CERTIFICATION

I certify under penalty of law that these documents and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violation.

Document Title: North Canyons Work Plan

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Work Plan for the North Canyons

Environmental Restoration Project

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A Department of Energy Environmental Cleanup Program

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Produced by the Canyons Focus Area

EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act facility investigation (RFI) work plan establishes the technical approach and methodology for environmental investigation of Barrancas, Bayo, Guaje, and Rendija Canyons (the "north canyons") at Los Alamos National Laboratory ("the Laboratory"). This work plan is tiered to the "Core Document for Canyons Investigations" ("the core document") and references the core document for general background information, technical approach, and risk assessment approach (LANL 1997, 62316).

Potential release sites (PRSs) on adjacent mesas and on the canyon floors have introduced potential contaminants to some of the canyons (including organic and inorganic chemicals to Rendija Canyon and inorganic chemicals, organic chemicals, and radionuclides to Bayo Canyon) during the past 50 yr or more. 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 in other parts of the canyons. No persistent surface water or alluvial groundwater is known to occur in the north canyons downstream of PRSs, and the potential for contamination of these media is low. Currently no Laboratory operations are conducted within the subject canyons.

Only a small part of Bayo and Barrancas Canyons are within Laboratory property. Most land within the north canyons is US Forest Service land, with some land belonging to Los Alamos County, the General Services Administration (GSA), and San Ildefonso Pueblo. The GSA property in Rendija Canyon and parts of Barrancas and Bayo Canyons within Technical Area (TA) 74 are proposed for transfer to San Ildefonso Pueblo and Los Alamos County.

Purpose of this Document

The purposes of the investigation are to evaluate the present-day human health and ecological risks from Laboratory-derived contaminants within the north 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 ecological systems and evaluate the potential for transport of contaminants that could cause future human health and ecological risks;
- determine the degree to which stream channel sediments, active floodplain sediments, and if present, persistent surface water in the north canyons, 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 as they relate to risk evaluation;
- provide supplemental characterization of surface water and alluvial groundwater (if present) that is associated with PRSs located in the canyons;
- conduct characterization activities in support of proposed transfer parcels within the north canyons investigation area;

- determine if any portions of the canyon floors currently have unacceptable human health or ecological effects; and
- recommend possible remedial actions for canyon-floor areas that have unacceptable present-day human health or ecological effects.

Response to Regulatory Requirements

The Laboratory Environmental Restoration (ER) Project addresses the requirements of Module VIII of the Laboratory's Hazardous Waste Facility Permit ("Module VIII") (modification dated May 19, 1994 [EPA 1994, 44146]), 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 Module VIII. This work plan addresses and satisfies portions of the requirements in Section I.5, Section Q, Tasks I through V, of Module VIII.

Because the north canyons systems are identified as potential transport pathways for contaminants that migrate across and off the Laboratory rather than as sources of contaminants, the Module VIII requirements for investigating the canyons systems differ from the Module VIII requirements for PRS investigations. These north canyons systems encompass US Forest Service, Los Alamos County, and San Ildefonso Pueblo land and eventually contribute sediment, surface water, and possibly alluvial groundwater to Los Alamos Canyon and the Rio Grande. The north canyons investigations differ 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 canyons systems rather than the investigation of PRSs, although possible characterization of surface water that is associated with PRSs may be included in the planned investigations. The general technical approach presented in the core document and the sampling and analysis plan in this work plan are designed to address the broad requirements of Module VIII, Sections I.5 and Q, as well as to provide data that support risk-based decisions for the PRSs.

Conceptual Model and Technical Approach

One of the significant differences between canyons investigations and 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 investigations' technical approach. This approach uses the findings of each successive investigation to refine contaminant occurrence and transport models.

The investigation area is bounded on the west by the upper portion of each canyon, on the east by Los Alamos Canyon, 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 base of the alluvium. The hydrogeologic work plan provides for investigation of deeper groundwater bodies (LANL 1998, 59599).

The north canyons characterization activities are designed to (1) collect data to support risk assessment based on present-day contaminant levels and (2) evaluate the potential future impacts of contaminant transport in the canyon systems. Systematic characterization of the entire north canyons system 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 the north canyons. The iterative approach allows the investigators to tailor characterization requirements to observed field conditions. This approach relies on frequent regulatory input that ultimately will lead to a well-defined and quantitative understanding of the natural systems involved in canyon contaminant fate and transport and defensible current and future risk assessments within the canyons. These investigations are integral to the overall ER Project strategy, which is to identify major sources of contaminants for the canyon systems and to reduce future contributions from 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 north canyons investigations will include two complementary investigation paths:

- geomorphic mapping, sampling, and analysis of surface sediments in selected reaches of the canyon floor to evaluate surface exposure pathways; and
- investigations that may be undertaken to characterize potential contaminants in biota if contaminants are found in concentrations above background values in sediments downstream of PRSs in Bayo Canyon.

If persistent surface water (surface water that is present for at least 3 continuous months) is present downstream of PRSs, surface water will be sampled and analyzed 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 ("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 areas between the reaches that will be sampled. These data will allow the investigation team to evaluate human and ecological effects within and between the reaches, test hypotheses about processes that control contaminant transport and deposition, and provide a means for testing the investigation approach.

Three canyon reaches in Bayo Canyon, one in Barrancas Canyon, three in Rendija Canyon, and one in Guaje Canyon have been selected for initial geomorphic mapping and sediment sampling based on their locations (downgradient from PRSs) and former Laboratory activities (where contaminants may have been transported to the canyons systems). Additionally, some canyon reaches identified for investigation are located on lands that are proposed for conveyance and transfer, in order to characterize the canyon floors within these parcels. If contaminants are identified in specific reaches, additional subreaches 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 for adjacent subreaches. Mesa tops, alluvial and colluvial deposits on canyon walls, and canyon wall drainages may contain contaminants from individual PRSs. For the most part these sites have been characterized in RFIs conducted by other ER Project focus areas; therefore this work plan will not address these areas.

Biological Sampling

Vegetation in middle Bayo Canyon at a portion of the former TA-10 site has been found to contain elevated concentrations of strontium-90 and possibly other contaminants. Canyons Focus Area investigations may be undertaken in appropriate canyon reaches to characterize potential contaminants in biota if the contaminants are found in concentrations above background values in sediments downstream of PRSs. Because part of the TA-74 land transfer parcel is proposed for transfer to the US Department of Interior in trust for San Ildefonso Pueblo, the ER Project will consult with San Ildefonso Pueblo representatives to help focus sampling activities before biota sampling begins.

Schedule and Reporting

Annex I of the core document contains a preliminary schedule for the north canyons 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.

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

Structure of the Work Plan

This work plan contains seven chapters and three appendixes.

Chapters

Chapter 1 introduces the overall regulatory, operational, and environmental setting and summarizes the planned north canyons investigations.

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

Chapter 3 describes the environmental setting for the north canyons and summarizes available environmental data that are germane to the planned investigation.

Chapter 4 develops the conceptual model for the north canyons and the implications in shaping the overall investigation efforts.

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

Chapter 6 refers to the core document and current ER Project guidance, which explain the human health and ecological effects assessment considerations and approach for evaluating the data derived from the investigation.

Chapter 7 contains the sampling and analysis plans for the initial characterization efforts in the north canyons and describes more fully the implementation of the reach concept for sediment investigations. Potential surface water 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 map referenced in the text.

Appendix B lists the PRSs in the north canyons watersheds and their current status.

Appendix C 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 Waste 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, 1585)

EPA (US Environmental Protection Agency), April 19, 1994. Module VIII of RCRA Permit No. NM0890010515, EPA Region VI, new requirements issued to Los Alamos National Laboratory, Los Alamos, New Mexico, effective May 19, 1994, EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1994, 44146)

LANL (Los Alamos National Laboratory), October 25, 1995. "Groundwater Protection Management Program Plan" (draft), Revision 2.0, Los Alamos, New Mexico. (LANL 1995, 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, 62316)

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

CONTENTS

List of Appendixes

List of Figures

List of Tables

List of Acronyms

AOC	area of concern
ARMS	Albuquerque-Los Alamos Area Aerial Radiological Measuring Survey
ASTM	American Society for Testing and Materials
bgs	below ground surface
BRET	Biological Resource Evaluation Team
BV	background value
CEARP	Comprehensive Environmental Assessment Response Program
CMS	corrective measures study
COPC	chemical of potential concern
CVAA	cold vapor atomic absorption
CWA	Clean Water Act
D&D	decontamination and decommission

DBH	diameter at breast height
DOE	US Department of Energy
EDL	estimated detection limit
EPA	US Environmental Protection Agency
EQL	estimated quantitation limit
ER	environmental restoration
ERDA	Energy Research and Development Administration
ER ID	ER identification number
ESH	Environment, Safety, and Health
EST	Ecological Studies Team
ET	evapotranspiration
FUSRAP	Formerly Utilized Sites Remedial Action Program
GMFZ	Guaje Mountain fault zone
GSA	General Services Administration
HE	high explosive
HMX	high melting explosive
IA	interim action
ICPES	inductively coupled plasma emission spectroscopy
ICPMS	inductively coupled plasma mass spectrometry
IDW	investigation-derived waste
LASL	Los Alamos Scientific Laboratory
MCAL	Mobile Chemical Analytical Laboratory
MDA	material disposal area
MOA	memorandum of agreement
MRAL	Mobile Radiochemical Analytical Laboratory
NFA	no further action
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Board
NOD	Notice of Deficiency
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetlands Inventory
P&A	plugged and abandoned
PCB	polychlorinated biphenyl
PRS	potential release site
QA	quality assurance
QC	quality control
RCFZ	Rendija Canyon fault zone
RCRA	Resource Conservation and Recovery Act

RFI	RCRA facility investigation
RGFZ	Rio Grande fault zone
SAL	screening action level
SAP	sampling and analysis plan
SOP	standard operating procedure
SR	state road
STP	sewage treatment plant
SVOC	semivolatile organic compound
TA	technical area
TAL	target analyte list
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
TSS	total suspended solids
USFS	US Forest Service
USGS	US Geological Survey
UTL	upper tolerance limit
VCA	voluntary corrective action
VOC	volatile organic compound
WWTP	wastewater treatment plant

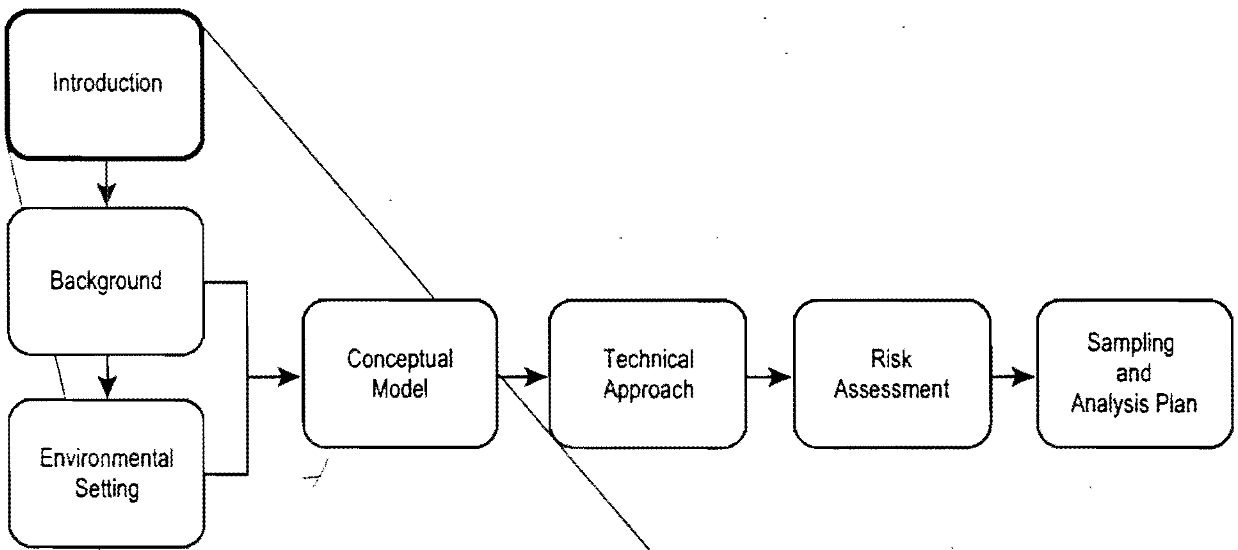
Metric to English Conversions

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)

Metric Prefixes

Term	Power of 10	Symbol
mega-	10^6	M
kilo-	10^3	k
deci-	10^{-1}	d
centi-	10^{-2}	c
milli-	10^{-3}	m
micro-	10^{-6}	µ
nano-	10^{-9}	n
pico-	10^{-12}	p

Chapter 1



Introduction

- Purpose
- Module VIII Requirements
- Canyon Description
- Summary of Planned Investigations
- Decisions 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 Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon systems as part of the Environmental Restoration (ER) Project at Los Alamos National Laboratory (the Laboratory). The Canyons Focus Area investigation team of the ER Project is conducting these investigations.

In this work plan, the Bayo, Barrancas, Rendija, and Guaje Canyons systems are referred to as the "north canyons systems." This work plan summarizes and evaluates previous hydrogeologic and contaminant studies in the north canyons systems and describes new investigations of surface sediments, surface water, and alluvial groundwater to evaluate potential present-day human health and ecological effects that may have resulted from Laboratory-related releases to the canyons.

These canyons are addressed by one work plan because of similarities common to all four canyons (LANL 1997, 62316, p. 1-5), all these canyons head in the northern part of the Pajarito Plateau north of the Laboratory; none contains perennial reaches on Laboratory property. Upper Guaje Canyon, however, does contain a spring-fed perennial reach on US Forest Service (USFS) land; this reach has been used to represent "background" environmental conditions for surface water and stream sediment investigations on the Pajarito Plateau (e.g., Ryti et al. 1998, 59730). With the exception of former Technical Area (TA) 10 area in Bayo Canyon, few areas of these canyons are directly and significantly impacted by Laboratory operations and are not expected to contain major quantities of contaminants, relative to other canyon systems within the Laboratory. Thus, the approach to characterizing most sections of these four canyons will be similar.

1.1 Purpose

The purpose of the north canyons systems investigations is to evaluate potential present-day human health and ecological effects from Laboratory-derived contaminants in sediments, surface water, and alluvial groundwater and to assess impacts of the potential future 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 future human health and ecological effects;
- determine the degree to which the stream channel sediments, active floodplain sediments, and, if present, any persistent surface water and underlying alluvial groundwater in the north canyons 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 as related to risk evaluation;
- provide supplemental characterization of surface water and alluvial groundwater (if present) that is associated with potential release sites (PRSs) located in the canyons;
- characterize contaminants in support of proposed land transfer parcels within the north canyons investigation area;

- determine if any portions of the canyon floors have unacceptable present-day human health or ecological effects; and
- recommend possible remedial actions for canyon floor areas that are found to have unacceptable present-day human health or ecological effects.

The investigations also will characterize contaminant distributions in sediments, surface water, and shallow alluvial groundwater where the canyon floors have been affected by Laboratory operations. Mesa tops and 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 investigation team will concentrate on contaminants within the active stream channels, adjacent floodplains, and, if present, associated surface water and alluvial groundwater. Results of field investigations conducted by other focus areas have been included in planning the investigations that will be conducted in the north canyons systems.

1.2 Relationship to Other Documents

This work plan is tiered to the "Core Document for Canyons Investigations" ("the core document") (LANL 1997, 62316), which provides the general framework for investigations in canyon systems and provides information common to all the investigations planned for canyon areas. The core document includes a description of the investigative regulatory and programmatic framework, historical information on Laboratory land uses and operations, a summary of the regional environmental setting, the generalized conceptual model for the canyons systems, the general technical approach for all canyons investigations, and the present-day human health and ecological effects assessment approach.

This canyon system-specific work plan contains

- an introduction and summary of the planned investigations,
- a discussion of the history of the canyons,
- summaries of the environmental setting and previous environmental investigations conducted in the canyons,
- the current conceptual model of contaminant occurrence and potential pathways for exposure,
- canyon system-specific details on 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, 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, 62316) where these requirements are addressed.

The deeper groundwater investigations in the north canyons area 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). The investigations of intermediate and deeper groundwater are not included as part of this work plan and are left to investigations already planned in the hydrogeologic work plan.

Table 1.2-1
Locations of Discussions of Module VIII[a] Requirements

Module VIII[a] Requirements	Core Document[b]	This Work Plan
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 Work Plan		
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 work plan		Entire document
Progress draft and final	Chapter 7 and Annex I	

[a] EPA 1994, 44146.
[b] LANL 1997, 62316.

Environmental investigations will follow an iterative approach in which information obtained from each successive sampling event will be evaluated in the context of the existing conceptual model and will be used to update the conceptual model. These ongoing evaluations are made in collaboration with other investigations implemented through routine Laboratory Environmental Surveillance Group activities and the hydrogeologic work plan. These evaluations may lead to changes in the locations, numbers, and sequence of future sampling events and characterization/observation wells. In accordance with the approach discussed in the hydrogeologic work plan, changes in the scope of any planned groundwater investigations are negotiated annually with the regulators.

The remainder of this chapter gives a physical description of Bayo, Barrancas, Rendija, and Guaje Canyons and outlines the organization of this work plan.

1.3 Relationship to Land Conveyance and Transfer

In 1997, Congress enacted legislation that required the Secretary of Energy to identify Laboratory land that would be considered for conveyance and transfer to Los Alamos County or to the Secretary of the Interior in trust for the Pueblo of San Ildefonso (Public Law 105-119, The Departments of Commerce, Justice, and State, the Judiciary, and Related Agencies Appropriations Act, 1988). The US Department of Energy (DOE) subsequently identified a total of ten land parcels for such transfer (DOE 1998, 58671). In

June 1998, both Los Alamos County and San Ildefonso Pueblo submitted preliminary statements of interest in some or all of the ten parcels (LANL 1999, 64128, p. i). Two of the land parcels identified for conveyance and transfer are partially or entirely within the north canyons area, as described below.

- Rendija Canyon Parcel

  The Rendija Canyon parcel consists of approximately 910 ac of General Services Administration (GSA) land located in Rendija Canyon north of the Los Alamos town site (Appendix A, Figure A-1, of this document). The site is undeveloped except for a shooting range that serves the local community. The shooting range is located on land that currently is leased from the DOE to the Los Alamos Sportsman's Club. The two land uses proposed by the potential recipients of the Rendija Canyon parcel are cultural and environmental preservation and residential development (LANL 1999, 64128, p. 42).

- TA-74 Parcel

  The TA-74 parcel (approximately 2715 ac) constitutes the northeast part of the Laboratory and is located north-northeast of the Los Alamos town site. Within the north canyons, the parcel spans portions of lower Bayo and Barrancas Canyons and is located just east of the former TA-10 site in middle Bayo Canyon (see Figure A-1). Most of the TA-74 parcel that is within Bayo and Barrancas Canyons is proposed for conveyance and transfer to the US Department of Interior in trust for San Ildefonso Pueblo. The land uses proposed by the potential recipient of the TA-74 parcel are cultural and environmental preservation (LANL 1999, 64128, pp. 57–58).

Investigations described in Section 1.5 and Chapter 7 of this work plan will provide characterization of the areas within these land parcels that are proposed for conveyance and transfer. Because the Rendija Canyon parcel and part of the TA-74 parcel are located within areas to be characterized, the ER Project will consult with the planned recipients to help focus characterization activities prior to sampling.

1.4 Locations and Environmental Settings

The following section briefly describes the locations and environmental settings of Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon. A comprehensive description of each canyon is located in Chapter 3 of this work plan. Figure 1.4-1 shows the locations of the subject canyons in relation to the Laboratory. Appendix A, Figure A-1, is a large-scale map that shows the locations of the canyons and watershed areas.

1.4.1 Bayo Canyon

Bayo Canyon is located north of Pueblo Canyon and extends across Los Alamos County land, Laboratory land, and San Ildefonso Pueblo land to its confluence with Los Alamos Canyon. Former Laboratory TA-10, which was located in middle Bayo Canyon, was used from 1943 to 1961 as a firing site to conduct experiments that used high explosives and radioactive materials. The site consisted of several firing pads, control buildings, a battery building, a radiochemistry laboratory, subsurface disposal systems, and other associated structures. The TA-10 site was decontaminated and decommissioned in 1963 and the land was released to Los Alamos County in 1967 (LANL 1992, 7668, p. 3-1). The lower portion of Bayo Canyon downstream of former TA-10 remains Laboratory property within TA-74 and has been proposed for land transfer (DOE 1998, 58671). TA-74 is an undeveloped area that the Laboratory uses as a safety buffer zone at the northeast side of the main Laboratory site (LANL 1992, 7667, p. 3-14). Bayo Canyon currently is undeveloped and is open to the public for recreational use, except for the lower part that is on San Ildefonso Pueblo land. The former TA-10 subsurface waste disposal areas contain the highest levels of known contaminants remaining within the north canyons systems included in this work plan.

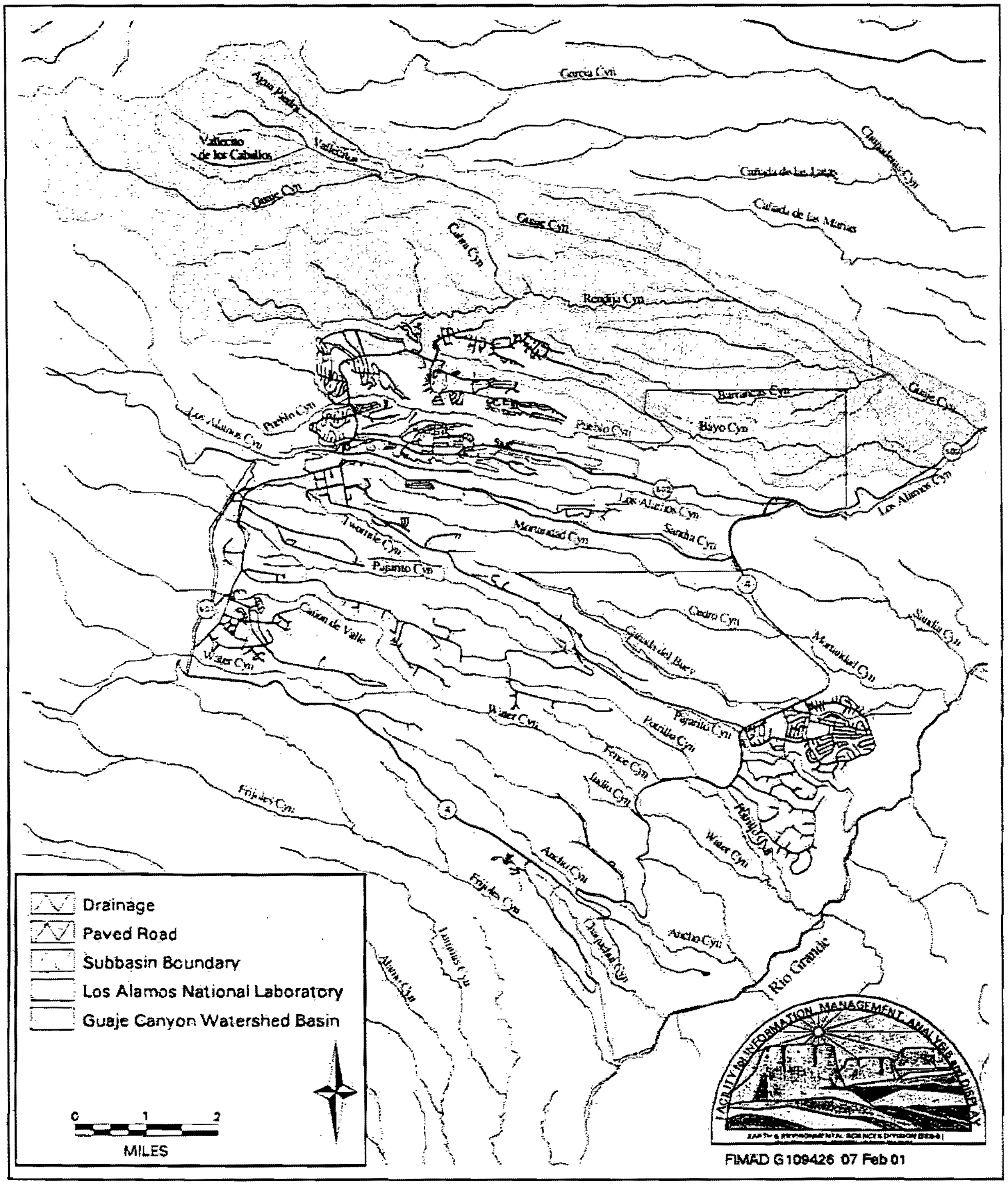


Figure 1.4-1. Locations of Bayo, Barrancas, Rendija, and Guaje Canyons

1.4.2 Barrancas Canyon

Barrancas Canyon is located north of Bayo Canyon and extends across Los Alamos County land, USFS land, Laboratory property, and San Ildefonso Pueblo land to its confluence with Guaje Canyon.

A portion of Barrancas Canyon is included in TA-74, which is an undeveloped area at the northeast side of the main Laboratory site; TA-74 has not been used for Laboratory operations and has been proposed for land transfer (DOE 1998, 58671). No historical or current laboratory structures or PRSs are known to be present in Barrancas Canyon. Barrancas Canyon is undeveloped and the portion of the canyon on Los Alamos County, USFS, and Laboratory land (including TA-74) is open for recreational use by the public.

Because Barrancas Canyon has not been used for Laboratory operations and does not contain known PRSs, limited information about this canyon is available.

1.4.3 Rendija Canyon

Rendija Canyon is located north of the Los Alamos town site and extends across USFS land, private land, Los Alamos County land, and GSA land to its confluence with Guaje Canyon. Cabra Canyon is a small tributary canyon to Rendija Canyon. Lower Cabra Canyon and a portion of the middle Rendija Canyon watershed are located within GSA property that is part of TA-0. "TA-0" is used to designate structures and PRSs that are located on non-Laboratory property, and several PRSs are located within the watershed on GSA land and Los Alamos County land. Rendija Canyon is entirely open for recreational use and includes the site of the Los Alamos Sportsmen's Club, a sport-shooting range. Portions of Rendija Canyon are residential areas along the north side of the Los Alamos town site. The GSA land within Rendija Canyon has been proposed for land transfer (DOE 1998, 58671).

1.4.4 Guaje Canyon

Guaje Canyon is located north of Rendija Canyon and Barrancas Canyon and extends across USFS land and San Ildefonso Pueblo land to the confluence with Los Alamos Canyon. Rendija and Barrancas Canyons are both tributaries to Guaje Canyon. Laboratory operations involving radionuclides are not known to have occurred in Guaje Canyon. The canyon has been used as a water-supply source for Los Alamos. From 1947 to 1991, water supplies were gravity-fed through pipelines to Los Alamos town site from Guaje Reservoir in the upper part of the canyon. The Guaje well field in lower Guaje Canyon has been a major source of drinking water for Los Alamos since 1951. One PRS associated with a polychlorinated biphenyl spill is located in lower Guaje Canyon.

1.5 Summary of the Bayo, Barrancas, Rendija, and Guaje Canyons Investigations

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

1.5.1 Problem and Approach to Problem Resolution

PRSs on adjacent mesas and on the canyon floors potentially have introduced contaminants to the north canyons during the past 50 or more years. Available 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 contaminants to occur in sediments, and possibly surface water and shallow alluvial groundwater (if present) in other parts of the canyons. Currently, portions of Bayo and Barrancas Canyons are undeveloped areas within TA-74, and all these canyons are accessible for recreational use. Land ownership is mixed in these canyons and includes private land, Laboratory property, land owned by the

USFS, Los Alamos County, GSA, and San Ildefonso Pueblo. There are no residential areas on the floors of these canyons, but residences exist on the mesas adjacent to Bayo, Barrancas, and Rendija Canyons. The Sportsmen's Club, a shooting range, is located in middle Rendija Canyon.

Systematic characterization of the entire north canyons systems is impractical because of the large surface area of the canyon floors. Therefore, a process-oriented, iterative approach is planned to determine the nature and extent of contaminants in the north canyons systems. An iterative approach allows the investigators to tailor the characterization requirements to observed field conditions. 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 models 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 canyons systems and to reduce future contributions from mesa-top and canyon sites that have the largest impact on the canyon systems. This approach is discussed in detail in the core document (LANL 1997, 62316), 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:

- geomorphic mapping, sampling, and analysis of surface sediments and deeper post-1942 sediments in selected reaches of the canyon floors to evaluate surface exposure pathways and
- sampling and analysis of surface water and shallow alluvial groundwater, if present, to assess potential water exposure pathways as well as transport pathways and potential impacts on the zones of saturation.

1.5.1.1 Surface Sediment Investigations

Representative sections of the canyon floors ("canyon reaches)" will be investigated in detail to evaluate contaminant concentrations and distributions as a function of proximity to PRSs, depositional environments, the sediment grain size, and the age of sediment deposits. Contaminant data obtained from nearby reaches are expected to define 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 effects within and between the reaches, to test hypotheses about processes that control contaminant transport and deposition and to provide a means for testing the investigative approach.

The initial step in characterizing surface sediments is to prepare a geomorphic map that defines the distributions of surface-sediment types. 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 potential human health or ecological 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 mainly restricted to post-1942 sediment deposits, including the active channels, adjacent floodplains, and abandoned channels. Furthermore, the sampling plan outlined in Chapter 7 of this document uses information from previous investigations of mesa-top PRSs, histories of activities at

PRSs, and the site-specific geomorphic map to focus sampling efforts on 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 contaminants' susceptibility to redistribution.

In May 2000, the Cerro Grande fire burned large parts of the upper Rendija Canyon and Guaje Canyon watersheds. Thus, fire-related chemicals and combustion products are expected to be present in these watersheds. Postfire sampling has shown that metal and radionuclide concentrations in ash and muck (sediment that is dominated by reworked ash) are greater than prefire sediment background concentrations (LANL 2000, 69054). Changes in sediment chemistry that result from the Cerro Grande fire will be considered in the assessment of media sampled in Rendija and Guaje Canyons.

1.5.1.2 Surface Water Investigations

In the north canyons area, no reaches with persistent surface water are known downstream of PRSs; therefore, the need to conduct surface water investigations is not anticipated. Canyons Focus Area investigations of surface water are limited to areas where water is persistent enough to potentially contribute to chronic exposure to human or ecological receptors and that may have been impacted by Laboratory contaminants. Characterization of storm water runoff is not part of Canyons Focus Area investigations but is included as part of some PRS investigations at the Laboratory (LANL 2000, 66802, pp. 1-11, B-63 et seq.).

Canyons Focus Area surface water investigations concentrate on areas downstream of PRSs that may contain contaminants derived from Laboratory activities. Surface water typically is collected quarterly to provide characterization data for general water quality parameters and chemicals of potential concern (COPCs). The investigations follow an iterative approach in which data obtained from each sampling event are evaluated in the context of other relevant surface water investigations and the current conceptual model of contaminant transport so that future characterization efforts may focus on critical data needs. These investigations typically are conducted in collaboration with the administrative authority and other investigators to obtain surface water data, and may lead to changes in surface water collection activities.

1.5.1.3 Alluvial Groundwater Investigations

No alluvial groundwater is known to be located downstream of any PRSs in the north canyons area; therefore, the need to conduct alluvial groundwater investigations is not anticipated. Canyons Focus Area investigations are undertaken to characterize the nature, extent, and potential transport of contaminants by alluvial groundwater. These investigations focus on areas downgradient of PRSs that may contain contaminants derived from Laboratory activities. Wells constructed for characterizing alluvial groundwater can be used to enhance current Laboratory groundwater monitoring systems, if necessary.

Canyons Focus Area alluvial groundwater investigations follow an iterative approach in which information obtained from each borehole is evaluated in the context of other relevant groundwater studies and the current conceptual model so that future characterization efforts may focus on critical data needs. These ongoing evaluations are made in collaboration with regulators and other investigators who implement the hydrogeologic work plan (LANL 1998, 59599) and may lead to changes in the locations and numbers of future boreholes.

1.5.1.4 Biological Investigations

Vegetation in middle Bayo Canyon at a portion of the former TA-10 site has been found to contain elevated concentrations of strontium-90 and possibly other contaminants. Where appropriate, investigations will be undertaken to characterize potential contaminants in biota if contaminants are found in concentrations above background values in sediments downstream of PRSs. The ER Project will consult with San Ildefonso Pueblo representatives to help focus sampling activities.

1.5.2 Decisions

Two primary decisions will be based on the results of the north canyons investigations.

The first decision deals with present-day risk from contaminants currently distributed in the canyon systems. If unacceptable levels of risk to human health or the environment are associated with contaminants in sediments, surface water, or alluvial groundwater in any parts of the north canyons, implementation of this work plan will identify areas and media in the canyons where corrective actions (e.g., removal, stabilization, and institutional control) could reduce present-day risk to an acceptable level. In addition, the data collected will identify PRSs within the canyon drainage areas that may continue to have unacceptable impacts on the canyons.

The second decision deals with the future impacts of natural processes that cause remobilization and redistribution of contaminants in the canyons systems. If an unacceptable future risk or consequence results from leaving the current contaminant inventory and projected inventory in the canyons, implementation of this work plan will identify areas and media in the canyons where corrective actions could reduce those impacts to an acceptable level.

In addition to the two primary decisions, data from the north canyons investigations will support Module VIII of the Laboratory's Hazardous Waste Facility Permit requirement to evaluate the hydrogeologic setting, with particular attention to identifying connections between alluvial groundwater, perched intermediate groundwater, and the regional aquifer (EPA 1994, 44146). The data collected also will satisfy some data needs identified in the hydrogeologic work plan (LANL 1998, 59599).

1.5.2.1 Input to Decision Making

Information is needed to support (1) risk assessments and (2) the basis for the administrative authority's determination that characterization of the north canyons system is sufficient. Concentrations of constituents listed in Table 7.1-1 in this document will be estimated in each media. In addition, the process-oriented iterative approach requires gathering data to test assumptions and hypotheses about how contaminants are transported through the various media of the canyons system. More specific information about the current conceptual model and data needs are discussed in Chapter 4 of this work plan.

1.5.2.2 Boundaries of the Investigation

These planned investigations encompass parts of Bayo, Barrancas, Rendija, and Guaje Canyons that may have been impacted by Laboratory activities and reaches of the canyons downstream of impacted areas. Limited investigations may be performed in upstream reaches to establish baseline conditions for sediment or water.

