maintenance subcontractor to retrofill transformers in the field. Included within the PRS boundary is an area downgradient from the storage area that drains to a tributary of Sandia Canyon. In 1991, approximately 1 ft to 2 ft (0.3 m to 0.6 m) of clean fill was placed on the site and surrounding area to correct drainage patterns (LANL 1995, 47257, p. 3).

In November 1991, five surface (0-in. to-3-in. [0-to-8-cm]) soil samples were collected along the fence north of TA-2-223 as part of an interim action reconnaissance survey before initiation of a slope stabilization project. PCBs were detected at a maximum concentration of 9600 ppm and mercury was detected at a maximum concentration of 0.471 ppm (LANL 1995, 47257, p. 5).

In August 1994, PRS 3-056(c) was sampled as part of the Phase I RFI for OU 1114. The sampling approach was designed to determine the extent of PCB contamination. Information from the "RFI Work Plan for Operable Unit 1114" (LANL 1993, 51977) and results from test kit analyses and the 1991 investigation were used to select 18 sample locations. PCBs were detected at 8 of the 18 sample locations at a maximum concentration of 980 ppm; the highest concentrations occur in surface soils (0-in. to 18-in. [0-cm to 46-cm]-deep intervals) and decrease with depth. Tetrachloroethylene was detected in two samples at intervals of 30 in. to 36 in. (76 to 91 cm) deep at concentrations of 0.044 ppm and 0.009 ppm, which is below its SAL of 1 ppm. Mercury was detected in three samples to a depth of 18 in. (46 cm) at concentrations ranging from 0.2 ppm to 1.7 ppm, which are above its UTL value of 0.1 ppm, yet below its SAL of 24 ppm (LANL. 1995, 47257, p. 7). Consequently, PCBs were retained as the COPC for this PRS.

The EC plan proposed excavation of the PCB-contaminated soil. The expected volume of soil to be excavated was approximately 30 yd^3 (23 m^3). A PCB cleanup level of 25 ppm was proposed for the portion of the area north of TA-3-223 on the mesa top where access is restricted by a fence, which meets the definition of an "other restricted access area" under 40 CFR 761.123. For portions of the PRS located north of the fence on the mesa slope, but still on Laboratory property and designated for continued industrial use, a PCB cleanup level of 10 ppm was proposed, in accordance with requirements for "commercial non-restricted access areas" (LANL 1995, 47257, pp. 9 and 11). EC activities commenced on August 21, 1995 (ERM/Golder 1996, 55746, p. 1).

In August 1995, the US Environmental Protection Agency (EPA) issued an NOD for the EC plan. This NOD indicated that cleanup levels proposed in the plan were not in accordance with the Toxic Substances Control Act (TSCA) EPA Region 6 policy of 1 mg/kg for PCB spills in a drainage area and that the extent of contamination had not been defined at PRS 3-056(c), as summarized in LANL 1995 (52359, p. 1). In December 1995, LANL submitted an EC status report that addressed the NOD (LANL 1995, 52359). The report indicated that characterization performed once EC activities had commenced revealed that the extent of contamination had been underestimated both horizontally and vertically. Contaminants were found both upgradient and downgradient of the PRS; in light of the fact that other PRSs and Laboratory operations known to have managed PCBs are located upgradient of PRS 3-056(c), this widespread contamination was not unexpected. Approximately 770 yd^3 (585 m^3) of material had been excavated and an additional 220 yd^3 (167 m^3) were removed by vacuuming methods. The volume of material removed to a cleanup level of 10 ppm was more than 30 times the original estimate of 30 yd^3 (23 m^3), and the cost approached $1 million. Human health and ecological risk assessments were submitted with the status report.

Wetlands below the site were sampled to directly evaluate the ecological risk and validate the ECOTRAN model results. PCBs were detected in one of four sediment samples collected from the wetlands at a concentration of 3.3 ppm. The results of the human health risk assessment indicated that a cleanup level of 10 ppm is conservatively protective for industrial use of the site (LANL 1995, 52359, pp. 1 through 3).

In March 1996, the EPA issued an NOD for the EC status report, which was summarized in the Laboratory’s response to the NOD (LANL 1996, 54398). The NOD requested clarification of information included in the EC status report (e.g., total depth of excavation, specific Aroclor detected), requested additional information (e.g., groundwater information for the site, stabilization plan, run-on and run-off controls, and a contingency plan), and specifically restated that a PCB cleanup level of 1 ppm remained appropriate. The response to the NOD provided provisions to either clarify or comply with the issues presented in the NOD with the exception of the 1-ppm cleanup level. The NOD response restated that the risk assessments presented in the EC status report, in conjunction with proposed slope stabilization and water monitoring activities, continue to support the proposed PCB cleanup level of 10 ppm (LANL 1996, 54398, p. 1-10).

Soil removal activities as part of the EC were conducted from August 1995 to approximately January 1996. Verification samples indicated that 15 of the 56 verification sample locations contained PCBs at concentrations that ranged from 13 ppm to 63 ppm, which exceed the cleanup level of 10 ppm (LANL 1998, 62340, pp. B-6 through B-7). Interim measures being taken to prevent stormwater flow across the mesa and slopes of the site include installing Curlex® erosion-control blankets and asphalt berms. Measures for final corrective action (further remediating the site to achieve PCB levels below 1 ppm) are pending (LANL 1998, 62340, p. B-6).

Upper Sandia Canyon Investigation

An investigation of upper Sandia Canyon was determined necessary based on the ecological sensitivity of the wetlands and the presence of PCB contaminants at numerous PRSs within the upper portion of the watershed, specifically at PRS 3-056(c), as described in the “Sampling and Analysis Plan for Upper Sandia Canyon” (LANL 1998, 62340). During the remedial action at PRS 3-056(c) (discussed above), the extent of contaminants was observed to be greater than initially suspected. Human health and ecological risk assessments conducted to address residual levels of PCBs and other chemicals at PRS 3-056(c) identified ecological risk as the remedial action decision driver for the site. These risk assessments also identified upper Sandia Canyon as the key location for assessing the potential impacts of residual contaminants.

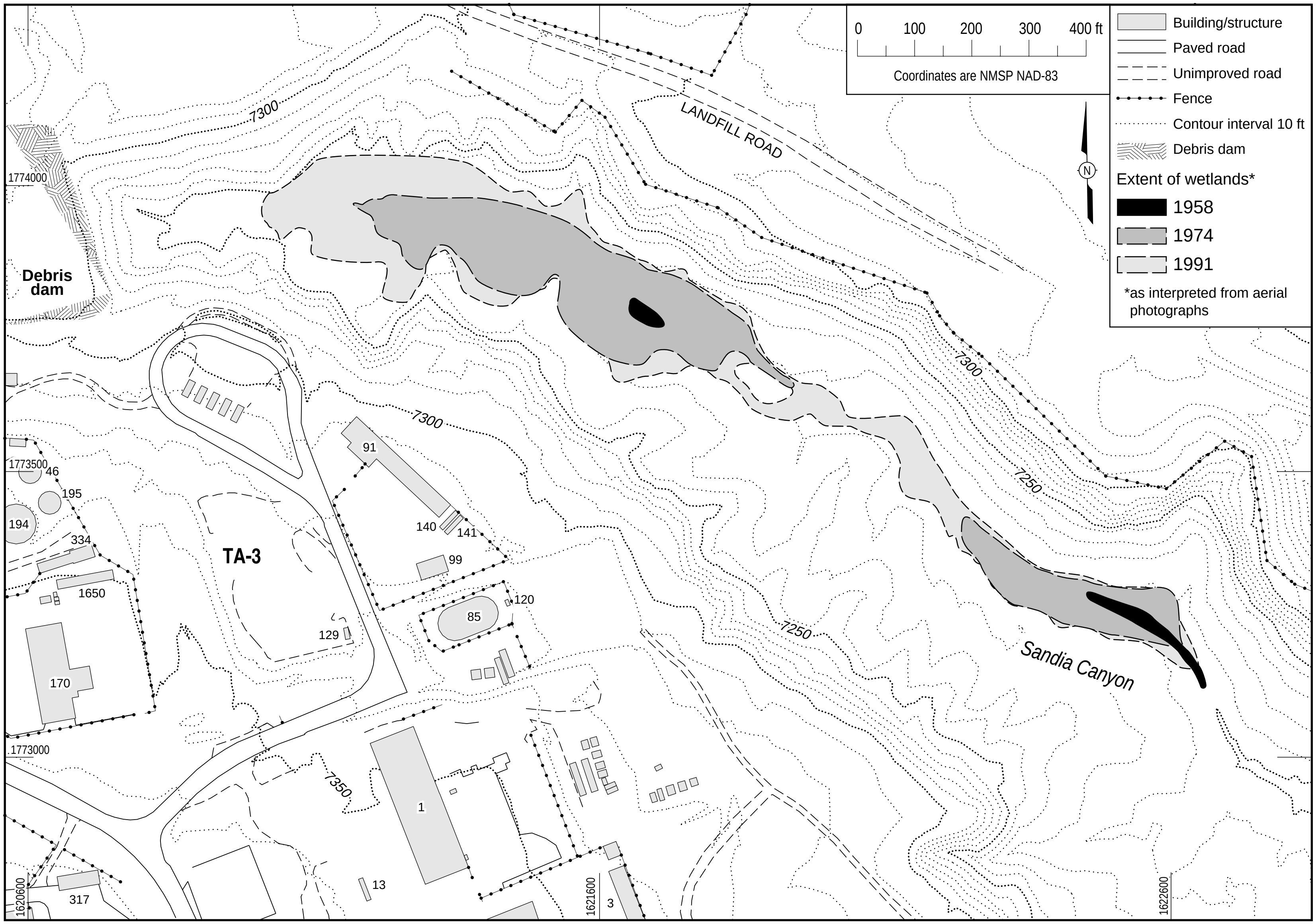
Preliminary sampling of sediments in the wetland and sediments transported in surface water upstream from the wetland indicated detectable quantities of PCBs. Samples from the internal organs and fat tissue of small mammals collected in the wetland also showed detectable quantities of PCBs. In addition to releases documented at PRS 3-056(c), other sites within the upper Sandia Canyon watershed contain known PCB releases. This suggests that other PCB sources in addition to PRS 3-056(c) may have contributed and may still be contributing to the PCB inventory in the Sandia Canyon wetland. The presence and distribution of contaminants other than PCBs is unknown, which necessitated the sampling and analysis proposed in the SAP for upper Sandia Canyon. Characterization of all potential contaminants in the wetland is an appropriate next step to define the nature and extent of contaminants in upper Sandia Canyon (LANL 1998, 62340, p. 1).

Current and former sources of water for Sandia Canyon include the following WWTP outfalls, power plant outfalls, and storm drains (LANL 1998, 62340, p. 11):

- the former rolling mill outfall (PRS 3-015, NPDES permit EPA 04A-140), which received effluent from janitor sinks, floor drains, and roof drains until early 1993 when the outfall was decommissioned;
- the TA-46 sanitary WWTP outfall (PRS 3-014(b_2), which discharges to Sandia Canyon via the former TA-3 sanitary wastewater outfall, NPDES permit EPA SSS-01S);
- the TA-3 storm drain outfall for the Laboratory support contractor shop Building TA-3-38 [PRSs 3-013(a, b)], NPDES permit EPA 03A-023, which receives stormwater from two grated inlets and leads into the head of Sandia Canyon;
- the motor pool drainage area [PRS 60-007(b)], which is a storm drainage ditch located north of the motor pool building (TA-60-1);
- two TA-3-power plant outfalls [PRS 3-012(b), NPDES permit EPA 01A-001; and PRS 3-045(c), NPDES permit EPA 03A-027];
- the former TA-3 WWTP abandoned outfall [PRS 3-014(c_2), NPDES permit NM0024210 from 1975 to 1985]; and
- the asphalted surfaces of TA-3 west of Diamond Drive, from which stormwater drains into the north and south tributaries leading into upper Sandia Canyon.

Expansion of the wetland in upper Sandia Canyon from 1958 to 1991 has been estimated by reviewing a sequence of aerial photographs. Figure 2.3.1-1 presents the chronology of the expansion.

Each point source (PRS) and nonpoint source that historically or currently could be a potential contaminant contributor to the upper Sandia Canyon wetland is listed in Table 2.3.1-2. The sites in Table 2.3.1-2 are potential current or past major or minor sources of contaminants to the wetland.



Source: FIMAD G105718

F2.3.1-1 / SANDIA & CDB WP / 070999 / PTM

Figure 2.3.1-1. Approximate extent of wetlands in Sandia Canyon during 1958, 1974, and 1991.

Table 2.3.1-2
Potential Wetland Contaminant Sources

Major Sources (COPCs exceeding SAL and/or PCBs exceeding 10 ppm)	Minor Sources (COPCs exceeding background but less than SAL and/or PCBs less than 10 ppm)
Current/Active PRSs	
3-012 and 3-045(b): TA-3 power plant outfall	3-014(b_2): WWTP current outfall
3-013(a, b) and 3-052(f): TA-3 storm drain outfall	3-059 and 3-003(n): Former salvage yard
3-014(c_2): TA-3 WWTP storm drain outfall	60-007(b): Motorpool storm drain areas
3-045(c): TA-3 power plant outfall	
Historical/Inactive PRSs	
3-014(a, e): TA-3 WWTP soil contamination	3-002(c): Former pesticide storage shed
3-003(m): TA-3 power plant capacitor banks	3-036(g): TA-3 power plant neutralization tank
3-015 and 3-053: TA-3-144 roof/floor drain outfall	3-045(a): TA-3 power plant outfall, if removed
3-036(j): TA-3 power plant diesel tanks	60-004(f): Motorpool outdoor storage pads
3-056(c): Outdoor transformer storage PCB soil contamination	61-002: TA-61-23 outdoor storage area 3-036(a, c, d, e) and 3-043(a, b, d, f, g, h): TA-3 Asphalt Batch Plant emulsion tanks, removed
Other Potential Contaminant Contributors to the upper Sandia Canyon Wetland	
Nonpoint source stormwater from TA-3 (east of Diamond Drive)	
Sediment loading from the Los Alamos County-municipal landfill, PRS 61-005	

Source: LANL 1998, 62340, p. 12.

Using the data from source PRSs listed in Table 2.3.1-2, a relative toxicity ranking for human health and ecological risk assessment was performed. The analysis suggests that PCBs and carcinogenic PAHs represent the risk drivers for potential human health effects, and that chromium (if hexavalent), arsenic, and PCBs represent the ecological-risk drivers. Because of the known effects of pesticides on birds, pesticides are included on the list of potential ecological-risk drivers. Thus, investigations and sampling upper Sandia Canyon will determine if PCBs, pesticides, PAHs, and metals are present as part of the overall nature and extent characteristics (LANL 1998, 62340, p. 12).

In the “Sampling and Analysis Plan for Upper Sandia Canyon” (LANL 1998, 62340), the portion of upper Sandia Canyon included in the investigation is composed of two primary reaches. Each reach has a distinct physiographic and geomorphic setting consisting of an active channel and buried channel deposits, as well as active and abandoned floodplain surfaces and deposits. The investigation is focused on sediments deposited after Laboratory operations began. Collection of quarterly surface base-flow and event-based stormwater runoff samples from five surface water sampling sites within the upper canyon is also planned (LANL 1998, 62340, pp. 30 through 31).

Field implementation of the upper Sandia Canyon SAP (LANL 1998, 62340) began during the spring of 1998 and is currently in progress. A preliminary report of the results of the investigation is pending. The Upper Sandia Canyon Sap reach investigations follow the Canyons Focus Area’s technical approach for characterization of surface sediments and complement the investigations proposed in this work plan (see Chapter 7).

2.3.2 Technical Area 60

TA-60 was created from a portion of TA-3 when the Laboratory redefined its technical areas in 1989. TA-60 lies east of present-day TA-3 on a finger-like mesa between Sandia Canyon to the north and Mortandad Canyon to the south. The mesa is known as Sigma Mesa; hence TA-60 is referred to as Sigma Mesa Site.

TA-60 contains Laboratory support and maintenance operations and contractor service facilities. The Nevada Test Site (NTS) test fabrication facility; the NTS test tower; several small abandoned experimental areas including a solar pond and a test drill hole; and storage sites for pesticides, topsoil, and recyclable asphalt are located on Sigma Mesa (LANL 1993, 51977, p. 2-3).

The buildings at TA-60 all occupy the western end of Sigma Mesa. The mobile equipment repair shop (TA-60-1) and warehouse (TA-60-2) were built in 1972. These buildings are surrounded by support structures for automotive repair, including a gas station and steam-cleaning facility. The test rack facility was built in 1985 to assemble racks used in underground testing of nuclear devices at the NTS. In the 1970s, a solar pond was built on the eastern end of Sigma Mesa to test the feasibility of reducing the volume of low-level radioactive wastewater from the TA-50 waste treatment facility. The experiment was not successful and the pond was abandoned. In 1979, a geothermal test well was drilled at the eastern end of Sigma Mesa. The site was not suitable for geothermal development and the experiment was terminated. In 1984, a small pesticide storage building (TA-60-29) was assembled just east of the test rack assembly enclosure. Other areas on the mesa were designated as storage sites over the years (LANL 1993, 51977, pp. 2-7 through 2-8).

PRSs located within the Sandia Canyon watershed at TA-60 have been addressed in the “RFI Work Plan for Operable Unit 1114” (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). The NMED issued an NOD for the work plan and the addendum to the work plan; the NODs and the Laboratory’s responses are presented in “Notice of Deficiency (NOD) Response for Operable Unit 1114” (LANL 1995, 45976), and response to the NOD for the RFI work plan for OU 1114, Addendum 1 (LANL 1996, 54088). Most TA-60 PRSs were recommended for NFA in the work plan and in the addendum to the work plan. PRSs 60-004(b, d, e, and f) and 60-007(a and b) were investigated and subsequently recommended for NFA in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467). PRS 60-006(a) was the subject of investigation and subsequent VCA and closure currently is in progress, as summarized below.

PRS 60-006(a)—Test Rack Septic Tank

PRS 60-006(a) is an abandoned septic system that served TA-60-17, the NTS test rack facility, and TA-60-19, a test tower. The system consists of a 1000-gal. (3800-L) septic tank and an associated seepage pit that measures approximately 4 ft by 50 ft (1.2 m by 15 m). The septic system received wastewater from facility bathrooms and seven floor drains, including one in a paint booth. The septic system was constructed in 1986 and was abandoned in place in 1989 when the facility was connected to the sanitary sewer system and the TA-3 WWTP. The contents of the tank were not removed before abandonment.

Because the tank still contained effluent at the time of the Phase I investigation conducted in 1994, the tank was inferred to be structurally sound. The samples collected during the Phase I investigation were liquid sludge rather than soil samples. The contents of the tank represented material that potentially could be released to the environment either through the seepage pit or from the tank if a leak had occurred. Two samples each of the liquid and sludge were collected from one manhole location. The liquid samples were submitted for VOC analysis. The sludge samples were submitted for analysis for SVOCs, PCBs, and metals. The tank atmosphere was monitored continuously throughout the sampling event for the presence of VOCs using a photoionization detector; no VOCs were detected within the tank.

A standard screening assessment was not conducted for these data. There are no appropriate background data for liquid samples, and SALs do not apply to this liquid matrix. The objective of the sampling was to determine if hazardous wastes were present in the septic tank. None of the constituents in the tank constitute a hazardous waste; the sludge and water can be disposed of into the LANL industrial waste system. Therefore, the ER Project plans to remove the contents of the septic tank and close the tank under appropriate state of New Mexico regulations. A VCA plan to implement this closure is proposed, but has not yet been developed. The discussion of the Phase I investigation for PRS 60-006(a) is presented in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467, pp. 181 through 189).

Proposed SWDA at TA-60

A 20-ac (0.08-km^2) site located at TA-60 near the solar pond at the east end of Sigma Mesa was proposed for use as a sanitary waste disposal area (SWDA) for land application of treated sludge generated by the SWSC facility as described by Risberg (1994, 62353). The 20-ac (0.08-km^2) site would be divided into 4 to 5 subplots of approximately 4 ac to 7 ac (0.016 to 0.028 km^2) each. Each subplot would receive one application of approximately 120 yd^3/yr (92 m^3/yr) not more than one time within 3 to 5 years of the project's initiation. The sludge would be applied at a rate limited by the total nitrogen uptake of the native grasses. This low application rate would ensure that the amount of nitrogen in the sludge did not exceed the nitrogen demand of the vegetation. Thus, the sludge would not contaminate runoff with excess nitrogen. One year after final sludge application, all sludge would be consumed. The proposed action anticipates no residual material and the site could be used for other development (Risberg 1994, 62353, pp. 1 through 2). The biological assessment is discussed further in Section 3.4.6 in Chapter 3 of this work plan.

TA-60 Fuel Yard

The TA-60 Fuel Yard is located at the west end of Sigma Mesa and south of the western margin of the wetland area in upper Sandia Canyon. The fuel yard contained five aboveground storage tanks (ASTs) and two transfer stations. The ASTs were categorized as two 25,000-gal. (95,000-L) tanks containing unleaded fuel; one 15,000-gal. (57,000-L) tank containing unleaded fuel; one 25,000-gal. (95,000-L) tank containing diesel fuel; and one 10,000-gal. (38,000-L) tank containing kerosene solvent. The ASTs were gravity-fed by individual underground pipes from transfer area TA-60-1A, located on the south side of the site. The fuel was then gravity fed from the tanks to transfer area TA-60-1B location on the north side of the site. From transfer area TA-60-1B, the fuel was loaded into tanker trucks for delivery to various locations around the Laboratory. The tanks and the north transfer area were located within an earthen and asphaltic containment berm with a containment capacity of 440,000 gal. (1,672,000 L). The containment berm drains into Sandia Canyon by way of stormwater drop inlets, piping, and valves. The south transfer area is located on top of the earthen berm and any fuel spill would flow into a stormwater drainage channel approximately 45 ft (13.5 m) away (Santa Fe Engineering 1995, 63493, pp. 2-1 and 4-2).

Spills at the fuel farm were reported on two occasions. On August 2, 1991, a release of an unspecified volume of a combination of kerosene, unleaded gasoline, and diesel fuel was discovered at the fuel loading station at the south side of the site. Four soil samples were collected in August 1991 but were inadequate to determine the extent of petroleum contamination. Ten additional soil samples were collected in August 1992 and analyzed for TPH and VOCs. It was determined from this sampling event that the depth of contamination was less than 13 ft (4 m) below land surface and the lateral extent of contamination was less than 33 ft (10 m) in all directions from the fuel loading station (Santa Fe Engineering 1995, 63493, p. 3-2).

On July 14, 1993, a spill of an unspecified volume of gasoline occurred while a fuel truck was being filled at transfer station TA-60-1B. The release was noticed during a routine surveillance check; approximately less than 5 gallons of product was discovered floating on a small pool of stormwater accumulated in the containment area. Sorbent materials were placed onto the spill area (Santa Fe Engineering 1995, 63493, pp. 3-2 through 3-3).

The five ASTs and associated underground pipes were considered underground storage tanks (USTs) according to 40 CFR, Part 280, Subpart A, and addressed under the Laboratory's UST program administered by ESH-19 (Santa Fe Engineering 1995, 63493 p. 2-1). The ASTs and transfer stations are not identified as PRSs and have not been the subject of the RFI at TA-60. The structures associated with the fuel farm were removed in 1997.

2.3.3 Technical Area 61

TA-61 was created from a portion of TA-3 when the Laboratory redefined its technical areas in 1989. The area contains the Los Alamos County-municipal landfill, a residential trailer park, a private concrete batch plant, and a Laboratory-operated asphalt batch plant. The landfill, established in 1974, dominates the site. Large trenches and disposal areas have been excavated from the north wall of Sandia Canyon to accommodate the landfill. TA-61 is bounded on the north by Los Alamos Canyon and on the south by Sandia Canyon, which is approximately 400 ft (120 m) wide and 40 to 140 ft (12 to 42 m) deep at TA-61 (LANL 1993, 51977, pp. 2-4 and 2-8).

PRSs located within the Sandia Canyon watershed at TA-61 have been addressed in "RFI Work Plan for Operable Unit 1114" (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). The NMED issued an NOD for the work plan and the addendum to the work plan; the NOD and the Laboratory's responses are presented in the NOD response for OU 1114 (LANL 1995, 45976), and the response to the NOD for the addendum to the OU 1114 RFI work plan (LANL 1996, 54088). Most TA-61 PRSs were recommended for NFA in the work plan and in the addendum to the work plan. PRS 61-002 was the subject of additional investigation and is summarized below.

PRS 61-002—Radio Repair Shop PCB Storage

PRS 61-002 is a storage area near the radio repair shop, TA-61-23, on East Jemez Road. The area originally was unpaved and was used as a storage yard for PCB-containing drums and equipment; storage was discontinued in 1985. PRS 61-002 currently is asphalted and includes an approximately 600 ft^2 (54 m^2) area downgradient (south side) of the asphalted area. This area may have been affected by sediments carried off-site before asphalt application and currently, as part of the Los Alamos County-municipal landfill, is used for employee parking and equipment storage. The PRS is located on the mesa top and the gentle southward slope toward the drainage at the head of Sandia Canyon.

In 1986, surface soil samples were collected and analyzed for PCBs. The results indicated PCB concentrations up to 691 ppm. The area then was excavated to a depth of at least 10 in. (25 cm) and resampled. The results of the second sampling effort indicated that PCB concentrations had decreased to a maximum of 51.3 ppm. The area then was covered with clean fill and asphalted. After the area was asphalted, it again was used to store PCB-containing drums and equipment, but this practice was discontinued by 1992.

The Phase I investigation conducted in 1994 was designed to determine whether PCBs were present above action levels in stains on the asphalt or in surface soils downgradient of PRS 61-002 (LANL 1993, 51977). The sampling was not designed to evaluate the concentrations of PCBs left in the soil under the asphalt and fill. Eighteen soil samples were collected from within and along the southern perimeter of the asphalt area. Of the 18 samples, 16 were analyzed for PCBs, 5 were analyzed for SVOCs and inorganics, and 1 was analyzed for VOCs. In addition, 11 samples were analyzed in the field using PCB test kits.

PCBs were retained as COPCs by the screening assessment process for PRS 61-002. PCBs were detected at concentrations of 1.4 mg/kg and 1.6 mg/kg, which exceed its SAL of 1 mg/kg. As a result of the Phase I investigation, a Phase II investigation was proposed to determine the extent of contamination. The Phase II field investigation was conducted in 1997 and the results of the investigation are planned to be presented in a future RFI report. The discussion of the Phase I investigation and the Phase II SAP are presented in the RFI report for 53 PRSs in TA-3, TA-59, TA-60, and TA-61 (LANL 1996, 54467, pp. 200 through 211).

2.3.4 Technical Area 53

The Los Alamos Neutron Science Center (LANSCE) (previously called the Los Alamos Meson Physics Facility [LAMPF] or the Clinton P. Anderson Meson Facility) consists of a 0.5-mi. (0.8-km)-long linear proton accelerator and associated experimental research areas, offices, laboratories, and shops. The accelerator is used to produce subatomic particles for basic research, isotope production, radiochemistry, solid state physics research, and accelerator technology development (LANL 1994, 34756, p. 2-5).

Construction of LAMPF began with site preparation in early 1967, followed by official groundbreaking in February 1968. Major construction funds became available in October 1968. The first proton beam, produced on June 10, 1970, had an energy of 5 million electron volts (MeV). Approximately one year later, a 100-MeV beam was produced, and on June 9, 1972, the full design energy of 800 MeV was attained. The first full year of operation was 1974. LAMPF then was shut down in January 1975 to complete construction activities and to install the radiation hardening necessary for full-intensity beam operation. After operations recommenced in April 1976, the beam current was increased steadily; 500 microamperes (µA) was reached in the fall of 1978 and 1.2 milliamperes (mA) by January 1983. The routine current operating level is 1 mA (LANL 1994, 34756, pp. 2-5 through 2-6).

The first stage of the accelerator contains three injection systems, one for each kind of particle: (protons (H^+), negative hydrogen ions (H^-), and polarized H^-. The particles in each injector are formed into a beam and accelerated to an energy of 750 kiloelectron volts (keV). In the second stage of the accelerator, a drift-tube type linear accelerator accelerates the beam particles to100 MeV. Finally, in the third stage, a side-coupled, cavity-type linear accelerator accelerates the particles to the peak energy of 800 MeV. The beams then enter a “switchyard,” where they are separated by magnets into beam lines. Lines A, B, and C are directed to Experimental Areas A, B, and C, respectively. In addition, a polarized proton beam may be directed to LANSCE as Line D. As the beams strike various targets, they produce secondary particles (including pions, muons, neutrons, and neutrinos) (LANL 1994, 34756, p. 2-6).

Experimental Area A contains two primary target cells, each of which generates two secondary beams (pions or muons). The proton beam passes through the targets to the beam stop in Area A East, where a neutrino beam is generated and is directed eastward to the neutrino experiment area. The west end of the facility contains an area for development and maintenance of remote manipulators and, on the floor below, two hot cells with manipulators. These hot cells are used for work on radioactive components and for nuclear chemistry experimentation (LANL 1994, 34756, p. 2-6).

Experimental Area A also contains the energetic pion channel and spectrometer, the low-energy pion channel, the high-energy pion channel, the stopped muon channel, and the time-of-flight isochronous spectrometer (LANL 1994, 34756, p. 2-6).

The former radiobiology and therapy research facility is located east of Experimental Area A. This facility was used for dosimetry, radiobiology, and therapy studies and for clinical trials of negative pions for radiation therapy. It contains a treatment room, control room, laboratories, offices, and patient-staging facilities (LANL 1994, 34756, p. 2-6).

Experiments using electron neutrinos generated at the Line A beam stop are carried out in the Neutrino Research Facility, a heavily shielded enclosure on the south side of the beam stop. On the north side of the beam line, immediately upstream of the beam stop, is the Radiation Damage and Isotope Production Facility. Here, isotopes are prepared by inserting targets into the proton beam; and neutrons from the beam stop are used in materials radiation damage studies (LANL 1994, 34756, p. 2-6).

Experimental Area B is the Nucleon Physics Laboratory, which includes the External Proton Beam Channel. This area is used to study nucleon-nucleon interactions using high-energy neutron beams. Area B also contains the medium-resolution spectrometer, the High-Resolution Atomic Beam Facility, and the Neutron Time-of-Flight Facility (LANL 1994, 34756, pp. 2-6 through 2-7).

Experimental Area C contains a high-resolution proton spectrometer used to study interactions of protons with various nuclei (LANL 1994, 34756, p. 2-7).

LANSCE, which includes the Weapons Neutron Research Facility/Proton Storage Ring (WNR/PSR) complex, receives beam line D, a polarized proton beam. Here, experiments are carried out in condensed matter physics, nuclear physics, biology, and national security programs using pulsed neutrons generated by the beam. The neutrino beam that exits the WNR is Line E (LANL 1994, 34756, p. 2-7).

Building TA-53-2, the Equipment Test Laboratory, contains a large hydrogen-brazing furnace shop; a radio-frequency (rf) test and assembly shop; development laboratories; a metrology laboratory containing alignment and tooling equipment; a staff shop; an assembly and staging area; and a polarized target laboratory. During construction, this facility was used to braze more than 1 million lb (450,000 kg) of oxygen-free, high-conductivity copper needed for the side-coupled linear accelerator structure. Since completion of construction, the facility has been used to assemble special components and experimental apparatus. The rf shop is used to repair and test klystrons and modulator assemblies (LANL 1994, 34756, p. 2-7).

Building TA-53-1, the laboratory-office building, houses administrative and technical offices, a library, laboratories (including a radiochemistry lab), shops, computer facilities, and a cafeteria (LANL 1994, 34756, p. 2-7).

The other major operating area at TA-53, which is not related to LAMPF, was the ground test accelerator (GTA) facility. The GTA was a linear accelerator that was being developed to test particle-beam weapons systems. The GTA and associated support facilities were located south of LAMPF and west of LANSCE (LANL 1994, 34756, p. 2-7). As of 1996, the GTA program was terminated and its former location now houses the low-energy demonstration accelerator (LEDA) project, which is discussed below (LANL 1996, 62339, p. 22).

The main activity at TA-53 currently centers around LANSCE and associated experimental areas. LANSCE produces intense sources of pulsed spallation neutrons, which provide this nation’s scientific community with the capability to perform experiments that support national security and civilian research.

LANSCE comprises a high-power, 800 MeV, proton linear accelerator (linac); a Proton Storage Ring; production target to the Manuel Lujan Jr. Neutron Scattering Center and the WNR facility; and a variety of associated experimental areas and spectrometers (LANL 1998, 58841, p. 2-1)

In 1996, an environmental assessment (EA) (summarized at the end of this section) was completed to address the environmental impacts associated with the construction of the LEDA. The LEDA is a prototype of the low-energy, front-end section of the linear accelerator (linac) to be used in an accelerator production of tritium (APT) plant. The APT process is one of two tritium production options recently under consideration by the DOE. LEDA construction and testing was proposed in order to verify equipment design and resolve related performance and production issues for full-scale operation at the Savannah River Site if the APT plant were built; production operations were not proposed for Los Alamos National Laboratory (LANL 1996, 62339, pp. ii and 1). LEDA activities at LANSCE ceased in December 1998.

PRSs located within the Sandia Canyon watershed at TA-53 have been addressed in the “RFI Work Plan for Operable Unit 1100” (LANL 1994, 34756). The NMED issued an NOD for the work plan; the NOD and the Laboratory’s response are presented in “Response to EPA’s NOD for the OU 1100 Work Plan” (LANL 1994, 43889). Most PRSs at TA-53 were recommended for NFA in the work plan. PRSs 53-001(a,b,e, and g) and 53-012(e) were investigated and subsequently recommended for NFA in the RFI report for PRSs in TA-20, TA-53, and TA-72 (LANL 1996, 54124). PRSs that were the subject of additional investigation, remedial action, or deferred action are summarized below. Investigations at some PRSs currently are in progress.

PRSs 53-001(c, d, and k)—Waste Accumulation Areas

PRS 53-001(c) is a former waste storage area located at the south side of Building TA-53-16, a machine shop associated with LANSCE. This area reportedly was used to store drums of ethylene glycol, organic solvents, and epoxy resins. Photographs taken during June 1989 show a single 55-gal. (209-L) drum at the storage area. No leakage from the drum or staining on the asphalt from the drum is evident. When the site was inspected in conjunction with work plan preparation, the storage area could not be located. The EM-8 (former Laboratory group ESH-18) tracking system confirmed that it had been removed. Staining was noted outside TA-53-16 during the inspection, on the asphalt on the south-southeast corner of the building. It could not be determined whether this staining was associated with PRS 53-001(c) (LANL 1994, 34756, p. 6-29).

PRS 53-001(d) is a former waste storage area located outside the southwest side of TA-53-14 (a general laboratory facility) for solvent-contaminated rags, acetone, ethanol, trichloroethane, and freon. The area is shown in a 1989 photograph identified by a satellite accumulation area (SAA) sign. Two drums bearing hazardous waste labels are visible next to a flammable-materials storage cabinet; some staining can be seen on the asphalt surface below the cabinet and may be present beneath the drums as well. When the site was inspected in conjunction with work plan preparation, the storage area could not be located. It apparently had been removed. No staining on the asphalt was noted. An addition to the southwest corner of Building TA-53-14 may cover the former location of this PRS (LANL 1994, 34756, pp. 6-29 through 6-30).

PRS 53-001(k) is a former waste storage area located in the middle of the road at the north side of Building TA-53-7 (a beam-line facility originally known as the WNR). Solvent-contaminated rags were stored at this site. When the site was inspected for preparation of the work plan, no waste storage area was located. The EM-8 tracking system lists an active SAA in the middle of the road on the north side of TA-53-7, and staff members confirmed that this is the former location of a solid-waste dumpster. No staining on the asphalt was noted in this area; however iron staining was noted on the asphalt north of the western portion of the facility in an area that may formerly have contained storage drums (LANL 1994, 34756, p. 6-30).

PRSs 53-001(c, d, and k) have been recommended for deferred characterization because soils near the storage areas now are covered by asphalt or structures and can be sampled when the site as a whole undergoes decontamination and decommissioning (D&D) (LANL 1994, 34756, p. 6-30).

PRS 53-002(a and b)—Surface Impoundments

PRSs 53-002(a and b) comprise three surface impoundments. Before 1997, PRSs 53-002(a and b) were considered treatment, storage, and disposal (TSD) units regulated under RCRA, and thus required a closure plan. On July 21, 1997, in response to a Laboratory request, NMED informed DOE of an approved change in status for the TA-53 surface impoundments. Under HSWA, the TA-53 surface impoundments were changed from TSD units to corrective action units. As a result, NMED requested an RFI work plan/SAP for the TA-53 surface impoundments. The RFI work plan and SAP for PRSs 53-002(a) and 53-002(b) addressed this requirement (LANL 1998, 58841, p. 1-2).

PRS 53-002(a) comprises two northern surface impoundments and all associated drainages that were used to treat sanitary and radiological waste from TA-53 facilities, primarily LANSCE. The northern surface impoundments at PRS 53-002(a) were installed in 1969 and began operating the early 1970s. These impoundments were constructed by excavating into the tuff, adding a clay liner on top of the tuff, and spraying gunite (concrete) onto the crushed tuff berm. Each impoundment is 210 ft (63 m) long by 210 ft (63 m) wide by 6 ft (1.8 m) deep and has a liquid storage capacity of approximately 1.6 million gal. (6.1 million L). To minimize the volume of water discharged to the outfall, two Aqua Aerobics™ surface turbine aerators were used in each impoundment for aeration and to enhance evaporation. In 1992, when SWSC became operational, all sanitary waste was diverted from the northern surface impoundments. Both surface impoundments are currently inactive and dry (LANL 1998, 58841, p. 1-6).

The original 1968 grading plan for the northern surface impoundments was revised in 1971 to an as-constructed drawing. The as-constructed drawing for the northern surface impoundments shows a drainage ditch exiting between the two northern surface impoundments. The drawing shows a drainage ditch continuing south for approximately 100 ft (30 m), while turning slightly west toward a tributary of Sandia Canyon. It is not known if the drainage ditch was ever used for discharges to Sandia Canyon; however it may have served as an overflow system. A second drainage ditch exits from the south side of the northern impoundments, turns east, and terminates in the current rock-lined drainage area at the head of a tributary to Los Alamos Canyon. This drainage ditch was used to route wastewater discharge. PRS 53-002(b), the southern impoundment, was built over these drainage ditches. A discharge pipe from the northeastern impoundment currently ends at an NPDES permitted outfall that drains at the location of the rock-lined drainage into the tributary of Los Alamos Canyon (LANL 1998, 58841, p. 2-3).

PRS 53-002(b), the southern surface impoundment, was constructed and began operating in 1985. It was installed by excavating into tuff, overlain with crushed tuff and sand, and then overlain with a Hypalon™ (rubber polymer) liner. The southern impoundment was constructed to accommodate excess wastewater from the northern surface impoundments and to treat both sanitary (1985 to 1989) and radiological (1985 to present) waste from TA-53 operations. The southern impoundment is approximately 305 ft (92 m) long by 148 ft (44 m) in. wide by 6 ft (1.8 m) deep, with a liquid storage capacity of 2.5 million gal. (9.5 million L). This surface impoundment contains liquid and sludge and was removed from service in December 1998.

Before its change in regulatory status from TSD to corrective action unit, PRS 52-002(a) was the subject of an interim action as described in “Interim Action Completion Report for Potential Release Site

53-002(a)" (LANL 1996, 55208). As a best management practice, the site was stabilized by covering the exposed sludge in the surface impoundments with a geotextile filter fabric cover in support of closure requirements. The cover was installed to serve as a barrier to wildlife intrusion and to contain contaminants (LANL 1996, 55208, p. 1).

Existing Data—PRS 53-002(a)

The sludge and water in the two northern surface impoundments [PRS 53-002(a)] previously were analyzed in four separate sampling events: during the DOE Headquarters (HQ) Environmental Survey in 1988, by the Laboratory's Environmental Protection Group in 1991 and in 1992, and by the ER Project in 1994/1995. The DOE HQ Environmental Survey collected three sludge samples from each impoundment; the samples were analyzed for VOCs, SVOCs, metals, and gamma-emitting radionuclides. The results indicate that two VOCs (acetone and toluene) and six SVOCs (benzoic acid, benzyl alcohol, fluoranthene, 2-methyl phenol, 4-methyl phenol, and pyrene) were detected, although most of these results are suspected of being false positives (LANL 1998, 58841, p. 2-18). Results from the gamma analyses showed that the following radionuclides were detected in all six samples: beryllium-7, sodium-22, managnese-54, cobalt-56, cobalt-57, cobalt-58, cobalt-60, zinc-65, selenium-75, rubidium-83, yttrium-88, and cesium-134. In addition, scandium-46 and zirconium-88 were present in three samples, silver 110m in two samples, cadmium-109 in one sample, and natural potassium-40 in all six samples (LANL 1998, 58841, p. 2-18).

Sludge and water in the surface impoundments were sampled by the Laboratory's Environmental Protection Group in July 1991. Samples of sludge and water were collected from three locations at each impoundment. All sludge samples were analyzed for VOCs, SVOCs, and toxicity characteristic leachate procedure (TCLP) metals; one sludge sample from each impoundment also was analyzed for gamma-emitting nuclides. All water samples were analyzed for VOCs, SVOCs, metals, and gross alpha and beta radioactivity; one water sample from each impoundment also was analyzed for tritium and gamma-emitting nuclides. The VOC analysis of sludge samples indicates only toluene was present above detection limits. Three SVOCs (benzidine, di-n-butylphthalate, and bis-2-ethylhexylphthalate) were detected in sludge samples. No VOCs were detected in any of the water samples. The only SVOC detected in water samples was benzoic acid, which was detected in one sample at 15 µg/L. Results showed that the following radionuclides were detected above the analytical uncertainty in water in both impoundments: tritium, beryllium-7, cobalt-58, cobalt-60, rubidium-83, cesium-134, europium-154, and hafnium-175. In addition, manganese-54, manganese-56, and cobalt-57 also were detected in the northwestern impoundment. The sludge results showed beryllium-7, cobalt-57, cobalt-58, cobalt-60, cesium-134, cesium-137, europium-154, hafnium-175, iridium-190, lutetium-173, manganese-54, manganese-56, and sodium-22 present in at least one impoundment above analytical uncertainty (LANL 1998, 58841, p. 2-20).

In April 1992 the Environmental Protection Group performed a more comprehensive sampling program, in accordance with a SAP approved by NMED. Sludge samples were collected from 15 grid locations in each impoundment. All sludge samples were analyzed for VOCs, SVOCs, TCLP metals, and PCBs; one sludge sample from each impoundment also was analyzed for organochlorine pesticides, chlorinated herbicides, pH, flash point, sulfide, and cyanide. The VOC analysis showed acetone was present above detection limits in 11 samples; 2-butanone in 1 sample; carbon disulfide in 6 samples; chloroform in 4 samples; 4-isopropyl toluene in 1 sample; toluene in 6 samples; and 1,2,3-trimethylbenzene in 1 sample. The SVOC analysis showed benzoic acid was present above detection limits in 3 samples; bis-2-ethylhexylphthalate in 21 samples; and di-n-butylphthalate in 9 samples. PCBs were detected in 3 sludge samples at concentrations of 0.27 mg/kg, 0.33 mg/kg, and 0.57 mg/kg. Several pesticides were present above detection limits. No herbicides were present above detection limits (LANL 1998, 58841, p. 2-21).

Metals present in the sludge and maximum TCLP concentrations include silver (5.1 mg/kg), arsenic (3.6 mg/kg), barium (50.2 mg/kg), cadmium (3.1 mg/kg), chromium (16.4 mg/kg), mercury (0.407 mg/kg), lead (44.8 mg/kg), and selenium (2.1 mg/kg) (LANL 1998, 58841, p. E-7). Water samples were collected from one location in each impoundment and analyzed for VOCs, SVOCs, metals, pesticides, gross-alpha, -beta, and -gamma radioactivity, and tritium. The only VOC detected was acetone, which was detected at 48 µg/L in the northeastern impoundment. No SVOCs or PCBs were detected in the water samples. The only radiological sampling reported was for tritium analysis. The results showed tritium detected in the water at 2200 pCi/L in the northwestern impoundment and 5000 pCi/L in the northeastern impoundment (LANL 1998, 58841, p. 2-21). Metals present in the water samples and maximum concentrations include arsenic (6.8 µg/L), barium (33.4 µg/L), cadmium (4.5 µg/L), chromium (5.8 µg/L), lead (3.1 µg/L), and selenium (4.5 µg/L) (LANL 1998, 58841, p. E-9).

In 1995 the Laboratory’s ER Project conducted sampling at the northern surface impoundments to assess the nature of the contaminants, determine if contaminants were migrating out of the surface impoundments, and collect sufficient data to perform a human health screening assessment. Samples of the sludge, bentonite clay liner, and the tuff below the gunite liner around the periphery were collected from the northern surface impoundments and analyzed for metals, total cyanide, reactive sulfides, SVOCs, VOCs, pesticides and PCBs, herbicides, isotopic uranium and plutonium, strontium-90, tritium, and gamma-emitting isotopes (LANL 1998, 58841, p. 2-22). The samples collected from 17 locations within each surface impoundment included each of the three media: the sludge, the clay liner, and the tuff below the liner. In addition, the gunite liner along the periphery of the surface impoundments was penetrated and the tuff below the gunite liner was sampled at a depth of 1.5 ft to 2.0 ft (0.5 m to 0.6 m) at eight locations (LANL 1998, 58841, p. F-5). The list of COPCs, detected at concentrations greater than 0.1 times SAL for noncarcinogens, or greater than SAL for radionuclides and carcinogenic organic chemicals identified for human health in the northern surface impoundments (LANL 1998, 58841, p. 2-22), are

- sludge: chromium, copper, lead, mercury, thallium, Aroclor-1254, Aroclor-1260, bis(2-ethylhexyl) phthalate, BHC(alpha-), cobalt-60, neptunium-237, sodium-22, and tritium;
- clay liner: thallium, dieldrin, cesium-134, cobalt-60, and manganese-54; and
- tuff: aluminum, cesium-134, and cobalt-60.

For purposes of ecological risk screening, the COPCs detected at or above background and detected in the sludge, clay liner, and tuff included those noted above for human health as well as the following:

- sludge: antimony, cadmium, DDT(4,4’-), DDE(4,4’-), endrin, endosulfan, selenium, silver, and zinc;
- clay liner: cadmium, BHC(gamma-), DDT(4,4’-), DDD(4,4’-), endrin, endosulfan, and zinc; and
- tuff: BHC(gamma-), DDT(4,4’-), DDD(4,4’-), dieldrin, and heptachlor.

Of the analytes listed above, Aroclors, bis(2-ethylhexyl)phthalate, DDT and metabolites, dieldrin, endosulfan, endrin, heptachlor, BHC(gamma-), aluminum, cadmium, copper, lead, mercury, and selenium are on the current NMED list of potentially persistent bioaccumulators and biomagnifiers and therefore have been added to the COPC list for the sampling campaign proposed in the RFI work plan and SAP for PRSs 53-002(a) and 53-002(b) (LANL 1998, 58841, p. 2-23).

Existing Data—PRS 53-002(b)

In 1991 and 1992 the sludge and water in the southern impoundment [PRS 53-002(b)] were analyzed in two separate sampling events by the Laboratory's Environmental Protection Group. In July 1991 sludge and water in the impoundment were collected from three locations within the impoundment. All sludge samples were analyzed for VOCs, SVOCs, and TCLP metals; one sludge sample was also analyzed for gamma-emitting radionuclides. The water samples were analyzed for VOCs, SVOCs, TCLP metals, and gross-alpha and -beta radioactivity; one water sample also was analyzed for tritium and gamma-emitting radionuclides. The VOC analysis of sludge samples indicates only toluene and 4-isopropyltolutene were present above detection limits. Only one SVOC, di-n-butylphthalate, was detected in sludge samples. No VOCs or SVOCs were detected in any of the water samples. Metals detected and their analytical results indicate that tritium, beryllium-7, cobalt-58, cobalt-60, cesium-137, manganese-54, manganese-56, rubidium-83, europium-154, hafnium-175, and lutetium-173 were detected above the analytical uncertainty in the water samples. Tritium concentrations were much higher in the southern impoundment water than in the two northern impoundments. Barium was the only metal present in the water samples; it was detected in all three water samples at a concentration of 40 µg/L (LANL 1998 58841, p. E-15). Metals present in the sludge and maximum TCLP concentrations include silver (0.014 mg/L), barium (1.2 mg/L), cadmium (0.03 mg/L), chromium (0.03 mg/L), lead (0.29 mg/L), and selenium (0.03 mg/L) (LANL 1998, 58841, p. E-14). Sludge results showed beryllium-7, cobalt-57, cobalt-58, cobalt-60, cesium-134, cesium-137, europium-154, hafnium-175, iridium-190, lutetium-173, manganese-54, manganese-56, and sodium-22 present above analytical uncertainty. The concentrations of radionuclides in the sludge generally were much higher in the southern impoundment than the northern impoundments, probably reflecting the change in influent routing since 1989. At that time, all radioactive liquid waste was routed to the southern impoundments exclusively (LANL 1998, 58841, pp. 2-23 through 2-24).

In April 1992 a more comprehensive round of sampling was performed by the Laboratory's Environmental Protection Group, in accordance with an NMED-approved SAP. Sludge samples were collected from 16 grid locations in the impoundment and analyzed for VOCs, SVOCs, TCLP metals, and PCBs. One sludge sample also was analyzed for organochlorine pesticides, chlorinated herbicides, pH, flash point, total sulfide, and total cyanide. Different VOCs and SVOCs were detected in the April 1992 sludge samples than were detected in the July 1991 sludge samples. The VOC analysis showed acetone was present above detection limits in three samples and 1,1,1-trichloroethane in four samples. SVOC analysis showed bis(2-ethylhexyl)phthalate was present above its detection limit in one sample. Metals present in the sludge and maximum TCLP concentrations include arsenic (2.0 mg/kg), barium (9.9 mg/kg), chromium (3.4 mg/kg), mercury (0.052 mg/kg), lead (2.9 mg/kg), and selenium (4.9 mg/kg) (LANL 1998, 58841, p. E-14). PCBs were not detected in the sludge samples at a detection limit of 0.06 mg/kg. No pesticides or herbicides were present above detection limits. No sludge samples were analyzed for specific radionuclides. One water sample was collected and analyzed for VOCs, SVOCs, metals, PCBs, pesticides, and herbicides. Three additional water samples were collected and analyzed for gross-alpha, -beta, and -gamma radioactivity, and tritium. The only VOC detected was acetone at a maximum concentration of 35 µg/L. No SVOCs, PCBs, pesticides, or herbicides were detected in the water samples. Metals present in the water samples and maximum concentrations include arsenic (9.6 µg/L), barium (40.9 µg/L), chromium (1.8 µg/L), and lead (8.2 µg/L) (LANL 1998, 58841, p. E-15). Two water samples showed much higher concentrations of tritium (at a maximum concentration of 2,260,000 pCi/L) than in the northern impoundments, reflecting the exclusive input of radioactive water to the southern impoundments since 1989 (LANL 1998, 58841, p. 2-24).

Existing Data—Vadose Zone Characterization

During a 1991 vadose zone study, eight boreholes were drilled adjacent to the three surface impoundments. Four boreholes (boreholes 53-1 through 53-4) were drilled to a depth of 50 ft (15 m) adjacent to the impoundments to determine if subsurface saturation is present and to determine if the release of contaminants from the impoundments has occurred. An additional 50-ft (15-m) borehole (borehole B) was drilled 450 ft (135 m) west of the impoundments to determine baseline moisture conditions and tritium levels. Grab samples of cuttings were collected every 5 ft (1.5 m) from each borehole. The boreholes were completed as neutron-moisture access holes (Purtymun 1995, 45344, p. 327; LANL 1998, 58841, p. 2-25). Additional information about these boreholes is provided in Section 3.4.2 of this work plan.

Supplemental RFI Sampling at PRSs 53-002(a and b)

Sampling of the three surface impoundments at TA-53 [PRSs 53-002(a and b)], and their adjacent piping and drainages is currently in progress to determine if any releases from these structures have resulted in contamination that poses a potential human health or ecological risk, as described in the RFI work plan and SAP for PRSs 53-002(a) and 53-002(b) (LANL 1998, 58841). Several types of media within the site are proposed for sampling during this effort: (1) sludge within all three surface impoundments, (2) the clay liner in the northern surface impoundments, (3) the sand layer beneath the Hypalon™ liner in the southern surface impoundment, (4) tuff underlying the three surface impoundments, (5) the soil and tuff surrounding the surface impoundments, and (6) the soil and tuff in the associated drainage areas, including the Sandia Canyon tributary area. Sludge samples will be collected to determine the nature of contaminants within the three surface impoundments. Samples will be collected from the clay liner and the sand layer to help support the conceptual model. Finally, samples will be collected in the tuff underlying all three surface impoundments and in the drainage pathways leading from the northern surface impoundments so that extent of contamination (to a depth of 12 ft [3.6 m]) can be better characterized. A follow-up sampling plan to determine extent for COPCs found below a depth of 12 ft (3.6 m) is planned to be designed using data obtained through implementation of the RFI work plan/SAP (LANL 1998, 58841, p. 2-39).

The COPC list for both the northern and southern surface impoundments was derived from assessing data previously collected at these sites. The noncarcinogenic COPCs identified for the northern surface impoundments include aluminum, antimony, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. The carcinogenic COPCs identified for the northern surface impoundments include Aroclor-1254, Aroclor-1260, BHC(alpha-), bis(2-ethylhexyl)phthalate, and dieldrin. The radionuclide COPCs identified for the northern surface impoundments include cesium-143, cobalt-57, cobalt-60, manganese-54, neptunium-237, sodium-22, and tritium (LANL 1998 58841, p. F-36). The full suites of analyses planned for the southern surface impoundment include PCBs, VOCs, SVOCs, metals, pesticides and herbicides. Radionuclide analyses will be performed for tritium, isotopic plutonium, isotopic uranium, strontium-90, and gamma-emitting isotopes (LANL 1998, 58841, pp. 2-40 through 2-41).

PRS 53-005—Waste Oil Pit

PRS 53-005 is a former waste oil pit that was located approximately 80 ft (24 m) southeast of the southeast corner of Building TA-53-2. The 1986 working draft Comprehensive Environmental Assessment and Response Program (CEARP) report (DOE 1986, 8657) describes this pit as full of a thick brownish liquid and covered by a steel grate. It apparently was unlined and was dug directly into the tuff. The pit was believed to be about 6 ft (1.8 m) deep and to have received acids and oils. The 1987 draft CEARP report (DOE 1987, 52975) indicates that the pit and its contents were removed in 1986 (LANL 1994, 34756, p. 5-42).

The waste-oil pit was not located during the Phase I investigation. Selection of the site location was based on site history. A preliminary reconnaissance-type geophysical investigation of the proposed sampling site was conducted before it was excavated. The geophysical investigation did reveal an anomaly that could be associated with the buried pit at the identified location. However, excavation at the location revealed only soil over welded bedrock tuff. A long-time Laboratory employee who remembered the pit was reinterviewed about the general location of the pit. An expanded geophysical investigation of the area subsequently was conducted, and a new location was identified for sampling. Sampling was proposed for 1996; all specific results, conclusions, and recommendations are planned to be included in a future addendum to the RFI report for PRSs in TA-20, TA-53, and TA-72 (LANL 1996, 54124, p. 5-57).

PRSs 53-006(a and f)—Underground Tanks

PRS 53-006(a) is an inactive UST 28 in. (70 cm) in diameter by 65 ft (20 m) long. It reportedly was used from 1974 until the 1980s to store spent ion-exchange resin used to treat water from LAMPF (LANL 1994, 34756, p. 6-31).

PRS 53-006(f) is an active 3,000-gal. (11,400-L) UST located in Building TA-53-1. Installed in 1972, this tank is used to store radioactive wastewater before it is removed for treatment or disposal. This tank appears to be the same structure that was also called a sump, which is part of PRS 53-007(a), in the SWMU report (LANL 1990, 7511). When the basement of D wing at TA-53-1 was inspected, one tank was identified that matched the descriptions of both PRSs [53-006(f) and 53-007(a)]. Wastes discharged to this tank consisted of neutralized wastes from sinks and other drains in radiochemistry laboratories. The CEARP report (DOE 1987, 52975) notes that both PRSs were included in the UST notification submitted to NMED on May 5, 1986 (LANL 1994, 34756. p. 6-31).

The effort required to sample for subsurface contaminants would involve intrusive activities that would be difficult to implement without disrupting current operations. Due to a lack of record or evidence of any releases from these PRSs, the RFI work plan for OU 1100 recommends that investigations be deferred until the tanks undergo D&D (LANL 1994, 34756, p. 6-32).

PRSs 53-006(b, c, d, and e)—Underground Storage Tanks

PRSs 56-006(b and c) are identified in the SWMU report (LANL 1990, 7511) as structures TA-53-68 and TA-53-69, respectively, and are described as 6 ft (1.8 m) in diameter by 18 ft (4.5 m) long. These USTs were installed in 1973 and are still active; they are used to store radioactively contaminated wastewater from LANSCE (formerly LAMPF). The major source of waste is the TA-53-3 radioactive liquid waste system, which collects wastewater from floor drains along the length of the accelerator tunnel (mainly deionized [DI] water that has become tritiated). These tanks also receive wastewater from a sink, a shower, and a clothes washer in Building TA-53-502 (LANL 1994, 34756, p. 6-12).

PRSs 53-006(d and e) are identified in the SWMU report (LANL 1990, 7511) as structures TA-53-144 and TA-53-145, respectively, and are described as 8-ft by 8-ft by 10-ft (2.4-m by 2.4-m by 3-m) USTs. Installed in 1977, both tanks are active and are used to store radioactively contaminated wastewater from the WNR facility. These tanks receive discharges from Buildings TA-53-7 (drainage from floor drains in the beam-line, target, and experimental areas), TA-53-8 (drainage from beneath a contaminated DI pump stand), TA-53-30 (drainage from contaminated floor drains and sink drains), and TA-53-368 (discharges from an equipment room floor drain). At one time, the tanks also received drainage form the DI water system in Building TA-53-36 (LANL 1994, 34756, p. 6-12).

The CEARP report (DOE 1987, 52975) notes that all four tanks were included on the May 5, 1986 UST notification submitted to NMED. Their locations were inspected during preparation of the RFI work plan. No evidence of past releases was noted (LANL 1994, 34756, p. 6-12).

PRSs 53-006(b, c, d, and e) are active components of the liquid radioactive waste system at TA-53. Due to a lack of record or evidence of any releases from these PRSs, the RFI work plan for OU 1100 recommends that investigations be deferred until the waste system undergoes D&D (LANL 1994, 34756, p. 6-12).

PRS 53-010—Bermed Mineral Oil Storage Area

PRS 53-010 is located in TA-53, approximately 90 ft (27 m) southeast of Building TA-53-1031. The site, located on a mesa top, is bounded on three sides by unimproved roadways. The site was used for secondary containment from 1989 to 1990 for two 3000-gal. (11,400-L) tanks and eighteen 55-gal. (209-L) drums containing mineral-oil-based scintillator liquid, described as containing a small percentage of pseudocumene (1,2,4-trimethylbenzene). The site measured 30 ft by 35 ft (9 m by 10.5 m) and was surrounded by 2-ft (0.6-m)-high soil berms. The interior slopes of the berms and floor were lined with a geotechnical liner overlain by soil. When the site was closed in 1990, the tanks and drums were removed, and two small areas of stained soil were cleaned up. At this time, the secondary containment appeared to be intact, although exposure to the elements may have caused deterioration of the liner. The Phase I investigation was conducted in May and June 1995. The Phase I sampling data, which included analyses for SVOCs and TPH, indicated nondetects for SVOCs and elevated TPH levels ranging from 0.0498 mg/kg to 5100 mg/kg. Consequently, a VCA plan was developed that proposed removal of the geotechnical liner and oil-contaminated soil; 1,2,4-trimethybenzene was identified as the health conservative indicator chemical of concern (LANL 1996, 53794, pp. 5 through 6).

VCA activities were performed on September 18, 1995, as described in the VCA completion report for PRSs 20-003(c) and 53-010 (LANL 1996, 53794). The activities included the removal of the liner and approximately 30 yd^3 (23 m^3) of soil. Six confirmatory samples were collected and analyzed for VOCs (including 1,2,4-trimethylbenzene). The confirmatory analytical data indicate that 1,2,4-trimethylbenzene was not detected. Site restoration was accomplished by removing the 2-ft (0.6-m) berm, and backfilling, recontouring, and reseeding the area (LANL 1996, 53794, p. 6).

PRS 53-014—Lead Shot Site

PRS 53-014 was the subject of a VCA, as described in the VCA completion report for PRS 53-014 (LANL 1997, 56589). PRS 53-014 is located south of Building TA-53-365 and includes a paved storage area continuing down a channel joining NPDES-permitted outfall EPA 03A-113. Lead shot apparently was spilled on the paved surface, and stormwater had begun washing the lead through a curb cut onto an asphalt apron and into the channel that joins the outfall drainage. The lead shot, ranging in size from 2 mm to 4 mm (0.08 in. to 0.16 in.), followed a path from the paved surface down the asphalt apron and into the storm channel below the outfall. Storm and outfall water drop sharply across rocks and through vegetation, and small sediment traps and pools of water occur in numerous locations in the channel. Lead was visible in a number of locations down the canyon, although the highest concentration of lead shot was contained by stormwater controls placed at the curb cut of the paved storage area (LANL 1997, 56589, p. 1).

The site was characterized visually and using x-ray fluorescence (XRF) field screening techniques in August 1995. The extent of visible lead shot was observed to be approximately 50 ft (15 m) downgradient of the asphalt apron. Fifteen XRF samples were taken beyond the last sighting of lead in the stormwater drainage and no detectable lead levels were noted in the samples. Lead was determined to be present at a maximum concentration of 210,000 mg/kg in the lead shot sized from 1.7 mm to 4.0 mm (0.07 in. to 0.16 in.) based on analysis of lead shot from a similarly contaminated site at TA-53 (PRS 53-013). Lead was the only contaminant of concern at PRS 53-014. A site-specific lead-soil cleanup level of 1000 mg/kg was established based on an industrial exposure scenario and preliminary comments received from EPA Region 6 (LANL 1997, 56589, pp. 1 and 3).

VCA activities were conducted and completed on March 20, 1997. The remedial action consisted of removing lead shot from the paved storage area and the surface soils along the stormwater drainage pathway leading away from the paved area. Lead removal techniques included picking up visible lead by hand as well as hand-sieving sediment using a 2-mm (0.08-in.) mesh from catchment areas and pockets within the drainage. Confirmatory samples were collected from five locations across the cleanup area that were considered likely areas of sediment accumulation. Lead was detected in all five samples at concentrations ranging from 4.3 mg/kg to 20 mg/kg, which are below the established cleanup level of 1000 mg/kg. No site restoration activities were required at the site (LANL 1997, 56589, pp. 3 through 4).

Environmental Assessment for the LEDA Project

Tritium, a radioactive gas, is crucial to the continuing operation of the United States' nuclear weapons stockpile. The half-life of tritium is a relatively short 12.3 years. For that reason, weapons components using tritium must be replenished periodically. The federal government has not produced tritium since 1988, and has had no production source since the shutdown of the K-reactor at the DOE's Savannah River Site facility in South Carolina. DOE needs the capability to produce tritium to meet the requirements set forth in the 1994 nuclear weapons stockpile plan. Ratification of the Strategic Arms Reduction Talks (START) II protocol would mean that a new source of tritium must be available by the year 2009, and new tritium must be available for stockpile use by 2011. The programmatic environmental impact statement (PEIS) issued in October 1995 examined alternatives for producing tritium. In the Record of Decision (ROD) issued December 5, 1995 for the PEIS, the DOE determined that over the next three years it would follow a dual-track acquisition strategy. Under that strategy, the DOE would further investigate and compare two options for producing tritium: (1) purchase an existing commercial light-water reactor or irradiation services with an option to purchase the reactor for conversion to a defense facility; and (2) design, build, and test critical components of an APT system (LANL 1996, 62339, p. 1). In December 1998, the Secretary of Energy announced the decision to select the reactor technology as the primary production option while retaining APT technology as an alternative option.

The EA analyzed the potential environmental effects that would be expected to occur if DOE designed, built, and tested critical prototypical components of the accelerator system for tritium production, specifically the low-energy, front-end section of the accelerator at the Laboratory. LEDA is a prototype of the low-energy, front-end of the linac to be used in an APT plant. LEDA must be capable of producing a proton beam of 20 MeV to 40 MeV energy and a current level of 100 mA to 200 mA and must be capable of sustained continuous operation. LEDA consists of a proton injector, a radio-frequency quadrupole (RFQ) accelerator, two sections of coupled-cavity drift-tube linac (CCDTL), a diagnostic beam line, and beamstops. The LEDA facility also includes beam diagnostics and a computer control system. The actual APT plant accelerator, to be located at Savannah River Site, would require a proton beam of up to 1800 MeV, which represents a 45- to 90-fold increase over the LEDA beam energy. Thus, LEDA is not a prototype for the complete, full-scale APT plant. LEDA is located in existing Building MPF-365, which is located on the north rim of Sandia Canyon (LANL 1996, 62339, p. 3).

The LEDA project consists of five stages. Stages I through IV operate in a continuous mode during their operating periods. Stage I consists of installing and testing a 75-keV, 110-MeV proton injector. In Stage II, a 350 MHz RFQ accelerator is added to accelerate a 100-mA proton beam to 7 MeV. In Stage III, a 700 MHz CCDTL is added to further accelerate the 100-mA proton beam to 20 MeV. In Stage IV, additional CCDTL modules are added to raise the final energy of the 100-mA proton beam to 40 MeV. Optional Stage V consists of adding a second parallel apparatus similar to that of Stage III and a beam combiner called a “funnel.” The funnel would combine the two 350-MHz, 100-mA, 20-MeV proton beams into a single 700 MHz, 200-mA, 20-MeV proton beam. This beam then may be accelerated with CCDTL modules to an energy as high as 30 MeV in continuous mode or to an energy as high as 40 MeV in pulsed mode. The LEDA project is scheduled to last about seven years. The near-term LEDA project objective was to complete Stage II and a substantial portion of Stage III before the Secretary’s decision, announced in December 1998.

The EA addressed the potential impacts of the LEDA project with respect to the following: utility demands, air, human health, ER, waste management, transportation, water, threatened and endangered species, wetlands, cultural resources, and environmental justice (LANL 1996, 62339, pp. ii through iii, 28 through 32, and 44). These potential impacts are described below.

- Utility demands. The project requires additional electricity, natural gas, and water that is provided by proposed and existing on-site support facilities.

- Air. The project will result in a slight increase in nonradioactive air emissions as a result of normal LEDA project operations and increased support facility activities. However, these air emissions will not exceed ambient air quality standards. Radioactive air emissions from accelerator operations at TA-53 are expected to remain relatively constant.

- Human health. The project will slightly increase the worker, co-located worker, and public dose from activated air products released from the LEDA building exhaust stack. However, no additional cancer fatalities in the population within 50 mi (80 km) of the Laboratory are expected to result from the LEDA project.

- ER. The Laboratory’s ER Project has identified 12 PRSs in the canyon area downgradient of the NPDES-permitted outfall (EPA 03A-113) that is to be used for the LEDA project. Two of these PRSs contain concentrations of contaminants above SALs and have been proposed for VCA. PRS 72-001 is a small firing range used by the Laboratory’s security force and is recommended for deferred action until the site is decommissioned. A stormwater pollution prevention plan for the firing range was being developed to prevent lead-shot migration to the nearby Sandia Canyon stream channel when the EA was completed in 1996. PRS 72-001 is discussed in detail in Section 2.3.6 of this work plan. An area of lead shot associated with PRS 53-014 was identified within part of the drainage channel below NPDES outfall EPA 03A-113. The lead shot, approximately 2 mm to 4 mm (0.08 to 0.16 in.) in diameter, is scattered on the soil surface in several locations. PRS 53-014 was the subject of a VCA and is discussed in detail in this section of this work plan. PRS 3-056(c), a material storage area, has undergone partial remediation for PCB contaminants as discussed in Section 2.3.1 of this work plan. A plan currently is in development to remediate this site to a cleanup level of 1 ppm for PCBs. Analysis of sediment samples obtained from below the EPA 03A-113 outfall indicate that PCBs have not migrated downstream at levels above the analytical detection limits. However, trace concentrations of PCBs were detected in the sediments of the main Sandia Canyon channel downgradient of the confluence with the EPA 03A-113 outfall channel, but not within the EPA 03A-113 outfall channel, which may indicate the migration of PCBs from an upgradient source location, possibly upper Sandia Canyon.

- Waste management. The LEDA project would generate construction and demolition debris, and other solid waste, nonradioactive, treated cooling water, asbestos waste, hazardous waste, and solid and liquid low-level radioactive waste. Construction and demolition debris would be disposed of in the Los Alamos County-municipal landfill. Treated cooling water would be discharged through NPDES outfall 03A-113. Asbestos and hazardous wastes would be managed on-site for off-site disposal. Low-level radioactive waste would be managed on-site by the Laboratory's waste management system.

- Transportation. No transportation accidents are likely.

- Water. Discharged cooling water could produce surface flow in Sandia Canyon during the third through seventh years of the LEDA project. The LEDA project is expected to discharge a total of 187 million gal. (710 million L) of "noncontact" cooling water to NPDES outfall 03A-113 over a 7-year period. Sandia Canyon sediments within the existing stream channel have no known radionuclides, heavy metals, or organics above SALs or detection limits that would move downstream. The alluvium in this section of Sandia Canyon below TA-53 has a water-holding capacity of approximately 33 million gal. (125 million L). Cooling towers discharge approximately 35 million gpd (125 million L/yr) of water to the ground at TA-53. Cooling towers at Building MPF-365 are permitted to discharge 2.7 million gpd (10.3 million L/yr) to NPDES outfall 03A-113; however recent discharges have been much less than expected. During 1995, the Laboratory's NPDES permit required annual sampling of all outfalls for compliance with NMWQCC standards for Section 2111, Interstate and Intrastate Streams. NPDES outfall 03A-113 met Section 2111 requirements for livestock watering and wildlife habitats.

- Threatened and endangered species. No effects on threatened and endangered species or their critical habitat have been identified.

- Wetlands. The increased discharge could produce saturated substrate conditions in Sandia Canyon. However other characteristics necessary to create a wetland are not expected to develop during the LEDA project.

- Cultural resources. No effects on cultural resources have been identified.

- Environmental justice. The proposed action would not result in any changes to current conditions.

The EA for the LEDA was approved, and a finding of no significant impact (FONSI) was issued by the DOE on April 1, 1996 (DOE 1996, 62338, p. 1).

2.3.5 Former TA-20

Former TA-20, now located partly within TA-53 and partly within TA-72, was used during the Manhattan Project by Group G-10 to test initiators (devices that generate neutrons to initiate nuclear explosions). Later, it was used briefly by Group M-4 for other types of implosion tests. The site consisted of a series of firing areas that were spaced along a small road heading west from state road NM4, the only access route (LANL 1994, 34756, p. 2-1).

The first facilities, constructed in the fall of 1944, included a guard post (TA-20-31), a gun facility (TA-20-16), a recovery bin (TA-20-10), two storage buildings TAs-20-18 and -19), and the "hot storage" shack (TA-20-11), an assembly building. Firing tests began at TA-20 in February 1945. By March 1945, additional areas, which included a small side canyon to the north, were being developed. Initiators of various designs were tested, either by implosion or by impaction against a target, to determine the most effective design for emission of neutrons. One test method involved placing the device inside a 3-in. (8-cm)-diameter metal sphere that was imploded with either 25 lb or 200 lb (11 kg or 90 kg) of explosives, and then recovering the crushed initiator for study. Another method was to fire the device from a smooth-bore US Navy gun into a recovery bin, or from a 20-mm (0.8-in.) gun into a target, as various measurements were taken. Many geometries were tried, as were various materials in thin layers or foils. Major components for the devices included polonium-210, beryllium, and nickel; and steel, aluminum, and beryllium for the spheres (LANL 1994, 34756, pp. 2-1 through 2-2).

In March 1945, several buildings were constructed to support these operations. These included a control building (TA-20-2) covered by a dirt berm, located across the road just south of the gun facility; a 20-ft by 40-ft (6 m-by 12-m) laboratory east of the gun facility; and a 3-kVa to 10-kVa elevated transformer substation (TA-20-30) just south of the laboratory. An underground conduit system was installed to connect the laboratory to the firing pit (TA-20-6), allowing shots to be detonated from the laboratory. Manholes at various points provided access to the system. A lead sink in the laboratory darkroom was connected to the buildings’ reinforced concrete septic tank (TA-20-27), a structure having interior dimensions of 3 ft by 6 ft by 5 ft (0.9 m by 1.8 m by 1.5 m) deep, located southeast approximately 107 ft (32 m). This tank was abandoned in place in 1948 and subsequently may have been removed (LANL 1994, 34756, p. 2-3).

A timber platform and overhead yoke (TA-20-29), built in February 1945, sat on a short side road leading to manhole TA-20-3. The yoke perhaps was used to lift test assemblies, being near the implosion test areas. The turnaround at the end of the road later became a Group M-4 firing site (LANL 1994, 34756, p. 2-3).

The first implosion test was conducted in a “dumbo,” a 5-ft (1.5-m)-diameter cylindrical steel vessel intended to contain the explosion and make recovery of fragments easier. The dumbo was mounted on a firing pad at one end of a 91-ft (27-m)-long concrete platform (TA-20-7) near the west end of TA-20. The shot, however, badly jammed the entry door on the dumbo. A second dumbo, built at the same time, was never used. Instead, subsequent shots were done in a 12-ft (3.6-m)-deep, 15-ft by 15-ft (4.5-m by 4.5-m) steel-lined firing pit (TA-20-6) at the far west end of the site. The pit was covered with a cage of pipe overlain by steel mats, which was designed to contain the explosion fragments (LANL 1994, 34756, p. 2-3).

Neutron timing tests, conducted in the north side canyon, used a 20-mm (0.8-in.) gun to fire initiators into a steel plate set against the cliff. The facility consisted of a steel framework on a concrete mounting pad in the ”20-mm hutment” (TA-20-44) built in February 1945, and a support building known as the 20-mm-gun building built in April 1945 (LANL 1994, 34756, p. 2-3).

Three magazines (TA-20-12, TA-20-14, and TA-20-45) were built near this side canyon in March and April 1945 for storage of explosives and munitions. They were partly covered with dirt for protection (including TA-20-12, even though it had been built on skids for portability) (LANL 1994, 34756, p. 2-3).

In late 1945, initiator work was transferred to a new site, TA-33. Group M-4 then carried out implosion studies at TA-20 until November 1946. Several tests were done in the vicinity of manhole TA-20-3. Group M-4 probably conducted fewer than 10 tests in all; they mainly used steel spheres, but may have used some uranium as well. Larger shots were rare, but one test using 500 lb (225 kg) of high explosive (HE) underwent a low-order explosion that scattered undetonated HE for a considerable distance. M-4 personnel immediately spent several days cleaning up the area (LANL 1994, 34756, p. 2-4).

TA-20 underwent an intensive radiation-monitoring and cleanup effort in the spring of 1946, during which soil contaminated with polonium was removed. The polonium reportedly came from firing areas, from a former Indian cave in the side canyon where radioactive materials had been stored, and from several material disposal pits. Contaminated items, such as rubber gloves, were found scattered about the area and were removed to a material disposal area at TA-21. Two structures, TA-20-18 (a storage building) and TA-20-17 (the "cut-off shack") also were removed. During 1947, testing was carried out at TA-20 by various experimenters, but the nature of these experiments is not known (LANL 1994, 34756, p. 2-4).

In April 1948, TA-20 was largely decommissioned to make way for a new road through the canyon for access to South Mesa and Los Alamos. Many of the remaining structures were dismantled and removed, including TA-20-10, the dirt-filled bin into which test devices had been fired for later recovery; transformer station TA-20-30; recovery pit TA-20-6; the two dumbos; and magazine TA-20-45. Magazines TA-20-12 and TA-20-14 were deactivated at this time, but were not destroyed until February 1960, when they were burned after having been monitored for HE, radiation, and toxic materials (LANL 1994, 34756, p. 2-4).

A final two-week site cleanup was conducted during the summer of 1948, just before road construction began; it netted 60 lb to 70 lb (27 kg to 32 kg) of HE. The road, first called South Mesa Road, is now East Jemez Road and is also referred to as the "truck route" (LANL 1994, 34756, p. 2-4).

In November 1948, a vehicle security checkpoint and pass office (TA-20-21) was built beside the road near the old 1944 guard post at the east end of former TA-20. The checkpoint was closed in 1957, when public access to Los Alamos became unrestricted. The present-day Laboratory security force small arms firing range (at TA-72) is located on the north side of the former checkpoint and uses one of the old buildings (TA-20-47, now renumbered TA-72-8) (LANL 1994, 34756, p. 2-4).

The Laboratory Safety Group conducted periodic follow-up searches for HE until 1973, when—after four years of finding no HE—they deemed the area safe and removed warning signs. No major activities have taken place at former TA-20 since then except construction and operations at the TA-72 small-arms range. A radiological survey on the remaining TA-20 structures (mainly underground structures such as manholes, pull boxes, and footings) was performed in 1985, and some of the structures were removed at that time. A search for abandoned septic tank TA-20 27 turned up only a depression where the tank should have been (LANL 1994, 34756, p. 2-4).

Contaminants possibly remaining at TA-20, despite the numerous cleanups and removal of structure, include trace quantities of HE, beryllium, uranium, and possibly some strontium-90 from lanthanum-140 sources. Given the short half-lives of polonium-210 and lanthanum-140 (138 days and 40 hours, respectively), it is unlikely that these elements remain at former TA-20 (LANL 1994, 34756, p. 2-5).

The decommissioning of TA-20 in 1948 produced most of the solid wastes generated by the site. Some (probably most) of the waste from dismantling the structures was transported to MDAs at TA-21. Solid wastes disposed of on-site before 1949 consisted mainly of contaminated metal scrap, such as old gun barrels. These are believed to have been dumped into three landfills [PRSs 20-001(a, b, and c)]; one is located near firing site TA-20-7, one near the Navy gun mount (TA-20-16), and one near the cut-off shack (TA-20-17). There is no evidence of other disposal areas at the site. Potential contaminants of concern include beryllium, uranium, and HE (LANL 1994, 34756, p. 2-5).

PRSs located within the Sandia Canyon watershed at former TA-20 have been addressed in the RFI work plan for OU 1100 (LANL 1994, 34756). The NMED issued an NOD for the work plan; the NOD and the Laboratory's response are presented in the response to EPA's NOD for the OU 1100 work plan (LANL 1994, 43889). Of the 16 PRSs at TA-20, 11 were recommended for Phase I investigation and 5 were recommended for NFA in the work plan. PRSs 20-001(a and b), 20-002(a, b, and c), 20-003(b), 20-004, and 20-005 were investigated and subsequently recommended for NFA in the RFI report for PRSs in TA-20, TA-53, and TA-72 (LANL 1996, 54124). PRS 20-001(c) was recommended for additional investigation and PRSs 20-002(d) and 20-003(c) were the subject of VCAs. Investigations at some PRSs are currently in progress.

PRS 20-001(c)Sandia Canyon Landfill Area 3

PRS 20-001(c) is a landfill located at the toe of the mesa slope south of present-day TA-53 and north of East Jemez Road. The landfill was located near a dumbo and its mount [PRS 20-002(b) and structure TA-20-7] at the west end of TA-20 and consisted of an excavated trench in which several 3-in. to 5-in. (8-cm to 13-cm)-bore guns, cut into sections, had been buried. The landfill, which was used from 1945 to 1948, subsequently may have been excavated in 1948. The landfill site, a gently sloping grassy area, has patches of badly weathered asphalt that may be remnants of the original TA-20 access road. The only other evidence of past activities is a 4-ft by 4-ft (1.2-m by 1.2-m) concrete box with a hinged steel lid, most likely a manhole (probably structure TA-20-4) that was used for electrical wiring; and an orange angle-iron stake marking the probable location of structure TA-20-7 (LANL 1994, 43889, pp. 5-1 through 5-3).

Sampling at PRS 20-001(c) was not conducted in the proper location during the Phase I investigation; therefore additional Phase I investigation was proposed in the RFI report for PRSs in TA-20, TA-53, and TA-72 (LANL 1996, 54124). A schedule for implementation of the additional Phase I investigation has not been established.

PRS 20-002(d)—Firing Site

PRS 20-002(d), located south of East Jemez Road near structure TA-20-3 (an electrical conduit manhole that is part of the detonation system), was a firing site used for implosion testing. The site apparently was used for less than 10 shots. However, one shot containing 500 lb (225 kg) of Composition B underwent a low-order explosion (i.e., did not detonate completely) and scattered undetonated HE over a wide area. Two cleanups are related to this incident: one conducted immediately after the incident and a second one that was part of the 1948 Sandia Canyon cleanup, when a crew spent two weeks searching the area and found 60 lb to 70 lb (27 kg to 32 kg) of explosives. An inspection in 1962 located one small (golf-ball size) piece of Composition B near structure TA-20-3. As a result, the area was posted with “Danger – Explosives – Keep Out” signs and the location of structure TA-20-3 was entered into engineering records. Seven subsequent inspections were performed between 1964 and 1975 during which a total of approximately 40 grams (1.4 oz) of explosives were found near structure TA-20-3. Upon finding no explosives during the last three inspections that were performed between 1971 and 1975, a recommendation was made to remove the warning signs (LANL 1994, 43889, pp. 5-21 through 5-22).

During the Phase I investigation, beryllium, cadmium-109, radium-226, strontium-85, strontium-90, uranium-234, uranium-235, and uranium-238 were detected above SALs. PRS 20-002(d) was proposed for VCA to address the COPCs present above SALs. A schedule for the VCA has not been established.

PRS 20-003(c)—Navy Gun Site

PRS 20-003(c) was the subject of a VCA as described in the VCA completion report for PRSs 20-003(c) and 53-010 (LANL 1996, 53794). PRS 20-003(c) was the site of a Navy gun mount between 1945 and 1948. The gun was fired into steel plates set along the nearby canyon walls. The site contained what appeared to be a concrete pad with anchor bolts covered by soil, and debris consisting of conduit and electrical wires. The site is located approximately 90 ft (27 m) north of East Jemez Road in Sandia Canyon. VCA activities were performed from August 20 until September 20, 1995; the site had been cleaned up three times previously: after it was initially closed, before construction of East Jemez Road, and in 1988. The VCA consisted of housekeeping tasks only, and included the demolition and removal of the pad, conduits, a manhole, and miscellaneous metal debris. No chemicals of concern were identified; therefore soils were not removed from the site and confirmatory sampling was not required (LANL 1996, 53794, p. 1-2).

2.3.6 Technical Area 72

TA-72 currently is used as a firing range by the Laboratory security force. This range has been operational since 1966. Structures on this site include a guard house and associated structures from the former TA-20, which were abandoned in 1957 when access to East Jemez Road became unrestricted, and some structures added as part of the firing range. In addition, two Laboratory water supply wells, each with associated facilities (chlorinator and pump station), are located within TA-72 (LANL 1994, 34756, p. 2-9).

Wastes generated at TA-72 included sanitary wastewater, hazardous wastes, and office trash. Sanitary wastewater, generated from restrooms and sinks, is discharged to a septic tank. Hazardous wastes included materials used to clean weapons and solvents used in recirculating systems, the solvents are replaced by a vendor when exhausted. Hazardous wastes, including solvent- and oil-contaminated rags, are collected at a SAA and periodically removed for disposal. Office trash is accumulated in dumpsters and removed to the Los Alamos County-municipal landfill (LANL 1994, 34756, p. 2-9).

One PRS (PRS 72-001) is present at TA-72. PRS 72-001 is described in “RFI Work Plan for Operable Unit 1100” (LANL 1994, 34756) and was proposed for deferred action in the RFI report for PRSs in TA-20, TA-53, and TA-72 (LANL 1996, 54124), and is discussed below.

PRS 72-001—Small Arms Firing Range

TA-72, the site of PRS 72-001, has been operational since 1966 as a small-arms firing range for the Laboratory’s security force. The firing range includes a 175-ft by 250-ft (53-m by 75-m) firing range surrounded by earth berms, an adjacent skeet shooting range, and some administration buildings. Lead is known to be present in the firing range; bullets are scattered around the base of the berms and cliffs. Lead shot from skeet shooting is visible on the ground surface. Sampling was conducted in sediment catchment areas in the drainage downgradient from the site to determine whether lead migration had occurred. No COPCs were present, suggesting that contaminants from the firing range have not migrated. Based on the sampling results and because the firing site currently is active, PRS 72-001 was recommended for deferred action until the site is decommissioned (LANL 1996, 54124, p. 5-39).

2.4 Sources of Potential Contaminants Within Cañada del Buey

Potential contaminant sources (as PRSs) on the mesa tops and within the Cañada del Buey watershed and their current regulatory status are listed in Appendix B of this work plan. The sequence of technical area descriptions, histories, and discussions of their associated PRSs are presented with respect to their approximate geographic location from west to east within the Cañada del Buey watershed. The technical areas and PRSs that are discussed in this section are shown in detail on Figure A-1 in Appendix A of this work plan. Technical areas located in the Cañada del Buey watershed that do not contain PRSs within the watershed are neither described nor included in this section.

The information compiled in this section is based on available reports and data as of circa November 1998. Additional and updated information about the status of PRSs can be obtained from the Laboratory’s ER Project office and/or the Community Reading Room in Los Alamos, New Mexico, as described in

Section 7.2.2 of "Installation Work Plan for Environmental Restoration Project" (LANL 1998, 62060, p. 7-3).

2.4.1 Technical Area 52

TA-52 is located on the south side of Puye Road at the head of Cañada del Buey. TA-52 was built in the mid-1960s to house the ultra-high temperature reactor experiment (UHTREX). The reactor was shut down in February 1970. Since then, the site has housed offices and laboratories used by the Energy Division and its successor, the Nuclear Technology and Engineering Division, and a classified document disposal operation (LANL 1992, 7666, p. 3-108).

Three principal structures exist at TA-52. The UHTREX building (TA-52-1), which housed the reactor, consists of the reactor containment area and areas outside the main containment area, which include the ground-floor level, the operations level, and a basement. This building currently houses the Nuclear Technology and Engineering Division offices and laboratories. The second main building at TA-52 is the mechanical assembly building (TA-52-11), which houses the document shredding facility. TA-52-33 is used for research and support. Other buildings at TA-52 are used primarily for office space (LANL 1992, 7666, p. 3-108).

Other structures at TA-52 include the waste neutralization and pumping facility, TA-52-2, in which acid wastes from UHTREX were treated; the filter pit, TA-52-1, in which the helium reactor coolant, possibly contaminated with fission products, was passed through a subgrade bank of high-efficiency particulate air (HEPA) and charcoal filters; and the heat-dump building and pad, TAs-52-15 and -16, which contained coils and fans for cooling the helium reactor coolant (LANL 1992, 7666, p. 108).

PRSs located within the Cañada del Buey watershed at TA-52 have been addressed in "RFI Work Plan for Operable Unit 1129" (LANL 1992, 7666) and in "Addendum to the OU 1129 RFI Work Plan" (Pratt 1994, 39932). All PRSs located within the Cañada del Buey watershed at TA-52 were recommended for NFA in the work plan or in the addendum to the work plan; therefore Phase I investigation has not been required for these sites.

2.4.2 Former Technical Area 4

Former TA-4 is located partially within the current boundaries of TA-52 along Puye Drive. Former TA-4 is located on a small finger mesa that is bound on the north by Ten Site Canyon and on the south by Cañada del Buey. Alpha Site, a firing site, was located at the former site of TA-4, which was abandoned in the late 1940s (LANL 1992, 7666, p. 3-2).

Alpha Site was established in 1944 to provide a test firing site for small charges. Alpha Site was used as a firing site for implosion studies using the "electric" method of detonation wave determination. The maximum charges fired were 200 lb (90 kg). Other studies at Alpha Site included smaller tests of the "pin shot" and "magnetic" methods of studying implosions and "equation of state" experiments. Alpha Site was abandoned in 1946. In 1955, TA-4 structures were surveyed for radioactivity and all but the darkroom and laboratory (TA-4-7) were found to be free of detectable radioactive contamination. The contaminated floor was removed and the building subsequently released along with all other Alpha Site structures, which were removed in 1956 (LANL 1992, 7666, p. 3-5).

PRSs located within the Cañada del Buey watershed at former TA-4 have been addressed in "RFI Work Plan for Operable Unit 1129" (LANL 1992, 7666) and the addendum to the OU 1129 RFI work plan (Pratt 1994, 39932). Only three PRSs at TA-4 are located within the Cañada del Buey watershed. PRS C-4-001 was recommended for NFA in the addendum to the work plan. PRSs 4-003(a) and 4-004 have been the subject of Phase I investigation and are described below.

PRSs 4-004 and 4-003(a)—Soil Contamination and Outfall

PRS 4-004 is an area of potential soil contamination at the site of the former darkroom and laboratory building TA-4-7. This building was used to develop photographic film of firing tests from approximately 1948 to 1955. The building was removed from the site in 1956. This site now is located just inside the northwest TA-52 fence corner. PRS 4-003(a) is a former photo-processing outfall that discharged from TA-4-7 to a trench that drained to the head of Cañada del Buey. Portions of the probable path of the outfall trench have since been covered by two buildings (TAs-52-114 and -115) and an asphalt parking lot.

Initial Phase I field activities at PRSs 4-004 and 4-003(a) were conducted in 1995. Thirty-one surface and subsurface soil samples were collected from ten locations and analyzed for radionuclides, metals, SVOCs, and VOCs. Most of the analyses were performed by a mobile chemistry laboratory. Due to data quality issues, supplemental Phase I sampling was proposed. In 1998, 29 additional surface and subsurface soil samples were collected from 10 locations. All 29 samples were analyzed by a contract laboratory for inorganics, SVOCs, and HE; 2 subsurface samples were also analyzed for VOCs.

Contaminants detected at concentrations above background values (BV) in the 1995 samples were arsenic, chromium, lead, plutonium-238 and -239, and pentachlorophenol. Data from the 1995 and 1998 sampling events and conclusions and recommendations for PRSs 4-003(a) and 4-004 are planned to be presented in a future RFI report.

2.4.3 Technical Area 46

Former Operable Unit 1140 covers approximately 270 ac (1.1 km^2) spread across the head of Cañada del Buey and extending south across Mesita del Buey into Pajarito Canyon. Laboratory operations have been conducted only in the developed complex at TA-46 where laboratories, office buildings, warehouses, and storage facilities are clustered in an area of approximately 50 ac (200,000 m^2) atop Mesita del Buey (LANL 1993, 20952, p. 2-1).

TA-46 is bounded on the north by Cañada del Buey. A sewage lagoon and filter beds are located on the point of the mesa at the eastern end of the site. A small tributary to Cañada del Buey, informally known as SWSC Canyon, originates near the southern end of TA-46 and drains northeast to Cañada del Buey. The main Laboratory sanitary waste treatment plant (the SWSC treatment plant) was constructed in 1992 and is located in this small tributary canyon, which is also informally called the TA-46 tributary. South of SWSC Canyon is a detached cluster of buildings and two sewage ponds. Pajarito Road extends along the southern boundary of TA-46 (LANL 1993, 20952, p. 2-1).

TA-46 was established in 1954 as a weapons assembly (WA) site; Building TA-46-1, a three-story laboratory building, was built for that purpose. The building was never used for assembling weapons, Instead, TA-46 housed the Nuclear Rocket (N) Division’s Rover Program to develop nuclear reactors for propulsion of space rockets. Other laboratory buildings were added in the mid-1950s. Experiments included coolant-flow and structural testing of fuel elements made of uranium-loaded graphite, which sometimes were tested until they failed. Hazardous materials used for the program included beryllium, beryllium oxide, cadmium nitrate, uranium-235, uranium-238, thorium, nickel carbonyl (in a closed system), and organic compounds. Mercury was used in equipment such as vacuum pumps. The Rover Program terminated in 1973 (LANL 1993, 20952, p. 2-1).

By 1976, Applied Photochemistry (AP) Division research groups at TA-46 established the Jumper Program to develop uranium-isotope separation methods. This program used lasers to excite hexafluoride gas of various enrichments. Uranium-237 (6.75-day half-life) served as a tracer. In 1978 the laser isotope enrichment building, TA-46-154, was built. The Jumper Program was terminated in the early 1980s. Laser research remains a principal activity at TA-46 (LANL 1993, 20952, p. 2-3).

Also in the 1970s, groups in the Energy (Q) Division conducted programs in support of solar energy, constructing experimental solar buildings and solar ponds east of TA-46-158. When the solar program ended in the late 1980s, the ponds were converted to sanitary waste lagoons. Other activities conducted at TA-46 included free-electron laser research, heat-pipe research, accelerator technology, electronics development, and production of nonradioactive isotopes of oxygen, carbon, and nitrogen. These activities generated little waste other than cleaning solvents such as trichloroethylene, 1,1,1-trichloroethane, and acetone (LANL 1993, 20952, p. 2-3).

PRSs located within the Cañada del Buey watershed at TA-46 have been addressed in “RFI Work Plan for Operable Unit 1140” (LANL 1993, 20952). The NMED issued an NOD for the work plan; the NOD and the Laboratory’s response are presented in “Response to Notice of Deficiency (NOD) for OU 1140 RCRA Facility Investigation (RFI) Work Plan” (LANL 1994, 40381). Of the 69 PRSs identified at TA-46, 51 were recommended for Phase I investigation and 18 were recommended for NFA in the work plan (LANL 1993, 20952). In the RFI report for PRSs in TA-46 (LANL 1996, 54929), PRSs 46-004(b, b_2, c_2, and d_2), 46-004(h, m, u, v, x, y, and z), 46-006(a, b, c, e, f, and g), 46-007, 46-008(b), 46-010(d), and C-46-002 were investigated and subsequently recommended for NFA, and PRSs 46-004(a_2), 46-004(g, q, and s), and 46-006(d) were investigated and subsequently recommended for Phase II investigation. Phase I investigations have not been conducted at PRSs 46-002, 46-003(a through g), 46-004(c, d, e, f, p, r, t, and w), 46-005, 46-008(a, d, e, f, and g), 46-009(a and b), and C-46-001. PRS 46-003(h) was the subject of a VCA conducted in 1994. Table 2.4.3-1 summarizes PRSs not yet investigated; PRSs that are proposed for Phase II investigation or have been the subject of VCA activities are discussed below.

PRS 46-003(h)—Outfall

PRS 46-003(h) was the subject of a VCA as described in the VCA completion report for a SWMU 46-003(h) (LANL 1996, 62341). PRS 46-003(h) is an inactive outfall that once served a sink in TA-46-77. TA-46-77 was constructed in the 1960s as a warehouse for general storage. The building now serves as a welding and machine shop facility. VOCs, SVOCs, and metals may have been discarded in the sink. The outfall was plugged in 1994. Phase I sampling was conducted from August to November 1994. Three soil samples were collected near the outfall discharge location. All samples were analyzed for inorganic and SVOCs; two of the three samples were analyzed for VOCs. A common plasticizer, bis(2-ethylhexylphthalate), was detected in two of the samples at concentrations of 0.42 and 1.1 mg/kg, which are below the SAL of 32 mg/kg. Toluene was detected in one sample at a trace concentration of 0.005 mg/kg, which is below its SAL of 1900 mg/kg. Table 2.4.3-2 summarizes inorganics detected in the soil samples. Cadmium, copper, and lead were identified as the COPCs for the site (LANL 1996, 62341, p. 1-6).

In a 3.5-ft by 4-ft (1-m by 1.2-m) area beneath the outfall, 1 yd^3 (0.76 m^3) of soil was removed to a depth of 0.5 ft (0.15 m). The lead cleanup level for industrial soil of 1000 mg/kg was adopted, as recommended by EPA Region 6. Proposed cleanup levels for cadmium (850 mg/kg) and copper (63,000 mg/kg) was adopted from the EPA Region 9 preliminary remediation goals (PRGs) for industrial soil. Two confirmatory samples were collected from within the excavated area and analyzed for inorganics and VOCs. Copper, mercury, and zinc were detected in the two confirmatory soil samples at concentrations exceeding background UTL values, but far below industrial cleanup levels. Methylene chloride was detected in one confirmatory soil sample. Table 2.4.3-3 summarizes the constituents detected in the confirmatory soil samples. Site restoration activities included backfilling, regrading, and reseeding the excavated area (LANL 1996, 62341, pp. 6 through 7).

Table 2.4.3-1
PRSs Awaiting Phase I Investigation at TA-46

PRS	Description	Potential Contaminants
46-002	Lagoon system, outfall	Metals; mercury; thorium; plutonium-238, -239/240; uranium-235, -238; VOCs; SVOCs; PCBs
46-003(a)	Septic system, outfall	Metals; mercury; thorium; uranium-235, -238; VOCs; SVOCs; PCBs
46-003(b)	Septic system	VOCs; SVOCs
46-003(c)	Septic system	Metals; mercury; uranium-235, -238; VOCs; SVOCs; PCBs
46-003(d)	Septic system	Metals; thorium; plutonium-238, -239/240; uranium-235, -238; asbestos; VOCs; SVOCs; PCBs
46-003(e)	Septic system	Metals; plutonium-238, -239/240; uranium-235, -248; VOCs; SVOCs
46-003(f)	Septic system, surface release, outfall	Metals; mercury; uranium-234, -235, -238; cesium-137, americium-241; SVOCs; VOCs; PCBs; pesticides
46-003(g)	Septic system, outfall	Metals; activation products; VOCs; SVOCs; PCBs
46-004(c)	Dry well	Metals; thorium; uranium-235, -238; asbestos; VOCs; SVOCs; PCBs
46-004(d)	Dry well	Metals; mercury; thorium-230; plutonium-238, -239/240; uranium-235, -238; VOCs; SVOCs; PCBs
46-004(e)	Dry well	Metals; mercury; thorium-230; plutonium-238, -239/240; uranium-235, -238; VOCs; SVOCs; PCBs
46-004(f)	Industrial drain outfall	Metals; mercury; uranium-235, -238; VOCs; SVOCs; PCBs
46-004(p)	Dry well	Metals; asbestos; VOCs; SVOCs
46-004(r)	Industrial drain outfall	Metals; mercury; uranium-235, -238; VOCs; SVOCs; PCBs
46-004(t)	Outfall	VOCs
46-004(w)	Outfall	VOCs; SVOCs; PCBs; oils
46-005	Lagoon system, outfall	Metals; uranium-235,-238; activation products; VOCs; SVOCs; PCBs
46-008(a)	Container storage area	Metals; VOCs; SVOCs
46-008(d)	Container storage area	Metals; uranium-235, -238; VOCs; SVOCs; oils
46-008(e)	Container storage area	Metals; uranium-235, -238; VOCs; SVOCs; PCBs; oils
46-008(f)	Container storage area	Metals; uranium-235, -238; VOCs; SVOCs; oils
46-008(g)	Container storage area	VOCs; SVOCs; PCBs; oils
46-009(a)	Landfill	Metals; thorium-230; uranium-235, -238; plutonium-239/240; cesium-137; asbestos; VOCs; SVOCs; PCBs
46-009(b)	Landfill	Metals; thorium; uranium-235, -238; plutonium-238, 239/240; asbestos; VOCs; SVOCs; PCBs
C-46-001	Surface release	Mercury

Source: LANL 1993, 20952, Chapter 5.

Table 2.4.3-2
Inorganics Detected at Concentrations Exceeding Background UTL Values or SALs in Phase I Soil Samples at PRS 46-003(h)

Sample ID	Depth (ft)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9508	1	**62.8**[a]	*149* [b]	**7640**	**902**	*12.2 (J)*[c]	*70.3*	*62.5*	*1130*
AAA9509	0.5	<0.66	5.7	*37*	17.3	*0.75 (J)*	<4.6	<1.7	*114*
AAA9510	1	<0.83	4.4	*18.2*	*24.2*	*0.57 (J)*	<3.6	<0.55	*186*
SAL	n/a[d]	38	210	2800	400	23	1500	380	23000
UTL	n/a	2.7	19.3	15.5	23.3	0.1	15.2	ND[e]	50.8

Source: LANL 1996, 62341, p. 3.

[a] Bold = result above SAL.

[b] Italics = result above background UTL value.

[c] J = estimated value.

[d] n/a = not applicable.

[e] ND = not determined.

Table 2.4.3-3
Inorganics and Organics Detected at Concentrations Exceeding Background UTL Values in VCA Confirmatory Soil Samples at PRS 46-003(h)

Sample ID	Depth (ft)	Cu (mg/kg)	Hg (mg/kg)	Zn (mg/kg)	Methylene Chloride (mg/kg)
46-96-0001	0–0.5[a]	*36*[b]	*0.21*	*160*	*0.0095*
46-96-0002	0–0.5	12	*0.22*	*70*	Not detected
SAL	n/a[c]	2800	23	23000	11
UTL	n/a	15.5	0.1	50.8	ND[d]

Source: LANL 1996, 62341, p. 8.

[a] Below excavated surface.

[b] Italics = result above background UTL value.

[c] n/a = not applicable.

[d] ND = not determined.

Although Phase I data indicate that contaminant concentrations were below the established cleanup levels before initiation of VCA activities, a cleanup was considered best management practice. Evaluation of the confirmatory sample data indicate that no contaminants were detected above the established cleanup levels; therefore PRS 46-003(h) subsequently is recommended for NFA (LANL 1996, 62341, p. 5).

PRS 46-004(a_2)—Industrial Drain

PRS 46-004(a_2) has been proposed for Phase II investigation as described in the RFI report for PRSs at TA-46 (LANL 1996, 54929). PRS 46-004(a_2) was the outfall (informally labeled MM) from sinks and floor drains in the southeast quadrant of TA-46-31. Historical information indicates that fissionable materials were used in several rooms in TA-46-31. The outfall was a 6-in. (15-cm)-diameter cast iron pipe located midway up a steep, 20-ft (6-m)-high slope. The pipe discharged to a shallow ditch located between the slope and the asphalt paving west of TA-46-25. The ditch is part of a storm drain network serving the northeastern quadrant of TA-46. From the outfall, the ditch lead approximately 50 ft (15 m) to a culvert that discharges to the steep slope of Cañada del Buey at outfall I. All lines leading to this outfall have been rerouted to the SWSC facility. Outfall MM is plugged and inactive (LANL 1996, 54929, p. 99).

During the Phase I investigation, 12 soil samples were collected from 9 locations below the outfall and in the drainage that discharges into Cañada del Buey. All samples were analyzed for radionuclides, inorganics, SVOCs, PCBs, and pesticides; 6 of the 12 samples were analyzed for VOCs. Eight inorganic constituents were detected above background UTL values but below SALs. Table 2.4.3-4 summarizes the Phase I inorganic data. Trace levels of uranium and plutonium isotopes were detected above background UTL values. Table 2.4.3-5 summarizes the Phase I radionuclide data (LANL 1996, 54929, pp. 99 through 107).

Table 2.4.3-4
Inorganic Analytes Detected at Concentrations
Exceeding Background UTL Values in Phase I Soil Samples at PRS 46-004(a_2)

Sample ID	Depth (ft)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9067	1	<0.1 (R)[a]	6.6	14.6	17 (J)[b]	*0.42*[c]	<4.9	<1.2	*91.5*
AAA9068	1.5	<0.07 (R)	13	7.8	8.7 (J)	<0.12	<8.5	<1.3	*59.2*
AAA9070	1	<0.07 (R)	5.5	<2.9	8.2 (J)	*0.51 (J)*	<5.1	<1.1	31.4
AAA9070D[d]	1	<0.07 (R)	5.4	4.1	9.5 (J)	*0.36 (J)*	5.2	1.2	35.4
AAA9071	2	<0.07 (R)	3	<1.5	4.3 (J)	*0.51 (J)*	<3.8	<0.78	43.5
AAA9073	1	<0.15	4.4	14.9	16.1	*1.2*	<3.3	<0.67	*100*
AAA9076	1	<0.44	2.6	13.4	16.3	<0.1	2.5	<0.67	*98.9*
AAA9076D	1	<0.12	3	13.7	14.5	<.0.11	<2.1	<0.11	*102.7*
AAA9077	1.5	<0.07	4.9	11	10.3	<0.11	<3.2	<0.12	*69.1*
AAA9100	0.3	<0.36	5.6	*21.4*	*23.9*	*0.44*	<4.3	<0.13	*183*
AAA9100D	0.3	0.23	12.7	*20.3*	19.8	*0.32*	12.5	<0.13	*144*
AAA9103	0.7	<0.07	<1.9	<2.8	14.8	<0.12	*23.7*	<0.12	31.1
AAA9323	0.5	<0.51	4.5	*36*	23.2	0.07	3.5	<2.2	*164*
AAA9323D	0.5	0.46	3.4	*32.7*	*67.6*	<0.04	<3.5	<2.2	*122*
AAA9326	0.3	2	8.9	*174*	*28.8*	*0.19*	<5.5	<2.3	*328*
AAA9329	0.5	*6*	*41*	*1610*	*157*	*0.4*	13	3.3	*2620*
SAL	n/a[e]	38	210	2800	400	23	1500	380	23000
UTL	n/a	2.7	19.3	15.5	23.3	0.1	15.2	ND[f]	50.8

Source: LANL 1996, 54929, p. 102.

[a] R = rejected value.

[b] J = estimated value.

[c] Italics = result above background UTL value.

[d] D = duplicate analysis.

[e] n/a = not applicable.

[f] ND = not determined.

Table 2.4.3-5
Radionuclides with Activities Greater than Background UTL Values in Phase I Soil Samples at PRS 46-004(a_2)

Sample ID	Depth (ft)	U-234 (pCi/g)	U-235 (pCi/g)	Pu-238 (pCi/g)
AAA9067	1	0.4875 (J)[a]	0.0293 (J)	*0.0352 (J)*[b]
AAA9068	0.5	0.3561 (J)	0.0154 (J)	*0.0232 (J)*
AAA9070	1	0.1604 (J)	0.0085 (J)	*0.0479 (J)*
AAA9071	2	0.1409 (J)	0.0104 (J)	*0.0297 (J)*
AAA9073	1	0.1254	0.0089	*0.0313*
AAA9103	0.7	0.6549 (J)	0.0489 (J)	*0.0251*
AAA9323	0.5	1.4	*0.1313*	NA[c]
AAA9329	0.5	*1.98*	*0.0914*	NA
SAL	n/a[d]	13	10	27
UTL	n/a	1.94	0.084	0.014

Source: LANL 1996, 54929, p. 103.

[a] J = estimated value.

[b] Italics = result above background UTL value.

[c] NA = not analyzed.

[d] n/a = not applicable.

Information discovered subsequent to the Phase I field investigation indicates that material most likely to be contaminated was not sampled. Construction work at outfall MM before sampling resulted in some original soil being removed from the ditch and placed on the adjacent bank. Because concentrations of several contaminants were found in samples that may not be representative of the highest contamination in the original soil, PRS 46-004(a_2) is recommended for Phase II investigation; the Phase II SAP is presented in the RFI report for PRSs at TA-46 (LANL 1996, 54929, pp. 99 and 107).

PRS 46-004(g)—Industrial Drain

PRS 46-004(g) has been proposed for Phase II investigation as described in the RFI report for PRSs in TA-46 (LANL 1996, 54929). PRS 46-004(g) consists of ducts and drains from building TA-46-1. Floor and roof drains from the central part of the building drained to manhole TA-46-15 and then discharged to the outfall informally labeled N. The drain is a 12-in. (30-cm)-diameter vitrified clay pipe (VCP) that intersects manhole TA-46-15 and discharges to Cañada del Buey northeast of the building. Building TA-46-2 housed the Rover Fuel Element Research Program between the late 1950s and the early 1970s. Work involved baking and high-temperature testing of fuel rods. Natural and depleted uranium, as well as uranium-235, were used. In 1965, an approved disposal practice involved the release of radioactive liquid waste containing uranium-235 to a drain in Room 8. Work at TA-46-1 involved large quantities of cesium and lithium, and also may have involved thorium. Heat-pipe experiments have been conducted at TA-46-1 since the 1960s. Suspected contaminants included mercury, other inorganics, VOCs, SVOCs, uranium, and thorium. Diverse research projects are still performed in the building. In 1994, drains from the building were reconfigured in the manhole to discharge to the SWSC facility (LANL 1996, 54929, pp. 31, 32, and 34).

During the Phase I investigation, 12 soil samples were collected from 10 locations below the outfall and in the drainage that discharges into Cañada del Buey. All samples were analyzed for radionuclides, inorganics, and SVOCs; 9 of the samples were analyzed for cesium and lithium, 8 of the samples were analyzed for VOCs, and 1 sample was analyzed for PCBs. Ten inorganic constituents were detected at concentrations above background UTL values; five of these constituents were present at levels exceeding SALs. Table 2.4.3-6 summarizes the Phase I inorganic data. Uranium-234, uranium-235, and uranium-238 were detected at concentrations above background UTL values; uranium-234 and uranium-235 were present at levels exceeding SALs. Table 2.4.3-7 summarizes the Phase I radionuclide data. Cesium was detected in 8 of the 9 samples at concentrations ranging from 0.337 mg/kg to 8.59 mg/kg. Lithium was detected in 7 of the 9 samples at concentrations ranging from 2.44 mg/kg to 22.4 mg/kg. No background UTL values exist for cesium and lithium; however the RFI report does not consider these constituents to be present at elevated concentrations (LANL 1996, 54929, pp. 32 through 37).

Table 2.4.3-6
Inorganic Analytes Detected at Concentrations
Exceeding Background UTL Values or SALs in Phase I Soil Samples at PRS 46-004(g)

Sample ID	Depth (ft)	As (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Se (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9163	0.25	2.9	0.77	5.6 (J)[a]	*56.1*[b]	15.3	*0.38 (J)*	10	<0.31	*2.9*	44.7
AAA9166	0.5	4.8	1.5	*19.7 (J)*	*218*	*50.6*	*2 (J)*	*16*	<0.3	*15.6*	*62.2*
AAA9175	0.5	<0.97	2	*63.3 (J)*	*681*	*96.8*	*7.7 (J)*	*23.2*	*4.5*	*23.8*	*162*
AAA9178	0.5	4.8	*4.6*	**281**[c]	*1690*	**474**	**26.6 (J)**	*41.3*	*3.7*	*141*	*261*
AAA9178D[d]	0.5	4.9	*5.3*	*198*	*1675*	**627**	**42.1 (J)**	*53.2*	*4.5 (R)* [e]	<147	*239*
AAA9179	4	5.1	<0.09	3	<6.4	9.1	<0.15 (UJ)[f]	<10.3	<0.74 (R)	<1.1	*59.2*
AAA9181	0.5	9	1.8	*110 (J)*	*831*	*328*	*20.9 (J)*	*21.3*	1.1	*97.1*	*98.4*
AAA9184	0.5	5.9	1.6	*171 (J)*	*787*	*159*	**27.9 (J)**	*23.7*	1.7	*155*	*110*
AAA9187	0.5	<1.7	<0.39	16	*86.3*	**963**	*4.1 (J)*	<6.9	<0.58 (R)	<0.27	*133*
AAA9190	0.5	<1.7	<0.53	*24.3*	*134*	*104*	*1.2 (J)*	<5.7	<0.68 (R)	<1.9	*157*
AAA9193	0.5	7.6	<0.08	*19.5*	<5.9	12.9	*0.39 (J)*	<5.6	<0.69 (R)	<0.42 (R)	38.1
AAA9485	0.5	**8.2**	*12.7*	**807**	**8060**	**705**	**123 (J)**	*217*	*23 (R)*	*178*	*1830*
SAL	n/a[g]	7.82	38	210	2800	400	23	1500	380	380	23000
UTL	n/a	7.82	2.7	19.3	15.5	23.3	0.1	15.2	1.7	ND[h]	50.8

Source: LANL 1996, 54929, p. 35.

[a] J = estimated value.

[b] Italics = result above background UTL value.

[d] Bold = result above SAL.

[d] D = duplicate analysis.

[e] R = rejected value.

[f] UJ = not detected in value reported as estimated.

[g] n/a = not applicable.

[h] ND = not determined.

Table 2.4.3-7
Radionuclides with Activities Greater than Background UTL Values or SALs in Phase I Soil Samples at PRS 46-004(g)

Sample ID	Depth (ft)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
AAA9163	0.25	**20.1**[a]	*0.876*[b]	*1.93*
AAA9166	0.5	**36.5**	*1.26*	1.67
AAA9175	0.5	**71.6**	*2.54*	1.24
AAA9176	4.5	*2.16*	*0.095*	1.14
AAA9178	0.5	**161.9 (J)**[c]	*7.436*	*2.98 (J)*
AAA9178D[d]	0.5	**180.5 (J)**	*7.836*	*3.358 (J)*
AAA9179	4	*2.58 (J)*	*0.1476*	0.5279 (J)
AAA9181	0.5	**471**	*14.1*	*8.62*
AAA9184	0.5	**276**	*8.81*	*3.31*
AAA9187	0.5	*2.438 (J)*	*0.1344*	0.4749 (J)
AAA9190	0.5	*4.971 (J)*	*0.1985*	0.3722 (J)
AAA9193	0.5	**603.3 (J)**	**31.8**	*13.7 (J)*
SAL	n/a[e]	13	10	67
UTL	n/a	1.94	0.084	1.82

Source: LANL 1996, 54929, p. 37.

[a] Bold = result above SAL.

[b] Italics = result above background UTL value.

[c] J = estimated value.

[d] D = duplicate analysis.

[e] n/a = not applicable.

Uranium and inorganics, principally mercury, have accumulated at levels of concern in sediment accumulation areas on the canyon bench. Phase I analytical results indicate that contamination appears to be minimal on the mesa top at TA-46; however, years of runoff may have concentrated contaminants in sediment accumulation areas located below the site in Cañada del Buey. PRS 46-004(g) is proposed for Phase II investigation; the SAP is presented in the RFI report for PRSs in TA-46 (LANL 1996, 54929).

PRS 46-004(q)—Industrial Drain

PRS 46-004(q) has been proposed for Phase II investigation, as described in the RFI report for PRSs in TA-46 (LANL 1996, 54929). PRS 46-004(q) is an outfall consisting of a 6-in. (15-cm)-diameter cast iron pipe that discharges to Cañada del Buey north of TA-46-58. The source of the outfall is unknown; the outfall was treated as an industrial drain for the Phase I investigation.

During the Phase I investigation, five soil samples were collected from five locations below the outfall and in the drainage that discharges into Cañada del Buey. All samples were analyzed for radionuclides, inorganics, VOCs, and SVOCs. Eight inorganic constituents were detected at concentrations above background UTL values; mercury was present at levels exceeding SALs. Table 2.4.3-8 summarizes the Phase I inorganic data. Uranium-234, uranium-235, and uranium-238 were detected at concentrations above background UTL values in one sample; uranium-234 and uranium-235 concentrations also exceeded SALs. Table 2.4.3-9 summarizes the Phase I radionuclide data. Bis(2-ethylhexyl phthalate was detected in three samples at concentrations ranging from 0.37 mg/kg to 1.3 mg/kg (LANL 1996, 54929, pp. 55 through 61).

Table 2.4.3-8
Inorganic Analytes Detected at Concentrations Exceeding Background UTL Values or SALs in Phase I Soil Samples at PRS 46-004(q)

Sample ID	Depth (ft)	Ba (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9043	0.5	*409*[a]	*5.1*	*208*	*76*	**156**[b]	*292*	*7*	*272*
AAA9049	1	<17	<0.26	*1420*	*112*	*1*	11.8	<0.11	*175*
AAA9052	0.5	91.6	2	*51.7*	*37.4*	*3.2*	<4.2	<0.11	*3350*
AAA9061	1	<29.2	<0.09	*16.6*	*51.5*	*0.9*	<2.8	<0.79	*61.8*
AAA9064	1	<31.3	<0.08	*17.1*	*104*	*0.38*	<3.2	<0.94	*59.7*
SAL	n/a[c]	5340	38	2800	400	23	1500	380	23000
UTL	n/a	315	2.7	15.5	23.3	0.1	15.2	ND[d]	50.8

Source: LANL 1996, 54929, p. 58.

[a] Italics = result above background UTL value.

[b] Bold = result above SAL.

[c] n/a = not applicable.

[d] ND = not determined.

Table 2.4.3-9
Radionuclides with Activities Greater than Background UTL Values or SALs in Phase I Soil Samples at PRS 46-004(q)

Sample ID	Depth (ft)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)
AAA9043	0.5	**228.3 (J)**[a,b]	**42.03 (J)**	*16.66 (J)*[c]
SAL	n/a[d]	13	10	67
UTL	n/a	1.94	0.084	1.82

Source: LANL 1996, 54929, p. 37.

[a] Bold = result above SAL.

[b] J = estimated value.

[c] Italics = result above background UTL value.

[d] n/a = not applicable.

Mercury and uranium were retained as COPCs for PRS 46-004(q). Contaminants at levels of concern appear to be concentrated at the outfall. PRS 46-004(g) is proposed for Phase II investigation; the SAP is presented in the RFI report for PRSs in TA-46 (LANL 1996, 54929).

PRS 46-004(s)—Outfalls

PRS 46-004(s) has been proposed for Phase II investigation, as described in RFI report for PRSs at TA-46 (LANL 1996, 54929). PRS 46-004(s) comprises two outfalls (one informally named outfall X and one unnamed outfall) from floor drains in TA-46-1. Outfall X served a trench and floor drain in Room 133 of the south high bay of TA-46-1. The unnamed outfall served the utility trench in Room 131. The outfalls are 4-in. (10-cm)-diameter cast iron pipes that discharged from the south side of TA-46-1. The floor and roof drains in the south high bay discharged to outfall X, an area scraped to near-bedrock. Effluent flowed a few feet to a ditch (PRS 46-007) that is part of a storm drain network discharging to Cañada del Buey. The unnamed outfall is buried. Both drains reportedly are plugged.

During the Phase I investigation, five soil samples were collected from five locations below outfall X and in the drainage below outfall X. The unnamed outfall was not sampled during the Phase I investigation. All samples were analyzed for inorganics, SVOCs, PCBs, and pesticides; four of the five samples were analyzed for radionuclides and VOCs. Seven inorganic constituents were detected at concentrations above background UTL values, but below SALs. Table 2.4.3-10 summarizes the Phase I inorganic data. No radionuclides were detected at levels above background UTL values. PAHs, several above SAL, were detected but were not carried forward in the screening process. The presence of the PAHs is attributed to continuing sources such as asphalt paving and roofing tar from the large exposure areas at TA-46.

Table 2.4.3-10
Inorganic Analytes Detected at Concentrations
Exceeding Background UTL Values in Phase I Soil Samples at PRS 46-004(s)

Sample ID	Depth (ft)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9273	0.5	*44.6*[a]	*67.5*	*0.29 (J)*[b]	<4.5	<0.5	*84.5*
AAA9274	0.5	*16.6*	*23.8*	*0.21 (J)*	<3.9 (R)[c]	<2.4	34.6
AAA9275	1	*22.3*	*61.8*	*0.66*	<4.5	<3.2	42.2
AAA9275D[d]	1	*19.7*	*4837*	*0.64*	4.5	*0.58*	39.1
AAA9278	0.5	*30.2*	*40.9*	*1.1 (J)*	<5.2 (R)	<0.48	49.5
AAA9281	0.5	*291*	*46.9*	*11.5 (J)*	*25.9 (J)*	*9.1*	*470*
SAL	n/a[e]	2800	400	23	1500	380	23000
UTL	n/a	15.5	23.3	0.1	15.2	ND[f]	50.8

Source: LANL 1996, 54929, p. 64.

[a] Italics = result above background UTL value.

[b] J = estimated value.

[c] R = rejected value.

[d] D = duplicate analysis.

[e] n/a = not applicable.

[f] ND = not determined.

No COPCs were retained for PRS 46-004(s) based on the results of the Phase I investigation at outfall X. However, the Phase I investigation is incomplete, as sampling was not conducted at the location of the unnamed outfall. Therefore PRS 46-004(s) is proposed for Phase II investigation; the SAP is presented in the RFI report for PRSs at TA-46 (LANL 1996, 54929).

PRS 46-006(d)—Surface Disposal Area

PRS 46-006(d) has been proposed for Phase II investigation, as described in the RFI report for PRSs at TA-46 (LANL 1996, 54929). PRS 46-006(d) is an unpaved surface disposal area located along the north side of TA-46-31. Before the Phase I investigation was conducted, the boundary of PRS 46-006(d) was extended to include the area north of laboratory building TA-46-58. TA-46-31 is a large laboratory building where many types of experiments have been conducted since 1944. It now houses laser and chemistry experiments. Oils and possibly other materials were spilled (or dumped) behind TA-46-31 by personnel stationed in the building. The 1986 CEARP survey included mention of 55-gal. (209-L) drums; old cans; rusty chemical storage units; a thick layer of oil on the back porch; and evidence of oil spills all along the canyon side. The 50-ft by 350-ft (15-m by 75-m) unpaved area is level 5 ft to 15 ft (1.5 m to 4.5 m) north of TA-46-31, and then drops steeply toward the TA-46 perimeter fence. The 500-ft by 100-ft (150-m by 30-m) area north of TA-46-58 is similar. Beyond the perimeter fence, the ground drops sharply 60 ft (18 m) into Cañada del Buey. An engineering drawing indicates a wash down-drain from Room 111A in TA-46-31 that discharges onto PRS 4-006(d) (LANL 1996, 54929, pp. 156 through 157).

PRS 46-006(d) was included in the 1989 DOE investigation of potentially hazardous sites at the Laboratory as Environmental Problem 25. Six soil grab samples were collected and analyzed for VOCs, SVOCs, inorganics, radionuclides, and pesticides. Inorganics detected above background and the maximum concentration for each are as follows: copper (179 mg/kg), mercury (20.3 mg/kg), silver (3.5 mg/kg), uranium (89 mg/kg), and zinc (341 mg/kg). QC reports from the analytical laboratory indicated that data on SVOCs were imprecise due to interferences caused by very high oil concentrations in all samples. PCBs were detected at a maximum concentration of 6.2 mg/kg (LANL 1993, 20952, pp. 5-85 through 5-88; LANL 1996, 54929, p. 157).

During the Phase I investigation, 34 surface and subsurface soil samples were collected from 25 locations behind Buildings TA-46-31 and TA-46-58 and in relevant drainages on the steep slope north of TA-46. Several hand-augered samples were collected from under asphalt. All samples were analyzed for radionuclides, inorganics, and SVOCs; 26 samples were analyzed for VOCs, and 27 samples were analyzed for PCBs and pesticides. Cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc were detected at concentrations above background UTL values; cadmium, copper, and mercury were present at levels exceeding SALs. Table 2.4.3-11 summarizes the Phase I inorganic data. Uranium-234, uranium-235, and uranium-238 were detected at concentrations above background UTL values in one sample; uranium-234 and uranium-235 concentration levels also exceeded SALs. Table 2.4.3-12 summarizes the Phase I radionuclide data. Bis(2-ethylhexyl phthalate was detected in three samples at concentrations ranging from 0.37 mg/kg to 1.3 mg/kg (LANL 1996, 54929, pp. 55 through 61). PCBs were detected at various sampling points within PRS 46-006(d) and points receiving runoff from the PRS. Table 2.4.3-13 summarizes the Phase I PCB data. Low levels of two PAHs and three pesticides were reported for this PRS. The PAHs and pesticides are believed to be derived from continuing sources such as asphalt paving, roofing tar, and routine pesticide spraying, and therefore were not carried forward in the screening process.

Multiple inorganics and PCBs were detected at concentrations exceeding SALs, and radionuclides were detected above background UTL values at PRS 46-006(d). Contamination appears spotty but widespread at the site. PRS 46-006(d) is proposed for Phase II investigation; the SAP is presented in the RFI report for PRSs at TA-46 (LANL 1996, 54929).

Table 2.4.3-11
Inorganic Analytes Detected at Concentrations Exceeding Background UTL Values Or SALs in Phase I Soil Samples at PRS 46-006(d)

Sample ID	Depth (ft)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Hg (mg/kg)	Ni (mg/kg)	Ag (mg/kg)	Zn (mg/kg)
AAA9055	1	<0.78	2.4	<4.5	17.2	*0.14*[a]	<3.3	<0.8	30.8
AAA9058	0.5	<0.77	2.2	5.8	19.6	*4.5*	<3.2	<0.79	*52.2*
AAA9059	1	<0.75	<1.9	<3.3	*29.1*	*0.93*	<3.2	<0.77	31.5
AAA9067	1	<0.1 (R)[b]	6.6	14.6	17 (J)[c]	*0.42 (J)*	<4.9	<1.2	*91.5*
AAA9068	1.5	<0.07(R)	13	7.8	8.7 (J)	<0.12	<8.5	<1.3	*59.2*
AAA9070	1	<0.07(R)	5.5	<2.9	8.2 (J)	*0.51 (J)*	<5.1	<1.1	31.4
AAA9070D	1	<0.07(R)	5.4	4.1	9.5 (J)	*0.36 (J)*	5.2	*1.2*	35.4
AAA9071	2	<0.07(R)	3	<1.5	4.3 (J)	*0.51 (J)*	<3.8	<0.78	43.5
AAA9073	1	<0.15	4.4	14.9	16.1	*1.2*	<3.3	<0.67	*100*
AAA9076	1	<0.44	2.6	13.4	16.3	<0.1	2.5	<0.67	*98.9*
AAA9076D[d]	1	<0.12	3	13.7	14.5	<0.11	<2.1	<0.11	*102.7*
AAA9077	1.5	<0.07	4.9	11	10.3	<0.11	<3.2	<0.12	*69.1*
AAA9100	0.3	<0.36	5.6	*21.4*	*23.9*	*0.44*	<4.3	<0.13	*183*
AAA9100D	0.3	0.23	12.7	*20.3*	19.8	*0.32*	12.5	<0.13	*144*
AAA9103	0.7	<0.07	<1.9	<2.8	14.8	<0.12	23.7	<0.12	31.1
AAA9121	1.5	<0.08	7	<4.8	10.8	*0.72*	<5.9	<0.11	37.6
AAA9122	3.5	<0.07	9.3	6.2	11.9	*0.44*	13.6	<0.12	32.4
AAA9124	0.5	<0.09	8.3	<4.6	9.4	*0.37*	<7.4	<0.19	41.4
AAA9127	0.5	<0.24	3.4	8.3	12.3	*1.6*	<7.2	<0.14	33.5
AAA9130	0.5	<0.07	<1.4	<2.2	5.6	*0.34*	<1.9	<0.12	27.2
AAA9139	0.5	0.08	1.3	1.16	3.9	*1.6*	1.5	<0.11	23.7
AAA9139D	0.5	<0.12	<1.6	<0.99	4.6	*3.3*	9.6	NA[e]	24.5
AAA9142	0.5	<0.07	<2.1	<2.2	7.2	*0.56*	<2.2	<0.12	18.9
AAA9313	0.5	<0.09	7.6	<5.2	12.5	*0.82 (R)*	<5.2	<0.32	48.7
AAA9440	0.5	0.06	2.7	1.7	7.8	*0.28*	2.7	*0.11*	31.2
AAA9465	0.5	0.35	4.9	*152*	*335*	*0.47 (R)*	4	*3.5*	*317*
AAA9465D	0.5	<0.38	5.3	*158*	**403**[f]	*0.47 (R)*	<4.2	*4.6*	*337*
AAA9469	0.5	2.1	14.8	*43.5*	*57.7*	*11.1 (R)*	<7.9	*2.8*	*109*
AAA9482	0.5	<0.23	9.9	13.2	12.3	*13.3 (R)*	<6.7	<0.37	*62.1*
AAA9483	4	<0.07	6.4	<2.6	4.6	*1.5 (R)*	<5	<0.46	23.2
AAA9488	1	<0.07	5.2	11.3	11.4	*4.1 (R)*	<4.8	<00.37	*54.3*
AAA9493	7	<0.91	3.3	<2.3	5.6	0.08 (R)	<3.9	<2.5	19.9
AAA9495	0.5	<0.69	<1.9	5.3	13.7	*7.2 (R)*	<1.7	<2.1	38.4
AAA9496	0.5	**46.8**	*34.6*	**4830**	*169*	**48.7 (R)**	*492*	*97.4*	*1590*
AAA9497	0.5	1.1	4.4	*34.4*	*61*	*12.9 (R)*	<1.7	<2.2	*201*
SAL	n/a[g]	38	210	2800	400	23	1500	380	23000
UTL	n/a	315	2.7	15.5	23.3	0.1	15.2	ND[h]	50.8

Source: LANL 1996, 54929, p. 168.

[a] Italics = result above background UTL value.

[b] R = rejected value.

[c] J = estimated value.

[d] D = duplicate analysis.

[e] NA = not analyzed.

[f] Bold = result above SAL.

[g] n/a = not applicable.

[h] ND = not determined.

Table 2.4.3-12
Radionuclides with Activities Greater than Background UTL Values in Phase I Soil Samples at PRS 46-006(d)

Sample ID	Depth (ft)	U-234 (pCi/g)	U-235 (pCi/g)	Pu-238 (pCi/g)
AAA9067	1	0.4875 (J)[a]	0.0293 (J)	*0.0352 (J)* [b]
AAA9068	1.5	0.3561 (J)	0.0154 (J)	*0.0232 (J)*
AAA9070	1	0.1604 (J)	0.0085 (J)	*0.0479 (J)*
AAA9071	2	0.1409 (J)	0.0104 (J)	*0.0297 (J)*
AAA9073	1	0.1254	0.0089	*0.0313*
AAA9103	0.7	0.6549 (J)	0.0489 (J)	*0.0251*
AAA9127	0.5	0.6411 (J)	0.0252 (J)	*0.0225 (J)*
AAA9130	0.5	0.1976 (J)	0.0165 (J)	*0.0244 (J)*
AAA9139D[c]	0.5	0.181 (J)	0.0217 (J)	*0.0229 (J)*
AAA9139	0.5	0.213 (J)	0.0618 (J)	*0.0268 (J)*
AAA9142	0.5	0.2449 (J)	0.0159 (J)	*0.0182 (J)*
AAA9313	0.5	0.841	0.017	*0.029`*
AAA9440	0.5	0.2139 (J)	0.0097 (J)	*0.0246 (J)*
AAA9469	0.5	0.905	0.0819	*0.0256*
AAA9475	0.5	0.85	0.0395	*0.0307*
AAA9482	0.5	0.76	0.0467	*0.0142*
AAA9488	1	0.636	0.0236	*0.0701*
AAA9491	0.5	0.813	0.0602	*0.0257*
AAA9491D	0.5	NA[d]	NA	*0.0414*
AAA9492D	5	NA	NA	*0.0431 (J)*
AAA9495	0.5	1.08	0.0573	*0.0596*
AAA9496	0.5	*4.6*	*0.175*	*0.0453*
AAA9497	0.5	0.636	0.0236	*0.023*
SAL	n/a[e]	13	10	27
UTL	n/a	1.94	0.084	0.014

Source: LANL 1996, 54929, p. 164.

[a] J = estimated value.

[b] Italics = result above background UTL value.

[c] D = duplicate analysis.

[d] NA = not analyzed.

[e] n/a = not applicable.

Table 2.4.3-13
PCBs Detected at Concentrations Exceeding Background
UTL Values or SALs in Phase I Soil Samples at PRS 46-006(d)

Sample ID	Depth (ft)	Aroclor 1260 (mg/kg)	Aroclor 1254 (mg/kg)
AAA9073	1	**1.95**[a]	ND[b]
AAA9323	0.7	*0.37 (J)* [c,d]	ND
AAA9326	0.3	*0.056 (J)*	*0.15*
AAA9329	0.5	*0.2 (J)*	*0.18 (J)*
AAA9469	1	ND	**21.3**
AAA9496	0.5	ND	**22.0**
AAA9497	0.5	ND	**1.2**
AAA9502	0.5	**43.4**	Not detected
SAL	n/a[e]	1	1
UTL	n/a	0.021	0.021

Source: LANL 1996, 54929, p. 165.

[a] Bold = result above SAL.

[b] ND = not determined.

[c] Italics = result above background UTL value.

[d] J = estimated value.

[e] n/a = not applicable.

2.4.4 Technical Area 51

TA-51 currently is the base of operations for the Experimental Engineering Test Facility (EETF), which supports research to develop effective isolation techniques for the burial of wastes in semiarid climates. The EETF was built in 1980; staff support offices were constructed in 1986 (LANL 1992, 7669, p. 1-26). The EETF currently supports research in waste-cover and stabilization alternatives, land reclamation, and contaminant movement. It includes two sets of research caissons that are used to study the movement of water through various cover materials and tuff (LANL 1992, 7669, p. 2-7).

PRSs located within the Cañada del Buey Canyon watershed at TA-51 have been addressed in “RFI Work Plan for Operable Unit 1148” (LANL 1992, 7669). Of the five PRSs at TA-51, one was recommended for Phase I investigation and four were recommended for NFA in the work plan. PRSs 51-002(a and b) (the research caissons), PRS C-51-001 (former drummed soil), and PRS C-51-002 (former explosives magazines) were recommended for NFA in the work plan and consequently were not the subject of Phase I investigation. However, sediment samples collected during the investigation of MDA J at TA-54 were obtained from locations that may contain sediment originating from areas which drain the PRSs associated with TA-51 (LANL 1996, 54462, p. 52). Discussion of the MDA J sediment investigation is presented in Section 2.4.5.3 of this work plan. PRS 51-001 was the subject of Phase I investigation and is summarized below.

PRS 51-001—Septic System

PRS 51-001 is an inactive septic system that provided service to the offices of the EETF. Structures comprising this PRS include TA-51-3, a 1000-gal. (8300-L) septic tank, and TA-51-31, a seepage pit. The seepage pit is 4 ft (1.2 m) in diameter and 50 ft (15 m) deep. The septic tank is connected to the seepage pit by a 4-in. (10-cm)-diameter VCP buried in a 2.5-ft (0.75-m)-deep trench. The VCP connects to a 4-in. (10-cm)-diameter, perforated polyvinyl chloride drop pipe that extends to within 2 ft (0.6 m) of the bottom of the pit. The pit is backfilled with screened gravel. The system was installed in 1983 to serve the Environmental Research Laboratory (TA-51-11) and the Environmental Science Laboratory (TA-51-12). Transportable offices for the Laboratory's Health Physics Policy and Programs Group (TAs-51-25, -26, and -27) were connected to the septic system when they were placed at TA-51 in 1986 (LANL 1992, 7669, p. 2-282).

PRS 51-001 became inactive when service was transferred to the SWSC facility during the early 1990s. The Phase I investigation was designed to confirm the absence of a release associated with the septic system (LANL 1992, 7669, p 2-282). The Phase I field investigation for PRS 51-001 was conducted in November and December 1995. Two surface grab samples of sludge were collected and analyzed for VOCs. One composite sludge sample was collected and analyzed for metals, cyanide, SVOCs, pesticides, and PCBs, and gross-alpha, -beta, and -gamma radiation. Two soil samples were collected from the associated seepage pit and analyzed for metals, cyanide, SVOCs, VOCs, pesticides, and PCBs, and gross -alpha, -beta, and -gamma radiation. The results of the investigation are planned to be presented in a future RFI report.

2.4.5 Technical Area 54

TA-54 is located on Mesita del Buey, which is bounded by Cañada del Buey on the north and lower Pajarito Canyon on the south. TA-54 contains four MDAs (G, H, J, and L); the nondestructive testing (NDT) program, which supports verification and certification of TRU waste to be transported to the Waste Isolation Pilot Plant (WIPP); a former radiation exposure facility and former animal holding facility; and supporting offices. Security fences enclose the four MDAs. PRSs associated with MDAs G, J, and L and the NDT program are located within the Cañada del Buey watershed. PRSs associated with MDA H are located in the Pajarito Canyon watershed and therefore are not considered potential sources for the purpose of the Cañada del Buey investigation. PRSs located within the Cañada del Buey watershed at TA-54 have been addressed in "RFI Work Plan for Operable Unit 1148" (LANL 1992, 7669). The NMED issued an NOD for the work plan; the NOD and the Laboratory's response are presented in "Response to the Notice of Deficiency (NOD) regarding the Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1148" (LANL 1993, 15296).

2.4.5.1 TA-54 West

A radiation exposure facility located in the western part of TA-54 was in operation from 1962 to the mid-1970s. The facility was used for biomedical research on the exposure of animals to radiation. The radiation sources were removed when research was terminated. Currently, the facility is used for research of animal exposure to nitrogen oxides. An animal holding facility was constructed in the mid-1960s in what is now the western part of TA-54. The facility housed animals used by the Laboratory's biomedical research program until the late 1980s. In 1992, the facility was being remodeled as an analytical laboratory for environmental samples (LANL 1992, 7669, p. 2-2).

The NDT facility was built to conduct final verification testing and certification of TRU waste that will be transported to the WIPP facility. Certification procedures include the use of NDT techniques such as real-time radiography, passive-active neutron assay, and ultrasonics. The operations will verify the physical composition of the waste inside the package; verify the specific identity and quantity of radioactive contaminants; and provide certification of waste that requires no further processing and meets WIPP waste acceptance criteria (LANL 1992, 7669, pp. 2-2 through 2-4, and 2-7).

PRSs located within the Cañada del Buey Canyon watershed at TA-54 have been addressed in “RFI Work Plan for Operable Unit 1148” (LANL 1992, 7669). Of the six PRSs at TA-54 West, three were recommended for Phase I investigation and three were recommended for NFA in the work plan. PRSs 54-007(c, d, and e) are septic systems that were proposed for Phase I investigation and are discussed below.

PRSs 54-007(c, d, and e)—Septic Systems

PRSs 54-007(c, d, and e) are septic systems that became inactive in the early 1990s when service was transferred to the SWSC facility.

PRS 54-007(c) formerly served office building TA-54-34 and the NDT facility (TA-54-38). Structures comprising PRS 54-007(c) include a 2000-gal. (7600-L) septic tank and a seepage trench constructed with 4-in. (10-cm)-diameter drain tile. The seepage trench also received sanitary and animal waste from the former animal holding facility through the PRS 54-007(e) septic system. There is no indication that radioactive or hazardous wastes were disposed of through the system (LANL 1992, 7669, pp. 5-282 and 5-288).

PRS 54-007(d) provided service to the former radiation exposure facility. The septic system includes a 972-gal. (3700-L) tank (TA-54-4) that is connected to a trench with 4-in. (10-cm)-diameter drain tile. The system was installed in 1962 at the time of the construction of the radiation exposure facility. Structures at the facility that were connected to the septic system are the former radiation exposure building (TA-54-1), the lift building (TA-54-2), the control building (TA-54-3), and the former dog holding facility (TA-54-7). The radiation exposure facility conducted research on the exposure of animals to gamma radiation from cobalt-60 sources. The research was conducted from 1962 to the mid-1970s. The three cobalt-60 sources (10 Ci, 100 Ci, and 1000 Ci) were removed when the radiation exposure research was completed. From the mid-1970s to the mid-1980s, structures at the former radiation exposure facility were used to house animals including mice, dogs, sheep, miniature swine, and cows. These animals were used in biomedical research on exposure to fiberglass, oil-shale dust, and oil-shale retort gases. Animal wastes routinely were removed from the facility for disposal in a sanitary landfill. PRS 54-007(d) received sanitary and animal waste. There is no indication that radioactive or hazardous waste was disposed of through the septic system (LANL 1992, 7669, p. 5-288).

PRS 54-007(e) provided service to the former animal holding facility. The septic system includes a 1500-gal. (5700-l) septic tank that is connected to a seepage trench formed by two parallel buried lines of 4-in. (10-cm)-diameter tile. The seepage trench also is connected to the septic tank in PRS 54-007(c) that provides service to an office building and the NDT facility. The septic system was installed in the mid-1960s during construction of the animal holding facility (TA-54-15). Animals were last held at the facility in 1987. The septic system received sanitary and animal waste. There is no indication that radioactive or hazardous wastes were disposed of through the system (LANL 1992, 7669, p. 5-288).

PRSs 54-007(c, d, and e) became inactive when service was transferred to the SWSC facility during the early 1990s. The Phase I investigation was designed to confirm the absence of a release associated with these septic systems (LANL 1992, 7669, p 2-282). Phase I field investigations were conducted at PRSs 54-007(c, d, and e) in November 1995. At each of the three septic systems, two surface grab samples of sludge were collected and analyzed for VOCs. One composite sludge sample was collected and analyzed for metals, cyanide, SVOCs, pesticides and PCBs, and gross-alpha, -beta, and -gamma radiation. Four soil samples were collected from the associated drainage trenches and analyzed for metals, cyanide, SVOCs, VOCs, pesticides and PCBs, and gross -alpha, -beta, and -gamma radiation. The results of the investigation are planned to be presented in a future RFI report.

2.4.5.2 MDA G

MDA G is the low-level waste (LLW) disposal area for the Laboratory and has been in use since 1957. MDA G also is used to store low-level, mixed, TRU, and TRU-mixed waste and will continue to store such wastes in support of the newly constructed area at TA-54 West for NDT of TRU waste. The north side of Mesita del Buey at MDA G is incised by multiple drainages that flow into adjacent Cañada del Buey, which is approximately 110 ft (33 m) below the mesa at this location (LANL 1992, 7669, pp. 2-1 and 3-1).

MDA G is a 65-ac (260,000-m^2) site containing several waste storage domes, a liquid-waste sump, a septic tank leach field, a solid waste compactor, four TRU-waste storage pads, 34 disposal pits, 174 shafts, and 4 subsurface TRU-waste trenches (LANL 1997, 55873, p. 3). In earlier years the site received a variety of waste types including some liquid hazardous and mixed wastes. Until 1971, no attempt was made to segregate waste by pits (Rogers 1977, 5707; Rogers 1977, 5708, p. G-10). Pits vary in size but, in general, are 200 ft by 60 ft (60 m by 18 m) and approximately 60 ft (18 m) deep. Three pits currently receive LLW, and one is receiving asbestos wastes; the remainder of the pits have been closed and capped with a layer of crushed tuff, and are not visible on the surface. Shafts are typically 6 ft (1.8 m) in diameter and 60 ft (18 m) deep and receive wastes that require special packaging (for example, tritium), special handling (for example, highly activated metals), or segregation (for example, PCB-contaminated waste). Many shafts currently receive waste. The TRU-waste trenches are between 200 ft and 300 ft (60 m and 90 m) long, 13 ft (4 m) wide, and 6 ft (1.8 m) deep. All these trenches have been closed and are covered with crushed tuff. The history of disposal practices at MDA G and old photographs from Laboratory archives are contained in “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Waste (Areas A, B, C, D, E, F, G, and T)” (Rogers 1977, 5707; Rogers 1977, 5708).

MDA G contains 24 PRSs; each PRS is composed of groups of disposal pits or shafts. Because of their proximity to each other and the common method of disposal, all PRSs were treated as a single aggregate for the purpose of characterization (LANL 1996, 54462, p. 3). Definitions of individual PRSs by pit and shaft numbers are provided in Sections 5.4.1.2.1.3 and 5.4.1.2.1.4 of “RFI Work Plan for Operable Unit 1148” (LANL 1992, 7669).

Documented historical releases at MDA G are limited. Three fires occurred at MDA G between 1960 and 1976. One fire that occurred on September 16, 1960, in Pit 1 burned most of the exposed waste before the fire was discovered. Another fire was reported in Pit 3 on November 21, 1964, which resulted in burned boxes and detectable alpha activity in the smoke. On April 14, 1976, a flame several feet high was observed in Pit 24 for several seconds, but no contamination from the burning waste was detectable (Rogers 1977, 5707; Rogers 1977, 5708, pp. G-102 through G-103).

A drum ruptured while workers were attempting to recover a pump from a pit; consequently three trucks and three dumpsters were contaminated. Because of this incident, a request for a decontamination (truck washing) pit was made, and Pit 19 was excavated in April 1971. Pit 19 first began receiving waste under its new definition as a decontamination pit on November 21, 1975 (Rogers 1977, 5707; Rogers 1977, 5708, p. G-40). Because of limited archival information, the extent of releases at the decontamination pit, PRS 54-013(b), is unknown.

During a visual site inspection, stains were reported on soil at PRS 54-015(a), which is a drum storage area where TRU-waste drums are stored before being sprayed with a corrosion inhibitor (LANL 1992, 7669, p. 5-202).

Surface contamination by plutonium-238, -239, and -240 has been reported around the disposal pits (PRSs 54-017 and 54-018) and around the disposal shafts (PRSs 54-019 and 54-020). This surface contamination may have resulted from fires caused by mixing incompatible wastes or from releases from vehicles hauling wastes to the pits and shafts (LANL 1992, 7669, p. 5-202).

A report investigating the hydrologic characteristics of the vadose zone at MDAs G and L was developed in response to a compliance order/schedule (Docket Number NMHWA 001007) issued to the Laboratory by the NMEID under the authority of New Mexico's Hazardous Waste Management Act. Beginning in 1985, eighteen 100-ft to approximately 135-ft (30-m to 40 m)-deep boreholes were drilled into the Bandelier Tuff from the top of Mesita del Buey, and approximately 1700 ft (510 m) of core were obtained. In addition, a 60-ft (18-m) borehole was drilled near a surface impoundment at MDA L. Selected core samples were analyzed for numerous parameters, and hydrologic testing and geophysical logging were performed in the boreholes. Selected boreholes were completed for pore-gas sampling, neutron-moisture monitoring, and psychrometer installation. In addition to the boreholes drilled from the top of the mesa, holes were drilled in the adjacent canyons to investigate possible alluvial aquifers. The assessment of the hydrologic investigation suggests that vapor-phase transport is the predominant mechanism controlling the potential subsurface movement of contaminants at MDAs G and L. Low moisture content of the underlying rock and observed high moisture-retention values indicated that there is no interconnection or movement of liquid water in the interval of the Bandelier Tuff examined during the assessment (International Technology Corporation 1987, 8998, pp. 1 through 2).