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 affected by

Laboratory operations (i.e., post-1942 deposits). The vertical extent of Laboratory-derived contaminants is not yet determined, but is expected to be largely confined to the upper 7 to 10 ft (2 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 in Section 1.5.2.3) 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, 62316) and in Chapter 7 of this work plan. The boundaries of the surface water and alluvial groundwater investigations are similar to those of the sediment investigations. The time frame for projecting future contaminant trends is not yet defined, but data will be gathered to evaluate a range of time frames.

1.5.2.3 Decision Factors for Bayo, Barrancas, Rendija, and Guaje Canyons

For each decision discussed in Section 1.5.2 (i.e., imminent present-day risk and potential future risk), risk will be assessed under a set of assumptions and exposure scenarios considered reasonable and appropriate by risk managers. The following decision factors are part of each risk-based decision and are consistent with the general technical approach flow diagram (Figure 5-1) in the core document (LANL 1997, 62316, p. 5-4).

- Which contaminants must be evaluated to support risk-based decisions?

  To establish COPCs for each canyon system, analytical results from each reach in the north canyons are compared to comparable background values, post-Cerro Grande fire concentrations, and relevant standards, according to the most recent methodologies and procedures provided by the ER Project Analysis and Assessment Focus Area. A weight-of-evidence approach is used to determine COPCs. The weight of evidence relies heavily on quantitative (statistical and graphical) approaches to evaluating reach data but also benefits from existing data 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 are carried forward to evaluate present-day human health and ecological effects.

- Are the data adequate to properly assess (and to revise, if needed) 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 data analysis and tests of statistical hypotheses, the investigators evaluate risk. If not, the investigators 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 effects assessment (LANL 2000, 66802, pp. 3-8, 3-12 et seq.).

- Are the data adequate to support risk-based decisions?

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

- Is unacceptable present-day risk associated with contaminants in specific reaches of the north canyons?

  Present-day risk is evaluated by comparing analytical results with risk screening levels for present-day use scenarios. The screening levels are determined in accordance with general US

Environmental Protection Agency (EPA) guidance on development of risk-based preliminary remediation goals (EPA 1991, 58234). If screening levels are exceeded, further analysis may include a more detailed risk assessment or appropriate interim or final measures studies. Best management practices or corrective actions (e.g., removal, stabilization, and institutional control) may be implemented to mitigate the present-day risk at a specific reach.

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

  Risk assessment to support final remedy selection considers all relevant present and future land-use scenarios and incorporates fate and transport calculations for surface and subsurface groundwater pathways and sediment resuspension by wind. If required, additional data needs are identified to ensure that necessary and sufficient data are available to project future risk for all potential transport and exposure pathways within an acceptable level of statistical confidence. Estimated future risk is only one factor in the final remediation decision.

1.6 Organization of this Work Plan

Chapter 2 of this document provides background information on Bayo, Barrancas, Rendija, and Guaje Canyons, including descriptions and histories of the areas and potential sources of contaminants. Chapter 3 provides details on canyon-specific environmental settings. Chapter 4 contains the conceptual model, which is an expansion of the conceptual model in the core document (LANL 1997, 62316). Chapter 5, the technical approach, incorporates the core document technical approach by reference (LANL 1997, 62316). Chapter 6, the present-day human health and ecological effects 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, Purpose.

A list of acronyms precedes Chapter 1. Definitions of unfamiliar terms can be found in the installation work plan for the ER Project (LANL 2000, 66802) and in Bates and Jackson's glossary of geology (Bates and Jackson 1987, 50287).

1.7 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 Waste 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.

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LANL (Los Alamos National Laboratory), May 1992. "RFI Work Plan for Operable Unit 1079," Los Alamos National Laboratory Report LA-UR-92-850, Los Alamos, New Mexico. (LANL 1992, 7668)

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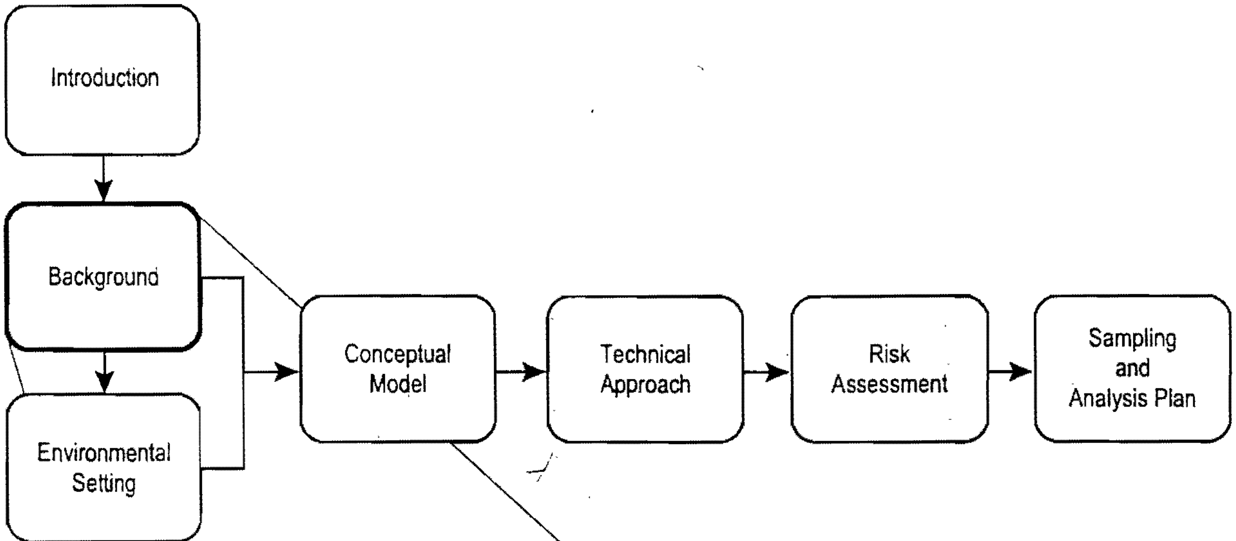
Chapter 2



Background

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

2.0 BACKGROUND

This chapter focuses on the history of Bayo, Barrancas, Rendija, and Guaje Canyons and their tributaries and discusses the topics in appropriate detail for a canyon-specific work plan. Chapter 2 of the "Core Document for Canyons Investigations" ("the core document") 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 (LANL 1997, 62316).

In this document references to the "Bayo Canyon watershed," "Barrancas Canyon watershed," "Rendija Canyon watershed," or "Guaje Canyon watershed" mean the entire drainage area of the canyon and its tributaries, including appropriate portions of mesa tops and canyon walls. Reference to the "Bayo Canyon system," "Barrancas Canyon system," "Rendija Canyon system," or "Guaje Canyon system" refers to only the floor of the main canyon and tributaries, which essentially comprise the floodplain, canyon-floor sediments, stream channel, and associated deposits on the canyon floor. Investigations planned as part of this work plan are located within the respective canyon systems. For simplicity, the area of the four canyons is sometimes referred to as the "north canyons area."

2.1 History of Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon

This section describes prehistoric, pre-Los Alamos National Laboratory (the Laboratory), and current Laboratory usage, as well as current non-Laboratory (such as recreational) usage of Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon.

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 sites are within the north canyons area (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, 10).

In general, there is evidence of sporadic Indian use of the Pajarito Plateau for some 10,000 yr. One Folsom point has been found, as well as many other archaic varieties of projectile points. Indian occupation of the area occurred principally from late Pueblo III period (late thirteenth century) until early Pueblo IV period (middle sixteenth century). Continued use of the region well into the historic period is indicated by pictographic art that portrays horses (Ferenbaugh et al. 1982, 6293, p. 26).

The north canyons area contains many small archeological ruins. Small dwellings, mid-sized pueblos, and lines of cliff dwellings are present along south-facing cliffs. Agricultural fields, rock rings, game pits, and tool-making sites are scattered throughout the area (Hoard 1993, 57491, p. 59). Many archaeological sites in the north canyons area are eligible for inclusion on the National Register of Historic Places. 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).

Two relatively large sites are located in the north canyons area, one on the southern divide of Bayo Canyon and one to the north of Guaje Canyon. The Otowi ruin is a large pueblo ruin located on a relatively flat ridge between Pueblo Canyon on the south and Bayo Canyon on the north, about 1.5 km east of the former Technical Area (TA) 10 site (Ferenbaugh et al. 1982, 6293, p. 25). The pueblo was a terraced structure probably reaching four stories at its highest point. Pottery from the Otowi ruin dates from the early fourteenth century to the mid-sixteenth century. The pueblo had been abandoned by the time it was discovered by the Spanish in the seventeenth century. The Commercial Museum of Philadelphia excavated portions of the Otowi ruin between 1915 and 1917. The excavators divided the artifacts between Philadelphia and Santa Fe. The ruin was almost totally excavated, but no comprehensive report of the work was ever written. The site, containing about 450 rooms, consisted of five house blocks connected by a wall. The excavation was backfilled in 1939 and is now rubble piles covered with weeds (Hoard 1993, 57491, p. 48).

An extensive group of ruins is present on the high mesa on the north side of Guaje Canyon on US Forest Service (USFS) land. The group of ruins consists of at least seven separate ruins that extend for about 1800 ft (550 m) along the crest of a narrow high mesa on the north side of Guaje Canyon. The ruins date from about 1150 to 1300 and consist of several groups of houses and possibly a small dam with a small pond for collecting runoff. A U-shaped pueblo open to the east, a large plaza site with three rock-cut kivas, another U-shaped structure open to the south, and two rock-cut kivas are present in the group of ruins. At the base of the low cliff that borders the site to the south is a string of perhaps 50 cavate rooms, many of which may have been ceremonial rooms (Steen 1977, 7148, p. 39).

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 (1600 to 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 (1890 to 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, 62316, 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 on the Pajarito Plateau (Foxx and Tierney 1984, 5950, p. 4).

Garcia Canyon north of Los Alamos County contains remnants of the homestead era that dominated the Pajarito Plateau from the early twentieth century until 1943. During that time the climate was suitable for dry farming, which depends on adequate rainfall rather than irrigation. Nearby residents from the Rio Grande Valley came up to the plateau and established homesteads. They settled in the area between the Ramon Vigil grant and the land claimed by the Santa Clara Pueblo. Many families built permanent homes on the Pajarito Plateau and one family, the Garcias, clustered in the timberland north of Los Alamos town site (Hoard 1993, 57491, p. 59). The middle part of Rendija Canyon was agricultural land. Bayo, Barrancas, and Guaje Canyons probably were too narrow to support agricultural activities but likely were used for livestock grazing.

2.1.3 Laboratory Operational Use

In 1942, when 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, 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, 62316, 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 on the Pajarito Plateau. 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, 62316, p. 2-6). The Los Alamos Ranch School and Anchor Ranch (present-day TA-8) became TAs, and 25 other outlying sites were developed. TA-10 was established in middle Bayo Canyon for testing explosives and radioactive materials. 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, Guaje, and Los Alamos Canyons for Laboratory and residential use. 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, pp. 4–5).

In 1943, the Manhattan Project engineers realized that existing water supply for Los Alamos was insufficient. Guaje Canyon held the largest remaining stream. By spring 1944, the government began condemnation proceedings in the Guaje region as far north as Garcia Canyon. By summer 1945, all owners had sold their property to the government (Hoard 1993, 57491, p. 61). A small diversion dam was constructed in upper Guaje Canyon and a gravity-fed pipeline was constructed to provide water for Los Alamos.

The earliest Laboratory-related activities within the Bayo Canyon, Rendija Canyon, and Guaje Canyon watersheds during the 1940s include the following:

- a former firing site and radiochemistry laboratory at the location of former TA-10 in middle Bayo Canyon,
- a mortar impact area in upper Bayo Canyon,
- a former small-arms firing range in upper Rendija Canyon,
- several miscellaneous former mortar-impact areas in upper and middle Rendija Canyon, and
- collection of surface water in upper Guaje Canyon for use at Los Alamos town site and the Laboratory.

The Laboratory primarily used middle Bayo Canyon for a radiochemistry building and firing-site area at former TA-10. Disposal of liquid waste from industrial and sanitary systems from the former TA occurred from the mid-1940s until about 1963. The TA-10 site was decommissioned in 1963 and the land that comprised former TA-10 was transferred to Los Alamos County in 1967 (LANL 1992, 7668, p. 3-1). A small portion of upper Bayo Canyon was the site of a mortar impact area. Lower Bayo Canyon currently is included with TA-74, a peripheral buffer zone for the Laboratory, and has been proposed for land transfer (DOE 1998, 58671).

The Laboratory has used Barrancas Canyon as a buffer zone (TA-74) for Laboratory operations. No Laboratory operations or discharges are known to have occurred in Barrancas Canyon. However, the canyon may have been impacted by fallout from explosives testing in nearby Bayo Canyon during the 1940s and 1950s. The part of Barrancas Canyon within TA-74 has been proposed for land transfer (DOE 1998, 58671).

The Laboratory used Rendija Canyon for a gunnery range and for a water collection system of pipelines and lift pumping stations for the Guaje well field. The middle portion of Rendija Canyon is currently General Services Administration (GSA) property. The GSA land in the Rendija Canyon area has been proposed for land transfer (DOE 1998, 58671).

The Laboratory and Los Alamos County use Guaje Canyon for a portion of their water supply. During the early days of the Laboratory, surface spring water was obtained from the Guaje Reservoir and the water was piped to Los Alamos using gravity flow. The Guaje well field, located in middle and lower Guaje Canyon, was installed in the early 1960s. The well field consisted of six water supply wells and provided a significant portion of the municipal water supply for Los Alamos. In 1998, four replacement wells were installed in the well field (ESP 1999, 64034, p. 158). The Laboratory currently does not own land within Guaje Canyon and does not use Guaje Canyon for operational or other purposes.

The Environmental Restoration (ER) Project has identified as potential release sites (PRSs) various former industrial and sanitary waste outfalls and sites of former or active operations that in the past discharged to the north canyons. Other major categories of PRSs identified within the north canyons watersheds include firing sites, former buildings, waste storage areas, and a polychlorinated biphenyl (PCB) spill. The PRSs are documented in the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plans for Operable Unit (OU) 1071 (LANL 1992, 7667) and OU 1079 (LANL 1992, 7668). These PRSs are shown in Appendix A, Figure A-1, of this document and are listed with their current status in Appendix B of this work plan; the PRSs are described later in this section.

2.1.4 Current Land Use

The Bayo Canyon watershed encompasses land managed by the Laboratory, land owned by the County of Los Alamos, land owned by San Ildefonso Pueblo, and private land on Barrancas Mesa, Otowi Mesa, and North Mesa. Bayo Canyon currently is used primarily for recreational purposes—picnicking, trail riding, jogging, and hiking (LANL 1992, 7668, p. 3-129). The upper part of Bayo Canyon has several popular hiking and horse riding trails. The trails extend along the length of the canyon down to the Bayo Wastewater Treatment Plant (WWTP), which is actually located in the adjacent Pueblo Canyon watershed to the south. A main sanitary wastewater pipeline runs down the main part of Bayo Canyon and collects wastewater from the north community and Barranca Mesa housing areas of Los Alamos. The wastewater line and WWTP are owned and maintained by the County of Los Alamos. Current gravel operations are located in lower Bayo Canyon on San Ildefonso Pueblo land.

The residential homes on the north side of Bayo Canyon on Barranca Mesa and Otowi Mesa overlook the canyon. The only remaining physical structures at former TA-10 are a number of asphalt-paved areas and roads, and a concrete pad from a former warehouse. Portions of the former Laboratory site are currently under institutional controls (fencing). In addition, concrete monuments were installed in 1983 to delineate an area where excavation is prohibited until 2142. This controlled area is located at the former subsurface disposal area, which has been investigated as PRS 10-007 (LANL 1992, 7668, p. 3-128).

The Barrancas Canyon watershed is used primarily for recreational purposes. A jeep trail enters a portion of the watershed from Rendija Canyon. Hiking trails are present on Deer Trap Mesa, the headland area to Barrancas Canyon and tributaries; however, Barrancas Canyon and tributaries apparently are used very little for recreational purposes and contain no designated hiking trails (Hoard 1993, 57491).

The Rendija Canyon watershed is used extensively for recreational purposes including hiking, trail riding (horses, mountain bikes, dirt bikes), and gun sports. Several popular hiking trails are located in upper Rendija Canyon and tributaries such as Cabra Canyon (Hoard, 1993, 57491, pp. 62–64, 66). The popular Los Alamos Sportsmen's Club, a gun shooting range, is located in middle Rendija Canyon. The upper part of the canyon extends into the Sierra de los Valle and has several popular hiking trails such as the Mitchell Trail (Hoard, 1993, 57491, p. 103). Ponderosa Estates, a housing development on the north side of Los Alamos, is located in Rendija Canyon and the Guaje Pines Cemetery is also located in the canyon. A public road extends east from Barranca Mesa down Rendija Canyon to Guaje Canyon.

The Guaje Canyon watershed is also used extensively for recreational purposes (several popular hiking trails are located in the upper parts of the canyon) as well as for municipal and industrial uses (lower Guaje Canyon was the location of former gravel operations). The upper part of the watershed has been used to collect surface water from springs at the Guaje Reservoir. The water has been piped to Los Alamos for supplemental uses such as irrigation. Additionally, Guaje Canyon is the site of one of the main groundwater-supply well fields for the County of Los Alamos and the Laboratory. Several deep water supply wells have been installed in middle and lower Guaje Canyon. Together with a water-collection system of pipelines and lift stations, these water supply systems comprise the primary use of Guaje Canyon. A public road extends from near Guaje Reservoir downstream to San Ildefonso Pueblo land and across San Ildefonso Pueblo land to the intersection with State Road (SR) 502. The portion of the road across pueblo land recently was closed to the public (circa 1995). The road has been used during public emergencies, such as when Los Alamos was evacuated during the Cerro Grande fire in May 2000, when the road down Rendija Canyon and Guaje Canyon to SR 502 was used as a primary evacuation route for the north part of the Los Alamos town site.

2.2 Environmental Monitoring and Regulatory Compliance

Chapter 2 of the core document summarizes Laboratory environmental protection and environmental monitoring programs that evaluate the chemical and radiological quality of surface water, groundwater, and sediments at the Laboratory (LANL 1997, 62316). Section 2.2.1 of this work plan summarizes environmental monitoring activities in Bayo, Rendija, and Guaje Canyons. Chapter 3 of this work plan discusses the results of that monitoring. Environmental monitoring has not been conducted in Barrancas Canyon.

2.2.1 Current and Proposed Environmental Monitoring

Environmental monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the US Geological Survey (USGS) to present efforts that include the ER Project, the "Groundwater Protection Management Program Plan" (LANL 1995, 50124), the Environmental Surveillance Program, the decommissioning project, emergency management and response programs, and the planned Watershed Protection Management Program. Other protection efforts include those required by various New Mexico state regulations, the National Pollutant Discharge Elimination System (NPDES) permit, and Module VIII of the Laboratory's Hazardous Waste Facility Permit ("Module VIII") (EPA 1994, 44146). Table 2.2-1 summarizes some of the existing environmental monitoring and surveillance programs that are being implemented by the Laboratory.

Table 2.2-2 lists the former NPDES-permitted outfalls in Rendija Canyon and Guaje Canyon and describes outfalls, locations, and operational status. No current NPDES outfalls are present in Bayo or Barrancas Canyons.

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 treatment at TA-46; the storm water pollution prevention program; the Spill Prevention, Control, and Countermeasures Program; and the Waste Stream Identification and Characterization Program. These programs are discussed further in Chapter 2 of the core document (LANL 1997, 62316) and in the "Groundwater Protection Management Program Plan" (LANL 1995, 50124).

Table 2.2-1
Summary of Laboratory Environmental Programs Related to the North Canyons

Program	Date Implemented	Approved Activity	Regulatory Agency	Comment
Annual Environmental Surveillance	Circa 1970	Environmental monitoring	DOE[a]	Annual environmental surveillance reports
NPDES, CWA	September 13, 1978 (current permit issued January 30, 1990; revised August 1994)	Discharge of industrial and sanitary liquid effluents, environmental monitoring	EPA[b] NMED[c]	No Laboratory NPDES outfalls currently are present in the north canyons. Oversight provided by ESH-18.
Module VIII	November 1989	Hazardous waste storage, treatment, and disposal	EPA NMED	Oversight provided by ESH-19.
Module VIII	May 23, 1990 (new requirements effective May 19, 1994)	Environmental characterization, RCRA corrective action	EPA NMED	RFI currently ongoing by ER Project.
NPDES storm water permit, CWA	General permit August 25, 1993	Discharge of storm water associated with industrial activities, environmental monitoring	EPA NMED	Oversight provided by ESH-18.
Groundwater Protection Management Program	January 1996	Groundwater monitoring	NMED	Hydrogeologic work plan approved by NMED on March 25, 1998.
Watershed Protection Management Program	Pending	Environmental monitoring	DOE	Watershed Management Plan (draft)

[a] DOE = US Department of Energy.
[b] EPA = US Environmental Protection Agency.
[c] NMED = New Mexico Environment Department.

Table 2.2-2
Former NPDES Outfalls in Rendija and Guaje Canyons

NPDES Number	Description	Discharge Location	Active	Discharge Volume	Comment
04A-171	Guaje well G-1 discharge to Guaje Canyon	Pump house	No	Intermittent	Well plugged and abandoned (P&A), deleted from NPDES permit September 21, 1999
04A-172	Guaje well No. G-1A discharge to Guaje Canyon	Pump house	No	Intermittent	Los Alamos County outfall
04A-173	Guaje well No. G-2 discharge to Guaje Canyon	Pump house	No		Well P&A, deleted from NPDES permit September 21, 1999
04A-174	Guaje well No. G-4 discharge to Guaje Canyon	Pump house	No	Intermittent	Well P&A, deleted from NPDES permit September 21, 1999
04A-175	Guaje well No. G-5 discharge to Guaje Canyon	Pump house	No	Intermittent	Well P&A, deleted from NPDES permit September 21, 1999
04A-176	Guaje well No. G-6 discharge to Rendija Canyon	Pump house	No	Intermittent	Los Alamos County outfall
04A-177	Guaje well No. GR-4 discharge to Guaje Canyon	Pump house	No	Intermittent	Los Alamos County outfall

Table 2.2-3 lists the water supply wells that are present in Guaje Canyon and Rendija Canyon. The Guaje well field consists of seven wells ranging from 1500 to 2000 ft deep. Wells G-1, G-2, G-3, G-4, and G-5 were completed in 1950. Well G-1A was completed in 1954, and G-6 was placed in service in 1964. Almost all well field production came from only four of these wells (G-1A, G-2, G-5, and G-6). Attempted rehabilitation of G-3 in 1986 damaged the casing beyond repair and the well was permanently taken out of production. Hence, no water levels have been collected from G-3 since 1986. Wells G-1 and G-4 were pumped sparingly during 1997, and nonpumping water levels were reported for only five months in these wells. Well G-5 was heavily pumped during 1997, but no water level records are available. Because of deteriorating well casings, screens, and gravel packs, most individual water yields in the Guaje well field have declined to uneconomical levels. Except for G-1A, the entire well field was replaced with four new production wells in 1998. Well G-1A was retained for additional water production capacity for emergency fire protection. The older wells were plugged and abandoned in accordance with New Mexico State Engineer Office regulations (McLin 1998, 63506, p. 6).

Table 2.2-3
Groundwater Supply Wells in Rendija and Guaje Canyons

Well	Date Installed	Ground Elevation (ft)	Depth of Casing (ft)	Screened Interval (ft)	Comment
G-1	1950s	5973	2000	282–1980	Water supply/plugged and abandoned
G1-A	1954	6014	1519	272–1513	Water supply
G-2	1954	6056	1970	281–1960	Water supply/plugged and abandoned
G-3	1951	6139	1792	441–1785	Observation well
G-4	1951	6229	1930	426–1925	Water supply/plugged and abandoned
G-5	1951	6306	1840	462–1830	Water supply/plugged and abandoned
G-6	1964	6422	1530	-	Supply (Rendija Canyon)
GR-1	1998	6414	2000	764–1980	Water supply/replacement
GR-2	1998	-	2000	565–1980	Water supply/replacement
GR-3	1998	6212	2000	590–1980	Water supply/replacement
GR-4	1998	6299	2000	656–1980	Water supply/replacement

Source: LANL 1997, 62316, p. 2-11; ESP 2000, 68661.

Four new replacement wells, GR-1, GR-2, GR-3, and GR-4, were installed in Guaje Canyon between October 1997 and March 1998 (McLin 1998, 63506, p. 1). The Guaje well field, located northeast of the Laboratory, now contains five wells. With one exception (G-1A), the older wells were retired in 1999 because of their age (ESP 2000, 68661, p. 174).

As of September 1998, the water supply system was owned by the US Department of Energy (DOE) and operated by the County of Los Alamos, under a lease agreement. The Laboratory deleted the Guaje well field outfalls from its NPDES permit on September 21, 1999 (ESP 2000, 68661, p. 39).

Table 2.2-4 lists observation wells and test holes in Bayo Canyon. Table 2.2-5 lists the test holes in Guaje Canyon. No wells or test holes in Rendija Canyon have been documented except for water supply well G-6.

Table 2.2-4
Observation Wells and Test Holes in Bayo Canyon

Hole	Date Installed	Ground Elevation (ft)	Depth of Hole (ft)	Screened Interval (ft)	Purpose
BCO-1	1994	6642	67.9	59.5–69.5	10-1277, shallow observation well
BCM-1	1994	6641	68	None	10-1276, neutron probe moisture access tube
TH-1	1961	6660	89	None	Determine if perched water occurred
TH-2	1961	6660	25	None	Determine if perched water occurred
TH-3	1961	6610	70	None	Determine if perched water occurred
TH-4	1961	6670	79	None	Determine if perched water occurred
M-1	1973	6630	40	None	Soil sampling
M-2	1973	6625	20	None	Soil sampling
M-3	1973	6625	8	None	Soil sampling

Source: LANL 1992, 7668, pp. 3-8, 3-13; Environmental Protection Group 1994, 45363, pp. vii–6.

Notes: 1. All holes were dry (drilled with a 4-in.-diameter auger).
2. Test hole M-1 is near the former waste pit (10-48).

Table 2.2-5
Test Holes in Guaje Canyon

Hole	Date Installed	Ground Elevation (ft)	Depth of Hole (ft)	Purpose
GT-1	1946	5624	400	Test hole
GT-2	1946	5560	50	Test hole
GT-3	1946	5620	475	Test hole
GT-4	1946	5675	315	Test hole
GT-5	1946	5609	475	Test hole

Source: Purtymun 1995, 45344, p. 245.

In 1994, 93 boreholes were drilled in Bayo Canyon as part of the RFI of PRSs at former TA-10. Boreholes were advanced to a minimum depth of 50 ft and two of the boreholes were completed as monitoring wells BCO-1 and BCM-1.

Environmental surveillance stations in the northern canyons system for monitoring and sampling surface water and sediment are listed in Table 2.2-6. Sediment samples are collected annually in Bayo Canyon and in Guaje Canyon at SR 502. Additional information regarding the results of environmental surveillance sampling is presented in Chapter 3 of this work plan.

The Laboratory's Water Quality and Hydrology Group (ESH-18) surface water collection sites known as the "Bayo STP outfall," "Bayo STP," and "Bayo 1" and "Bayo 2" were sampled as part of past routine and special environmental surveillance projects; however, these sampling stations are located in Pueblo Canyon and will not be discussed in this work plan for the Bayo Canyon watershed.

Table 2.2-6
Routine Environmental Surveillance Monitoring Stations in Bayo, Rendija, and Guaje Canyons

Station Name	Media	Attribute	Location/Comment
Guaje at SR 502	Sediments, surface water, storm water	Flow volume, water quality, and sediment analysis	Guaje at SR 502
Guaje Canyon	Surface water, storm water	Flow volume and water quality	Middle to upper Guaje Canyon
Guaje Canyon near G-4	Sediment	Sediment analysis	Guaje Canyon near G-4, sampled historically, not a routine sample collection site.
Guaje Canyon at G-5	Storm water	Water quality	Guaje Canyon near G-5, sampled historically, not a routine sample collection site.
Guaje Reservoir	Surface water, Sediment	Water quality, sediment analysis	Guaje Reservoir in upper Guaje Canyon
G-1	Groundwater	Water quality	Guaje Canyon
G-1A	Groundwater	Water quality	Guaje Canyon
G-2	Groundwater	Water quality	Guaje Canyon
G-3	Groundwater	Water quality	Guaje Canyon
G-4	Groundwater	Water quality	Guaje Canyon
G-5	Groundwater	Water quality	Guaje Canyon
G-6	Groundwater	Water quality	Lower Rendija Canyon
Bayo at SR-502	Sediment	Sediment analysis	Bayo at SR 502

2.2.2 Module VIII Requirements

Section C of Module VIII (EPA 1994, 44146) does not contain requirements for special monitoring of alluvial groundwater or surface water in the north canyons beyond that conducted within the current Laboratory Environmental Surveillance Program by ESH-18 in accordance with DOE orders. However, Module VIII requires the characterization of existing contamination in the north canyons, including surface water and alluvial groundwater (if present) pathways.

2.3 Sources of Potential Contaminants within Bayo Canyon

Potential contaminant sources (as PRSs) on the mesa tops that are within the Bayo 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 in this section with respect to their approximate geographic locations from west to east within the Bayo Canyon watershed. The technical areas and PRSs that are discussed in this section are shown in detail in Appendix A, Figure A-1, of this work plan. Technical areas located in the Bayo Canyon watershed that do not contain PRSs (i.e., TA-74) 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 December 2000. 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 2000, 66802, p. 7-3).

2.3.1 Technical Area 0

The term "Technical Area 0" or "TA-0" applies to sites used by the Laboratory that are located outside DOE-owned land and/or former or present TAs. TA-0 consists of a series of geographically separated structures and areas scattered across the Pajarito Plateau in the northern part of Los Alamos County and in adjacent Santa Fe County. All PRSs in TA-0 are located outside the boundaries of active TAs. The PRSs in the north canyons area are located on the tops of Barranca, Kwage, and Otowi Mesas and in Bayo, Cabra, and Rendija Canyons (LANL 1992, 7667, p. 3-1).

PRSs located within the Bayo Canyon watershed at TA-0 have been addressed in the "RFI Work Plan for Operable Unit 1079" (LANL 1992, 7668) and are summarized below. All PRSs within TA-0 in Bayo Canyon have been recommended for no further action (NFA).

PRS 0-011(d)

PRS 0-011(d) is the Barranca Mesa firing impact area in upper Bayo Canyon just northeast of the intersection of San Ildefonso Road and Diamond Drive. The US Army fired various types of ordnance into this area between 1944 and 1948 (LANL 1990, 7511; LANL 1992, 7667, p. 5-26).

Currently the site is fenced and marked to prevent the public from entering the site. Materials recovered from the PRS included ordnance fragments of 2.36-in. (6.0-cm) bazooka rounds. After geomorphic mapping was performed by the ER Project, 20 soil/sediment samples were collected during 2 sampling events. The data quality and screening assessments of the analytical results show that no high explosives (HEs) are present at the site and the concentrations of all inorganic chemicals except lead are comparable to regional background levels. Concentrations of lead ranged from 31 to 156 mg/kg, below the screening action level (SAL) value of 500 mg/kg (LANL 1994, 59427, p. ii).

All ordnance shrapnel and fragments recovered from the site were found in an area about 160 $\times$ 80 ft along the base of the cliff. The fragments were entirely 2.36-in. (6.0-cm) bazooka fragments except for one partly intact round. The material included tail fin assemblies, motors, bullets, and other fragments. The fragments mostly were found in the subsurface. Approximately 0.5 m^3 of ordnance fragments were recovered. The geophysical survey identified over 100 ferrous objects. All objects identified in the geophysics survey were investigated by an explosives ordnance team (LANL 1994, 59427, p. 15).

Based on the absence of any significant contaminants found in the search and removal operation and the absence of any significant contaminants in the soil or sediments, PRS 0-011(d) was recommended for NFA and the site was recommended for approval as residential land use (LANL 1994, 59427, p. ii).

PRS 0-008

PRS 0-008, the North Mesa surface disposal area, is a small, open disposal area containing building debris that appears to have come from a demolished weather hutment called "Point Weather." The hutment, which was located on Kwage Mesa (an eastern arm of North Mesa) either near the eastern end of the mesa or approximately 1.25 mi (2 km) east of the rodeo grounds, housed a generator and served as a weather station used in connection with shots fired at Bayo Canyon (Aldrich 1991, 11493). No Laboratory testing activities were conducted on North Mesa or Kwage Mesa. PRS 0-008 is located on Los Alamos County land and was proposed for NFA in the RFI work plan (LANL 1992, 7667, p. 6-2).

Reasons for proposing PRS 0-008 for NFA were

- no known laboratory activities occurred at the site,
- the generator probably was removed before the building was demolished in accordance with standard operation procedures (SOPs) for demolition,
- the debris observed by the Comprehensive Environmental Assessment and Response Program (CEARP) field survey team in 1986 is consistent with the type of debris that would be expected from demolition of the weather station hutment, and
- no hazardous materials were used at the weather hutment (Aldrich 1991, 11493; LANL 1992, 7667, p. 6-1; DOE 1986, 8657; DOE 1987, 52975).

PRS 0-025

PRS 0-025 is the "Tank Mesa Landfill," which was listed as a possible waste disposal area (LANL 1990, 7511). "Tank Mesa," currently known as Otowi Mesa on topographic maps (USGS 1984, 736), is located between Barrancas and Bayo Canyons at the east end of Barranca Mesa in what is now a residential area. Examination of historic engineering files did not reveal documentation that "Tank Mesa" was the site of a landfill. The only reference to "Tank Mesa" occurred in what appear to be reminder notes from a meeting. Although the notes include a few references to disposal areas, the words "Tank Mesa" were distinctly separate from those references. There was no evidence that Otowi Mesa was ever associated with the disposal areas. The archive search uncovered no additional information for PRS 0-025, which was recommended for NFA in the RFI work plan (LANL 1992, 7667, p. 6-4).

The basis for NFA includes the following.

- Reexamination of available site information shows that the reference cited for a landfill on Tank/Otowi Mesa in the PRS report contains no documentation that such a site ever existed (LANL 1990, 7511).
- Based on this information and on the fact that Otowi Mesa is an extremely narrow arm of Barranca Mesa, whose surface consists of undisturbed bedrock, there is no reason to expect that a landfill ever existed on the mesa (LANL 1992, 7667, p. 6-4).