The proposed RFI characterization strategy for the MDAs includes the analysis of samples from several transport pathways, including surface water, sediment, air, and subsurface vapor. Because of the size, number, complexity, and purpose of the MDAs, potential releases are being investigated in stages, each of which is based on the individual transport pathways. The investigations focus on the MDAs as a whole rather than individual disposal units, such as pits and shafts (LANL 1996, 54462, p. 3).

MDA G and the surrounding mesa and canyons are monitored by Laboratory environmental surveillance groups for chemical releases by way of surface water runoff, sediment transport, air pathways, and soil vapor in the subsurface (LANL 1996, 54462, p. 3). Supplemental MDA G environmental surveillance sampling has been conducted annually since 1993 by ESH-19 personnel to provide data for existing radioactive (and other constituent) contamination in surface soils, sediments, and surface-water runoff. The data have been used to augment environmental surveillance sampling and to provide data for the RFI at TA-54. Reports currently are available for the results of surveillance conducted for 1993 through 1995 (Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518).

A series of RFI status reports have been planned to address potential contaminants at the MDAs with respect to the identified transport pathways. To date, the RFI report for channel sediment pathways from MDAs G, H, J, and L, TA-54 (LANL 1996, 54462) and the RFI status report for tritium in surface soils at

MDA G, TA-54 (LANL 1997, 55873) have been completed; the status reports for tritium in the air and surface water pathways at MDA G are in progress. The distributions of other radionuclides, metals, and organic compounds are planned to be reported in other upcoming status reports (LANL 1997, 55873).

The channel sediment pathway report focused on the transport of mesa-top sediments into the adjacent canyons. Topographic maps and aerial photographs were examined and direct field observations were made; 14 drainage channels associated with MDA G were selected for sediment and runoff sampling (LANL 1996, 54462). The drainage divide between Cañada del Buey and Pajarito Canyon is located on the north side of the mesa top, causing most surface runoff from MDA G to flow south into a series of canyon-wall embayments and into Pajarito Canyon. Smaller amounts of surface runoff flow from the east and north sides of MDA G into channels that drain into Cañada del Buey. Six of the fourteen drainage channels associated with MDA G drain into Cañada del Buey. Forty-seven sediment samples were collected from these six channels. All 47 samples were submitted to the mobile radiological analytical laboratory for analysis of gross-alpha, -beta, and -gamma radiation; 24 (plus duplicates) of the 47 samples were submitted to a fixed-site contract laboratory for pesticides, herbicides, PCBs, inorganics, and radionuclides analyses. The reported mobile radiological data ranges are as follows: gross-alpha (0.00 pCi/g to 29.31 pCi/g), gross-beta (0.00 pCi/g to 36.43 pCi/g), and gross-gamma (59.93 pCi/g to 71.55 pCi/g) (LANL 1996, 54462, p. 38). No PCBs were detected in any of the samples submitted to the contract laboratory. Methoxychlor was detected at a maximum concentration of 0.059 mg/kg (LANL 1996, 54462, p. 44). Table 2.4.5-1 presents inorganics concentrations exceeding background UTL values in the samples submitted to the contract laboratory. Location IDs 54-5117, 54-5122, and 54-5125 are all present in drainage G-15, which is a tributary to Cañada del Buey located east of MDA G. Radionuclide concentrations in the samples submitted to the contract laboratory are presented in Table 2.4.5-2. The SAL comparisons and the multiple chemical evaluation suggested that unacceptable risk from inorganic chemicals and radionuclides is unlikely and no COPCs were retained from the screening assessment. Therefore, the RFI report recommended no further evaluation or remediation of the drainage channels adjacent to MDA G (LANL 1996, 54462, p. 46).

Table 2.4.5-1
Inorganics in Sediment with Concentrations
Greater than Background UTL Values (MDA G Drainages into Cañada del Buey)

Location ID	Sample ID	Al (mg/kg)	Ba (mg/kg)	Ca (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Mg (mg/kg)
54-5080	AAB3177	**14600**[a]	125.0	2990	**9.4**	6.7	12100	13.8	2250
54-5093	AAB3159	5040	66.8	1980	17.9	<3.7	5560	10.4	1050
54-5117	AAB3019	3570	62.4	1290	2.2	<2.4	**39000**	7.9	<784
54-5122	AAB3112	7780	**144.0**	2460	5.5	5.9	8290	11.2	1880
54-5125	AAB3113	**12900**	**180.0**	**3520**	8.3	10.1	12200	**14.6**	**2660**
UTL	n/a[b]	11748	144	3336	8.77	9.85	14411	13.84	2313
SAL	n/a	77000	5300	n/a	210	2800	n/a	400	n/a

Source: LANL 1996, 54462, p. 39.

[a] Bold = result above UTL values.

[b] n/a = not applicable.

Table 2.4.5-2
Radionuclides in Sediment with Concentrations Greater than Background or No Calculated Background (MDA G Drainages into Cañada del Buey)

Location ID	Sample ID	Am-241 (pCi/g)	Cs-137 (pCi/g)	Co-60 (pCi/g)	Pu-238 (pCi/g)	Pu-239 (pCi/g)	Po-210 (pCi/g)	Sr-90 (pCi/g)	Tc-99 (pCi/g)	H-3 (pCi/g)	U-235 (pCi/g)	Y-90 (pCi/g)
54-5077	AAB3170	0.005	<0.034	<0.03	**0.005**[a]	0.004	0.7	0.020	<0.2	0.003	0.09	0.02
54-5078	AAB3172	0.01	0.500	<0.08	**0.009**	**0.020**	1.46	.020	<0.2	0.012	0.04	0.02
54-5080	AAB3177	0.025	**0.680**	<0.03	**0.025**	**0.118**	2.54	0.020	0.25	0.046	0.10	0.02
54-5082	AAB3171	0.026	**1.240**	0.23	**0.007**	**0.073**	2.11	0.290	<0.2	0.016	0.11	0.29
54-5085	AAB3158	0.008	0.270	<0.06	**0.013**	0.015	2.01	0.08	<0.2	0.022	0.07	0.08
54-5085	AAB3166	0.007	0.360	<0.07	**0.012**	**0.021**	2.05	0.240	<0.2	0.018	0.08	0.24
54-5086	AAB3155	0.007	<0.034	<0.06	**0.006**	0.012	1.53	0.060	<0.2	0.027	0.08	0.06
54-5088	AAB3156	0.006	<0.034	<0.03	**0.006**	0.007	1.11	<0.008	<0.2	0.013	0.05	0
54-5090	AAB3154	0.008	0.340	<0.07	**0.010**	0.015	1.84	0.050	<0.2	0.024	0.07	0.05
54-5093	AAB3159	0.123	<0.034	<0.07	**0.059**	**0.194**	1.68	0.150	<0.2	0.067	**0.13**	0.15
54-5094	AAB3161	0.036	<0.034	<0.04	**0.020**	**0.068**	1.4	0.060	<0.2	0.041	0.07	0.06
54-5095	AAB3157	0.066	0.320	<0.03	**0.033**	**0.163**	1.1	0.040	<0.2	0.053	0.06	0.04
54-5096	AAB3164	0.145	0.430	<0.05	**0.176**	**0.423**	2.14	0.220	<0.2	0.045	0.08	0.22
54-5101	AAB3178	0.024	<0.034	<0.05	**0.236**	**0.064**	1.22	0.070	<0.2	0.05	0.04	0.07
54-5102	AAB3168	0.027	0.250	<0.04	**0.242**	**0.065**	1.05	**3.000**	<0.2	0.017	0.06	-0.09
54-5103	AAB3163	0.014	<0.034	<0.04	**0.182**	**0.045**	1.44	0.110	<0.2	0.025	0.11	0.11
54-5104	AAB3169	0.055	<0.034	<0.06	**1.483**	**0.171**	2.31	<0.008	<0.2	0.029	0.06	-0.02
54-5108	AAB3117	0.011	<0.034	<0.02	0.026	**0.029**	1.84	0.110	<0.2	0.022	0.10	0.11
54-5110	AAB3127	0.02	0.480	<0.09	**0.073**	**0.087**	2.22	0.190	<0.2	0.023	0.08	0.19
54-5111	AAB3116	0.013	0.380	<0.04	**0.027**	**0.033**	1.52	1.40	<0.2	0.012	0.10	0.14
54-5113	AAB3167	0.024	**1.120**	<0.06	0.044	**0.089**	2.18	0.380	<0.2	0.013	0.08	0.38
54-5117	AAB3109	0.109	**0.670**	<0.04	**0.183**	**0.582**	1.96	0.040	<0.2	0.067	0.03	0.04
54-5118	AAB3111	0.056	0.420	<0.09	**0.011**	**0.046**	2.09	0.120	<0.2	0.043	0.07	0.12
54-5122	AAB3112	0.041	<0.034	<0.05	0.001	**0.360**	1.97	0.090	<0.2	0.039	0.11	0.09
54-5122	AAB3110	0.04	**0.570**	<0.01	**0.151**	**0.153**	1.6	0.010	<0.2	0.06	0.11	0.01
54-5125	AAB3113	0.105	**1.300**	<0.03	**0.006**	0.008	3.09	0.350	<0.2	0.107	0.07	0.35
UTL	n/a[b]	n/a	0.504	n/a	0.0047	0.0195	n/a	0.896	n/a	n/a	0.117	n/a
SAL	n/a	22	5.1	1.1	27	24	63	4.4	28	260	10	4.4

Source: LANL 1996, 54462, p. 39.

[a] Bold = result above UTL values.

[b] n/a = not applicable.

Tritium activity in surface soils and sediments has been evaluated as described in the RFI status report for tritium in surface soils at MDA G, TA-54 (LANL 1997, 55873). The data presented in the status report were compiled from data collected by the routine Environmental Surveillance Program from 1993 to 1996, because the surveillance data satisfy the requirements of the RFI work plan for OU 1148 (LANL 1992, 7669). The data were not collected specifically for the RFI work plan or for RCRA purposes. The RFI report did not propose additional surface soil sampling at MDA G for RFI purposes. After the MDA G series status reports have been completed, a multipathway assessment is planned to be incorporated into a final report. Recommendations regarding any additional site investigations or other RFI-related activities are planned to be deferred to the final evaluation report. Routine environmental surveillance activities will continue to be conducted at MDA G by the Laboratory Environmental Surveillance Program (LANL 1997, 55873, p. 46).

A performance assessment (PA) and composite analysis (CA) were conducted for MDA G in 1997. The purpose of the PA was to determine if LLW has been (and will continue to be) disposed of at MDA G in a manner that will not result in radiation doses to the public that exceed DOE-specified performance objectives. In a complementary fashion, the CA was used to evaluate options for ensuring that in future, exposures from all waste disposed of at MDA G will not impart radiation doses to the public in excess of specified limits. Together, the PA and CA are designed to provide a comprehensive evaluation of the potential radiological exposures to future members of the public from past, present, and future disposals at MDA M. Doses were projected beyond 1000 years after facility closure, which is assumed to occur in 2044. The projected doses for all considered pathways were found to be well below applicable performance objectives (Hollis et al. 1997, 57523).

2.4.5.3 MDA J

MDA J is a 2.7-ac (10,800-m^2) fenced, active disposal area for disposal of administratively controlled waste, for surface storage of nonfriable asbestos, and for land-farming (aeration) of petroleum-contaminated soils. Examples of administratively controlled wastes are classified items such as safes with secured locks, objects with classified shapes, scrap equipment, treated sand from barium sand treatment operations at MDA L, and empty containers. Historically MDA J received wastes that were potentially contaminated with trace quantities of nonreactive HE residues. Other wastes buried in early operations include discarded equipment, asbestos, and residual amounts of hazardous waste (LANL 1992, 7669, p. 5-1). Waste disposal began at MDA J in 1961. Subsurface disposal units at MDA J consist of six pits and four shafts, collectively identified as PRS 54-005. Three of the pits and two of the shafts are active; others are closed and covered with crushed tuff (LANL 1996, 54462, p. 5).

A series of RFI status reports have been planned to address potential contaminants at the MDAs with respect to the identified transport pathways. To date, the RFI report for channel sediment pathways from MDAs G, H, J, and L, TA-54 (LANL 1996, 54462) has been completed and an RFI status report for investigation of contaminant migration in subsurface rock is in preparation. The distributions of potential contaminants in other media such as air, surface water, pore gas, and subsurface water are planned to be reported in other upcoming status reports.

The sediment investigation has been conducted at MDA J as described in the RFI report for channel sediment pathways from MDAs G, H, J, and L, TA-54 (LANL 1996, 54462). The objective and methodology of the investigation were the same as described for MDA G in Section 2.4.5.2. MDA J consists of one PRS and has one significant channel carrying surface runoff into Cañada del Buey to the north. Sediment samples were collected from eight locations along the drainage channel; all eight samples were submitted to the mobile radiological analytical laboratory for analysis of gross-alpha, -beta, and -gamma radiation, and four of the eight samples were submitted to a fixed-site contract laboratory for pesticide, herbicide, PCB, inorganic, and radionuclide analyses. The reported mobile radiological data ranges are as follows: gross-alpha (2.23 pCi/g to 21.42 pCi/g), gross-beta (1.55 pCi/g to 29.23 pCi/g), and gross-gamma (59.93 pCi/g to 64.42 pCi/g) (LANL 1996, 54462, p. A1-9). No PCBs or inorganics were detected in any of the samples submitted to the contract laboratory. Methoxychlor was detected in one sample at a concentration of 0.027 mg/kg. Radionuclide concentrations in the samples submitted to the contract laboratory are presented in Table 2.4.5-3. The SAL comparisons and the multiple chemical evaluation suggested that unacceptable risk from radionuclides is unlikely and no COPCs were retained from the screening assessment. Therefore, the RFI report recommended no further evaluation or remediation of the drainage channel adjacent to MDA J (LANL 1996, 54462, pp. 51 through 56).

Table 2.4.5-3
Radionuclides in Sediment with Concentrations
Greater than Background or No Calculated Background (MDA J Drainage)

Location ID	Sample ID	Am-241 (pCi/g)	Cs-137 (pCi/g)	Po-210 (pCi/g)
54-5136	AAB3151	0.003	**0.740**[a]	1.12
54-5138	AAB3147	0.005	<0.05	1.15
54-5141	AAB3130	0.007	<0.06	1.14
54-5142	AAB3162	0.007	<0.3	1.79
UTL	n/a[b]	n/a	0.504	n/a
SAL	n/a	22	5.1	63

Source: LANL 1996, 54462, p. 55.

[a] Bold = result above UTL values.

[b] n/a = not applicable.

A field investigation of subsurface soils at PRS 54-005 (MDA J) has been completed. Four boreholes were drilled to characterize subsurface contamination. Approximately 18 subsurface samples were collected and submitted to contract laboratories for analysis of various combinations of the following analyte suites: VOCs; SVOCs; PCBs; pesticides; metals; cyanide; gross-alpha, -beta, and -gamma radiation; gamma-emitting radionuclides; and/or tritium. Preliminary data confirm the presence of anthropogenic contamination in the subsurface environment at MDA J. Detailed results of the investigation are planned to be presented in a future RFI status report.

Future investigations of contaminant transport through the air and surface water pathways are planned to be used to determine the impact of MDA J, if any, to Cañada del Buey.

2.4.5.4 MDA L

MDA L, a 2.5-ac (10,000-m^2) facility, includes 4 covered chemical waste disposal pits, 34 covered shafts, and surface storage facilities for chemical-mixed, hazardous, and PCB wastes. The site currently is used for hazardous waste storage and treatment but was used for subsurface disposal of liquid hazardous wastes between the late 1950s and 1985. Early disposal activities resulted in a subsurface volatile organic vapor plume that extends beyond the MDA boundary. The plume is monitored on a quarterly basis in numerous monitoring wells (LANL 1996 54462, pp. 5 through 6). Few surface spills are documented for MDA L, and transport pathways appear limited to migration of chemicals in the subsurface. MDA L comprises a single PRS aggregate, which includes 13 PRSs, for the purpose of RFI investigation (LANL 1996, 54462, p. 6). Surface water runoff from MDA L is directed to a single discharge point through a flume that discharges down the mesa slope into Cañada del Buey (LANL 1992, 7669, p. 5-99).

PRSs located within the Cañada del Buey watershed have been addressed in the RFI work plan for OU 1148 (LANL 1992, 7669). A series of RFI status reports are planned to address potential contaminants at the MDAs with respect to the identified transport pathways. To date, the RFI report for channel sediment pathways from MDAs G, H, J, and L, TA-54 (LANL 1996, 54462) has been completed and an RFI status report for the investigation of subsurface transport of hazardous constituents at MDA L is in preparation. The distributions and transport of other radionuclides, metals, and organic compounds through the air and surface water pathways are planned to be reported in other upcoming status reports (LANL 1997, 55873).

The sediment investigation has been conducted at MDA L as described in the RFI report for channel sediment pathways from MDAs G, H, J, and L, TA-54 (LANL 1996, 54462). The objective and methodology of the investigation were the same as described for MDA G in Section 2.4.5.2. MDA L is a single aggregate and consists of 13 PRSs, including 4 closed disposal pits, 34 closed shafts, and several surface storage units. Runoff is channeled into one drainage from MDA L into a tributary of Cañada del Buey. Sediment samples were collected from eight locations along the drainage channel; all eight samples were submitted to the mobile radiological analytical laboratory for analysis of gross-alpha, -beta, and -gamma radiation. Four of the eight samples were submitted to a fixed-site contract laboratory for pesticides, herbicides, PCBs, inorganics, and radionuclides analyses. The reported mobile radiological data ranges are as follows: gross-alpha (2.25 pCi/g to 30.44 pCi/g), gross-beta (1.38 pCi/g to 28.99 pCi/g), and gross-gamma (61.89 pCi/g to 63.58 pCi/g) (LANL 1996, 54462, p. A1-9). No PCBs were detected in any samples submitted to the contract laboratory. Methoxychlor was detected in three samples at a maximum concentration of 0.063 mg/kg (LANL 1996, 54462, p. 59). Lead was detected in one of the four samples submitted to the contract laboratory at a concentration of 15.3 mg/kg, which exceeds its background UTL value of 13.84 mg/kg. Radionuclide concentrations in the samples submitted to the contract laboratory are presented in Table 2.4.5-1. The SAL comparisons and the multiple chemical evaluation suggested that unacceptable risk from inorganic chemicals and radionuclides is unlikely and no COPCs were retained from the screening assessment. Therefore, the RFI report recommended no further evaluation or remediation of the drainage channels adjacent to MDA L (LANL 1996, 54462, pp. 59 through 61).

Table 2.4.5-4
Radionuclides in Sediment with Concentrations
Greater than Background or No Calculated Background (MDA J Drainage)

Location ID	Sample ID	Am-241 (pCi/g)	Pu-238 (pCi/g)	Po-210 (pCi/g)
54-5143	AAB3134	0.009	**0.006**[a]	1.88
54-5145	AAB3179	0.006	0.003	1.23
54-5147	AAB3149	0.004	**0.005**	1.5
54-5148	AAB3138	0.009	**0.011**	1.43
UTL	n/a[b]	n/a	0.0047	n/a
SAL	n/a	22	27	63

Source: LANL 1996, 54462, p. 59.

[a] Bold = result above UTL values.

[b] n/a = not applicable.

A field investigation of subsurface soils and vapor measurements at MDA L has been completed. Objectives of the investigation were to determine if chemicals present in the subsurface VOC vapor plume were migrating from the subsurface units, and to collect data to investigate the possibility of active extraction as a method of remediating the subsurface VOC vapor plume. Eighteen boreholes were drilled to characterize the plume deep below MDA L and east of MDA L near the disposal units. Approximately 172 core samples were collected and submitted to contract laboratories for analysis of various combinations of the following analyte suites: VOCs, SVOCs, PCBs, pesticides, herbicides, metals, cyanide, total uranium, and/or tritium. The data were analyzed in a progression of comparison tests. Chemicals with concentrations greater than background and chemicals with no background levels were evaluated for their migration potential. Preliminary data confirm the release of low-level tritium and significant amounts of VOCs from the pit, impoundments, and/or shaft disposal environments. Preliminary recommendations propose continued vapor monitoring of VOC plume constituents, no further characterization of the distribution of subsurface contaminants, and deferred remedial action until the entire site undergoes RCRA closure. Detailed results of the investigation are planned to be presented in a future RFI status report.

A report investigating the hydrologic characteristics of the vadose zone at MDAs G and L was developed in response to a compliance order/schedule (Docket Number NMHWA 001007) issued to the Laboratory by the NMEID under the authority of New Mexico's Hazardous Waste Management Act. Beginning in 1985, eighteen 100-ft to approximately 135-ft (30-m to 40-m)-deep boreholes were drilled into the Bandelier Tuff from the top of Mesita del Buey, and approximately 1700 ft (510 m) of core were obtained. In addition, a 60-ft (18-m) borehole was drilled near a surface impoundment at MDA L. Selected core samples were analyzed for numerous parameters, and hydrologic testing and geophysical logging were performed in the boreholes. Selected boreholes were completed for pore-gas sampling, neutron-moisture monitoring, and psychrometer installation. In addition to the boreholes drilled from the top of the mesa, holes were drilled in the adjacent canyons to investigate possible alluvial aquifers. The assessment of the hydrologic investigation suggests that vapor-phase transport is the predominant mechanism controlling the potential subsurface movement of contaminants at MDAs G and L. Low moisture content of the underlying rock and observed high moisture-retention values indicated that there is no interconnection or movement of liquid water in the interval of the Bandelier Tuff examined during the assessment (International Technology Corporation 1987, 8998, pp. 1 through 2).

2.4.6 Technical Area 18

TA-18, known as Pajarito Site, is located at the confluence of Pajarito Canyon and Threemile Canyon. The site was first developed in August 1943 during the Manhattan Project by Group P-5, the Radioactivity Group, to study rates of spontaneous fission from samples of radioactive materials. In 1944 Group G-3 took over the site (named Pajarito Canyon Laboratory), enlarged it, and used it as a proving ground to study implosions. Explosives testing ended in late 1945. In April 1946 the site was transferred to the Critical Assemblies Group. Since that time TA-18's history has revolved around critical assembly work.

From 1955 to 1972, fission reactor mockup studies for the Rover Program, a nuclear rocket propulsion program, were conducted at TA-18. Termination of the Rover Program in 1973 resulted in a major downsizing and reorganization of TA-18 personnel. The work shifted to mockups of a plasma-core power reactor, which used fuel elements and beryllium (components left over from the Rover Program), enriched uranium foils, and uranium hexafluoride gas. Criticality work involving reactor safety and later, nuclear detection technologies, continued under various other groups.

TA-18's facilities and expertise in critical assemblies have made it the center of training in criticality safety for the DOE and other institutions. TA-18 presently continues its long history in nuclear criticality research, nuclear weapons safeguards and security, and treaty verification technology as the Los Alamos Critical Experiments Facility (LACEF).

PRSs at TA-18 have been addressed in the RFI work plan for OU 1093 (LANL 1993, 15310). TA-18 is located primarily within the Pajarito Canyon watershed; only two PRSs are located within the Canada del Buey watershed near the west end of TA-54 on Mesita del Buey. PRSs 18-005(b and c) are magazines that were proposed for NFA in the work plan; therefore Phase I investigation has not been required for these sites.

References for Chapter 2

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

Biggs, J. R., and S. Cross, 1995. "Biological and Floodplain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1140; TA-46," Los Alamos National Laboratory Report LA-UR-95-3716, Los Alamos, New Mexico. (Biggs and Cross 1995, ER ID 52028)

Childs, M., and R. Conrad, September 1997. "Area G Perimeter Surface-Soil and Single-Stage Water Sampling: Environmental Surveillance for Fiscal Year 95," Los Alamos National Laboratory Progress Report LA-13369-PR, Los Alamos, New Mexico. (Childs and Conrad 1997, ER ID 57518)

Conrad, R. M., M. Childs, C. Rivera-Dirks, and F. Coriz, July 1995. "Area G Perimeter Surface Soil and Single-Stage Water Sampling Environmental Surveillance for Fiscal Year 1993," Los Alamos National Laboratory Report LA-12986, Los Alamos, New Mexico. (Conrad et al. 1995, ER ID 52014)

Conrad, R. M., M. Childs, C. Rivera Lyons, and F. Coriz, August 1996. "Area G Perimeter Surface Soil and Single-Stage Water Sampling Environmental Surveillance for Fiscal Year 1994," Los Alamos National Laboratory Progress Report LA-13165-PR, Los Alamos, New Mexico. (Conrad et al. 1996, ER ID 55621)

Cross, S., 1994. "Biological and Flood Plain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1114, TAs-3, 30, 59, 60, 61, and 64," Los Alamos National Laboratory Report LA-UR-94-21, Los Alamos, New Mexico. (Cross 1994, ER ID 26071)

Dale, L. J., December 16, 1998. "ESH-18 NPDES Outfall Discharge Data for Outfalls in the Sandia Canyon and Cañada del Buey Watersheds," Daily Activity Log, Los Alamos, New Mexico. (Dale 1998, ER ID 62337)

DOE (US Department of Energy), October 1986. "Comprehensive Environmental Assessment and Response Program, Phase 1: Installation Assessment, Los Alamos National Laboratory," Vol. 1 of 2, Working Draft, US Department of Energy, Albuquerque Operations Office, Environment Safety and Health Division, Environmental Programs Branch, Albuquerque, New Mexico. (DOE 1986, ER ID 8657)

DOE (US Department of Energy), October 1987. “Phase I: Installation Assessment, Los Alamos National Laboratory,” Volumes 1 and 2 (draft), Comprehensive Environmental Assessment and Response Program, Albuquerque Operations Office, Albuquerque, New Mexico. (DOE 1987, ER ID 52975)

DOE (US Department of Energy), April 3, 1996. Transmittal Letter for the Final Environmental Assessment for the Low Energy Demonstration Accelerator, US Department of Energy Letter LAAMEP:9EW-266 to Dr. Ed Kelley (NMED) from Elizabeth Withers (DOE), Los Alamos, New Mexico. (DOE 1996, ER ID 62338)

Elder, J. C., E. J. Cox, D. P. Hohner, and A. M. Valentine, September 1986. “Radioactive Liquid Water Lines Removal Project at Los Alamos (1981 – 1986),” Los Alamos National Laboratory Report LA-10821-MS, Los Alamos, New Mexico. (Elder et al. 1986, ER ID 3089)

Environmental Protection Group, July 1994. “Environmental Surveillance at Los Alamos During 1992,” Los Alamos National Laboratory Report LA-12764-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1994, ER ID 45363)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

Environmental Surveillance Reports. Numerous environmental surveillance reports were prepared annually by the Environmental Studies Group (ESG), which in 1971 was renamed the Environmental Surveillance Group. This organization also was called the Environmental Surveillance and Compliance Program, and the Environmental Protection Group. The reports bear a Los Alamos Scientific Laboratory number before January 1, 1981, and a Los Alamos National Laboratory number thereafter. In this document, environmental surveillance reports also include citations for Apt and Lee, Herceg, Kennedy et al., and Schiager.

ERM/Golder, 1996. “Draft Field Summary Report Solid Waste Management Unit 3-056(c) Expedited Cleanup April 1996,” Rev. 0, ERM/Golder, Los Alamos, New Mexico. (ERM/Golder 1996, ER ID 55746)

Foxx, T. S., and G. D. Tierney, September 1984. “Status of the Flora of the Los Alamos National Environmental Research Park: A Historical Perspective,” Los Alamos National Laboratory Report LA-8050-NERP, Vol. II, Los Alamos, New Mexico. (Foxx and Tierney 1984, ER ID 5950)

Foxx, T., G. Tierney, M. Mullen, and M. Salisbury, October 1997. “Old-Field Plant Succession on the Pajarito Plateau,” Los Alamos National Laboratory Report LA-13350, Los Alamos, New Mexico. (Foxx et al. 1997, ER ID 57580)

Hollis, D., E. Vold, R. Shuman, K. Birdsell, K. Bower, W. Hansen, D. Krier, P. Longmire, B. Newman, D. Rogers, and E. Springer, March 1997. “Performance Assessment and Composite Analysis for Los Alamos National Laboratory Material Disposal Area G,” Report-54G-013.R.2, Revision 2, Los Alamos National Laboratory Report LA-UR-97-85, Los Alamos, New Mexico. (Hollis et al. 1997, ER ID 57523)

International Technology Corporation, March 1987. “Hydrogeologic Assessment of Technical Area 54, Areas G and L, Los Alamos National Laboratory,” Project No. 301017.02, Los Alamos, New Mexico. (International Technology Corporation 1987, ER ID 8998)

LANL (Los Alamos National Laboratory), November 1990. “Solid Waste Management Units Report,” Vol. I–IV, Los Alamos National Laboratory Report LA-UR-90-3400, prepared by International Technology Corporation, Contract No. 9-XS8-0062R-1, Los Alamos, New Mexico. (LANL 1990, ER ID 7511)

LANL (Los Alamos National Laboratory), May 1992. “RFI Work Plan for Operable Unit 1129,” Los Alamos National Laboratory Report LA-UR-92-800, Los Alamos, New Mexico. (LANL 1992, ER ID 7666)

LANL (Los Alamos National Laboratory), May 1992. “RFI Work Plan for Operable Unit 1148,” Los Alamos National Laboratory Report LA-UR-92-855, Los Alamos, New Mexico. (LANL 1992, ER ID 7669)

LANL (Los Alamos National Laboratory), May 1993. “RFI Work Plan for Operable Unit 1093,” Los Alamos National Laboratory Report LA-UR-93-422, Los Alamos, New Mexico. (LANL 1993, ER ID 15310)

LANL (Los Alamos National Laboratory, June 4, 1993. “Response to the Notice of Deficiency (NOD) Regarding the Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Operable Unit (OU) 1148,” Los Alamos National Laboratory Letter LESH:3TT-001 to Guanita Reiter (EPA) from Joseph C. Vozella (DOE), Los Alamos, New Mexico. (LANL 1993, ER ID 15296)

LANL (Los Alamos National Laboratory), July 1993. “RFI Work Plan for Operable Unit 1114,” Los Alamos National Laboratory Report LA-UR-93-1000, Los Alamos, New Mexico. (LANL 1993, ER ID 51977)

LANL (Los Alamos National Laboratory), August 1993. “RFI Work Plan for Operable Unit 1140,” Los Alamos National Laboratory Report LA-UR-93-1940, Los Alamos, New Mexico. (LANL 1993, ER ID 20952)

LANL (Los Alamos National Laboratory), May 1994. “RFI Work Plan for Operable Unit 1100,” Los Alamos National Laboratory Report LA-UR-94-1097, Los Alamos, New Mexico. (LANL 1994, ER ID 34756)

LANL (Los Alamos National Laboratory, August 19, 1994. “Response to the Notice of Deficiency (NOD) for OU 1140 RCRA Facility Investigation (RFI) Work Plan,” Los Alamos National Laboratory Letter LAAMEP:2TT-011 to William K. Honker (EPA) from Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1994, ER ID 40381)

LANL (Los Alamos National Laboratory, December 16, 1994. “Response to EPA’s NOD for the OU 1100 Work Plan,” Los Alamos National Laboratory Letter to William Honker (EPA) from Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1994, ER ID 43889)

LANL (Los Alamos National Laboratory), 1995. “Voluntary Corrective Action Plan for PRS 3-001(i), Former Equipment Storage Area, OU 1114, Field Unit 1,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1995, ER ID 46198)

LANL (Los Alamos National Laboratory), April 12, 1995. “Notice of Deficiency (NOD) Response for Operable Unit 1114,” Los Alamos National Laboratory Letter EM/ER:95-148 to Barbara Driscoll (EPA) from Jorg Jansen (LANL) and Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1995, ER ID 45976)

LANL (Los Alamos National Laboratory), June 1995. “Expedited Cleanup Plan for Solid Waste Management Unit 3-056(c),” Rev. 0, Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1995, ER ID 47257)

LANL (Los Alamos National Laboratory), July 1995. “RFI Work Plan for Operable Unit 1114, Addendum 1,” Los Alamos National Laboratory Report LA-UR-95-731, Los Alamos, New Mexico. (LANL 1995, ER ID 51981)

LANL (Los Alamos National Laboratory), October 25, 1995. “Groundwater Protection Management Program Plan” (draft), Rev. 2.0, Los Alamos, New Mexico. (LANL 1995, ER ID 50124)

LANL (Los Alamos National Laboratory), December 6, 1995. “Status Report for Solid Waste Management Unit (SWMU) 3-056(c) and Proposal for Cleanup Level,” Los Alamos National Laboratory Letter EM/ER:95-685 to David Neleigh (EPA) from Jorg Jansen (LANL) and Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1995, ER ID 52359)

LANL (Los Alamos National Laboratory), January 1996. “Voluntary Corrective Action Completion Report for Potential Release Sites 20-003(c) and 53-010, Field Unit 2,” Rev. 1, Los Alamos National Laboratory Report LA-UR-96-1089, Los Alamos, New Mexico. (LANL 1996, ER ID 53794)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for Channel Sediment Pathways from MDAs G, H, J, and L, TA-54 (Located In Former Operable Unit 1148), Field Unit 5,” Los Alamos National Laboratory Report LA-UR-96-110, Los Alamos, New Mexico. (LANL 1996, ER ID 54462)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for 53 Potential Release Sites in TA-3, TA-59, TA-60, TA-61,” Los Alamos National Laboratory Report LA-UR-96-726, Los Alamos, New Mexico. (LANL 1996, ER ID 54467)

LANL (Los Alamos National Laboratory), February 1996. “Response to the Notice of Deficiency (NOD) for the RFI Work Plan for Operable Unit 1114, Addendum 1, Field Unit 1,” Los Alamos, New Mexico. (LANL 1996, ER ID 54088)

LANL (Los Alamos National Laboratory), February 26, 1996. “Voluntary Corrective Action Completion Report for Potential Release Sites 03-003(p), 03-047(d), and 03-051(c), Field Unit 1,” Los Alamos National Laboratory Report LA-UR-96-431, Los Alamos, New Mexico. (LANL 1996, ER ID 53780)

LANL (Los Alamos National Laboratory), March 19, 1996. “RFI Report for Potential Release Sites in TA-20, TA-53, and TA-72 (Located in Former Operable Unit 1100), Field Unit 2,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1996, ER ID 54124)

LANL (Los Alamos National Laboratory), April 1, 1996. “Final Environmental Assessment for the Low Energy Demonstration Accelerator, Technical Area 53,” Los Alamos National Laboratory Report DOE/EA 1147, Los Alamos, New Mexico. (LANL 1996, ER ID 62339)

LANL (Los Alamos National Laboratory), May 2, 1996. “Response to the Notice of Deficiency (NOD) for Solid Waste Management Unit (SWMU) 3-056(c), Technical Area (TA) 3, Expedited Cleanup Status Report,” Los Alamos National Laboratory Letter ER/ER:96-253 to Benito Garcia (NMED) from Jorg Jansen (LANL) and Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1996, ER ID 54398)

LANL (Los Alamos National Laboratory), June 1996. “RFI Report for Potential Release Sites in TA-46, 46-003(h), 46-004(b, g, h, m, q, s, u, v, x, y, z, a_2, b_2, c_2, d_2, e_2, f_2), 46-006(a, b, c, d, f, g, 46-007), 46-008(b), 46-010(d), C-46-002, C-46-003, Field Unit 3,” Los Alamos National Laboratory Report LA-UR-96-1957, Los Alamos, New Mexico. (LANL 1996, ER ID 54929)

LANL (Los Alamos National Laboratory), September 1996. “Voluntary Corrective Action Completion Report for a Solid Waste Management Unit at TA-46, 46-003(h) Outfall, Field Unit 3,” Los Alamos National Laboratory Report, Los Alamos New Mexico. (LANL 1996, ER ID 62341)

LANL (Los Alamos National Laboratory), September 25, 1996. “Interim Action Completion Report for Potential Release Site 53-002(a),” Los Alamos National Laboratory Report LA-UR-96-3315, Los Alamos New Mexico. (LANL 1996, ER ID 55208)

LANL (Los Alamos National Laboratory), April 1997. “Core Document for Canyons Investigations,” Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), May 1997. “RFI Status Report for Tritium in Surface Soils at MDA G, TA-54, Field Unit 5,” Los Alamos National Laboratory Report LA-UR-97-1308, Los Alamos, New Mexico. (LANL 1997, ER ID 55873)

LANL (Los Alamos National Laboratory), September 1997. “RFI Report for Potential Release Sites 3-004(c, d), 3-007, 3-014(k, l, o), 3-012, 3-049(a), 3-052(b), 3-056(k) and C-3-014, Field Unit 1,” Los Alamos National Laboratory Report LA-UR-97-3571, Los Alamos, New Mexico. (LANL 1997, ER ID 56660)

LANL (Los Alamos National Laboratory), September 15, 1997. “Voluntary Corrective Action Completion Report for Potential Release Site 53-014, Lead Shot Site, Field Unit 2,” Los Alamos National Laboratory Report LA-UR-97-XXXX, Los Alamos, New Mexico. (LANL 1997, ER ID 56589)

LANL (Los Alamos National Laboratory), March 27, 1998. “Sampling and Analysis Plan for Upper Sandia Canyon,” Los Alamos National Laboratory Report LA-UR-98-4893, Los Alamos, New Mexico. (LANL 1998, ER ID 62340)

LANL (Los Alamos National Laboratory), June 1998. “RFI Work Plan and SAP for Potential Release Sites 53-002(a) and 53-002(b) and Associated Drainages at TA-53," Los Alamos National Laboratory Report LA-UR-98-2547, Los Alamos, New Mexico. (LANL 1998, ER ID 58841)

LANL (Los Alamos National Laboratory), November 1998. “Installation Work Plan for Environmental Restoration Project,” Revision 7, Los Alamos National Laboratory Report LA-UR-98-4652, Los Alamos, New Mexico. (LANL 1998, ER ID 62060)

LANL, (Los Alamos National Laboratory), February 9, 1999. “Draft Watershed Management Plan,” Los Alamos National Laboratory draft report, Los Alamos, New Mexico. (LANL 1999, ER ID 62920)

Mathien, F. J., C. R. Steen, and C. D. Allen, 1993. “The Pajarito Plateau: A Bibliography,” Southwest Cultural Resources Center Professional Paper No. 49, US Department of the Interior, Santa Fe, New Mexico. (Mathien et al. 1993, ER ID 57520)

Pratt, A., June 2, 1994. “Addendum to the OU 1129 RFI Work Plan,” Los Alamos National Laboratory Memorandum EES-13-ER-05-94-011 to Tracy Glatzmaier from Allyn Pratt, Los Alamos, New Mexico. (Pratt 1994, ER ID 39932)

Purtymun, W. D., 1975. “Geohydrology of the Pajarito Plateau with Reference to Quality of Water, 1949–1972,” Los Alamos Scientific Laboratory Informal Report LA-5744, Los Alamos, New Mexico. (Purtymun 1975, ER ID 11787)

Purtymun, W. D., January 1, 1995. “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area,” Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Risberg, D., February 3, 1994. “Biological Assessment for Sanitary Waste Disposal Areas in TAs 60 and 65,” Revision 1, Los Alamos National Laboratory Report LA-UR-94-583, Los Alamos, New Mexico. (Risberg 1994, ER ID 62353)

Rogers, M. A., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Waste (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory Report LA-6848-MS, Vol. I, Los Alamos, New Mexico. (Rogers 1977, ER ID 5707)

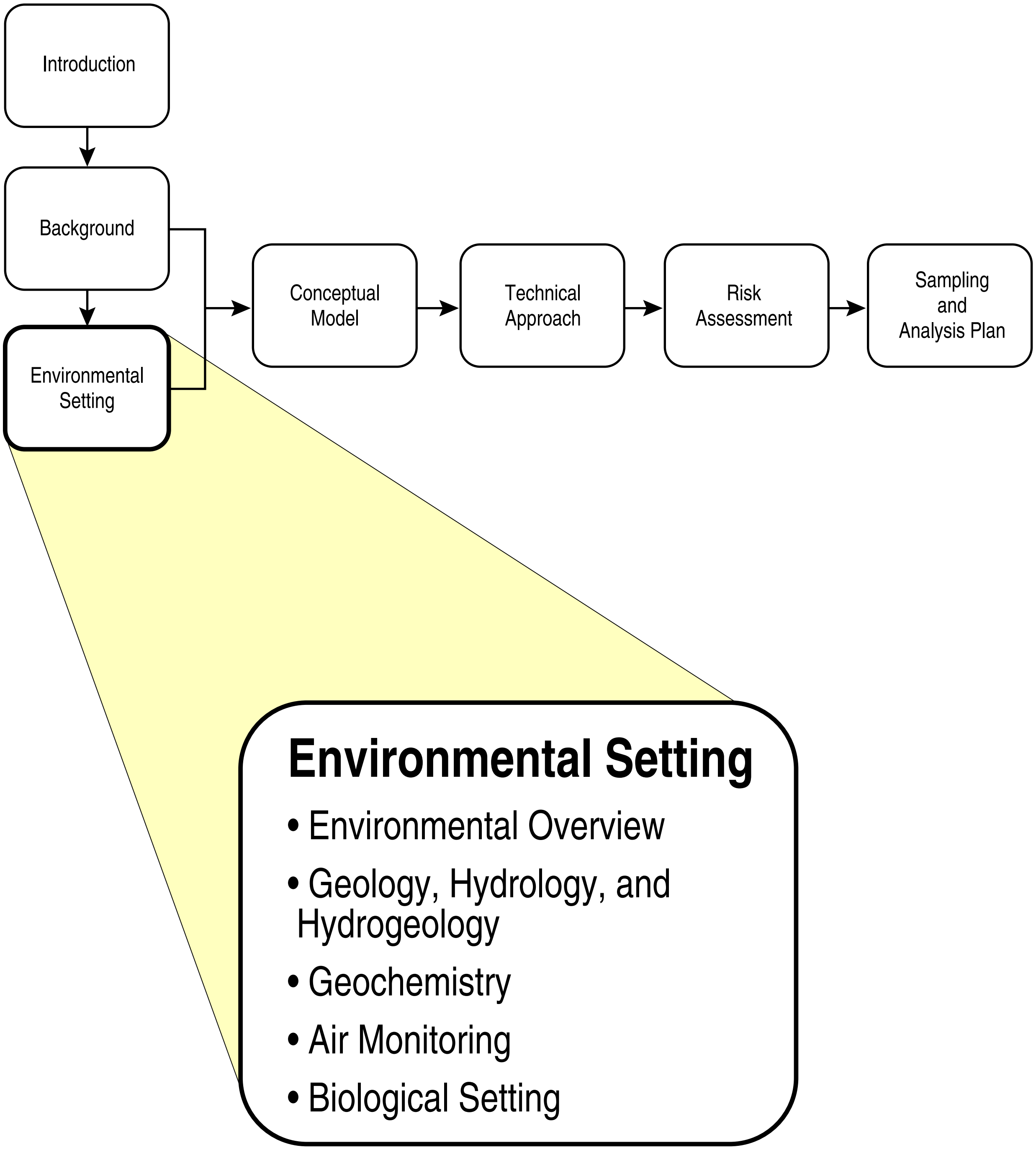
Rogers, M. A., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Waste (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory Report LA-6848-MS, Vol. II, Los Alamos, New Mexico. (Rogers 1977, ER ID 5708)

Santa Fe Engineering, Ltd., March 30, 1995. “Group SPCC Implementation Plan (GSIP) for the TA-60 Fuel Farm,” prepared by Santa Fe Engineering, Ltd., Santa Fe, New Mexico. (Santa Fe Engineering 1995, ER ID 63493

Steen, C. R., May 1977. “Pajarito Plateau Archaeological Survey and Excavations,” Los Alamos Scientific Laboratory Report LASL-77-4, Los Alamos, New Mexico. (Steen 1977, ER ID 7148)

Steen, C. R., April 1982. “Pajarito Plateau Archaeological Surveys and Excavations, II,” Los Alamos National Laboratory Report LA-8860-NERP, Los Alamos, New Mexico. (Steen 1982, ER ID 6056)

Chapter 3



Environmental Setting

- Environmental Overview
- Geology, Hydrology, and Hydrogeology
- Geochemistry
- Air Monitoring
- Biological Setting

3.0 ENVIRONMENTAL SETTING

This chapter has four major functions: it

- describes the environmental setting of Sandia Canyon and Cañada del Buey;
- summarizes existing information relevant to the characterization of the Sandia and Cañada del Buey Canyon systems;
- identifies additional information needed to expand the conceptual understanding of the environmental processes that occur within the system and to assess the magnitude and importance of potential exposure pathways within the canyon systems; and
- provides the technical basis for the conceptual model, which is described in Chapter 4 of this work plan. Chapter 2, Chapter 3, and Chapter 4 are then used to develop the specific field sampling plans presented in Chapter 7 of this work plan.

The regional environmental setting of the Laboratory is presented in Chapter 3 of “Core Document for Canyons Investigations” (hereafter referred to as the “core document”) (LANL 1997, 55622) and in Chapter 2 of the “Installation Work Plan for Environmental Restoration Program” (IWP) (LANL 1996, 55574).

Since 1966 boreholes drilled in Sandia and Cañada del Buey have been completed for their intended purpose, left open and uncompleted, or abandoned. These boreholes and completions are designated by letters and numbers. The first two or three letters or numbers designate the canyon, mesa, or technical area (TA) (for example, SC = Sandia Canyon, CDB = Cañada del Buey, 53 = TA-53, 54 = TA-54, etc.), and the last letter or letters designate the function, as follows.

O	Observation well; completed with screen or perforated casing in alluvium; intended for water level measurement and water sample collection; installed by personnel from the Laboratory Water Quality and Hydrology group (ESH-18) for environmental surveillance monitoring
MW	Monitoring well; completed with screen or perforated casing in alluvium; intended for measuring water levels and collecting water samples; most have been installed by the Laboratory Environmental Restoration (ER) Project for groundwater monitoring
OI	Observation intermediate well; completed in a deeper, intermediate perched groundwater zone or potential intermediate groundwater zone
M	Moisture access hole; borehole cased with 2-in. (5.08-cm)-diameter plastic or aluminum pipe with a plug at the bottom to keep water out of the pipe, intended for logging *in situ* moisture measurements with a neutron moisture/density probe
C/CH	Core hole; not completed as a well; usually plugged and abandoned
WB	Water-balance; well completed in alluvium intended primarily for water level measurement but may be used to collect water samples

Each letter typically is followed by a number, which normally indicates the downstream sequence of well installation. Any letters after the numbers indicate multiple installations at approximately the same location in the canyon, usually as transects or replacement wells.

Other well designations include the following water supply wells that are designated by the location of the well field.

LA	Los Alamos Canyon
PM	Pajarito Mesa
G	Guaje Canyon
O	Otowi

Test wells, typically drilled to the regional aquifer (to monitor water levels and collect samples), are designated R- (regional aquifer), TW-, or DT- (deep test); SHB as a sole designator refers to a seismic hazard borehole, which has not been completed as a well; EGH means exploratory geothermal hole, which also was not completed. In addition, a special set of boreholes, originally designated TH for test hole were drilled as water exploration test holes through the Bandelier Tuff (Purtymun 1995, 45344, p. 211). The letter and number/letter designations for these installations also are used as locations on various maps provided in this work plan.

Within this work plan, the term “well” refers to a completed borehole with the capability to contain water, specifically the water supply, test, observation, and water-balance wells. Uncompleted core holes are referred to as “boreholes,” whereas the “moisture access holes” are referred to as such. A comprehensive compilation and description of boreholes and completions installed by the Laboratory before circa 1993 are provided by Purtymun (1995, 45344).

Environmental surveillance sediment sampling locations are designated as “Sandia at SR-4,” “Sandia at Rio Grande,” and “Cañada del Buey at SR-4,” which indicate a location near a major highway or river. Other sediment sample locations designated by the ER Project are designated by the technical area designation and a unique ER Project site identification (ID) number, such as 54-2001 (see Figure A-1 in Appendix A of this work plan).

The New Mexico Environment Department (NMED) Oversight Bureau describes collection sites by the canyon name abbreviation and the distance in miles as measured from the Rio Grande. For example, surface water has been collected at station SA-6.1, which is located in middle Sandia Canyon 0.8 mi (1.3 km) east of the TA-53 entrance; this station approximately corresponds to environmental surveillance sample site SCS-3.

3.1 Location, Topography, and Surface Drainage

3.1.1 Sandia Canyon

Sandia Canyon has a relatively small drainage area (5.5 mi^2) (14.3 km^2) that heads on the western Pajarito Plateau at TA-3 at an elevation of approximately 7450 ft (2270 m) (LANL 1997, 55622, p. 3-2). The canyon extends east/southeast from TA-3 to the Rio Grande for a distance of approximately 10 mi (16.1 km). The canyon contains a stream that is continuous in the upper canyon from effluent discharges from the Laboratory sanitary wastewater sewage treatment plant and from cooling tower discharges. The middle and lower parts of the canyon contain a stream that is mainly ephemeral from natural runoff. The Sandia Canyon watershed has no named tributaries on Laboratory property.

For discussion purposes, Sandia Canyon is divided into upper, middle, lower, and lower off-site sections, as described below.

The **upper canyon** is that portion of the canyon that extends from the head of the canyon at TA-3 to the western edge of TA-53, where state road NM501 (East Jemez Road) enters the canyon from the west.

The **middle canyon** is that portion of the canyon that extends from the west end of TA-53 (where East Jemez road enters the canyon) to the structures at TA-72.

The **lower canyon** is that portion of the canyon that extends from the structures at TA-72 (the small arms firing range) to the eastern Laboratory boundary at state road NM4.

The lower off-site canyon is the remaining portion of the canyon that extends from the Laboratory boundary to the Rio Grande.

The Sandia Canyon watershed extends from the western part of the Pajarito Plateau at TA-3 east-southeast for approximately 5.7 mi (9.1 km) on Laboratory property, and another 3.8 mi (6 km) on San Ildefonso Pueblo land to the confluence with the Rio Grande at an elevation of 5460 ft (1665 m). The drainage area of Sandia Canyon on Laboratory property is 2.65 mi^2 (6.9 km^2). The total drainage area of Sandia Canyon above the confluence with the Rio Grande is 5.57 mi^2 (14.4 km^2) (McLin 1992, 12014, pp. 19 and 24). Figure A-1 shows the area of the Sandia Canyon watershed (shaded gray).

Sandia Canyon transects the north-central part of the Laboratory and encompasses portions of several different technical areas, including TAs-3, -53, -60, -61, and -72, and former TA-20. The canyon drains most of the north half of TA-3, the north side of Sigma Mesa, the Los Alamos County landfill, and most of the Meson Physics site at TA-53. The Sandia Canyon watershed on the Laboratory property varies in width from about 1700 to 2500 ft (510 to 760 m); the widest is at TA-53 and the narrowest is near the firing range at TA-72. The widest part of the Sandia Canyon watershed is east of the Laboratory near Bandelier National Monument where the largest tributary, informally called the north fork of Sandia Canyon, parallels Sandia Canyon for about 1.5 mi (2.4 km) miles; here the watershed is about 6600 ft (2000 m) wide (see Figure A-1).

The upper portion of the canyon is incised approximately 80 ft to 150 ft (24 to 46 m) into the Tshirege Member of the Bandelier Tuff. The amount of incision is greatest in the middle canyon near TA-53, where the canyon floor is about 200 ft (60 m) below the mesa top. The amount of incision of the canyon decreases toward the east where the mesas are not as high; at the Laboratory boundary the canyon floor is approximately 120 ft (36 m) lower than the surrounding mesas.

The upper and middle portion of Sandia Canyon contain a continuous streamflow that is fed by several outfalls in the upper portion of the canyon at TA-3. Wastewater from the TA-46 sanitary waste system consolidation (SWSC) plant is reused in cooling towers at TA-3 and discharges from National Pollutant Discharge Elimination System (NPDES) outfalls 001 and/or 01S into upper Sandia Canyon (Environmental Surveillance and Compliance Programs 1998, 59904, p. 28). Cooling tower outfalls at TA-3 and TA-53 also discharge intermittently to Sandia Canyon. Flow is intermittent in the canyon from the SWSC outfall to near TA-53, and the rest of the canyon has an ephemeral stream extending from TA-53 downstream to the confluence with the Rio Grande. Sandia Spring discharges a small amount of groundwater into lower Sandia Canyon but does not maintain a flow for an appreciable distance. Local runoff and streamflow from seasonal rainstorms occasionally extend from the Laboratory boundary downstream as far as the Rio Grande.

3.1.2 Cañada del Buey

Cañada del Buey has a relatively small drainage area that heads on the central Pajarito Plateau at TA-52 and TA-36 at an elevation of 7220 ft (2200 m). The canyon extends southeast from TA-52 and TA-63 to the confluence with Mortandad Canyon for a distance of approximately 7.4 mi (11.8 km). Mortandad Canyon extends another 0.5 mi (0.8 km) to the Rio Grande. Cañada del Buey extends southeast from TA-52 along the north sides of TA-46, TA-51, and TA-54 for a distance of 5 mi (8 km) to the eastern Laboratory boundary at an elevation of 6400 ft (1950 m) at White Rock. East of TA-54 the canyon turns toward the east and extends for 2.6 mi (4.2 km) through White Rock to the confluence with Mortandad Canyon at an elevation of 5600 ft (1707 m) on San Ildefonso Pueblo land.

The canyon contains a stream that is entirely ephemeral on Laboratory property. The stream channels in the canyon are generally narrow, with few cutbanks, indicating small and infrequent runoff (Purtymun and Kennedy 1971, 4798, p. 9). In some areas of the canyon, no defined stream channel exists and in some areas the main channel is not well defined, braiding out in places along the canyon floor (Devaurs and Purtymun 1985, 7415, p. 11). The White Rock sewage treatment plant (STP) discharges into lower off-site Cañada del Buey east of White Rock at an approximate elevation of 6250 ft (1905 m). A small amount of continuous flow in lower Cañada del Buey extends downstream from this discharge point to a point near the confluence with Mortandad Canyon, but flow in lower Mortandad Canyon to the Rio Grande is ephemeral.

Cañada del Buey has one main tributary on Laboratory property that informally is called the south fork of Cañada del Buey. This tributary canyon heads at the eastern side of TA-51 and extends along the north side of Mesita del Buey and north of MDA J and MDA L at TA-54 for a distance of 1.6 mi (2.5 km). The south fork of Cañada del Buey heads at an elevation of about 7000 ft (2134 m) and joins Cañada del Buey north of the west end of MDA G at TA-54 at an elevation of 6620 ft (2018 m).

Another small tributary is informally called the TA-46 fork of Cañada del Buey. This small drainage area heads at TA-46 and passes through the TA-46 SWSC plant and joins Cañada del Buey about 1500 ft (450 m) east of the SWSC plant at an elevation of 7870 ft (2095 m).

Two other tributaries to Cañada del Buey are located north of Laboratory property on San Ildefonso Pueblo land. These two tributaries are informally referred to as the middle fork of Cañada del Buey and the north fork of Cañada del Buey (Figure A-1). These tributaries are entirely on San Ildefonso Pueblo property and are not discussed further in this document.

For discussion purposes, Cañada del Buey is divided into upper, middle, lower, and lower off-site sections, as described below.

The **upper canyon** is that portion of the canyon that extends from the head of the canyon at TA-52 to the confluence with the TA-46 fork of Cañada del Buey.

The **middle canyon** is that portion of the canyon that extends from the confluence with the TA-46 fork of Cañada del Buey to the confluence with the south fork of Cañada del Buey.

The **lower canyon** is that portion of the canyon that extends from the confluence with the south fork of Cañada del Buey to the eastern Laboratory boundary at the western edge of White Rock.

The **lower off-site canyon** is the remaining portion of the canyon that extends from the Laboratory boundary to the confluence with Mortandad Canyon.

The Cañada del Buey watershed extends from the central Pajarito Plateau at TA-52 east-southeast for approximately 6.1 mi (9.8 km) on Laboratory property. It also extends another 2.6 mi (4.2 km) through White Rock and on San Ildefonso Pueblo land to the confluence with Mortandad Canyon at an elevation of 5600 ft (1707 m). The drainage area of Cañada del Buey on Laboratory property is 2.10 mi^2 (5.44 km^2). The total drainage area of Cañada del Buey above the confluence with Mortandad Canyon is 4.3 mi^2 (11.1 km^2) (McLin 1992, 12014, pp. 19 and 24; LANL 1997, 55622, p. 3-2). Figure A-1 shows the area of the Cañada del Buey watershed in gray shading. Approximately 50% of the drainage area of Cañada del Buey is on Laboratory property.

Cañada del Buey transects the southeast part of the Laboratory and forms the approximate boundary of the south side of the San Ildefonso Pueblo sacred land. The canyon encompasses portions of several different technical areas, including, from west to east, TAs-63, -52, -46, -51, and -54. The canyon drains the south half of TAs-52 and -63 and the north side of Mesita del Buey. The Cañada del Buey watershed varies in width from about 2500 ft (760 m) near TA-46 to about 6300 ft (1920 m) at the eastern Laboratory boundary west of state road NM4. The portion of the watershed on Laboratory property varies in width from about 1000 ft (300 m) north of MDA G to about 2500 ft between MDAs J and L (see Figure A-1).

The upper portion of the canyon is incised approximately 80 ft (25 m) into Units 2 and 3 of the Tshirege Member of the Bandelier Tuff. The middle canyon and the south fork are incised about 100 ft (30 m) into Units 1 and 2 of the Tshirege Member. The amount of incision of the canyon decreases toward the east where the canyon bottom is generally wider and the mesas are not as high; at the Laboratory boundary the canyon floor is approximately 80 ft (25 m) lower than the surrounding mesas.

Cañada del Buey contains a stream that is entirely ephemeral. The discharge point from the TA-46 SWSC plant discharges into upper Sandia Canyon. Local runoff from seasonal rainstorms occasionally extends from the Laboratory boundary downstream as far as the Rio Grande, but flow in the upper and middle canyon is rarely continuous.

3.2 Climate

The climate of the Pajarito Plateau and the vicinity of Sandia Canyon and Cañada del Buey are described in the core document (LANL 1997, 55622, p. 3-1) and briefly discussed in this section. The Laboratory has one meteorological station in Sandia Canyon located at TA-53 and another in Cañada del Buey located at TA-54 that provide site-specific meteorological data for the canyons; (e.g., Environmental Surveillance and Compliance Programs 1997, 56684). The locations of the meteorological stations are shown in Figure A-1. See Sections 3.4.5 and 3.5.5 for a discussion of site-specific meteorological monitoring in Sandia Canyon and Cañada del Buey.

Climate influences sediment formation and transport, and the transport of contaminants in surface and subsurface environments. The speed, frequency, direction, and stability of winds influence the airborne transport of contaminants; the form, frequency, intensity, and evaporation potential of precipitation influences surface water runoff and infiltration within the canyons.

Los Alamos County has a semiarid, temperate, mountain climate, which is summarized in the core document (LANL 1997, 55622, p. 3-1) and Chapter 2 of the IWP (LANL 1996, 55574). Detailed data compilations and extensive statistical summaries, including projected probabilities, are provided by Bowen (1990, 6899).

Past investigations of the hydrology of the Pajarito Plateau have mentioned evapotranspiration (ET) as a process for removing shallow alluvial groundwater (e.g., Baltz et al. 1963, 8402, p. 82; Purtymun 1974, 5476, p. 4; Purtymun et al. 1983, 6407, p. 3). Site-specific ET data for Sandia Canyon and Cañada del

Buey are not available. However estimates for nearby watersheds are available for comparison. Some studies for Mortandad Canyon indicate approximately 20% of the input to the stream channel is ultimately lost to ET (Purtymun 1974, 5476, p. 7). A study of the Los Alamos Canyon system indicated that approximately 75 to 85% of the total input to the watershed is lost to ET (Gray 1997, 58208, p. 68). Annual summaries of climate are presented in the annual environmental surveillance reports.

3.3 Geology

Discussions of the regional geologic setting of the Pajarito Plateau are presented in Griggs (1964, 8795), the IWP (LANL 1996, 55574), the hydrogeologic work plan (LANL 1996, 55430), and most recently in the core document (LANL 1997, 55622, p. 3-6). The following discussion uses the core document as the technical basis for the geology setting and provides detail that is specific to Sandia Canyon and Cañada del Buey. Unless otherwise noted, locations of wells and boreholes mentioned herein are shown in Figure A-1. Some locations are beyond the extent of Figure A-1; these wells and boreholes can be found in maps and figures in the core document (LANL 1997, 55622) and/or the hydrogeologic work plan (LANL 1996, 55430).

The surface distribution of bedrock geologic units in the Sandia Canyon and Cañada del Buey areas is shown on geologic maps prepared by Griggs (1964, 8795); Smith et al. (1970, 9752); Purtymun and Kennedy (1971, 4798); Vaniman and Wohletz (1990, 21589); Rogers (1995, 54419); Dethier (1997, 49843); and others. The subsurface geology has been investigated by a number of deep boreholes including those for wells PM-1 and PM-3 located in Sandia Canyon; EGH-LA-1, located on Sigma Mesa south of Sandia Canyon; PM-4 located on Mesita del Buey south of Cañada del Buey; and SHB-2 at TA-3 (Purtymun 1995, 45344, p. 225). Two shallow boreholes on the floor of Sandia Canyon have penetrated alluvium and upper bedrock units and at least five shallow boreholes in Cañada del Buey have penetrated through the alluvium into upper bedrock units. Additionally, numerous boreholes on Mesita del Buey at TA-54, especially around Material Disposal Area (MDA) L, have penetrated down to or into lower stratigraphic units, including basaltic rocks of the Cerros del Rio volcanic field. A list of the wells pertinent to Sandia Canyon and Cañada del Buey is included in Appendix C and Appendix D of this work plan.

3.3.1 Stratigraphy

The principal bedrock units in the Sandia Canyon and Cañada del Buey area consist of the following, in ascending order:

- Santa Fe Group: 4 to 21 Ma (Manley 1979, 11714);
- Puye Formation: 1.7 to 4 Ma (Turbeville et al. 1989, 21587; Spell et al. 1990, 21586) and interstratified volcanic rocks including the Tschicoma Formation on the west (2.53 to 6.7 Ma) and basalts of the Cerros del Rio volcanic field on the east (2 to 3 Ma) (Gardner and Goff 1984, 44021; WoldeGabriel et al. 1996, 54427);
- Otowi Member of the Bandelier Tuff: ca 1.61 Ma (Izett and Obradovich 1994, 48817);
- tephras and volcaniclastic sediments of the Cerro Toledo interval (Broxton and Reneau 1995, 49726, p. 11); and
- Tshirege Member of the Bandelier Tuff: ca 1.22 Ma (Izett and Obradovich 1994, 48817; Spell et al. 1990, 21586).

The bedrock stratigraphy is illustrated in Figure 3.3.1-1, and a brief description of the principal bedrock units is given below. The stratigraphy is based on the site-wide three-dimensional stratigraphic model, which contains detailed stratigraphic mapping for the sedimentary deposits and has been supplemented for this work plan by additional detail on the volcanic units. Stratigraphic information for pertinent wells in the Sandia Canyon and Cañada del Buey area is provided in Tables C-6 and D-6 in Appendixes C and D. Stratigraphic information from the site-wide three-dimensional model pertinent to Sandia Canyon and Cañada del Buey is provided in Appendix E.

3.3.1.1 Santa Fe Group

In the general area of Sandia Canyon and Cañada del Buey, the Santa Fe Group was penetrated by water supply wells PM-1, PM-2, PM-3, PM-4, and PM-5 and by borehole EGH-LA-1. Based on borehole lithological and geophysical logs, Purtymun (1995, 45344, p. 4) informally divided the Santa Fe Group into three formations, which include (in ascending order) the Tesuque Formation, the Chamita Formation, and a coarse-grained upper facies.

The Tesuque and Chamita Formations are terrestrial sedimentary deposits that filled the Española basin of the Rio Grande during subsidence in late Tertiary time. The coarse-grained upper facies of the Santa Fe Group was deposited in a late Miocene trough 3 to 4 mi (4.8 to 6.4 km) wide and 7 to 8 mi (11 to 13 km) long that extended northeastward beneath the Pajarito Plateau (see Figure 2-4 in the hydrogeologic work plan [LANL 1996, 55430]). This trough is filled with up to 1500 ft (approximately 450 m) of gravels, cobbles, and boulders derived from the Jemez volcanic field and with volcanic, metamorphic, and sedimentary rocks derived from highlands to the north and east. The trough is partly coincident with low-gravity anomalies that Ferguson et al. (1995, 56018) interpreted as a sediment-filled graben on the western side of the Española basin of the Rio Grande rift. The eastern side of this trough crosses Cañada del Buey near state road NM4. The western margin of the trough is not well constrained but may be located in the western portion of the Laboratory.

3.3.1.1.1 Tesuque Formation

In PM-3 (located in Sandia Canyon) and PM-4 (located south of Cañada del Buey on Mesita del Buey) the Tesuque Formation primarily consists of poorly consolidated, light pinkish brown, silty sandstone, siltstone, and claystone (Cooper et al. 1965, 8582, p. 59). The sandstones are predominately fine- to medium-grained, and the sand grains are subrounded to well rounded. The Tesuque Formation also contains interbedded gravel and conglomerate beds and basalt flows in PM-2 located in Pajarito Canyon.

3.3.1.1.2 Chamita Formation

The Chamita Formation is similar in appearance to the Tesuque Formation but reportedly contains a larger proportion of volcanic and granitic clasts in its gravel layers (Galusha and Blick 1971, 21526, p. 71) and Paleozoic limestone cobbles in its conglomerate layers (Dethier and Manley 1985, 21506). The Chamita Formation contains lithologically distinct quartzitic gravels (Galusha and Blick 1971, 21526, p. 71). Upper layers of the Chamita Formation may contain cobbles of Jemez volcanic rocks, primarily andesites and dacites. However, because of similarities of appearance, obvious time overlaps, and interfingering relations, differentiation of the Chamita Formation from the coarse-grained upper facies of the Santa Fe Group is often difficult, particularly in borehole investigations. The Chamita Formation was reported to be 40 ft (12 m) thick in PM-2, 80 ft (24 m) thick in PM-5, and absent in PM-3 (Purtymun 1995, 45344, pp. 275 through 277). The coarse-grained upper facies of the Santa Fe Group may be a facies variation of the Chamita Formation.

Bandelier Tuff	Tshirege Member	Qbt 4	Ash-Flow Units
		Qbt 3	
		Qbt 2	
		Qbt 1v	
		Qbt 1g	
		Tsankawi Pumice Bed	
Cerro Toledo Interval		Volcaniclastic Sediments and Ash-Falls	
Bandelier Tuff	Otowi Member	Ash-Flow Units	
		Guaje Pumice Bed	
Puye Formation	Fanglomerate	Fanglomerate Facies includes sand, grave, conglomerate, and tuffaceous sediments	
	Basalt and Andesite	Cerros del Rio Basalts intercalated within the Puye Formation, includes up to four interlayered basaltic flows. Andesites of the Tschicoma Formation present in western part of plateau	
	Fanglomerate	Fanglomerate Facies includes sand, grave, conglomerate, and tuffaceous sediments; includes "Old Alluvium"	
	Axial facies deposits of the ancestral Rio Grande	Totavi Lentil	
Santa Fe Group	Coarse Sediments	Coarse-Grained Upper Facies (formerly called the "Chaquehui Formation" by Purtymun 1995, 45344)	
	Basalt		
	Coarse Sediments		
	Basalt		
	Coarse Sediments		
	Basalt		
	Coarse Sediments		
	Basalt		
	Coarse Sediments		
	Arkosic clastic sedimentary deposits	Undivided Santa Fe Group (includes Chamita[?] and Tesuque Formations)	

Source: Baltz et al. 1963, 8402; Purtymun 1995, 45344; LANL 1996, 55430; Broxton and Reneau 1995, 49726.

F3.3.1-1 / SANDIA & CDB WP / 071699 / PTM

Figure 3.3.1-1. Generalized stratigraphy of bedrock geologic units of the Pajarito Plateau.

3.3.1.1.3 Coarse-Grained Upper Facies of the Santa Fe Group

The coarse-grained upper facies of the Santa Fe Group is composed of a mixture of volcanic debris from the Sierra de los Valles and arkosic and granitic debris from the highlands to the north and east of the Pajarito Plateau. Purtymun (1995, 45344, p. 6) called this distinctive group of coarse-grained sediments at the top of the Santa Fe Group the “Chaquehui Formation.” The name “Chaquehui Formation” as related to Santa Fe Group sediments is a potentially confusing designation because the type section of the “Chaquehui Formation” in Chaquehui Canyon is much younger than the coarse-grained upper facies of the Santa Fe Group identified in boreholes on the Pajarito Plateau. The Chaquehui Formation constitutes quartzite clast-bearing maar deposits of the Cerros del Rio volcanic field. In PM-3 the upper coarse-grained facies consists of medium- to coarse-grained sandstone, conglomerate, and siltstone (Purtymun 1967, 11829, p. 9). Because of the high permeability characteristics of this facies, it is an important aquifer for the development of high-yield, low-drawdown municipal and industrial water supply wells on the Pajarito Plateau.

The deep boreholes in lower Sandia Canyon and in lower Pajarito Canyon encountered basaltic lava flows that are interbedded with the sedimentary deposits of the upper Santa Fe Group. These basalts range in thickness from 30 ft to 480 ft (9.1 m to 146 m). They generally are described as dark gray and dense, but red vesicular zones are also present (Cooper et al. 1965, 8582, p. 60; Purtymun 1967, 11829, p. 9; Purtymun 1995, 45344, p. 263). These basalts probably are also present in the Santa Fe Group beneath lower Cañada del Buey.

3.3.1.2 Puye Formation, Tschicoma Formation, and Cerros del Rio Basalts

The Puye Formation is mostly a fanglomerate deposit generally consisting of poorly sorted boulders, cobbles, and coarse sands. At PM-3 the clasts are composed of dacite, rhyolite, and fragments of basalt and pumice (Purtymun 1967, 11829, p. 8). At TW-8 in Mortandad Canyon, the fanglomerate consists predominately of fine- to coarse-grained sands and interbedded clay, silt, and gravel (Baltz et al. 1963, 8402, Figure 4). The lower fanglomerate includes more than 95 ft (29 m) of light tan to light gray tuff and tuffaceous sand.

The lower Puye Formation includes coarse sand and boulder deposits interpreted to represent an axial facies deposit of the ancestral Rio Grande as described by Manley (1976, 57673) and Dethier (1997, 49843). The axial facies deposit was previously (informally) called the “Totavi Lentil” of Griggs (1964, 8795). At PM-3 this deposit is composed of gravel and boulders of dacite, rhyolite, and quartzite (Purtymun 1967, 11829, p. 9). The thickness of the axial facies deposit varies from 40 ft (12 m) at PM-4 to 70 ft (21 m) at PM-2 and PM-5 (Purtymun 1995, 45344, pp. 275 through 277). The axial facies deposit interfingers with the fanglomerates of the Puye Formation and basaltic rocks of the Cerros del Rio volcanic field in White Rock Canyon.

At PM-2, PM-3, PM-4, and PM-5 a sequence of brown and gray basaltic lava flows split the Puye Formation into the main lower part and a thin upper part (Purtymun 1995, 45344, pp. 275 through 277) (see Figure A-3 in Appendix A of this work plan). Similar basalts were penetrated in the Puye Formation by other deep boreholes in the area. These basalts are present beneath the Guaje Pumice Bed at PM-2 and PM-4, although variable thickness of fanglomerate facies may be present above the basalts. The basalts are stratigraphically equivalent to the basaltic rocks of the Cerros del Rio volcanic field and probably represent an extension of that volcanic field beneath the Pajarito Plateau.

Dacitic volcanic rocks, presumably representing the distal edge of a Tschicoma Formation lava flow, were encountered beneath the Bandelier Tuff in borehole SHB-1 (located west of TA-55). The dacite flow appears to occupy a similar stratigraphic position within the Puye Formation, as do the basalts. Similar dacite flows may underlie the upper and middle sections of Sandia Canyon. However, several deep boreholes drilled to 750 ft (225 m) at TA-46 did not encounter either the dacite or the basalt flows in the upper Puye Formation (Purtymun 1995, 45344, p. 209) (see Figure A-1). This may indicate that the volcanic flows in the Puye Formation do not extend laterally beneath the entire Pajarito Plateau.

The top of the regional zone of saturation beneath the Pajarito Plateau is usually encountered within the fanglomerate facies of the Puye Formation and the associated interbedded basalts. The regional zone of saturation initially was encountered beneath Sandia Canyon at a depth of 722 ft (220 m) in PM-1, 740 ft (225 m) in PM-3, and recently at a depth of 805 ft (245 m) in characterization well R-12. Beneath Cañada del Buey the regional zone of saturation initially was encountered at a depth of 1060 ft (323 m) in PM-4 at an elevation of 5960 ft (1787 m). A possible intermediate perched zone was encountered at a depth of 450 ft (140 m) in basalts within the Puye Formation during the drilling of PM-1. A perched intermediate zone of saturation was encountered from a depth of 443 ft to 519 ft in the lower part of the basaltic rocks of the Cerros del Rio volcanic field and in the underlying old alluvium in R-12 (Purtymun 1995, 45344; LANL 1998, 59665). Additional information about the regional zone of saturation is presented in Sections 3.4.4.6 and 3.5.4.6.

3.3.1.3 Otowi Member of the Bandelier Tuff

The Otowi Member is a nonwelded, poorly consolidated ignimbrite sheet composed of stacked ash-flow units. These units are composed of pumice lapilli supported by a matrix of ash and crystal fragments. The Otowi Member varies in reported thickness from 184 ft (56 m) in SHB-1 to 465 ft (142 m) in EGH-LA-1. The deposits of the Otowi Member beneath upper Sandia and middle Mortandad Canyon (near TW-8 and EGH-LA-1) are among the thickest on the Pajarito Plateau from deposition in a pre-Bandelier Tuff paleovalley (see Figure 5 in Broxton and Reneau 1996 [55429, p. 330]). The paleovalley containing the thick Otowi Member sediments continues southward across middle Cañada del Buey and Pajarito Canyon.

The Otowi Member outcrops in lower-offsite Sandia Canyon east of state road NM4 and is known to exist in the subsurface beneath the canyons from drill-hole data. The Otowi Member is 320 ft (98 m) thick at PM-4, 140 ft (43 m) thick at PM-3, and 120 ft (37 m) thick at PM-1. The Otowi Member thins eastward against a north-trending basaltic highland that crosses Sandia Canyon and Cañada del Buey near state road NM4. The Otowi Member is absent in the lower off-site Sandia Canyon and Cañada del Buey where it either was not deposited or was removed by erosion before the Tshirege Member was deposited. See Appendix C, Appendix D, and Figures A-2 and A-3 for stratigraphic information from test holes and wells.

The basal part of the Otowi Member includes the Guaje Pumice Bed, which is a sequence of well-stratified pumice-fall and ash-fall deposits. The Guaje Pumice Bed typically is 30 ft to 35 ft (9.1 m to 10.7 m) thick beneath the Pajarito Plateau (27 ft [8 m] at PM-2). Beneath lower Sandia Canyon the Guaje Pumice Bed thickens from west to east and is 20 ft (6 m) thick in PM-3 and 45 ft (13.7 m) thick in PM-1 (Purtymun 1995, 45344, pp. 275 through 276). No boreholes have penetrated the Guaje Pumice Bed in Cañada del Buey; however the Guaje Pumice Bed beneath lower Pajarito Canyon thins from west to east and is 27 ft (8.2 m) thick in PM-2, 20 ft (6 m) thick in PCTH-6, and 11 ft (3.3 m) thick in PCTH-5 (Purtymun 1995, 45344, pp. 223 and 275).

3.3.1.4 Tephras and Volcaniclastic Sediments of the Cerro Toledo Interval

Tephras and volcaniclastic sediments of the Cerro Toledo interval is an informal name given to a complex sequence of epiclastic sediments and tephras of mixed provenance (Broxton and Reneau 1995, 49726, p. 11). This unit includes well-stratified tuffaceous sandstones and siltstones, primary ash-fall and pumice-fall deposits, and dacite-rich gravel and boulder deposits. The Cerro Toledo deposits, which vary in thickness from 0 to more than 100 ft (30 m), likely were deposited episodically with unevenly distributed local deposits. Some sediments were deposited in drainage channels developed on top of the Otowi Member before deposition of the Tshirege Member. Other blanket-type fallout deposits were deposited across the plateau, including on paleotopographic drainage divides. Erosion and possible redeposition of the Cerro Toledo interval sediments and possibly the underlying Otowi Member occurred in places before deposition of the Tshirege Qbt 1 unit, which may have contributed to locally variable thickness. The Cerro Toledo interval is approximately 140 ft (43 m) thick in SHB-1 (Gardner et al. 1993, 12582, p. 9) and approximately 80 ft (24 m) thick in borehole 35-2028 located in Ten-Site Canyon (LANL 1996, 54422, p. 2-3).

The Cerro Toledo interval crops out along the steep south-facing walls of lower Sandia Canyon near PM-1 where dacite-rich gravels occur between the Tshirege and Otowi Members (Reneau and McDonald 1996, 55538, p. 38). These and other similar deposits indicate the presence of a pre-Tshirege paleodrainage that likely trends northwest to southeast, oblique to Sandia Canyon (Broxton and Reneau 1996, 55429, p. 329). One small outcrop of Cerro Toledo deposits is present in lower Cañada del Buey north of the east end of MDA G. Cerro Toledo interval deposits were not previously identified in any boreholes or wells drilled in Cañada del Buey. However, numerous boreholes drilled at TA-54 on Mesita del Buey encountered Cerro Toledo interval sediments, providing adequate documentation of its probable presence in Cañada del Buey. During preparation of this work plan, some borehole logs were reinterpreted to identify probable Cerro Toledo deposits beneath Sandia Canyon and Cañada del Buey, which was based partly on results of drilling at TA-54 and the expected thickness of the Tshirege Qbt 1g unit and the Tsankawi Pumice Bed in lower Cañada del Buey.

3.3.1.5 Tshirege Member of the Bandelier Tuff

The Tshirege Member is a multiple-flow ignimbrite sheet that underlies the alluvium on the floor of upper and middle Sandia Canyon and Cañada del Buey and forms the prominent cliffs and mesas adjacent to the canyon. The Tshirege Member includes a number of subunits that can be recognized based on differences in physical and weathering properties. This work plan follows the nomenclature of Broxton and Reneau (1995, 49726, p. 8), which was adopted for use as a standard by the ER Project. Both Purtymun and Kennedy (1971, 4798) and Rogers (1995, 54419) applied different systems of stratigraphic nomenclature to subunits of the Tshirege Member. The correlation among these different systems of nomenclature is shown in Figure 3-8 of the core document (LANL 1997, 55622, p. 3-19).

Within the Sandia Canyon and Cañada del Buey watershed, the following subunits of the Tshirege Member are present.

- The Tsankawi Pumice Bed (Qbtt) is the basal pumice fallout deposit of the Tshirege Member. This pumice bed typically is 1 ft to 3 ft (0.30 m to 0.91 m) thick in this part of the Laboratory. It is composed of angular to subangular clast-supported pumice lapilli up to 2.4 in. (6 cm) in diameter. The Tsankawi Pumice Bed is exposed on the south-facing canyon wall of lower Sandia Canyon near PM-1 and on the south-facing canyon wall of lower Cañada del Buey east of MDA G.

- Qbt 1g is the lowermost unit in the thick ignimbrite sheet that makes up most of the Tshirege Member. Qbt 1g is a porous, nonwelded, poorly sorted, vitric ignimbrite. It is poorly indurated but nonetheless forms steep cliffs because a resistant bench near the top of the unit forms a protective cap over the softer underlying tuff. Qbt 1g underlies the canyon floor in lower Cañada del Buey east of the confluence with the south fork of Cañada del Buey and underlies much of middle and lower Sandia Canyon. Qbt 1g outcrops as lower parts of cliff walls in middle and lower sections of Sandia Canyon and in lower Cañada del Buey.

- Qbt 1v is a series of cliff- and slope-forming outcrops composed of porous, nonwelded, devitrified ignimbrite. (All units above Qbt 1g are vapor-phase-altered and devitrified.) The base of the unit is a thin, horizontal zone of preferential weathering that marks the abrupt transition from vitric tuffs below to devitrified tuffs above; this feature forms a mappable marker horizon on canyon walls in portions of middle and lower Sandia Canyon. The lower part of Qbt 1v is a resistant orange brown colonnade tuff (Qbt 1v-c) that forms a distinctive low cliff characterized by columnar jointing. The colonnade tuff is overlain by a distinctive white band of slope-forming tuffs. Qbt 1v is exposed in canyon walls in middle and lower Sandia Canyon and is present beneath the canyon floor west of TA-53. Qbt 1v also is exposed in the canyon walls in lower Cañada del Buey and subcrops beneath the canyon floor in the middle canyon.

- Qbt 2 forms a distinctive, medium-brown, vertical cliff-forming unit that stands out in marked contrast to the slope-forming, lighter-colored tuffs above and below. This unit is devitrified, relatively highly welded, and forms the steep, narrow canyon walls of middle and upper Sandia Canyon and underlies the canyon floor at the head of Sandia Canyon. Qbt 2 forms a resistant caprock on mesa tops surrounding lower Sandia Canyon and is the caprock at Mesita del Buey and mesas surrounding Cañada del Buey.

- Qbt 3 is a nonwelded to partially welded, devitrified ignimbrite. The basal part of Qbt 3 consists of a soft, nonwelded tuff that forms a broad gently sloping bench on top of Qbt 2 in canyon wall exposures and on the broad canyon floor in upper Sandia Canyon. The upper part of Qbt 3 is a partially welded tuff that forms the caprock of mesas adjacent to upper and middle Sandia Canyon. This unit is more densely welded to the west and locally contains apparent horizontal bedding and/or fracturing.

- Qbt 4 is a partially to densely welded ignimbrite characterized by small, sparse pumices and numerous intercalated surge deposits. This unit is exposed on mesa tops west of TA-53 and TA-60 in the upper Sandia Canyon area. Some of the most densely welded areas occur on the western margin of the Laboratory.

3.3.1.6 Alluvium

Alluvium of Pleistocene and Holocene age rests unconformably on the Bandelier Tuff in Cañada del Buey and Sandia Canyon west of state road NM4. The alluvium overlies the Cerro Toledo interval in the lower Sandia Canyon near observation well SCO-2 and in lower Cañada del Buey east of TA-54. East of state road NM4 and through White Rock the stream channel in the canyons often is located directly on basalts of the Cerros del Rio volcanic field, with relatively minor alluvium being present (see Figure A-2). The alluvium in the canyons is derived from weathering of the Bandelier Tuff, which forms the steep walls on the sides of the canyons. The alluvium also contains sediment derived from eolian sources and fallout pumice deposits. In the upper parts of the canyons, the alluvium is thin and consists of gravels, sand, silt, and clay (Devaurs and Purtymun 1985, 7415, p. 11). The sand consists mainly of fine- to coarse-grained crystals of quartz and sanidine. The gravel fraction of the alluvium is composed mostly of low-density tuff clasts that are soft and relatively easily pulverized, and dark, resistant, angular-to-subangular volcanic clasts that are present in the tuff as lithic fragments, and which remain in the alluvium after tuff weathering (Reneau and McDonald 1996, 55538, p. 46).

The alluvium is relatively thin in the upper and middle parts of the canyons but generally widens and thickens downstream. In lower Sandia Canyon the Cerro Toledo interval outcrops on the north side of the canyon near wells R-12 and PM-1. Large boulders of Tschicoma Formation dacite are present within the Cerro Toledo interval at this location. The alluvium downstream from these outcrops may contain some reworked boulders and sediment from this unit.

Adequate borehole information for the alluvium in middle Sandia Canyon is not available to construct an isopach map. In lower Sandia Canyon the thickest part of the alluvium may be in middle Sandia Canyon or in lower Sandia Canyon near PM-3 and SCO-1. The alluvium is approximately 18 ft (5.5 m) thick at SCO-1 and SCO-2. The alluvium in Sandia Canyon thins eastward until the stream channel rests directly on basalt bedrock east of state road NM4. The location of the base of the alluvium may be difficult to determine in the lower canyon near R-12 and PM-1 where the Cerro Toledo interval subcrops beneath the alluvium.

In Cañada del Buey the thickest part of the alluvium may be in the middle canyon near CDBO-5 and CDBO-6, although no data exist on the thickness of the alluvium in Cañada del Buey east of CDBO-4. The alluvium at CDBO-5 is 17 ft (5 m) thick and at CDBO-6 may be 19 ft (5.8 m) thick. The alluvium north of MDA G is approximately 10 ft (3 m) thick and is 9 ft thick at CDBO-9 and CDBO-4. In the middle canyon the alluvium is 7 ft (2.1 m) thick at CDBO-8, and 19 ft (5.8 m) at CDBO-7. The alluvium in the lower part of the south fork of Cañada del Buey at monitoring well CDBO-3 is approximately 8 ft to 10 ft (2.4 m to 3 m). The alluvium is widest in the middle canyon near CDBO-8 and in the lower canyon east of TA-54. Eastward from TA-54 the alluvium thins until the stream channel rests directly on basalt bedrock near state road NM4. The location of the base of the alluvium may be difficult to determine in the lower canyon where the Cerro Toledo interval subcrops beneath the alluvium.

Figure A-2 shows the longitudinal cross section along the axis of the Sandia Canyon drainage channel. The figure contains information from boreholes in Sandia Canyon and information from deep boreholes that are present in and near the canyon, which are projected into the line of cross section. The cross section shows the approximate maximum thickness of the alluvium present at the center of the canyon. Figure A-2 also shows four lateral cross sections across Sandia Canyon at the following locations:

- near the head of the canyon at the wetland and SCS-1,
- below the confluence with the south fork of Sandia Canyon near SCS-2,
- in the canyon at SCO-1 and PM-3, and
- in the canyon at SCO-2 and PM-1 near the Laboratory boundary.

The approximate thickness and distribution of the alluvium in the canyon is shown on each lateral cross section. The bedrock stratigraphy from the site-wide geologic model also is shown on the lateral cross sections.

Figure A-3 shows the longitudinal cross section along the axis of the Cañada del Buey drainage channel and the main tributary channel, the south fork of Cañada del Buey. The figure contains information from boreholes in Cañada del Buey and information from deep boreholes that are present adjacent to the canyon. These boreholes are projected into the line of cross section. The cross section shows the approximate maximum thickness of the alluvium present at the center of the canyon. Figure A-3 also shows six lateral cross sections across Cañada del Buey at the following locations:

- in the upper canyon at CDBO-5,
- in the middle canyon at CDBO-6 and PM-4,

- in the middle canyon at CDBO-1, CDBO-2, CDBO-8 and CDBM-1,
- near MDA L at CDBO-3,
- at the west end of MDA G at CDBO-9 and CDBM-2,
- below the confluence of the south fork of Cañada del Buey, and
- at the east end of MDA G at CDBO-4.

The approximate thickness and distribution of the alluvium in the canyon is shown on each lateral cross section.

The lateral cross sections shown on Figures A-2 and A-3 generally are located where alluvial monitoring wells have been drilled, and the construction information from these monitoring wells is shown on the cross sections. The lateral cross sections are shown at the same reference elevation to illustrate the change in shape, elevation, and dimensions of the alluvium and approximate prealluvium incision throughout each canyon. The vertical scale exaggeration shown is 10 times the horizontal scale so that changes in the channel gradient are obvious on the cross sections. Additional subsurface and canyon-wall stratigraphic information (see Appendix E) is shown on the cross sections. Additional detail was added for the volcanic deposits by reference to the original drilling lithological logs that are summarized in Tables C-6 and D-6 in Appendices C and D.

The tuff underlying the alluvium is variably weathered, and it is often difficult to distinguish the fine-grained alluvium above the tuff from the tuff that has weathered in place. The weathered tuff ranges from a few feet thick up to approximately 20 ft (6.1 m). In the lower canyons, the Cerro Toledo interval subcrops beneath the alluvium in the area west of state road NM 4. Distinguishing tuffs and sediments of the Cerro Toledo interval from alluvium in borehole cuttings may be difficult; therefore, identification of this unit in the subsurface in Sandia Canyon has not been previously documented. The Cerro Toledo interval has been documented in boreholes drilled on Mesita del Buey at TA-54.

3.3.2 Geomorphology

3.3.2.1 Geomorphology of Sandia Canyon

Sandia Canyon has several geomorphically distinct sections between its headwaters in TA-3 and its mouth at the Rio Grande. These sections vary in their potential for sediment deposition and subsequent remobilization. The major longitudinal variations in morphology largely are controlled by the bedrock geology.

The upper canyon is relatively steep and narrow where the stream incises through Tshirege units Qbt 1v through Qbt 4. In this section, local variations in stream gradient and resultant variations in the potential for sediment storage occur relative to stratigraphic variations in the tuff. Relatively flat sections of the canyon floor occur upstream of resistant units in the tuff, particularly west of where the channel begins incising through unit Qbt 2, which provides opportunities for sediment storage. This area is approximately coincident with the occurrence of the wetland areas in upper Sandia Canyon. In some areas, the narrow canyon floor is partially filled with boulders derived from adjacent Qbt 2 and Qbt 3 cliffs, which creates steep reaches with relatively little potential for sediment storage.

A wetland in upper Sandia Canyon is downstream from NPDES outfalls at TA-3. The National Wetlands Inventory conducted by the US Department of the Interior Fish and Wildlife Service (FWS) shows three types of wetlands or water systems in Sandia Canyon. The primary wetland area is located adjacent to

TA-3 and is described as a “persistent, artificially flooded, palustrine wetland” (Bennett and Biggs 1996, 57541, p. 5). This wetland area is primarily a cattail-dominated marsh with a ponderosa pine overstory (Bennett and Biggs 1996, 57541, p. 5). The approximate length of the wetland from west to east is 2275 ft (840 m) (LANL 1998, 62340, p. 6).

Downstream from the primary wetland area in upper Sandia Canyon the stream designation changes to “temporarily flooded, palustrine wetland” (Bennett and Biggs 1996, 57541, p. 5). This area is much drier than the primary wetland area and is more riparian than marsh in nature. In the middle canyon south of TA-53 the stream designation changes to “intermittent, temporarily flooded, riverine streambed” (Bennett and Biggs 1996, 57541, p. 5).

Immediately upstream of the wetland area in upper Sandia Canyon is a rubble landfill that has been placed across the canyon to form the base for a proposed road. West of the rubble pile two small tributary channels at the head of the canyon drain TA-3.

The canyon floor begins widening and the channel gradient decreases where the channel reaches the nonwelded tuff of Tshirege unit Qbt 1g about 2.5 mi (4 km) east of Diamond Drive and 7.5 mi (12 km) west of the Rio Grande, which provides greater opportunity for sediment deposition and long-term sediment storage (Figure A-1). The channel gradient slowly decreases from about 0.028 m/m (2.8%, 1.6 degrees) near the south fork of Sandia Canyon to a minimum of about 0.020 m/m (2.0%, 1.17 degrees) near state road NM4. The alluvium is dominated by sand and begins to thicken downstream of the confluence with the south fork to approximately well SCO-1, where it is approximately 20 ft (6 m) thick. The combination of decreasing channel gradient, widening canyon floor, and a thick section of permeable, sandy alluvium all contribute to surface water infiltration and sediment deposition; this occurs primarily in middle Sandia Canyon south of TA-53 and upstream from well SCO-1. Downstream of state road NM4 the channel continues to be incised into the relatively nonwelded Otowi Member for a distance of approximately 1.8 mi (2.9 km). The alluvium pinches out where basalt is first exposed in the canyon floor at an elevation of 6250 ft (1905 m) approximately 1.6 mi (2.5 km) west of the Rio Grande.

At the western boundary of TA-72 in middle Sandia Canyon the alluvium has experienced incision of up to about 13 ft (4 m) since about 1935. The relatively recent incision may have been due to an increase in runoff from developed areas at the Laboratory in the upper part of the watershed or from straightening the channel and restricting the channel to the south side of the canyon when the modern road was built (Reneau and McDonald 1996, 55538, p. 39). In this area the canyon has had a similar depth for at least the last 80,000 to 1000,000 years, indicated by late Pleistocene soils, colluvium, and pumice beds exposed in stream banks. These deposits also indicate that canyon bottom sediments can have very long residence times (>10,000 years) in some areas. The sediment beneath the main canyon bottom in middle Sandia Canyon is late Holocene in age, with the upper 13 ft (4 m) deposited in the last 2500 years (Reneau and McDonald 1996, 55538, pp. 40-47).

The base level for most of Sandia Canyon is a prominent nick point that is developed on the top of a late Pliocene basalt flow that underlies the middle and lower canyon and outcrops in the walls of White Rock Canyon along the Rio Grande (see Figure A-2). The streamflow in Sandia Canyon has not been sufficient to effectively erode into the basalt and reduce the level of the streambed in that area. In the middle part of Sandia Canyon the exposures of alluvium along the stream channel indicate a period of net streambed incision during the past 50 to 60 thousand years (Reneau and McDonald 1996, 55538, p. 41).

In lower off-site Sandia Canyon, downstream of state road NM4, the channel steepens and drops through a narrow slot cut into basalt and into underlying Tertiary sediments. This part of the channel is much more rocky than the upstream part, and cobble- to boulder-size basalt clasts are common. The channel gradient progressively decreases between the basalt and the Rio Grande, although the gradient remains relatively high (>0.03 m/m) to the river. Near the Rio Grande, the canyon is a rocky alluvial fan that borders the Rio Grande floodplain.

3.3.2.2 Geomorphology of Cañada del Buey

Cañada del Buey has several geomorphically distinct sections between the headwaters on the central portion of the Pajarito Plateau and the confluence with Mortandad Canyon. These sections vary in their potential for sediment deposition and subsequent remobilization. The major longitudinal variations in morphology are largely controlled by the bedrock geology.

The upper canyon is relatively steep and narrow where the stream incises through Tshirege units Qbt 1v through Qbt 4. In this section, local variations in stream gradient and resultant variations in the potential for sediment storage occur relative to stratigraphic variations in the tuff. Relatively flat sections of the canyon floor occur upstream of resistant units in the tuff, particularly west of where the channel begins incising through unit Qbt 2, which provides opportunities for sediment storage. This area is located north of TA-46 where the channel gradient is relatively gentle. In some areas, the narrow canyon floor is partially filled with boulders derived from adjacent Qbt 2 and Qbt 3 cliffs, which creates steep reaches with relatively little potential for sediment storage.

The canyon floor begins widening and the channel gradient decreases where the channel reaches the nonwelded tuff of Tshirege unit Qbt 1v in the middle canyon, which provides greater opportunity for sediment deposition and long-term sediment storage (Figure A-1). The channel gradient slowly decreases from about 0.033 m/m (3.3%, 1.9 degrees) near TA-46 (through unit Qbt 2) to a minimum of about 0.026 m/m (2.6%, 1.5 degrees) near state road NM4. The alluvium is dominated by sand and begins to thicken downstream of the confluence with the TA-46 fork to approximately well CDBO-8, where it is approximately 20 ft (6 m) thick. The combination of decreasing channel gradient, widening canyon floor, and a thick section of permeable, sandy alluvium all contribute to runoff infiltration and sediment deposition; this occurs primarily in middle Cañada del Buey near TA-51 and upstream from well CDBO-8. The alluvium pinches out where basalt is first exposed in the canyon floor at an elevation of about 6500 ft (1980 m) approximately 0.6 mi (0.9 km) west of the Laboratory boundary at state road NM4. Through the town of White Rock the stream channel rests on basalt or in places on a thin veneer of weathered tuff of the Bandelier Tuff.

In lower off-site Cañada del Buey, downstream from state road NM4 through White Rock, the stream channel gradient flattens slightly (average gradient 0.017 m/m [1.7%]) as the channel flows over relatively resistant basalt and where relatively little sediment is stored. On the north side of White Rock, at the west edge of White Rock Canyon, the channel drops over basalt cliffs and onto Tertiary sediments of the Puye Formation. In White Rock Canyon the channel traverses a bouldery alluvial fan deposited at the base of the basalt cliff before draining into Mortandad Canyon about 2500 ft (760 m) upstream of the Rio Grande.

3.3.3 Geological Structure

See Appendix E for a compilation of the site-wide geologic model of the geologic units in the Sandia Canyon and Cañada del Buey areas. Generalized stratigraphic information for sites in and near Sandia Canyon is shown on accompanying cross section Figure A-2 and for Cañada del Buey is shown on cross section Figure A-3). Stratigraphic information from boreholes in the Sandia Canyon and Cañada del Buey areas are summarized in Tables C-6 and D-6 (see Appendices C and D).

Subunits of the Tshirege Member dip gently southeastward in the Sandia Canyon and Cañada del Buey area. The southeastward dip of these tuffs probably is the primary initial dip, mainly resulting from the burial of a southeast-dipping paleotopographic surface and thinning of subunits away from the volcanic source to the west.

The paleotopography of the pre-Tshirege surface may strongly influence the direction of possible groundwater flow in the Cerro Toledo interval beneath Sandia Canyon and Cañada del Buey. Available data from test wells and borehole drilling on the Pajarito Plateau, especially in the Pajarito Mesa municipal supply well field and at TA-54, help define this paleotopographic surface; however, few data points exist in the middle Sandia Canyon area and in Cañada del Buey. The existing data indicate that a Cerro Toledo-age drainage system likely heads on the flanks of the Sierra de los Valles in the area of the headwaters of Los Alamos Canyon. The channel system appears to trend to the southeast and crosses obliquely beneath upper Sandia Canyon and upper Cañada del Buey and continues southeastward to south of the White Rock basalt high (Broxton and Reneau 1996, 55429, p. 331). Dacite boulders in the Cerro Toledo interval are exposed in lower Water Canyon east of state road NM4, which indicates the presence of a large channel system within the Cerro Toledo interval. Similar volcanic boulders in the Cerro Toledo interval have also been encountered in boreholes SHB-1 and 35-2028 (in Ten-Site Canyon) and outcrop in lower Sandia Canyon near PM-1. The dacite boulders in lower Sandia Canyon may represent a separate channel system within the Cerro Toledo interval that may head in the upper reaches of the modern Rendija Canyon watershed (Broxton and Reneau 1996, 55429 p. 331).

Paleotopography of the pre-Otowi surface may also influence the flow direction of potential perched groundwater in the Sandia Canyon and Cañada del Buey areas. A significant zone of intermediate perched zone groundwater occurs in the Guaje Pumice Bed approximately 300 ft (91 m) beneath Los Alamos Canyon. This intermediate perched zone groundwater contains elevated concentrations of tritium (Broxton et al. 1995, 50121, p. 97), which are declining over time, suggesting the passage of a tritiated groundwater plume (Longmire et al. 1996, 54168, p. 476). Although this perched groundwater has been found only in the area beneath Los Alamos Canyon, structure contour maps suggest that the gradient of the perching layer changes from eastward to southward near TA-21 and that water confined to this zone may move down gradient along the axis of a large pre-Otowi paleodrainage toward the south, beneath Sandia Canyon and Cañada del Buey (Broxton and Reneau 1996, 55429, p. 329; Davis et al. 1996, 55446, p. 54). The location of the axis of this paleodrainage cannot be constrained precisely, but the available data suggest that the axis crosses beneath Sandia Canyon near TA-53 and crosses Cañada del Buey near water supply well PM-4. Groundwater infiltrating to and potentially perching in the Guaje Pumice Bed from Los Alamos Canyon could tend to migrate toward the axis of this paleodrainage and then flow toward the south or southwest beneath Sandia Canyon and Cañada del Buey.

Faults and fractures may play a role as infiltration pathways if they become saturated, particularly in the canyon floor. A complex zone of faulting associated with the southern part of the Rendija Canyon fault zone is exposed at the Los Alamos County landfill and crosses upper Sandia Canyon in the area of the wetlands (Gardner et al. 1998, 63496, p. 5; Gardner et al. 1999, 63492, p. 20). The southerly trace of the Guaje Mountain fault could also cross Sandia Canyon in the upper reaches of the watershed but that is not certain. Numerous small-displacement faults have also been documented at TA-54 near lower Cañada del Buey (Reneau et al. 1998, 63497, p. 5) and likely occur in other areas.

3.3.4 Geological Data Requirements

The following data are needed in the geologic investigations of the Sandia Canyon and Cañada del Buey systems to resolve uncertainties in the conceptual model for the canyon, particularly those that relate to potential contaminant pathways.

- Characterization of the geologic nature and distribution of possible perching layers for intermediate-depth groundwater is important for defining potential groundwater zones. Additional hydrologic information at the interfaces between the Cerro Toledo interval, Otowi Member, Guaje Pumice Bed, and the basalts would be especially important.

- The geologic nature of possible saturated zones in the Tshirege Member of the Bandelier Tuff and the possible relationship with shallow perched groundwater in middle Cañada del Buey would be important.
- Refinement of the location of the axis and downgradient direction for pre-Tshirege and pre-Otowi paleodrainages is important for regional characterization of the subsurface units.
- Evaluation of the geometry and distribution of geologic units below the canyons, especially near the axes of the paleodrainages and near the flow limits of the discontinuous volcanic flows, if present, such as between the Tschicoma Formation and Cerros del Rio basalts that overlie the regional aquifer is important to assess potential contaminant migration pathways.

3.4 Environmental Setting of Sandia Canyon

3.4.1 Surface Sediments

3.4.1.1 Natural Background Conditions

Sediments in Sandia Canyon are derived primarily from erosion of the Bandelier Tuff and soils that have developed in the watershed; the latter include components of wind-blown sediment and fallout pumice. The natural background chemistry of the sediments reflects both the source materials and particle size distribution of resultant deposits. No background data are available from sediments in Sandia Canyon, but background data have been obtained from geologically similar settings in Ancho Canyon and Indio Canyon (Reneau et al. 1998, 63497), which are also similar to background data collected from upper Guaje Canyon, Los Alamos Canyon, and Pueblo Canyon by the canyons investigation team in 1996 (Ryti et al. 1998, 59730). Because background sediment data obtained from other places on the Pajarito Plateau are similar in provenance to sediments in Sandia Canyon, these background data are used in Sections 3.4.1.3 and 3.5.1.3 to provide the basis for evaluating the nature of contaminants in the canyon sediments. Background values (BVs) reported for sediment, soil, and Bandelier Tuff units equate to the 95% upper tolerance limit (UTL) value for each analyte reported. The UTL value represents the upper range of the background concentrations (Ryti et al. 1998, 59730, p. 1).

3.4.1.2 Historic Channel Changes

Changes are known to have occurred in the Sandia Canyon channel since the beginning of Laboratory operations on the Pajarito Plateau. The most significant channel changes have been the result of road building in Sandia Canyon. Major channel changes were imposed with the construction of East Jemez Road in the middle canyon. The channel was straightened for a distance of about 1000 ft (300 m) along the south side of the road where the road was constructed over portions of the former channel. Channel changes also occurred in upper Sandia Canyon adjacent to TA-3 where a 40-ft (12-m) high rubble/debris pile of fill was placed across the canyon south of the county landfill for a planned roadway. The stream is channeled through the fill via a culvert. Expansion of the wetland area from 1958 to 1991 has been documented by comparing aerial photographs obtained over time (LANL 1998, 62340). The chronology of the wetlands expansion is presented in Figure 2.3.1-1. Although these and other channel changes have been only partially defined, they potentially affect the horizontal and vertical distribution of possible contaminants in the alluvium. Other channel changes include both aggradation that has locally raised the level of the streambed and degradation that has locally caused incision of streambeds. For example, part of Sandia Canyon south of TA-53 has incised 13 ft (4 m) since 1935, while a downstream area west of TA-72 is currently aggrading (Reneau and McDonald 1996, 55538, p. 39).

3.4.1.3 Contaminants in Sandia Canyon Sediments

3.4.1.3.1 Routine Environmental Surveillance of Active Channel Sediments

Since 1978 the Laboratory has collected surficial sediment samples annually from various locations along the active channel of Sandia Canyon. The sediment sampling locations in Sandia Canyon are listed in Table 3.4.1-1 and shown in Figure A-1. At present, the active channel is sampled annually at one location on Laboratory property (Sandia Canyon at SR-4). Surface sediment samples are collected at two locations on San Ildefonso Pueblo land (Sandia at Rio Grande and Rio Grande at Sandia). In addition, samples have been collected periodically from three sites in lower Sandia Canyon on San Ildefonso land (Sandia Canyon Stations 1, 2, and 3). These sediment samples typically are analyzed for radioactive constituents and are periodically analyzed for trace metals. Results are reported in the annual surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684). A summary of the analytical results for radionuclides is shown in Figure 3.4.1-1; a summary of the metals results is shown in Figure 3.4.1-2.

Table 3.4.1-1
Environmental Surveillance Sediment Sampling Locations in Sandia Canyon

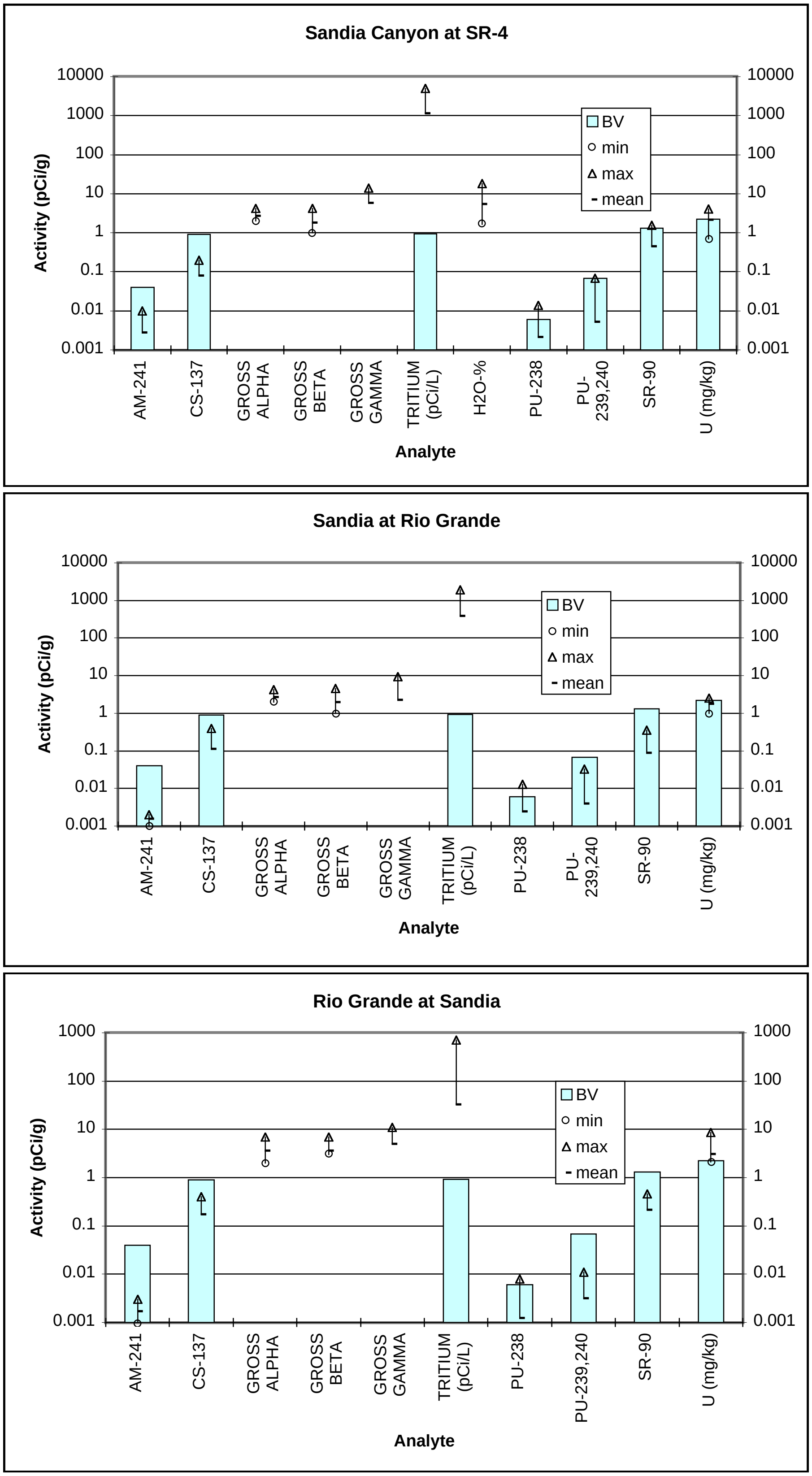
Location	Comment
Sandia Canyon on Laboratory Property*	
Sandia Canyon at SR-4	Active channel sediment site at state road NM4 1973 to 1997
Sandia Canyon on San Ildefonso Land	
SS-1	Sandia Canyon Station 1, 1992 to 1994
SS-2	Sandia Canyon Station 2, 1992, 1994
SS-3	Sandia Canyon Station 3, 1993, 1994
SS-4	Sandia Canyon Station 4, 1993
Sandia at Rio Grande	Sandia Canyon just upstream from the Rio Grande, 1977 to 1995
Rio Grande at Sandia	Rio Grande upstream of confluence with Sandia Canyon, 1979 to 1994

Source: Environmental surveillance reports 1973–1997.

* See Figure A-1 in Appendix A of this work plan for locations.

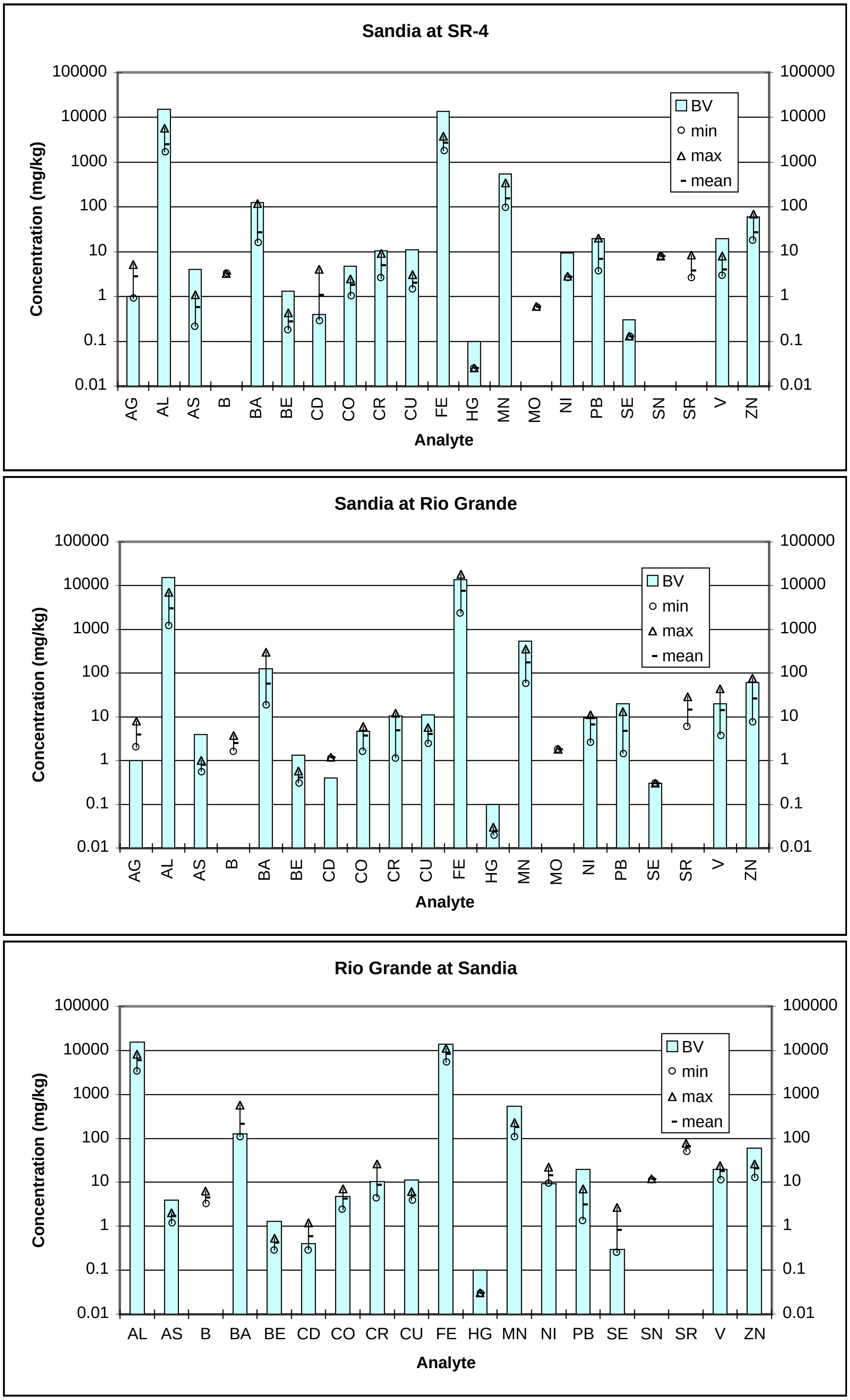
3.4.1.3.1.1 Sandia Canyon at State Road NM4

Since 1978 active channel sediment samples have been collected from Sandia Canyon near the eastern Laboratory boundary at site Sandia at SR-4. These samples were analyzed for radionuclide activity including americium-241; cesium-137; plutonium-238; plutonium-239,240; strontium-90; and total uranium (e.g., Environmental Surveillance and Compliance Programs 1998, 59904). Figure 3.4.1-1 summarizes the results of the analyses. The activities for most radionuclides have been below BVs for canyon sediments (Ryti et al. 1998, 59730). However, samples collected in 1990 and 1991 contained plutonium-238 activity of 2.3 times BV and in 1990 the plutonium-239,240 activity was slightly above BV. Additionally, uranium concentrations (using SW-846 method 3050 [nitric acid digestion]) have exceeded BV 5 different years with the maximum concentration measured (4.1 mg/kg uranium) about 2 times BV. In 1981 the activity of tritium in moisture distilled from the sediment samples was 4900 pCi/L, but since 1990 the observed tritium activity has been in the range of 100 pCi/L to 500 pCi/L, near the detection limit for tritium using liquid scintillation techniques. Elevated tritium in the sediment moisture may be from the proximity of the linear accelerator at TA-53.



Source: Environmental surveillance reports; BVs from Ryti et al. (1998, 59730).

Figure 3.4.1-1. Summary of radiological data from environmental surveillance sediment sampling.



Source: Environmental surveillance reports 1974–1997; BVs from Ryti et al. (1998, 59730).

Figure 3.4.1-2. Summary of metals data from environmental surveillance sediment sampling.

The sediment samples were analyzed for trace metals in 1990, 1992 to 1994, and 1996. A summary of the results is shown in Figure 3.4.1-2. The concentrations of the trace metals are generally below BV but a few samples have contained concentrations in excess of BV. Two samples collected in 1993 contained silver in a concentration of 5.1 mg/kg, about 5 times BV. One sample collected in 1990 contained 4.0 mg/kg cadmium, 10 times BV and 20 mg/kg lead, slightly above BV. The sample collected in 1992 contained 69 mg/kg zinc, slightly above BV. The mean values measured for each trace metal have been below BVs.

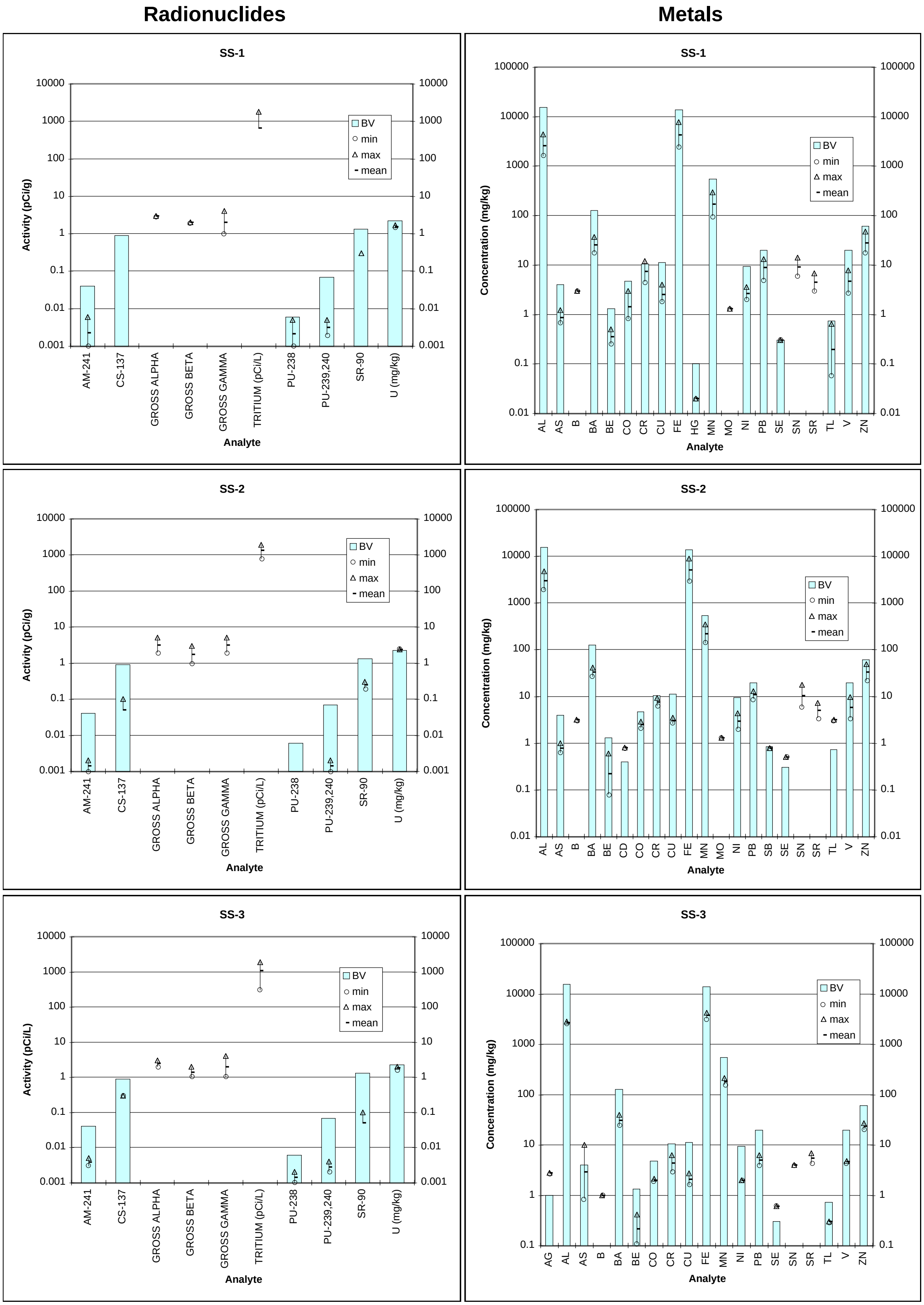
3.4.1.3.1.2 Sandia Canyon on San Ildefonso Pueblo Land

Since 1977 active channel sediment samples have been collected most years from lower Sandia Canyon above the confluence with the Rio Grande. The samples have been analyzed for radionuclide activity. A summary of the results of the sampling is shown in Figure 3.4.1-3. The activities of most radionuclides have been measured below BV with the exception of plutonium-238, which was measured at 0.007 pCi/g in 1993 and 0.013 pCi/g in 1995, which is about 2 times BV. Two samples also contained uranium concentrations slightly above BV (2.22 mg/kg), once in 1980 (2.5 mg/kg) and another in 1994 (2.4 mg/kg). Tritium activity in the moisture distilled from the sediment samples has been measured as high as 1900 pCi/L in 1992.

The samples collected in Sandia Canyon above the confluence with the Rio Grande were analyzed for trace metals from 1991 to 1995 and in 1997. Figure 3.4.1-2 summarizes the results of the analyses. Most results are below BV; however metals and trace metals observed above BV include silver, barium, cadmium, cobalt, chromium, iron, vanadium, and zinc. Trace metals with maximum observed concentrations at least 2 times BV are silver, barium, cadmium, and vanadium. The trace metals associated with these samples likely are derived from rock units exposed in White Rock Canyon. The Laboratory BVs for sediments may not be applicable for metals comparison at this site because sediments derived from units (for example basalt) exposed in White Rock Canyon typically contain higher trace metal contents than sediments derived from the Bandelier Tuff.

From 1979 to 1994, sediment samples were collected from the Rio Grande near the confluence with Sandia Canyon. The samples were routinely analyzed for radionuclide activity. Figure 3.4.1-1 summarizes the results of the sampling. The activities of most radionuclides have been measured below BV with the exception of plutonium-238, which was measured at 0.007 pCi/g in 1993 and 0.013 pCi/g in 1995, which is about 2 times BV. Two samples also contained uranium concentrations slightly above BV (2.22 mg/kg), once in 1980 (2.5 mg/kg) and another in 1994 (2.4 mg/kg). Tritium activity associated with the moisture distilled from the sediment samples at this site have been measured as high as 700 pCi/L, which is near the detection limit using liquid scintillation techniques.

The samples collected from the Rio Grande at Sandia Canyon were analyzed for trace metals from 1991 through 1994. Figure 3.4.1-2 summarizes the results of the analyses. Trace metals observed above BV include barium, cadmium, cobalt, chromium, nickel, selenium, and vanadium. Trace metals measured at concentrations greater than 2 times BV include barium, cadmium, chromium, nickel, and selenium. The trace metals associated with these samples likely are derived from rock units exposed in White Rock Canyon or upstream in the Rio Grande. The Laboratory BVs for sediments may not be applicable for metals comparison at this site because sediments derived from units (for example, basalt) exposed in White Rock Canyon typically contain higher trace metal contents than sediments derived from the Bandelier Tuff.



Source: Environmental Protection Group 1994, ER ID 45363; 1995, Environmental Protection Group ER ID 50285; Environmental Protection Group 1996, ER ID 54769.

Figure 3.4.1-3. Summary of sediment sampling at SS-1, SS-2, and SS-3, 1992–1994.

In 1992, 1993, and 1994, sediment samples were collected from two of three new sites established in lower Sandia Canyon on San Ildefonso Pueblo land, sites SSI-1, SSI-2, and SSI-3. These sites also are referred to as Sandia Canyon Stations 1, 2, and 3 (Environmental Protection Group 1994, 45363, p. IV-91; Environmental Protection Group 1995, 50285, p. IV-28). The samples were analyzed for trace metals and radionuclides and the results were reported in the annual environmental surveillance reports for 1992, 1993, and 1994. The results of the sampling are shown in Figure 3.4.1-3. Radionuclide activities were measured below BV at each site except that one sample from site SS-2 contained 2.4 mg/kg uranium, slightly above BV (2.22 mg/kg). The tritium activity of moisture distilled from the sediment samples has been measured as high as 1900 pCi/L. The trace metals at site SS-1 were measured below BV. However, at site SS-2 cadmium, selenium, and thallium were measured above respective BVs. At site SS-3 silver, arsenic, and selenium were measured above BV. The trace metals associated with these samples may be derived from rock units exposed in lower Sandia Canyon, such as the Cerro Toledo interval. The Laboratory BVs for sediments may not be applicable for metals comparison at these sites because sediments derived from units (for example, boulders of Tschicoma Formation dacite) exposed in White Rock Canyon typically contain higher trace metal contents than sediments derived from the Bandelier Tuff.

3.4.1.3.1.3 Other Environmental Surveillance Sediment Sampling in Sandia Canyon

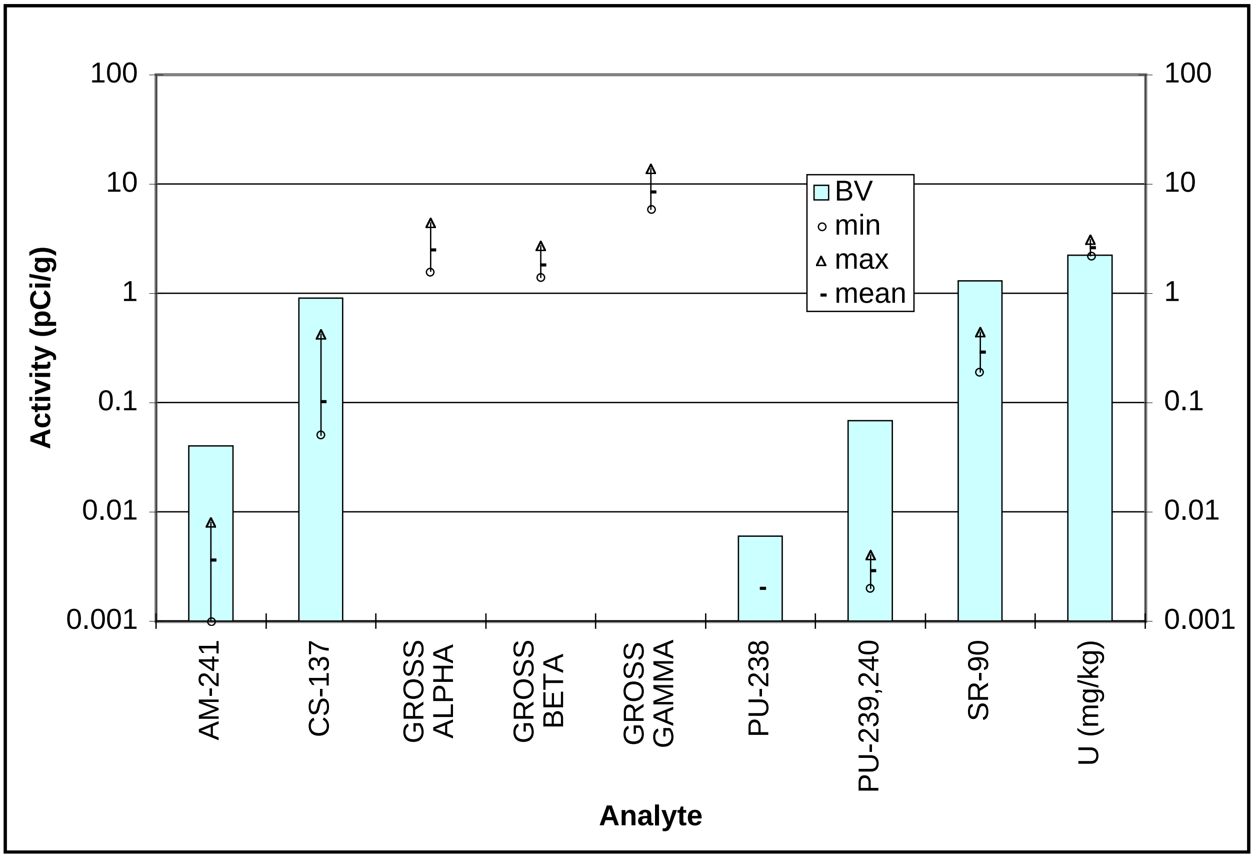
In 1978, 1979, and 1980 sediment samples were collected from the active channel in Sandia Canyon at site SCS-2, which normally is a surface water collection site. The samples were analyzed for radionuclides. The summary of the results of the sampling is shown in Figure 3.4.1-4. For the radionuclides analyzed, all activities were below BVs except uranium, which was measured in concentrations of 2.2 and 3.1 mg/kg, which is 1 to 1.4 times BV (ESG 1979, 5819; ESG 1980, 5961; ESG 1981, 6055).

3.4.1.3.2 RFI Sediment and Soil Sampling and Analysis in Sandia Canyon

This section describes the results of RFI soil and sediment sampling that has been conducted at PRSs in the Sandia Canyon watershed. The description of the history of RFI sampling in Sandia Canyon is in Section 2.3.1. RFI activities in Sandia Canyon began circa 1993 and some activities are scheduled to continue into the late 1990s. The current and former sources of contaminants to Sandia Canyon are also discussed in Section 2.3.1. RFI sampling activities in and adjacent to Sandia Canyon at TA-3 and TA-60 were described in the “RFI Work Plan for Operable Unit 1114” (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). The results of the RFI activities at TA-3 and TA-60 have been reported in the “RFI Report for 53 Potential Release Sites in TA-3, TA-59, TA-60, TA-61” (LANL 1996, 54467) and the “RFI Report for TA-3 for Potential Release Sites 3-004(c,d), 3-007, 3-014(k,l,o), 3-021, 3-049(a), 3-052(b), 3-056(k), and C-3-014” (LANL 1997, 56660).

The RFI sampling activities in and adjacent to Sandia Canyon at TA-53, former TA-20, and TA-72 were described in the “RFI Work Plan for Operable Unit 1100” (LANL 1994, 34756). The NMED issued a notice of deficiency (NOD) for the work plan; the NOD and the Laboratory’s response are presented in the “Response to EPA’s NOD for OU 1100 Work Plan” (LANL 1994, 43889). The results of the RFI activities at TA-53, former TA-20, and TA-72 have been reported in the “RFI Report for Potential Release Sites in TA-20, TA-53, and TA-72” (LANL 1996, 54124).

Most RFI samples have been collected from surface soil and subsurface bedrock sediments and are not samples of active channel sediments as discussed in the previous sections. However, a summary of the results obtained for surface soil samples, which often include sediments in catchment areas associated with PRSs, is provided in the following discussion to indicate which contaminants are present on the mesas surrounding Sandia Canyon.



Source: Environmental surveillance reports (ESG 1979, 5819; ESG 1980, 5961; ESG 1981, 6055).

Figure 3.4.1-4. Summary of radiological data from site SCS-2.

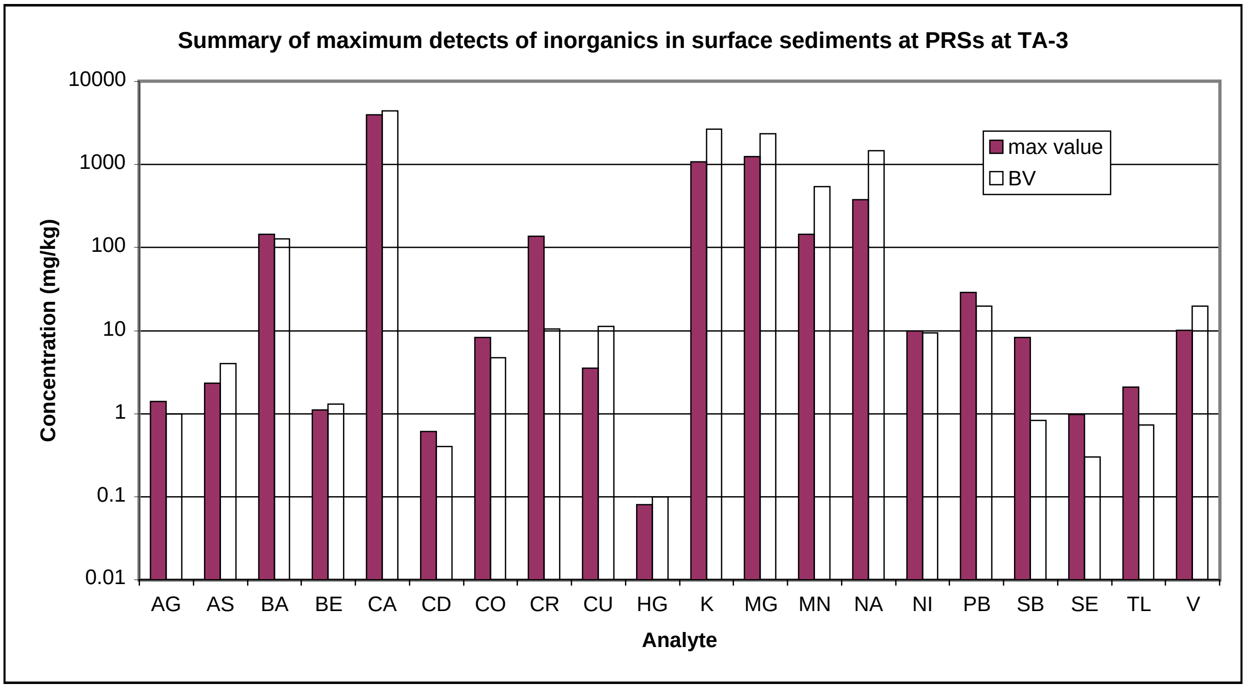
A special canyon-like investigation of upper Sandia Canyon was initiated in 1998 based on the ecological sensitivity of the wetlands and the presence of polychlorinated biphenyl (PCB) contaminants at numerous PRSs within the upper portion of the watershed, specifically at PRS 3-056(c) (see Section 2.3.1). The planned activities are described in the “Sampling and Analysis Plan for Upper Sandia Canyon” (LANL 1998, 62340). Preliminary sampling of sediments in the wetland and sediments transported in surface water upstream from the wetland indicated detectable quantities of PCBs. The presence and distribution of contaminants other than PCBs is unknown, which prompted the need for the canyon-like investigation for upper Sandia Canyon (LANL 1998, 62340, p. 1).

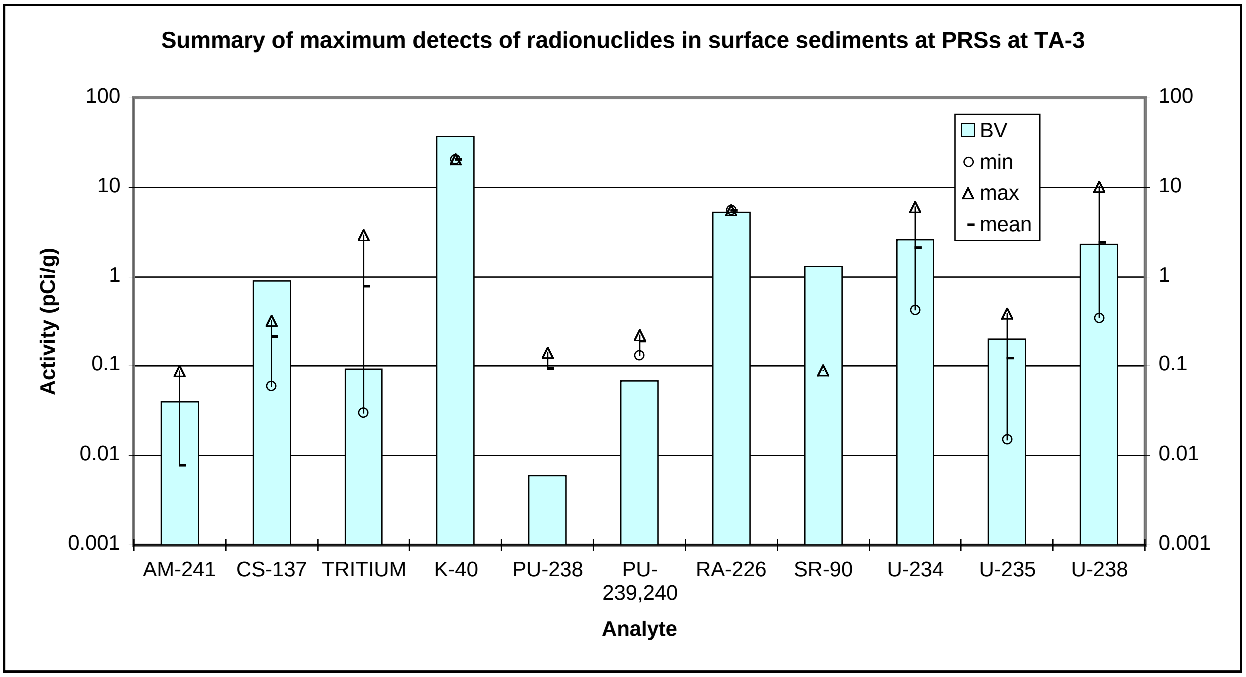
3.4.1.3.2.1 Summary of RFI Sediment and Soil Sampling in Upper Sandia Canyon

The Laboratory ER Project has conducted field investigations and sampling activities at PRSs within the upper Sandia Canyon watershed. Results of the investigations are summarized below.

3.4.1.3.2.1.1 Summary of Soil and Sediment Sampling at TA-3

Figure 3.4.1-5 summarizes the maximum results of inorganic constituents and radionuclides detected in surface sediment samples collected from 14 PRSs at TA-3 that are in the upper Sandia Canyon watershed. The figure also shows, for the data that have been reported, the maximum measured values for inorganic constituents obtained from the RFI at TA-3. The BVs for sediments are also shown for comparison. The results of the RFI sampling show that most inorganic constituents have been measured in concentrations below BV. However a few constituents have been measured above BV, including silver, barium, cadmium, chromium, lead, antimony, selenium, and thallium. Figure 3.4.1-5 also summarizes the maximum detects of radionuclide activities observed at 14 PRSs at TA-3. This figure shows the minimum, maximum, and mean values of the maximum observations at the different PRSs and the BVs for each radionuclide. Maximum activities measured for americium-241, tritium, plutonium-238, plutonium-239,240, uranium-234, uranium-235, and uranium-236 are above BVs for sediment. Maximum activities measured for cesium-137, potassium-40, and strontium-90 are below BVs.





Source: LANL 1996, 54467; LANL 1995, 46198; LANL 1997, 56660, BVs from Ryti et al. 1998, 59730.

Figure 3.4.1-5. Summary of maximum detects of inorganics and radionuclides at TA-3 PRSs.

Organic compounds detected in sediment samples at TA-3 above detection limits include the following compounds:

> Acenaphthene; acenaphthylene; acetone; anthracene; Aroclor-1016; Aroclor-1242; Aroclor-1254; Aroclor-1260; benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(g,h,i)perylene; benzo(k)fluoranthene; benzoic acid; bis(2-ethylhexyl)phthalate; butylbenzylphthalate; carbazole; chrysene; dibenz(a,h)anthracene; dibenzofuran; dibromofluoromethane; dibutyl; Chlordane; 1,4-dichlorobenzene; fluoranthene; fluorene, 2-fluorobiphenyl; 2-fluorophenol; indeno(1,2,3-c,d)pyrene; Mecoprop; methylene chloride; naphthalene; total petroleum hydrocarbons (TPH) (diesel range); phenanthrene; pyrene; tetrachloroethene; and toluene.

3.4.1.3.2.1.2 Summary of Soil Sampling at TA-60

Soil samples were collected at PRSs during the RFI conducted on the mesa top at TA-60 in 1994. The sampling was performed according to the sampling and analysis plan (SAP) in "RFI Work Plan for Operable Unit 1114" (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). Most TA-60 PRSs were recommended for NFA in the work plan and in the addendum to the work plan. PRSs 60-004(b, d, e, and f), and 60-007(a and b) were investigated and subsequently recommended for NFA in the "RFI Report for 53 Potential Release Sites in TA-3, TA-59, TA-60, TA-61" (LANL 1996, 54467). Most constituents analyzed during the RFI at TA-60 were found to be below BVs for soil; inorganic constituents that were measured in concentrations slightly above BV include cadmium, mercury, and zinc. Organic compounds that were detected in the samples included Aroclor-1254, Aroclor-1260, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, 2,4-dimethylphenol, and phenol (LANL 1996, 54467).

3.4.1.3.2.1.3 Summary of Soil Sampling at TA-61

PRSs located within the Sandia Canyon watershed at TA-61 have been addressed in the "RFI Work Plan for Operable Unit 1114" (LANL 1993, 51977) and the addendum to the work plan (LANL 1995, 51981). Most TA-61 PRSs were recommended for NFA in the work plan and in the addendum to the work plan. PRS 61-002 was the subject of and RFI. Surface soil samples were collected at this site and PCBs were retained as a chemical of potential concern (COPC) by the screening assessment process for PRS 61-002. PCBs were detected at concentrations of 1.4 mg/kg and 1.6 mg/kg, which exceeds the screening action level (SAL) value of 1 mg/kg. As a result of the Phase I investigation, a Phase II investigation was proposed to determine the extent of contamination. The Phase II field investigation was conducted in 1997 and the results of the investigation are planned to be presented in a future RFI report. The discussion of the Phase I investigation and the Phase II SAP are presented in the "RFI Report for 53 Potential Release Sites in TA-3, TA-59, TA-60, TA-61" (LANL 1996, 54467, pp. 200 through 211). The results of the Phase I RFI indicated that all inorganic constituents were below BVs for soil except zinc. Zinc was measured at a maximum concentration of 59.9 mg/kg, above the soil BV (48.8 mg/kg). Preliminary results of the Phase II sampling indicated that of 25 samples with detected organic compounds, one sample was above the SAL value of 1 mg/kg and the mean value of all samples collected was about 0.1 mg/kg.

3.4.1.3.2.1.4 Risk Assessment Based on PRSs in the Upper Sandia Canyon Watershed

A summary of the RFI activity that has occurred in upper Sandia Canyon at TA-3, TA-60, and TA-61 was presented in the "Sampling and Analysis Plan for Upper Sandia Canyon" (LANL 1998, 62340). Using data from 14 source PRSs, a relative toxicity ranking for human health and ecological risk assessment was performed. The analysis suggests that PCBs and carcinogenic polyaromatic hydrocarbons (PAHs) represent the risk drivers for potential human health effects, and that chromium (if hexavalent), arsenic, and PCBs represent the ecological risk drivers. Because of the known effects of pesticides on birds, pesticides are included on the list of potential ecological risk drivers. Thus, investigations and sampling upper Sandia Canyon will determine if PCBs, pesticides, PAHs, and metals are present as part of the overall nature and extent characteristics (LANL 1998, 62340, p. 12).

The “Sampling and Analysis Plan for Upper Sandia Canyon” calls for investigating a portion of upper Sandia Canyon in two primary reaches (LANL 1998, 62340). Each reach has a distinct physiographic and geomorphic setting consisting of an active channel and buried channel deposits, as well as active and abandoned floodplain surfaces and deposits. The investigation planned in the upper Sandia Canyon SAP focuses on sediments that were deposited after Laboratory operations began, including sampling base-flow surface water and stormwater runoff. Based on the preliminary results of the upper Sandia Canyon investigation, the necessity for a subsurface and/or groundwater investigation in upper Sandia Canyon will be evaluated as part of the SAP in Chapter 7 of this document (LANL 1998, 62340, p. 30 through 31).

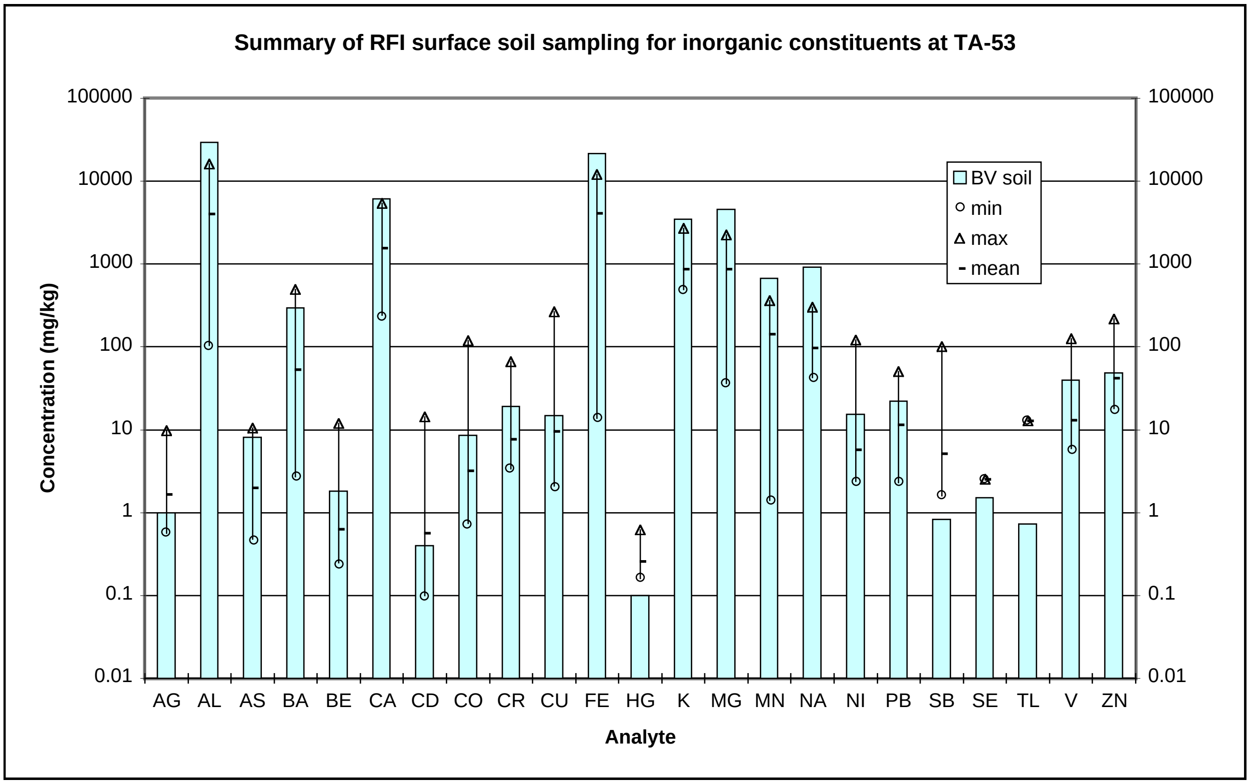
The initial phase of field implementation of the upper Sandia Canyon SAP (LANL 1998, 62340) was conducted during the spring and summer of 1998 and the investigation is continuing into the summer of 1999. A preliminary report of the results of the investigation is pending.

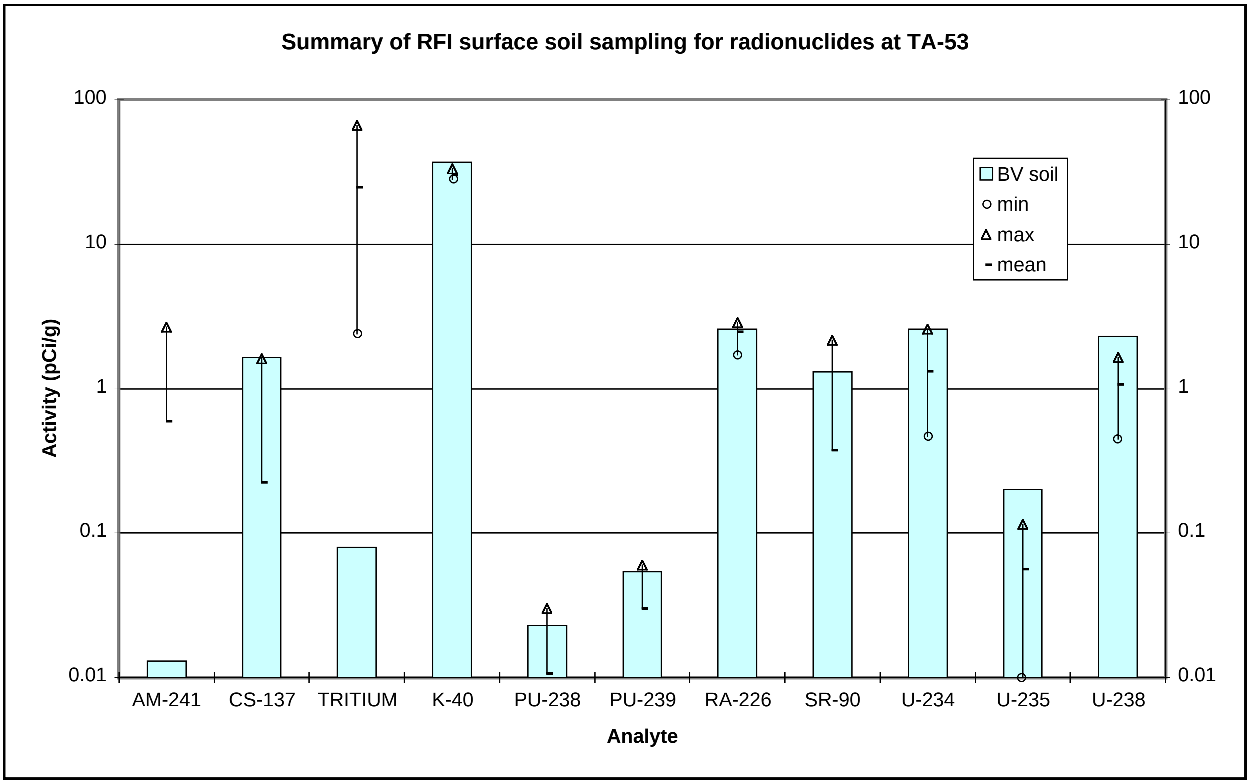
3.4.1.3.2.2 Summary of Soil Sampling at TA-53

PRSs located in the Sandia Canyon watershed area at TA-53 have been addressed in the “RFI Work Plan for Operable Unit 1100” (LANL 1994, 34756). Most PRSs at TA-53 were recommended for NFA in the work plan. PRSs 53-001(a, b, e, and g) and 53-012(e) were investigated and subsequently recommended for NFA in the “RFI Report for Potential Release Sites in TA-20, TA-53, and TA-72” (LANL 1996, 54124). The RFI at some PRSs are in progress. The analytical results of surface soil samples collected at PRSs at TA-53 are shown in Figure 3.4.1-6. Inorganic constituents detected in the samples above the BV for soil include silver, arsenic, barium, beryllium, cadmium, cobalt, chromium, copper, mercury, nickel, lead, antimony, selenium, thallium, vanadium, and zinc.

3.4.1.3.2.3 Former TA-20

In May 1995 an RFI was performed at PRSs at former TA-20 in middle Sandia Canyon. Surface soil and sediment samples were collected at a total of nine PRSs. Shallow boreholes were drilled to a depth of about 3 ft (0.9 m), and several trenches were excavated to a depth of 11 ft (3.3 m). The trenches were located at PRSs 20-001(a) and 20-001(b) and samples were collected in the trenches at the following depths: 0–12 in, 30–36 in, 54–60 in, and 108–132 in. The RFI sediment samples were analyzed for organic, inorganic, and radionuclide constituents according the SAP in the “RFI Work Plan for Operable Unit 1100” (LANL 1994, 34756). The results of the sampling and analyses were reported in the “RFI Report for Potential Release Sites in TA-20, TA-53, and TA-72” (LANL 1996, 54124). Figure 3.4.1-7 summarizes the maximum values detected for inorganic and radionuclide constituents and shows BVs for sediments. Inorganic constituents detected in concentrations significantly above BV for sediments include barium, beryllium, cobalt, chromium, copper, mercury, manganese, lead, selenium, thallium, and uranium. Radionuclides detected in activities significantly higher than BV include americium-241, strontium-90, uranium-234, uranium-235, and uranium-238. Most samples that contained elevated uranium isotopes were from PRS 20-002(d), a firing site, which was proposed for voluntary corrective action (VCA) to address COPCs present above SAL values. A schedule for the VCA has not been established.





Source: LANL 1996, 54124, BVs from Ryti et al. 1998, 59730.

Figure 3.4.1-6. Summary of RFI surface soil sampling at TA-53.

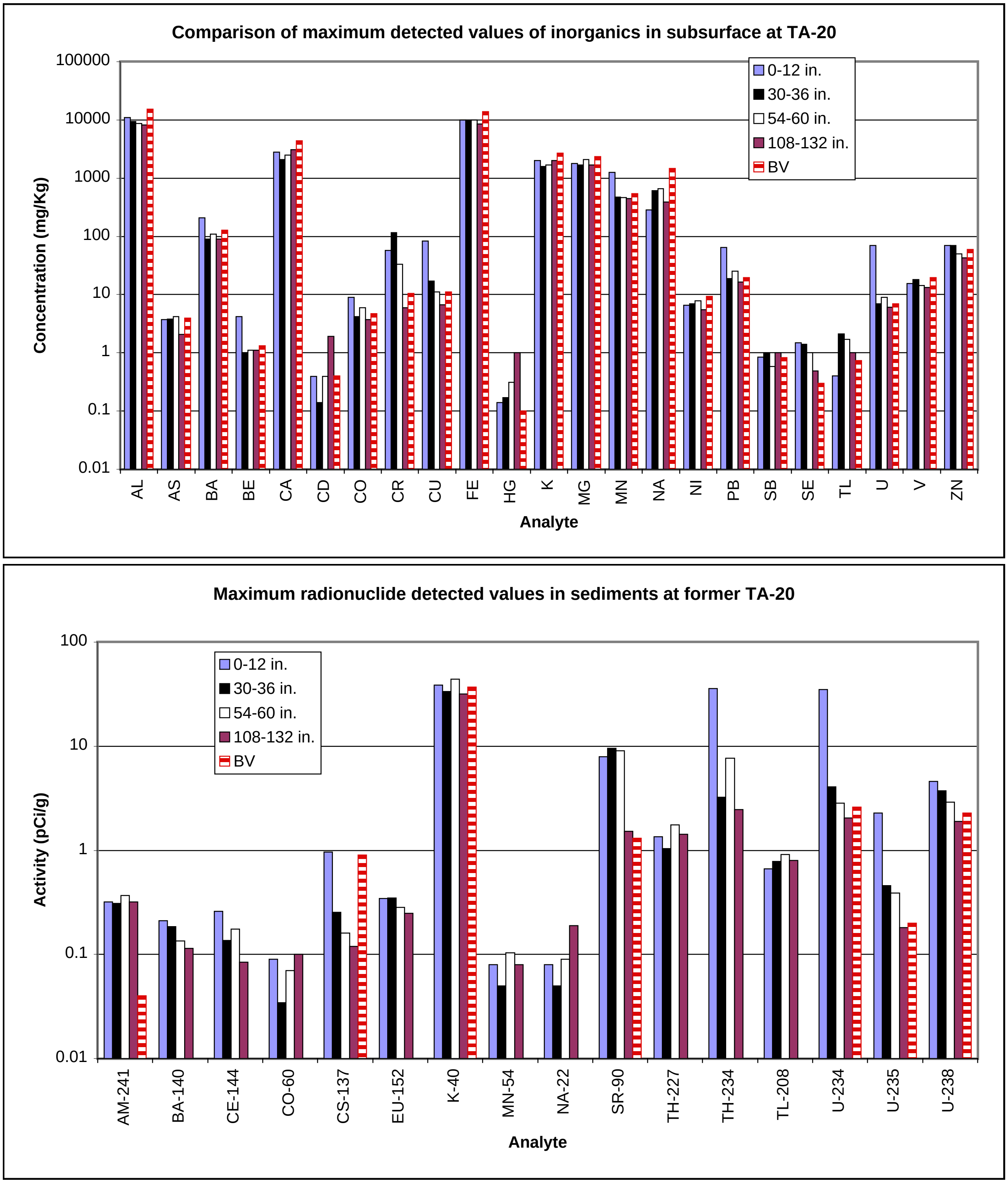


Figure 3.4.1-7. Summary of RFI sampling at former TA-20 in middle Sandia Canyon.

On March 22, 1996, soil and sediment samples were collected in Sandia Canyon adjacent to TA-53. The samples were collected from four sample locations at the following depth intervals: 0–6 in. and 6–12 in., for a total of eight samples. The sample sites were SA-0002, SA-0003, SA-0004, and SA-0005 (see Figure A-1). The samples were analyzed for PCBs. Analytical results showed that the sample that was collected out of the stream channel (SA-0002) did not contain PCBs. However, the samples that were collected from within the active stream channel in Sandia Canyon contained identifiable amounts of Aroclor-1260 at estimated concentrations below the detection limit. Table 3.4.1-2 shows the preliminary results of the sampling.

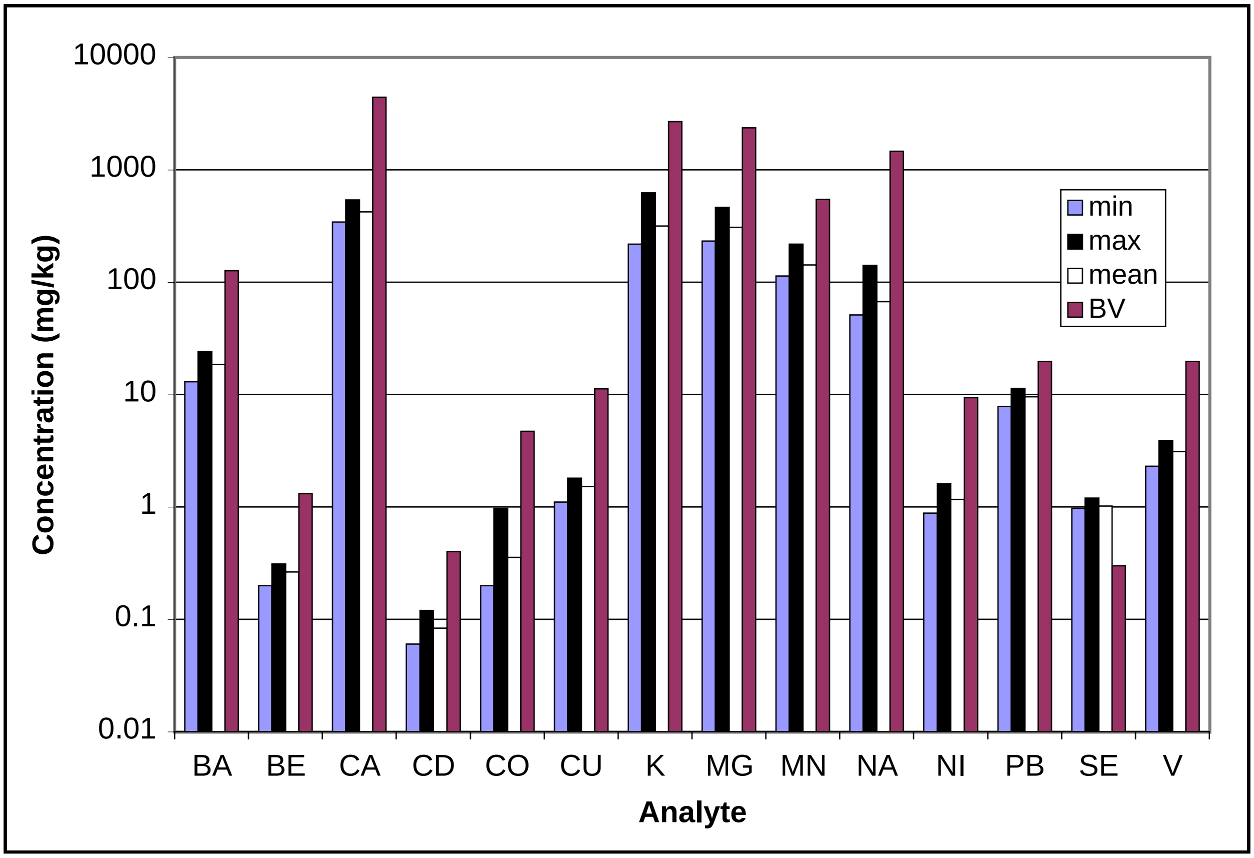
Table 3.4.1-2
PCBs Detected in Soil and Sediment Samples Collected in Sandia Canyon in 1996

Sample ID	Location ID	Depth (in.)	Analyte	% Moisture	Value	Units	Qual*	Matrix
04SA-96-0003	SA-0003	0–6	Aroclor-1260	2.39	.027	mg/kg	J	Soil
04SA-96-0008	SA-0005	6–12	Aroclor-1260	7.92	.017	mg/kg	J	Soil
04SA-96-0009	SA-0005	0–6	Aroclor-1260	5.77	.019	mg/kg	J	Soil
04SA-96-0005	SA-0004	0–6	Aroclor-1260	14.83	.015	mg/kg	J	Soil
04SA-96-0006	SA-0004	6–12	Aroclor-1260	16.47	.014	mg/kg	J	Soil
04SA-96-0007	SA-0005	0–6	Aroclor-1260	6.24	.022	mg/kg	J	Soil

* "J" qualifier means the data value is estimated, qualitatively correct, but quantitatively suspect.

3.4.1.3.2.4 Technical Area 72

In May 1995 an RFI was performed at PRS 72-001 at TA-72 in middle Sandia Canyon according to the "RFI Work Plan for Operable Unit 1110" (LANL 1994, 34756). PRS 72-001 is located in lower Sandia Canyon at TA-72 and is associated with the small-arms firing range for the Laboratory's security force. The site includes a 175-ft by 250-ft (53-m by 75-m) firing range surrounded by earth berms, an adjacent skeet shooting range, and some administration buildings. Lead is known to be present in the soil at the firing range; bullets are scattered around the bases of the berms and cliffs and lead shot from skeet shooting is present on the ground surface. Surface soil/sediment sampling was conducted at seven sites that included sediment catchment areas in the drainage downgradient from the site to determine if migration of lead or other possible contaminants has occurred. The samples were analyzed for inorganic constituents including metals and trace metals. A summary of the results of the analyses is shown in Figure 3.4.1-8**.** All inorganic constituents were measured below BV except selenium. However the results for selenium were at or near the detection limit for selenium (1 mg/kg), which was higher than BV (0.3 mg/kg). The results indicated that no COPCs were present, suggesting that contaminants at the firing range have not migrated from the site. Based on the sampling results and because the firing site is currently active, PRS 72-001 was recommended for a deferred action until the site is decommissioned (LANL 1996, 54124, p. 5-39).



Source: LANL 1996, 54124, p. 5-39; BVs from Ryti et al. 1998, 59730.

Figure 3.4.1-8. Results of sediment sampling at PRS 72-001 in Sandia Canyon.

3.4.1.3.3 Summary of Surface Sediment Data in Sandia Canyon and Data-Collection Activities Needed to Understand Surface Sediments and Associated Contaminants

Significant information about surface sediments provided in Section 3.4.1.3 is summarized below.

- Surface soil and sediment samples collected from PRSs at TA-3 in the upper Sandia Canyon watershed contain silver, barium, cadmium, chromium, lead, antimony, selenium, and thallium above BV. Additionally, americium-241, plutonium-238, plutonium-239,240, uranium-234, uranium-235, and uranium-236 have been measured in concentrations above BV. Numerous organic compounds have been detected in the surface soil and sediment at TA-3 PRSs.
- A wetland area is present in upper Sandia Canyon. Sampling of sediments in the wetland and sediments transported in surface water upstream from the wetland indicated detectable quantities of PCBs. The presence and distribution of contaminants other than PCBs is unknown. A special canyon-like investigation of upper Sandia Canyon in the vicinity of the wetland was initiated in 1998.
- Using data from 14 source PRSs in upper Sandia Canyon, a relative toxicity ranking for human health and ecological risk assessment suggests that PCBs and carcinogenic PAHs represent the risk drivers for potential human health effects, and that chromium (if hexavalent), arsenic, and PCBs represent the ecological risk drivers. The canyon-like investigation conducted in upper

Sandia Canyon focused on sediments that were deposited after Laboratory operations began. Surface base-flow and stormwater runoff samples also will be collected. Based on the preliminary results of the upper Sandia Canyon investigation, the necessity of a subsurface and/or groundwater investigation will be evaluated prior to implementing the SAP in Chapter 7 of this document.

- Little historical information is known about contaminants in the middle Sandia Canyon stream channel sediments upstream from the eastern Laboratory boundary. Routine environmental surveillance sampling for stream sediments in the active channel has occurred at the eastern boundary of the Laboratory and downstream.
- Sediment samples collected from the active channel in Sandia Canyon at site SCS-2 contained uranium in concentrations up to 1.4 times BV.
- Several sediment samples collected from the active stream channel in middle Sandia Canyon contained trace amounts of PCBs at estimated concentrations below the detection limit.
- Sediment sampling at the eastern Laboratory boundary shows concentrations of uranium and plutonium isotopes above BV. Samples collected in 1990 and 1991 contained plutonium-238 activity 2.3 times BV and in 1990 the plutonium-239,240 activity was slightly above BV. Uranium concentrations (using SW-846 method 3050 [nitric acid digestion]) have exceeded the BV in five different years with the maximum concentration measured about 2 times BV.
- Sediment sampling at the eastern Laboratory boundary shows some trace metal concentrations above BV. Two samples collected in 1993 contained silver about 5 times BV. One sample collected in 1990 contained a cadmium concentration 10 times BV and lead slightly above BV. The sample collected in 1992 contained zinc slightly above BV.
- In 1993 sediment sampling east of the Laboratory boundary on San Ildefonso Pueblo land showed that plutonium-238 present about 2 times BV. Samples also contained uranium concentrations slightly above BV in 1980 and in 1994.
- The stream channel in middle Sandia Canyon has been highly disturbed by straightening the stream channel during road construction. Impacts to sediment transport and possible contaminant transport and redistribution are not well understood.

The following additional data-collection activities are needed to evaluate contaminants within the sediments of the Sandia Canyon system.

- The full suite of contaminants that are present within the sediments at or above BV need to be determined.
- The locations of significant contaminant sources need to be determined.
- The potential presence of contaminants in sediments in the middle and lower parts of Sandia Canyon has not been determined. Investigations of the sediments in the middle and lower sections are needed to understand the distribution of contaminants in Sandia Canyon.
- The average concentrations, the range of concentrations, and approximate inventories of contaminants contained with different geomorphic units and different sediment facies need to be investigated, particularly for those contaminants that may be shown to be risk drivers.

- The horizontal and vertical distribution of contaminated sediments that have been deposited by flood events, including the nature and effects of historic channel changes needs to be understood. For example, channel bed aggradation and/or degradation, lateral migration and diversion of the active channel, and abandonment of inactive channels needs to be investigated at key locations within Sandia Canyon.

See Section 7.2 of this work plan for a complete description of the sediment SAP.

3.4.2 Previous Subsurface Sediment and Bedrock Investigations

This section summarizes the results of previous borehole drilling in and adjacent to Sandia Canyon. The locations of boreholes are shown in Figure A-1. Information about the boreholes is summarized in Appendix C, and additional information is shown in Figure A-2.

Historic Boreholes in Sandia Canyon

In February 1965 water supply well PM-1 was drilled to a depth of 2501 ft (762 m) in lower Sandia Canyon near the eastern Laboratory boundary at state road NM4 (see Figure A-1). The well was drilled into the regional zone of saturation in the Puye Formation and Santa Fe Group sediments. Basalt in the Puye Formation was encountered beneath the Bandelier Tuff at a depth of 432 ft (132 m). The Santa Fe Group was encountered at 1410 ft (430 m). The well was completed in the regional aquifer as a municipal and industrial supply well. The screened interval is from 945 ft to 2479 ft (288 m to 756 m) (Purtymun 1995, 45344, p. 275). Additional information about this well can be found in Section 3.4.4.6 and in Figure A-2.

In November 1966 water supply well PM-3 was drilled to a depth of 2552 ft (778 m) in middle-lower Sandia Canyon (see Figure A-1). This well also was drilled into the regional aquifer and was completed as a municipal water supply well. Basalt in the Puye Formation was encountered at a depth of 540 ft (165 m). The Santa Fe Group was encountered at 805 ft (245 m). The screened interval is from 956 ft to 2532 ft (291 m to 772 m) (Purtymun 1995, 45344, p. 276). Additional information about this well can be found in Section 3.4.4.6 and Figure A-2.

The first alluvial boreholes drilled in lower Sandia Canyon were observation wells drilled in 1966 by the Environmental Surveillance Group (now ESH-18). Observation wells SCO-1 and SCO-2 were drilled in lower Sandia Canyon to determine the presence of water in the alluvium near supply wells PM-3 and PM-1, respectively (Purtymun 1995, 45344, p. 67). For a time these wells were called SCO-3 and SCO-4, probably with the expectation that at least two additional wells would be drilled upstream in Sandia Canyon (e.g., Purtymun 1973, 4971, p. 3; Purtymun 1975, 11787, p. 117). Appendix C summarizes the information obtained from these holes; Figure A-1 shows their locations. The stratigraphic information obtained from these holes is shown graphically in Figure A-2. These original observation wells in Sandia Canyon were both drilled to a depth of 20 ft (6 m) and did not encounter water in the alluvium at the time they were drilled. After a significant stormwater runoff event in September 1969, SCO-4 (SCO-2) contained some water. However SCO-3 (SCO-1) was never observed to contain water (Purtymun 1975, 11787, p. 117). These two wells subsequently were damaged and were plugged and abandoned (Purtymun 1995, 45344, p. 67). The well information associated with the original wells in Sandia Canyon is provided in Appendix C as SCO-1-old and SCO-2-old.

Replacement wells SCO-1 and SCO-2 were drilled in 1989 adjacent to the locations of the former wells SCO-1 and SCO-2. SCO-1 was drilled to a depth of 79 ft (24 m); alluvium was encountered from surface to a depth of 18 ft (5.5 m) and the well was drilled into the Otowi Member of the Bandelier Tuff. SCO-1 was completed to a depth of 20 ft (6 m) with a perforated screen interval from 9.3 ft to 19.3 ft (2.8 m to 5.9 m) (Purtymun 1995, 45344, p. 142). SCO-2 was drilled to a depth of 29 ft (9.1 m) in the Otowi Member. The alluvium was encountered to a depth of 15 ft (4.6 m) and the well was completed with a screen interval from 8.4 ft to 18.4 ft (2.6 m to 5.6 m). Water has never been observed in wells SCO-1 and SCO-2.

Borehole SHB-2 was drilled as a seismic hazards test at TA-3 in the winter of 1991-1992. This borehole is located on the mesa-top within the upper reach of the Sandia Canyon watershed. This borehole was drilled to a depth of 200 ft (60 m) into the densely welded Unit 2 of the Tshirege Member of the Bandelier Tuff. Samples were not collected for analyses, but core samples are archived at the Laboratory Sample Management Office (Gardner et al. 1993, 12582, p. 9).

In 1991 a total of eight boreholes were drilled adjacent to the three surface impoundments at TA-53 to characterize subsurface conditions beneath the surface impoundments. Four boreholes (boreholes 53-1 through 53-4) were drilled to a depth of 50 ft (15 m) adjacent to the impoundments to determine if subsurface saturation is present and to determine if the release of contaminants from the impoundments has occurred. An additional 50-ft (15-m) borehole (borehole B) was drilled 450 ft (135 m) west of the impoundments to determine baseline moisture conditions and tritium levels. Grab samples of cuttings were collected every 5 ft (1.5 m) from each borehole. The boreholes were completed as neutron-moisture access holes (Purtymun 1995, 45344, p. 327; LANL 1998, 58841, p. 2-25).

Borehole 53-5 was drilled to a depth of 100 ft (30 m) between the three impoundments to further evaluate leakage from the impoundments. Grab samples of cuttings were collected every 5 ft (1.5 m) for the first 50 ft (15 m), and every 10 ft (3 m) thereafter. These samples also were analyzed for tritium and gravimetric moisture content. This borehole was completed with a pore-gas monitoring system (LANL 1998, 58841, p. 2-25).

Borehole 53-6 was drilled between the northwestern and northeastern impoundments and was completed at a total depth of 150 ft (45 m). Samples were collected at 5-ft (1.5-m) intervals for the first 30 ft (9 m) and at 10-ft (3-m) intervals thereafter. The core samples were analyzed for tritium and gravimetric moisture at each sampling depth. Volatile organic compounds (VOCs) and semivolatile organic compounds (VOCs) analyses were performed on the 5-ft (1.5-m) through 30-ft (9-m) samples and on the 50-ft (15-m), 80-ft (24-m), 100-ft (30-m), 110-ft (33-m), 140-ft (42-m), and 150-ft (45-m) samples. Total metals analysis was performed on the 20-ft (6-m) and 100-ft (30-m) samples (LANL 1998, 58841, p. 2-25).

Borehole 53-7 was drilled near the head of a small canyon directly adjacent to and southwest of the impoundments to identify impacts from the impoundments at greater depths than boreholes 53-2 through 53-6 and 53-B. Samples were collected at 5-ft (1.5-m) intervals for the first 35 ft (10.5 m), and at 10-ft (3-m) intervals thereafter, to a depth of 80 ft (24 m). These samples were analyzed for tritium and gravimetric moisture content. Samples collected at 5 ft (1.5 m), 20 ft (6 m), and 80 ft (24 m) were analyzed for VOCs and SVOCs. This borehole was completed as a neutron-moisture access well (LANL 1998, 58841, p. 2-25).

Samples from boreholes 53-6 and 53-7 were used to determine the hydraulic properties of the Bandelier Tuff that immediately underlies the surface impoundments. Cores were collected from the Tshirege Member in borehole 53-6 and from the Otowi Member in borehole 53-7. The samples were measured for gravimetric and volumetric moisture content, density, and moisture retention characteristics. Porosity and saturated hydraulic conductivity of the samples were also determined (LANL 1998, 58841, p. 2-25).

Saturation was not observed in any of the six boreholes around the surface impoundments (LANL 1998, 58841, p. 2-25). Boreholes drilled adjacent to the impoundments showed only tritium at depth. The highest concentration of tritium was seen in borehole 53-5 located immediately south of the middle of the two northern impoundments, in the area of the former unlined drainage ditch. The highest concentration detected was 100 nCi/L at 100 ft (30 m) (the bottom of the borehole), which is approximately 100–1000 times greater than tritium concentrations detected at baseline borehole B. The other five boreholes, drilled within approximately 50 ft (15 m) of the impoundment dikes, all had tritium 30 ft (9 m) from the impoundment, while vertical tritium migration is at least 100 ft (30 m) in this location (LANL 1998, 58841, p. 2-27).

Borehole SCOI-3 was drilled in May 1996 as part of the “Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon” (LANL 1995, 50290). SCOI-3 was completed to a depth of 132.5 ft (40 m) before operations were temporarily suspended because of a lack of funds to complete the hole. SCOI-3 was planned to be completed as an intermediate-depth well. Originally it was to be used in sampling perched groundwater identified at a depth of 450 ft (37 m) in the Cerros del Rio basalt within the Puye Formation; this water was encountered during drilling of water supply well PM-1 in 1964 (Cooper et al. 1965, 8582, p. 40). The purpose of SCOI-3 was reevaluated during development of the Laboratory’s hydrogeologic work plan (LANL 1996, 55430), and it was decided that a single well designed to characterize perched zones and the regional aquifer was needed at this location. This new well was named R-12, to be consistent with the nomenclature used to designate regional aquifer characterization wells described in the hydrogeologic work plan and the core document (LANL 1997, 55622). Instead of deepening SCOI-3, R-12 was drilled as a new well so that larger casing sizes could be used to ensure that a well of adequate diameter could be installed into the regional aquifer (LANL 1998, 59665, p. 2). The core samples from SCOI-3 core are archived at the ER Field Support Facility (FSF).

In 1998 characterization well R-12 was drilled to a total depth of 847 ft (258 m) in lower Sandia Canyon near the eastern boundary of the Laboratory. This well is located adjacent to abandoned borehole SCOI-3 and about 350 ft (100 m) west of supply well PM-1. R-12 was located to provide information about hydrologic and geologic data for the vadose zone, perched zones, and the regional aquifer and to provide an early warning for contaminants approaching water supply well PM-1. This borehole provided information about subsurface geologic units including the alluvium, tephras and volcaniclastic sediments of the Cerro Toledo interval, Otowi Member of the Bandelier Tuff, basaltic rocks of the Cerros del Rio volcanic field, old alluvium, Puye Formation, and basaltic rocks of the Santa Fe Group (LANL 1998, 59665, p. 1).

Core was collected in R-12 to provide undisturbed samples for geological, contaminant, and hydrological characterization. In addition, core was used to identify perching layers beneath perched groundwater and to provide information for placing casing seals. Core was not collected from the land surface to a depth of 132.5 ft (40 m) because this interval was continuously cored during drilling of SCOI-3. In R-12, A total of 91.6 ft (28 m), or 10.8% of the 847 ft (258 m) depth was cored. Fourteen samples of core and cuttings were collected from R-12 and analyzed for metals and radionuclides. Ten samples of cuttings were collected from nine depth intervals: 25–25.5 ft (7.6–7.8 m), 31.5–32.5 ft (9.6–9.9 m), 122–125 ft (37.2–38.1 m), 135–136 ft (41.2–41.5 m), 455–456.5 ft (138.7–139.2 m), 555–559 ft (169.2–170.4 m), 791–792.5 ft (241.2–241.6 m), 800–805 ft (243.9–245.4 m), 812–814.6 ft (247.6–248.4 m), and 812–814.6 ft (247.6– 248.4 m) (duplicate). Four core samples were collected from four intervals: 431–438 ft (131.4–133.5 m), 520–521.9 ft (158.5–159.1 m), 555–559 ft (169.2–170.4 m) (duplicate), and 567–569 ft (172.9–173.5 m).

The results of the analyses show that activities of isotopic uranium in the samples suggest that little if any Laboratory contaminants are present in these samples. Activities of americium-241; cesium-137; plutonium-238; plutonium-239,240; and strontium-90 generally are less than detection in the samples of core and cuttings, indicating that no Laboratory-derived contamination from these isotopes is detectable in most of these core samples. Possible exceptions include detectable plutonium-239,240 within cuttings collected in the 31.5- to 32.5-ft (9.6- to 9.9-m) interval and in the 431- to 438-ft (131.4- to 133.5-m) interval. The 31.5- to 32.5-ft interval is within the uppermost part of the Otowi Member. The 431- to 438-ft interval is just above the saturated zone encountered at a depth of 443 ft (135.1 m). Further comparisons with background data will be made when ongoing background studies for basalts are completed. Core and cuttings samples were analyzed for metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, uranium, vanadium, and zinc. However, these metals are not contaminants of concern in Sandia Canyon. Transition metals, including cobalt, copper, manganese, nickel, and iron, occur naturally within the basalt flows (concentrated within oxide and silicate minerals) at concentrations above those for the Bandelier Tuff. Background distributions of metals within basalt are being assessed and will be added to the Laboratory background data set (LANL 1998, 59665, p. 19).

3.4.3 Surface Water Hydrology

The water that flows through Sandia Canyon is used by wildlife and plants and potentially by humans; therefore, it constitutes a transport pathway to potential receptors. The results of past investigations of surface water (described in this section) and groundwater (described in Section 3.4.4) provide the background of known conditions needed to assess the importance of these transport pathways and to improve the understanding of surface water transport and possible transport through the unsaturated and saturated zones within the canyon system.

Surface water flow provides one of the primary mechanisms for redistributing and transporting contaminants that may be present in the Sandia Canyon system.

Relevant aspects of surface water hydrology include the following:

- areas, pathways, and rates of surface water runoff, wastewater discharges, and sediment deposition;
- rates of contaminant dissolution and desorption, transport, and sedimentation;
- relationships between infiltration, runoff, evaporation and transpiration, and wastewater discharges;
- presence and effectiveness of adsorptive media in the sediments in retarding infiltration of waterborne contaminants; and
- where contaminants are present, fate of surface water that infiltrates into the alluvium.

The general hydrology of the canyon systems is discussed in Section 2.4.2 of the IWP (LANL 1996, 55574) and Section 3.5 of the core document (LANL 1997, 55622). The discussion in this section elaborates on surface water as a potential contaminant transport pathway in the Sandia Canyon system.

3.4.3.1 Sandia Canyon Stream Channel System and Streamflow

The geomorphology of the stream channel characteristics of Sandia Canyon and its tributaries are described in Section 3.1.

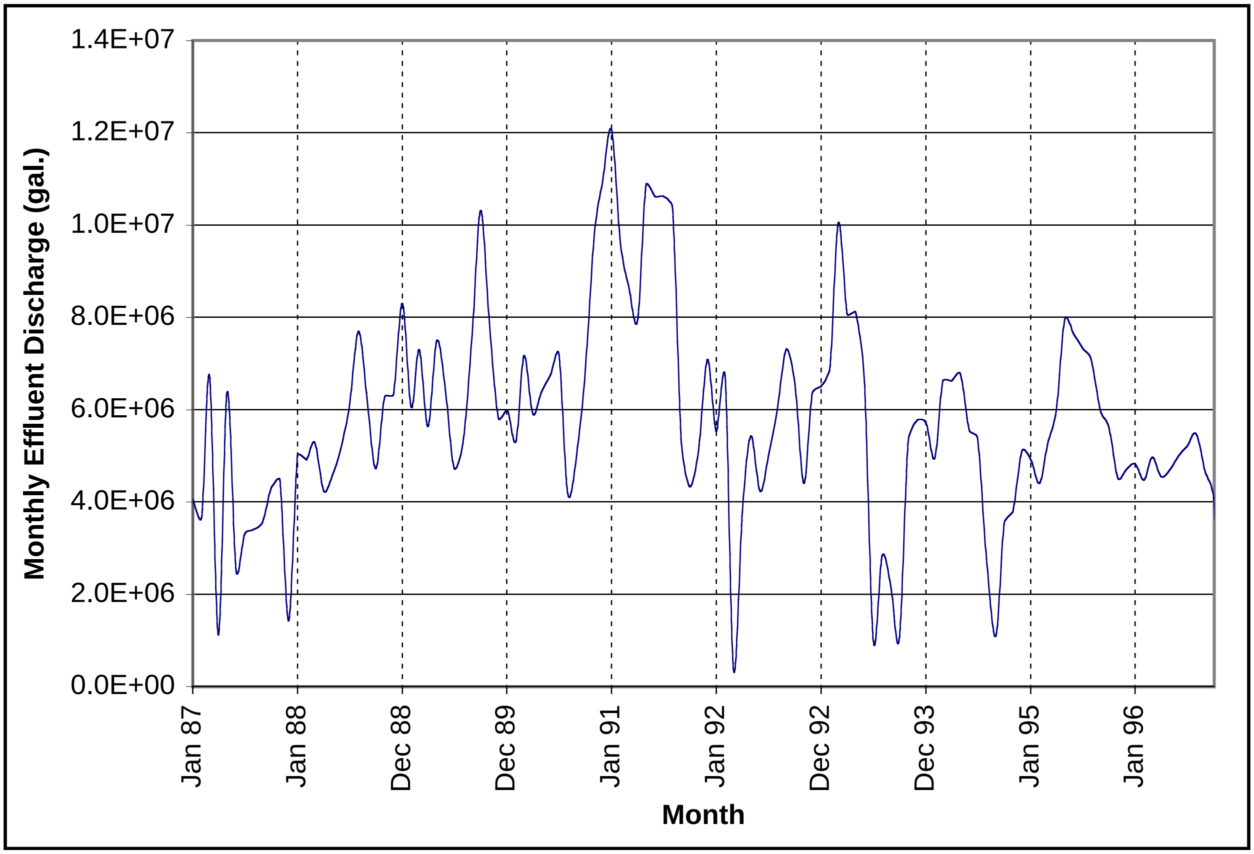
Sandia Canyon has a relatively small drainage area that heads at TA-3 on Laboratory property. The canyon receives discharged water from the cooling tower at the TA-3 power plant and treated effluent from the TA-3 and TA-46 sanitary treatment plants. The canyon also receives stormwater runoff from parking lots and streets at TA-3. The discharged effluents support a continuous flow in a short reach of the upper canyon. During summer thundershowers streamflow reaches the Laboratory boundary at state road NM4, and only during periods of heavy thunderstorms or snowmelt does streamflow from Sandia Canyon extend beyond the Laboratory boundary or reach the Rio Grande (Environmental Surveillance and Compliance Programs 1998, 59904, p. 127) .

The Sandia Canyon drainage basin area from the headwaters at TA-3 to the eastern Laboratory boundary is approximately 2.65 mi^2 (6.9 km^2) (McLin 1992, 12014, p. 19). Streamflow in the upper reach of the canyon system is fed by Laboratory discharges and is continuous for a distance downstream of TA-3 to approximately the middle section of the Canyon. Figure A-1 shows the approximate reach of the stream that contains continuous streamflow in Sandia Canyon. The remaining portions of the canyon contain an ephemeral stream.

A total of five stream gages have been installed in Sandia Canyon to measure streamflow and runoff. The first stream gage (E125) was installed near the eastern Laboratory boundary in 1993 and the other four stream gages were installed in 1999 in upper and middle Sandia Canyon. Gaging station E121 was installed on an upstream tributary to Sandia Canyon (South Fork) at TA-3 below the Laboratory power plant. Gaging station E122 was installed in upper Sandia Canyon at TA-3 near the roads and grounds maintenance building and upstream from the tributary where gaging station E121 was installed. Gaging station E123 was installed in upper Sandia Canyon near TA-3 and below the wetlands area. Gaging station E124 was installed in central Sandia Canyon at the truck route (East Jemez Road) and south of TA-53 (LANL 1999, 62920, p. 8-9). This station is located downstream from the normal eastern extend of the continuous flow from Laboratory discharges in upper Sandia Canyon. Figure A-1 shows the approximate location of the new stream gages in Sandia Canyon. No records of stream flow are yet available from these four new gaging stations in upper and middle Sandia Canyon.

Table 2.2.1-2 of this document lists the NPDES-permitted outfalls into Sandia Canyon and summarizes the current status and source of each outfall and its discharge point. Figure A-1 shows the locations of NPDES-permitted outfalls in the Sandia Canyon watershed and shows the location of the wetlands in Sandia Canyon. In 1972 the estimated combined release of effluents from the sewage treatment plant and power plant at TA-3 into Sandia Canyon was estimated to be about 61.4 million gallons (2.3×10^5 m^3) of effluent (Purtymun 1975, 11787, p. 113) or about 168,200 gpd. The monthly effluent flows to Sandia Canyon from the TA-3 sanitary treatment plant for the 10-year period from January 1987 through December 1996 are shown on Figure 3.4.3-1. During this period the sanitary outfalls discharged an average of about 5.77 million gallons monthly or approximately 192,000 gpd to the Sandia Canyon watershed, at an average rate of 133 gpm. During the past few years, most NPDES outfalls in the watershed have been deleted from the NPDES permit and rerouted to the TA-46 SWSC plant. Sanitary waste volumes discharged to Sandia Canyon have decreased in recent years and in 1996 the average monthly discharge was 4.79 million gallons or approximately 160,000 gpd.

The largest volume of discharge to Sandia Canyon is effluent discharges from the SWSC plant at TA-46 that began operations August 1992 (e.g., Environmental Protection Group 1996, 54769, p. 144). This primary Laboratory sewage treatment plant is located in the TA-46 fork of Cañada del Buey and could potentially discharge treated sanitary effluent to Cañada del Buey. However because portions of the Cañada del Buey channel near TA-54 and MDA G are on San Ildefonso Pueblo land, Cañada del Buey does not offer an adequate length of stream channel on Laboratory property to ensure that surface water effluent flow would remain entirely on Laboratory property. Therefore the effluent from the SWSC plant at TA-46 is pumped to TA-3, reused in cooling towers, and discharged from the cooling towers or from the TA-3 sanitary treatment plant outfall into upper Sandia Canyon (e.g., Environmental Surveillance and Compliance Programs 1998, 59904, p. 28). In 1998 the location of the TA-3 sanitary outfall in upper Sandia Canyon was relocated down-canyon.



Source: LANL 1998, 63504.

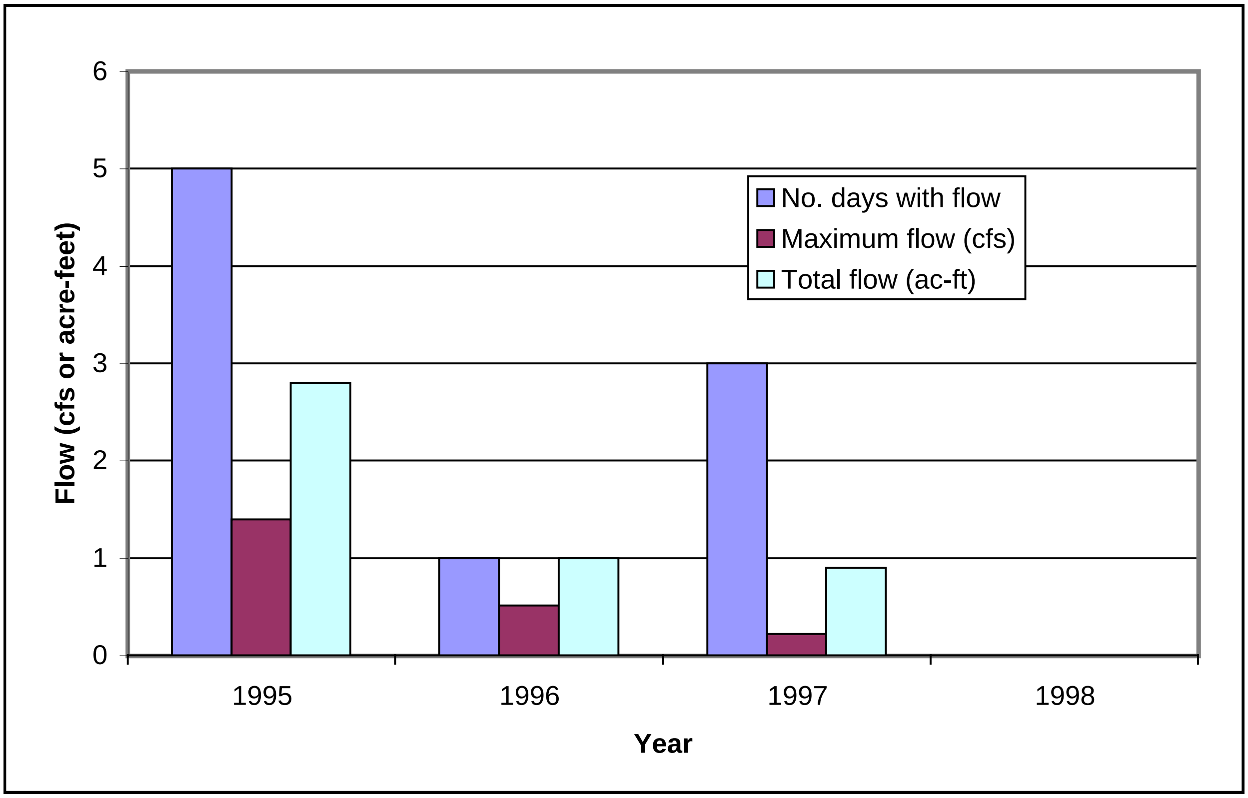
Figure 3.4.3-1. Monthly sanitary effluent discharges to Sandia Canyon from TA-3.

A wetland area is present in upper Sandia Canyon downstream from NPDES outfalls at TA-3. The National Wetlands Inventory conducted by the FWS shows three types of wetlands or water systems in Sandia Canyon. The uppermost wetland area is located adjacent to TA-3 and is described as a "persistent, artificially flooded, palustrine wetland" (Bennett and Biggs 1996, 57541, p. 5). Downstream from the primary wetland area in upper Sandia Canyon the water system designation changes to "temporarily flooded, palustrine wetland," and in the middle canyon south of TA-53 the water system designation is "intermittent, temporarily flooded, riverine streambed" (Bennett and Biggs 1996, 57541, p. 5).

In lower Sandia Canyon ephemeral streamflow is supported primarily by local runoff and possibly by occasional streamflow from up-canyon. Periodic storm events and snowmelt runoff occasionally may create continuous flow throughout the canyon to the Rio Grande.

The first stream gaging station was constructed in lower Sandia Canyon in 1993 to measure streamflow volumes near the eastern Laboratory boundary. Stream gaging station E125 (08313125) is located in lower Sandia Canyon at an elevation of 6495 ft (1980 m) approximately 1500 ft (460 m) upstream of the stream crossing at state road NM4. The location of the stream gage is shown on Figure A-1. The drainage area at this gage is 2.52 mi^2 (6.5 km^2) and the period of record is from October 1, 1994, through September 30, 1998 (Shaull et al. 1996, 56019, p. 20; Shaull et al. 1996, 56020, p. 20; Shaull et al. 1998, 57581, p. 20; Shaull et al. 1999, 63505, p. 20). The stream gage is dry except during flow associated with precipitation events and snowmelt runoff. Since installation of the Sandia Canyon stream gage near the eastern Laboratory boundary in October 1993, flow has been recorded at the eastern Laboratory boundary from zero to four times each year.

During the 1995 water year, stream gaging station E125 recorded flow on a total of five days, two days each in November and August, and one day in September. During the 1996 water year the gage recorded flow one day in December, and during the 1997 water year the gage recorded flow on three days in August. No flow was recorded at this station in the 1998 water year. Figure 3.4.3-2 shows the annual summary of flow recorded at the stream gage in lower Sandia Canyon.



Source: Shaull et al. 1996, 56019; Shaull et al. 1996, 56020; Shaull et al. 1998, 57581; Shaull et al. 1999, 63505.

Figure 3.4.3-2. Summary of annual streamflow measurements in lower Sandia Canyon at gage E125.

The small amount of streamflow recorded at gage E125 suggests that flow at this site is primarily locally derived runoff as the result of periodic precipitation events. If accumulated runoff from the entire watershed passed through gage E125, measured flow volumes likely would be significantly larger. The effluent-based streamflow in upper Sandia Canyon does not extend beyond the middle canyon where virtually all of the streamflow from the upper canyon infiltrates into the alluvium.

ESH-18 personnel collect surface water and runoff samples from Sandia Canyon for environmental monitoring. Runoff samples have occasionally been collected at one station in lower Sandia Canyon (at state road NM4), and surface water is collected at three locations. Historical surface water sampling stations SCS-1, SCS-2, and SCS-3 are located in upper and middle Sandia Canyon where continuous streamflow is maintained by effluent discharges at TA-3 (see Figure A-1). These surface water sample sites were established in 1969 and surface water samples have been collected annually. The results of the sampling and analyses are discussed in Section 3.4.3.1.5.1.

3.4.3.1.1 Springs in Sandia Canyon

One spring is known to exist in Sandia Canyon. Sandia Spring is located in lower Sandia Canyon about 3000 ft (915 m) upstream of the confluence with the Rio Grande (see Figure A-1). Sandia Spring was listed in an early inventory of springs on the Pajarito Plateau as a seep flowing from the Tesuque Formation at an elevation of 5640 ft (1720 m). Flow from the seep was estimated to be 0.25 gpm (John et al. 1966, 8796, p. 122). Sandia Spring was later reported to flow from the Totavi Lentil at the base of the Puye Formation at an elevation of 5700 ft (1738 m) with a temperature of 72° F (22° C). Flow is not sufficient from the spring to reach the Rio Grande and is depleted by infiltration and evaporation (Purtymun et al. 1980, 6048, p. 6; Purtymun 1995, 45344, p. 284).

NMED Oversight Bureau personnel collected samples from Sandia Spring in 1994 and 1995 and measured a flow of 3-5 gpm and a temperature of 16.8° C (62.2° F) (Dale et al. 1996, 57014, pp. 11 and 24). Based on the similarity of the temperature with other springs in White Rock Canyon and with the regional aquifer water temperature in deep wells on the Pajarito Plateau, Oversight Bureau personnel concluded that the water from Sandia Spring may be discharged from the regional aquifer (Dale et al. 1996, 57014, p. 15). However, elevated concentrations of cations and anions at Sandia Spring possibly suggest a different source of water either within the regional aquifer or possibly from alluvial sources in Sandia Canyon or Mortandad Canyon (Dale et al. 1996, 57014, p. 13). Additional information about the chemistry of Sandia Spring is presented in Section 3.4.4.6.

3.4.3.1.2 Surface Water Runoff in Sandia Canyon

3.4.3.1.2.1 Normal Seasonal Runoff

Surface water runoff into the canyon system varies with the amount of seasonal precipitation in the watershed. Snowmelt and stormwater runoff from the upper canyon at TA-3 have not historically been monitored but in early 1999 four new gaging stations were installed in upper and middle Sandia Canyon.

Gaging station E125 measures runoff at the eastern Laboratory boundary. Records at this gage begin on October 1, 1994, and show that flow has occurred at the eastern Laboratory boundary from zero to three times each year since monitoring began.

3.4.3.1.2.2 Stormwater and Snowmelt Runoff Investigations

Personnel from ESH-18 periodically monitor runoff from stormwater and snowmelt. Runoff samples were collected in Sandia Canyon at state road NM4 during three runoff events in 1978 and once in 1994. These results were reported in the annual environmental surveillance reports (ESG 1979, 5819, p. 24; Environmental Protection Group 1996, 54769, p. 151). These data are further discussed in Section 3.4.3.1.5.1.2.

In 1993 a stream gage was installed in lower Sandia Canyon at state road NM4. The records of streamflow are provided annually in surface water data reports (e.g., Shaull et al. 1996, 56020). The records of stormwater runoff in Sandia Canyon are discussed above in Section 3.4.3.1.

3.4.3.1.3 Flooding Potential

Flow and floodplain estimates for the Los Alamos region were developed by McLin (1992, 12014) using computer-based models (HEC 1 and 2) developed by the US Army Corps of Engineers Hydrologic Engineering Center. The models project the effects of severe thunderstorms on all the watersheds in the Los Alamos area. This modeling effort predicts the effects of storm runoff on flood elevations within the canyons and on different Laboratory areas and structures. Precipitation totals and floodplain elevations were projected for 2-, 5-, 10-, 25-, 50-, and 100-year storms (LANL 1995, 50124).

The theoretically estimated 24-hour runoff for a probability of 0.02 (“2-year recurrence interval”) 6-hour storm for Sandia Canyon at the Laboratory boundary at state road NM4 is less than 1 acre-foot (McLin 1992, 12014, p. 20). The estimated 24-hour runoff for a 50-year recurrence, 6-hour storm for Sandia Canyon at this location is 32 acre-feet. This 50-year event corresponds to a calculated 6-hour precipitation total of 2.07 in. (over the entire watershed area), creating a peak flow of 54 cfs at the eastern Laboratory boundary (McLin 1992, 12014, pp. 13 and 19).

In Sandia Canyon the 100-year floodplain occupies an area along the canyon floor more or less centered on the stream channel (McLin 1992, 12014, p. 4). Therefore, PRSs near or adjacent to the stream channel at former TA-20 may be within the 100-year floodplain. Most of the structures and PRSs at TA-72, the East Entry Site and the small arms firing range, are above the 100-year floodplain.

Since installation of the stream gage in Sandia Canyon at the Laboratory boundary in 1994, the peak 5 minute flow recorded at has been 1.4 cfs at E125 (Shaull et al. 1996, 56019; Shaull et al. 1996, 56020; Shaull et al. 1998, 57581). The maximum flow recorded at the Laboratory boundary for the period of record is approximately 2.6% of the calculated 50-year, 6-hour precipitation event; however, the period of record is not sufficient to represent a 50-year event.

The highest five 24-hour precipitation events recorded at Los Alamos are shown in Table 3.4.3-1 (Bowen 1990, 6899, Table 1.1). Because of the nature of thunderstorms on the Pajarito Plateau and the extreme variation in elevation differences in the Sandia Canyon watershed area, it is unlikely that the entire Sandia Canyon watershed has received the maximum amounts of precipitation that have been recorded during any specific event. Since 1911 the average annual maximum precipitation in a 24-hour period at Los Alamos is approximately 1.5 in. (Bowen et al. 1990, 6899). The location of the "official" meteorological station has changed over the years; however all locations are within 30 m (100 ft) of each other in elevation and 5 km (3 mi) in distance. The composite record from the official stations was used to obtain the data shown in Table 3.4.3-1, which are from an elevation of approximately 2250 m (7400 ft) above sea level.

Table 3.4.3-1
Highest 24-Hour Precipitation Events Recorded at Los Alamos

Rank	24-Hour Precipitation (in.)	Date
1	3.48	October 5, 1911
2	2.51	June 10, 1913
3	2.47	July 31, 1968
4	2.45	January 27, 1916
5	2.26	August 1, 1951
Maximum Annual Average	1.5	1911 to 1996

Source: Bowen 1990, 6899.

3.4.3.1.4 Infiltration in Sandia Canyon

Surface water enters Sandia Canyon from runoff and discharges from NPDES outfalls at TA-3. Most of the surface water normally infiltrates into the alluvium and likely recharges a body of perched alluvial groundwater in the middle and lower sections of the canyon on Laboratory property. As the groundwater moves through the alluvium, some is lost to ET, and the remainder seeps into the underlying tuff, the Cerro Toledo interval, or the basalt, as the water in the alluvium continues to move downgradient.

The extent of seepage into suballuvial units in Sandia Canyon is not known. In the past boreholes such as PM-1, PM-3, and SCO-1, which were drilled into the suballuvial units in lower Sandia Canyon, encountered dry rock beneath the alluvium (Purtymun 1995, 45344, pp. 142, 260 through 276). However, during drilling of PM-1 indications of the presence of water in the basalt at a 450-ft (137-m) depth suggest the presence of some intermediate perched groundwater.

Records of discharge volumes from the TA-3 sanitary treatment plant, the SWSC plant at TA-46, and cooling towers at TA-3 suggest that about 200,000 gpd of water flow into Sandia Canyon. Nearly all of this water infiltrates into the alluvium in the upper and middle parts of Sandia Canyon. Streamflow at the eastern Laboratory boundary in Sandia Canyon is recorded only during precipitation events and normally includes mostly runoff from the vicinity of the stream gage.

A portion of the streamflow in Sandia Canyon probably recharges a shallow alluvial groundwater body in the middle canyon, and the remainder is lost through infiltration into subsurface units and through ET (e.g., Baltz et al. 1963, 8402, p. 82; Purtymun 1974, 5476, p. 4; Purtymun et al. 1983, 6407, p. 3). No monitor wells have been installed in the middle part of Sandia Canyon to detect and monitor potential alluvial groundwater, but investigations planned as part of the SAP in Chapter 7 of this work plan include installation of observation wells for this purpose. Two alluvial monitor wells are located in the lower canyon on Laboratory property, but water is not usually present in these wells.

An intermediate perched groundwater system was encountered in R-12 from depths of 443 ft to 519 ft (135 m to 158 m) in the lower part of the Cerros del Rio basalt and in underlying old alluvium in the Puye Formation. The saturated thickness of this groundwater body is approximately 75 ft. Solute chemical data show the presence of possible elevated concentrations of some anions (chloride, nitrate, and sulfate) within groundwater samples collected during the drilling of R-12. These solutes may be derived from alluvial groundwater in middle Sandia Canyon. Nitrate concentrations observed in R-12 groundwater at depths of 443 and 495 ft (4.9 and 5.5 mg/L, respectively) are above background values, which are typically less than 0.5 ppm nitrate as nitrogen. In addition, nitrogen isotopic data for these two samples is consistent with derivation of nitrate from a sewage source, possibly the TA-3 outfall (LANL 1998, 59665, pp. 33-34). These data suggest a possible infiltration pathway of surface water and alluvial groundwater to deeper intermediate perched zones beneath Sandia Canyon.

Infiltration through mesa tops is very slow. At the surface of the mesa tops, ET consumes approximately 90% of precipitation, which leaves little water for runoff or infiltration. The mean annual calculated percolation of water beneath the surface on mesa tops is approximately 0.04 in. (1 mm) per year. Infiltration beneath canyon floors is higher and has been calculated to be approximately 0.18 in. (4.4 mm) per year beneath Cañada del Buey and between 0.8 and 4 in. (20 and 100 mm) per year beneath Pajarito Canyon (LANL 1998, 57576, p. 54).

3.4.3.1.5 Surface Water Quality and Contaminant Data in Sandia Canyon

3.4.3.1.5.1 Results of Environmental Surveillance Sampling of Surface Waters

ESH-18 personnel annually collect surface water samples from the Sandia Canyon stream at three sampling stations, SCS-1, SCS-2, and SCS-3, which are located in upper and middle Sandia Canyon.

The locations of the sampling stations are shown on Figure A-1. Since 1969 a total of 58 surface water samples have been collected at SCS-1 and SCS-2, and since sampling began at site SCS-3 in 1976, 29 samples have been collected. Fewer samples have been collected at SCS-3 in part because surface water has not always extended downstream to this site when sampling was conducted. During the early 1970s four to six samples were collected each year, and from 1976 to 1988 one to two samples were collected each year. Since 1988, samples have been collected annually at each site. The samples are routinely analyzed for radionuclide activity, and about 75% of the samples have been analyzed for general inorganic water quality constituents. Since 1990 the samples have also been analyzed for trace metal constituents; before 1990 analysis for trace metals was performed periodically. Trace metal analyses are available for about 30% of the samples.

Additionally, stormwater runoff samples have been collected periodically from the stream channel at state road NM4 after significant runoff events. Runoff sampling was performed three times in 1978 and once in 1994. The following discussion of the results of environmental surveillance sampling is based on data presented annually in the environmental surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684).

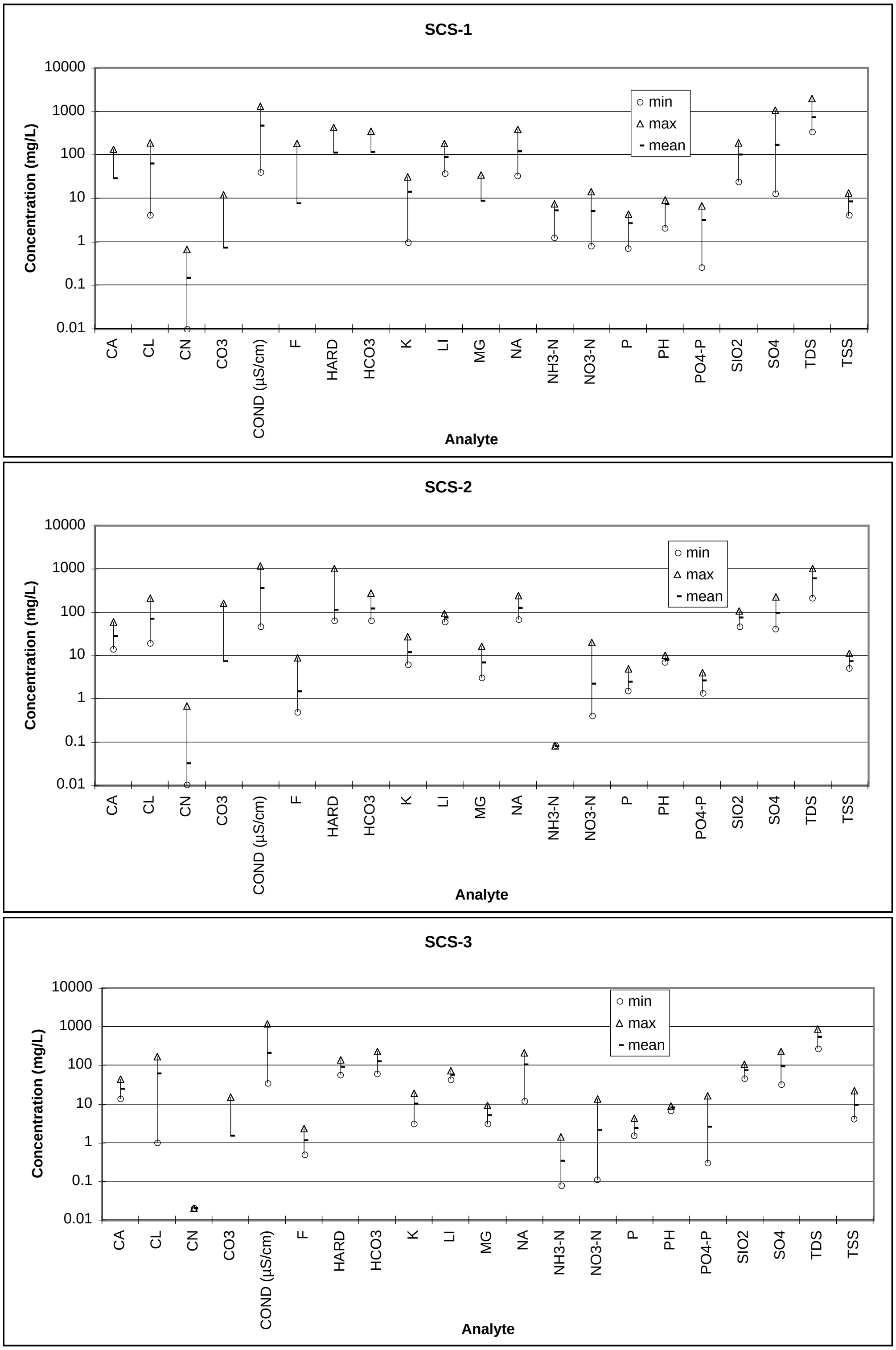
3.4.3.1.5.1.1 Surface Water Quality in Sandia Canyon

General Water Quality

Figure 3.4.3-3 summarizes the results of surface water sampling in Sandia Canyon for general inorganic water quality parameters at each collection site**.** The stream in Sandia Canyon is fed primarily by effluent discharges from outfalls at TA-3. Since 1992 the SWSC plant at TA-46 has also discharged to Sandia Canyon. Figure 3.4.3-3 shows the minimum, maximum, and mean concentrations of analytes sampled. Most cations and anions vary approximately an order of magnitude at the SCS-1 site, with slightly less variation observed at the downstream sites. The amount of variation observed in analytes reflects both sampling techniques and seasonal variations in water quality parameters, likely caused by dilution of the effluent discharges by variable runoff volumes. No significant trends in the annual or historical variation of surface water quality data at the SCS sites are obvious, due in part to the annual sampling being conducted at different times of the year and sampling techniques that were used (for some analytes, samples were not filtered before analysis).

Nitrate (as N) was measured above 10 mg/L at each collection site in July 1994, when the highest value observed was 14 mg/L at site SCS-1. One other sample collected from site SCS-1 in 1987 contained 11 mg/L nitrate (as N), but in general most results have been below 10 mg/L, with a mean value of 5 mg/L at site SCS-1. Ammonium (NH_3-N) has also been detected at site SCS-1 in concentrations as high as 7.46 mg/L during the early 1980s. Ammonium concentration observed at SCS-2 and SCS-3 have generally been below 1.4 mg/L. In 1972 a maximum fluoride concentration of 179 mg/L was observed at SCS-1 and 9 mg/L was observed at SCS-2, but fluoride concentrations are generally less than 2 mg/L.

A comparison of the mean surface water quality data at each collection site in Sandia Canyon is shown in Figure 3.4.3-4. The mean concentrations of most analytes including calcium, specific conductance, fluoride, potassium, lithium, magnesium, sodium, ammonia, nitrate (as nitrogen), phosphorous, phosphate, sulfate, and total dissolved solids (TDS) are highest at the SCS-1 site, which is located downstream of the effluent outfalls at TA-3. The mean concentration of bicarbonate appears to increase slightly in the downstream sample sites. This increase possibly is related to a slight increase in the pH of the surface water observed in the downstream sample sites. Water quality in the stream in Sandia Canyon is generally poorer quality than other streams on the Pajarito Plateau because, except for periodic times of stormwater runoff and snowmelt, the stream in Sandia Canyon is entirely from effluent discharges (e.g., Schiager and Apt, 1974, 5467, p. 41).

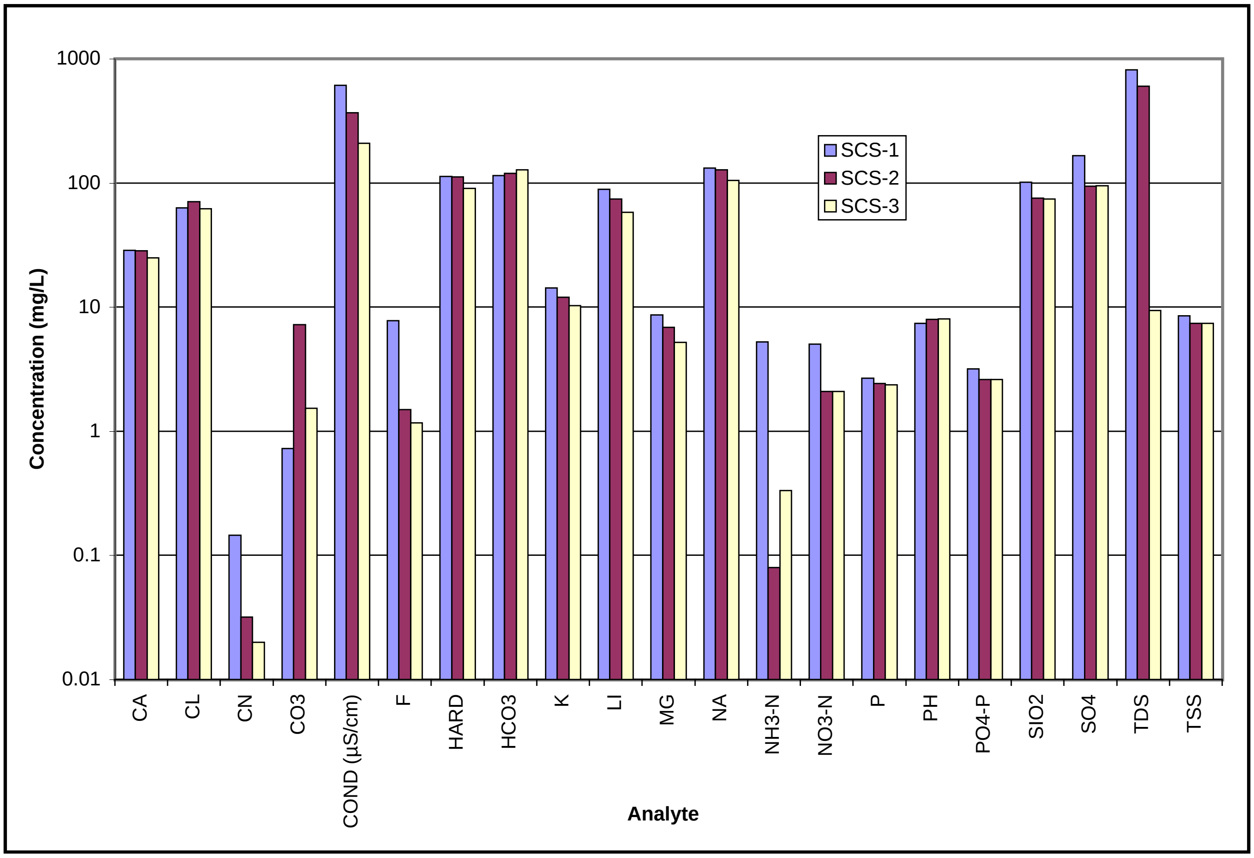


COND = specific conductance.		TDS = total dissolved solids.
HARD = hardness.			TSS = total suspended solids.

pH is measured in standard units.

Source: Environmental surveillance reports; Purtymun 1975, 11787.

Figure 3.4.3-3. Summary of environmental surveillance sampling in Sandia Canyon for general water quality parameters.



COND = specific conductance.
HARD = hardness.

TDS = total dissolved solids.
TSS = total suspended solids.

pH is measured in standard units.

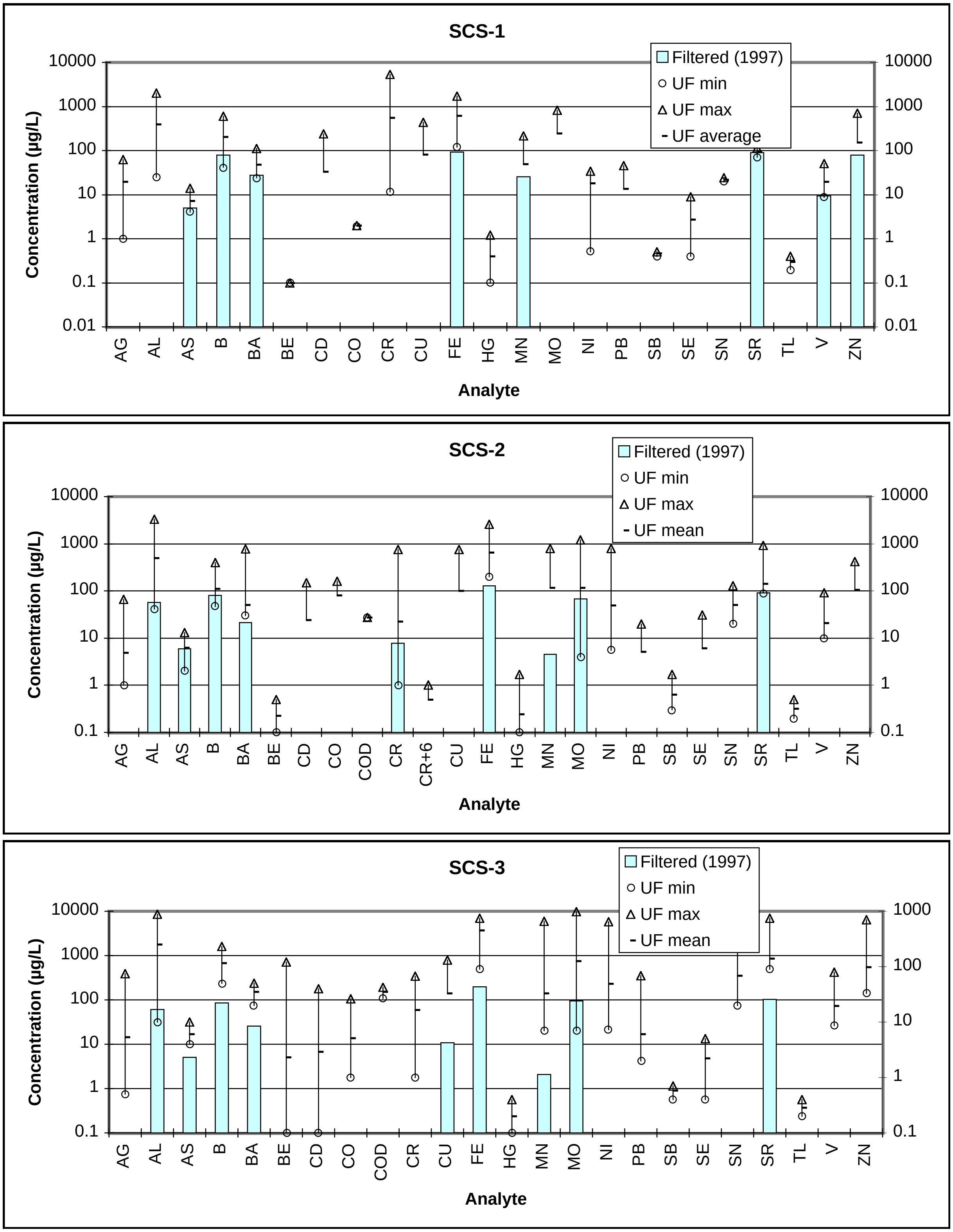
Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

Figure 3.4.3-4. Comparison of mean surface water quality in Sandia Canyon.

Metals

The summary of results of surface water sampling for metal constituents at the sampling sites in Sandia Canyon is shown in Figure 3.4.3-5. Before 1993 the analyses for metals were performed on samples that were acidified at the time of sampling and later filtered in the laboratory before analysis (AF samples). From 1993 through 1996 the analyses for metals were performed on unfiltered samples (UF samples), which represent the total concentration of the analytes in the samples. In 1997 the samples were filtered at the time of collection and before being acidified (F samples); these results represent the concentrations of the dissolved analytes. A review of the results of the sample analyses indicate that over the years the range of the results observed for the AF and the UF samples for most analytes are virtually indistinguishable. Therefore the AF and UF sample results were combined for the following summary discussion.

Figure 3.4.3-5 shows the minimum, maximum, and mean total concentrations for each analyte through 1996. In 1997 the surface water data represent dissolved concentrations of the metals and therefore these data are not included with the total concentration summary data and are shown separately on the figure. For most analytes the dissolved (filtered) data obtained in 1997 are below detection limits (concentrations are not shown on the figure) or are observed in concentrations less than the mean concentrations obtained for the total metals (unfiltered) samples.



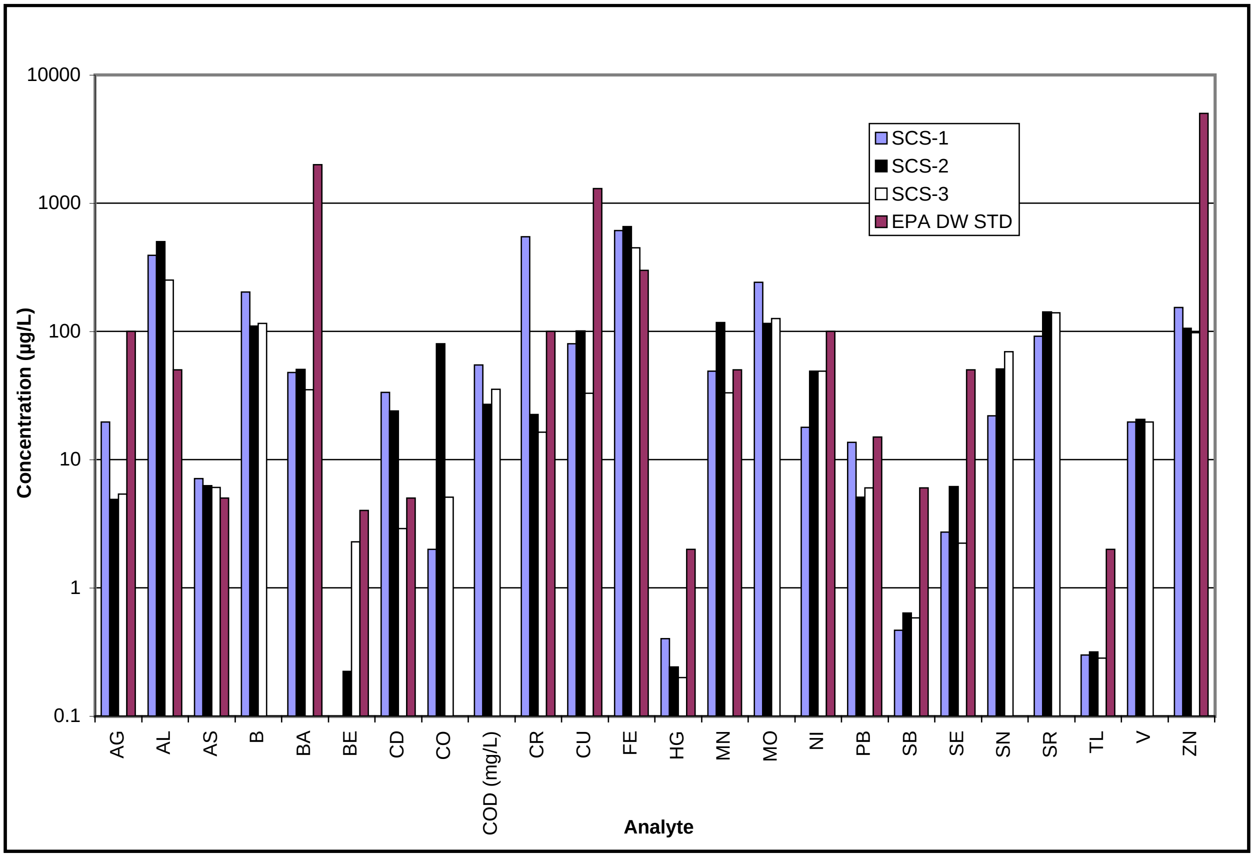
COD = chemical oxygen demand.

Source: Environmental surveillance reports 1970–1997.

Figure 3.4.3-5. Summary of environmental surveillance sampling of Sandia Canyon surface water for metal constituents.

Chromium concentrations have been observed as high as 5380 µg/L in 1978 at SCS-1 and 760 µg/L at SCS-2 in 1994. In addition, hexavalent chromium was used in the treatment of water at the power plant at TA-3 before 1972. This resulted in the presence of hexavalent chromium in the surface water as high as 11.2 mg/L at SCS-1 and as high as 7.3 mg/L at SCS-2 in 1971. The use of hexavalent chromium was discontinued in April 1972 (Purtymun 1975, 11787, p. 115). In 1974 the concentration of hexavalent chromium was 1 µg/L at SCS-2. Other trace metals including cadmium and nickel have been detected in the unfiltered surface water samples, the highest concentrations are observed at SCS-1.

Comparison of the mean metals concentrations at the three collection sites is shown in Figure 3.4.3-6. The mean concentrations of most metals are highest at SCS-1, the upstream site, and decrease downstream. Those metals with concentrations highest at site SCS-2 include aluminum, barium, cobalt, copper, iron, manganese, antimony, selenium, strontium, thallium, and vanadium. Only beryllium, nickel, and tin appear to increase in concentration downstream. Metals with significantly higher mean concentrations at site SCS-1 below the effluent outfalls are silver and chromium, which may be associated with discharges from the cooling water towers. Although the surface water in Sandia Canyon is not a source of drinking water, the EPA drinking water standard values are also shown on Figure 3.4.3-6 for comparison. All mean metals concentration are below the drinking water standard except for aluminum, arsenic, cadmium, chromium, iron, and manganese.



COD = chemical oxygen demand.

Source: Environmental surveillance reports 1970–1997.

Figure 3.4.3-6. Comparison of mean metals concentrations in surface water in Sandia Canyon.

Radionuclides

The summary of the results of surface water sampling for radionuclides is shown in Figure 3.4.3-7, and the comparisons of the average values obtained at each surface water site are shown in Figure 3.4.3-8. In general, the highest observed activities of tritium (41100 pCi/L at SCS-1) were collected at each site in Sandia Canyon in 1981. Since that time tritium activities have generally been less than 1000 pCi/L (the Environmental Protection Agency [EPA] drinking water standard is 20,000 pCi/L).

The highest activity of plutonium-238 was 0.28 pCi/L in 1984 and the average value observed at SCS-1 is 0.0343 pCi/L. The highest observed activity of plutonium-239,240 was 0.12 pCi/L in 1971 and the average value observed at SCS-1 is 0.0225 pCi/L. No historical trend in plutonium isotope activity in Sandia Canyon is apparent. The highest average activities of americium-241 are observed at the SCS-3 site, which is the result of one sample that contained an activity of 1 pCi/L (+/-0.5 pCi/L) in 1976. The radioactive liquid waste is treated at TA-50 and discharged into Mortandad Canyon so little radioactive constituents are present in the effluent entering Sandia Canyon.

In 1997 surface water samples were also analyzed for organic constituents. Several organic compounds such as bis(2-ethylhexyl)phthalate, bromoform, bromodichloromethane, chloroform, and acetone were detected in the samples but the results for all samples were either below the quantitation limits or the organic compounds were also detected in the laboratory blank.

Other Sampling of Surface Waters

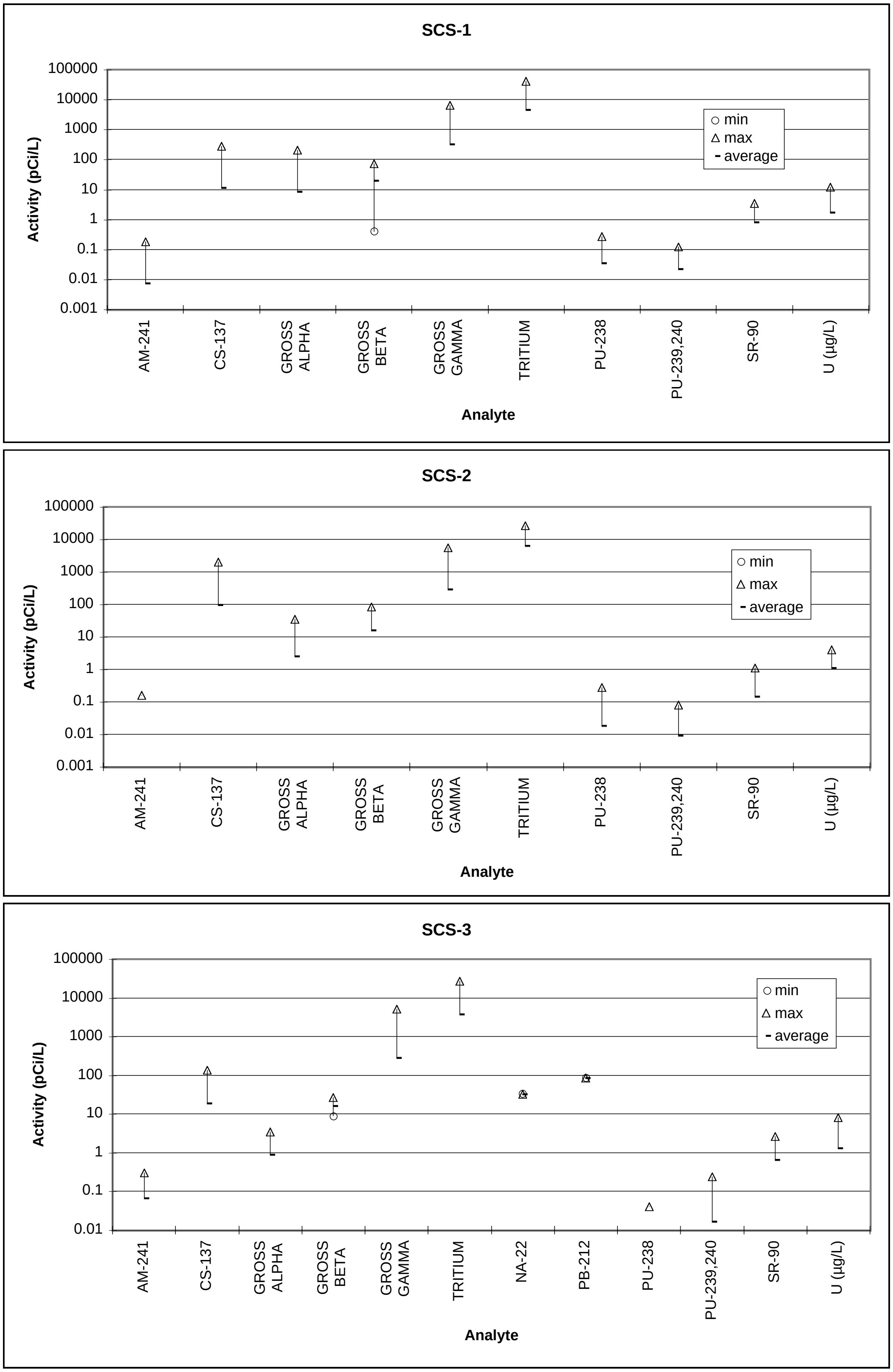
In 1996 and 1997 ER Project personnel and representatives from ESH-19 collected a total of seven surface water base-flow samples at several locations in upper Sandia Canyon. The samples were analyzed for PCBs in 1996 and for selected metals and PCBs in 1997. The analytical data were summarized in the “Sampling and Analysis Plan for Upper Sandia Canyon” (LANL 1998, 62340, p. 19 et seq.). Metals, PCBs, gross alpha, gross beta, and radium were detected in the surface water and stormwater runoff samples. The organic compounds methylene chloride and bis(2-ethylhexylphthalate) were also detected in some of the samples, but these compounds may be attributable to Laboratory contamination (LANL 1998, 62340, p. 19).

3.4.3.1.5.1.2 Stormwater Runoff Water Quality in Sandia Canyon

Stormwater runoff is sampled periodically by the Laboratory and the NMED Oversight Bureau. Analytical results are discussed below.

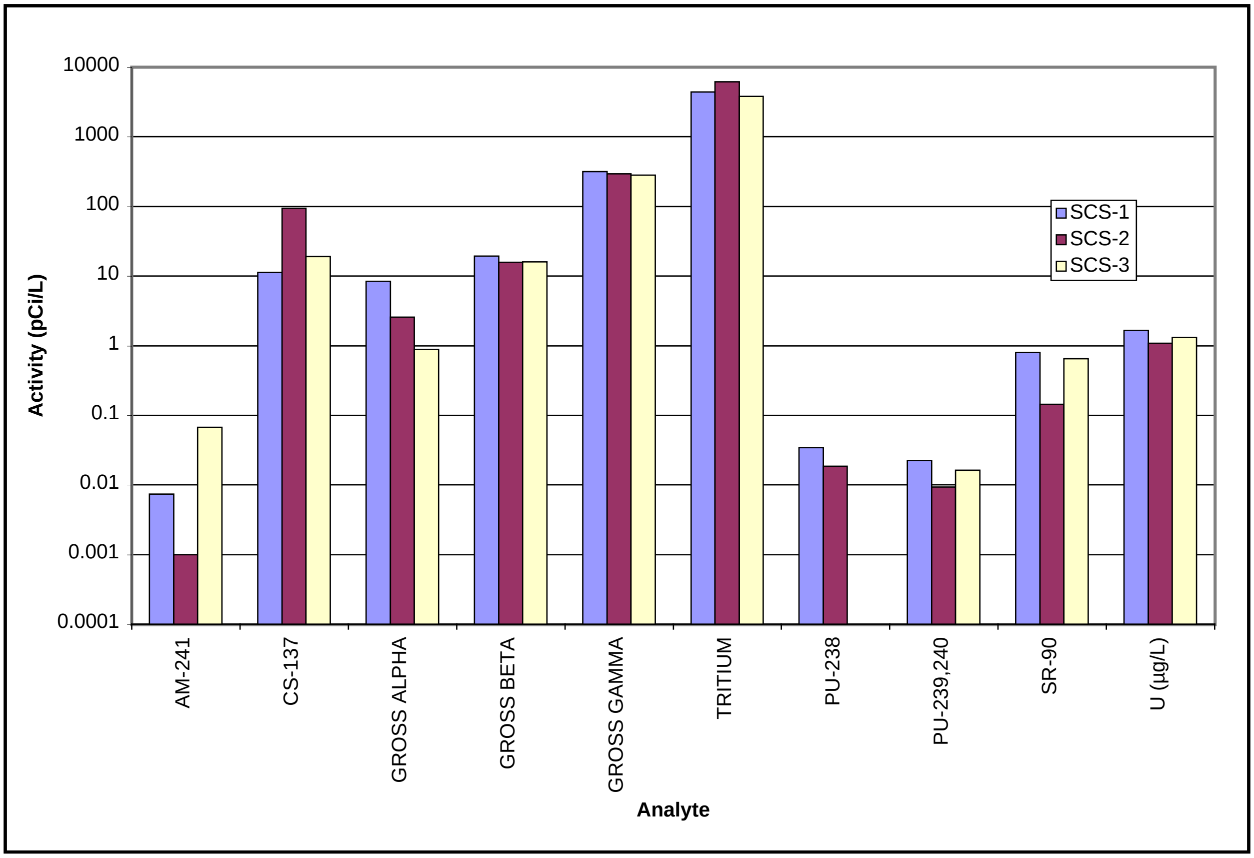
Environmental Surveillance Runoff Sampling

ESH-18 personnel periodically collect runoff samples from Sandia Canyon at state road NM4. Samples were collected after three runoff events in 1978 and one in 1994. The runoff samples were filtered and analyzed for selected general inorganic constituents and selected radionuclides. The results of the runoff sampling are provided in annual environmental surveillance reports (ESG 1979, 5819, p. 24; Environmental Protection Group 1996, 54769, p. 151). The runoff event collected on August 10, 1978, contained 10,500 pCi/L tritium and 2.8 µg/L uranium. However observed tritium activity of the runoff event in 1994 was 100 pCi/L. Plutonium-238 activity measured in the suspended sediment fraction of the runoff event in 1994 was 0.007 pCi/g, slightly above the sediment BV (0.0006 pCi/g). The highest plutonium-239,240 activity measured in the dissolved fraction was 0.002 pCi/L and the highest activity in the suspended sediment was 0.13 pCi/g, also in 1978.



Source: Environmental surveillance reports; Purtymun 1975, 11787.

Figure 3.4.3-7. Summary of environmental surveillance results for radionuclides in surface water in Sandia Canyon.



Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

Figure 3.4.3-8. Comparison of mean radionuclide activities in surface water in Sandia Canyon.

DOE NMED Oversight Bureau Sampling

In 1992 and 1993 personnel from the NMED DOE Oversight Bureau collected snowmelt runoff samples at one site in Sandia Canyon, station SA-6.1, which corresponds to the location of SCS-3. The samples were analyzed for general inorganic constituents, radionuclides, VOCs, and total and dissolved metals. The results of the sampling are reported by Monahan et al. (1996, 63507) and are similar to the results obtained by the environmental surveillance sampling.

In 1996 a series of stormwater runoff samples were collected at site SA-3.48, which corresponds to ESR site Sandia at SR-4. During a runoff event on October 4, 1996, a series of four runoff samples were collected at five-minute intervals. The samples were analyzed for suspended solids, uranium, and PCBs. The suspended solid content decreased in each consecutive sample from a high of 12,200 mg/L to 3230 mg/L (Yanicak 1998, 57583, Table 7). PCBs were not detected in the water above the detection limit of 1.0 µg/L (Yanicak 1998, 57583, Table 12). The uranium concentration in the filtered water samples varied with the mass of suspended solids and varied from 1.03 µg/L to 28.9 µg/L (Yanicak 1998, 57583, Table 9).

On June 29, 1996, a surface water sample was collected at site SA-8.7, which corresponds to the wetland area in upper Sandia Canyon. The sample was analyzed for PCBs. The water did not contain PCBs in concentrations above the detection limit, which was 0.5 µg/L (Yanicak 1998, 57583, Table 12).

On June 3, 1997, a surface water sample was collected from site SCS-3. On August 5, 1997, a surface water sample was collected from site SA-7.0, which approximately corresponds to site SCS-2 (see Figure A-1). The sample collected at SCS-3 was analyzed for limited water quality parameters, mercury, and strontium-90. The sample contained 0.17 mg/L nitrate (as N), 76 mg/L chloride, 150 mg/L bicarbonate, and 59 mg/L sulfate (Yanicak 1998, 57583, Table 7). Mercury and strontium-90 were not detected above detection limits. The sample collected from site SA-7.0 was analyzed for PCBs, which were not detected above the detection limit of 1 mg/L (Yanicak 1998, 57583, Table 12).

On July 1, 1998, another runoff sample supported by continuous flow was collected at site SA-7.0, which corresponds to site SCS-2. The sample was analyzed for selected general water quality parameters, metals (dissolved except for mercury and selenium, which were totals), and uranium (dissolved). The samples were also analyzed for organochlorines, pesticides, and PCBs in the unfiltered water and in the suspended sediment fraction and for metals in the suspended sediment fraction (Yanicak 1999, 63495). The results of the analyses showed the water contained 1200 mg/L total suspended sediment that contained PCBs at a concentration of 210 µg/kg (Aroclor 1260) and chromium, lead, and zinc in concentrations above BVs for sediment. Metals concentrations in the filtered runoff (dissolved) were below the detection limit except for aluminum, iron, molybdenum, and silica. Mercury was detected in the unfiltered water at a concentration of 0.0009 mg/L; selenium was not measured above detection limits. Uranium (dissolved) was measured at a concentration of 0.30 µg/L (Yanicak 1999, 63495).

3.4.3.1.6 Summary of Surface Water Hydrology Issues and Data-Collection Activities Needed to Understand the Surface Water Hydrology of Sandia Canyon

The surface water hydrology of Sandia Canyon is summarized below.

- Natural streamflow in Sandia Canyon is ephemeral. A short reach of continuous flow from NPDES outfalls at TA-3 extends from TA-3 for a distance in upper part of Sandia Canyon. The continuous flow combined with stormwater runoff does not usually extend beyond the middle canyon.
- NPDES sanitary outfalls at TA-3 discharge approximately 160,000 gpd to Sandia Canyon. The continuous flow infiltrates into the alluvium in the upper and middle parts of the canyon.
- A wetland area is present in upper Sandia Canyon downstream from NPDES outfalls at TA-3. The uppermost wetland area is located adjacent to TA-3 and is described as a persistent, artificially flooded, palustrine wetland. Downstream from the primary wetland area in upper Sandia Canyon the water system designation is a temporarily flooded, palustrine wetland, and in the middle canyon south of TA-53 the water system designation is intermittent, temporarily flooded, riverine streambed.
- Chromium concentrations have been observed as high as 5380 µg/L in 1978 at SCS-1 and 760 µg/L in 1994 at SCS-2. In addition, hexavalent chromium was used in the treatment of water at the power plant at TA-3 before 1972. This resulted in the presence of hexavalent chromium in the surface water as high as 11.2 mg/L at SCS-1 and as high as 7.3 mg/L at SCS-2 in 1971. The use of hexavalent chromium was discontinued in April 1972.
- Surface flow across the eastern Laboratory boundary at state road NM4 is ephemeral. Flow reaches the Rio Grande occasionally as the result of high snowmelt runoff or periodic storm events.
- One short perennial reach occurs in lower off-site Sandia Canyon below Sandia Spring. This short perennial reach does not extend to the Rio Grande.

The following additional data-collection activities are needed to understand the surface water hydrology of Sandia Canyon.

- Monitor streamflow volumes in upper Sandia Canyon to determine the amount of stream loss in this area.
- Determine quarterly surface water quality parameters.

3.4.4 Hydrogeology

This section presents a summary of prior investigations of the hydrogeology of Sandia Canyon and discusses the hydrogeology of the known saturated zones located in the alluvium, intermediate zones, and in the regional aquifer. Intermediate perched zones have been identified in the Sandia Canyon area and may be present in the Cañada del Buey area.

Groundwater pathways beneath the Canyons are important because of the possibility of contaminant transport laterally or downward to zones of saturation that may be capable of contaminant transport off-site. Understanding the unsaturated zones at the upper portion of the alluvium and, most importantly, in the underlying tuff and deeper zones, is an important aspect of understanding potential transport pathways.

Special low-detection-limit (0.67 pCi/L) measurements of tritium have confirmed the presence of recent recharge (less than 50 years old) to intermediate zones and the regional aquifer at characterization well R-12 and at several locations in other deep wells including TW-8 in Mortandad Canyon. The source or recharge to these zones is apparently from alluvial sources (Blake et al. 1995, 49931, p. 33; Rogers et al. 1996, 54714, Table 2; LANL 1998, 59665**,** p. 2).

3.4.4.1 Shallow Unsaturated Alluvial Zone

The shallow unsaturated alluvium is that portion of the alluvium from the surface downward to the top of the alluvial saturated zone. Sandia Canyon receives inflow from stormwater runoff, snowmelt, and several NPDES-permitted discharges, including the TA-46 SWSC plant effluent outfall at TA-3. In the upper canyon, near TA-3 flow from the effluent discharges is maintained for a distance downstream in the channel. Where continuous flow occurs, the thin alluvium probably is saturated. Alluvium in floodplains 3 ft to 4 ft (0.91 m to 1.2 m) above the stream channel through these reaches are not saturated but probably contribute to storage.

In middle Sandia Canyon the surface flow normally infiltrates into the alluvium, and the stream channel is dry except during periods of heavy precipitation and snowmelt runoff. Shallow alluvial groundwater is likely present in middle Sandia Canyon; however water levels in the alluvium in Sandia Canyon are not known.

During periods of precipitation and increased streamflow, the surface water front advances downstream. The surface water infiltrates into the alluvial sediments, and the alluvium becomes saturated. The unsaturated zone in the alluvium may be dissected down the center of the canyon by the infiltration of surface water.

3.4.4.2 Alluvial Groundwater in Sandia Canyon

This section describes the wells that have been installed in Sandia Canyon and summarizes the information that is known about the alluvial groundwater. An understanding of the bedrock stratigraphy, alluvial stratigraphy, and the relationship between water in the alluvium and water in suballuvial intermediate perched zones, if present, is needed to understand the hydrogeology of Sandia Canyon.

An alluvial groundwater body of limited extent is probably present in the upper and middle portions of Sandia Canyon. Two observation wells installed in the alluvium in lower Sandia Canyon do not contain water, indicating that an alluvial groundwater system does not extend to the lower reaches of the canyon (Purtymun and Stoker 1990, 7508, p. 6). The two wells, SCO-1 and SCO-2, were installed near existing water supply wells PM-1 and PM-3 as required by conditions of the HSWA permit (EPA 1990, 1585, p. 7; LANL 1998, 58841, p. 2-10).

The extent of the probable shallow alluvial groundwater body in Sandia Canyon is not known. The presence of alluvial groundwater is likely in middle Sandia Canyon and particularly at the wetlands in upper Sandia Canyon; however alluvial groundwater has not been intersected by the observation wells drilled to date. One well in lower Sandia Canyon, SCO-2-old (for a time also referred to as SCO-4) was dry when drilled in 1966, and usually is dry. However in September 1969, after a stormwater runoff event in Sandia Canyon, this well contained enough water to collect an alluvial groundwater sample (Purtymun 1975, 11787, p. 117). The results of the analyses of the alluvial groundwater sample are discussed in Section 3.4.3.

The only known groundwater discharges in Sandia Canyon are the wetlands in upper Sandia Canyon, which are fed by surface water, and any losses from ET (e.g., Purtymun and Kennedy 1971, 4798, p. 8). An unknown volume of alluvial groundwater presumably seeps downward into subsurface units through the bedrock at the base of the alluvium. The depth to the regional zone of saturation near TA-72 is approximately 750 ft (230 m). Sandia Spring in lower off-site Sandia Canyon discharges groundwater from the Puye Formation and is probably not directly connected to the alluvial groundwater.

Figure A-2 is a longitudinal cross section that shows the locations of existing wells in and near Sandia Canyon. Six tables in Appendix C (Table C-1 through Table C-6) describe the wells and boreholes; provide location information and current status; provide construction information; provide stratigraphic information; and provide available water level measurements. Some of the stratigraphic information provided when some of the boreholes were originally drilled was found to be inconsistent with that from adjacent boreholes and with current understanding of the stratigraphy of the area. Therefore, Table C-6 contains both the original stratigraphic information, which is largely obtained from Purtymun (1995, 45344), and a revised set of stratigraphic picks based on review of lithologic descriptions and on local and regional stratigraphic information. Discussion of some of the revised stratigraphy is presented in the following sections.

3.4.4.2.1 Early Alluvial Groundwater Investigations in Sandia Canyon

The first alluvial boreholes drilled in lower Sandia Canyon were observation wells drilled in 1966 by the Environmental Surveillance Group (now ESH-18). Observation wells SCO-1 and SCO-2 were drilled in 1966 in lower Sandia Canyon to determine the presence of water in the alluvium near supply wells PM-3 and PM-1, respectively (Purtymun 1995, 45344, p. 67). For a time these wells were called SCO-3 and SCO-4, probably expecting that at least two additional wells would be drilled upstream in Sandia Canyon (e.g., Purtymun 1973, 4971, p. 3; Purtymun 1975, 11787, p. 117). A summary of the information obtained from these holes is in Appendix C, and the locations of these test holes are shown in Figure A-1. The stratigraphic information obtained from these holes is shown graphically in Figure A-2. These original observation wells in Sandia Canyon were both drilled to a depth of 20 ft (6 m) and did not encounter water in the alluvium at the time they were drilled. After a significant stormwater runoff event in September 1969, SCO-4 (SCO-2) contained some water; however SCO-3 (SCO-1) was never observed to contain water (Purtymun 1975, 11787, p. 117). These two wells were subsequently damaged and were plugged and abandoned (Purtymun 1995, 45344, p. 67). The well information associated with the original wells in Sandia Canyon is provided in Appendix C as SCO-1-old and SCO-2-old.

Replacement wells SCO-1 and SCO-2 were drilled in 1989 adjacent to the previous locations of the former wells SCO-1 and SCO-2. SCO-1 was drilled to a depth of 79 ft (24 m), the alluvium was encountered from surface to a depth of 18 ft (5.5 m), and the well was drilled into the Otowi Member of the Bandelier Tuff. SCO-1 was completed to a depth of 20 ft (6 m). with a perforated screen interval from 9.3 ft to 19.3 ft (2.8 m to 5.9 m) (Purtymun 1995, 45344, p. 142). SCO-2 was drilled to a depth of 29 ft (9.1 m) in the Otowi Member. The alluvium was encountered to a depth of 15 ft (4.6 m) and the well was completed with a screen interval from 8.4 ft to 18.4 ft (2.6 to 5.6 m). Water has never been observed in wells SCO-1 and SCO-2.

In 1991 a total of eight boreholes were drilled adjacent to the three surface impoundments at TA-53 for the purpose of characterizing the subsurface conditions beneath the surface impoundments. Seven of the boreholes were drilled on the mesa at TA-53 but one borehole was drilled on the north flank of Sandia Canyon. Borehole 53-7 was drilled near the head of a small canyon directly adjacent to and southwest of the impoundments to identify impacts from the impoundments and to determine the possible presence of perched groundwater. This borehole drilled to a total depth of 80 ft (24.4 m) and was dry; the borehole was completed as a neutron-moisture access hole (Purtymun 1995, 45344, p. 329; LANL 1998, 58841, p. 2-25).

Core samples from borehole 53-7 were used to determine the hydraulic properties of the Bandelier Tuff that underlies the surface impoundments at TA-53. Core samples were collected from the Otowi Member in borehole 53-7. The samples were measured for gravimetric and volumetric moisture content, density, and moisture retention characteristics. Porosity and saturated hydraulic conductivity of the samples were also determined (LANL 1998, 58841, p. 2-25).

Saturation was not observed in any of the six boreholes around the surface impoundments (LANL 1998, 58841, p. 2-25). Boreholes drilled adjacent to the impoundments showed only tritium at depth. The highest concentration of tritium was seen in borehole 53-5 located immediately south of the middle of the two northern impoundments, in the area of the former unlined drainage ditch. The highest concentration detected was 100 nCi/L at 100 ft (30 m) (the bottom of the borehole), which is approximately 100–1000 times greater than tritium concentrations detected at baseline borehole 53-B. The other five boreholes, drilled within approximately 50 ft (15 m) of the impoundment dikes, all had tritium concentrations at depths that ranged from less than 0.1 nCi/L to approximately 10 nCi/L, considerably less than in borehole 53-5. Metals were detected below background concentrations, and VOCs and SVOCs were not detected. These measurements indicate that tritium is the only contaminant that has migrated into the vadose zone below the surface impoundments; the lateral tritium migration is at most 30 ft (9 m) from the impoundment, while vertical tritium migration is at least 100 ft (30 m) in this location (LANL 1998, 58841, p. 2-27).

3.4.4.2.2 Recent Groundwater Investigations in Sandia Canyon

Borehole SCOI-3 was drilled in May 1996 as part of the “Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon” (LANL 1995, 50290). SCOI-3 was completed to base of the Guaje Pumice Bed at a depth of 132.5 ft (40.4 m) before operations were temporarily suspended because of a lack of funds. SCOI-3 was planned to be an intermediate-depth well, and its original intent was to sample perched groundwater identified at a depth of 450 ft (137.2 m) in basalt within the Puye Formation that was encountered during drilling of water supply well PM-1 in 1964 (Cooper et al. 1965, 8582, p. 40). The purpose of SCOI-3 was reevaluated during development of the Laboratory's hydrogeologic work plan (LANL 1996, 55430), and it was decided that a single well designed to characterize perched zones and the regional aquifer was needed at this location. This new well was named R-12, to be consistent with the nomenclature used to designate regional aquifer wells in the work plan and the core document (LANL 1997, 55622). Instead of deepening SCOI-3, R-12 was drilled as a new well so that larger casing sizes could be used to ensure that a well of adequate diameter could be installed into the regional aquifer (LANL 1998, 59665, p. 2). SCOI-3 did not encounter water in the alluvium or in units of the Bandelier Tuff.

In 1998 characterization well R-12 was drilled to a total depth of 847 ft (258.2 m) in lower Sandia Canyon near the eastern boundary of the Laboratory. This well is located adjacent to abandoned borehole SCOI-3 and about 400 ft (122 m) southwest of supply well PM-1. At the level of intermediate perched groundwater zones and the regional aquifer, R-12 is downgradient of multiple contaminant source areas that potentially include PRSs in Sandia Canyon, Los Alamos Canyon, and Mortandad Canyon watersheds. R-12 was also sited to provide early warning for contaminants approaching water supply well PM-1 and to provide hydrologic and geologic data for understanding the vadose zone and regional aquifer in this part of the Pajarito Plateau. In descending order, geologic units penetrated in R-12 included alluvium, tephras and volcaniclastic sediments of the Cerro Toledo interval, Otowi Member of the Bandelier Tuff, basaltic rocks of the Cerros del Rio volcanic field, old alluvium, Puye Formation, and basaltic rocks of the Santa Fe Group (LANL 1998, 59665, p. 1). R-12 did not encounter groundwater in the alluvium.

Hydrologic characteristics of the shallow alluvial groundwater in Sandia Canyon, such as permeability and transmissivity, have not been determined. However, it is likely that hydrologic characteristics of the alluvium in Sandia Canyon are similar to those properties obtained from slug tests performed on alluvial observation wells in Los Alamos Canyon. The mean hydraulic conductivity obtained from five slug tests of alluvial wells in Los Alamos Canyon was 3.2 E–04 ft/sec (9.6 E–05 m/sec). Using a gradient of 0.027, which is equivalent to the slope of the steam channel, and an assumed porosity of 0.3, the average rate of groundwater movement in the alluvium in Los Alamos Canyon was estimated to be approximately 900 ft (270 m) per year (Gallaher 1995, 49679). A summary of the general hydraulic properties of alluvium is provided in Table 3-2 of the core document (LANL 1997, 55622, p. 3-30).

Figure A-2 shows transverse cross sections of the alluvium-filled channel at several locations along the canyon, including locations of wells where information about the shape of the channel is approximately known. The character of the alluvial groundwater is probably similar to other adjacent canyons and is probably restricted to the lower portion of the alluvium within the V-shaped channel in the middle canyon. The alluvial saturated zone is probably widest south of TA-53, where the canyon floor is widest.

There are no documented observations of water level fluctuations in the alluvial groundwater in Sandia Canyon. However, the water levels likely fluctuate seasonally, much like the fluctuations observed in Mortandad Canyon (LANL 1997, 56835, p. 3-93), which shows that saturated conditions in the alluvium are transient. Also, the probable nature of deposition of the alluvial sediments (shifting streambed and overbank flood deposits [e.g., Reneau and McDonald 1996, 55538, p. 47]) indicates that a high degree of heterogeneity in the physical characteristics of the alluvial groundwater body is likely. Groundwater flow in the alluvium is probably controlled by highly conductive zones such as buried stream channels, braided deposits, and point-bar deposits. The flow may be limited in portions of the alluvium by finer-grained deposits such as floodplain and overbank deposits.

Currently, two alluvial groundwater wells are checked as part of the Laboratory's routine monitoring program. These include SCO-1 and SCO-2, which are both completed to a depth of 20 ft (6 m). These wells have been dry when checked since these wells were reinstalled in 1989.

3.4.4.2.3 Relationship Between Alluvium and Bedrock Stratigraphic Units in Sandia Canyon

Figure A-2 shows the bedrock stratigraphic units identified during borehole drilling for the test holes and the alluvial monitoring wells in Sandia Canyon (Purtymun 1995, 45344, pp. 141 and 142). The cross section shows the location and depth of the wells and the available gamma log traces adjacent to the boreholes. The figure also shows the approximate base of the alluvium at the deepest part of the canyon (generally near the center of the canyon). Regionally, the Tsankawi Pumice Bed and the Cerro Toledo interval are present at the base of the Tshirege Member. However, none of the deep boreholes drilled in Sandia Canyon identified the presence of these units because when the deep wells were drilled in Sandia Canyon the presence of these units in the subsurface was not well documented.

The Tsankawi Pumice Bed and Cerro Toledo interval sediments including boulder gravel beds outcrop in lower Sandia Canyon near wells SCO-2, R-12, and PM-1. Large boulders of Tschicoma Formation dacite present on the south wall of the canyon have been assigned to the Cerro Toledo interval (Reneau and McDonald 1996, 55538, p. 38). The presence of the Cerro Toledo interval beneath upper and middle Sandia Canyon has not been identified in previous drill holes, but recent boreholes drilled in Mortandad Canyon and elsewhere have encountered sediments of the Cerro Toledo interval.

The cross section shows the projected position of the stratigraphic contact between the base of the Tshirege Member and the Tsankawi Pumice Bed/Cerro Toledo interval in the Sandia Canyon area. Based on this projection, the base of the alluvium intersects the Tsankawi Pumice Bed/Cerro Toledo interval in lower Sandia Canyon west of well SCO-1 in the vicinity of TA-72. Boreholes drilled west of SCO-1 and south of TA-53 will probably encounter a thin, weathered section of the Tshirege Qbt 1g unit, which may be too thin to recognize in auger cuttings, and will then penetrate into the Cerro Toledo interval. The upper part of the Cerro Toledo interval consists of well-stratified tuffaceous sandstones, siltstones, and primary ash-fall and pumice-fall deposits as described in Section 3.3.1.4. In auger cuttings these deposits may be difficult to distinguish from the alluvial sediments. In the lower canyon east of SCO-1, boreholes will encounter the Otowi Member of the Bandelier Tuff beneath the alluvium.

In the middle canyon, the intersection of the alluvium and the Cerro Toledo interval demarks potentially differing hydrogeologic units to the west and to the east. West of this intersection the Cerro Toledo interval may be present as a separate hydrogeologic unit and may form an intermediate perched zone of saturation. However, east of the intersection the alluvial hydrogeologic unit may merge with the Cerro Toledo interval to form a single hydrogeologic unit. If these hydrogeologic units merge, lateral flows of groundwater in this combined hydrogeologic unit may be controlled by the geometry and orientation of paleochannels in the Cerro Toledo interval. Efforts to characterize the fate of flow and contaminants in the alluvium will consider the probability that paleochannels within the Cerro Toledo interval do not coincide with the orientation of Sandia Canyon, thus creating potential pathways for groundwater flow laterally away from the canyon.

3.4.4.3 Geochemistry of Alluvial Groundwater in Sandia Canyon

The purpose of this section is to discuss the geochemistry of alluvial groundwater in Sandia Canyon. Normally the alluvial observation wells in Sandia Canyon are dry. However, in September 1969, after a stormwater runoff event in Sandia Canyon, one sample of alluvial groundwater was obtained from SCO-2-old, which for a time was also referred to as SCO-4 (Purtymun 1975, 11787, p. 117).

Since the two observation wells were drilled in lower Sandia Canyon in 1966, ESH-18 personnel have checked for the presence of alluvial groundwater the SCO wells. The wells have been dry except after a runoff event in September 1969 when water was sampled from the original SCO-2 well, which at the time was referred to as SCO-4. The results of the analyses were reported by Purtymun (1975, 11787, p. 117).

The sample collected from the alluvial groundwater in Sandia Canyon was analyzed for general inorganic constituents and radionuclides. The sample contained 320 mg/L TDS, including 80 mg/L sodium, 15 mg/L chloride, 0.18 mg/L chromate, and 1.3 mg/L nitrate (as N). The conductance was reported to be 350 µS/cm. The alluvial groundwater contained 0.4 µg/L total uranium and less than 0.05 pCi/L plutonium-238 and plutonium-239, and less than 4 nCi/L tritium (Purtymun 1975, 11787, p. 117). The results of the analyses indicate that the alluvial groundwater was likely the result of infiltration of stormwater runoff and probably not associated with sanitary waste discharges from TA-3 at the head of Sandia Canyon.

3.4.4.4 Summary of the Alluvial Groundwater System in Sandia Canyon and Data-Collection Activities Needed to Understand the Alluvial Groundwater System

Known information about the alluvial groundwater in Sandia Canyon is summarized below.

- The character and extent of the shallow alluvial groundwater body in Sandia Canyon is not known.
- Surface water infiltration from streamflow is likely to be the major source of recharge to the alluvial groundwater.
- There are no known alluvial groundwater discharge points in Sandia Canyon. Losses from evapotranspiration and infiltration into deeper bedrock units are the likely sources of loss of alluvial groundwater. An unknown volume of alluvial groundwater is hypothesized to seep downward into subsurface units through the base of the alluvium.
- Two alluvial groundwater monitoring wells were drilled in lower Sandia Canyon in 1966; these wells were redrilled and replaced in 1989. These wells were installed for environmental surveillance purposes and have historically been dry. No alluvial groundwater wells have been installed in the middle canyon where the presence of alluvial groundwater is likely.
- One sample of alluvial groundwater was collected from SCO-2 in 1969 after a large runoff event. The results of the analyses of the sample indicated that the alluvial groundwater was likely the result of infiltration of stormwater runoff and probably not associated with sanitary waste discharges from TA-3 at the head of Sandia Canyon.
- The Bandelier Tuff underlies the alluvium throughout most of the upper and middle canyon. However, in lower Sandia Canyon near TA-72 and west of SCO-1, the Cerro Toledo interval is likely to be present beneath the alluvium. This unit may provide an enhanced infiltration pathway and lateral groundwater flowpaths for movement of alluvial groundwater into the subsurface.

The following additional data-collection activities are needed to understand the alluvial groundwater in Sandia Canyon.

- To characterize and understand the movement of alluvial groundwater in Sandia Canyon, additional alluvial groundwater monitor wells need to be installed at key locations. Intact core samples of alluvial material will need to be collected during drilling of the well boreholes and analyzed for hydrologic properties (saturated hydraulic conductivity, effective porosity, and specific yield) to provide data necessary for the understanding of the groundwater flow model of the alluvial groundwater. Transducers may be installed in selected wells to continuously monitor water level fluctuations.
- Alluvial groundwater samples need to be collected from the alluvial groundwater monitoring wells and analyzed to determine water quality and seasonal water quality changes.

- To understand and model solid/solution phase interactions, both filtered and unfiltered groundwater samples need to be collected from wells and analyzed for major cations and anions, trace elements, radionuclides, dissolved organic carbon, stable isotopes, and anthropogenic organic compounds.
- Geochemical modeling simulations of surface water and groundwater chemistry need to be performed to quantify speciation, mineral stability, adsorption reactions, and mixing reactions between different media.
- Groundwater flow modeling simulations of the alluvial groundwater need to be conducted to quantify water-balance components for the alluvial system and estimate infiltration losses from the alluvium into deeper subsurface units.

3.4.4.5 Deep Unsaturated Zones and Possible Intermediate Perched Zones

Understanding the hydrogeologic properties of the unsaturated zone of the Bandelier Tuff and other units present beneath Sandia Canyon is important because the unsaturated zone may serve as either a barrier or a conduit to the vertical and horizontal movement of alluvial groundwater or to potential transient perched intermediate groundwater zones beneath the canyons.

The following features of the unsaturated tuff control the rates of vertical contaminant transport (Kearl et al. 1986, 8414):

- physical properties (density, porosity, and specific gravity);
- hydraulic properties (saturated and unsaturated permeabilities, conductivities, and moisture characteristic curves);
- properties of fractures and joints (frequency, orientation, degree of interconnectedness, and filling materials);
- properties of unit contacts or paleosurfaces (flow paths or barriers);
- geochemical properties (specific surface area, ion exchange capacity, retardation factors, and mineralogy); and
- depth to groundwater.

Intermediate Perched Zones in Sandia Canyon

There is evidence that intermediate perched zones of saturation are present beneath lower Sandia Canyon. Intermediate perched zones have not been identified beneath upper and middle Sandia Canyon. However the presence of an intermediate perched zone beneath TA-53 has been inferred (LANL 1998, 58841, p. 2-10). Perched groundwater was encountered at a depth of about 450 ft (137 m) in water supply well PM-1 when the well was drilled in 1964 and 1965 (Cooper et al. 1965, 8582, p. 40). This perched zone was located in the Cerros del Rio basalts and is separated from the top of the regional water table by approximately 298 ft (91 m) of basalt and conglomerate. Supply well Otowi-4, located in middle Los Alamos Canyon north of TA-53, also encountered perched intermediate groundwater when the well was drilled in 1990. Intermediate perched groundwater was encountered at a depth of approximately 253 ft (77 m), where water cascaded into the hole from a layer of coarse gravel in the upper fanglomerate section of the Puyé Formation above the Cerros del Rio basalts (Stoker et al. 1992, 12017). This intermediate saturated zone is separated from the top of the regional water table by about 527 ft (161 m) of conglomerate and basalt. The lateral extent of these perched groundwater bodies is not known nor is it known if the perched groundwater at PM-1 is connected to the perched groundwater at Otowi-4. It is also not known if these intermediate-depth groundwater bodies are hydraulically interconnected with the regional water table (e.g., LANL 1998, 58841, p. 2-10).

In 1998 a perched groundwater system was encountered in regional aquifer well R-12, from depths of 443 ft to 519 ft (135 m to 158 m) in the lower part of the Cerros del Rio basalt and in underlying old alluvium in the Puye Formation. The level of the groundwater in this zone rose in the borehole, indicating that the groundwater was confined. The water level stabilized at a depth of 424 ft (129 m) after the top of the zone was penetrated. The confining layer at the top of this zone is apparently massive basalt, and the lower perching layer is a clay-rich lacustrine deposit. The saturated thickness of this groundwater body is approximately 75 ft (23 m), making it the thickest intermediate-depth perched groundwater body identified on the eastern part of the Pajarito Plateau.

Groundwater samples were collected from the perched zone in R-12 at depths of 443 ft (135 m), 464 ft (141 m), and 495 ft (151 m). These samples were chemically characterized with respect to major ions, trace elements, dissolved organic carbon (DOC), stable isotopes, tritium, and other radionuclides. Analytical methods recommended by both the EPA and the Laboratory were followed for groundwater (filtered and nonfiltered) samples. Groundwater compositions are similar for the samples collected at depths of 443 ft (135 m) and 495 ft (151 m), but the groundwater sampled at 464 ft (141 m) has a distinctive chemistry (LANL 1998, 59665, p. 1).

Groundwater from the perched zone is dominantly a calcium-sodium-bicarbonate-chloride type as represented by the samples collected at depths of 443 ft (135 m) and 495 ft (151 m). There is also a sodium-calcium-chloride-sulfate-bicarbonate groundwater at a depth of 464 ft (141 m). Groundwater from the depths of 443 ft and 495 ft was found to contain 249.3 pCi/L to 254.7 pCi/L tritium (analysis by low-level electrolytic enrichment), 31.5 parts per million (ppm) to 33.4 ppm chloride, <0.02 to 0.26 ppm ammonium, 4.9 ppm to 5.5 ppm nitrate, and 2.46 parts per billion (ppb) to 2.51 ppb uranium. Groundwater from the depth of 464 ft was found to contain 208.1 pCi/L tritium, 200 ppm chloride, 13.5 ppm ammonium, 0.21 ppm nitrate, and 2.04 ppb uranium (LANL 1998, 59665, p. 1).

3.4.4.6 Regional Aquifer

The regional aquifer beneath the Laboratory has been partially delineated by information provided from the boreholes for 8 deep test wells and 14 water supply wells within the Laboratory boundaries (e.g., Environmental Surveillance and Compliance Programs, 59904, p. 135). The regional zone of saturation occurs in the Puye Formation and the Santa Fe Group at depths below Sandia Canyon and Cañada del Buey ranging from approximately 1200 ft (365 m) at the head of the canyons to approximately 750 ft (230 m) near the eastern Laboratory boundary. Beneath Cañada del Buey the regional zone of saturation is separated from the perched water in the alluvium/Tshirege Member at CDBO-6 and CDBO-7 by more than 800 ft (244 m) of tuff and volcanic sediments at PM-4 near TA-51 (e.g., McLin et al. 1997, 57754). Continuously recorded water level data collected at test wells since the fall of 1992 indicate that throughout the Pajarito Plateau the regional aquifer responds to barometric and earth-tide effects in a manner typical of confined to partially confined aquifers (McLin 1996, 56025).

In 1965 when water supply well PM-1 was drilled, the static water level of the regional aquifer was initially encountered at a depth of 722.1 ft (220 m) (elevation 5798 ft [1768 m]). Recent non-pumping water levels in PM-1 have been measured at a depth of about 761 ft (232 m) (elevation 5758 ft [1755 m]), for a lowering of the regional aquifer level of about 40 ft (12 m) in the past 31 years (McLin et al. 1998, 63506, p. 43).

In 1968 when water supply well PM-3 was drilled, the static water level of the regional aquifer was initially encountered at a depth of 740 ft (226 m) (elevation 5900 ft [1799 m]). Recent nonpumping water levels in PM-3 have been measured at a depth of about 779 ft (238 m) (elevation 5867 ft [1789 m]), for a lowering of the regional aquifer level of about 39 ft (12 m) in the past 31 years (McLin et al. 1998, 63506, p. 45).

Beneath lower Sandia Canyon the regional water table in R-12 was encountered at a depth of 805 ft (245 m) (elevation 5696 ft [1737 m]) in fractured basalt of the Santa Fe Group. Groundwater at the top of the regional aquifer in this area appears to be unconfined, and the static water level occurs at the same elevation at R-12 as that encountered in well R-9 (elevation 5696 ft [1737 m]). However, the elevation at the top of the regional water table in R-12 is about 62 ft (19 m) lower than the nonpumping water level in adjacent well PM-1, which is at an elevation of 5758 ft (1755 m). Figure A-2 shows the recent water levels observed in the wells in lower Sandia Canyon.

The higher static water levels observed in nearby water supply well PM-1 are probably due to the long screen lengths in the water supply wells that intersect multiple deeper zones, which may contribute to a higher-level composite hydraulic head. For example, PM-1 is screened over a 1554-ft (474-m)-interval (Cooper et al. 1965, 8582, p. 48), the top of which is 86 ft (26 m) below the total depth of R-12. The higher static water levels in the supply wells indicate that higher-head zones occur in the regional aquifer at depths greater than those penetrated by R-12 and R-9. The regional aquifer may have upward hydraulic gradients in some saturated zones in this part of the Pajarito Plateau (LANL 1998, 59665, p. 17).

Figure A-2 shows the general construction information for PM-1 and PM-3 and the stratigraphy encountered in these wells. At PM-1 a surface casing was installed to a depth of 474 ft (144 m) using 24-in. (61-cm)-diameter steel pipe. The production casing was installed from the surface to a depth of 2499 ft (662 m) using a 12-in. (30-cm)-diameter steel casing, which was slotted from 945 ft to 2479 ft (288 m to 756 m) (Purtymun 1995, 45344, p. 275). The well was equipped with a down-hole turbine pump powered from the surface with a steel shaft drive. A pumping test of the well was conducted in February 1965 after the well was completed. At that time the optimum yield of the well was about 700 gpm and the specific capacity of the well was approximately 15 gpm/ft of drawdown. The transmissibility of the aquifer was calculated from drawdown measurements to be approximately 55,000 gpd/ft (Cooper et al. 1965, 8582, pp. 48–53). In 1974 PM-1 was cleaned out after an accumulation of 500 ft (152 m) of sediment in the casing occurred after 7.5 years of service, indicating a potential problem with the construction of the well (Cushman and Purtymun 1975, 5479, p. 12). Since 1976 the specific capacity of PM-1 has been about 26 gpm/ft of drawdown at an average pump rate of 585 gpm (McLin et al. 1997, 57754, p. 35).

At PM-3 a surface casing was installed to a depth of 552 ft (168 m) using 26-in. (66-cm)-diameter steel pipe. The production casing was installed from the surface to a depth of 2552 ft (778 m) using a 14-in. (36-cm)-diameter steel casing, which was slotted from 956 to 2532 ft (291 to 772 m) (Purtymun 1995, 45344, pp. 276). The well was equipped with a down-hole turbine pump powered from the surface with a steel shaft drive. A pumping test of the well was conducted in November 1966 after the well was completed. At that time the optimum yield of the well was about 1400 gpm and the specific capacity of the well was approximately 31 gpm/ft of drawdown. The transmissibility of the aquifer was calculated from drawdown measurements to be approximately 320,000 gpd/ft (Purtymun 1967, 11829, pp. 15–18). Since 1972 the specific capacity of PM-3 has averaged 57 gpm/ft of drawdown at an average pump rate of 1380 gpm (McLin et al. 1997, 57754, p. 37). PM-3 is the best producing well in the Pajarito Mesa well field (e.g., ESG 1983, 6418, p. 78). PM-3 has approximately twice the specific capacity of well PM-1.

In 1965 when water supply well PM-2 was drilled, the static water level of the regional aquifer was 823 ft (251 m) below ground level. The water level was not observed to rise above this level before the well was pumped in 1966. However, when PM-4 was drilled in 1981 adjacent to Cañada del Buey, the depth to water was 1060 ft (323 m) below ground level. Before pumping in 1982, the level was 1050 ft (320 m) below ground level, which indicates that the water level rose between completion and pumping of the well or that some confining conditions may have been present at this location (McLin et al. 1997, 57754, p. 38).

Figure A-3 shows the general construction information for municipal supply wells PM-4 and PM-5 and the stratigraphy that was encountered in these wells. In PM-4 a surface casing was installed to a depth of 41 ft (12.5 m) using 42-in. (106-cm)-diameter steel pipe. The production casing was installed from the surface to a depth of 2874 ft (876 m) using a 16-in. (41-cm)-diameter steel casing, which was slotted from 1260 ft to 2854 ft (384 m to 870 m) (Purtymun 1995, 45344, p. 277). The well was equipped with a down-hole turbine pump powered from the surface with a steel shaft drive. A pumping test of the well was conducted in July 1982 after the well was completed. At that time, the specific capacity of the well was approximately 29 gpm/ft of drawdown; after producing the well for about 6 months at 1400 gpm, the specific capacity increased to 34 gpm/ft. Transmissibility of the aquifer was calculated from drawdown measurements to be approximately 49,000 gpd/ft (ESG 1983, 6418, p. 78). Since 1984 the specific capacity of PM-4 has averaged 34 gpm/ft of drawdown at an average pump rate of 1310 gpm (McLin et al. 1997, 57754, p. 36). PM-4 has the second highest specific capacity of the wells in the Pajarito Mesa well field, and has an average specific capacity about 60% of that at PM-3.

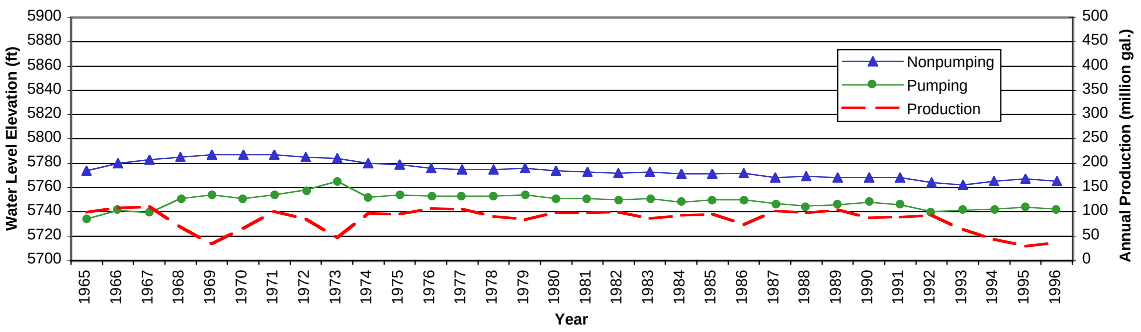
Municipal supply well PM-5, located adjacent to the Cañada del Buey watershed and near the head of the watershed, was drilled in 1981 and 1982. In PM-5 a surface casing was installed to a depth of 40 ft (12.2 m) using 42-in. (106-cm)-diameter steel pipe. The production casing was installed from the surface to a depth of 3092 ft (943 m) using a 16-in. (41-cm)-diameter steel casing, which was slotted from 1440 ft to 3072 ft (439 to 937 m) (Purtymun 1995, 45344, p. 277). The well was equipped with a down-hole turbine pump powered from the surface with a steel shaft drive. A pumping test of the well was conducted in September 1982 after the well was completed. At that time the specific capacity of the well was approximately 8.7 gpm/ft of drawdown at a pumping rate of 1200 gpm. Transmissibility of the aquifer was calculated from drawdown measurements to be approximately 12,000 gpd/ft (ESG 1984, 6523, p. 65). Since 1987 when PM-5 began production, the specific capacity has averaged about 12 gpm/ft of drawdown at an average pump rate of 1230 gpm (McLin et al. 1997, 57754, p. 36). PM-5 is the poorest producing well in the Pajarito Mesa well field.

Figure 3.4.4-1 shows the annual production history and nonpumping and pumping water levels for production wells PM-1, PM-3, PM-4, and PM-5 (McLin et al. 1997, 57754, Appendix A). The drawdown of pumping water levels at PM-1 averages 22 ft (6.7 m), at PM-3 the average drawdown is 24 ft (7.3 m), at PM-4 the drawdown averages 39 ft (11.9 m), and at PM-5 the drawdown averages 102 ft (31 m). Water levels at each well are related to production. In general, as production at each well increases the water levels decline, and conversely, if production is reduced water levels tend to rise slightly.

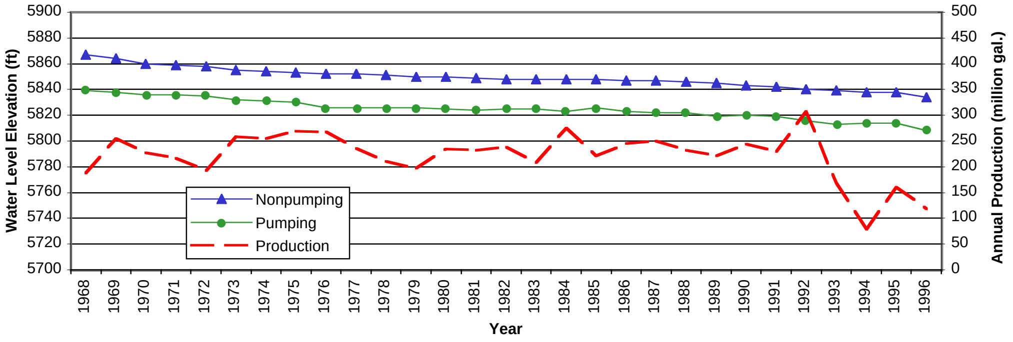
Since 1965 the nonpumping water level at PM-1 has declined 33 ft (10 m). Since 1968 the nonpumping water level at PM-3 has declined 36 ft (11 m). Since 1982 the nonpumping water level at PM-4 has declined 41 ft (12.5 m). Since 1985 the nonpumping water level at PM-5 has declined 50 ft (15 m).

Groundwater elevations obtained in deep wells located on the Pajarito Plateau indicate that the elevation of the potentiometric surface of the regional water table rises westward from the Rio Grande to the flanks of the Sierra del los Valle. In the Sandia Canyon and Cañada del Buey areas, the top of the regional zone of saturation is primarily in the fanglomerate member of the Puye Formation (see Figures A-2 and A-3) (Purtymun and Johansen 1974, 11835; Rogers et al. 1996, 54714, Figure 2a; LANL 1997, 55622, p. 3-33; LANL 1996, 55430, p. 2-19). In lower Sandia Canyon at R-12, however, the top of the regional zone of saturation was encountered in fractured basalt of the Santa Fe Group. Between PM-3 and PM-1 the hydraulic gradient of the regional water table averages approximately 70 ft (21 m) per mile within the Puye Formation.

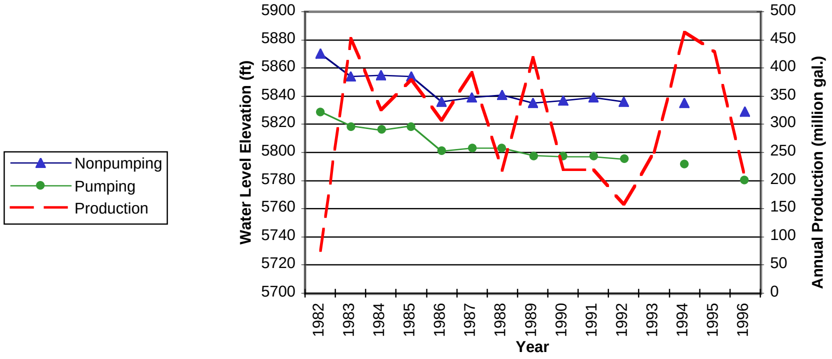
Annual production and water levels at PM-1



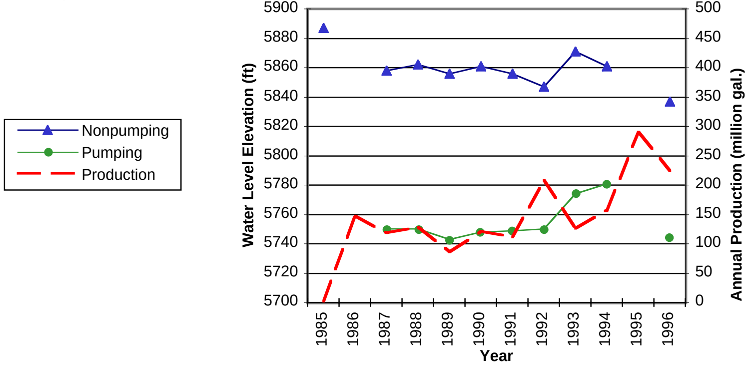
Annual production and water levels at PM-3



Annual production and water levels at PM-4



Annual production and water levels at PM-5



Source: McLin et al. 1997, 57754.

Figure 3.4.4-1. Annual production and water level measurements of the regional aquifer.

Near PM-4 and PM-5 the hydraulic gradient of the regional water table averages approximately 60 ft (18 m) per mile within the Puye Formation. Along the eastern edge of the Pajarito Plateau as the water in the aquifer nears discharge points in White Rock Canyon, the hydraulic gradient increases to 80 ft to 100 ft (24.4 m to 30.5 m) per mile. The rate of movement of water in the upper section of the regional aquifer varies depending on the stratigraphy. Aquifer performance tests indicate that movement ranges from 20 ft/yr (6.1 m/yr) in the Santa Fe Group to 345 ft/yr (105 m/yr) in the more permeable Puye Formation (Purtymun 1984, 6513, pp. 7 and 16).

The age of the regional aquifer groundwater has been estimated using carbon-14 and tritium dating methods. The carbon-14 data suggest that older water is found near the Rio Grande and that younger water is present under the central Pajarito Plateau. Water from PM-1 has been calculated to be as young as 39 years and as old as 3500 years. Water from PM-3 has been calculated to potentially range in age from 37 to 4500 years, and water from PM-5 has been calculated to range in age from 49 to 10,000 years (Blake et al. 1995, 49931, Table 4). The water from PM-5 has been estimated to range in age from a minimum of 1040 to a maximum of 5140 years using carbon-14 age dating techniques. Using tritium age estimates, the water could be as young as 85 years or greater than 10,000 years (Rogers et al. 1996, 54714, p. 410). Water from the regional aquifer discharges to springs along the west side of White Rock Canyon. Recent investigations suggest that the regional aquifer water that discharges to springs on the west side of the Rio Grande may be recharged from the Sangre de Cristo Mountains and that a groundwater divide is present within the aquifer west of the Rio Grande (Rogers et al. 1996, 54714, Figure 2b).

The source of recharge to the regional aquifer has not been determined (LANL 1996, 55430, p. 2-22). It has been postulated that withdrawals from the regional aquifer are mining the aquifer (Rogers et al. 1996, 54714, p. 412). Possible infiltration of alluvial groundwater downward to the regional aquifer has been investigated (e.g., Rogers et al. 1996, 55543). Three possible pathways for alluvial groundwater and potential contaminants, such as tritium in surface water and alluvial groundwater, to reach the regional aquifer were proposed by Gallaher (1995, 54716).

- Alluvial groundwater could migrate down a well bore where surface casing passes through the shallow alluvial groundwater. In Sandia Canyon and Cañada del Buey. However, the deep boreholes PM-1, PM-3, PM-4, and PM-5 do not intersect alluvial groundwater.
- Water could migrate through fractures or faults as saturated flow.
- Water could migrate as unsaturated flow through the unsaturated zone.

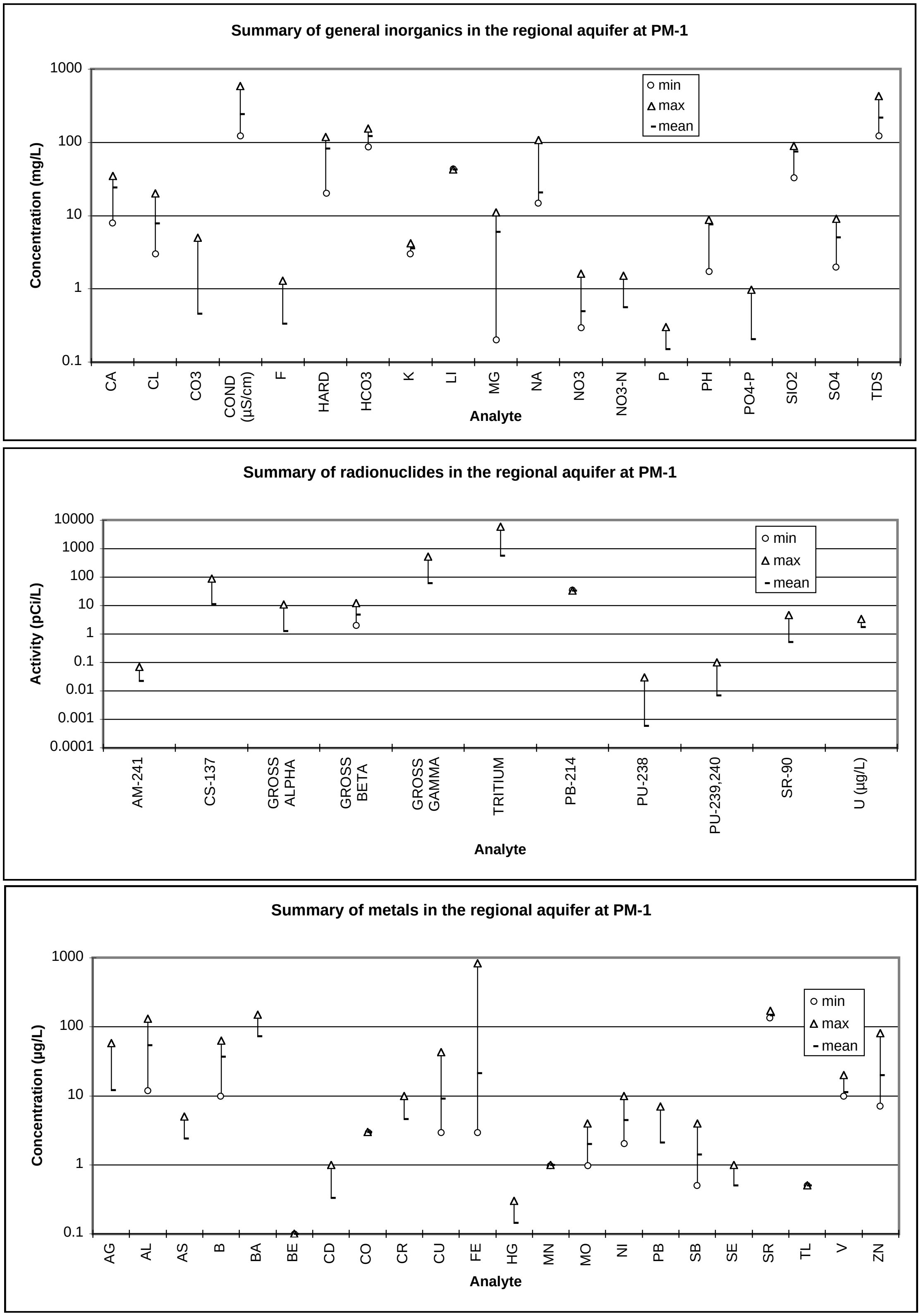
Environmental Sampling of the Regional Aquifer in Sandia Canyon

Personnel from ESH-18 have collected groundwater samples annually from supply wells in Sandia Canyon and Cañada del Buey, including PM-1, PM-3, PM-4 and PM-5. Additionally, samples are collected annually from Sandia Spring, which is located in lower Sandia Canyon within White Rock Canyon. The samples are collected for analysis of water quality parameters, metals, and radionuclides. The results of the sampling are reported annually in the environmental surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684).

Groundwater samples collected from municipal supply wells for the analyses of general inorganic constituents were acidified in the field prior to being filtered in the laboratory (AF samples) from 1964 to 1992. Samples collected for general inorganic constituent analyses since 1993 have not been filtered (UF samples). Samples collected for the analyses for radionuclides were acidified in the field prior to filtering in the laboratory (AF samples) from 1965 through 1995, and were unfiltered (UF samples) in 1996 and 1997. Samples collected for metals analyses were acidified in the field prior to being filtered in the laboratory (AF samples) from 1977 to 1992 and were unfiltered (UF samples) from 1993 to 1997. Summaries of the results of the analyses are discussed below. Figures 3.4.4-2 through 3.4.4-5 show summaries for the analytes detected above method detection limits; results reported below method detection limits are not included in the summaries. The range of values obtained for each analyte, including the minimum, maximum, and mean values obtained since sampling began at each site are shown on the figures.

A summary of the results of the analyses of groundwater from PM-1 since sampling began in 1964 is shown in Figure 3.4.4-2**.** The water from the regional aquifer in PM-1 has ranged from 122 mg/L to 429 mg/L TDS and the nitrate (as N) has been less than 1.5 mg/L, with a mean value of 0.5 mg/L. Radionuclides have typically been measured at very low levels at or near the detection limits for each radionuclide. The highest activity of cesium-137 measured was 90 pCi/L with an uncertainty of 140 pCi/L (ESG 1982, 6245, p. 36). Tritium has been observed in activities as high as 5900 pCi/L (±800 pCi/L) in 1981 and 1500 pCi/L (±500 pCi/L) in 1975. Either these samples were contaminated with surface waters or Laboratory effluents possibly impacted the regional aquifer. Since 1982 the activity of tritium has been measured at or below detection limits using the liquid scintillation method. The activities of plutonium-238 and plutonium-239,240 have been measured near detection limits. The highest measured activity of strontium-90 was 4.6 pCi/L in 1995, below the EPA primary drinking water standard for strontium-90 of 8 pCi/L (Environmental Surveillance Program 1996, 55333, pp. 198 through 201). The highest concentration of uranium measured was 3.4 µg/L in 1989 and the average value measured was 1.8 µg/L. Metal concentrations measured in the regional aquifer at PM-1 have been generally less than 100 µg/L. Barium was measured at 150 µg/L in 1981, but the average concentration of barium has been 73 µg/L.

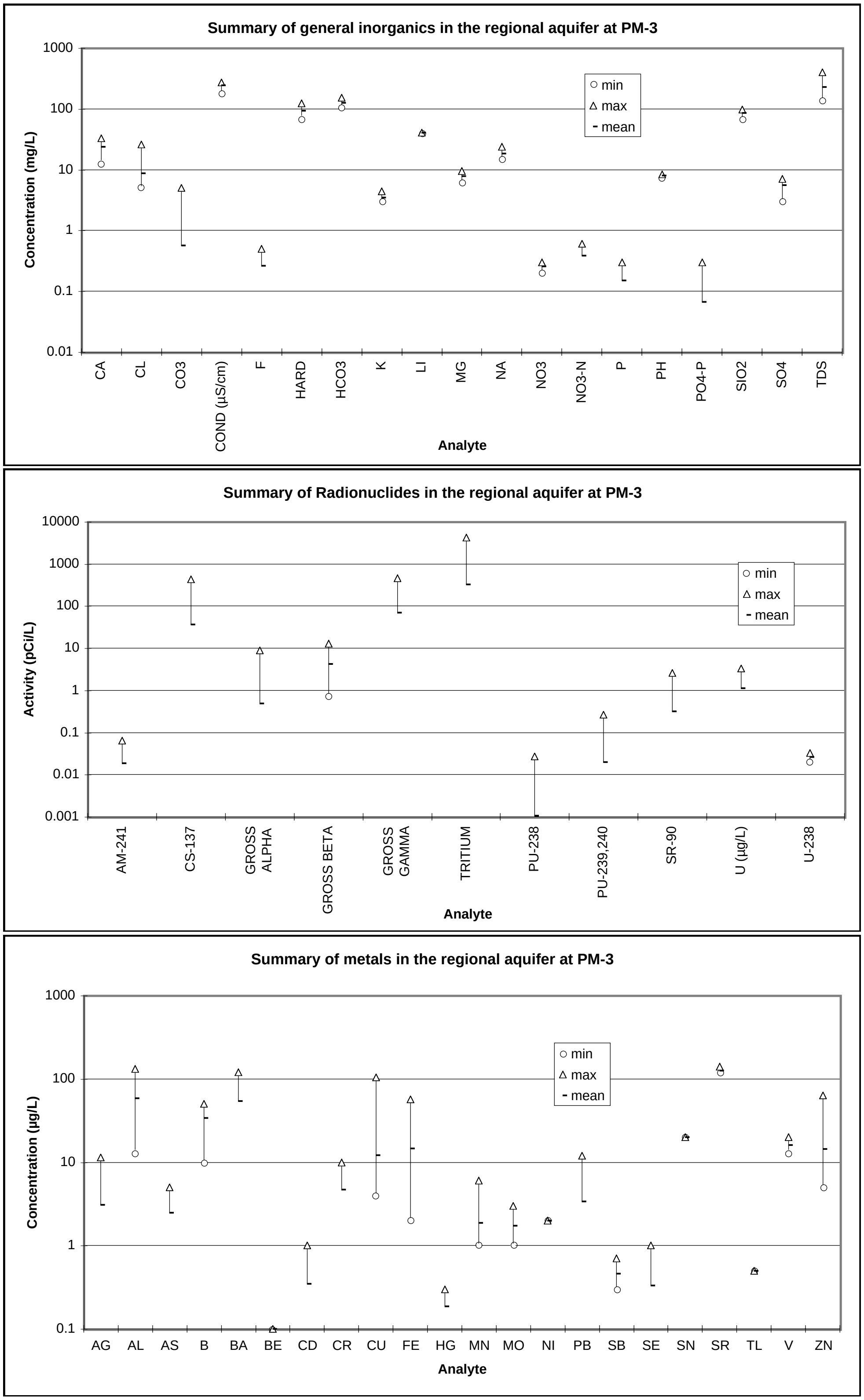
A summary of the results of the analyses of groundwater from PM-3 since sampling began in 1966 is shown in Figure 3.4.4-3. The water from the regional aquifer in PM-3 has ranged from 138 mg/L to 402 mg/L TDS and the nitrate (as N) has been less than 0.6 mg/L, with a mean value of 0.38 mg/L. Radionuclides have typically been measured at very low levels at or near the detection limits for each radionuclide. The highest activity of cesium-137 measured was 431 pCi/L with an uncertainty of 138 pCi/L. Several results for cesium-137 in the regional aquifer in 1991 were unusually elevated; the measurements were believed to be suspect due to large counting uncertainties (Environmental Protection Group 1993, 23249, p. VII-6). Tritium has been observed in activities as high as 4200 pCi/L (±600 pCi/L) in 1982 and 2000 pCi/L (±400 pCi/L) in 1974. Either these samples were contaminated with surface waters or Laboratory effluents possibly impacted the regional aquifer. Since 1983 the activity of tritium has been measured at or below detection limits using the liquid scintillation method. The activities of plutonium-238 have been measured near detection limits. The highest measured activity of plutonium-239,240 was 0.264 (±0.032) pCi/L in 1985. Since 1988 however, the activity of plutonium-239,240 has been near detection limits. The highest measured activity of strontium-90 was 2.6 pCi/L in 1996, below the EPA primary drinking water standard for strontium-90 of 8 pCi/L (e.g., Environmental Surveillance Program 1996, 55333, p. 198-201). The highest concentration of uranium measured at PM-3 was 3.3 µg/L in 1989 and the average value measured was 1.1 µg/L. Metal concentrations measured in the regional aquifer at PM-3 have been generally less than 100 µg/L. Copper was measured at 104 µg/L in 1988, but the average concentration of copper has been 12 µg/L.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness.

Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

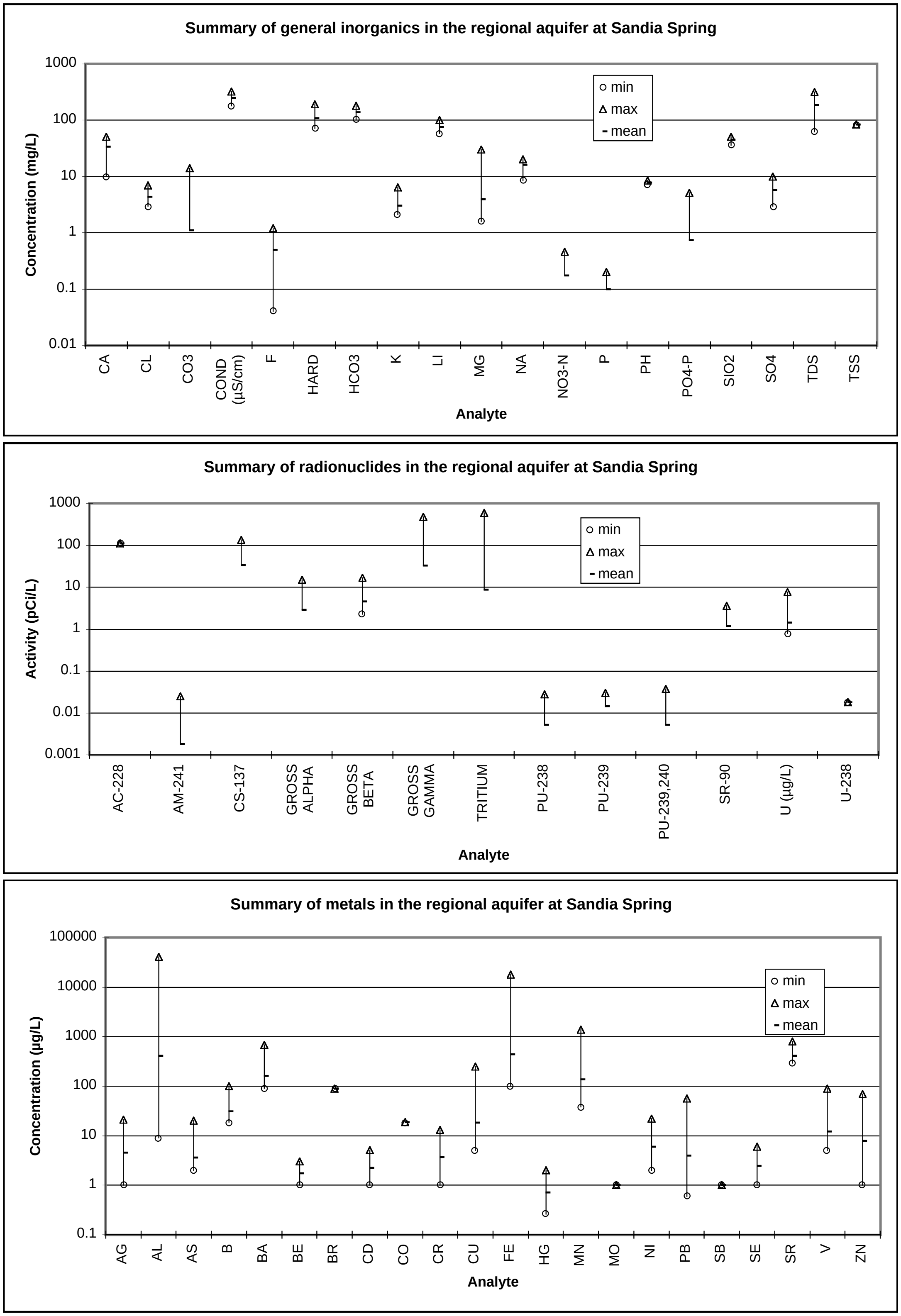
Figure 3.4.4-2. Summary of results from the regional aquifer at PM-1.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness.

Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

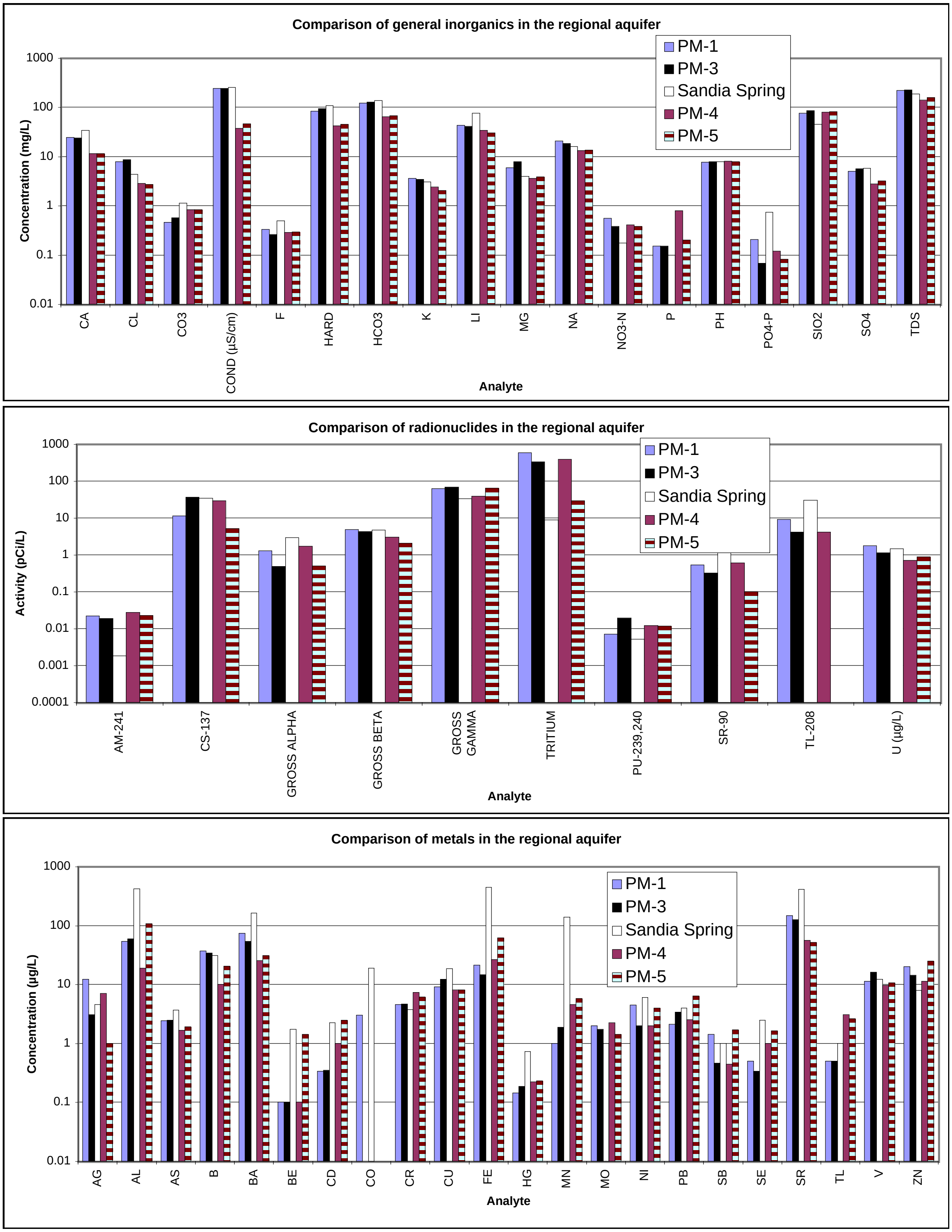
Figure 3.4.4-3. Summary of results from the regional aquifer at PM-3.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness. TSS = total suspended solids.

Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

Figure 3.4.4-4. Summary of results from the regional aquifer at Sandia Spring.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness.

Source: Environmental surveillance reports 1971–1997; Purtymun 1975, 11787.

Figure 3.4.4-5. Comparison of results in the regional aquifer.

A summary of the results of annual sampling at Sandia Spring since sampling began in 1959 is shown in Figure 3.4.4-4. Samples have been collected from Sandia Spring in 1959, 1961–1963, 1969, 1974, 1977, 1978, and annually since 1980. Samples are usually analyzed for general inorganic constituents and radionuclides. Since 1986 the samples have been analyzed for metals. The water from the regional aquifer at Sandia Spring has ranged from 62 mg/L to 316 mg/L TDS. Nitrate (as N) has been less than 0.5 mg/L, with a mean value of 0.17 mg/L. Radionuclides have typically been measured at very low levels at or near the detection limits for each radionuclide. The highest measured tritium activity has been 600 pCi/L, which is the approximate detection limit using the liquid scintillation method. The activities of plutonium-238 have been measured near detection limits. The measured activities of plutonium-238 and plutonium-239,240 have been within detection limits. The highest measured activity of strontium-90 was 3.6 pCi/L in 1996, below the EPA primary drinking water standard for strontium-90 of 8 pCi/L (e.g., Environmental Surveillance Program 1996, 55333, p. 201). The highest concentration of uranium measured at Sandia Spring was 7.6 µg/L in 1995 and the average value measured is 1.4 µg/L.

Metal concentrations measured in the regional aquifer at Sandia Spring have been generally less than 1000 µg/L. However Sandia Spring contains higher concentrations of aluminum and iron that have been measured in concentrations over 10,000 µg/L. Barium was measured at 690 µg/L in 1995, but the mean concentration of barium has been 162 µg/L. Manganese was measured at 1400 µg/L in 1995 and the mean concentration measured for manganese has been 139 µg/L.

A comparison of the mean concentrations of general inorganic water quality parameters, radionuclides, and metals in groundwater at PM-1, PM-3, and Sandia Spring is shown in Figure 3.4.4-5. The comparison of the general inorganic water quality parameters of the regional aquifer beneath Sandia Canyon shows that the parameters are quite similar at PM-1 and PM-3 for most analytes. Sandia Spring contains slightly higher mean concentrations in calcium, fluoride, lithium, and phosphate (as P), and slightly lower mean concentrations of chloride, magnesium, nitrate (as N) silicate, and possibly TDS. Radionuclide constituents are also similar from the three locations, although the mean measurements of tritium have been about an order of magnitude lower from Sandia Spring. The largest differences between the well water at PM-1 and PM-3 and the water from Sandia Spring are observed in the metals and trace element concentrations. The water from PM-1 and PM-3 are similar in concentrations, but the water from Sandia Spring contains significantly higher concentrations of aluminum, barium, beryllium, cadmium, cobalt, iron, mercury, manganese, selenium, and elemental strontium. The water from Sandia Spring contains slightly lower mean concentrations of molybdenum and zinc. The variations in trace elements and metals may be the result of Sandia Spring discharging from just the top of the regional aquifer and the wells discharging water from deeper units within the regional aquifer.

Groundwater samples were collected from the top of the regional zone of saturation during drilling of characterization well R-12. The water from this well is a calcium-sodium-bicarbonate type with a TDS content of 386 ppm. The major cation and anion chemistry of this water is similar to groundwater in supply wells PM-1 and PM-3. Measurable tritium activity in the regional saturated zone (46.9 pCi/L) suggests that a component of the groundwater is less than 50 years old (LANL 1998, 59665, p. 2).

3.4.4.7 Summary of the Hydrology of Sandia Canyon and Data-Collection Activities Needed to Understand the Hydrogeology

The hydrogeology of Sandia Canyon is summarized below.

- The primary inputs to the groundwater in Sandia Canyon are liquid discharges from Laboratory operations and contemporary precipitation as snowmelt or stormwater runoff.

- In Sandia Canyon a continuous reach of surface water is completely lost into the subsurface, probably initially to the alluvium. The water probably infiltrates into deeper units and moves into the subsurface along fractures, bedding planes, or unit contacts; the ultimate fate of the water is not known. In recent years, approximately 160,000 gpd infiltrate in Sandia Canyon.
- Most of the water entering the canyons must be lost to either ET or to seepage into deeper units because surface flow out of each canyon the Laboratory at state road NM4 is ephemeral and in recent years has occurred only after significant storm events. The amount and fate of water leaving the alluvium or shallow perched zone are not known.
- Intermediate perched groundwater is present beneath lower Sandia Canyon at a depth of approximately 450 ft (137 m). In 1965 perched groundwater was encountered at a depth of about 450 ft (137 m) in water supply well PM-1. In 1998 a confined perched groundwater system was encountered in regional aquifer well R-12, from depths of 443 ft (135 m) to 519 ft (158 m) in the lower part of the Cerros del Rio basalt and in underlying old alluvium. The water level stabilized at a depth of 424 ft (129 m) after the top of the zone was penetrated. The saturated thickness of this groundwater body is approximately 75 ft (23 m), making it one of the thickest intermediate-depth perched groundwater bodies identified yet on the Pajarito Plateau. This intermediate saturated zone is separated from the top of the regional aquifer by about 527 ft (161 m) of conglomerate and basalt. The lateral extent of these perched groundwater bodies is not known. It is also not known if these intermediate-depth groundwater bodies are hydraulically interconnected with the regional aquifer.
- The regional aquifer extends beneath the Sandia Canyon watershed. The regional aquifer is pumped at supply wells PM-1 and PM-3 in lower Sandia Canyon. The upper portion of the regional aquifer probably discharges at Sandia Spring in lower off-site Sandia Canyon.
- In PM-1 and PM-3 elevated tritium activity has been observed as high as 5900 pCi/L (±800 pCi/L) in 1981. Laboratory effluents may have impacted the regional aquifer beneath Sandia Canyon. Since 1982 the activity of tritium has been measured at or below detection limits using the liquid scintillation method.
- Measurable tritium activity (46.9 pCi/L) in the regional saturated zone in R-12 suggests that a component of the groundwater is less than 50 years old (LANL 1998, 59665, p. 2).

The following additional data-collection activities are needed to understand the subsurface hydrology of Sandia Canyon.

- The lithology and stratigraphy of bedrock units needs to be better understood to adequately characterize the hydrogeologic system and to provide input to hydrogeologic models. Data on the lithology, stratigraphy, and hydraulic properties and geotechnical properties (including bulk density, porosity, saturated and unsaturated hydraulic conductivity, moisture content, storativity or specific yield, and matric potential) are needed. These data may be obtained from laboratory analyses of borehole core samples and by aquifer performance testing.
- The possible presence of saturated zones beneath middle Sandia Canyon needs to be investigated by drilling the currently planned regional aquifer boreholes to characterize the Bandelier Tuff and underlying units to the regional aquifer. If saturation is found in intermediate perched zones, investigations to determine the source and fate of the water should be considered.

- Water samples need to be collected from the alluvial groundwater, the regional aquifer, and any other saturated zones encountered. The samples need to be both filtered in the field and unfiltered, followed by preservation of appropriate aliquots to provide appropriate data on dissolved and suspended constituent concentrations. Analyses for colloidal materials are needed to provide data on possible colloidal transport of contaminants.

3.4.5 Air Monitoring Investigations in Sandia Canyon

3.4.5.1 AIRNET Monitoring

The Laboratory operates a network of more than 50 environmental air monitoring stations (called AIRNET) to sample radionuclides in ambient air. The network is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Annual Laboratory emissions include microcurie (µCi) quantities of plutonium and americium, millicurie (mCi) quantities of uranium, and curie (Ci) quantities of tritium and activation products. In addition to Laboratory emissions, natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the air surveillance program. Each station collects both a total particulate matter sample and a water vapor sample for analysis (Environmental Surveillance and Compliance Programs 1997, 56684, p. 59).

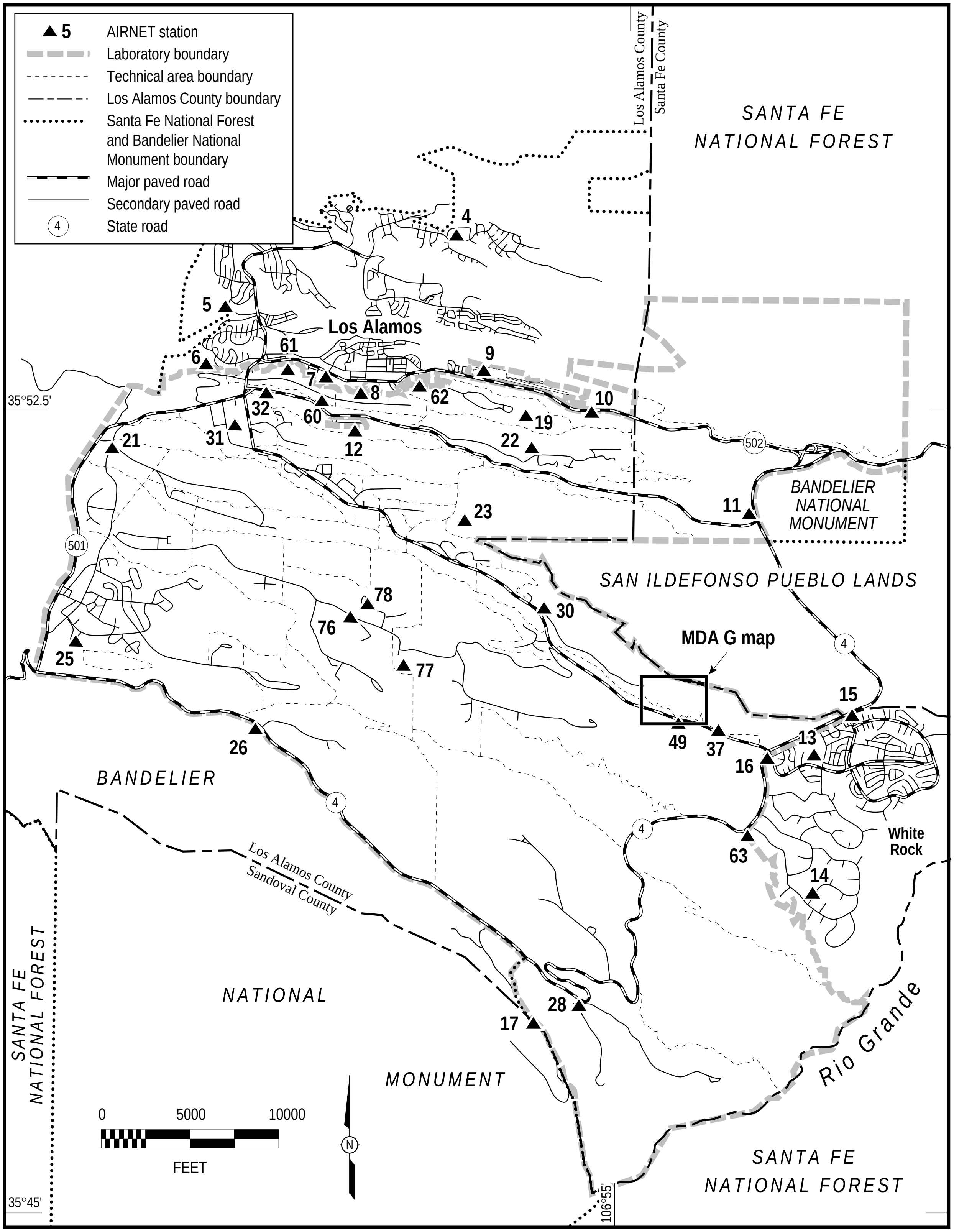
Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on meteorological conditions. Windy, dry days can increase the soil resuspension, but precipitation can wash particulate matter out of the air. Consequently, there are often large daily and seasonal fluctuations in airborne radioactivity concentrations caused by changing meteorological conditions. The measured airborne concentrations are less than the EPA concentration limit for the general public. The EPA limit represents a concentration that would result in an annual dose of 10 mrem (Environmental Surveillance and Compliance Programs 1997, 56684, p. 10).

The environmental surveillance program monitors four air stations within the Sandia Canyon watershed annually. Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239,240; uranium-234; uranium-235; and uranium-238. A summary of air monitoring stations within the Sandia Canyon watershed is presented in Table 3.4.5-1. The station locations are shown in Figure 3.4.5-1.

Table 3.4.5-1
Sandia Canyon Air Monitoring Stations

Station Number	Station Location	Station Type
11	Well PM-1 (E. Jemez Road)	Perimeter
12	Royal Crest Trailer Court	Perimeter
22	TA-53	On-site
32	County landfill	On-site

Source: Environmental Surveillance and Compliance Programs 1997, 56684, pp. 76 through 77.



Source: FIMAD G104732; Environmental Surveillance and Compliance Programs 1997, 56684.

F3.4.5-1 / SANDIA & CDB WP / 070999 / PTM

Figure 3.4.5-1. Locations of off-site perimeter and on-site Laboratory AIRNET stations.

In 1997 one instance of elevated air concentrations within the Sandia Canyon watershed was investigated by ESH-17. At station 32, located at the landfill, air concentration values for gross alpha exceeded action levels for sample periods November and December 1997. Because of these exceedances, the samples were reanalyzed for gross alpha and gross beta. Isotopic analyses were also performed to provide information as to which radionuclides were causing the gross alpha and beta increases. From these data, it was concluded that polonium-210, a radionuclide within the natural radon-222 decay chain was responsible for the increased gross alpha values at the time of the reanalysis, but not necessarily at the time of the original analysis. Plutonium, uranium, and americium from Laboratory operations were not elevated and did not cause the elevated gross alpha for either the original analysis or the reanalysis. Large, short-term fluctuations in atmospheric levels of radon and radon decay products are very common, but it cannot be concluded that these natural fluctuations caused the gross alpha and gross beta increases in late 1997. Since naturally occurring radon decay products are constantly being deposited on the surface of materials exposed to the atmosphere, it is likely that handling any material will resuspend these decay products, such as lead-210 and polonium-210, to some extent. Such resuspensions will occur with regularity at a landfill. Therefore, nearby samplers such as this AIRNET sampler will occasionally collect elevated concentrations of these naturally occurring radioactive materials. For compliance with the Clean Air Act, this elevated value was considered a release of polonium-210 when the annual dose to a member of the public was calculated for compliance with 40 CFR 61 Subpart H (Environmental Surveillance and Compliance Programs 1998, 59904, pp. 72 and 73).

The long-term trends identified by evaluation of historical data include a significant decrease in ambient tritium activity compared with that measured in the 1970s and early 1980s (Environmental Surveillance Program 1996, 55333). Review of the AIRNET monitoring data does not indicate other significant trends at this time.

Routine publication of AIRNET data on the World Wide Web began during 1997, and data are now available on the World Wide Web within two to three months following the sampling period. The web site, located at http://www.air-quality.lanl.gov/airnet.htm, also includes follow-up information on investigations of higher than normal values.

3.4.5.2 Stack Air Sampling

As of the end of 1997, the Laboratory was continuously sampling 31 stacks for the emission of radioactive material to the ambient air. The Laboratory has identified four types of radioactive stack emissions: (1) particulate matter, (2) vaporous activation products (VAP), (3) tritium, and (4) gaseous/mixed air activation products (G/MAP). Three of these emissions types are present at the Los Alamos Neutron-Scattering Center (LANSCE) at TA-53: VAP, tritium, and G/MAP. Measurements of Laboratory stack emissions during 1997 totaled 20,000 Ci. Of this total, tritium emissions comprised 420 Ci, and air activation products from LANSCE contributed 19,600 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and particulate/vapor activation products were less than 1 Ci. Emissions from LANSCE increased from 1996 to 1997. This increase was a result of an increase in run-time for the accelerator. G/MAP emissions and tritium emissions comprise the vast majority of radioactive stack emissions. Because G/MAP emissions account for most of the airborne radioactivity, and because one stack at LANSCE is the primary source of G/MAP isotopes, LANSCE operating personnel have developed and implemented a delay line to reduce these emissions. The delay line operates by removing a large part of the concentrated activated air from the production point at the LANSCE beam stop. With the delay line operating, G/MAP emissions were reduced by 28.8%, as compared to similar operations without the benefit of the delay line (Environmental Surveillance and Compliance Programs 1998, 59904, pp. 73 through 76).

3.4.5.3 TLDNET Monitoring

In an attempt to distinguish any impact from Laboratory operations, 58 thermoluminescent dosimeter (TLD) stations (TLDNET) are placed around the Laboratory and in the surrounding communities. This network of dosimeters is divided into three groups. (1) The off-site regional group has six locations ranging from 17 mi to 73 mi (28 km to 117 km) from the Laboratory boundary. These regional stations are located at Fenton Hill and in the neighboring communities of Española, Pojoaque, Santa Fe, and the Pueblos of San Ildefonso and Jemez. Taos Pueblo was part of this network in 1995, but was discontinued in 1996 because of repeated loss of measurements. (2) The off-site perimeter group has 25 locations within 2.5 mi (4 km) of the Laboratory. These stations are placed in residential areas surrounding the Laboratory and in locations where people work. (3) The on-site group has 27 locations within Laboratory boundaries, generally around operations that may produce ionizing radiation. Four new on-site stations were added in 1996: East Gate (#56); TA-54 West at the TLD laboratory #57); TA-54 Lagoon on Pajarito Road (#58); and Los Alamos Canyon between the ice rink and TA-2 (#59) (Environmental Surveillance and Compliance Programs 1997, 56684, pp. 65 through 66).

To monitor external penetrating radiation from airborne gases, particles, and vapors resulting from LANSCE operations at TA-53, a network of 24 TLD stations is used (LANSCENET). Twelve of these monitoring locations are approximately 0.5 mi (800 m) north of and downwind from the LANSCE stack. The other 12 TLD stations are located about 5.5 mi (9 km) from LANSCE, near the southern boundary of the Laboratory and are used as a background measurement. Both sets of 12 monitoring locations are placed at approximately the same elevations to help eliminate elevation effects from the cosmic component of the natural radiation (Environmental Surveillance and Compliance Programs 1997, 56684, p. 66). In 1997, five new monitoring locations near the LANSCE lagoons and stacks indicated doses ranging from 222 mrem to 934 mrem for nine months of monitoring. These results are not representative of potential doses to a member of the public because they include operational exposures at areas where public access is restricted. The TLD measurements collected at the 12 stations located directly north of LANSCE were statistically compared to the 12 background stations. There is no significant difference ($p > 0.05$) between the site and background TLD measurements observed in the vicinity of LANSCE. The average dose at the 12 site stations was 164 ± 10 mrem, while the background was 165 ± 10 mrem (Environmental Surveillance and Compliance Programs 1998, 59904, p. 78).

3.4.5.4 NEWNET Monitoring

Site-specific meteorological monitoring in Cañada del Buey is provided by four Neighborhood Environmental Watch Network (NEWNET) meteorological stations (G Site, Buey West, Buey East, and the TA-54 Meteorological Tower) that are located in Cañada del Buey approximately north and east of MDA G at TA-54. These stations collect meteorological data at 15-minute intervals. The data are posted daily on the World Wide Web at the NEWNET site at http://newnet.jdola.lanl.gov/. The data include the date, time, gamma radiation intensity (μR/hr), wind direction, wind speed, barometric pressure, temperature, and humidity. Other NEWNET sites located near TA-54 are located at TA-36 (Kappa Site) and TA-18 (Sewage Lagoon) in Pajarito Canyon. Figure A-1 shows the locations of the NEWNET meteorological stations.

3.4.5.5 Summary of Air Monitoring Data in Sandia Canyon and Data-Collection Activities Needed to Understand These Data

Significant information about air monitoring data provided in Section 3.4.5 is summarized below.

- At AIRNET station 32, located at the Los Alamos County landfill, air concentration values for gross alpha exceeded action levels for sample periods November and December 1997. It is suspected that polonium-210, a radionuclide within the natural radon-222 decay chain was responsible for the increased gross alpha values, and that the polonium-210 was resuspended as a function of landfill activities.

- The long-term trends identified by evaluation of AIRNET historical data include a significant decrease in ambient tritium activity compared with that measured in the 1970s and early 1980s.
- LANSCE is a primary source of VAP, tritium, and G/MAP stack emissions at the Laboratory, and was the only facility to increase emissions from 1996 and 1997, due to an increase in run time for the accelerator. A delay line was implemented which has reduced LANSCE G/MAP emissions by 28.8%.
- Five new TLDNET monitoring locations near the LANSCE lagoons and stacks indicated doses ranging from 222 mrem to 934 mrem for nine months of monitoring. The TLD measurements collected at the 12 stations located directly to the north of LANSCE were statistically compared to the 12 background stations; no significant difference between the site and background TLD measurements were observed in the vicinity of LANSCE.

The various air monitoring networks described above will continue to be monitored and reported as part of the Laboratory's Environmental Surveillance program. No additional air monitoring is proposed in this work plan.

3.4.6 Biological Setting of Sandia Canyon

The general biological setting for the Los Alamos region and the canyons is discussed in Section 3.8 of the core document (LANL 1997, 55622). The unique aspects of the biological setting of the Sandia Canyon system are described here.

Several anthropogenic sources of surface water, as well as stormwater runoff, enter the Sandia Canyon system. Discharges of liquid effluent have occurred into Sandia Canyon since the earliest days of the Laboratory. In recent years many of these discharges were continued as NPDES-permitted discharges. Since 1994 many of these NPDES discharges have been eliminated or redirected to the sanitary waste consolidation station (SWSC) at TA-46 (see Section 2.2.1 of this document). The reduction in both number and volume of discharges may not have significantly impacted surface water flow in Sandia Canyon because the SWSC plant discharges to upper Sandia Canyon (see Section 3.4.3). The impact to the extent of wetland areas has not been determined.

A more important factor affecting the wetland areas may be the amount of precipitation in the watershed area. The National Wetlands Inventory has identified two wetland types within Sandia Canyon: riverine, which are contained within a channel, and palustrine, which are dominated by vegetation. A portion of the upper Sandia Canyon system has been identified as a palustrine wetland presently maintained by effluent discharges and stormwater runoff (Cross 1994, 26071, p. 32).

3.4.6.1 Potential Receptors

A summary of species thought to occur throughout the Laboratory canyons system can be found in Section 3.8 of the core document (LANL 1997, 55622). Only supplemental data specific to Sandia Canyon is presented in this here.

3.4.6.1.1 Flora

Vegetation types vary by elevation within the Sandia Canyon system. A detailed description of 6 major plant communities and 16 plant habitats were studied for the Los Alamos National Environmental

Research Park (Foxx and Tierney 1984, 5950). The descriptions of plant communities were prepared from work in Pajarito Canyon and cover the entire length of the canyon from Pajarito Mountain to the Rio Grande. A study of plant succession on old homestead fields on the Pajarito Plateau includes floral succession information for an abandoned agricultural field (the Montoya Field) located on Sigma Mesa between Sandia Canyon and Mortandad Canyon (Foxx et al. 1997, 57580).

ESH-20 personnel have completed three biological assessments, which address many of the technical areas within the Sandia Canyon watershed area (Cross 1994, 26071; Haarmann 1994, 52023; Risberg 1994, 62353). The purpose of the assessments was to evaluate the impact of ER Project site characterization activities and proposed Laboratory activities on potentially present threatened, endangered, and sensitive species and on floodplains and wetlands. The assessments were based on reconnaissance surveys, habitat evaluations, and species-specific surveys that were conducted for compliance with the Federal Endangered Species Act; the New Mexico Wildlife Conservation Act; the New Mexico Endangered Plant Species Act; Federal Executive Order 11990, “Protection of Wetlands”; Federal Executive Order 11988, “Floodplain Management”; the Code of Federal Regulations (10 CFR Part 1022, ”Compliance with Floodplain/Wetlands Environmental Review Requirements”); the National Environmental Policy Act (NEPA); and DOE Order 5400.1, **“**General Environmental Protection Program.” The assessments identified the presence of habitats that are capable of supporting threatened, endangered, and sensitive species; however, the assessments do not conclude that these species are present. A summary of the threatened, endangered, and sensitive species that are potentially present based on the habitats identified by these assessments is discussed in Section 3.4.6.2.

3.4.6.1.2 Fauna

The biological assessments discussed in Section 3.4.6.1.1 include fauna evaluations conducted in many of the technical areas within the Sandia Canyon watershed area (Cross 1994, 26071; Haarmann 1994, 52023; Risberg 1994, 62353). A summary of the threatened, endangered, and sensitive species that are potentially present based on the habitats identified by these assessments is presented in Section 3.4.6.2.

A study of wildlife use of NPDES-permitted outfalls at the Laboratory defines the watering potential of outfalls located in Sandia Canyon (Foxx and Blea-Edeskuty 1995, 62348). The purpose of the study was to determine the use of the outfalls by wildlife, to document the presence/absence of hydrophytic vegetation downstream from each outfall source, and to determine the presence and distance of surface water flow. The report provides a summary of the watering potential and the fauna and hydrophytic vegetation associated with each outfall surveyed.

Baseline nocturnal small mammal population data was gathered from three live-trapping arrays (webs) within the wetland in upper Sandia Canyon during 1994 and 1995. The small mammal species captured during this time frame include the long-tailed vole (*Iklicrotus longicaudus*), the montane vole (*Microtus montanus*), the brush mouse (*Peromyscus boylii*), the deer mouse (*Peromyscus maniculatus*), the pinyon mouse (*Peromyscus trueii*), the harvest mouse (*Reithrodontomys megalotis*), the vagrant shrew (*Sorex vagrans*), and an unidentified species of shrew (*Sorex sp.*) (Bennett and Biggs 1996, 57541, p. 11). The study compared small mammal characteristics (species diversity and composition, small mammal density, biomass, physical characteristics, and lean body mass) within the three areas of Sandia Canyon. The highest species diversity, densities and biomass of animals were found in the upstream web (closest to the outfalls at the head of Sandia Canyon) with a continual decrease in these attributes in each web downstream. The report recommended additional monitoring studies be conducted in Sandia Canyon to allow temporal comparisons, and rodent tissues be sampled for contaminants and then compared to the rodent population characteristics to assess potential impacts to the rodent community in Sandia Canyon. (Bennett and Biggs 1996, 57541, p. 1).

During the early summer of 1990, from 1000 gal to 1400 gal (3800 L to 5300 L) of sulfuric acid spilled from the TA-3 power plant acid storage tank to the cattail dominated wetland in Sandia Canyon. As a result of this incident, the Biological Resources Evaluation Team (BRET) of the Laboratory's ESH Division was asked to review the impact of the spill on the downstream wetland. The study was subsequently extended to acquire baseline information on aquatic macroinvertebrate communities of Sandia Canyon to determine if these communities are affected by routine industrial and sanitary waste discharges. Data on macroinvertebrate species composition and diversity and on water quality were gathered from three stations from 1990 to 1992 and five stations during 1993 and 1994. Initially following the spill in 1990, no macroinvertebrates were found at any of the sample locations, but within a month communities began to reestablish.

Another spill occurred during mid-summer of 1992, sending a discharge of chlorine from the sewage treatment plant into Sandia Canyon. Investigation showed a significant decline in the number of macroinvertebrates in the stream. However, by the end of the summer, the relative numbers of macroinvertebrates were nearly back to normal (Bennett 1994, 57542, p. 10). The study indicates that water quality parameters (dissolved oxygen, pH, temperature, and conductivity) are within ranges that do not cause gross impacts to aquatic invertebrates. However, the number of aquatic invertebrates is lower at the wetland stations than at the downgradient stations. Although not conclusive, the study suggests several factors that could have caused the lower abundance of aquatic invertebrates, including erosion of sediments from the adjacent Los Alamos County landfill, incision and channelization of water flow in the wetland, naturally occurring lack of acceptable substrates for aquatic invertebrates, and historical releases from PRSs (Cross and Nottelman 1996, 57540). The macroinvertebrate communities at the wetland stations are characterized by low diversities and unstable communities. In contrast, the downstream stations appear to be in a zone of recovery, where water quality parameters more closely resemble those found in natural streams of the area. The lower stations have increased macroinvertebrate diversity and stable communities, further indicating downstream water quality improvement (Cross 1994, 57544, p. 1; Cross 1995, 57543, p. 1).

3.4.6.2 Threatened, Endangered, and Sensitive Species

Potential threatened and endangered species in the canyon systems are listed in Chapter 3 of the core document (Section 3.8, Table 3-6) (LANL 1997, 55622). Surveys conducted during the biological assessments discussed in Section 3.4.6.1.1 did not confirm the presence of threatened, endangered, or sensitive species in the study areas. Preliminary risk assessments for the threatened Mexican spotted owl, the peregrine falcon, the southwestern willow flycatcher, and the bald eagle have been completed (Gallegos et al. 1997, 57915; Gallegos et al. 1997, 59790; Gonzales et al. 1998, 62349; Gonzales et al. 1998, 62350); no nesting or roosting zones have been identified within the Sandia Canyon watershed.

Biological evaluations and wetland/floodplain assessments were performed by ESH-20 personnel in the early 1990s. The assessments noted that suitable foraging areas for northern goshawks occur (Cross 1994, 26071, p. 48) and potential roosting sites for the spotted bat may be present in Sandia Canyon (Risberg 1994, 62353, p. 13). Unpublished investigations of reptile and amphibian species have been conducted since 1978 and have identified the presence of the western terrestrial garter snake (*Thamnophis elegans*), the canyon treefrog *(Hyla arenicolor*), the short-horned lizard (*Phrynosoma douglassi*), the many-lined skink (*Eumeces multivirgatus*), and the prairie rattlesnake (*Crotalus viridis viridis*) within Sandia Canyon. These investigations also indicate the presence of the eastern fence lizard (*sceloporus undulatas*) throughout Los Alamos County between the elevations of 5412 ft to 8250 ft (1640 m to 2500 m) (Bogart 1986, 50038).

Table 3.4.6-1 presents a summary of the threatened, endangered, and sensitive species that are potentially present within the Sandia Canyon watershed, based on the habitats identified in the biological assessments conducted by ESH-20 personnel for the ER Project (see Section 3.4.6.1.1 and Section 3.4.6.1.2).

Table 3.4.6-1
Threatened, Endangered, and Sensitive Species Potentially Occurring in the Sandia Canyon Watershed

Common Name	Scientific Name	Legal Status	Potential for Occurrence
Northern goshawk	*Accipiter gentilis*	Federal candidate	Moderate to high
Mexican spotted owl	*Strix occidentalis lucida*	Federally threatened	Low to high
Peregrine falcon	*Falco peregrinus*	Federally endangered/state endangered	Moderate
Spotted bat	*Euderma maculatum*	Federal candidate/state threatened	Moderate
Common black hawk	*Buteogallus anthracinus*	State protected	Moderate
Jemez Mountain salamander	*Plethodon neomexcicaus*	Federal candidate/state protected	Moderate
Willow flycatcher	*Empidonax traillii*	Federally endangered/state threatened	Moderate
Checker lily	*Fritillaria atropurpurea*	State sensitive	Moderate
Meadow jumping mouse	*Zapus hudsonius*	Federal candidate/state threatened	Low to moderate
Wood lily	*Lilium philadelphicum var. andium*	*State sensitive*	Low to moderate
Sandia alumroot	*Heuchera pulchella*	State sensitive	Low to moderate
Pagosa phlox	*Phlox caryophylla*	State sensitive	Low to moderate
Sessile-flowered false carrot	*Aletes sessiliflorus*	State sensitive	Low to moderate
Santa Fe cholla	*Opunita viridiflora*	Federal candidate	Low to moderate
Bald eagle	*Haliaeetus leucocephalus*	Federally endangered	Low
Broad-billed hummingbird	*Cynanthus latirostris*	State protected	Low
Pine marten	*Martes americana*	State protected	Low
Threadleaf horsebrush	*Tetradymia filifolia*	State sensitive	Low
Plank’s catchfly	*Silene plankii*	State sensitive	Low to none
Cyanic milk vetch	*Astragalus cyaneus*	State sensitive	Low to none
Santa Fe milk vetch	*Astragalus feensis*	State sensitive	Low to none
Mathew’s woolly milk vetch	*Astragalus Mathewsii*	State sensitive	Low to none
Taos milk vetch	*Astragalus puniceus var. gertudis*	State sensitive	Low to none
Grama grass cactus	*Toumeya papyracantha*	Federal candidate	Low to none
Wright fishhook cactus	*Mammillaria wrightii*	State sensitive	Low to none
White-faced ibis	*Plegadis chihi*	Federal candidate	Low to none
Say’s pond snail	*Lymneae captera*	State endangered	Low to none
Tufted sand verbena	*Abronia bigelovii*	State sensitive	Low to none

Source: Haarmann 1994, 52023, pp. 16 through 17; Risberg 1994, 62353, pp. 10 through 12; Cross 1994, 26071, pp. 34 through 35.

3.4.6.3 Species Viability Studies

No studies addressing species viability have been identified for the Sandia Canyon system.

3.4.6.4 Contaminant Uptake

3.4.6.4.1 Radionuclide Concentrations in Biota

3.4.6.4.1.1 Flora

As part of ongoing research concerning the use of honeybees (*Apis mellifera L*.) as indicators of environmental radionuclide contamination and bioavailable contaminants, samples of water, flowers, and honeybees were collected for two consecutive years from a location adjacent to the radioactive liquid waste treatment lagoon, PRS 53-002(b), at TA-53, a study site containing radionuclide contamination above background levels. The samples were analyzed for concentrations of tritium and gamma-emitting radionuclides, and the results were compared using rank sum, correlation, and trend analysis. Results were then used to assess the redistribution pathway of radionuclides within the study site. Results indicate that honeybees receive the majority of their contamination directly from the source, the radioactive waste lagoon. The amount of contamination the honeybees receive from flowers during nectar collection appears to be insignificant compared to the amount they received during lagoon water collection. Results did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results showed a significant bioaccumulation of cobalt-60 and sodium-22 within the honeybees but no significant bioaccumulation within the flowers (Haarmann 1998, 62352, p. 1072).

3.4.6.4.1.2 Insects

A study investigating contaminant redistribution using concentrations in water, flowers, and honeybees was conducted by Haarmann (1998, 62352) as discussed above in Section 3.4.6.4.1.1.

3.4.6.4.1.3 Mammals

Studies have been conducted at various locations at the Laboratory to evaluate contaminants in small and large mammals. However, to date no data are available on contaminants in medium-sized mammals. Because of their relatively low densities and frequently nocturnal habits, medium-sized mammals are difficult to study. An unpublished study by Hansen et al. (1998, 63508) evaluated a new application of radio frequency identification (RFID) technology, which allows remote recording of the amount of time individual animals spend at a PRS, to record potential contaminant exposure time. The PRS chosen as the study site was PRS 53-002(b), the radioactive liquid waste treatment lagoon at TA-53. The PRS was fenced and a monitor was established as the only easy access to the site. Medium-sized mammals (rock squirrels, raccoons, striped skunk, and bobcat) were captured using cage traps during 1998 at two different areas at TA-53: within 1320 ft (400 m) of the lagoon (at the lagoon), and more than 1320 ft (400 m) from the lagoon (away from the lagoon), and from two locations on Santa Fe Forest Service lands. The captured animals were taken to an animal holding facility where the animals were measured, RFID tags were inserted between their shoulder blades, and hair and urine samples were collected for tritium and metals analysis. The animals were released the next day to their capture site. The RFID monitor tracks the entrance and egress of animals to and from the fenced area around the lagoon by reading the RFID tag in each animal, as in barcode technology. The RFID monitor system effectively documented animal passages into the lagoon area. Urine was used in liquid scintillation analysis to measure levels of tritium. The highest value recorded was for a raccoon that had 1.1 million pCi/L of tritium in its urine. An analysis of tritium levels in rock squirrel urine from the three different areas (at the lagoon, away from the lagoon, and control) found significant differences among the groups. Rock squirrels from the lagoon area had significantly higher concentrations of tritium in their urine than animals away from the lagoon or in the control area. The concentrations of metals in rock squirrel hair was also analyzed among the three areas; there was no significant evidence of elevated levels of metals in animals from TA-53, although there was a slight trend toward higher levels of lead. A low number of marked animals visited the lagoon relative to the number of animals with elevated tritium levels compared to the control animals. This finding suggests that indirect uptake routes are important in the transport of tritium from the TA-53 lagoon to wildlife.

Large mammals, such as mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*), forage in many areas at the Laboratory that may contain radioactivity above natural and/or worldwide fallout levels. A report by Fresquez et al. (1998, 62347**)** summarizes radionuclide concentrations (tritium, strontium-90, cesium-137, -plutonium-239,240, americium-241, and total uranium) in muscle and bone tissue of deer and elk collected from Laboratory lands from 1991 through 1998, including deer collected from TA-53 in Sandia Canyon and elk collected from TA-46 in Cañada del Buey. Also, the committed effective dose equivalent (CEDE) and risk of excess cancer fatalities (RECF) to people who ingest muscle and bone from deer and elk collected from Laboratory lands were estimated. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from Laboratory lands were either at less than detectable quantities (where the analytical results were smaller than two counting uncertainties) and/or within upper (95%) level background concentrations. As a group, most radionuclides in muscle and bone of deer and elk from Laboratory lands were not significantly higher ($p < 0.05$) than in similar tissues from deer and elk collected from background locations. Also, elk that had been radio-collared and tracked for two years and spent an average 50% of their time on Laboratory lands were not significantly different in most radionuclides from road kill elk that have been collected as part of the environmental surveillance program. Overall, the upper (95%) level net CEDE (the CEDE plus two sigma for each radioisotope minus background) at the most conservative ingestion rate (51 lb of muscle and 13 lb of bone) were as follows: deer muscle = 0.220 mrem/yr, deer bone = 3.762 mrem/yr, elk muscle = 0.117 mrem/yr, and elk bone = 1.67 mrem/yr. All CEDEs were far below the International Commission on Radiological Protection guideline of 100 mrem/yr, and the highest muscle plus bone CEDE (4.0 mrem/yr) corresponded to a RECF of 2E-06, which is far below the EPA guideline of 1E-04 (Fresquez et al. 1998, 62347, p. 1).

3.4.6.4.2 Organic Contaminant Uptake

3.4.6.4.2.1 Insects

During the summer of 1996, aquatic insects were collected within the upper Sandia Canyon wetland area. The insects were submitted for seven PCB Aroclor analyses. No PCBs were detected in the aquatic invertebrates. However the detection limits did not meet the data quality objective of 100 µg/kg for PCBs (Michael 1998, 57497). The results of this investigation had not been published as of December 1998.

3.4.6.4.2.2 Mammals

Studies of small mammals have been conducted in upper Sandia Canyon since 1994 by the Laboratory's ESH Division. These studies determined the presence and density of various small mammals in the wetland and an area down-canyon from the wetland as discussed in Section 3.4.6.1.2. In addition to the published report on the 1994 and 1995 small mammal population data for Sandia Canyon, there are unpublished PCB results for 64 samples of animal carcasses sampled in 1995 and 1996. Preliminary analytical data from organ and fat tissue from carcasses sampled in 1995 indicated nine of 30 animals contained detectable quantities of PCBs. Preliminary analytical data from the 1996 sampling indicated that 16 of 34 animals contained detectable quantities of Aroclor-1260, which was the only PCB detected in the animal samples. The range of Aroclor-1260 concentrations detected in small mammals for the 1995 and 1996 sampling activities are as follows: mouse (0.140 mg/kg to 0.920 mg/kg), vole (0.040 mg/kg to 2.500 mg/kg), and shrew (8.400 mg/kg to 19.000 mg/kg) (Dale 1999, 63494). These preliminary results suggest that Aroclor-1260 is being taken into the Sandia Canyon food web. However, area baseline data for total or specific PCBs in small mammals is not available for comparison. It should also be noted that the small mammal studies suggest that the wetland harbors more small mammals, and gross population characteristics such as mean body size show no differences between trapping grids (LANL 1998, 62340, p. 25).

3.4.6.4.3 Inorganic Contaminant Uptake

An 1998 unpublished report by Hansen et al. (1998, 63508**)** evaluated the concentrations of metals in hair samples collected from medium-sized mammals at TA-53 see Section 3.4.6.4.1.3. Hair samples were analyzed for concentrations of aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and thallium. There was no significant evidence of elevated levels of metals in animals from TA-53 when compared to animals collected from off-site background locations, although there was a slight trend toward higher levels of lead.

3.4.6.4.4 Bioaccumulator Uptake

Bioaccumulating chemicals that have been evaluated with respect to uptake in biota in Sandia Canyon include aluminum, cadmium, copper, lead, mercury, nickel, and selenium in medium-sized mammals; PCBs in small mammals and aquatic insects; and americium-241, strontium-90, cesium-137, and total uranium in large mammals. The data suggest that Aroclor-1260 is being taken up in the Sandia Canyon food web by small mammals, and there is a slight trend toward higher levels of lead in select medium-sized mammals. Although contaminant uptake has been addressed in numerous studies as summarized throughout Section 3.4.6.4, no other data for the uptake of specific bioaccumulating chemicals were found for species within the Sandia Canyon system.

3.4.6.4.5 Summary of Biological Setting in Sandia Canyon and Requirements to Understand Contaminant Uptake in Biota

Significant information about the biological setting in Sandia Canyon provided in Section 3.4.6 is summarized below.

- The National Wetland Inventory has identified wetland areas in upper Sandia Canyon. Although many NPDES outfalls have been eliminated or redirected to the SWSC plant at TA-46, the reduction in both number and volume of discharges may not have significantly impacted surface water flow in Sandia Canyon because the SWSC plant discharges to upper Sandia Canyon.

- Discharges of sulfuric acid and chlorine to the upper Sandia Canyon wetland in the early 1990s resulted in an evaluation of impact on aquatic macroinvertebrates. Initial study indicated a loss of macroinvertebrate communities. By the mid-1990s, the macroinvertebrate communities appeared to be in a zone of recovery. Other factors that may impact the communities include sediment influx, incision and channelization of surface water flow through the wetland, lack of substrates for aquatic invertebrates, and releases from PRSs.

- A contaminant indicator study at the TA-53 radioactive liquid waste treatment lagoon indicate a significant bioaccumulation of cobalt-60 and sodium-22 within honeybees but no significant bioaccumulation within flowers.

- Rock squirrels and a raccoon captured from the TA-53 radioactive liquid waste treatment lagoon area had significantly higher concentrations of tritium in their urine (maximum 1,000,000 pCi/L) than animals away from the lagoon or from a control area.
- The concentrations of metals in rock squirrel hair was also analyzed among three areas: the TA-53 radioactive liquid waste treatment lagoon, an area distal to the lagoon, and a control site; there was no significant evidence of elevated levels of metals in animals from TA-53, although there was a slight trend toward higher levels of lead.
- As a group, most radionuclides in muscle and bone of deer from Laboratory lands (including deer collected from TA-53) were not significantly higher ($p < 0.05$) than in similar tissues from deer collected from background locations.
- Aquatic insects were collected within the upper Sandia Canyon wetland area and submitted for seven PCB Aroclor analyses. No PCBs were detected in the aquatic invertebrates; however the detection limits did not meet the data quality objective of 100 µg/kg for PCBs.
- Preliminary analytical data indicated that 16 of 34 small mammals collected from webs in the upper Sandia Canyon wetland area contained detectable quantities of Aroclor-1260, which was the only PCB detected in the animal samples. The range of Aroclor-1260 concentrations detected in the small mammals are mouse (0.140 mg/kg to 0.920 mg/kg), vole (0.040 mg/kg to 2.500 mg/kg), and shrew (8.400 mg/kg to 19.000 mg/kg). These preliminary results suggest that Aroclor-1260 is being taken into the Sandia Canyon food web.

Consideration issues and deficiencies in the data required for the evaluation of contaminant uptake in biota in Sandia Canyon include the following:

- No data have yet been found to document uptake of organic or inorganic contaminants in flora.
- No data have been found to address species viability in Sandia Canyon.
- Bioaccumulator data is limited for all biota.
- No data were found on tissue concentrations of contaminants for predator species such as coyotes, owls, and raptors in Sandia Canyon, which makes it difficult to evaluate food chain transfer effects. However, data are available for small mammals, such as mice, voles, and shrews. Because of the extensive burrowing of these species and their localized range, small mammals could present a significant pathway for contaminant dispersion and transfer.
- Data reflecting current concentrations in biota are limited. data reflecting historical concentrations in biota are not available. Contaminant concentrations are expected to have changed during the past 20 to 25 years, and contaminant transfer processes are not necessarily linear. In addition, some contaminants compete for uptake processes in biota, which indicates a potential for differential uptake of the same contaminant if the mixture of contaminants is altered.

3.5 Environmental Setting of Cañada del Buey

3.5.1 Surface Sediments

3.5.1.1 Natural Background Conditions

Sediments in Cañada del Buey are primarily derived from erosion of the Bandelier Tuff and soils that have developed in the watershed; the latter include components of wind-blown sediment and fallout pumice. The natural background chemistry of the sediments reflects both the source materials and particle size distribution of resultant deposits. No background data are available from sediments in Cañada del Buey. However, background data have been obtained from geologically similar settings in Ancho Canyon and Indio Canyon (Reneau et al. 1996, 56047). These data also are similar to background data the canyons investigation team collected in 1996 from upper Guaje Canyon, Los Alamos Canyon, and Pueblo Canyon (Ryti et al. 1998, 59730). Because background sediment data obtained from other places on the Pajarito Plateau are similar in provenance to sediments in Cañada del Buey, these background data are used in Section 3.5.3 as the basis for evaluating the nature of contaminants in the canyon sediments. BVs reported for sediment, soil, and Bandelier Tuff units equate to the 95% UTL value for each analyte reported, which represent the upper range of the background concentrations (Ryti et al. 1998, 59730, p. 1).

3.5.1.2 Historic Channel Changes

The stream channels in Cañada del Buey west of White Rock and the south fork of Cañada del Buey have not been significantly impacted by development and are essentially in a natural state. Channel-bed aggradation and degradation likely occur in different areas, resulting in net deposition and erosion of sediment. The stream channel through White Rock has been straightened and/or diverted in places adjacent to developments, under bridges, and through culverts.

3.5.1.3 Contaminants in Cañada del Buey Sediments

3.5.1.3.1 Routine Environmental Surveillance of Active Channel Sediments

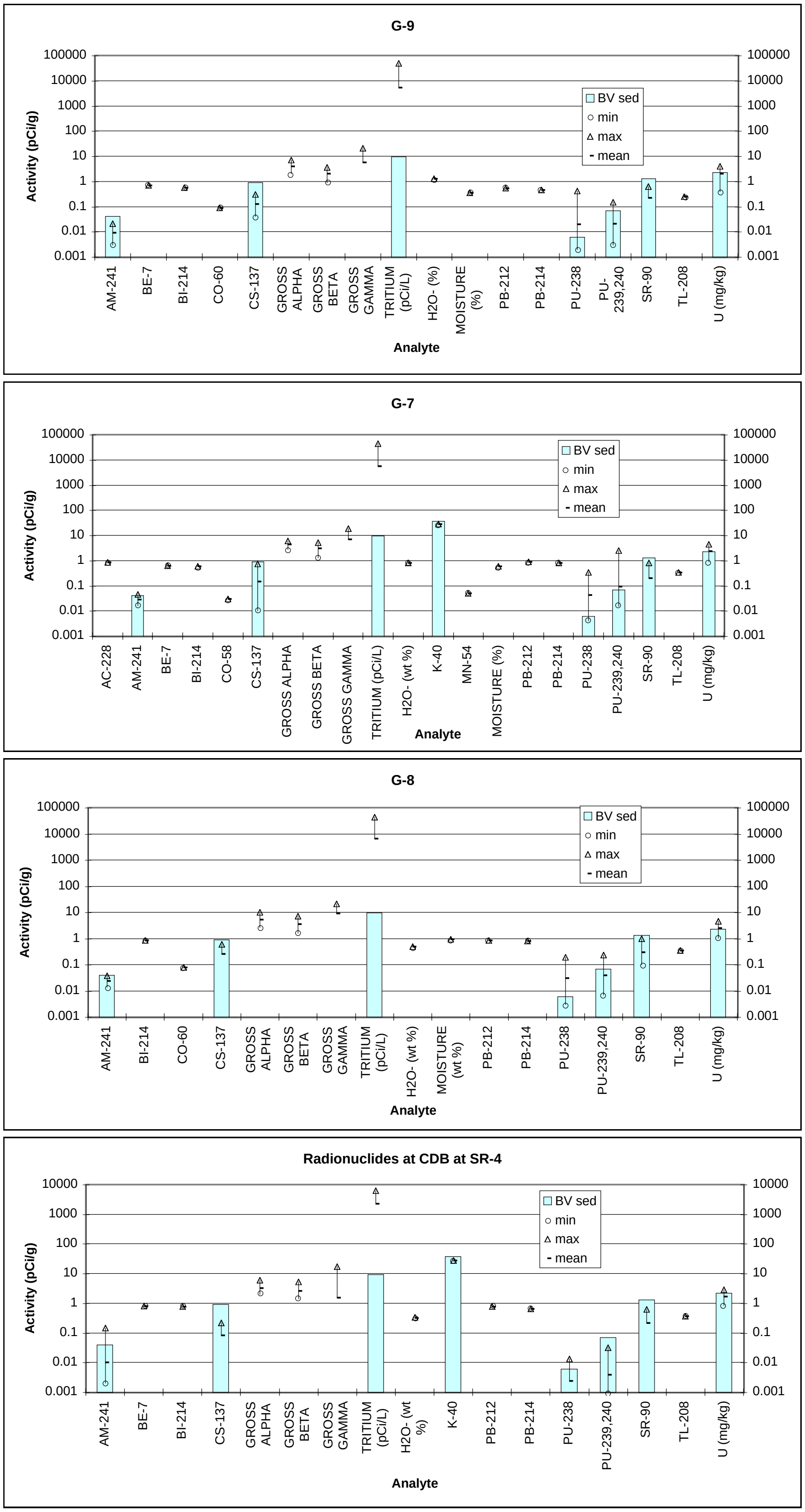
Since 1977 the Laboratory has collected surficial sediment samples annually from various locations along the active channel of Cañada del Buey. At present, the active channel is sampled at one location on Laboratory property. In addition, samples are collected annually from three ephemeral channels that drain MDA G at TA-54. These sediment samples are typically analyzed for radioactive constituents and trace metals. Results are reported in the annual surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684). The sediment sampling locations in Cañada del Buey are listed in Table 3.5.1-1 and shown in Figure A-1. A summary of the analytical results for radionuclides is shown in Figure 3.5.1-1; a summary of the metals results is shown in Figure 3.5.1-2.

Table 3.5.1-1
Routine Environmental Surveillance Sediment Sampling Locations in Cañada del Buey

Location	Comment
Cañada del Buey on Laboratory Property*	
Cañada del Buey at SR-4	Active channel sediment site upstream of state road NM4
Station G-7	Ephemeral tributary channel at east side of MDA G
Station G-8	Ephemeral stream channel from downstream MDA G
Station G-9	Ephemeral stream channel northeast of MDA G
Cañada del Buey at SR-4	Active channel sediment site upstream of state road NM4 near gaging station E230
Downstream of Cañada del Buey on San Ildefonso Pueblo Land	
Mortandad at Rio Grande	Mortandad Canyon just upstream from the Rio Grande
Rio Grande at Mortandad	Rio Grande upstream from confluence with Mortandad Canyon

Source: Environmental surveillance reports 1977–1997.

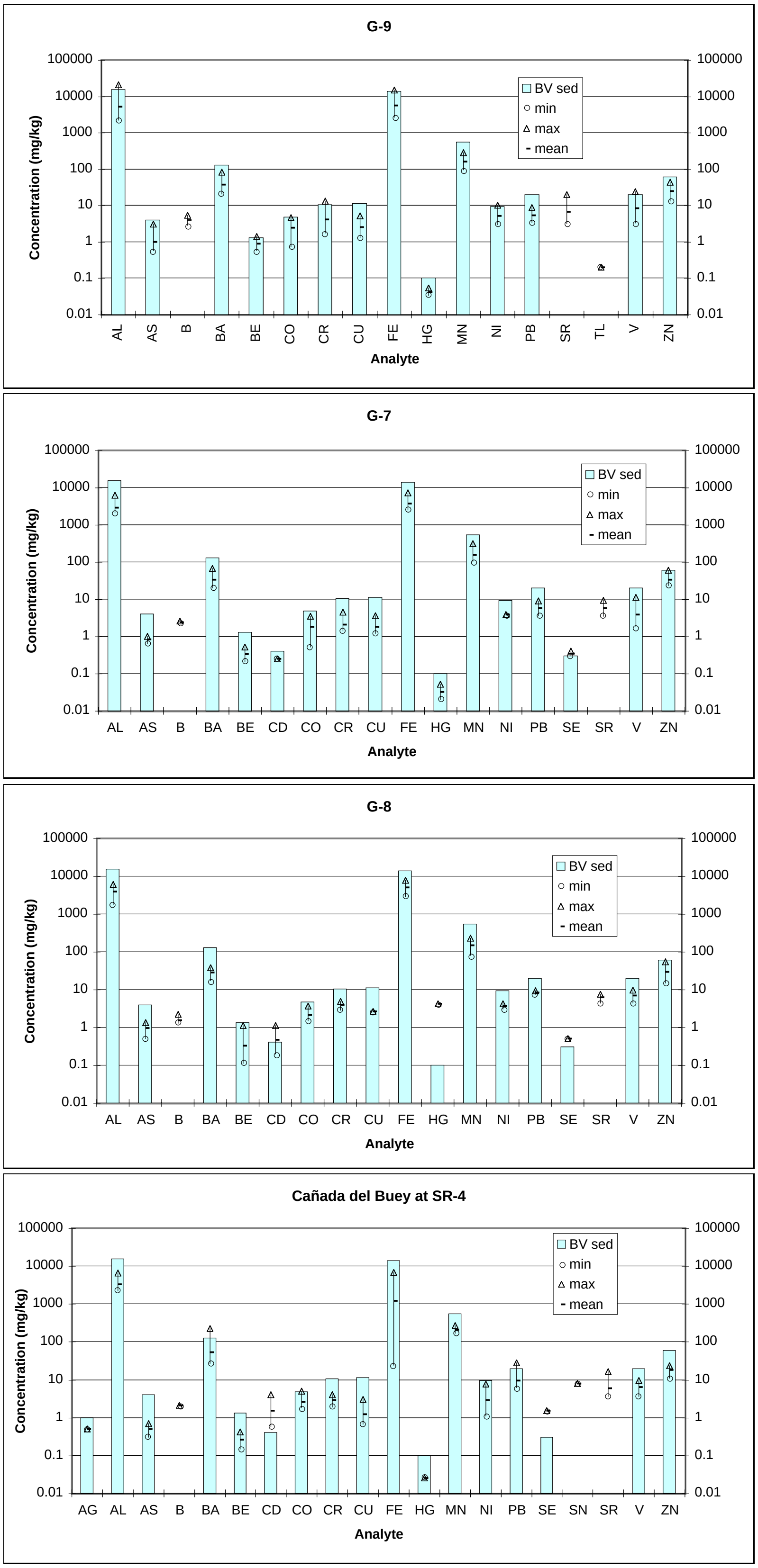
* See Figure A-1 in Appendix A of this work plan for locations.



CDB = Cañada del Buey.

Source: Environmental surveillance reports 1978-1997; BVs from Ryti et al. 1998, 59730.

Figure 3.5.1-1. Summary of radiological data from environmental surveillance sediment sampling.



Source: Environmental surveillance reports 1990–1997; BVs from Ryti et al. 1998, 59730.

Figure 3.5.1-2. Summary of metals data from environmental surveillance sediment sampling.

3.5.1.3.1.1 Cañada del Buey at State Road NM4

Sediment samples collected from the active stream channel at the state road NM4 collection site (Cañada del Buey at SR-4) have been analyzed for radionuclide constituents annually since 1978. Figure 3.5.1-1 summarizes the results of the environmental surveillance sampling at this site. Generally, most radionuclide activities have been measured below BV. One result for americium-241 in 1992 was 0.148 pCi/g, 3.7 times BV (0.04 pCi/g), and one result for plutonium-238 in 1992 was 0.013 pCi/g, 2.2 times BV (0.006 pCi/g). Subsequent sampling has not substantiated these results, but they indicate the potential for the occurrence of contaminated sediments near the eastern Laboratory boundary. Tritium activity in the moisture recovered from the sediment samples occurs up to 6100 pCi/L, with a mean value of 2238 pCi/L. The higher values were obtained from samples collected in the early 1980s, while significantly lower tritium activities (0-500 pCi/L) have been observed in the 1990s (Environmental Surveillance Program 1996, 55333).

The sediment samples collected at state road NM4 were analyzed for metal constituents in 1990 and 1992 through 1996. A summary of the results of the analyses is shown in Figure 3.5.1-2. The summary data include only those results obtained above method detection limits. Metals and trace elements including barium, cadmium, lead, and selenium have been measured in concentrations greater than BV. The metals observed at more than two times BV include cadmium and selenium. In 1990 cadmium was detected at a concentration of 10 mg/kg, 10 times BV, and selenium was detected at a concentration of 1.5 mg/kg, 5 times BV. Since 1990 the results obtained for these constituents have been below BV and sometimes have been reported below detection limits.

3.5.1.3.1.2 Lower Mortandad Canyon Below the Confluence with Cañada del Buey

In 1978 two sediment samples were collected lower Mortandad Canyon about 300 ft (92 m) above the confluence with the Rio Grande and below the confluence with Cañada del Buey. The samples were analyzed for radionuclide constituents, including cesium-137, plutonium-238, plutonium-239,240, and strontium-90. The results of the analyses were below BV for sediment for all constituents except plutonium-238, which was measured at 0.01 pCi/g in one sample, slightly above BV (ESG 1979, 5819).

3.5.1.3.1.3 Rio Grande at Mortandad Canyon

In 1992 one sediment sample was collected from the Rio Grande River near the confluence with Mortandad Canyon and downstream of the confluence of Mortandad Canyon and Cañada del Buey. The sample was analyzed for trace metals and radionuclides. The results were below BV for radionuclide constituents and for most trace metals except barium, lead, and vanadium, which were slightly above BV for Pajarito Plateau sediments. The trace metals are likely derived from rock units in White Rock Canyon or from upstream in the Rio Grande drainage. The Laboratory BVs for sediments may not be applicable for metals comparison at this site because sediments derived from units (for example, basalt) exposed in White Rock Canyon typically contain higher trace metal contents than sediments derived from the Bandelier Tuff.

3.5.1.3.1.4 Sediment Sampling Adjacent to TA-54, MDA G

In 1982 ESH-18 established nine sediment sampling stations outside the perimeter fence at MDA G to monitor possible radionuclide transport by surface runoff from the active waste storage and disposal area. Three of the sampling stations (G-7 through G-9) are on the east and north side of Mesita del Buey within the Cañada del Buey watershed area (Environmental Surveillance and Compliance Programs 1997, 56684, p. 209). Sediment samples from these sites provide information about possible contaminant migration in sediments and runoff from MDA G and TA-54. Sample sites G-7 and G-8 are located in ephemeral tributary channels east of MDA G at the foot of the mesa. Site G-9 is located in the active stream channel of Cañada del Buey northeast of MDA G (see Figure A-1). These samples have been collected and analyzed for radionuclides annually (except 1987) since 1982; the summary of the results of the sampling for radionuclides is shown in Figure 3.5.1-1. The samples were analyzed for metals in 1993, 1994, 1996, and 1997, the summary of the metals results are shown in Figure 3.5.1-2. Figure 3.5.1-3 shows the annual variation of plutonium-238 and plutonium-239,240 activity at sites G-7, G-8, and G-9.

The data on Figures 3.5.1-1 and 3.5.1-2 are arranged generally from upstream to downstream locations; site G-9 (shown first) represents the most upstream site. At site G-9, plutonium-238 has been detected in activities as high as 0.416 pCi/g (in 1988); the mean activity observed since 1982 is about 0.02 pCi/g, which is 3.3 times BV. Plutonium-239,240 has been measured at site G-9 greater than BV in 1989 (0.15 pCi/g) and in 1993 (0.134 pCi/g). However the mean activity observed (0.021 pCi/g) is below BV. No distinct temporal trends in the activity of plutonium species are noted in Figure 3.5.1-3 at site G-9.

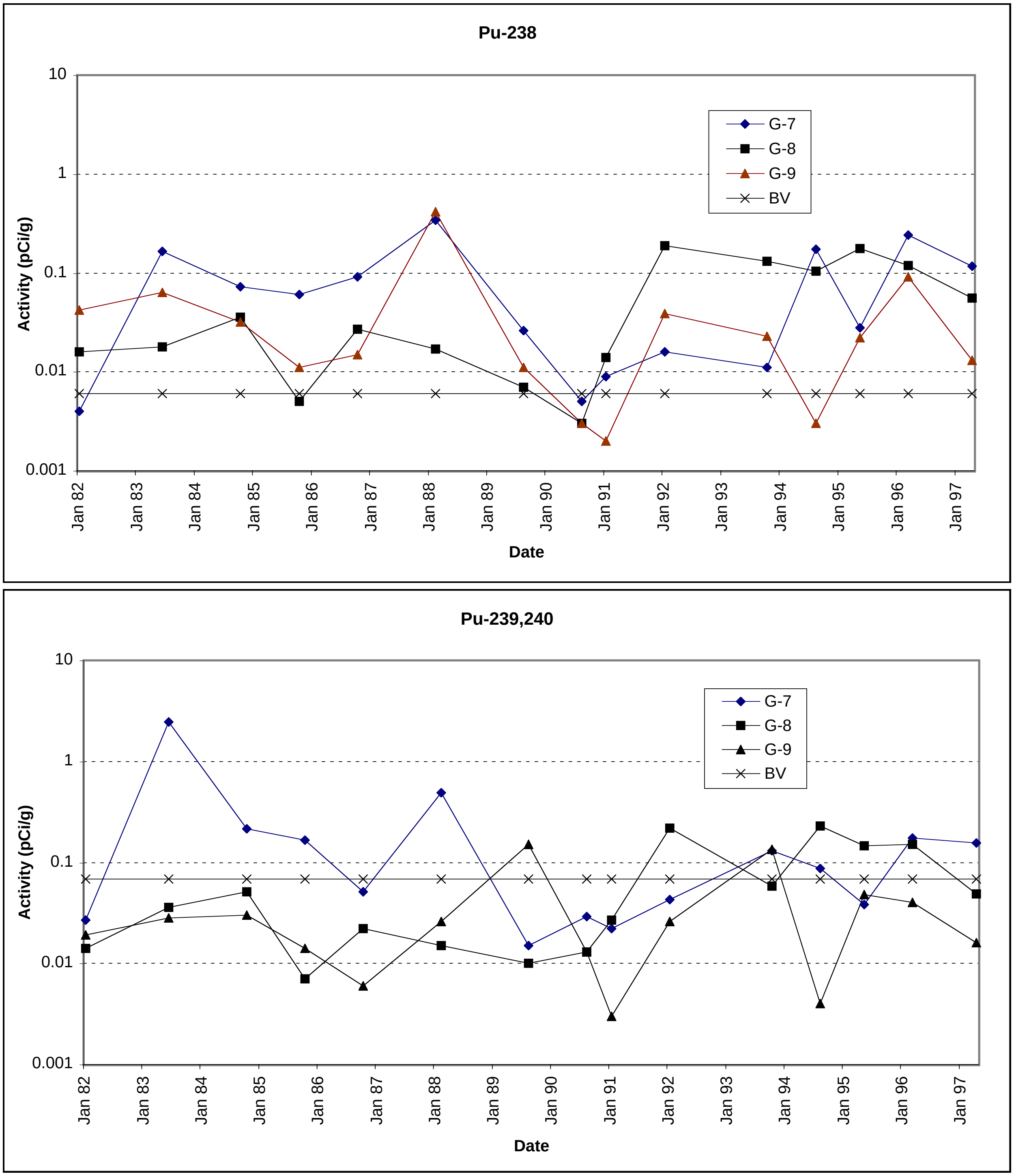
Tritium activity in moisture collected with the sediment samples at site G-9 has been measured as high as 49,000 pCi/L, whereas the mean value since 1982 is about 5300 pCi/L. Total uranium concentrations have ranged from 0.4 mg/kg to 4.0 mg/kg with a mean value of 2.0 mg/kg, below BV (2.2 mg/kg) for uranium. Other radionuclides such as americium-241, cesium-137, and strontium-90 have been measured below BV at site G-9.

At site G-7, located in a tributary to Cañada del Buey at the foot of the mesa east of MDA G, the plutonium-238 activity ranges from 0.004 pCi/g to 0.343 pCi/g. The mean value of 0.042 pCi/g, is 7 times BV. The highest activities of plutonium-239,240 observed in any G-series sediment samples were measured at this site during the early 1980s. As shown in Figure 3.5.1-3, the activity of plutonium-239,240 was measured as high as 2.44 pCi/g in 1983. Since 1988 the value has been in the 0.01 pCi/g range, with a mean value of 0.092 pCi/g, which is 1.35 times the BV.

Tritium in moisture collected with the sediment samples at site G-7 has been measured as high as 44,000 pCi/L; however the mean value since 1982 is about 5600 pCi/L as shown in Figure 3.5.1-1. Total uranium concentrations range from 0.9 mg/kg to 4.4 mg/kg with a mean value of 2.4 mg/kg, slightly above BV (2.2 mg/kg) for uranium. Other radionuclides such as americium-241, cesium-137, and strontium-90 have been observed below BV at site G-7.

At site G-8, located in a small tributary to Cañada del Buey downstream from TA-54, the plutonium-238 activity has also been measured above the BV in all years except 1985 and 1990. The plutonium-238 activity in the 1980s was measured around 0.01 pCi/g, but after 1991 the activity shows a notable increase to around 0.1 pCi/g, similar to sites G-7 and G-9 (Figure 3.5.1-3). Before 1992 the plutonium-239,240 activity measured at site G-8 was below BV, but also showed an increase in activity in 1992 to generally above BV (Figure 3.5.1-3). The increase in plutonium activity after 1991 may represent contaminated sediment material that moved downstream from tributary channels and from upstream during heavy runoff events in 1991. Tritium activity in moisture associated with the sediment material at site G-8 is similar to that of sites G-7 and G-9, ranging up to 43,000 pCi/L with a mean value of 6500 pCi/L. Total uranium concentrations at G-8 range from 1 mg/kg to 4.6 mg/kg, with a mean value of 2.5 mg/kg, slightly above the BV of 2.2 mg/kg. Other radionuclides such as americium-241, cesium-137, and strontium-90 have been observed below BV at site G-8.

Plutonium-238 activities average 5 times BV for all samples collected. Figure 3.5.1-3 shows the results of the annual sediment sampling for plutonium-238 and plutonium-239,240. Before 1992 the highest activity typically is from station G-7 or G-9, but after 1992 station G-8 typically shows the higher levels of plutonium activity. These data indicate that plutonium isotopes have been transported from MDA G in suspended or bed sediments into channels that drain the area. The contamination is reported to be “residual” contamination from the mesa that resulted from earlier handling of wastes at MDA G and not related to the buried wastes in the pits and shafts (Environmental Protection Group 1994, 45363 p. IV-41).



Source: Environmental surveillance reports 1982–1997.

Figure 3.5.1-3. Plutonium activity in sediments adjacent to TA-54.

Sediment samples collected in Cañada del Buey near Mesita del Buey were analyzed for metals in 1993, 1994, 1996, and 1997. Figure 3.5.1-2 summarizes the results. Most results are below BV, except cadmium, mercury, and selenium at site G-8, which are observed, on average, to be 1.7, 43, and 1.7 times BV.

The comparison of the mean concentrations of trace metals and radionuclides obtained from sample sites G-9, G-7, G-8, and Cañada del Buey at SR-4 is shown in Figure 3.5.1-4. The BVs for specific analytes are also shown on the figure. The data for each analyte are arranged from upstream to downstream to determine spatial trends in the data. For most trace metals no obvious trend in the data is apparent. However mean concentrations of cadmium, lead, and selenium increase slightly at downstream sites. Other trace metals such as arsenic, boron, beryllium, and nickel show decreased concentrations in downstream sample sites. Several radionuclides such as americium-241, cesium-137, gross alpha, gross beta, gross gamma, plutonium-238, and uranium show a mean increase in concentration at downstream sites near TA-54, but lower concentration at the Laboratory boundary site at state road NM4.

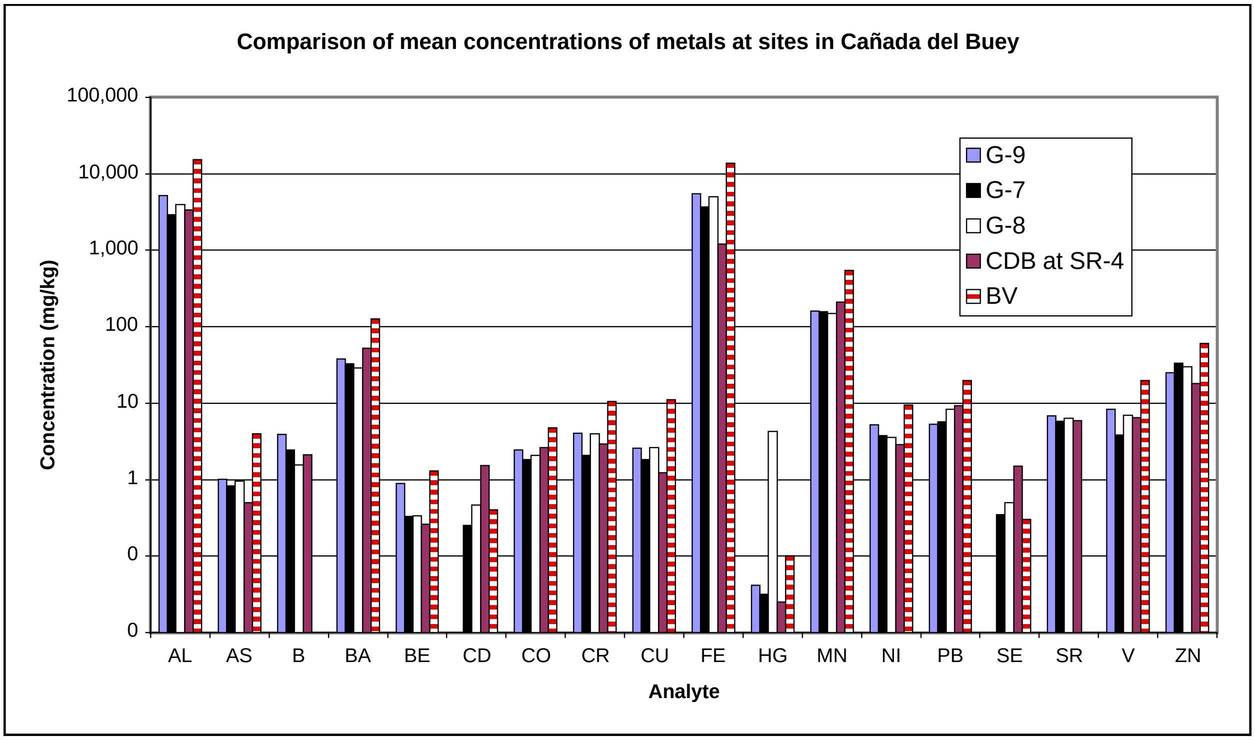
3.5.1.3.2 Special Environmental Surveillance Sampling in Cañada del Buey – 1992

In 1992, 19 sediment samples were collected from the active stream channel of Cañada del Buey to document potential contaminant conditions prior to the possible release of treated effluent from the SWSC plant at TA-46 (Environmental Protection Group 1994, 45363, p. IV-58). Sample sites CDB-A through CDB-K were located upstream of MDA G and sites CDB-L and CDB-M were located north of MDA G. Sample site CDB-M coincided with routine sample site G-9 (Figure A-1). Sample sites CDB-N through CDB-R were located downstream of MDA-G; site CDB-R coincided with routine environmental surveillance sample site Cañada del Buey at SR-4. The samples were analyzed for radionuclides, including tritium, cesium-137, uranium (total), plutonium-238, and plutonium-239,240. The results are shown on Figure 3.5.1-5, where the sample sites are indicated spatially from upstream to downstream on the horizontal axis. The BVs for appropriate constituents are also shown on the figure. All constituents are below BVs except for sample site M (which corresponds to sample site G-9 downstream from MDA G) where 0.029 pCi/g plutonium-238 was measured. This sample site also contains the highest activity of plutonium-239,240. The highest tritium activity was measured upstream of MDA G at sample site D where 2.5 nCi/L tritium was present in the moisture distilled from the sediment sample (Environmental Protection Group 1994, 45363, p. IV-61). This tritium activity may suggest a historical source of tritiated water in the upper reaches of Cañada del Buey upstream of MDA G. Discharges from the former experimental reactor at TA-52 or discharges from TA-46 may have been a source of tritium in the water.

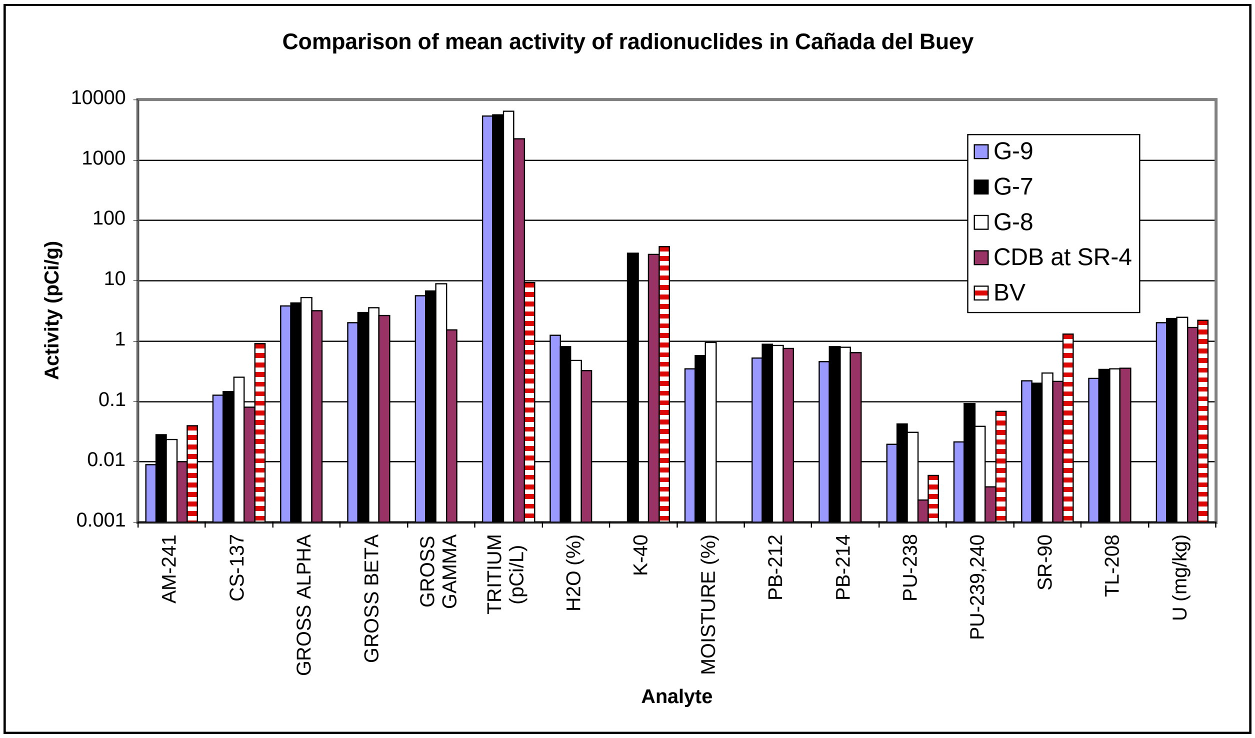
3.5.1.3.3 Supplemental Environmental Surveillance Sampling at TA-54

In addition to the data presented annually in the environmental surveillance reports, a supplemental environmental surveillance investigation was initiated at TA-54 in 1993. The investigation was designed to monitor potential contaminant migration from MDA G through the surface sediment transport pathway. In 1993, 1994, and 1995, soil and sediment samples were collected from the perimeter of MDA G to supplement existing environmental surveillance of the TA-54 area (Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518). The resulting data were used subsequently in status reports as part of the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) for Operable Unit (OU) 1148 (LANL 1996, 54462; LANL 1997, 55873).

The sediment investigation established an extensive perimeter sampling network that is limited to the Mesita del Buey mesa-top perimeter outside the fence at MDA G, the hillsides directly below MDA G, and one major drainage within the disposal area itself. Generally, these soil/sediment locations are upstream from the channel sediment samples collected for routine environmental surveillance (MDA G sample sites G-7 through G-8, which are shown in Figure A-1). A summary of the results of the samples collected and analyzed in 1993, 1994, and 1995 is shown in Figure 3.5.1-6.



Comparison of mean concentrations of metals at sites in Cañada del Buey

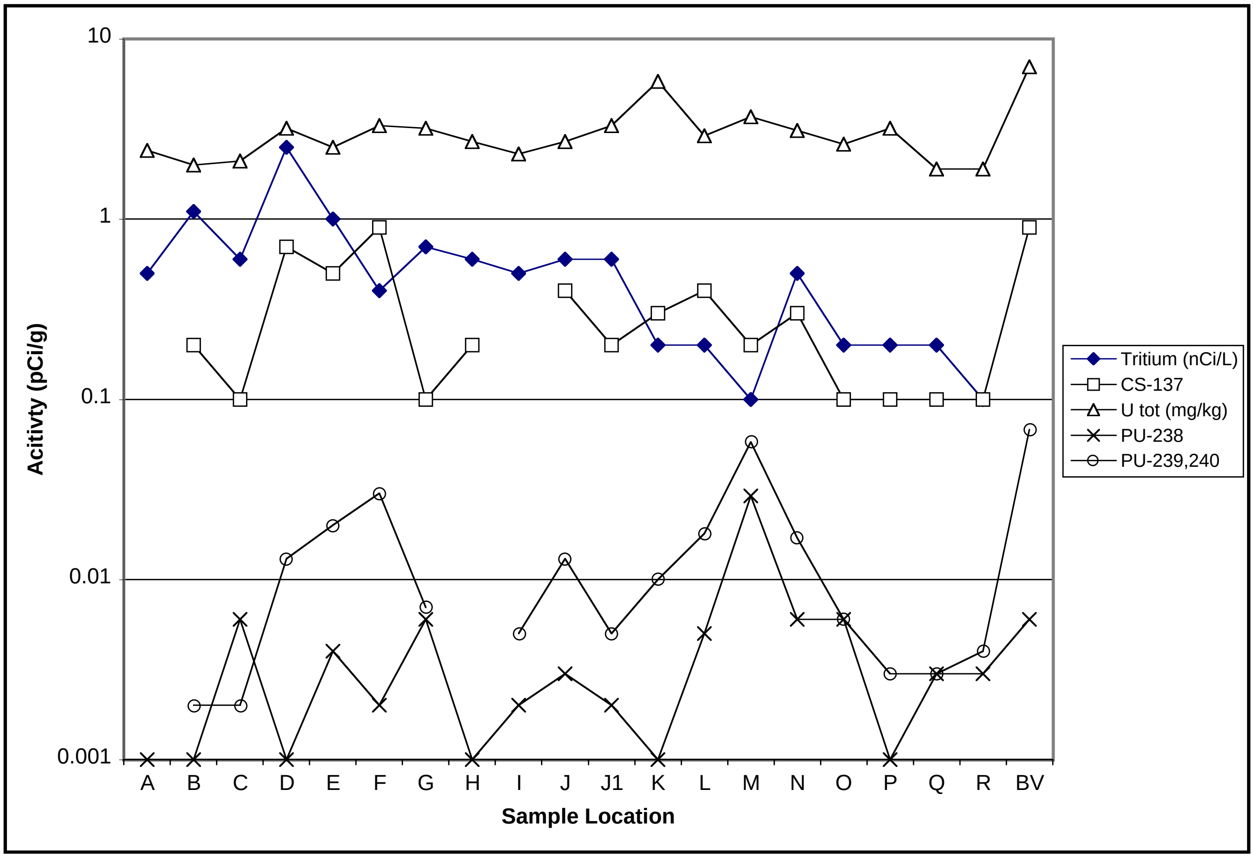


Comparison of mean activity of radionuclides in Cañada del Buey

CDB = Cañada del Buey.

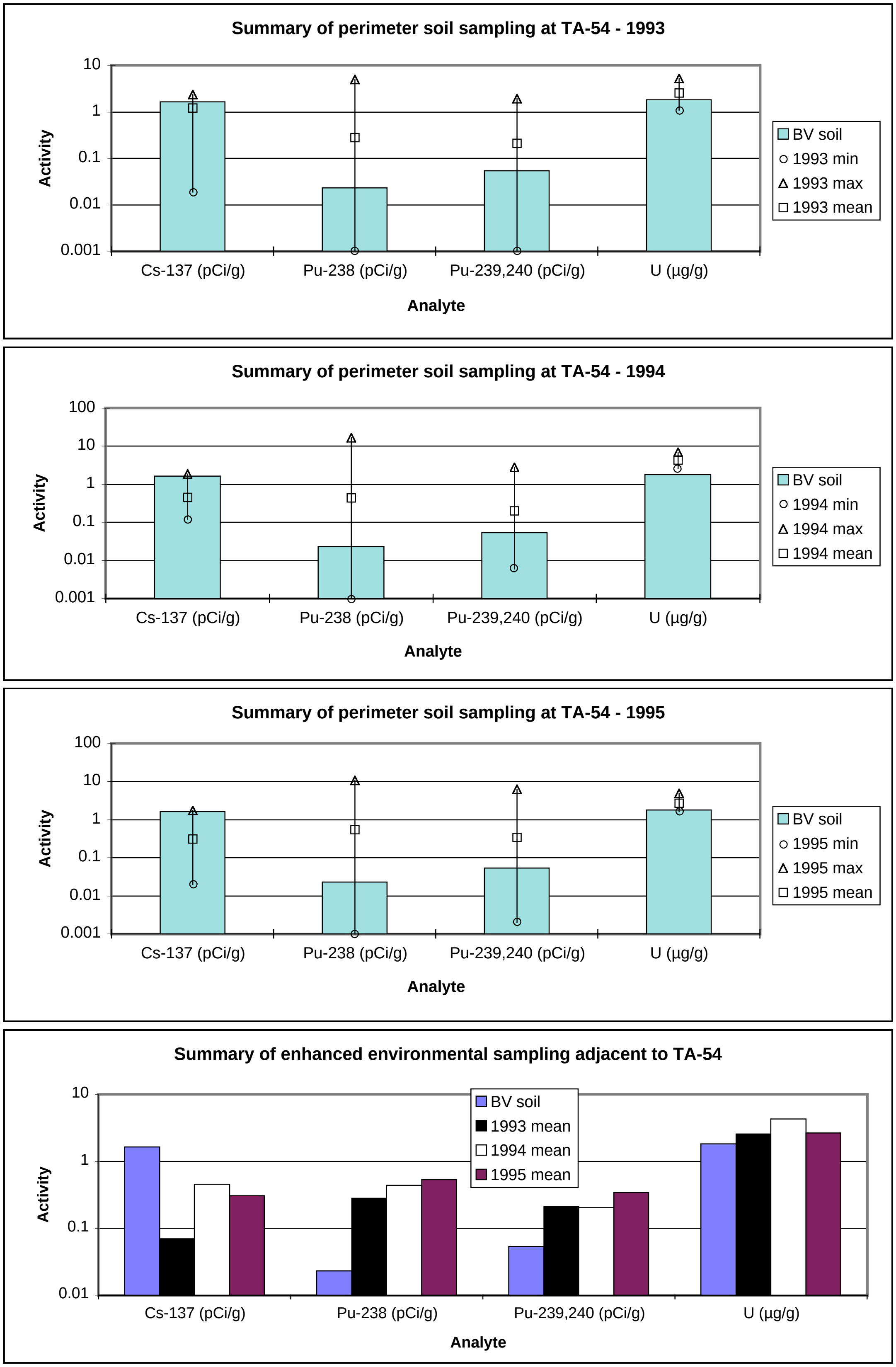
Source: Environmental surveillance reports 1978–1997.

Figure 3.5.1-4. Comparison of mean values of metals and radionuclides at sites in Cañada del Buey.



Source: Environmental Protection Group 1994, 45363, p. IV-61

Figure 3.5.1-5. Radionuclides in sediment in Cañada del Buey – 1992.



Source: Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518.

Figure 3.5.1-6. Summary of data from supplemental environmental surveillance sampling at TA-54.

In 1993 83 soil/sediment samples collected from the perimeter of MDA G were analyzed for the radionuclides tritium, total uranium, isotopic plutonium, americium-241, and cesium-137, and for the metals barium, lead, and mercury using x-ray fluorescence (XRF) methods. Elevated levels of tritium (as high as 117,200 pCi/L) were found in moisture in soil samples along the eastern half of the north side of MDA G, which drains into Cañada del Buey. East and south of the transuranic (TRU) pads, which are located at the east end of MDA G, the samples contained slight increases (3000 pCi/L to 5000 pCi/L) above baseline tritium levels (100 pCi/L to 1000 pCi/L for MDA G soils). A summary of the results of the sampling for selected radionuclides is shown in Figure 3.5.1-6 (Conrad et al. 1995, 52014).

In 1994 108 samples were collected that on average contained slightly higher plutonium-238 activity and uranium concentrations compared with data collected in 1993. A summary of the results obtained in 1994 is shown in Figure 3.5.1-6. The maximum tritium activity in 1994 was 1,715,560 pCi/L collected from the north side of MDA G. Plutonium-238 activities ranged from 0.001 pCi/g to 16.68 pCi/g; the average activity was 0.435 pCi/g. Measured activities of plutonium-239,240 and cesium-137 were similar to values obtained in 1993. Plutonium-239,240 activities ranged from 0.006 pCi/g to 2.77 pCi/g; the average activity was 0.203 pCi/g. The cesium-137 activities ranged from 0.12 pCi/g to 1.89 pCi/g. The mean activity of americium-241 was 0.059 pCi/g. The average uranium concentration observed in the samples was 4.3 µg/g.

In 1994 the metals analyte list was expanded to include arsenic, beryllium, cadmium, chromium, nickel, selenium, and silver. Analytical methods for metals were expanded to include inductively coupled plasma and atomic absorption techniques in addition to the XRF technique. Metals analyses were performed on 21 perimeter samples; the results showed that samples were below baseline concentrations. Baseline concentrations were determined from sample sites located in an undisturbed area west of active operations at MDA G. The undisturbed area was sampled as part of a program to determine baseline concentrations for future disposal operations in the proposed MDA G expansion area (Conrad et al. 1996, 55621).

The results of the 1995 surveillance sampling are also shown in Figure 3.5.1-6. The results show lower tritium concentrations in soil compared with the 1994 data. The elevated tritium levels (as high as 105,000 pCi/L) found in the perimeter soil samples were substantially lower than those found during the corresponding sampling in 1994 but similar to tritium levels in soils collected during 1993. The average plutonium-238 activity was 0.539 pCi/g, and the average plutonium-239,240 activity was 0.343 pCi/g. Activity of cesium-137 values ranged from 0.02 pCi/g to 1.76 pCi/g, which is consistent with the results obtained in 1993 and 1994. The mean activity of americium-241 was 0.202 pCi/g. The average uranium concentration was 2.67µg/g, which is consistent with the 1993 data. Metals were analyzed in six perimeter soil samples, and all samples were found to be below the baseline concentrations established during the expansion area baseline study.

The results of the supplemental environmental surveillance investigation performed at TA-54 from 1993 through 1995 showed that low levels of radionuclides are present in MDA G perimeter surface soils and sediments. Small amounts of radioactivity are leaving the confines of MDA G through the surface sediment transport pathway (Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518). Additional discussion of the results of the supplemental soil/sediment sampling can be found in Section 3.5.1.3.4.4.

3.5.1.3.4 RFI Sediment Sampling and Analysis in Cañada del Buey

This section describes the currently available results of the RCRA RFI in the Cañada del Buey watershed. Chapter 2 of this work plan discusses the history of the investigations within the Cañada del Buey watershed.

Most RFI samples were collected from surface soil and subsurface bedrock sediments and are not samples of active channel sediments, as discussed in the previous sections of this work plan for Cañada del Buey. However, a summary of the results obtained for surface soil samples, which often included sediments in catchment areas associated with PRSs, is provided in this section to indicate which contaminants are present on the mesas and side canyons surrounding Cañada del Buey.

3.5.1.3.4.1 RFI Sampling at TA-46

TA-46 is an industrial site located on Mesita del Buey adjacent to upper Cañada del Buey. PRSs located within the Cañada del Buey watershed at TA-46 have been addressed in “RFI Work Plan for Operable Unit 1140” (LANL 1993, 20952). Of the 69 PRSs identified at TA-46, 51 were recommended for Phase I investigation and 18 were recommended for NFA in the work plan (LANL 1993, 20952). After the Phase I RFI, 21 PRSs subsequently were recommended for NFA and 5 PRSs were recommended for Phase II investigation in “RFI Report for Potential Release Sites in TA-46” (LANL 1996, 54929). Phase I investigations have not yet been conducted at 27 PRSs. One PRS, 46-003(h), was the subject of a VCA conducted in 1994. A total of 25 PRSs have not been investigated at TA-46.

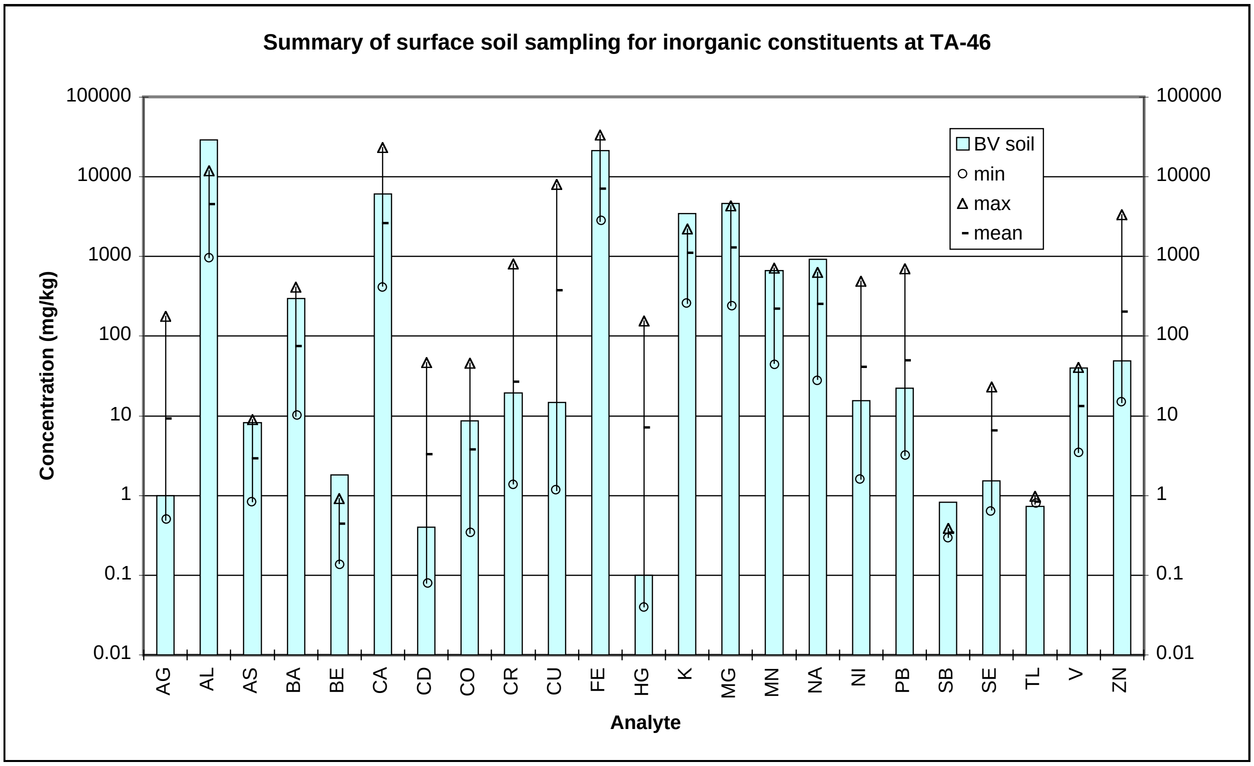
Figure 3.5.1-7 summarizes the results of sampling 33 PRSs at TA-46 for inorganic constituents and radionuclides. The minimum, maximum, and mean values obtained for each analyte are shown on the figure as well as the BV for soil, obtained from Ryti et al. (1998, 59730). Radionuclides detected above BV include americium-241, plutonium-238, plutonium-239, uranium-234, uranium-235, and uranium-238, most of which were measured in activities at least an order of magnitude higher than BV.

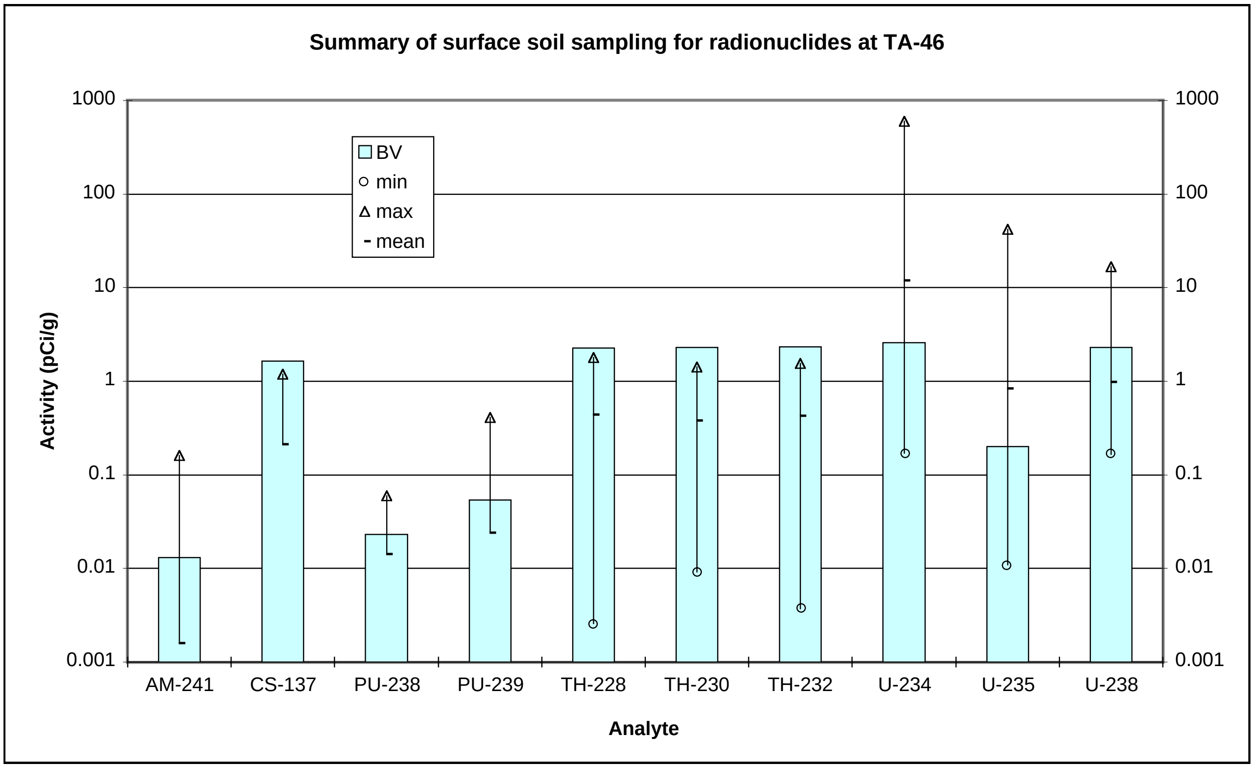
Inorganic constituents detected in concentrations significantly above soil BVs include silver, barium, calcium, cadmium, cobalt, chromium, copper, mercury, nickel, lead, selenium, and zinc. PRS 46-003(h), an inactive outfall, was the subject of a VCA as described in “Voluntary Corrective Action Completion Report for a Solid Waste Management Unit at TA-46, 46-003(h)” (LANL 1996, 62341) (see Section 2.4.3 of this work plan). Inorganic constituents detected in the soil in the drainage downstream from the outfall were cadmium, copper, and lead, which were identified as the COPCs for the site (LANL 1996, 62341, p. 1-6). Organic compounds detected in soil samples at TA-46 were the following:

> Acenaphthene; acenaphthylene; acetone; Aldrin; Anthracene; Aroclor-1254; Aroclor-1260; Aroclors (mixed); benz(a)anthracene; benzo(a)pyrene; benzo(b)fluoranthene; benzo(g,h,i)perylene; benzo(k)fluoranthene; alpha-BHC; delta-BHC; gamma-BHC; bis(2-ethylhexyl)phthalate; 4-bromofluorobenzene; butylbenzylphthalate; chrysene; 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; di-n-butylphthalate; di-n-octylphthalate; dibenz(a,h)anthracene; dibenzofuran; Dieldrin; dibromofluoromethane; Endosulfan II; Endosulfan Sulfate; Endrin; Endrin Aldehyde; fluoranthene; fluorene; Heptachlor; Heptachlor Epoxide; indeno(1,2,3-cd)pyrene; 4-isopropyltoluene; 4,4'-methoxychlor; methylene chloride; 2-methylnaphthalene; 4-methylphenol; naphthalene; phenanthrene; phenol; pyrene; toluene; 1,2,2-trichloro-1,1,2-trifluoroethane; 1,1,1-trichloroethane; trichloroethene, and trichlorofluoromethane.

3.5.1.3.4.2 RFI Sampling at TA-52 and former TA-4

TA-52 includes the area of former TA-4 and is located at the head of Cañada del Buey. PRSs located within the Cañada del Buey watershed at TA-52 and former TA-4 have been addressed in “RFI Work Plan for Operable Unit 1129” (LANL 1992, 7666) and “Addendum to the OU 1129 RFI Work Plan” (Pratt 1994, 39932). All PRSs located within the Cañada del Buey watershed at TA-52 were recommended for NFA in the work plan or in the addendum to the work plan; therefore a Phase I investigation was not required for these sites.





Source: LANL 1995, 47257; BVs from Ryti et al. 1998, 59730.

Figure 3.5.1-7. Summary of sediment sampling near TA-46.

The Phase I RFI for PRSs 4-004 and 4-003(a) was conducted in 1995 when 31 surface and subsurface soil samples were collected from 10 locations; the samples were analyzed for radionuclides, metals, SVOCs, and VOCs. Most of the analyses were performed by the mobile chemistry laboratory. Due to data quality issues, supplemental Phase I sampling was conducted in 1998 when 29 additional surface and subsurface soil samples were collected from 10 locations. These samples were analyzed by a contract laboratory for inorganics, SVOCs, and high explosives (HE); two subsurface samples were also analyzed for VOCs.

Figure 3.5.1-8 summarizes the results of the analyses for the surface soil/sediment samples collected at former TA-4. Also shown on the figure are the soil BVs from Ryti et al. (1998, 59730). The inorganic constituents detected in concentrations significantly above BV include silver, arsenic, beryllium, cadmium, cobalt, chromium, copper, nickel, lead, selenium, thallium, and vanadium. One radionuclide constituent, plutonium-238, was detected above BV. In 1995 one organic compound, pentachlorophenol, was detected.

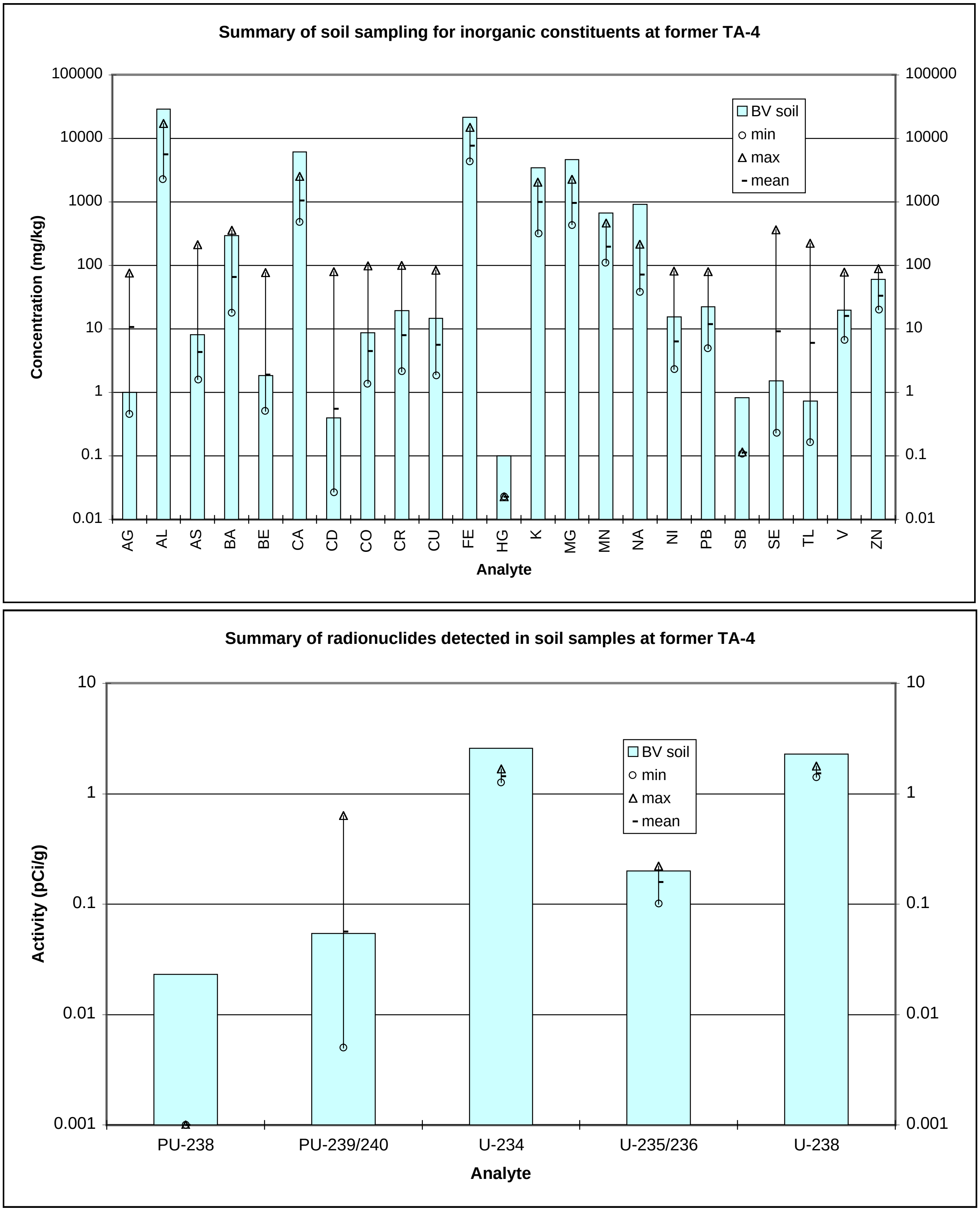
3.5.1.3.4.3 RFI Sampling at TA-51

PRSs located within the Cañada del Buey Canyon watershed at TA-51 were addressed in “RFI Work Plan for Operable Unit 1148” (LANL 1992, 7669). PRS 51-001, a septic system, was the subject of a Phase I investigation in November and December 1995. Two subsurface soil samples were collected from the seepage pit associated with the septic system. The samples were analyzed for metals, cyanide, SVOCs, VOCs, pesticides, and PCBs, and gross -alpha, -beta, and -gamma radiation. The results of the investigation are planned to be presented in a RFI report.

Sediment samples collected as part of the RFI of MDA J at TA-54 were obtained from locations that may contain sediment originating from areas associated with PRSs located at TA-51 (LANL 1996, 54462, p. 52). Discussion of the MDA J sediment investigation is presented in Section 2.4.5.3 of this work plan.

3.5.1.3.4.4 RFI Sampling at TA-54

Channel sediment was sampled along the perimeter of MDA G in support of the RFI for TA-54 (see Section 3.5.1.3.3). An RFI report for the channel sediment pathway was prepared that focused on the transport of mesa-top sediments into the adjacent canyons (LANL 1996, 54462). Topographic maps and aerial photographs were examined, and direct field observations were made. Fourteen drainage channels associated with MDA G were selected for channel sediment sampling. Drainage basins were determined for each of the channels to estimate the area and relative contribution of sediments and water to each channel. The channels were examined from their origin on top of the mesa down to the point where they merged with larger drainage channels of Cañada del Buey to the north or Pajarito Canyon to the south. Depositional areas were identified, and 7 to 10 sample locations were selected in each channel. Deposits of coarse sediment and of fine sands, silts, and clays were selected for measurement. Sampling locations were also selected in depositional areas of channels that did not extend to the master stream, but where runoff infiltrates into the alluvium and deposits its sediment load (LANL 1996, 54462).



Source: LANL 1995, 47257; BVs from Ryti et al. 1998, 59730.

Figure 3.5.1-8. Summary of soil and sediment sampling at former TA-4.

The results of the channel sediment sampling showed that several radionuclides were present. Some of those radionuclides have no BVs; others were present at activities above their BVs. Those radionuclides were americium-241; cesium-137; cobalt-60; plutonium-238; plutonium-239,240; polonium-210; strontium-90; technetium-99; tritium; uranium-235; and yttrium-90, which are all present at levels below their respective SAL values. These results are consistent with environmental surveillance data obtained since 1987 (ESG 1988, 6877; ESG 1989, 6894; Environmental Surveillance Group 1990, 6995; Environmental Protection Group 1992, 7004; Environmental Protection Group 1993, 23249; Environmental Protection Group 1994, 45636; Conrad et al. 1995, 52014). Several of the sediment samples contained concentrations of some inorganic constituents (including barium in one channel, copper and chromium in two channels, and lead in six channels) above BVs. See Section 2.4.5.2 for a summary of the RFI activities at MDA G.

Tritium activity in surface soil/sediments was evaluated in another RFI status report for MDA G (LANL 1997, 55873). All the data presented in the status report were compiled from the supplemental environmental surveillance data collected from 1993 to 1996, pursuant to the RFI work plan for OU 1148 (LANL 1992, 7669) (see Section 3.5.1.3.3 of this work plan). For the evaluation of tritium in surface soil/sediments, MDA G was divided into nine sectors. Sediment samples were collected from approximately 310 locations within the nine sectors and from 53 locations within the proposed MDA G expansion area. The expansion area is located west of the current disposal area at MDA G and has been proposed for development to provide additional storage disposal capabilities. Samples were collected from within the expansion area to provide local BVs, or baseline data, for comparison with data collected from the MDA G sectors.

Comparing the results of channel sediment sampling with the baseline data collected from the expansion area indicates that tritium concentrations throughout MDA G are greater than local BVs. Three locations at MDA G in particular show tritium concentrations in surface soils that are much greater than BVs. These locations are

- along the southern border of MDA G, adjacent to the active tritium disposal shafts (sector 4);
- just west of the TRU pads near a set of inactive tritium disposal shafts (sector 6); and
- near the TRU pads, in particular at TRU Pad 2 (sector 9) (LANL 1997, 55873).

However, comparison of the tritium data with the SAL value (260 pCi/g) indicated that only one sample at MDA G exhibited a tritium concentration exceeding the SAL value; all other tritium values were less than the SAL value. One measurement of 2191 pCi/g tritium was elevated compared with other soil samples collected throughout MDA G. The next highest concentration observed in the samples was approximately 100 pCi/g. The RFI report did not propose additional soil/sediment sampling at MDA G for RFI purposes. Routine environmental surveillance activities will continue at MDA G (LANL 1997, 55873).

3.5.1.3.5 Summary of Surface Sediment Data in Cañada del Buey and Data-Collection Activities Needed to Understand Surface Sediments and Associated Contaminants

Significant information about surface sediments provided in Section 3.5.1.3 is summarized below.

- Little historical information is available about contaminants in the sediments in the upper and middle parts of the Cañada del Buey stream channel. Routine environmental surveillance sampling for stream sediments has occurred at the eastern boundary of the Laboratory and downstream.

- At former TA-4 (now TA-52), inorganic constituents detected in concentrations significantly above BVs were arsenic, beryllium, cadmium, cobalt, chromium, copper, nickel, lead, selenium, silver, thallium, and vanadium. One radionuclide constituent, plutonium-238, was also detected above BV.

- The results of surface soil/sediment sampling of 33 PRSs at TA-46 indicate that americium-241, plutonium-238, plutonium-239, uranium-234, uranium-235, and uranium-238 are present in activities at least an order of magnitude higher than BV. Inorganic constituents detected in concentrations significantly above soil BVs were silver, barium, calcium, cadmium, cobalt, chromium, copper, mercury, nickel, lead, selenium, and zinc. In addition, numerous organic compounds were detected in the samples.

- Supplemental environmental surveillance of sediments along the perimeter of MDA G shows that americium-241, cesium-137, cobalt-60, plutonium-238, plutonium-239,240, polonium-210; strontium-90, technetium-99, tritium, uranium-235, and yttrium-90 are present in activities that exceed the soil BVs but are below SAL values. Tritium activities in soil throughout MDA G are greater than local BVs.

- At site G-9 in lower Cañada del Buey, plutonium-238 has been detected in activities 3.3 times BV, and plutonium-239,240 has been measured in activities greater than BV. Tritium activity in moisture collected with the sediment samples at site G-9 has been measured as high as 49,000 pCi/L. Total uranium concentrations and other radionuclides such as americium-241, cesium-137, and strontium-90 have been measured below BV at site G-9. Tributary drainages from MDA G, however, have shown an increase in plutonium activity since 1991 that may represent contaminated sediment material moving downstream into Cañada del Buey.

- Sediment samples collected from the active stream channel at Cañada del Buey at SR-4 have contained americium-241 in concentrations 3.7 times BV and plutonium-238 in activities up to 2.2 times BV. Tritium activity in the moisture recovered from the sediment samples has been as high as 6100 pCi/L. The sediment samples have also contained barium, cadmium, lead, and selenium in concentrations above BV. Cadmium was detected at a concentration 10 times BV and selenium was detected at a concentration 5 times BV.

The following additional data-collection activities are required to evaluate the contaminants within the sediments of Cañada del Buey.

- The full suite of contaminants that are present within the sediments at or above BV will need to be determined.

- The locations of significant contaminant sources will need to be determined.

- The average concentrations, the range of concentrations, and approximate inventories of contaminants contained within different geomorphic units and different sediment facies will need to be investigated, particularly for contaminants that may be shown to be risk drivers.

- The horizontal and vertical distribution of contaminated sediments that have been deposited by flood events, including the nature and effects of historic channel changes, if any, will need to be investigated. For example, channel bed aggradation and/or degradation, lateral migration and diversion of the active channel, and abandonment of inactive channels will need to be investigated at key locations within Cañada del Buey.

See Section 7.2.2 of this work plan for a complete description of the sediment SAP.

3.5.2 Previous Subsurface Sediment and Bedrock Investigations

3.5.2.1 Historic Boreholes in Cañada del Buey area

In 1971 boreholes were drilled at TA-46 for construction of cryogenic separation columns for stable isotopes. The holes were drilled to a depth of 747 ft (224 m) using mud rotary techniques; the casings diameter is 13 3/8 in. (34 cm). The holes penetrated to the top of the Puye Formation and reportedly did not encounter water (Purtymun 1995, 45344, p. 209).

In 1983 five boreholes were drilled in upper Cañada del Buey south of TA-52 to determine soil and bed rock properties for possible siting of a sanitary landfill. Boreholes CDB-TH-1 through CDB-TH-5 were drilled to total depths of 12 ft to 27 ft (3.6 m to 8.2 m) (see Figure A-1). Up to 22 ft (6.7 m) of soil and weathered tuff material, probably consisting of alluvium, colluvium, and in-place weathered tuff, were encountered in the boreholes (Purtymun 1994, 58233, p. 128-1). Samples collected at borehole CDB-TH-3 were sent to a material testing laboratory for engineering analysis. The soil material was classified as silty loam with a hydraulic conductivity of 3.0 cm/hr, and electrical conductivity of 0.38 mmhos/cm. The sample contained 0.56% organic matter, 0.4 ppm nitrogen, 1.5 ppm phosphorus, and 9.5 parts per million (ppm) potassium. The sample contained 61.6% material sizes larger than silt-size, ranging up to coarse sand-sized material. Maximum compaction of 102.3 lb/cu ft was obtained at 16% moisture content. The falling head permeability test result was 8.85×10^{-7} feet per minute and the Atterberg limits indicated the sample was nonplastic (Purtymun 1994, 58233, p. 128-1 and pp.138-12 et seq.).

In 1985 the first boreholes were drilled in Cañada del Buey to determine the presence of alluvial groundwater. Four observation wells (CDBO-1, -2, -3, and -4) were drilled in 1985, as described more fully in Section 3.5.4. Subsurface sediment samples were not collected for analysis (Devaurs and Purtymun 1985, 7415, p. 10; Devaurs 1985, 7416, p. 6).

3.5.2.1.1 RFI Borehole Drilling in the Cañada del Buey Watershed

As part of the RFI for OU 1148 at MDA L, TA-54, two angle boreholes were drilled in the south fork of Cañada del Buey. In 1995 boreholes 54-1015 and 54-1016 were drilled at a 30-degree angle from vertical toward the south beneath MDA L. The purpose of the borehole investigation was to characterize the subsurface units beneath MDA L and to determine if chemicals present in the subsurface VOC vapor plume were migrating from the subsurface units.

Borehole 54-1015 was drilled to a total length of 530 ft (161.6 m) at a total vertical depth of 465.8 ft (142 m). At a depth of 523 ft beneath Mesita del Buey, methylene chloride and trichlorofluoromethane were detected in pore gases in the core samples. The borehole was instrumented with seven ports, five for the collection of pore gases and two for the collection pore gases and water.

Borehole 54-1016 was drilled to a total angle depth of 607 ft (185 m) and a total vertical depth of 523 ft (159.5 m). Multiple organic compounds, including benzene, bromochloromethane, 1,1,1-trichloroethane, and trichlorofluoromethane were detected in the core samples at depths ranging from 129 ft to 597 ft beneath Mesita del Buey. A small pocket of perched groundwater was encountered in basalt within the Puye Formation at a depth of 592 ft (178 m), which was at an elevation of approximately 6188 ft (1856 m) (see Figure A-3). This borehole was completed as a vapor monitoring well with seven monitoring ports, three for pore gases and four for pore gases and water. A water sample collection port was installed at 600 ft (180 m), just below the occurrence of the wet zone (LANL 1995, 45978). Detailed results of the investigation are planned to be presented in a future RFI status report.

3.5.2.1.2 Boreholes, Shafts, Pits, and Subsurface Sampling at TA-54

Migration of tritium in the MDA G shaft disposal area was first detected in 1970. Tuff samples were collected from approximately 15 shafts and analyzed for moisture content and tritium content in moisture. The moisture content averaged 1.2% by volume, and the tritium content in moisture activity ranged from 0 pCi/mL to 1180 pCi/mL. Monitoring during the 1970s revealed that tritium at concentrations of 100 pCi/mL had moved a distance of approximately 105 ft (32 m) west along the contact between two ash-flow units. The areal distribution of the concentrations and the low moisture content of the tuff indicate that the tritium was being distributed through the pore space of the tuff by diffusion in water vapor. The tritium concentration data indicated the presence of a lens-shaped plume, shortened to the east and elongated to the west. The 100 pCi/mL contour line was extrapolated beneath the shafts to a depth of approximately 97 ft (29 m) below the surface of the mesa (Purtymun 1973, 4975; Rogers 1977, 5708).

Recorded tritium concentrations around Pit 1 at MDA G were three orders of magnitude greater than the average measured BV of 0 pCi/mL to 20 pCi/mL for both solid and near-surface tuff. The significant concentration gradient toward the surface indicates that tritium was diffusing toward and perhaps out of the ground surface (Rogers 1977, 5708; Purtymun et al. 1978, 5728).

In 1985 18 test holes were cored or augered at TA-54 to characterize the vadose zone in and around the chemical disposal pits and shafts at MDA L and the radioactive waste disposal pits and shafts at MDA G. The holes ranged in depth from 60 ft to 145 ft (18 m to 44 m) and were used for pore moisture measurements, core pore-gas sampling, psychrometer tests, in situ permeability tests, and neutron probe moisture access holes in an effort to investigate the hydrologic properties of the tuff. Core samples were analyzed for organic and inorganic constituents and radionuclides. Seven additional holes were cored in 1986 for core and pore-gas sampling, and ten more holes were cored between 1988 and 1990 to monitor vapors in the tuff (Purtymun 1995, 45344, p. 185). The results of the investigations were presented by Kearl et al. (1986, 8414).

From 1985 to 1990 a total of 27 boreholes were drilled at TA-54 to characterize the vadose zone beneath the chemical disposal pits and shafts at MDA L. The holes ranged in depth from 120 ft to approximately 300 ft (36 m to 90 m). In 1988 several holes were drilled to the Cerros del Rio basalts within the top of the Puye Formation. The basalts were encountered at depths ranging from 198 ft to 298 ft (59 m to 89 m) (Purtymun 1995, 45344, p. 185). The results of the drilling showed that an organic vapor plume is present beneath MDA L that extends to the depth of the basalt. The RFI for OU 1148 continued characterization of the vadose zone beneath MDA L. A total of 21 organic compounds have been identified in the plume; the most concentrated compound is 1,1,1-trichloroethane (LANL 1996, 53791).

In 1985 seven shallow boreholes were drilled in Pajarito Canyon just south of Cañada del Buey to determine if tritium and other contaminants from TA-54 had migrated southward into sediments, bedrock, or alluvial groundwater. The results of the drilling showed that no tritium or other contaminants were present in Pajarito Canyon (Devaurs and Purtymun 1985, 7415, p. 12; Devaurs 1985, 7416). Three of the holes were completed as monitoring wells (PCO-1, -2, and -3), and four were completed as moisture-access holes (PCM-1, -2, -3, and -4.) These boreholes and wells are more fully described in Section 3.7.2 of “Work Plan for Pajarito Canyon” (LANL 1998, 59577).

3.5.3 Surface Water Hydrology

The water that flows through Cañada del Buey is used by wildlife and plants and potentially by humans; therefore, it constitutes a transport pathway to potential receptors. The results of past investigations of surface water (described in this section) and groundwater (described in Section 3.5.4 of this document) describe known environmental conditions that must be understood to successfully assess the importance of contaminant transport pathways.

Surface water flow provides one of the primary mechanisms for redistributing and transporting contaminants that may be present in the Cañada del Buey canyon system.

Relevant aspects of surface water hydrology include the following:

- areas, pathways, and rates of surface water runoff, wastewater discharges, and sediment deposition;
- rates of contaminant dissolution and desorption, transport, and sedimentation;
- relationships between infiltration, runoff, evaporation and transpiration, and wastewater discharges;
- presence and effectiveness of adsorptive media in the sediments in retarding infiltration of waterborne contaminants; and
- where contaminants are present, fate of surface water that infiltrates into the alluvium.

The general hydrology of the canyon is discussed in Section 2.4.2 of the IWP (LANL 1996, 55574) and Section 3.5 of the core document (LANL 1997, 55622).

3.5.3.1 Cañada del Buey Stream Channel System and Streamflow

The geomorphology of the stream channel characteristics of Cañada del Buey and its tributaries are described in Section 3.1.2 of this work plan.

Cañada del Buey has a relatively small drainage area that heads at TA-46 and TA-52 on Laboratory property. The canyon receives runoff from surrounding mesa tops and discharged water from NPDES outfalls at TA-46. The canyon also receives stormwater runoff from parking lots and disposal areas at TA-54. The runoff and NPDES outfalls do not support continuous flow in any part of the canyon; the stream is entirely ephemeral on Laboratory property. During summer, runoff from thundershowers collects in the stream channel and flows for a certain distance downstream, depending on the intensity and duration of the thunderstorm. The stream channel is narrow with few cutbanks, indicating small and infrequent runoff (Purtymun and Kennedy 1971, 4798, p. 9). The stream channel is not well defined, braiding out along the canyon floor; the lack of channel definition indicates only limited runoff in the canyon (Devaurs and Purtymun 1985, 7415, p. 11). Locally derived streamflow occasionally reaches the Laboratory boundary at state road NM4, and only during periods of heavy thunderstorms or snowmelt does streamflow from Cañada del Buey extend beyond the Laboratory boundary to White Rock and the Rio Grande.

The SWSC plant is located at TA-46 and was initially considered for discharge into the TA-46 fork of Cañada del Buey. But because portions of the Cañada del Buey channel near TA-54 and MDA G cross onto San Ildefonso Pueblo land (see Figure A-1), Cañada del Buey did not offer an adequate length of stream channel on Laboratory property to ensure that surface water effluent flow would remain on Laboratory property. Therefore, effluent from the SWSC plant at TA-46 is pumped to TA-3 and discharged into upper Sandia Canyon. No treated effluent has been discharged from the SWSC plant to Cañada del Buey (Environmental Surveillance and Compliance Programs 1997, 56684, p. 28).

The White Rock STP discharges treated effluent into Cañada del Buey near the White Rock STP and above the confluence with Mortandad Canyon. These discharges support a small amount of streamflow in lower Cañada del Buey for a distance downstream but streamflow does not extend to the Rio Grande.

In most canyons on the Pajarito Plateau and likely in Cañada del Buey, the 100-year floodplain occupies an area along the canyon floor more or less centered on the stream channel (McLin 1992, 12014, p. 4). No PRSs or structures (other than observation wells) are located in or adjacent to the stream channel and are therefore not located within the 100-year floodplain.

Table 2.2.1-2 in this work plan lists the NPDES-permitted outfalls that have discharged into Cañada del Buey and summarizes the current status and source of each outfall and its discharge point. Figure A-1 shows the locations of former NPDES-permitted outfalls in the Cañada del Buey watershed. During the past few years, the outfalls in the watershed have been deleted from the NPDES permit. Except for occasional discharges from municipal supply well PM-4, no NPDES outfalls currently discharge to Cañada del Buey. No wetlands are known to be present in Cañada del Buey.

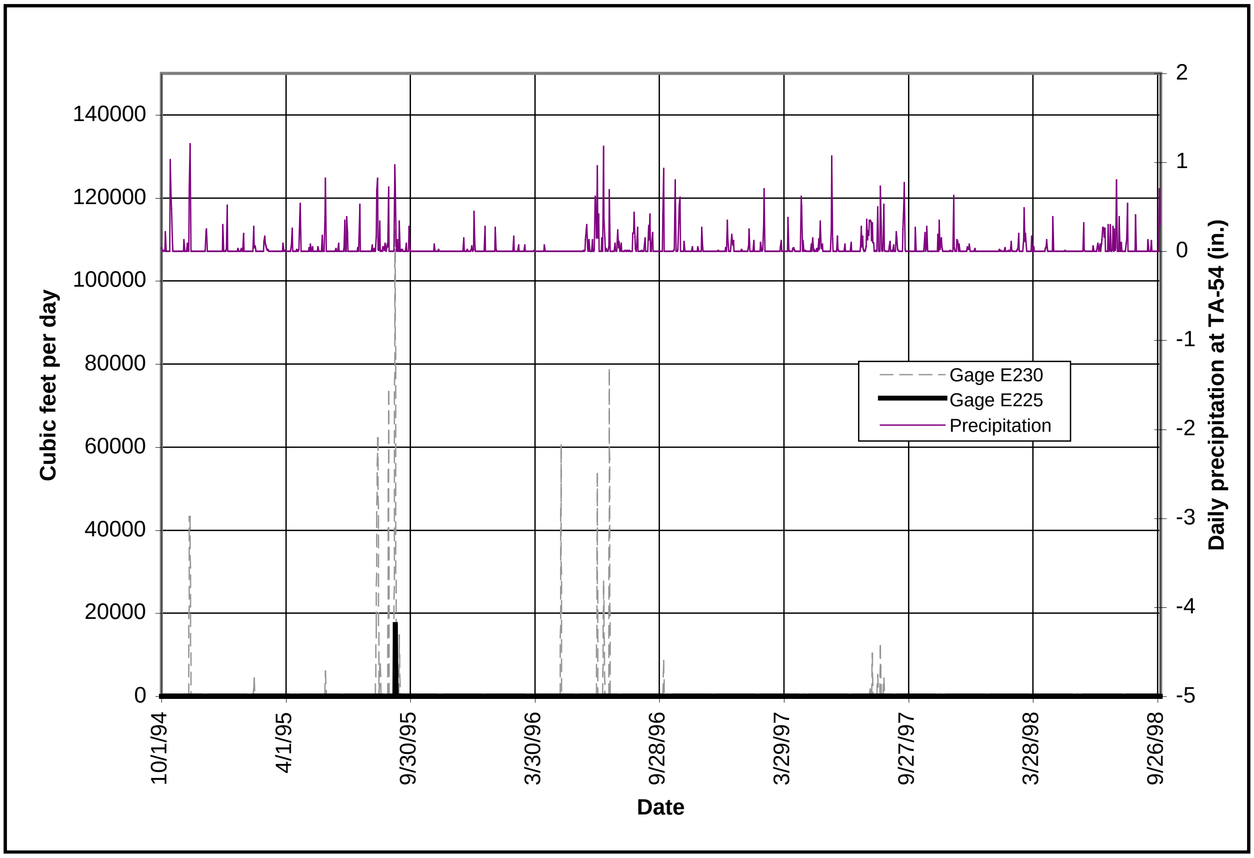
Municipal supply well PM-4 is located on a small mesa overlooking Cañada del Buey. Potentially one of the largest volumes of discharge to Cañada del Buey may be from occasional purging of PM-4. When this well is placed back online after being shut down for service, the discharge of water is necessary so that the water pressure in the line can be increased gradually. Discharge directly into the supply line at startup would potentially rupture the supply line between the well and the tank. This purge water has been suggested as the source of water encountered in observation wells CDBO-6 and CDBO-7, which are located downstream from the well discharge point in Cañada del Buey (Purtymun 1995, 45344, p. 114). The most recent discharge from PM-4 occurred November 10, 1997, when 1350 gpm were discharged for 20 min for a total discharge of 27,000 gal. (LANL 1996, 55430, p. 4-61).

A portion of the streamflow in the upper reaches of Cañada del Buey may also contribute recharge to the shallow alluvial groundwater body in the middle canyon, and the remainder is likely lost through infiltration into subsurface units and through ET.

Gaging station E230 (08313230) is located in lower Cañada del Buey at state road NM4 at an elevation of 6415 ft (1956 m). This gage was installed in October 1991 to measure flow volume at the eastern Laboratory boundary. The drainage area at this gage is 2.10 mi^2 (5.4 km^2) and the period of record is from October 1, 1994, to September 30, 1998. Flow at stream gage E230 is ephemeral and flow is recorded only as a result of local precipitation events. A summary of the runoff flow records obtained in Cañada del Buey at stream gaging station E230 is shown in Figure 3.5.3-1.

Gaging station E225 (08313225) is located in middle Cañada del Buey north of MDA G at TA-54 about 1.6 miles upstream from gage E230 and about 1500 ft below the confluence of the south fork of Cañada del Buey. This gage was installed in 1993 at an elevation of 6620 ft (2018 m). The drainage area of this gage is 1.58 mi^2 (4.1 km^2) and the period of record is from October 1, 1993, to September 30, 1997. The stream at this gage is normally dry, although flow was measured on one day (September 8, 1995) since 1993 (Shaull et al. 1996, 56019, p. 26; Shaull et al. 1997, 56020, p. 26; Shaull et al. 1998, 57581, p. 30; Shaull et al. 1999, 63505, p. 30). The flow recorded at gaging station E225 is shown in relation to the flow recorded at gaging station E230 in Figure 3.5.3-1.

Gaging station E218 (08313218), formerly called gaging station CB-46, is located in upper Cañada del Buey north of TA-46. This gage was installed in May 1997 at an elevation of approximately 6940 ft (2116 m). The drainage area of this gage is about 0.35 mi^2 (0.9 km^2). This gage has been used to detect flow events and to collect runoff samples as part of planning for the Phase II RFI at TA-46; therefore there is no current period of record. The stream at this gage is normally dry except during periods of heavy precipitation when flow was recorded once (in 1998) since installation in 1997.



Source: Shaull et al. 1996, 56019; Shaull et al. 1996, 56020; Shaull et al. 1998, 57581.

Figure 3.5.3-1. Summary of runoff at stream gaging station E230 in Cañada del Buey.

In addition to the stream gages on the main channel in Cañada del Buey, two other temporary gaging stations have been installed in tributary channels. Gaging station G-SWMS-6 is located in an unnamed side tributary that drains the north side of MDA G at TA-54 into Cañada del Buey (see Figure A-1). This gaging station was installed in 1994 and drains a small area at the north-central portion of MDA G. Flow at this gage was recorded October 21, 1997, when samples were collected for the analyses of radionuclide activity. The results of the runoff sampling are discussed in Section 3.5.3.1.5 of this document.

Another temporary flume and flow detector with stage-sampling capability was located in a tributary to upper Cañada del Buey north of TA-46 in 1997. This gage was located downstream from NPDES outfall 000-7 and was used to collect runoff samples on the north side of TA-46. This gage was not instrumented to obtain flow records and was removed in 1998.

ESH-18 personnel collect surface water and runoff samples in Cañada del Buey for environmental monitoring. Surface water samples are collected at one location north of TA-46 (at the site of the recently installed stream gage CB-46) and runoff samples have been collected at two locations, at state road NM4 (corresponding to the location of gage E230), and from gage G-SWMS-6. In addition, surface water samples have been collected in lower-offsite Cañada del Buey downstream from the White Rock sewage treatment plant. The results of the sampling and analyses are discussed in Section 3.5.3.1.5 of this document.

In 1998 personnel from the NMED DOE Oversight Bureau established a temporary surface water gaging and runoff sampling station in the TA-46 fork of Cañada del Buey about 100 ft (30 m) downstream of the TA-46 sanitary sewage treatment plant. The station was called CDBS-0.3, referring to the distance up the south fork of Cañada del Buey from the main channel of Cañada del Buey (Yanicak 1999, 63495). The gage did not detect flow over 4 in. (10 cm) deep in 1998 and did not trip the automatic sampler. However grab stormwater runoff samples were collected from this site; the results of the sampling are discussed in Section 3.5.3.1.5.

3.5.3.1.1 Springs in Cañada del Buey

No springs are known to be present in Cañada del Buey. However, a possible seep may be present north of TA-46 near the location of temporary flume TA-46-1, which is downgradient from NPDES outfalls on the north side of TA-46. It is not known if a natural seep is present at this location or if damp soil conditions are the result of effluent discharges at TA-46. There is no flow from the possible seep and flow does not extend to the Cañada del Buey stream channel.

3.5.3.1.2 Surface Water Runoff in Cañada del Buey

3.5.3.1.2.1 Normal Seasonal Runoff

Surface water runoff into the Cañada del Buey system varies with the amount of seasonal precipitation in the watershed. Snowmelt and stormwater runoff into the canyon are monitored by streamflow at gaging stations 08313255 (E225) and 08313230 (E230). Stream gage E225 is located downstream of the confluence of Cañada del Buey and the south fork of Cañada del Buey and north of MDA G. Stream gage E230 is located in Cañada del Buey at the eastern Laboratory boundary at state road NM4, and at the west edge of White Rock (see Figure A-1). Gage E225 was installed in 1993 and gage E230 was installed in 1991; the period of published records from the gages begins October 1, 1994 (Shaull et al. 1996, 56019, pp. 25 through 28).

The available flow records show that seasonal runoff is highly variable based on the amount of precipitation received in the watershed. At gage E225 flow was recorded on 1 day in the 1995 water year (October 1994 through September 1995), 0 days in 1996, and 0 days in 1997. Flow at gage E230 was recorded on 15 days in 1995, 6 days in 1996, and 6 days in 1997. The daily discharge at gage E230 and the daily precipitation records from the meteorological station at TA-54 are shown in Figure 3.5.3-1. Flow at gage E230 was measured on 15 days in 1995, 6 days in 1996, and 6 days in 1997 (Shaull et al. 1996, 56019, p. 28; Shaull et al. 1997, 56020, p. 28; Shaull et al. 1998, 57581, p. 32). During the period of record, the total flow recorded at gage E225 was 0.4 acre-feet in 1995. The total flow recorded at gage E230 was 14 acre-feet in 1995, 5.05 acre-feet in 1996, and 50.7 acre-feet in 1996. These data suggest that streamflow in Cañada del Buey at the eastern Laboratory boundary is usually associated with local runoff rather than from continuous flow derived from the upper portion of the canyon.

For the period of record, a total of 0.4 acre-feet of water passed gaging station E225 in the middle canyon. During this time 14 acre-feet passed through gage E230 at the Laboratory boundary in 1995, 5.05 acre-feet in 1996, and 10 acre-feet in 1997.

3.5.3.1.2.2 Stormwater and Snowmelt Runoff Investigations

Personnel from ESH-18 periodically monitor runoff from stormwater and snowmelt. The results are reported annually in environmental surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684) and in surface water data reports (e.g., Shaull et al. 1996, 56020).

3.5.3.1.3 Flooding Potential in Cañada del Buey

Flow and floodplain estimates for the Los Alamos region were developed by McLin (1992, 12014) using computer-based models (HEC 1 and 2) developed by the US Army Corps of Engineers Hydrologic Engineering Center. The models project the effects of severe thunderstorms on all watersheds in the Los Alamos area. The modeling effort predicts the effects of storm runoff on flood elevations within the canyons and on different Laboratory areas and structures. Precipitation totals and floodplain elevations were projected for 2-, 5-, 10-, 25-, 50-, and 100-year storms (LANL 1995, 50124).

The theoretically estimated 24-hour runoff for a probability of 0.02 (“2-year recurrence interval”) 6-hour storm for Cañada del Buey at the Laboratory boundary at state road NM4 is less than 1 acre-foot (less than 1233 m^3) (McLin 1992, 12014, p. 20). The estimated 24-hour runoff for a 50-year recurrence 6-hour storm for Cañada del Buey at this location is 24 acre-feet (30,000 m^3). This 50-year event corresponds to a calculated 6-hour precipitation total of 2.04 in. (5.2 cm) (over the entire watershed area), creating a peak flow of 54 cfs at the eastern Laboratory boundary (McLin 1992, 12014, pp. 13 and 19).

Since installation of the stream gages in Cañada del Buey in 1991 and 1993, the peak 5-min flow recorded at each stream gage has been 17 cfs at E225, and 112 cfs at E230 (Shaull et al. 1998, 57581, pp. 29 and 31). The maximum flow recorded at the Laboratory boundary for the period of record is approximately 200% of the calculated 50-year, 6-hour precipitation event; however, the period of record is not sufficient to represent a 50-year event.

The highest five 24-hour precipitation events recorded at Los Alamos are shown in Table 3.4.3-1 (Bowen 1990, 6899, Table 1.1). Because of the nature of thunderstorms on the Pajarito Plateau and the extreme variation in elevation difference in the Pajarito watershed area, it is unlikely that the entire Cañada del Buey watershed has received the maximum amounts of precipitation recorded during any specific event. Since 1911 the average annual maximum precipitation in a 24-hour period is approximately 1.5 in. (3.8 cm) (Bowen et al. 1990, 6899).

3.5.3.1.4 Infiltration in Cañada del Buey

Surface water enters the canyon from stormwater runoff and snowmelt, and discharges from NPDES outfalls. Most surface water normally infiltrates into the alluvium and probably recharges a small body of perched alluvial groundwater in the middle canyon. As groundwater moves through the alluvium, some is lost to ET, and the remainder probably seeps into the underlying tuff and/or the Cerro Toledo interval, or continues to flow downgradient.