PRS 0-026

PRS 0-026 is the "Gun Mount Landfill" on North Mesa. The location of this PRS is unknown. According to the PRS report the "Gun Mount Landfill" consisted of a buried gun mount, radio poles, hutments, and similar miscellaneous structures (LANL 1990, 7511). A CEARP interviewee reported that a uranium-contaminated gun mount, approximately 5 x 5 x 6 ft, was disposed of on North Mesa in 1946 (LANL 1992, 7667, p. 6-4), although that report has not been verified. Interviews with another former Laboratory employee and a Zia Company employee who had knowledge of such operations indicate that the gun mount is probably not on North Mesa but may be somewhere on Laboratory property or perhaps was shipped to Idaho or some other location (LANL 1992, 7667, p. 6-4).

The radio poles and hutments are shown on a 1948 topographic map at a location that is now in the vicinity of the Los Alamos Middle School. The exact function of the former hutments is unknown; however, they may have housed generators. The disposition of the decommissioned structures is unknown. The PRS report speculates that the gun mount and remains of two structures are in a "landfill" but provides no supporting information (LANL 1990, 7511). PRS 0-026 was recommended for NFA in the RFI work plan (LANL 1992, 7667). The NFA was based on the following.

- If the gun mount is buried in North Mesa, the exact location is unknown. The best information available indicates that it is not on North Mesa; however, even if it were buried there, the associated uranium would not be in a form that could migrate in the environment, nor would it be biologically available if the structure were uncovered.
- The disposition of the decommissioned structure that was associated with radio communications is unknown. However, because no known Laboratory activities occurred at the site, any debris associated with the hutments should not pose a hazard to human health or the environment (LANL 1992, 7667, p. 6-4).

PRS 0-028(b)

PRS 0-028(b), the North Mesa athletic fields, is located in the northern portion of Los Alamos County. The North Mesa athletic fields may have been watered by effluent from the former Pueblo Canyon WWTP beginning in 1952; however, there is no documentation to support this possibility. Although the plant was intended to handle only sanitary waste, small but detectable levels of radiation and chemical wastes have been observed in its effluents (LANL 1992, 7667, p. 5-78).

Field investigations were performed in April 1996 at PRS 0-028(b). Activities consisted of a soil and hand-augered borehole sampling program designed to determine if contaminants were present in the soil. Samples were collected at the surface, from a depth approximately half the distance to welded tuff contact, and at the welded tuff interface. Five locations at the North Mesa athletic fields were sampled. The results of the analyses showed that two samples contained low concentrations of mercury, nickel, silver, and sodium. Neptunium-237 was detected in low (estimated) concentrations in several samples. Organic constituents detected in low levels in some samples included dieldrin, trichloroethane, tetrachloroethene, and toluene. PRS–028(b) was recommended for NFA in the RFI report (LANL 1996, 54837, p. 19).

2.3.2 Technical Area 10

2.3.2.1 Description of TA-10

Former TA-10 was located in the middle portion of Bayo Canyon and is sometimes referred to as the "Bayo site." Used as a firing site from approximately 1944 through 1963, TA-10 also housed a radiochemistry laboratory to facilitate preparation of the shots. Four shot pads were rotated in use because the area immediately surrounding a pad would be radioactively contaminated for up to a month after each shot. The principal structures comprising former TA-10 included a radiochemistry laboratory (10-1); two assembly buildings (10-10 and 10-12); an inspection building (10-8); a personnel building (10-21); and structures at two detonation control complexes, particularly the control buildings (10-13 and 10-15) and adjacent firing pads. Ancillary facilities, mainly for the Laboratory, included sanitary and radioactive liquid waste sewage lines, manholes, septic tanks and seepage pits, and solid radioactive waste disposal pits (Mayfield et al. 1979, 11717, p. 12). PRSs at former TA-10 and the associated structures are listed in Table 2.3-1.

Table 2.3-1
PRSs at Former TA-10

PRS	Structure	Description	Function
10-001(a)	10-22	Firing site	X-unit chamber
	10-23	Firing site	Electronics chamber
	10-13	Firing site	Control building
	10-14	Firing site	Battery building
	10-8	Firing site	Inspection building
10-001(b)	10-24	Firing site	X-unit chamber
	10-25	Firing site	Electronics chamber
	10-13	Firing site	Control building
	10-14	Firing site	Battery building
	10-8	Firing site	Inspection building
10-001(c)	10-26	Firing site	X-unit chamber
	10-27	Firing site	Electronics chamber
	10-15	Firing site	Control building
	10-16	Firing site	Battery building
	10-8	Firing site	Inspection building
10-001(d)	10-28	Firing site	X-unit chamber
	10-29	Firing site	Electronics chamber
	10-15	Firing site	Control building
	10-16	Firing site	Battery building
	10-8	Firing site	Inspection building
10-001(e)	None	Firing site (sand pile detonation)	None
10-002(a)	10-44	Disposal pit	Laboratory disposal pit
	10-1	Disposal pit	Radiochemistry laboratory
10-002(b)	10-48	Disposal pit	Laboratory disposal pit
	10-1	Disposal pit	Radiochemistry laboratory
10-003(a)	10-41	Liquid disposal pit	Liquid disposal pit
10-003(b)	10-42	Liquid disposal pit	Liquid disposal pit
10-003(c)	10-43	Liquid disposal pit	Liquid disposal pit
10-003(d)	Near 10-42	Liquid disposal pit	Liquid disposal pit
10-003(e)	Near 10-41	Liquid disposal pit	Liquid disposal pit
10-003(f)	Near 10-50	Liquid disposal pit	Industrial waste (acid waste) manhole
10-003(g)	10-50	Manhole	Industrial waste (acid waste) manhole
10-003(h)	10-51	Manhole	Industrial waste (acid waste) manhole
10-003(i)	10-39	Septic tank	Industrial waste (acid waste) septic tank
10-003(j)	Near 10-39	Stainless steel tank	Industrial waste (acid waste) septic tank
10-003(k)	Near 10-39	Stainless steel tank	Industrial waste (acid waste) septic tank
10-003(l)	Near 10-39	Stainless steel tank	Industrial waste (acid waste) septic tank

Table 2.3-1 (continued)
PRSs at Former TA-10

PRS	Structure	Description	Function
10-003(m)	10-41	Clay drain pipe	Liquid disposal pit
	10-42		Liquid disposal pit
	10-43		Liquid disposal pit
10-003(n)	Near 10-50	Leach field	Industrial waste (acid waste) manhole
10-003(o)	Near 10-1	Decontamination holes	Radiochemistry laboratory
10-004(a)	10-40	Septic tank	Septic tank
	10-21		Personnel building
10-004(b)	10-38	Septic tank	Septic tank
	10-1		Radiochemistry laboratory
10-005		Disposal pit	All firing sites
10-006	Unknown	Open burning	Unknown
10-007	None	Landfill	None
10-008	None	Satellite firing site	Firing site
10-009	None	Landfill	Laboratory disposal pit

Source: LANL 1992, 7668, pp. 3-11, 3-12.

TA-10 was established to test assemblies of conventional HEs that included components fashioned from depleted or natural uranium. The assemblies were loaded with a lanthanum-140 "source" of several hundred to several thousand curies for blast diagnostics. The lanthanum-140 (half-life 40.3 hr) was contaminated with a small portion of strontium-90 (half-life 28.8 yr). The lanthanum-140 was separated from its host material and prepared as a source in the radiochemistry building. Detonation of the assemblies at the firing sites dispersed uranium and source activity to both air and ground. Liquid and solid wastes generated at the radiochemistry laboratory were placed in waste pits near structure 10-1, which resulted in contaminants being deposited in the subsurface (Courtright 1963, 4771, p. 19).

During operation of TA-10, several environmental investigations were conducted to determine the presence and extent of potential contaminants. A radiological survey of surface sediments was conducted in summer 1954 at the Bayo site explosive testing pads and laboratory as follow-up to similar work conducted in 1946 and 1947. Twenty-four samples were collected and analyzed for plutonium, polonium, strontium, and uranium. Results from the investigation indicated that sediments contained 5000 disintegrations per minute per gram (d/m/g) of beta activity and 15,000 d/m/g of gross beta/gamma activity in a small area adjacent to the former Bayo laboratory building. Other sediment samples at the site contained gross beta/gamma activity ranging from 36 to 125 d/m/g (Dodd 1956, 4695, pp. 3, 4, 10).

In 1956, an investigation of Bayo site was conducted to assess potential contaminants from Laboratory activities. Sediment samples were collected near the Bayo site laboratory. The surface sediment samples contained 15,000 c/m/g and samples from a depth of 3 ft (0.9 m) contained 200 to 300 c/m/g. The results of the investigation identified runoff and groundwater as potential migration pathways for contaminants (Abrahams 1956, 5319).

During 1961 and 1962, the Albuquerque-Los Alamos Area Aerial Radiological Measuring Survey (ARMS) conducted radiation surveys in the Los Alamos area, including Bayo Canyon. The nationwide program was designed to measure current environmental gamma radiation levels by conducting aerial surveys using a thallium-activated sodium iodide detector to count activity at specific altitudes. The results from the ARMS investigation determined that the measured terrestrial radioactivity could be attributed to area geology and materials used in urban development. Furthermore, results indicated that artificial radionuclides are present in small quantities, which were assumed to be in uniform distribution (Guillou 1964, 15096, pp. 5, 11, 16). The ARMS test was conducted again in 1975 using improved equipment. The results of the aerial survey found that yttrium-90 and uranium-238 were not measured in significant concentrations in the vicinity of Bayo site (Mayfield et al. 1979, 11717, p. 15).

2.3.2.2 TA-10 Decontamination and Decommissioning Activities

Decontamination and decommissioning (D&D) activities started at TA-10 in 1960 with the demolition and/or burning of several buildings. The sitewide decommissioning of both the firing sites and the radiochemistry laboratory and associated structures was completed in 1963. During cleanup activities in 1963, 90 truckloads of debris, shrapnel, and HE materials were removed from a radius of 760 m from the detonation control buildings at the firing sites, and transported to Material Disposal Area (MDA)-C at TA-50 and MDA-G at TA-54. The liquid waste disposal system associated with the radiochemistry laboratory was also removed, and the contaminated waste pits were excavated (Courtright 1963, 4771, pp. 19–20). Radiological surveys showed that the site was sufficiently free of contaminants to permit the land to be released from federal control. The land was transferred ~~to~~ Los Alamos County by quit claim deed on July 1, 1967 (Mayfield et al. 1979, 11717, p. 1).

2.3.2.3 Post-D&D Investigations

In 1973, 3 boreholes were drilled to investigate the subsurface at former TA-10; in 1974, 12 additional boreholes were drilled near each of the 3 test holes drilled in 1973. Subsurface samples were collected and analyzed for gross alpha and gross beta activity. Samples collected from the boreholes indicated that strontium-90 was present above background levels in the subsurface near several former structures at TA-10. Samples collected from a borehole near the former concrete tank (10-50) contained 1500 to 24,000 pCi/g gross beta activity at 14- to 16-ft (4.3- to 4.9-m) depth, indicating that some migration of radionuclides into the bedrock tuff had occurred (Mayfield et al. 1979, 11717, pp. 14, 51).

2.3.2.4 FUSRAP Investigation

In 1976 the Energy Research and Development Administration (ERDA) identified former TA-10 for reevaluation as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP). The FUSRAP used modern instrumentation and analytical methods to determine whether any further corrective actions were needed. The investigation was undertaken by the Los Alamos Scientific Laboratory (LASL) under contract to ERDA and subsequently to the DOE (Mayfield et al. 1979, 11717, p. 1).

The FUSRAP investigation included surface and subsurface soil sampling and radiochemical analyses. Results showed that surface materials contained an average concentration of 1.4 pCi/g of strontium-90, which was about 3 times the level attributable to worldwide fallout. The average uranium concentration in surface materials was about 4.9 µg/g, about 1.5 times the level naturally present in the soils. Subsurface contamination associated with the waste disposal system at former TA-10 was found to be confined within an area of about 10,000 m^2 (108,000 ft^2 or about 2.5 ac) that extended to a depth of about 5 m (16 ft). A total of 378 subsurface samples was collected, of which about 12% contained gross beta activity that exceeded background levels (Mayfield et al. 1979, 11717, p. 1).

During the 1977 FUSRAP investigation, several boreholes were drilled and trenches were dug around several former structures at TA-10 including the former septic tank (10-40), the personnel building

(10-21), the acid-waste lines leading from the radiochemistry laboratory to a manhole (10-51), and the acid waste septic tank (10-39). Trench samples showed background levels of gross-alpha and gross-beta activity. However, strontium-90 levels were nearly 6 pCi/g, approximately 15 times the background level (LANL 1992, 7668, p. 3-60).

Radiological dose calculations based on a residential scenario (50-yr residence time) were calculated based on the results of the FUSRAP sampling and analyses. The calculated residential dose for an average resident of Bayo Canyon was 0.43 mrem/yr due to external penetrating radiation from the sediments. This dose amount was 0.086% of existing DOE guidelines (500 mrem/yr) and 0.24% of the dose received from natural radiation in Bayo Canyon (180 mrem/yr). The maximum exposure scenario was ingestion of 50 kg/yr (for 50 yr) of vegetables and fruits produced from garden plots located in contaminated soil in Bayo Canyon. The calculated dose for this scenario was 45.6 mrem to the bone, which was 3.0% of the DOE guidelines for annual exposure and 25% of annual exposure from natural radiation in the canyon. Another exposure scenario that was calculated provided for inhalation of dust containing contaminants, such as which would be expected for a construction worker over 50 yr. The calculated dose was 23 mrem to the bone (Mayfield et al. 1979, 11717, p. 2).

2.3.2.5 RCRA Facility Investigation

PRSs located within the Bayo Canyon watershed at former TA-10 were addressed in the "RFI Work Plan for Operable Unit 1079" (LANL 1992, 7667). Results of the investigations performed under the work plan were reported in the RFI report for TA 10 PRSs 10-002(a,b), 10-003(a–o), 10-004(a,b), 10-005, 10-007, (LANL 1996, 54332) and the addendum RFI report on the results of radionuclide analyses (LANL 1996, 54617). The results of a voluntary interim action (IA) cleanup at PRSs 10-002(a,b), 10-003(a–o), 10-004(a,b), and 10-007 were reported in an IA report (LANL 1996, 54491).

2.3.2.5.1 RFI Characterization

The 1994 RFI for the TA-10 subsurface disposal aggregate included geodetic, radiological, and geophysical surveys; drilling; and subsurface sampling. The geodetic survey identified the locations of former buildings and structures associated with TA-10 operations. The radiological survey was conducted by the Laboratory's Health Physics Operations Group (ESH-1) for health and safety purposes. The results of the geophysical survey were used to determine the location of PRS 10-005, a surface disposal pit (LANL 1996, 54332).

A total of 93 boreholes was drilled and sampled (see Appendix A, Figure A-1). Boreholes were advanced to a minimum depth of 50 ft below ground surface. At least four subsurface samples were collected from each borehole for laboratory analysis of selected radiological and nonradiological constituents (LANL 1996, 54332). Soil samples also were collected at 5-ft intervals for on-site analysis of gross radioactivity by the Laboratory's Analytical Chemistry Services Group (CST-9) Mobile Radiochemical Analytical Laboratory (MRAL) and off-site analyses of selected nonradiological constituents by CST-9's Mobile Chemical Analytical Laboratory (MCAL). The TA-10 Bayo Canyon subsurface sampling field summary report describes the site characterization activities conducted to address potential contaminant releases from PRSs 10-002(a-b), 10-003(a–o), 10-004(a,b), 10-005, and 10-007 (LANL 1995, 49073, p. i).

Analyses of target analyte list (TAL) metals and semivolatile organic compounds (SVOCs) indicated that neither metals nor SVOCs were present above SALs in any of the 93 boreholes. Radiological screening results indicated the presence of radioactivity above background levels in some boreholes associated with former structure 10-48. On average, radiological contaminants were detected in the various boreholes in depths ranging from approximately 14- to 22-ft depth (LANL 1995, 49073, p. i).

The 1996 RFI report for TA-10 was for the subsurface aggregate, which includes all areas of TA-10 where subsurface contaminants were of concern. The PRSs in the subsurface aggregate are located near the former radiochemistry laboratory, and include PRSs 10-002(a-b), 10-003(a–o), 10-004(a,b), 10-005, and 10-007. The list of chemicals of potential concern (COPCs) for these PRSs includes TAL metals, HE compounds, volatile organic compounds (VOCs), SVOCs, total uranium, isotopic uranium, and strontium-90 (LANL 1996, 54332).

2.3.2.5.2 RFI Interim Action for Shrapnel Removal

Radioactively contaminated shrapnel fragments were found in 1993 during geomorphic mapping activities at the former TA-10 firing site. The shrapnel present in middle Bayo Canyon resulted from surface detonations at the firing sites at former TA-10; the original distribution of shrapnel was primarily on the ground surface. However, in the more than 50 yr since the detonations began, and since 1960 when activities were suspended, shrapnel was redistributed by a combination of natural and anthropogenic processes (LANL 1996, 54491, p. 3).

When the firing sites at former TA-10 were active in the late 1940s and 1950s, shrapnel was redistributed by human activities at the firing sites. Shrapnel was redistributed when firing pads were cleared for subsequent shots, the area around firing sites was regraded with earth-moving equipment, and shrapnel material was deliberately buried for disposal. Redistribution of shrapnel fragments also likely occurred during decommissioning of the site in the early 1960s when firing pads, bunkers, and other structures were removed. Additional inadvertent transport and burial of shrapnel probably occurred during decommissioning disturbance by trucks and heavy equipment.

Storm water runoff may have transported shrapnel fragments down canyon side slopes to the canyon floor and possibly into the main stream channel. A geomorphic survey of the middle Bayo Canyon area found that surface and geological processes in the area are dynamic (Drake and Inoue 1993, 53456). At least two cycles of erosion and deposition have occurred since the firing sites at former TA-10 began activity, resulting in incorporation of shrapnel into alluvium up to depths of 1.1 m (3.6 ft). Shrapnel may have been transported downstream by flood events along the main drainage channel (LANL 1996, 54491, pp. 3, 4).

During the RFI characterization of the former TA-10 site, a small percentage (1% to 2%) of shrapnel fragments were found to be radioactively contaminated. Several shrapnel fragments contained radioactivity with measured dose rates up to 8 mrem/hr (LANL 1996, 54491, p. 5).

Due to the potential for human health risks to recreational users of the canyon, a voluntary corrective action (VCA) was planned initially. The VCA plan called for shrapnel pieces in the upper 4 ft of soil to be located using geophysical techniques and removed by hand. During the first few days of the survey, thousands of pieces of shrapnel per acre were discovered in the vicinity of the former firing pads. Removal of all the shrapnel by hand was then recognized to be an impractical solution (LANL 1996, 54491, p. l).

The VCA plan was changed to an IA with three main objectives:

- immediately reducing potential public risk by removing surface shrapnel from those areas of Bayo Canyon that are open to the public;
- performing a systematic shrapnel-density distribution study to support future remedy selection alternatives, should further shrapnel removal be necessary; and

- obtaining data concerning radioactive contaminant distribution on shrapnel pieces sufficient to support a risk assessment.

The IA shrapnel project was performed in fall and winter 1994. The shrapnel density distribution investigation was performed in an area about 2400 ft (730 m) wide and 24,000 ft (7300 m) long, which covered approximately 11 ac. Shrapnel distribution was determined by close inspection of selected 10-ft (3-m)-square grids. Shrapnel depth distribution was recorded in 3-in. (7.6-cm)-depth intervals. Depth-distribution data and shrapnel count data from the selected grid squares were used to estimate the total distribution of shrapnel over the middle Bayo Canyon area. Additionally, a geophysical survey was conducted in the active stream channel (dry streambed). Shrapnel densities were recorded in 10-ft (3-m)-square grids at 200-ft (60-m) intervals along the length of the stream channel for 8600 ft (LANL 1996, 54491, p. 7).

The results of the shrapnel distribution investigation showed considerable variation in shrapnel densities within Bayo Canyon at former TA-10. Near the former firing sites, shrapnel densities in excess of 2,000,000 pieces per ac were found. Shrapnel densities of 5000 pieces per acre or greater covered an area of approximately 75 ac. Most (65%) of the shrapnel was found within the upper 3 in. (7.6 cm) of soil and 68% of the shrapnel was found within the upper 6 in. (15 cm) of soil. Less than 4% of the shrapnel was present at depths greater than 1 ft (0.3 m). During the shrapnel density distribution investigation, less than 1% of the 8513 pieces of shrapnel that were collected were radioactive. In the stream channel, from 1 to 3 pieces of shrapnel consistently were found to be present in each of the 10-ft^2 (3-m^2) grids that were located every 200 ft (60 m) along the stream channel (LANL 1996, 54491, p. 11).

During the shrapnel removal phase of the project, a 100-ft^2 (30-m^2) grid pattern was established over an area about 1000 ft (305 m) wide and 6000 ft (1830 m) long in middle Bayo Canyon and on the adjacent Kwage Mesa. Figure 2.3-1 shows the grid pattern and the result of the shrapnel removal. Over 19,000 pieces of shrapnel were collected, of which 458 pieces (2.4%) were radioactive. Most shrapnel pieces (87%) were less than 6 in. (15 cm) long and 53% were greater than 2 in. (5 cm) long (LANL 1996, 54491, p. 8).

A risk assessment was performed based on the data collected during the shrapnel distribution investigation and the surface shrapnel removal activity. Exposure pathways considered by the risk assessment included ingestion of radioactive shrapnel fragments and external exposure to the skin surface. The external skin exposure assessments included a two hypothetical scenarios: a child picking up a piece of radioactive shrapnel and carrying it in a pocket for up to 48 hr and an adult making a necklace of a piece of shrapnel and wearing the necklace next to the skin for 18 hr a day for a year (LANL 1996, 54491, pp. 12–15).

Risk modeling shows that the increased cancer risk from the shrapnel is less than the US Environmental Protection Agency (EPA)-accepted risk range of 1 in 10^4 to 1 in 10^6. The potential acute effects were determined to be negligible. Therefore, the human health consequences of the remaining Bayo Canyon shrapnel were determined to be minimal and no further action was recommended for the remaining shrapnel in Bayo Canyon (LANL 1996, 54491, pp. i, ii).

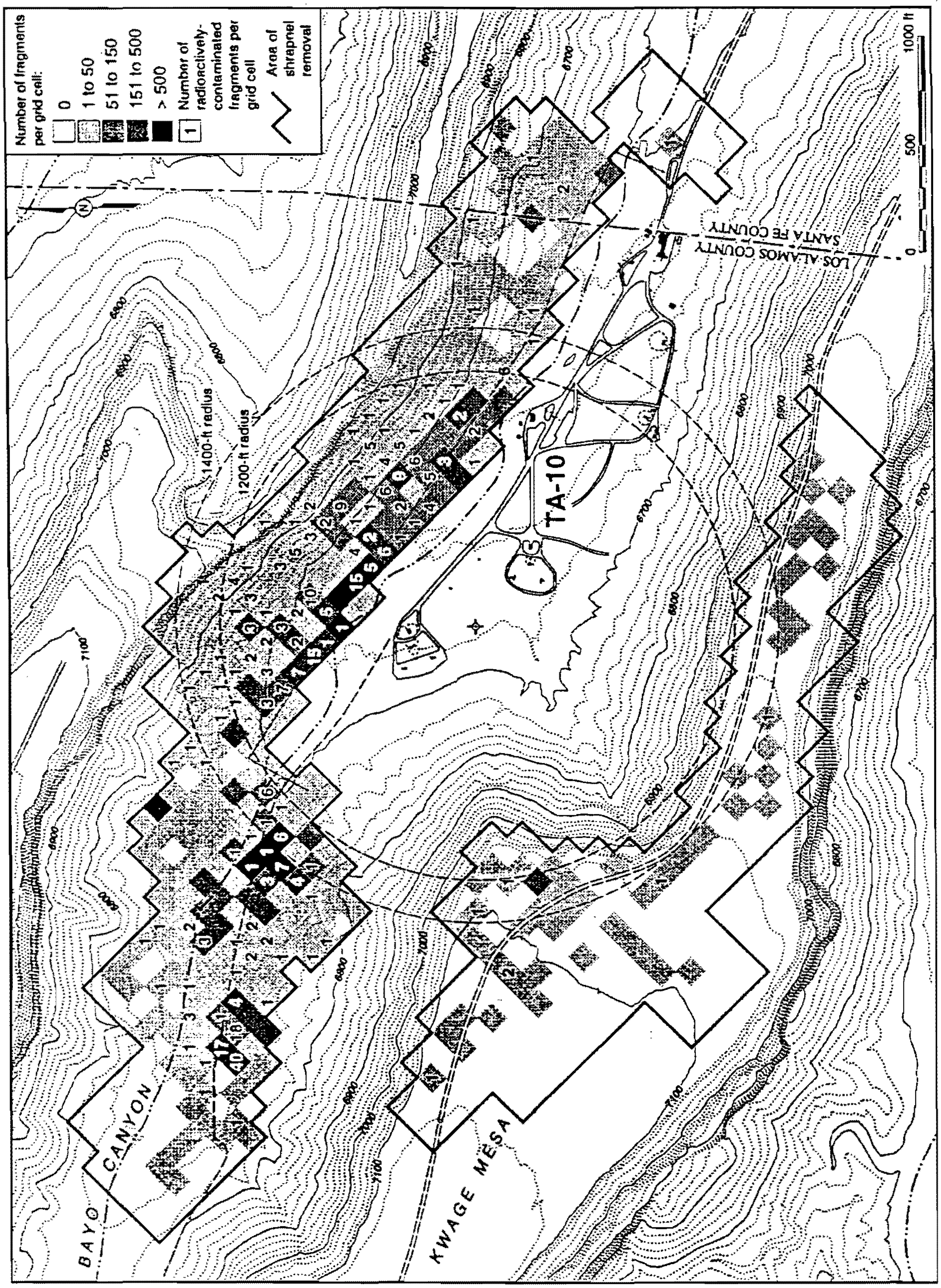


Figure 2.3-1. Area of shrapnel removal in middle Bayo Canyon

2.3.2.5.3 RFI Interim Action for Strontium-90 in Vegetation

An IA was conducted in 1996 and in 1997 to address strontium-90 in vegetation at the former site of the central portion of TA-10 in Bayo Canyon. The IA related to PRSs 10-002(a,b), 10-003(a–o), 10-004(a,b), and 10-007 (LANL 1997, 56358). Initially, IA activities were planned to address only chamisa that contained elevated activity (LANL 1996, 55698, p. 1). However, during a radiation survey conducted to determine which chamisa plants would be removed, surface soil and several plant species in addition to chamisa were found to contain elevated radioactivity. A characterization plan was prepared and implemented to define the nature and extent of plant and soil contaminants. A total of 56 soil and sediment samples was collected during the characterization phase of the IA. Strontium-90 in the sediment samples ranged from 2 to 146 pCi/g and vegetation samples ranged from 14 to 199 pCi/g dry weight (LANL 1997, 56358, Table 1). This information was used to prepare a revised IA approach. This revised approach was expected to mitigate the potential for exposure to strontium-90 in plants and soil at the TA-10 central area pending selection and implementation of a final remedy for the site. Pending implementation of a final remedy, silt fences and straw bales were installed at the site (LANL 1997, 56358, p. 1).

A risk assessment was developed from the characterization data obtained during the IA. Pathways used in the assessment included (1) inhalation of resuspended dust and soil, (2) ingestion of soil, (3) ingestion of plant material, (4) ingestion of meat from animals that had foraged in the area, and (5) inhalation of wood smoke from firewood gathered at the site. Plant ingestion was the primary contributor to annual dose (93%) and ingestion of game meat was the second highest contributor (5%). The annual dose calculated from the plant ingestion scenario was less than 10 mrem/yr (LANL 1997, 56358, p. 11).

PRSs that were the subject of investigations, remedial action, or deferred action at former TA-10 are described and investigations performed at the sites are summarized in this section. Additional investigations at some PRSs may be planned in the future.

PRS C-10-001

PRS C-10-001 consists of two small sites that contained radioactive soil. These sites were within an area where materials and soil associated with the former firing sites at TA-10, PRSs 10-001(a–d), were apparently bulldozed and left remaining after D&D activities were conducted in 1963. The sites were discovered using hand-held radiation screening instruments during routine shrapnel removal operations in summer and fall 1994 (LANL 1995, 53782, p. 1).

Field activities were implemented in 1995 in accordance with the VCA plan for PRS C-10-001 (LANL 1995, 49546). The initial phase of the VCA involved a survey at each site to delineate the areas with elevated radioactivity but previous removal of shrapnel during 1994 from one site effectively removed the field-detectable radioactivity from that site. At the second site, analyses of soil from the area that showed the highest level of radioactivity, as determined by field screening, yielded 3518 pCi/g of strontium-90 (LANL 1995, 53782, p. 1).

The second phase of the VCA involved collecting subsurface samples from shallow hand-augered holes at each site to determine the extent of subsurface contaminants and the appropriate mode of excavation. The area containing the strontium-90 was approximately 1 m in diameter and 30 cm deep (LANL 1995, 53782, p. 1). The third phase of the VCA involved excavation of approximately 1 m^3 of the radioactive soil and site restoration. Confirmation samples indicated that the highest concentration of strontium-90 remaining after excavation was 12.8 pCi/g. PRS C-10-001 was recommended for NFA in the VCA completion report (LANL 1995, 53782).

PRSs 10-001(a–d)

PRSs 10-001(a), 10-001(b), 10-001(c), and 10-001(d) are former firing sites in the western part of former TA-10. The firing sites included shot pads and a series of buildings and chambers. The COPCs at the former firing sites are HE, uranium, strontium-90, lead, beryllium, and barium. SVOCs also may have been dispersed by the explosives testing (LANL 1995, 49974, p. 1).

The 1995 RFI report summarizes the results of surface sampling and analyses done at PRSs 10-001(a–d) during 1994. A geodetic survey was performed to establish the surface sampling grid, stream sampling transects, and former structures associated with former TA-10 operations. The grid consisted of 68 surface sampling locations plus 10 random sampling locations. Of the 68 grid samples, the 10 samples that indicated the highest radioactivity during field screening were to have been analyzed for TAL metals, radionuclides, and HE (LANL 1995, 49974, p. 21). Samples were collected from the finest-grained sediments from the surface to a depth of no more than 6 in. to maximize the potential for detecting residual contaminants. An additional 10 samples were collected 100 ft (30 m) from randomly selected grid nodes in a randomly selected cardinal direction. These random samples were analyzed for gross alpha, beta, and gamma radiation by the MRAL and for total uranium, strontium-90, beryllium, barium, lead, TAL metals, and HE at fixed laboratories (LANL 1995, 49974, p. 23).

PRSs 10-001(a–d) were recommended for NFA in the RFI report because the PRS had been characterized or remediated in accordance with current applicable state or federal regulations; available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 1995, 49974). In 1999 the four firing site PRSs were consolidated into one decision set, 10-001(a)-99.

PRS 10-002(a)

PRS 10-002(a) is the site of a former pit (10-44) dug for the disposal of spent chemicals, laboratory equipment, and trash. The pit received such items as gloves, rags, and acid bottles. The exact dates of use for this pit are unknown, but are thought to have been between 1945 and 1950. This PRS measured about 8 ft (2.4 m) wide, 5 ft (1.5 m) long, and 12 ft (3.6 m) deep (LANL 1990, 7511). It is not known whether this pit was covered during or after the period of active use, but it is thought that after it was no longer in use in the early 1950s, it was covered with soil until cleanup activities began in 1963. The quantities of contaminants buried in the pit are also unknown. The COPCs for PRS 10-002(a) are strontium-90, total uranium, barium, cadmium, VOCs, and SVOCs (LANL 1996, 54332, p. 40).

During the RFI in 1994, no inorganic constituents were detected at concentrations greater than background values (BVs) (LANL 1996, 54332, p. 46). The organic compounds bis(2-ethylhexyl)phthalate and diethyl phthalate were detected in low concentrations (LANL 1996, 54332, p. 46). Strontium-90 was measured in concentrations up to 1.62 pCi/g at a depth of 41 ft in borehole 10-1252 (LANL 1996, 54617, p. 15). No analyses were obtained for VOCs or HE, which represented a deviation from the approved sampling plan (LANL 1996, 54332, p. 43). The IA to address strontium-90 in vegetation at former TA-10 included the site of PRS 10-002(a) (see Section 2.3.2.5.3 of this document).

PRS 10-002(a) was recommended for NFA in the RFI reports because the PRS had 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 (LANL 1996, 54332; LANL 1996, 54617). In 1999, PRS 10-002(a) was consolidated into one decision set with other similar PRSs; the decision set was designated 10-002(a)-99.

PRS 10-002(b)

PRS 10-002(b) was the site of a former pit (10-48) dug for the disposal of spent chemicals, laboratory equipment, and trash. The pit received gloves, rags, and acid bottles. In addition, this pit was used for the disposal of residues from the lanthanum-140 extraction process performed in the radiochemistry laboratory. The total amount of liquid waste generated at the radiochemistry laboratory contained an estimated 117 Ci of strontium-90. The exact dates for use of this pit are unknown, but it is thought to have been used between 1945 and 1950. Former structure 10-48 was divided into two sections, each measuring approximately 5 ft (1.5 m) wide, 5 ft long, and 10 ft (3 m) deep. The pit sections were lined with boards and had wood covers (LANL, 1990, 7511).

It was thought that after use of 10-48 was discontinued in the early 1950s, PRS 10-002(b) was covered with soil until cleanup activities began in 1963. The quantities of contaminants buried in this pit are unknown. Specific contaminants listed as present in the wastes include strontium-90, uranium, barium, cadmium, platinum, benzene, carbon tetrachloride, unspecified acids (probably nitric, hydrochloric, hydrofluoric, and sulfuric acids), and other unspecified organic and inorganic compounds (LANL 1992, 7668, p. 3-55).

During the 1963 D&D, it was determined that some strontium-90 remained in the bottom of the pit. All solid waste was removed and the pit was excavated to a depth of 26 ft (8 m). Because gross beta radioactivity was near background levels, the pit was backfilled with clean fill (LANL 1996, 54332, p. 49).

An RFI was conducted in 1994. The COPCs for PRS 10-002(b) include strontium-90, total uranium, barium, cadmium, VOCs, and SVOCs (LANL 1996, 54332, p. 49). The results of the investigation showed that two inorganic compounds, copper and zinc, had concentrations greater than the background screening values. Statistical comparisons were made between copper and zinc for PRS data and Laboratory-wide soil background data. The concentrations of copper and zinc were not above BVs.