The extent of seepage into suballuvial units in Cañada del Buey is not known. In the past, holes such as CDBM-1 and CDBM-2, which were drilled into the suballuvial units in middle Cañada del Buey, encountered dry rock beneath the alluvium (Purtymun 1995, 45344, p. 130). However, observation wells CDBO-6 and CDBO-7 contain water that appears to be present in the colonnade tuff at the base of Unit 1v, which underlies the alluvium in the middle portion of the canyon. Some of this stream loss is attributable to evaporation, but most is probably caused by infiltration into the alluvium. Some of this stream loss may infiltrate into the adjacent tuff and provide a source of recharge to possible perched intermediate zones. Alluvial groundwater does not reappear as downstream flow or in the lower alluvial basin.

Moisture profiles obtained from moisture-access hole CDBM-1 show that saturation increases from the surface down to the Cerro Toledo interval and then decreases downward in the Otowi Member. Head values increase with depth from the surface to the Cerro Toledo interval and then decrease with depth into the Otowi Member. The suction profile in CDBM-1 is uniform below about 50 ft (15 m). The head gradient profile suggests that the direction of liquid water flow is upward above the Cerro Toledo interval, and downward below this zone. The upward flux is estimated to be about 0.02 cm/yr and the downward flux beneath the Cerro Toledo interval occurs at an estimated rate of 0.2 cm/yr. Lateral flow may occur within the Cerro Toledo interval. In the Cerro Toledo interval and the Otowi Member the average hydraulic gradient is approximately unity, which suggests that vertical flow is at steady state (Rogers et al. 1996, 55543, p. 415).

Infiltration through mesa tops is very slow. At the surface of the mesa tops, ET consumes approximately 90% of precipitation, which leaves little water for runoff or infiltration. The mean annual calculated percolation of water beneath the surface on mesa tops is approximately 1 mm (0.04 in.) per year. Infiltration beneath canyon floors is higher and has been calculated to be approximately 4.4 mm (0.18 in.) per year beneath Cañada del Buey (LANL 1998, 57576, p. 54).

3.5.3.1.5 Surface Water Quality and Contaminant Data in Cañada del Buey

3.5.3.1.5.1 Results of Environmental Surveillance Sampling of Surface Waters

ESH-18 personnel annually collect surface water samples from Cañada del Buey in the upper canyon at sample station Cañada del Buey. This sample site has also been called “Cañada del Buey at TA-46,” “Nr. TA-46,” and “TA-46.” Although the samples are called “surface water” samples, the stream channel is usually dry except during periods of precipitation and snowmelt runoff. Therefore these surface water samples may more appropriately be considered runoff samples. In 1997 this sample station was equipped with a permanent stream gaging station (E218), although streamflow records have not been obtained from this station.

Surface water samples have been collected annually at the “Cañada del Buey” station at state road NM4 since 1970. The samples are routinely analyzed for general inorganic constituents and radionuclide activity. In 1974, 1978, 1988, 1991 through 1995, and 1997 the samples were also analyzed for metals.

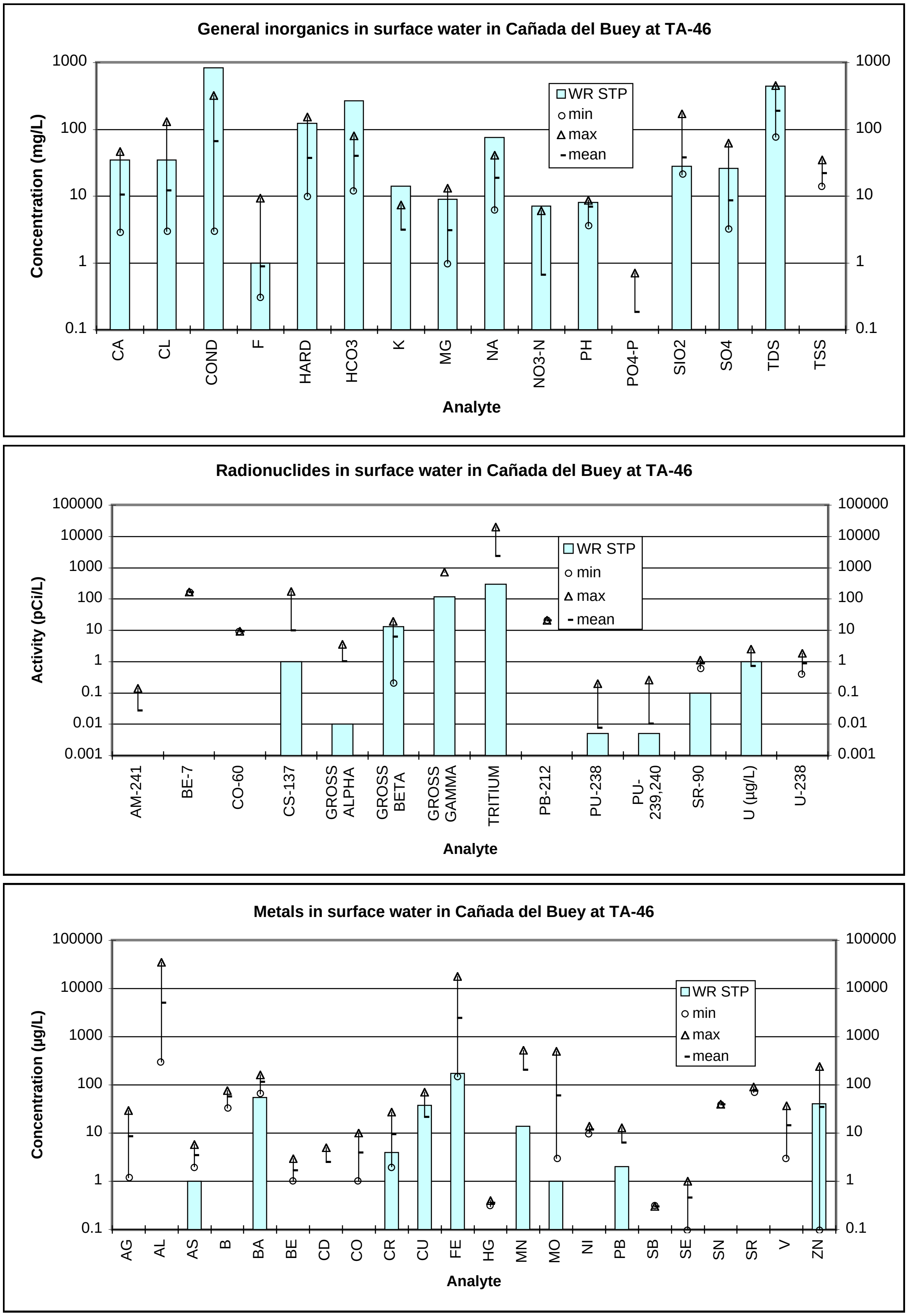
Surface water samples were collected in July and October 1973 from the Cañada del Buey stream below the White Rock STP, and analyzed for radionuclides. In October 1987, samples were again collected from this site and analyzed for general inorganic constituents, radionuclides, and metals.

In recent years stormwater runoff samples have been collected from two sites in Cañada del Buey after storm events. In July 1996 samples were collected from the stream channel at state road NM4 sample stations (Cañada del Buey at WR) and in October 1997 runoff samples were collected from the tributary gaging station north of MDA G (G-SWMS-6). The following sections discuss the results of environmental surveillance sampling that are presented annually in environmental surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684), supplemented with data from Purtymun (1975, 11787).

3.5.3.1.5.1.1 Surface Water Quality

General Water Quality

Figure 3.5.3-2 summarizes the results of surface water sampling in upper Cañada del Buey for general water quality parameters. A total of 28 samples have been analyzed for general inorganic constituents since sampling began in 1967. Samples have been collected annually since 1971, except in 1973 and 1996. Before 1995 the samples were acidified at the time of collection and filtered in the laboratory before analysis. Since 1995 the samples have not been filtered or acidified before analysis. This figure shows the minimum, maximum, and mean concentrations of analytes sampled for the years for which results are available and the results of 1987 surface water sampling from below the White Rock STP.



COND = specific conductance. TDS = total dissolved solids. WR STP = White Rock sewage treatment plant.
HARD = hardness. TSS = total suspended solids.
pH is measured in standard units.

Source: Environmental surveillance reports; Purtymun 1975, 11787.

Figure 3.5.3-2. Summary of environmental surveillance sampling in Cañada del Buey.

The Cañada del Buey surface water samples show a nitrate (as nitrogen) range of 0 mg/L to 6 mg/L, well below the drinking water standard of 10 mg/L. A sample collected in 1987 contained 9.3 mg/L fluoride, but most samples collected in the past decade have been below 1.1 mg/L and within the EPA drinking water standard of 4 mg/L. Most cations and anions vary approximately an order of magnitude, which reflects both sampling techniques and seasonal variations in water quality parameters. No significant trends in the annual variation of surface water quality data are obvious.

Surface water samples collected from lower Cañada del Buey below the White Rock STP are primarily from STP effluent discharge. These samples contain higher concentrations of nearly every constituent, especially potassium, sodium, bicarbonate (HCO_3), total dissolved solids (TDS), and higher conductivity. The water below the White Rock STP is obviously not similar in constituents to the surface water runoff collected in upper Cañada del Buey, as would be expected for STP effluent discharges.

Metals

The summary of results of surface water sampling for metal constituents at the surface water collection sites in Cañada del Buey is shown in Figure 3.5.3-2. Before 1993 the samples were acidified at the time of collection and filtered at the laboratory before analysis (AF samples). Since 1993 the samples have not been filtered or acidified before analysis (UF samples). The minimum, maximum, and mean concentrations for each analyte from upper Cañada del Buey and the results of the October 1987 sampling below the White Rock STP are shown in the figure.

The average concentrations of aluminum and iron in the surface water in upper Cañada del Buey are several thousand micrograms per liter, showing the nature of the acidified and unfiltered samples. The samples collected from lower Cañada del Buey below the White Rock STP contain generally lower concentrations for the metals detected in the STP effluent.

Radionuclides

The summary of the results of surface water sampling in upper Cañada del Buey and the results of sampling below the White Rock STP for radionuclides is shown in Figure 3.5.3-2**.** Tritium activity in the upper Cañada del Buey water adjacent to TA-46 has been as high as 20,000 pCi/L in 1971, although in the last decade it has been less than 700 pCi/L. The activity of tritium in the White Rock STP effluent in 1987 was 300 pCi/L. The highest activity of plutonium-238 was 0.2 pCi/L in 1972, and the highest activity of plutonium-239,240 was 0.26 pCi/L in 1973. Most observations of plutonium species have been near detection limits, and the average activity of plutonium-238 is 0.0077 pCi/L and of plutonium-239,240 is 0.0106 pCi/L. The highest uranium concentration has been 2.5 µg/L.

3.5.3.1.5.1.2 Stormwater Runoff Water Quality

In recent years stormwater runoff samples have been collected from two sites in Cañada del Buey after runoff events. In July 1996 samples were collected from the stream channel at state road NM4 (the Cañada del Buey at WR station); both filtered and unfiltered samples were collected and analyzed for general inorganic constituents, radionuclides, and metals (Environmental Surveillance and Compliance Programs 1997, 56684, pp. 118 and 147). Table 3.5.3-1 shows the results of the analyses for general inorganic constituents, metals, and radionuclides. The table also shows the background activity values for sediment for comparison with radionuclides in the suspended sediment fraction. The calculated total activity of radionuclides dissolved in the water and in the suspended sediment is also shown.

Table 3.5.3-1
Results of Analyses of Runoff in Cañada del Buey at State Road NM4 at White Rock

General Inorganics

Date	Matrix	Units	Ca	HARD	HCO_3	K	Mg	Na	NO_3-N	pH	PO_4-P	SiO_2	SO_4	TDS	TSS
7/8/96	RO	mg/kg	7110	NA[a]	NA	5210	5102	349	NA	8.4	n/a[b]	NA	NA	NA	NA
7/8/96	RO/D	mg/L	11	32.4	77		1.2	3	1.26	n/a	0.63	18	2.5	280	9100

Metals

Date	Matrix	Units	Al	B	Ba	Be	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	V	Zn
7/8/96	RO/D	µg/L	1400	54	480				17400	720	12			49		30
7/8/96	RO/TOT	mg/kg	29762	10.5	265	1.95	7.36	19.2		21822	495	18	25	49	28.1	80

Radionuclides

Date	Matrix	Units	Am-241	Cs-137	Gross Alpha	Gross Beta	Gross Gamma	Tritium	Pu-238	Pu-239,240	Sr-90	U
7/8/96	RO/D	pCi/L	-0.01	-0.55	0.1	5.35	-82	-232	-0.001	0.01	-0.3	0.2 µg/L
7/8/96	RO/SS	pCi/g	0.009	-0.14	12.05	6.35	3.9		0.002	0.021	0.15	2.75 mg/kg
BV Sediment		pCi/g	0.04	0.9				0.093	0.006	0.068	1.3	6.99
Total Activity		pCi/L	0.0699	-1.869	109.76	63.13	-46.5		0.0172	0.2011	1.065	25.27 µg/L
EPA STD		pCi/L									8	20 µg/L

Note: Blank cells are less than detection limit.

[a] NA = not analyzed.

[b] n/a = not applicable.

The TDS concentration was 280 mg/L and the dissolved concentration reported for copper was 17.4 mg/L, which is unusually high and may represent an error in reporting units. Tritium activity was reported below detection limits (0 pCi/L) and the total calculated activities of plutonium-238 and plutonium-239,240 were 0.0172 pCi/L and 0.2011 pCi/L, respectively. The total calculated activity of uranium in the samples, based on 0.2 µg/L of dissolved uranium and 2.75 mg/kg of uranium in the suspended sediment, was 25.27 µg/L.

3.5.3.1.5.1.2.1 Runoff Sampling at TA-54

Runoff samples have been collected from the perimeter of MDA G to supplement existing environmental surveillance of the TA-54 area and as part of the RFI for OU 1148. In addition to the data presented annually in the environmental surveillance reports, a supplemental environmental surveillance study was initiated in 1993 to monitor potential contaminant migration from MDA G via the surface water pathway. In 1993, 110 single-stage water samples from the perimeter of MDA G were analyzed for tritium, total uranium, isotopic plutonium, and cesium-137 (Conrad et al. 1995, 52014). The results of the analyses of the runoff samples showed that six single-stage water samples contained tritium activities greater than 1000 pCi/L. One of these samples contained tritium activity greater than 2000 pCi/L (maximum value 2300 pCi/L). Elevated plutonium activity was detected in the filtered sediment and water fractions of runoff samples from stations adjacent to the TRU pads and the area's oldest disposal pits. Maximum activities measured in filtered runoff were 0.604 pCi/L plutonium-238 and 0.155 pCi/L plutonium-239,240. Maximum activities measured in the sediment fraction of the runoff samples were 26.61 pCi/g plutonium-238 and 1.25 pCi/g plutonium-239,240 (Conrad et al. 1995, 52014).

Beginning in 1994 the single-stage runoff samples (filtered) were submitted for tritium analysis only, and the sediment fraction of the runoff was analyzed for isotopic plutonium. The results of the 1994 sampling showed an increase in tritium concentrations in the single-stage water samples compared with data collected in 1993. Ten of the 159 single-stage water samples contained tritium activities exceeding 1000 pCi/L; the maximum tritium value in runoff (from a sample collected northeast of MDA G) was 17,200 pCi/L. The runoff containing the highest tritium activity discharges into Cañada del Buey (Conrad et al. 1996, 55621).

In 1995 a total of 131 single-stage runoff samples were collected, of which five contained tritium activity greater than 1000 pCi/L. Elevated plutonium activity was detected in the sediment fraction of runoff sample collected adjacent to the TRU pads and the oldest disposal pits, which is consistent with the results obtained in 1993 and 1994. Maximum activities measured in the sediment fraction were 9.46 pCi/L plutonium-238 and 2.13 pCi/g plutonium-239,240 (Childs and Conrad 1997, 57518).

The conclusion derived in each of the supplemental environmental surveillance reports for MDA G runoff sampling from 1993 through 1995 is that small amounts of radioactivity are leaving the confines of MDA G via the surface water runoff pathway (Conrad et al. 1995, 52014; Conrad et al. 1996, 55621; Childs and Conrad 1997, 57518).

3.5.3.1.5.1.2.2 Other Runoff Sampling in Cañada del Buey

In 1996 NMED Oversight Bureau personnel collected a series of stormwater runoff samples at site CDB-2.01, which corresponds to environmental surveillance sample site Cañada del Buey at SR-4. During a runoff event on July 17, 1996, a series of four runoff samples were collected at 5-min intervals. The samples were analyzed for suspended solids, mercury, PCBs, and selected metals in the suspended solids. The suspended solid content in the samples ranged from 17,000 mg/L to 27,000 mg/L (Yanicak 1998, 57583, Table 7). PCBs were not detected in the water above the detection limit of 0.5 µg/L (Yanicak 1998, 57583, Table 12). The mercury concentration in one unfiltered water sample was 0.0006 µg/L (Yanicak 1998, 57583, Table 8). The concentration of selected metals in the suspended solids were 160 mg/kg barium, 1.2 mg/kg beryllium, 8 mg/kg chromium, 9 mg/kg copper, and 13 mg/kg lead. Mercury was not detected in the suspended solids above the detection limit of 0.1 mg/kg (Yanicak 1998, 57583, Table 13) The suspended solid in one sample contained 2.89 mg/kg uranium (Yanicak 1998, 57583, Table 14).

In 1998 personnel from the NMED DOE Oversight Bureau collected filtered and unfiltered stormwater runoff samples from three sites in Cañada del Buey. One site (CDB-6.1) corresponds to gaging station E218, another site (CDBSTRIB-0.01) was collected in the south fork just upstream from the confluence with the main channel of Cañada del Buey, and the third site (CDBS-0.3) is located in theTA-46 fork. The CDBS-0.3 site was located about 100 ft (30 m) downstream from TA-46 and about 50 ft (15 m) upstream from an inactive outfall from the SWSC plant at TA-46 . The samples were collected on July 20, 1998, and were analyzed for general inorganics, metals (dissolved), uranium-234, uranium-235, uranium-238, gross alpha, and gross beta (Yanicak 1999, 63495). The results of the analyses show that the highest concentrations of the uranium isotopes were from the south fork of Cañada del Buey where uranium-234 (total) was 0.95 pCi/L and uranium-238 (total) was 0.41 pCi/L. The highest concentrations of general inorganic constituents were collected from runoff in the TA-46 fork, where the TDS (283 mg/L) and other constituents were about four times higher that the other runoff samples collected in Cañada del Buey. Most metals concentrations (dissolved) were below detection limits except for aluminum, iron, molybdenum, silicon, strontium, vanadium, and zinc (Yanicak 1999, 63495).

3.5.3.1.5.2 Results of RFI Sampling of Surface Waters

3.5.3.1.5.2.1 RFI Runoff Sampling at TA-46

In 1997 and 1998 the ER Project collected runoff samples from the upper Cañada del Buey watershed area north of TA-46. The purpose of the runoff sampling was to provide background information for planning Phase II investigations of PRSs. The results of soil/sediment sampling on the edge of Cañada del Buey below outfalls at TA-46 (discussed in Section 3.5.1.3.1) showed elevated levels of heavy metals and trace metals. Therefore limited runoff sampling was performed to determine if the PRSs have impacted runoff into Cañada del Buey. The results of the runoff sampling are pending and are planned to be presented in a future RFI document.

3.5.3.1.5.2.2 RFI Runoff Sampling at TA-54

The results of RFI runoff sampling at TA-54 are summarized in Section 3.5.3.1.5.1.2.1.

3.5.3.1.6 Summary of Surface Water Hydrology Issues and Data-Collection Activities Needed to Understand the Surface Water Hydrology of Cañada del Buey

The surface water hydrology of Cañada del Buey is summarized below.

- No perennial reaches occur in Cañada del Buey on Laboratory property. A continuous reach extends a short distance downstream from the White Rock STP discharge point.
- Surface water flow in the stream channel and across the eastern Laboratory boundary at state road NM4 is ephemeral. Flow reaches the Rio Grande occasionally as the result of high snowmelt runoff or periodic storm events. The geochemistry of surface water collected in lower off-site Cañada del Buey at the Rio Grande is likely associated with discharges from the White Rock STP.

The following additional data-collection activities are needed to understand the surface water hydrology of Cañada del Buey.

- Monitor runoff volumes in the upper canyon adjacent to TA-46 to determine the amount of stream loss in this area.
- Sample runoff in upper and middle Cañada del Buey to determine if contaminants from PRSs at TA-52 and TA-46 are entering the canyon.

3.5.4 Hydrogeology

This section summarizes prior investigations of Cañada del Buey hydrogeology and discusses the hydrogeology of the known saturated zones located in the alluvium, intermediate zones, and regional aquifer. Intermediate perched zones have been identified in the Sandia Canyon area and may be present in the Cañada del Buey area.

Groundwater pathways beneath the canyons are important because of the possibility of contaminant transport laterally or downward to zones of saturation that may be capable of contaminant transport off-site. Understanding the unsaturated zones at the upper portion of the alluvium and, most importantly, in the underlying tuff and deeper zones is an important aspect of understanding potential transport pathways.

Special low-detection-limit (0.67 pCi/L) tritium measurements have confirmed the presence of recent recharge (less than 50 years old) to intermediate zones and the regional aquifer at characterization well R-12 and at several locations in other deep wells, including TW-8 in Mortandad Canyon. The source of recharge to these zones is apparently alluvial sources (Blake et al. 1995, 49931, p. 33; Rogers et al. 1996, 54714, Table 2; LANL 1998, 59665, p. 2). Site-specific information does not exist about contaminants at depth below Cañada del Buey; however, similar pathways probably occur for potential contaminant transport to deeper zones. In addition, lateral contaminant transport from other canyons may occur in the subsurface.

3.5.4.1 Shallow Unsaturated Alluvial Zone

The shallow unsaturated alluvium is the portion of the alluvium from the surface downward to the top of the alluvial saturated zone, where present. Cañada del Buey receives inflow from stormwater runoff, snowmelt, and previously, from several NPDES-permitted discharges. One of the major contributors to shallow groundwater in Cañada del Buey may be water purged from municipal supply well PM-4.

In upper and middle Cañada del Buey the runoff normally infiltrates into the alluvium, and the stream channel is dry except during periods of heavy precipitation and snowmelt runoff. Water levels in the middle canyon are approximately 35 ft (10 m) below ground surface. In this area of the canyon, the unsaturated alluvial zone is relatively thick. Alluvium in floodplains 3 ft to 4 ft (0.91 m to 1.2 m) above the stream channel throughout the canyon are not saturated but probably contribute to storage.

During periods of precipitation and increased runoff, the surface-water front advances downstream. Runoff infiltrates into the sediments, and at least a portion of the top part of the alluvium becomes saturated. The unsaturated zone in the alluvium may be dissected down the center of the canyon by the infiltration of surface water.

3.5.4.2 Alluvial/Shallow Perched Groundwater in Cañada del Buey

This section describes the wells that have been installed in Cañada del Buey and summarizes the information that is known about the alluvial groundwater. An understanding of the bedrock stratigraphy, alluvial stratigraphy, and the relationship between water in the alluvium and water in possible suballuvial intermediate perched zones, if present, is needed to understand the hydrogeology of Cañada del Buey.

Since 1985 a total of nine alluvial groundwater-monitoring wells and nine moisture-access holes have been installed in Cañada del Buey. Appendix D contains a summary of the information about these wells, including well status, location, water level data, and stratigraphic information. Figure A-1 shows the locations of the wells. The results of sampling these wells are discussed in Section 3.5.4.3.1.

Early reports of possible alluvial groundwater in Cañada del Buey mentioned that “the alluvium in Cañada del Buey is thin and contains no perennial water owing to the small amount of runoff” (Purtymun and Kennedy 1971, 4798, p. 9). Because the drainage area of the canyon is so small, no investigations were conducted of possible alluvial groundwater in Cañada del Buey until four observation wells were drilled in 1985. Then two wells (CDBO-1 and CDBO-2) were drilled in the south fork of Cañada del Buey downstream from MDA J. CDBO-3 was drilled in the lower south fork of Cañada del Buey adjacent to MDA L. Another well (CDBO-4) was installed in lower Cañada del Buey down stream from MDA G. These four observation wells were drilled through the alluvium into the underlying bedrock tuff. All of these four original observation wells were dry “due to the small drainage area of the canyon that results in little or no surface runoff to form a body of water in the alluvium” (Devaurs and Purtymun 1985, 7415, p. 11).

The four observation wells in Cañada del Buey were cased with 4-in. (10.2-cm)-diameter polyvinyl chloride (PVC) casing and were screened with wire-wrap stainless steel tubing with 0.25 in. (0.64 cm) perforations. The annular space adjacent to the screen intervals were gravel packed to within 2 ft (0.61 m) of the surface. The wells were developed by jetting and pumping water into the formation (Devaurs 1985, 7416, p. 6).

Construction of the new SWSC plant at TA-46 was completed in late 1992. Because treated effluent from the SWSC plant may at some time be discharged to Cañada del Buey in an emergency or accidentally, five new shallow alluvial groundwater observation wells (CDBO wells) and two moisture-access holes (CDBM holes) were installed in Cañada del Buey in the summer of 1992. These five new observations wells, CDBO-5, -6, -7, -8, and -9, together with CDBO-4, which was installed in 1985, provide the monitoring network for the Cañada del Buey alluvium (Environmental Protection Group 1995, 50285, p. VII-26).

CDBO-5 is located in upper Cañada del Buey about 500 ft (150 m) upstream from the confluence with the TA-46 fork. This observation well monitors alluvial groundwater in Cañada del Buey upstream from the TA-46 fork where potential treated effluent from the SWSC plant would discharge into Cañada del Buey. CDBO-5 was drilled to a total depth of 17.5 ft (5.3 m); unweathered bedrock tuff was encountered at 17 ft (5 m). The screen interval is from 7 ft to 17 ft (2.1 m to 5 m). Water has never been observed in this well, although the well may not have been checked at appropriate times after significant runoff events.

CDBO-6 is located in middle Cañada del Buey about 2800 ft (850 m) below the confluence with the TA-46 SWSC tributary. This observation well is the first down-canyon from the TA-46 fork that could potentially detect alluvial groundwater from any discharges from the TA-46 SWSC plant. CDBO-6 was drilled to a total depth of 49 ft (14.9 m) and is screened from 34 ft to 44 ft (10.4 m to 13.4 m). The base of the alluvium is probably at about 19 ft (5.8 m), although drilling and lithologic records do not state where the base of the alluvium was encountered (Purtymun 1995, 45344, p. 131). A 10-ft- (3-m) thick perched water zone was encountered from 34 ft to 44 ft (10.3 m to 13.4 m) (Environmental Protection Group 1995, 50285, p. VII-26). The perched water was in a dark yellowish brown zone of weathered tuff, which extended from 19 ft to 44 ft (5.8 m to 13.4 m). Local bedrock stratigraphic data suggest that the perched groundwater zone may be in the colonnade tuff at the base of Unit 1v of the Tshirege Member of the Bandelier Tuff (see Figure A-3). CDBO-6 was equipped with a dedicated bladder pump for sampling and was added to the routine environmental surveillance program in 1992 (Environmental Protection Group 1995, 50285, p. VII-26). This well has contained enough water for sampling each year since 1992. Since 1992, water levels have ranged from 0 ft (dry) to 12 ft of saturation (LANL 1996, 55430, p. 4-16).

CDBO-7 is located in middle Cañada del Buey about 2000 ft (600 m) downstream from CDBO-6. This well was drilled to a total depth of 44 ft (13.4 m) and is screened from 29 ft to 39 ft (8.8 ft to 11.9 m). The base of the alluvium was probably encountered at about 19 ft (5.8 m) although drilling and lithologic records do not state where the base of the alluvium was encountered (Purtymun 1995, 45344, pp. 123 and 131). A 1-ft to 2-ft (0.3-m to 0.6-m)-thick zone of perched groundwater was encountered in this well, probably between 38 ft to 39 ft (11.6 to 11.9 m). However, the drilling information does not state at what depth the saturated zone was encountered (Environmental Protection Group 1995, 50285, p. VII-26; Purtymun 1995, 45344, p. 131). Local bedrock stratigraphic data suggest that the perched groundwater zone may be in the colonnade tuff at the base of Unit 1v of the Tshirege Member of the Bandelier Tuff (see Figure A-3). CDBO-7 did not contain enough water to sample in 1992, but was added to the routine environmental surveillance program in 1992 and is inspected periodically to determine the presence of perched groundwater (Environmental Protection Group 1995, 50285, p. VII-26). This well has contained enough water for sampling each year since 1993 and has contained up to 7 ft (2.1 m) of saturation (LANL 1996, 55430, p. 4-16).

Municipal supply well PM-4 is located on a ledge of the south canyon wall adjacent to CDBO-6. Connected to PM-4 is an NPDES outfall that discharges into Cañada del Buey at the approximate location of CDBO-6. When PM-4 is taken out of service for repair, the well must be purged and start-up pump pressure bled off to the NPDES outfall each time the pump is returned to service. Because the upstream well, CDBO-5, is dry, it has been suggested that the purge water from PM-4 is the apparent source of the saturation at CDBO-6 and CDBO-7 (Environmental Protection Group 1995, 50285, p. VII-26; Purtymun 1995, 45344, p. 114). A recent discharge from PM-4 occurred November 10, 1997 when 1350 gpm were discharged for 20 minutes for a total discharge of 27,000 gal. (LANL 1996, 55430, p. 4-61).

CDBO-8 is located in middle Cañada del Buey about 2100 ft (640 m) downstream from CDBO-7. This well was drilled to a total depth of 28 ft (8.5 m) and is screened from 3 ft to 13 ft (0.9 m to 4 m). The base of the alluvium was encountered at an approximate depth of 19 ft (5.8 m). This well is located about 10 ft from moisture-access hole CDBM-1, which was drilled to a depth of 189 ft (57.6 m) into the Otowi Member. Both boreholes were dry when drilled and CDBO-8 has never been observed to contain water. These boreholes, however, are about 30 ft (9 m) from the tuff outcrops at the north side of the canyon bottom and may not be located appropriately in the middle of the canyon to intercept shallow perched groundwater. Figure A-3 shows the lateral cross section across the canyon at the location of CDBO-8 and CDBM-1.

CDBO-9 is located in middle Cañada del Buey about 4000 ft (1200 m) downstream from CDBO-8 and about 400 ft (120 m) upstream from the confluence with the south fork of Cañada del Buey. This well was drilled to a total depth of 34 ft (10.3 m) and contains a screened interval from 19 ft to 29 ft (5.8 m to 8.8 m). The base of the alluvium was encountered at a depth of approximately 19 ft (5.8 m), although the drilling and lithologic records do not state where the base of the alluvium was encountered (Purtymun 1995, 45344, p. 132). This well is located about 8 ft (2.4 m) from moisture access hole CDBM-2, which was drilled to a depth of 99 ft (30 m) into the Otowi Member. Both boreholes were dry when drilled and CDBO-9 has never been observed to contain water.

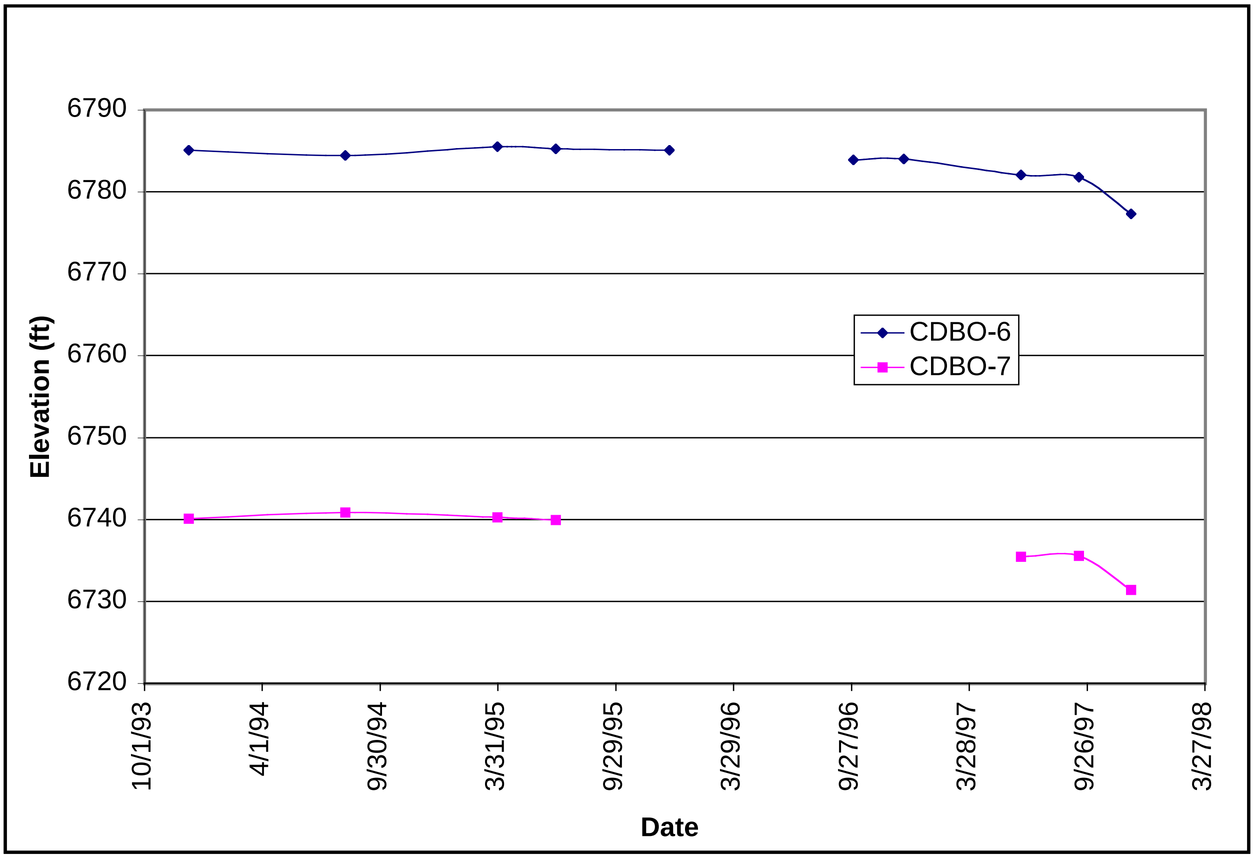
Observation wells CDBO-5 through CDBO-9 were cased with 2-in. (5-cm)-diameter PVC pipe. Screen-hole diameter was 0.010 in. The borehole annulus opposite the screened intervals was packed with silica sand with grain sizes from 0.010 in. to 0.020 in. A steel surface casing and security cap were cemented at surface to a depth of 1 ft to 3 ft (Purtymun 1995, 45344, pp. 131 et seq.). Moisture access holes CDBM-1 and CDBM-2 were cased with 2-in. (5-cm)-diameter aluminum pipe that was not perforated. The annulus around the aluminum pipe was packed with 0.010-in. to 0.020-in. silica sand at depth and bentonite near the surface; steel surface casing was cemented within several feet of the surface (Purtymun 1995, 45344, pp. 133 through 134).

The shallow perched groundwater body beneath middle Cañada del Buey extends from approximately CDBO-6 downstream for a distance of at least 2000 ft (600 m) to CDBO-7, and probably for some distance further downstream. The perched groundwater does not appear to be located within the alluvium but may be present within the bedrock tuff beneath the alluvium. “Anticipating that saturation may develop in either unit, the design of the new wells allows for water to enter the well screen from both horizons” (Environmental Protection Group 1995, 50285, p. VII-26). The principal source of recharge to the shallow groundwater has been ascribed to purge water from PM-4, but also may be from runoff infiltration from the upper canyon reaches supplemented by infiltration of local precipitation and by NPDES discharges. During heavy snowmelt and summer rainstorms, the runoff front probably extends down the canyon for an unknown distance.

There are no known groundwater discharge points in Cañada del Buey. The shallow perched groundwater present at depths of 34 ft to 44 ft (10 to 13 m) at CDBO-6 and 37 ft to 39 ft (11 m to 11.9 m) in CDBO-7 in the middle canyon is likely lost either to infiltration to deeper units or to lateral flow along bedrock unit contacts.

Figure A-3 is a longitudinal cross section that shows the locations of existing wells in and near Cañada del Buey. Six tables in Appendix D (Table D-1 through Table D-6) describe the wells, boreholes, and moisture access holes and provide location information and current status, construction information, stratigraphic information; and available water level measurements. Some of the stratigraphic information provided when some of the boreholes were originally drilled was found to be inconsistent with that from adjacent boreholes and with current understanding of the stratigraphy of the area. Therefore, Table D-6 contains both the original stratigraphic information, which is largely obtained from Purtymun (1995, 45344), and a revised set of stratigraphic picks based on review of lithologic descriptions and on local and regional stratigraphic information. Some of the revised stratigraphy is discussed in the following sections.

Figure 3.5.4-1 shows the historic water level elevations measured at the two wells that contain water in Cañada del Buey (see Table D-5 in Appendix D of this document). Water levels in CDBO-6 and CDBO-7 have typically been obtained three times per year since 1995. Significant seasonal variations are not apparent in the data set and the water levels have typically varied by less than 5 ft (1.5 m). The lowest water level recorded at CDBO-6 and CDBO-7 was in December 1997, when the recorded water levels were about 4 ft (1.2 m) below those previously recorded. The data for CDBO-7 are limited because the well is dry at times. However the water levels measured in 1997 are about 5 ft (1.5 m) lower than those recorded from 1993 to 1995.



Source: ESH-18 field records.

Figure 3.5.4-1. Historic water levels in Cañada del Buey alluvial wells.

Moisture access holes CDB-1 and -2 were installed in 1992 adjacent to CDBO-8 and CDBO-9, respectively. CDBM-1 is located along the north edge of Cañada del Buey and near the base of the south-facing cliff wall on the north side of the canyon. These holes were located to observe alluvial groundwater from Cañada del Buey that might extend to depth into the bedrock units. Both CDBM boreholes were dry. Three similar moisture-access holes drilled in Pajarito Canyon south of Mesita del Buey "document that perched water in Pajarito Canyon, adjacent to Mesita del Buey, is confined to the alluvium in the stream channel, and does not extend to the flank of the canyon" (Devaurs and Purtymun 1985, 7415, p. 12). Equally important, the holes also document that perched alluvial groundwater does not extend beneath Mesita del Buey. The moisture-access holes in Cañada del Buey were dry when drilled and document that shallow perched groundwater does not appear to be present at depth. Boreholes drilled on Mesita del Buey at TA-54 have confirmed that no saturated groundwater zones are present at the level of the perched alluvial groundwater.

Hydrologic characteristics of the shallow alluvial groundwater in Cañada del Buey, such as permeability and transmissivity, have not been determined. However, it is likely that hydrologic characteristics of the alluvium in Cañada del Buey are similar to those properties calculated from slug tests performed on alluvial observation wells in Los Alamos Canyon. The mean hydraulic conductivity obtained from five slug tests of alluvial wells in Los Alamos Canyon was 3.2 E–04 ft/sec (9.6 E–05 m/sec). Using a gradient of 0.027, which is equivalent to the slope of the steam channel, and an assumed porosity of 0.3, the average rate of groundwater movement in the alluvium in Los Alamos Canyon was estimated to be approximately 900 ft (270 m) per year (Gallaher 1995, 49679).

Figure A-3 also shows transverse cross sections of the alluvium-filled channel at the lines of wells where information about the shape of the channel is known. The groundwater observed in wells CDBO-6 and CDBO-7 may be restricted to a narrow ribbon of saturation present below the V-shaped channel in the middle canyon or may be locally planar in nature. The width of the saturated zone has not been determined; the saturated thickness varies from a few feet to about 10 ft (3 m).

The observed water level fluctuations show that the perched saturated conditions beneath the canyon in wells CDBO-6 and CDBO-7 have been declining over the past few years. The nature of deposition of the alluvial sediments (shifting streambed and overbank flood deposits) indicates that a high degree of heterogeneity in the physical characteristics of the perched groundwater body is likely. Groundwater flow in the alluvium and subsurface units is probably controlled by highly conductive zones such as buried stream channels, braided deposits, point-bar deposits, or fractures in deeper units. The flow may be limited in portions of the alluvium by finer-grained deposits such as floodplain and overbank deposits.

Currently, two groundwater wells are sampled as part of the Laboratory's routine monitoring program. These include CDBO-6, which is completed (screened) to a depth of 44 ft (13.4 m) and CDBO-7, which is completed to a depth of 39 ft (11.9 m). The depths to water in these wells typically range from 32 to 40 ft (10 to 12 m). The sampling results are discussed in Section 3.5.4.3.1.

3.5.4.3 Relationship Between Alluvium and Bedrock Stratigraphic Units in Cañada del Buey

Figure A-3 shows the bedrock stratigraphic units identified during borehole drilling for the test holes around Cañada del Buey and the alluvial monitoring wells (Purtymun 1995, 45344, p. 113). The cross section shows the location and depth of the wells and the gamma log traces adjacent to the boreholes. The figure also shows the approximate base of the alluvium at the deepest part of the canyon (generally near the center of the canyon). Regionally, the Tsankawi Pumice Bed and the Cerro Toledo interval are present at the base of the Tshirege Member; however, none of the deep municipal supply wells drilled in the vicinity of Cañada del Buey identified the presence of these units because when the deep wells were drilled the presence of these units in the subsurface was not well documented.

Boreholes drilled at TA-54 on Mesita del Buey have confirmed the presence of the Tsankawi Pumice Bed and the Cerro Toledo interval. Stratigraphic data from these boreholes have been compiled into a site-wide geologic model (see Appendix E). Data from the model were extrapolated southward to determine the approximate subsurface stratigraphy in the Cañada del Buey area. The stratigraphic data points obtained from the site-wide geologic model are shown as single vertical lines with tick marks at the tops of stratigraphic units on the longitudinal cross section of Cañada del Buey in Figure A-3. The cross section shows the approximate stratigraphic position of the Tsankawi Pumice Bed and the Cerro Toledo interval in the Cañada del Buey area. Table D-6 lists the revised stratigraphic picks that are interpreted to have been encountered in the deep boreholes in the Cañada del Buey area.

The cross section shows the projected position of the stratigraphic contact between the base of the Tshirege Member and the Tsankawi Pumice Bed/Cerro Toledo interval in the Cañada del Buey area. Based on this projection and on outcrops of the bedrock units, the base of the alluvium intersects the Tsankawi Pumice Bed/Cerro Toledo interval in lower Cañada del Buey near CDBO-4. Boreholes drilled west of CDBO-4 will probably encounter a thin, weathered section of the Tshirege Qbt 1g unit, which may be too thin to recognize in auger cuttings, and will then penetrate into the Tsankawi Pumice bed and the Cerro Toledo interval. The upper part of the Cerro Toledo interval consists of well-stratified tuffaceous sandstones, siltstones, and primary ash-fall and pumice-fall deposits as described in Section 3.3.1.4. In auger cuttings these deposits may be difficult to distinguish from the alluvial sediments. In the lower canyon the Cerro Toledo interval and the Otowi Member pinch-out eastward against a basalt high that is located near the intersection of Pajarito Road and state road NM4 (Broxton and Reneau 1996, 55429, p. 329). These units usually have a southeastward dip similar to the regional dip of the Bandelier Tuff. However, in lower Cañada del Buey a localized reversal of dip toward the north or south may occur on the western flank of the basalt high (see Figure A-3). Locally beneath lower Cañada del Buey this may direct possible flow in the Cerro Toledo interval to the north or south around the basalt high.

The intersection of the alluvium and the Cerro Toledo interval demarks potentially differing hydrogeologic units to the west and to the east. West of this intersection, the Cerro Toledo interval may be present as a separate hydrogeologic unit. However, east of the intersection the alluvial hydrogeologic unit may merge with the Cerro Toledo interval to form a single hydrogeologic unit. If these hydrogeologic units merge, lateral flows of groundwater in this combined hydrogeologic unit may be controlled by the geometry and orientation of paleochannels in the Cerro Toledo interval. Efforts to characterize the fate of flow and contaminants in the alluvium will consider the probability that paleochannels within the Cerro Toledo interval do not coincide with the orientation of Cañada del Buey, thus creating potential lateral pathways for groundwater flow away from the canyon.

3.5.4.4 Geochemistry of Alluvial/Shallow Perched Groundwater in Cañada del Buey

This section discusses the geochemistry of alluvial groundwater in Cañada del Buey. Since 1992 personnel from ESH-18 (or its predecessor) have routinely collected unfiltered water samples from alluvial wells CDBO-6 and CDBO-7. This discussion focuses on temporal and spatial variations in major ion chemistry, uranium, and radionuclide distributions in alluvial groundwater.

3.5.4.4.1 Results of Environmental Surveillance Sampling of Alluvial Groundwater in Cañada del Buey

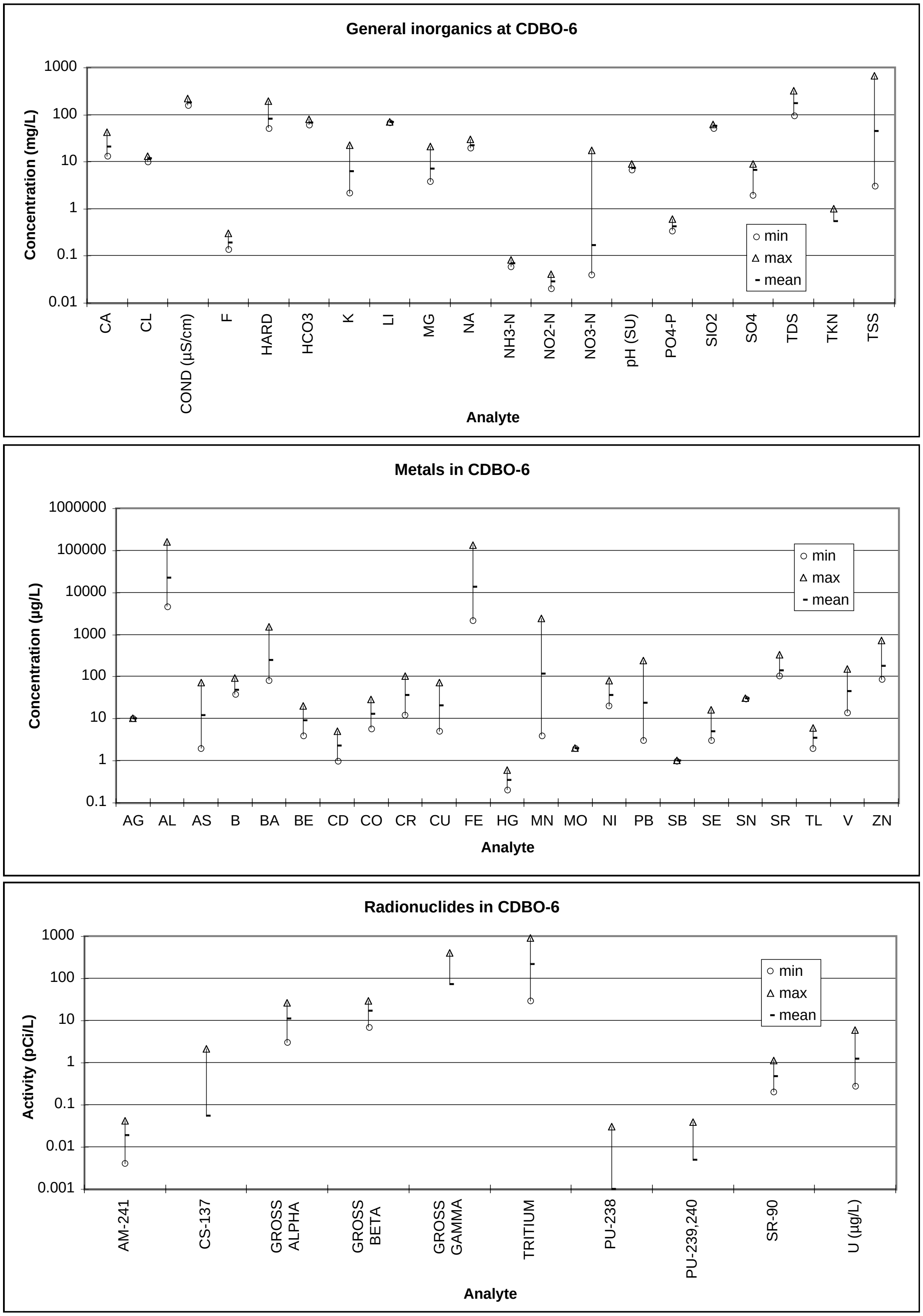
Since 1992, ESH-18 personnel have collected groundwater samples from CDBO-6 and CDBO-7. The samples typically are analyzed for general inorganic constituents, major and trace metals, and radionuclides. Results of the analyses have been reported in the annual environmental surveillance reports (e.g., Environmental Surveillance and Compliance Programs 1997, 56684). Most samples collected have not been filtered (UF samples) before analysis, or have been acidified at the time of collection and later filtered in the laboratory prior to analysis (AF samples), so relatively wide ranges of concentrations of some analytes have been measured. Background data are not yet available for comparison with alluvial groundwater upgradient from the Laboratory; therefore, comparison discussion of environmental surveillance report data in Cañada del Buey is not possible.

Figure 3.5.4-2 summarizes the results of sampling CDBO-6 for water quality parameters, major and trace metals, and radionuclides. This figure and Figures 3.5.4-3 and 3.5.4.4 show the minimum, maximum, and average values obtained from the annual environmental surveillance sampling. Water quality parameters observed at CDBO-6 show a relatively narrow range in concentration for most parameters. The widest range in concentration has been for potassium (2 mg/L to 22 mg/L) and nitrate (as N), which has ranged from 0.04 mg/L to 17 mg/L, with a mean concentration of 0.17 mg/L nitrate (as N). Most results for nitrate (as N) have been less than 0.2 mg/L, but one result in August 1995 was 17 mg/L. Three analyses for total suspended sediment (TSS) resulted in 3 mg/L in 1995, 46 mg/L in 1996, and 660 mg/L in 1997. This is likely the result of sampling techniques at the time of collection.

Since 1995 all concentrations of the water quality parameters are within New Mexico Water Quality Control Commission (NMWQCC) standards. TDS concentrations at CDBO-6 ranged from 96 mg/L to 322 mg/L and average 177 mg/L. Most results for metals concentrations also range approximately an order of magnitude, except aluminum, iron, manganese, and lead, which vary approximately two orders of magnitude. This is likely caused by the collection of unfiltered samples. The highest measured activity of plutonium-238 was 0.03 pCi/L in 1993, and the highest activity of plutonium-239,240 was 0.039 pCi/L in 1994. The results of tritium analyses by liquid scintillation techniques have normally been near detection limits; the highest activity recorded was 400 pCi/L in 1992.

Figure 3.5.4-3 summarizes the results of sampling CDBO-7. The concentrations of TDS at CDBO-7 range from 196 mg/L to 220 mg/L and average 207 mg/L, which is very similar to CDBO-6. The results of analyses for trace metals are also similar to the groundwater in CDBO-6. The highest measured activity of plutonium-238 was 0.034 pCi/L in 1994, and the highest activity of plutonium-239,240 was 0.014 pCi/L in 1995. The results of tritium analyses by liquid scintillation techniques have normally been near detection limits; the highest activity recorded was 500 pCi/L in 1995. In 1997 a possible detection of gross alpha activity (50.4 pCi/L) and strontium-90 (5.2 pCi/L), and slightly elevated gross beta activity (57.1 pCi/L) was observed in CDBO-7 (Environmental Surveillance and Compliance Programs 1998, 59904, pp. 137 through 138, 188.)

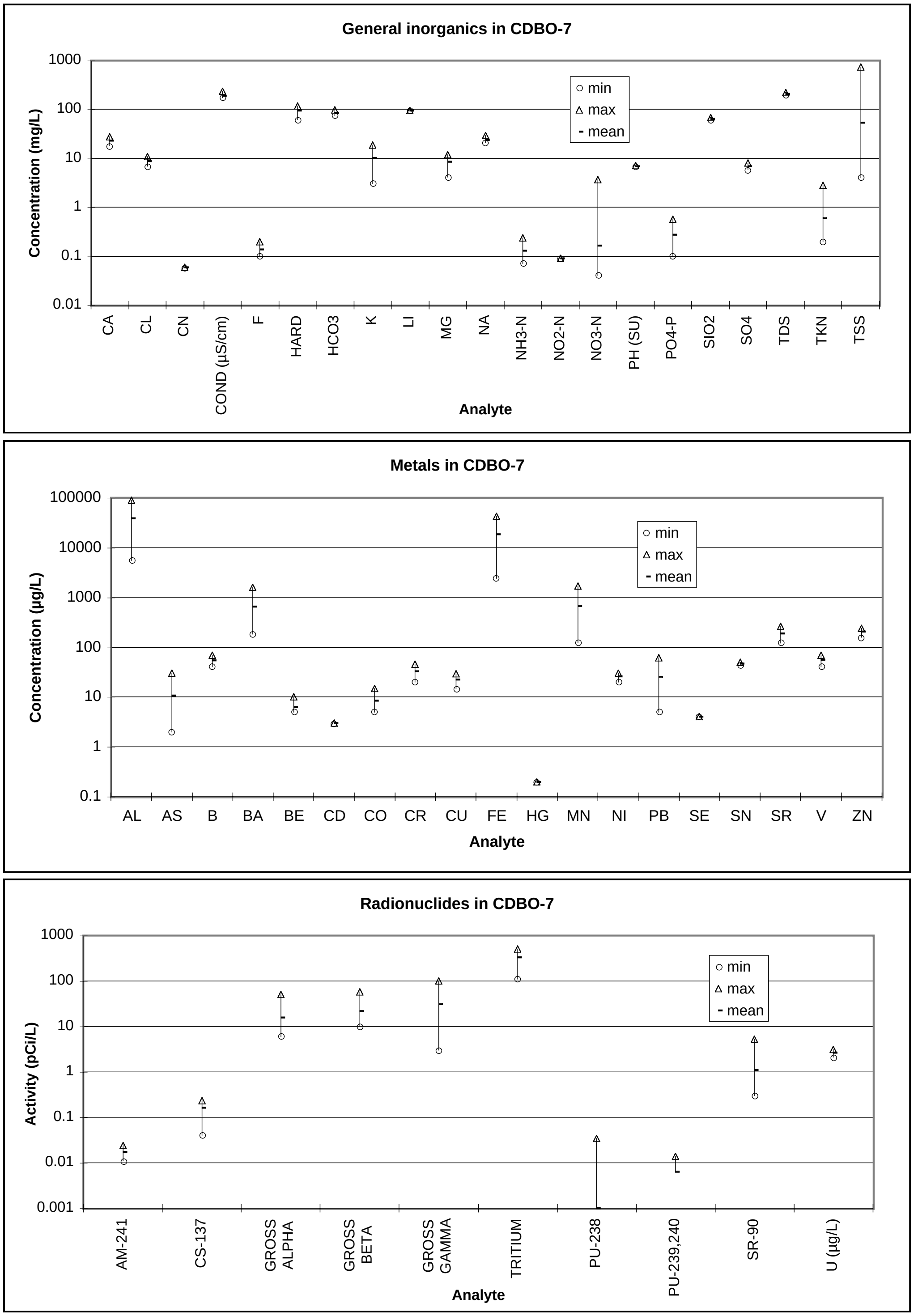
Figure 3.5.4-4 shows the comparisons of the mean concentration measured for water quality parameters, metals, and radionuclides from 1992 to 1997 in each of the CDBO wells. Generally, CDBO-7 contains slightly higher concentrations of water quality parameters, trace metals, and radionuclides, which may be attributable to longer residence time in the alluvium and/or bedrock units. Mean trace metal concentrations that are lower in CDBO-7 than in CDBO-6 include beryllium, cobalt, chromium, mercury, nickel, and selenium, although the differences in concentration are small. Slightly lower activities of americium-241 and gross gamma are observed in the shallow perched groundwater at CDBO-7, but slight increases in activities of other radionuclides are observed. Significant increases in radionuclides in the perched groundwater down canyon from CDBO-6 to CDBO-7 are not observed.



COND = specific conductance.	TKN = total kjeldahl nitrogen.	TSS = total suspended solids.
HARD = hardness.	TDS = total dissolved solids.	
pH is measured in standard units.		

Source: Environmental surveillance reports 1992–1997.

Figure 3.5.4-2. Summary of environmental surveillance sampling of shallow perched groundwater at CDBO-6.

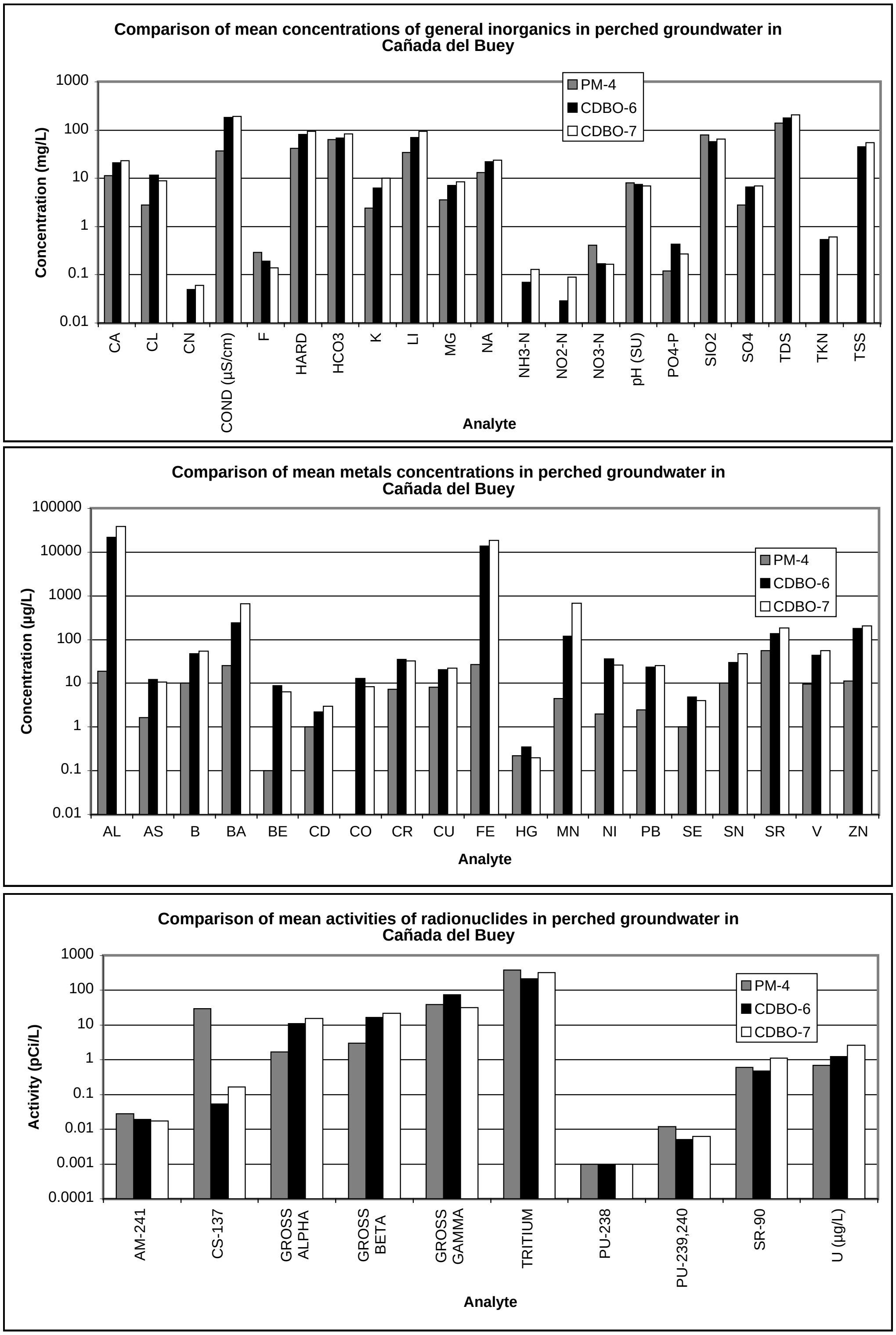


COND = specific conductance.	SU = standard units	TDS = total dissolved solids.
HARD = hardness.	TKN = total kjeldahl nitrogen.	TSS = total suspended solids.

pH is measured in standard units.

Source: Environmental surveillance reports 1993–1997.

Figure 3.5.4-3. Summary of environmental surveillance sampling of shallow perched groundwater at CDBO-7.



COND = specific conductance.
HARD = hardness.
pH is measured in standard units.
TKN = total kjeldahl nitrogen.
TDS = total dissolved solids.
TSS = total suspended solids.

Source: Environmental surveillance reports 1986–1997.

Figure 3.5.4-4. Comparison of mean concentrations of constituents in perched groundwater at CDBO-6, CDBO-7, and regional aquifer water from PM-4.

Also shown on Figure 3.5.4-4 are the mean concentrations measured for water quality parameters, metals, and radionuclides from the regional aquifer at PM-4 from 1982 to 1997. The mean values observed in the groundwater from PM-4 are compared with the shallow perched groundwater because it has been suggested that the perched groundwater is the result of purging municipal supply well PM-4. The groundwater sample collection method was similar to the method used to collect samples from the wells in Cañada del Buey. For metals analyses, AF samples were collected before 1993;since 1993 unfiltered (UF) samples have been collected. For radionuclide analyses, AF samples were collected before 1996 and unfiltered (UF) samples were collected in 1997.

In general, the regional aquifer groundwater contains significantly lower concentrations of general water quality parameters and trace metals. Constituents that are measured in higher concentrations in the regional aquifer than in the shallow perched groundwater in Cañada del Buey were fluoride, nitrate (as N), and silicate. Several trace metals are measured in the regional aquifer at mean concentrations that are at least an order of magnitude lower in concentrations than were observed in the perched groundwater; these constituents include aluminum, arsenic, barium, beryllium, iron, manganese, nickel, lead, and zinc. The mean activities of americium-241 and cesium-137 in the regional aquifer at PM-4 are about an order of magnitude higher that those observed in the perched groundwater. Tritium activities in the perched groundwater and the regional aquifer are near the detection limit using liquid scintillation techniques, and the results are not significantly different. The mean concentration of total uranium in the regional aquifer is slightly less than the mean concentrations of uranium observed in the perched groundwater. No significant differences in the mean activities of plutonium-238, plutonium-239,240, and strontium-90 are observed.

The comparison of the constituents in the shallow perched groundwater in Cañada del Buey with those in the regional aquifer from well PM-4 appears to support the suggestion that the perched groundwater could be the result of purging PM-4 (Environmental Protection Group 1994, 45363, p. 230; Purtymun 1995, 45344, p. 114). The purged regional aquifer water that is discharged to Cañada del Buey probably dissolves constituents in the sediments and increases in concentration in most general groundwater constituents and trace metals due to a residence time in the alluvium and/or bedrock units. Increases in sodium and chloride may be due to runoff from road salt used on Pajarito road and the access road to TA-54 on Mesita del Buey. An unknown percentage of the shallow perched groundwater in Canada del Buey likely comes from snowmelt and stormwater runoff.

3.5.4.4.2 RFI Sampling of Alluvial Groundwater in Cañada del Buey

No RFI has been conducted in Cañada del Buey and therefore no RFI data are available for the alluvial groundwater in Cañada del Buey.

3.5.4.5 Summary of Alluvial/Shallow Perched Groundwater System in Cañada del Buey and Data-Collection Activities Needed to Understand the Alluvial Groundwater System

Known information about the alluvial groundwater in Cañada del Buey is summarized below.

- A total of nine alluvial/shallow perched groundwater monitoring wells were installed in Cañada del Buey in 1985 and 1992 for environmental surveillance purposes.
- Two groundwater monitoring wells in Cañada del Buey contain shallow perched groundwater. The water does not appear to be perched within the alluvium, but rather is perched in weathered tuff, which probably correlates to the colonnade tuff at the base of Unit 1v.

- The known extent of the shallow perched groundwater body in Cañada del Buey is from CDBO-6 near PM-4 downstream to at least CDBO-7, a distance of approximately 2000 ft (600 m).
- Shallow monitor well CDBO-8 may not be located appropriately in the canyon to encounter the shallow perched groundwater. Therefore, the shallow perched groundwater may extend for an unknown distance downstream from CDBO-7.
- The source of the shallow perched groundwater in Cañada del Buey is partially from discharges of regional aquifer water from municipal supply well PM-4. The chemistry of the shallow perched groundwater and the regional aquifer water from PM-4 are similar, but the shallow perched groundwater contains higher concentrations of most constituents, which could be from stormwater and snowmelt runoff.
- There are no known shallow perched groundwater discharge points in Cañada del Buey. Infiltration into deeper bedrock units is the likely source of loss of the shallow perched groundwater. An unknown volume of alluvial groundwater is hypothesized to seep downward into subsurface units.
- The Bandelier Tuff underlies the alluvium throughout most of the canyon. However, in lower Cañada del Buey near well CDBO-4 and eastward, the Cerro Toledo interval is likely to be present beneath the alluvium. This unit may provide an enhanced infiltration pathway and lateral groundwater flowpaths for movement of alluvial groundwater into the subsurface.

The following additional data-collection activities are needed to understand the alluvial groundwater in Cañada del Buey.

- To characterize and understand the movement of shallow perched groundwater in Cañada del Buey, an additional shallow groundwater monitor well may be needed in middle Cañada del Buey near CDBO-8. Intact core samples of alluvial and suballuvial material will be needed during well borehole drilling for hydrologic-property analysis (saturated hydraulic conductivity, effective porosity, and specific yield). Data from these boreholes will enhance understanding of the groundwater flow model of the shallow perched groundwater. Transducers may be installed in selected wells to continuously monitor water level fluctuations.
- Shallow perched groundwater samples may be needed to determine water quality and seasonal water quality changes.

3.5.4.6 Deep Unsaturated Zones and Possible Intermediate Perched Zones

Understanding the hydrogeologic properties of the unsaturated zone of the Bandelier Tuff and other units present beneath Cañada del Buey is important because the unsaturated zone may serve as either a barrier or a conduit to the vertical and horizontal movement of alluvial groundwater or to potential transient perched intermediate groundwater zones beneath the canyons.

The following features of the unsaturated tuff control the rates of vertical contaminant transport (Kearl et al. 1986, 8414):

- physical properties (density, porosity, and specific gravity);
- hydraulic properties (saturated and unsaturated permeabilities, conductivities, and moisture characteristic curves);

- properties of fractures and joints (frequency, orientation, degree of interconnectedness, and filling materials);
- properties of unit contacts or paleosurfaces (flow paths or barriers);
- geochemical properties (specific surface area, ion exchange capacity, retardation factors, and mineralogy); and
- depth to groundwater.

Intermediate Perched Zones in Cañada del Buey

The shallow perched groundwater discussed in Section 3.5.4.2 may be regarded as an intermediate perched zone. However additional information about this shallow perched groundwater zone is needed to determine if it is an intermediate zone. To date, no other perched intermediate zones of saturation have been delineated beneath Cañada del Buey.

A possible intermediate wet zone was reported in a slant borehole that was drilled beneath Mesita del Buey from the south fork of Cañada del Buey. On March 9, 1995, a small intermediate perched groundwater zone was encountered in borehole 54-1016. This borehole was drilled in the south fork of Cañada del Buey at an angle toward the south to intercept units beneath MDA L. The borehole was drilled to monitor the presence of VOCs as part of the RFI for OU 1148. A small pocket of groundwater was encountered in basalt within the Puye Formation at a depth of 592 ft (178 m), which was at an elevation of approximately 6188 ft (1856 m) (see Figure A-3). After encountering the water, drilling operations were halted until the next day when an attempt was made to obtain a sample of the water. However, no water accumulated in the borehole overnight and no water was present for sampling the next day. The borehole was drilled to a total angle depth of 605 ft (182 m) and was completed as a vapor monitoring well. A water sample collection port was installed at 600 ft (180 m), just below the occurrence of the wet zone (LANL 1995, 45978). The regional water table beneath the location of borehole 54-1016 is approximately 340 ft (102 m) below this possible intermediate perched zone at an approximate elevation of 5850 ft (1755 m).

Additionally, two boreholes near TA-18 in Pajarito Canyon just south of Cañada del Buey may have encountered perched intermediate groundwater. In borehole SHB-4, wet core samples were retrieved from the interval 125 ft to 145 ft (38 m to 44 m) within the Cerro Toledo interval (Gardner et al. 1993, 12582, p. 16). In PM-2 a possible wet zone was reported as “a show of water at 335 ft” (102 m), which may indicate a zone of intermediate perched groundwater (Cooper et al. 1965, 8582, p. 56; Davis et al. 1996, 55446, p. 38). The pilot hole for this well was drilled using cable tools to a depth of 617 ft (185 m). No other mention of water in the unsaturated zone is found in the descriptive log of drill cuttings for this well (Cooper et al. 1965, 8582, pp. 55 through 61). Electrical resistivity (geophysical) logs of the borehole at PM-2 did not confirm the presence of water at 335 ft (102 m). The middle of the Otowi Member is present in PM-2 at a depth of 335 ft (102 m); this zone has not been observed to contain perched groundwater in other boreholes on the Pajarito Plateau.

At the location of PM-4 and CDBO-6 there is approximately 900 ft (275 m) of unsaturated volcanic tuff, sediments, and basaltic rocks between the perched water in Cañada del Buey and the top of the regional zone of saturation. However, the vadose zone in the Cañada del Buey area has not been well characterized and the subsurface geology and stratigraphy directly beneath Cañada del Buey is largely undetermined. Therefore, the presence of possible perched intermediate saturated zones beneath Cañada del Buey has not been determined. Information from nearby deep boreholes is shown on

Figure A-3, which shows the approximate volcanic stratigraphy beneath the Bandelier Tuff. Lower Cañada del Buey is underlain by Cerros del Rio basalt flows intercalated with the Puye Formation, whereas the upper and middle canyon are underlain by thick sequences of the Bandelier Tuff.

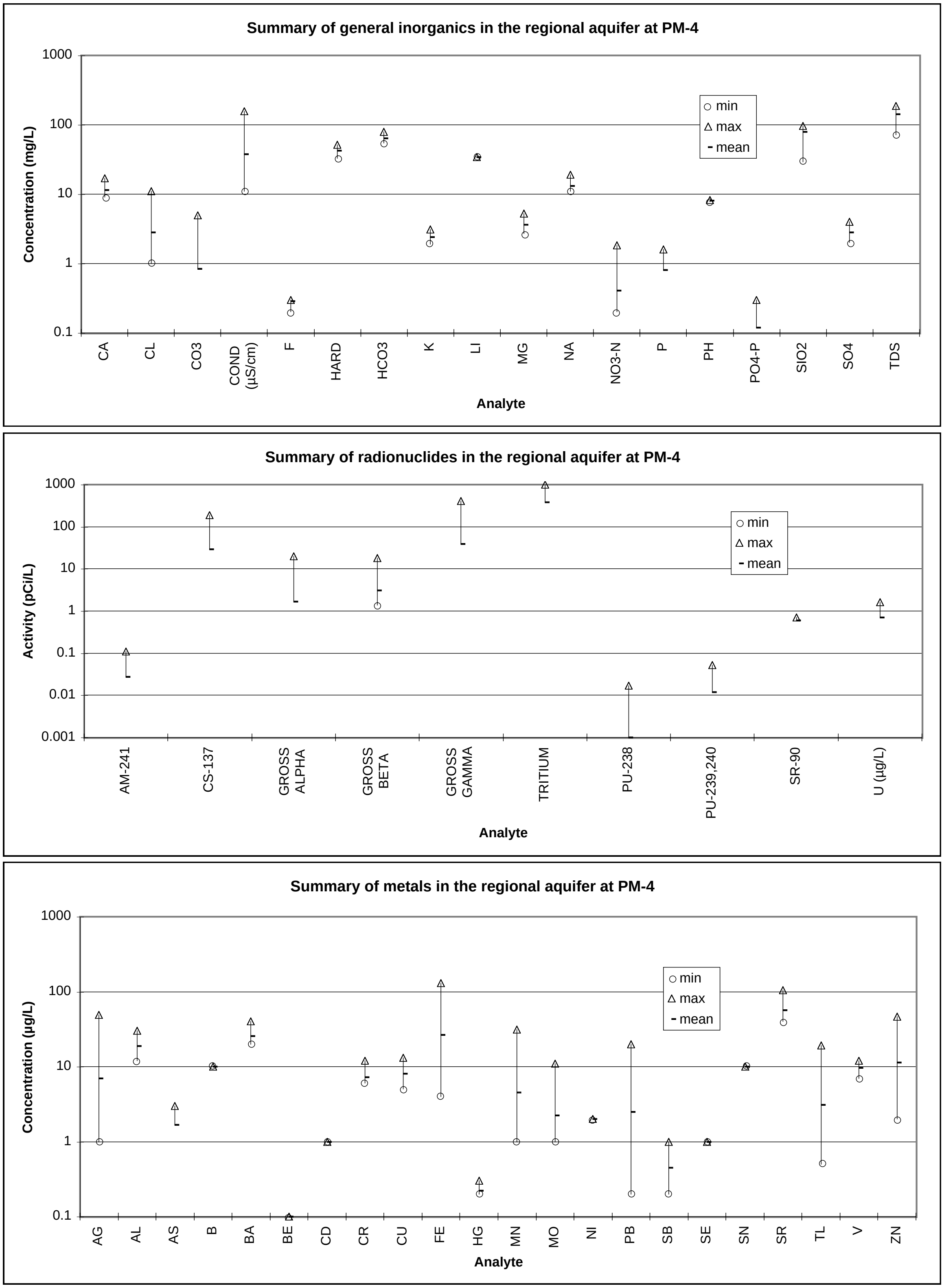
3.5.4.7 Regional Aquifer

A discussion of the regional aquifer is presented in Section 3.4.4.6.

Environmental Sampling of the Regional Aquifer in Cañada del Buey

A summary of the results of the analyses of groundwater from PM-4 since sampling began in 1982 is shown in Figure 3.5.4-5. The water from the regional aquifer at PM-4 has ranged in TDS from 72 mg/L to 188 mg/L and the nitrate (as N) has been less than 1.8 mg/L, with a mean value of 0.40 mg/L. Radionuclides have typically been measured at very low levels at or near the detection limits for each radionuclide. The highest measured activity of cesium-137 was 189 pCi/L (±120 pCi/L) in 1991. Several results for cesium-137 in the regional aquifer in 1991 were unusually elevated; the measurements were believed to be suspect due to large counting uncertainties (Environmental Protection Group 1993, 23249, p. VII-6). Tritium has been observed in activities as high as 1000 pCi/L (±800 pCi/L) in 1984. Tritium activity has usually been measured at or below detection limits using the liquid scintillation method. In 1995 an elevated activity of 0.109 pCi/L ± 0.028 pCi/L of americium-241 was measured. The sample was reanalyzed and the result was 0.023 pCi/L ± 0.009 pCi/L (Environmental Surveillance Program 1996, 55333, p. 160). Also in 1995, the activities of plutonium-238 and plutonium-239,240 were measured above detection limits at 0.017 pCi/L (±0.006 pCi/L) and 0.052 pCi/L (±0.025 pCi/L), respectively. The samples were reanalyzed and the plutonium-239,240 activity was measured 0.023 (±0.009) pCi/L. The elevated plutonium activities may be the result of large counting uncertainties in the measurements at the low levels of radionuclides that occur in the regional aquifer (Environmental Surveillance Program 1996, 55333, pp. 159 and 198). The highest measured activity of strontium-90 was 0.7 pCi/L in 1996, below the EPA primary drinking water standard for strontium-90 of 8 pCi/L (e.g., Environmental Surveillance Program 1996, 55333, pp. 198 through 201). The highest concentration of uranium measured at PM-4 was 1.6 µg/L in 1984 and the average value measured was 0.7 µg/L. Metal concentrations measured in the regional aquifer at PM-4 have been generally less than 100 µg/L.

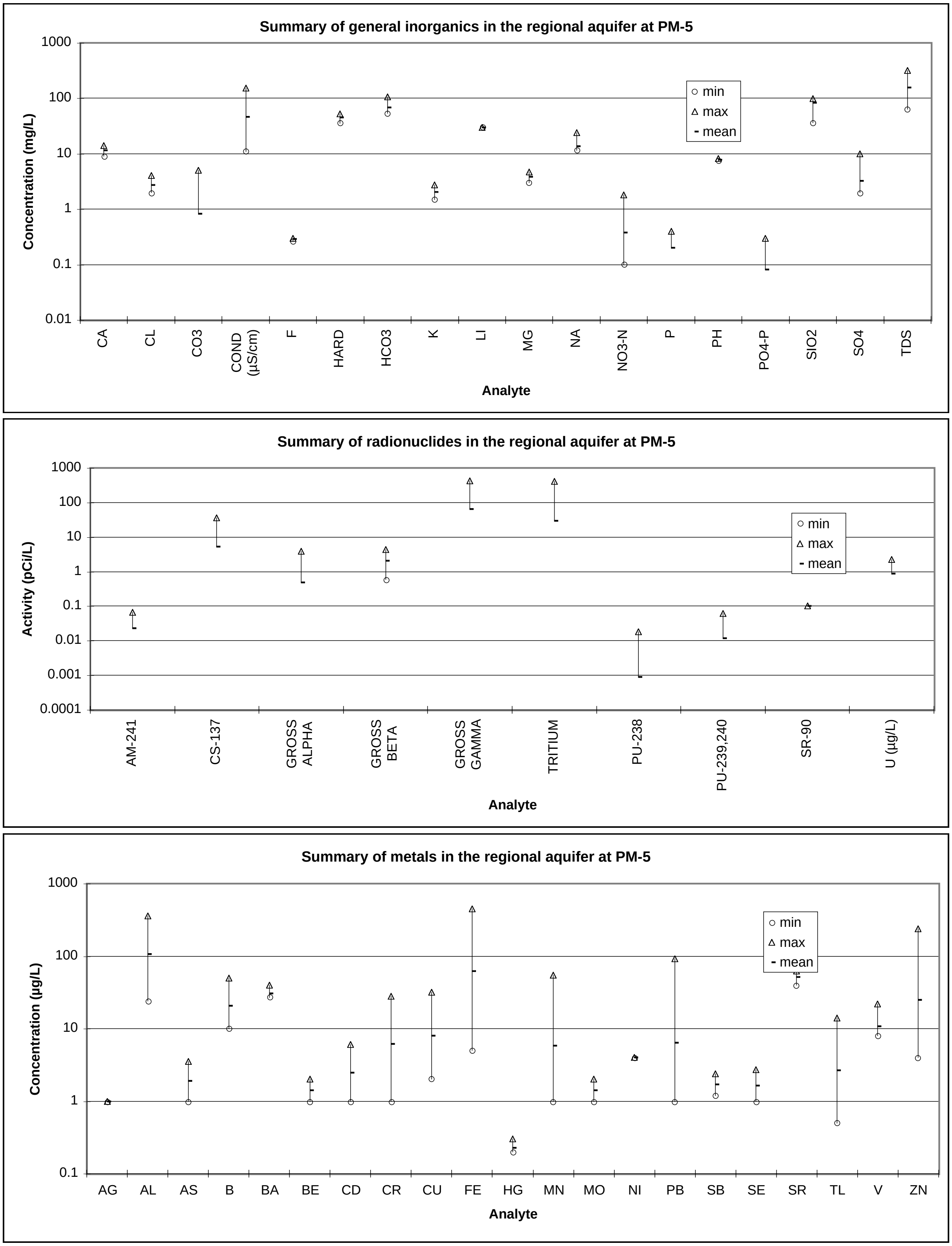
A summary of the results of the analyses of groundwater from PM-5 since sampling began in 1982 is shown in Figure 3.5.4-6. The water from the regional aquifer at PM-4 has ranged in TDS from 64 mg/L to 320 mg/L and the nitrate (as N) has been less than 1.8 mg/L, with a mean value of 0.38 mg/L. Radionuclides have typically been measured at very low levels at or near the detection limits for each radionuclide. The highest measured activity of cesium-137 was 36 pCi/L (±34 pCi/L) in 1982. Tritium activity has usually been measured at or below detection limits using the liquid scintillation method. The activities of plutonium-238 and plutonium-239,240 have been measured near detection limits. The highest measured activity of strontium-90 was 0.1 pCi/L in 1996, well below the EPA primary drinking water standard for strontium-90 of 8 pCi/L (e.g., Environmental Surveillance Program 1996, 55333, pp. 198 through 201). The highest measured uranium concentration at PM-5 was 2.2 µg/L in 1984 and the average value measured was 0.9 µg/L. Metal concentrations measured in the regional aquifer at PM-5 have been generally less that 100 µg/L except for one value of 237 µg/L zinc in 1990; the mean zinc value observed was 25 µg/L.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness.

Source: Environmental surveillance reports 1982–1997.

Figure 3.5.4-5. Summary of results from the regional aquifer at PM-4.



COND = specific conductance. TDS = total dissolved solids.
HARD = hardness.

Source: Environmental surveillance reports 1982–1997.

Figure 3.5.4-6. Summary of results from the regional aquifer at PM-5.

A comparison of the mean concentrations of general inorganic water quality parameters, radionuclides, and metals, in groundwater at PM-4 and PM-5 is shown in Figure 3.4.4-5. This figure also shows the mean concentrations of analytes in the regional aquifer at PM-1, PM-3, and Sandia Spring for comparison. The comparison of the general inorganic water quality parameters of the regional aquifer beneath Cañada del Buey shows that concentrations of water quality parameters are similar at PM-4 and PM-5 for all analytes. When compared to PM-1 and PM-3, PM-4 and PM-5 contain lower concentrations of most general water quality parameters including calcium, chloride, hardness, bicarbonate, potassium, magnesium, sodium, sulfate, and TDS. PM-4 and PM-5 also have lower conductivity. Radionuclide constituents are also similar in the groundwater at PM-4 and PM-5, which are also similar to PM-1 and PM-3; the radionuclide activities are at or near detection limits. The concentrations of most trace elements and metals are also similar at PM-4 and PM-5, and most trace elements are similar to those measured at PM-1 and PM-3. The mean concentrations of elemental strontium at PM-4 and PM-5 are lower than at PM-1 and PM-3 and the mean concentrations of thallium are higher at PM-4 and PM-5 than at PM-1 and PM-3.

3.5.4.8 Summary of the Hydrology of Cañada del Buey and Data-Collection Activities Needed to Understand the Hydrogeology

The hydrology of Cañada del Buey is summarized below.

- The primary inputs to the groundwater in Cañada del Buey are liquid discharges from Laboratory operations and contemporary precipitation as snowmelt or stormwater runoff.

- Shallow perched groundwater is present in middle Cañada del Buey where stormwater, snowmelt runoff, and discharges from municipal supply well PM-4 accumulate.

- Most water entering the canyons is lost to either ET or to seepage into deeper units because surface flow out of each canyon at state road NM4 is ephemeral and in recent years has occurred only after significant storm events. The amount and fate of water leaving the alluvium or shallow perched zone are not known.

- Intermediate perched groundwater may be present beneath Cañada del Buey in several subsurface units, including local perched zones within units of the Tshirege Member (Qbt 1v), the Cerro Toledo interval, and the Puye Formation.

- The regional aquifer extends beneath the Cañada del Buey watershed. The regional aquifer is pumped at supply wells PM-4 and PM-5 in the vicinity of upper Cañada del Buey. The upper portion of the regional aquifer probably discharges from springs (Spring 2 and Spring 3) below the confluence of Mortandad Canyon and the Rio Grande.

The following additional data-collection activities are needed to understand the subsurface hydrology of Cañada del Buey.

- The lithology and stratigraphy of bedrock units needs to be better understood to adequately characterize the hydrogeologic system and to provide input to hydrogeologic models. Data on the lithology, stratigraphy, and hydraulic properties and geotechnical properties (including bulk density, porosity, saturated and unsaturated hydraulic conductivity, moisture content, storativity or specific yield, and matric potential) are needed. These data may be obtained from laboratory analyses of borehole core samples and by aquifer performance testing.

- Water samples need to be collected from the alluvial groundwater, the regional aquifer, and any other saturated zones encountered. The samples need to be both filtered in the field and unfiltered followed by preservation of appropriate aliquots to provide appropriate data on dissolved and suspended constituent concentrations. Analyses for colloidal materials are needed to provide data on possible colloidal transport of contaminants.
- If possible, water samples should be collected from the top 20 ft (6.1 m) of the regional aquifer in PM-4 and PM-5 to sample water from the upper portion of the regional aquifer. Time-series sampling (48 hours) should be conducted for analysis of inorganic chemicals and radionuclides.

3.5.5 Air Monitoring Investigations in Cañada del Buey

3.5.5.1 AIRNET Monitoring

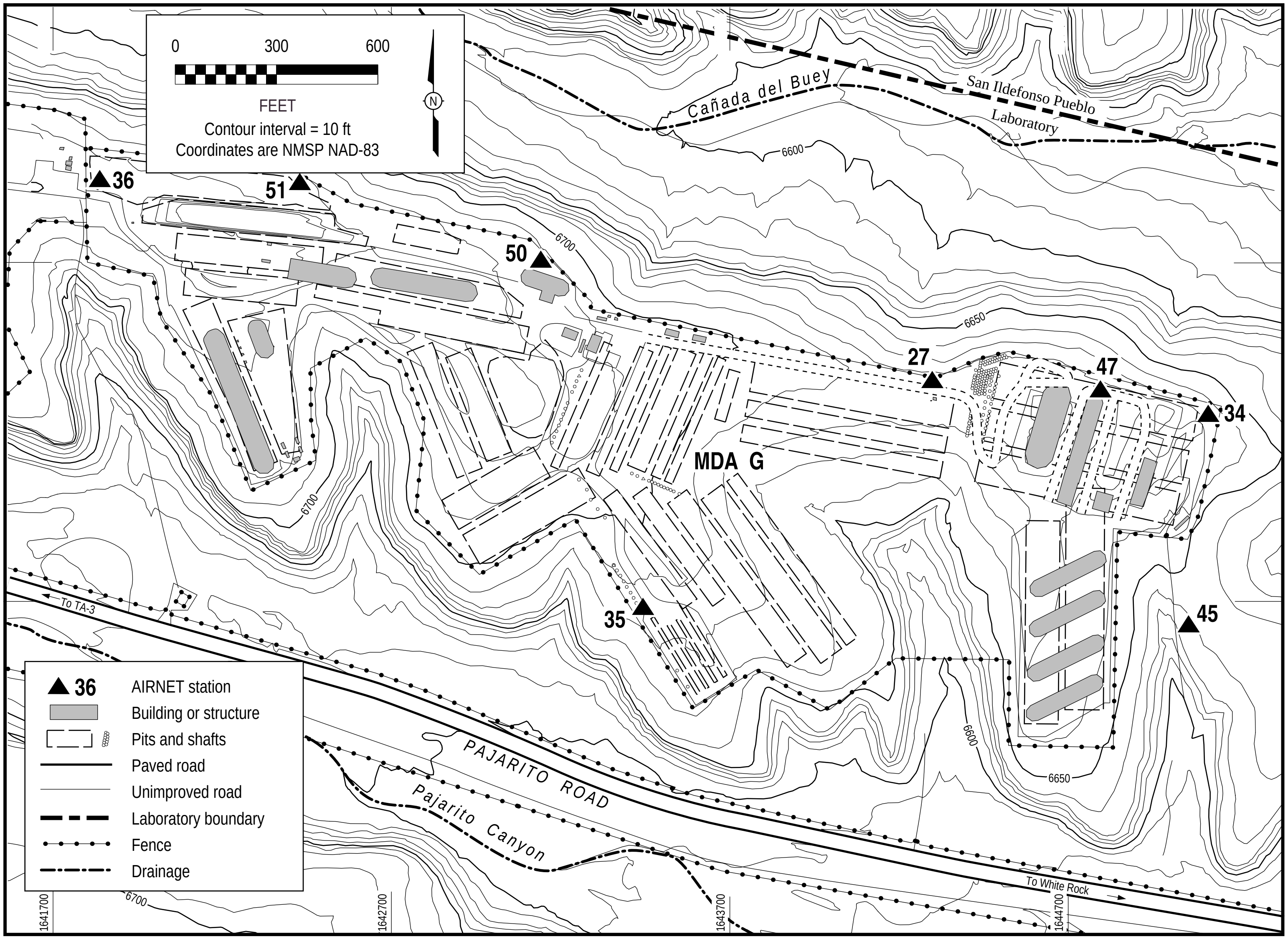
The Laboratory operates a network of more than 50 environmental air monitoring stations (called AIRNET) to sample radionuclides in ambient air. A description of the monitoring program is presented in Section 3.4.5.1.

The environmental surveillance program monitors 13 air stations within the Cañada del Buey watershed annually. Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239,240; uranium-234; uranium-235; and uranium-238. A summary of air monitoring stations within the Cañada del Buey watersheds is presented in Table 3.5.5-1. The station locations are shown in Figures 3.4.5-1 and 3.5.5-1.

Table 3.5.5-1
Cañada del Buey Air Monitoring Stations

Station Number	Station Location	Station Type
13	Piñon School	Perimeter
15	White Rock Fire Station	Perimeter
27	TA-54 MDA G	On-site
30	Pajarito Booster 2 (P-2)	On-site
34	TA-54 MDA G-1 (behind trailer)	On-site
35	TA-54 MDA G-2 (back fence)	On-site
36	TA-54 MDA G-3 (by office)	On-site
37	TA-54 MDA G-4 (water tank)	On-site
38	TA-54 MDA G (adjacent to station 27)	On-site
45	MDA G (Southeast Perimeter)	On-site
47	MDA G (North Perimeter)	On-site
50	TA-54 MDA G	On-site
51	TA-54 MDA G	On-site

Source: Environmental Surveillance and Compliance Programs 1997, 56684, pp. 76 through 77.



Source: FIMAD G104546; Environmental Surveillance and Compliance Programs 1997, 56684.

F3.5.5-1 / SANDIA & CDB WP / 070999 / PTM

Figure 3.5.5-1. Locations of AIRNET stations in Cañada del Buey.

In 1996 several of the results of air sampling exceeded investigation levels established by the Laboratory Air Quality Group (ESH-17). Two such instances occurred within or adjacent to the Cañada del Buey watershed. At station 27, located on-site at MDA G, air concentrations of americium-241 and plutonium-239 have been increasing since 1995. During 1995 and 1996 average air concentrations of americium-241 and plutonium-239 increased from 11 aCi/m^3 for each radionuclide to approximately 600 aCi/m^3 and 900 aCi/m^3, respectively. A ground survey of the vicinity revealed a small area a few tens of meters from the station that had soil contamination at levels approximately 100 times the average concentrations of nearby soils. After investigation, it was determined that trenching operations related to the installation of water lines were conducted in this area during 1995 and 1996, and the nearby road had been rerouted in early 1996. The construction activity correlated with the initial and subsequent observed increases in air concentrations. Evidently the trenching or the roadwork had brought some contaminated material to the surface. A remedial action that included covering the area with clean dirt followed by additional monitoring is discussed in the 1996 environmental surveillance report (Environmental Surveillance and Compliance Programs 1997, 56684, pp. 59 through 62). The increase in air concentrations appeared to be localized and was limited to americium-241 and plutonium-239; no other radionuclides were elevated significantly at station 27. Other monitoring stations at MDA G and other nearby off-site stations in White Rock did not show evidence of elevated activity in the air samples. Monitoring data from 1997 indicate that since mitigation measures were implemented in 1996, air concentrations of americium-241 and plutonium-239 have decreased to 44 aCi/m^3 and 47 aCi/m^3, respectively. Although these are major reductions, the concentrations do not appear to have dropped to pre-1995 levels (Environmental Surveillance and Compliance Programs 1998, 59904, p. 72).

Air station 30, which is located at the turnoff from Pajarito Road to TA-54, recorded elevated levels of americium-241 and plutonium-239 for the second quarter of 1996. Review of data from other sample periods did not identify a trend. The cause of the elevated measurements at this site is not known (Environmental Surveillance and Compliance Programs 1997, 56684, p. 63).

The long-term trends identified by evaluation of historical data include the situation observed at station 27 (described above) and a significant decrease in ambient tritium activity compared with that measured in the 1970s and early 1980s (Environmental Surveillance Program 1996, 55333). Review of the AIRNET monitoring data does not indicate other significant trends at this time.

Routine publication of AIRNET data on the World Wide Web began during 1997, and data are now available on the World Wide Web within two to three months following the sampling period. The web site (http://www.air-quality.lanl.gov/airnet.htm) also includes follow-up information on investigations of higher-than-normal values.

3.5.5.2 TLDNET Monitoring

In an attempt to be able to distinguish any impact from Laboratory operations, 58 TLD stations (TLDNET) are placed around the Laboratory and in the surrounding communities. This network of dosimeters is divided into three groups: an off-site regional group, an off-site perimeter group, and an on-site group.

The off-site regional group has six locations ranging from 17 mi to 73 mi (28 km to 117 km) from the Laboratory boundary. These regional stations are located at Fenton Hill and in the neighboring communities of Española, Pojoaque, and Santa Fe, and at San Ildefonso and Jemez Pueblos. Taos Pueblo was part of this network in 1995, but was discontinued in 1996 because of repeated loss of measurements.

The off-site perimeter group has 25 locations within 2.5 mi (4 km) of the Laboratory. These stations are placed in residential areas surrounding the Laboratory and in work areas.

The on-site group has 27 locations within Laboratory boundaries, generally around operations that may produce ionizing radiation. Four new on-site stations were added in 1996: East Gate (#56); TA-54 West at the TLD Lab (#57); TA-54 Lagoon on Pajarito Road (#58); and Los Alamos Canyon between the ice rink and TA-2 (#59) (Environmental Surveillance and Compliance Programs 1997, 56684, pp. 65 through 66).

The Laboratory has 10 inactive and 1 active (TA-54, Area G) low-level, radioactive waste management areas. To monitor any external penetrating radiation from these areas, 86 dosimeters are placed around the perimeter of these waste management areas (WASTENET). Of these 86 dosimeters, Area G at TA-54 has 25 dosimeters placed at strategic locations around the facility. All waste management areas are controlled-access areas and are not accessible to the general public. The average annual dose at each waste area is calculated from a set of TLDs located around each site (Environmental Surveillance and Compliance Programs 1997, 56684, p. 66). The highest waste management area annual average dose for 1997 was measured at TA-54, Area G. During the second half of 1997, several TLD stations at TA-54, Area G, in the vicinity of the Transuranic Waste Inspectable Storage Project (TWISP) were higher than the 10-year historical means (1985–1995). The TWISP project entails removing TRU waste from storage for further characterization and ultimate shipment to the Waste Isolation Pilot Project (WIPP). The radiological constituents of these drums varies greatly, and the drum inventory near the TLDs changes constantly. As the TWISP project progresses, changes in external penetrating radiation doses near the project are expected to vary. These TLD locations are on-site and not in an area that can be routinely accessed by the public. The environmental surveillance TLDs at TA-54, Area G, are located within the waste site and along the perimeter fence. The doses measured at this site are considered representative of storage and disposal operations that occur at the facility, and the dose equivalent ranges observed in 1997 are consistent with natural background radiation or the 1996 measurements (Environmental Surveillance and Compliance Programs 1998, 59904, pp. 78 through 79).

3.5.5.3 NEWNET Monitoring

Site-specific meteorological monitoring in Cañada del Buey is provided by four NEWNET meteorological stations (G-Site, Buey West, Buey East, and the TA-54 Meteorological Tower) that are located in Cañada del Buey approximately north and east of MDA G at TA-54. These stations collect meteorological data at 15-minute intervals. The data are posted daily on the World Wide Web at the NEWNET site (http://newnet.jdola.lanl.gov/). The data include the date, time, gamma radiation intensity (µR/hr), wind direction, wind speed, barometric pressure, temperature, and humidity. Other NEWNET sites near TA-54 are located at TA-36 (Kappa Site) and TA-18 (Sewage Lagoon) in Pajarito Canyon. Figure A-1 shows the locations of the NEWNET meteorological stations.

3.5.5.4 Summary of Air Monitoring Data in Cañada del Buey and Requirements Needed to Understand the Air Monitoring Data

Significant information about air monitoring data provided in Section 3.5.5 is summarized below.

- At AIRNET station 27, located on-site at MDA G, air concentrations of americium-241 and plutonium-239 have been increasing since 1995. The increases are believed to be localized. They are believed to be caused by the disturbance of contaminated soil associated with road construction. Monitoring data from 1997 indicate that since mitigation measures were implemented in 1996, air concentrations of americium-241 and plutonium-239 have shown major reductions. However, the concentrations do not appear to have dropped to pre-1995 levels.

- AIRNET station 30, which is located at the turnoff from Pajarito Road to TA-54, recorded elevated levels of americium-241 and plutonium-239 for the second quarter of 1996. Review of data from other sample periods did not identify a trend. The cause of the elevated measurements at this site is not known.

- The long-term trends identified by evaluation of AIRNET historical data include a significant decrease in ambient tritium activity compared with that measured in the 1970s and early 1980s.
- During the second half of 1997, several TLDNET stations at TA-54, Area G, in the vicinity of the TWISP were higher than the 10-year historical means (1985–1995).

Monitoring and reporting will continue for the air monitoring networks described above as part of the Laboratory's Environmental Surveillance Program. No additional air monitoring is proposed in this work plan.

3.5.6 Biological Setting of Cañada del Buey

The general biological setting for the Los Alamos region and the canyons is discussed in Section 3.8 of the core document (LANL 1997, 55622). The unique aspects of the biological setting of the Cañada del Buey system are described here.

Several anthropogenic sources of surface water, as well as stormwater runoff, enter the Cañada del Buey system. Discharges of liquid effluent into Cañada del Buey began in the 1950s. In recent years many of these discharges were continued as NPDES-permitted discharges. Since 1994 many of these NPDES discharges have been eliminated or redirected to the SWSC at TA-46 (see Section 2.2.1).

Although no wetlands have been identified within Cañada del Buey, outfalls within the canyon have produced several small discharge receiving areas that possess hydrophytic vegetation (Biggs and Cross 1995, 52028, p. 29).

3.5.6.1 Potential Receptors

A summary of species thought to occur throughout the Laboratory canyons system can be found in Section 3.8 of the core document (LANL 1997, 55622). Only supplemental data specific to Cañada del Buey is presented here.

3.5.6.1.1 Flora

Vegetation types vary by elevation within the Cañada del Buey system. A detailed description of 6 major plant communities and 16 plant habitats were studied for the Los Alamos National Environmental Research Park (Foxx and Tierney 1984, 5950). The descriptions of plant communities were prepared from work in Pajarito Canyon and cover the entire length of the canyon from Pajarito Mountain to the Rio Grande. In addition, unpublished vegetation surveys were conducted in Cañada del Buey by Foxx and Tierney in 1986 and by Foxx in 1988 (Biggs and cross 1995, 52028).

ESH-20 personnel have completed three biological assessments, which address many of the technical areas within the Cañada del Buey watershed area (Dunham 1992, 31276; Banar 1996, 58192; Biggs and Cross 1995, 52028). The purpose of the assessments was to evaluate the impact of ER Project site characterization activities on potentially present threatened, endangered, and sensitive species and on floodplains and wetlands. The assessments were based on reconnaissance surveys, habitat evaluations, and species-specific surveys that were conducted for compliance with the Federal Endangered Species Act; the New Mexico Wildlife Conservation Act; the New Mexico Endangered Plant Species Act; Federal Executive Order 11990, "Protection of Wetlands"; Federal Executive Order 11988, "Floodplain

Management"; the Code of Federal Regulations (10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"); NEPA; and DOE Order 5400.1, "General Environmental Protection Program." The assessments identified the presence of habitats that are capable of supporting threatened, endangered, and sensitive species; however, the assessments do not conclude that these species are present. Section 3.5.6.2 summarizes the threatened, endangered, and sensitive species that are potentially present, based on the habitats identified by these assessments.

3.5.6.1.2 Fauna

The biological assessments discussed in Section 3.5.6.1.1 include fauna evaluations conducted in many of the technical areas within the Cañada del Buey watershed area (Dunham 1992, 31276; Banar 1996, 58192; Biggs and Cross 1995, 52028). In addition, a number of unpublished small-mammal and bird surveys were conducted (e.g., Felthauser in 1980, Kent in 1986, and Morrison in 1990) (Biggs and Cross 1995, 52028). Section 3.5.6.2 summarizes the threatened, endangered, and sensitive species that are potentially present, based on the habitats identified by these assessments.

3.5.6.2 Threatened, Endangered, and Sensitive Species

Potentially threatened and endangered species in the canyon systems are listed in Chapter 3 of the core document (Section 3.8, Table 3-6) (LANL 1997, 55622). Surveys conducted during the biological assessments discussed in Section 3.5.6.1.1 did not confirm the presence of threatened, endangered, or sensitive species in the study areas. Preliminary risk assessments for the threatened Mexican spotted owl, the peregrine falcon, the southwestern willow flycatcher, and the bald eagle have been completed (Gallegos et al. 1997, 57915; Gallegos et al. 1997, 59790; Gonzales et al. 1998, 62349; Gonzales et al. 1998, 62350). No nesting or roosting zones have been identified within the Cañada del Buey watershed.

Biological evaluations and wetland/floodplain assessments were performed by ESH-20 personnel in the early 1990s. The assessments noted that suitable foraging areas for the peregrine falcon, northern goshawk, and Mexican spotted owl occur in Cañada del Buey (Banar 1996, 58192, p. 3; Biggs and Cross 1995, 52028, pp. 28 and 29). Unpublished investigations of reptile and amphibian species conducted since 1978 identified the presence of the woodhouse toad (*Bufo woodhousei*), the collared lizard (*Crotaphytus collaris*), the Chihuahua whiptail (*Cnemidophorus exsanguis*), the New Mexico whiptail (*Cnemidophorus neomexicanus*), the Plateau striped whiptail (*Cnemidophorus velox*), the coachwhip snake (*Masticophis flagellum*), the striped whipsnake (*Masticophis taeniatus*), the gopher snake (*Pituophis melanoleucus*), the western terrestrial garter snake (*Thamnophis elegans*), the short-horned lizard (*Phrynosoma douglassi*), the many-lined skink (*Eumeces multivirgatus*), and the prairie rattlesnake (*Crotalus viridis viridis*) within Cañada del Buey, and the eastern fence lizard (*sceloporus undulatas*) throughout Los Alamos County between the elevations of 5412 ft to 8250 ft (1640 m to 2500 m) (Cross 1994, 26071, Appendix D).

Table 3.5.6-1 presents a summary of the threatened, endangered, and sensitive species that are potentially present within the Sandia Canyon watershed based on the habitats identified in the biological assessments conducted by ESH-20 personnel for the ER Project (see Section 3.5.6.1.1 and Section 3.5.6.1.2).

3.5.6.3 Species Viability Studies

No studies have been identified that address species viability for the Cañada del Buey system.

Table 3.5.6-1
Threatened, Endangered, and Sensitive Species
Potentially Occurring in the Cañada del Buey Watershed

Common Name	Scientific Name	Legal Status	Potential for Occurrence
Spotted bat	*Euderma maculatum*	Federal candidate/state threatened	Moderate to high
Peregrine falcon	*Falco peregrinus*	Federally endangered	Moderate to high
Northern goshawk	*Accipiter gentilis*	Federal candidate	Low
Mexican spotted owl	*Strix occidentalis lucida*	Federally threatened	Low
Wood lily	*Lilium philadelphicum var. andium*	State endangered	Low
Checker lily	*Fritillaria atropurpurea*	State sensitive	Low
Bald eagle	*Haliaeetus leucocephalus*	Federally endangered	Low to none
Willow flycatcher	*Empidonax traillii*	Federal candidate	Low to none
Meadow jumping mouse	*Zapus hudsonius*	Federal candidate/state endangered	Low to none
Common black hawk	*Buteogallus anthracinus*	State protected	Low to none
Gramma grass cactus	Toumeya papyracantha	Federal candidate/state endangered	Low to none
Threadleaf horsebrush	*Tetradymia filifolia*	State sensitive	Low to none
Say's pond snail	*Lymneae captera*	State endangered	Low to none
Broad-billed hummingbird	*Cyantyhs latirostris*	State endangered	Low to none
Mississippi kite	*Ictinia mississippiensis*	State endangered	Low to none
Sandia alumroot	*Heuchera pulchella*	State sensitive	Low to none
Pagosa phlox	*Phlox caryophylla*	State sensitive	Low to none
Wright fishhook cactus	*Mammillaria wrightii*	State sensitive	Low to none
Sessile-flowered false carrot	*Aletes sessiliflorus*	State sensitive	Low to none
Plank's catchfly	*Silene plankii*	State sensitive	Low to none
Cyanic milk vetch	*Astragalus cyaneus*	State sensitive	Low to none
Santa Fe milk vetch	*Astragalus feensis*	State sensitive	Low to none
Taos milk vetch	*Astragalus puniceus var. gertudis*	State sensitive	Low to none
Mathew's woolly milk vetch	*Astragalus Mathewsii*	State sensitive	Low to none
Santa Fe cholla	*Opunita viridiflora*	Federal candidate	Low to none
Tufted sand verbena	*Abronia bigelovii*	Federal candidate/state sensitive	Low to none

Source: Banar 1996, 58192, pp. 37 through 43; Biggs and Cross 1995, 52028, pp. 21 through 28; Dunham 1992, 31276, pp. 34 through 46.

3.5.6.4 Contaminant Uptake

3.5.6.4.1 Radionuclide Concentrations in Biota

The collection and analysis of small mammals at TA-54, MDA G, was initiated in 1994 as part of the enhanced environmental annual surveillance program at MDA G by the ESH Division in collaboration with the Solid Waste Management Group. The program is intended to provide data to aid in meeting requirements of DOE Order 5400.1, which specifies monitoring existing operations at radioactive waste burial sites (Biggs et al. 1997, 62344, p. 1). As part of the Environmental Surveillance Program, vegetation, bees, and honey have been sampled on an annual basis from within and around MDA G to help monitor and assess the site's impact on the surrounding community.

3.5.6.4.1.1 Flora

Vegetation has been sampled at MDA G as part of the Environmental Surveillance Program as described in a series of reports by Fresquez et al. (1996, 62345; 1997, 62346). Overstory (piñon pine) and understory (grass and forb) vegetation were collected within and around selected points at MDA G, TA-54, for the analysis of tritium, strontium-90, plutonium-238, plutonium-239, cesium-137, and total uranium. Also, heavy metals (silver, arsenic, barium, beryllium, cadmium , chromium, mercury, nickel, lead, antimony, selenium, and thallium) in/on vegetation were determined. In general, most (unwashed) vegetation collected within and around MDA G contained tritium, uranium, plutonium-238, and plutonium-239 in higher concentrations than in vegetation collected from background areas. Tritium, in particular, was detected as high as 7300 pCi/mL in understory vegetation collected from the west side of the TRU pads during the 1995 investigation. Data from 1996 reflect tritium concentrations as high as 14,744 pCi/mL in understory vegetation collected from TRU pad #4. The south and west ends of the tritium shaft field have also contained elevated levels of tritium in overstory, and especially in understory vegetation, compared to background. This finding suggests that tritium may be migrating from this waste repository through surface and subsurface pathways. Also, understory vegetation collected north of the TRU pads (adjacent to the fence line of MDA G) contained the highest values of plutonium-238 and plutonium-239 compared to background, and may be a result of surface holding, storage, and/or disposal activities (Fresquez et al. 1996, 62345, p. 1; Fresquez et al. 1997, 62346, p. 1).

3.5.6.4.1.2 Insects

As part of the ongoing Environmental Surveillance Program at MDA G, TA-54, samples of honeybees were collected from beehives during the summer of 1997. Honeybees can be considered mobile samplers that efficiently cover a large sample area and then return to a central location. Each hive contains literally thousands of bees; most will forage for nectar, water, pollen, and plant resins, which are all brought back into the hive. During these foraging flights, bees inadvertently contact and accumulate a wide array of pollutants, some of which are brought back to the colony. Two colonies were established near the south edge of MDA G, near the tritium shafts, and a control site with one colony was established 6 mi (10 km) south of Jemez Springs. After three months, bee tissue samples were collected from each of the colonies. All samples were analyzed for tritium, cesium-137, americium-241, plutonium-238, plutonium 239,240, total uranium, and gamma activity. In general, most radionuclides, with the exception of plutonium-238 and tritium, were within or just above the regional statistical reference level (RSRL). The RSRL is the upper (95%) level background concentration (mean + two standard deviations) from the present data. And, of these two radionuclides (plutonium-238 and tritium), only tritium concentrations were at detectable levels—where the analytical result was higher than two times the counting uncertainty. Tritium levels in the MDA G bees, for example, were at 82.8 pCi/mL and 110.20 pCi/mL; the control colony contained only 1.03 pCi/mL (Haarmann and Fresquez 1998, 62351, pp. 1 through 6). These data are consistent with other surveillance studies of tritium (and other radionuclides) at Area G in bees, small mammals (Biggs et al. 1997, 62344), and vegetation (Fresquez et al. 1997, 62346).

3.5.6.4.1.3 Mammals

Small mammals (deer, harvest, and piñon mice) were sampled at two waste burial sites at MDA G, TA-54, and a control site within the proposed MDA G expansion area in 1996 to (1) identify radionuclides that are present within rodent tissues at waste burial sites; (2) compare the amount of radionuclide uptake by small mammals (at waste burial sites) to a control site; and (3) identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. The investigation was initiated in 1994 as discussed in Section 3.5.6.4.1. The sampling sites include site 1, a recently disturbed/contaminated storage area for TRU drums overlying previously filled disposal pits; site 2, a partially disturbed/contaminated waste burial site; site 3, a control site; site 4, a background site on Frijoles Mesa; and locations at the tritium shafts and active open pits. Three of these sites were trapped in 1994, and five sites were trapped in 1995. The five sites trapped in 1996 were selected to correlate with vegetation sampling sites (Fresquez et al. 1997, 62346) (see Section 3.5.6.4.1.1). Trapping at the open active pits and tritium shafts was conducted for the first time in 1996. During each year of the investigation, three composite samples of approximately five animals per sample were collected at each site with the following exception: in 1996, only one sample was collected at the open active pit (three animals) and the tritium shafts (two animals) due to the low capture rate. The pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for americium-241, strontium-90, plutonium-238, plutonium-239, total uranium, cesium-137, and tritium. The 1996 sampling event indicates higher levels of total uranium, americium-241, plutonium-238, and plutonium-239 were detected in pelts compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Although not statistically analyzed, the pelt sample from the open active pit had much higher concentrations of total uranium, americium-241, plutonium-238, and plutonium-239 compared to any other site, in either pelts or carcasses. Due to low sample sizes in total number of animals captured, statistical analysis for site-to-site comparisons could not be conducted. However, mean concentrations of total uranium, plutonium-238, plutonium-239, and cesium-137 in rodent carcasses were higher at site 1 than site 2 or the control site and americium-241 was higher at site 2 than site 1 or the control site (Biggs et al. 1997, 62344, pp. 1 through 7). The results from the 1996 sampling event are consistent with data presented in previous reports for the 1994 and 1995 sampling events (Biggs et al. 1995, 62343; Bennett et al. 1997, 62342).

Large mammals, such as mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*), forage in many areas at the Laboratory that may contain radioactivity above natural and/or worldwide fallout levels. A report by Fresquez et al. (1998, 62347) summarizes radionuclide concentrations (tritium, strontium-90, cesium-137, plutonium-238, plutonium-239,240, americium-241, and total uranium) in muscle and bone tissue of deer and elk collected from Laboratory lands from 1991 through 1998, including deer collected from TA-53 in Sandia Canyon and elk collected from TA-46 in Cañada del Buey, (see Section 3.4.6.4.1.3). Also, the CEDE and RECF were estimated for people who ingest the muscle and bone of deer and elk from Laboratory lands. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from Laboratory lands were either at less than detectable quantities (where the analytical results were smaller than two counting uncertainties) and/or within upper (95%) level background concentrations. As a group, most radionuclides in muscle and bone of deer and elk from Laboratory lands were not significantly higher ($p < 0.05$) than in similar tissues from deer and elk collected from background locations. Also, elk that had been radio-collared and tracked for two years and averaged 50% of their time on Laboratory lands were not significantly different in most radionuclides from road kill elk collected as part of the Environmental Surveillance Program. Overall, the upper (95%) level net CEDE (the CEDE plus two sigma for each radioisotope minus background) at the most conservative ingestion rate (51 lb of muscle and 13 lb of bone) were deer muscle, 0.220 mrem/yr; deer bone, 3.762 mrem/yr; elk muscle, 0.117 mrem/yr; and elk bone, 1.67 mrem/yr. All CEDEs were far below the International

Commission on Radiological Protection guideline of 100 mrem/yr, and the highest muscle plus bone CEDE (4.0 mrem/yr) corresponded to a RECF of 2E-06, which is far below the EPA guideline of 1E-04 (Fresquez et al. 1998, 62347, p. 1).

3.5.6.4.2 Inorganic Contaminant Uptake

Sampling of vegetation at MDA G has been conducted as part of the Environmental Surveillance Program as described in a series of reports by Fresquez et al. (1996, 62345; 1997, 62346) (see Section 3.5.6.4.1.1). Overstory (piñon pine) and understory (grass and forb) vegetation was collected within and around selected points at MDA G, TA-54, for the analysis of tritium, strontium-90, plutonium-238, plutonium-239, cesium-137, and total uranium. Also, heavy metals (silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, and thallium) in/on vegetation were determined. The 1995 data indicate, with the exception of a few slightly elevated heavy metal elements in/on vegetation at few sites compared to background, most heavy metals in/on overstory and understory vegetation collected within and around MDA G were within normal background concentrations . Barium was detected in slightly higher concentrations than upper limit background concentrations in vegetation collected at almost all MDA G sites. The reasons for the slightly higher barium values in/on vegetation at MDA G compared to background are not completely known, as barium in soils within and around MDA G were within normal background concentrations (Conrad et al. 1995, 52014). Only one site, understory vegetation collected at the south end of the tritium shaft field (#l), exhibited any kind of trend; that is, more than one heavy metal element, namely barium, beryllium, cadmium, chromium, and nickel, was detected at above-background concentrations (Fresquez et al. 1996, 62345, p. 9). The 1996 data are consistent with data reported for the 1995 investigation and indicate that most metals in washed and unwashed overstory and understory vegetation are present at concentrations below background levels or RSRLs (Fresquez et al. 1997, 62346, p. 7),

3.5.6.4.3 Bioaccumulator Uptake

Bioaccumulating chemicals that have been evaluated with respect to uptake in biota in Cañada del Buey include strontium-90, cesium-137, total uranium, cadmium, lead, mercury, nickel, and selenium in/on vegetation; americium-241, cesium-137, and total uranium in honeybees; and americium-241, strontium-90, cesium-137, and total uranium in small and large mammals. The data suggest higher concentrations of americium-241, strontium-90, cesium-137, and total uranium may be present in select small mammals. Although contaminant uptake has been addressed in numerous studies as summarized throughout Section 3.5.6.4, no other data for the uptake of specific bioaccumulating chemicals were found for species within the Cañada del Buey system.

3.5.6.5 Summary of Biological Setting in Cañada del Buey and Data-Collection Activities Needed to Understand Contaminant Uptake in Biota

Significant information about the biological setting in Cañada del Buey that is provided in Section 3.5.6 is summarized below.

- Although no wetlands have been identified within Cañada del Buey, outfalls within the canyon have produced several small discharge receiving areas that possess hydrophytic vegetation.
- Vegetation collected within and around MDA G contained tritium, uranium, plutonium-238, and plutonium-239 in higher concentrations than vegetation collected from background areas. Tritium concentrations as high as 14,744 pCi/mL were detected in understory vegetation collected from TRU pad #4. The south and west ends of the tritium shaft field have also contained elevated

levels of tritium in overstory, and especially in understory vegetation, compared to background. This finding suggests that tritium may be migrating from this waste repository through surface and subsurface pathways.

- The maximum tritium level in bees collected from colonies at MDA G was 110.20 pCi/mL; the control colony contained only 1.03 pCi/mL. These data are consistent with other surveillance studies of tritium at MDA G in bees.
- The mean concentrations of total uranium, americium-247, plutonium-238, plutonium-239, and cesium-137 were elevated in rodent carcasses collected at MDA G compared to animals collected from a control site. Higher levels of total uranium, americium-247, plutonium-238, and plutonium-239 were detected in the pelts than in the carcasses.
- As a group, most radionuclides in muscle and bone of elk from Laboratory lands (including elk collected from TA-46) were not significantly higher ($p < 0.05$) than in similar tissues from elk collected from background locations. Also, elk that had been radio-collared and tracked for two years and spent an average of 50% of their time on Laboratory lands were not significantly different in most radionuclides from road-kill elk that have been collected as part of the Environmental Surveillance Program.
- Barium concentrations in vegetation collected at almost all MDA G sites were slightly higher than the upper limit background concentration. The reasons for the slightly higher barium concentrations in/on vegetation at MDA G compared to background are not completely known, as barium levels in soils within and around MDA G were within normal background concentrations. Only one site, understory vegetation collected at the south end of the tritium shaft field (#l), exhibited any kind of a trend; that is, more than one heavy metal element, namely barium, beryllium, cadmium, chromium, and nickel, were detected at above-background concentrations.

The following issues and deficiencies in the data required to evaluate contaminant uptake in Cañada del Buey biota must be considered:

- No data have yet been found to document uptake of inorganic contaminants in fauna.
- No data have yet been found to document uptake of organic contaminants in any biota.
- No data have been found to address species viability in Cañada del Buey.
- Bioaccumulator data are limited for all biota.
- No data were found on tissue concentrations of contaminants for predator species such as coyotes, owls, and raptors in Cañada del Buey, which makes it difficult to evaluate food chain transfer effects. However, data are available for small rodents. The extensive burrowing of these small mammals and their localized range could present significant pathways for contaminant dispersion and transfer.
- Data that reflect current concentrations in biota are limited. Data reflecting historical concentrations in biota are not available. Contaminant concentrations are expected to have changed during the past 20 to 25 years, and contaminant transfer processes are not necessarily linear. In addition, some contaminants will compete for uptake processes in biota, which indicates a potential for differential uptake of the same contaminant if the contaminant mixture is altered.

References for Chapter 3

The following list includes all references cited in this document. Parenthetical information following each reference provides the author, publication date, and ER record identification (ER ID) number. This information also is included in the citations in the text and can be used to locate the documents.

ER ID numbers are assigned by the Laboratory's ER Project to track records associated with the project. These numbers can be used to locate copies of the actual documents at the ER Project's Records Processing Facility and, where applicable, within the ER Project 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 US Department of Energy-Los Alamos Area Office; US Environmental Protection Agency, Region 6; and the ER Project Canyons Focus Area. 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 document. However, documents previously submitted to the administrative authority are not included in the reference library.

Apt, K. E., and V. J. Lee (Comps.), May 1975. "Environmental Surveillance at Los Alamos During 1974," Los Alamos Scientific Laboratory Report LA-5977-PR, Los Alamos, New Mexico. (Apt and Lee 1975, ER ID 5488)

Apt, K. E., and V. J. Lee (Comps.), April 1976. "Environmental Surveillance at Los Alamos During 1975," Los Alamos Scientific Laboratory Report LA-6321-MS, Los Alamos, New Mexico. (Apt and Lee 1976, ER ID 5559)

Baltz, E. H., J. H. Abrahams, Jr., and W. D. Purtymun, March 1963. "Preliminary Report on the Geology and Hydrology of Mortandad Canyon near Los Alamos, N. M., with Reference to Disposal of Liquid Low-Level Radioactive Waste," US Geological Survey Open File Report, Albuquerque, New Mexico. (Baltz et al. 1963, ER ID 8402)

Banar, A., 1996. "Biological Assessment for Environmental Restoration Program Operable Unit 1148 TA-54 and TA-51," Los Alamos National Laboratory Report LA-UR-93-1054, Los Alamos, New Mexico. (Banar 1996, ER ID 58192)

Bennett, K., May 1994. "Aquatic Macroinvertebrates and Water Quality in Sandia Canyon," Los Alamos National Laboratory Report LA-12738-MS, Los Alamos, New Mexico. (Bennett 1994, ER ID 57542)

Bennett, K., and J. Biggs, November 1996, "Small Mammal Study of Sandia Canyon, 1994 and 1995," Los Alamos National Laboratory Report LA-13199-MS, Los Alamos, New Mexico. (Bennett and Biggs 1996, ER ID 57541)

Bennett, K., J. Biggs, and P. R. Fresquez, 1997. "Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, Los Alamos National Laboratory," Los Alamos National Laboratory Report LA-13242-MS, Los Alamos, New Mexico. (Bennett et al. 1997, ER ID 62342)

Biggs, J. R., K. Bennett, and P. R. Fresquez, 1995. "Radionuclide Contaminant Analysis of Small Mammals at Area G, TA-54, 1994," Los Alamos National Laboratory Report LA-13015-MS, Los Alamos, New Mexico. (Biggs et al. 1995, ER ID 62343)

Biggs, J. R., K. Bennett, and P. R. Fresquez, 1997. “Radionuclide Contaminant Analysis of Small Mammals at Area G, Technical Area 54, 1996 (with Cumulative Summary for 1994 – 1996),” Los Alamos National Laboratory Report LA-13345-MS, Los Alamos, New Mexico. (Biggs et al. 1997, ER ID 62344)

Biggs, J., and S. Cross, 1995. “Biological and Floodplain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1140, TA-46,” Los Alamos National Laboratory Report LA-UR-95-3716, Los Alamos, New Mexico. (Biggs and Cross 1995, ER ID 52028)

Blake, W. D., F. Goff, A. I. Adams, and D. Counce, May 1995. “Environmental Geochemistry for Surface and Subsurface Waters in the Pajarito Plateau and Outlying Areas, New Mexico,” Los Alamos National Laboratory Report LA-12912-MS, Los Alamos, New Mexico. (Blake et al. 1995, ER ID 49931)

Bogart, C., 1986. “The Amphibians and Reptiles of the Los Alamos National Environmental Research Park,” Los Alamos National Laboratory unpublished report, Los Alamos, New Mexico. (Bogart 1986, ER ID 50038)

Bowen, B. M., May 1990. “Los Alamos Climatology,” Los Alamos National Laboratory Report LA-11735-MS, Los Alamos, New Mexico. (Bowen 1990, ER ID 6899)

Broxton, D. E., G. H. Heiken, S. J. Chipera, and F. M. Byers, Jr., June 1995. “Stratigraphy, Petrography, and Mineralogy of Bandelier Tuff and Cerro Toledo Deposits,” in *Earth Science Investigation for Environmental Restoration—Los Alamos National Laboratory Technical Area 21*, Los Alamos National Laboratory Report LA-12934-MS, Los Alamos, New Mexico, pp. 33–63. (Broxton et al. 1995, ER ID 50121)

Broxton, D. E., and S. L. Reneau, August 1995. “Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13010-MS, Los Alamos, New Mexico. (Broxton and Reneau 1995, ER ID 49726)

Broxton, D. E., and S. L. Reneau, 1996. “Buried Early Pleistocene Landscapes Beneath the Pajarito Plateau, Northern New Mexico,” in *New Mexico Geological Society Guidebook*, 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 325–334. (Broxton and Reneau 1996, ER ID 55429)

Childs, M., and R. Conrad, September 1997. “Area G Perimeter Surface-Soil and Single-Stage Water Sampling: Environmental Surveillance for Fiscal Year 95,” Los Alamos National Laboratory Progress Report LA-13369-PR, Los Alamos, New Mexico. (Childs and Conrad 1997, ER ID 57518)

Conrad, R. M., M. Childs, C. Rivera-Dirks, and F. Coriz, July 1995. “Area G Perimeter Surface Soil and Single-Stage Water Sampling Environmental Surveillance for Fiscal Year 1993,” Los Alamos National Laboratory Report LA-12986, Los Alamos, New Mexico. (Conrad et al. 1995, ER ID 52014)

Conrad, R. M., M. Childs, C. Rivera Lyons, and F. Coriz, August 1996. “Area G Perimeter Surface Soil and Single-Stage Water Sampling Environmental Surveillance for Fiscal Year 1994,” Los Alamos National Laboratory Progress Report LA-13165-PR, Los Alamos, New Mexico. (Conrad et al. 1996, ER ID 55621)

Cooper, J. B., W. D. Purtymun, and E. C. John, July 1965. “Records of Water-Supply Wells, Guaje Canyon 6, Pajarito Mesa 1, and Pajarito Mesa 2, Los Alamos, New Mexico, Basic Data Report,” US Geological Survey, Albuquerque, New Mexico. (Cooper et al. 1965, ER ID 8582)

Cross, S., January 1994. “Biological Evaluation for Environmental Restoration Program; Operable Unit 1114; Technical Areas 3, 30, 59, 60, 61, and 64,” Rev. 1, Los Alamos National Laboratory Report LA-UR-94-21, Los Alamos, New Mexico. (Cross 1994, ER ID 26071)

Cross, S., September 1994. “Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: December 1992–October 1993,” Los Alamos National Laboratory Report LA-12734-SR, Los Alamos, New Mexico. (Cross 1994, ER ID 57544)

Cross, S., August 1995. “Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory: November 1993–October 1994,” Los Alamos National Laboratory Report LA-12971-SR, Los Alamos, New Mexico. (Cross 1995, ER ID 57543)

Cross, S., and H. Nottelman, November 1996. “Aquatic Macroinvertebrates and Water Quality of Sandia Canyon, Los Alamos National Laboratory, 1995,” Los Alamos National Laboratory Report LA-UR-96-3684, Los Alamos, New Mexico. (Cross and Nottelman 1996, ER ID 57540)

Cushman, R. L., and W. D. Purtymun, September 1975. “Evaluation of Yield and Water-Level Relations,” Los Alamos Scientific Laboratory Report LA-6086-MS, Los Alamos, New Mexico. Cushman and Purtymun 1975, ER ID 5479)

Dale, M. R., and S. Yanicak, 1996. “Characteristics of Springs in the Western Pajarito Plateau, Los Alamos National Laboratory, New Mexico,” in *New Mexico Geological Society Guidebook*, 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 77–78. (Dale and Yanicak 1996, ER ID 57753)

Dale, M. R., S. M. Yanicak, and S. P. Anderson, December 1996. “Ground-Water Oversight at Los Alamos National Laboratory and Surrounding Areas, 1994 Through 1995,” NMED/DOE/AIP-96/4, DOE Oversight Bureau, New Mexico Environment Department, Santa Fe, New Mexico. (Dale et al. 1996, ER ID 57014)

Dale, L. J., July 9, 1999. “Preliminary PCB Data for Small Mammals in Upper Sandia Canyon,” Daily Activity Log, Los Alamos, New Mexico. (Dale 1999, ER ID 63494)

Davis, T. D., S. Hoines, and K. T. Hill, July 1996. “Hydrogeologic Evaluation of Los Alamos National Laboratory,” NMED-HRMB-96/1, Hazardous and Radioactive Materials Bureau, New Mexico Environment Department, Santa Fe, New Mexico. (Davis et al. 1996, ER ID 55446)

Dethier, D. P., 1997. “Geology of White Rock Quadrangle, Los Alamos and Santa Fe Counties, New Mexico,” New Mexico Bureau of Mines and Mineral Resources, Geologic Map 73. (Dethier 1997, ER ID 49843)

Dethier, D. P., and K. Manley, 1985. “Geologic Map of the Chili Quadrangle, Rio Arriba County, New Mexico,” US Geological Survey Miscellaneous Field Studies Map MF-1814, Washington, DC. (Dethier and Manley 1985, ER ID 21506)

Devaurs, M., November 1985. “Core Analyses and Observation Well Data from Mesita del Buey Waste Disposal Areas and in Adjacent Canyons,” Los Alamos National Laboratory Report LA-UR-85-4003, Los Alamos, New Mexico. (Devaurs 1985, ER ID 7416)

Devaurs, M., and W. D. Purtymun, 1985. “Hydrologic Characteristics of the Alluvial Aquifers in Mortandad, Cañada del Buey, and Pajarito Canyons,” Los Alamos National Laboratory Report LA-UR-85-4002, Los Alamos, New Mexico. (Devaurs and Purtymun 1985, ER ID 7415)

Dunham, D. A., December 17, 1992. “Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program, Operable Unit 1129, TA-4, -5, -35, -42, -48, -52, -55, -63, -66 and Operable Unit 1147, TA-50” (draft), Environmental Protection Group (EM-8), Los Alamos National Laboratory, Los Alamos, New Mexico. (Dunham 1992, ER ID 31276)

Environmental Protection Group, March 1992. “Environmental Surveillance at Los Alamos During 1990,” Los Alamos National Laboratory Report LA-12271-MS, Los Alamos, New Mexico. (Environmental Protection Group 1992, ER ID 7004)

Environmental Protection Group, August 1993. “Environmental Surveillance at Los Alamos During 1991,” Los Alamos National Laboratory Report LA-12572-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1993, ER ID 23249)

Environmental Protection Group, July 1994. “Environmental Surveillance at Los Alamos During 1992,” Los Alamos National Laboratory Report LA-12764-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1994, ER ID 45363)

Environmental Protection Group, October 1995. “Environmental Surveillance at Los Alamos During 1993,” Los Alamos National Laboratory Report LA-12973-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1995, ER ID 50285)

Environmental Protection Group, July 1996. “Environmental Surveillance at Los Alamos During 1994,” Los Alamos National Laboratory Report LA-13047-ENV, Los Alamos, New Mexico. (Environmental Protection Group 1996, ER ID 54769)

Environmental Surveillance and Compliance Programs, September 1997. “Environmental Surveillance and Compliance at Los Alamos During 1996,” Los Alamos National Laboratory Report LA-13343-ENV, Los Alamos, New Mexico. (Environmental Surveillance and Compliance Programs 1997, ER ID 56684)

Environmental Surveillance and Compliance Programs, September 1998. “Environmental Surveillance and Compliance at Los Alamos During 1997,” Los Alamos National Laboratory Report LA-13487-ENV, Los Alamos, New Mexico. (Environmental Surveillance and Compliance Programs 1998, ER ID 59904)

Environmental Surveillance Program, 1996. “Environmental Surveillance at Los Alamos during 1995,” Los Alamos National Laboratory Report LA-13210-ENV, Los Alamos, New Mexico. (Environmental Surveillance Program 1996, ER ID 55333)

Environmental Surveillance Reports. Numerous environmental surveillance reports were prepared annually by the Environmental Studies Group (ESG), which in 1971 was renamed the Environmental Surveillance Group. This organization also was called the Environmental Surveillance and Compliance Program, and the Environmental Protection Group. The reports bear a Los Alamos Scientific Laboratory number before January 1, 1981, and a Los Alamos National Laboratory number thereafter. In this document, environmental surveillance reports also include citations for Apt and Lee, Herceg, Kennedy et al., and Schiager.

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

ESG (Environmental Studies Group), April 1977. “Environmental Surveillance at Los Alamos During 1976,” Los Alamos Scientific Laboratory Report LA-6801-MS, Los Alamos, New Mexico. (ESG 1977, ER ID 5703)

ESG (Environmental Surveillance Group), April 1978. “Environmental Surveillance at Los Alamos During 1977,” Los Alamos Scientific Laboratory Report LA-7263-MS, Los Alamos, New Mexico. (ESG 1978, ER ID 5724)

ESG (Environmental Surveillance Group), April 1979. “Environmental Surveillance at Los Alamos During 1978,” Los Alamos Scientific Laboratory Report LA-7800-ENV, Los Alamos, New Mexico. (ESG 1979, ER ID 5819)

ESG (Environmental Surveillance Group), April 1980. “Environmental Surveillance at Los Alamos During 1979,” Los Alamos Scientific Laboratory Report LA-8200-ENV, Los Alamos, New Mexico. (ESG 1980, ER ID 5961)

ESG (Environmental Surveillance Group), April 1981. “Environmental and Emergency Response Capabilities of Los Alamos National Laboratory’s Radiological Air Sampling Program” in *Environmental Surveillance at Los Alamos During 1980*, Los Alamos National Laboratory Report LA-8810-ENV, Los Alamos, New Mexico. (ESG 1981, ER ID 6055)

ESG (Environmental Surveillance Group), April 1982. “Environmental Surveillance at Los Alamos During 1981,” Los Alamos National Laboratory Report LA-9349-ENV, Los Alamos, New Mexico. (ESG 1982, ER ID 6245)

ESG (Environmental Surveillance Group), April 1983. “Environmental Surveillance at Los Alamos During 1982,” Los Alamos National Laboratory Report LA-9762-ENV, Los Alamos, New Mexico. (ESG 1983, ER ID 6418)

ESG (Environmental Surveillance Group), April 1984. “Environmental Surveillance at Los Alamos During 1983,” Los Alamos National Laboratory Report LA-10100-ENV, Los Alamos New Mexico. (ESG 1984, ER ID 6523)

ESG (Environmental Surveillance Group), April 1985. “Environmental Surveillance at Los Alamos During 1984,” Los Alamos National Laboratory Report LA-10421-ENV, Los Alamos, New Mexico. (ESG 1985, ER ID 6610)

ESG (Environmental Surveillance Group), April 1986. “Environmental Surveillance at Los Alamos During 1985,” Los Alamos National Laboratory Report LA-10721-ENV, Los Alamos, New Mexico. (ESG 1986, ER ID 6626)

ESG (Environmental Surveillance Group), April 1987. “Environmental Surveillance at Los Alamos During 1986,” Los Alamos National Laboratory Report LA-10992-ENV, Los Alamos New Mexico. (ESG 1987, ER ID 6678)

ESG (Environmental Surveillance Group), May 1988. “Environmental Surveillance at Los Alamos During 1987,” Los Alamos National Laboratory Report LA-11306-ENV, Los Alamos, New Mexico. (ESG 1988, ER ID 6877)

ESG (Environmental Surveillance Group), June 1989. “Environmental Surveillance at Los Alamos During 1988,” Los Alamos National Laboratory Report LA-11628-ENV, Los Alamos, New Mexico. (ESG 1989, ER ID 6894)

ESG (Environmental Surveillance Group), December 1990. “Environmental Surveillance at Los Alamos During 1989,” Los Alamos National Laboratory Report LA-12000-ENV, Los Alamos, New Mexico. (ESG 1990, ER ID 6995)

Ferguson, J. F., W. S. Baldridge, L. W. Braile, S. Biehler, B. Gilpin, and G. R. Jiracek, 1995. “Structure of the Española Basin, Rio Grande Rift, New Mexico, from Sage Seismic and Gravity Data,” in *New Mexico Geological Society Guidebook*, 46th Field Conference, Geology of the Santa Fe Region, New Mexico, pp. 105–110. (Ferguson et al. 1995, ER ID 56018)

Foxx, T., G. Tierney, M. Mullen, and M. Salisbury, October 1997. “Old-Field Plant Succession on the Pajarito Plateau,” Los Alamos National Laboratory Report LA-13350, Los Alamos, New Mexico. (Foxx et al. 1997, ER ID 57580)

Foxx, T. S., and B. Blea-Edeskuty, 1995. “Wildlife Use of NPDES Outfalls at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13009-MS, Los Alamos, New Mexico. (Foxx and Blea-Edeskuty 1995, ER ID 62348)

Foxx, T. S., and G. D. Tierney, September 1984. “Status of the Flora of the Los Alamos National Environmental Research Park,” Los Alamos National Laboratory Report LA-8050-NERP, Vol. II, Los Alamos, New Mexico. (Foxx and Tierney 1984, ER ID 5950)

Fresquez, P. R., E. L. Vold, and L. Naranjo, 1996. “Radionuclide Concentrations in/on Vegetation at Radioactive-Waste Disposal Area G During the 1995 Growing Season,” Los Alamos National Laboratory Report LA-13124-PR, Los Alamos, New Mexico. (Fresquez et al. 1996, ER ID 62345)

Fresquez, P. R., E. L. Vold, and L. Naranjo, 1997. “Radionuclide Concentrations in Soils and Vegetation in Radioactive-Waste Disposal Area G During the 1996 Growing Season,” Los Alamos National Laboratory Report LA-13332-PR, Los Alamos, New Mexico. (Fresquez et al. 1997, ER ID 62346)

Fresquez, P. R., J. R. Biggs, K. D. Bennett, D. H. Kraig, M. A. Mullen, and J. K. Ferenbaugh, 1998. “Radionuclide Concentrations in Deer and Elk from los Alamos National Laboratory: 1991-1998,” Los Alamos National Laboratory Report LA-13553-MS, Los Alamos, New Mexico. (Fresquez et al. 1998, ER ID 62347)

Gallaher, B., February 1, 1995. “Update on Tritium in Los Alamos Groundwater,” Los Alamos National Laboratory Memorandum ESH-18/WQ&H-95-0044 to Distribution from Bruce Gallaher (ESH-18), Los Alamos, New Mexico. (Gallaher 1995, ER ID 54716)

Gallaher, B., September 11, 1995. “Groundwater Velocities in Los Alamos Canyon,” Los Alamos National Laboratory Memorandum ESH-18/WQ&H-95-409 to ESH-18 Reading File from Bruce Gallaher (ESH-18), Los Alamos, New Mexico. (Gallaher 1995, ER ID 49679)

Gallegos, A. F., G. J. Gonzales, K. D. Bennett, and L. E. Pratt, February 1997. “Preliminary Risk Assessment of the Mexican Spotted Owl under a Spatially-Weighted Foraging Regime at the Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13259-MS, Los Alamos, New Mexico. (Gallegos et al. 1997, ER ID 57915)

Gallegos, A. F., G. J. Gonzales, K. D. Bennett, L. E. Pratt, and D. S. Cram, June 1997. “A Spatially-Dynamic Preliminary Risk Assessment of the American Peregrine Falcon at the Los Alamos National Laboratory, Ver 1.0,” Los Alamos National Laboratory Report LA-13321-MS, Los Alamos, New Mexico. (Gallegos et al. 1997, ER ID 59790)

Galusha, T., and J. C. Blick, April 1971. “Stratigraphy of the Santa Fe Group, New Mexico,” in *Bulletin of the American Museum of Natural History*, Vol. 144, Article 1, Lund Humphries, Great Britain, pp. 1–128. (Galusha and Blick 1971, ER ID 21526)

Gardner, J. N., and F. Goff 1984. “Potassium-Argon Dates from the Jemez Volcanic Field: Implications for Tectonic Activity in the North-Central Rio Grande Rift,” in *New Mexico Geological Society Guidebook,* 35th Field Conference, Los Alamos National Laboratory Report LA-UR-84-1210, Los Alamos, New Mexico. (Gardner and Goff 1984, ER ID 44021)

Gardner, J. N., T. Kolbe, and S. Chang, January 1993. “Geology, Drilling, and Some Hydrologic Aspects of Seismic Hazards Program Core Holes, Los Alamos National Laboratory, New Mexico,” Los Alamos National Laboratory Report LA-12460-MS, Los Alamos, New Mexico. (Gardner et al. 1993, ER ID 12582)

Gardner, J. N., A. Lavine, D. Vaniman, and G. WoldeGabriel, June 1998, “High-Precision Geologic Mapping to Evaluate the Potential for Seismic Surface Rupture at TA-55, Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13456-MS, Los Alamos, New Mexico. (Gardner et al. 1998, ER ID 63496)

Gardner, J. N., A. Lavine, G. WoldeGabriel, D. Krier, D. Vaniman, F. Caporuscio, C. Lewis, P. Reneau, E. Kluk, and M. J. Snow, March 1999. “Structural Geology of the Northwestern Portion of Los Alamos National Laboratory, Rio Grande Rift, New Mexico: Implications for Seismic Surface Rupture Potential from TA-3 to TA-55,” Los Alamos National Laboratory Report LA-13589-MS, Los Alamos, New Mexico. (Gardner et al. 1999, ER ID 63492)

Gonzales, G. J., A. F. Gallegos, M. A. Mullen, K. Bennett, and T. S. Foxx, October 1998. “Preliminary Risk Assessment of the Southwestern Willow Flycatcher (Empidonax traillii extimus) at the Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13508-MS, Los Alamos, New Mexico. (Gonzales et al. 1998, ER ID 62349)

Gonzales, G. J., A. F. Gallegos, T. S. Foxx, P. R. Fresquez, M. A. Mullen, L. E. Pratt, and P. E. Gomez, 1998. “A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-13399-MS, Los Alamos, New Mexico. (Gonzales et al. 1998, ER ID 62350)

Gray, R. N., May 1997. “Hydrologic Budget Analysis and Numerical Simulations of Groundwater Flow in Los Alamos Canyon Near Los Alamos, New Mexico,” thesis, Vols. 1 and 2, Albuquerque, New Mexico. (Gray 1997, ER ID 58208)

Griggs, R. L., 1964. “Geology and Ground-Water Resources of the Los Alamos Area New Mexico,” with a section on Quality of Water by John D. Hem, US Geological Survey Water-Supply Paper 1753, Washington, DC. (Griggs 1964, ER ID 8795)

Haarmann, T., 1994. “Biological and Floodplain/Wetland Assessment for Environmental Restoration Program, Operable Unit 1100,” Los Alamos National Laboratory Report LA-UR-95-11, Los Alamos, New Mexico. (Haarmann 1994, ER ID 52023)

Haarmann, T. K., October 1998. “Honey Bees (Hymenoptera: Apidae) as Indicators of Radionuclide Contamination: Investigating Contaminant Redistribution Using Concentrations in Water, Flowers, and Honey Bees,” *Journal of Economic Entomology*, Vol. 91, No. 5, pp. 1072-1077. (Haarmann 1998, ER ID 62352)

Haarmann, T. K, and P. R. Fresquez, 1998. “Radionuclide Concentrations in Honey Bees from Area G in TA-54 During 1997,” Los Alamos National Laboratory Report LA-13480-PR, Los Alamos, New Mexico. (Haarmann and Fresquez 1998, ER ID 62351)

Hansen, L. A., R. Robinson, P. Fresquez, T. Foxx, and J. Huchton, 1998. “Development and Evaluation of a Radio Frequency Identification System to Measure Time Spent at Contaminated Sites for Medium-Sized Mammals at Los Alamos National Laboratory,” Los Alamos National Laboratory unpublished report, Los Alamos, New Mexico. (Hansen et al. 1998, ER ID 63508)

Herceg, J. W. (Comp.), January 1972. “Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, January through June, 1971,” Los Alamos Scientific Laboratory Report LA-4871-MS, Los Alamos, New Mexico. (Herceg 1972, ER ID 31458)

Herceg, J. W. (Comp.), July 1972. “Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, July through December 1971,” Los Alamos Scientific Laboratory Report LA-4970, Los Alamos, New Mexico. (Herceg 1972, ER ID 4955)

Herceg, J. E. (Comp.), March 1973. “Environmental Monitoring in the Vicinity of the Los Alamos Scientific Laboratory, Calendar Year 1972,” Los Alamos Scientific Laboratory Report LA-5184, Los Alamos, New Mexico. (Herceg 1973, ER ID 4966)

Izett, G. A., and J. D. Obradovich, February 10, 1994. “^{40}Ar/^{39}Ar Age Constraints for the Jaramillo Normal Subchron and the Matuyama-Brunhes Geomagnetic Boundary,” *Journal of Geophysical Research,* Vol. 99, No. B2, pp. 2925–2934. (Izett and Obradovich 1994, ER ID 48817)

John, E. C., E. Enyart, and W. D. Purtymun, October 1966. “Records of Wells, Test Holes, Springs, and Surface-Water Stations in the Los Alamos Area, New Mexico,” US Geological Survey Open-File Report, Albuquerque, New Mexico. (John et al. 1966, ER ID 8796)

Kearl, P. M., J. J. Dexter, and M. Kautsky, March 1986. “Vadose Zone Characterization of Technical Area 54, Waste Disposal Areas G and L, Los Alamos National Laboratory, New Mexico, Report 3: Preliminary Assessment of the Hydrogeologic System,” Report GJ-44, Bendix Field Engineering Corporation, Grand Junction, Colorado. (Kearl et al. 1986, ER ID 8414)

Kennedy, W. R., W. D. Purtymun, and H. F. Schulte, July 1971. “Los Alamos Environmental Monitoring Program, July through December 1970,” Los Alamos Scientific Laboratory Report LA-4672-MS, Los Alamos, New Mexico. (Kennedy et al. 1971, ER ID 4800)

LANL (Los Alamos National Laboratory), May 1992. “RFI Work Plan for Operable Unit 1129,” Los Alamos National Laboratory Report LA-UR-92-800, Los Alamos, New Mexico. (LANL 1992, ER ID 7666)

LANL (Los Alamos National Laboratory), May 1992. “RFI Work Plan for Operable Unit 1148,” Los Alamos National Laboratory Report LA-UR-92-855, Los Alamos, New Mexico. (LANL 1992, ER ID 7669)

LANL (Los Alamos National Laboratory), 1993. “RFI Work Plan for Operable Unit 1140,” Los Alamos National Laboratory Report LA-UR-93-1940, Los Alamos, New Mexico. (LANL 1993, ER ID 20952)

LANL (Los Alamos National Laboratory), May 1993. “RFI Work Plan for Operable Unit 1093,” Los Alamos National Laboratory Report LA-UR-93-422, Los Alamos, New Mexico. (LANL 1993, ER ID 15310)

LANL (Los Alamos National Laboratory), July 1993. “RFI Work Plan for Operable Unit 1114,” Los Alamos National Laboratory Report LA-UR-93-1000, Los Alamos, New Mexico. (LANL 1993, ER ID 51977)

LANL (Los Alamos National Laboratory), May 1994. “RFI Work Plan for Operable Unit 1100,” Los Alamos National Laboratory Report LA-UR-94-1097, Los Alamos, New Mexico. (LANL 1994, ER ID 34756)

LANL (Los Alamos National Laboratory, December 16, 1994. “Response to EPA’s NOD for the OU 1100 Work Plan,” Los Alamos National Laboratory Letter to William Honker (EPA) from Theodore J. Taylor (DOE), Los Alamos, New Mexico. (LANL 1994, ER ID 43889)

LANL (Los Alamos National Laboratory), 1995. “Voluntary Corrective Action Plan for PRS 3-001(i), Former Equipment Storage Area, OU 1114, Field Unit 1,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1995, ER ID 46198)

LANL (Los Alamos National Laboratory), June 1995. “Expedited Cleanup Plan for Solid Waste Management Unit 3-056(c),” Rev. 0, Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1995, ER ID 47257)

LANL (Los Alamos National Laboratory), April 7, 1995. “Notification of Groundwater Encountered Below Material Disposal Area (MDA) L,” Letter to Barbara Driscoll (US Environmental Protection Agency, Region 6) from Jorg Jansen (Project Manager, Environmental Restoration) and Theodore J. Taylor (Program Manager, Los Alamos Area Office), Los Alamos, New Mexico. (LANL 1995, ER ID 45978)

LANL (Los Alamos National Laboratory), July 1995. “RFI Work Plan for Operable Unit 1114,” Addendum 1, Los Alamos National Laboratory Report LA-UR-95-731, Los Alamos, New Mexico. (LANL 1995, ER ID 51981)

LANL (Los Alamos National Laboratory), October 25, 1995. “Groundwater Protection Management Program Plan” (draft), Revision 2.0, Los Alamos, New Mexico. (LANL 1995, ER ID 50124)

LANL (Los Alamos National Laboratory), November 1995. “Task/Site Work Plan for Operable Unit 1049, Los Alamos Canyon and Pueblo Canyon,” Los Alamos National Laboratory Report LA-UR-95-2053, Los Alamos, New Mexico. (LANL 1995, ER ID 50290).