The highest concentration of strontium-90 was 340.02 pCi/g in a sample from 4.2-ft (1.3-m) depth. Four organic compounds were detected in subsurface samples at PRS 10-002(b), including acetone; di-n-butylphthalate; 2,-4,dinitrotoluene; and 2,-6,dinitrotoluene at levels below SALs (LANL 1996, 54332, p. 57). No inorganic constituents exceeded soil BVs. The IA to address strontium-90 in vegetation at former TA-10 included PRS 10-002(b) (see Section 2.3.2.5.3).

PRS 10-002(b) was not recommended for NFA in the RFI report (LANL 1996, 54332; LANL 1996, 54617). In 1999, PRS 10-002(b) was consolidated into one decision set with similar PRSs; the decision set was designated 10-002(a)-99.

PRSs 10-003(a–o) and 10-007

PRSs 10-003(a–g, m) are associated with the former liquid waste disposal complex that served the former radiochemistry laboratory, structure 10-1. The radiochemistry laboratory was used to process lanthanum-140 into radioactive sources. The liquid disposal complex consisted of liquid disposal pits, industrial waste (acid waste), manholes and septic tanks, industrial waste (acid waste) lines, and a leach field that handled the liquid radioactive and chemical wastes generated by the radiochemistry laboratory operations. PRSs 10-003(a–c) were three liquid disposal pits (10-41, -42, and -43) constructed of reinforced concrete with steel covers. Each pit was 2 ft (0.6 m) wide, 2 ft long, and 5 ft (1.5 m) deep. A leach field was found beneath PRS 10-003(c). A clay drain pipe [PRS 10-003(m)] that connected PRSs 10-003(a–c) was discovered 10 ft below the surface during the D&D of TA-10 and was removed in 1963 (LANL 1990, 7511; LANL 1992, 7668, pp. 3-46 et seq.).

PRSs 10-003(d–f) are the sites of three former liquid disposal pits with unidentified structure numbers. These pits were discovered during the 1963 D&D of TA-10. PRS 10-003(g) is the site of a former industrial waste (acid waste) manhole (10-50) constructed of reinforced concrete, which was 4 ft (1.2 m) wide, 5 ft (1.5 m) long, and 5 ft (1.5 m) deep. This manhole was along the industrial waste (acid waste) line leading from the radiochemistry building. A drainpipe from the manhole (10-50) discharged to the leach field [PRS 10-003(n)] in the stream channel approximately 125 ft (38 m) north-northeast of the manhole (TA-10-50) (LANL 1990, 7511). During the 1963 D&D of the pits, tanks, drain lines, and large amounts of contaminated soil were removed (LANL 1990, 7511).

Test holes drilled in 1973 and 1974 at the former disposal pits indicated the presence of surface and subsurface strontium-90. Five additional test holes were drilled in 1974. Samples from these holes had gross beta activity at levels above background, with some indication of contaminant movement. Extensive sampling also was performed at the former radiochemistry laboratory (10-1) and the entire liquid waste disposal complex [PRS 10-003(a–o)] through trenching and drilling during the FUSRAP survey. The FUSRAP results indicated that subsurface contaminants mostly were present in low levels and were within about 31 ft of the radiochemistry laboratory and the liquid waste disposal complex. The highest levels of contaminants were found near the former liquid waste disposal pit 10-42 [PRS 10-003(b)] (LANL 1996, 54332, p. 60).

PRS 10-003(h) was the former site of an industrial waste (acid waste) manhole (10-51) constructed of reinforced concrete, and measured 4 ft (1.2 m) wide, 5 ft (1.5 m) long, and 5 ft deep. This manhole was along the industrial waste (acid waste) line leading from the radiochemistry laboratory (LANL 1992, 7668, p. 3-58). Manhole 10-51 was removed during the D&D of TA-10 in 1963.

PRS 10-003(i–l) was the site of part of the liquid waste disposal complex for the radiochemistry laboratory. PRS 10-003(i) is the site of the former acid waste septic tank (10-39). PRSs 10-003(j–l) are the sites of three former stainless steel tanks with no identified structure numbers. Each tank had a capacity of 200 gal. (LANL 1990, 7511). The steel tanks were removed during the D&D of TA-10 in 1963 (LANL 1992, 7668, p. 3-60).

PRSs 10-003(n–o) are the former site of a leach field for the liquid waste disposal complex that served the radiochemistry laboratory (TA-10). It is likely that this was also a leach field for the septic system [PRS 10-004(b)] that served the radiochemistry laboratory. This leach field was located in the streambed north of TA-10. The dimensions and description of the leach field are unknown. A chemist who worked at the radiochemistry laboratory remembers decontamination holes [PRS 10-003(o)] that were located near the streambed leach field. It is possible that the decontamination holes were part of the streambed leach field [PRS 10-003(n)] (LANL 1990, 7511).

During the D&D of TA-10 in 1963, the highest levels of radioactivity encountered were associated with the liquid waste disposal complex that served the radiochemistry laboratory. The entire complex of tanks, lines, and manholes was excavated to a depth of approximately 20 ft (6 m). During the excavation, radiation levels ranged as high as 35 mrad/hr, and the bottom of this excavation contained up to 1.5 mrad/hr. The large excavation was backfilled with dirt from other parts of the canyon and building debris from the D&D of the Bayo site. It is unknown whether the leach field and decontamination holes were excavated during this effort (LANL 1992, 7668, p. 3-60). Residual radiation levels during the D&D project were much higher in the samples collected from the trench near the streambed. In the 2- to 4-ft (60- to 120-cm) layer, samples contained no gross-alpha activity, but maximum gross-beta activity was 48 pCi/g and the maximum strontium-90 activity was 67.2 pCi/g (LANL 1992, 7668, p. 3-61).

The RFI at PRS 10-003(a–o) performed in 1994 included investigation of the nearby landfill used during D&D of the site, PRS 10-007. The RFI at PRS 10-003(a–o) and PRS 10-007 detected silver in nine samples above background screening values. The maximum concentration was observed in one sample from the alluvium that contained 13.3 mg/kg silver; however most detects of silver were below 1 mg/kg (LANL 1996, 54332, p. 74). Organic compounds detected in the samples included bis(2-ethylhexyl)phthalate, dichloroethene, diethylphthalate, dinitrotoluene, ethylbenzene, high melting explosive (HMX), naphthalene, nitrotoluene, trimethylbenzene, and xylenes (LANL 1996, 54332, pp. 76, 77). Americium-241 was detected in three samples from depths of 11 to 20 ft (3.3 to 6 m) in one borehole. The maximum observed americium-241 concentration was 1395 pCi/g. Cesium-137 was detected in a concentration of 0.0777 pCi/g in one sample from a borehole in the alluvium at 16.5 ft (5 m) depth. Strontium-90 was detected at up to 41,887 pCi/g in borehole 10-1220 in alluvium at 17.5-ft (5.3-m) depth (LANL 1996, 54617, pp. 29–32).

The IA to characterize strontium-90 in vegetation at former TA-10 included the site of PRS 10-003(a–o) (see Section 2.3.2.5.3). PRSs 10-003(a–o) were not recommended for NFA as a result of the RFI (LANL 1996, 54332; LANL 1996, 54617) because concentrations of strontium-90 detected at depths of 11 to 16 ft (3.3 to 4.9 m) in the area of PRSs 10-007 and 10-003(a–o) could result in an unacceptable dose under a residential-use scenario. Under a residential-use scenario, a dose of 2400 mrem/yr could occur, mainly from routine ingestion of garden produce, which equates to an excess cancer risk of 1 in 100. This represents an unacceptable dose rate for potential future use as a residential area (LANL 1996, 54617, pp. 36–37). In 1999, PRSs 10-003(a–o) were consolidated into one decision set with similar PRSs; the decision set was designated 10-002(a)-99.

PRS 10-004(a)

PRS 10-004(a) is the location of a former sanitary septic tank that served the personnel building (10-21) at TA-10 from 1949 through 1963. The tank had a capacity of 1060 gal. (4 m^3) and discharged to a pit 8 ft (2.4 m) long × 12 ft (3.6 m) deep. This septic system discharged to a drain line and outfall located in a stream channel approximately 200 ft (60 m) north-northeast of PRS 10-002(a). The COPCs for this site are strontium-90, total uranium, barium, cadmium, lead, beryllium, VOCs, and SVOCs (LANL 1992, 7668, p. 3-61).

The septic tank, structure 10-21, was removed during the D&D of TA-10 in 1963 and was taken to MDA-G at TA-54. No information is available concerning the fate of the dispersal pit associated with this PRS. It was not clear whether the 4-in. (10-cm)-diameter tile drain to this outfall or soil around the outfall was removed during decommissioning (LANL 1990, 7511).

The RFI at PRS 10-004(a) was conducted in 1994. The investigation found mercury above background levels in two subsurface samples (maximum concentration 0.84 mg/kg) and silver was detected in a concentration of 0.38 mg/kg in one sample (LANL 1996, 54332, p. 86). Organic compounds detected in the samples included bis(2-ethylhexyl)phthalate, di-n-butylphthalate, ethylbenzene, propylbenzene, trimethylbenzene, and xylenes (LANL 1996, 54332, p. 88). Strontium-90 was detected in one sample in borehole 10-1276 at a depth of 3.6 ft in a concentration of 0.78 pCi/g (LANL 1996, 54617, p. 41).

The IA to address strontium-90 in vegetation at former TA-10 included the site of PRS 10-004(a) (see Section 2.3.2.5.3). PRS 10-004(a) was recommended for NFA in the RFI reports because the PRS had been characterized or remediated in accordance with current applicable state or federal regulations, and available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 1996, 54332; LANL 1996, 54617).

PRS 10-004(b)

PRS 10-004(b) is the site of a former 540-gal. (2-m^3)-capacity sanitary septic tank (10-38) that served the radiochemistry laboratory. It was constructed of reinforced concrete and measured 4 ft (1.2 m) wide, 10 ft (3 m) long, and 4 ft (1.2 m) deep. This tank handled sanitary waste, but is suspected to have also received liquid wastes from the radiochemistry laboratory (10-1). The overflow from tank 10-38 drained through a 4-in. (10-cm)-diameter vitrified clay, open-joint drainpipe to the stream channel. Tank 10-38 was used from 1944 to 1963 (LANL 1990, 7511).

The septic tank was removed during the 1963 D&D activities and taken to TA-54 for disposal. The line and soil surrounding the tank probably were removed during the liquid waste disposal system excavation. Gross beta activity from the tank prior to its removal was less than 5.0 mrad/hr (LANL 1990, 7511).

In 1973, a test hole designated as M-2 was drilled to a depth of 6.1 m (19 ft) at the outfall of the former septic tank. Sample analysis indicated strontium-90 in the surface and subsurface, while plutonium levels were at background. Five additional test holes were drilled near the M-2 hole in 1974. These holes indicated above background gross beta activity (Mayfield et al. 1979, 11717, p. 51).

The RFI at PRS 10-004(b) was conducted in 1994. COPCs for PRS 10-004(b) include strontium-90, total uranium, barium, cadmium, lead, beryllium, VOCs, and SVOCs. The investigation found no inorganics exceed soil background concentrations. One organic compound, di-n-butylphthalate, was found in low concentrations in three samples (LANL 1996, 54332, p. 96). Strontium-90 was detected in one sample from borehole 10-1264 at a depth of 4.1 ft (1.25 m) in a concentration of 2.54 pCi/g (LANL 1996, 54617, p. 46). EPA Region VI approval of the Notice of Deficiency (NOD) response for the RFI work plan stipulated that samples must be collected for VOC analysis regardless of field screening results. No samples were submitted for VOCs or HE, which was a deviation from the sampling plan (LANL 1996, 54332, p. 93).

The IA to address strontium-90 in vegetation at former TA-10 included the site of PRS 10-004(b) (see Section 2.3.2.5.3). PRS 10-004(b) was recommended for NFA in the RFI reports because the PRS had been characterized or remediated in accordance with current applicable state or federal regulations, and available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 1996, 54332; LANL 1996, 54617). In 1999 PRS 10-004(b) was included with decision set 10-002(a)-99.

PRS 10-005

PRS 10-005 is the former site of an open pit about 100 ft (30 m) west of the northwest firing point. During the 1940s and 1950s, the pit was used to contain shot debris swept from the firing sites and adjacent areas. The exact dimensions of this former pit are unknown, as are the quantities and type of materials that were placed into it. The debris may have contained small quantities of uranium, strontium-90, lead, HE residues, and possibly beryllium (LANL 1990, 7511). In 1957, the pit debris was excavated, the wastes burned, and the ash taken to MDA-C at TA-50. The specifics on how this operation was conducted (i.e., whether uranium was burned), including pre- and postburning monitoring activities, are unknown (LANL 1990, 7511).

During the 1986 CEARP field survey the approximate extent of this disposal area (observed as a depression) was discovered, as was residual metal debris within the depression (LANL 1992, 7668, p. 3-63). The RFI at PRS 10-005 was conducted in 1994. No inorganic chemicals exceed soil background concentrations, and no inorganic chemicals were carried forward to the screening assessment for PRS

10-005. No inorganic chemicals, organic chemicals, or radionuclides were found to be COPCs in samples collected from PRS 10-005 (LANL 1996, 54332, p. 102, LANL 1996, 54617, p. 51).

PRS 10-005 was recommended for NFA in the RFI reports because the PRS had been characterized and 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 (LANL 1996, 54332; LANL 1996, 54617, p. 51). In 1999 PRS 10-005 and the four firing site PRSs were consolidated into one decision set, 10-001(a)-99.

PRS 10-007

PRS 10-007 is the site of a landfill located in and near the arroyo at TA-10 that was used to dispose of building debris from the 1963 D&D of TA-10 facilities. The boundaries of the landfill are not well known. However, the landfill was located within the excavation created by the removal of the liquid disposal complex [PRSs 10-0039(a–o)], thus providing some constraints on the location and dimensions. Some items in the landfill were concrete from the two former firing-site detonation control buildings (10-13 and -15), soil from the vicinity of the former inspection building (10-8), one of the former battery buildings (10-14), and former building 10-13 (LANL 1990, 7511).

RFI activities for PRS 10-007 were performed in 1994 and are discussed above with the description of activities at PRSs 10-003(a–o). The IA to address strontium-90 in vegetation at former TA-10 included the site of PRS 10-007. The contaminated vegetation is believed to be associated with residual contaminants contained within the landfill material (see Section 2.3.2.5.3).

PRS 10-007 was not recommended for NFA in the RFI reports because elevated levels of strontium-90 were detected at depths of 11 to 16 ft (3.3 to 4.9 m) in the area of PRS 10-007. In 1999, PRS 10-007 was consolidated into one decision set with other similar PRSs; the decision set was designated 10-002(a)-99.

PRS 10-008

PRS 10-008 is a former satellite firing site located approximately 1400 ft (427 m) northwest of the primary firing sites (PRSs 10-001[a–d]). This PRS was identified during 1994 IA activities to address shrapnel in Bayo Canyon. During the IA, shrapnel was found embedded in the northwestern sides of trees in this area, opposite the known primary firing sites. This suggested the existence of an additional firing site. Archival records indicate that this firing site was used for nonradioactive shots during the 1940s. The primary firing pads were active from 1943 to 1961 (Environmental Restoration Project 1997, 56660.423, p. i).

The RFI for PRS 10-008 was performed using previously obtained results from part of the investigation of PRSs 10-001(a–d). Samples were collected and shipped to fixed laboratories for analysis of TAL metals, HE, gamma spectroscopy, total uranium, and strontium-90. No COPCs were detected at concentrations greater than their SALs (Environmental Restoration Project 1997, 56660.423, p. 26).

The results of the evaluation for PRS 10-008 indicated that no chemical levels at the site pose an unacceptable risk to human health (Environmental Restoration Project 1997, 56660.423, p. 25). Therefore, PRS 10-008 was proposed for NFA because the PRS had 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 (Environmental Restoration Project 1997, 56660.423, p. i). In 1999 PRS 10-008 was consolidated into one decision set with the firing site PRSs 10-001(a–d); the decision set was designated 10-001(a)-99.

PRS 10-009

PRS 10-009 is a small landfill located in Bayo Canyon west of the main TA-10 area. PRS 10-009 currently is not listed in Module VIII. During the 1994 RFI for PRSs that are part of former TA-10, the site was fenced to restrict public access. A preliminary magnetic gradiometer survey was conducted over the landfill in 1995. This survey identified numerous buried metallic objects. No other investigations have been conducted at this site.

2.3.3 Technical Area 74

TA-74 is an undeveloped safety buffer zone located in the northeast corner of the current Laboratory site. Lying north of SR 502, TA-74 is bounded by US Forest Service (USFS) land to the north, San Ildefonso Pueblo land to the east, Los Alamos County land to the west, and TA-72 to the south. It includes portions of Bayo and Pueblo Canyons. A small portion of the parcel (less than 20 ac) is situated on a mesa top and is adjacent to a business park on Los Alamos County land.

No current Laboratory structures are associated with TA-74; the Laboratory maintains the site as a safety buffer zone. Former TA-19 was located within the current boundaries of TA-74. However, because the portion of TA-74 within the north canyons area has not been used for Laboratory operations, no PRSs are present within TA-74 within the north canyons.

Operations at former TA-10, which is adjacent to and upstream (west) of TA-74, are described in Section 2.2 and may have created environmental impacts at TA-74. TA-10 was located in Bayo Canyon just west of the Otowi Section. The part of TA-74 within Bayo and Barrancas Canyons has been proposed for land transfer to San Ildefonso Pueblo (DOE 1998, 58671).

2.4 Sources of Potential Contaminants within Barrancas Canyon

Appendix B of this work plan lists potential contaminant sources (PRSs) on the mesa tops that are within the Barrancas watershed and their current regulatory status. Former firing sites at TA-10 in Bayo Canyon may have introduced shrapnel and contaminants into Barrancas Canyon (see Section 2.3.2). Barrancas Canyon was sampled above the confluence with Guaje Canyon and analyzed for gross activity in 1965 and again in 1970 for gross activity and plutonium. The information compiled in this section is based on available reports and data as of circa December 2000.

2.4.1 Technical Area 0

A single PRS is located within the Barrancas Canyon watershed, PRS 00-025. This PRS is discussed in Section 2.3.1, Technical Area 0.

2.4.2 Technical Area 74

TA-74 is discussed in Section 2.4 for Bayo Canyon. The site is a buffer zone that contains land in Barrancas Canyon. No PRSs or potential sources of contamination in TA-74 directly or indirectly influence Barrancas Canyon.

2.5 Sources of Potential Contaminants within Rendija Canyon

Rendija Canyon contains five PRSs that are assigned to TA-0. The PRSs include PRS 0-011(a–c), PRS 0-015, and PRS 0-016. No effluent discharges into Rendija Canyon; surface flow is derived primarily from ephemeral storm water runoff, although runoff from snowmelt is a possible contributor.

PRSs located within the Rendija Canyon watershed were addressed in the "RFI Work Plan for Operable Unit 1079" (LANL 1992, 7668). PRSs that were identified within the Rendija Canyon watershed are summarized below. All PRSs within TA-0 in Rendija Canyon have been recommended for NFA (LANL 1994, 59427; LANL 1995, 45365; LANL 1996, 54925). A parcel of GSA land in Rendija Canyon consisting of 909 ac is proposed for land transfer (DOE 1998, 58671).

AOC C-0-020

Area of concern (AOC) C-0-020 is a possible mortar impact area. This site covers about 30 ac and is located in a small tributary of Rendija Canyon west of the Guaje Pines Cemetery and the inactive firing range (PRS 0-016). The army may have fired mortars from Barranca Mesa into this area. The possible impact area was marked by a nearly illegible, bilingual sign (removed in June 1991), and a "US Property-No Trespassing" sign had been posted on a tree on the south side of the canyon. In summer 1991, an ordnance team from Fort Bliss inspected this site and concluded that it is not a former impact area. However, the arrangement of signs and the canyon geometry are similar to those of PRSs 0-011(c) and 0-011(d). Because the information is ambiguous, the site was designated an AOC (LANL 1992, 7667, p. 5-26). AOC C-0-020 is not included in Module VIII (EPA 1994, 44146).

A fatal accident involving a "dud" bazooka shell in the early 1960s prompted a semiannual sweep of known impact areas to identify ordnance newly exposed by erosion. A 1965 survey of these impact areas resulted in the removal of two tail assembly shrouds from the Barranca Mesa area and a piece of shrapnel from an exploded 60-mm mortar at the Rendija Canyon area (McAndrew 1965, 3070). It is not known when these surveys were discontinued. The US Department of Defense periodically conducted ordnance sweeps at some of the impact areas (LANL 1992, 7667, p. 5-26).

The RFI was performed at AOC C-0-020 in 1993, when an ordnance sweep of the site was performed. No ordnance fragments or other signs that the site had been used as mortar impact area were obtained. The results of the survey indicated that the site was never used as a mortar impact area (LANL 1994, 59427, p. 28).

AOC C-0-020 was recommended for NFA and for residential land use because the site had been characterized in accordance with current applicable state or federal regulations, and the available data indicate that no contaminants are present (LANL 1994, 59427, p. ii).

PRS C-0-041

PRS C-0-041 was the site of a former asphalt batch plant that was contaminated with asphalt, asphalt road mix, large concrete blocks, and miscellaneous construction debris, primarily steel. The PRS includes part of a side slope and drainage channel that flows into Rendija Canyon. The asphalt was visible along the channel bottom and in a thin layer on the west bank of the channel at the south end. Asphalt/aggregate road mix was present in several piles on the west bank. Several large concrete blocks were present in the north (downstream) end of the channel. Miscellaneous debris, mostly 3-gal. buckets and pieces of wire rope, was scattered along the banks (LANL 1992, 7668).

Aerial photos indicate that the batch plant was on the site from the late 1940s until about 1958, while the Atomic Energy Commission, predecessor of the DOE, owned the land. The plant was gone by 1969, when the land was transferred to the USFS. The USFS requested that the DOE remediate the site because USFS regulations in effect at the time the plant was operational required that industrial sites be restored when operations ended. Further, the New Mexico Environment Department (NMED) surface water division considered the asphalt and concrete to be refuse in a watercourse and recommended its removal (LANL 1996, 54925, p. 1).

PRS C-0-041 is not included in Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1994, 44146). The RFI at PRS C-0-041 was performed in 1995 to characterize the site. Samples of soil and water were analyzed for VOCs, PCBs and pesticides, total petroleum hydrocarbons (TPH), SVOCs, and RCRA-listed metals. All results were below regulatory limits (LANL 1996, 54925, p. 1, 2).

PRS C-0-041 was the subject of a VCA in 1995. Because the land is owned by the USFS, the cleanup and site restoration activities were done under the direction of a USFS representative. The visible asphalt was removed from the stream channel with a backhoe. The sides of the excavation were inspected to see that no asphalt remained; if asphalt was present, more material was excavated. Along most of the drainage, the asphalt was confined to the channel. At the extreme southern end of the channel, a horizontal layer of asphalt was found at a depth of 3 to 4 ft (0.9 to 1.2 m) and was 0.5 to 8 in. (1.3 to 3.1 cm) thick. The excavation was widened to approximately 1500 ft^2 to remove this layer. Excavation at a locality ended when the remaining asphalt was thinned to a layer approximately 1/16 to 1/4 in. (0.16 to 0.6 cm) thick x 3 ft (0.9 m) wide, at a depth of 4 ft (1.2 m) at the southern end of the excavation. This remaining fragment of asphalt was well covered with overburden and vegetation and does not have the potential for mobilization within the subsurface (LANL 1996, 54925, p. 2).

In 1999 after an inspection of PRS C-0-041, a small amount of visible tar/asphalt was removed from the drainage channel, a standpipe drain was installed downstream of the Ponderosa Estates subdivision, and rock check dams were installed in the drainage channel. The standpipe drain was designed to use the natural drainage basin downstream of the subdivision as a storm water retention area and to dissipate flow from large runoff events into the drainage channel where PRS C-0-041 was located (Veenis 1999, 69722).

PRS 0-C-041 was recommended for NFA in 1995 because the site had been characterized or remediated in accordance with current applicable state or federal regulations, and available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 1995, 45365).

PRS 00-011(a)

PRS 00-011(a) is a former mortar impact area located on GSA land approximately 0.4 mi (0.6 km) east of the Sportsman's Club firing range in Rendija Canyon. Various types of ordnance were fired into this area by the military between 1944 and 1948. HE compounds and metallic shell residues may have remained at the site (LANL 1992, 7668; Environmental Restoration Project 1993, 45271).

Before the RFI site investigation in 1993, the PRS was thought to be delimited by a barbed-wired fence (and marked with warning signs) erected to keep individuals out of the site. However, the RFI surveys found that the impact area extended to the south, well beyond the fence, increasing the size of the PRS from approximately 7 to approximately 28.5 ac. Live HE mortar rounds with live fusing were found, as were approximately 2400 pieces of ordnance fragments including tail fins, fuses, and scrap material (LANL 1994, 59427, p. i).

During the RFI at PRS 00-011(a) in 1993, samples were collected from surface sediment storage locations within the drainage channels that drained the areas of high fragment concentration. No HE compounds were found in the samples. All inorganic chemical concentrations except arsenic and barium were found to be below SALs. Arsenic and barium SAL values were below background values. The inorganic chemicals were comparable to regional background levels available at the time the RFI was conducted (LANL 1994, 59427, p. 12). However, the maximum lead and selenium concentrations observed during the RFI are above BVs, which subsequently were developed (see Section 3.4.1).

PRS 00-011(a) was recommended for NFA because the site had been characterized and remediated in accordance with current applicable state or federal regulations, and the available data indicated that contaminants pose an acceptable level of risk under current and projected future land use. The site was recommended for approval as residential land use (LANL 1994, 59427, p. i).

PRS 00-011(c)

PRS 00-011(c) is the possible site of a former mortar impact area in Cabra Canyon, a tributary to Rendija Canyon. The site is an elongated area extending southeast to northwest, located on GSA and USFS property. The sole indication that this site might be a PRS was the presence of two deteriorating danger signs warning of explosives. Ordnance surveys of the PRS did not locate any unexploded ordnance or even a single fragment of explosive ordnance wastes (LANL 1992, 7668; LANL 1994, 59427, p. ii).

Therefore, due to the complete absence of these materials, indicating that this site was not used as an ordnance impact area, PRS 00-011(c) was recommended for NFA and for residential use (LANL 1994, 59427, p. ii).

PRS 00-011(e)

PRS 00-011(e) is a former mortar impact area located in an area that extends north along a tributary of Rendija Canyon, informally known as "Thirty-Seven Millimeter Canyon." The site is located north-northeast of the Sportsmen's Club and was used by tanks firing 37-mm rounds in the mid- to late 1940s. The PRS is largely on USFS, land except for a small segment at the southern boundary that is on GSA land. The GSA land is part of a proposed land transfer (DOE 1998, 58671). Shells fired into this area may have been from weapons such as 2.36-in. (6.0-cm) bazookas, 60-mm mortars, and 37-mm canons. The impact area was used between 1944 and 1948. HE compounds and metallic shell residues could have remained in the PRS 0-011(e) area (Environmental Restoration Project 1993, 45270).

A second fenced area north of the Sportsmen's Club that was designated PRS 0-011(b) (labeled "37 mm Canyon" on a 1962 range clearance map) was found to be the same site as PRS 0-011(e). Because these two PRSs are the same site, the designation "PRS 0-011(b)" was dropped in favor of PRS 0-011(e) (LANL 1992, 7667, p. 5-26).

The RFI at PRS 00-011(e) was performed in 1993. The area was swept for unexploded ordnance and ordnance explosive waste. Materials recovered during the ordnance sweep included two 20-mm rounds, 102 armor-piercing rounds, and fragments of 37-mm HE rounds. Other materials found included 350 pieces of ordnance explosive waste fragments and expended bullets (LANL 1994, 59427, p. ii).

Soil samples were collected from surface sediment storage locations within the drainage channels that drained the areas of high fragment concentration and along the major channel that drained the site into Rendija Canyon. HE was not detected and concentrations of all inorganic chemicals were comparable to regional background levels. All other COPCs either were not detected or were below background levels.

Human health and ecological screening assessments showed no potential for adverse impacts from this PRS. The extent of contaminants in surface samples was also confirmed (LANL 1994, 59427, p. ii).

PRS 00-011(e) was recommended for NFA under assumptions of residential land use because the site had been characterized or remediated in accordance with current applicable state or federal regulations, and available data indicate that contaminants pose an acceptable level of risk under current and projected future land uses (LANL 1994, 59427, p. ii).

PRS 00-015

PRS 0-015 is the site of an active firing range, the Sportsmen's Club, located on GSA land in Rendija Canyon. The site consists of several small-arm ranges and has been in operation since 1966 (LANL 1990, 7511). Lead is present in earthen berms and on the surface of the ranges. Shattered clay projectiles are present on the skeet and trap ranges. The extent of contaminants in the soil and surface water is unknown. There are no documented occurrences of releases from the site.

Contaminants at the site are directly related to use of the firing range, and there are no plans to change the use of this land in the future. Because the site will continue to be used as a firing range and additional contamination will occur as a result, it was determined that the site should not be cleaned up until the range is decommissioned. This PRS is similar to thousands of other firing ranges in the United States and likely has no higher risk (LANL 1992, 7667, p. 6-3).

PRS 00-015 was recommended for NFA because the site is regulated under another state and/or federal authority. If the site is known or suspected of releasing RCRA solid or hazardous wastes and/or constituents to the environment, it will be investigated and/or remediated in accordance with applicable state and/or federal regulations (LANL 1995, 45365). PRS 00-015 is part of a proposed land transfer parcel in Rendija Canyon (DOE 1998, 58671).

PRS 00-016

PRS 00-016 is the site of a former small-arms firing range located on USFS property at the northern end of Range Road, just west of Guaje Pines Cemetery in Los Alamos. The small-arms firing range was constructed in 1947 for use by the Laboratory security force. The security force continued to use the firing range for target practice until the current firing range was built in Sandia Canyon in the early 1960s. In 1976, the DOE released the site and surrounding areas to the USFS. The public unofficially used the site for recreational target practice from the time the security force vacated the site in the early 1960s until 1992 (LANL 2000, 67472, p. 2-1). The lead bullets and associated fragments were assumed to be largely restricted to the range itself, with most of the remaining bullets in the target and backstop berms. The primary COPC was elemental lead; however, copper and zinc, commonly present as minor components of lead bullets used with small arms, were also considered COPCs (LANL 2000, 67472, p. 2-5).

The site comprises approximately 2 ac. The firing site had earthen ridges (berms) arranged in a semicircle to retain bullets during target practice.

In 1991, as part of the process for initiating a projected land transfer, the USFS conducted a study of PRS 00-016 that included analyses of soil for lead. Twenty-one surface soil samples were collected from the earthen berms and analyzed for total lead only. Analytical results showed lead levels up to 156,100 mg/kg, which was attributed to the presence of lead bullets on the surface of the berms. As a result of this study, the ER Project initiated a VCA to address the lead in surface soils at PRS 00-016 (LANL 2000, 67472, p. 2-3).

VCA activities were conducted from 1993 through 1997. Two screening methods were used to assist in determining the extent of contaminants and to screen the soil prior to the collection of samples: metal detection of lead and bullets in the soil and analysis of lead in the soil using x-ray fluorescence. These methods allowed selecting sampling locations that targeted higher concentrations of lead (LANL 2000, 67472, p. 2-4).

Soil from the various berms, the range floor, and an area on the hillside immediately north of the backstop berms were consolidated into a large soil stockpile in the location of the original backstop berms. The soil-washing technology used a process similar to that used for gold placer deposit mining that separated the heavier lead particulates (to be recycled) from the lighter soil matrix. A private land developer used the soil that met cleanup target criteria for off-site road fill material (to regrade and widen Range Road). Fine sediment from two recirculation ponds was sampled periodically at three locations to confirm that all sediment being sent off-site was nonhazardous. The samples were collected (1) at the discharge point into the ponds, (2) from the pond bottoms, and (3) from the pump trucks. This processed sediment was transported as a slurry to Sigma Mesa in TA-60 and a borrow pit in Sandia Canyon for drying. A total of 6700 yd^3 of soil was processed by the soil washing process (LANL 1998, 59996, p. 2).

In 1995, the soil-washing method was terminated when discussions with the NMED indicated that the unprocessed inactive firing range soil could possibly be transferred to the active firing range at TA-72 for reuse in expanding the berms at that site. After subsequent discussions with NMED and the EPA, it was determined that the soil should not be moved to TA-72 without first being processed to remove most of the lead bullets. Because the soil-washing contractor had demobilized from the site, other alternatives were investigated in an effort to complete lead removal and recycling efforts more quickly and cost-effectively. The method selected was dry sieving (LANL 1998, 59996, p. 2).

In early 1996, a second VCA plan was developed to implement a dry sieving process that would remove the lead bullets and larger fragments from the remaining stockpiled soil (LANL 1996, 54839.2). This method separated the bullet-sized particles from both the larger and smaller materials in the soil matrix, using a shaker plant equipped with various sizes of slotted wire screens. The processed coarse and fine soil fractions that were separated from the bullets were transported to TA-16 for use as industrial fill and to TA-72 for reuse as berm material, respectively. Batches of the fine particles that were determined to be hazardous were shipped off-site for disposal at a RCRA landfill. The remaining bullet-sized soil fraction was further refined using an impact crusher, further sieving, and finally a vacuum-truck separation that lifted the lighter gravel from the heavier lead. A total of 7000 yd^3 of soil was processed by the dry-sieving process (LANL 1998, 59996, p. 3).

After completing the initial full-scale shaker plant operations, 16 discrete grab samples were collected in 1996 from the upper 6 in. (15.2 cm) of the firing range floor. These samples were collected to confirm that all soils containing total lead concentrations greater than the cleanup level of 400 mg/kg had been removed from the site. Due to a remobilization of the shaker plant and crusher in late 1996, a second set of eight confirmation samples was collected to ensure the remobilization activities did not contribute contaminants to the range floor. Sample concentrations ranged from 3.7 to 66.0 mg/kg lead (LANL 1998, 59996, p. 46).

Confirmation samples also were collected from the upper 6 in. (15.2 cm) of sediment in the primary first-order drainages that captured the bulk of surface water runoff from the site during VCA operations. Sample concentrations ranged from 40.8 to 70.6 mg/kg lead (LANL 1998, 59996, p. 48). Background values for total lead in soil are 22.3 mg/kg. Confirmation sampling determined that all soils containing elevated concentrations of lead, copper, and zinc, the COPCs identified for this PRS, had been effectively removed from the site. Samples were collected in native soil beneath imported topsoil that was emplaced in 1994 to facilitate revegetation of the hillside. Sample concentrations at the cleanup site ranged from 3.7 to 85.6 mg/kg lead (LANL 1998, 59996, pp. 46–48).

Confirmation samples were collected from back-area soils in 1997 following removal of all materials that failed field-screening criteria. This step ensured that all soils containing lead concentrations greater than the cleanup level of 400 mg/kg had been removed. Lead was detected above its BV in some confirmation samples; however, it was eliminated as a COPC because the maximum detected concentration of lead was 85.6 mg/kg, which is well below the 400-mg/kg residential cleanup level for lead (LANL 2000, 67472, p. 2-3).

Since completion of the VCA, the firing range floor area has undergone further modification to meet the needs of the private land developer. Modification included further excavation and soil removal to promote the desired grade for proper surface drainage and edge contouring. The area was also covered with a 1-ft layer of base coarse material. These modifications, considered with the current land use of the site and information from the ecological scoping checklist for PRS 00-016, support a determination that no ecological receptors are present and no viable exposure pathways of off-site transport pathways exist at this exposure area (LANL 2000, 67472, p. 2-7).

NMED approved the final VCA completion report in a letter dated September 22, 1999 (NMED 1999, 64564), and approved the Laboratory's response to two NMED comments about the remediation (NMED 1999, 65312). Concerns pertaining to the use of material from the cleanup area in road construction near the Ponderosa Estates subdivision were addressed by installation of a geotextile material on the slope of the road. Additionally, a postremediation surface water site assessment was performed at the site, which concluded that remediation activities had created little potential for erosion (LANL 2000, 66880).

PRS 00-016 was recommended for NFA because the site was characterized and remediated in accordance with applicable state and/or federal regulations, and available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 2000, 67472, p. 2-1).

Pending completion of the land exchange between the USFS and a private land developer, the USFS is allowing the developer to use the site as a storage area for construction equipment and materials. After removal of PRS 00-016 from Module VIII (EPA 1994, 44146), the USFS will transfer the land parcel containing the PRS to a Los Alamos land developer who plans to develop the land for residential housing (LANL 2000, 67472, p. 2-3).

PRS 0-024

PRS 0-024 is the former site of a cistern located on private property on Barranca Mesa. The cistern was an unlined hole in the Bandelier tuff with a wood cover that was used as a disposal site for military ordnance (Aldrich 1991, 11493). The cistern is located on a residential lot at the east end of Barranca Road just west of the Deer Trap Mesa trailhead. The cistern was located in 1965, and its entire contents of expended munitions and gun components were removed (Aldrich 1991, 11493).

The result of the RFI indicated that the abandoned cistern does not pose a threat to human health or the environment because all expended munitions and gun components have been removed. Additionally, the exact location of the cistern is no longer known and locating the cistern would be difficult and would require significant disruption of private property (LANL 1992, 7667, pp. 6-3, 6-4).

PRS 0-024 was recommended for NFA because the site can no longer be located (LANL 1995, 50166).

2.6 Sources of Potential Contaminants within Guaje Canyon

Guaje Canyon contains one PRS [0-029(c)], which is located in the lower part of the canyon approximately 2 mi (3.2 km) above its confluence with Los Alamos Canyon.

PRS 0-029(c)

PRS 0-029(c) is the former site of a transformer that was located in Guaje Canyon near Guaje well G-1. The transformer was identified as Transformer No. 00-0234 (Environmental Restoration Project 1993, 45260; LANL 1993, 26972, p. 24). The dielectric oil capacity of the transformer was approximately 43 gal. Chemical analyses of the dielectric oil samples detected PCBs (less than 50 ppm). The location and date of sampling and analyses are unrecorded. This transformer is known to have released oil that contained PCBs to the environment. The transformer was removed from the site in 1986 (Environmental Restoration Project 1993, 45260).

An RFI was performed at PRS 0-029(c) in 1992, according to a sampling plan developed in 1992 (Romero 1992, 21071). The results of the investigation showed that one sample contained the PCB Aroclor-1260 in a concentration of 0.09 (+/-0.04) mg/kg. Other samples were below the method detection limit for PCBs (LANL 1993, 26972, p. 28).

PRS 0-029(c) was recommended for NFA in the RFI report because the site was characterized and remediated in accordance with applicable state and/or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use (LANL 1993, 26972, p. 30).

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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 Waste 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.

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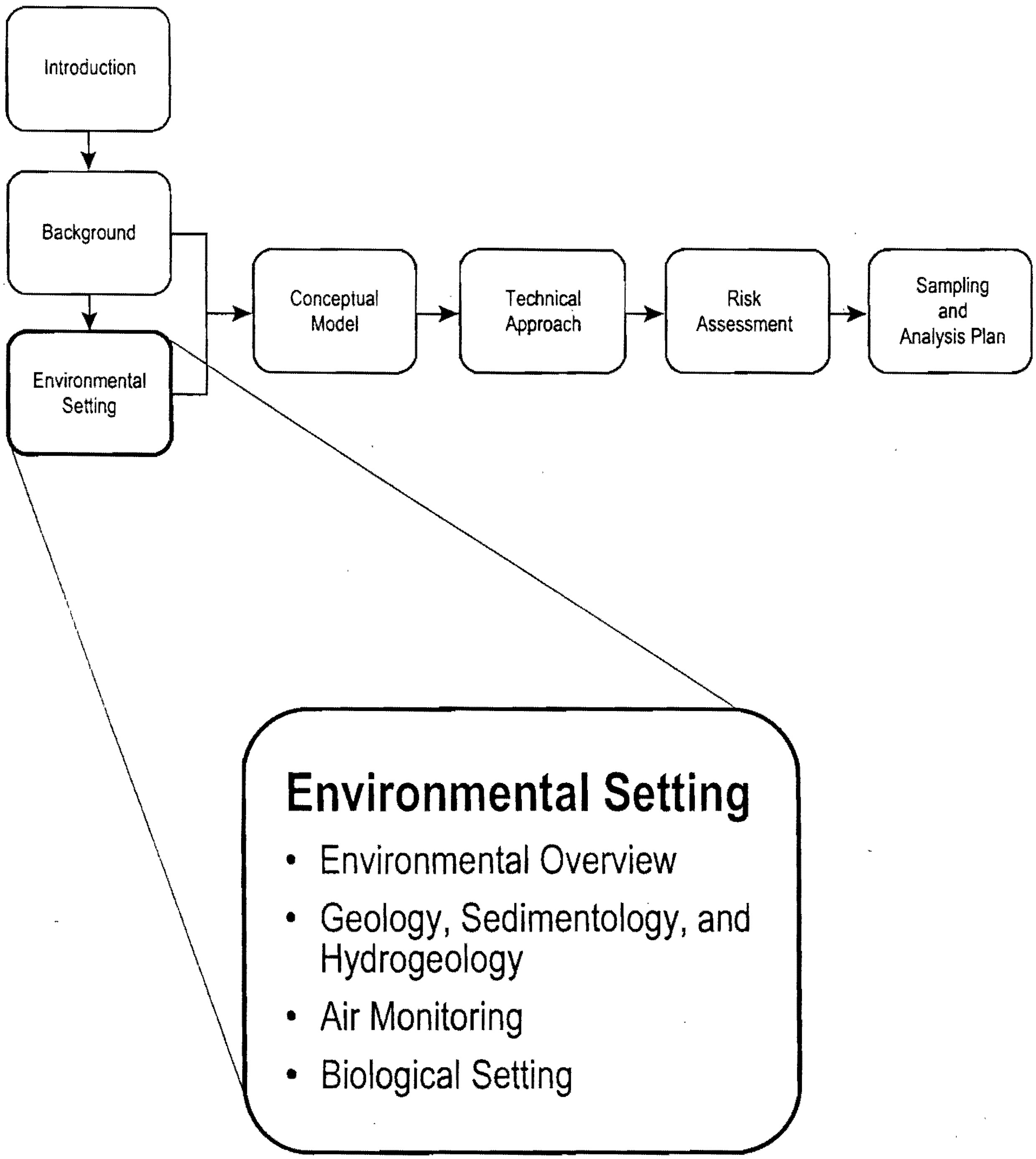
Chapter 3



Introduction
Background
Environmental Setting
Conceptual Model
Technical Approach
Risk Assessment
Sampling and Analysis Plan
Environmental Setting
• Environmental Overview
• Geology, Sedimentology, and Hydrogeology
• Air Monitoring
• Biological Setting

3.0 ENVIRONMENTAL SETTING

This chapter has four major functions: it

- describes the environmental settings of Bayo, Barrancas, Rendija, and Guaje Canyons (the "north canyons systems");
- summarizes existing information relevant to the characterization of the northern canyons systems;
- identifies additional information needed to expand the conceptual understanding of the environmental processes that occur within the systems 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.

The regional environmental setting of Los Alamos National Laboratory (the "Laboratory") is presented in Chapter 3 of "Core Document for Canyons Investigations" (the "core document") (LANL 1997, 62316) and in Chapter 2 of the "Installation Work Plan for Environmental Restoration Project" (IWP) (LANL 2000, 66802).

Nomenclature used in this Document

Since circa 1961, boreholes drilled in the north canyons have been advanced for their intended purpose, completed, left open and uncompleted, or plugged and abandoned. These boreholes and completions are designated by letters and numbers. Generally, the first two or three letters or numbers designate the canyon or technical area (TA). For example, BC = Bayo Canyon, GC = Guaje Canyon, 10- = boreholes at TA-10. The last letter or letters designate borehole function. Historic drilling efforts have often used additional notations. Municipal water well locations often are designated by a single letter to identify the canyon.

BCO-	observation well in Bayo Canyon; completed with screen or perforated casing to monitor groundwater
BCM-	moisture access hole in Bayo Canyon; borehole cased with 2-in. (5.08-cm)-diameter aluminum pipe, plugged at the bottom to keep water out of the pipe; intended for logging in situ moisture measurements with a neutron moisture/density probe
Well G-	Guaje Canyon municipal water supply well
GR-	Guaje Canyon municipal water supply replacement wells; completed to replace aging municipal wells in Guaje Canyon
GT-	Guaje test wells
LA-	Los Alamos Canyon municipal water supply wells
TH-	test hole

Each letter typically is followed by a number, which normally indicates the sequence of well installation. In some canyons the number designation increased down-canyon. However, due to the paucity of wells in the north canyons, no numbering system has been implemented. The Guaje Canyon municipal supply wells generally are numbered in the order of installation, which was from the lower canyon upward.

Some boreholes, originally designated "TH" for test hole, were drilled as exploration test holes in various canyons on the Pajarito Plateau. For clarification in this work plan, a two-letter abbreviation that designates the specific canyon has been added to "TH" (such as GCTH, for Guaje Canyon test hole) to provide a specific symbol relating to each borehole's location.

Within this work plan, "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 "Bayo at SR 502," and "Guaje at SR 502," which indicate a location near a major highway.

The New Mexico Environment Department (NMED) Oversight Bureau describes collection sites by various nomenclatures. Springs are identified by local name as "Indian Springs" or by the canyon abbreviation preceding the spring number (e.g., "Guaje Canyon Spring 1"). Surface water locations are identified by the canyon name abbreviation and the distance in miles as measured upstream from the Rio Grande. For example, surface water has been collected at station Guaje Canyon Spring 5.7, which is located in Guaje Canyon 5.7 mi (9.17 km) from the confluence with the Rio Grande. It should be noted that the abbreviation "GC" also has been used to designate samples collected in Garcia Canyon. Groundwater sampling locations are identified by the Laboratory well nomenclature.

3.1 Location, Topography, and Surface Drainage

3.1.1 Bayo Canyon

Bayo Canyon has a relatively small drainage area of 4.0 mi^2 (10.4 km^2) that heads on the Pajarito Plateau in a residential area of Los Alamos at an elevation of approximately 7400 ft (2256 m) (LANL 1997, 62316, p. 3-2). The location of the canyon and watershed area is shown in Appendix A, Figure A-1. The canyon extends east/southeast between North Mesa on the south and Barranca and Otowi Mesas on the north, for a distance of approximately 8.2 mi (13.2 km) to the confluence with Los Alamos Canyon. The elevation at the confluence is approximately 5790 ft (1765 m) (LANL 1997, 62316, p. 3-2).

Bayo Canyon contains an ephemeral stream. Most surface water flow occurs after heavy summer rains and is generally short in duration (less than 2 hr). There are currently no effluent discharges in Bayo Canyon (Purtymun, 1995, 45344, p. 43). The channel length is approximately 3.47 mi (5.58 km) on Los Alamos County property, 3.12 mi (5.0 km) on Laboratory property (TA-74), and approximately 1.66 mi (2.66 km) on San Ildefonso Pueblo land to the confluence with Los Alamos Canyon (LANL 1997, 62316, p. 3-2). The watershed has an unnamed tributary (the "south fork of Bayo Canyon") on Laboratory property approximately 1.9 mi (3.1 km) from the confluence with Los Alamos Canyon." Another unnamed tributary in the western part of the watershed between Camino Encantada and Barranca Mesa is called the "north fork of Bayo Canyon" (Figure A-1).

Bayo Canyon transects the northern section of the Laboratory and encompasses former TA–10 and portions of TA-74. The canyon drains a portion of the Barranca Mesa residential area, some potential release sites (PRSs) within TA-0, former TA-10, and the central portion of TA-74 (Figure A-1).

3.1.2 Barrancas Canyon

Barrancas Canyon has a relatively small drainage area of 4.9 mi^2 (12.7 km^2) that heads on the northern Pajarito Plateau east of Barranca Mesa at an elevation of 7278 ft (2219 m) (LANL 1997, 62316, p. 3-2). The canyon extends east-southeast approximately 5.5 mi (8.9 km) to its confluence with Guaje Canyon at an elevation of 5860 ft (1786 m) (LANL 1997, 62316, p. 3-2) (Figure A-1).

The main Barrancas Canyon channel crosses approximately 1.6 mi (2.6 km) of Los Alamos County land, approximately 0.4 mi (0.6 km) on US Forest Service (USFS) land, 2.7 mi (4.3 km) on Laboratory property, and 0.7 mi (1.1 km) on San Ildefonso Pueblo land. The Barrancas Canyon watershed contains three unnamed tributaries. The southernmost tributary (south fork) intersects the Barrancas Canyon channel about 0.66 mi (1 km) west of the Guaje Canyon confluence and is about 1 m (1.6 km) long. The south fork is located predominately on Laboratory property within TA-74. Two longer tributaries north of the main Barrancas Canyon channel extend east from Deer Trap Mesa approximately 2.7 mi (4.3 km) (middle fork) and 2.9 mi (4.6 km) (north fork) before merging and continuing an additional 1.9 mi (3.1 km) to the main Barrancas Canyon channel. These northern tributaries are mostly within USFS land but the headland areas are within Los Alamos County land (Figure A-1).

Barrancas Canyon and tributaries contain ephemeral streams that receive intermittent flow from snowmelt and storm water runoff. The Barrancas Canyon watershed drains a portion of the Los Alamos town site, Laboratory property at TA-74, and USFS land. There are no effluent discharges in the watershed (Figure A-1).

3.1.3 Rendija Canyon

Rendija Canyon is located immediately north of the Los Alamos town site. The watershed has a drainage area of 9.5 mi^2 (24.6 km^2). The canyon heads on the flanks of the Sierra de los Valle just west of the town site at an elevation of 9826 ft (2311 m). The canyon contains an ephemeral stream channel that extends approximately 9 mi (14.5 km) east to the confluence with Guaje Canyon. The minimum elevation of the watershed is approximately 6300 ft (1920 m) (LANL, 1997, 62316, p. 3-2).

Rendija Canyon primarily crosses USFS land except for approximately 1.6 mi (2.6 km) of the middle portion of the canyon that crosses General Services Administration (GSA) land. Parcels of private land and Los Alamos County land, such as the Guaje Pines Cemetery, are located in Rendija Canyon along the north side of Los Alamos. One named tributary, Cabra Canyon, enters the Rendija Canyon channel from the north in the central portion of the watershed. Cabra Canyon trends northwest to southeast, is approximately 2 mi (3.2 km) long, and has a watershed area of 1.2 mi^2 (3.1 km^2) on USFS and GSA land (Figure A-1). Three unnamed tributaries to Rendija Canyon are located west of Cabra Canyon and drain south-southeast into the main Rendija Canyon channel. These tributaries are approximately 1.5, 2, and 1.2 mi (2.4, 3.2, and 1.9 km) long.

Rendija Canyon and its tributaries contain ephemeral streams. There are no effluent discharges in the Canyon. The watershed drains portions of Los Alamos town site, GSA land, and USFS land (Figure A-1).

3.1.4 Guaje Canyon

Guaje Canyon is the northernmost canyon discussed in this work plan. The watershed drainage is approximately 16.9 mi^2 (43.8 km^2). The watershed heads on the flanks of the Sierra de los Valles at an elevation of 10,497 ft (3199 m). The Guaje Canyon channel extends east-southeast for approximately 16.4 mi (26.4 km) to the confluence with Los Alamos Canyon at an elevation of approximately 5660 ft (1725 m) (LANL, 1997, 62316, p. 3-2). The Guaje Canyon channel transverses predominately USFS land except for the lower 2.3 mi (3.7 km), which are within San Ildefonso Pueblo land. The Guaje Canyon watershed primarily drains USFS land.

Three named tributaries are present in upper Guaje Canyon on the flanks of the Sierra de los Valles; each canyon trends northwest to southeast. Aqua Piedra Canyon is approximately 3.0 mi (4.8 km) long and has a watershed area of 1.61 mi^2 (4.1 km^2). Aqua Piedra Spring is located in the middle part of Aqua Piedra Canyon. Caballos Canyon is approximately 2.9 mi (4.6 km) in length and contains another tributary canyon called Vallecitos Canyon, which is the westernmost tributary to Guaje Canyon, and extends for approximately 1.7 mi (2.7 km) to the confluence with Caballos Canyon. Vallecitos Canyon and Caballos Canyon contain ephemeral streams, receiving snowmelt and storm water runoff from watershed areas of 1.2 and 1.5 mi^2 (3.1 and 3.9 km^2), respectively.

In addition to the named tributaries, two unnamed tributaries of significance to Guaje Canyon are present in the middle and lower sections of the Guaje Canyon watershed. The south fork of Guaje Canyon extends for approximately 1.3 mi (2.1 km) on the north side of Guaje Ridge and enters Guaje Canyon from the southwest. The north fork of Guaje Canyon extends for about 2.3 mi (3.7 km) parallel to Guaje Canyon on the north and enters Guaje Canyon from the north-northeast. These tributaries contain ephemeral streams and occasionally contribute flow to Guaje Canyon. The lower reaches of Guaje Canyon also receive runoff from Rendija Canyon and Barrancas Canyon (Figure A-1).

Guaje Canyon is informally divided into three sections for discussion purposes. The upper part of Guaje Canyon refers to the portion upstream and up-channel of the confluence with the south fork of Guaje Canyon. The middle part of Guaje Canyon extends from the confluence with the south fork to the confluence with Rendija Canyon. The lower part of Guaje Canyon extends from the confluence with Rendija Canyon to Los Alamos Canyon.

Two springs at an elevation of approximately 8850 ft (2700 m) support a perennial reach in upper Guaje Canyon. Guaje Reservoir, a small concrete structure, is located in upper Guaje Canyon at an elevation of 8020 ft (2445 m), approximately 3 mi (4.8 km) upstream from the confluence with the south fork. The reservoir is about 25 ft long and 11 ft high with a capacity of 250,000 gal.; it receives flow from the springs and from the watershed area of 6 mi^2 (15.4 km^2) above the reservoir. The reservoir was constructed and equipped with a pipeline system to divert water to Los Alamos (Purtymun 1975, 11787, pp. 276–282). The reservoir served as a municipal water supply from 1947 to 1959 with annual production ranging from approximately 24 x 10^6 to 213 x 10^6 gal. From 1972 to 1992, water diverted from the reservoir was used for irrigation purposes by Los Alamos County. During this period, annual production ranged from 2.2 x 10^6 to 9.7 x 10^6 gal. (McLin et al. 1998, 63506, p. 13).

The Guaje well field is located in the lower and middle parts of the canyon. The Guaje well field provides a significant portion of the municipal water supply for the Los Alamos area (Figure A-1).

3.2 Climate

Los Alamos County has a semiarid, temperate, mountain climate, which is summarized in the core document (LANL 1997, 62316, p. 3-1) and Chapter 2 of the IWP (LANL 2000, 66802). Detailed data compilations and extensive statistical summaries, including projected probabilities of meteorological occurrences, are provided by Bowen (1990, 6899).

Historical site-specific meteorological data for the north canyons are not available. The monitoring locations closest to the canyons are tower stations at TA-53 (mesa top) and TA-41 (canyon site) and precipitation gages at TA-74 and the North Community of Los Alamos (see Figure A-1). Annual climate summaries are presented in the annual environmental surveillance reports (ESP 2000, 68661).

In 2000 after the Cerro Grande fire, several remote automated weather stations (RAWS) were installed north of Los Alamos. The Guaje Canyon and the Garcia Canyon RAWS are located in or near the north canyons watersheds. Two RAWS are located within the north canyons watershed area. One, the "Garcia Canyon" station, is located at the northern boundary of Aqua Piedra Canyon, which is a tributary to Guaje Canyon, and another, the "Guaje Canyon" station, is located on Guaje Ridge between Rendija Canyon and Guaje Canyon (BAER, 2000, 68662, p. 199; Figure A-1 of this document). These stations monitor meteorological parameters including precipitation and are used to provide a flash flood warning in areas of risk. A flash flood warning is issued when a RAWS records a sustained rainfall at a rate of 1 in./hr. RAWS data are available at the Desert Research Institute web site at http://www.wrcc.dri.edu/losalamos/.

3.3 Geology

Discussions of the regional geologic setting of the Pajarito Plateau are presented in Griggs (1964, 65649), the IWP (LANL 2000, 66802), the hydrogeologic work plan (LANL 1998, 59599), and most recently in the core document (LANL 1997, 62316, p. 3-6). The following discussion uses the core document as the technical basis for the geologic setting and provides detail that is specific to Guaje, Rendija, Bayo, and Barrancas Canyons. Unless otherwise noted, locations of wells and boreholes discussed in this document are shown on Figure A-1. Some locations are beyond the extent of Figure A-1; these wells and boreholes can be found on maps and figures in the core document (LANL 1997, 62316) and/or the hydrogeologic work plan (LANL 1998, 59599).

The surface distribution of bedrock geologic units is shown on geologic maps prepared by Griggs (1964, 65649), Smith et al. (1970, 9752), and Rogers (1995, 54419). Structure is discussed in Wachs et al. (1988, 6690).

3.3.1 Stratigraphy

The principal bedrock units in the Guaje-Rendija-Bayo-Barrancas Canyons 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 in the Pajarito Plateau area is illustrated in Figure 3.3-1. The stratigraphy is based on the sitewide three-dimensional stratigraphic model, which contains detailed stratigraphic mapping for the sedimentary deposits and has been supplemented by additional detail on the volcanic units (Carey et al., 66782). Stratigraphic information for pertinent wells in the Guaje Canyon and Bayo Canyon areas is discussed in Section 3.4.2.

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 and intercalated volcanic rocks	Fanglomerate		Fanglomerate facies includes sand, gravel, conglomerate, and tuffaceous sediments
	Volcanic rocks		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, gravel, 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 (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 1998, 59599; Broxton and Reneau 1995, 49726.

Figure 3.3-1. Generalized stratigraphy of bedrock geologic units of the Pajarito Plateau

Alluvium of Pleistocene and Holocene age rests unconformably on the Bandelier Tuff and deeper units in some parts of all four canyons. The alluvium in the canyons generally consists of reworked Bandelier Tuff and older bedrock units. The alluvium may also contain a minor eolian component.

3.3.2 Geomorphology

3.3.2.1 Bayo Canyon

Bayo Canyon is the smallest (in area) of the four northern canyons. The total change in elevation is 1610 ft (491 m); and the average gradient over its entire length is 0.037 m/m (3.7%, 2.1 degrees) (LANL 1997, 62316, p. 3-2). The channel gradient changes in response to bedrock lithologic changes over the length of the canyon.

The canyon heads in unit Qbt 3 of the Tshirege Member of the Bandelier Tuff, where the channel gradient is about 0.067 m/m (6.7%, 3.8 degrees). As the canyon cuts through the Cerro Toledo interval and into the more erodible Otowi Member approximately 2 mi (3.2 km) downstream, the gradient decreases to about 0.03 m/m (3%, 1.9 degrees). Approximately 1.9 mi (3.1 km) further downstream the channel incises the Puye Formation fanglomerates, and the gradient increases again to about 0.05 m/m (5%, 2.9 degrees). Bayo Canyon is incised into the upper Santa Fe Group for a short distance upstream of the confluence with Los Alamos Canyon.

A veneer of late Quaternary alluvium forms the floor of much of Bayo Canyon, ranging in thickness from 0 to 26 ft (0 to 7.9 m) as measured in several test holes drilled in the canyon. The alluvium near the axis of the canyon is typically greater than 13 ft (4 m) thick (Cogbill 1994, 46146, p. 2). Bayo Canyon at former TA-10 is asymmetric, with the active channel shifted to the north side of the canyon and flanked by one or more stepped terraces (Drake and Inoue 1993, 53456, p. 18).

A series of Quaternary terraces has been identified in Bayo Canyon at former TA-10. Quaternary alluvial deposits have been subdivided into three units, the youngest of which (Qal 3) contains historic artifacts from TA-10 and probably dates from the period 1944 to 1963 (Drake and Inoue 1993, 53456, p. 6). These units are 0.5 to 3.5 ft (0.15 to 1.1 m) thick at former TA-10 and downstream. The alluvial deposits consist of terraces along the main channel and tributary channels, fan deposits associated with side drainages, and colluvial deposits at the base of steep valley side slopes. The Q3 surface of Drake and Inoue is defined as the top of the Qal 3 sediment deposits. The Q3 terrace surfaces have a maximum width of about 250 ft (76 m), but generally occur as laterally restricted terraces 30 to 80 ft (9 to 24 m) across. They are 0.5 to 2 ft (0.15 to 0.6 m) above local base level along the main channel, but can be up to 3.7 ft (1.1 m) above local base level along tributary channels.

The Qal 1 and Qal 2 sediments as characterized by Drake and Inoue lie beneath the Q1 and Q2 surfaces, do not contain historic artifacts, and are considered older than 50 yr. The older Qal 1 sediments consist primarily of fan deposits near the valley floor and colluvium underlying valley side slopes, and are typically about 6 ft (1.8 m) thick. The younger Qal 2 sediments consist of terrace and fan deposits at or near the canyon floor, and are typically greater than 2.5 ft (0.76 m) thick. Q1 surfaces comprise most of the canyon floor on the south side of the active channel, and Q2 surfaces comprise most of the remainder of the narrow inner canyon (Drake and Inoue 1993, 53456, pp. 17–18).

The late Quaternary terraces and soils in Bayo Canyon appear to reflect at least two cycles of incision and aggradation, followed by a third period of incision during the late Holocene. Preliminary interpretations suggest that sediment is cycled through some parts of the canyon on a time scale of 10^2 to 10^3 yr. Up to 3.5 ft (1.1 m) of historic sediment has been deposited along the main channel on the south side of the canyon below the former TA-10 since about 1944 (Drake and Inoue 1993, 53456, pp. 1–26).

3.3.2.2 Barrancas Canyon

Barrancas Canyon is the shortest of the four northern canyons discussed in this work plan. Barrancas Canyon contains an ephemeral stream with no perennial reaches, springs, or wetlands. Stream loss caused by infiltration and evaporation generally prevents runoff from reaching Guaje Canyon (LANL 1998, 59599, p. 4-86).

The total change in elevation from the head of Barrancas Canyon to its confluence with Guaje Canyon is about 1370 ft (417 m). The canyon heads in the Tshirege Member of the Bandelier Tuff. The relatively steep and narrow upper portion of the canyon cuts through Tshirege units Qbt 2 through Qbt 1v and the gradient in the upper portion is about 0.05 m/m (5%, 2.9 degrees). The channel then cuts through the Cerro Toledo interval and into the Otowi Member, where the gradient decreases slightly to about 0.04 m/m (4%, 2.3 degrees). About 1.3 mi (2.1 km) further downstream, the channel is incised into Tertiary sediments of the Puye Formation, and from that point to Guaje Canyon the gradient averages about 0.033 m/m (3.3%, 1.9 degrees).

3.3.2.3 Rendija Canyon

Rendija Canyon contains an ephemeral stream with no springs, perennial reaches, or wetlands (LANL 1998, 59599, p. 4-85). The upper reach (~1 km, 0.6 mi) of Rendija Canyon is cut into the lava flows and associated rocks of the Tschicoma Formation on the flanks of the Sierra de los Valles. Beginning about 13.5 km (8.4 mi) upstream from the confluence with Guaje Canyon, the channel is cut into the Bandelier Tuff, including tephras and volcaniclastic sediments of the Cerro Toledo interval. The channel is incised into the Puye Formation at about 5 km (3 mi) upstream from Guaje Canyon (Reneau and McDonald 1996, 55538, Figure 2-18). Changes in bedrock lithology along the length of the canyon result in some changes in the morphology of the channel and associated deposits. Exposures of the relatively erodible Otowi Member of the Bandelier Tuff and Cerro Toledo interval pumice deposits, for example, have led to extensive lateral stream erosion and development of relatively broad stream terraces. Where the Puye Formation is exposed, the gradient increases, the channel becomes more incised, and terraces are narrower (Reneau and McDonald 1996, 55538).

The total change in elevation from the head of Rendija Canyon to its confluence with Guaje Canyon is 3530 ft (1076 m), and the average gradient is 7.4%. The gradient varies significantly, largely in response to changes in lithology along the length of the canyon. In the upper reach where the Tschicoma Formation is exposed, the gradient is about 0.15 m/m (15%, 8.5 degrees), and the canyon is narrow and steep-sided. Where the canyon floor consists of the Tshirege Member of the Bandelier Tuff, the gradient is more moderate, ranging from about 0.08 m/m (8%, 4.6 degrees) to 0.05 m/m (5%, 2.9 degrees). In the Otowi Member and the Cerro Toledo interval, the gradient decreases to about 0.02 m/m (2%, 1.1 degree), and the canyon is broader. As the canyon cuts into the Puye Formation downstream of the Sportsman's Club, the gradient increases again to about 0.04 m/m (4%, 2.3 degrees).

Rendija Canyon contains at least five Pleistocene and four Holocene stream terraces that are perhaps the best-preserved flight of terraces on the Pajarito Plateau. They range in age from about 0.5 to greater than 160 ka, as determined by carbon-14 dating and soil chronofunctions (Reneau and McDonald 1996, 55538). In the reaches downstream of the Sportsman's Club, the Rendija Canyon channel is incised into fanglomerates of the Puye Formation, with a significant increase in stream gradient and narrowing of the Holocene terraces.

3.3.2.4 Guaje Canyon

Guaje Canyon is the longest of the four canyons addressed in this work plan, and it contains an interrupted stream. A perennial reach extends from a series of springs located upstream of Guaje Reservoir to some distance downstream of the reservoir. The stream is ephemeral downstream from that point to its confluence with Los Alamos Canyon (LANL 1997, 62316, p. 3-26).

The total change in elevation from the head of Guaje Canyon to its confluence with Los Alamos Canyon is about 4840 ft (1476 m) (LANL 1997, 62316, p. 3-2), and the average gradient is about 0.056 m/m (5.6%, 3.2 degrees). The gradient changes along the length of the canyon largely in response to changes in bedrock lithology. For about the first 3 mi (4.8 km), the canyon is cut into Tschicoma Formation, and is steep and narrow, with a gradient of about 0.07 m/m (7%, 4 degrees). The canyon is incised into the Puye Formation down to the basal axial facies west of the Guaje Mountain fault zone (GMFZ), at which point the Tschicoma Formation is again exposed for less than 1 mi (1.6 km). The gradient over the conglomerates of the Puye Formation west of the fault zone is about 0.04 m/m (4%, 2.3 degrees). East of the GMFZ the canyon again is incised into Puye Formation rocks, including the axial facies but primarily the upper fanglomerate deposits, and is mantled with late Quaternary alluvial channel and terrace deposits. The gradient in the Puye Formation east of the fault zone averages about 0.035 m/m (3.5%, 2 degrees), but decreases gradually to about 1% or less in the lower reach immediately upstream of Los Alamos Canyon.

3.4 Environmental Setting

3.4.1 Surface Sediments

3.4.1.1 Background Conditions

Background data on concentrations of inorganic chemicals and radionuclides in sediments are available from several areas on the Pajarito Plateau that are unaffected by Laboratory operations (Ryti et al. 1998, 59730). These data include samples from Guaje Canyon and from other canyons that are geologically similar to the north canyons. The term "background value" (BV) indicates an estimate of the upper range of the background concentrations, and is either the 95% upper tolerance limit (UTL) value for an analyte or detection limits for infrequently detected analytes (Ryti et al. 1998, 59730).

Portions of the north canyons receive runoff from urban areas at Los Alamos. Therefore, sediments may contain concentrations of metals and other constituents that may be more representative of urban "baseline" conditions rather than developed BV conditions (e.g., Reneau et al. 1998, 59160, p. 1-7).

In May 2000, the Cerro Grande fire burned large parts of upper Rendija Canyon and Guaje Canyon. Thus, fire-related chemicals and combustion products are present in these watersheds. Postfire sampling has shown that concentrations of metals and radionuclides in ash and muck (sediment that is dominated by reworked ash) are greater than previously determined sediment BVs (LANL 2000, 69054). Changes in sediment chemistry as a result of the Cerro Grande fire will be considered in the assessment of media sampled in Rendija and Guaje Canyons.

3.4.1.2 Historic Channel Changes

Changes are known to have occurred in the north canyons' channels since the beginning of Laboratory operations. An understanding of recent sedimentation and erosion patterns may identify potential contaminant transport mechanisms and horizontal and vertical distribution of possible contaminants in the alluvium. Sedimentation and erosion patterns have not been well defined in the north canyons.