LANL (Los Alamos National Laboratory), 1996. “Fact Sheet for Operable Unit 1148 Resource Conservation and Recovery Act Facility Investigation Work Plan,” Los Alamos, New Mexico. (LANL 1996, ER ID 53791)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for Channel Sediment Pathways from MDAs G, H, J, and L, TA-54,” Los Alamos National Laboratory Report LA-UR-96-110, Los Alamos, New Mexico. (LANL 1996, ER ID 54462)

LANL (Los Alamos National Laboratory), February 1996. “RFI Report for 53 Potential Release Sites in TA-3, TA-59, TA-60, TA-61,” Los Alamos National Laboratory Report LA-UR-96-726, Los Alamos, New Mexico. (LANL 1996, ER ID 54467)

LANL (Los Alamos National Laboratory), March 19, 1996. “RFI Report for Potential Release Sites in TA-20, TA-53, and TA-72,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1996, ER ID 54124)

LANL (Los Alamos National Laboratory), June 1996, “RFI Report for Potential Release Sites in TA-46,” Los Alamos National Laboratory Report LA-UR-96-1957, Los Alamos, New Mexico. (LANL 1996, ER ID 54929)

LANL (Los Alamos National Laboratory), June 1996. “RFI Report for Potential Release Sites 35-003(d, e, f, g, l, m, o, q, and r) 35-016(g and h) (Located in Former Operable Unit 1129) Field Unit 4,” Los Alamos National Laboratory Report LA-UR-96-1605, Los Alamos, New Mexico. (LANL ER ID 1996, 54422).

LANL (Los Alamos National Laboratory), September 1996. “Voluntary Corrective Action Completion Report for a Solid Waste Management Unit at TA-46 46-003(h) Outfall, Field Unit 3,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (LANL 1996, ER ID 62341)

LANL (Los Alamos National Laboratory), December 1996. “Installation Work Plan for Environmental Restoration,” Revision 6, Los Alamos National Laboratory Report LA-UR-96-4629, Los Alamos, New Mexico. (LANL 1996, ER ID 55574)

LANL (Los Alamos National Laboratory), December 6, 1996. “Hydrogeologic Workplan” (draft), Revision 1.0, Los Alamos, New Mexico. (LANL 1996, ER ID 55430)

LANL (Los Alamos National Laboratory), April 1997. “Core Document for Canyons Investigations,” Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), May 1997. “RFI Status Report for Tritium in Surface Soils at MDA G, TA-54,” Los Alamos National Laboratory Report LA-UR-97-1308, Los Alamos, New Mexico. (LANL 1997, ER ID 55873)

LANL (Los Alamos National Laboratory), September 1997. “RFI Report for Potential Release Sites 3-04(c, d), 3-007, 3-014(k, l, o), 3-012, 3-049(a), 3-052(b), 3-056(k) and C-3-014,” Los Alamos National Laboratory Report LA-UR-97-3571, Los Alamos, New Mexico. (LANL 1997, ER ID 56660)

LANL (Los Alamos National Laboratory), September 1997. “Work Plan for Mortandad Canyon,” Los Alamos National Laboratory Report LA-UR-97-3291, Los Alamos, New Mexico. (LANL 1997, ER ID 56835)

LANL (Los Alamos National Laboratory), September 1998. “Draft Interim Completion Report for Characterization Well R-12,” Los Alamos National Laboratory Report LA-UR-98-3976, Los Alamos, New Mexico. (LANL 1998, ER ID 59665)

LANL (Los Alamos National Laboratory), March 25, 1998. “Groundwater Annual Status Summary Report, FY97,” Los Alamos, New Mexico. (LANL 1998, ER ID 57576)

LANL (Los Alamos National Laboratory), March 27, 1998. “Sampling and Analysis Plan for Upper Sandia Canyon,” Los Alamos National Laboratory Report LA-UR-98-4893, Los Alamos, New Mexico. (LANL 1998, ER ID 62340)

LANL (Los Alamos National Laboratory), June 1998. “RFI Work Plan and SAP for Potential Release Sites 53-002(a) 53-002(b) and Associated Piping and Drainages at TA-53,” Los Alamos National Laboratory Report LA-UR-98-2547, Los Alamos, New Mexico. (LANL 1998, ER ID 58841)

LANL (Los Alamos National Laboratory), September 1998. “Work Plan for Pajarito Canyon,“ Los Alamos National Laboratory Report LA-UR-98-2550, Los Alamos, New Mexico. (LANL 1998, ER ID 59577)

LANL (Los Alamos National Laboratory), “Source Data for Sanitary TA-3 Effluent Discharges,” Los Alamos, New Mexico. (LANL 1998, ER ID 63504)

LANL (Los Alamos National Laboratory), February 9, 1999. “Draft Watershed Management Plan,” Los Alamos National Laboratory draft plan, Los Alamos, New Mexico. (LANL 1999, ER ID 62920)

Longmire, P. A., S. Kung, J. M. Boak, A. I. Adams, F. Caporuscio, and R. N. Gray, 1996. “Aqueous Geochemistry of Upper Los Alamos Canyon, Los Alamos, New Mexico,” in *New Mexico Geological Society Guidebook,* 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 473–480. (Longmire et al. 1996, ER ID 54168)

Manley, K., 1976. “The Late Cenozoic History of the Española Basin, New Mexico,” thesis, University of Colorado, Boulder, Colorado. (Manley 1976, ER ID 57673)

Manley, K., 1979. “Stratigraphy and Structure of the Española Basin, Rio Grande Rift, New Mexico,” in *Rio Grande Rift: Tectonics and Magmatism,* R. Riecker, Ed*.,* American Geophysical Union, Washington, DC, pp. 71–86. (Manley 1979, ER ID 11714)

McLin, S. G., August 1992. “Determination of 100-Year Floodplain Elevations at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-12195-MS, Los Alamos, New Mexico. (McLin 1992, ER ID 12014)

McLin, S. G., September 1996. “Analysis of Water Level Fluctuations in Pajarito Plateau Wells,” in *New Mexico Geological Society Guidebook,* 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 421–426. (McLin 1996, ER ID 56025)

McLin, S. G., W. D. Purtymun, M. N. Maes, and P. A. Longmire, December 1997. “Water Supply at Los Alamos During 1996,” Los Alamos National Laboratory Report LA-13371-PR, Los Alamos, New Mexico. (McLin et al. 1997, ER ID 57754)

McLin, S. G., W. D. Purtymun, M. N. Maes, December 1998. “Water Supply at Los Alamos during 1997,” Los Alamos National Laboratory Report LA-13548-PR, Los Alamos, New Mexico. (McLin et al. 1998, ER ID 63506)

Michael, M., February 1998. “Assessment of PCB Analytical Data Obtained from the July 1996 Collection of Aquatic Insects in the Upper Sandia Canyon Wetlands, 3-056(c),” Department of Energy Oversight Bureau, Los Alamos, New Mexico. (Michael 1998, ER ID 57497)

Monahan, P. K., R. Ford-Schmid, and H. L. Decker, 1996. “Surface Water Quality Monitoring at Department of Energy Facilities in New Mexico 1992—1993,” NMED/DOE/AIP-96/5, New Mexico Environment Department, Department of Energy Oversight Bureau, Santa Fe, New Mexico. (Monahan et al. 1996, ER ID 63507)

New Mexico Water Quality Control Commission, January 23, 1995. State of New Mexico Standards for Interstate and Intrastate Streams, Report 20 NMAC 6.1, Santa Fe, New Mexico. (New Mexico Water Quality Control Commission 1995, ER ID 50265)

Pratt, A., June 2, 1994, “Addendum to the OU 1129 RFI Work Plan,” Los Alamos National Laboratory Memorandum EES-13-ER-05-94-011 to Tracy Glatzmaier from Allyn Pratt, Los Alamos, New Mexico. (Pratt 1994, ER ID 39932)

Purtymun, W. D., June 1967. “Record of Water-Supply Well PM-3, Los Alamos, New Mexico,” Los Alamos Scientific Laboratory Report, Los Alamos, New Mexico. (Purtymun 1967, ER ID 11829)

Purtymun, W. D., 1973, “Underground Movement of Tritium from Solid-Waste Storage Shafts,” Los Alamos Scientific Laboratory Informal Report LA-5286-MS, Los Alamos, New Mexico. (Purtymun 1973, ER ID 4975)

Purtymun, W. D., April 1973. “Regional Survey of Tritium in Surface and Ground Water in the Los Alamos Area, New Mexico, August 1966 through May 1969,” Los Alamos Scientific Laboratory Report LA-5234-MS, Los Alamos, New Mexico. (Purtymun 1973, ER ID 4971)

Purtymun, W. D., September 1974. “Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon at the Los Alamos Scientific Laboratory,” Los Alamos Scientific Laboratory Report LA-5716-MS, Los Alamos, New Mexico. (Purtymun 1974, ER ID 5476)

Purtymun, W. D., 1975. “Geohydrology of the Pajarito Plateau with Reference to Quality of Water, 1949–1972,” Los Alamos Scientific Laboratory Informal Report LA-5744, Los Alamos, New Mexico. (Purtymun 1975, ER ID 11787)

Purtymun, W. D., January 1984. “Hydrologic Characteristics of the Main Aquifer in the Los Alamos Area: Development of Ground Water Supplies,” Los Alamos National Laboratory Report LA-9957-MS, Los Alamos, New Mexico. (Purtymun 1984, ER ID 6513)

Purtymun, W. D., March 1, 1994. “Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990,” Los Alamos National Laboratory Report LA-12733-MS, Los Alamos, New Mexico. (Purtymun 1994, ER ID 58233)

Purtymun, W. D., January 1995. “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area,” Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Purtymun, W. D., and A. K. Stoker, September 1990. “Perched Zone Monitoring Well Installation,” Los Alamos National Laboratory Report LA-UR-90-3230, Los Alamos, New Mexico. (Purtymun and Stoker 1990, ER ID 7508)

Purtymun, W. D., M. L. Wheeler, and M. A. Rogers, May 1978. “Geologic Description of Cores from Holes P-3 MH-1 Through P-3 MH-5, Area G, Technical Area 54,” Los Alamos Scientific Laboratory Report LA-7308-MS, Los Alamos, New Mexico. (Purtymun et al. 1978, ER ID 5728)

Purtymun, W. D., R. J. Peters, and J. W. Owens, December 1980. “Geohydrology of White Rock Canyon of the Rio Grande from Otowi to Frijoles Canyon,” Los Alamos Scientific Laboratory Report LA-8635-MS, Los Alamos, New Mexico. (Purtymun et al. 1980, ER ID 6048)

Purtymun, W. D., and S. Johansen, 1974. “General Geohydrology of the Pajarito Plateau,” in *New Mexico Geological Society Guidebook,* 25th Field Conference, Ghost Ranch, New Mexico, pp. 347–349. (Purtymun and Johansen 1974, ER ID 11835)

Purtymun, W. D., W. R. Hansen, and R. J. Peters, March 1983. “Radiochemical Quality of Water in the Shallow Aquifer in Mortandad Canyon 1967–1978,” Los Alamos National Laboratory Report LA-9675-MS, Los Alamos, New Mexico. (Purtymun et al. 1983, ER ID 6407)

Purtymun, W. D., and W. R. Kennedy, May 1971. “Geology and Hydrology of Mesita del Buey,” Los Alamos Scientific Laboratory Report LA-4660, Los Alamos, New Mexico. (Purtymun and Kennedy 1971, ER ID 4798)

Reneau, S. L., and E. V. McDonald, “Landscape History and Processes on the Pajarito Plateau, Northern New Mexico,” Rocky Mountain Cell, Friends of the Pleistocene, Field Trip Guidebook, September 12–15, 1996, Los Alamos National Laboratory Report LA-UR-96-3035, Los Alamos, New Mexico. (Reneau and McDonald 1996, ER ID 55538)

Reneau, S. L., K. Campbell, P. Longmire, and E. McDonald, March 4, 1996. “Geochemistry of Background Sediment Samples at Technical Area 39” (draft), Los Alamos National Laboratory Report, Los Alamos, New Mexico. (Reneau et al. 1996, ER ID 56047)

Reneau, S. L., D. E. Broxton, J. S. Carey, and C. LaDelfe, December 1998. “Structure of the Tshirege Member of the Bandelier Tuff at Mesita del Buey, Technical Area 54, Los Alamos, National Laboratory,” Los Alamos National Laboratory Report LA-13538-MS, Los Alamos, New Mexico. (Reneau et al. 1998, ER ID 63497)

Risberg, D., February 3, 1994. “Biological Assessment for Sanitary Waste Disposal Areas In TAs 60 and 65,” Revision 1, Los Alamos National Laboratory Report LA-UR-94-583, Los Alamos, New Mexico. (Risberg 1994, ER ID 62353)

Rogers, D. B., A. K. Stoker, S. G. McLin, and B. M. Gallaher, 1996. “Recharge to the Pajarito Plateau Regional Aquifer System,” Los Alamos National Laboratory Report LA-UR-96-486, Los Alamos, New Mexico. (Rogers et al. 1996, ER ID 54714)

Rogers, D. B., B. M. Gallaher, and E. L. Vold, 1996. “Infiltration Beneath the Pajarito Plateau at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-UR-96-485 in *New Mexico Geological Society Guidebook,* 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 413–420. (Rogers et al. 1996, ER ID 55543)

Rogers, M. A., June 1977. “History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Waste (Areas A, B, C, D, E, F, G, and T),” Los Alamos Scientific Laboratory Report LA-6848-MS, Vol. II, Los Alamos, New Mexico. (Rogers 1977, ER ID 5708)

Rogers, M. A., 1995. “Geologic Map of the Los Alamos National Laboratory Reservation,” prepared by Mara, Inc., Los Alamos, New Mexico. (Rogers 1995, ER ID 54419)

Ryti, R. T., P. A. Longmire, D. E. Broxton, S. L. Reneau, and E. V. McDonald, September 1998, “Inorganic and Radionuclide Background Data for Soils, Sediments and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory Report LA-UR-98-4847. (Ryti et al. 1998, 59730)

Schiager, K. J., and K. E. Apt (Comps.), May 1974. “Environmental Surveillance at Los Alamos During 1973,” Los Alamos Scientific Laboratory Report LA-5586, Los Alamos, New Mexico. (Schiager and Apt 1974, ER ID 5467)

Shaull, D. A., M. R. Alexander, and R. P. Reynolds, August 1996. “Surface Water Data at Los Alamos National Laboratory: 1995 Water Year,” Los Alamos National Laboratory Report LA-13177-PR, Los Alamos, New Mexico. (Shaull et al. 1996, ER ID 56019)

Shaull, D. A., M. R. Alexander, R. P. Reynolds, and C. T. McLean, November 1996. “Surface Water Data at Los Alamos National Laboratory: 1996 Water Year,” Los Alamos National Laboratory Report LA-13234-PR, Los Alamos, New Mexico. (Shaull et al. 1996, ER ID 56020)

Shaull, D. A., M. R. Alexander, R. P. Reynolds, and C. T. McLean, January 1998. “Surface Water Data at Los Alamos National Laboratory: 1997 Water Year,” Los Alamos National Laboratory Report LA-13403-PR, Los Alamos, New Mexico. (Shaull et al. 1998, ER ID 57581)

Shaull, D. A, M. R. Alexander, R. P. Reynolds, C. T. McLean, and R. P. Romero, February 1999. “Surface Water Data at Los Alamos National Laboratory: 1998 Water Year,” Los Alamos National Laboratory Report LA-13551-PR, Los Alamos, New Mexico. (Shaull et al. 1999, ER ID 63505)

Smith, R. L., R. A. Bailey, and C. S. Ross, 1970. “Geologic Map of Jemez Mountains, New Mexico,” US Geological Survey Miscellaneous Investigations Series Map I-571, Washington, DC. (Smith et al. 1970, ER ID 9752)

Spell, T. L., T. M. Harrison, and J. A. Wolf, January 18, 1990. “^{40}Ar/^{39}Ar Dating of the Bandelier Tuff and San Diego Canyon Ignimbrites, Jemez Mountains, New Mexico: Temporal Constraints on Magmatic Evolution,” *Journal of Volcanology and Geothermal Research*, Vol. 43, pp. 175–193. (Spell et al. 1990, ER ID 21586)

Stoker et al., May 1992, “Water Supply at Los Alamos During 1989,” Los Alamos National Laboratory Report LA-12276-PR, Los Alamos, New Mexico. (LANL 1992, ER ID 12017)

Turbeville, B. N., D. B. Waresback, and S. Self, February 1989. “Lava-Dome Growth and Explosive Volcanism in the Jemez Mountains, New Mexico: Evidence from the Plio-Pleistocene Puye Alluvial Fan,” *Journal of Volcanology and Geothermal Research,* Vol. 36, pp. 267–291. (Turbeville et al. 1989, ER ID 21587)

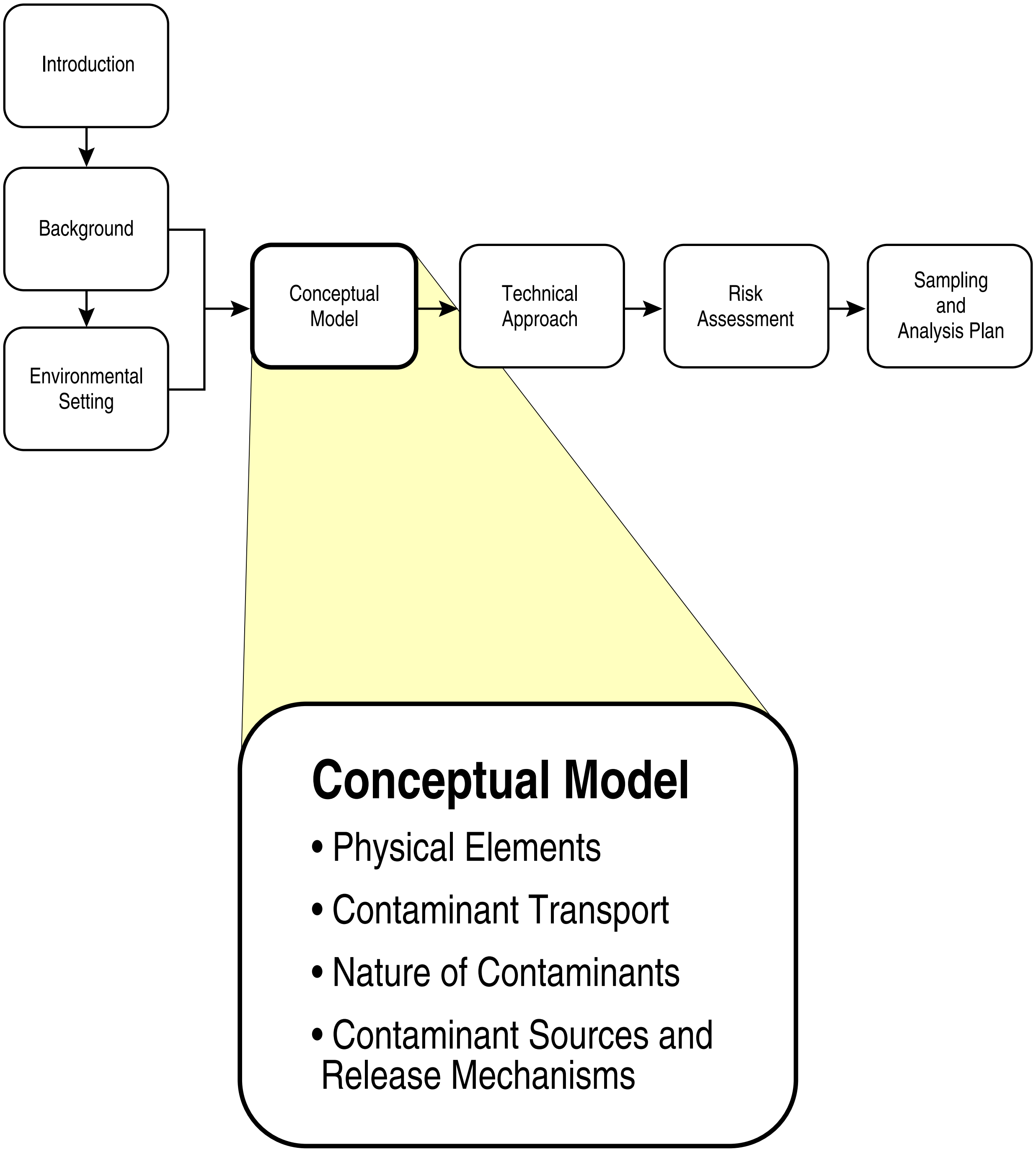
Vaniman, D., and K. Wohletz, November 14, 1990. “Results of Geological Mapping/Fracture Studies: TA-55 Area,” Los Alamos National Laboratory Memorandum EES1-SH90-17 to J. Gardner (EES-1) from D. Vaniman and K. Wohletz, Los Alamos, New Mexico. (Vaniman and Wohletz 1990, ER ID 21589)

WoldeGabriel, G., A. W. Laughlin, D. P. Dethier, and M. Heizler, 1996. “Temporal and Geochemical Trends of Lavas in White Rock Canyon and the Pajarito Plateau, Jemez Volcanic Field, New Mexico, USA,” Los Alamos National Laboratory Report LA-UR-96-583, Los Alamos, New Mexico. (WoldeGabriel et al. 1996, ER ID 54427)

Yanicak, S., February 12, 1998. “Release of Ground- and Surface-Water Data Related to Split-Sampling and Independent Sampling at Los Alamos National Laboratory and Surrounding Areas During 1996 and 1997,” Letter to Mat Johansen (AIP POC, US Department of Energy, Los Alamos Area Office) from Steve Yanicak (LANL POC, Department of Energy Oversight Bureau), Santa Fe, New Mexico. (Yanicak 1998, ER ID 57583)

Yanicak, S., July 2, 1999. “1998 Surface-Water Quality Data Obtained from Sampling Cañada del Buey and Sandia Canyon,” Letter to Joe Vozella (AIP POC, US Department of Energy, Los Alamos Area Office) from S. Yanicak (LANL POC, New Mexico Environment Department DOE Oversight Bureau), Los Alamos, New Mexico. (Yanicak 1999, ER ID 63495)

Chapter 4



Conceptual Model

- Physical Elements
- Contaminant Transport
- Nature of Contaminants
- Contaminant Sources and Release Mechanisms

4.0 CONCEPTUAL MODEL

The conceptual model links existing knowledge of the Sandia Canyon and Cañada del Buey systems (see Chapter 2 and Chapter 3 of this work plan) and the additional information needed to adequately understand the canyon systems. This chapter summarizes the significant geologic, hydrologic, and biological features, events, and processes operating in the Sandia Canyon and Cañada del Buey systems. Most importantly, this chapter describes working hypotheses based on

- historical information presented in Chapter 2;
- environmental information presented in Chapter 3;
- information and processes applicable to canyon systems in general (see Chapter 4 of the “Core Document for Canyons Investigations,” hereafter referred to as “the core document”) (LANL 1997, 55622); and
- the unique environmental factors and processes occurring in Sandia Canyon and Cañada del Buey that need to be tested or confirmed.

The concepts and the hypotheses presented in the conceptual model will be tested by collecting new data and by interpreting the new data together with existing information. The result will be an improved understanding of the canyons and the processes that operate in the canyons and an improved conceptual model with less uncertainty. This understanding will lead to a greater ability to project future impacts of contaminants both spatially and temporally.

The improved conceptual framework is intended to facilitate human health and ecological risk assessments for current contamination conditions and to project trends of reasonable future environmental impacts. The hypotheses presented in this section lead directly to elements of the sampling and analysis plan (SAP), which is presented in Chapter 7 of this work plan.

The conceptual model also includes updates and some new hypotheses regarding the regional aquifer that are particularly relevant to Sandia Canyon and Cañada del Buey and should be applicable on a wider scale across the Pajarito Plateau. These additions to concepts included in the core document (LANL 1997, 55622) and the “Hydrogeologic Workplan” (LANL 1998, 59599) have evolved as a result of information collected during the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) activities conducted through May 1999. This information comes from work accomplished in Pueblo Canyon and Los Alamos Canyon, and as a result of drilling regional aquifer wells R-9 in Los Alamos Canyon and R-12 in Sandia Canyon (LANL 1998, 59158; LANL 1998, 59665).

Updates to the conceptual model are documented in the annual hydrogeologic work plan reports.

4.1 Sandia Canyon Conceptual Model

Summaries of the important concepts obtained from the environmental data described in Chapter 3 are presented in this section. An illustration of the Sandia Canyon conceptual model is shown in Figure A-4 in Appendix A of this work plan and is an integral part of the description of the conceptual model.

4.1.1 Sediment Transport Concepts

Most elements of the conceptual model for sediment transport processes in Sandia Canyon are the same as those described in the core document (LANL 1997, 55622) and are not repeated in this work plan.

Section 3.4.1 of this work plan describes the information known about surface sediments, and Section 3.4.2 of this work plan describes the information known about subsurface sediments.

Most contaminants within the Sandia Canyon system that have reached active stream channels following release from outfalls or from surface transport from PRSs are associated with sediment particles derived from the erosion of surface soils and/or bedrock. The present and future distributions of these sediment particles are strongly affected by sediment transport processes that occur during flood events. Sediments and associated contaminants are deposited in different geomorphic units within the canyon, such as active stream channel sediments, inactive channel sediments, and floodplain sediments. These sediments will remain in place for varying lengths of time. The remobilization of sediments in geomorphic units by transport in stormwater runoff is the major mechanism for moving contaminants in canyon systems. Contaminants that are associated with sediment can be available for uptake by humans and animals through ingestion of unfiltered water from streamflow, runoff, and ponded water. Sediments can be ingested directly or as rain splash deposition on vegetation, by inhaling resuspended airborne particulates from sediments, and by consuming plants and animals that have been contaminant receptors. Resuspension of sediment and soils by wind is considered to be one of the predominant pathways for radiological exposure to humans because dust can be easily lifted high enough to be inhaled by humans. Chapter 6 of the core document (LANL 1997, 55622) discusses exposure pathways and scenarios.

In upper Sandia Canyon, local variations in stream gradient and resultant variations in the potential for sediment storage occur relative to stratigraphic variations in the bedrock tuff. Relatively flat sections of the canyon floor occur upstream of relatively more resistant units in the tuff that provide opportunities for sediment storage. One such area is approximately coincident with the occurrence of the wetlands in upper Sandia Canyon, which act as enhanced sediment deposition areas, helping to prevent potentially contaminated sediments from moving further down the canyon. In some areas, the narrow canyon floor is partially filled with boulders derived from adjacent cliffs composed of units Qbt 2 and Qbt 3, which creates steep reaches with relatively little potential for sediment storage.

The stream channel in middle Sandia Canyon was highly disturbed when the stream channel was straightened during road construction. Impacts to sediment transport and possible contaminant transport and redistribution are not well understood. Potential contaminants in the sediments associated with firing sites at former TA-20 in middle Sandia Canyon were present before major road-building in the canyon; it is not known how road building may have impacted possible contaminant redistribution. The current geomorphology of middle Sandia Canyon comprises a decreasing channel gradient, widening canyon floor, and a thick section of sandy, permeable alluvium, all of which contribute to surface water infiltration and sediment deposition.

Downstream of state road NM4 the channel continues to incise the nonwelded Otowi Member. The alluvium pinches out where basalt is first exposed in the canyon approximately 1.6 mi (2.5 km) west of the Rio Grande. In lower off-site Sandia Canyon, downstream of state road NM4, the channel steepens and drops through a narrow slot cut into basalt and into underlying Tertiary sediments. The primary areas of sediment deposition in the lower and lower off-site portions of Sandia Canyon are anticipated to be upstream of the basalt outcrops with smaller amounts of deposition occurring between the basalt and the Rio Grande.

4.1.2 Hydrologic Transport Concepts

This section outlines the canyon-specific hydrologic transport concepts for Sandia Canyon. Figure A-4 illustrates the major elements of the Sandia Canyon hydrologic conceptual model and the current hypotheses regarding the connecting pathways and processes. The following brief descriptions highlight the most important elements of the Sandia Canyon hydrologic transport conceptual model. The descriptions are organized from west to east down the canyon. Features and geographic locations discussed in this section are also shown in Figure A-1 in Appendix A of this work plan.

4.1.2.1 Snowmelt and Stormwater Runoff

One input of new water to the canyon system is contemporary precipitation, which includes snowmelt from annual snowfall and precipitation from rainfall. Snowmelt runoff each spring usually releases part of the snowpack to the system. Stormwater runoff into the canyon system varies with the amount of seasonal precipitation in the watershed. Snowmelt and stormwater runoff from the upper canyon near TA-3 currently are not monitored by a gaging station. However there are plans to install several gaging stations in 1999 (LANL 1999, 62920). Stream gage data for the upper and middle parts of the canyon will enhance the understanding of the volumes of snowmelt and stormwater runoff in Sandia Canyon.

During summer thundershowers streamflow occasionally reaches the Laboratory boundary at state road NM4, and only during periods of heavy thunderstorms or snowmelt does streamflow from Sandia Canyon extend beyond the Laboratory boundary or reach the Rio Grande. Since 1994 surface flow at the eastern Laboratory boundary has been measured only a few times during periods of heavy precipitation.

4.1.2.2 Effluent Discharge

The major source of water to Sandia Canyon is effluent discharges from the Laboratory sanitary wastewater sewage treatment plant (STP) and cooling tower discharges at TA-3. The canyon also receives stormwater runoff from parking lots and streets at TA-3. The discharged effluents support a reach of continuous streamflow and a wetland area in the upper canyon (see Section 3.3.2.1).

4.1.2.3 Mesa-Top Runoff

Stormwater runoff from Laboratory installations and from mesa tops contributes to the volume of water entering the canyon. Nonpoint source contamination is known to be present locally on the floor of the middle canyon as a result of dynamic explosives testing at former TA-20 and firing range activities at TA-72.

4.1.2.4 Perennial Streamflow

National Pollutant Discharge Elimination System (NPDES) discharges from TA-3 support a reach of continuous Laboratory-supported flow to the wetland areas in upper Sandia Canyon. The continuous flow normally extends approximately 2.4 mi (3.8 km) below the TA-3 sanitary treatment plant outfall. No naturally occurring perennial reaches are present in Sandia Canyon on Laboratory property. One short perennial reach occurs in lower off-site Sandia Canyon below Sandia Spring. This perennial reach does not extend to the Rio Grande.

4.1.2.5 Surface Water and Sediment Transport

Two major mechanisms for moving contaminants in the canyon system are surface water and surface sediment transport. Several processes are involved, which are described in Chapter 4 of the core document (LANL 1997, 55622). Except for the reach of continuous flow in the upper canyon supported by Laboratory effluent discharges and one relatively short perennial reach of streamflow located below Sandia Spring in the lower off-site canyon, surface water flow and sediment transport through the canyon are ephemeral. Since 1994 surface flow at the eastern Laboratory boundary has been measured only a few times during periods of heavy precipitation. Land-use changes in the watershed could impact runoff volumes, velocities, and water quality and cause accelerated erosion and/or redeposition of contaminants.

4.1.2.6 Upper and Middle Sandia Canyon Alluvial Groundwater System

An alluvial groundwater body of limited extent potentially could be present in the upper and middle portions of Sandia Canyon. Two observation wells (SCO-1 and SCO-2) installed in the alluvium in lower Sandia Canyon do not contain water, indicating that an alluvial groundwater system does not extend to the lower reaches of the canyon (Purtymun and Stoker 1990, 7508, p. 6). The extent of the probable shallow alluvial groundwater body in middle Sandia Canyon is not known. The presence of alluvial groundwater is likely but has not been intersected by the observation wells drilled to date. The installation of additional alluvial groundwater observation wells is needed to understand the alluvial groundwater system.

Evapotranspiration (ET) removes an unknown amount of water from the Sandia Canyon system each year. An unknown amount of shallow alluvial groundwater may be lost from the alluvium by moving downward into underlying units. Alluvial groundwater likely seeps into the underlying Cerro Toledo interval and Bandelier Tuff and possibly other hydrogeologic units. Neither the mechanism nor the location of the water loss from the alluvial groundwater system is known.

Contrasting hydraulic properties between units of the Bandelier Tuff may cause zones of high moisture content to develop near the contacts in the Tshirege Member, the Tsankawi Pumice Bed, the Cerro Toledo interval, the Otowi Member, and the Guaje Pumice Bed. These zones of increased water saturation also may divert flow laterally and may be a mechanism for water loss from the alluvium.

Evaluating the location and amount of water loss from the alluvium is necessary to determine possible contaminant transport pathways. Additional data needed to perform water-balance calculations include water level measurements (preferably time-series data from transducers), site-specific soil moisture measurements and precipitation amounts, ET measurements, and streamflow volumes.

4.1.2.7 Contact of Alluvium with Cerro Toledo Interval and Older Units

Throughout the upper part of the canyon, the alluvium overlies the Bandelier Tuff, the weathered top of which may provide a perching layer for the alluvial groundwater. However, in middle Sandia Canyon south of TA-53, the alluvium overlies the Cerro Toledo interval, which in part consists of older alluvial sediments. In the middle canyon, the alluvial groundwater may seep into the Cerro Toledo interval sediments. Flow within the Cerro Toledo interval may be controlled by paleochannels that potentially provide flow pathways away from the stream channel, possibly toward the south or southeast.

East of state road NM4 the stream channel in Sandia Canyon is often located directly on basalts of the Cerros del Rio volcanic field, with relatively minor alluvium present. Surface water that seeps into the basalt may flow laterally and/or downward via fractures or intermediate perched zones within the basalt.

4.1.2.8 Bedrock Faults and Fractures

Faults and fractures may act as infiltration pathways if they become saturated, particularly in the canyon floor. Open joints, faults, and fractures may provide additional pathways for deeper infiltration, transient flow, and lateral transport in the subsurface. Such pathways could account for some of the major water loss from the alluvium where saturation is present. The southern part of the Rendija Canyon fault zone intersects upper Sandia Canyon near the wetlands (Gardner et al. 1999, 63492), and a higher density of open fractures may be present in this area and contribute to infiltration.

4.1.2.9 Perched Groundwater

As described above, surface water enters Sandia Canyon from runoff and discharges from National Pollutant Discharge Elimination System (NPDES) outfalls at TA-3. Most surface water normally infiltrates the alluvium and likely recharges a body of perched alluvial groundwater in the upper and middle sections of the canyon on Laboratory property. As the groundwater moves through the alluvium, some is lost to ET and the remainder seeps into the underlying tuff, the Cerro Toledo interval, or the basalt, as the water in the alluvium continues to move downgradient.

The extent of seepage into suballuvial units in Sandia Canyon is not known. In the past boreholes such as PM-3 and SCO-1, which were drilled into the suballuvial units in lower Sandia Canyon, encountered dry rock beneath the alluvium (Purtymun 1995, 45344, pp. 142, 260 through 276). However, during drilling of PM-1, indications of the presence of water in the basalt at 450 ft (167 m) depth suggest the presence of some intermediate perched groundwater. Perched groundwater may be present in several places within lower Sandia Canyon. Potential occurrences of perched groundwater include the following:

- Perched groundwater was encountered in the Cerros del Rio basalts at a depth of about 450 ft (167 m) in water supply well PM-1 when the well was drilled in 1964 and 1965 (Cooper et al. 1965, 8582, p. 40).

- Water supply well Otowi-4, located in middle Los Alamos Canyon north of TA-53, also encountered perched intermediate groundwater at a depth of approximately 253 ft (76 m) in the upper fanglomerate section of the Puye Formation above the Cerros del Rio basalts when the well was drilled in 1990 (LANL 1992, 12017, p. 22).

- In 1998 a perched groundwater system was encountered in regional aquifer well R-12 from depths of 443 ft to 519 ft (133 m to 156 m) in the lower part of the Cerros del Rio basalt and in underlying old alluvium within the Puye Formation. The groundwater level in this zone rose in the borehole after penetration by drilling, indicating that the groundwater was confined. The water level stabilized at a depth of 424 ft (127 m) (LANL 1998, 59665). Nitrate concentrations observed in R-12 groundwater at depths of 443 (133 m) and 495 ft (149 m) (4.9 and 5.5 mg/L, respectively) are above background values (BVs), which typically are less than 0.5 ppm nitrate as nitrogen. In addition, nitrogen isotopic data for these two samples is consistent with derivation of nitrate from a sewage source, possibly the TA-3 outfall (LANL 1998, 59665, pp. 33-34). These data suggest a possible infiltration pathway of surface water and alluvial groundwater to deeper intermediate perched zones beneath Sandia Canyon.

Intermediate perched zones have not been identified beneath upper and middle Sandia Canyon; however the presence of an intermediate perched zone beneath TA-53 has been inferred (LANL 1998, 58841, p. 2-10). It is not known whether losses from alluvium recharge any intermediate perched zones. The lateral extent of these perched groundwater bodies is not known nor is it known if the perched groundwater at PM-1 is connected to the perched groundwater at Otowi-4. It is also not known if these intermediate-depth groundwater bodies are hydraulically interconnected with the regional aquifer (e.g., LANL 1998, 58841, p. 2-10).

4.1.2.10 Buried Paleochannels

Intermediate perched zones have not been observed to extend laterally beneath mesas. However, lateral spreading of such perched zones could occur if the canyon course and the gradient of the perched zone do not coincide. Buried paleochannels in the subsurface may provide collection points and conduits for intermediate perched zones and lateral transport pathways for groundwater. The following are possible locations of buried paleochannels:

- The Cerro Toledo interval channel/fluvial deposits may include a major channel system that extends from the upper reaches of Los Alamos Canyon southeast to Potrillo Canyon. This channel system or a similar channel system may cross Sandia Canyon near water supply well PM-1, where large boulders of andesite are present within the upper Cerro Toledo interval (Broxton and Reneau 1996, 55429).

- The pre-Bandelier Tuff (pre-Guaje Pumice Bed) surface locally may be the top of the Puye Formation, the top of Tschicoma Formation intermediate volcanic flows, or the top of Cerros del Rio basalt flows. A paleochannel eroded into the pre-Bandelier Tuff surface appears to trend toward the south-southwest across the Pajarito Plateau and cross Sandia Canyon near TA-53 (Broxton and Reneau 1996, 55429).

4.1.2.11 Regional Aquifer

The regional aquifer is composed of many different rock types and is extremely heterogeneous and anisotropic both geologically and hydrologically. The uppermost layers of saturation in the regional aquifer are typically within the fanglomerate member of the Puye Formation, which is interbedded with layered dense volcanic flows that overlie Santa Fe Group sediments. Lateral flow of groundwater in the regional aquifer is probably controlled by subhorizontal permeability contrasts within the different rock types. The deep water supply wells are screened across many stratigraphic layers with widely varying hydrogeologic and geochemical properties. Historically, the long screened intervals have resulted in a limited understanding of the aquifer based on averaging of hydrologic and geochemical characteristics across the screened intervals.

The regional aquifer occurs in the Puye Formation and the Santa Fe Group at depths below Sandia Canyon and Cañada del Buey ranging from approximately 1200 ft (365 m) at the head of the canyons to approximately 750 ft (230 m) near the eastern Laboratory boundary. Continuously recorded water level data collected at test wells since 1992 indicate that throughout the Pajarito Plateau the regional aquifer responds to barometric and earth tide effects in a manner typical of confined to partially confined aquifers (McLin 1996, 56025).

The hydrogeology of Sandia Canyon is summarized below.

- In Sandia Canyon a continuous reach of surface water is completely lost into the subsurface, initially to the alluvium. The water probably seeps into deeper units and moves into the subsurface along fractures, bedding planes, or unit contacts; the ultimate fate of this water is not known. In recent years, approximately 160,000 gpd (608,000 L per day [L/d]) infiltrate into the subsurface in Sandia Canyon (see Section 3.4.3.1).

- Most water entering the canyon must be lost either to ET or to seepage into deeper units because surface flow out of the canyon at the Laboratory boundary at state road NM4 is entirely ephemeral and in recent years has occurred only after significant storm events. The amount and fate of water leaving the alluvium or shallow perched zone are not known.

- The regional aquifer extends beneath the Sandia Canyon watershed. The regional aquifer is pumped at supply wells PM-1 and PM-3 in lower Sandia Canyon. The upper portion of the regional aquifer probably discharges at Sandia Spring in lower off-site Sandia Canyon.
- In PM-1 and PM-3 elevated tritium activity was observed as high as 5900 pCi/L (±800 pCi/L) in 1981. Laboratory effluents may have impacted the regional aquifer beneath Sandia Canyon. Since 1982 the activity of tritium has been measured at or below detection limits using the liquid scintillation method.
- Measurable tritium activity (46.9 pCi/L) in the regional saturated zone in R-12 suggests that a component of the groundwater is less than 50 years old (LANL 1998, 59665, p. 2).

4.1.2.12 Deep Water Supply Wells

Groundwater withdrawn from the regional aquifer is used directly by people in Los Alamos County. No contamination from Laboratory operations has been identified in the regional aquifer water supply wells in or adjacent to Sandia Canyon. The water from the deep wells is collected from long screen intervals, often more than 1000 ft (300 m) thick, and is a mixture of water from different stratigraphic formations. The water from different formations may have different piezometric heads and geochemical characteristics. Data from vertical flow measurements and down-hole video logs in some wells indicate that most water withdrawal comes from a relatively small number of stratigraphic units within the screened interval. Additional information is needed about the source of water from the regional aquifer to the water supply wells and the geochemical characteristics of the water from different units.

4.1.2.13 Springs near the Rio Grande

One spring is known to occur in the Sandia Canyon watershed area. Sandia Spring is located in lower off-site Sandia Canyon about 3000 ft (900 m) upstream of the confluence with the Rio Grande. Flow from the spring was estimated to be 0.25 gpm (0.95 L/m) in 1966 and measured to be 3 gpm to 5 gpm (11.4 L/m to 19 L/m) in 1994 and 1995 (see Section 3.4.3.1.1). Spring flow is not sufficient to reach the Rio Grande and is depleted by infiltration and evaporation.). The source of Sandia Spring has been reported as the regional aquifer from the Totavi Lentil at the base of the Puye Formation (Purtymun 1995, 45344, p. 284). However, other geochemical data possibly suggest a different source of water either within the regional aquifer or possibly from alluvial sources in Sandia Canyon or Mortandad Canyon (Dale et al. 1996, 57014, p. 13).

Groundwater in the upper saturated zones of the regional aquifer apparently moves generally eastward from the Sierra de los Valles toward the Rio Grande under natural and induced (due to pumping wells) hydraulic gradients. The water that discharges at Sandia Spring in lower off-site Sandia Canyon may come from the upper part of the regional aquifer. However, isotopic dating of the regional aquifer water and transport rates calculated from hydraulic gradients and hydraulic properties are widely divergent and inconsistent. The groundwater flow system is poorly understood, especially as it concerns layering and the influence of anisotropy in the vertical and horizontal permeability.

4.1.3 Biological Transport Concepts

The biological transport conceptual model is presented in the core document (LANL 1997, 55622, p. 4-12).

A wetland area is present in upper Sandia Canyon near TA-3. Special biological investigations have been initiated at the wetland that are planned for completion as part of the canyons RFI. The results of the existing investigations will be evaluated for applicability to the Sandia Canyon investigation and will form the basis of a biological transport conceptual model.

4.1.4 Potential Sources of Contamination to the Sandia Canyon Watershed

4.1.4.1 Upper Canyon Contaminant Sources

In upper Sandia Canyon, possible sources of contaminants to surface water, surface sediments, and possibly to shallow groundwater identified through RFIs include the following (see Figure A-1):

- Potential Release Sites (PRSs) 3-012(b) and 3-045(b) (see Section 2.3.1);
- PRSs 3-013(a and b) and 3-052(f) (see Section 2.3.1);
- PRS 3-014(c_2) (see Section 2.3.1);
- PRS 3-003(n) (see Section 2.3.1);
- PRSs 3-015 and 3-053 (see Section 2.3.1);
- PRS 3-036(j) (see Section 2.3.1);
- PRS 3-045(c) (see Section 2.3.1)
- PRS 3-056(c) (see Section 2.3.1);
- PRS 61-002 (see Section 2.3.3);
- outfall discharges, which mostly consist of deep aquifer water from supply wells with altered constituents or added contaminants;
- leaching of contaminants by runoff and/or infiltration at PRSs with contaminants; and
- remobilization of contaminants in sediments in upper Sandia Canyon.

4.1.4.2 Middle and Lower Canyon Contaminant Sources

Possible sources of contamination in the middle reaches of Sandia Canyon include the following:

- PRS 53-002(a) (see Section 2.3.4);
- PRS 53-014 (see Section 2.3.4);
- outfall discharges, which mostly consist of deep aquifer water from supply wells with altered constituents or added contaminants; and
- nonpoint contaminant sources from firing sites at former TA-20 and the active firing range at TA-72 (see Sections 2.3.5 and 2.3.6).

The principal contaminants in Sandia Canyon are organic chemicals (including PCBs) and inorganic chemicals.

4.2 Cañada del Buey Conceptual Model

Summaries of the important concepts obtained from the environmental data described in Chapter 3 are presented in this section. The conceptual illustration of the Cañada del Buey conceptual model is shown in Figure A-5 in Appendix A of this work plan and is an integral part of the description of the conceptual model.

4.2.1 Sediment Transport Concepts

Most elements of the conceptual model for sediment transport processes in Cañada del Buey are the same as those described in the core document (LANL 1997, 55622) and are not repeated in this work plan. Section 3.5.1 of this work plan describes the information known about surface sediments, and Section 3.5.2 of this work plan describes the information known about subsurface sediments. Additional general concepts concerning contaminated sediments are presented for Sandia Canyon in Section 4.1.1 and also apply to Cañada del Buey.

In upper Cañada del Buey, local variations in stream gradient and resultant variations in the potential for sediment storage occur relative to stratigraphic variations in the bedrock tuff. Relatively flat sections of the canyon floor occur upstream of relatively more resistant units in the tuff that provide opportunities for sediment storage. One such section is approximately coincident with the area located north of TA-46 where the channel gradient is relatively gentle. In some areas, the narrow canyon floor is partially filled with boulders derived from adjacent cliffs composed of units Qbt 2 and Qbt 3, which creates steep reaches with relatively little potential for sediment storage.

The canyon floor begins widening and the channel gradient decreases in the middle part of the canyon, providing greater opportunity for sediment deposition and long-term sediment storage. The combination of decreasing channel gradient, widening canyon floor, and a thick section of permeable, sandy alluvium all contribute to allowing runoff infiltration and sediment deposition; this occurs primarily in middle Cañada del Buey near TA-51 and upstream from well CDBO-8. The alluvium pinches out where basalt is first exposed in the canyon floor at an elevation of about 6500 ft (1980 m) approximately 0.6 mi (0.9 km) west of the Laboratory boundary at state road NM4.

In lower off-site Cañada del Buey, downstream from state road NM4 through White Rock, the stream channel gradient flattens slightly as the channel flows over relatively resistant basalt where relatively little sediment is stored.

4.2.2 Hydrologic Transport Concepts

The canyon-specific hydrologic conditions identified in Cañada del Buey are outlined in this section. Figure A-5 illustrates the major elements of the Cañada del Buey hydrologic conceptual model and the current hypotheses regarding the connecting pathways and processes. The following brief descriptions highlight the most important elements of the Cañada del Buey hydraulic transport conceptual model. The descriptions are organized from west to east down the canyon. Features and geographic locations discussed in this section are also shown in Figure A-1 in Appendix A of this work plan.

4.2.2.1 Snowmelt and Stormwater Runoff

One input of new water to the canyon system is contemporary precipitation, which includes snowmelt from annual snowfall and precipitation from rainfall. Snowmelt runoff each spring usually releases part of the snowpack to the system. Stormwater runoff into the canyon system varies with the amount of seasonal precipitation in the watershed. Snowmelt and stormwater runoff from the upper canyon near TA-46 is not currently monitored. However, the installation of a new gaging station is planned for 1999 (LANL 1999, 62920, p. 8-9). Stream gage data for the upper and middle canyon will greatly enhance understanding of the volumes of snowmelt and stormwater runoff in Cañada del Buey.

The canyon receives runoff from surrounding mesa tops and discharged water from NPDES outfalls at TA-46. The canyon also receives stormwater runoff from parking lots and disposal areas at TA-54. The runoff and NPDES outfalls do not support continuous flow in any part of the canyon; the stream is entirely ephemeral on Laboratory property. During summer, runoff from thundershowers collects in the stream channel and flows for a distance downstream, depending on the intensity and duration of the thunderstorm. Locally derived streamflow occasionally reaches the Laboratory boundary at state road NM4, and only during periods of heavy thunderstorms or snowmelt does streamflow from Cañada del Buey extend beyond the Laboratory boundary to White Rock and the Rio Grande.

4.2.2.2 Mesa-Top Runoff

Stormwater runoff from Laboratory installations and from mesa tops contributes to the volume of water entering the canyon. The primary sources of potential mesa-top contamination are associated with PRSs located at TA-46, TA-54, and former TA-4.

4.2.2.3 Springs

No springs are known to be present in Cañada del Buey. However, a possible seep may be present north of TA-46 near the location of temporary flume TA-46-1, which is downgradient from NPDES outfalls on the north side of TA-46. It is not known if a natural seep is present at this location or if damp soil conditions are the result of effluent discharges at TA-46. There is no flow from the possible seep and flow does not extend to the Cañada del Buey stream channel.

4.2.2.4 Surface Water and Sediment Transport

Two major mechanisms for moving contaminants in the canyon system are surface water and surface sediment transport. Several processes are involved, which are described in Chapter 4 of the core document (LANL 1997, 55622). Surface water flow and sediment transport through the canyon are entirely ephemeral. Gaging station data suggest that surface flow at the eastern Laboratory boundary is usually associated with local runoff rather than from continuous flow derived from the upper portion of the canyon. Land-use changes in the watershed could impact runoff volumes, velocities, and water quality and cause accelerated erosion and/or redeposition of contaminants.

4.2.2.5 Perennial Streamflow

No perennial reaches occur in Cañada del Buey on Laboratory property. Surface water flow in the Cañada del Buey stream channel and across the eastern Laboratory boundary at state road NM4 is ephemeral. Flow reaches the Rio Grande occasionally as the result of high snowmelt runoff or periodic storm events. A continuous reach extends a short distance downstream from the White Rock STP discharge point. The geochemistry of surface water collected in lower off-site Cañada del Buey at the Rio Grande is likely associated with discharges from the White Rock STP.

4.2.2.6 Alluvial and Perched Groundwater

Surface water enters the canyon from stormwater runoff, snowmelt, and discharges from NPDES outfalls (including discharge from municipal well PM-4). Most surface water normally infiltrates the alluvium and probably recharges a small body of perched alluvial groundwater in the middle canyon. As the groundwater moves through the alluvium, some is lost to ET, and the remainder probably seeps into the underlying tuff and/or the Cerro Toledo interval or continues to flow downgradient.

Stream loss is attributable to evaporation, but most is probably caused by infiltration into the alluvium. Some of this stream loss may seep into the adjacent tuff and provide a source of recharge to possible perched intermediate zones. The extent of seepage into suballuvial units in Cañada del Buey is not known. In the past, holes such as CDBM-1 and CDBM-2, which were drilled into the suballuvial units in middle Cañada del Buey, encountered dry rock beneath the alluvium (Purtymun 1995, 45344, p. 130). However, observation wells CDBO-6 and CDBO-7 contain water that appears to be present in the colonnade tuff at the base of unit Qbt 1v, which underlies the alluvium in the middle portion of the canyon. Alluvial groundwater, if present, and/or perched water in the colonnade tuff do not reappear as flow downstream in the lower alluvial basin.

Known information about perched groundwater in Cañada del Buey is summarized below:

- A total of nine alluvial/shallow perched groundwater observation wells were installed in Cañada del Buey in 1985 and 1992 for environmental surveillance purposes.
- Two groundwater monitoring wells in Cañada del Buey contain shallow perched groundwater. The water does not appear to be perched within the alluvium, but rather is perched in weathered tuff, which probably correlates to the colonnade tuff at the base of unit Qbt 1v.
- The shallow perched groundwater body in Cañada del Buey is known to extend from CDBO-6 near PM-4 downstream to at least CDBO-7, a distance of approximately 2000 ft (600 m).
- Shallow monitor well CDBO-8 may not be located appropriately in the canyon to encounter the shallow perched groundwater. If it is not, the shallow perched groundwater may extend for an unknown distance downstream from CDBO-7.
- The possible source of the shallow perched groundwater in Cañada del Buey has been attributed to NPDES outfall discharges of regional aquifer water from municipal supply well PM-4 (discussed in Section 3.5.4.2). The chemistry of the shallow perched groundwater and the regional aquifer water from PM-4 are similar, but the shallow perched groundwater contains higher concentrations of most constituents, which could be the result of residence time in the alluvium/bedrock and also of stormwater and snowmelt runoff.
- There are no known shallow perched groundwater discharge points in Cañada del Buey. Infiltration into deeper bedrock units is the likely source of loss of the shallow perched groundwater. An unknown volume of shallow perched groundwater is hypothesized to seep downward into subsurface units.

The shallow perched groundwater discussed above may be regarded as an intermediate perched zone; however additional information about this shallow perched groundwater zone is needed to determine if it is an intermediate zone of saturation. To date, no other perched intermediate zones of saturation have been delineated beneath Cañada del Buey.

Intermediate-depth units within the Bandelier Tuff such as the Guaje Pumice Bed, Cerro Toledo interval, basalts, and the Puye Formation in the Cañada del Buey system have the potential to contain perched groundwater zones caused by recharge from the overlying alluvium. These units are similar to those found in canyons to the north (Mortandad Canyon, Pueblo Canyon, Los Alamos Canyon, and Sandia Canyon).

Evaluating the location and amount of water loss from the alluvium is necessary to determine possible contaminant transport pathways. Additional data needed to perform water-balance calculations include additional water level measurements (preferably time-series data from transducers), site-specific soil moisture measurements and precipitation amounts, ET measurements, and streamflow volumes.

4.2.2.7 Contact of Alluvium with the Cerro Toledo Interval and Older Units

Throughout most of the canyon, the alluvium overlies the Bandelier Tuff, the weathered top of which may provide a perching layer for the alluvial groundwater. However, the alluvium overlies the Cerro Toledo interval in lower Cañada del Buey east of TA-54. Flow within the Cerro Toledo interval may be controlled by paleochannels that potentially provide flow pathways away from the stream channel, possibly toward the south or southeast.

In the lower part of Cañada del Buey the Cerro Toledo interval and the Otowi Member pinch-out against a basalt high that is located near the intersection of Pajarito Road and state road NM4. These units usually have a southeast dip similar to the regional dip of the Bandelier Tuff. However, in lower Cañada del Buey a localized reversal of dip toward the west or northwest may occur on the western flank of the basalt high (see Figure A-3). Locally beneath lower Cañada del Buey, this reversal may direct possible flow in the Cerro Toledo interval to the north or south around the basalt high.

East of state road NM4 and through White Rock, the stream channel in Cañada del Buey is often located directly on basalts of the Cerros del Rio volcanic field, with relatively minor alluvium present. Surface water and alluvial groundwater that seep into the basalt may flow laterally and/or downward through fractures or intermediate perched zones within the basalt.

4.2.2.8 Buried Paleochannels

Intermediate perched zones have not been observed to extend laterally beneath mesas. However, lateral spreading of such perched zones could occur if the canyon course and the gradient of the perched zone do not coincide. Buried paleochannels in the subsurface may provide collection points and conduits for intermediate perched zones and lateral transport pathways for groundwater. The following are possible locations of buried paleochannels:

- The Cerro Toledo interval channel/fluvial deposits may include a major channel system that extends from the upper reaches of Los Alamos Canyon southeast to Potrillo Canyon. One small outcrop of Cerro Toledo interval deposits is present in lower Cañada del Buey north of the east end of MDA G. However, numerous boreholes drilled at TA-54 on Mesita del Buey encountered Cerro Toledo interval sediments, providing adequate documentation of its probable presence beneath Cañada del Buey (Broxton and Reneau 1996, 55429).

- The pre-Bandelier Tuff (pre-Guaje Pumice Bed) surface locally occurs at the top of the Puye Formation, the top of Tschicoma Formation intermediate volcanic flows, or the top of Cerros del Rio basalt flows. A paleochannel eroded into the pre-Bandelier Tuff surface appears to trend south-southwest across the Pajarito Plateau and cross Cañada del Buey near water supply well PM-4 and CDBO-6 (Broxton and Reneau 1996, 55429).

4.2.2.9 Vapor Phase Transport

Vapor-phase transport is important for some volatile contaminants and is a viable mechanism by which organic vapors and tritium may have moved into the subsurface beneath MDA H and MDA L at TA-54.

4.2.2.10 Faults and Fractures

Faults and fractures may act as infiltration pathways if they become saturated, particularly in the canyon floor. Open joints, faults, and fractures may provide additional pathways for deeper infiltration, transient flow, and lateral transport in the subsurface. Such pathways could account for some of the major losses of water from the alluvium. No major faults or fractures are known to intersect Cañada del Buey.

4.2.2.11 Regional Aquifer

The regional aquifer is composed of many different rock types and is extremely heterogeneous and anisotropic both geologically and hydrologically. The uppermost layers of saturation in the regional aquifer are typically within the fanglomerate member of the Puye Formation, which is interbedded with layered dense volcanic flows that overlie Santa Fe Group sediments. Lateral groundwater flow in the regional aquifer is probably controlled by subhorizontal permeability contrasts within the different rock types. The deep water supply wells are screened across many stratigraphic layers with widely varying hydrogeologic and geochemical properties. Historically, the long screened intervals have resulted in a limited understanding of the aquifer based on averaging of hydrologic and geochemical characteristics across the screened intervals.

The hydrogeology of Cañada del Buey is summarized below:

- Primary inputs to the groundwater in Cañada del Buey include liquid discharges from Laboratory operations and contemporary precipitation as snowmelt or stormwater runoff.
- Shallow perched groundwater is present in middle Cañada del Buey where stormwater and snowmelt runoff and discharges from municipal supply well PM-4 may accumulate.
- Most water entering the canyon must be lost either to ET or to seepage into deeper units because surface flow out of the canyon at the Laboratory boundary at state road NM4 is ephemeral and in recent years has occurred only after significant storm events. The amount and fate of water leaving the alluvium or shallow perched zone are not known.
- Intermediate perched groundwater may be present beneath Cañada del Buey in several subsurface units, including local perched zones within units of the Tshirege Member (Qbt 1v), the Cerro Toledo interval, and the Puye Formation.
- The regional aquifer extends beneath the Cañada del Buey watershed. The regional aquifer is pumped at supply wells PM-4 and PM-5 in the vicinity of upper Cañada del Buey. The upper portion of the regional aquifer in the vicinity of Cañada del Buey probably discharges from springs (Spring 2, Spring 3) in White Rock Canyon downstream from the confluence of Mortandad Canyon and the Rio Grande.

4.2.2.12 Deep Water Supply Wells

Groundwater withdrawn from the regional aquifer is used directly by people in Los Alamos County. No contamination from Laboratory operations has been identified in the regional aquifer water supply wells in or adjacent to Cañada del Buey. The water from the deep wells is collected from long screen intervals, often more than 1000 ft (300 m) thick, and is a mixture of water from different formations. The water from different formations may have different piezometric heads and geochemical characteristics. Data from vertical flow measurements and down-hole videotape logs in some wells indicate that most water withdrawal comes from a relatively small number of layers within the screened interval. Additional information is needed about the source of water from the regional aquifer to the water supply wells and the geochemical characteristics of the water from different units.

4.2.3 Biological Transport Concepts

The biological transport conceptual model is presented in the core document (LANL 1997, 55622, p. 4-12).

Although no wetlands have been identified within Cañada del Buey, outfalls within the canyon have produced several small discharge receiving areas that possess hydrophytic vegetation (Biggs and Cross 1995, 52028, p. 29).

4.2.4 Potential Sources of Contamination to the Cañada del Buey Watershed

4.2.4.1 Upper Canyon Contaminant Sources

In upper Cañada del Buey, possible sources of contaminants to surface water, surface sediments, and possibly to shallow groundwater identified through RFIs include the following (see Figure A-1):

- PRSs 4-004 and 4-003(a) (see Section 2.4.2);
- PRS 46-003(h) (see Section 2.4.3);
- PRS 46-004(a_2) (see Section 2.4.3);
- PRS 46-004(g) (see Section 2.4.3);
- PRS 46-004(q) (see Section 2.4.3);
- PRS 46-004(s) (see Section 2.4.3);
- PRS 46-006(d) (see Section 2.4.3);
- outfall discharges, which mostly consist of deep aquifer water from supply wells with altered constituents or added contaminants;
- leaching of contaminants by runoff and/or infiltration at PRSs with contaminants; and
- remobilization of contaminants in sediments in Cañada del Buey.

4.2.4.2 Middle and Lower Canyon Contaminant Sources

Possible sources of contamination in the middle reaches of Cañada del Buey include the following:

- MDA G (see Section 2.4.5.2);
- MDA J (see Section 2.4.5.3);
- MDA L (see Section 2.4.5.4); and
- outfalls and septic systems at TA-51 and TA-54 West (see Section 2.4.4 and Section 2.4.5.1).

In the lower part of the canyon, a potential source of contamination is TA-54, where a subsurface tritium plume of unknown extent is present beneath MDA H; an organic vapor plume extends downward several hundred feet in the subsurface beneath MDA L; and a subsurface tritium vapor plume and aqueous phase contaminants are potentially present beneath MDA G. Cesium and plutonium contamination have been measured in sediments derived from MDA G in drainages to Cañada del Buey.

References for Chapter 4

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

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Biggs, J., and S. Cross, 1995. "Biological and Floodplain/Wetland Assessment for Environmental Restoration Program Operable Unit 1140, TA-46," Los Alamos National Laboratory Report LA-UR-95-3716, Los Alamos, New Mexico. (Biggs and Cross 1995, ER ID 52028)

Broxton, D. E., and S. L. Reneau, 1996. "Buried Early Pleistocene Landscapes Beneath the Pajarito Plateau, Northern New Mexico," in *New Mexico Geological Society Guidebook*, 47th Field Conference, Jemez Mountains Region, New Mexico, pp. 325–334. (Broxton and Reneau 1996, ER ID 55429)

Cooper, J. B., W. D. Purtymun, and E. C. John, July 1965. "Records of Water-Supply Wells Guaje Canyon 6, Pajarito Mesa 1, and Pajarito Mesa 2, Los Alamos, New Mexico, Basic Data Report," US Geological Survey, Albuquerque, New Mexico. (Cooper et al. 1965, ER ID 8582)

Dale, M. R., S. M. Yanicak, and S. P. Anderson, December 1996. "Ground-Water Oversight at Los Alamos National Laboratory and Surrounding Areas, 1994 Through 1995," NMED/DOE/AIP-96/4, DOE Oversight Bureau, New Mexico Environment Department, Santa Fe, New Mexico. (Dale et al. 1996, ER ID 57014)

Gardner, J. N., A. Lavine, G. WoldeGabriel, D. Krier, D. Vaniman, F. Caporuscio, C. Lewis, P. Reneau, E. Kluk, and M. J. Snow, March 1999. "Structural Geology of the Northwestern Portion of Los Alamos National Laboratory, Rio Grande Rift, New Mexico: Implications for Seismic Surface Rupture Potential from TA-3 to TA-55," Los Alamos National Laboratory Report LA-13589-MS, Los Alamos, New Mexico. (Gardner et al. 1999, ER ID 63492)

LANL (Los Alamos National Laboratory), May 1992, "Water Supply at Los Alamos During 1989," Los Alamos National Laboratory Report LA-12276-PR, Los Alamos, New Mexico. (LANL 1992, ER ID 12017)

LANL (Los Alamos National Laboratory), April 1997. "Core Document for Canyons Investigations," Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), May 22, 1998. “Hydrogeologic Workplan,” Los Alamos, New Mexico. (LANL 1998, ER ID 59599)

LANL (Los Alamos National Laboratory), June 1998. “RFI Work Plan and SAP for Potential Release Sites 53-002(a) 53-002(b) and Associated Piping and Drainages at TA-53,” Los Alamos National Laboratory Report LA-UR-98-2547, Los Alamos, New Mexico. (LANL 1998, ER ID 58841)

LANL (Los Alamos National Laboratory), September 1998. “Interim Completion Report for Characterization Well R-9,” Los Alamos National Laboratory Report LA-UR-98-3569, Los Alamos, New Mexico. (LANL 1998, ER ID 59158)

LANL (Los Alamos National Laboratory), September 1998. “Interim Completion Report for Characterization Well R-12,” Los Alamos National Laboratory Report LA-UR-98-3976, Los Alamos, New Mexico. (LANL 1998, ER ID 59665)

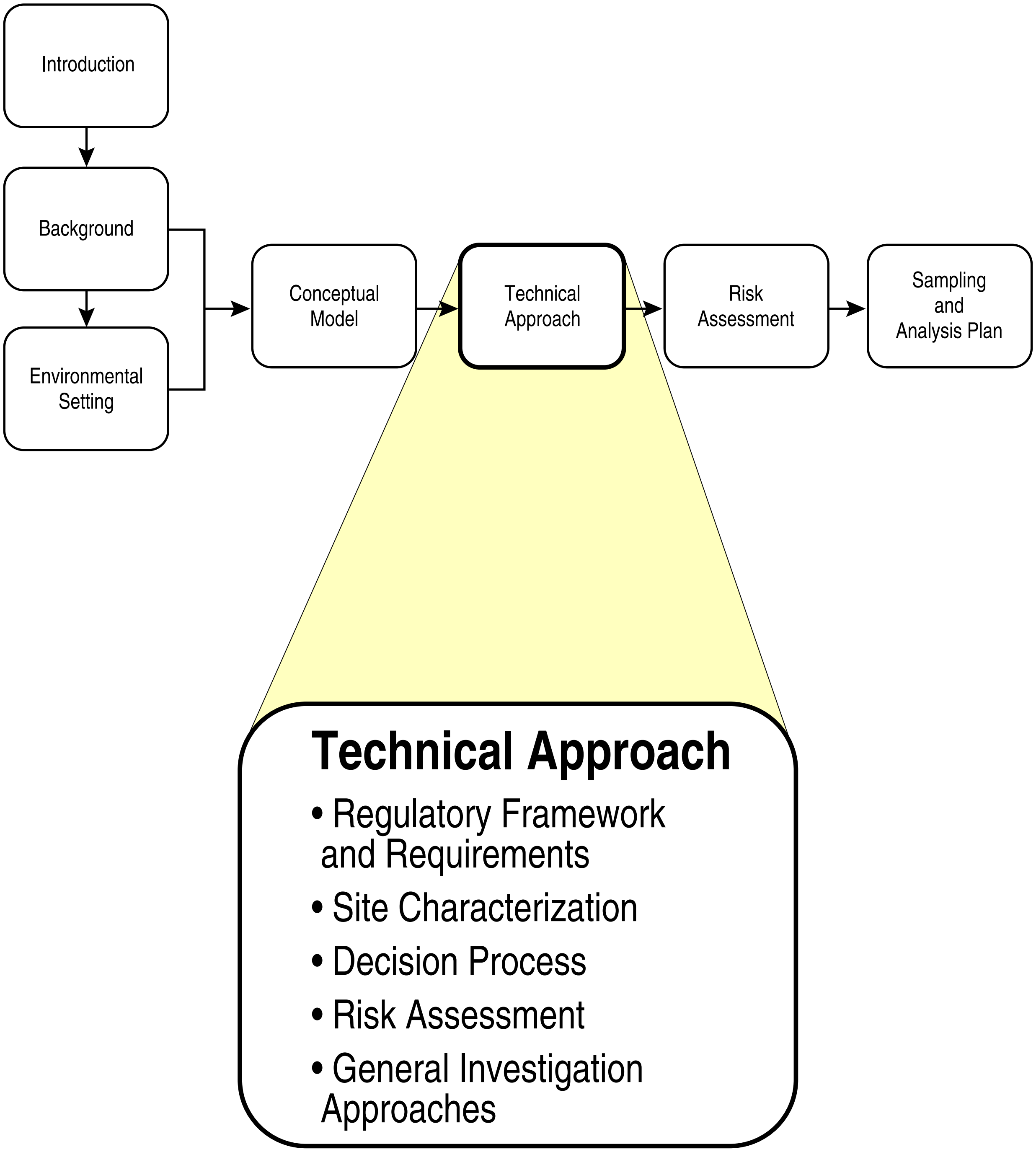
LANL, (Los Alamos National Laboratory), February 9, 1999. “Draft Watershed Management Plan,” Los Alamos National Laboratory draft report, Los Alamos, New Mexico. (LANL 1999, ER ID 62920)

McLin, S. G., 1996. “Analysis of Water Level Fluctuations in Pajarito Plateau Wells,” in *New Mexico Geological Society Guidebook*, 47th Field Conference, Jemez Mountains Region, New Mexico. (McLin 1996, ER ID 56025)

Purtymun, W. D., January 1995. “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area,” Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Purtymun, W. D., and A. K. Stoker, September 1990. “Perched Zone Monitoring Well Installation,” Los Alamos National Laboratory Report LA-UR-90-3230, Los Alamos, New Mexico. (Purtymun and Stoker 1990, ER ID 7508)

Chapter 5



Technical Approach

- Regulatory Framework and Requirements
- Site Characterization
- Decision Process
- Risk Assessment
- General Investigation Approaches

5.0 TECHNICAL APPROACH

The technical approach employed in the Sandia Canyon and Cañada del Buey investigations is identical to that described in Chapter 5 of the “Core Document for Canyons Investigations” (LANL 1997, 55622).

Reference for Chapter 5

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

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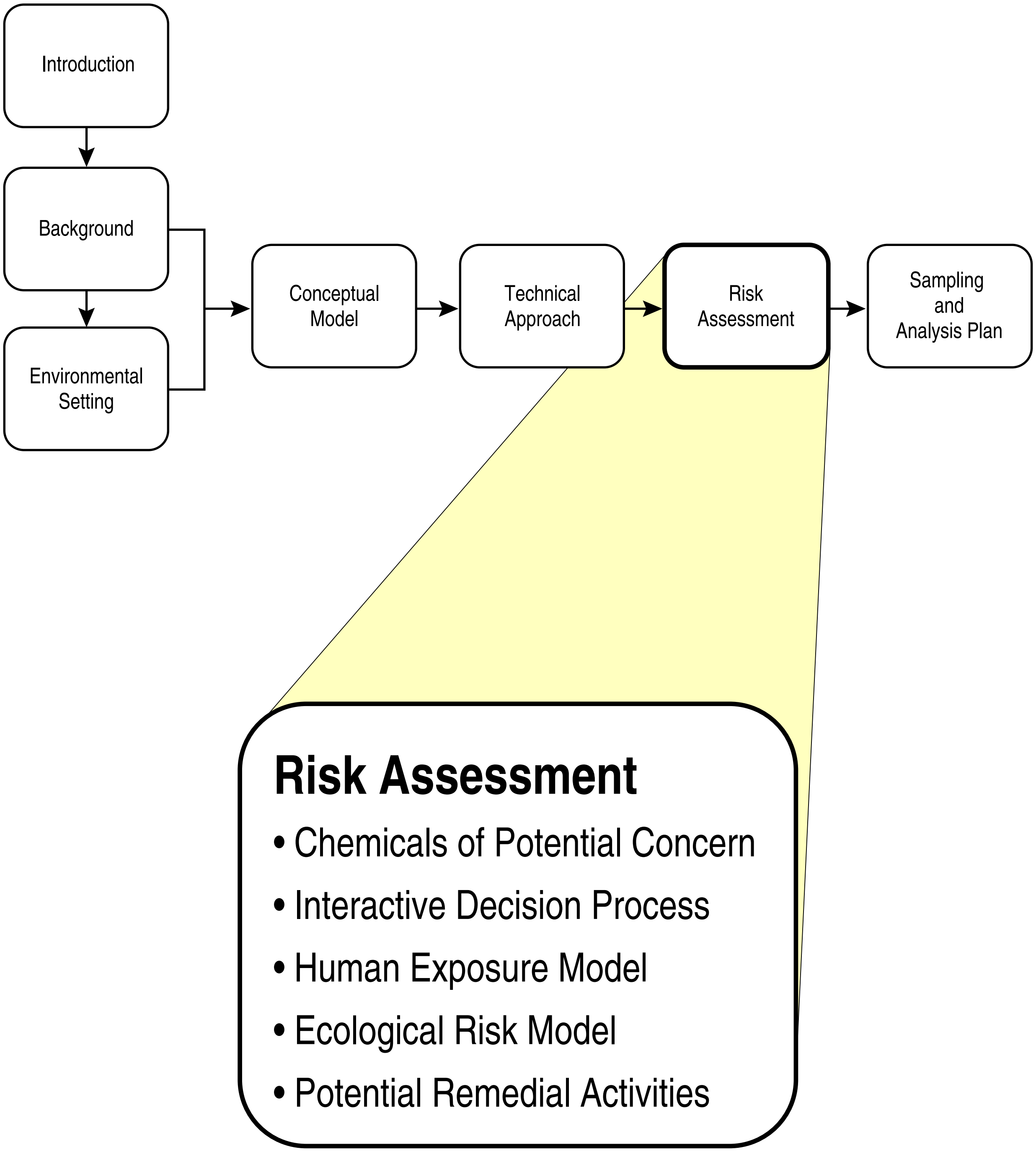
LANL (Los Alamos National Laboratory), April 1997. "Core Document for Canyons Investigations," Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

Chapter 6



Risk Assessment

- Chemicals of Potential Concern
- Interactive Decision Process
- Human Exposure Model
- Ecological Risk Model
- Potential Remedial Activities

6.0 RISK ASSESSMENT

The approach to risk assessment to be employed in the Sandia Canyon and Cañada del Buey investigations is related to that presented in Chapter 6 of the "Core Document for Canyons Investigations" (LANL 1997, 55622), but will be modified to reflect the Environmental Restoration Project's evolving approach for risk assessment. The current approach to evaluating human health risk is presented by Perona et al. (1998, 62049), and the approach to evaluating ecological risk is presented by Kelly et al. (1998, 57916). Examples of the application of these approaches to evaluating the risk associated with sediment contamination are presented in Chapter 5 of the reach reports for Los Alamos Canyon and Pueblo Canyon (Reneau et al., 1998, 59159; Reneau et al., 1998, 59160; Reneau et al., 1998, 59667).

References for Chapter 6

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Kelly, E., G. Gonzales, L. Soholt, M. Hooten, and R. Ryti. May 1998. "Screening Level Ecological Risk Assessment Approach for the Environmental Restoration Project at Los Alamos National Laboratory," Los Alamos National Laboratory Report LA-UR-98-1822, Los Alamos, New Mexico. (Kelly et al. 1998, ER ID 57916)

LANL (Los Alamos National Laboratory), April 1997. "Core Document for Canyons Investigations," Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

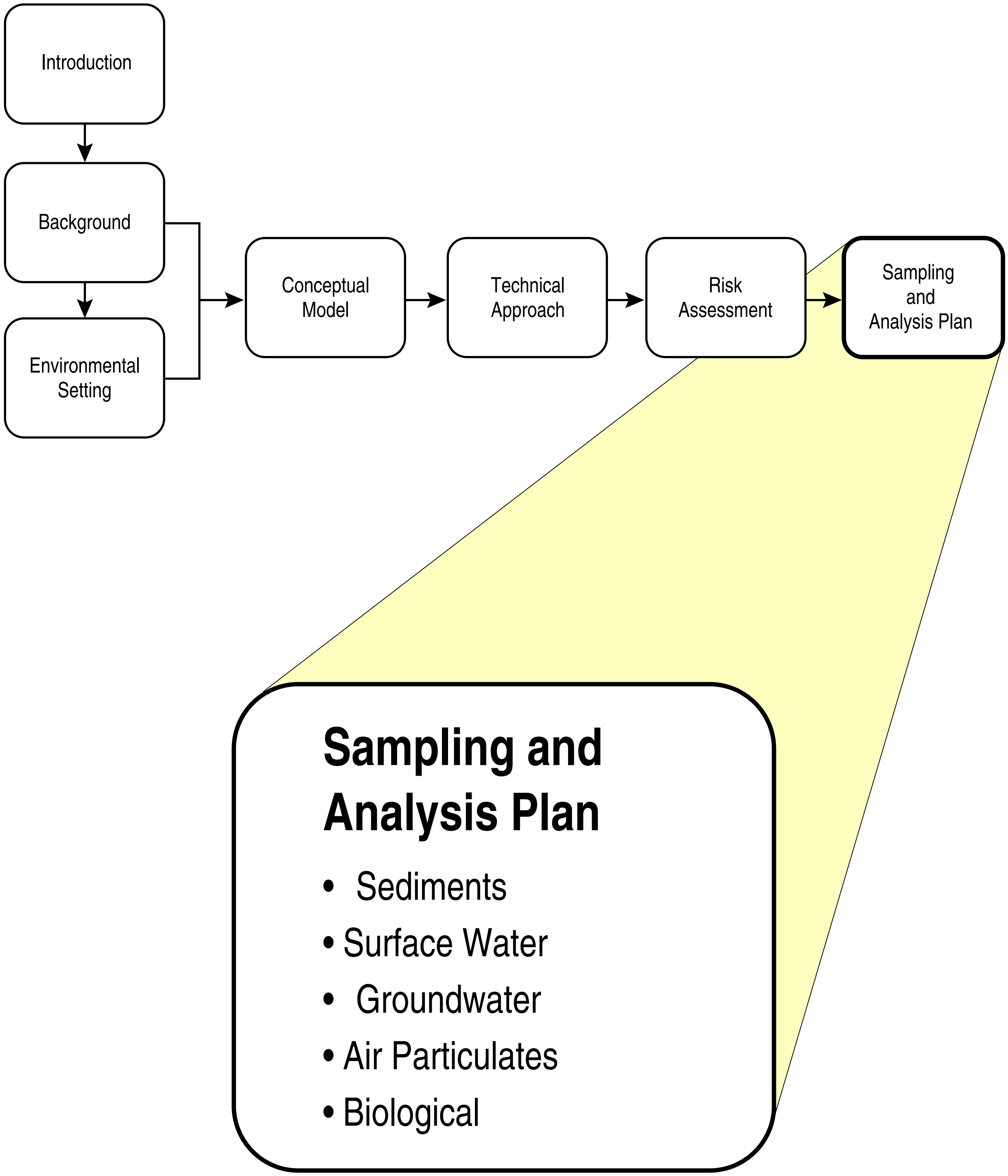
Perona, R., M. Tardiff, and R. Ryti, December 1998. "Documentation of the Canyons Human Health Risk Screening Model," Los Alamos National Laboratory Report LA-UR-98-5523, Los Alamos, New Mexico. (Perona et al. 1998, 62049)

Reneau S., R. Ryti, M. Tardiff, and J. Linn, September 1998. "Evaluation of Sediment Contamination in Lower Los Alamos Canyon, Reaches LA-4 and LA-5," Los Alamos National Laboratory Report LA-UR-98-3975, Los Alamos, New Mexico. (Reneau et al., 1998, 59667)

Reneau S., R. Ryti, M. Tardiff, and J. Linn, September 1998. "Evaluation of Sediment Contamination in Pueblo Canyon Reaches P-1, P-2, P-3, and P-4," Los Alamos National Laboratory Report LA-UR-98-3324, Los Alamos, New Mexico. (Reneau et al. 1998, 59159)

Reneau S., R. Ryti, M. Tardiff, and J. Linn, September 1998. "Evaluation of Sediment Contamination in Upper Los Alamos Canyon Reaches LA-1, LA-2, and LA-3," Los Alamos National Laboratory LA-UR-98-3974, Los Alamos, New Mexico. (Reneau et al. 1998, 59160)

Chapter 7


Introduction
Background
Environmental Setting
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Technical Approach
Risk Assessment
Sampling and Analysis Plan
Sampling and Analysis Plan
• Sediments
• Surface Water
• Groundwater
• Air Particulates
• Biological

7.0 SAMPLING AND ANALYSIS PLAN FOR SANDIA CANYON AND CAÑADA DEL BUEY SYSTEMS

Section 7.1 describes the Sandia Canyon SAP. Section 7.2 describes the Cañada del Buey SAP.

7.1 Sampling and Analysis Plan for Sandia Canyon

7.1.1 Introduction

This section describes the rationale and plans for collecting and analyzing samples and field survey data to characterize the Sandia Canyon system. These data will be used to support an evaluation of present-day risks to human health and the environment from Laboratory-derived contaminants that move through the Sandia Canyon system. These data also will be used to support an evaluation of the potential for future off-site exposure and impact on the Rio Grande. Evaluation of these risks and impacts requires testing and refining of the conceptual model of occurrence, transport, and exposure route of contaminants in the Sandia Canyon system (hereafter “the conceptual model”) (see Chapter 4 of this work plan). In accordance with the focused sampling strategy described in Chapter 5 of the core document for canyons investigations (hereafter “the core document”) (LANL 1997, 55622), results of field surveys and sample analyses initially conducted will be used in conjunction with comparison to and reinterpretation of existing data to revise subsequent sampling and analyses. Sampling and analysis plans (SAPs) presented in this chapter describe general approaches to be followed and general areas to be sampled. Specific sampling locations will be defined based on data collected from the initial tasks.

Sections of this chapter present the plans for sampling and analysis of each transport pathway and exposure route described in Chapter 3 and Chapter 4 of this work plan. Each section will (1) state the objectives for the investigation of each media and transport pathway; (2) discuss elements of the transport pathways and their importance; (3) identify issues to be addressed to assess risk and impacts and identify appropriate remedial measures; and (4) describe the approaches used to resolve the issues.

The remainder of this section defines issues to be addressed and provides overviews of the information to be collected, the specific objectives of the SAP, and the data quality requirements for the investigations. Section 7.1.2 describes plans for sediment characterization. Section 7.1.3 describes plans for characterizing surface water. Section 7.1.4 describes plans for characterizing groundwater including (1) alluvial groundwater (and the alluvium that contains it), (2) intermediate-depth groundwater, if present, and (3) the regional aquifer. Section 7.1.5 discusses the air exposure pathway. Section 7.1.6 describes the biological sampling program, which will include an evaluation of the impact of Laboratory-derived contaminants on the canyon ecosystems and an evaluation of the human-health risks from contaminants in plants and animals.

Table 7.1.1-1 summarizes the known chemicals of potential concern (COPCs) and their potential original source areas in the Sandia Canyon system. The COPCs are grouped in part according to protocols that will be used for sample analyses. This table is based on the list of COPCs and on data collected from previous studies (summarized in Chapter 3 of this work plan) showing actual occurrence of contaminants in the Sandia Canyon system.

Table 7.1.1-2 shows the initial estimates of the numbers and types of samples to be collected during the investigations. The numbers will be revised throughout the characterization in accordance with the focused sampling strategy and the various tests of data adequacy discussed in Section 5.3.7 and Section 5.3.8 in Chapter 5 of the core document (LANL 1997, 55622). Changes to the numbers of samples will be recorded and described in reports on these investigations.

Table 7.1.1-1
Chemicals of Potential Concern in Sandia Canyon and Source Areas

Known COPC	Source Area
Radionuclides	
Cobalt-60	TA-53
Cesium-137	TA-3, TA-53
Plutonium-238	TA-3
Plutonium-239	TA-3
Strontium-90	TA-20
Tritium	TA-3, TA-53
Uranium	TA-20
Organic chemicals	
High explosives	TA-20
Hydrocarbons	TA-3
Polychlorinated biphenyls	TA-3, TA-61, TA-53
Pesticides	General
Solvents	TA-3
Semivolatile organic compounds	TA-3, TA-53
Inorganic Chemicals	
Aluminum	TA-53
Antimony	TA-53
Arsenic	TA-53
Barium	TA-53
Beryllium	TA-20
Cadmium	TA-3, TA-53
Chromate	TA-3
Chromium	TA-3, TA-53
Copper	TA-53
Lead	TA-3, TA-53, TA-72
Mercury	TA-3, TA-53
Nickel	TA-53
Selenium	TA-53
Silver	TA-3, TA-53
Thallium	TA-53
Zinc	TA-53

Note: This table contains preliminary information from Resource Conservation and Recovery Act facility investigation (RFI) work plans, draft RFI reports, and other available reports.

Table 7.1.1-2
Initial Estimates of Sample Collection and Analysis in Sandia Canyon

Sample Type	Estimated Number of Samples
Sediment[a] and Core	
Full-suite[b] sediment	45–90
Limited-suite[c] sediment	TBD[d]
Key contaminants[e] sediment	TBD
Alluvial borehole core[f]	18
Regional borehole core	24
Groundwater[g] and Surface Water[h]	
Surface water – stream	8
Sandia Spring	8
Alluvium (new monitoring wells)	30
Alluvium (existing monitoring wells)	16
Regional aquifer	72
Biological	
Wild plant species	TBD
Livestock forage plants	TBD

[a] Sediment samples will be collected to determine COPCs, to define contaminant concentrations and distributions, and to define risk.

[b] Full-suite analyses are for all organic and inorganic chemicals and radionuclides, and for the determination of COPCs.

[c] Limited-suite analyses are for identified COPCs. (The collection of approximately 5 to 10 samples per reach is anticipated).

[d] TBD = to be determined.

[e] Sediment samples will be collected and analyzed for “key contaminants” (for example, HE or metal constituents) to obtain information about contaminant concentrations, contaminant distributions, and sediment transport processes. The “key contaminants” for each canyon and the actual number of samples collected will be decided by the technical team based on the initial survey and sampling results. (The collection of approximately 10 to 50 samples per reach is anticipated.)

[f] At a minimum, one core sample will be collected above and below each major stratigraphic contact. Additional samples may be collected at the judgment of the field geologists (see Table 7.1.4-4)

[g] The number of groundwater samples reflects the total number of filtered and unfiltered samples to be collected after well completion and quarterly for a period of one year.

[h] The number of surface water samples reflects the total number of filtered and unfiltered samples to be collected quarterly for a period of one year.

7.1.1.1 Issues To Be Addressed

The general objectives for the canyons investigations discussed in the executive summary of the core document (LANL 1997, 55622) will be addressed in the investigations described in this work plan. The following issues, which are of concern to the Sandia Canyon system (excluding mesa-top potential release sites [PRSs]), will be addressed in order of priority.

1. Are there any risks to human health or the environment as a result of legacy and present-day contaminants in sediments and other soils, surface water, or groundwater, including risks from exposure to plant and animal tissues? This issue will be addressed quantitatively on-site and in selected off-site areas.

2. What is the potential for human health or ecological risk (in the present as well as the future) as a result of migration of present-day contaminants? Pueblo and state concerns indicate that the effect of contaminant migration on altering risk estimates needs to be evaluated along with the present-day risk. The complexity of the problem makes identification of trends a feasible approach.

7.1.1.2 Site Description

A detailed description of Sandia Canyon is provided in Chapter 3 of this work plan.

7.1.1.3 Historical Data

Detailed discussions of historical uses, sources of environmental data, sources of potential contaminants, and current environmental conditions in the Sandia Canyon system are provided in Chapter 2 and Chapter 3 of this work plan.

The primary Laboratory use of Sandia Canyon has been disposal of liquid waste from industrial and sanitary systems. The canyon also was the location of a brief operation of a small-charge implosion and initiator experiment site in the 1940s, and in recent years was the location of the Laboratory's security-force firing range. These operations, conducted in and adjacent to Sandia Canyon, might have discharged to Sandia Canyon and its tributaries since the Laboratory began operation in 1943. These early discharges were associated with outfalls, surface runoff, and firing-site activities located at Technical Area (TA) 3, which is the current location of the Laboratory administration complex, and former TA-20, which briefly operated in the 1940s as a firing site. Additional discharges began with the continued expansion of Laboratory operations to include accelerator technology research and a firing range in the 1960s, specifically at TAs-53 and -72. Table 7.1.1-1 lists COPCs in the Sandia Canyon system by technical area. The principal contaminants are organic chemicals (including polychlorinated biphenyls [PCBs]) and inorganic chemicals.

7.1.1.4 Regulatory Requirements

A summary of regulatory requirements for this work plan is presented in Section 1.4 in Chapter 1 of the core document (LANL 1997, 55622). The primary regulatory requirements are found in the Hazardous and Solid Waste Amendments (HSWA) Module of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 1585). The US Environmental Protection Agency (EPA) (EPA 1996, 55500) and the New Mexico Water Quality Control Commission (NMWQCC) (1995, 50265; 1995, 54406) have set standards for nonradionuclides and some radionuclides for drinking water, surface water, and groundwater that may be applicable to water examined during these investigations; US Department of Energy (DOE) Order 5400.5 sets guidelines for radionuclide concentrations in water.

7.1.1.5 Overview of Information To Be Collected

To address the general objectives and the specific issues discussed Section 7.1.1.1, data sufficient to meet the following objectives will be necessary.

Identification of contaminant concentrations and distributions in (1) sediments and associated soils, (2) surface water, (3) groundwater, and (4) the biological environment in the Sandia Canyon system within and outside the Laboratory boundaries. These data may be obtained through a combination of literature review, compilation and interpretation of previously unpublished data, media sampling and analysis, and techniques such as geostatistical modeling, as appropriate, for uncertainty reduction.

1. Refinement of the conceptual model, which is discussed for the canyons in general in Chapter 4 of the core document (LANL 1997, 55622) and for the Sandia Canyon system specifically in Chapter 4 of this work plan. The refinement will include quantifying known pathways, testing hypotheses to determine the existence of potential or suspected pathways, and defining the transport processes sufficiently to permit projections of transport that could alter estimates of human-health or ecological risk in the future as a result of migration of present-day contaminants. The process of refinement will involve identification of "reaches" or locations for investigating sediments, surface water, and groundwater most important for addressing present-day risk to human health and ecosystems and contaminant transport components of the conceptual model, including a variety of contaminant sources.

2. Identification of contaminant transport pathways and improvement in understanding transport mechanisms, including sediment and water sampling accompanied by chemical and physical analyses described in Sections 7.1.2 and 7.1.3, and the ability to predict the potential for movement of present-day contaminants to off-site areas.

3. Identification of risks to biological communities (including humans) that inhabit or use the Rio Grande (now and in the future) as a result of transport of contaminants from Sandia Canyon.

4. Identification of remediation strategies for potential cleanup of specific areas in Sandia Canyon, as determined in these investigations.

5. Long-term monitoring needs and/or needs for institutional controls.

The following topics will be addressed in each section that follows, which describe the sampling and analysis of each media and transport pathway:

- how the data will be used to address the issues and objectives discussed above,
- assumptions underlying the data collection process,
- requirements for data quality to meet the intended use, and
- measurements to verify the underlying assumptions and data quality requirements.

The decisions driving data collection are described in Section 5.2 of the core document (LANL 1997, 55622, p. 5-3 et seq.) and in Appendix 4 of the hydrogeologic work plan (LANL 1998, 59599). Specific decisions concerning Sandia Canyon that are discussed in Section 1.4 of this work plan include obtaining information sufficient to reduce uncertainties in model input parameters for transport, human-health risk assessment, and ecological risk assessment to acceptable levels. The focus is on reducing uncertainties only to a point where (1) a remediation decision will not be affected by further reduction in uncertainty or (2) the cost of the additional data needed to further reduce uncertainty exceeds the cost of the remedial action.

Objectives 1, 2, and 3 listed above are partly met by summarizing existing data (Chapter 3 of this work plan), using the data to develop preliminary distributions of parameters where possible, and designing appropriate field SAPs to iteratively reduce uncertainties in the parameters that contribute most to the uncertainty in assessment and contaminant transport evaluation. These parameters might include field analyte concentrations, hydrological connectivity and groundwater extent, groundwater geochemistry, particle size determination, bioconcentration/bioaccumulation in plant and animal tissues, or extent of post-1942 geomorphic units with respect to area, thickness, and age of deposition. These and other parameters will be addressed by sampling and analysis to the extent necessary to either minimize uncertainty in the distributions or distinguish between risk and remediation decisions with a high degree of confidence.

7.1.2 Sediment Sampling and Analysis Plan

This section presents the SAP for investigating potentially contaminated sediment in the Sandia Canyon system. A minimum of five canyon reaches or subreaches downstream of known Laboratory sources of contaminants initially have been selected for investigation; these reaches are shown in solid outlines on Figure A-1 (in Appendix A of this work plan). Additional subreaches or “contingency” reaches may be investigated contingent upon the findings of initial investigations in upgradient reaches; the contingency reaches are shown in dashed outlines on Figure A-1. These reaches will be characterized by geomorphic surveys and by chemical analysis of sediment samples collected from potentially contaminated geomorphic units. Some geomorphic characterization of pre-1943 sedimentary deposits may also be conducted to improve the ability to evaluate longer-term (greater than 50 years) sediment transport processes.

7.1.2.1 Objectives

The objectives of the sediment investigation are summarized as follows:

- determine the nature and extent of Laboratory-derived contaminants associated with post-1942 sediment deposits;
- evaluate the present-day risk to human health and ecosystems from contaminated sediments on-site and off-site;
- collect data to evaluate and refine the contaminant transport components of the conceptual model; and
- assess the projected impact of contaminated sediments on off-site receptors and on the Rio Grande by identifying the types, concentrations, and distribution of contaminants that have migrated beyond Laboratory boundaries; evaluating processes associated with potential future migration; and projecting trends in risk estimates that may result from migration of contaminants off-site.

The following sections present the sediment investigation SAP and describe the technical approach adopted to achieve these objectives.

7.1.2.2 General Approach for Sediment Investigation

This section briefly describes the general approach for the geomorphic surveys and the sediment sampling and analysis portion of this chapter for Sandia Canyon.

7.1.2.2.1 Geomorphic Survey Approach

Issue

What is the nature and extent of potentially contaminated post-1942 sediment deposits within the canyons?

Technical Approach

Determine which geomorphic subdivisions of the canyon floors are most appropriate for delineating the major spatial variations in geomorphic units and sedimentary facies that are important in the context of contamination and relative location to source terms. Post-1942 sediments will be categorized by geomorphic unit, and a separate sampling strategy will be developed for each unit. If units have significant vertical variation in sedimentary facies or contaminant concentrations, the units may be subdivided into two or more distinct stratigraphic layers. Laboratory analyses will be examined to determine whether the original geomorphic unit designations are appropriate to define the contaminant distributions and inventories in each reach.

Determine which locations in each geomorphic unit should be sampled for full-suite, key contaminant, and limited-suite analyses to meet the investigation objectives (see Section 7.1.2.1). Full-suite, key-contaminant, and limited-suite analyses are discussed in Section 5.6.3 in Chapter 5 of the core document (LANL 1997, 55622) and summarized in Section 7.1.2.3 and Section 7.1.2.5.1 of this work plan. This determination will be based on the following information:

- identified mapping units,
- characteristics of post-1942 sedimentary deposits, and
- areal extent of units.

Generally, the sampling will be restricted to sediments deposited after 1942, when potential contamination of the canyons began. Limited sampling of older sediments may be conducted to test the validity of criteria for distinguishing post-1942 sediment and to gage the importance of other potential contaminant transport pathways. The potential need, number, and location of such samples in inferred pre-1943 deposits will be dependant on the specific conditions occurring in each reach and will be based on professional judgment. For example, in reaches where geomorphic characteristics and/or field radiological measurements provide high confidence in the extent of contaminated post-1942 sediment, little or no exploratory sampling to determine the boundaries of pre-1943 sediment may be required. In contrast, in reaches with subtle geomorphic changes and low levels of radiological contaminants, extensive exploratory sampling of pre-1943 sediment may be judged necessary to determine the extent of contamination.

The sampling will be largely restricted to the stream channel and its floodplain in Sandia Canyon and to areas downstream of the first identified location of Laboratory-derived contaminants.

Post-1942 sediments will be categorized by geomorphic unit and possibly by stratigraphic layer within each unit, and a separate sampling strategy for contaminants will be developed for each unit. The sampling and analyses will be conducted as described in Section 7.1.2.5.1 for full-suite, key contaminant, and limited-suite analyses. If the field mapping data indicate mappable subdivisions within any geomorphic unit (definable areas with potential variations in thickness, history, and/or contaminants), the site geomorphologist will identify appropriate subdivisions of the unit.

Limits on decision errors will be based on the relation of uncertainty to the decision points discussed in Chapter 5 and Chapter 6 of the core document (LANL 1997, 55622). Additional data will be obtained if reduction in uncertainty has the potential of changing the risk-based decision as discussed in Chapter 6 of the core document.

7.1.2.2.2 Sediment Sampling Approach

Issue

What is the nature, extent, and inventory of contaminants in sediments in the Sandia Canyon system? More specifically, the problem is to develop descriptions of the spatial distributions of contaminants at levels of uncertainty sufficient to (1) determine whether any risks to human health or the ecosystem currently exist on-site or off-site, and (2) quantitatively estimate contaminant transport with regard to spatial and temporal trends and future risks.

Technical Approach

Determine which contaminants are present in Sandia Canyon sediments and their horizontal and vertical distribution based on data obtained from sample analyses in the geomorphic units within each reach. The following information will be used for this determination:

- archival information,
- sample location,
- sample unit, and
- concentrations of contaminants in each sample.

Spatial boundaries will be determined by the boundary of each specified reach.

Area and thickness data will form part of the basis for selecting locations to be sampled for laboratory analyses. Samples will be selected to represent the range of geomorphic units observed but will be biased to sample most intensively the units with the largest area and/or the greatest volume of fine-grained sediments.

Any contaminant identified at concentrations exceeding the 95% upper tolerance limit (UTL) of the current sediment background value (BV) (Ryti et al. 1998, 59730) or whose distribution is different from that of the background data in the full-suite analyses will be added to the limited-suite analytical protocol for samples from that reach (see Table 7.1.2-4 and Table 7.1.2-5 for BVs in sediments).

Any contaminant identified at concentrations exceeding the 95% UTL value of the current background or whose statistical distribution is different from that of the background data will be evaluated in the risk assessment for that reach.

Limits on decision errors will be based on the relation of uncertainty to the decision points discussed in Chapter 5 and Chapter 6 of the core document (LANL 1997, 55622). Additional data will be obtained if reduction in uncertainty has the potential to change the risk-based decision as discussed in Chapter 6 of the core document.

7.1.2.3 Sampling and Analysis Plan for Sediment Investigation

The sampling and analysis plan for the sediment investigation follows the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622) and includes testing the conceptual model for the Sandia Canyon system, which is discussed in Chapter 4 of this work plan. The investigation will focus on potentially contaminated sediment deposits but may also include supplemental characterization of pre-1943 deposits.

The sediment SAP focuses on selected areas of the Sandia Canyon system downstream of known or potential contaminant sources. Field surveys and mapping, as well as sampling and analysis tasks, will initially concentrate on five reaches, which may be expanded to include up to one additional canyon reach for a maximum of six reaches that may be investigated. Some reaches include multiple subreaches. Figure A-1 shows the locations of the reaches. Table 7.1.2-1 summarizes the reaches and subreaches for which investigations are planned.

Table 7.1.2-1
Summary of Reaches to be Investigated in Sandia Canyon

Canyon	Reach	Subreach	Priority Areas No. of Reaches for Initial Characterization	Contingency Areas No. of Reaches for Possible Additional Characterization
Sandia	S-1*	None	1	
	S-2*	None	1	
	S-3	None	1	
	S-4	S-4 West	1	
		S-4 Central	1	
		S-4 East	1	
	S-5	S-5 West	1	
		S-5 Central	1	
		S-5 East	1	
	S-6	S-6 West		1
		S-6 East		1
Total	**6**	**11**	**9**	**2**

* Reaches S-1 and S-2 are being investigated as part of the “Sampling and Analysis Plan for Upper Sandia Canyon” and are included in this document for completeness (LANL 1998, 62340).

Each reach may be either undivided, with a length of approximately 100 m to 1000 m (328 ft to 3280 ft), or may include two or three subreaches each approximately 100 m to 500 m (330 ft to 1650 ft) long. A “reach” refers to a specific area of a canyon that will be treated as a single unit for sampling, analysis, and present-day human-health and ecosystem risk assessment. A “subreach” refers to a specific area that is geographically related to other subreaches but that is investigated separately to evaluate issues relating to contaminant sources and/or contaminant transport and deposition. The regions of the main canyon and selected tributary canyons planned for investigation are shown in Figure A-1 (in Appendix A of this work plan). The precise length and area of each canyon reach or subreach will be defined by both the geomorphic survey and the results of sediment sampling and will be designed to encompass the local variability in geomorphic units and to constitute a reasonable area for use in the risk assessments. Initially some subreaches may be short (100 m to 200 m [330 ft to 660 ft]) and may be either eliminated from further investigation or expanded, depending on the results of sediment sampling. Focusing on relatively short subreaches will allow the efficient collection of key exploratory data. The approach will be iterative to allow the expansion of specific reaches or subreaches to supplement the data set if significant contaminants are detected in these areas or other relevant areas.

Supplemental investigations, such as field mapping and measuring the sizes of sediment deposits, may be conducted in intervening areas to improve confidence in extrapolation between reaches. Possible decisions to obtain such supplemental measurements between specific reaches will be made following evaluation of data from the reaches and identification of significant uncertainties. It is expected that no data will be required for intervening areas where levels of contamination in adjacent sampled reaches are below levels that may warrant remediation or other institutional actions. In contrast, if data from the sampled reaches indicate the need for remedial action, it is expected that data on contamination levels in the adjacent unsampled areas will be required.

One or more of the following criteria were used to select the reaches and subreaches:

- areas where contaminant concentrations are expected to be highest as judged from previous sampling and analysis activities and from the proximity of the canyon reach to the source areas;
- areas immediately upstream and downstream of drainage confluences to allow better identification of significant contaminant sources and evaluation of contaminant dilution;
- areas with a variety of geomorphic characteristics to allow better estimates of the total contaminant inventory in the canyon and of variations in contaminant distribution between reaches; and
- institutional boundaries, to define contaminants that have migrated off Laboratory property.

Each reach or subreach will be used to address particular issues regarding potential contaminants in the Sandia Canyon system. The set of reaches and subreaches is intended to represent key aspects of the entire system. Issues to be addressed by sampling in the individual reaches and subreaches are discussed in Section 7.1.2.4.

In addition to the field survey and mapping tasks (described in Section 7.1.2.4), the sediment SAP includes three types of sampling tasks.

- Collect samples for “full-suite” analysis (see Section 7.1.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of full-suite analysis)

  Purpose: analyze for the full-suite of COPCs (organic and inorganic chemicals and radionuclides) to define the limited-suite of COPCs for the sediment investigation

- Collect samples for “key contaminant” analysis (see Section 7.1.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of key contaminants)

  Purpose: analyze for one or more key contaminants to define vertical and horizontal variations in contamination and evaluate recent sediment transport processes

- Collect samples for “limited-suite” analysis (see Section 7.1.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of limited-suite analysis)

  Purpose: analyze for the limited-suite of COPCs to define the degree of collocation between different contaminants and to perform the present-day risk assessment

The samples will also be analyzed for particle-size distribution to identify relationships between sediment particle sizes and contaminant concentrations.

Section 7.1.2.5 presents the strategy and rationale for sample collection. The strategy for each sampling task will be decided based on the data collected during the initial field surveys and/or prior sampling.

Requirements for additional data, including selection of key contaminant or limited-suite analyses, will be developed based on the judgment of the technical team and through frequent dialogue with the regulators. Some sampling may also address particular stakeholder concerns that could arise based on data collected early in the investigation.

The products of the sediment investigation will be

- data to support an assessment of the present-day risk to on-site (within Laboratory boundaries) receptors and the potential for off-site exposure from deposits of contaminated sediments in the canyon system;
- a description of contaminant transport associated with sediments in the canyon system; and
- an assessment of the potential future trends in risk estimates due to existing contaminated sediments moving downstream on Laboratory property, across Bandelier National Monument and San Ildefonso Pueblo land, and to the Rio Grande.

7.1.2.4 Canyon Reaches Planned for Investigation

The following sections describe each canyon reach planned for investigation and the significance of each reach for evaluating present-day risk and potential future trends in risk from exposure to

Laboratory-derived contaminants (see Figure A-1 in Appendix A for reach locations). Six reaches in Sandia Canyon (S-1 through S-6) have been chosen for the sediment investigation.

Reaches S-1 and S-2 are currently being investigated as part of the “Sampling and Analysis Plan for Upper Sandia Canyon” (LANL 1998, 62340). The upper Sandia Canyon SAP follows the canyons technical approach as outlined in the core document, and the results of the investigations in reaches S-1 and S-2 will be compatible and fully integrated with the canyon sediment investigations described in this work plan. Data collected as part of the upper Sandia Canyon SAP will satisfy the sediment characterization needs for the western part of Sandia Canyon for the Canyons Focus Area investigations.

This list of potential reaches contains several subreaches, which are summarized in Table 7.1.2-1 and are described in the following sections. The strategy is to begin with a series of short subreaches, each approximately 100 m to 200 m (110 to 220 yd) long located near identified PRSs within the Sandia Canyon watershed. This planned strategy is intended to identify the PRSs that contribute significant contaminants to the stream channels to potentially eliminate parts of the watershed from further investigation and to narrow the analytical suite planned for each reach. A second phase of investigation could expand the size of the key subreaches and perhaps add additional subreaches if questions remain. The list of subreaches also contains “contingency” reaches that may or may not be sampled, depending on the results from the investigations of upstream or downstream reaches. For example, some subreaches intended to evaluate dilution of contaminants from upstream PRSs may not be sampled if significant contaminant levels are not found upstream close to the PRSs. The boundaries shown in Figure A-1 indicate the general areas that will be investigated; more precise definitions of the investigation boundaries will be based on the significant geomorphic units found within each reach. Characterization activities will focus on the geomorphic units that are most likely to contain Laboratory-derived contaminants, supplemented by some limited geomorphic characterization of pre-1943 sediment deposits.

Sandia Canyon Reaches

Reach S-1: Upper Sandia Canyon Near TA-3

Investigation of Reach S-1, near the head of Sandia Canyon, is planned to evaluate potential contaminants from a series of PRSs located at TA-3. Reach S-1 is located immediately downgradient of TA-3 and upgradient of the wetland areas in upper Sandia Canyon and includes two short tributary drainages and their confluence. Potential contaminants associated with these sources include cesium, plutonium, tritium, hydrocarbons, PCBs, pesticides, solvents, semivolatile organic compounds (SVOCs), cadmium, chromate, chromium, lead, mercury, and silver. Reach S-1 will allow the determination of the relative contributions of contaminants from each of the unnamed tributaries and the contaminant inventory in upper Sandia Canyon near TA-3. Investigation of reach S-1 began in 1998 as part of the upper Sandia Canyon SAP (LANL 1998, 62340).

Reach S-2: Upper Sandia Canyon at the Wetland Areas

Investigation of Reach S-2, located at the wetland areas in upper Sandia Canyon approximately 800 ft (245 m) downgradient of reach S-1, is planned to evaluate the concentration of contaminants from TA-3 (observed in reach S-1), and the possible addition of contaminants from TA-60 and TA-61. Potential contaminants in this reach include cesium, plutonium, tritium, hydrocarbons, PCBs, pesticides, solvents, SVOCs, cadmium, chromate, chromium, lead, mercury, and silver. Reach S-2, in combination with reach S-1, will allow the determination of the relative contributions of contaminants from these different sources, and the nature and concentrations of contaminants present in the wetland areas in upper Sandia Canyon. Investigation of reach S-2 began in 1998 as part of the upper Sandia Canyon SAP (LANL 1998, 62340).

Reach S-3: Upper Sandia Canyon West of TA-53

Investigation of Reach S-3, which spans the boundary between upper and middle Sandia Canyon near the western end of TA-53, is planned to evaluate the dilution of contaminants from PRSs upstream of TA-53 and determine the contaminant inventory in this part of the canyon. No COPCs have been identified for the few PRSs located between reach S-2 and reach S-3. Therefore contribution of contaminants from these additional sources is not anticipated. Potential contaminants in this reach include cesium, plutonium, tritium, hydrocarbons, PCBs, pesticides, solvents, SVOCs, cadmium, chromate, chromium, lead, mercury, and silver. Reach S-3 will allow the evaluation of dilution of contaminants from upstream sources and the determination of the nature and concentrations of contaminants present at the eastern margin of upper Sandia Canyon upstream of TA-53 sources.

Reach S-4: Middle Sandia Canyon

Reach S-4, located in middle Sandia Canyon south of TA-53, contains three subreaches. Investigation of these reaches is planned to evaluate dilution of contaminants from upstream PRSs, and identify the possible addition of contaminants from TA-53 and former TA-20. Potential contaminants in this reach include cobalt, cesium, plutonium, strontium, tritium, uranium, high explosive (HE) compounds, hydrocarbons, PCBs, pesticides, solvents, SVOCs, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromate, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. The subreaches are described below.

- S-4 West. Investigation of S-4 West, located south of the western end of TA-53, is planned to evaluate dilution of contaminants from upstream PRSs, and the potential contribution of contaminants from PRSs located at TA-53 above three small drainages to Sandia Canyon.

- S-4 Central. Investigation of S-4 Central, located south of the central portion of TA-53, is planned to evaluate dilution of contaminants from upstream PRSs, and the potential contribution of contaminants from PRSs located at TA-53 above a single small drainage to Sandia Canyon.
- S-4 East. Investigation of S-4 East, located south of the eastern end of TA-53, is planned to evaluate dilution of contaminants from upstream PRSs, and the potential contribution of contaminants from TA-53 and former TA-20, specifically National Pollutant Discharge Elimination System (NPDES) outfall 03A0311 (the low-energy demonstration accelerator (LEDA) outfall), PRS 53-014 (lead shot site), PRS 20-001(c) (former landfill), PRS 20-002(d) (former firing site), and PRS 20-003(c) (Navy gun firing site).

Collectively, the S-4 subreaches will allow the determination of the relative contribution of contaminants from the majority of sources at TA-53 and former TA-20.

Reach S-5: Lower Sandia Canyon

Reach S-5, extending from TA-53 to the eastern Laboratory boundary, contains three subreaches. Investigation of these subreaches is planned to evaluate dilution of contaminants from upstream PRSs, identify the possible addition of contaminants from the far eastern end of TA-53 and from TA-72, and determine the contaminant inventory at the eastern Laboratory boundary. Potential contaminants in this reach include cobalt, cesium, plutonium, strontium, tritium, uranium, HE compounds, hydrocarbons, PCBs, pesticides, solvents, SVOCs, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromate, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. The subreaches are described below.

- S-5 West. Investigation of S-5 West, located in Sandia Canyon immediately west of TA-72, is planned to evaluate the dilution of contaminants from upstream PRSs, the possible addition of contaminants from PRSs (specifically PRSs 53-002[a and b] [surface impoundments]) located above the far eastern drainage from TA-53 to Sandia Canyon, and allow the determination of contaminant inventory at the western margin of lower Sandia Canyon.
- S-5 Central. Investigation of S-5 Central, located east of TA-72, is planned to evaluate the dilution of contaminants from upstream PRSs and the possible addition of contaminants from TA-72.
- S-5 East. Investigation of S-5 East, located upstream of the intersection of Sandia Canyon and state road NM4 above the eastern Laboratory boundary, is planned to evaluate the dilution of contaminants from upstream PRSs and will allow the determination of the contaminant inventory at the eastern Laboratory boundary.

Collectively, the S-5 subreaches will allow the determination of the relative contributions of contaminants from these different sources and the nature and concentrations of contaminants west of the eastern Laboratory boundary.

Reach S-6: Sandia Canyon East of State Road NM4

Reach S-6, located on San Ildefonso Pueblo land east of the Laboratory boundary, contains two subreaches. Investigation of these subreaches is planned to evaluate the potential contribution of contaminants to the Rio Grande. Potential contaminants in this reach include cobalt, cesium, plutonium, strontium, tritium, uranium, HE compounds, hydrocarbons, PCBs, pesticides, solvents, SVOCs, aluminum, antimony, arsenic, barium, beryllium, cadmium, chromate, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. Sampling of this reach is contingent on identification of significant levels of contaminants in reach S-5. The subreaches are described below.

- S-6 West. Investigation of S-6 West, located in a gently sloping area in Sandia Canyon approximately 1.6 mi (2.6 km) east of state road NM4, will allow the evaluation of the dilution of contaminants potentially transported across the Laboratory boundary.
- S-6 East. Investigation of S-6 East, located immediately at and above the confluence of Sandia Canyon with the Rio Grande, will allow the determination of the nature and concentration of contaminants discharged to the Rio Grande.

7.1.2.5 Sediment Sample Collection and Analysis

This section describes the sediment sample collection process in the canyon reaches. Particular emphasis is given to the criteria for selecting sample locations within each reach and the rationale for the choice of analytical suites. The methods for sample collection and for the chemical, radiochemical, and geotechnical analyses are also provided in this section.

7.1.2.5.1 Sampling Design

Samples of sediments from potentially contaminated geomorphic units will be collected in most reaches planned for investigation (see Section 7.1.2.4). Specific sample locations in the initial sampling phases will be selected following the geomorphic survey and will include the full range in age and particle size characteristics in post-1942 sediments as identified in the geomorphic survey (LANL 1997, 55622, p. 5-24 et seq.). Specific sampling locations in subsequent sampling rounds will be based both on the geomorphic survey and on analytical results from the initial sampling phases and will be biased to locations where the highest levels of contaminants are expected.

Surface and shallow subsurface samples will be collected at variable depths depending on the thickness and variability of the sediment layers at each location. In general, each sample will be collected from a discrete sediment layer or from a series of adjacent texturally similar layers to avoid mixing layers that may have very different contaminant concentrations. For example, discrete flood layers only 1-in. to 2-in. (2.5-cm to 5.0-cm) thick may comprise some samples, whereas other samples may homogenize 1 ft (0.30 m) or more of relatively uniform layers.

Each sample location will be marked, surveyed, and assigned a unique Environmental Restoration (ER) Project sample location identification number. All samples will be field-screened using hand-held instruments at the point of collection for gross radioactivity. Before the samples are submitted to the Field Support Facility, gross-alpha, -beta, and -gamma radiation measurements will be taken on each sample.

As explained in Section 7.1.2.3, three sampling tasks have been defined for the sediment investigation: full-suite COPC, key contaminant, and limited-suite COPC analyses. Field quality assurance (QA) and quality control (QC) samples, such as field blanks and collocated samples, will be collected in accordance with the guidelines of the “Quality Assurance Project Plan Requirements for Sampling and Analysis” (LANL 1996, 53450).

Because of the scarcity of information available on contaminants in the Sandia Canyon system, the initial round of sampling and analysis will be full-suite analyses from a series of subreaches throughout the watershed. An initial estimate of 5 to 10 samples will be collected from each subreach; the actual number of samples collected will be determined as a result of the geomorphic surveys and at the discretion of the site geomorphologist.

Sample collection for full-suite analyses, as described below, will be distributed on a canyon-system-wide rather than a reach-wide basis in the initial round to ensure that no contaminants were overlooked during the historical analyses. Subsequent analyses will probably involve both limited-suite and key-contaminant analyses, depending on the results of the full-suite sampling.

Following completion of the phased investigations in the reaches it is possible that supplemental characterization may be required between some reaches to confirm the assumed levels and extent of contamination, and possibly to locate specific sites for remediation. Activities in these areas could include geomorphic mapping and associated geomorphic characterization, sediment sampling and analyses, and data evaluation focused on identifying and mapping areas where contamination exceeds a level to be defined based on risk analyses. Specific details of such supplemental investigations will be determined based on evaluation of data from the reaches.

7.1.2.5.1.1 Sample Collection for Full-Suite Analysis

The general approach discussed in Section 5.6.3.2 in Chapter 5 of the core document (LANL 1997, 55622) will be followed. Sediment samples will be collected in the initial sampling task and analyzed for a full-suite of potential contaminants to define the limited-suite analyses (see Section 7.1.2.5.1.3) for subsequent sampling and analysis tasks. These samples will be focused in areas located closest to known source areas.

7.1.2.5.1.2 Sample Collection for Key-Contaminant Analysis

The general approach discussed in Section 5.6.3.3 in Chapter 5 of the core document (LANL 1997, 55622) will be followed. The selection of key contaminants allows analyses to be obtained from a large number of samples at a reasonable cost.

One or more constituents present at levels that may contribute significantly to present-day risk will be selected as key contaminants. The key contaminant analyses are critical to the sediment investigations because those analytes are most important for evaluating risk.

7.1.2.5.1.3 Sample Collection for Limited-Suite Analysis

The general approach discussed in Section 5.6.3.4 in Chapter 5 of the core document will be followed (LANL 1997, 55622). Because the database on radionuclide, inorganic, and organic contaminants in Sandia Canyon is sparse, potential contaminant suites in the sediments are poorly defined. The number of samples will be determined by the technical team based on the complexity of the contamination and will be sufficient to develop a defensible, representative statistic for present-day risk assessment purposes. To best sample a range of contaminant concentrations, more samples probably will be collected for limited-suite analysis in reaches close to contaminant sources than in downstream reaches.

The results of the limited-suite and full-suite analyses comprise part of the data set that will be used for the present-day human-health and ecological risk assessments. The analyte suite for limited-suite analyses will be decided by the technical team on the basis of analytes identified at concentrations above background levels from the full-suite analyses.

7.1.2.5.2 Sampling Methods

Sediment samples will be collected using the methods and ER Project standard operating procedures (SOPs) (most recent revisions) listed in Table 7.1.2-2. Sampling intervals will be determined in the field based on the judgment of field geologists. The tools used to collect the sediment samples will depend on the cohesion of the sediment material, the collection depth, and the presence of flowing or standing surface water. A spade and scoop will be used to collect surface sediment samples at depths of 0 ft to 1.0 ft (0.0 cm to 30.5 cm). Depth samples will be collected from either stream bank exposures or shallow excavations, homogenizing through the thickness of selected sediment layers. If surface water is present at the sampling location, a scoop, trowel, or hand corer will be used to collect grab sediment samples.

Table 7.1.2-2
Summary of Sediment Sampling Methods Requirements

Sampling Tool	Sample Type	Sampling Depth (ft)	LANL ER SOP No.
Spade and scoop	Surface grab	0–1	06.09
Thin-wall tube	Surface grab; lithologic (undisturbed)	0–5	06.10
Hand auger	Surface or subsurface grab; vertical composite	0–5	06.10
Open tube (Trier)	Lithologic (undisturbed)	0–5	06.17
Scoop and trowel	Grab (under surface water)	0–0.5	06.14
Hand corer	Grab (under surface water)	0–0.5	06.14

All samples will be collected using the most recent revised versions of the applicable ER Project SOPs for the collection, preservation, identification, storage, transport, and documentation of environmental samples. Decontamination of sampling equipment will be performed in accordance with ER-SOP-01.08, “Field Decontamination of Drilling and Sampling Equipment.” All investigation-derived waste (IDW) generated during the sampling operation will be managed and disposed of in accordance with ER-SOP-1.06, “Management of Environmental Restoration Project Wastes,” and ER-SOP-1.10, “Waste Characterization.”

7.1.2.5.3 Analytical Methods

Sediment samples will be collected to represent specific geomorphic strata; therefore, it is important that the laboratory sample is representative of the sediment stratum that is collected in the field. To identify patterns in the distribution of contaminants in the geomorphic strata, it is important that the sample preparation method is consistent. To meet the objectives for representativeness and comparability, the sediment samples will be homogenized in the field using a stainless steel bowl and spoon before being placed in a container. All samples will be sieved, in either the field or the laboratory, to remove stones and organic matter greater than 2 mm (0.08 in.) in diameter. The laboratory will be instructed to take representative aliquots from the homogenized sample for each analysis. All analyses will be performed at ER Project-approved fixed-site laboratories.

7.1.2.5.3.1 Organic Chemicals

The analytical suites and methods for analysis of organic chemicals are listed in Table 7.1.2-3. The analytical suites include SVOCs, organochlorine pesticides, PCBs, total petroleum hydrocarbons (TPH), and HE compounds. All analyses for organic chemicals will be performed in accordance with the EPA SW-846 protocols (EPA 1987, 57589). The detailed analyte lists, estimated quantitation limits (EQLs), required QC procedures, and acceptance criteria are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Table 7.1.2-3
Analyte Suites and Analytical Methods for Analysis of Organic Chemicals in Sediment Samples

Analyte Suite	Analytical Method	Analytical Protocol*
Organochlorine pesticides	Gas chromatography/electron capture detector	SW-8081A
PCBs	Gas chromatography/electron capture detector	SW-8081A or SW-8082
SVOCs	Gas chromatography/mass spectrometry	SW-8270
HE	High-performance liquid chromatography	SW-8330
TPH	Gas chromatography (total petroleum hydrocarbons-diesel range organics)	EPA Method 8015M

Note: Detailed analyte lists and estimated quantitation limits can be found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738).

* EPA SW-846 Methods, EPA 1987, 57589.

7.1.2.5.3.2 Inorganic Chemicals and Radionuclides

For inorganic chemicals the target analytes, conservative estimated detection limits (EDLs), analytical methods, and background values (BVs) in sediments are listed in Table 7.1.2-4. All analyses for inorganic chemicals will be performed in accordance with EPA SW-846 protocols using mineral acid (nitric acid at a pH value of 1) sample extraction procedures for the inductively coupled plasma emission spectroscopy (ICPES), electrothermal vapor atomic absorption (ETVAA), cold vapor atomic absorption (CVAA), and inductively coupled plasma mass spectrometry (ICPMS) techniques.

For radionuclides the target analytes and their half-lives, detected emission, minimum detectable activities, analytical methods, and BVs in sediments are listed in Table 7.1.2-5. Before chemical separation and counting for alpha or high-energy beta emissions, samples will undergo a complete digestion or fusion procedure. Measurements of strontium-90 will be performed by beta-counting of yttrium-90 progeny after an ingrowth period of at least 10 days after separation. All samples submitted for tritium analysis will also be analyzed for moisture content.

Sediment samples will be prepared for gamma spectroscopy measurements by homogenization and drying; no sample extraction will be performed. The ER Project analyte list for the gamma spectroscopy analysis (see Table 7.1.2-6) includes the decay series of the naturally occurring radionuclides radium-226, uranium-235, and uranium-238, as well as fission and activation products and their progeny. Measurements of naturally occurring radionuclides known to be present in Laboratory soils provide an indication of the quality of the gamma spectroscopy measurement. Data for short-lived radionuclides can be useful when values reported for a parent radionuclide are evaluated because the relative activity concentration of parent and daughter isotopes is a known quantity. The shorter-lived radionuclides are usually included in the analyte list to verify the presence of longer-lived parent isotopes, but they are not evaluated as primary radionuclides because they decay to unmeasurable concentrations within the span of several years or less. The naturally occurring radionuclide potassium-40 is present in Laboratory soils at concentrations ranging from 25 pCi/g to 40 pCi/g and is always present in the gamma spectra of Laboratory soil samples. The potassium-40 gamma emission peak provides a qualitative indicator of the accuracy and precision of the gamma spectroscopy measurement, but potassium-40 is not considered a potential contaminant in Sandia Canyon sediments.

Table 7.1.2-4
Analyte List, Estimated Detection Limits, and Analytical Methods for Inorganic Chemicals in Sediment Samples

Analyte	EDL (mg/kg)	Background Value[a] (mg/kg)	Analytical Method	Analytical Protocol[b]
Metals				
Aluminum	40	15,400	ICPES	SW-6010B
Antimony	0.5	0.83	ICPMS	SW-6020
Arsenic	2	3.98	ETVAA	SW-7060A
Barium	40	127	ICPES	SW-6010B
Beryllium	1	1.31	ICPES	SW-6010B
Cadmium	0.4	0.4	ICPES or ICPMS	SW-6010B or SW-6020
Calcium	500	4420	ICPES	SW-6010B
Chromium	2	10.5	ICPES	SW-6010B
Cobalt	10	4.73	ICPES	SW-6010B
Copper	5	11.2	ICPES	SW-6010B
Iron	20	13,800	ICPES	SW-6010B
Lead	0.6	19.7	ETVAA or ICPMS	SW-7421 or SW-6020
Magnesium	1000	2370	ICPES	SW-6010B
Manganese	3	543	ICPES	SW-6010B
Mercury	0.1	0.1	CVAA	SW-7470A
Nickel	8	9.38	ICPES	SW-6010B
Potassium	500	2690	ICPES	SW-6010B
Selenium	0.3	0.3	ETVAA	SW-7740
Silver	1	1	ICPES	SW-6010B
Sodium	500	1470	ICPES	SW-6010B
Thallium	0.73	0.73	ICPMS	SW-6020
Uranium	0.5	2.22	ICPMS	SW-6020
Vanadium	10	19.7	ICPES	SW-6010B
Zinc	4	60.2	ICPES	SW-6010B
Other Inorganic Chemicals				
Total cyanide	0.05	0.82	Colorimetry	SW-9012A

[a] BVs for sediment samples from Ryti et al. 1998, 59730.

[b] EPA SW-846 Method, EPA 1987, 57589.

Table 7.1.2-5
Analyte List, Minimum Detectable Activities, and Analytical Methods for Radionuclides in Sediment Samples

Analyte	Half-Life (yr)	Detected Emission	Minimum Detectable Activity (pCi/g)	Background Value[a] (pCi/g)	Analytical Method
Americium-241	432.2	α	0.05	0.040	α-Spectrometry
Plutonium-238	87.7	α	0.05	0.006	α-Spectrometry
Plutonium-239,240[b]	2.411×10^4	α	0.05	0.068	α-Spectrometry
Strontium-90	28.7	β	0.5	1.3	Gas proportional counter (GPC)
Tritium	12.4	β	250 pCi/L	0.093	Liquid scintillation counting (LSC)
Uranium-234	2.46×10^5	α	0.1	2.59	α-Spectrometry
Uranium-235	7.04×10^8	α	0.1	0.20	α-Spectrometry
Uranium-238	4.47×10^9	α	0.1	2.29	α-Spectrometry
Gamma spectroscopy[c]	n/a[d]	γ	0.2[e]	n/a	γ-Spectroscopy
Gross-alpha	n/a	α	1.0	N.A.[f]	GPC
Gross-beta	n/a	β	1.0	N.A.	GPC
Gross-gamma	n/a	γ	2.0	N.A.	Thallium-doped sodium iodide (NaI[Tl]) or high-purity germanium (HPGe) detection

[a] BVs for sediment samples from Ryti et al. 1998, 59730.

[b] Plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.

[c] The gamma spectroscopy analyte list is given in Table 7.1.2-6.

[d] n/a = not applicable.

[e] The minimum detectable activity for cesium-137 is 0.2 pCi/g; the minimum detectable activity for other analytes will vary.

[f] N.A. = not available.

Radionuclide sample results will be reviewed against process knowledge of waste streams released into Sandia Canyon. Radionuclides detected in environmental media samples in activities above BVs will be included as COPCs. Detected radionuclides from gamma spectroscopy also include short-lived (less than one year) daughter radionuclides of naturally occurring uranium and thorium isotopes. These uranium and thorium daughters are not identified as COPCs because radiological dose conversion factors for the parent radionuclides include the expected activity of daughter products. These short-lived daughter products are not included as COPCs if they are not identified in the process knowledge of Sandia Canyon waste streams and warrant exclusion as COPCs based on their rapid elimination from environmental media.

The required QC procedures and acceptance criteria for both the inorganic chemical and radiochemical analyses (except uranium-236) are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Table 7.1.2-6
Analyte List and Half-Lives of Radionuclides Measured Using Gamma Spectroscopy

Radionuclide	Half-life*	Emissions
Th-232 Decay Series (Thorium Series)		
Lead-212	10.64 h	β,γ
Thallium-208	3.053 m	β,γ
U-235 Decay Series (Actinium Series)		
Bismuth-211	2.14 m	α,β,γ
Thorium-227	18.72 d	α,γ
Uranium-235	7.04 x 10^8 y	α,γ
U-238 Decay Series (Uranium Series)		
Bismuth-214	19.9 m	α,β,γ
Lead-214	26.8 m	β,γ
Thorium-234	24.10 d	β,γ
Activation Products (and Their Decay Products)		
Americium-241	432.7 y	α,γ
Cobalt-60	5.271 y	β,γ
Sodium-22	2.605 y	β,γ
Protactinium-233	27.0 d	β,γ
Fission Products		
Cesium-134	2.065 y	β,γ
Cesium-137	30.17 y	β,γ
Europium-152	13.48 y	β,γ
Ruthenium-106	372.6 d	β
Other		
Potassium-40	1.25 x 10^9 y	β,γ

* m = minutes, h = hours, d= days, y = years.

7.1.2.5.3.3 Geotechnical Analysis

In addition to the chemical and radiochemical analyses, sediment samples will undergo geotechnical analysis for particle size distribution using a method determined appropriate to meet the investigation goals. Methods used may be those recommended by the US Geological Survey for geological applications (Janitzky 1986, 57674) or methods recommended for engineering applications by the American Society for Testing and Materials (ASTM) described in ER-SOP-11.02, “Particle Size Distribution of Soil/Rock Samples” (ASTM Method D-422-63). Goals of these analyses may include evaluating relationships between contaminant concentrations and particle size distribution and determining the 10-µm-size fraction (respirable particulate) in sediment samples. Other geotechnical analyses, such as mineralogy or organic matter content, may be performed at the discretion of the technical team geologists and geochemist.

7.1.3 Surface Water Sampling and Analysis Plan

This section presents the SAP for investigating surface water in selected reaches in the Sandia Canyon system. The strategy for sampling surface water in appropriate reaches (including streamflow and spring discharges) is described. To meet the objectives of the surface water investigation sampling and analysis of surface water in appropriate reaches is planned to characterize both the baseline surface water quality and the occurrence and extent of Laboratory-derived contaminants present in the surface water. In addition, two evapotranspiration (ET) measurement stations are planned to support water balance determination.

Surface water investigations planned for Sandia Canyon will be coordinated with the upper Sandia Canyon SAP (LANL 1998, 62340) and the draft watershed management plan (LANL 1999, 62920). These investigations will focus on quantifying pathways for contaminant migration as part of the risk analysis.

No natural perennial reaches occur on Laboratory property in Sandia Canyon. A reach of continuous flow supported by Laboratory effluent discharges occurs in the upper canyon, and a short perennial reach occurs below Sandia Spring in the lower off-site canyon (see Section 3.4.3 and Figure A-1). Surface water investigations currently are being conducted at five locations in the upper canyon as part of the upper Sandia Canyon SAP (LANL 1998, 62340). Quarterly surface base-flow and event-based stormwater runoff sampling is being conducted at locations in the north and south tributaries of upper Sandia Canyon immediately west of Diamond Drive, at locations in the north and south tributaries immediately upstream of the confluence of the two tributaries, and at the toe of the wetland area. The last quarter of base-flow sampling for this effort is scheduled to occur in July 1999 and stormwater sampling is scheduled to begin in the summer of 1999.

7.1.3.1 Objective

The objective of the surface water SAP is to address the HSWA Module (EPA 1990, 1585) requirements for characterizing the hydrogeology of the Sandia Canyon watershed and to determine the Laboratory's impact on surface water. The surface water investigation is a component of characterizing the natural setting of the Laboratory as required by Task III (Facility Investigation), Section A (Environmental Setting) of the HSWA Module. These requirements are discussed in detail in Chapter 1 of the core document (LANL 1997, 55622). The surface water investigations address the presence of Laboratory-derived contaminants and will evaluate the present and future potential for off-site exposures and impacts extending along the entire canyon to the Rio Grande.

More specifically, the objectives of this plan are to clearly define

- the role of surface water in the potential transport of contaminants along selected reaches of the canyon system,
- all or relevant parts of the system's overall water budget,
- the role of surface water as a potential recharge source to underlying units, and
- the role of spring discharges from underlying hydrogeologic units.

The qualitative understanding of hydrologic interconnections as well as quantitative descriptions of process rates are necessary to evaluate the hydrologic and contaminant transport relationships pertinent to surface water within appropriate reaches of the Sandia Canyon hydrogeologic system. Understanding the interactions between surface water, vadose zone, and groundwater in different water-bearing zones within the canyon system is needed to optimize future environmental surveillance efforts. The integration of existing information and new data from planned field investigations will provide a basis for understanding if surface water contaminant concentrations, inventories, or spatial and temporal projections approach or exceed regulatory or administrative thresholds. If the results indicate unacceptable present-day or potential future risks, a corrective measures study (CMS) would be required.

7.1.3.2 General Approach for Surface Water Investigation

The general approach to the surface water investigation will be to collect new field data and extend existing interpretations as necessary to establish adequate confidence in the upper limits of the risk estimates or to clarify surface water occurrence and geochemical and transport processes sufficiently to meet the requirements of the HSWA Module for continued surface water monitoring (EPA 1990, 1585).

- Investigations of surface water will focus on determining (1) the nature and extent of surface water contaminants; (2) the magnitude, distribution, and temporal characteristics of streamflow in specific reaches of the canyon system; (3) the magnitude and distribution of infiltration losses from streamflow; (4) the possible hydrologic connectivity between surface runoff in the upper canyon reaches and spring discharges further downstream; and (5) the significance of the surface water component of the canyon's water budget and its role in facilitating contaminant mobilization and migration into the subsurface.

- Water-balance studies for the Sandia Canyon watershed will be performed by the Canyons Focus Area technical team with technical input from the personnel in the Laboratory Water Quality and Hydrology Group (ESH-18) and the watershed management protection plan team concurrently with the alluvial groundwater investigations described in Section 7.1.4.2 of this document. The water-balance studies may include a variety of data-collection methods including techniques employing the existing and recently installed streamflow gaging stations, and the two planned ET stations along with meteorological data collected by ESH-17 personnel. These studies will define and quantify the magnitude of water infiltration into the subsurface, which is a critical component of the water budget.

- Data collected in this surface water investigation will be integrated with data from other previous and ongoing Laboratory studies, such as the activities described in the upper Sandia Canyon SAP (LANL 1998, 62340), the draft groundwater protection management program plan (LANL 1995, 50124) and the draft watershed management plan (LANL 1999, 62920), to improve understanding of the surface water hydrology of the Pajarito Plateau.

The investigation team will make recommendations regarding corrective measures to alleviate any significant surface water contaminants and monitoring strategies for the ER Project and/or the Laboratory environmental surveillance program. Addressing each of these questions requires an integrated technical approach of data collection, data evaluation, and refinement of the conceptual model. The approach is described in terms of a specific programmatic issue that will be addressed by the investigation. Each technical approach to an issue also addresses the hypotheses included in the conceptual model.

Issue

What is the nature and extent of contaminants in continuous surface water and the reach of Laboratory-supported continuous flow in the Sandia Canyon system? What is the present-day risk posed by contaminants present in surface water in the Sandia Canyon system? How will that risk change with time?

Technical Approach

Determine if contaminants in surface water are at levels above the maximum contaminant levels (MCLs), NMWQCC standards (1995, 54406), UTL values for background, or levels exceeding other regulatory or administratively adopted levels that define unacceptable human-health or ecological risks in appropriate land-use scenarios. Additionally, other physical properties of surface water need to be understood, such as the following.

- Determine if there is a process or pathway for contaminant exposure.
- Determine the volume and extent of surface water flow in the Sandia Canyon system.
- Determine the character (timing, flow volume, and location) of ephemeral and intermittent surface water flow in the canyon.
- Determine how much recharge to perched groundwater in the alluvium is provided by surface water infiltration.

The following data will be collected to provide input to the decisions:

- measurements of surface water quality parameters (including streamflow and spring discharges) and geochemical parameters and analytes (including indicators of natural or contaminant sources, temporal water quality variations, and a refined conceptual model of surface water geochemistry);
- volumetric streamflow runoff information (discrete data) at specific locations within the canyon system during representative maximum flow (spring snowmelt and summer storms) and minimum flow conditions;
- amount of surface water infiltration within discrete reaches defined by measurement station locations, such as
    - ♦ spring discharge volumes and temporal variability,
    - ♦ site-specific and/or representative precipitation and ET rates;
    - ♦ land-use (and potential surface water use) scenarios; and
    - ♦ a conceptual model of the hydrologic system including a surface water budget.

For initial planning use, the investigation will be limited to specific locations within boundaries established for the Sandia Canyon investigation. Surface water samples will be collected at the Sandia Spring discharge point and at a surface water collection site to be located in the upper canyon between recently installed gaging stations E123 and E124. In situ field measurements for volumetric flux and selected water quality parameters will be collected quarterly for a period of one year. Sampling events during annual high- and low-flow conditions will be conducted four times for one year, and chemical indicators sufficient to determine seasonal effects will be analyzed. The quarterly sampling will be coordinated with quarterly sampling of alluvium wells in Sandia Canyon (see Section 7.1.4.2) to provide a snapshot of water quality conditions throughout the watershed for surface water and shallow groundwater.

The interpretive investigation will be a major component of the investigation. Available data for streamflow runoff, surface water quality, and meteorological parameters (precipitation and ET) including both published and unpublished archival data, will be integrated with the newly collected data, followed by conceptual and quantitative interpretation of the entire data set. Before data can be used in groundwater-flow, contaminant-transport or risk-analysis models, the data must be checked for consistency with the conceptual hydrogeologic model.

Data needed to evaluate the present-day human-health and ecological risk will be collected as part of a single field investigation and should reflect high- and low-runoff conditions to establish appropriate ranges and uncertainties in source term distribution. Sufficient data will be collected to evaluate potential annual variations in separate elements of the risk assessment.

Present-day human-health and ecological risk assessments will include evaluation of surface water with the following assumptions.

Drinking water pathways

- Contaminants will be evaluated it they have concentrations above standards or UTL values for background or show trends (observed or predicted) in concentrations over time, which indicate that contaminants may exceed standards, UTL values, or other quantitative risk levels administratively adopted for remedial decisions in the future.

Livestock and wildlife watering pathways

- Appropriate state and other regulatory agency standards will be used to identify COPCs.

Plant uptake pathways

- Contaminants that exceed the limits noted above will be evaluated.

The SAP for surface water consists of three phases:

1. field investigation,
2. data analysis, and
3. development and refinement of the detailed conceptual model of the canyon hydrogeologic and geochemical system.

The field investigation phase includes the following activities. Investigators will

- sample and analyze surface water at appropriate locations in the effluent-supported continuous reach and the perennial reach below Sandia Spring to characterize potential contaminants and to determine surface water geochemistry and the origin of the water (e.g., contemporary precipitation, older groundwater, or Laboratory effluent).
- measure field parameters in water samples (pH, temperature, specific conductance, dissolved oxygen, and turbidity) to characterize general water quality variability.
- collect discrete surface water flow data using a hand-held flow meter. Surface water flow time-series data will also be available from four permanent and continuous recording streamflow gaging stations (E121 through E124) recently installed in the upper and middle canyons as described in the draft Watershed Management Plan (LANL 1999, 62920) and from existing station E125, located in the lower canyon near the eastern Laboratory boundary.

- collect data on latent heat energy flux from two stations instrumented for continuous simultaneous measurements of absolute humidity and vertical wind speed to be located at representative canyon-floor sites. Latent heat flux rates will be determined by application of the eddy correlation method. These data will be used to quantify ET for water-balance calculations.

The data analysis phase includes the following activities. Investigators will

1. quantify surface runoff volumes and assess relative contributions from various runoff sources such as stormwater, snowmelt, spring discharges, and Laboratory effluent discharges.
2. evaluate surface water infiltration losses into the alluvium and/or underlying formations.
3. quantify precipitation inputs to the canyon system watershed by analyzing historical weather data and recent data obtained from nearby meteorological stations operated by the Laboratory air quality group (ESH-17).
4. evaluate ET losses from the canyon system watershed by analyzing site-specific latent heat flux data from the two ET stations to be located on the canyon floor and from two meteorological stations located at nearby representative mesa-top sites (TA-6 and TA-53) operated by ESH-17.
5. prepare a surface water budget for the watershed.
6. evaluate the geochemistry of surface water samples.
7. evaluate the potential for hydraulic and mass transport of contaminants via surface water to off-site locations and also to underlying hydrogeologic units.

In conjunction with the field investigation and data analysis phases, the surface water investigations will be performed at the same time as the groundwater investigations described in Section 7.1.4, in order to develop an integrated hydrogeologic conceptual model of the Sandia Canyon system. Further development and refinement of details of the conceptual model (described in Chapter 4 of this work plan) include the following activities. Investigators will

1. integrate the results of surface water field investigations and data analyses with groundwater investigation results to more precisely describe the interconnections and interactions between hydrologic (surface water) and hydrogeologic (subsurface) components of the conceptual model.
2. refine the conceptual model by synthesizing the results of field investigations and data analyses into an integrated flow-transport model (or models) that quantitatively describes and simulates interactions between surface water and groundwater within the Sandia Canyon hydrogeologic system.
3. where necessary, use numeric simulations to describe present-day and projected future concentrations and inventories at various potential receptor locations.
4. evaluate potential contaminant exposure pathways for present-day and projected future risks at potential receptor locations.
5. compare present-day exposures and projected future exposures at important receptor locations to evaluate the regulatory and administrative risk levels to identify contaminants that require remedial action.

The conceptual model is the basis for applying numerical computer models that simulate hydrologic processes and interactions of the surface water and groundwater. Geochemical interactions within the system will also be modeled as needed. These models will quantitatively describe the pertinent aspects of surface water within the Sandia Canyon hydrogeologic system that address the three primary objectives described above.

After all three phases have been successfully completed, the Laboratory will satisfy the following requirements:

- hydrogeological and geochemical characterization of surface water in the Sandia Canyon system;
- evaluation of historical, present, and future exposure risks associated with surface water in the Sandia Canyon system; and
- detailed recommendations for a long-term environmental surveillance program plan that optimizes future surface water sample collection and the frequencies and locations of streamflow measurements.

Additional data will be obtained if reduced data uncertainty has the potential to change any risk-based decision. This process is discussed in detail in Chapter 6 of the core document (LANL 1997, 55622).

7.1.3.3 Sampling and Analysis Plan for Surface Water Investigation

The SAP for the surface water investigation follows the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622). The SAP is designed to be flexible, and the objectives and approaches will be refined and modified as new data are obtained. Revisions or refinements to the different components of the conceptual model (see Chapter 4 of this work plan) will be based on the integration of results from all components of the investigation as well as an integration and further interpretive analysis of data from other previous and ongoing Laboratory studies (as discussed in Chapter 2 and Chapter 3 of this work plan). Information gathered from implementing this work plan will also be used to focus geologic, geochemical, and hydrogeologic characterization efforts in future work plans for other canyon systems.

7.1.3.3.1 Surface Water Flow Measurements

Surface water flow measurements will be made by employing several proven methodologies including continuous data recording at permanent flow gaging stations, and quarterly in situ field measurements of flow and related parameters.

Surface Water Gaging Techniques

Surface water flow will be measured concurrently with surface water sampling activities (described in Section 7.1.3.4 of this work plan) and groundwater sampling activities (described in Section 7.1.4) on a quarterly basis for one year to provide a snapshot of hydrologic conditions throughout the canyon. Surface water collection sites where flow will be measured include one location between recently installed gaging stations E123 and E124 in the upper canyon and Sandia Spring, located in the lower off-site canyon. Surface water flow will be measured at these locations using a hand-held flow meter.

In addition, four new stream gaging stations (E121 through E124) have recently been installed in upper and middle Sandia Canyon, as described in the draft Watershed Management Plan (LANL 1999, 62920). Gaging station E125 was installed near the eastern Laboratory boundary in 1993. ESH-18 personnel monitor these stations and the data are published on an annual basis in the environmental surveillance reports. These data will be available to support the evaluation of surface water in Sandia Canyon. The new gaging stations are

- gage E121, located in upper Sandia Canyon in the north tributary of reach S-1 (defined in Section 7.1.2.4);
- gage E122, located in upper Sandia Canyon in the south tributary of reach S-1;
- gage E123, located below the wetland area in upper Sandia Canyon; and
- gage E124, located south of TA-53 in middle Sandia Canyon.

The recently installed streamflow gaging stations are listed in Table 7.1.3-1. Locations of the gaging stations are shown in Figure A-1.

Table 7.1.3-1
Recently Installed Surface Water Gaging Stations and Planned ET Stations in Sandia Canyon

Designation[a]	Description
E121	Permanent station for flow gaging, sampling, and water quality parameter measurement with continuous data-recording capability. Station is located in the north tributary of reach S-1 in upper Sandia Canyon.
E122	Permanent station for flow gaging, sampling, and water quality parameter measurement with continuous data-recording capability. Station is located in the south tributary of reach S-1 in upper Sandia Canyon.
E123	Permanent station for flow gaging, sampling, and water quality parameter measurement with continuous data-recording capability. Station is located below the wetland area in upper Sandia Canyon.
E124	Permanent station for flow gaging, sampling, and water quality parameter measurement with continuous data-recording capability. Station is located south of TA-53 in middle Sandia Canyon.
SCET-1	Planned ET station[b] in Sandia Canyon (location to be determined).
SCET-2	Planned ET station[b] in Sandia Canyon (location to be determined).

[a] SC = Sandia Canyon, ET = evapotranspiration measurement station.

[b] Planned ET station locations will be determined pending field reconnaissance of site suitability.

7.1.3.3.2 Evapotranspiration Measurements

Measurements will be obtained to determine ET parameters to support a water-balance investigation in Sandia Canyon. The measurement of ET is included in the surface water SAP because ET is a significant component of the overall water budget. ET is typically the most difficult water-balance parameter to measure, even indirectly. Data directly relevant to the determination of this parameter are currently available from two existing continuously recording meteorological stations (operated by ESH-17), which are located on mesa-top sites at TA-6 and TA-53. These stations are equipped with instrumentation located 33 ft (10 m) above ground level to measure absolute humidity and vertical wind speed. The upward flux of latent evaporative heat within the atmosphere is then determined through the application of the eddy correlation method. ET amounts can be computed by dividing the latent heat flux rates by the latent heat of evaporation.

Two additional solar-powered ET stations using this technology are currently located at sites on the floor of Mortandad Canyon, with instrumentation mounted 6.6 ft (2 m) above ground level. ESH-18 personnel installed these stations to characterize ET rates specific to the environment on the floor of Mortandad Canyon. ET rates on the floor of the canyon are thought to differ significantly from the mesa-top sites because of denser vegetation and generally wetter conditions. Operational difficulties have precluded accurate data collection from the Mortandad Canyon stations (the solar panels were not situated properly to maintain continuous power to the instruments), and they are currently inactive pending relocation to sites with favorable solar exposure.

The installation of two new continuous recording ET stations is being considered in Sandia Canyon to quantify ET amounts in the Sandia Canyon site-specific canyon-floor environment. The planned ET stations are listed in Table 7.1.3-1. Their locations will be determined pending field reconnaissance of site suitability. A brief discussion of the data applications and rationale for the new ET stations follows.

Two ET stations (SCET-1 and SCET-2) are planned to be installed at sites within the canyon watershed representative of varying vegetation conditions. The instruments at this station will be tower-mounted at a height of approximately 10 m (33 ft) or at the height needed to measure transpiration from the trees. This station will provide data to ensure that the transpiration component from treetops will be included in the measurements.

These data will allow an assessment of ET rates for differing site-specific environments on the canyon floor that, in combination with representative ET data from the adjacent mesa-top stations operated by ESH-17, will enable quantification of this component of the canyon's surface water budget. This information is important for quantifying the water balance for the canyon watershed because ET is the predominant component of the water budget for surface water.

7.1.3.4 Surface Water Sampling and Analysis

The HSWA Module (EPA 1990, 1585) requires that this work plan include an investigation of the potential for transport of contaminants within canyon watersheds. Because surface water is a primary mechanism for contaminant mobilization in the Sandia Canyon system, chemical analyses of surface water samples are necessary to address this requirement. This section describes the sampling design for collecting surface water samples. The methods for sample collection and for chemical and radiochemical analyses are also provided in this section.

7.1.3.4.1 Surface Water Sampling

All surface water samples will be collected and handled in accordance with the most recent revision of the appropriate ER Project SOP (ER-SOP-6.13, "Surface Water Sampling").

Surface water samples will be collected for analysis on a quarterly basis for one year. The quarterly surface water samples will be collected concurrently with groundwater samples (described in Section 7.1.4 of this work plan) to provide a snapshot of surface water and groundwater geochemistry throughout the canyon. The following sites have been designated as sampling locations; the sampling rationale for each location is also included.

- Surface water collection site, to be located between gaging stations E123 and E124 to determine the possible impacts from PRSs in upper Sandia Canyon; and

- Sandia Spring, to determine the groundwater source geochemistry.

Samples will be collected in the middle of the stream to provide representative surface water chemical data for the location in the upper canyon. Spring samples will be collected as close to the discharge point as possible to identify the groundwater source chemistry. Duplicate surface water samples will be collected at each site, and one sample will be filtered (to remove particulates larger than 0.45 µm) before preservation, whereas the other sample will remain unfiltered. Comparison of these data will permit an evaluation of chemical concentrations in solution versus constituents adsorbed onto suspended particulate matter.

Table 7.1.3-2 summarizes the collection design for surface water samples.

Table 7.1.3-2
Summary of Surface Water Samples to be Collected in Sandia Canyon

Sample Type	No. of Sites	Sampling Frequency	Total No. of Samples
Surface water (streamflow)	1	Quarterly for one year	8 (4 filtered, 4 unfiltered)
Surface water (springs)	1	Quarterly for one year	8 (4 filtered, 4 unfiltered)

7.1.3.4.2 Analysis of Surface Water Samples

This section describes the methods for analyzing surface water samples for inorganic and organic chemicals, radionuclides, and radiogenic and stable isotopes. The analysis of surface water samples has three purposes: (1) to detect and measure Laboratory-derived COPCs, (2) to obtain information about the natural geochemistry of surface water within the Sandia Canyon watershed, and (3) to assess potential recharge sources for spring discharges, thus identifying potential groundwater flow paths and mixing scenarios.

Specific conductance, turbidity, pH, temperature, and dissolved oxygen will be measured in the field at the time of water sampling. Each sample will be analyzed for the parameters listed in Table 7.1.3-3. Where appropriate, these data will be combined with analyses of unfiltered samples collected either by ER Project personnel or for environmental monitoring by ESH-18 personnel to reduce uncertainty in the distributions of surface water quality for contaminant transport and risk model inputs.

Analytical Methods

Surface water samples collected according to the strategy outlined in Section 7.1.3.4.1 will initially undergo full-suite analyses for organic and inorganic chemicals and radionuclides at ER Project-approved fixed-site laboratories. The analytical suites for analysis of organic and inorganic chemicals and radionuclides are listed in Table 7.1.3-3. All analyses for organic chemicals will be performed in accordance with EPA SW-846 protocols (EPA 1987, 57589). The detailed analyte lists, EQLs, minimum detectable activities, required QC procedures, and the acceptance criteria are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented. The first sample collected from each surface water sampling location will undergo analysis for the full suite of organic and inorganic chemicals and radionuclides. If organic chemicals are identified as COPCs for a particular sampling location, all subsequent samples from that location will be analyzed for organic COPCs. Any organic compound reported as not detected will be excluded from subsequent limited-suite analyses.

Table 7.1.3-3
Analytical Suite for Surface Water Samples

Field-Measured Parameters		
Specific conductance	pH	Dissolved oxygen
Turbidity	Temperature	
Major and Minor Ions		
Alkalinity	Fluoride	Phosphate
Aluminum	Iron	Potassium
Ammonium	Magnesium	Silica
Bromide	Manganese	Sodium
Calcium	Nitrate	Sulfate
Chloride	Nitrite	Total kjeldahl nitrogen
Trace Elements		
Aluminum	Chromium	Silver
Antimony	Cobalt	Thallium
Arsenic	Copper	Uranium
Barium	Lead	Vanadium
Beryllium	Mercury	Zinc
Boron	Nickel	
Cadmium	Selenium	
Organic Chemicals		
TOC	PCBs	Volatile organic compounds
HE	TPH	
Dissolved Organic Carbon (fractionation analysis)		
Total Suspended Solids		
Total Dissolved Solids		
Hardness		
Cyanide		
Radionuclides		
Americium-241	Strontium-90	Gamma spectroscopy
Cesium-137	Uranium-234	Gross-alpha, -beta, and -gamma
Plutonium-238	Uranium-235	Tritium*
Plutonium-239,240	Uranium-238	

Note: Filtered (<0.45 µm) and unfiltered water samples will be analyzed.

* Low detection limit (1 pCi/L).

All water samples will be analyzed for inorganic chemicals to identify COPCs and to obtain a better understanding of the baseline geochemistry of surface water in Sandia Canyon. The target analytes, conservative EDLs, and analytical methods for inorganic chemicals are listed in Table 7.1.3-4. Measurements for inorganic chemicals include analyses for 26 trace metals; major anions (chloride, fluoride, nitrate, and sulfate); minor anions (bromide, nitrite, and orthophosphate); total kjeldahl nitrogen; dissolved silica; and total cyanide. All analyses for inorganic chemicals will be performed in accordance with EPA SW-846 protocols (EPA 1987, 57589), EPA standard methods (EPA 1983, 56406), or standard methods for chemical analysis of water (Franson 1995, 56405). The required QC procedures and acceptance criteria for the metals and total cyanide analyses are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Table 7.1.3-4
Estimated Detection Limits and Analytical Methods for Inorganic Chemicals in Surface Water Samples

Analyte	EDL (µg/L)	Analytical Method	Analytical Protocol[a]
Metals (total and dissolved)			
Aluminum	10	ICPES	SW-6010B
Ammonium	20	IC	SW-9056
Antimony	0.1	ICPMS	SW-6020
Arsenic	1	ETVAA	SW-7060A
Barium	2	ICPES	SW-6010B
Beryllium	5	ICPES or ICPMS	SW-6010B or SW-6020
Boron	10	ICPES	SW-6010B
Cadmium	1	ICPMS	SW-6020
Calcium	10	ICPES	SW-6010B
Chromium	2	ICPES	SW-6010B
Cobalt	2	ICPES	SW-6010B
Copper	2	ICPES	SW-6010B
Iron	10	ICPES	SW-6010B
Lead	3	ETVAA or ICPMS	SW-7421 or SW-6020
Magnesium	10	ICPES	SW-6010B
Manganese	2	ICPES	SW-6010B
Mercury	0.2	CVAA	SW-7470A
Nickel	2	ICPES	SW-6010B
Potassium	10	ICPES	SW-6010B
Selenium	0.2	ETVAA	SW-7740
Silver	0.2	ICPES	SW-6010B
Sodium	50	ICPES	SW-6010B
Thallium	2	ICPMS	SW-6020
Uranium	1	ICPMS or KPA[b]	SW-6020
Vanadium	2	ICPES	SW-6010B
Zinc	10	ICPES	SW-6010B
Anions (dissolved)			
Bromide	20	IC	SW-9056
Chlorate	20	IC	SW-9056
Chloride	20	IC	SW-9056
Fluoride	20	IC	SW-9056
Nitrate	40	IC	SW-9056
Nitrite	40	IC	SW-9056
Total kjeldahl nitrogen	40	IC	SW-9056
Orthophosphate	20	IC	SW-9056
Sulfate	100	IC	SW-9056
Other Inorganic Chemicals (dissolved)			
Silica	200	Colorimetry	EPA Method 370.1
Total cyanide	50	Colorimetry	SW-9012A

Note: Both unfiltered (total) and filtered (dissolved) water samples will be collected. Water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

[a] EPA SW-846 Method (EPA 1987, 57589) or equivalent.

[b] KPA = kinetic phosphorimetric analysis.

The target analytes and their half-lives, detected emissions, minimum detectable activities, and analytical methods for radionuclides are listed in Table 7.1.3-5. In addition to measurements of gross-alpha, -beta, and -gamma radioactivity, the radionuclide analytes include americium-241; plutonium-238; plutonium-239,240; strontium-90; tritium; uranium-234; uranium-235; and uranium-238

Table 7.1.3-5
Minimum Detectable Activity and Analytical Methods for Radionuclides in Surface Water Samples

Analyte	Half-Life (yr)	Detected Emission	Minimum Detectable Activity (pCi/L)	Analytical Method
Americium-241	432.2	α	0.05	α-Spectrometry
Plutonium-238	87.7	α	0.05	α-Spectrometry
Plutonium-239,240[a]	2.411 x 10^4	α	0.05	α-Spectrometry
Strontium-90	28.7	β	1.0	Gas proportional counter (GPC)
Tritium	12.4	β	250	Liquid scintillation counting (LSC)
Tritium (low level)	12.4	β	1	Electrolytic enrichment/GPC
Uranium-234	2.46 x 10^5	α	0.1	α-Spectrometry[b]
Uranium-235	7.04 x 10^8	α	0.1	α-Spectrometry[b]
Uranium-238	4.47 x 10^9	α	0.1	α-Spectrometry[b]
Gamma spectroscopy[c]	n/a[d]	γ	10[f]	γ-Spectroscopy
Gross-alpha	n/a	α	1.0	GPC or LSC
Gross-beta	n/a	β	1.0	GPC or LSC
Gross-gamma	n/a	γ	20	NaI(Tl) or HPGe detection

Note: All water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

[a] The plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.

[b] Radionuclides may also be analyzed by ICPMS.

[c] The gamma spectroscopy analyte list is given in Table 7.1.2-6.

[d] n/a = not applicable.

The ER Project analyte list for the gamma spectroscopy analysis (see Table 7.1.2-6) includes the decay series of the naturally occurring radionuclides radium-226, uranium-235, and uranium-238 as well as fission and activation products and their progeny. Measurements of naturally occurring radionuclides known to be present in Laboratory soils provide an indication of the quality of the gamma spectroscopy measurement. Data for short-lived radionuclides can be useful when values reported for a parent radionuclide are evaluated because the relative activity concentration of parent and daughter isotopes is a known quantity. The shorter-lived radionuclides are usually included in the analyte list to verify the presence of longer-lived parent isotopes, but they are not evaluated as primary radionuclides because they decay to unmeasurable concentrations within the span of several years or less. The naturally occurring radionuclide potassium-40 is present in Laboratory soils at concentrations ranging from 25 pCi/g to 40 pCi/g and is always present in the gamma spectra of Laboratory soil samples. The potassium-40 gamma emission peak provides a qualitative indicator of the accuracy and precision of the gamma spectroscopy measurement, but potassium-40 is not considered a potential contaminant. The required QC procedures and acceptance criteria for the radiochemical analyses (except low-level tritium and uranium-236) are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Surface water samples will also be analyzed for organics and stable and radiogenic isotopes using the methods listed in Table 7.1.3-6. Analysis for stable isotope ratios of nitrogen-15/nitrogen-14, deuterium/hydrogen, and oxygen-18/oxygen-16 will be performed only on the spring samples to characterize their water chemistry with regard to these constituents and permit assessment of potential recharge sources. Analyses for carbon-13 and dissolved organic carbon (humic acids by fractionation analysis) will be performed to provide a better understanding of the organic geochemistry of the surface water.

Table 7.1.3-6
Analytical Methods for Organics and Radiogenic Isotopes in Surface Water Samples

Analyte	Analytical Method
Stable and Radiogenic Isotopes[a]	
Carbon-14, carbon-13	Accelerator MS
Deuterium/hydrogen	Isotope ratio mass spectrometry
Oxygen-18/oxygen-16	Isotope ratio mass spectrometry
Nitrogen-15/nitrogen-14	Isotope ratio mass spectrometry
Organic Chemicals	
VOCs	SW-8260[b]
SVOCs	SW-8270
HE	EPA Method 8330 (high-performance liquid chromatography)
PCBs	SW-8081A or SW-8082
TPH	EPA Method 8015M
Other Analytes	
Total organic carbon	SW-415.1[c]
Dissolved organic carbon (humic substances)	USGS/WRI 79-4
Hardness (as calcium carbonate)	EPA Method 130

Note: All water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

[a] Stable isotopes will be measured in spring samples only.

[b] EPA SW-846 Methods, EPA 1987, 57589.

[c] EPA 1983, 56406.

Table 7.1.3-7 lists the field measurements that will be made at the time of sample collection.

Table 7.1.3-7
Field Measurements for Surface Water Samples

Measurement	Precision[a]	Method
pH	±0.02	LANL-ER-SOP-06.02
Specific conductance	±1 mmho/cm (µS/cm)	LANL-ER-SOP-06.02
Temperature	±1 °C	LANL-ER-SOP-06.02
Dissolved oxygen	±0.1 mg/L	LANL-ER-SOP-06.02
Turbidity (nephelometric)	±1 NTU[b]	EPA Method 180.1

[a] Precision with which measurement will be recorded.

[b] NTU = nephelometric turbidity unit.

7.1.4 Groundwater Sampling and Analysis Plan

This section presents the SAP for investigating groundwater in the Sandia Canyon system. The strategy for sampling alluvial groundwater, intermediate groundwater zones, if encountered, and the regional aquifer is described. Borehole cores will also be sampled and analyzed to determine the baseline and potential contaminant geochemistry and the hydraulic properties of water-bearing zones. To meet the objectives of the groundwater investigation, 6 wells are planned: 3 alluvium wells, and 3 regional aquifer wells. One of the regional aquifer wells, R-12, was drilled in 1998 and final completion as a monitor well is pending. The preliminary results of the drilling and sampling of R-12 are discussed in the “Interim Completion Report for Characterization Well R-12” (LANL 1998, 59665) and are summarized in Section 3.4.4.6. of this document.

The regional aquifer wells are being drilled as part of the draft groundwater protection management program plan (LANL 1995, 50124), a Laboratory program to characterize the hydrogeology of the Pajarito Plateau by installing a Laboratory-wide groundwater monitoring network. The regional aquifer wells are being installed as part of a cooperative effort between Laboratory Defense Programs and the ER Project; the planning for these wells is described in the hydrogeologic work plan (LANL 1998, 59599). The ER Project plans to install two of the regional aquifer wells to characterize potential contaminants in perched groundwater systems and the regional aquifer. Defense Programs plans to install one regional aquifer well to satisfy hydrogeological characterization goals of the hydrogeologic work plan.

7.1.4.1 Objective of Groundwater Investigations

The objective of the groundwater SAP is to address the HSWA Module (EPA 1990, 1585) requirements for characterizing the hydrogeology of the Sandia Canyon system to determine the potential impact on groundwater by the Laboratory. These requirements are discussed in detail in Chapter 1 of the core document (LANL 1997, 55622). The HSWA Module requires that the Laboratory investigate the potential for movement or transport of contaminants within canyon watersheds and contaminant interactions with alluvial groundwater and other groundwater. The scope and general technical approach of the groundwater investigations are also described in Chapter 5 of the core document. Installation of the alluvium wells and regional aquifer characterization boreholes identified in this work plan will satisfy requirements to characterize the alluvial groundwater system and the intermediate perched zone and regional aquifer zones of saturation, as identified in the hydrogeologic work plan (LANL, 1998, 59599). A complete list of objectives associated with these groundwater investigations is in Appendix 4 of the hydrogeologic work plan (LANL 1998, 59599).

The groundwater investigations address the presence of Laboratory-derived contaminants and will evaluate present and future potential off-site exposures and impacts extending along accessible reaches of the entire canyon to the Rio Grande, which result from interactions between surface water and groundwater in different water-bearing zones. In addition to characterizing contaminant presence and transport within the alluvial system, intermediate zones of saturation, and the regional aquifer systems, the results obtained from the groundwater investigations are essential to evaluating potential transport pathways from the alluvium to the intermediate-depth and regional aquifer groundwater systems. Detailed contaminant characterization within the alluvial system allows the comparison of unique chemical signatures to those obtained from the deeper groundwater systems to determine the degree of connectivity between groundwater systems. Alluvial and regional aquifer wells constructed for characterization of groundwater can be used in the future to enhance Laboratory groundwater monitoring systems.

7.1.4.2 Alluvial Groundwater Sampling and Analysis Plan in Sandia Canyon

This section describes the sampling design for collecting alluvial groundwater samples and alluvial borehole core samples and describes the criteria for selecting the locations of the planned new wells. The methods for sample collection and for chemical, radiochemical, and geotechnical analyses are also provided in this section. The groundwater sampling strategy involves installation of 3 new alluvium observation wells. Supplemental alluvium wells may be planned in the future if saturation and contaminants encountered while drilling warrant the installation of supplemental alluvial groundwater observation wells.

The HSWA Module (EPA 1990, 1585) requires that this work plan include an investigation of the potential for transport of contaminants within canyon watersheds and the interactions with alluvial groundwater and other groundwater. Three characteristics of groundwater in the alluvium are relevant to these requirements: continuity, potential recharge to deeper groundwater, and levels of contaminants. A detailed discussion of these topics is in Section 3.4.4.2 of this work plan.

7.1.4.2.1 General Approach for Alluvial Groundwater Investigations

This section describes the general approach for the alluvial groundwater characterization and sampling and analysis. Alluvial groundwater investigations focus on areas of insufficient data and areas most likely to contain contaminants, such as areas down gradient of known release sites and in areas where Laboratory surveillance data indicate that Laboratory-derived contaminants could be present. The approach for the groundwater investigation follows the data needs outlined in Chapters 3 and 4 of this document and the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622).

The following fundamental questions to be addressed for the alluvial system have been identified.

- What is the nature and extent of contaminants in alluvial groundwater?
- If the groundwater contains contaminants, where does the loss from the alluvial system occur in Sandia Canyon and what is the flux?
- If contaminants are being transported in alluvial groundwater, what are the flow paths for this alluvial groundwater?

- What are the major processes by which the alluvial groundwater moves?
- What geochemical processes influence water chemistry and contaminant migration in alluvial groundwater?

Addressing each of these questions requires an integrated technical approach of data collection, data evaluation, and refinement of the conceptual model. The approach is described in terms of a specific programmatic issue that will be addressed by the investigation. Each technical approach to an issue also addresses the hypotheses included in the conceptual model.

Issue

What is the present-day risk posed by contaminants in the alluvial groundwater in Sandia Canyon? How will that risk change with time?

Technical Approach

Determine if alluvial groundwater is present in Sandia Canyon and if contaminants are present, determine if contaminants are at levels above MCLs, NMWQCC standards (1995, 54406), EPA standards, UTL values for background, or levels that pose unacceptable human-health or ecological risks in appropriate land-use scenarios. Additionally, other physical properties of alluvial groundwater need to be understood, such as

- the flux of groundwater moving through the alluvium in upper, middle, and lower Sandia Canyon;
- the areal extent of groundwater in the alluvium; and
- if there is a process or pathway for exposure.

The following data will be collected to provide input to decision-making.

- Results of core and/or water samples analyses for geochemical parameters and analytes, including contaminant indicators, sufficient to provide temporal water quality variations, and a refined conceptual model of groundwater geochemistry
- Infiltration rates of surface water, runoff, and alluvial groundwater
- Moisture content/saturation, water levels, saturated thickness, and temporal variations in the alluvium and possible perched zones in the Bandelier Tuff
- Hydrologic properties, geologic structure, hydraulic gradients and predicted flow directions, land use scenarios, spring discharge information, current and planned well-withdrawal points, and a refined conceptual model of the hydrologic system

For initial planning use, the study will be limited by the boundaries of the Sandia Canyon basin area. Quarterly sampling events will be conducted for one year, and chemical indicators sufficient to determine seasonal effects will be analyzed. Data needed to evaluate the present-day human-health and ecological risk will be collected as part of a single field investigation and will reflect information from high and low water levels to establish appropriate ranges and uncertainties in contaminant distribution.

Present-day human-health and ecological risk assessments will include evaluation of alluvial groundwater with the following assumptions.

Drinking water pathways

- Contaminants will be evaluated if they have concentrations above standards or UTL values for background or show trends (observed or predicted) in concentrations over time, which indicates that contaminants may exceed standards or UTL values in the future.
- Duration parameters and pathway of exposure will be adjusted to reflect characteristics of the alluvium (considering specific yield), characteristics of the alluvial groundwater, and potential availability for consumption.

Livestock and wildlife watering pathways

- Appropriate state and other regulatory authority standards will be used to identify COPCs.
- Duration parameters and pathway of exposure will be adjusted to reflect water saturation times and characteristics of the alluvial groundwater, considering potential availability to livestock and wildlife.

Plant uptake pathways

- Contaminants that exceed the limits noted above will be evaluated if alluvial groundwater is located such that it is available for plant uptake.

Additional data will be obtained if reduced data uncertainty has the potential to change any risk-based decision. This process is discussed in detail in Chapter 6 of the core document (LANL 1997, 55622).

The groundwater investigation consists of three phases:

1. field investigation,
2. data analysis, and
3. development and refinement for the detailed conceptual model of the canyon’s hydrogeological and geochemical system.

All phases will interface iteratively until the results of the investigation successfully merge into a conceptual model that describes the hydraulic and contaminant mass transport relationships between surface water and groundwater. An important objective of the investigation is to evaluate the interactions between surface water and groundwater in different water-bearing zones within the canyon system, and to optimize future environmental surveillance efforts. A CMS may be identified during the field investigation. This study would be implemented after the field investigation phase is completed and data have been evaluated.

The field investigation phase includes the following activities. Investigators will

- sample and analyze alluvial and shallow intermediate perched zones (if present) groundwater to characterize nature and extent of the water and of any contaminants that are present.
- collect water level time-series data from each groundwater zone; measure field parameters in water samples (pH, temperature, specific conductance, dissolved oxygen, and turbidity).
- collect hydrogeologic data from core samples to characterize the vadose zone and saturated zones.

The data analysis phase includes the following activities. Investigators will

- evaluate surface water and runoff infiltration losses into the alluvium.
- measure infiltration into bedrock units.
- compare and contrast (through geochemical modeling and analysis) the geochemistry of all water samples.
- evaluate the potential for hydraulic and mass transport among all water-bearing zones.

Continued development of a detailed conceptual model includes the following activities. Investigators will

- refine the conceptual model by integrating the results of field investigations and data analyses into flow-transport models, as necessary.
- evaluate present-day and future exposure at various locations.
- evaluate potential contaminant migration pathways and future concentrations.
- identify contaminant problems that may require remediation.

After all three phases of the investigation have been successfully completed, the Laboratory will satisfy the following requirements of the HSWA Module (EPA 1990, 1585):

- hydrogeological and geochemical characterization of Sandia Canyon;
- evaluation of historical, present, and future exposure risks; and
- detailed recommendations for a long-term environmental surveillance program plan that optimizes future environmental surveillance of the canyon, primarily water sample collection and the frequencies and locations of water level measurements.

The SAP is designed to be flexible, and the objectives and approaches will be refined and modified as new data are obtained. Revisions or refinements to the different components of the conceptual model (see Chapter 4 of this work plan) will be based on the integration of results from all components of the investigation as well as an integration and further interpretive analysis of data from other previous and ongoing Laboratory studies (as discussed in Chapter 2 and Chapter 3 of this work plan). Information gathered from implementing this work plan will also be used to focus geologic, geochemical, and hydrogeologic characterization efforts in future work plans for other canyon systems.

7.1.4.2.2 Planned Alluvium Wells in Sandia Canyon

Investigations are planned to address the objectives of the Sandia Canyon investigations and to sustain the approaches described in the foregoing section. The investigations will determine the presence of saturation in the alluvium and adjacent underlying bedrock units beneath Sandia Canyon and characterize the geochemistry of saturated zones. Significant amounts of saturation are not expected to occur in (1)-the lower part of the canyon where existing alluvium observation wells are dry, and (2) east of state road NM4 due to thinning and the absence of alluvium in that reach. Three alluvial monitoring wells will be installed in middle Sandia Canyon, consistent with the hydrogeologic work plan (LANL 1998, 59599, p. 4-54). The general locations of the three alluvium wells are listed in Table 7.1.4-1 and the locations of the planned alluvium wells are shown on Appendix Figure A-1.

Table 7.1.4-1
Location of Planned Alluvial Groundwater Monitoring Wells in Sandia Canyon

Well Designation[a]	Location[b]
SCAO-1	Middle Sandia Canyon north of highway and west of gaging station E124
SCAO-2	Middle Sandia Canyon south of highway and east of gaging station E124
SCAO-3	Middle Sandia Canyon north of highway and west of TA-72

[a] SC = Sandia Canyon, A = alluvial, O = observation.

[b] See Figure A-1 for planned locations.

The hydrogeologic work plan provided that these three wells would be a transect of three piezometers at a location south of the western part of TA-53 (LANL 1998, 59599, p. 4-54). The piezometer transect was to be located near the anticipated eastern limit of saturation in the alluvium and perpendicular to the longitudinal axis of the canyon. The purpose of the piezometer transect was to determine the width and thickness of saturation and to characterize alluvial groundwater quality. However, the eastern limit of saturation in the alluvium is not known, and due to the presence of a major highway that passes through the canyon, a perpendicular transect of piezometers would be difficult to locate at evenly spaced intervals across the canyon floor. Because it will also be necessary to sample alluvial groundwater, alluvium observation wells will be installed instead of piezometers. The alluvium observation wells will be equipped with continuous-recording pressure transducers to obtain water level data for a period of at least two years and bladder pumps may be installed to allow groundwater samples to be collected without disturbing the pressure transducers.

The alluvial monitoring wells will be located spatially in middle Sandia Canyon to determine the length and thickness of saturation and to characterize groundwater geochemistry. In addition, this information will help define the area of possible infiltration pathways, calculate seepage losses, and assess transport of contaminants adsorbed to sediments within the alluvium. The following list describes the location and rationale each of the alluvium observation wells planned for Sandia Canyon. Each alluvium well planned for Sandia Canyon is on Laboratory property and is shown in Appendix Figure A-1.

- SCAO-1 will be installed in middle Sandia Canyon downstream of sanitary effluent and cooling tower outfalls at TA-3. This well will be located as far upstream in the middle part of the canyon as reasonably possible (other possible sites further up-canyon in this area are not easily accessible due to restricted access caused by the elevated highway that passes through the canyon). This well is also located downstream from outfalls at the western and central part of TA-53 and down gradient from the location of a former landfill at former TA-20; see Section 2.3.5, PRS 20-001(c). SCAO-1 will be located north of the highway in the center of the canyon where the thickest section of alluvium and saturation is anticipated and near the former location of the natural stream channel. The stream channel in this reach of the canyon was relocated to the south side of the highway during road construction. Alluvial groundwater is expected to be present due to the infiltration of surface water in the upstream portion of middle Sandia Canyon.
- A potential contribution to alluvial groundwater chemistry may be the use of road salt on the highway during winter months. This well could also be used to determine water balance and seepage loss from the alluvium in middle Sandia Canyon. This well will satisfy planned well A-26 in the hydrogeologic work plan (LANL 1998, 59599, p. 4-54).
- SCAO-2 will be installed in middle Sandia Canyon about 800 ft (244 m) down-canyon from SCAO-1. This well will be located on the south side of the highway within a few hundred feet of gaging station E124 and near the usual eastern extent of runoff. This well will be located adjacent

to the modern stream channel and at the approximate location of the natural stream channel in the center of the canyon floor where the alluvium is expected to be thickest and where the saturation in the alluvium should be thickest. This well will also be used to determine water balance and the amount of water loss from the alluvium in this portion of the canyon. This well will satisfy planned well A-27 in the hydrogeologic work plan (LANL 1998, 59599, p. 4-54).

- SCAO-3 will be installed in middle Sandia Canyon about 2000 ft (600 m) downstream from SCAO-2. This well be located on the north side of the highway adjacent to the modern (and natural) stream channel and in the center of the canyon floor where the alluvium is expected to be thickest and where the saturation in the alluvium should be thickest. SCAO-3 will be located downstream from outfalls at the eastern end of TA-53 and south of test hole 53-3, which was drilled at the base of the mesa south of the TA-53 impoundments (see Section 3.4.2 of this document). This well will be about 2500 ft (760 m) upstream of observation well SCO-1, which has been dry since original installation in 1966 (see Section 3.4.2). This well will also be used to determine water balance and the amount of water loss from the alluvium through the middle section of the canyon.
- Existing wells. Alluvial groundwater may be collected from the two existing observation wells in lower Sandia Canyon if appropriate samples can be obtained from the wells. Existing wells that may be sampled in Sandia Canyon include SCO-1 and SCO-2, which historically have been dry except for one occasion after a heavy runoff event in 1969 when SCO-2 contained enough water to collect a groundwater sample (see Section 3.4.4.2.1 of this work plan).

7.1.4.2.3 Alluvial Borehole Advancement and Well Installation

Borehole advancement and well installation specifications for Type 1 (alluvial) wells will follow those discussed in Section 4.1.1.1 in Chapter 4 of the hydrogeologic work plan (LANL 1998, 59599, p. 4-18). The boreholes will be drilled using a hollow stem auger drill rig equipped with a wire-line retrievable split core barrel. The wells will be drilled through the alluvium and the Cerro Toledo interval and at least 10 ft (3 m) into the Otowi Member to investigate the perching mechanism at the base of the alluvium. The wells are expected to encounter up to 50 ft to 60 ft (15 m to 18 m) of alluvium and approximately 40 ft to 60 ft (12 ft to 18 m) Cerro Toledo interval sediments. The alluvium likely truncates the upper portion of the Cerro Toledo interval sediments in the middle part of the canyon and since no wells have previously been drilled in this area, the unit thicknesses are unknown. Well procedures and designs are based on HSWA, Resource Conservation and Recovery Act (RCRA), and New Mexico Environment Department (NMED) guidelines and follow ER Project SOPs, which are listed in Table 7.1.4-2.

Table 7.1.4-2
Procedures for Borehole Installation, Core and Groundwater Sampling

Activity	LANL-ER-SOP No.
Monitoring well construction	05.01
Well development	05.02
Purging of wells for representative sampling	06.01
Pressure transducer measurements	07.01
Fluid level measurements	07.02
Drilling methods and drill site management	04.01
General borehole logging	04.04
Core-barrel sampling for subsurface earth materials	06.26
Field logging, handling, and documenting of borehole samples	12.01

7.1.4.2.4 Alluvial Borehole Core and Groundwater Sampling

Core Sampling

Continuous core samples will be obtained throughout each alluvial borehole and selected portions of the core may be archived at the Field Support Facility for possible future investigation. Samples of the core will be collected at the approximate intervals shown in Table 7.1.4-3. In general, core samples will be collected from 10- to 20-ft (3- to 6-m) intervals and analyzed for one of three analytical suites, full-suite, limited-suite, or minimal-suite analysis, as indicated in Table 7.1.4-3. Core samples for full-suite analysis will be analyzed for the analytes listed in Table 7.1.4-4. The analytical methods are listed in Section 7.1.4.4. All samples will be collected using applicable ER Project SOPs (Table 7.1.4-2) for the collection, preservation, identification, storage, transport, and documentation of environmental samples. Decontamination of sampling equipment will be performed in accordance with ER-SOP-1.08, “Field Decontamination of Drilling and Sampling Equipment.” All IDW generated during the sampling operation will be managed and disposed of in accordance with ER-SOP-1.06, “Management of Environmental Restoration Project Wastes,” and ER-SOP-1.10, “Waste Characterization.”

Table 7.1.4-3
Summary of Core Samples Planned for Alluvium Boreholes in Sandia Canyon

Borehole	Planned Depth (ft)	Formation	Planned Depth Beginning (ft)	Planned Depth Ending (ft)	Core Sampling Frequency (ft)	Analytical Suite/ Planned No. of Core Samples			Comment
						a	b	c	
SCAO-1	70	Qal	0	40	10	1	1	2	Qal truncates upper Qct, thickness of units unknown
		Qct	40	60	20	1			
		Qbo	60	70	10	1			
SCAO-2	70	Qal	0	40	10	1	1	2	Qal truncates upper Qct, thickness of units unknown
		Qct	40	60	20	1			
		Qbo	60	70	10	1			
SCAO-3	60	Qal	0	40	10	1	1	2	Qal truncates upper Qct, thickness of units unknown
		Qct	40	60	20	1			
		Qbo	60	70	10	1			
					Total Samples	**9**	**3**	**6**	

[a] Full-suite core sample analysis listed in Table 7.1.4-4.

[b] Limited-suite core sample analysis, including the following: trace elements, tritium (high detection limit), hydrologic properties, anions, HE and PCBs.

[c] Minimal analyses on core samples for moisture, chloride, bromide, nitrate and sulfate only.

Table 7.1.4-4
Analytical Suite for Borehole Core Samples

Hydrologic Analyses		
Moisture content		
Moisture potential		
Saturated hydraulic conductivity		
Anions		
Bromide	Fluoride	Sulfate
Chloride	Nitrate	
Trace Elements		
Aluminum	Cobalt	Selenium
Antimony	Copper	Silver
Arsenic	Iron	Thallium
Barium	Lead	Titanium
Beryllium	Manganese	Uranium
Cadmium	Mercury	Vanadium
Chromium	Nickel	Zinc
Organic Chemicals		
Percent organic carbon		
SVOCs		
PCBs		
HE		
Total Organic Carbon		
Cyanide		
Radionuclides		
Americium-241	Strontium-90	
Cesium-137	Uranium-234	Gamma spectroscopy
Plutonium-238	Uranium-235	Gross-alpha, -beta, and gamma
Plutonium-239,240	Uranium-238	Tritium
Selected Samples for		
X-ray diffraction		

Alluvial Groundwater Sampling

After successful development of each well is completed (i.e., purged water exhibits acceptable turbidity levels), water samples will be collected for analysis on a quarterly basis for one year. Table 7.1.4-5 summarizes the groundwater samples planned to be collected from the alluvium observation wells in Sandia Canyon. Because each new well will be drilled through the Cerro Toledo interval, for planning purposes perched groundwater is assumed to be present in the alluvium and in one zone within the Cerro Toledo interval. The quarterly groundwater samples will be collected concurrently with surface water samples (described in Section 7.1.3) to provide a snapshot of surface water and alluvial groundwater geochemistry throughout the canyon. The analytes for characterization of groundwater samples are shown in Table 7.1.4-6. The analytical methods are listed in Section 7.1.4.4.

Table 7.1.4-5
Summary of Alluvial Groundwater Samples to be Collected in Sandia Canyon

Well	Sampling Frequency	No. of Filtered Samples	No. of Unfiltered Samples	Total No. of Samples
SCAO-1	Qal—quarterly for 1 year	4	4	8
	Qct—during drilling	1	1	2
SCAO-2	Qal—quarterly for 1 year	4	4	8
	Qct—during drilling	1	1	2
SCAO-3	Qal—quarterly for 1 year	4	4	8
	Qct—during drilling	1	1	2
SCO-1*	If water is present in well	4	4	8
SCO-2*	If water is present in well	4	4	8
	Totals	**23**	**23**	**46**

* Existing wells have historically been dry when checked.

Final well designs will depend upon conditions encountered during drilling. Completion details such the total depth and screen interval will be submitted to NMED before the well is constructed. Well screens will span the expected seasonal variations in water levels. Pressure transducers will be installed in the newly drilled alluvium wells in Sandia Canyon to provide real-time water level data that will be used to determine water balance in the alluvium. Down-hole bladder pumps may be installed in each well to enable sampling of the groundwater without removal of the pressure transducers and to collect groundwater samples more representative of the natural groundwater in the alluvium. After installation activities are completed, all well locations and elevations will be surveyed by a registered professional surveyor.

7.1.4.3 Sampling and Analysis Plan for Intermediate Perched Zone and Regional Aquifer Groundwater in Sandia Canyon

This section describes the sampling design for collecting intermediate depth and regional aquifer groundwater samples and borehole core samples and describes the criteria for selecting the locations of the planned new wells. The methods for sample collection and for chemical, radiochemical, and geotechnical analyses are also provided in this section. The intermediate perched zones of saturation and the regional aquifer will be characterized and sampled through existing wells and a total of three new regional aquifer characterization boreholes, one of which has already been drilled by the ER Project. Supplemental intermediate-depth wells may be planned in the future if saturation and contaminants encountered while drilling the regional aquifer wells warrant additional characterization.

The HSWA Module (EPA 1990, 1585) requires that this work plan include an investigation of the potential for transport of contaminants within canyon watersheds and the interactions with shallow groundwater and deeper groundwater. Three characteristics of deeper groundwater are relevant to these requirements: lateral continuity, potential recharge between perched zones and the regional aquifer, and contaminant levels. A detailed discussion of these topics is in Section 3.4.4.5 of this work plan.

Table 7.1.4-6
Analytical Suite for Alluvial Groundwater Samples

Field-Measured Parameters		
Dissolved oxygen	pH	Temperature
Turbidity	Specific conductance	
Laboratory-Measured Parameters		
Major and Minor Ions		
Aluminum	Fluoride	Total kjeldahl nitrogen
Alkalinity	Iron	Phosphate
Ammonium	Magnesium	Potassium
Bromide	Manganese	Silica
Calcium	Nitrate	Sodium
Chlorate	Nitrite	Sulfate
Chloride		
Trace Elements		
Aluminum	Chromium	Silver
Antimony	Cobalt	Thallium
Arsenic	Copper	Uranium
Barium	Lead	Vanadium
Beryllium	Mercury	Zinc
Boron	Nickel	
Cadmium	Selenium	
Organic Chemicals		
VOCs		
SVOCs		
PCBs		
HE		
Dissolved Organic Carbon (fractionation analysis)		
Total Suspended Solids		
Total Dissolved Solids		
Hardness		
Cyanide		
Radionuclides		
Americium-241	Strontium-90	
Cesium-137	Uranium-234	Gamma spectroscopy
Plutonium-238	Uranium-235	Gross-alpha, -beta, and -gamma
Plutonium-239,240	Uranium-238	Tritium (low detection limit)

Note: Filtered (<0.45 µm) and unfiltered water samples will be collected if the turbidity of the sample is greater than 5 nephelometric turbidity units.

7.1.4.3.1 General Approach for Intermediate Perched Zone and Regional Aquifer Investigations

This section describes the general approach for the intermediate perched and regional groundwater characterization, sampling, and analysis. The approach for the intermediate and deep groundwater investigation follows the data needs outlined in Chapters 3 and 4 of this document and the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622).

The following fundamental questions to be addressed for the intermediate and regional groundwater systems have been identified.

- What is the nature and extent of contaminants in intermediate and regional groundwater?
- If the groundwater contains contaminants, where does the groundwater move beneath Sandia Canyon and what is the flux?
- If contaminants are being transported in intermediate or regional groundwater, what are the flow paths for this groundwater?
- What are the major processes by which the intermediate and regional groundwater move?
- Which geochemical processes influence water chemistry and contaminant migration in intermediate and regional groundwater?

Addressing each of these questions requires an integrated technical approach of data collection, data evaluation, and refinement of the conceptual model. The approach is described in terms of a specific programmatic issue that will be addressed by the investigation. Each technical approach to an issue also addresses the hypotheses included in the conceptual model.

Issue

Does the potential exist for contaminants to move into intermediate perched zones and/or the regional aquifer? Does the movement of contaminants pose a potential risk?

Technical Approach

Determine if there could be contaminant levels at or above the MCLs, NMWQCC standards (1995, 54406), EPA standards, UTL values for background, or levels that pose unacceptable human-health or ecological risks in appropriate land-use scenarios. If contaminants are present at unacceptable levels, other physical properties of intermediate perched zone water need to be understood, such as the following:

- Determine where intermediate-depth perched groundwater occurs beneath Sandia Canyon, and the water quality, hydrologic, and geologic characteristics;
- Determine if contaminants are present in Sandia Spring, and if so what is (are) the spring’s source(s); and
- Determine the process or pathway for exposure.

The following data will be collected to provide input to the decisions.

- Moisture content/saturation, water levels, saturated thickness, temporal variations, and spatial variations of saturated zones
- Results of core and/or water samples analyses for geochemical parameters and analytes including contaminant indicators, distribution coefficients, temporal water quality variations, and a refined conceptual model of groundwater chemistry
- Hydrologic properties, stratigraphy, geologic structure, hydraulic gradients and predicted flow directions, spring discharge information, current and planned well-withdrawal points, and a refined conceptual model of the hydrologic system

The investigation included in this section of the work plan will be limited to the boundaries of Sandia Canyon. Characterization of intermediate perched zones may require extension of the investigation area north or south of the limits of the canyon and possibly deeper toward the regional aquifer, depending on the actual observations encountered. Continuous groundwater levels will be recorded for two years in wells containing pressure transducers, and chemical indicators sufficient to determine seasonal effects will be analyzed.

Data needed to evaluate the present-day human-health and ecological risk will be collected as part of a single field investigation. Present-day human-health and ecological risk assessments will include evaluation of intermediate perched zone groundwater and the regional aquifer with the following assumptions.

Drinking water pathways

- Contaminants will be evaluated if they have concentrations above standards or UTL values for background or show trends (observed or predicted) in concentrations over time, which indicates that contaminants may exceed standards or UTL values in the future.
- Duration and pathway of exposure will be adjusted to reflect hydrologic characteristics of the saturated zones and characteristics of the perched groundwater considering potential availability for consumption.

Livestock and wildlife watering pathways

- Appropriate state and other regulatory agency standards will be used to identify COPCs.
- Duration parameters and pathway of exposure will be adjusted to reflect water saturation times and characteristics of the perched groundwater considering potential availability to livestock and wildlife.

Plant uptake pathways

- Contaminants that exceed the limits noted above will be evaluated if groundwater is located such that it is available for plant uptake.

Additional data will be obtained if reduced data uncertainty has the potential to change any risk-based decision. This process is discussed in detail in Chapter 6 of the core document (LANL 1997, 55622).

The groundwater investigation consists of three phases:

1. field investigation,
2. data analysis, and
3. development and refinement for the detailed conceptual model of the canyon's hydrogeological and geochemical system.

All phases will interface iteratively until the investigation has successfully developed a conceptual model that describes the hydraulic and contaminant mass transport relationships between surface water and groundwater. An important objective of the plan is to evaluate the interactions between groundwater in different water-bearing zones beneath the canyon in order to optimize future environmental surveillance efforts. A CMS may be identified during the field investigation. This study would be implemented after the field investigation phase is completed and data have been evaluated.

The field investigation phase includes the following activities. Investigators will

- sample and analyze borehole cuttings and core to characterize the subsurface geology, stratigraphy, and structure. The results of drilling well R-12 indicate the presence of tuffaceous sediments in the lower Puye Formation above Miocene basalts that previously were identified as Santa Fe Group sediments. The results of drilling R-10 and R-11 will clarify the stratigraphy at the base of the Puye Formation and the top of the Santa Fe Group in the central portion of the Laboratory.
- sample and analyze intermediate perched zones (if present) and groundwater in the regional aquifer to characterize nature and extent of the water and of any contaminants that are present.
- collect water level time-series data from each groundwater zone; measure field parameters in water samples (pH, temperature, specific conductance, dissolved oxygen, and turbidity).
- collect hydrogeologic data from core samples to characterize the vadose zone and saturated zones.

The data analysis phase includes the following activities. Investigators will

- evaluate infiltration through bedrock units.
- evaluate interconnections between groundwater zones by comparing the geochemistry of groundwater samples through geochemical modeling and analysis.
- evaluate the potential for hydraulic and mass transport among all water-bearing zones.

Continued development of a detailed conceptual model includes the following activities. Investigators will

- refine the conceptual model by integrating the results of field investigations and data analyses into flow-transport models.
- evaluate present-day and future exposure at various locations.
- evaluate potential contaminant migration pathways and future concentrations.
- identify contaminant problems that may require remediation.

After all three phases of the investigation have been successfully completed, the Laboratory will satisfy the following requirements of the HSWA Module (EPA 1990, 1585):

- hydrogeological and geochemical characterization of Sandia Canyon;
- evaluation of historical, present, and future exposure risks; and
- detailed recommendations for a long-term environmental surveillance program plan that optimize future environmental surveillance of the canyon, primarily water sample collection and the frequencies and locations of water level measurements.

The SAP is designed to be flexible and the objectives and approaches will be refined and modified as new data are obtained. Revisions or refinements to the different components of the conceptual model (see Chapter 4 of this work plan) will be based on the integration of results from all components of the investigation as well as an integration and further interpretive analysis of data from other previous and ongoing Laboratory studies (as discussed in Chapter 2 and Chapter 3 of this work plan). Information gathered from implementing this work plan will also be used to focus geologic, geochemical, and hydrogeologic characterization efforts in future work plans for other canyon systems.

7.1.4.3.2 Planned Regional Aquifer Wells in Sandia Canyon

Investigations are planned to address the objectives of the Sandia Canyon groundwater investigations and to sustain the approaches described in the foregoing section. Three regional aquifer wells are planned for Sandia Canyon in the hydrogeologic work plan (LANL 1998, 59599). Generally, these wells are planned to identify the presence of intermediate perched zones, measure the thickness of the zones, and analyze for the presence of contaminants within those zones that would indicate contaminant transport is actively occurring (LANL 1998, 59599, p4-54). Regional aquifer well R-12 was drilled lower Sandia Canyon in 1998. The general locations of the three regional aquifer wells are listed in Table 7.1.4-7 and the locations of the two remaining planned regional aquifer wells are shown on Appendix Figure A-1.

Table 7.1.4-7
Location of Planned Regional Aquifer Wells in Sandia Canyon

Well Designation[a]	Funding Source	Location[b]
R-10	ER[c]	Middle Sandia Canyon south of TA-53
R-11	DP[d]	Lower Sandia Canyon west of PM-3
R-12	ER	Lower Sandia Canyon west of PM-1 (drilled in 1998)

[a] R = regional aquifer.

[b] See Appendix Figure A-1 for planned locations.

[c] ER = Environmental Restoration Project

[d] DP = Defense Programs.

The regional aquifer wells planned for Sandia Canyon are all located on Laboratory property. The rationale for each well conforms to the hydrogeologic work plan (LANL 1998, 59599). The rationale for drilling each well follows.

- **R-10.** The purposes of well R-10 are to investigate the possible presence of intermediate perched zones of saturation and to monitor water quality in the regional aquifer. Regional aquifer well R-10 will be located in middle Sandia Canyon near the central portion of the Laboratory as shown on Figure A-1. This well will be located as far up-canyon in the middle section of the canyon that is possible for drill rig accessibility. The location of well R-10 will be refined, if necessary, using information derived from the drilling of well R-15 in Mortandad Canyon, which is scheduled to be drilled during the summer of 1999. The axis of the pre-Bandelier paleodrainage extends approximately north-south through this area and well R-10 will be approximately located to intersect the northern end of this paleodrainage basin and possible intermediate perched zones of saturation in the Guaje Pumice Bed at the base of the Bandelier Tuff. Locating the inferred pre-Bandelier paleodrainage and characterization of any saturated zones found at intermediate levels will provide information regarding any possible lateral flow paths and continuity of intermediate perched zones beneath Los Alamos Canyon, Sandia Canyon, and possibly Mortandad Canyon. Data from R-10 will provide information regarding groundwater geochemistry in the regional aquifer and help define groundwater elevations and flow direction in the central part of the laboratory. Information from well R-10 will also provide geologic and hydrologic data for TA-53 mesa-top ER Project assessments. R-10 is planned as a type 2 well and replaces planned intermediate well SCOI-3.

- **R-11.** Regional aquifer well R-11 will be located in lower Sandia Canyon about 500 ft (150 m) west of municipal supply well PM-3 as shown on Figure A-1. This well is being installed by the Laboratory Defense Programs as part of their responsibilities for the hydrogeologic work plan (LANL 1998, 59599). This well is described in this SAP to provide information about a significant investigation that will contribute information toward the groundwater conceptual model for Sandia Canyon. Installation of this well is planned to provide early detection of contaminants that may have reached the upper levels of the regional aquifer before such contaminants reach the supply well. Geologic and hydrologic data from this well will help refine the understanding of the pre-Bandelier paleosurface, the pre-Puye paleosurface, and the subsurface stratigraphy. Hydrologic and contaminant information obtained from perched zones of saturation will provide better understanding of intermediate zone flow paths. Data collected from this well will also provide information on geochemistry, local flow directions and water levels in the regional aquifer near PM-3. R-11 is planned as a type 2 well in the hydrogeologic work plan (LANL 1998, 59599).

- **R-12.** Regional aquifer characterization well R-12 was drilled in 1998 in lower Sandia Canyon near the eastern Laboratory boundary (see Figure A-1). The preliminary results of the drilling and sampling of this well were compiled into an interim completion report (LANL 1998, 59665) and are summarized in Sections 3.4.2 and 3.4.4.6 of this document. Well R-12 replaced intermediate-depth well SCOI-3.

The work plan for Los Alamos and Pueblo Canyons included two intermediate-depth observation wells that were to be drilled in Sandia Canyon to investigate the presence of intermediate-depth perched water near PM-1 and south of LADP-3 (LANL 1995, 50290, p. 7-54). Planned observation well SCOI-1 was located in middle Sandia Canyon and planned observation well SCOI-3 was located in lower Sandia Canyon near PM-1. In early 1996, SCOI-3 was drilled to a depth of 132.5 ft (40 m) before operations were temporarily suspended because of a lack of funds to complete the hole (see Section 3.4.2). The methodology for characterizing intermediate-perched zones of saturation was modified in the hydrogeologic work plan (LANL 1998, 59599), which provided that intermediate perched zones would be characterized concurrently with the drilling of boreholes to the regional aquifer. Therefore, in 1998 regional aquifer well R-12 was drilled adjacent to SCOI-3, negating the need for completion of SCOI-3. Similarly, regional aquifer well R-10 is planned to be drilled near the planned site of SCOI-1, and will replace the need for SCOI-1.

7.1.4.3.3 Regional Aquifer Borehole Advancement and Well Installation

Borehole advancement and well installation specifications for wells R-10 and R-11 are planned to be Type 2 (regional aquifer) wells, the specifications of which are discussed in Section 4.1.1.2 in Chapter 4 of the hydrogeologic work plan (LANL 1998, 59599, p. 4-20). Type 2 wells are planned to collect intact core samples from selected intervals up to about 10% of the total depth of the well. Well procedures and designs are based on HSWA, RCRA, and NMED guidelines and follow ER Project SOPs, which are listed in Table 7.1.4-2.

The procedures described in this section for borehole core sampling and groundwater sampling generally follow those in Chapter 4 of the hydrogeologic work plan (Section 4.1.3 and Section 4.1.4) (LANL 1998, 59599) with several exceptions. Due to the number of exceptions, the procedures are fully described in this section rather than incorporating the hydrogeologic work plan by reference. In general, the following guidelines will apply to sampling the boreholes before completion of the wells.

The regional aquifer characterization boreholes in Sandia Canyon are expected to be drilled to a depth of about 100 ft (30 m) into the regional aquifer. Table 7.1.4-8 shows the projected prognosis for boreholes R-10 and R-11. The approximate locations of these boreholes and the anticipated stratigraphy in each hole are shown schematically on Appendix Figure A-2. Regional aquifer characterization borehole R-10 is planned to be drilled through the Puye Formation and possibly into the Santa Fe Group to a total depth of about 1000 ft (300 m). Regional aquifer characterization borehole R-11 is planned to be drilled into the Puye Formation and possibly into the Santa Fe Group at a depth of 900 ft (275 m). The Cerros del Rio basalt 1 correlates to the tholeiitic basalts encountered in R-12 and the Cerros del Rio basalt 2 correlates to the alkalic basalts encountered in R-12 (LANL 1998, 59665, p. 11).

7.1.4.3.4 Regional Aquifer Borehole Core and Groundwater Sampling

Core/Cuttings Sampling

Core samples may be obtained through selected sections of the borehole based on the results of drilling activities if technically feasible by the drilling methods that are employed. Selected portions of this core may be archived at the Field Support Facility for possible future investigation. Pore water samples may be obtained from selected intervals of core from unsaturated zones.

Table 7.1.4-9 lists the planned core/cuttings sampling plan for geochemical characterization. The analytical suite planned for the samples is shown in Table 7.1.4-4. Core/cuttings samples will be collected for analyses from the following zones in each well:

- the alluvium/bedrock contact;
- the upper portion of the bedrock formation;
- three zones associated with each perched zone of saturation, including a sample from above the saturated zone, a sample within the saturated zone, and a sample from the perching layer (two perched zones for planning purposes);
- three zones within the regional aquifer, including at the top of the regional zone of saturation and up to two additional samples from the regional aquifer; and
- one contingency sample from the borehole.

Table 7.1.4-8
Projected Drilling Prognosis for Wells R-10 and R-11

Geologic Unit or Datum	Planned Depth (ft)	Elevation (ft)	Comment
R-10			
Surface elevation	0	6730	
Alluvium	Surface		
Cerro Toledo interval	40	6690	
Otowi Member	55	6675	
Guaje Pumice Bed	320	6410	Possible intermediate zone of saturation
Puye Formation	360	6370	
Cerros del Rio Basalt 1	370(?)	6360	Probably not present
Cerros del Rio Basalt 2	435	6295	Correlates with alkalic basalts in R-12
Puye Formation (L)	600	6130	
Puye Old Alluvium (?)	720	6010	Possible perching layer
Regional zone of saturation	860	5870	
Totavi lentil (?)	930	5800	Possibly Puye clastics
Santa Fe Group	970	5760	May not be present at this depth
Total Depth	**1000**	**5730**	
R-11			
Surface elevation	0	6630	
Alluvium	Surface		
Cerro Toledo interval	30	6600	Presence beneath alluvium possible
Otowi Member	35	6595	
Guaje Pumice Bed	170	6460	
Puye Formation	190	6440	
Cerros del Rio Basalt 1	220	6410	Correlates with tholeiitic basalts in R-12
Cerros del Rio Basalt 2	340	6290	Correlates with alkalic basalts in R-12
Puye Formation (L)	530	6100	
Puye Old Alluvium (?)	620	6010	Possible perching layer
Regional zone of saturation	780	5850	
Totavi lentil (?)	870	5760	Possibly Puye clastics
Santa Fe Group	880	5750	May not be present
Total Depth	**900**	**5730**	

Note: Stratigraphic nomenclature from Broxton and Reneau 1995, 49726. Stratigraphic information based on data from Purtymun, 1995, 45344; LANL 1998, 59665; and stratigraphic data listed in Appendix E.

Table 7.1.4-9
Summary of Core/Cuttings Samples from Regional Aquifer Boreholes in Sandia Canyon

Borehole	Zone to be Sampled	Sample Description	Number of Samples	Comment
R-10	Qal/bedrock contact		1	Qct probably beneath Qal
	Upper bedrock unit		1	
	Intermediate perched zone #1	Above saturation	1	Assume two intermediate perched zones
		Within saturation	1	
		Perching layer	1	
	Intermediate perched zone #2	Above saturation	1	
		Within saturation	1	
		Perching layer	1	
	Regional aquifer	Top of aquifer	1	Top of the regional zone of saturation
		Within top 100 ft	1	Sample from within the top 100 ft of the aquifer
		Bottom of hole	1	Sample from the bottom of the borehole
	Contingency		1	Contingency sample for planning purposes
		R-10 Total Samples	**12**	
R-11	Qal/bedrock contact		1	Qct may be present beneath Qal
	Upper bedrock unit		1	
	Intermediate perched zone #1	Above saturation	1	Assume two intermediate perched zones
		Within saturation	1	
		Perching layer	1	
	Intermediate perched zone #2	Above saturation	1	
		Within saturation	1	
		Perching layer	1	
	Regional aquifer	Top of aquifer	1	Top of the regional zone of saturation
		Within top 100 ft	1	Sample from within the top 100 ft of the aquifer
		Bottom of hole	1	Sample from the bottom of the borehole
	Contingency sample		1	Contingency sample for planning purposes
		R-11 Total Samples	**12**	

For planning the number of core/cuttings samples to be collected for analysis, it is assumed that two intermediate perched zones of saturation will be encountered in each well. The samples of core/cuttings obtained will be analyzed for a full-suite of analytes listed in Table 7.1.4-4. The analytical methods are listed in Section 7.1.4.4. All samples will be collected using applicable ER Project SOPs (Table 7.2.4-2) for the collection, preservation, identification, storage, transport, and documentation of environmental samples. Decontamination of sampling equipment will be performed in accordance with ER-SOP-01.08, “Field Decontamination of Drilling and Sampling Equipment.” All IDW generated during the sampling operation will be managed and disposed of in accordance with ER-SOP-1.06, “Management of Environmental Restoration Project Wastes,” and ER-SOP-1.10, “Waste Characterization.”

Core and cutting samples will be field screened for radioactivity using a Geiger-Müller detector and monitored for volatile organic compounds (VOCs) using a photoionization detector. Field screening will be conducted at regular intervals during borehole advancement.

The following additional hydraulic and geotechnical analyses may be performed on selected core and cuttings samples. The geotechnical, hydraulic and geophysical analyses will be performed on selected core samples based on the judgment of the field geologist and the canyons investigation technical team.

- Moisture content will be routinely analyzed in core and cuttings samples at 10-ft (3-m) intervals. Samples will not be analyzed for moisture content where saturation is encountered or where drilling fluids are introduced into the borehole.
- Samples of core and cuttings will be selected for geochemical analysis based on the changes in lithology, alteration features, moisture content, and field screening results. Samples will be collected from representative lithologies at regular intervals in the absence of other criteria for sample selection.
- Hydraulic properties analyses may be conducted on core samples in each borehole based on geologic and hydrologic conditions encountered and the need to provide critical parameters for site-wide numerical models evaluating flow and transport. Hydrologic analyses may include moisture content, moisture potential, and saturated hydraulic conductivity, bulk density, particle size distribution, porosity, and specific gravity.
- Samples of cuttings or core will be selected based on geologic conditions encountered and, as appropriate, will be submitted for petrographic, x-ray fluorescence, and x-ray diffraction analyses to characterize the lithologic units penetrated.
- Samples may be collected for isotopic dating of the Cerros del Rio basalts or tuff deposits in the Puye Formation to provide correlation with similar volcanic deposits encountered in widespread boreholes.

Pore water samples may be obtained from core samples in selected unsaturated zones. The pore water samples will be analyzed for the analytes listed in Table 7.1.4-10. The analytical methods are listed in Section 7.1.4.4.

Geophysical Logging

If possible, based on borehole advancement techniques and borehole conditions, geophysical logging may be conducted on the boreholes for the wells completed in the regional aquifer. The application of logging techniques will complement hydrogeologic data collected from core samples. Cased-hole wireline logging will be conducted on the regional aquifer boreholes and/or wells. Application of the various logging techniques will depend on geologic conditions encountered and will be determined on a well-by-well basis.

Table 7.1.4-10
Analytical Suite for Pore Water Extracted from Borehole Core Samples in the Deep Unsaturated Zone

<table>
<tr><td colspan="12"><i>Laboratory-Measured Parameters</i></td></tr>
<tr><td colspan="6">Alkalinity</td><td colspan="6">Specific conductance</td></tr>
<tr><td colspan="6">pH</td><td colspan="6">Temperature</td></tr>
<tr><td colspan="12"><i>Major and Minor Ions</i></td></tr>
<tr><td colspan="4">Aluminum</td><td colspan="4">Iron</td><td colspan="4"></td></tr>
<tr><td colspan="4">Ammonium</td><td colspan="4">Magnesium</td><td colspan="4">Phosphate</td></tr>
<tr><td colspan="4">Bromide</td><td colspan="4">Manganese</td><td colspan="4">Potassium</td></tr>
<tr><td colspan="4">Calcium</td><td colspan="4">Nitrate</td><td colspan="4">Silica</td></tr>
<tr><td colspan="4">Chloride</td><td colspan="4">Nitrite</td><td colspan="4">Sodium</td></tr>
<tr><td colspan="4">Fluoride</td><td colspan="4">Total kjeldahl nitrogen</td><td colspan="4">Sulfate</td></tr>
<tr><td colspan="12"><i>Trace Elements</i></td></tr>
<tr><td colspan="4">Aluminum</td><td colspan="4">Chromium</td><td colspan="4">Selenium</td></tr>
<tr><td colspan="4">Antimony</td><td colspan="4">Cobalt</td><td colspan="4">Silver</td></tr>
<tr><td colspan="4">Arsenic</td><td colspan="4">Copper</td><td colspan="4">Thallium</td></tr>
<tr><td colspan="4">Barium</td><td colspan="4">Lead</td><td colspan="4">Uranium</td></tr>
<tr><td colspan="4">Beryllium</td><td colspan="4">Mercury</td><td colspan="4">Vanadium</td></tr>
<tr><td colspan="4">Boron</td><td colspan="4">Nickel</td><td colspan="4">Zinc</td></tr>
<tr><td colspan="4">Cadmium</td><td colspan="4"></td><td colspan="4"></td></tr>
<tr><td colspan="12"><i>Dissolved Organic Carbon (fractionation analysis)</i></td></tr>
<tr><td colspan="12"><i>Total Suspended Solids</i></td></tr>
<tr><td colspan="12"><i>Total Dissolved Solids</i></td></tr>
<tr><td colspan="12"><i>Hardness</i></td></tr>
<tr><td colspan="12"><i>Cyanide</i></td></tr>
<tr><td colspan="12"><i>HE</i></td></tr>
<tr><td colspan="12"><i>Stable Isotopes</i></td></tr>
<tr><td colspan="12">Deuterium/hydrogen</td></tr>
<tr><td colspan="12">Oxygen-18/oxygen-16</td></tr>
<tr><td colspan="12"><i>Radionuclides</i></td></tr>
<tr><td colspan="3">Americium-241</td><td colspan="3">Plutonium-239,240</td><td colspan="3">Uranium-235</td><td colspan="3">Gamma spectroscopy</td></tr>
<tr><td colspan="3">Cesium-137</td><td colspan="3">Strontium-90</td><td colspan="3">Uranium-238</td><td colspan="3">Gross-alpha, -beta, and -gamma</td></tr>
<tr><td colspan="3">Plutonium-238</td><td colspan="3">Uranium-234</td><td colspan="3"></td><td colspan="3">Tritium</td></tr>
</table>

Note: Filtered (<0.45 µm) and unfiltered water samples will be collected if adequate pore water is available.

Note: If sample volume is limited, analyses will focus on major cations, anions, metals, and tritium.

Portions of the boreholes for the regional aquifer wells may be logged with open-hole logging tools if borehole stability is such that the borehole can be advanced without casing. After logging, casing will be set through the logged interval, and the borehole will be advanced to a nominal total depth of 100 ft (30 m) into the top of the regional aquifer. Due to the unconsolidated nature of the subsurface strata, these boreholes may be cased before open borehole logging can be accomplished. Cased-hole logging will be performed from surface to total depth. Procedures for open-hole and cased-hole geophysical logging are discussed in Section 4.1.6 in Chapter 4 of the hydrogeologic work plan (LANL 1998, 59599).

Groundwater Sampling

Groundwater from the newly installed regional aquifer wells will be sampled during drilling when saturated zones are encountered, and quarterly after the well is completed for a period of one year. Groundwater sampled during the drilling of the wells will be according to the following general procedures and assumptions.

As the boreholes are being drilled, drilling will be interrupted whenever intermediate perched zone groundwater is encountered and when the top of the regional aquifer is encountered. The casing string may be retracted slightly, as necessary, to ensure representative sampling. The borehole will be bailed to reduce the effect of drilling operations, and the borehole may be rested for up to 12 hours before sampling. Samples will be retained for an appropriate period of time to enable reanalysis, if needed.

For planning and conceptual design purposes, it has been assumed that three water-bearing zones will be encountered during advancement of each borehole, including two intermediate perched zones and the regional aquifer. Three zones were selected for planning purposes because deep wells recently drilled in the Sandia Canyon area (R-9 and R-12) encountered multiple perched zones in addition to the regional aquifer. Groundwater samples will be collected from each water-bearing zone and analyzed for the parameters listed in Table 7.1.4-9. Laboratory analyses for these different analytes will be performed on filtered samples and on unfiltered samples.

Table 7.1.4-11 summarizes groundwater samples that will be collected from the regional aquifer characterization boreholes in Sandia Canyon. Groundwater samples will be collected from each well during drilling and after successful well development is completed (i.e., purged water exhibits acceptable turbidity levels). For planning purposes it is assumed that wells R-10 and R-11 will be completed in one zone within the regional aquifer and R-12 will be completed in two intermediate perched zones and one zone in the regional aquifer. After completion of each well groundwater samples will be collected for analysis on a quarterly basis for one year. The analytical suite for characterization of deep groundwater samples is shown in Table 7.1.4-12. The analytical methods are listed in Section 7.1.4.4. After this period of characterization, the wells may be turned over to the Laboratory Water Quality and Hydrology Group (ESH-18) for possible use in long-term groundwater monitoring.

Regional aquifer groundwater that discharges from Sandia Spring in lower Sandia Canyon on the west side of White Rock Canyon will be sampled concurrently with surface water and alluvial groundwater. The SAP for collecting water from Sandia Spring is in Section 7.1.3 of this work plan.

7.1.4.4 Analytical Methods

This section describes the methods for analyzing groundwater samples for organic and inorganic chemicals and radionuclides and the methods for analyzing borehole core samples for inorganic chemicals, radionuclides, and hydraulic parameters. Analysis of groundwater and borehole core samples has two purposes: (1) to detect and measure Laboratory-derived COPCs and (2) to obtain characterization information about the geochemistry of the water-bearing zones.

Table 7.1.4-11
Summary of Intermediate Perched Zone and Regional Aquifer Groundwater Samples to be Collected in Sandia Canyon

Well	Sampling Event	Zone to be Sampled	No. of Filtered Samples	No. of Unfiltered Samples	Total No. of Samples
R-10	During drilling	Intermediate zone #1	1	1	2
		Intermediate zone #2	1	1	2
		Top of regional zone of saturation	1	1	2
		Within regional zone of saturation	2	2	4
		Contingency sample	1	1	2
	Quarterly for 1 year	One zone in regional aquifer	4	4	8
		Subtotal	**10**	**10**	**20**
R-11	During drilling	Intermediate zone #1	1	1	2
		Intermediate zone #2	1	1	2
		Top of regional zone of saturation	1	1	2
		Within regional zone of saturation	2	2	4
		Contingency sample	1	1	2
	Quarterly for 1 year	One zone in regional aquifer	4	4	8
		Subtotal	**10**	**10**	**20**
R-12*	During drilling	Intermediate zone #1	1	1	2
		Intermediate zone #2	1	1	2
		Top of regional zone of saturation	1	1	2
		Within regional zone of saturation	2	2	4
		Contingency sample	1	1	2
	Quarterly for 1 year	Three zones	12	12	24
		Subtotal	**18**	**18**	**36**
		Totals	**38**	**38**	**72**

* R-12 has been drilled and is awaiting completion in 1999.

Table 7.1.4-12
Analytical Suite for Intermediate Perched Zone and Regional Aquifer Groundwater Samples

<table>
<tr><td colspan="12"><i>Field-Measured Parameters</i></td></tr>
<tr><td colspan="4">Dissolved oxygen</td><td colspan="4">Specific conductance</td><td colspan="4">Turbidity</td></tr>
<tr><td colspan="4">pH</td><td colspan="4">Temperature</td><td colspan="4"></td></tr>
<tr><td colspan="12"><i>Major and Minor Ions</i></td></tr>
<tr><td colspan="4">Aluminum</td><td colspan="4">Chloride</td><td colspan="4">Nitrite</td></tr>
<tr><td colspan="4">Alkalinity</td><td colspan="4">Fluoride</td><td colspan="4">Total kjeldahl nitrogen</td></tr>
<tr><td colspan="4">Ammonium</td><td colspan="4">Iron</td><td colspan="4">Phosphate</td></tr>
<tr><td colspan="4">Bromide</td><td colspan="4">Magnesium</td><td colspan="4">Potassium</td></tr>
<tr><td colspan="4">Calcium</td><td colspan="4">Manganese</td><td colspan="4">Sodium</td></tr>
<tr><td colspan="4">Chlorate</td><td colspan="4">Nitrate</td><td colspan="4">Sulfate</td></tr>
<tr><td colspan="12"><i>Trace Elements</i></td></tr>
<tr><td colspan="4">Aluminum</td><td colspan="4">Chromium</td><td colspan="4">Silicate</td></tr>
<tr><td colspan="4">Antimony</td><td colspan="4">Cobalt</td><td colspan="4">Silver</td></tr>
<tr><td colspan="4">Arsenic</td><td colspan="4">Copper</td><td colspan="4">Thallium</td></tr>
<tr><td colspan="4">Barium</td><td colspan="4">Lead</td><td colspan="4">Uranium</td></tr>
<tr><td colspan="4">Beryllium</td><td colspan="4">Mercury</td><td colspan="4">Vanadium</td></tr>
<tr><td colspan="4">Boron</td><td colspan="4">Nickel</td><td colspan="4">Zinc</td></tr>
<tr><td colspan="4">Cadmium</td><td colspan="4">Selenium</td><td colspan="4"></td></tr>
<tr><td colspan="12"><i>Organic Chemicals</i></td></tr>
<tr><td colspan="6">VOCs</td><td colspan="6">HE</td></tr>
<tr><td colspan="6">SVOCs</td><td colspan="6">PCBs</td></tr>
<tr><td colspan="12"><i>Dissolved Organic Carbon (fractionation analysis)</i></td></tr>
<tr><td colspan="12"><i>Total Suspended Solids</i></td></tr>
<tr><td colspan="12"><i>Total Dissolved Solids</i></td></tr>
<tr><td colspan="12"><i>Hardness</i></td></tr>
<tr><td colspan="12"><i>Cyanide</i></td></tr>
<tr><td colspan="12"><i>Stable and Radiogenic Isotopes</i></td></tr>
<tr><td colspan="4">Carbon-14</td><td colspan="4">Chlorine-36</td><td colspan="4">Oxygen-18/oxygen-16</td></tr>
<tr><td colspan="4">Carbon-13</td><td colspan="4">Deuterium/hydrogen</td><td colspan="4">Nitrogen-15/nitrogen-14</td></tr>
<tr><td colspan="12"><i>Radionuclides</i></td></tr>
<tr><td colspan="3">Americium-241</td><td colspan="3">Plutonium-239,240</td><td colspan="3">Uranium-235</td><td colspan="3">Gross-alpha, -beta, and -gamma</td></tr>
<tr><td colspan="3">Cesium-137</td><td colspan="3">Strontium-90</td><td colspan="3">Uranium-238</td><td colspan="3">Tritium (low-detection-limit)</td></tr>
<tr><td colspan="3">Plutonium-238</td><td colspan="3">Uranium-234</td><td colspan="3">Gamma spectroscopy</td><td colspan="3"></td></tr>
</table>

Note: Filtered (<0.45 µm) water samples will also be collected if the turbidity of the samples is >5 nephelometric turbidity units.

7.1.4.4.1 Analysis of Borehole Core Samples

Borehole core samples collected according to the criteria outlined in Sections 7.1.4.2.4 and 7.1.4.3.4 of this document will undergo analysis at ER Project-approved laboratories for the organic (HE and PCB) and inorganic chemicals and radionuclides listed in Table 7.1.4-4. In addition, the percent organic carbon or amount of solid organic carbon will be measured in borehole core samples containing or potentially containing HE compounds and degradation products. The purpose of the analyses is to identify COPCs and to obtain a better understanding of the baseline geochemistry of the water-bearing zones. The target analytes, EDLs, and analytical methods for inorganic chemicals are listed in Table 7.1.4-13. Measurements for inorganic chemicals include analyses for 26 trace metals, major and trace anions (bromide, chloride, fluoride, nitrate, nitrite, and sulfate), and total cyanide. All analyses for inorganic chemicals will be performed according to EPA SW-846 protocols (EPA 1987, 57589) or EPA standard methods for chemical analysis of wastes. Core samples will be processed using EPA SW-846 mineral acid (HNO_3) extraction procedures (EPA SW-846 Method SW-3050 [EPA 1987, 57589]) for analysis of trace metals. The anion analyses will be performed on the leachate formed from a deionized water slurry (leaching time is 16 hours) of the homogenized core samples. The required QC procedures and acceptance criteria for the metals and total cyanide analyses are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Borehole core samples may also be analyzed using the hydraulic and geophysical methods identified in Table 7.1.4-14.

The ER Project analyte list for the gamma spectroscopy analysis (see Table 7.1.2-6) includes the decay series of the naturally occurring radionuclides radium-226 and uranium-235 as well as fission and activation products and their progeny. Measurements of naturally occurring radionuclides known to be present in Laboratory soils indicate the quality of the gamma spectroscopy measurement. Data for short-lived radionuclides can be useful when values reported for a parent radionuclide are evaluated because the relative activity concentration of parent and daughter isotopes is a known quantity. The shorter-lived radionuclides are usually included in the analyte list to verify the presence of longer-lived parent isotopes, but they are not evaluated as primary radionuclides because they decay to unmeasurable concentrations within the span of several years or less. The naturally occurring radionuclide potassium-40 is present in Laboratory soils at concentrations ranging from 25 pCi/g to 40 pCi/g and is always present in the gamma spectra of Laboratory soil samples. The potassium-40 gamma emission peak provides a qualitative indicator of the accuracy and precision of the gamma spectroscopy measurement, but potassium-40 is not considered to be a potential contaminant. The required QC procedures and acceptance criteria for the radiochemical analyses (except low-level tritium and uranium-236) are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

7.1.4.4.2 Analysis of Groundwater Samples

Groundwater samples will be collected according to the strategy outlined in Sections 7.1.4.2.4 and 7.1.4.3.4. At the time of sample collection, field measurements will be obtained using the methods listed in Table 7.1.4-15.

Groundwater samples collected during drilling of a well will initially undergo full-suite analyses for organic and inorganic chemicals and radionuclides at ER Project-approved fixed-site laboratories. The analytical suites for analysis of organic and inorganic chemicals and radionuclides are listed in Tables 7.1.4-6, Table 7.1.4-10, and Table 7.1.4-12. All analyses for organic chemicals will be performed in accordance with EPA SW-846 protocols (EPA 1987, 57589). The detailed analyte lists, EQLs, minimum detectable activities, required QC procedures, and the acceptance criteria are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented. The first sample collected from each alluvial and regional aquifer well location will undergo analysis for the full suite of organic and inorganic chemicals and radionuclides. If chemicals are identified as COPCs for a particular sampling location, all subsequent samples from that location will be analyzed for appropriate COPCs. Any analyte reported as not detected may be excluded from subsequent limited-suite analyses.

Table 7.1.4-13
Estimated Detection Limits and Analytical Methods for Inorganic Chemicals in Borehole Core Samples

Analyte	EDL (mg/kg)	Analytical Method	Analytical Protocol[a]
Metals			
Aluminum	40	ICPES	SW-6010B
Ammonium	0.1	IC	SW-9056
Antimony	0.5	ICPMS	SW-6020
Arsenic	2	ETVAA	SW-7060A
Barium	40	ICPES	SW-6010B
Beryllium	1	ICPES	SW-6010B
Cadmium	0.4	ICPMS	SW-6020
Chromium	2	ICPES	SW-6010B
Cobalt	10	ICPES	SW-6010B
Copper	5	ICPES	SW-6010B
Iron	20	ICPES	SW-6010B
Lead	0.6	ETVAA or ICPMS	SW-7421 or SW-6020
Manganese	3	ICPES	SW-6010B
Mercury	0.1	CVAA	SW-7471A
Nickel	8	ICPES	SW-6010B
Selenium	0.3	ETVAA	SW-7740
Silver	1	ICPES	SW-6010B
Thallium	0.73	ICPMS	SW-6020
Uranium	0.5	ICPMS	SW-6020
Vanadium	10	ICPES	SW-6010B
Zinc	4	ICPES	SW-6010B
Anions[b]			
Bromide	0.1	IC	SW-9056
Chloride	0.1	IC	SW-9056
Fluoride	0.02	IC	SW-9056
Nitrate	0.1	IC	SW-9056
Nitrite	0.1	IC	SW-9056
Sulfate	0.1	IC	SW-9056
Other Organic and Inorganic Chemicals			
Organic carbon	0.001 wt %	Elemental analysis	SW-415.1[c]
Total cyanide	0.05	Colorimetry	SW-9012A

[a] EPA SW-846 Method, EPA 1987, 57589.

[b] Anion analyses will be performed on the leachate formed from a deionized water slurry of the homogenized core sample.

[c] EPA 1983, 56406.

Table 7.1.4-14
Geochemical, Hydrologic, and Geophysical Analyses of Borehole Core Samples

Analysis	Analytical Method
Geotechnical Analyses	
Bulk density	ASTM D 2937-94
Distribution coefficient (K_d)	ASTM D 4319-93
Particle size distribution	ASTM D 422-63(90)
Porosity (calculated total)	Calculated from bulk density and specific gravity measurements
Porosity (effective)	ASTM D 425-88(94)
Specific gravity	ASTM D 854-92
Geochemical Analyses	
Mineralogical composition	X-ray diffraction, electron microprobe*
Hydrologic Analyses	
Moisture content	ASTM D 2216-92
Moisture potential	Pressure plate extractor (or other techniques)
Saturated hydraulic conductivity	ASTM D 5084-90
Geophysical Analyses	
Lithological logging	TBD
Natural gamma logging	TBD
Neutron moisture logging	TBD

* Geochemical analyses are described in the ER-SOP-09 series.

Table 7.1.4-15
Field Measurements for Groundwater Samples

Measurement	Precision[a]	Method
Dissolved oxygen	±0.1 mg/L	ER-SOP-06.02
pH	±0.02	ER-SOP-06.02
Specific conductance	±1 mmho/cm (µS/cm)	ER-SOP-06.02
Temperature	±1 °C	ER-SOP-06.02
Turbidity (nephelometric)	±1 NTU[b]	EPA Method 180.1

[a] Precision with which measurement will be recorded.

[b] NTU = nephelometric turbidity unit.

All water samples will be analyzed for inorganic chemicals to identify COPCs and to obtain a better understanding of the baseline geochemistry of surface water and groundwater. The target analytes, conservative EDLs, and analytical methods for inorganic chemicals are listed in Table 7.1.4-16. Water samples collected for inorganic analyses will be filtered at the time of collection to remove particles larger than 0.45 µm. In addition, unfiltered water samples will be collected to evaluate the influence of suspended particles on water chemistry (including suspended solids), if the measured turbidity is less than 5 turbidity units. Analyses of these samples may be supplemented by analyses of unfiltered samples collected for environmental monitoring by the Laboratory Water Quality and Hydrology Group (ESH-18). Measurements for inorganic chemicals include analyses for 26 trace metals, major anions (bromide, chloride, fluoride, nitrate, sulfate, and alkalinity), minor anions (chlorate, nitrite, and orthophosphate), dissolved silica, total kjeldahl nitrogen, and total cyanide. All analyses for inorganic chemicals will be performed in accordance with EPA SW-846 protocols (EPA 1987, 57589), EPA standard methods (EPA 1983, 56406), or standard methods for chemical analysis of water (Franson 1995, 56405). The required QC procedures and acceptance criteria for the metals and total cyanide analyses are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

Groundwater samples will be analyzed for the organic chemicals, stable and radiogenic isotopes, and other parameters using the methods listed in Table 7.1.4-17. To better understand the nature of recharge to an intermediate-depth groundwater zone and the regional aquifer, analysis for carbon-14, chlorine-36, and stable isotope ratios nitrogen-15/nitrogen-14, deuterium/hydrogen and oxygen-18/oxygen-16 may be performed to estimate the age of water and to help identify specific sources of recharge. Analyses for carbon-13 and dissolved organic carbon (humic acids by fractionation analysis) will be performed to provide a better understanding of the organic geochemistry of the groundwater.

The target analytes and their half-lives, detected emission, minimum detectable activities, and analytical methods for radionuclides in groundwater samples are listed in Table 7.1.4-18. In addition to measurements of gross-alpha, -beta, and -gamma radioactivity, the radionuclide analytes include americium-241; plutonium-238; plutonium-239,240; strontium-90; tritium; uranium-234; uranium-235; uranium-236; and uranium-238. The analyses for low-detection-limit tritium and uranium-236 will help identify whether recent recharge to an intermediate aquifer and the regional aquifer has occurred.

7.1.4.5 Hydrologic and Geochemical Modeling

Hydrologic and geochemical modeling may be performed as part of data synthesis and evaluation activities and may help to determine additional data needs. Hydrologic modeling is addressed in Section 4.1.5 of the hydrogeologic work plan (LANL 1998, 59599, p. 4-31). One goal of this work plan relates to an understanding and prediction of hydrologic flow paths and an evaluation of geochemical reactions and the resultant movement of solutes in groundwater in Sandia Canyon. Tools for this purpose include computer models, such as MINTEQA2 (Allison et al. 1991, 49930), and others discussed in Section 5.3.1 in Chapter 5 of the core document (LANL 1997, 55622). Geochemical modeling is used to quantify solute speciation, mineral precipitation, adsorption processes and fate and transport of contaminants for characterization and risk analysis.

Table 7.1.4-16
Estimated Detection Limits and Analytical Methods for Inorganic Chemicals in Groundwater Samples

Analyte	EDL (µg/L)	Analytical Method	Analytical Protocol*
Metals (total and dissolved)			
Aluminum	10	ICPES	SW-6010B
Ammonium	20	IC	SW-9056
Antimony	0.1	ICPMS	SW-6020
Arsenic	1	ETVAA	SW-7060A
Barium	2	ICPES	SW-6010B
Beryllium	5	ICPES	SW-6010B
Boron	10	ICPES	SW-6010B
Cadmium	1	ICPMS	SW-6020
Calcium	10	ICPES	SW-6010B
Chromium	2	ICPES	SW-6010B
Cobalt	2	ICPES	SW-6010B
Copper	2	ICPES	SW-6010B
Iron	10	ICPES	SW-6010B
Lead	3	ETVAA or ICPMS	SW-7421 or SW-6020
Magnesium	10	ICPES	SW-6010B
Manganese	2	ICPES	SW-6010B
Mercury	0.2	CVAA	SW-7470A
Nickel	2	ICPES	SW-6010B
Potassium	10	ICPES	SW-6010B
Selenium	0.2	ETVAA	SW-7740
Silver	0.2	ICPES	SW-6010B
Sodium	50	ICPES	SW-6010B
Thallium	2	ICPMS	SW-6020
Uranium	1	ICPMS	SW-6020
Vanadium	2	ICPES	SW-6010B
Zinc	10	ICPES	SW-6010B
Anions (total and dissolved)			
Bromide	20	IC	SW-9056
Total kjeldahl nitrogen	20	IC	SW-9056
Chloride	20	IC	SW-9056
Fluoride	20	IC	SW-9056
Nitrate	40	IC	SW-9056
Nitrite	40	IC	SW-9056
Orthophosphate	20	IC	SW-9056
Sulfate	100	IC	SW-9056
Other Inorganic Chemicals (dissolved)			
Silica	200	Colorimetry	EPA Method 370.1
Total cyanide	50	Colorimetry	SW-9012A

Note: Both unfiltered (total) and filtered (dissolved) water samples will be collected. Water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

* EPA SW-846 Method (EPA 1987, 57589) or equivalent.

Table 7.1.4-17
Analytical Methods for Organic Chemicals, Stable and Radiogenic Isotopes, and other Parameters in Groundwater Samples

Analyte	Analytical Method
Stable and Radiogenic Isotopes[a]	
Carbon-14, carbon-13	Accelerator MS
Deuterium/hydrogen	Isotope ratio mass spectrometry
Nitrogen-15/nitrogen-14	Isotope ratio mass spectrometry
Oxygen-18/oxygen-16	Isotope ratio mass spectrometry
Chlorine-36	Accelerator MS
Organic Chemicals	
VOCs	SW-8260[b]
SVOCs	SW-8270
HE[c]	SW-8330
Other Analytes	
Total organic carbon	SW-415.1[d]
Dissolved organic carbon (humic substances)	USGS/WRI 79-4
Hardness (as calcium carbonate)	EPA Method 130

Note: All water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

[a] Stable isotopes will be measured in intermediate-depth and regional aquifer groundwater samples.

[b] EPA SW-846 Methods, EPA 1987, 57589.

[c] All alluvial and perched groundwater samples will be analyzed for HE compounds. The initial samples of the regional aquifer will be analyzed for HE compounds, but subsequent samples of the regional aquifer will be analyzed for HE compounds only if detected in the initial samples.

[d] EPA 1983, 56406.

Hydrologic modeling may be useful first to describe and verify water-balance estimates. More specifically, the response of the hydrogeologic system to the hydrologic cycle and effluent releases may be addressed in phases. The first phase may consist of a water-balance study that would include records of historical discharges and precipitation. The second phase could be simulation of the system by a groundwater flow and transport code, such as FEHM. This may be followed by a third phase, in which results of this process modeling could be checked by comparing with those of an integrated, probabilistic, mass-transfer-simulation code, such as RIP. Models used could include MODFLOW and others as outlined in Section 5.4.2.1.2 in Chapter 5 of the core document (LANL 1997, 55622). Movement in the alluvium may be modeled using MODFLOW; unsaturated flow may be modeled using UNSATII, FEHM, or TRACR3D. The regional aquifer will likely require development of a new model (Frenzel 1995, 56028).

Hydrologic and geochemical modeling may be applied at any stage of this investigation. In the project design phase, modeling may be used to examine hypotheses relating to the hydrogeologic components of the conceptual model and to determine where additional information is needed. In later phases, hydrologic and geochemical modeling may be used to refine the conceptual model and assess viable techniques to remediate actinide-contaminated sediments and groundwater, as needed. Results of the modeling efforts could provide source term inputs to stochastic human-health and ecological risk models for determining relative risks from water exposure pathways now and in the future.

Table 7.1.4-18
Minimum Detectable Activity and Analytical Methods for Radionuclides in Groundwater Samples

Analyte	Half-Life (yr)	Detected Emission	Minimum Detectable Activity (pCi/L)	Analytical Method
Americium-241	432.2	α	0.05	α-Spectrometry
Plutonium-238	87.7	α	0.05	α-Spectrometry
Plutonium-239,240[a]	2.411×10^4	α	0.05	α-Spectrometry
Strontium-90	28.7	β	1.0	Gas proportional counter (GPC)
Tritium	12.4	β	250	Liquid scintillation counting (LSC)
Tritium (low level)	12.4	β	1	Electrolytic enrichment/GPC
Uranium-234	2.46×10^5	α	0.1	α-Spectrometry[b]
Uranium-235	7.04×10^8	α	0.1	α-Spectrometry[b]
Uranium-238	4.47×10^9	α	0.1	α-Spectrometry[b]
Gamma spectroscopy[c]	n/a[d]	γ	10[f]	γ-Spectroscopy
Gross-alpha	n/a	α	1.0	GPC or LSC
Gross-beta	n/a	β	1.0	GPC or LSC
Gross-gamma	n/a	γ	20	NaI(Tl) or HPGe detection

Note: All water samples will be filtered at the time of collection to remove particles larger than 0.45 µm.

[b] The plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.

[c] Radionuclide may also be analyzed by ICPMS.

[d] The gamma spectroscopy analyte list is given in Table 7.1.2-6.

[e] n/a = not applicable.

As new data are acquired, the data will be continually evaluated to refine the hydrogeologic and geochemical components of the conceptual model. For example, new data collected in Sandia Canyon may be compared with groundwater flow maps, water chemistry, conceptual hypotheses, and model predictions to assess the level of understanding regarding recharge and discharge areas, groundwater flow directions, geochemical reactions such as adsorption and mineral-solid phase precipitation and interconnections between alluvial groundwater, intermediate perched zones, and the regional aquifer. If there is agreement between the modeled features and the observed features in Sandia Canyon, it will be possible to incorporate reasonable assumptions into the groundwater and geochemical modeling effort. This type of analysis can determine whether it is necessary to collect additional field data for the groundwater characterization.

Key steps in refining the Sandia Canyon conceptual model are as follows.

1. Integrate available data for Sandia Canyon geology, hydrology, and water quality/geochemistry.
    - Incorporate hydrologic, stratigraphic, geophysical, and chemical data for Sandia Canyon into a centralized database (the Facility for Information Management, Analysis, and Display [FIMAD]).
    - Develop a three-dimensional representation of stratigraphy and geology for Sandia Canyon.

- Model and display data related to geology, geochemistry, boreholes, and observed groundwater.
- Extrapolate existing data and estimate uncertainties in resultant models.
- Synthesize the existing information to identify areas where data needs are most critical.

2. Perform preliminary evaluation of hydrologic and geochemical processes for Sandia Canyon.
    - Evaluate existing water quality/geochemistry, vadose zone, and water level data for the various zones of saturation with respect to trends and indications of interconnection.
    - If appropriate, develop a canyon-specific model and evaluate data needs with respect to placement of wells for characterization.
3. Refine the conceptual model and upgrade the groundwater monitoring network for Sandia Canyon.
    - Drill boreholes for subsurface characterization at highest priority locations (that is, the locations with highest risk and most critical data needs).
    - Use information as each borehole is drilled to optimize the placement and determine the need for subsequent boreholes.

7.1.5 Air-Particulate Sampling and Analysis Plan

The Laboratory operates a network of more than 50 environmental air stations (called AIRNET) to sample radionuclides in ambient air. Four of these stations are located within the Sandia Canyon watershed. These stations are monitored regularly, and the results of the monitoring are reported annually. The 4 stations located within the Sandia Canyon watershed include 2 stations located on Laboratory property and 2 perimeter stations (one north of upper Sandia Canyon and one at the eastern Laboratory boundary). Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239,249; uranium-234; uranium-235; and uranium-238. A discussion of the Laboratory's air monitoring surveillance program in Sandia Canyon is presented in Section 3.4.5 in Chapter 3 of this work plan.

No contaminant sources in the air resulting from sources in Sandia Canyon have been identified as a result of the AIRNET monitoring. Existing surface sediment data collected in Sandia Canyon, as described in Section 3.4.1 in Chapter 3 of this work plan, do not indicate the presence of a significant source of radioactive contaminants in sediments. Continued monitoring of the AIRNET stations will be provided by ESH-17 personnel and published annually in the Laboratory's annual environmental surveillance reports. These AIRNET stations currently provide site-specific air monitoring data, and no significant long-term trends indicative of an airborne release within the Sandia Canyon watershed have been identified. Therefore, no additional air monitoring in Sandia Canyon is proposed as part of this work plan.

7.1.6 Biological Sampling and Analysis Plan

As discussed in the core document (LANL 1997, 55622), the approach for evaluating ecological risks is currently being discussed with the NMED, DOE, Laboratory ER Project, and EPA. A draft document has been submitted to NMED and is being reviewed. Based on the results of this process, a sampling plan for Sandia Canyon will be developed to be consistent with that approach.

7.2 Sampling and Analysis Plan for Cañada del Buey

7.2.1 Introduction

This section describes the rationale and plans for collecting and analyzing samples and field survey data to characterize the Cañada del Buey system. These data will be used to support an evaluation of present-day risks to human health and the environment from Laboratory-derived contaminants that move through the Cañada del Buey system and an evaluation of the potential for future off-site exposure and impact on the Rio Grande. Evaluation of these risks and impacts requires testing and refining of the conceptual model of occurrence, transport, and exposure route of contaminants in the Cañada del Buey system (hereafter referred to as "the conceptual model") (see Chapter 4 of this work plan). In accordance with the focused sampling strategy described in Chapter 5 of the core document (LANL 1997, 55622), results of field surveys and sample analyses initially conducted will be used in conjunction with comparison to and reinterpretation of existing data to revise subsequent sampling and analyses. SAPs presented in this chapter describe general approaches to be followed and general areas to be sampled. Specific sampling locations will be defined based on data collected from the initial tasks.

Sections of this chapter present the plans for sampling and analysis of each of the transport pathways and exposure routes described in Chapter 3 and Chapter 4 of this work plan. Each section will (1) state the objectives for the investigation of each media and transport pathway; (2) discuss elements of the transport pathways and their importance; (3) identify issues to be addressed to assess risk and impacts and identify appropriate remedial measures; and (4) describe the approaches used to resolve the issues.

The remainder of this section defines issues to be addressed and provides overviews of the information to be collected, the specific objectives of the SAP, and the data quality requirements for the investigations. Section 7.2.2 describes plans for sediment characterization. Section 7.2.3 describes plans for characterizing surface water. Section 7.2.4 describes plans for characterizing groundwater including (1) alluvial groundwater (and the alluvium that contains it), (2) intermediate-depth groundwater, if present, and (3) the regional aquifer. Section 7.2.5 discusses the air exposure pathway. Section 7.2.6 describes the biological sampling program, which includes an evaluation of the impact of Laboratory-derived contaminants on the canyon ecosystems and an evaluation of the human-health risks from contaminants in plants and animals.

Table 7.2.1-1 summarizes the known COPCs and their potential original source areas in the Cañada del Buey system. The COPCs are grouped in part according to protocols that will be used for sample analyses. This table is based on the list of COPCs and on data collected from previous studies (summarized in Chapter 3 of this work plan) showing actual occurrence of contaminants in the Cañada del Buey system.

Table 7.2.1-2 shows the initial estimates of the numbers and types of samples to be collected during the investigations. The numbers will be revised throughout the characterization in accordance with the focused sampling strategy and the various tests of data adequacy discussed in Section 5.3.7 and Section 5.3.8 in Chapter 5 of the core document (LANL 1997, 55622). Changes to the numbers of samples will be recorded and described in reports on these investigations.

Table 7.2.1-1
Chemicals of Potential Concern in Cañada del Buey and Source Areas

Known COPCs	**Source Areas**
Radionuclides	
Americium-241	TA-46, TA-54
Cobalt-60	TA-54
Cesium-137	TA-54
Plutonium-238	TA-4, TA-46, TA-54
Plutonium-239	TA-4, TA-46, TA-54
Strontium-90	TA-54
Yttrium-90	TA-54
Tritium	TA-54
Thorium	TA-46
Uranium	TA-46, TA-54
Organic Chemicals	
PCBs	TA-46
Pesticides	General
Photographic chemicals (organic acids)	TA-4
Solvents	TA-4, TA-46
SVOCs	TA-46
Inorganic Chemicals	
Aluminum	TA-54
Asbestos	TA-46
Arsenic	TA-4, TA-46
Barium	TA-46, TA-54
Beryllium	TA-54
Cadmium	TA-46
Calcium	TA-46, TA-54
Chromium	TA-4, TA-46
Cobalt	TA-46
Copper	TA-46
Iron	TA-54
Lead	TA-4, TA-46, TA-54
Magnesium	TA-54
Mercury	TA-46
Nickel	TA-46
Selenium	TA-46
Silver	TA-46
Zinc	TA-46

Note: This table contains preliminary information from RFI work plans, draft RFI reports, and other available reports.

Table 7.2.1-2
Initial Estimates of Sample Collection and Analysis in Cañada del Buey

Sample Type	Cañada del Buey	South Fork of Cañada del Buey
Sediment[a] and Core		
Full-suite[b] sediment	25–50	10–20
Limited-suite[c] sediment	TBD	TBD
Key contaminants[d] sediment	TBD	TBD
Regional borehole core	12	0
Groundwater[e]		
Alluvial (existing monitoring wells)	32	0
Regional aquifer	20	0
Biological		
Wild plant species	TBD	TBD
Livestock forage plants	TBD	TBD

[a] Sediment samples will be collected to determine COPCs, to define contaminant concentrations and distributions, and to define risk.

[b] Full-suite analyses are for all organic and inorganic chemicals and radionuclides, and for the determination of COPCs.

[c] Limited-suite analyses are for identified COPCs. (The collection of approximately 5 to 10 samples per reach is anticipated).

[d] Sediment samples will be collected and analyzed for "key contaminants" (for example, HE or metal constituents) to obtain information about contaminant concentrations, contaminant distributions, and sediment transport processes. The "key contaminants" for each canyon and the actual number of samples collected will be decided by the technical team based on the initial survey and sampling results. (The collection of approximately 10 to 50 samples per reach is anticipated.)

[e] The number of groundwater samples reflects the total number of filtered and unfiltered samples to be collected after well completion and quarterly for one year.

7.2.1.1 Issues To Be Addressed

The general objectives for the canyons investigations discussed in the Executive Summary of the core document (LANL 1997, 55622) will be addressed in the investigations described in this work plan. The following issues, which are of concern to the Cañada del Buey system (excluding mesa-top potential release sites [PRSs]), will be addressed in order of priority.

1. Are there any risks to human health or the environment as a result of legacy and present-day contaminants in sediments, surface water, or groundwater, including risks from exposure to plant and animal tissues? This issue will be addressed quantitatively on-site and in selected off-site areas.

2. What is the potential for human-health or ecological risk (in the present as well as the future) as a result of migration of present-day contaminants? Pueblo and state concerns indicate that the effect of contaminant migration on altering risk estimates needs to be evaluated along with the present-day risk. The complexity of the problem makes identification of trends a feasible approach.

7.2.1.2 Site Description

A detailed description of Cañada del Buey and its tributaries is provided in Chapter 3 of this work plan.

7.2.1.3 Historical Data

Detailed discussions of historical uses, sources of environmental data, sources of potential contaminants, and current environmental conditions in the Cañada del Buey system are provided in Chapter 2 and Chapter 3 of this work plan.

The Laboratory has used Cañada del Buey primarily as a buffer zone for surface and subsurface material disposal areas (MDAs) at TA-54 on Mesita del Buey, just south of the Canyon, and to a lesser extent for liquid waste disposal. The earliest discharges were associated with outfalls, surface runoff, and dispersion from firing sites located at former TA-4 (Alpha Site), which is now part of TA-52. Additional discharges began with the expansion of Laboratory operations to new sites in the 1950s through the 1990s, specifically at the following technical areas:

- TA-46, which housed nuclear propulsion, isotope separation, and solar energy experiments, and the Laboratory's sanitary waste treatment facility;
- TA-51, the waste-burial technologies laboratory;
- TA-52, which formerly served as the site for reactor experiments; and
- TA-54, the Laboratory's on-site waste treatment, storage, and disposal facility.

A summary of COPCs in the Cañada del Buey system by technical area is presented in Table 7.2.1-1. The principal contaminants are inorganic chemicals and radionuclides.

7.2.1.4 Regulatory Requirements

A summary of regulatory requirements for this work plan is presented in Section 1.4 in Chapter 1 of the core document (LANL 1997, 55622). The primary regulatory requirements are found in the HSWA Module of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 1585). The EPA (EPA 1996, 55500) and the NMWQCC (1995, 50265; 1995, 54406) have set standards for nonradionuclides and some radionuclides for drinking water, surface water, and groundwater that may be applicable to water examined during these investigations; DOE Order 5400.5 sets guidelines for radionuclide concentrations in water.

7.2.1.5 Overview of Information To Be Collected

To address the general objectives and specific issues discussed Section 7.2.1.1, data sufficient to meet the following objectives will be necessary.

1. Identification of contaminant concentrations and distributions in (1) sediments and associated soils, (2) surface water, (3) groundwater, and (4) the biological environment in the Cañada del Buey system within and outside the Laboratory boundaries. These data may be obtained through a combination of literature review, compilation and interpretation of previously unpublished data, media sampling and analysis, and techniques such as geostatistical modeling, as appropriate, for uncertainty reduction.
2. Refinement of the conceptual model, which is discussed for the canyons in general in Chapter 4 of the core document (LANL 1997, 55622) and for the Cañada del Buey system specifically in Chapter 4 of this work plan. The refinement will include quantifying known pathways, testing hypotheses to determine the existence of potential or suspected pathways, and defining the

transport processes sufficiently to permit projections of transport that could alter estimates of human-health or ecological risk in the future as a result of migration of present-day contaminants. The process of refinement will involve identification of "reaches" or locations for investigating sediments, surface water, and groundwater most important for addressing present-day risk to human health and ecosystems and contaminant transport components of the conceptual model including a variety of contaminant sources.

3. Identification of contaminant transport pathways and improvement in understanding transport mechanisms, including sediment and water sampling accompanied by chemical and physical analyses described in Sections 7.2.2 and 7.2.3 of this document, and the ability to predict the potential for movement of present-day contaminants to off-site areas.
4. Identification of risks to biological communities (including humans) that inhabit or use the Rio Grande (now and in the future) as a result of transport of contaminants from Cañada del Buey.
5. Identification of remediation strategies for potential cleanup of specific areas in Cañada del Buey, as determined in these investigations.
6. Long-term monitoring needs and/or needs for institutional controls.

The following topics will be addressed in each section that follows, which describe the sampling and analysis of each media and transport pathway:

- how the data will be used to address the issues and objectives discussed above,
- assumptions underlying the data collection process,
- requirements for data quality to meet the intended use, and
- measurements to verify the underlying assumptions and data quality requirements.

The decisions driving data collection are described in Section 5.2 of the core document (LANL 1997, 55622, p. 5-3 et seq.) and in Appendix 4 of the hydrogeologic work plan (LANL 1998, 59599). Decisions specific to Cañada del Buey are discussed in Section 1.4 of this work plan and include obtaining information sufficient to reduce uncertainties in model input parameters for transport, human-health risk assessment, and ecological risk assessment to acceptable levels. The focus is on reducing uncertainties only to a point where (1) a remediation decision will not be affected by further reduction in uncertainty or (2) the cost of the additional data needed to further reduce uncertainty exceeds the cost of the remedial action.

Objectives 1, 2, and 3 listed above are partly met by summarizing existing data (Chapter 3 of this work plan), using the data to develop preliminary distributions of parameters where possible, and designing appropriate field SAPs to iteratively reduce uncertainties in the parameters that contribute most to the uncertainty in assessment and contaminant transport evaluation. These parameters might include field analyte concentrations, hydrological connectivity and groundwater extent, groundwater geochemistry, particle size determination, bioconcentration/bioaccumulation in plant and animal tissues, or extent of post-1942 geomorphic units with respect to area, thickness, and age of deposition. These and other parameters will be addressed by sampling and analysis to the extent necessary to either minimize uncertainty in the distributions or to distinguish between risk and remediation decisions with a high degree of confidence.

7.2.2 Sediment Sampling and Analysis Plan

This section presents the SAP for investigating potentially contaminated sediment in the Cañada del Buey Canyon system. A minimum of five canyon reaches downstream of known Laboratory sources of contaminants initially have been selected for investigation; these reaches are shown in solid outlines on Figure A-1 (in Appendix A). Additional subreaches or “contingency” reaches may be investigated contingent upon the findings of initial investigations in upgradient reaches; the contingency reaches are shown in dashed outlines on Figure A-1. These reaches will be characterized by geomorphic surveys and by chemical analysis of sediment samples collected from potentially contaminated geomorphic units. Some geomorphic characterization of pre-1943 sedimentary deposits may also be conducted to improve the ability to evaluate longer-term (greater than 50 years) sediment transport processes.

7.2.2.1 Objectives

The objectives of the sediment investigation are summarized as follows:

- determine the nature and extent of Laboratory-derived contaminants associated with post-1942 sediment deposits;
- evaluate the present-day risk to human health and ecosystems from contaminated sediments on-site and off-site;
- collect data to evaluate and refine the contaminant transport components of the conceptual model; and
- assess the projected impact of contaminated sediments on off-site receptors and on the Rio Grande by identifying the types, concentrations, and distribution of contaminants that have migrated beyond Laboratory boundaries; evaluating processes associated with potential future migration; and projecting trends in risk estimates that may result from migration of contaminants off-site.

The following sections present the sampling and analysis plan for the sediment investigation and describe the technical approach adopted to achieve these objectives.

7.2.2.2 General Approach for Sediment Investigation

This section briefly describes the general approach for the geomorphic surveys and the sediment sampling and analysis portion of this chapter for Cañada del Buey.

7.2.2.2.1 Geomorphic Survey Approach

Issue

What is the nature and extent of potentially contaminated post-1942 sediment deposits within the canyons?

Technical Approach

Determine what geomorphic subdivisions of the canyon floors are most appropriate for delineating the major spatial variations in geomorphic units and sedimentary facies that are important in the context of contamination. Post-1942 sediments will be categorized by geomorphic unit, and a separate sampling strategy will be developed for each unit. If units have significant vertical variation in sedimentary facies or contaminant concentrations, the units may be subdivided into two or more distinct stratigraphic layers. Laboratory analyses will be examined to determine whether the original geomorphic unit designations are appropriate to define the contaminant distributions and inventories in each reach.

Determine which locations in each geomorphic unit should be sampled for full-suite, key contaminant, and limited-suite analyses to meet the investigation objectives (see Section 7.2.2.1). Full-suite, key-contaminant, and limited-suite analyses are discussed in Section 5.6.3 in Chapter 5 of the core document (LANL 1997, 55622) and summarized in Section 7.2.2.3 and Section 7.2.2.5.1 of this work plan. This determination will be based on the following information:

- identified mapping units,
- characteristics of post-1942 sedimentary deposits, and
- areal extent of units.

Generally, the sampling will be restricted to sediments deposited after 1942, when potential contamination of the canyons began. Limited sampling of older sediments may be conducted to test the validity of criteria for distinguishing post-1942 sediment and to gauge the importance of other potential contaminant transport pathways**.** The potential need, number, and location of such samples in inferred pre-1943 deposits will be dependent on the specific conditions occurring in each reach and will be based on professional judgment. For example, in reaches where geomorphic characteristics and/or field radiological measurements provide high confidence in the extent of contaminated post-1942 sediment, little or no exploratory sampling to determine the boundaries of pre-1943 sediment may be required. In contrast, in reaches with subtle geomorphic changes and low levels of radiological contaminants, extensive exploratory sampling of pre-1943 sediment may be judged necessary to determine the extent of contamination.

The sampling will be largely restricted to the stream channel and its floodplain in Cañada del Buey and selected tributary canyons and to areas downstream of the first identified location of Laboratory-derived contaminants.

Post-1942 sediments will be categorized by geomorphic unit and possibly by stratigraphic layer within each unit, and a separate sampling strategy for contaminants will be developed for each unit. The sampling and analyses will be conducted as described in Section 7.2.2.5.1 for full-suite, key-contaminant, and limited-suite analyses. If the field mapping data indicate mappable subdivisions within any geomorphic unit (definable areas with potential variations in thickness, history, and/or contaminants), the site geomorphologist will identify appropriate subdivisions of the unit.

Limits on decision errors will be based on the relation of uncertainty to the decision points discussed in Chapter 5 and Chapter 6 of the core document (LANL 1997, 55622). Additional data will be obtained if reduction in uncertainty has the potential of changing the risk-based decision as discussed in Chapter 6 of the core document.

7.2.2.2.2 Sediment Sampling Approach

Issue

What is the nature, extent, and inventory of contaminants in sediments in the Cañada del Buey system? More specifically stated, the problem is to develop descriptions of the spatial distributions of contaminants at levels of uncertainty sufficient to (1) determine whether any risks to human health or the ecosystem currently exist on-site or off-site, and (2) quantitatively estimate contaminant transport with regards to spatial and temporal trends and future risks.

Technical Approach

Determine what contaminants are present in the sediments in Cañada del Buey and selected tributary canyons and their horizontal and vertical distribution based on data obtained from sample analyses in the geomorphic units within each reach. The following information will be used for this determination:

- archival information,
- sample location,
- sample unit, and
- concentrations of contaminants in each sample.

Spatial boundaries will be determined by the boundary of each specified reach.

Area and thickness data will form part of the basis for selecting locations to be sampled for laboratory analyses. Samples will be selected to represent the range of geomorphic units observed but will be biased to sample most intensively the units with the largest area and/or the greatest volume of fine-grained sediments.

Any contaminant identified at concentrations exceeding the 95% UTL value of the current sediment background (Ryti et al. 1998, 59730) or whose distribution is different from that of the background data in the full-suite analyses will be added to the limited-suite analytical protocol for samples from that reach (see Table 7.2.2-4 and Table 7.2.2-5 for 95% UTLs for background levels in sediments).

Any contaminant identified at concentrations exceeding the 95% UTL value of the current background or whose statistical distribution is different from that of the background data will be evaluated in the risk assessment for that reach.

Limits on decision errors will be based on the relation of uncertainty to the decision points discussed in Chapter 5 and Chapter 6 of the core document (LANL 1997, 55622). Additional data will be obtained if reduction in uncertainty has the potential of changing the risk-based decision as discussed in Chapter 6 of the core document.

7.2.2.3 Sampling and Analysis Plan for Sediment Investigation

The sampling and analysis plan for the sediment investigation follows the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622) and includes the testing of the conceptual model for the Cañada del Buey system, which is discussed in Chapter 4 of this work plan. The investigation will focus on potentially contaminated sediment deposits but may also include supplemental characterization of pre-1943 deposits.

The sediment SAP focuses on selected areas of the Cañada del Buey system downstream of known or potential contaminant sources. Field surveys and mapping, as well as sampling and analysis tasks, will initially concentrate on 5 reaches, which may be expanded to include up to 1 additional canyon reach for a maximum of 6 reaches that may be investigated. Figure A-1 shows the locations of the reaches and Table 7.2.2-1 summarizes the reaches that are planned to be investigated.

Table 7.2.2-1
Summary of Reaches to be Investigated in Cañada del Buey

Canyon/Tributary	Reach	Subreach	Priority Areas No. of Reaches for Initial Characterization	Contingency Areas No. of Reaches for Possible Additional Characterization
Cañada del Buey	CDB-1	None	1	
	CDB-2	CDB-2 West	1	
		CDB-2 Central	1	
		CDB-2 East		1
	CDB-3	CDB-3 West		1
		CDB-3 East	1	
	CDB-4	None	1	
	CDB-5	None		1
South fork of Cañada del Buey	CDBS-1	CDBS-1 West	1	
		CDBS-1 East	1	
Total	**6**	**10**	**7**	**3**

Each reach may be either undivided, with a length of approximately 100 m to 1000 m (110 yd to 1100 yd), or may include two or three subreaches each approximately 100 m to 500 m (110 yd to 550 yd) long. A “reach” refers to a specific area of a canyon that will be treated as a single unit for sampling, analysis, and present-day human-health and ecosystem risk assessment. A “subreach” refers to a specific area that is geographically related to other subreaches but that is investigated separately to evaluate issues relating to contaminant sources and/or contaminant transport and deposition. The regions of the main canyon and selected tributary canyons planned for investigation are shown in Figure A-1 (in Appendix A of this work plan). The precise length and area of each canyon reach or subreach will be defined by both the geomorphic survey and the results of sediment sampling and will be designed to encompass the local variability in geomorphic units and to constitute a reasonable area for use in the risk assessments. Initially some subreaches may be short (100 m to 200 m [110 yd to 220 yd]) and may be either eliminated from further investigation or expanded depending on the results of sediment sampling. Focusing on relatively short subreaches will allow the collection of key exploratory data in an efficient manner. The approach will be iterative to allow the expansion of specific reaches or subreaches to supplement the data set if significant contaminants are detected in these areas or other relevant areas.

Supplemental investigations, such as field mapping and measurements of the sizes of sediment deposits, may be conducted in intervening areas to improve confidence in extrapolation between reaches. Possible decisions to obtain such supplemental measurements between specific reaches will be made following evaluation of data from the reaches and identification of significant uncertainties. It is expected that no data will be required for intervening areas where levels of contamination in adjacent sampled reaches are below levels that may warrant remediation or other institutional actions. In contrast, if data from the sampled reaches indicate the need for remedial action, it is expected that data on levels of contamination in the adjacent unsampled areas will be required.

One or more of the following criteria were used to select the reaches and subreaches:

- areas where contaminant concentrations are expected to be highest as judged from previous sampling and analysis activities and from the proximity of the canyon reach to the source areas;
- areas immediately upstream and downstream of drainage confluences to allow better identification of significant contaminant sources and evaluation of contaminant dilution;
- areas with a variety of geomorphic characteristics to allow better estimates of the total contaminant inventory in the canyon and of variations in contaminant distribution between reaches; and
- institutional boundaries, to define contaminants that have migrated off Laboratory property.

Each reach or subreach will be used to address particular issues regarding potential contaminants in Cañada del Buey system. The set of reaches and subreaches is intended to represent key aspects of the entire system. Issues to be addressed by sampling in the individual reaches and subreaches are discussed in Section 7.2.2.4.

In addition to the field survey and mapping tasks (which are described in Section 7.2.2.4), the sediment SAP includes three types of sampling tasks.

- Collect samples for “full-suite” analysis (see Section 7.2.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of full-suite analysis).
- Purpose: analyze for the full suite of COPCs (organic and inorganic chemicals and radionuclides) to define the limited suite of COPCs for the sediment investigation.
- Collect samples for “key contaminant” analysis (see Section 7.2.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of key contaminants).
- Purpose: analyze for one or more key contaminants to define vertical and horizontal variations in contamination and evaluate recent sediment transport processes.
- Collect samples for “limited-suite” analysis (see Section 7.2.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of limited-suite analysis).
- Purpose: analyze for the limited-suite of COPCs to define the degree of collocation between different contaminants and to perform the present-day risk assessment.

In addition, the samples will be analyzed for particle-size distribution to identify relationships between sediment particle sizes and contaminant concentrations.

Section 7.2.2.5 presents the strategy and rationale for sample collection. The strategy for each sampling task will be decided based on the data collected during the initial field surveys and/or prior sampling. Requirements for additional data, including selection of key contaminant or limited-suite analyses, will be developed based on the judgment of the technical team and through frequent dialogue with the regulators. Some sampling may also address particular stakeholder concerns that could arise based on data collected early in the investigation.

The products of the sediment investigation will be

- data to support an assessment of the present-day risk to on-site (within Laboratory boundaries) receptors and the potential for off-site exposure from deposits of contaminated sediments in the canyon system;
- a description of contaminant transport associated with sediments in the canyon system; and
- an assessment of the potential future trends in risk estimates due to existing contaminated sediments moving downstream on Laboratory property, across Los Alamos County and privately owned land, and to the Rio Grande.

7.2.2.4 Canyon Reaches Planned for Investigation

The following sections describe each of the canyon reaches planned for investigation and the significance of each reach for evaluating present-day risk and potential future trends in risk from exposure to Laboratory-derived contaminants (see Figure A-1 in Appendix A for reach locations). The following reaches have been chosen for the sediment investigation:

- five reaches in Cañada del Buey (CDB-1 through CDB-5), and
- one reach in the south fork of Cañada del Buey (CDBS-1).

This list of potential reaches contains many subreaches, which are summarized in Table 7.2.2-1 and are described in the following sections. The strategy is to begin with a series of short subreaches, each approximately 100 m to 200 m (110 yd to 220 yd) long located near identified PRSs in the Canada del Buey watershed. This planned strategy is intended to identify the PRSs that contribute significant contaminants to the stream channels to potentially eliminate parts of the watershed from further investigations and to narrow the analytical suite planned for each reach. A second phase of investigations could expand the size of the key subreaches and perhaps add additional subreaches if questions remain. The list of subreaches also contains “contingency” reaches that may or may not be sampled, depending on the results from the investigations of upstream or downstream reaches. For example, some subreaches intended to evaluate dilution of contaminants from upstream PRSs may not be sampled if significant levels of contaminants are not found upstream close to the PRSs. The boundaries shown in Figure A-1 indicate the general areas that will be investigated; more precise definitions of the investigation boundaries will be based on the significant geomorphic units found within each reach. Characterization activities will focus on those geomorphic units that are most likely to contain Laboratory-derived contaminants, supplemented by some limited geomorphic characterization of pre-1943 sediment deposits.

7.2.2.4.1 Cañada del Buey Reaches

Reach CDB-1: Upper Cañada del Buey

Investigation of Reach CDB-1, located downstream of TA-52 in upper Cañada del Buey, is planned to evaluate potential contaminants from TA-52 and former TA-4. Potential contaminants associated with these sources include plutonium, pesticides, photographic chemicals, solvents, arsenic, chromium, and lead. Investigation of Reach CDB-1 will allow the determination of the contaminant inventory near the head of the canyon.

Reach CDB-2: Middle Cañada del Buey

Reach CDB-2, located in middle Cañada del Buey extending from TA-46 and including the confluence with the TA-46 fork of Cañada del Buey to the confluence with the south fork of Cañada del Buey, contains three subreaches. Investigation of these subreaches is planned to evaluate the dilution of contaminants from TA-52 and former TA-4 (observed in reach CDB-1), and the possible addition of contaminants from TA-46 and TA-51. Potential contaminants associated with these sources include americium, plutonium, thorium, uranium, PCBs, pesticides, photographic chemicals, solvents, SVOCs, asbestos, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, and zinc. The subreaches are described below.

- CDB-2 West. Investigation of CDB-2 West, located within Cañada del Buey upstream of the confluence with the TA-46 fork of Cañada del Buey, will allow evaluation of the potential contribution of contaminants from a series of TA-46 PRSs.

- CDB-2. Investigation of CDB-2 Central, located within Cañada del Buey downstream of the confluence with the TA-46 fork of Cañada del Buey, will target the potential contribution of contaminants from additional TA-46 PRSs, and possibly additional contaminants from TA-51, to Cañada del Buey.

- CDB-2 East. Investigation of CDB-2 East, located within Cañada del Buey upstream of the confluence with the south fork of Cañada del Buey, will allow the evaluation of the dilution of contaminants as well as the determination of contaminant inventory in middle Cañada del Buey. Sampling of this reach is contingent on the identification of significant levels of contaminants in reach CDB-2 Central.

Investigation of CDB-2, in combination with investigation of CDB-1, will allow the determination of the relative contributions of contaminants from these different sources and the contaminant inventory of Cañada del Buey upstream of the south fork of Cañada del Buey.

Reach CDB-3: Cañada del Buey Downstream from the South Fork of Cañada del Buey

Reach CDB-3, located downstream from the confluence of Cañada del Buey and the south fork of Cañada del Buey, contains two subreaches. Investigation of these subreaches is planned to evaluate the dilution of contaminants from upstream PRSs and the possible addition of contaminants from TA-54 sources within the south fork of Cañada del Buey. Potential contaminants associated with this reach include americium, cobalt, cesium, plutonium, strontium, yttrium, tritium, thorium, uranium, PCBs, pesticides, photographic chemicals, solvents, SVOCs, aluminum, asbestos, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, mercury, nickel, selenium, silver, and zinc. The subreaches are described below.

- CDB-3 West. Investigation of CDB-3 West, located in Cañada del Buey downstream of the confluence with the south fork of Cañada del Buey, is planned to determine the relative contribution of contaminants from upstream sources in Cañada del Buey and the south fork of Cañada del Buey. Sampling of this reach is contingent on identification of significant levels of contamination in reaches CDBS-1 East (see Section 7.2.2.4.2) or CDB-2 .

- CDB-3 East. Investigation of CDB-3 East, located in Cañada del Buey downstream of the confluence with the primary drainage east of MDA G, is planned to evaluate the dilution of contaminants from upstream sources and the potential contribution of contaminants from MDA G.

Reach CDB-4: Cañada del Buey Near State Road NM4

Investigation of Reach CDB-4, located upstream of the intersection of Cañada del Buey and state road NM4, is planned to evaluate dilution of contaminants from upstream PRSs, and identify the types and concentrations of contaminants present at the eastern Laboratory boundary. Potential contaminants in this reach include americium, cobalt, cesium, plutonium, strontium, yttrium, tritium, thorium, uranium, PCBs, pesticides, photographic chemicals, solvents, SVOCs, aluminum, asbestos, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, mercury, nickel, selenium, silver, and zinc. Investigation of Reach CDB-4 will allow the determination of the contaminant inventory west of the eastern Laboratory boundary. Reach CDB-4 is part of a land parcel whose ownership is scheduled to be transferred from DOE to the County of Los Alamos or San Ildefonso Pueblo. Characterization of CDB-4 will occur before the ownership transfer and will help identify any restrictions that should be placed on potential land uses. The sediment investigation of reach CDB-4 began in May 1999 in support of the land transfer process.

Reach CDB-5: Cañada del Buey Near Mortandad Canyon

Investigation of Reach CDB-5, located east of the community of White Rock and upstream of the confluence with Mortandad Canyon, is planned to evaluate the potential contribution of contaminants to Mortandad Canyon and possibly the Rio Grande. Potential contaminants in this reach include americium, cobalt, cesium, plutonium, strontium, yttrium, tritium, thorium, uranium, PCBs, pesticides, photographic chemicals, solvents, SVOCs, aluminum, asbestos, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, mercury, nickel, selenium, silver, and zinc. Sampling of this reach is contingent on identification of significant levels of contaminants in reach CDB-4.

7.2.2.4.2 Reach in the South Fork of Cañada del Buey

Reach CDBS-1

Reach CDBS-1, located in the south fork of Cañada del Buey upstream of the confluence with Cañada del Buey, contains two subreaches. Investigation of these subreaches is planned to evaluate the potential contaminants contributed by PRSs associated with TA-54. Potential contaminants associated with these sources include americium, cobalt, cesium, plutonium, strontium, yttrium, tritium, uranium, pesticides, antimony, barium, beryllium, calcium, iron, lead, and magnesium. The subreaches are described below.

- CDBS-1 West is located in the south fork of Cañada del Buey downstream of TA-54 West and MDAs J and H. Investigation of this subreach is planned to evaluate the potential contribution of contaminants from these sources.
- CDBS-1 East is located in the south fork of Cañada del Buey downstream of MDA L and upstream of the confluence with Cañada del Buey. Investigation of this subreach is planned to evaluate the dilution of contaminants from upstream sources and the potential contribution of contaminants from MDA L.

Collectively, data from the CDBS-1 subreaches will allow the determination of the relative contribution of contaminants from these different sources and the contaminant inventory in the south fork of Cañada del Buey.

7.2.2.5 Sediment Sample Collection and Analysis

This section describes the sediment sample collection process in the canyon reaches. Particular emphasis is given to the criteria for selecting sample locations within each reach and the rationale for the choice of analytical suites. The methods for sample collection and for the chemical, radiochemical, and geotechnical analyses are also provided in this section.

7.2.2.5.1 Sampling Design

Samples of sediments from potentially contaminated geomorphic units will be collected in most reaches planned for investigation (see Section 7.2.2.4). The locations of sediment samples will be determined based on the criteria provided in Section 5.6.3 of the core document (LANL 1997, 55622, p. 5-24 et seq.). Specific sample locations in the initial sampling phases will be selected following the geomorphic survey and will include the full range in age and particle size characteristics in post-1942 sediments as identified in the geomorphic survey. Specific sampling locations in subsequent sampling rounds will be based both on the geomorphic survey and on analytical results from the initial sampling phases and will be biased to locations where the highest levels of contaminants are expected.

Surface and shallow subsurface samples will be collected at variable depths depending on the thickness and variability of the sediment layers at each location. In general, each sample will be collected from a discrete sediment layer or from a series of adjacent texturally similar layers to avoid mixing layers that may have very different contaminant concentrations. For example, discrete flood layers only 1 to 2 in. (2.5 to 5.0 cm) thick may comprise some samples, whereas other samples may homogenize 1 ft (0.30 m) or more of relatively uniform layers.

Each sample location will be marked, surveyed, and assigned a unique ER Project sample location identification number. All samples will be field-screened using hand-held instruments at the point of collection for gross radioactivity. Before the samples are submitted to the Field Support Facility, gross-alpha, -beta, and -gamma radiation measurements will be taken on each sample.

As explained in Section 7.2.2.3, three sampling tasks have been defined for the sediment investigation: full-suite COPC, key contaminant, and limited-suite COPC analyses. Field quality assurance and quality control samples, such as field blanks and collocated samples, will be collected in accordance with the guidelines of the “Quality Assurance Project Plan Requirements for Sampling and Analysis” (LANL 1996, 53450).

Because of the scarcity of information available on contaminants in the Cañada del Buey system, the initial round of sampling and analysis will be full-suite analyses from a series of subreaches throughout the watershed. An initial estimate of 5 to 10 samples will be collected from each subreach; the actual number of samples collected will be determined as a result of the geomorphic surveys and at the discretion of the site geomorphologist.

Sample collection for full-suite analyses, as described below, will be distributed on a canyon-system-wide rather than a reach-wide basis in the initial round to ensure that no contaminants were overlooked during the historical analyses. Subsequent analyses will probably involve both limited-suite and key contaminant analyses, depending on the results of the full-suite sampling.

Following completion of the phased investigations in the reaches it is possible that supplemental characterization will be required between some of the reaches to confirm the assumed levels and extent of contamination, and possibly to locate specific sites for remediation. Activities in these areas could include geomorphic mapping and associated geomorphic characterization, sediment sampling and analyses, and data evaluation focused on identifying and mapping areas where contamination exceeds a level to be defined based on risk analyses. Specific details of such supplemental investigations will be determined based on evaluation of data from the reaches.

7.2.2.5.1.1 Sample Collection for Full-Suite Analysis

The general approach discussed in Section 5.6.3.2 in Chapter 5 of the core document (LANL 1997, 55622) will be followed. Sediment samples will be collected in the initial sampling task and analyzed for a full-suite of potential contaminants to define the limited-suite analyses (see Section 7.2.2.5.1.3) for subsequent sampling and analysis tasks. These samples will be focused in areas located closest to known source areas.

7.2.2.5.1.2 Sample Collection for Key-Contaminant Analysis

The general approach discussed in Section 5.6.3.3 in Chapter 5 of the core document (LANL 1997, 55622) will be followed. The selection of key contaminants allows analyses to be obtained from a large number of samples at a reasonable cost.

One or more constituents present at levels that may contribute significantly to present-day risk will be selected as key contaminants. The key contaminant analyses are critical to the sediment investigations because those analytes are most important for evaluating risk.

7.2.2.5.1.3 Sample Collection for Limited-Suite Analysis

The general approach discussed in Section 5.6.3.4 in Chapter 5 of the core document will be followed (LANL 1997, 55622). Because the database on radionuclide and metal contaminants in Cañada del Buey is sparse, potential contaminant suites in the sediments are poorly defined. The number of samples will be determined by the technical team based on the complexity of the contamination and will be sufficient to develop a defensible, representative statistic for present-day risk assessment purposes. To best sample a range of contaminant concentrations, more samples probably will be collected for limited-suite analysis in reaches close to contaminant sources than in downstream reaches.

The results of the limited-suite and full-suite analyses comprise part of the data set that will be used for the present-day human-health and ecological risk assessments. The analyte suite for limited-suite analyses will be decided by the technical team on the basis of analytes identified as being present at concentrations above background levels from the full-suite analyses.

7.2.2.5.2 Sampling Methods

Sediment samples will be collected using the methods and ER Project SOPs (most recent revisions) listed in Table 7.2.2-2. Sampling intervals will be determined in the field based on the judgment of field geologists. The tools used to collect the sediment samples will depend on the cohesion of the sediment material, the collection depth, and the presence of flowing or standing surface water. A spade and scoop will be used to collect surface sediment samples at depths of 0 to 1.0 ft (0.0 to 30.5 cm). Depth samples will be collected from either stream bank exposures or shallow excavations, homogenizing through the thickness of selected sediment layers. If surface water is present at the sampling location, a scoop, trowel, or hand corer will be used to collect grab sediment samples.

Table 7.2.2-2
Summary of Sediment Sampling Methods Requirements

Sampling Tool	Sample Type	Sampling Depth (ft)	ER-SOP No.
Spade and scoop	Surface grab	0–1	06.09
Thin-wall tube	Surface grab; lithologic (undisturbed)	0–5	06.10
Hand auger	Surface or subsurface grab; vertical composite	0–5	06.10
Open tube (Trier)	Lithologic (undisturbed)	0–5	06.17
Scoop and trowel	Grab (under surface water)	0–0.5	06.14
Hand corer	Grab (under surface water)	0–0.5	06.14

All samples will be collected using the most recent revised versions of the applicable ER Project SOPs for the collection, preservation, identification, storage, transport, and documentation of environmental samples. Decontamination of sampling equipment will be performed in accordance with ER-SOP-01.08, “Field Decontamination of Drilling and Sampling Equipment.” All IDW generated during the sampling operation will be managed and disposed of in accordance with ER-SOP-1.06, “Management of Environmental Restoration Project Wastes,” and ER-SOP-1.10, “Waste Characterization.”

7.2.2.5.3 Analytical Methods

Sediment samples will be collected to represent specific geomorphic strata; therefore, it is important that the laboratory sample is representative of the sediment stratum that is collected in the field. To identify patterns in the distribution of contaminants in the geomorphic strata, it is important that the sample preparation method is consistent. To meet the objectives for representativeness and comparability, the sediment samples will be homogenized in the field using a stainless steel bowl and spoon before being placed in a container. All samples will be sieved, in either the field or the laboratory, to remove stones and organic matter greater than 2 mm (0.08 in.) in diameter. The laboratory will be instructed to take representative aliquots from the homogenized sample for each analysis. All analyses will be performed at ER Project-approved fixed-site laboratories.

7.2.2.5.3.1 Organic Chemicals

The analytical suites and methods for analysis of organic chemicals are listed in Table 7.2.2-3. The analytical suites include SVOCs, organic carbon, organochlorine pesticides, PCBs, and HE compounds. All analyses for organic chemicals will be performed in accordance with the EPA SW-846 protocols (EPA 1987, 57589). The detailed analyte lists, EQLs, required QC procedures, and the acceptance criteria are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

7.2.2.5.3.2 Inorganic Chemicals and Radionuclides

For inorganic chemicals the target analytes, conservative EDLs, analytical methods, and BVs in sediments are listed in Table 7.2.2-4. All analyses for inorganic chemicals will be performed in accordance with EPA SW-846 protocols using mineral acid (nitric acid at a pH value of one) sample extraction procedures for the ICPES, ETVAA, CVAA, and ICPMS techniques.

Table 7.2.2-3
Analyte Suites and Analytical Methods for Analysis of Organic Chemicals in Sediment Samples

Analyte Suite	Analytical Method	Analytical Protocol*
Organochlorine pesticides	Gas chromatography/electron capture detector	SW-8081A
PCBs	Gas chromatography/electron capture detector	SW-8081A or SW-8082
SVOCs	Gas chromatography/mass spectrometry	SW-8270
HE	High-performance liquid chromatography	SW-8330

Note: Detailed analyte lists and estimated quantitation limits can be found in the 1995 ER Project analytical services statement of work, LANL 1995, 49738.

* EPA SW-846 Methods, EPA 1987, 57589.

Table 7.2.2-4
Analyte List, Estimated Detection Limits, and Analytical Methods for Inorganic Chemicals in Sediment Samples

Analyte	EDL (mg/kg)	Background Value[a] (mg/kg)	Analytical Method	Analytical Protocol[b]
Metals				
Aluminum	40	15,400	ICPES	SW-6010B
Antimony	0.5	0.83	ICPMS	SW-6020
Arsenic	2	3.98	ETVAA	SW-7060A
Barium	40	127	ICPES	SW-6010B
Beryllium	1	1.31	ICPES	SW-6010B
Cadmium	0.4	0.4	ICPMS	SW-6010B or SW-6020
Calcium	500	4420	ICPES	SW-6010B
Chromium	2	10.5	ICPES	SW-6010B
Cobalt	10	4.73	ICPES	SW-6010B
Copper	5	11.2	ICPES	SW-6010B
Iron	20	13,800	ICPES	SW-6010B
Lead	0.6	19.7	ICPMS	SW-7421 or SW-6020
Magnesium	1000	2370	ICPES	SW-6010B
Manganese	3	543	ICPES	SW-6010B
Mercury	0.1	0.1	CVAA	SW-7470A
Nickel	8	9.38	ICPES	SW-6010B
Potassium	500	2690	ICPES	SW-6010B
Selenium	0.3	0.3	ETVAA	SW-7740
Silver	1	1	ICPES	SW-6010B
Sodium	500	1470	ICPES	SW-6010B
Thallium	0.73	0.73	ICPMS	SW-6020
Uranium	0.5	2.22	ICPMS	SW-6020
Vanadium	10	19.7	ICPES	SW-6010B
Zinc	4	60.2	ICPES	SW-6010B
Other Inorganic Chemicals				
Total cyanide	0.05	0.82	Colorimetry	SW-9012A

[a] Background values for sediment samples from Ryti et al. 1998, 59730.

[b] EPA SW-846 Method, EPA 1987, 57589.

For radionuclides the target analytes and their half-lives, detected emission, minimum detectable activities, analytical methods, and BVs in sediments are listed in Table 7.2.2-5. Before chemical separation and counting for alpha or high-energy beta emissions, samples will undergo a complete digestion or fusion procedure. Measurements of strontium-90 will be performed by beta-counting of yttrium-90 progeny after an ingrowth period of at least 10 days after separation. All samples submitted for tritium analysis will also be analyzed for moisture content.

Table 7.2.2-5
Analyte List, Minimum Detectable Activities, and Analytical Methods for Radionuclides in Sediment Samples

Analyte	Half-Life (yr)	Detected Emission	Minimum Detectable Activity (pCi/g)	Background Value[a] (pCi/g)	Analytical Method
Americium-241	432.2	α	0.05	0.040	α-Spectrometry
Plutonium-238	87.7	α	0.05	0.006	α-Spectrometry
Plutonium-239,240[b]	2.411 x 10^4	α	0.05	0.068	α-Spectrometry
Strontium-90	28.7	β	0.5	1.3	Gas proportional counter (GPC)
Tritium	12.4	β	250 pCi/L	0.093	Liquid scintillation counting (LSC)
Uranium-234	2.46 x 10^5	α	0.1	2.59	α-Spectrometry
Uranium-235	7.04 x 10^8	α	0.1	0.20	α-Spectrometry
Uranium-238	4.47 x 10^9	α	0.1	2.29	α-Spectrometry
Gamma spectroscopy[c]	n/a[d]	γ	0.2[f]	n/a	γ-Spectroscopy
Gross-alpha	n/a	α	1.0	N.A.[e]	GPC
Gross-beta	n/a	β	1.0	N.A.	GPC
Gross-gamma	n/a	γ	2.0	N.A.	Thallium-doped sodium iodide (NaI[Tl]) or high-purity germanium (HPGe) detection

[a] BVs for sediment samples from Ryti et al. 1998, 59730.

[b] The plutonium-239 and plutonium-240 isotopes cannot be distinguished by alpha spectrometry. The half-life of plutonium-239 is given.

[c] The gamma spectroscopy analyte list is given in Table 7.2.2-6.

[d] n/a = not applicable.

[e] N.A. = not available.

Sediment samples will be prepared for gamma spectroscopy measurements by homogenization and drying; no sample extraction will be performed. The ER Project analyte list for the gamma spectroscopy analysis (see Table 7.2.2-6) includes the decay series of the naturally occurring radionuclides radium-226, uranium-235, and uranium-238 as well as fission and activation products and their progeny. Measurements of naturally occurring radionuclides known to be present in Laboratory soils provide an indication of the quality of the gamma spectroscopy measurement. Data for short-lived radionuclides can be useful when values reported for a parent radionuclide are evaluated because the relative activity concentration of parent and daughter isotopes is a known quantity. The shorter-lived radionuclides are usually included in the analyte list to verify the presence of longer-lived parent isotopes, but they are not evaluated as primary radionuclides because they decay to unmeasurable concentrations within the span of several years or less. The naturally occurring radionuclide potassium-40 is present in Laboratory soils at concentrations ranging from 25 pCi/g to 40 pCi/g and is always present in the gamma spectra of Laboratory soil samples. The potassium-40 gamma emission peak provides a qualitative indicator of the accuracy and precision of the gamma spectroscopy measurement, but potassium-40 is not considered to be a potential contaminant in Cañada del Buey sediments.

Table 7.2.2-6
Analyte List and Half-Lives of Radionuclides Measured Using Gamma Spectroscopy

Radionuclide	Half-life*	Emissions
Th-232 decay series (Thorium series)		
Lead-212	10.64 h	β,γ
Thallium-208	3.053 m	β,γ
U-235 decay series (Actinium series)		
Bismuth-211	2.14 m	α,β,γ
Thorium-227	18.72 d	α,γ
Uranium-235	7.04×10^8 y	α,γ
U-238 decay series (Uranium series)		
Bismuth-214	19.9 m	α,β,γ
Lead-214	26.8 m	β,γ
Thorium-234	24.10 d	β,γ
Activation products (and their decay products)		
Americium-241	432.7 y	α,γ
Cobalt-60	5.271 y	β,γ
Sodium-22	2.605 y	β,γ
Protactinium-233	27.0 d	β,γ
Fission products		
Cesium-134	2.065 y	β,γ
Cesium-137	30.17 y	β,γ
Europium-152	13.48 y	β,γ
Ruthenium-106	372.6 d	β
Other		
Potassium-40	1.25×10^9 y	β,γ

* m = minutes, h = hours, d= days, y = years.

Radionuclide sample results will be reviewed against process knowledge of waste streams released into Sandia Canyon. Radionuclides detected in environmental media samples in activities above BVs will be included as COPCs. Detected radionuclides from gamma spectroscopy also include short-lived (less than one year) daughter radionuclides of naturally occurring uranium and thorium isotopes. These uranium and thorium daughters are not identified as COPCs because radiological dose conversion factors for the parent radionuclides include the expected activity of daughter products. These short-lived daughter products are not included as COPCs if they are not identified in the process knowledge of Sandia Canyon waste streams and warrant exclusion as COPCs based on their rapid elimination from environmental media.

The required QC procedures and acceptance criteria for both the inorganic chemical and radiochemical analyses (except uranium-236) are found in the 1995 ER Project analytical services statement of work (LANL 1995, 49738) or the version that is current when this work plan is implemented.

7.2.2.5.3.3 Geotechnical Analysis

In addition to the chemical and radiochemical analyses, sediment samples will undergo geotechnical analysis for particle size distribution using a method determined appropriate to meet the investigation goals. Methods used may be those recommended by the US Geological Survey for geological applications (Janitzky 1986, 57674) or methods recommended for engineering applications by the ASTM described in ER-SOP-11.02, “Particle Size Distribution of Soil/Rock Samples” (ASTM Method D-422-63). Goals of these analyses may include evaluating relationships between contaminant concentrations and particle size distribution and determining the 10-µm size fraction (respirable particulate) in sediment samples. Other geotechnical analyses, such as mineralogy or organic matter content, may be performed at the discretion of the technical team geologists.

7.2.3 Surface Water Sampling and Analysis Plan

There are no natural perennial reaches occurring in Cañada del Buey, therefore surface water investigations are not proposed as part of this work plan. However, stormwater investigations for Cañada del Buey are addressed in the draft watershed management plan (LANL 1999, 62920, p. 8-3).

7.2.4 Groundwater Sampling and Analysis Plan

This section presents the SAP for investigating groundwater in Cañada del Buey. The strategy for sampling alluvial groundwater, intermediate groundwater zones, if encountered, and the regional aquifer is described. Borehole cores will also be sampled and analyzed to determine the baseline and potential contaminant geochemistry and the hydraulic properties of water-bearing zones. To meet the objectives of the groundwater investigation, 2 wells are planned: 1 alluvium well, and 1 regional aquifer well.

The regional aquifer well is being drilled as part of the groundwater protection management program plan (LANL 1995, 50124), a Laboratory program to characterize the hydrogeology of the Pajarito Plateau by installing a Laboratory-wide groundwater monitoring network. The regional aquifer well program is a part of a cooperative effort between Laboratory Defense Programs and the ER Project; the planning for these wells is described in the hydrogeologic work plan (LANL 1998, 59599). The regional aquifer well in Cañada del Buey is planned to be installed by Defense Programs to meet the site-wide characterization goals of the hydrogeologic work plan (LANL 1998, 59599, p. 4-8).

7.2.4.1 Objective of Groundwater Investigations

The objective of the groundwater SAP is to address the HSWA Module (EPA 1990, 1585) requirements for characterizing the hydrogeology of the Cañada del Buey system to determine the Laboratory’s potential impact on groundwater. These requirements are discussed in detail in Chapter 1 of the core document (LANL 1997, 55622). The HSWA Module requires that the Laboratory investigate the potential for movement or transport of contaminants within canyon watersheds and contaminant interactions with alluvial groundwater and other groundwater. The scope and general technical approach of the groundwater investigations are also described in Chapter 5 of the core document. Installation of the alluvium wells and regional aquifer characterization boreholes identified in this work plan will satisfy requirements to characterize the alluvial groundwater system and the intermediate perched zone and regional aquifer zones of saturation, as identified in the hydrogeologic work plan (LANL, 1998, 59599). A complete list of objectives associated with these groundwater investigations is in Appendix 4 of the hydrogeologic work plan (LANL 1998, 59599).

The groundwater investigations address the presence of Laboratory-derived contaminants and will evaluate present and future potential off-site exposures and impacts extending along the entire canyon to the Rio Grande, which result from interactions between surface water and groundwater in different water-bearing zones. In additional to characterizing contaminant presence and transport within the alluvial system, intermediate zones of saturation, and the regional aquifer systems, the results obtained from the groundwater investigations are essential to evaluating potential transport pathways from the alluvium to the intermediate depth and regional aquifer groundwater systems. Detailed contaminant characterization within the alluvial system allows the comparison of unique chemical signatures to those obtained from the deeper groundwater systems to determine the degree of connectivity, if any, between groundwater systems.

7.2.4.2 Alluvial Groundwater Sampling and Analysis Plan in Cañada del Buey

This section describes the sampling design for collecting alluvial groundwater samples. The methods for sample collection and for chemical, radiochemical, and geotechnical analyses are also provided in this section. The groundwater sampling strategy involves collection of shallow groundwater from the existing wells in Cañada del Buey to determine if contaminants are present. Supplemental alluvium wells may be planned in the future if saturation and contaminants encountered warrant the installation of supplemental alluvial groundwater observation wells.

The HSWA Module (EPA 1990, 1585) requires that this work plan include an investigation of the potential for transport of contaminants within canyon watersheds and the interactions with alluvial groundwater and other groundwater. Three characteristics of groundwater in the alluvium are relevant to these requirements: continuity, potential recharge to deeper groundwater, and levels of contaminants. A detailed discussion of these topics is in Section 3.5.4 of this work plan.

7.2.4.2.1 General Approach for Alluvial Groundwater Investigations

This section describes the general approach for the alluvial groundwater characterization and sampling and analysis. Alluvial groundwater investigations focus on areas of insufficient data and areas most likely to contain contaminants, such as areas downgradient of known release sites and in areas where Laboratory surveillance data indicate that Laboratory-derived contaminants could be present. The approach for the groundwater investigation follows the data needs outlined in Chapters 3 and 4 of this document and the decision logic discussed in Chapter 5 of the core document (LANL 1997, 55622).

The following fundamental questions to be addressed for the alluvial system have been identified.

- What is the nature and extent of contaminants in alluvial and/or shallow perched groundwater?
- If the groundwater contains contaminants, where does the loss from the alluvial system occur in Cañada del Buey and what is the flux?
- If contaminants are being transported in shallow perched groundwater, what are the flow paths for this groundwater?
- What are the major processes by which the shallow perched groundwater moves?
- What geochemical processes influence water chemistry and contaminant migration in the shallow perched groundwater?