Man-made alterations to the Bayo, Rendija, and Guaje Canyon watersheds likely have altered the channel and drainage pathways in these canyons. Anthropogenic impact to the canyon floors and drainage has occurred from the installation of the roads serving these canyons, construction of sewers and water-supply pipelines for Los Alamos town site, and from Laboratory activities conducted within some of the watersheds. Within Guaje Canyon, additional changes have resulted from the installation of Guaje Reservoir and municipal water supply wells and pump stations.

Recent sedimentation and degradation rates vary within each watershed and have not been fully identified. Localized aggradation and degradation processes may occur to raise or incise a specific interval of the streambed. In Bayo Canyon, sediments deposited since the 1950s near former TA-10 range from 0.5 to 2 ft (0.15 to 0.6 m) and include fragments of laboratory debris. Sediment deposits associated with activities at former TA-10 are up to 3.5 ft (1 m) (Drake and Inoue 1993, 53456, pp. 1, 26, 27). Sediments appear to cycle through Bayo Canyon every 100 to 1000 yr. Tributary drainages exhibit additional cycles of erosion and deposition occurring on a time scale of tens to hundreds of years (Drake and Inoue 1993, 53456, pp. 1, 6, 27).

The upper portions of the Guaje Canyon and Rendija Canyon watersheds burned extensively during the Cerro Grande fire in May 2000 (BAER 2000, 68662). Hydrologic changes caused by the fire have increased sediment load, peak flood discharges, and runoff volumes in these canyons. Postfire floods have already contributed to significant channel erosion in some places and sediment aggradation in others, and additional channel changes are likely in the next several years.

Barrancas Canyon and its tributaries have not been significantly impacted by Laboratory operations or other historic activities, with the exception of grazing and logging, and may be in a relatively natural state.

3.4.1.3 Historic Sediment Investigations

3.4.1.3.1 Plutonium Investigations in North Canyons

In 1965 and 1970, investigations were conducted across the Los Alamos area to assess the concentration and movement of soil-bound plutonium and radioactivity in stream channels. As part of the investigation, sediments were collected from each of the north canyons. Sediments from Bayo and Barrancas Canyons were sampled and analyzed for gross activity in 1965, and, in 1970, for gross activity and plutonium. Sampling locations in Bayo Canyon were approximately 1 mi downstream of former TA-10 and above the confluence with Los Alamos Canyon. Barrancas Canyon was sampled above the confluence with Guaje Canyon. Three sediment stations were established in Rendija Canyon and sampled for plutonium-238 and plutonium-239 in 1970. These stations were located near Guaje Pines Cemetery, downstream of the Sportsman's Club, and above the confluence with Guaje Canyon (Mayfield et al. 1979, 11717, pp. 50, 56; Purtymun 1970, 4795; Purtymun 1975, 11787, pp. 23–30).

In 1970, sediment stations were also established in Guaje Canyon and samples were collected for the analyses of plutonium isotopes. The three Guaje Canyon sediment stations were located above the confluence with Rendija Canyon, Barrancas Canyon, and Los Alamos Canyon. Sediments were collected from active channels (less than 1-in. [2.5-cm] depth) in each of the north canyons. Particle-sized distribution of the sediments was determined on material less than 4 mm to assess the percentage of clay- and silt-sized particles. Generally, the sediments were composed of 3% to 7.5% (by weight) of silt- and clay-sized material. Analyses for plutonium-238 and plutonium-239 were conducted by concentration and purification using ion exchange chemistry followed by an alpha spectrometer assay. Results of the analyses indicated activity within the range attributed to worldwide fallout (Mayfield et al. 1979, 11717, pp. 50, 56; Purtymun 1970, 4795; Purtymun 1975, 11787, pp. 23–30).

3.4.1.3.2 Former TA-10 Site in Bayo Canyon

Historic activities at former TA-10, Bayo site, are the primary Laboratory activities that affect Bayo Canyon. Bayo site was active from 1949 to 1963. An estimated 1.4 Ci of "natural uranium," 1.2 Ci of depleted uranium, and from 30 to 40 Ci of strontium-90 were dispersed to the surface environment in Bayo Canyon and beyond by the explosives testing. An additional 85 to 120 Ci of strontium-90 were deposited in the waste handling facilities (Mayfield et al. 1979, 11717, p. 4). In 1964 buildings and structures were decommissioned and decontaminated and in 1967 the property was transferred to Los Alamos County (see Section 2.3.2.2 of this document).

In 1973, four sediment sampling stations were established along Bayo Canyon including

- Station A - approximately 6500 ft (2000 m) upstream from Bayo site;
- Station B - within Bayo site;
- Station C - approximately 6500 ft (2000 m) downstream of Bayo site; and
- Station D – approximately 15,000 ft (4600 m) downstream of Bayo site.

Each station included five sampling locations, a center location, and locations 65 ft (20 m) and 650 ft (200 m) east and west of the center. Samples were collected from the bed sediments or stream bank. Stations A and B (upstream and within Bayo site) were analyzed for gross alpha and beta activity, and plutonium-238 and plutonium-239. Stations C and D (downstream of Bayo site) were analyzed only for plutonium-238 and plutonium-239. Analytical results from Stations A and B (upstream of Bayo site and within Bayo site) showed that gross alpha activity and plutonium concentrations were approximately background levels while gross beta concentrations were approximately twice background levels. Soil samples were collected from Stations A and B at points 20 and 200 m (65 ft and 650 ft) north and south of the center sediment sampling location. Analytical results showed that gross alpha and plutonium isotope concentrations were within background levels for the area. Gross beta activity was about 2 to 3 times background levels. The investigation concluded that elevated gross beta activity seen at Stations A and B appears attributable to the presence of strontium-90 (Mayfield et al. 1979, 11717, p. 50).

The Formerly Utilized Sites Remedial Action Program (FUSRAP) investigation included the collection of samples from approximately 27 random and nonrandom sampling locations in natural drainage pathways and the active stream channel at the former TA-10 site. The purpose of the sampling was to assess the redistribution or deposition of residual contaminants by surface water runoff (Mayfield et al. 1979, 11717, pp. 25, 26, 30). The sample depths were approximately 0 to 30 cm (0 to 12 in.) and included core samples (composite) and profile samples (discrete intervals). Results of the analyses showed that total uranium concentrations in sediment samples ranged from 1.6 to 7.6 μg/g, with highest concentrations from shallow depths (0 to 5 cm [0 to 2 in.]) at the former TA-10 site (Mayfield et al. 1979, 11717, p. 35). Concentrations of strontium-90 ranged from 0 to 8.2 pCi/g with the highest concentrations from the 0- to 5-cm (0- to 2-in.) interval. (Mayfield et al. 1979, 11717, p. 34). The background concentration of strontium-90 attributable to worldwide fallout at the time was estimated to be 0.4 pCi/g (Mayfield et al., 1979, 11717, p. 32).

3.4.1.3.3 Routine Environmental Surveillance of Active Channel Sediments

Since 1973, the Laboratory Environmental Surveillance Program has collected active channel sediment samples from locations in Bayo Canyon and Guaje Canyon. Table 3.4-1 summarizes the sediment sampling locations and dates. The sampling locations are shown on Figure A-1.

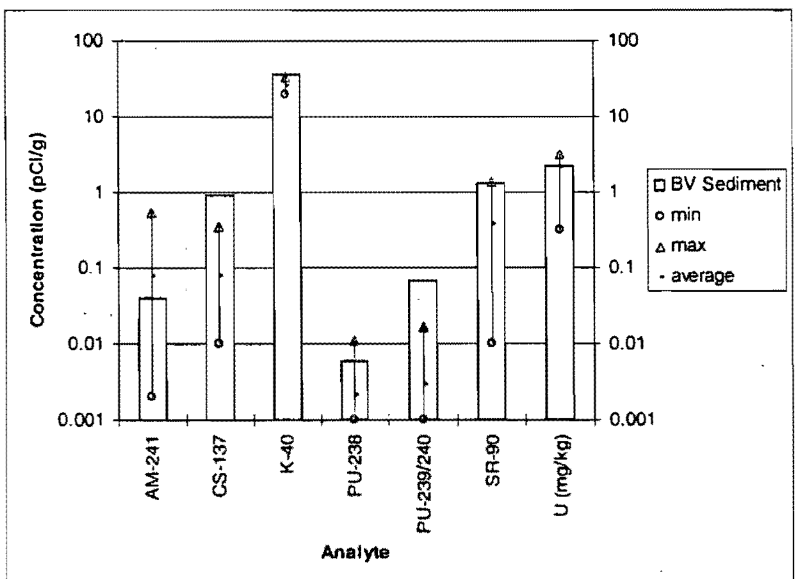
Table 3.4-1
Environmental Surveillance Sediment Sampling Locations

Location	Comment
Bayo Canyon at SR 502	Active channel sediment site at SR* 502, 1978 to 1999
Guaje Canyon at SR 502	Active channel sediment site at SR 502, 1977 to 1999
Guaje Canyon near G-4	Active sediment site near municipal well G-4, 1973 to 1980
Guaje Reservoir	Sediment collected from Guaje Reservoir, 1999

Source: Environmental Surveillance Reports, 1973–1999.
*SR = state road.

Bayo Canyon

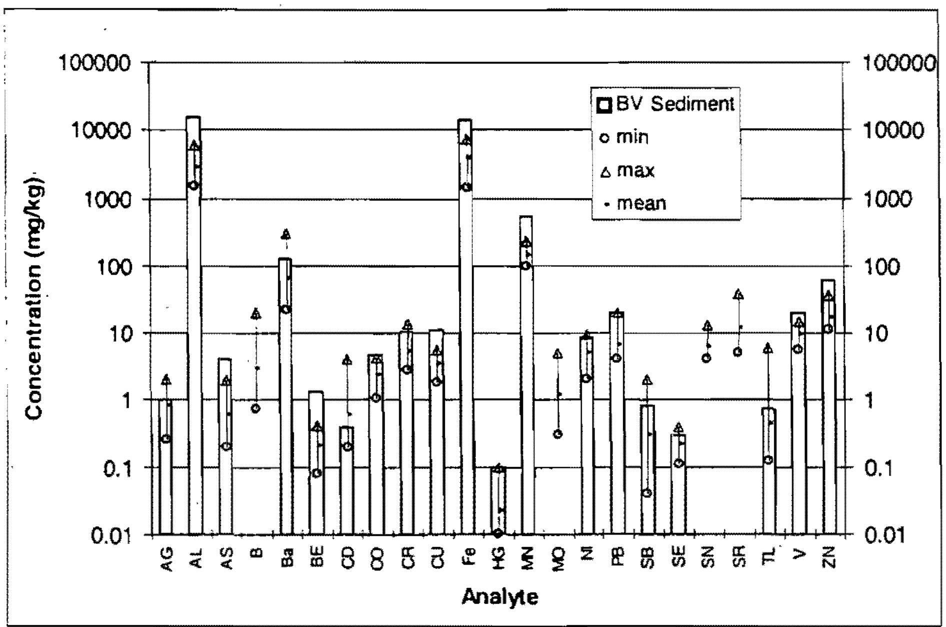
Active channel sediment samples have been collected in Bayo Canyon above the confluence with Los Alamos Canyon at State Road (SR) 502 annually since 1978. The samples are routinely analyzed for radionuclides. In some years since 1990 the samples were analyzed for metals. A summary of the results for radionuclides is shown in Figure 3.4-1. The radionuclide concentrations have generally been found to be within sediment BVs. However, americium-241 has been measured in concentrations above the sediment BV in 1992, 1998, and 1999, at concentrations of 0.106, 0.17, and 0.55 pCi/g, respectively (Environmental Surveillance Reports, 1978–1999). All americium-241 concentrations observed above BV were analyzed by gamma spectroscopy; results of alpha spectrometry for americium-241 have all been below BV.



Source: Environmental Surveillance Reports, 1978—1999.

Figure 3.4-1. Summary of radionuclides in Bayo Canyon sediments at SR 502

The summary of the results of analyses of sediments for metals is shown in Figure 3.4-2. Most metals have been observed in concentrations below the BV for sediments. Metals found in concentrations above the sediment BV include barium, cadmium, and thallium. In 1996 the sediment samples from Bayo Canyon were also analyzed for high explosive (HE) compounds, which were found to be below detection limits for HE compounds.

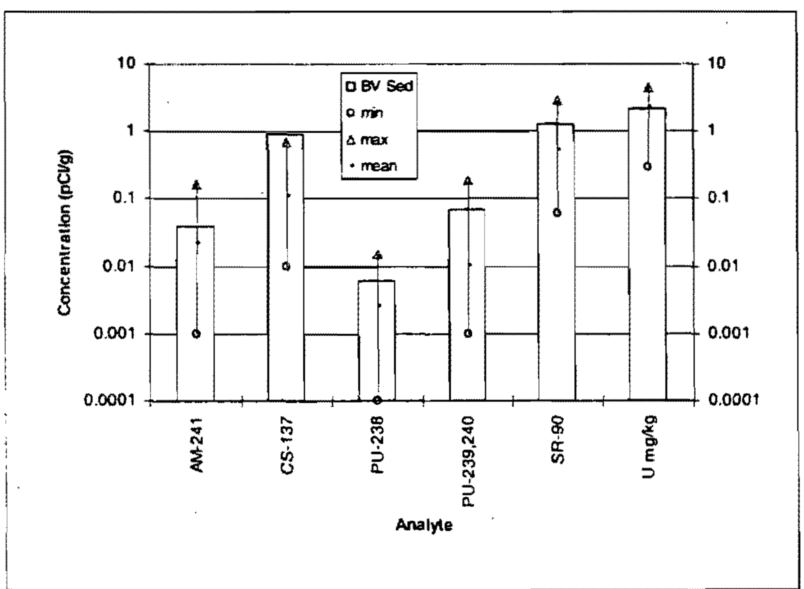


Source: Environmental Surveillance reports, 1990–1999.

Figure 3.4-2. Summary of metals in Bayo Canyon sediments at SR 502

Guaje Canyon

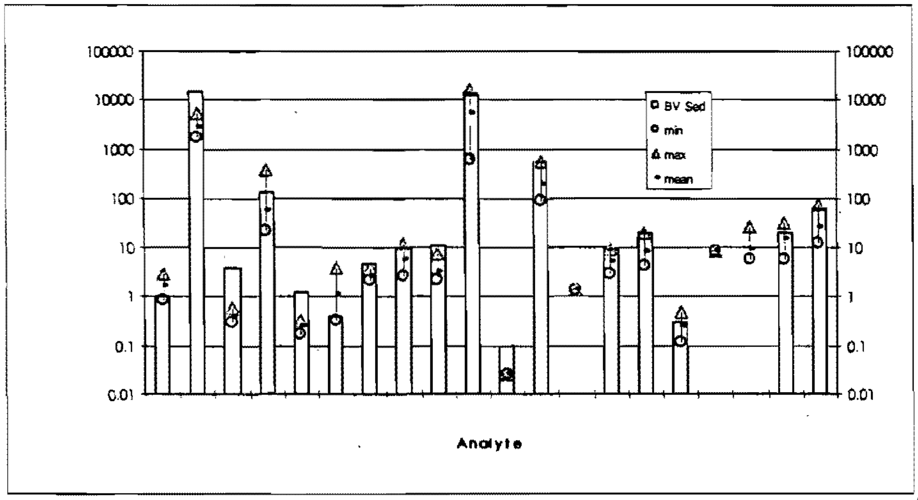
Active channel sediment samples have been collected annually in lower Guaje Canyon at SR 502 above the confluence with Los Alamos Canyon since 1977. The samples are routinely analyzed for radionuclides; since 1990, the samples also have been analyzed for metals. A summary of radionuclide analyses is shown in Figure 3.4-3. Maximum values for americium-241, plutonium-238, plutonium-239,240, strontium-90, and uranium have been above the BV for sediments. All results of americium-241 that have been observed above the BV have been from gamma spectroscopy measurements; all measurements of americium-241 using alpha spectrometry have been below the BV.



Source: Environmental Surveillance Reports, 1977–1999.

Figure 3.4-3. Summary of radionuclides in Guaje Canyon sediments at SR 502

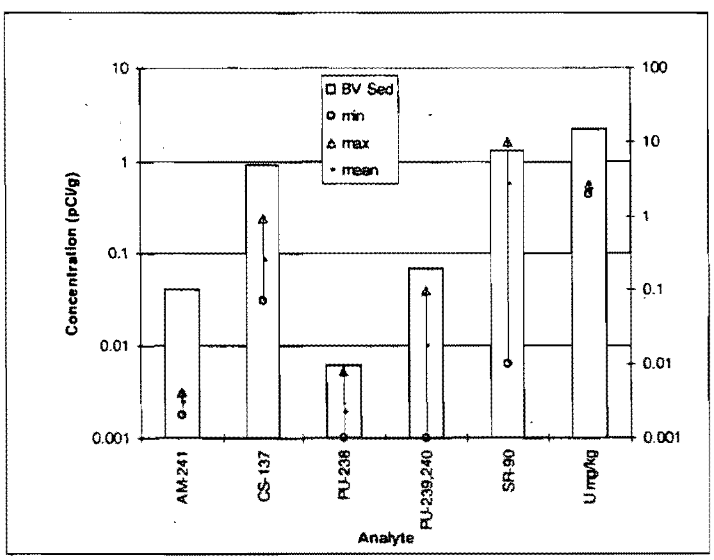
A summary of metals analyses obtained since 1990 for sediment samples collected in Guaje Canyon at SR 502 is shown in Figure 3.4-4. Most metals showed concentrations below the BV for sediments; however, maximum values of silver, barium, and cadmium have been above the BV.



Source: Environmental Surveillance Reports, 1990–1999.

Figure 3.4-4. Summary of metals in sediments collected at Guaje Canyon at SR 502

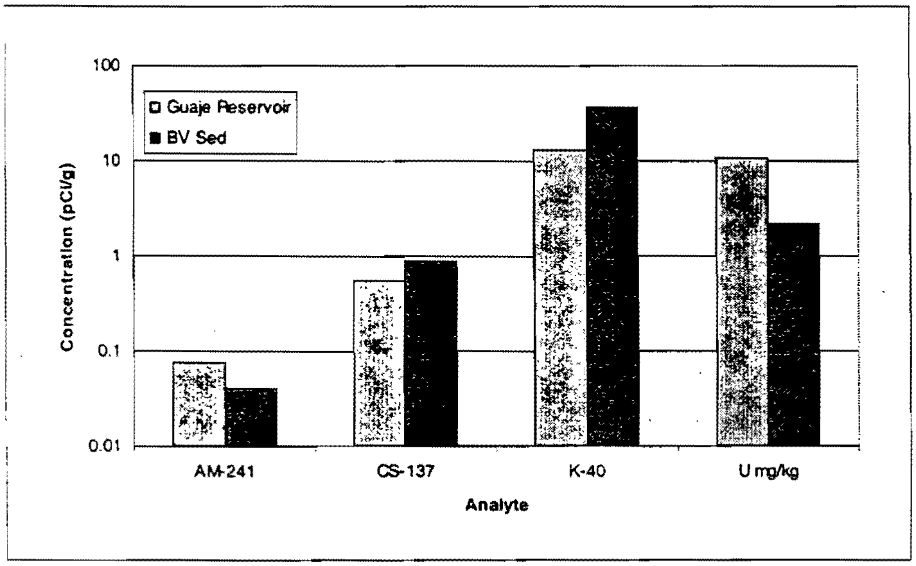
From 1973 through 1980, six sediment samples were collected in Guaje Canyon near well G-4 and the samples were analyzed for radionuclides. A summary of the results is shown in Figure 3.4-5. Gross gamma and strontium-90 were measured in concentrations above the BV for sediments. Three of four samples collected in Guaje Canyon contained strontium-90 in concentrations above the BV. The maximum concentration of strontium-90 was 10.4 pCi/g, which was collected in October 1976 (Environmental Surveillance Reports, 1973–1980).



Source: Environmental Surveillance Reports, 1973–1980.

Figure 3.4-5. Summary of radionuclides in Guaje Canyon sediment near well G-4, 1973 through 1980

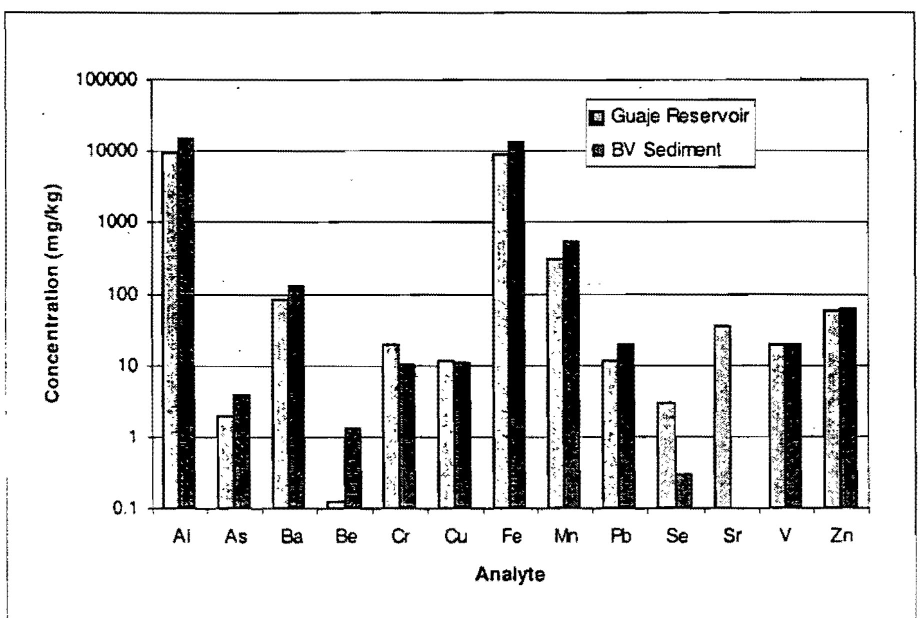
In 1999 a sediment sample was collected from Guaje Reservoir in Guaje Canyon and analyzed for metals and radionuclides (ESP 2000, 68661, p. 170). A summary of the radionuclide analyses is shown in Figure 3.4-6. Americium-241 (gamma spectroscopy), gross alpha, gross beta, and uranium were measured in concentrations above the BV for sediments (ESP 2000, 68661, pp. 225 et seq.).



Source: ESP 2000, 68661, pp. 170, 225.

Figure 3.4-6. Summary of radionuclides in Guaje Reservoir sediment, 1999

A summary of the metals analyses from samples collected from Guaje Reservoir in 1999 is shown in Figure 3.4-7. Metals measured in concentrations above the BV for sediments included copper and selenium (ESP 2000, 68661, pp. 245 et seq.).



Source: ESP 2000, 68661, pp. 170, 245, 251.

Figure 3.4-7. Summary of metals in Guaje Reservoir sediment, 1999

3.4.1.3.4 Recent Environmental Surveillance Sediment and Soil Sampling

In 1999, the US Environmental Protection Agency (EPA) collected four sediment samples from Bayo Canyon approximately 1 mi (1.6 km) east of former TA-10. Sediment collection depths were as follows: Bayo-1, 0-14 cm; Bayo-2, 14 to 27 cm; Bayo-3, 10 to 22 cm; and Bayo-4, 4 to 11 cm. Split samples were collected by the Laboratory Water Quality and Hydrology Group (ESH-18). The samples collected by ESH-18 were analyzed for radionuclides and metals.

Figure 3.4-8 summarizes the radionuclide analyses and Figure 3.4-9 summarizes the metals analyses obtained by ESH-18. All radionuclides were found in concentrations below the BV for sediment except for one sample that contained americium-241 in a concentration of 0.129 pCi/g using gamma spectroscopy; however, the same sample analyzed using alpha spectrometry contained 0.0037 pCi/g americium-241, below the sediment BV. All metals were found in concentrations below the BV for sediments (ESP 2000, 68661, pp. 170, 223, 297).

From June 1 to 19, 2000, after the Cerro Grande fire in May, surface soil samples were collected from locations on Laboratory property, at perimeter stations, and at background stations to assess potential contaminants from fallout ash, smoke and Laboratory air stack emissions, and fugitive dust (e.g., the resuspended dust from contaminated areas at Laboratory facilities). One perimeter station was located in Rendija Canyon near the Sportsman's Club. Analysis of samples from that location indicated the average concentrations of radionuclides and trace elements were similar to results obtained from soils collected in 1999 (Fresquez 2000, 68663, pp. 3, 5, 8).

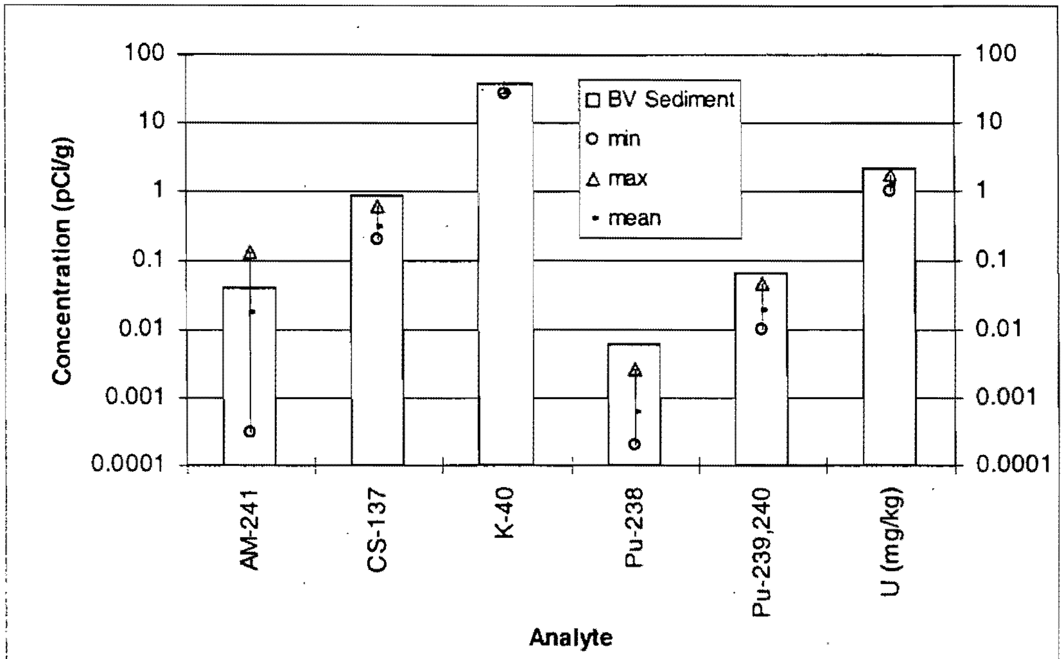
3.4.1.3.5 RFI Sediment and Soil Sampling

The Laboratory ER Project has conducted field investigations and sampling activities at PRSs within TA-0 in Rendija Canyon and upper Bayo Canyon, and at PRSs at former TA-10 in Bayo Canyon and Barrancas Canyon. Resource Conservation Recovery Act facility investigation (RFI) soil sampling has been conducted at the Guaje well field G-1 site in Guaje Canyon. The results of the investigation were reported in the RFI reports for former TA-10 in Operable Unit (OU) 1079 (LANL 1995, 49974; LANL 1996, 54332), the supplemental RFI report (LANL 1996, 54617), and RFI reports for PRSs at TA-0 in OU 1071 (LANL 1994, 59427; LANL 1996, 54837; LANL 1998, 59996). Results of the investigations are summarized below.

3.4.1.3.5.1 Summary of Soil and Sediment Sampling at TA-0

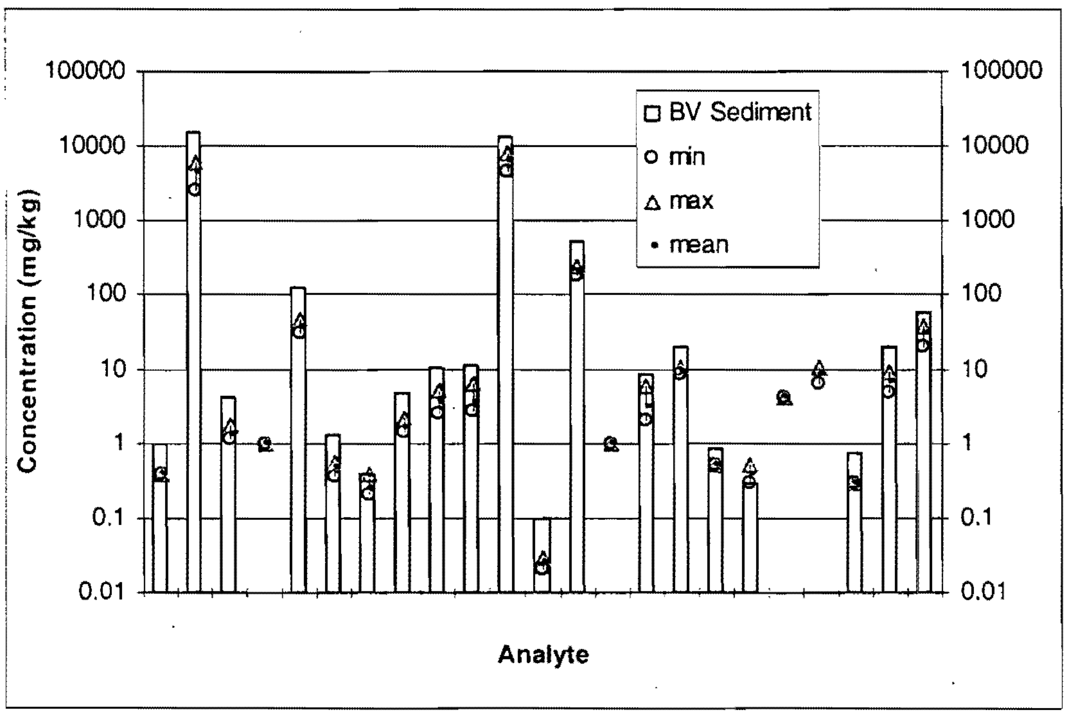
Rendija Canyon

In 1993, 1994, 1996, and 1997 sediment samples were collected from 78 locations in side drainages in Rendija Canyon as part of the RFI for PRSs 0-011(a), 0-011(e), and 0-016 in the canyon. Most were surface samples (less than 1-ft [0.3-m] depth), with a few samples collected from depths up to 1.17 ft (0.36 m). The samples were analyzed for inorganic constituents and HE compounds (LANL 1998, 59996; LANL 1994, 59427). Figure 3.4-10 shows the aggregated results of the sample analyses. Metals measured in concentrations above BVs include cobalt, lead, and selenium, of which lead was measured most often above BV. A total of 70 samples were analyzed for lead and 24 (34%) contained concentrations above the BV. Of 26 samples analyzed for cobalt and selenium, 14 samples (54%) contained cobalt above the BV and 13 samples (50%) contained selenium above the BV.



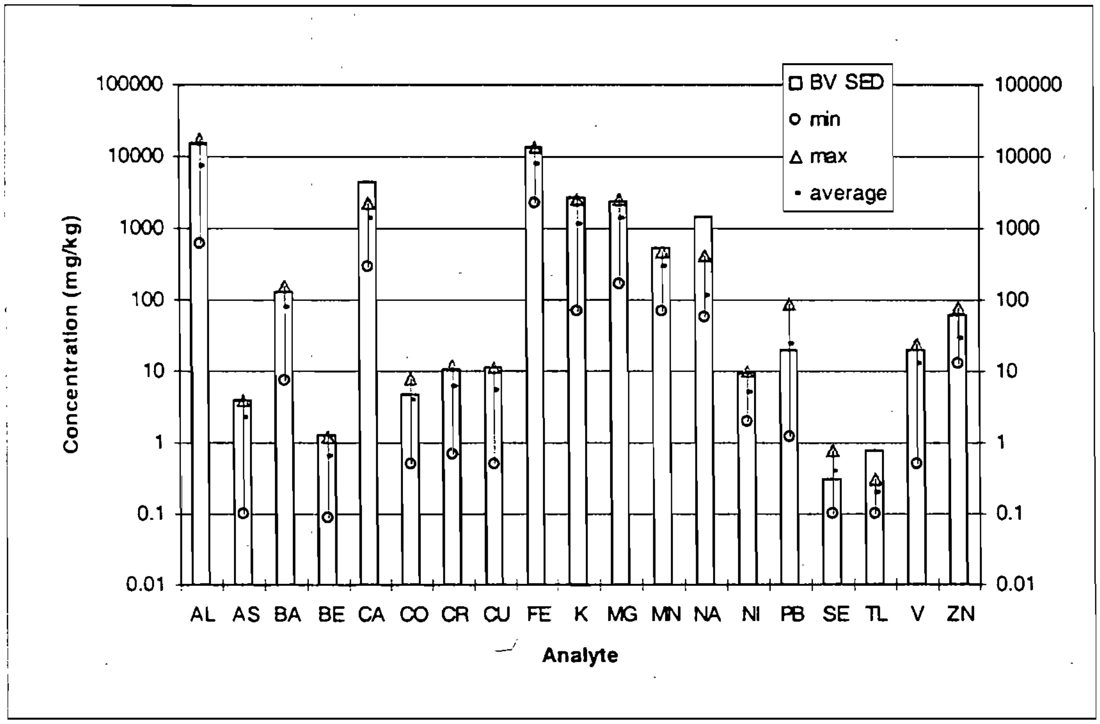
Source: Environmental Surveillance Report, 1999.

Figure 3.4-8. Summary of radionuclides in Bayo Canyon sediment, December 1999



Source: Environmental Surveillance Report, 1999.

Figure 3.4-9. Summary of metals in Bayo Canyon sediments, December 1999



Source: LANL 1998,59996; LANL 1994, 59427.

Figure 3.4-10. Summary of detects of inorganic constituents in Rendija Canyon surface sediment samples

At PRS 00-016, the maximum lead concentration remaining after the voluntary corrective action (VCA) was performed was 85.6 mg/kg in the main cleanup area. The maximum concentration remaining in the side drainage channel area north of the main cleanup site was 70.6 mg/kg. Of 41 samples in the main cleanup areas, 15 were above the soil BV of 22.3 mg/kg, and 3 of 3 first-order-drainage samples were above the BV (LANL 1998, 59996, pp. 48–53; LANL 2000, 67472, p. 2-6).