Addressing each of these questions requires an integrated technical approach of data collection, data evaluation, and refinement of the conceptual model. The approach is described in terms of a specific programmatic issue that will be addressed by the investigation. Each technical approach to an issue also addresses the hypotheses included in the conceptual model.

Issue

What is the present-day risk posed by contaminants in the alluvial/shallow perched groundwater in Cañada del Buey? How will that risk change with time?

Technical Approach

Determine if alluvial/shallow perched groundwater is present in Cañada del Buey and if present, determine if contaminants are present at levels above the MCLs, NMWQCC standards (1995, 54406), EPA standards, UTL values for background, or levels that pose unacceptable human-health or ecological risks in appropriate land-use scenarios. Additionally, other physical properties of alluvial groundwater need to be understood, such as

- the flux of groundwater moving through the alluvium/shallow perched zone in middle Cañada del Buey;
- the areal extent of groundwater in the alluvium/shallow perched zone; and
- if there is a process or pathway for exposure.

The following data will be collected to provide input to the decisions.

- Results of groundwater sample analyses for geochemical parameters and analytes, including contaminant indicators, sufficient to provide temporal water quality variations, and a refined conceptual model of groundwater geochemistry
- Infiltration rates of runoff and alluvial/shallow perched groundwater
- Moisture content/saturation, water levels, saturated thickness, and temporal variations in the alluvium and possible perched zones in the Bandelier Tuff
- Hydrologic properties, geologic structure, hydraulic gradients and predicted flow directions, land use scenarios, spring discharge information, current and planned well-withdrawal points, and a refined conceptual model of the hydrologic system

For initial planning use, the study will be limited by the boundaries of the Cañada del Buey basin area. Quarterly sampling events will be conducted for one year, and chemical indicators sufficient to determine seasonal effects will be analyzed.

Data needed to evaluate the present-day human-health and ecological risk will be collected as part of a single field investigation and will reflect information from high and low water levels to establish appropriate ranges and uncertainties in contaminant distribution. Present-day human-health and ecological risk assessments will include evaluation of alluvial groundwater with the following assumptions.

Drinking water pathways

- Contaminants will be evaluated if they have concentrations above standards or UTL values for background or show trends (observed or predicted) in concentrations over time, which indicates that contaminants may exceed standards or UTL values in the future.

- Duration parameters and pathway of exposure will be adjusted to reflect characteristics of the alluvium considering specific yield and characteristics of the alluvial groundwater considering potential availability for consumption.

Livestock and wildlife watering pathways

- Appropriate state and other regulatory authority standards will be used to identify COPCs.
- Duration parameters and pathway of exposure will be adjusted to reflect water saturation times and characteristics of the alluvial groundwater considering potential availability to livestock and wildlife.

Plant uptake pathways

- Contaminants that exceed the limits noted above will be evaluated if alluvial groundwater is located such that it is available for plant uptake.

Additional data will be obtained if reduced data uncertainty has the potential to change any risk-based decision. This process is discussed in detail in Chapter 6 of the core document (LANL 1997, 55622).

The groundwater investigation consists of three phases:

1. field investigation,
2. data analysis, and
3. developmental and refinement phase for the detailed conceptual model of the canyon's hydrogeological and geochemical system.

All phases will interface iteratively until the investigation has successfully developed a conceptual model that describes the hydraulic and contaminant mass transport relationships between surface water and groundwater. An important objective of the plan is to evaluate the interactions between surface water and groundwater in different water-bearing zones within the canyon system so that future environmental surveillance efforts can be optimized. A corrective measures study may be identified during the field investigation. This study would be implemented after the field investigation phase is completed and data have been evaluated.

The field investigation phase includes the following activities. Investigators will

- sample and analyze alluvial and shallow intermediate perched zone(s) to characterize nature and extent of the water and of any contaminants that are present.
- collect water level time-series data from each groundwater zone; measure field parameters in water samples (pH, temperature, specific conductance, dissolved oxygen, and turbidity).
- collect hydrogeologic data from core samples to characterize the vadose zone and saturated zones.

The data analysis phase includes the following activities. Investigators will

- evaluate runoff infiltration losses into the alluvium.
- evaluate infiltration into bedrock units.

- compare and contrast (through geochemical modeling and analysis) the geochemistry of all water samples.
- evaluate the potential for hydraulic and mass transport among all water-bearing zones.

Continued development of a detailed conceptual model includes the following activities.

- Refine the conceptual model by integrating the results of field investigations and data analyses into a flow-transport models.
- Evaluate present-day and future exposure at various locations.
- Evaluate potential contaminant migration pathways and future concentrations.
- Identify contaminant problems that may require remediation.

After all three phases of the investigation have been successfully completed, the Laboratory will satisfy the following requirements of the HSWA Module (EPA 1990, 1585):

- hydrogeological and geochemical characterization of Cañada del Buey;
- evaluation of historical, present, and future exposure risks; and
- detailed recommendations for a long-term environmental surveillance program plan that optimizes future environmental surveillance of the canyon, primarily water sample collection and the frequencies and locations of water level measurements.

The SAP is designed to be flexible, and the objectives and approaches will be refined and modified as new data are obtained. Revisions or refinements to the different components of the conceptual model (see Chapter 4 of this work plan) will be based on the integration of results from all components of the investigation as well as an integration and further interpretive analysis of data from other previous and ongoing Laboratory studies (as discussed in Chapter 2 and Chapter 3 of this work plan). Information gathered from implementing this work plan will also be used to focus geologic, geochemical, and hydrogeologic characterization efforts in future work plans for other canyon systems.

7.2.4.2.2 Planned Alluvial Groundwater Sampling in Cañada del Buey

Investigations are planned to address the objectives of the Cañada del Buey investigations and to sustain the approaches described in the foregoing section. The investigations will determine the presence of saturation in the alluvium and adjacent underlying bedrock units beneath Cañada del Buey and characterize the geochemistry of saturated zones. Significant amounts of saturation are not expected to occur in (1) the lower part of the canyon where existing alluvium observation wells are dry, and (2) east of state road NM4 due to thinning and the absence of alluvium in that reach. Two existing alluvial monitoring wells, CDBO-6 and CDBO-7, will be sampled in middle Cañada del Buey quarterly for one year. No additional alluvial/shallow perched zone monitoring wells in Cañada del Buey were included in the hydrogeologic work plan (LANL 1998, 59599, p. 4-61). The locations of the existing alluvium wells in Cañada del Buey are shown on Appendix Figure A-1.

The hydrogeologic work plan did not provide for alluvium wells in Cañada del Buey because “existing borehole data indicates that this canyon does not contain alluvial groundwater” (LANL 1998, 59599, p. 4-61). This statement does not account for the shallow groundwater that is present in wells CDBO-6 and CDBO-7, which may not be in the alluvium, but may be present in the Colonnade Tuff of Unit Qbt 1v, which is present beneath the alluvium in this part of Cañada del Buey (See Section 3.5.4.2, Figure A-3).

Potential contributions to alluvial/shallow perched zone groundwater chemistry may be from the use of road salt on the highway during winter months or from possible accidental discharges from the sanitary waste system consolidation (SWSC) plant at TA-46. Monitor wells CDBO-6 and CDBO-7 could also be used to determine water balance and seepage loss from the alluvium in middle Cañada del Buey.

Alluvial groundwater may also be collected from other existing observation wells in middle Cañada del Buey if appropriate samples can be obtained from the wells. Existing wells that may be sampled in Cañada del Buey include CDBO-8 and/or CDBO-9; other wells in lower Cañada del Buey have historically been dry (see Section 3.5.4.2).

Groundwater samples will be collected for analysis on a quarterly basis for one year. Table 7.2.4-1 summarizes the shallow groundwater samples to be collected in Cañada del Buey. If possible, the quarterly groundwater samples will be collected concurrently with sampling of stormwater runoff pursuant to the draft watershed management plan (LANL 1999, 62920) to provide a snapshot of stormwater and alluvial groundwater geochemistry throughout the canyon. The analytes for characterization of groundwater samples are shown in Table 7.1.4-6. The analytical methods are listed in Section 7.1.4.4.

Table 7.2.4-1
Summary of Alluvial Groundwater Samples to be Collected in Cañada del Buey

Well	Sampling Frequency	No. of Filtered Samples	No. of Unfiltered Samples	Total No. of Samples
CDBO-6	Quarterly for 1 year	4	4	8
CDBO-7	Quarterly for 1 year	4	4	8
SCO-8*	If water is present in well	4	4	8
SCO-9*	If water is present in well	4	4	8
	Totals	**16**	**16**	**32**

* These existing wells are normally dry.

Pressure transducers may be installed in the alluvium observation wells in Cañada del Buey to provide real-time water level data that will be used to determine water balance in the alluvium. Down-hole bladder pumps may be installed in each well to enable sampling of the groundwater without removal of the pressure transducers and to collect groundwater samples more representative of the natural groundwater in the alluvium.

7.2.4.3 Intermediate Perched Zone and Regional Aquifer Groundwater Sampling and Analysis Plan in Cañada del Buey

The ER Project does not plan to install intermediate-depth or regional aquifer wells within the Cañada del Buey watershed. However, one regional aquifer characterization borehole, R-16, is located in the White Rock area in lower off-site Cañada del Buey as part of the hydrogeologic work plan (LANL 1998, 59599, p. p 4-61). This well is planned to be installed by the Laboratory Defense Programs. A brief summary of R-16 and the data to be collected is provided for completeness and to provide information about a groundwater investigation that may be relevant to the regional setting of groundwater in the Cañada del Buey watershed area.

7.2.4.3.1 General Approach for Intermediate Perched Zone and Regional Aquifer Investigations

The rationale and general approach for investigations related to intermediate perched zones and the regional aquifer in Cañada del Buey coincide with those described in Section 7.1.4.3.1 of the Sandia Canyon SAP in this work plan.

The rationale for drilling R-16 is provided in the hydrogeologic work plan (LANL 1998, 59599) and conforms to the rationale for drilling the Sandia Canyon wells, which is discussed in Section 7.1.4.3 of this work plan.

7.2.4.3.2 Planned Regional Aquifer Well in Cañada del Buey

Regional aquifer well R-16 is planned to characterize the geology and hydrology of the area of lower Cañada del Buey near the Rio Grande. The well will also be used to identify the presence of intermediate perched zones, measure the thickness of the zones, and analyze for the presence of contaminants within those zones that would indicate contaminant transport is actively occurring (LANL 1998, 59599, p 4-61). The general location of the regional aquifer characterization borehole is listed in Table 7.2.4-2 and the location is shown on Appendix Figure A-1.

Table 7.2.4-2
Location of Planned Regional Aquifer Well in Cañada del Buey

Well Designation[a]	Funding Source	Location[b]
R-16	DP[c]	Lower Cañada del Buey northeast of White Rock

[a] R = regional aquifer.

[b] See Appendix Figure A-1 for planned locations.

[c] DP = Defense Programs.

The regional aquifer well planned for Cañada del Buey is located on Los Alamos County property. Regional aquifer characterization borehole R-16 will provide baseline information on the geology, hydrology, and geochemistry for a large uncharacterized area between the eastern boundary of the Laboratory and the Rio Grande. Numerous springs in White Rock Canyon probably represent discharge points for intermediate perched zones and the regional aquifer and water from the springs exhibit significant differences in major ion chemistry and stable isotopes. Information obtained from drilling and sampling R-16 will determine water quality for possible intermediate perched zones of saturation and the regional aquifer between the Laboratory and the Rio Grande and will provide information about the depth to the regional aquifer west of the Rio Grande. The well will also clarify the relationship between springs in White Rock Canyon and various groundwater zones. Hydrologic data obtained from R-16 will contribute to the construction of accurate groundwater elevation and contaminant maps and will enable the potential location of additional monitoring wells on the eastern side of the Laboratory (LANL 1998, 59599, p. 4-8).

7.2.4.3.3 Regional Aquifer Borehole Advancement and Well Installation

Borehole advancement and well installation specifications for well R-16 is planned to be a Type 2 (regional aquifer) well, the specifications of which are discussed in Section 4.1.1.2 in Chapter 4 of the hydrogeologic work plan (LANL 1998, 59599, p. 4-20). Type 2 wells are planned to collect intact core samples from selected intervals up to about 10% of the total depth of the well. Well procedures and designs are based on HSWA, RCRA, and NMED guidelines and follow ER Project SOPs, which are listed in Table 7.1.4-2.

The procedures described in this section for borehole core sampling and groundwater sampling generally follow those in Chapter 4 of the hydrogeologic work plan (Section 4.1.3 and Section 4.1.4) (LANL 1998, 59599) with several exceptions. Due to the number of exceptions, the procedures are fully described in this section rather than incorporating the hydrogeologic work plan by reference. In general, the following guidelines will apply to sampling the boreholes before completion of the wells.

The regional aquifer well in Cañada del Buey is expected to be drilled to a depth of about 100 ft (30 m) into the regional aquifer. Table 7.2.4-3 shows the expected prognosis for characterization borehole R-16. The approximate locations of the borehole and the anticipated stratigraphy in the hole are shown schematically on Figure A-3 in Appendix of this document. Regional aquifer characterization borehole R-16 is planned to be drilled through the Puye Formation and possibly into the Santa Fe Group to a total depth of about 800 ft (245 m). The regional aquifer is expected at a depth of about 680 ft (200 m).

Table 7.2.4-3
Expected Drilling Prognosis for Well R-16

Geologic Unit or Datum	Planned Depth (ft)	Elevation (ft)	Comment
Surface elevation	0	6290	
Alluvium	Surface		
Cerros del Rio Basalt	10	6280	Tcb3 of Dethier (1997, 49843)
Puye Formation (U)	260	6030	Ta of Dethier (1997, 49843)
Cerros del Rio Basalt	300	5990	Tcba of Dethier (1997, 49843)
Puye Formation (L)	530	5930	
Regional zone of saturation	680	5610	
Santa Fe Group	700	5540	
Total Depth	**800**	**5490**	

Note: Stratigraphic Nomenclature from Broxton and Reneau 1995, 49726. Stratigraphic information based on data from Purtymun (1995, 45344) and Dethier (1997, 49843), and stratigraphic data listed in Appendix E.

7.2.4.3.4 Regional Aquifer Borehole Core and Groundwater Sampling

Core/Cuttings Sampling

Core samples may be obtained through selected sections of the borehole based on the results of drilling activities if technically feasible by the drilling methods that are employed. Selected portions of the core may be archived at the Field Support Facility for possible future investigation. Pore water samples may be obtained from selected intervals of core from unsaturated zones.

Table 7.2.4-4 lists the planned core/cuttings sampling plan for geochemical characterization. Core/cuttings samples will be collected for analyses from the following zones in the well:

- the alluvium/bedrock contact;
- the upper portion of the bedrock formation;

- three zones associated with each perched zone of saturation, including a sample from above the saturated zone, a sample within the saturated zone, and a sample from the perching layer (two perched zones for planning purposes);
- three zones within the regional aquifer, including at the top of the regional zone of saturation and up to two additional samples from the regional aquifer; and
- one contingency sample from the borehole.

Table 7.2.4-4
Summary of Core/Cuttings Samples from Regional Aquifer Borehole R-16 in Cañada del Buey

Borehole	Zone to be Sampled	Location of Sample	Number of Samples	Comment
R-16	Qal/bedrock contact		1	
	Upper bedrock unit		1	
	Intermediate perched zone #1	Above	1	Assume two intermediate perched zones
		Within	1	
		Perching layer	1	
	Intermediate perched zone #2	Above	1	
		Within	1	
		Perching layer	1	
	Regional aquifer	Top of aquifer	1	Top of the regional zone of saturation
		Within top 100 ft	1	Sample from within the top 100 ft of the aquifer
		Bottom of hole	1	Sample from the bottom of the borehole
	Contingency		1	Contingency sample for planning purposes
		Total Samples	**12**	

For planning the number of core/cuttings samples to be collected for analysis, it is assumed that two intermediate perched zones of saturation will be encountered in the borehole. The samples of core/cuttings obtained will be analyzed for a full suite of analytes listed in Table 7.1.4-4. The analytical methods are listed in Section 7.1.4.4. All samples will be collected using applicable ER Project SOPs (Table 7.2.4-2) for the collection, preservation, identification, storage, transport, and documentation of environmental samples. Sampling equipment will be decontaminated in accordance with ER-SOP-1.08, “Field Decontamination of Drilling and Sampling Equipment.” All IDW generated during the sampling operation will be managed and disposed of in accordance with ER-SOP-1.06, “Management of Environmental Restoration Project Wastes,” and ER-SOP-1.10, “Waste Characterization.”

Core and cutting samples will be field screened for radioactivity using a Geiger-Müller detector and monitored for VOCs using a photoionization detector. Field screening will be conducted at regular intervals during borehole advancement.

The following additional hydraulic and geotechnical analyses will be performed on selected core and cuttings samples. The geotechnical, hydraulic, and geophysical analyses will be performed on selected core samples based on the judgment of the field geologist and the canyons investigation technical team.

- Moisture content will be routinely analyzed in core and cuttings samples at 10-ft (3-m) intervals. Samples will not be analyzed for moisture content where saturation is encountered or where drilling fluids are introduced into the borehole.
- Samples of core and cuttings will be selected for geochemical analysis based on the changes in lithology, alteration features, moisture content, and field screening results. Samples will be collected from representative lithologies at regular intervals in the absence of other criteria for sample selection.
- Hydraulic properties analyses will be conducted on core samples in each borehole based on geologic and hydrologic conditions encountered and the need to provide critical parameters for site-wide numerical models evaluating flow and transport. Hydrologic analyses include moisture content, moisture potential, and saturated hydraulic conductivity.
- Geotechnical analyses of selected core samples will include bulk density, particle size distribution, porosity, and specific gravity.
- Samples of cuttings or core will be selected based on geologic conditions encountered and, as appropriate, will be submitted for petrographic, x-ray fluorescence, and x-ray diffraction analyses to characterize the lithologic units penetrated.
- Samples may be collected for isotopic dating of basalts or tuff deposits in the Puye Formation to provide correlation with similar volcanic deposits encountered in widespread boreholes.

Pore water samples may be obtained from core samples in selected unsaturated zones. The pore water samples will be analyzed for the analytes listed in Table 7.1.4.10. The analytical methods are listed in Section 7.1.4.4.

Geophysical Logging

If possible, based on borehole advancement techniques and borehole conditions, geophysical logging may be conducted on the boreholes for the wells completed in the regional aquifer. The application of logging techniques will complement hydrogeologic data collected from core samples. Cased-hole wireline logging will be conducted on the regional aquifer boreholes and/or wells. Application of the various logging techniques will depend on geologic conditions encountered and will be determined on a well-by-well basis.

Portions of the boreholes for the regional aquifer wells may be logged with open-hole logging tools if borehole stability is such that the borehole can be advanced without casing. After logging, casing will be set through the logged interval, and the borehole will be advanced to a nominal total depth of 100 ft (30 m) into the top of the regional aquifer. Due to the unconsolidated nature of the subsurface strata and use of air-rotary drilling, these boreholes may be cased before open borehole logging can be accomplished. Cased-hole logging will be performed from surface to total depth. Procedures for open-hole and cased-hole geophysical logging are discussed in Section 4.1.6 in Chapter 4 of the hydrogeologic work plan (LANL 1998, 59599).

Groundwater Sampling

Groundwater from the newly installed regional aquifer well will be sampled during drilling when saturated zones are encountered, and quarterly after the well is completed for a period of one year. Groundwater sampled during the drilling of the wells will be according to the following general procedures and assumptions.

As the borehole is being drilled, drilling will be interrupted whenever intermediate perched zone groundwater is encountered and when the top of the regional aquifer is encountered. The casing string may be retracted slightly, as necessary, to ensure representative sampling. The borehole will be bailed to reduce the effect of drilling operations, and the borehole may be rested for up to 12 hours before sampling. Samples will be retained for an appropriate period of time to enable reanalysis, if needed.

For planning and conceptual design purposes, it has been assumed that three water-bearing zones will be encountered during advancement of each borehole, including two intermediate perched zones and the regional aquifer. Three zones were selected for planning purposes because deep wells recently drilled in Los Alamos Canyon and Sandia Canyon (R-9 and R-12) encountered multiple perched zones in addition to the regional aquifer. Groundwater samples will be collected from each water-bearing zone and analyzed for the parameters listed in Table 7.1.4-12. Laboratory analyses for these different analytes will be performed on filtered samples and on unfiltered samples.

Table 7.2.4-5 summarizes groundwater samples that will be collected from the regional aquifer characterization borehole in Cañada del Buey. Groundwater samples will be collected from the well after successful well development is completed (i.e., purged water exhibits acceptable turbidity levels). Groundwater samples will be collected for analysis thereafter on a quarterly basis for one year. The analytical suite for characterization of deep groundwater samples is shown in Table 7.1.4-12. The analytical methods are listed in Section 7.1.4.4. After this period of characterization, the borehole may be turned over to the Laboratory Water Quality and Hydrology Group (ESH-18) for possible use in long-term groundwater monitoring.

Table 7.2.4-5
Summary of Intermediate Perched Zone and
Regional Aquifer Groundwater Samples to be Collected in Cañada Del Buey

Well	Sampling Event	Zone to be Sampled	No. of Filtered Samples	No. of Unfiltered Samples	Total No. of Samples
R-16	During drilling	Intermediate zone #1	1	1	2
		Intermediate zone #2	1	1	2
		Top of regional zone of saturation	1	1	2
		Within regional zone of saturation	2	2	4
		Contingency sample	1	1	2
	Quarterly for one year	One zone	4	4	8
		Total	**10**	**10**	**20**

7.2.5 Air-Particulate Sampling and Analysis Plan

The Laboratory operates a network of more than 50 environmental air stations (called AIRNET) to sample radionuclides in ambient air. Thirteen of these stations are located within or adjacent to the Cañada del Buey watershed. These stations are monitored regularly, and the results of the monitoring are reported annually. The 13 stations located within or adjacent to the Cañada del Buey watershed include 11 stations located on Laboratory property and 2 perimeter stations located in White Rock. Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239,249; uranium-234; uranium-235; and uranium-238. A discussion of the Laboratory's air monitoring surveillance program in Cañada del Buey is presented in Section 3.5.5 in Chapter 3 of this work plan.

No contaminant sources in the air resulting from sources in Cañada del Buey have been identified as a result of the AIRNET monitoring. Continued monitoring of the AIRNET stations will be provided by ESH-17 personnel and published annually in the Laboratory's annual environmental surveillance reports. These AIRNET stations currently provide site-specific air monitoring data, and no significant long-term trends indicative of an airborne release within the Cañada del Buey watershed have been identified. Therefore, no additional air monitoring in Cañada del Buey is proposed as part of this work plan.

7.2.6 Biological Sampling and Analysis Plan

As discussed in the core document (LANL 1997, 55622), the approach for evaluating ecological risks is currently being discussed with the NMED, DOE, Laboratory ER Project, and EPA. A draft document has been submitted to NMED and is being reviewed. Based on the results of this process, a sampling plan for Cañada del Buey will be developed to be consistent with that approach.

References for Chapter 7

The following list includes all references cited in this chapter. The parenthetical information following the reference provides the author, publication date, and ER Project identification (ER ID) number. This information is also included in the citation in the text and can be used to locate the document.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

Allison, J. D., D. S. Brown, and K. J. Novo-Gradac, March 1991. "MINTEQA2/PRODEFA2, A Geochemical Assessment Model for Environmental Systems: Version 3.0 User's Manual," EPA/600/3-91/021, Office of Research and Development, Athens, Georgia. (Allison et al. 1991, ER ID 49930)

Broxton, D. E., and S. L. Reneau, August 1995. "Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory," Los Alamos National Laboratory Report LA-13010-MS, Los Alamos, New Mexico. (Broxton and Reneau 1995, ER ID 49726)

Dethier, D. P., 1997. "Geology of White Rock Quadrangle, Los Alamos and Santa Fe Counties, New Mexico," New Mexico Bureau of Mines and Mineral Resources Geologic Map 73, Socorro, New Mexico. (Dethier 1997, ER ID 49843)

EPA (US Environmental Protection Agency), March 1983. "Methods for Chemical Analysis of Water and Wastes," EPA-600 4-79-020, Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, Ohio. (EPA 1983, ER ID 56406)

EPA (US Environmental Protection Agency), May 1987. "Test Methods for Evaluating Solid Waste, Laboratory Manual, Physical/Chemical Methods," SW-846, Third Edition, Update III, Washington, DC. (EPA 1987, ER ID 57589)

EPA (US Environmental Protection Agency), April 10, 1990. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 23, 1990, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, ER ID 1585)

EPA (US Environmental Protection Agency), October 1996. "Drinking Water Regulations and Health Advisories," EPA 822-B-96-002, Office of Water, Washington, DC. (EPA 1996, ER ID 55500)

Franson, M. A. H. (Ed.), 1995. "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, Washington, DC. (Franson 1995, ER ID 56405)

Frenzel, P. F., 1995. "Geohydrology and Simulation of Groundwater Flow Near Los Alamos, North-Central New Mexico," US Geological Survey Water-Resources Investigations Report 95-4091, Albuquerque, New Mexico. (Frenzel 1995, ER ID 56028)

Janitzky, P., 1986. “Particle-size Analysis,” in *Field and Laboratory Procedures Used in a Soil Chronosequence Study*, US Geological Survey Bulletin 1648, Washington, DC, pp. 11–17. (Janitzky 1986, ER ID 57674)

LANL (Los Alamos National Laboratory), July 1995. “Statement of Work – Analytical Support,” Revision 2, RFP No. 9-XS1-Q4257, Los Alamos, New Mexico. (LANL 1995, ER ID 49738)

LANL (Los Alamos National Laboratory), October 25, 1995. “Groundwater Protection Management Program Plan” (draft), Revision 2.0, Los Alamos, New Mexico. (LANL 1995, ER ID 50124)

LANL (Los Alamos National Laboratory), November 1995. “Task/Site Work Plan for Operable Unit 1049, Los Alamos Canyon And Pueblo Canyon,” Los Alamos National Laboratory Report LA-UR-95-2053, Los Alamos, New Mexico. (LANL 1995, ER ID 50290).

LANL (Los Alamos National Laboratory), March 1996. “Quality Assurance Project Plan Requirements for Sampling and Analysis,” Los Alamos National Laboratory Report LA-UR-96-441, Los Alamos, New Mexico. (LANL 1996, ER ID 53450)

LANL (Los Alamos National Laboratory), April 1997. “Core Document for Canyons Investigations,” Los Alamos National Laboratory Report LA-UR-96-2083, Los Alamos, New Mexico. (LANL 1997, ER ID 55622)

LANL (Los Alamos National Laboratory), March 27, 1998. “Sampling and Analysis Plan for Upper Sandia Canyon,” Los Alamos National Laboratory Report LA-UR-98-4893, Los Alamos, New Mexico. (LANL 1998, ER ID 62340)

LANL (Los Alamos National Laboratory), May 22, 1998. “Hydrogeologic Workplan,” Los Alamos, New Mexico. (LANL 1998, ER ID 59599)

LANL (Los Alamos National Laboratory), September 1998. “Interim Completion Report for Characterization Well R-12,” Los Alamos National Laboratory Report LA-UR-98-3976, Los Alamos, New Mexico. (LANL 1998, ER ID 59665)

LANL (Los Alamos National Laboratory), February 9, 1999. “Draft Watershed Management Plan,” Los Alamos National Laboratory draft report, Los Alamos, New Mexico. (LANL 1999, ER ID 62920)

NMWQCC (New Mexico Water Quality Control Commission), January 23, 1995. State of New Mexico Standards for Interstate and Intrastate Streams, Report 20 NMAC 6.1, Santa Fe, New Mexico. (NMWQCC 1995, ER ID 50265)

NMWQCC (New Mexico Water Quality Control Commission), December 1, 1995. State of New Mexico Ground and Surface Water Quality Protection Regulations, Report 20 NMAC 6.2, and Utility Operator Certification Regulations, Report 20 NMAC 7.4, Santa Fe, New Mexico. (NMWQCC 1995, ER ID 54406)

Purtymun, W. D., January 1995. “Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area,” Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Ryti, R. T., P. A. Longmire, D. E. Broxton, S. L. Reneau, and E. V. McDonald, September 22, 1998. “Inorganic and Radionuclide Background Data for Soils, Canyons Sediments and Bandelier Tuff at Los Alamos National Laboratory,” Los Alamos National Laboratory Report, Los Alamos, New Mexico. (Ryti et al. 1998, ER ID 59730)

Appendix A

Maps

Appendix B

Status of PRSs

Table B-1
PRSs in the Sandia Canyon Watershed

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-001(a)	<90 day storage	Yes	1114	Remedial-Industrial	Removed from permit	
03-001(d)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(f)	<90 day storage	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(i)	Satellite accumulation area	No	1114	Remedial-Industrial		
03-001(n)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(o)	Waste container	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(p)	Satellite accumulation area	No	1114	Remedial-Industrial	Final DOE approval of permit modification	4
03-001(q)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(v)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-001(x)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-002(a)	Container storage area	Yes	1114	Remedial-Industrial	Proposed in permit modification	4
03-002(b)	Storage area	Yes - Removed	1114	Remedial-Industrial	Removed from permit	4
03-002(c)	Storage area	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-003(c)	Equipment storage area	Yes	1114	Remedial-Industrial	Proposed in permit modification	4
03-003(d)	Storage area (transformers)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA[b]	4
03-003(f)	Storage area (transformers)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-003(g)	One-time spill (transformer)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-003(m)	Storage area (capacitor banks)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-003(n)	Storage area	No	1114	Remedial-Industrial		
03-003(o)	Storage area (capacitor bank)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-006(a)	Burn site - duplicate of 61-003	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	1
03-008(b)	Firing site	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-009(a)	Surface disposal (soil fill)	Yes	1114	Remedial-Industrial	Proposed in permit modification	2
03-009(i)	Surface disposal site	Yes	1114	Remedial-Industrial	Proposed in permit modification	2

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-010(c)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
03-010(d)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification 11/28/95	2
03-012(b)	Operational release and outfall	Yes	1114	Remedial-Industrial		
03-013(a)	Operational release	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-013(b)	Operational release	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-013(c)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
03-013(d)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
03-013(e)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
03-013(f)	Operational release	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
03-014(a)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(a2)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(b)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(b2)	Outfall	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(c)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(c2)	Outfall	No	1114	Remedial-Industrial		
03-014(d)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(e)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(f)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(g)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(h)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(i)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(j)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(k)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(l)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(m)	Waste water treatment facility	Yes	1114	Remedial-Industrial		
03-014(n)	Waste water treatment facility	Yes	1114	Remedial-Industrial		
03-014(o)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(p)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-014(q)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(r)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(s)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(t)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(u)	Waste water treatment facility	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(v)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(w)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(x)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(y)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-014(z)	Waste water treatment facility	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-015	Outfall	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-016(b)	Septic system	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-016(c)	Septic system	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-016(d)	Septic system	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-016(e)	Septic system - duplicate of 3-014(s)	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	1
03-016(f)	Septic system - duplicate of 3-014(s)	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	1
03-020(a)	Disposal pit	Yes - Removed	1114	Remedial-Industrial	Removed from permit	5
03-020(b)	Surface disposal site	No	1114	Remedial-Industrial	Final DOE approval of permit modification	5
03-021	Surface disposal site	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
03-023	Sump	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-026(b)	Sumps	Yes	1114	Remedial-Industrial	Proposed in permit modification	3
03-027	Separation site	No	1114	Remedial-Industrial	Proposed for Deferral	
03-028	Surface impoundment	Yes	1114	Remedial-Industrial	AA concurrence for deferral	
03-029	Landfill	Yes	1114	Remedial-Industrial	Proposed in work plan that received a disapproval letter from AA	2
03-032	Tank and/or assoc. equipment	Yes	1114	Remedial-Industrial	Proposed in permit modification	3
03-035(a)	Underground tank	Yes - Removed	1114	Remedial-Industrial	Removed from permit	4
03-035(b)	Underground storage tank	Yes - Removed	1114	Remedial-Industrial	Removed from permit	4

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-036(a)	Aboveground tanks	Yes	1114	Remedial-Industrial	Proposed for Deferral	
03-036(b)	Aboveground tanks	No	1114	Remedial-Industrial	Proposed for Deferral	
03-036(c)	Aboveground tanks – duplicate of 3-043(f)	Yes	1114	Remedial-Industrial		1
03-036(d)	Aboveground tanks – duplicate of 3-043(g)	Yes	1114	Remedial-Industrial		1
03-036(e)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-036(f)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-036(g)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	4
03-036(h)	Aboveground tanks	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-036(i)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-038(d)	Waste lines	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-038(e)	Waste lines	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-039(a)	Silver recovery unit	Yes - Removed	1114	Remedial-Industrial	Removed from permit	3
03-039(b)	Silver recovery unit	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
03-039(d)	Silver recovery unit	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
03-039(e)	Silver recovery unit	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
03-040(b)	Storage area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-043(a)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-043(b)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
03-043(d)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
03-043(e)	Underground tank	Yes	1114	Remedial-Industrial	Proposed in permit modification	4
03-043(f)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-043(g)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-043(h)	Aboveground tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-044(a)	Container storage	Yes	1114	Remedial-Industrial	Proposed in permit modification	3
03-045(a)	Outfall (industrial or sanitary waste water treatment)	Yes	1114	Remedial-Industrial	Proposed in permit modification	4
03-045(b)	Industrial or sanitary waste water treatment	Yes	1114	Remedial-Industrial		
03-045(c)	Outfall	Yes	1114	Remedial-Industrial		
03-045(d)	Aboveground storage tank (industrial or sanitary waste water treatment)	Yes - Removed	1114	Remedial-Industrial	Removed from permit	1
03-045(e)	Outfall (industrial or sanitary waste water treatment)	Yes	1114	Remedial-Industrial	Proposed in permit modification	3
03-045(f)	Outfall from drain (industrial or sanitary waste water treatment)	Yes	1114	Remedial-Industrial	Proposed in permit modification	2
03-045(g)	Storm drain	Yes	1114	Remedial-Industrial		
03-045(h)	Outfall (industrial or sanitary waste water treatment)	Yes	1114	Remedial-Industrial	Proposed in permit modification	2
03-045(i)	Outfall (industrial or sanitary waste water treatment)	Yes	1114	Remedial-Industrial	Proposed in permit modification	2
03-046	Aboveground storage tank (physical, chemical &/or biological treatment)	Yes	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-047(a)	Storage area	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-047(b)	Storage area	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-047(c)	Drum storage	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-047(d)	Storage area	No	1114	Remedial-Industrial	Cleanup report Submitted	5
03-047(e)	Storage area	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-047(f)	Storage area	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-047(g)	Drum storage	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
03-047(h)	Storage area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-047(i)	Satellite accumulation area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-049(c)	Outfall	Yes	1114	Remedial-Industrial	Proposed in permit modification	1
03-050(c)	Exhaust emissions off-gas scrubber of HEPA filter system	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	5
03-051(c)	Soil contamination (vacuum pump leak)	No	1114	Remedial-Industrial	Cleanup report Submitted	5
03-052(b)	Storm drainage	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-052(c)	Storm drainage	Yes	1114	Remedial-Industrial	Proposed in permit modification	4
03-052(d)	Storm drainage (non PCB transformers/capacitors)	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-052(f)	Storm drainage	Yes	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
03-053	Operational facility	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
03-054(c)	Outfall	Yes	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-056(a)	Storage area	Yes	1114	Remedial-Industrial	Final AA approval of permit modification NOD Response 12/8/97	2
03-056(b)	Container storage area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-056(c)	Transformer storage area	Yes	1114	Remedial-Industrial	EC permit modification Submitted	
03-056(d)	Drum storage	Yes	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	3
03-056(h)	Transformer storage area	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
03-056(i)	Drum storage	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
03-056(k)	Container storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
03-056(l)	Drum storage	Yes	1114	Remedial-Industrial	Proposed in work plan that received a disapproval letter from AA	2
03-056(n)	Drum storage	Yes	1114	Remedial-Industrial	Proposed in permit modification	3
03-057	Sump/grease trap	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
03-059	Storage area	Yes	1114	Remedial-Industrial		

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
20-001(a)	Landfill	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
20-001(b)	Landfill	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
20-001(c)	Landfill	Yes	1100	Remedial-Industrial		
20-002(a)	Firing site	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
20-002(b)	Firing site	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
20-002(c)	Firing site	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
20-002(d)	Firing site	Yes	1100	Remedial-Industrial		
20-003(a)	Control building at a firing site	Yes	1100	Remedial-Industrial	Proposed in work plan - approved on 12/28/94	2
20-003(b)	Firing site	No	1100	Remedial-Industrial	(tentative agreement) Proposed in report/work plan, reviewed by AA	5
20-003(c)	Firing site	No	1100	Remedial-Industrial	Cleanup report Submitted	5
20-003(d)	Firing site	No	1100	Remedial-Industrial	Final DOE approval of permit modification	1
20-004	Septic system	No	1100	Remedial-Industrial	(tentative agreement) Proposed in report/work plan, reviewed by AA	5
20-005	Septic tank	Yes	1100	Remedial-Industrial	(tentative agreement) Proposed in report/work plan, reviewed by AA	5
53-001(a)	Storage area - PCB only site	Yes	1100	Remedial-Industrial	Cleanup report Submitted	5
53-001(b)	Storage area	Yes	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
53-001(c)	Storage area	No	1100	Remedial-Industrial	Proposed for Deferral	
53-001(d)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(e)	Storage area	No	1100	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	5
53-001(f)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(g)	Storage area	No	1100	Remedial-Industrial	(tentative agreement) Proposed in report/work plan, reviewed by AA	5
53-001(h)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
53-001(i)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(j)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(k)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(l)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(m)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(n)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-001(o)	Storage area	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-002(a)	Disposal lagoons (inactive) (NE, NW impoundments)	Yes	1100	Remedial-Industrial	Addendum to work plan submitted on 10/30/98. Proposed in report/work plan; originally a closure plan, status changed to corrective action and a new work plan/SAP was submitted 6/18/98.	
53-002(b)	Disposal lagoon (active) RCRA corrective action	Yes	1100	Remedial-Industrial	Addendum to work plan submitted on 10/30/98. RFI work plan due 4/30/98; originally a closure plan, status changed to corrective action and a new work plan/SAP was submitted 6/18/98.	
53-003	Septic tank	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
53-004	Operational facility	No	1100	Remedial-Industrial	Proposed in report/work plan	3
53-005	Disposal pit	Yes	1100	Remedial-Industrial		
53-006(a)	Underground tank	No	1100	Remedial-Industrial	Addendum to SAP submitted 10/30/98	
53-006(b)	Underground tank	Yes	1100	Remedial-Industrial	Addendum to SAP submitted 10/30/98	
53-006(c)	Underground tank	Yes	1100	Remedial-Industrial	Addendum to SAP submitted 10/30/98	
53-006(d)	Underground tank	Yes	1100	Remedial-Industrial	Addendum to SAP submitted 10/30/98	
53-006(e)	Underground tank	Yes	1100	Remedial-Industrial	Addendum to SAP submitted 10/30/98	
53-007(b)	Aboveground tanks (2)	Yes - Removed	1100	Remedial-Industrial	Removed from permit	3
53-008	Storage area, bone yard	No	1100	Remedial-Industrial	Reviewed for RCRA NFA; Rad/other Component must be addressed.	
53-009	Aboveground tanks (3)	No	1100	Remedial-Industrial	Proposed for Deferral	
53-010	Container storage	No	1100	Remedial-Industrial	Cleanup report Submitted	5
53-011(a)	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
53-011(d)	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
53-011(e)	Transformer - doesn’t exist	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
53-012(d)	Outfall	No	1100	Remedial-Industrial	Proposed in report/work plan, reviewed by AA	4
53-012(f)	Outfall	No	1100	Remedial-Industrial	Proposed in report/work plan, reviewed by AA	4
53-012(g)	Outfall	No	1100	Remedial-Industrial	Proposed in report/work plan, reviewed by AA	4
53-012(h)	Outfall	No	1100	Remedial-Industrial	Proposed in report/work plan, reviewed by AA	4
53-013	Soil contamination -lead storage site I	No	1100	Remedial-Industrial		
53-014	Soil contamination-lead storage site II	No	1100	Remedial-Industrial	Cleanup report submitted	5
60-001(a)	Storage area (active)	No	1114	Remedial-Industrial	Final DOE approval of permit modification	4
60-001(b)	Storage area (active)	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
60-001(c)	Storage area (active)	No	1114	Remedial-Industrial	Final DOE approval of permit modification	4
60-001(d)	Storage area, pesticide shed	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
60-002	Storage area	Yes	1114	Remedial-Industrial	Proposed in permit modification	2
60-003	Oil-water separator	No	1114	Remedial-Industrial	Final DOE approval of permit modification	3
60-004(a)	Storage area	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
60-004(b)	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
60-004(c)	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
60-004(d)	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
60-004(e)	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
60-004(f)	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
60-005(a)	Surface impoundment -formerly 3-029(a)	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
60-005(b)	Drilling mud pit	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
60-006(a)	Septic tank	Yes	1114	Remedial-Industrial		
60-006(b)	Septic system	No	1114	Remedial-Industrial	Final DOE approval of permit modification	2
60-006(c)	Septic tank	No	1114	Remedial-Industrial	Final DOE approval of permit modification	1
60-007(a)	Systematic or intentional product release	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
60-007(b)	Systematic or intentional product release	Yes	1114	Remedial-Industrial	Proposed in report/work plan	5
61-001	Storage area	No	1114	Remedial-Industrial	Final DOE approval of permit modification	1

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
61-002	Transformer storage area - PCB only site	Yes	1114	Remedial-Industrial		
61-003	Burn sites	No	1114	Remedial-Industrial	Final DOE approval of permit modification	1
61-004(a)	Septic tank	Yes	1114	Remedial-Industrial	Proposed in permit modification	1
61-004(c)	Septic tank	No	1114	Remedial-Industrial	Final DOE approval of permit modification	5
61-005	Landfill (LA county-municipal)	Yes	1114	Remedial-Industrial	AA concurrence for deferral	
61-006	Waste oil tank	Yes	1114	Remedial-Industrial	AA concurrence for deferral	
72-001	Firing range	No	1100	Remedial-Industrial	Proposed for deferral/(tentative agreement) Proposed in report/work plan, reviewed by AA	
72-002	Firing site	No	1100	Remedial-Industrial	Final DOE approval of permit modification	2
72-003(a)	Septic system	No	1100	Remedial-Industrial	Final DOE approval of permit modification	2
72-003(b)	Septic system	No	1100	Remedial-Industrial	Final DOE approval of permit modification	1
C-03-001	Gas trap	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
C-03-002	One-time spill- leak from asphalt machine	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-004	Miscellaneous debris	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	2
C-03-005	Oil spill	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	4
C-03-007	Storage area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-009	Storage area	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-011	Waste oil tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-014	Storage area	No	1114	Remedial-Industrial	Proposed in report/work plan	5
C-03-015	Underground storage tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-016	Oil metal bin	No	1114	Remedial-Industrial		
C-03-017	Underground storage tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-018	Underground storage tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	3
C-03-020	Storage tank	No	1114	Remedial-Industrial	Proposed in work plan or RFI report that received an NOD or disapproval letter from AA	4
C-03-022	Kerosene tanker trailer	No	1114	Remedial-Industrial	Proposed in work plan that received a disapproval letter from AA	2
C-20-001	Storage building	No	1100	Remedial-Industrial	Final DOE approval of permit modification	3
C-20-002	Storage building	No	1100	Remedial-Industrial		

Table B-1 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion[a]
C-20-003	Building	No	1100	Remedial-Industrial		
C-53-001	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-002	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-003	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-004	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-005	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-006	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-007	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-008	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-009	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-010	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-011	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-012	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-013	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-014	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-015	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-016	Transformer	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-018	One-time spill	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-53-019	One-time spill	No	1100	Remedial-Industrial	Final DOE approval of permit modification	4
C-60-001	Underground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	4
C-60-002	Underground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	4
C-60-003	One-time spill at pesticide shed	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	4
C-60-004	Underground tank	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	1
C-61-001	Transformer storage area- PCB leak	No	1114	Remedial-Industrial	Proposed in permit modification 9/96	1
C-61-002	Subsurface contamination - new AOC	No	1114	Remedial-Industrial		

[a] NMED (New Mexico Environment Department), March 1998. "RPMP Document Requirement Guide," Hazardous and Radioactive Materials Bureau, RCRA Permits Management Program, Santa Fe, New Mexico. (NMED 1998, 57897)

[b] AA = administrative authority.

Table B-2
PRSs in the Cañada Del Buey Watershed

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion*
4-004	Soil contamination	No	1129	Remedial-Industrial		
4-003(a)	Outfall	Yes	1129	Remedial-Industrial		
46-001	Aboveground tank	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-002	Surface impoundment	Yes	1140	Remedial-Industrial		
46-003(a)	Septic system	Yes	1140	Remedial-Industrial		
46-003(b)	Septic system	Yes	1140	Remedial-Industrial		
46-003(c)	Septic system	Yes	1140	Remedial-Industrial		
46-003(d)	Septic system	Yes	1140	Remedial-Industrial		
46-003(e)	Septic system	Yes	1140	Remedial-Industrial		
46-003(f)	Septic system	Yes	1140	Remedial-Industrial		
46-003(g)	Septic system	Yes	1140	Remedial-Industrial		
46-003(h)	Operational release	Yes	1140	Remedial-Industrial	Cleanup report submitted	5
46-004(a)	Waste line	Yes	1140	Remedial-Industrial	Proposed in permit modification	1
46-004(a2)	Outfall	Yes	1140	Remedial-Industrial		
46-004(b)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(b2)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(c)	Sump	Yes	1140	Remedial-Industrial		
46-004(c2)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(d)	Sump	Yes	1140	Remedial-Industrial		
46-004(d2)	Stack emissions	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(e)	Sump	Yes	1140	Remedial-Industrial		
46-004(e2)	Outfall from building TA-46-42	No	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(f)	Outfall	Yes	1140	Remedial-Industrial		
46-004(f2)	Outfall from building TA-46-31	No	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(g)	Outfall/stack emissions	Yes	1140	Remedial-Industrial		
46-004(h)	Outfall/stack emissions	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(i)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2
46-004(j)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2

Table B-2 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion*
46-004(k)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2
46-004(l)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2
46-004(m)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(n)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2
46-004(o)	Outfall	No	1140	Remedial-Industrial	Final DOE approval of permit modification	2
46-004(p)	Sump	Yes	1140	Remedial-Industrial		
46-004(q)	Outfall	Yes	1140	Remedial-Industrial		
46-004(r)	Outfall	Yes	1140	Remedial-Industrial		
46-004(s)	Outfall	Yes	1140	Remedial-Industrial		
46-004(t)	Outfall	Yes	1140	Remedial-Industrial		
46-004(u)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(v)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(w)	Outfall	Yes	1140	Remedial-Industrial		
46-004(x)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(y)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-004(z)	Outfall	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-005	Surface impoundment	Yes	1140	Remedial-Industrial		
46-006(a)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-006(b)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-006(c)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-006(d)	Operational release	Yes	1140	Remedial-Industrial		
46-006(e)	Surface disposal	No	1140	Remedial-Industrial	Final DOE approval of permit modification	1
46-006(f)	Storage area	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-006(g)	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-007	Operational release	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-008(a)	Storage area	Yes	1140	Remedial-Industrial		
46-008(b)	Storage area	Yes	1140	Remedial-Industrial	Proposed in report/work plan	5
46-008(c)	Storage area - doesn’t exist	Yes - Removed	1140	Remedial-Industrial	Removed from permit	1
46-008(d)	Storage area	Yes	1140	Remedial-Industrial		

Table B-2 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion*
46-008(e)	Storage area	Yes	1140	Remedial-Industrial		
46-008(f)	Storage area	Yes	1140	Remedial-Industrial		
46-008(g)	Storage area	Yes	1140	Remedial-Industrial		
46-008misc	Storage area - doesn’t exist	No	1140	Remedial-Industrial	Final DOE approval of permit modification	1
46-009(a)	Surface disposal	Yes	1140	Remedial-Industrial		
46-009(b)	Surface disposal	Yes	1140	Remedial-Industrial		
46-010(a)	Storage area	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-010(b)	Storage area	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-010(c)	Storage area	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-010(d)	Operation release satellite accumulation area	Yes	1140	Remedial-Industrial	Proposed in report/work plan	4
46-010(e)	Storage area	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-010(f)	Storage area	No	1140	Remedial-Industrial	Final DOE approval of permit modification	4
46-010misc	Storage area - doesn’t exist	No	1140	Remedial-Industrial	Final DOE approval of permit modification	1
51-001	Septic system	No	1148	MDA		
51-002(a)	Usage site (Environmental Research Caisson)	No	1148	MDA	Final DOE approval of permit modification	2
51-002(b)	Usage site (Environmental Research Caisson)	No	1148	MDA	Final DOE approval of permit modification	2
52-001(a)	UHTREX equip.	Yes - Removed	1129	Remedial-Industrial	Removed from permit	2
52-001(b)	UHTREX equip.	Yes - Removed	1129	Remedial-Industrial	Removed from permit	2
52-001(c)	UHTREX equip.	Yes - Removed	1129	Remedial-Industrial	Removed from permit	2
52-001(d)	UHTREX equip.	Yes	1129	Remedial-Industrial	Proposed in permit modification	5
52-002(b)	Septic system	Yes - Removed	1129	Remedial-Industrial	Removed from permit	2
52-002(c)	Septic system - doesn’t exist	Yes - Removed	1129	Remedial-Industrial	Removed from permit	1
52-002(d)	Septic system - doesn’t exist	Yes - Removed	1129	Remedial-Industrial	Removed from permit	1
52-002(e)	Septic system with 63-001(a)	Yes - Removed	1129	Remedial-Industrial	Removed from permit	1
52-002(f)	Septic system	Yes - Removed	1129	Remedial-Industrial	Removed from permit	2
52-002(g)	Septic system	No	1129	Remedial-Industrial	Final DOE approval of permit modification	2
52-003(a)	Waste treatment facility	No	1129	Remedial-Industrial		

Table B-2 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion*
52-003(b)	Industrial waste line	No	1129	Remedial-Industrial	Final DOE approval of permit modification	5
52-004	Evaporator	No	1129	Remedial-Industrial	Final DOE approval of permit modification	2
54-001(a)	Storage area surface	Yes	1148	MDA		
54-001(b)	Storage area	No	1148	MDA		
54-001(c)	Storage area	Yes - Removed	1148	MDA	Removed from permit	2
54-001(d)	Storage area	No	1148	MDA		
54-001(e)	Storage area	No	1148	MDA		
54-001(f)	Storage area	No	1148	MDA	Final DOE approval of permit modification	2
54-002	Storage area (gas cylinder storage area)	No	1148	MDA		
54-005	Material disposal area (MDA J) (Pits 1-5, Shafts 1-4)	Yes	1148	MDA		
54-006	Material disposal area (MDA L) (All subsurface units such as Pit A, SI B,C,D Shafts 1-28, 29-34)	Yes	1148	MDA		
54-007(a)	Septic system (tank and seepage trench)	Yes	1148	MDA		
54-007(b)	Septic system	Yes	1148	MDA	Proposed in permit modification - additional info was provided on this PRS (response on 4/25/97)	2
54-007(c)	Septic system	Yes	1148	MDA		
54-007(d)	Septic system	No	1148	MDA		
54-007(e)	Septic system	No	1148	MDA		
54-008	Underground tank	No	1148	MDA	Final DOE approval of permit modification	2
54-009	Aboveground tanks (treatment tanks)	No	1148	MDA		
54-010	Underground tank (supply wash-water tank)	No	1148	MDA	Final DOE approval of permit modification	2
54-012(a)	Reduction site (drum compactor)	No	1148	MDA		
54-012(b)	Reduction site	Yes	1148	MDA		
54-013(a)	Decontamination facility (not built)	Yes - Removed	1148	MDA	Removed from permit	1
54-014(a)	Material disposal area (MDA L) storage shafts (Pb stringer shafts)	No	1148	MDA		

Table B-2 (continued)

PRS No.	Description	HSWA	OU	Focus Area	NFA Status	NFA Criterion*
54-015(a)	Storage area (active surface corrosive inhibitor)	No	1148	MDA		
54-015(b)	Storage area (TRU surface storage)	No	1148	MDA		
54-015(c)	Storage area, TRU Pad 1	No	1148	MDA		
54-015(d)	Storage area, TRU Pad 2	No	1148	MDA		
54-015(e)	Storage area, TRU Pad 3	No	1148	MDA		
54-015(f)	Storage area, TRU Pad 4	No	1148	MDA		
54-015(g)	Storage area (Pb casks near shaft 4)	No	1148	MDA	Final DOE approval of permit modification	3
54-015(h)	Storage area(drums)	Yes	1148	MDA	RFI Report approved by NMED on 9/23/97.Proposed in permit modification - additional info was provided on this PRS (response on 4/25/97)	3
54-015(i)	Storage area-forklift battery	No	1148	MDA	Final DOE approval of permit modification	3
54-015(j)	Storage area (Dome #49, mixed waste sludge)	No	1148	MDA		
54-015(k)	Storage area (TRU waste mound)	Yes	1148	MDA		
54-016(a)	Sump	No	1148	MDA	Final DOE approval of permit modification	3
54-016(b)	Sump	No	1148	MDA		
54-021	Aboveground oil storage tanks (6)	No	1148	MDA	Final DOE approval of permit modification	5
54-022	Transformer spill (PCB)	No	1148	MDA	Final DOE approval of permit modification	5
C-04-001	Former building location	No	1129	Remedial-Industrial	Final DOE approval of permit modification	3
C-46-001	One-time spill	No	1140	Remedial-Industrial		
C-46-002	Stack emissions	No	1140	Remedial-Industrial	Proposed in report/work plan	5
C-46-003	Stack emissions	No	1140	Remedial-Industrial	Proposed in report/work plan	5

* NMED (New Mexico Environment Department), March 1998. "RPMP Document Requirement Guide," Hazardous and Radioactive Materials Bureau, RCRA Permits Management Program, Santa Fe, New Mexico. (NMED 1998, 57897)

No Further Action (NFA) Proposal Criteria

NFA Criterion 1	The solid waste management unit/area of concern (SWMU/AOC) cannot be located, does not exist or is a duplicate SWMU/AOC.
NFA Criterion 2	The SWMU/AOC has never been used for the management (i.e., generation, treatment, storage and/or disposal) of Resource Conservation and Recovery Act (RCRA) solid waste or hazardous wastes and/or constituents or other Comprehensive Environmental Response, Conservation, and Liability Act (CERCLA) hazardous substances.
NFA Criterion 3	No release to the environment has occurred or is likely to occur in the future from the SWMU/AOC.
NFA Criterion 4	A release from the SWMU/AOC to the environment has occurred, but the SWMU/AOC was characterized and/or remediated under another authority (such as the New Mexico Environment Department’s Underground Storage Tank Bureau or Ground Water Quality Bureau), which adequately addressed RCRA corrective action, and documentation (such as a closure letter) is available.
NFA Criterion 5	The SWMU/AOC has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use.

Appendix C

Data for Wells, Boreholes, and Moisture Access Tubes in Sandia Canyon

Table C-1
Summary and Status of Sandia Canyon Wells, Boreholes, and Moisture Access Tubes

Hole ID	ER ID	Date Completed	Total Depth (ft)	Depth Completed (ft)	Location	Current Status	Well Comment
53-TH-1	None	7/15/91	49	46	TA-53	Active monitor hole	Moisture access tube
53-TH-2	None	7/15/91	49	46	TA-53	Active monitor hole	Moisture access tube
53-TH-3	None	7/15/91	49	48	TA-53	Active monitor hole	Moisture access tube
53-TH-4	None	7/15/91	49	47	TA-53	Active monitor hole	Moisture access tube
53-TH-5	None	7/15/91	100	93.5	TA-53	Active monitor hole	Pore gas hole
53-TH-6	None	7/15/91	150	0	TA-53	Active monitor hole	Open hole
53-TH-7	None	7/15/91	80	77	TA-53 Sandia Canyon	Active monitor hole	Lysimeter port at 37 ft
53-TH-B	None	7/15/91	49	48	TA-53	Active monitor hole	Moisture access tube
EGH-LA-1	None	7/31/79	2292	0	Sigma Mesa	Plugged and abandoned	Geothermal test on Sigma Mesa
PM-1	None	2/1/65	2501	2499	Lower Sandia Canyon	Producing supply well	Pajarito Mesa well field
PM-3	None	11/1/66	2552	2552	Lower Sandia Canyon	Producing supply well	Pajarito Mesa well field
R-12	None	6/8/98	847	847	Lower Sandia Canyon	Temporary monitor well	Regional aquifer monitor well
SCO-1	None	8/14/89	79	20	Lower Sandia Canyon	Active monitor well	Sandia Canyon alluvial monitor well
SCO-1-old	None	7/1/66	20	20	Lower Sandia Canyon	Plugged and abandoned	SCO-3, Well damaged and replaced with SCO-1
SCO-2	None	8/16/89	29	20	Lower Sandia Canyon	Active monitor well	Sandia Canyon alluvial monitor well
SCO-2-old	None	7/1/66	20	20	Lower Sandia Canyon	Plugged and abandoned	SCO-4, Well damaged and replaced with SCO-2
SCOI-3	None	5/10/96	132.5	0	Lower Sandia Canyon	Plugged and abandoned	Well replaced by R-12
SHB-2	None	1/1/92	200	0	TA-3	3-in. tubing w/water	Seismic hazards borehole
60-SM-19	None	10/31/83	108	20	Sigma Mesa	Open boreholes	Two boreholes for rack alignment

Table C-2
Coordinates for Sandia Canyon Wells and Boreholes

Site ID	Easting (ft)	Northing (ft)	Elevation (ft)	Land Surface Datum Measuring Point	Coordinate Source	Coordinate Confidence	Coordinate Comment
53-TH-1	1639400	1771140	6916.6	Ground	FIMAD*	Good	Located on mesa at TA-53
53-TH-2	1639780	1771250	6919.5	Ground	FIMAD	Good	Located on mesa at TA-53
53-TH-3	1639970	1770810	6910.9	Ground	FIMAD	Good	Located on mesa at TA-53
53-TH-4	1639990	1771040	6910.1	Ground	FIMAD	Good	Located on mesa at TA-53
53-TH-5	1639700	1770980	6920.3	Ground	FIMAD	Good	Located on mesa at TA-53
53-TH-6	1639700	1771080	6921.2	Ground	FIMAD	Good	Located on mesa at TA-53
53-TH-7	1639350	1770510	6701	Ground	FIMAD	Good	Located in Sandia Canyon
53-TH-B	1638980	1771150	6920.7	Ground	FIMAD	Good	Located on mesa at TA-53
EGH-LA-1	1628830	1770620	7215	Ground	FIMAD	Good	Located on Sigma Mesa
PM-1	1647734.3	1768112.1	6520	Ground	FIMAD	Good	Lower Sandia Canyon
PM-3	1642590	1769530	6640	Ground	FIMAD	Good	Lower Sandia Canyon
R-12	1647427.3	1767907.1	6500.78	Ground	LANL 1998, 59665	Good	Elevation is that of adjacent SCOI-3
SCO-1	1642297.6	1769502.3	6618.67	Ground	FIMAD	Good	Near PM-3
SCO-1-old	1642300	1769500	6620	Ground	Estimated	Approximate	Former SCO-1 and SCO-3
SCO-2	1647259	1767864	6500.67	Ground	FIMAD	Good	Near R-12
SCO-2-old	1647260	1767860	6500	Ground	Estimated	Approximate	Former SCO-2 and SCO-4
SCOI-3	1647442.1	1767903	6500.78	Ground	LANL 1998, 59665	Good	Surveyed coordinates
SHB-2	1617643	1773155	7436	Ground	FIMAD	Good	Located on mesa at TA-3
60-SM-19	1623260	1771960	7330	Ground	FIMAD	Good	Located on Sigma Mesa

*FIMAD = Facility for Information Management, Analysis, and Display.

Table C-3
Casing Construction Information for Sandia Canyon Wells and Boreholes

Hole ID	Tubing Type	Tubing Diameter (in.)	Top of Tubing (ft)	Measuring Point	Surface Casing Type	Surface Casing Diameter (in.)	Casing Source	Casing Comment
53-TH-1	Aluminum	2	N.A.[a]	N.A.	None		Purtymun 1995, 45344	2-in. 0–46 ft
53-TH-2	Aluminum	2	N.A.	N.A.	None		Purtymun 1995, 45344	2-in. 0–46 ft
53-TH-3	Aluminum	2	N.A.	N.A.	None		Purtymun 1995, 45344	2-in. 0–48 ft
53-TH-4	Aluminum	2	N.A.	N.A.	None		Purtymun 1995, 45344	2-in. 0–47 ft
53-TH-5	Aluminum	1		GL[b]	Aluminum	4	Purtymun 1995, 45344	4-in. 0–4 ft, pore gas tubing 0–93.5 ft (5 ports)
53-TH-6	None		N.A.	N.A.	None		Purtymun 1995, 45344	Open hole, no casing
53-TH-7	Aluminum	2	N.A.	N.A.	None		Purtymun 1995, 45344	2-in. 0–77 ft
53-TH-B	Aluminum	2	N.A.	N.A.	None		Purtymun 1995, 45344	2-in. 0–45 ft
60-SM-19	None				CMP[c]	122	Purtymun 1995, 45344, p. 297	122-in.-diameter casing 0–20 ft
EGH-LA-1	Steel	20	N.A.	N.A.	Steel	30	Purtymun 1995, 45344	30-in. 0–85, 20-in. 0–1627
PM-1	Steel	12	0	TOC[d]	Steel	24	Purtymun 1995, 45344	24-in. 0–474, 12-in. 0–2499
PM-3	Steel	14			Steel	26	Purtymun 1995, 45344	26-in. 0–552, 14-in. 0–2552
R-12	PVC	4	N.A.	Temp	Steel	16	LANL 1998, 59665	16-in. 0–20, 14-in. 0–449, 10.75-in. 0–520.5, 8-5/8-in. 0–790, PVC[e] 0–829
SCO-1	PVC	2	0.66	TOT[f]	Steel	8.625	Purtymun and Stoker 1990, 7508	2-in. to 19.3 ft
SCO-1-old	Plastic	2			None		Purtymun 1995, 45344	2-in. to 20 ft, plugged and abandoned
SCO-2	PVC	2	0.85	TOT	Steel	8.625	Purtymun and Stoker 1990, 7508	2-in. to 19.4 ft
SCO-2-old	Plastic	2	n/a[g]	n/a	None		Purtymun 1995, 45344	2-in. to 20 ft, plugged and abandoned
SCOI-3	None		n/a	n/a	Steel	16	LANL 1998, 59665	16-in. to 25 ft, plugged and abandoned
SHB-2	PVC	3	N.A.	N.A.	Steel	8	Gardner et al. 1993, 12582	3-in. tubing filled with water

[a] N.A. = not available.
[b] GL = ground level.
[c] CMP = corrugated metal pipe.
[d] TOC = top of casing.
[e] TOT = top of tubing.
[f] PVC = polyvinyl chloride.
[g] n/a = not applicable.

Table C-4
Screen Interval Information for Sandia Canyon Wells

Hole ID	Top of Screen (ft)	Bottom of Screen (ft)	Perf Size (in.)	Annulus Pack	Sump Length (ft)	Screen Source	Screen Comment
53-TH-1							No screened interval
53-TH-2							No screened interval
53-TH-3							No screened interval
53-TH-4							No screened interval
53-TH-5	20	93.5		Sand		Purtymun 1995, 45344	Ports at 20, 40, 60, 80, 93.5 ft
53-TH-6							No screened interval
53-TH-7	37	39		Fine silica sand		Purtymun 1995, 45344	Lysimeter port at 37 ft
53-TH-B							No screened interval
EGH-LA-1							No screened interval
PM-1	945	2479		Gravel	20	Purtymun 1995, 45344	Louvers from 945 to 2479 ft
PM-3	956	2532		Gravel	20	Purtymun 1995, 45344	Louvers from 956 to 2532 ft
R-12	800	820	0.010	30–70 grade sand	10.5	LANL 1998, 59665	Temporary completion
SCO-1	9.3	19.3	0.010	0.010–0.020 sand	0	Purtymun 1995, 45344	New well installed 8/89
SCO-1-old	10	20		Cuttings?	0	Purtymun 1995, 45344	Former SCO-1
SCO-2	8.4	18.4	0.010	0.010–0.020 sand	0	Purtymun 1995, 45344	New well installed 8/89
SCO-2-old	10	20		Cuttings?	0	Purtymun 1995, 45344	Former SCO-2
SCOI-3							Plugged and abandoned, no screened interval
SHB-2							No screened interval
60-SM-19							No screened interval

Table C-5
Average Daily Groundwater Elevation of the R-12 Regional Zone of Saturation

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
6/16/98	5695.94	5695.79	7.41	812.25	6500.78
6/17/98	5695.84	5695.79	7.31	812.25	6500.78
6/18/98	5695.66	5695.79	7.13	812.25	6500.78
6/19/98	5695.72	5695.79	7.19	812.25	6500.78
6/20/98	5695.80	5695.79	7.27	812.25	6500.78
6/21/98	5695.78	5695.81	7.25	812.25	6500.78
6/22/98	5695.75	5695.80	7.22	812.25	6500.78
6/23/98	5695.83	5695.80	7.30	812.25	6500.78
6/24/98	5695.87	5695.82	7.34	812.25	6500.78
6/25/98	5695.85	5695.82	7.32	812.25	6500.78
6/26/98	5695.86	5695.82	7.33	812.25	6500.78
6/27/98	5695.88	5695.82	7.35	812.25	6500.78
6/28/98	5695.82	5695.82	7.29	812.25	6500.78
6/29/98	5695.80	5695.82	7.27	812.25	6500.78
6/30/98	5695.80	5695.81	7.27	812.25	6500.78
7/1/98	5695.75	5695.81	7.22	812.25	6500.78
7/2/98	5695.77	5695.80	7.24	812.25	6500.78
7/3/98	5695.80	5695.80	7.27	812.25	6500.78
7/4/98	5695.79	5695.79	7.26	812.25	6500.78
7/5/98	5695.80	5695.79	7.27	812.25	6500.78
7/6/98	5695.82	5695.80	7.29	812.25	6500.78
7/7/98	5695.80	5695.81	7.27	812.25	6500.78
7/8/98	5695.80	5695.81	7.27	812.25	6500.78
7/9/98	5695.79	5695.82	7.26	812.25	6500.78
7/10/98	5695.82	5695.83	7.29	812.25	6500.78
7/11/98	5695.82	5695.82	7.29	812.25	6500.78
7/12/98	5695.84	5695.81	7.31	812.25	6500.78
7/13/98	5695.86	5695.82	7.33	812.25	6500.78
7/14/98	5695.89	5695.83	7.36	812.25	6500.78
7/15/98	5695.84	5695.84	7.31	812.25	6500.78
7/16/98	5695.71	5695.86	7.18	812.25	6500.78
7/17/98	5695.76	5695.86	7.23	812.25	6500.78
7/18/98	5695.87	5695.87	7.34	812.25	6500.78
7/19/98	5695.94	5695.87	7.41	812.25	6500.78
7/20/98	5695.93	5695.87	7.40	812.25	6500.78
7/21/98	5695.94	5695.87	7.41	812.25	6500.78
7/22/98	5695.92	5695.88	7.39	812.25	6500.78
7/23/98	5695.89	5695.89	7.36	812.25	6500.78

Note: The existing alluvial groundwater monitoring wells were dry when checked by ESH-18 personnel.

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
7/24/98	5695.88	5695.90	7.35	812.25	6500.78
7/25/98	5695.86	5695.90	7.33	812.25	6500.78
7/26/98	5695.83	5695.89	7.30	812.25	6500.78
7/27/98	5695.83	5695.88	7.30	812.25	6500.78
7/28/98	5695.89	5695.87	7.36	812.25	6500.78
7/29/98	5695.96	5695.87	7.43	812.25	6500.78
7/30/98	5695.94	5695.86	7.41	812.25	6500.78
7/31/98	5695.85	5695.86	7.32	812.25	6500.78
8/1/98	5695.80	5695.86	7.27	812.25	6500.78
8/2/98	5695.84	5695.88	7.31	812.25	6500.78
8/3/98	5695.89	5695.88	7.36	812.25	6500.78
8/4/98	5695.80	5695.87	7.27	812.25	6500.78
8/5/98	5695.78	5695.87	7.25	812.25	6500.78
8/6/98	5695.90	5695.87	7.37	812.25	6500.78
8/7/98	5696.00	5695.87	7.47	812.25	6500.78
8/8/98	5695.94	5695.87	7.41	812.25	6500.78
8/9/98	5695.87	5695.87	7.34	812.25	6500.78
8/10/98	5695.87	5695.89	7.34	812.25	6500.78
8/11/98	5695.88	5695.92	7.35	812.25	6500.78
8/12/98	5695.84	5695.92	7.31	812.25	6500.78
8/13/98	5695.82	5695.92	7.29	812.25	6500.78
8/14/98	5695.92	5695.92	7.39	812.25	6500.78
8/15/98	5696.02	5695.92	7.49	812.25	6500.78
8/16/98	5696.03	5695.91	7.50	812.25	6500.78
8/17/98	5695.98	5695.92	7.45	812.25	6500.78
8/18/98	5695.97	5695.93	7.44	812.25	6500.78
8/19/98	5695.94	5695.96	7.41	812.25	6500.78
8/20/98	5695.85	5695.96	7.32	812.25	6500.78
8/21/98	5695.82	5695.96	7.29	812.25	6500.78
8/22/98	5695.91	5695.96	7.38	812.25	6500.78
8/23/98	5696.01	5695.94	7.48	812.25	6500.78
8/24/98	5696.07	5695.93	7.54	812.25	6500.78
8/25/98	5696.02	5695.93	7.49	812.25	6500.78
8/26/98	5696.01	5695.94	7.48	812.25	6500.78
8/27/98	5695.96	5695.96	7.43	812.25	6500.78
8/28/98	5695.81	5695.97	7.28	812.25	6500.78
8/29/98	5695.81	5695.97	7.28	812.25	6500.78
8/30/98	5695.94	5695.96	7.41	812.25	6500.78
8/31/98	5696.01	5695.95	7.48	812.25	6500.78
9/1/98	5695.99	5695.94	7.46	812.25	6500.78

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
9/2/98	5696.01	5695.94	7.48	812.25	6500.78
9/3/98	5696.03	5695.96	7.50	812.25	6500.78
9/4/98	5695.96	5695.98	7.43	812.25	6500.78
9/5/98	5695.92	5695.98	7.39	812.25	6500.78
9/6/98	5695.93	5695.98	7.40	812.25	6500.78
9/7/98	5695.97	5695.99	7.44	812.25	6500.78
9/8/98	5696.03	5696.00	7.50	812.25	6500.78
9/9/98	5696.00	5696.00	7.47	812.25	6500.78
9/10/98	5695.98	5695.99	7.45	812.25	6500.78
9/11/98	5696.01	5695.99	7.48	812.25	6500.78
9/12/98	5696.05	5695.99	7.52	812.25	6500.78
9/13/98	5696.12	5696.00	7.59	812.25	6500.78
9/14/98	5696.04	5696.01	7.51	812.25	6500.78
9/15/98	5695.89	5696.03	7.36	812.25	6500.78
9/16/98	5695.90	5696.03	7.37	812.25	6500.78
9/17/98	5695.95	5696.03	7.42	812.25	6500.78
9/18/98	5696.04	5696.02	7.51	812.25	6500.78
9/19/98	5696.18	5696.01	7.65	812.25	6500.78
9/20/98	5696.15	5696.02	7.62	812.25	6500.78
9/21/98	5696.06	5696.03	7.53	812.25	6500.78
9/22/98	5695.94	5696.03	7.41	812.25	6500.78
9/23/98	5695.98	5696.03	7.45	812.25	6500.78
9/24/98	5696.02	5696.03	7.49	812.25	6500.78
9/25/98	5696.11	5696.01	7.58	812.25	6500.78
9/26/98	5696.05	5696.00	7.52	812.25	6500.78
9/27/98	5695.92	5696.01	7.39	812.25	6500.78
9/28/98	5695.94	5696.01	7.41	812.25	6500.78
9/29/98	5695.97	5696.01	7.44	812.25	6500.78
9/30/98	5696.00	5696.01	7.47	812.25	6500.78
10/1/98	5695.98	5696.01	7.45	812.25	6500.78
10/15/98	5695.84	5695.62	8.06	813.00	6500.78
10/16/98	5695.82	5695.62	8.04	813.00	6500.78
10/17/98	5695.59	5695.62	7.81	813.00	6500.78
10/18/98	5695.52	5695.62	7.74	813.00	6500.78
10/19/98	5695.55	5695.62	7.77	813.00	6500.78
10/20/98	5695.56	5695.65	7.78	813.00	6500.78
10/21/98	5695.48	5695.65	7.70	813.00	6500.78
10/22/98	5695.47	5695.66	7.69	813.00	6500.78
10/23/98	5695.66	5695.69	7.88	813.00	6500.78
10/24/98	5695.74	5695.72	7.96	813.00	6500.78

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
10/25/98	5695.88	5695.76	8.10	813.00	6500.78
10/26/98	5695.91	5695.79	8.13	813.00	6500.78
10/27/98	5695.87	5695.83	8.09	813.00	6500.78
10/28/98	5695.90	5695.88	8.12	813.00	6500.78
10/29/98	5695.93	5695.91	8.15	813.00	6500.78
10/30/98	5695.97	5695.92	8.19	813.00	6500.78
10/31/98	5695.92	5695.92	8.14	813.00	6500.78
11/1/98	5695.92	5695.93	8.14	813.00	6500.78
11/2/98	5695.99	5695.93	8.21	813.00	6500.78
11/3/98	5695.92	5695.93	8.14	813.00	6500.78
11/4/98	5695.87	5695.95	8.09	813.00	6500.78
11/5/98	5695.90	5695.94	8.12	813.00	6500.78
11/6/98	5696.01	5695.92	8.23	813.00	6500.78
11/7/98	5695.86	5695.90	8.08	813.00	6500.78
11/8/98	5695.92	5695.88	8.14	813.00	6500.78
11/9/98	5696.21	5695.87	8.43	813.00	6500.78
11/10/98	5695.82	5695.86	8.04	813.00	6500.78
11/11/98	5695.73	5695.86	7.95	813.00	6500.78
11/12/98	5695.71	5695.85	7.93	813.00	6500.78
11/13/98	5695.73	5695.86	7.95	813.00	6500.78
11/14/98	5695.76	5695.85	7.98	813.00	6500.78
11/15/98	5695.84	5695.81	8.06	813.00	6500.78
11/16/98	5695.87	5695.81	8.09	813.00	6500.78
11/17/98	5695.93	5695.82	8.15	813.00	6500.78
11/18/98	5695.95	5695.82	8.17	813.00	6500.78
11/19/98	5695.86	5695.83	8.08	813.00	6500.78
11/20/98	5695.75	5695.83	7.97	813.00	6500.78
11/21/98	5695.77	5695.83	7.99	813.00	6500.78
11/22/98	5695.84	5695.83	8.06	813.00	6500.78
11/23/98	5695.73	5695.84	7.95	813.00	6500.78
11/24/98	5695.85	5695.85	8.07	813.00	6500.78
11/25/98	5695.79	5695.85	8.01	813.00	6500.78
11/26/98	5695.78	5695.85	8.00	813.00	6500.78
11/27/98	5695.86	5695.87	8.08	813.00	6500.78
11/28/98	5696.01	5695.89	8.23	813.00	6500.78
11/29/98	5696.14	5695.92	8.36	813.00	6500.78
11/30/98	5695.77	5695.95	7.99	813.00	6500.78
12/1/98	5695.79	5695.98	8.01	813.00	6500.78
12/2/98	5695.96	5696.00	8.18	813.00	6500.78
12/3/98	5696.12	5695.99	8.34	813.00	6500.78

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
12/4/98	5696.07	5695.98	8.29	813.00	6500.78
12/5/98	5696.14	5695.94	8.36	813.00	6500.78
12/6/98	5696.18	5695.93	8.40	813.00	6500.78
12/7/98	5695.94	5695.93	8.16	813.00	6500.78
12/8/98	5695.80	5695.90	8.02	813.00	6500.78
12/9/98	5695.90	5695.87	8.12	813.00	6500.78
12/10/98	5695.65	5695.85	7.87	813.00	6500.78
12/11/98	5695.73	5695.82	7.95	813.00	6500.78
12/12/98	5695.74	5695.79	7.96	813.00	6500.78
12/13/98	5695.67	5695.82	7.89	813.00	6500.78
12/14/98	5695.79	5695.85	8.01	813.00	6500.78
12/15/98	5695.79	5695.88	8.01	813.00	6500.78
12/16/98	5695.77	5695.91	7.99	813.00	6500.78
12/17/98	5695.89	5695.93	8.11	813.00	6500.78
12/18/98	5696.26	5695.95	8.48	813.00	6500.78
12/19/98	5696.17	5695.96	8.39	813.00	6500.78
12/20/98	5696.20	5695.96	8.42	813.00	6500.78
12/21/98	5696.03	5695.97	8.25	813.00	6500.78
12/22/98	5695.92	5695.99	8.14	813.00	6500.78
12/23/98	5695.99	5695.99	8.21	813.00	6500.78
12/24/98	5695.79	5695.96	8.01	813.00	6500.78
12/25/98	5695.77	5695.94	7.99	813.00	6500.78
12/26/98	5695.92	5695.93	8.14	813.00	6500.78
12/27/98	5695.95	5695.94	8.17	813.00	6500.78
12/28/98	5695.91	5695.95	8.13	813.00	6500.78
12/29/98	5695.88	5695.95	8.10	813.00	6500.78
12/30/98	5696.01	5695.95	8.23	813.00	6500.78
12/31/98	5696.02	5695.96	8.24	813.00	6500.78
1/1/99	5696.21	5695.95	8.43	813.00	6500.78
1/2/99	5696.03	5695.96	8.25	813.00	6500.78
1/3/99	5695.93	5695.98	8.15	813.00	6500.78
1/4/99	5695.79	5695.97	8.01	813.00	6500.78
1/5/99	5695.86	5695.96	8.08	813.00	6500.78
1/6/99	5695.89	5695.95	8.11	813.00	6500.78
1/7/99	5696.04	5695.95	8.26	813.00	6500.78
1/8/99	5696.08	5695.95	8.30	813.00	6500.78
1/9/99	5695.85	5695.93	8.07	813.00	6500.78
1/10/99	5695.85	5695.95	8.07	813.00	6500.78
1/11/99	5695.96	5695.98	8.18	813.00	6500.78
1/12/99	5696.20	5696.00	8.42	813.00	6500.78

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
1/13/99	5695.98	5695.99	8.20	813.00	6500.78
1/14/99	5695.78	5695.98	8.00	813.00	6500.78
1/15/99	5696.02	5696.01	8.24	813.00	6500.78
1/16/99	5696.16	5696.06	8.38	813.00	6500.78
1/17/99	5696.09	5696.08	8.31	813.00	6500.78
1/18/99	5695.93	5696.05	8.15	813.00	6500.78
1/19/99	5696.00	5696.05	8.22	813.00	6500.78
1/20/99	5696.15	5696.06	8.37	813.00	6500.78
1/21/99	5696.43	5696.07	8.65	813.00	6500.78
1/22/99	5696.10	5696.06	8.32	813.00	6500.78
1/23/99	5695.95	5696.06	8.17	813.00	6500.78
1/24/99	5695.89	5696.06	8.11	813.00	6500.78
1/25/99	5695.91	5696.06	8.13	813.00	6500.78
1/26/99	5696.13	5696.04	8.35	813.00	6500.78
1/27/99	5696.08	5696.01	8.30	813.00	6500.78
1/28/99	5696.07	5695.99	8.29	813.00	6500.78
1/29/99	5695.99	5696.01	8.21	813.00	6500.78
1/30/99	5695.92	5696.02	8.14	813.00	6500.78
1/31/99	5695.97	5696.03	8.19	813.00	6500.78
2/1/99	5696.05	5696.02	8.27	813.00	6500.78
2/2/99	5695.96	5696.02	8.18	813.00	6500.78
2/3/99	5696.09	5696.02	8.31	813.00	6500.78
2/4/99	5696.00	5696.02	8.22	813.00	6500.78
2/5/99	5696.05	5696.06	8.27	813.00	6500.78
2/6/99	5696.05	5696.06	8.27	813.00	6500.78
2/7/99	5696.05	5696.02	8.27	813.00	6500.78
2/8/99	5696.08	5696.01	8.30	813.00	6500.78
2/9/99	5696.02	5696.01	8.24	813.00	6500.78
2/10/99	5696.33	5696.03	8.55	813.00	6500.78
2/11/99	5695.93	5696.04	8.15	813.00	6500.78
2/12/99	5695.68	5696.06	7.90	813.00	6500.78
2/13/99	5695.80	5696.07	8.02	813.00	6500.78
2/14/99	5696.08	5696.09	8.30	813.00	6500.78
2/15/99	5696.25	5696.09	8.47	813.00	6500.78
2/16/99	5696.14	5696.06	8.36	813.00	6500.78
2/17/99	5696.25	5696.08	8.47	813.00	6500.78
2/18/99	5696.22	5696.11	8.44	813.00	6500.78
2/19/99	5696.27	5696.14	8.49	813.00	6500.78
2/20/99	5696.02	5696.14	8.24	813.00	6500.78
2/21/99	5696.00	5696.15	8.22	813.00	6500.78

Table C-5 (continued)

Date*	GW Elevation	10-Day Average	Avg. Daily Reading	Transducer Datum	Surface Elevation
2/22/99	5696.18	5696.15	8.40	813.00	6500.78
2/23/99	5696.02	5696.13	8.24	813.00	6500.78
2/24/99	5696.06	5696.13	8.28	813.00	6500.78
2/25/99	5696.18	5696.13	8.40	813.00	6500.78
2/26/99	5696.28	5696.15	8.50	813.00	6500.78
2/27/99	5696.15	5696.19	8.37	813.00	6500.78
2/28/99	5696.09	5696.20	8.31	813.00	6500.78
3/1/99	5696.21	5696.22	8.43	813.00	6500.78
3/2/99	5696.22	5696.24	8.44	813.00	6500.78
3/3/99	5696.27	5696.26	8.49	813.00	6500.78
3/4/99	5696.46	5696.26	8.68	813.00	6500.78
3/5/99	5696.33	5696.27	8.55	813.00	6500.78
3/6/99	5696.14	5696.30	8.36	813.00	6500.78
3/7/99	5696.36	5696.31	8.58	813.00	6500.78
3/8/99	5696.39	5696.32	8.61	813.00	6500.78

*Transducer was removed from well for sampling October 2 to October 15.

Table C-6
Stratigraphic Information from Sandia Canyon Wells and Boreholes

Hole ID	Formation	Purtymun 1995, 45344		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
SCO-1	Alluvium	0	18			6618.7	6600.7	6618.7	Purtymun 1995, 45344	
SCO-1	Tuff	18	79			6600.7	6539.7	6618.7	Purtymun 1995, 45344	Otowi Member
SCO-2	Alluvium	0	18	0	15	6500.7	6485.7	6500.7	Purtymun 1995, 45344	
SCO-2	Cerro Toledo			15	18	6485.7	6482.7	6500.7		Revised based on lithology
SCO-2	Tuff	18	29	18	29	6482.7	6471.7	6500.7	Purtymun 1995, 45344	
EGH-LA	Tshirege	0	345			7215	6870	7215	Purtymun 1995, 45344	
EGH-LA	Otowi	345	695			6870	6520	7215	Purtymun 1995, 45344	
EGH-LA	Guaje	695	725			6520	6490	7215	Purtymun 1995, 45344	
EGH-LA	Puye-fanglomerate	725	1305			6490	5910	7215	Purtymun 1995, 45344	
EGH-LA	Basalt Unit 2	910	1050			6305	6165	7215	Purtymun 1995, 45344	
EGH-LA	Puye-Totavi Lentil	1305	1330			5910	5885	7215	Purtymun 1995, 45344	
EGH-LA	Puye-Chaquehui	1330	1895			5885	5320	7215	Purtymun 1995, 45344	
EGH-LA	Basalt Unit 1	1580	2292			5635	4923	7215	Purtymun 1995, 45344	
PM-1	Otowi	0	120			6520	6400	6520	Purtymun 1995, 45344	
PM-1	Guaje	120	165			6400	6355	6520	Purtymun 1995, 45344	
PM-1	Basalt Unit 3	165	507			6355	6013	6520	Purtymun 1995, 45344	
PM-1	Puye-old alluvium	507	550			6013	5970	6520	Purtymun 1995, 45344	
PM-1	Puye-fanglomerate	550	775			5970	5745	6520	Purtymun 1995, 45344	
PM-1	Puye-Totavi Lentil	775	795			5745	5725	6520	Purtymun 1995, 45344	
PM-1	Puye-Chaquehui	795	1798			5725	4722	6520	Purtymun 1995, 45344	
PM-1	Puye- clastics			775	836	5745	5684	6520	LANL 1998 (59665)	Revised based on results of R-12
PM-1	Basalt Unit 1	836	1548			5684	4972	6520	Purtymun 1995, 45344	Santa Fe Group basalt

Table C-6 (continued)

Hole ID	Formation	Purtymun 1995, 45344		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
PM-1	Chamita	1798	1874			4722	4646	6520	Purtymun 1995, 45344	
PM-1	Tesuque	1874	2501			4646	4019	6520	Purtymun 1995, 45344	
PM-3	Alluvium	0	30			6640	6610	6640	Purtymun 1995, 45344	
PM-3	Otowi	30	170			6610	6470	6640	Purtymun 1995, 45344	
PM-3	Guaje	170	190			6470	6450	6640	Purtymun 1995, 45344	
PM-3	Puye-fanglomerate	190	745			6450	5895	6640	Purtymun 1995, 45344	
PM-3	Basalt Unit 2	215	540			6425	6100	6640	Purtymun 1995, 45344	
PM-3	Puye-old alluvium			615	630	6025	6010	6640		Correlation with R-12
PM-3	Puye-Totavi Lentil	745	805			5895	5835	6640	Purtymun 1995, 45344	
PM-3	Puye-Chaquehui	805	2060			5835	4580	6640	Purtymun 1995, 45344	
PM-3	Puye- clastics			630	900	6010	5740	6640		Estimated from Figure A-2
PM-3	Santa Fe Group			900	1105	5740	5535	6640		Estimated from Figure A-2
PM-3	Basalt Unit 1	1105	1540			5535	5100	6640	Purtymun 1995, 45344	Santa Fe Group basalt
PM-3	Tesuque	2060	2552			4580	4088	6640	Purtymun 1995, 45344	
SCOI-3	Alluvium	0	28			6500	6472	6500	LANL 1998, 59665	
SCOI-3	Otowi	28	109			6472	6391	6500	LANL 1998, 59665	
SCOI-3	Guaje	109	130			6391	6370	6500	LANL 1998, 59665	
SCOI-3	Pliocene soil	130	131			6370	6369	6500	LANL 1998, 59665	
SCOI-3	Basalt	131	132			6369	6368	6500	LANL 1998, 59665	
R-12	Alluvium	0	12			6500.1	6488.1	6500.1	LANL 1998, 59665	
R-12	Cerro Toledo	12	31			6488.1	6469.1	6500.1	LANL 1998, 59665	
R-12	Otowi	31	112			6469.1	6388.1	6500.1	LANL 1998, 59665	
R-12	Guaje	112	131			6388.1	6369.1	6500.1	LANL 1998, 59665	

Table C-6 (continued)

Hole ID	Formation	Purtymun 1995, 45344		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
R-12	Pliocene soil	131	132			6369.1	6368.1	6500.1	LANL 1998, 59665	
R-12	Basalt tholeiitic	132	342			6368.1	6158.1	6500.1	LANL 1998, 59665	
R-12	Basalt alkalic	342	489			6158.1	6011.1	6500.1	LANL 1998, 59665	
R-12	Basalt tephra	489	492			6011.1	6008.1	6500.1	LANL 1998, 59665	
R-12	Puye old alluvium	492	545			6008.1	5955.1	6500.1	LANL 1998, 59665	
R-12	Puye fanglomerate	545	784			5955.1	5716.1	6500.1	LANL 1998, 59665	
R-12	Santa Fe Group basalt	784	847			5716.1	5653.1	6500.1	LANL 1998, 59665	
53-TH-1	Soil	0	1			6916.6	6915.6	6916.6	Purtymun 1995, 45344	
53-TH-1	Tshirege	1	49			6915.6	6867.6	6916.6	Purtymun 1995, 45344	
53-TH-2	Soil	0	1			6919.5	6918.5	6919.5	Purtymun 1995, 45344	
53-TH-2	Tshirege	1	49			6918.5	6870.5	6919.5	Purtymun 1995, 45344	
53-TH-3	Soil	0	1			6910.9	6909.9	6910.9	Purtymun 1995, 45344	
53-TH-3	Tshirege	1	49			6909.9	6861.9	6910.9	Purtymun 1995, 45344	
53-TH-4	Soil	0	1			6910.1	6909.1	6910.1	Purtymun 1995, 45344	
53-TH-4	Tshirege	1	49			6909.1	6861.1	6910.1	Purtymun 1995, 45344	
53-TH-5	Soil	0	3			6920.3	6917.3	6920.3	Purtymun 1995, 45344	
53-TH-5	Tshirege	3	100			6917.3	6820.3	6920.3	Purtymun 1995, 45344	
53-TH-6	Soil	0	3			6921.2	6918.2	6921.2	Purtymun 1995, 45344	
53-TH-6	Tshirege	3	150			6918.2	6771.2	6921.2	Purtymun 1995, 45344	
53-TH-7	Alluvium	0	1			6701	6700	6701	Purtymun 1995, 45344	
53-TH-7	Tshirege	1	24			6700	6677	6701	Purtymun 1995, 45344	
53-TH-7	Tsankawi	24	43	24	25	6677	6676	6701	Purtymun 1995, 45344	Revised based on correlation (see Figure A-2)

Table C-6 (continued)

Hole ID	Formation	Purtymun 1995, 45344		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
53-TH-7	Cerro Toledo			25	70	6676	6631	6701		Revised based on correlation (see Figure A-2)
53-TH-7	Otowi	43	80	70	80	6631	6621	6701	Purtymun 1995, 45344	Revised based on correlation (see Figure A-2)
53-TH-B	Soil	0	1			6920.7	6919.7	6920.7	Purtymun 1995, 45344	
53-TH-B	Tshirege	1	49			6919.7	6871.7	6920.7	Purtymun 1995, 45344	
SHB-2	Tshirege	0	200			7436	7236	7436	Gardner et al. 1993, 12582	

References for Appendix C

The following list includes all the references cited in this appendix. The parenthetical information following each reference provides the author, publication date, and Environmental Restoration Project identification (ER ID) number. This information is also included in the citations in the text and can be used to locate the documents.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

Gardner, J. N., T. Kolbe, and S. Chang, January 1993. "Geology, Drilling, and Some Hydrologic Aspects of Seismic Hazards Program Core Holes, Los Alamos National Laboratory, New Mexico," Los Alamos National Laboratory Report LA-12460-MS, Los Alamos, New Mexico. (Gardner et al. 1993, ER ID 12582)

LANL (Los Alamos National Laboratory), September 1998. "Interim Completion Report for Characterization Well R-12, ER Project, A Department Of Energy Environmental Cleanup Program," LA-UR-98-3976 Los Alamos National Laboratory Report LA-UR-98-3976, Los Alamos, New Mexico. (LANL 1988, ER ID 59665)

Purtymun, W. D., January 1995. "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Purtymun, W. D., and Stoker, September 1990. "Perched Zone Monitoring Well Installation," Los Alamos National Laboratory Report LA-UR-90-3230, Los Alamos, New Mexico. (Purtymun and Stoker 1990, ER ID 7508)

Appendix D

Data for Wells, Boreholes, and Moisture Access Tubes in Cañada del Buey

Table D-1
Summary and Status of Cañada del Buey Watershed Wells, Boreholes, and Moisture Access Tubes

Hole ID	ER ID	Date Completed	Total Depth (ft)	Depth Completed (ft)	Location	Current Status	Well Comment
52-Air-I-1	None	6/15/95	97	0	TA-52	Abandoned hole	Air injection hole
52-Air-NE-1	None	6/15/95	97	0	TA-52	Abandoned hole	Air injection hole
52-Air-NE-2	None	6/15/95	297	0	TA-52	Abandoned hole	Air injection hole
52-Air-NW-1	None	6/15/95	97	0	TA-52	Abandoned hole	Air injection hole
52-Air-SE-1	None	6/15/95	97	0	TA-52	Abandoned hole	Air injection hole
54-1001	54-1001	9/16/93	315	315	MDA L	Inactive monitor hole	Angle characterization borehole
54-1002	54-1002	9/23/93	310	304.3	MDA L	Pore gas monitor well	Angle borehole equipped with Seamist
54-1003	54-1003	10/4/93	299	295.2	MDA L	Pore gas extraction well	Vertical borehole equipped with Seamist
54-1004	54-1004	10/14/93	340	338	MDA L	Pore gas monitor well	Vertical borehole equipped with Seamist
54-1005	54-1005	12/3/93	291	n/a*	MDA L	Pore gas monitor well	Angle borehole equipped with Seamist
54-1006	54-1006	10/1/93	323	n/a	MDA L	Pore gas monitor well	Angle borehole equipped with Seamist
54-1007	54-1007	11/30/93	150	n/a	MDA L	Pore gas monitor well	Vertical characterization borehole
54-1008	54-1008	11/19/93	150	n/a	MDA L	Pore gas monitor well	Vertical characterization borehole
54-1009	54-1009	11/17/93	150	n/a	MDA L	Pore gas monitor well	Vertical characterization borehole
54-1015	54-1015	1/9/95	530	465.8	South fork CDB, MDA L	Vapor/water monitor hole	Angle borehole equipped with Solinst
54-1016	54-1016	3/17/95	607	523	South fork CDB, MDA L	Vapor/water monitor hole	Angle borehole equipped with Solinst
54-1017	54-1017	4/20/95	159	159	MDA L	Pore gas monitor well	Pilot vapor extraction study well
54-1018	54-1018	5/8/95	328	328	MDA L	Pore gas monitor well	Pilot vapor extraction monitor well
CDB-TH-1	None	8/1/83	17	0	Upper CDB near TA-52	Abandoned hole	Aggregate material test hole
CDB-TH-2	None	8/1/83	27	0	Upper CDB near TA-52	Abandoned hole	Aggregate material test hole
CDB-TH-3	None	8/1/83	27	0	Upper CDB near TA-52	Abandoned hole	Aggregate material test hole
CDB-TH-4	None	8/1/83	12	0	Upper CDB near TA-52	Abandoned hole	Aggregate material test hole
CDB-TH-5	None	8/1/83	12	0	Upper CDB near TA-52	Abandoned hole	Aggregate material test hole
CDBM-1	None	1/1/92	189	0	Middle CDB	Moisture access tube	Adjacent to CDBO-8
CDBM-2	None	1/1/92	99	0	Middle CDB	Moisture access tube	Adjacent to CDBO-9

Table D-1 (continued)

Hole ID	ER ID	Date Completed	Total Depth (ft)	Depth Completed (ft)	Location	Current Status	Well Comment
CDBO-1	None	4/17/85	15	13	South Fork CDB	Active monitor well	Purtymun has 1 and 2 reversed
CDBO-2	None	4/18/85	18	18	South Fork CDB	Active monitor well	Downstream of MDAs J, K
CDBO-3	None	4/18/85	12	12	South Fork CDB	Active monitor well	Downstream of MDA L
CDBO-4	None	4/18/85	12	12	Lower CDB	Active monitor well	Downstream of MDA G
CDBO-5	None	1/1/92	17.5	17	Upper CDB	Active monitor well	West of TA-46 drainage
CDBO-6	None	1/1/92	49	44	Middle CDB	Active monitor well	Near PM-4, downstream of TA-46
CDBO-7	None	1/1/92	44	39	Middle CDB	Active monitor well	Adjacent to MDAs J, K
CDBO-8	None	1/1/92	23	13	Middle CDB	Active monitor well	Upgradient of MDA L
CDBO-9	None	1/1/92	34	29	Middle CDB	Active monitor well	Downgradient of MDA L
LGC-89-32	54-2032	1/1/89	171	0	MDA G	Abandoned hole?	Core hole - pore gas
LGM-85-06	54-2006	1/1/85	124	0	MDA G	Moisture hole	
LGM-85-11	54-2011	1/1/85	124	0	MDA G	Moisture hole	
LGN-85-08	54-2008	1/1/85	120	0	MDA G	Neutron moisture hole	
LGP-85-07	54-2007	1/1/85	60	0	MDA G	Psychrometer hole	
LLC-85-12	54-2012	8/15/85	120	0	MDA L	Abandoned hole?	Core obtained 0–99 ft
LLC-85-14	54-2014	8/15/85	120	0	MDA L	Abandoned hole?	Core obtained 0–99 ft
LLC-85-15	54-2015	8/15/85	120	82	MDA L	Pore gas sample well	Core obtained 0–99 ft
LLC-85-16	54-2016	8/15/85	120	102	MDA L	Pore gas sample well	Core obtained 0–99 ft
LLC-85-17	54-2017	1/1/85	150	0	MDA L	Abandoned hole?	Core hole
LLC-85-18	54-2018	1/1/85	120	0	MDA L	Abandoned hole?	Core hole
LLC-86-20	54-2020	1/1/86	198	198	MDA L	Pore gas sample well	Core hole
LLC-86-22	54-2022	1/1/86	197	0	MDA L	Abandoned hole?	Core hole
LLC-86-24	54-2024	1/1/86	198	198	MDA L	Pore gas sample well	Core hole
LLC-86-25	54-2025	1/1/86	198	190	MDA L	Pore gas sample well	Core hole
LLC-88-26	54-2026	1/1/88	198	250	MDA L	Pore gas sample well	Core hole
LLC-88-27	54-2027	1/1/88	263	250	MDA L	Pore gas sample well	Core hole

Table D-1 (continued)

Hole ID	ER ID	Date Completed	Total Depth (ft)	Depth Completed (ft)	Location	Current Status	Well Comment
LLC-89-30	54-2030	1/1/89	273	243	MDA L	Pore gas sample well	Core hole
LLC-90-34	54-2034	1/1/90	317	0	MDA L	Abandoned hole?	Core hole
LLM-85-01	54-2001	1/1/85	140	0	MDA L	Abandoned hole?	Moisture hole
LLM-85-02	54-2002	1/1/85	145	145	MDA L	Pore gas sample well	Moisture hole
LLM-85-05	54-2005	1/1/85	145	0	MDA L	Abandoned hole?	Moisture hole
LLN-85-04	54-2004	1/1/85	120	n/a	MDA L	Neutron moisture hole	Moisture hole
LLP-85-03	54-2003	1/1/85	120	n/a	MDA L	Psychrometer hole	Moisture hole
PM-4	CA-PM-4	8/1/81	2920	2854	Near TA-51	Production supply well	Municipal supply well
PM-5	CA-PM-5	9/1/82	3110	3072	TA-5 at head of CDB	Production supply well	Municipal supply well
TA-46	None	1/1/71	747	747	TA-46	Cased borehole	Carbon isotope production hole

*n/a = not applicable.

Table D-2
Coordinates for Cañada del Buey Watershed Wells, Boreholes, and Moisture Access Tubes

Site ID	Easting (ft)	Northing (ft)	Elevation (ft)	Land Surface Datum Measuring Point	Coordinate Source	Coordinate Confidence	Coordinate Comment
52-Air-I-1	1629046	1768200	7168.8	Ground	FIMAD*	Good	BH-1119, located on mesa at TA-52
52-Air-NE-1	1629056	1768206	7169.2	Ground	FIMAD	Good	BH-1258, located on mesa at TA-52
52-Air-NE-2	1629060	1768244	7171.5	Ground	FIMAD	Good	BH-1259, located on mesa at TA-52
52-Air-NW-1	1629043	1768202	7169.1	Ground	FIMAD	Good	BH-1260, located on mesa at TA-52
52-Air-SE-1	1629055	1768181	7167.4	Ground	FIMAD	Good	BH-1338, located on mesa at TA-52
54-1001	1640464.7	1759065.1	6782.52	Ground	FIMAD	Good	Bottom hole location 137.4 ft S13E
54-1003	1640249.7	1759124	6794.46	Ground	FIMAD	Good	Located on Mesita del Buey
54-1004	1640235.3	1759247.6	6788.37	Ground	FIMAD	Good	Located on Mesita del Buey
54-1005	1640389.9	1759253.2	6779.53	Ground	FIMAD	Good	Bottom hole location 104 ft N78E
54-1006	1640156	1759289.2	6790.57	Ground	FIMAD	Good	Bottom hole location 136 ft S10E
54-1007	1640125.3	1759323	6790.29	Ground	FIMAD	Good	Located on Mesita del Buey
54-1008	1639720.9	1759585.6	6796.6	Ground	FIMAD	Good	Located on Mesita del Buey
54-1009	1639955.5	1759464.6	6791.99	Ground	FIMAD	Good	Located on Mesita del Buey
54-1015	1639786	1759842.7	6708.21	Ground	FIMAD	Good	Bottom hole location 252.9 ft S16.4W
54-1016	1640128.9	1759686	6700.4	Ground	FIMAD	Good	Bottom hole location 334 ft S11.5W
CDB-TH-1	1628520	1767400	7130	Ground	FIMAD	Approximate	Estimated from Purtymun 1995, 45344, p. 128-1
CDB-TH-2	1628720	1767520	7090	Ground	FIMAD	Approximate	Estimated from Purtymun 1995, 45344, p. 128-1
CDB-TH-3	1629070	1767530	7070	Ground	FIMAD	Approximate	Estimated from Purtymun 1995, 45344, p. 128-1
CDB-TH-4	1629380	1767550	7060	Ground	FIMAD	Approximate	Estimated from Purtymun 1995, 45344, p. 128-1
CDB-TH-5	1630140	1767590	7050	Ground	FIMAD	Approximate	Estimated from Purtymun 1995, 45344, p. 128-1
CDBM-1	1639303.2	1762365.1	6722	Ground	FIMAD	Good	Adjacent to CDBO-8
CDBM-2	1642119.1	1759702.8	6633.71	Ground	FIMAD	Good	Switched FIMAD coord with CDBO-9
CDBO-1	1637968.6	1760944	6757.6	Ground	FIMAD	Good	BH-1045
CDBO-2	1638119	1761103.1	6748.2	Ground	FIMAD	Good	BH-1046
CDBO-3	1640677.1	1759611	6670.2	Ground	FIMAD	Good	BH-1047

Table D-2 (continued)

Site ID	Easting (ft)	Northing (ft)	Elevation (ft)	Land Surface Datum Measuring Point	Coordinate Source	Coordinate Confidence	Coordinate Comment
CDBO-4	1645475	1758547	6564.5	Ground	FIMAD	Good	BH-1048
CDBO-5	1633583.4	1765818.4	6879.01	Ground	FIMAD	Good	BH-1049
CDBO-6	1636209.2	1764759.8	6817.2	Ground	FIMAD	Good	BH-1050
CDBO-7	1637400	1763301	6771.81	Ground	FIMAD	Good	BH-1051
CDBO-8	1639293.9	1762366	6722.47	Ground	FIMAD	Good	BH-1052
CDBO-9	1642126	1759697	6633	Ground	FIMAD	Good	BH-1053 switched FIMAD coord with CDBM-2
LGC-89-32	1645130.8	1757763.9	6669.7	Ground	FIMAD	Good	Located on Mesita del Buey
LGM-85-06	1642484.1	1758499.4	6730	Ground	FIMAD	Good	Located on Mesita del Buey
LGM-85-11	1643222.2	1758039.4	6715.6	Ground	FIMAD	Good	Located on Mesita del Buey
LGN-85-08	1642439.9	1758524.4	6731.7	Ground	FIMAD	Good	Located on Mesita del Buey
LGP-85-07	1639721.5	1759598.8	6795.1	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-12	1640025.8	1759418.3	6791.9	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-14	1640139	1759378.6	6789.3	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-15	1640093.6	1759412.7	6788.9	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-16	1639948	1759547.4	6788.4	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-17	1639942.6	1759502.6	6790.4	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-85-18	1640328.6	1759362.5	6776.2	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-86-20	1639577.8	1759688.1	6795.5	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-86-22	1640232.6	1759170.5	6790.9	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-86-24	1640173.3	1759338.6	6787.8	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-86-25	1640422	1759026.9	6788.9	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-88-26	1640386.9	1759216.4	6784.5	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-88-27	1640518.3	1759115.6	6782.1	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-89-30	1645130.8	1757763.9	6669.7	Ground	FIMAD	Good	Located on Mesita del Buey
LLC-90-34	1639433	1759777	6798.7	Ground	FIMAD	Good	Located on Mesita del Buey
LLM-85-01	1639646.4	1759614.9	6797.7	Ground	FIMAD	Good	Located on Mesita del Buey

Table D-2 (continued)

Site ID	Easting (ft)	Northing (ft)	Elevation (ft)	Land Surface Datum Measuring Point	Coordinate Source	Coordinate Confidence	Coordinate Comment
LLM-85-02	1640096.8	1759323.8	6792	Ground	FIMAD	Good	Located on Mesita del Buey
LLM-85-05	1640715.6	1758981	6772.5	Ground	FIMAD	Good	Located on Mesita del Buey
LLN-85-04	1640165.5	1759328	6788	Ground	FIMAD	Good	Located on Mesita del Buey
LLP-85-03	1642449.6	1758519	6731.5	Ground	FIMAD	Good	Located on Mesita del Buey
LLP-85-03a	1640168	1759331.1	6788.7	Ground	FIMAD	Good	Located on Mesita del Buey
PM-4	1635716.6	1764674.1	6920	Ground	FIMAD	Good	Located on mesa south of Cañada del Buey
PM-5	1632110	1767790	7095	Ground	FIMAD	Good	Located on mesa north of Cañada del Buey
TA-46	1630810	1765620	7105	Ground	FIMAD	Good	BH-1351, located on mesa at TA-46

*FIMAD = Facility for Information Management, Analysis, and Display.

Table D-3
Casing Construction Information for Selected Cañada del Buey Wells, Boreholes, and Moisture Access Tubes

Hole ID	Tubing Type	Tubing Diameter (in.)	Top of Tubing (ft)	Measuring Point	Surface Casing Type	Surface Casing Diameter (in.)	Casing Source	Casing Comment
52-Air-I-1	Plastic	N.A.[a]	N.A.	n/a[b]	Steel	6	Purtymun 1995, 45344, p. 178	Depth of surface casing not reported
52-Air-NE-1	Plastic	N.A.	N.A.	n/a	Steel	6	Purtymun 1995, 45344, p. 178	Depth of surface casing not reported
52-Air-NE-2	Plastic	N.A.	N.A.	n/a	Steel	6	Purtymun 1995, 45344, p. 178	Depth of surface casing not reported
52-Air-NW-1	Plastic	N.A.	N.A.	n/a	Steel	6	Purtymun 1995, 45344, p. 178	Depth of surface casing not reported
52-Air-SE-1	Plastic	N.A.	N.A.	n/a	Steel	6	Purtymun 1995, 45344, p. 178	Depth of surface casing not reported
54-1015	PVC[c]/Teflon	2	N.A.	GL[d]	Steel	10	Preliminary RFI Report	
54-1016	PVC/Teflon	2	N.A.	GL	Steel	10	Preliminary RFI Report	
CDB-TH-1	None	n/a	N.A.	n/a	None	n/a	Purtymun 1994, 52957	Hole not cased, Hole abandoned
CDB-TH-2	None	n/a	N.A.	n/a	None	n/a	Purtymun 1994, 52957	Hole not cased, hole abandoned
CDB-TH-3	None	n/a	N.A.	n/a	None	n/a	Purtymun 1994, 52957	Hole not cased, hole abandoned
CDB-TH-4	None	n/a	N.A.	n/a	None	n/a	Purtymun 1994, 52957	Hole not cased, hole abandoned
CDB-TH-5	None	n/a	N.A.	n/a	None	n/a	Purtymun 1994, 52957	Hole not cased, hole abandoned
CDBM-1	Aluminum	2	N.A.	TOT[e]	Steel	N.A.	Purtymun 1995, 45344, p. 133	2-in. 0–189 ft
CDBM-2	Aluminum	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 134	2-in. 0–99 ft
CDBO-1	PVC	4	1.37	TOT	Steel	9	Purtymun 1995, 45344, p. 127; Devaurs 1985, 7416	4-in. 0–13.1 ft
CDBO-2	PVC	4	1.3	TOT	Steel	9	Purtymun 1995, 45344, p. 127; Devaurs 1985, 7416	4-in. 0–17.9 ft
CDBO-3	PVC	4	1.2	TOT	Steel	9	Purtymun 1995, 45344, p. 127; Devaurs 1985, 7416	4-in. 0–12.4 ft
CDBO-4	PVC	4	1.3	TOT	Steel	9	Purtymun 1995, 45344, p. 127; Devaurs 1985, 7416	4-in. 0–12.1 ft
CDBO-5	PVC	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 131	2-in. 0–17 ft
CDBO-6	PVC	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 131	2-in. 0–49 ft
CDBO-7	PVC	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 131	2-in. 0–44 ft
CDBO-8	PVC	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 132	2-in. 0–23 ft

Table D-3 (continued)

Hole ID	Tubing Type	Tubing Diameter (in.)	Top of Tubing (ft)	Measuring Point	Surface Casing Type	Surface Casing Diameter (in.)	Casing Source	Casing Comment
CDBO-9	PVC	2	N.A.	TOT	Steel	N.A.	Purtymun 1995, 45344, p. 132	2-in. 0–34 ft
PM-4	Steel	16	0	TOC[f]	Steel	42	Purtymun 1995, 45344, p. 277	42-in. 0–41 ft; 28-in. 0–923 ft; 16-in. 0–2874 ft
PM-5	Steel	16	0	TOC	Steel	42	Purtymun 1995, 45344, p. 277	42-in. 0–40 ft; 28-in. 0–1178 ft; 16-in. 0–092 ft
TA-46	None	n/a	n/a	n/a	Steel	13.375	Purtymun 1995, 45344, p. 209	13.375-in. 0–747 ft

[a] N.A. = not available.

[b] n/a = not applicable.

[c] PVC = polyvinyl chloride.

[d] GL = ground level.

[e] TOT = top of tubing.

[f] TOC = top of casing.

Table D-4
Screen Interval Information for Cañada del Buey Wells

Hole ID	Top of Screen (ft)	Bottom of Screen (ft)	Perf Size (in.)	Annulus Pack (in.)	Sump Length (ft)	Screen Source	Screen Comment
52-Air-I-1	87	97		Pea gravel	0	Purtymun 1995, 45344, p. 177	Perforated plastic tubing
52-Air-NE-1	87	97		Pea gravel	0	Purtymun 1995, 45344, p. 177	Perforated plastic tubing
52-Air-NE-2	160	291		Pea gravel	0	Purtymun 1995, 45344, p. 177	Perforated plastic tubing
52-Air-NW-1	87	97		Pea gravel	0	Purtymun 1995, 45344, p. 177	Perforated plastic tubing
52-Air-SE-1	87	97		Pea gravel	0	Purtymun 1995, 45344, p. 177	Perforated plastic tubing
CDBM-1				0.010–0.020		Purtymun 1995, 45344, p. 133	Tubing not screened
CDBM-2				0.010–0.020		Purtymun 1995, 45344, p. 134	Tubing not screened
CDBO-1	5.1	13.1	0.25	Gravel	0	Devaurs 1986, 7416	Stainless steel wire screen
CDBO-2	5.9	17.9	0.25	Gravel	0	Devaurs 1986, 7416	Stainless steel wire screen
CDBO-3	4.4	12.4	0.25	Gravel	0	Devaurs 1986, 7416	Stainless steel wire screen
CDBO-4	4.1	12.1	0.25	Gravel	0	Devaurs 1986, 7416	Stainless steel wire screen
CDBO-5	7	17	0.01	0.010–0.020	0	Purtymun 1995, 45344, p. 131	
CDBO-6	34	44	0.01	0.010–0.020	5	Purtymun 1995, 45344, p. 131	
CDBO-7	29	39	0.01	0.010–0.020	5	Purtymun 1995, 45344, p. 131	
CDBO-8	13	23	0.01	0.010–0.020	0	Purtymun 1995, 45344, p. 132	
CDBO-9	19	29	0.01	0.010–0.020	5	Purtymun 1995, 45344, p. 132	
PM-4	1260	2854		Gravel	20	Purtymun 1995, 45344, p. 277	Louvers
PM-5	1440	2072		Gravel	20	Purtymun 1995, 45344, p. 277	Louvers
TA-46						Purtymun 1995, 45344, p. 209	No screened interval

Table D-5
Water Level Measurements in Cañada del Buey Alluvial Monitor Wells

Hole ID	Well Elevation (ft)	Measured Depth of Well (ft)	Measured Depth Date	SWL[a] Date	SWL (ft)	GL[b] or MP[c]	SWL Elevation (ft)	SWL Source	SWL Confidence	SWL Comment
CDBO-6	6817.2	N.A.[d]	N.A.	12/8/93	32.11	MP	6785.09	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	8/7/94	32.78	MP	6784.42	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	3/30/95	31.68	MP	6785.52	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	6/28/95	31.97	MP	6785.23	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	12/21/95	32.09	MP	6785.11	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	7/2/96	Dry	MP		ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	9/30/96	33.29	MP	6783.91	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	12/17/96	33.18	MP	6784.02	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	6/16/97	35.12	MP	6782.08	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	9/13/97	35.42	MP	6781.78	ESH-18	Good	Field notes
CDBO-6	6817.2	N.A.	N.A.	12/3/97	39.87	MP	6777.33	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	12/8/93	31.73	MP	6740.07	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	8/7/94	30.96	MP	6740.84	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	3/30/95	31.53	MP	6740.27	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	6/28/95	31.86	MP	6739.94	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	12/21/95	Dry	MP		ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	7/2/96	Dry	MP		ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	9/30/96	Dry	MP		ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	12/17/96	Dry	MP		ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	6/16/97	36.37	MP	6735.43	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	9/13/97	36.23	MP	6735.57	ESH-18	Good	Field notes
CDBO-7	6771.8	N.A.	N.A.	12/3/97	40.39	MP	6731.41	ESH-18	Good	Field notes

[a] SWL = static water level.
[b] GL = ground level.
[c] MP = measuring point.
[d] N.A. = not available.

Table D-6
Stratigraphic Information from Cañada del Buey Wells, Boreholes and Moisture Access Tubes

Hole ID	Formation	Purtymun 1995 (45344) Data		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
CDBM-1	Alluvium	0	7	0	19	6722	6703	6722	Purtymun 1995, 45344	Revised based on correlation
CDBM-1	Tshirege	7	83	19	83	6703	6639	6722	Purtymun 1995, 45344	
CDBM-1	Tsankawi	83	94	83	94	6639	6628	6722	Purtymun 1995, 45344	
CDBM-1	Cerro Toledo			94	158	6628	6564	6722		Revised based on correlation
CDBM-1	Otowi	94	189	158	189	6564	6533	6722	Purtymun 1995, 45344	
CDBM-2	Alluvium	0	14			6633	6619	6633	Purtymun 1995, 45344	
CDBM-2	Tshirege	14	51			6619	6582	6633	Purtymun 1995, 45344	
CDBM-2	Tsankawi	51	54			6582	6579	6633	Purtymun 1995, 45344	
CDBM-2	Otowi	54	99			6579	6534	6633	Purtymun 1995, 45344	
CDBO-1	Alluvium	0	6			6757.6	6751.6	6757.6	Purtymun 1995, 45344	
CDBO-1	Tuff	6	15			6751.6	6742.6	6757.6	Purtymun 1995, 45344	
CDBO-2	Alluvium	0	12			6748.2	6736.2	6748.2	Purtymun 1995, 45344	
CDBO-2	Tuff	12	18			6736.2	6730.2	6748.2	Purtymun 1995, 45344	
CDBO-3	Alluvium	0	8			6670.2	6662.2	6670.2	Purtymun 1995, 45344	
CDBO-3	Tuff	8	12			6662.2	6658.2	6670.2	Purtymun 1995, 45344	
CDBO-4	Alluvium	0	9			6564.5	6555.5	6564.5	Purtymun 1995, 45344	
CDBO-4	Tuff	9	12			6555.5	6552.5	6564.5	Purtymun 1995, 45344	
CDBO-5	Alluvium	0	17			6879	6862	6879	Purtymun 1995, 45344	
CDBO-5	Tuff	17	17.5			6862	6861.5	6879	Purtymun 1995, 45344	
CDBO-6	Alluvium	0	4	0	19	6817	6798	6817	Purtymun 1995, 45344	Revised based on correlation
CDBO-6	Tuff	4	49	19	49	6798	6768	6817	Purtymun 1995, 45344	Revised based on correlation
CDBO-7	Alluvium	0	9	0	19	6771	6752	6771	Purtymun 1995, 45344	Revised based on correlation
CDBO-7	Tuff	9	44	19	44	6752	6727	6771	Purtymun 1995, 45344	Revised based on correlation

Table D-6 (continued)

Hole ID	Formation	Purtymun 1995 (45344) Data		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
CDBO-8	Alluvium	0	7	0	19	6722	6703	6722	Purtymun 1995, 45344	Revised based on correlation
CDBO-8	Tuff	7	23	19	23	6703	6699	6722	Purtymun 1995, 45344	Revised based on correlation
CDBO-9	Alluvium	0	9	0	19	6633	6614	6633	Purtymun 1995, 45344	Revised based on correlation
CDBO-9	Tuff	9	34	19	34	6614	6599	6633	Purtymun 1995, 45344	Revised based on correlation
LGC-85-09	Tshirege	0	99			6659.9	6560.9	6659.9	Purtymun 1995, 45344	
LGC-85-10	Tshirege	0	99			6707.7	6608.7	6707.7	Purtymun 1995, 45344	
LGM-85-06	Tshirege	0	124			6730	6606	6730	Purtymun 1995, 45344	
LGM-85-11	Tshirege	0	124			6715.6	6591.6	6715.6	Purtymun 1995, 45344	
LGP-85-07	Tshirege	0	49			6731.7	6682.7	6731.7	Purtymun 1995, 45344	
LLC-85-12	Tshirege	0	99			6794.7	6695.7	6794.7	Purtymun 1995, 45344	
LLC-85-13	Tshirege	0	99			6856.1	6757.1	6856.1	Purtymun 1995, 45344	
LLC-85-14	Tshirege	0	99			6791.4	6692.4	6791.4	Purtymun 1995, 45344	
LLC-85-15	Tshirege	0	99			6787.5	6688.5	6787.5	Purtymun 1995, 45344	
LLC-85-16	Tshirege	0	99			6788	6689	6788	Purtymun 1995, 45344	
LLC-85-17	Tshirege	0	149			6788.4	6639.4	6788.4	Purtymun 1995, 45344	
LLC-85-18	Tshirege	0	99			6790.4	6691.4	6790.4	Purtymun 1995, 45344	
LLC-86-19	Tshirege	0	201			6854.5	6653.5	6854.5	Purtymun 1995, 45344	
LLC-86-20	Tshirege	0	198			6775.9	6577.9	6775.9	Purtymun 1995, 45344	
LLC-86-21	Tshirege	0	198			6803.1	6605.1	6803.1	Purtymun 1995, 45344	
LLC-86-22	Tshirege	0	197			6796.4	6599.4	6796.4	Purtymun 1995, 45344	
LLC-86-23	Tshirege	0	199			6793.8	6594.8	6793.8	Purtymun 1995, 45344	
LLC-86-24	Tshirege	0	198			6790.6	6592.6	6790.6	Purtymun 1995, 45344	
LLC-86-25	Tshirege	0	198			6787.8	6589.8	6787.8	Purtymun 1995, 45344	
LLC-88-26	Tshirege	0	198			6788.9	6590.9	6788.9	Purtymun 1995, 45344	

Table D-6 (continued)

Hole ID	Formation	Purtymun 1995 (45344) Data		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
LLC-88-27	Tshirege	0	190			6784.5	6594.5	6784.5	Purtymun 1995, 45344	
LLC-88-27	Otowi and Guaje	190	263			6594.5	6521.5	6784.5	Purtymun 1995, 45344	
LLC-88-28	Tshirege	0	195			6796.2	6601.2	6796.2	Purtymun 1995, 45344	
LLC-88-28	Otowi and Guaje	195	263			6601.2	6533.2	6796.2	Purtymun 1995, 45344	
LLC-88-28	Basalt	263	267			6533.2	6529.2	6796.2	Purtymun 1995, 45344	
LLC-88-29	Tshirege	0	225			6793.4	6568.4	6793.4	Purtymun 1995, 45344	
LLC-88-29	Otowi and Guaje	225	298			6568.4	6495.4	6793.4	Purtymun 1995, 45344	
LLC-89-30	Tshirege	0	205			6782.1	6577.1	6782.1	Purtymun 1995, 45344	
LLC-89-30	Otowi and Guaje	205	273			6577.1	6509.1	6782.1	Purtymun 1995, 45344	
LLC-89-31	Tshirege	0	225			6803.7	6578.7	6803.7	Purtymun 1995, 45344	
LLC-89-31	Otowi and Guaje	225	291			6578.7	6512.7	6803.7	Purtymun 1995, 45344	
LLC-89-32	Tshirege	0	150			6669.7	6519.7	6669.7	Purtymun 1995, 45344	
LLC-89-32	Otowi and Guaje	150	171			6519.7	6498.7	6669.7	Purtymun 1995, 45344	
LLC-89-33	Tshirege	0	180			6747	6567	6747	Purtymun 1995, 45344	
LLC-89-33	Otowi and Guaje	180	293			6567	6454	6747	Purtymun 1995, 45344	
LLC-90-34	Tshirege	0	195			6800	6605	6800	Purtymun 1995, 45344	
LLC-90-34	Otowi and Guaje	195	317			6605	6483	6800	Purtymun 1995, 45344	
LLC-90-35	Tshirege	0	201			6810	6609	6810	Purtymun 1995, 45344	
LLC-90-35	Otowi and Guaje	201	351			6609	6459	6810	Purtymun 1995, 45344	
LLM-85-01	Tshirege	0	124			6797.4	6673.4	6797.4	Purtymun 1995, 45344	
LLM-85-02	Tshirege	0	124			6791.7	6667.7	6791.7	Purtymun 1995, 45344	
LLM-85-05	Tshirege	0	124			6772.5	6648.5	6772.5	Purtymun 1995, 45344	
LLP-85-03	Tshirege	0	99			6788.7	6689.7	6788.7	Purtymun 1995, 45344	
52-Air-N-1	Tshirege	0	94			7241.8	7147.8	7241.8	Purtymun 1995, 45344	

Table D-6 (continued)

Hole ID	Formation	Purtymun 1995 (45344) Data		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
52-Air-N-1	Tshirege	0	97			7245.2	7148.2	7245.2	Purtymun 1995, 45344	
52-Air-N-2	Tshirege	0	112			7247.7	7135.7	7247.7	Purtymun 1995, 45344	
52-Air-NE-1	Tshirege	0	118			7246.6	7128.6	7246.6	Purtymun 1995, 45344	
52-Air-NE-1	Tshirege	0	118			7246.6	7128.6	7246.6	Purtymun 1995, 45344	
CDB-TH-1	Alluvium	0	12			7130	7118	7130	Purtymun 1995, 45344	
CDB-TH-1	Tshirege	12	17			7118	7113	7130	Purtymun 1995, 45344	
CDB-TH-2	Alluvium	0	22			7090	7068	7090	Purtymun 1995, 45344	
CDB-TH-2	Tshirege	22	27			7068	7063	7090	Purtymun 1995, 45344	
CDB-TH-3	Alluvium	0	22			7070	7048	7070	Purtymun 1995, 45344	
CDB-TH-3	Tshirege	22	27			7048	7043	7070	Purtymun 1995, 45344	
CDB-TH-4	Alluvium	0	9			7060	7051	7060	Purtymun 1995, 45344	
CDB-TH-4	Tshirege	9	12			7051	7048	7060	Purtymun 1995, 45344	
CDB-TH-5	Alluvium	0	7			7050	7043	7050	Purtymun 1995, 45344	
CDB-TH-5	Tshirege	7	12			7043	7038	7050	Purtymun 1995, 45344	
PM-4	Tshirege	0	220			6920	6700	6920	Purtymun 1995, 45344	
PM-4	Otowi	220	540			6700	6380	6920	Purtymun 1995, 45344	
PM-4	Guaje	540	600			6380	6320	6920	Purtymun 1995, 45344	
PM-4	Basalt Unit 2	600	1100			6320	5820	6920	Purtymun 1995, 45344	
PM-4	Puye-fanglomerate	1100	1300			5820	5620	6920	Purtymun 1995, 45344	
PM-4	Puye-Totavi Lentil	1300	1420			5620	5500	6920	Purtymun 1995, 45344	
PM-4	Puye-Chaquehui	1420	2920			5500	4000	6920	Purtymun 1995, 45344	
PM-4	Basalt Unit 1	1950	2430			4970	4490	6920	Purtymun 1995, 45344	
PM-5	Tshirege	0	335			7095	6760	7095	Purtymun 1995, 45344	

Table D-6 (continued)

Hole ID	Formation	Purtymun 1995 (45344) Data		Revised Model		Start Elevation (ft)	End Elevation (ft)	Land Surface Datum (ft)	Stratigraphic Source	Stratigraphic Pick Comment
		Start Depth (ft)	End Depth (ft)	Start Depth (ft)	End Depth (ft)					
PM-5	Otowi	335	710			6760	6385	7095	Purtymun 1995, 45344	
PM-5	Guaje	710	740			6385	6355	7095	Purtymun 1995, 45344	
PM-5	Basalt Unit 2	740	1145			6355	5950	7095	Purtymun 1995, 45344	
PM-5	Puye-fanglomerate	760	1470			6335	5625	7095	Purtymun 1995, 45344	
PM-5	Puye-Totavi Lentil	1470	1550			5625	5545	7095	Purtymun 1995, 45344	
PM-5	Puye-Chaquehui	1550	2780			5545	4315	7095	Purtymun 1995, 45344	
PM-5	Basalt Unit 1	1765	2740			5330	4355	7095	Purtymun 1995, 45344	
PM-5	Chamita	2780	2860			4315	4235	7095	Purtymun 1995, 45344	
PM-5	Tesuque	2860	3120			4235	3975	7095	Purtymun 1995, 45344	

References for Appendix D

The following list includes all the references cited in this appendix. The parenthetical information following each reference provides the author, publication date, and Environmental Restoration Project identification (ER ID) number. This information is also included in the citations in the text and can be used to locate the documents.

ER ID numbers are assigned by the Laboratory's ER Project to track all material associated with 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 work plan 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 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 work plan. However, documents previously submitted to the administrative authority are not included in the reference library.

Devaurs, M., 1985. "Core Analysis and Observation Well Data from Mesita Del Buey Waste Disposal Areas and in Adjacent Canyons," Los Alamos National Laboratory Report LA-UR-85-4003, Los Alamos, New Mexico. (Devaurs 1985, ER ID 7416)

Purtymun, W. D., March 1, 1994. "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory Report LA-12733-MS, Los Alamos, New Mexico. (Purtymun 1994, ER ID 58233)

Purtymun, W. D., January 1995. "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory Report LA-12883-MS, Los Alamos, New Mexico. (Purtymun 1995, ER ID 45344)

Appendix E

Stratigraphic Information Used to Construct Cross Sections

G. Cole (Los Alamos National Laboratory Earth and Environmental Sciences Division, Geology and Chemistry Group) derived the stratigraphic information for this appendix in November 1998 from the sitewide geologic model. R. Koch (Science Applications International Corporation) provided the spatial coordinates for the stratigraphic points.

Table E-1
Stratigraphic Information used to Construct Cross Sections in Sandia Canyon

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
101	Surface	1621000	1772500	7366.77	0
101	Qbt4	1621000	1772500	7307.59	59.18
101	Qbt3	1621000	1772500	7235.16	131.61
101	Qbt1g	1621000	1772500	7042.44	324.32
101	Qbtt	1621000	1772500	7037.25	329.52
101	Qct	1621000	1772500	6948.8	417.97
101	Qbof	1621000	1772500	6761.68	605.08
101	Qbog	1621000	1772500	6722.42	644.34
101	Tpf	1621000	1772500	5856.44	1510.32
101	Tpt	1621000	1772500	5791.44	1575.32
102	Surface	1621500	1774800	7312.19	0
102	Qbt4	1621500	1774800	7299.87	12.32
102	Qbt3	1621500	1774800	7229.17	83.02
102	Qbt1g	1621500	1774800	6990.32	321.87
102	Qbtt	1621500	1774800	6985.04	327.15
102	Qct	1621500	1774800	6895.04	417.15
102	Qbof	1621500	1774800	6727.75	584.44
102	Qbog	1621500	1774800	6687.77	624.42
102	Tpf	1621500	1774800	5894.04	1418.15
102	Tpt	1621500	1774800	5829.04	1483.15
103	Surface	1632900	1770000	7100.25	0
103	Qbt3	1632900	1770000	7020.67	79.58
103	Qbt2	1632900	1770000	6952.47	147.78
103	Qbt1v	1632900	1770000	6867.9	232.35
103	Qbt1g	1632900	1770000	6784.95	315.3
103	Qbtt	1632900	1770000	6780.85	319.4
103	Qct	1632900	1770000	6733.67	366.58
103	Qbof	1632900	1770000	6422.02	678.23
103	Qbog	1632900	1770000	6392.8	707.45
103	Tpf	1632900	1770000	5744.77	1355.48
103	Tpt	1632900	1770000	5679.77	1420.48
103	Tsfuv	1632900	1770000	4499.01	2601.24
104	Surface	1633150	1772500	7086.44	0
104	Qbt3	1633150	1772500	7036.21	50.23
104	Qbt2	1633150	1772500	6960.47	125.97
104	Qbt1v	1633150	1772500	6877.67	208.76
104	Qbt1g	1633150	1772500	6795.51	290.93

Table E-1 (continued)

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
104	Qbtt	1633150	1772500	6791.24	295.2
104	Qct	1633150	1772500	6758.19	328.25
104	Qbof	1633150	1772500	6451.04	635.39
104	Qbog	1633150	1772500	6418.58	667.86
104	Tpf	1633150	1772500	5851.66	1234.78
104	Tpt	1633150	1772500	5786.66	1299.78
104	Tsfuv	1633150	1772500	4795.26	2291.18
105	Surface	1642000	1767800	6845.28	0
105	Qbt2	1642000	1767800	6805.82	39.46
105	Qbt1v	1642000	1767800	6688.66	156.62
105	Qbt1g	1642000	1767800	6629.32	215.96
105	Qbtt	1642000	1767800	6625.95	219.33
105	Qct	1642000	1767800	6608.78	236.5
105	Qbof	1642000	1767800	6441.05	404.23
105	Qbog	1642000	1767800	6417.31	427.97
105	Tpf	1642000	1767800	5770.2	1075.08
105	Tpt	1642000	1767800	5705.2	1140.08
105	Tsfuv	1642000	1767800	4568.44	2276.84
106	Surface	1642450	1770400	6855.1	0
106	Qbt2	1642450	1770400	6816.59	38.51
106	Qbt1v	1642450	1770400	6694.61	160.49
106	Qbt1g	1642450	1770400	6626.5	228.61
106	Qbtt	1642450	1770400	6623.04	232.06
106	Qct	1642450	1770400	6610.34	244.76
106	Qbof	1642450	1770400	6468.17	386.93
106	Qbog	1642450	1770400	6442.82	412.28
106	Tpf	1642450	1770400	5851.06	1004.04
106	Tpt	1642450	1770400	5786.06	1069.04
106	Tsfuv	1642450	1770400	4647.03	2208.07
107	Surface	1646900	1766650	6618.2	0
107	Qbt1v	1646900	1766650	6591.3	26.91
107	Qbt1g	1646900	1766650	6548.93	69.28
107	Qbtt	1646900	1766650	6545.72	72.49
107	Qct	1646900	1766650	6534.09	84.12
107	Qbof	1646900	1766650	6415.39	202.81
107	Qbog	1646900	1766650	6393.61	224.59
107	Tpf	1646900	1766650	5699.25	918.95
107	Tpt	1646900	1766650	5634.25	983.95

Table E-1 (continued)

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
107	Tsfuv	1646900	1766650	4872.35	1745.85
108	Surface	1647350	1768400	6548.47	0
108	Qbt1g	1647350	1768400	6543.95	4.52
108	Qbtt	1647350	1768400	6540.73	7.74
108	Qct	1647350	1768400	6530.69	17.78
108	Qbof	1647350	1768400	6399.64	148.82
108	Qbog	1647350	1768400	6376.95	171.52
108	Tpf	1647350	1768400	5747.78	800.69
108	Tpt	1647350	1768400	5682.78	865.69
108	Tsfuv	1647350	1768400	4759.25	1789.21

Table E-2
Stratigraphic Information used to Construct Cross Sections in Cañada del Buey

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
201	Surface	1633000	1764600	7049.7	0
201	Qbt3	1633000	1764600	6961.87	87.82
201	Qbt2	1633000	1764600	6914.38	135.32
201	Qbt1v	1633000	1764600	6802.63	247.06
201	Qbt1g	1633000	1764600	6741.54	308.16
201	Qbtt	1633000	1764600	6737.81	311.89
201	Qct	1633000	1764600	6686.17	363.52
201	Qbof	1633000	1764600	6333.77	715.92
201	Qbog	1633000	1764600	6310.06	739.64
201	Tpf	1633000	1764600	5626.76	1422.93
201	Tpt	1633000	1764600	5561.76	1487.93
201	Tsfuv	1633000	1764600	4420.17	2629.52
202	Surface	1633700	1766300	7030.68	0
202	Qbt3	1633700	1766300	6970.66	60.02
202	Qbt2	1633700	1766300	6918.33	112.35
202	Qbt1v	1633700	1766300	6816.06	214.62
202	Qbt1g	1633700	1766300	6736.77	293.92
202	Qbtt	1633700	1766300	6732.98	297.7
202	Qct	1633700	1766300	6686.82	343.86
202	Qbof	1633700	1766300	6361.33	669.36
202	Qbog	1633700	1766300	6336.01	694.67
202	Tpf	1633700	1766300	5620.61	1410.08
202	Tpt	1633700	1766300	5555.61	1475.08
202	Tsfuv	1633700	1766300	4334.14	2696.54
203	Surface	1635100	1763350	6964.48	0
203	Qbt3	1635100	1763350	6914.94	49.55
203	Qbt2	1635100	1763350	6881.72	82.77
203	Qbt1v	1635100	1763350	6756.58	207.9
203	Qbt1g	1635100	1763350	6677.19	287.29
203	Qbtt	1635100	1763350	6673.66	290.82
203	Qct	1635100	1763350	6632.17	332.32
203	Qbof	1635100	1763350	6320.49	643.99
203	Qbog	1635100	1763350	6298.48	666
203	Tpf	1635100	1763350	5604.42	1360.07
203	Tpt	1635100	1763350	5539.42	1425.07
203	Tsfuv	1635100	1763350	4335.79	2628.7
204	Surface	1636570	1765450	6939.87	0

Table E-2 (continued)

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
204	Qbt3	1636570	1765450	6915.39	24.47
204	Qbt2	1636570	1765450	6881.7	58.17
204	Qbt1v	1636570	1765450	6768.54	171.33
204	Qbt1g	1636570	1765450	6680.48	259.39
204	Qbtt	1636570	1765450	6676.92	262.95
204	Qct	1636570	1765450	6642.85	297.02
204	Qbof	1636570	1765450	6365.67	574.2
204	Qbog	1636570	1765450	6342.02	597.85
204	Tpf	1636570	1765450	5654.12	1285.75
204	Tpt	1636570	1765450	5589.12	1350.75
204	Tsfuv	1636570	1765450	4386.09	2553.78
205	Surface	1637650	1760650	6842.91	0
205	Qbt2	1637650	1760650	6807.06	35.85
205	Qbt1v	1637650	1760650	6700.21	142.69
205	Qbt1g	1637650	1760650	6596.02	246.89
205	Qbtt	1637650	1760650	6592.71	250.2
205	Qct	1637650	1760650	6558.49	284.41
205	Qbof	1637650	1760650	6338.28	504.62
205	Qbog	1637650	1760650	6319.11	523.8
205	Tpf	1637650	1760650	5397.82	1445.08
205	Tpt	1637650	1760650	5332.82	1510.08
205	Tsfuv	1637650	1760650	4424.12	2418.78
206	Surface	1639500	1762600	6845.88	0
206	Qbt3	1639500	1762600	6844.33	1.56
206	Qbt2	1639500	1762600	6813.95	31.93
206	Qbt1v	1639500	1762600	6700.48	145.41
206	Qbt1g	1639500	1762600	6587.4	258.49
206	Qbtt	1639500	1762600	6584.09	261.8
206	Qct	1639500	1762600	6554.06	291.82
206	Qbof	1639500	1762600	6406.55	439.33
206	Qbog	1639500	1762600	6386.18	459.7
206	Tpf	1639500	1762600	5484.36	1361.52
206	Tpt	1639500	1762600	5419.36	1426.52
206	Tsfuv	1639500	1762600	4537.14	2308.75
207	Surface	1640200	1759000	6794.02	0
207	Qbt3	1640200	1759000	6790.66	3.37
207	Qbt2	1640200	1759000	6738.93	55.09
207	Qbt1v	1640200	1759000	6649.74	144.28

Table E-2 (continued)

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
207	Qbt1g	1640200	1759000	6529.29	264.73
207	Qbtt	1640200	1759000	6526.06	267.97
207	Qct	1640200	1759000	6496.11	297.92
207	Qbof	1640200	1759000	6421.58	372.44
207	Qbog	1640200	1759000	6403.54	390.49
207	Tpf	1640200	1759000	5435.36	1358.67
207	Tpt	1640200	1759000	5370.36	1423.67
207	Tsfuv	1640200	1759000	4793.81	2000.21
208	Surface	1642000	1761500	6797.35	0
208	Qbt2	1642000	1761500	6758.71	38.64
208	Qbt1v	1642000	1761500	6659.13	138.22
208	Qbt1g	1642000	1761500	6596.95	200.4
208	Qbtt	1642000	1761500	6593.71	203.64
208	Qct	1642000	1761500	6568.74	228.61
208	Qbof	1642000	1761500	6456	341.35
208	Qbog	1642000	1761500	6436.81	360.54
208	Tpf	1642000	1761500	5512.39	1284.96
208	Tpt	1642000	1761500	5447.39	1349.96
208	Tsfuv	1642000	1761500	4866.7	1930.65
209	Surface	1641550	1758500	6750.4	0
209	Qbt2	1641550	1758500	6708.87	41.53
209	Qbt1v	1641550	1758500	6629.5	120.91
209	Qbt1g	1641550	1758500	6535.29	215.11
209	Qbtt	1641550	1758500	6532.06	218.34
209	Qct	1641550	1758500	6505.73	244.67
209	Qbof	1641550	1758500	6444.92	305.48
209	Qbog	1641550	1758500	6427.22	323.18
209	Tpf	1641550	1758500	5460.38	1290.03
209	Tpt	1641550	1758500	5395.38	1355.03
209	Tsfuv	1641550	1758500	4970.72	1779.68
210	Surface	1643100	1761500	6764.85	0
210	Qbt2	1643100	1761500	6737.17	27.67
210	Qbt1v	1643100	1761500	6643.25	121.6
210	Qbt1g	1643100	1761500	6579.28	185.57
210	Qbtt	1643100	1761500	6576.05	188.8
210	Qct	1643100	1761500	6553.89	210.96
210	Qbof	1643100	1761500	6470.33	294.52
210	Qbog	1643100	1761500	6451.25	313.6

Table E-2 (continued)

Point	Unit Name	Easting (ft)	Northing (ft)	Elevation (ft)	Depth to Base of Unit (ft)
210	Tpf	1643100	1761500	5538.39	1226.45
210	Tpt	1643100	1761500	5473.39	1291.45
210	Tsfuv	1643100	1761500	4988.79	1776.06
211	Surface	1645050	1757400	6647.48	0
211	Qbt2	1645050	1757400	6631.9	15.59
211	Qbt1v	1645050	1757400	6591.21	56.28
211	Qbt1g	1645050	1757400	6569.15	78.34
211	Qbtt	1645050	1757400	6565.91	81.58
211	Qct	1645050	1757400	6550.62	96.86
211	Qbof	1645050	1757400	6475.99	171.5
211	Qbog	1645050	1757400	6459.14	188.34
211	Tpf	1645050	1757400	5527.95	1119.53
211	Tpt	1645050	1757400	5462.95	1184.53
211	Tsfuv	1645050	1757400	5420.98	1226.5
212	Surface	1645600	1758900	6637.13	0
212	Qbt1v	1645600	1758900	6600.29	36.84
212	Qbt1g	1645600	1758900	6563.3	73.83
212	Qbtt	1645600	1758900	6560.07	77.05
212	Qct	1645600	1758900	6544.58	92.55
212	Qbof	1645600	1758900	6508.03	129.1
212	Qbog	1645600	1758900	6490.5	146.62
212	Tpf	1645600	1758900	5561.64	1075.49
212	Tpt	1645600	1758900	5496.64	1140.49
212	Tsfuv	1645600	1758900	5392.12	1245.01

Appendix F

List of Contributors

Name and Affiliation	Education and Expertise	Function
Kathryn Bennett (EM/ER)	M.S. Biology/Environmental Science 10 years experience in field biology of the Pajarito Plateau	Biological assessment support
Roy Bohn (EM/ER)	B.S. Biology 19 years experience in environmental monitoring and regulatory compliance	Regulatory compliance support
David Broxton (EES-1)	M.S. Geology 21 years experience conducting field investigations in geology, geologic disposal of high-level nuclear waste, and project management	Canyons technical team leader and technical lead for geology
Margo Buksa (ES&WT)	A.S. Environmental Science 7 years experience in database design and management in addition to technical document support	Provided RFI status data
Leslie Dale (Science Applications International Corporation)	M.S. Geology 7 years experience in site characterization and remediation, waste management, and regulatory compliance	Technical author and technical support for geology and archival research
Michael Dale (NMED DOE OB)	M.S. Geology with emphasis on hydrogeology 7 years experience	Provided oversight input for hydrologic processes
Alison Dorries (EES-13)	Ph.D. Chemistry/M.P.H. Public Health 10 years experience in toxicology, pulmonary health research, regulation development, and human health risk assessment	Analysis and assessment focus area leader
Philip Fresquez (ESH-20)	Ph.D. Environmental Soil and Plant Science 20 years experience in site characterization, reclamation, and monitoring and surveillance.	Biological assessment support
Penelope Gomez (ESH-18		Environmental Surveillance database support
Timothy Haarmann (ESH-20)	Ph.D. Ecology 6 years experience in biological assessments, threatened and endangered species evaluations, and ecotoxicology	Biological assessment support
Leslie Hansen (ESH-20)	Ph.D. Wildlife Biology threatened and endangered species management, estimation of animal abundance, natural resources management	Biological assessment support
Marcia Jones (FIMAD)	8 years experience in the geographical information system specializing in cartography	Produced large maps
Danny Katzman (EES-13)	M.S. Geology 14 years experience in geologic and geomorphic investigations, RCRA site characterization and remediation, and project management	Technical support
Richard Kelley (Los Alamos Technical Associates, Inc.)	B.S. Geology 19 years experience in geologic and petroleum geologic exploration including 8 years of environmental and hydrological specialization	GIS mapping consultant
Richard Koch (Science Applications International Corporation)	M.S. Geology 24 years experience in conducting field investigations and integrating and analyzing geologic, hydrologic, geophysical, and geochemical data	Document lead and technical support for geology, hydrogeology, and geochemistry

Name and Affiliation	Education and Expertise	Function
Patrick Longmire (CST-7)	Ph.D. Aqueous Geochemistry 20 years experience in field hydrogeochemistry and soil chemistry regulatory oversight, the UMTRA project, and RCRA/CERCLA remediation	Technical lead for aqueous geochemistry
Max Maes (ESH-18)	Environmental surveillance	Provided water level data
Pamela Maestas (CIC-1)	B.A. Human Resources Management 3 years experience as an electronic publications specialist; 4 years experience in word processing, data entry, and various software	Electronic publications specialist
Kenneth Mullen (ESH-18)	Ph.D. Analytical Chemistry 16 years experience in environmental monitoring	Environmental Surveillance database support
Allyn Pratt (EES-13)	B.S. Environmental Science/M.B.A. 20 years experience in natural resource management, project management, and environmental management	Canyons focus team leader
Steven Reneau (EES-1)	Ph.D. Geology 19 years experience in geosciences; 9 years at the Laboratory, including 7 years evaluating surface transport of contaminants for the Environmental Restoration Project	Technical lead for geomorphology
David Rogers (ESH-18)	Ph.D. Earth Sciences (Hydrogeology) 26 years experience in geosciences including 11 years as a geophysicist; 7 years experience in hydrological investigations, modeling of groundwater flow and contaminant transport, and geochemistry	Technical support
Michael Saladen (ESH-18)	13 years experience in emergency response and reporting, environmental permitting and regulatory compliance.	Provided NPDES outfall status data
David Shaull (ESH-18)	34 years experience in all phases of hydrologic data collection and analysis	Provided gaging station data
William Stone (EES-5)	Ph.D. Geology 28 years experience in hydrogeology, including university teaching and hydrogeologic investigations	Technical lead for hydrology
Jan Torline (CIC-1)	B.S. Journalism 10 years experience writing/editing DOE environmental remediation/restoration documentation, including LANL, UMTRA Project, SNL	Technical editor