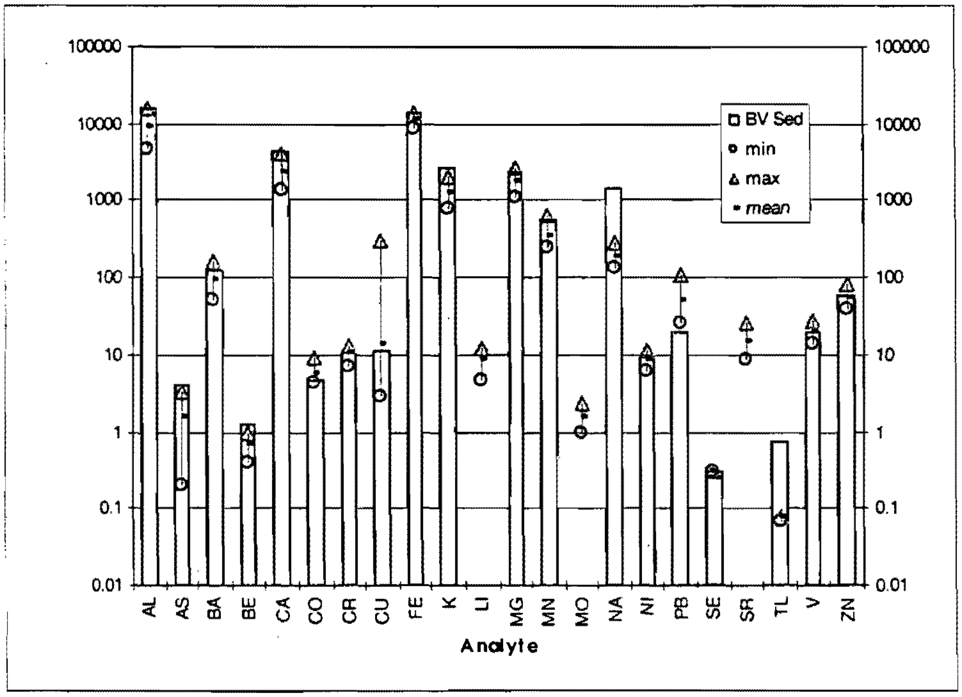
At PRS 00-011(a), 1 sample of 17 was above the BV for lead; the maximum lead concentration in drainages was 29 mg/kg. Selenium was above the BV (0.3 mg/kg) in 13 of 17 samples collected at PRS 00-011(a) and the highest selenium concentration was 0.8 mg/kg (LANL 1994, 59427, pp. 11, 12).

At PRS 0-011(e), no samples were above the BV for lead or other inorganic constituents (LANL 1994, 59427, p. 26).

Organic HE compounds were not detected in samples from the mortar impact sites.

Upper Bayo Canyon

In October 1992 surface sediment samples were collected from seven side-drainage locations at PRS 00-011(d), a bazooka impact area in upper Bayo Canyon. The samples were analyzed for metals (using hydrofluoric acid-leach procedure) and HE compounds (LANL 1994, 59427, p. 16). The results showed that three samples contained lead above the BV but below the screening action level (SAL) value. Additionally, the surface samples contained detectable amounts of the HE compound ethyl-4-nitrobenzene. However, the holding time for HE analysis had been exceeded, so in June 1993 nine additional samples were collected and analyzed for HE compounds and some samples were analyzed for metals using the nitric-acid leach procedure. The summary of the results of the metals analyses is shown in Figure 3.4-11. Metals measured in concentrations above sediment BVs included copper (one sample contained 300 mg/kg copper) and lead, which was measured above the sediment BV in all samples. Lead concentrations ranged from 31 to 156 mg/kg. HE compounds were not detected in concentrations above the method detection limits in any of the samples (LANL 1994, 59427, p. 18).



Source: LANL 1994, 59427.

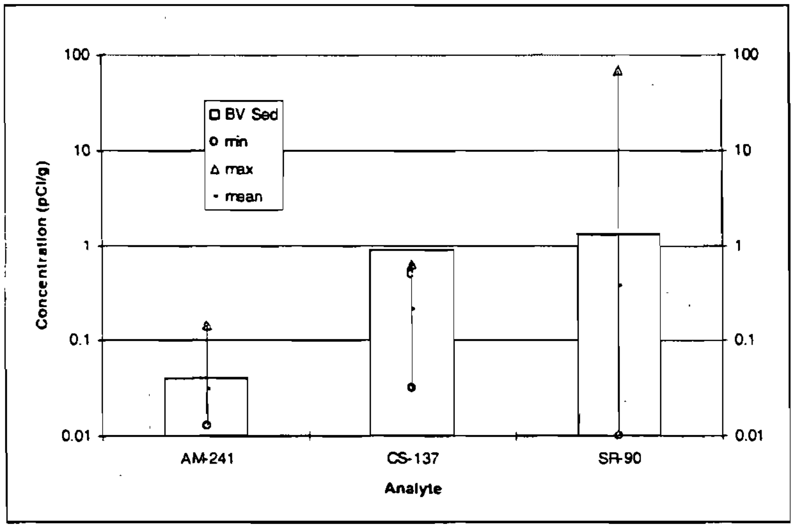
Figure 3.4-11. Summary of metals analyses at PRS 00-011(d) in upper Bayo Canyon

3.4.1.3.5.2 Summary of RFI Sampling at Former TA-10

Middle Bayo Canyon

The RFI for PRSs at former TA-10 in Bayo Canyon was performed from 1994 through 1996. Surface samples were analyzed for semivolatile organic compounds (SVOCs), metals, total uranium, and strontium-90; about 50% of the samples were analyzed for HE compounds. The results of the investigation were reported in the RFI reports for former TA-10 in OU 1071 (LANL 1995, 49974; LANL 1996, 54332) and the supplemental RFI report (LANL 1996, 54617). These samples were collected in a grid that covered much of the canyon floor in the area within and surrounding former TA-10. Some sampling locations were within post-1942 sediment along the channel in Bayo Canyon, but most were located throughout the rest of the valley floor to characterize contamination associated with shot dispersal from the former firing sites.

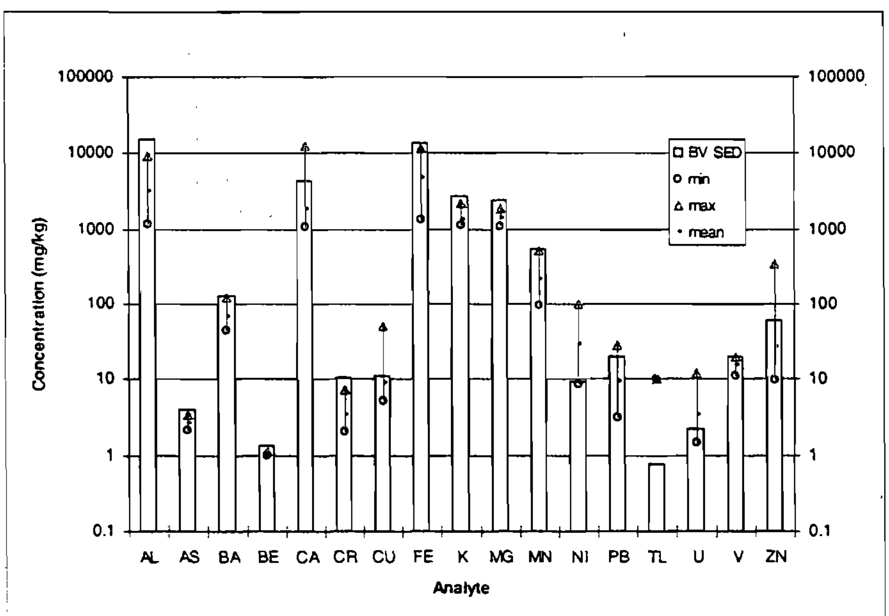
Figure 3.4-12 shows the results of radionuclide analyses of 103 surface samples (less than 1 ft [0.3 m] deep). The radionuclide detected most often was strontium-90; 7 samples contained strontium-90 above the sediment BV. The highest concentration of strontium-90 observed in the surface samples was 67 pCi/g. Americium-241 was detected in 2 samples above the BV, with a maximum concentration of 0.144 pCi/g using gamma spectroscopy (LANL 1996, 54617).



Source: LANL 1996, 54617.

Figure 3.4-12. Summary of radionuclides in surface samples in middle Bayo Canyon

The summary of inorganic constituents in surface sediments from Bayo Canyon is shown in Figure 3.4-13. Inorganic constituents measured in concentrations greater than sediment BVs include calcium, copper, nickel, lead, uranium, and zinc (LANL 1995, 49974; LANL 1996, 54332). Metals found in concentrations greater than the sediment BV include copper (3 of 98 samples above the BV), nickel (1 of 98 samples above the BV), and uranium, which was measured in 78 of 98 (80%) samples at concentrations greater than the sediment BV. The sediment BV for uranium is 2.22 mg/kg whereas the Qbt 1v BV is 6.22 mg/kg. Many of the samples may have been collected from material associated with units of the Tshirege Member of the Bandelier Tuff, which outcrops in the area where the samples were collected, and for which sediment BVs are not an appropriate comparison.



Source: LANL 1996, 54332.

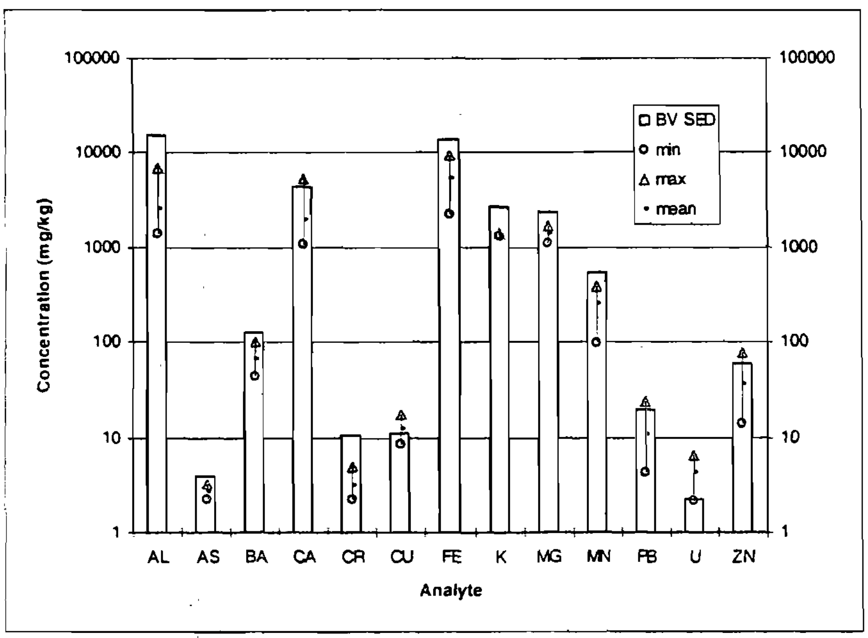
Figure 3.4-13. Summary of inorganic constituents in surface sediments at former TA-10 in Bayo Canyon

HE compounds detected in Bayo Canyon surface samples include nitrobenzene, nitrotoluene, and dinitrotoluene (LANL 1995, 49974; LANL 1996, 54332).

In 1996, surface samples were collected from an area about 200 ft (61 m) long and 160 ft (49 m) wide at former TA-10 in Bayo Canyon (LANL 1996, 55698). The samples were collected from beneath vegetation and from a grid spaced at 20-ft (6-m) centers. Field screening measurements for beta/gamma activity were obtained for sediment samples that were used to estimate the strontium-90 concentration. Strontium-90 concentrations in surface and near-surface soil samples ranged from 2 to 146 pCi/g with a mean of 21.9 pCi/g and a median value of 13 pCi/g (LANL 1997, 56358, Table 1, pp. 6–9). Of 98 surface sample sites collected in the grid pattern for analyses at off-site laboratories, 25 sites (25%) contained strontium-90 in concentrations above the sediment BV of 1.3 pCi/g (LANL 1997, 56358, p. 5).

Barrancas Canyon

Sediment samples were collected in the Barrancas Canyon watershed in 1994 and 1995 during the RFI investigation of former TA-10 in Bayo Canyon. Surface sediment samples were collected from 12 locations in small drainages on mesa-tops and side-canyons and analyzed for inorganic constituents, HE, and strontium-90. The results of analyses for inorganic constituents that were detected in the samples are shown in Figure 3.4-14. Copper was detected in two samples, one of which contained 17.7 mg/kg, above the BV of 11.2 mg/kg. Uranium was detected in all 12 samples analyzed and 11 samples contained uranium above the sediment BV of 2.22 mg/kg. The highest uranium concentration measured was 6.4 mg/kg (LANL 1995, 49974, pp. 24–27, Table A-4). The samples collected in Barrancas Canyon may have been collected from material derived from unit Qbt 1v, which outcrops in the area where the samples were collected. Qbt 1v has a uranium BV of 6.22 mg/kg, about 3 times the BV of other units in the Tshirege Member of the Bandelier Tuff and of stream sediment BVs at the Laboratory (Ryti et al. 1998, 59730, Table 6-1). Other inorganic constituents generally were measured in concentrations below sediment BVs.



Source: LANL 1995, 49974.

Figure 3.4-14. Summary of inorganic constituents detected in surface sediment samples from Barrancas Canyon

Two samples collected from small drainages on the side of a mesa within the Barrancas Canyon watershed detected strontium-90 but in concentrations below the sediment BV. One sample contained high melting explosive (HMX) in a concentration of 1.56 mg/kg and nitrobenzene in a concentration of 0.154 mg/kg (LANL 1995, 49974, p. 25, Table A-6, p. A-33). The presence of these HE compounds in the Barrancas Canyon watershed probably resulted from the experimental detonations conducted in Bayo Canyon during the 1940s and 1950s (see Section 2.3.2).

3.4.1.4 Summary of Surface Sediment Data

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

- Surface sediments in upper Bayo Canyon near PRS 00-011(d) contained lead in concentrations of 31 to 156 mg/kg (above the sediment BV) and one sample contained 300 mg/kg copper.
- Surface sediments in middle Bayo Canyon near former TA-10 contained calcium, copper, nickel, uranium, and zinc in concentrations above sediment BV; copper, nickel, and uranium were above the sediment BV. Strontium-90 was present in surface sediments in concentrations up to 67 pCi/g. HE compounds detected in Bayo Canyon surface sediment samples included nitrobenzene, nitrotoluene, and dinitrotoluene.
- Surface sediments from small side drainages to Barrancas Canyon were found to contain copper and uranium above BVs. The HE compounds HMX and nitrobenzene were also detected in the surface sediments.
- Routine environmental surveillance sampling for stream sediments in the active channel was conducted at Bayo Canyon at SR 502 and Guaje Canyon at SR 502, but no sampling of floodplain sediments has occurred.
- Active channel samples collected in lower Bayo Canyon at SR 502 generally contained radionuclide concentrations within sediment BVs. Barium, cadmium, and thallium also were found in concentrations above the sediment BV.
- In Rendija Canyon, metals measured in concentrations above BVs include cobalt, lead, and selenium; lead was measured most often (in 34% of samples) above BV. The maximum lead concentration at PRS 00-016 after the VCA was performed was 85.6 mg/kg. The maximum lead concentration at PRS 0-011(a) was 29 mg/kg and selenium was above the BV in 13 samples. Lead concentrations at PRS 0-011(e) were below the BV. Organic HE compounds were not detected in samples from the mortar impact sites in Rendija Canyon.
- Sediment samples collected from Guaje reservoir in 1999 contained americium-241, gross alpha, gross beta, and uranium in concentrations above the sediment BV.
- Sediment samples collected in Guaje Canyon near well G-4 contained gross gamma and strontium-90 in concentrations above BVs.
- Active channel sediment samples collected in lower Guaje Canyon at SR 502 showed average values for all radionuclides within the BVs for sediments, although maximum values for plutonium-238, plutonium-239,240, strontium-90, and uranium were above the sediment BVs. Silver, barium, and cadmium concentrations have been measured above the sediment BVs.

3.4.2 Previous Subsurface Investigations

Subsurface investigations conducted to a limited extent in middle Bayo Canyon at former TA-10 and in a small area in middle Guaje Canyon provide information on potential alluvial groundwater. Subsurface investigations have not been conducted in Barrancas Canyon or Rendija Canyon.

3.4.2.1 Bayo Canyon

In 1961 four test holes, TH-1 through TH -4, were drilled at TA-10 in middle Bayo Canyon. Borehole locations are shown in Figure A-1. For clarification in nomenclature, the boreholes currently are identified as BCTH-1 through BCTH-4. The test holes were drilled to determine if shallow groundwater was present at the former TA-10, Bayo site. Three test holes were drilled into the top of the Puye Formation to maximum depth of 88.9 ft (27.1 m). Alluvium was reported to be 5 to 16 ft (1.5 to 4.9 m) thick above the tuff in these holes. There was no indication of perched water or excessive moisture in the tuff above the Puye Formation. The small volumes of water hauled in and used for previous site operations and normal precipitation and runoff in the watershed precluded a transport mechanism for contaminant migration to the top of the Puye Formation (Mayfield et al. 1979, 11717, pp. 50, 58). No contaminant analyses were performed on these samples.

In 1973 and 1974, additional test holes (the M-series) were drilled in the vicinity of the former liquid waste disposal area at TA-10 to collect samples for contaminant analysis. These holes were drilled from 8 to 39 ft (2.4 to 11.9 m) deep. No groundwater was encountered in the test holes. Cuttings from some holes contained strontium-90 in concentrations greater than the BV. The area was further investigated by drilling 10 additional boreholes. These test holes (the E and W series) were advanced from 6 to 35 ft (1.8 to 10.7 m). No groundwater was reported. The results of sample analyses showed that gross alpha activity was near background levels with the exception of one borehole where 4 to 10 times the background levels was detected. Gross beta activity generally was detected above background levels at all locations. The maximum gross beta value was 24,000 pCi/g (Mayfield et al. 1979, 11717, pp. 47–59).

During the 1974 FUSRAP investigation, subsurface samples were collected from the firing sites, former structures, and the canyon floor in middle Bayo Canyon. About 380 subsurface soil samples were collected and analyzed for gross alpha and beta activity. Laboratory analyses for selected radionuclides were performed on selected and random samples, and strontium-90 analyses were conducted on 68 of the subsurface samples. Twelve of the subsurface samples contained strontium-90 in concentrations greater than 20 pCi/g and eight samples exceeded 100 pCi/g; the maximum strontium-90 concentration was 4310 pCi/g. No groundwater or excessive moisture was reported from the sampling effort (Mayfield et al. 1979, 11717, pp. 4, 25, 26, 30, 51, 88).

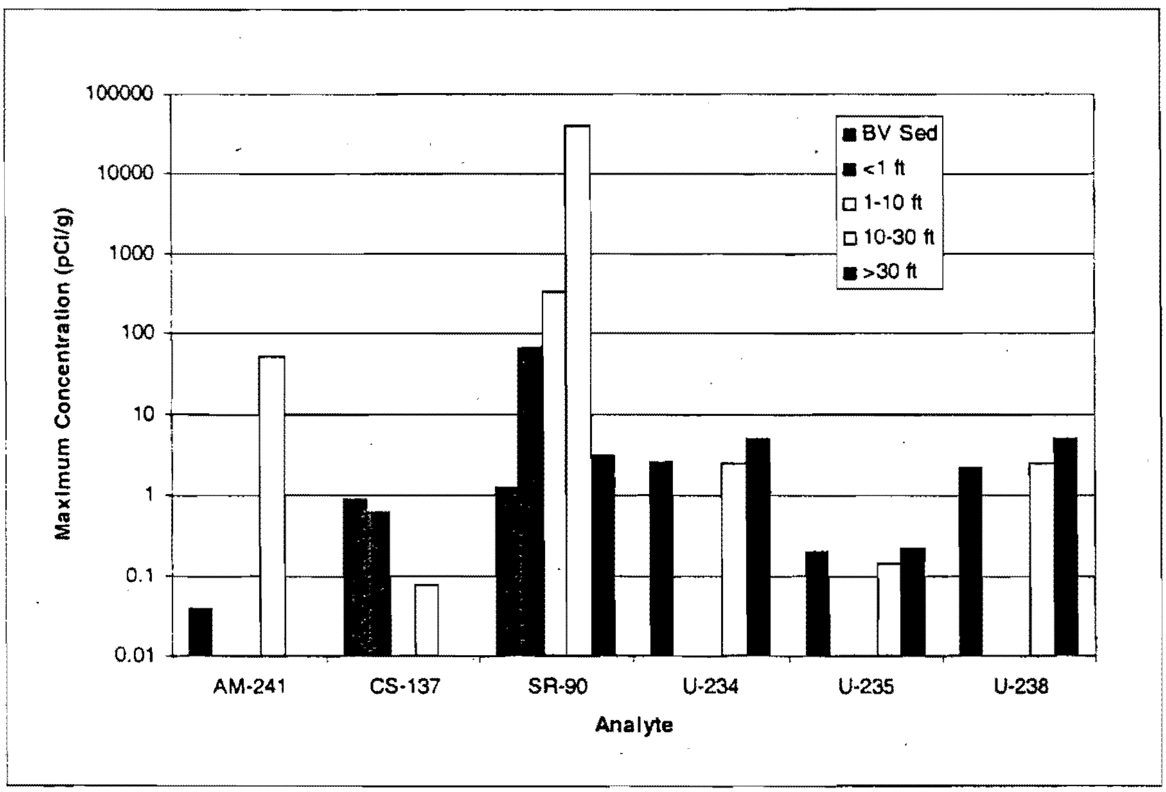
Seven additional test holes were drilled in Bayo Canyon in 1980 to further define the extent of potential contaminants identified in previous investigations. The boreholes were drilled to depths of 12 to 37 ft (3.6 to 11.2 m). The soil/tuff contact generally was encountered at depths from 6 ft to 27 ft (1.8 to 8.2 m). Groundwater was not detected (Purtymun 1994, 58233, p. 97-1). Samples collected within 10 ft (3 m) of the surface were within background levels for gross alpha and gross beta activity at all locations. At greater depths, strontium-90 concentrations were found to be above 100 pCi/g (FBD Inc. 1981, 8032, p.1-4).

In 1996, three samples were collected from a borehole drilled to 4.5 ft (1.4 m) during the RFI at PRS 00-028(b), located on North Mesa within the Bayo Canyon watershed. Samples were collected at depths of 0 to 0.5 ft, 2.5 to 3 ft, and 4 to 4.5 ft (0 to 0.2 m, 0.8 to 0.9 m, and 1.2 to 1.4 m). The samples were analyzed for radionuclides, metals, volatile organic compounds (VOCs), SVOCs, and PCB compounds

(LANL 1996, 54837, p. 19). Metals generally were found in concentrations below the sediment BV; however, metals measured in concentrations slightly above sediment BVs included silver, uranium, and vanadium (LANL 1996, 54837).

The RFI for PRSs at former TA-10 in Bayo Canyon was performed from 1994 through 1996. Surface and subsurface sediment samples were collected from 93 boreholes. At least 4 subsurface samples were collected from each borehole and analyzed for SVOCs, metals, total uranium, and strontium-90; about 50% of the samples were analyzed for HE compounds. The results of the investigation were reported in the RFI reports for former TA-10 in OU 1071 (LANL 1995, 49073; LANL 1995, 49974; LANL 1996, 54332) and the supplemental RFI report (LANL 1996, 54617). Two of the boreholes were completed as observation wells. BCM-1, a moisture monitoring tube and BCO-1, a shallow observation well, were installed in middle Bayo Canyon in 1994. The moisture access tube and the observation well were dry at the time of installation and since 1995 have not been monitored.

Figure 3.4-15 shows the maximum radionuclide concentrations measured in samples from different depths in the RFI boreholes. The radionuclide detected most often was strontium-90. Of 349 samples collected from the subsurface (deeper than 1 ft [0.3 m]) in middle Bayo Canyon, 44 samples (13%) contained strontium-90 in concentrations greater than the sediment BV. The highest concentrations of strontium-90 were observed at depths from 10 to 30 ft (3 to 9 m), where numerous locations contained strontium-90 in concentrations of several hundred picocuries per gram up to a maximum observed concentration of 40,325 pCi/g (LANL 1996, 54617).

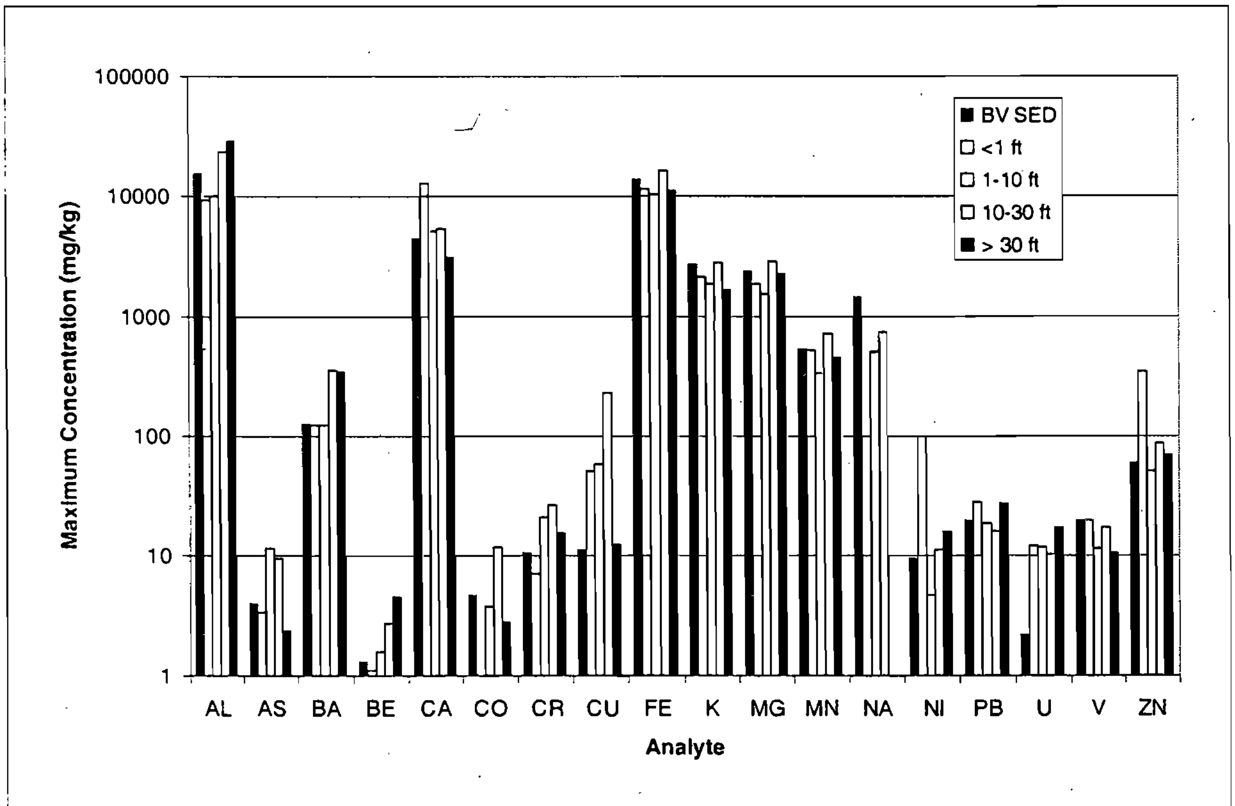


Source: LANL 1996, 54617.

Figure 3.4-15. Summary of radionuclides in RFI subsurface samples from middle Bayo Canyon

Other radionuclides measured in concentrations above sediment BVs in Bayo Canyon included americium-241, uranium-234, and uranium-238, which were detected in samples collected deeper than 10 ft (3 m). Americium-241 (using gamma spectroscopy) was detected in two of 21 samples with a maximum value of 51 pCi/g. Uranium-234 was detected above the sediment BV in 1 of 17 samples (maximum value 5.15 pCi/g) and uranium-238 (maximum value 5.11 pCi/g) was detected above the sediment BV in 2 of 17 samples. These samples were collected from deeper geologic formations present beneath the canyon floor that may not be representative of sediment background conditions (LANL 1996, 54617).

The summary of inorganic analyses (maximum concentrations) for surface and subsurface sediments collected in Bayo Canyon is shown on Figure 3.4-16. Inorganic constituents in subsurface samples measured in concentrations higher than the sediment BV include arsenic, barium, beryllium, cobalt, chromium, copper, and uranium (LANL 1995, 49974; LANL 1996, 54332). The units present in the subsurface in middle Bayo Canyon may not be comparable with sediment BVs.



Source: LANL 1996, 54332.

Figure 3.4-16. Summary of inorganic constituents in subsurface sediments in Bayo Canyon

HE compounds were not detected in subsurface samples in concentrations above the method detection limit (LANL 1995, 49974; LANL 1996, 54332).

3.4.2.2 Guaje Canyon

In 1946, test wells were installed in lower Los Alamos and Guaje Canyons to determine if a groundwater supply could be developed for Los Alamos. Test well GT-4 (also known as LA-3A) was installed in lower

Guaje Canyon at the confluence with Los Alamos Canyon to a total depth of 315 ft (96 m). Artesian conditions were encountered, and the well was screened with 2-in., perforated, galvanized steel from 60 to 315 ft (18 to 96 m). The borehole log indicates 54 ft (16.5 m) of alluvium was penetrated. No alluvial groundwater was noted, and no core samples were collected (Purtymun 1995, 45344, pp. 245, 246).

In 1950, the Layne Western company installed a well to supply water to drill and construct the municipal supply wells in the Guaje field. The well, referred to as the "Layne Western well," is located in lower Guaje Canyon and was installed to a depth of 157 ft (48 m). Approximately 12 ft (3.8 m) of alluvium was encountered. No alluvial groundwater was reported, and no samples were collected for analyses (Purtymun 1995, 45344, pp. 211, 219, 226).

From 1950 to 1954, six municipal water supply wells were completed in Guaje Canyon. A seventh well was completed in 1964 (Purtymun 1995, 45344, p. 247). The wells are identified as G-1, G-1A, G-2, G-3, G-4, G-5, and G-6. Alluvium ranged from 8 ft (2.5 m) at G-5 to 40 ft (12.2 m) at G-6. Alluvial groundwater was not reported in any water supply wells (Purtymun 1995, 45344, pp. 253–259). Four replacement wells (GR-1 through GR-4) were installed near the original wells in 1997 and 1998 (LANL 1999, 63516, p. 77).

Two test holes, TH-1 and TH-2, were drilled in Guaje Canyon between the Rendija Canyon and Guaje Mountain faults in fall 1966 to investigate geologic structures and their relationship to the presence of groundwater. For clarification in nomenclature, the boreholes are identified as GCTH-1 and GCTH-2. The boreholes are located approximately 3 mi (4.8 km) downstream of Guaje Reservoir. GCTH-1 was drilled in alluvium to a depth of 23 ft (7 m). The alluvium was saturated from the base of the borehole to approximately stream level. GCTH-2 was drilled to a depth of 103 ft (31.4 m), encountering 17 ft (5.1 m) of alluvium overlying the Puye Formation. Both units were reported as saturated to near-stream level (Purtymun 1995, 45344, p. 299). GCTH-1 and GCTH-2 were completed as 2-in. (5.0-cm)-diameter monitoring wells. Specific screen intervals were not reported (Purtymun 1995, 45344, p. 299).

3.4.2.3 Summary of Subsurface Investigations

Significant information about subsurface sediments provided in Section 3.4.2 is summarized below.

- Subsurface sediments in middle Bayo Canyon at former TA-10 contain arsenic, barium, beryllium, cobalt, chromium, copper, and uranium in concentrations higher than the sediment BV.
- Subsurface sediments in middle Bayo Canyon at former TA-10 contain strontium-90 in concentrations up to a maximum observed concentration of 40,325 pCi/g.
- The alluvium in middle Bayo Canyon was reported to be 5 to 16 ft thick overlying the Guaje Pumice Bed and the Puye Formation.
- Subsurface investigations have not been conducted in Barrancas or Rendija Canyon.
- Two test wells were drilled in middle Guaje Canyon west of the GMFZ in 1966. Saturated alluvium was observed in both wells and saturation was observed to a depth of 103 ft (31 m) in the Puye Formation.
- The alluvium in lower Guaje Canyon in the Guaje well field ranged from 8 ft (2.5 m) to 40 ft (12 m) in thickness.
- No alluvial groundwater has been reported downstream of any north canyons PRSs.

3.4.3 Surface Water

The water that flows through the north canyons is used by plants, may be used by wildlife, and potentially may be used by humans; therefore, surface water constitutes a potential contaminant transport pathway to receptors. Surface water flow also provides one of the primary mechanisms for redistributing contaminants that may be present in the north canyons system. The results of past investigations (see Section 3.4.4) provide the background of conditions needed to assess the importance of these contaminant transport pathways. This section elaborates on surface water as a potential contaminant transport pathway in the north canyons systems.

The general hydrology of the canyon systems is discussed in Section 2.2.2.2 of the IWP (LANL 2000, 66802) and Section 3.5 of the core document (LANL 1997, 62316).

3.4.3.1 Stream Channel System and Streamflow

The stream channel characteristics and geomorphology of the north canyons and their tributaries are described in Sections 3.1 and 3.3.2. The watershed areas of each canyon are shown in Appendix A, Figure A-1. Streamflow in Bayo Canyon, Barrancas Canyon, and Rendija Canyon is entirely ephemeral. Perennial streamflow in upper Guaje Canyon is maintained by two springs in the upper watershed. Streamflow characteristics of each canyon are described in the following sections.

3.4.3.1.1 Bayo Canyon

Currently, there are no outfalls or National Pollutant Discharge Elimination System (NPDES)-permitted discharges in or into the Bayo Canyon watershed. Streamflow in the canyon is entirely ephemeral, arising from storm water runoff and snowmelt. Runoff is augmented by storm water discharges from a portion of Los Alamos town site on North Mesa and Barranca Mesa. Other runoff comes from San Ildefonso Pueblo land and Laboratory property in TA-74. During periods of heavy thunderstorms, streamflow from runoff in Bayo Canyon may extend beyond the Laboratory boundary to Los Alamos Canyon. However, there are no stream gaging stations in Bayo Canyon so no data for runoff events are available.

3.4.3.1.2 Barrancas Canyon

Barrancas Canyon and its three tributaries contain entirely ephemeral streams. The canyon receives storm water runoff and snowmelt from a small portion of Los Alamos town site on Barranca Mesa and Otowi Mesa, from USFS land, and from a small part of Laboratory property at TA-74. There are no outfalls or NPDES-permitted discharges into the Barrancas Canyon watershed. During periods of heavy thunderstorms streamflow from Barrancas Canyon runoff may discharge into Guaje Canyon. However, no data for runoff events are available because there are no stream gaging stations in Barrancas Canyon.

3.4.3.1.3 Rendija Canyon

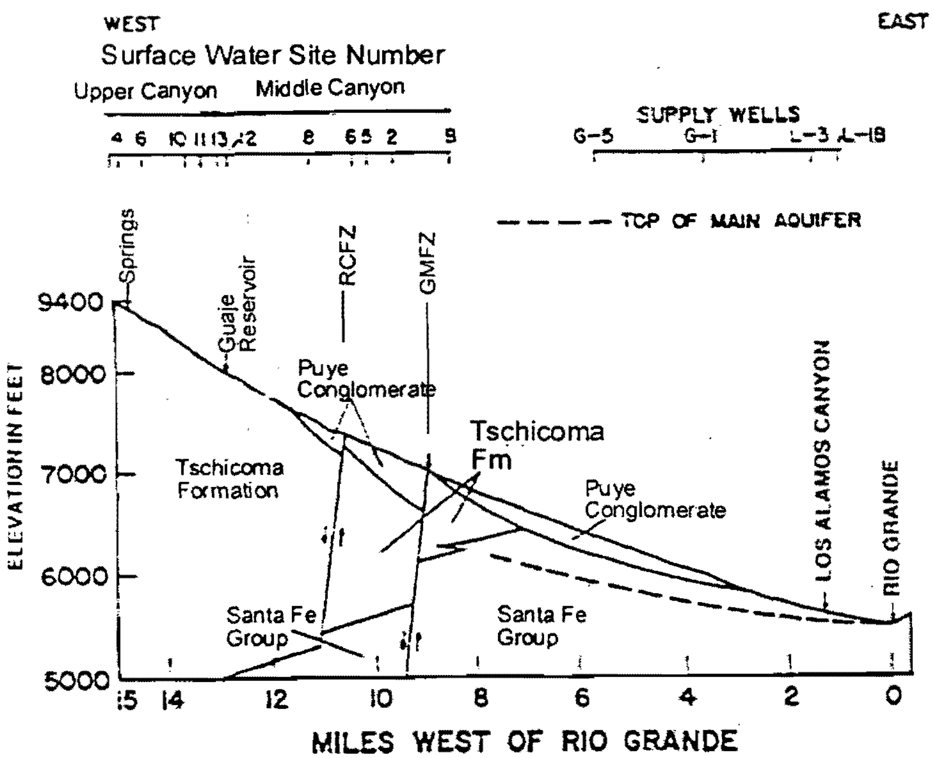
Rendija Canyon and its tributaries contain ephemeral streams. The watershed receives storm water runoff and snowmelt from portions of Los Alamos town site, GSA land containing former firing sites and mortar impact areas, and USFS land (Figure A-1). No data for runoff events is available because no gaging stations are located in Rendija Canyon. The installation of a new gaging station in lower Rendija Canyon above the confluence with Guaje Canyon is planned for 2001.

Two NPDES-permitted outfalls associated with wells G-6 (04A-176) and GR-4 (04A-177) in the Guaje well field were located in lower Rendija Canyon. These NPDES-permitted outfalls were transferred from the Laboratory to Los Alamos County with the transfer of the water supply system. Discharges from these outfalls are intermittent and are associated with start-up of the pumps after the pumps were shut down for maintenance. Discharge rates and volumes are not known.

3.4.3.1.4 Guaje Canyon

Two springs in upper Guaje Canyon supply perennial streamflow to the upper part of the canyon. Agua Piedra Spring in Agua Piedra Canyon supplies base flow for a short distance downstream. Guaje Canyon receives storm water runoff and snowmelt primarily from USFS land in the upper and middle part of the canyon and occasional runoff from Rendija and Barrancas Canyons in the lower part of the canyon. Five NPDES-permitted outfalls associated with wells in the Guaje well field were located in middle and lower Guaje Canyon. These NPDES-permitted outfalls were transferred from the Laboratory to Los Alamos County with the transfer of the water supply system. Discharges from these outfalls are intermittent and are associated with start-up of the pumps after the pumps were shut down for maintenance. Discharge rates and volumes are not known.

Figure A-1 shows locations of the springs and the approximate perennial reach. Figure 3.4-17 shows the stream channel profile of Guaje Canyon and the locations of streamflow monitoring stations that were monitored periodically from 1958 to 1967.



Source: Purtymun 1995, 45344, p. 317; Purtymun 1975, 11787, p. 279.
GMFZ = Guaje Mountain fault zone.
RCFZ = Rendija Canyon fault zone.

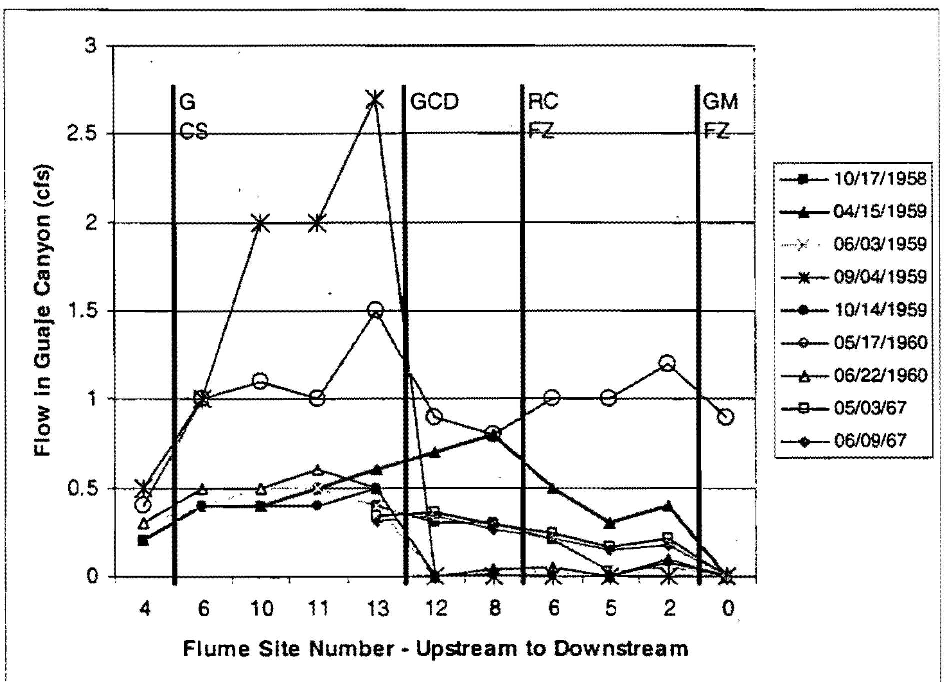
Figure 3.4-17. Channel profile of Guaje Canyon showing locations of historical surface water monitoring stations

Flow investigations were conducted in Guaje Canyon periodically from 1958 through 1960 to relate geologic structure to loss or gain in streamflow. Flow measurements were collected at 11 sites located from approximately 2 mi (3.2 km) upstream to about 4 mi (6.4 km) downstream of the reservoir. During this period (1958–1960), flows obtained in the months of September were 0.5 to 2.7 cfs and in the months of May, 0.4 to 1.5 cfs, which likely reflected the effect of seasonal precipitation events and snowmelt. Flows obtained downstream of Guaje Reservoir typically ranged from 0.0 to 0.3 cfs; however, at the time of the investigation, surface water was being diverted from the reservoir to Los Alamos town site. On one occasion, when water was not diverted, downstream flows were slightly higher than those upstream (Purtymun 1995, 45344, pp. 315–321).

The installation of two new gaging stations in Guaje Canyon is planned for 2001. One gaging station is planned for Guaje Canyon upstream of the confluence with Rendija Canyon and another gaging station is planned for lower Guaje Canyon upstream of the confluence with Los Alamos Canyon.

The springs in upper Guaje Canyon provide perennial base flow in Guaje Canyon as far as the Guaje Reservoir, and when water is not diverted at the reservoir, for a distance of approximately 6 mi (9.7 km) downstream (Purtymun, 1975, 11787, pp. 276–279). Water from the reservoir has not been diverted to Los Alamos since 1992 (McLin et al. 1998, 63506, p.13).

Figure 3.4-18 shows the results of monitoring low streamflow in Guaje Canyon at nine discrete times from October 1958 to June 1967. Flow was measured using Parshall flumes at 11 sites in the upper part of the canyon. The flume monitoring sites were numbered in descending integers (from 13) away from the intake to the reservoir both upstream and downstream; however the numbers attached to the flume sites do not represent a unit of distance away from the reservoir. Figure 3.4-17 shows the locations of the flume sites in upper Guaje Canyon (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).



Source: Purtymun 1975, 11787, p. 280.
GCS = Guaje Canyon springs.
GCD = Guaje Canyon Dam.
RCFZ = Rendija Canyon fault zone.
GMFZ = Guaje Mountain fault zone.

Figure 3.4-18. Streamflow in upper Guaje Canyon measured at 11 Parshall flume sites

The uppermost flume measurement site was upstream of Guaje Canyon Spring 1, where streamflow ranged from 0.2 to 0.5 cfs (90 to 220 gal./min). Flow measured downstream of Guaje Canyon Spring 1 increased to 0.4 to 1.0 cfs (180 to 450 gal./min), indicating that flow from the spring contributed from 0.1 to 0.6 cfs (45 to 270 gal./min). At most measurement times, flow from Guaje Canyon Spring 1 to the reservoir was relatively steady at about 0.4 to 0.6 cfs (180 to 270 gal./min). Measurements obtained on September 4, 1959, and May 17, 1960, however, showed increased flow downstream from Guaje Canyon Spring 1 to the reservoir, up to 2.7 cfs (1200 gal./min), possibly from storm water runoff and snowmelt runoff, respectively, and possibly from tributaries above the reservoir (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).

Water was being diverted from the reservoir when measurements were obtained, except on April 15, 1959. When water was diverted form the reservoir, flow in the channel downstream of the reservoir was always less than the flow entering the reservoir. All six measurements obtained in 1959 and 1960 showed no streamflow downstream of the reservoir. In 1959 and 1967 when flow measurements above the reservoir were about 0.5 cfs (220 gal./min), streamflow downstream of the reservoir was 0.3 cfs (135 gal./min), indicating a diverted volume of flow of about 0.2 cfs (90 gal./min). The streamflow measurements obtained on April 15, 1959, when water was not diverted from the reservoir, increased in the reach below the reservoir from 0.6 cfs (above the reservoir) to 0.8 cfs (270 to 360 gal./min), a gain of 0.2 cfs (90 gal./min) (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317).

During four of the eight measurement periods when water was being diverted from the reservoir, streamflow downstream of the reservoir was 0.3 to 0.9 cfs (135 to 405 gal./min). At these times streamflow usually decreased downstream by about 0.1 cfs (45 gal./min) between each flume station, probably due to evapotranspiration (ET) and infiltration into the alluvium. During four measurement periods when there was no discharge from the reservoir at station #12, streamflow was observed downstream at station 8; this streamflow continued downstream to station #6 during two measurement periods (Purtymun 1975, 11787, p. 180; Purtymun 1995, 45344, p. 317). Flow in the channel downstream of the reservoir was likely from baseflow emerging from the alluvium downstream from the reservoir.

The Rendija Canyon fault zone (RCFZ) is located downstream of the reservoir between flume stations 8 and 6. The GMFZ is located downstream of the RCFZ between stations 2 and 0. Of 11 measurement periods, 10 showed that flow in the channel decreased across the RCFZ. One measurement period obtained on May 17, 1960, showed an increase in flow across the RCFZ from 0.8 to 1 cfs (360 to 450 gal./min), possibly due to snowmelt runoff contributions from tributaries.

3.4.3.2 Springs

There are no known springs or seeps in Bayo, Barrancas, or Rendija Canyons or their tributaries. Springs on the eastern flank of the Sierra de los Valles supply base flow in the upper reaches of Guaje Canyon. Guaje Canyon Spring 1 and Guaje Canyon Spring 2 are present in upper Guaje Canyon at an elevation of 8850 ft (2698 m) and 8840 ft (2695 m), respectively. Guaje Canyon Spring 1 is located in the main Guaje channel and Guaje Canyon Spring 2 is located in a small southern tributary near the head of Guaje Canyon (Figure A-1). Both springs are located on canyon floors in Bandelier Tuff. The estimated spring flow is 25 and 40 gal./min (Purtymun 1995, 45344, pp. 26, 282, 284; Griggs 1964, 65649, p. 137).

Aqua Piedra Spring is located at an elevation of 8100 ft (2470 m) in Aqua Piedra Canyon, a tributary to Guaje Canyon. The flow volume from Agua Piedra Spring has not been documented. Streamflow from Agua Piedra Spring extends downstream for an unknown distance.

3.4.3.3 Storm Water and Snowmelt Runoff Investigations

Personnel from ESH-18 have sampled storm water runoff periodically at several sites in the north canyons area. Runoff samples have been collected from Rendija Canyon near the confluence with Guaje Canyon at municipal well G-6, and from Guaje Canyon near SR 502. The results are reported in the annual environmental surveillance reports. Results of the analyses of runoff samples are discussed in Section 3.4.3.7. Because no gaging stations are present in the north canyons area, flow volumes of runoff were not obtained at sampling times. Three new gaging stations in lower Rendija and Guaje Canyons are planned for installation in 2001.

3.4.3.4 Flooding Potential

Flow and floodplain estimates for the Los Alamos region were developed using computer-based models (HEC 1 and HEC 2) developed by the US Army Corps of Engineers Hydrologic Engineering Center (McLin 1992, 12014, p. 4). The models project the effects of severe thunderstorms on all watersheds in the Los Alamos area and 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-yr storms.

A theoretically estimated 24-hr runoff resulting from a 2-yr recurrent, 6-hr thunderstorm event and an estimated 24-hr runoff, 50-yr recurrent, 6-hr thunderstorm event were modeled for Bayo, Barrancas, and Guaje Canyons. The model assessed the runoff for the events at specific locations for each watershed. Table 3.4-2 shows the estimates for the 24-hr runoff volumes, the associated 50-yr peak flow at the eastern Laboratory boundary, and the calculated precipitation for the 50-yr event for Bayo, Barrancas, and Guaje Canyons.

Table 3.4-2
Estimates of 24-hr Runoff in the North Canyons Area

Canyon	Locations for Runoff Estimates	2-yr/6-hr Runoff (ac-ft)	50-yr/6-hr Runoff (ac-ft)	50-yr/6-hr Peak Flow (cfs)	50-yr/6-hr Subbasin Precipitation (in.) and Average Elevation (ft)
Bayo	Tributary confluence upstream of east Laboratory boundary	<1	44	111	2.32 in. at town site (7220 ft) 1.75 in. at the main channel (6500 ft) 1.43 in. at the southern tributary at Totavi (6100 ft)
Barrancas	Tributary confluence below east Laboratory boundary	<1	24	67	1.81 in. at town site tributary (6580 ft) 1.51 in. at southern tributary (6200 ft) 1.83 in. at northern 2 tributaries (6600 ft) 1.46 in. above elevation of 5897 ft
Guaje	Above Barrancas Canyon confluence	8	333	666	3.03 in. above 7172 ft 1.91 in. above 6253 ft 2.23 in. near Rendija Canyon at 6253 ft 1.67 in. at Barrancas Canyon above 5897 ft 1.29 in. above the Los Alamos Canyon confluence (5920 ft)

Source: McLin 1992, 12014, pp. 13, 19, 20.

In most canyons on the Pajarito Plateau, and likely for the north canyons, the 100-yr floodplain occupies an area along the canyon floor that is more or less centered on the stream channel (McLin 1992, 12014, p. 4). PRSs at former TA-10 in Bayo Canyon are located near the channel and are thus in the potential flood areas.

In May 2000, the Cerro Grande fire severely burned portions of numerous watersheds in the Los Alamos area. Figure 3.4-19 shows the areas in the north canyons that were affected by the fire. The upper portions of both Guaje and Rendija Canyon watersheds were damaged.

The fire burned approximately 56% of the Guaje Canyon watershed and about 78% of the Rendija Canyon watershed. About 30% of the burned acreage in the Guaje Canyon watershed and about 51% in the Rendija Canyon watershed were classified as high-burn severity (BAER 2000, 68662, p. 280). The areas with high-burn severity generate more runoff than unburned areas and increase the volume of storm water runoff from a storm event. The anticipated time needed to return to prefire hydrologic conditions is approximately 5 yr.

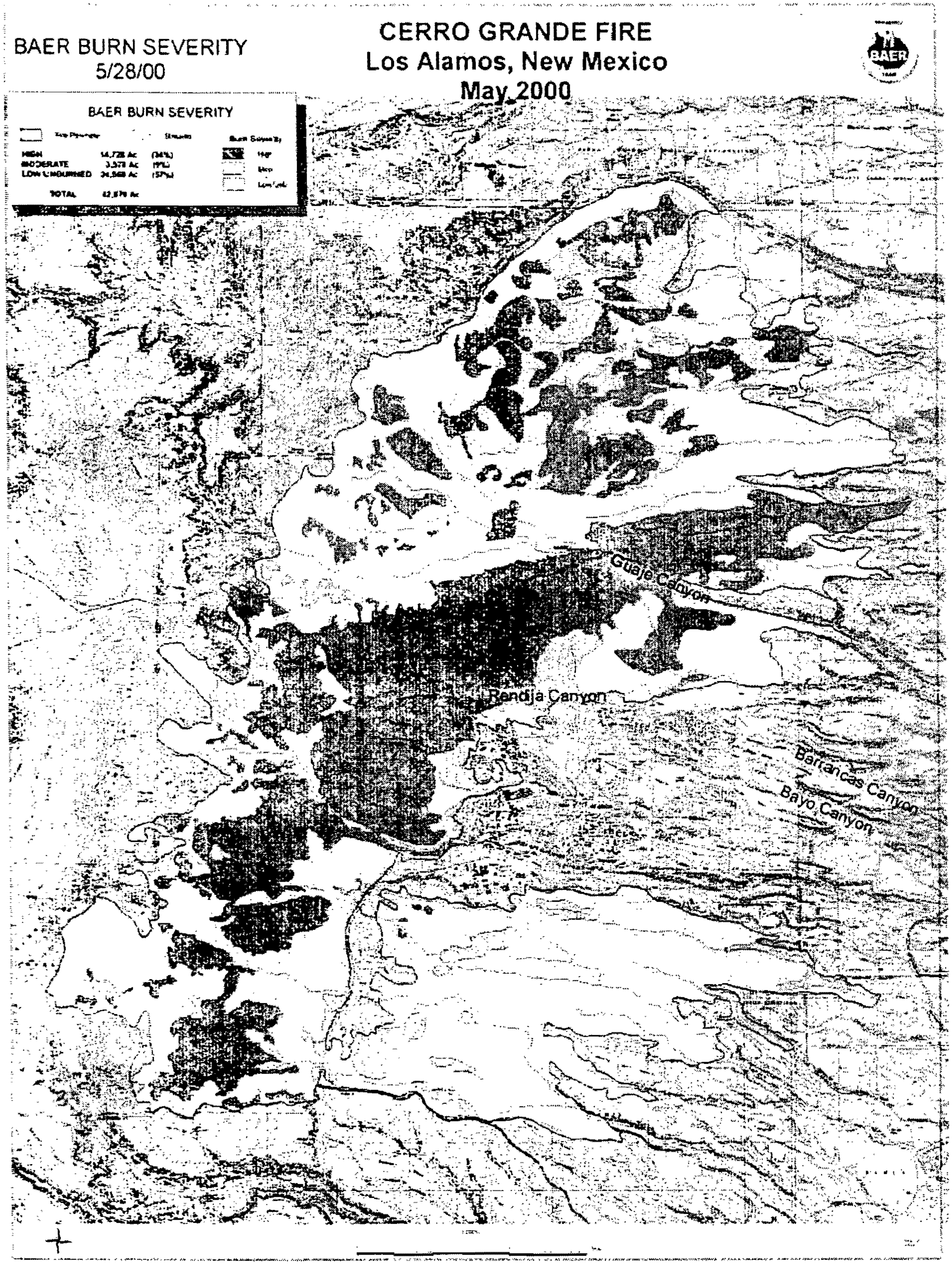
Storm water runoff projections were modeled after the Cerro Grande fire using pre- and postfire parameters. Results of modeling for the Guaje Canyon watershed under prefire conditions for a 25-yr, 1-hr event (1.9 in.) predicted a peak flow of 30 cfs at the Rendija Canyon confluence. Flow projections calculated for after the fire for the same 25-yr, 1-hr event are a maximum of 437 cfs at the Guaje Reservoir. Total runoff for the watershed at the Rendija Canyon confluence was predicted to be 179 ac-ft (BAER 2000, 68662, p. 287).

Storm water runoff flow modeling in Rendija Canyon using prefire parameters for a 25-yr, 1-hr event (1.9 in.) predicted a peak flow of 4 cfs. Flow modeling for after the fire for the same 25 yr, 1-hr event predicted a peak flow of 2398 cfs at the Guaje Pines Cemetery and 686 cfs at the confluence with Guaje Canyon. Total postfire runoff for the watershed was projected to be 283 ac-ft (BAER 2000, 68662, pp. 280, 286, 287).

3.4.3.5 Infiltration Below Stream Bed

Surface water enters the north canyons channels from storm water runoff and snowmelt. As the surface water flows downstream, the water infiltrates into the alluvium, into underlying formations, or is lost to ET. Site-specific infiltration data for the north canyons are not available, although infiltration beneath canyon floors is higher than beneath mesa-tops and has been calculated to be approximately 0.18 in. (4.4 mm)/yr beneath Cañada del Buey and between 0.8 and 4 in. (20 and 100 mm)/yr beneath Pajarito Canyon (LANL 1998, 57576, p. 54).

Geologic investigations in Guaje Canyon have provided data that can be used to infer general rates of infiltration in the canyon. In the upper part of the canyon to about the confluence with the south fork of Guaje Canyon (Figure A-1), the channel is underlain by thin deposits of alluvium overlying the Tschicoma Formation. The upper surface of the Tschicoma Formation may form a barrier to the infiltration of water from the streambed. Streamflow measurements obtained above and below Guaje Reservoir indicate no significant loss by infiltration into the underlying rocks (Tschicoma Formation) at the reservoir. Downstream, in middle Guaje Canyon, the channel is underlain by thicker deposits of alluvium that overlie the Puye Formation. In this reach surface water is lost by ET and infiltration. When water is not diverted at Guaje Reservoir, continuous surface water flow is maintained for approximately 3 mi (4.8 km) below the reservoir before ET and infiltration into the alluvium and underlying Puye Formation depletes the surface water flow (Purtymun 1975, 11787, pp. 276–282).



Source: BAER 2000, 68662.

Figure 3.4-19. Burn severity of the Cerro Grande fire in the north canyons area

Two shallow test holes were drilled west of the Guaje Mountain fault in 1966. The holes contained saturation to depth and indicated that infiltration of surface water into the shallow alluvium and underlying formation may be occurring. The test holes, GCTH-1 and GCTH-2, were drilled to 23 ft (7 m) and 103 ft (31.4 m), respectively. GCTH-1 was completed in the alluvium and was saturated to near-stream level. GCTH-2 encountered 17 ft (5.2 m) of alluvium and 86 ft (26.2 m) of Puye Formation gravel. GCTH-2 was also saturated to near-stream level (Purtymun 1995, 45344, p. 299). The results of the investigation suggested that surface water was being lost to the alluvium and underlying bedrock in middle Guaje Canyon. The surface water may be providing direct recharge to the regional aquifer (Purtymun 1975, 11787, p. 281).

In the lower reaches of Guaje Canyon, NPDES-permitted outfalls are associated with the Guaje water supply wells. The rate and frequency of discharge are not known; however, portions of the discharges likely infiltrate into the shallow alluvium.

When BCO-1 and BCM-1 were installed in middle Bayo Canyon in 1994, dampness was noted in the cuttings at the base of the alluvium at about 30-ft (9.1-m) depth, indicating that some infiltration to depth below the base of the alluvium likely occurred.

3.4.3.6 Surface Water and Runoff Quality and Contaminant Data

3.4.3.6.1 Environmental Surveillance Sampling of Perennial Surface Water

Surface water samples have been collected from Guaje Canyon since 1968. Most stream channels within the north canyons have ephemeral flow and therefore are not subject to surface water monitoring. Guaje Canyon is the only canyon within the north canyons that has a reach of perennial flow. Historic surface water sampling locations include the Guaje Canyon Reservoir and "Guaje Canyon," a sampling location in Guaje Canyon below the confluence with Aqua Piedra Canyon (e.g., ESP 2000, 68661, p. 291). Figure A-1 shows the locations of surface water sample-collection sites. Laboratory personnel have not collected surface water samples from Bayo Canyon, Rendija Canyon, or Barrancas Canyon. Surface water samples identified as Bayo-1, Bayo-2, and Bayo Sewage Treatment Plant (STP) are located in Pueblo Canyon downstream of the Bayo STP.

Guaje Canyon

Guaje Reservoir

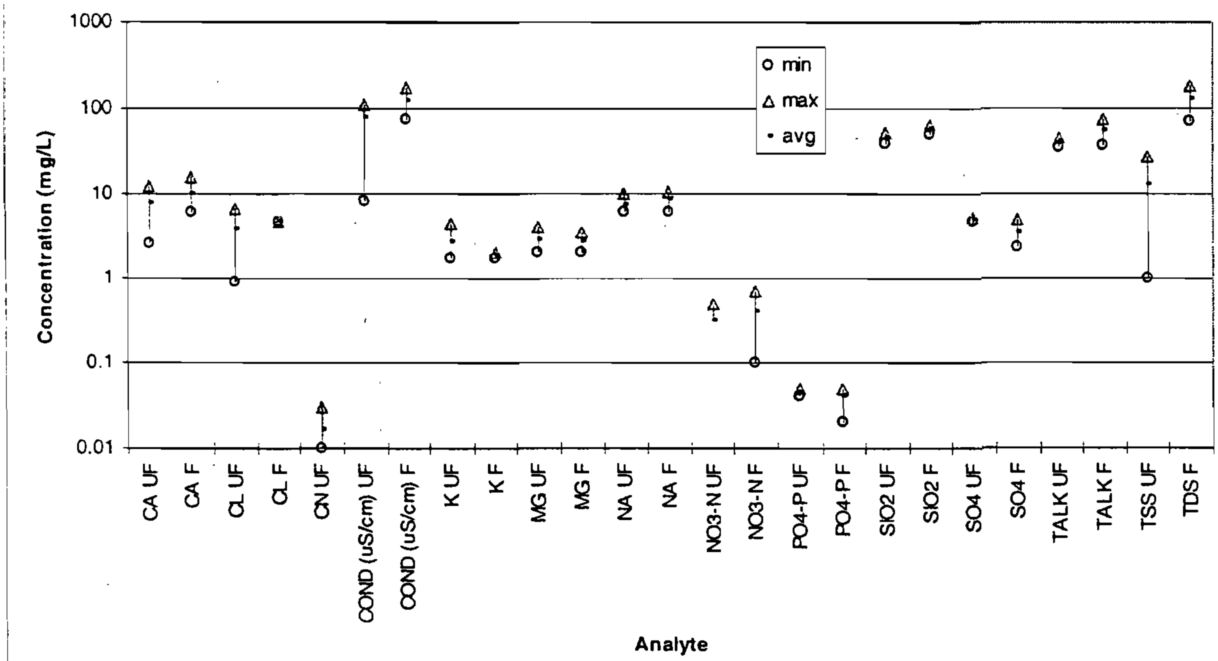
In 1968, 1986, 1988, and 1989 unfiltered surface water samples were collected from Guaje Reservoir and analyzed for radionuclides. Table 3.4-3 shows the radionuclide concentrations obtained from the analyses. The maximum concentration for cesium-137 was 6 pCi/L and for tritium was 2400 pCi/L.

Table 3.4-3
Radionuclides in Unfiltered Surface Water from Guaje Reservoir, 1968-1989

Sample Date	Cs-137 (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (pCi/L)	H-3 (pCi/L)	Pu-238 (pCi/L)	Pu-239,240 (pCi/L)	U (μg/L)
24-Apr-68		2					0.5
02-Sep-86	-14		-840	2400	0.014	0.019	1
01-Jan-88	6		48	-800	0	-0.009	1
15-Mar-89	-46		-624	200	-0.005	-0.011	2.4

Source: Environmental Surveillance Reports, 1968, 1986, 1988, 1989.

In 1989 the surface water samples from Guaje Reservoir were also analyzed for general inorganic constituents. The total dissolved solids (TDS) values were 97 mg/L and the hardness was 23 mg/L. The summary of the results of the analyses including surface water from the Guaje Canyon site is shown in Figure 3.4-20.



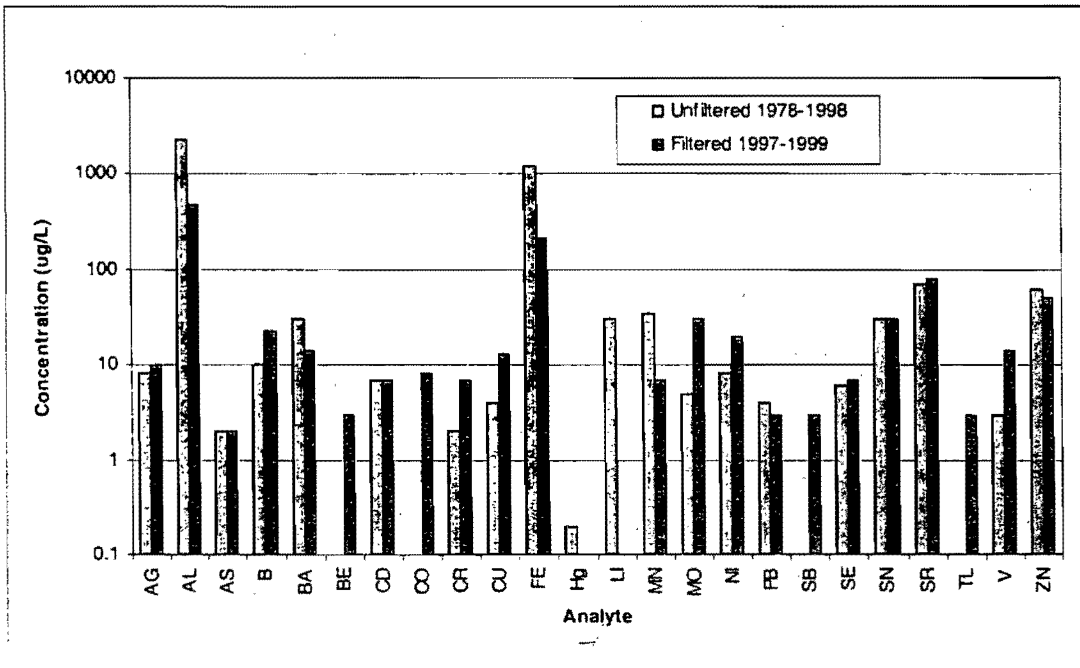
Source: Environmental Surveillance Reports, 1978, 1981–1999.
F = filtered, UF = unfiltered.

Figure 3.4-20. Summary of general inorganic constituents in filtered and unfiltered surface water from Guaje Canyon site, 1978, 1981–1999

Guaje Canyon Site

Surface water samples were collected from Guaje Canyon below the confluence with Agua Piedra Canyon in 1978 and annually since 1981. From 1978 through 1996, analyses were performed on unfiltered samples for general inorganic constituents and radionuclides. Since 1997, the samples were filtered for the analyses of general inorganic constituents and the samples remained unfiltered for radionuclide analyses. The summary of the results of the analyses for general inorganic constituents (filtered and unfiltered samples) is shown in Figure 3.4-20.

Surface water samples from the Guaje Canyon site were analyzed for metals in 1978 and from 1991 through 1999. Early analyses were performed on unfiltered samples but since 1997 analyses have been performed on filtered samples. Figure 3.4-21 shows the maximum values obtained for metals in both filtered and unfiltered samples. In 1998 selenium was observed in a concentration of 3 μg/L, above the New Mexico Water Quality Control Commission (NMWQCC) wildlife habitat standard of 2 μg/L (ESG 1999, 64034, pp. 140, 172).



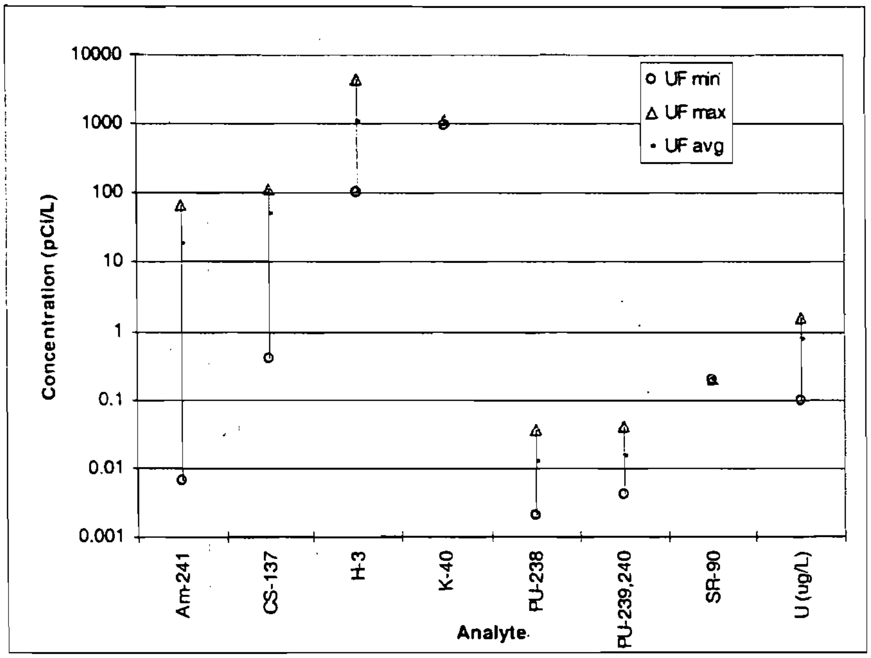
Source: Environmental Surveillance Reports, 1978, 1991–1999.

Figure 3.4-21. Maximum metals values in filtered and unfiltered surface water from Guaje Canyon site, 1978, 1991–1999

Surface water samples from the Guaje Canyon site were analyzed for radionuclides in 1974 and annually since 1978. Most analyses were performed on unfiltered samples. Figure 3.4-22 summarizes the analyses for radionuclides on the unfiltered samples. During the early 1980s tritium concentrations ranged from 1000 to 2000 pCi/L with the highest concentration, 4500 pCi/L, observed in 1983. Since 1985 tritium has been measured at near-detection limits. The sample collected in November 1998 contained 68 pCi/L americium-241, the highest recorded; the concentration measured in November 1999 was 4.29 pCi/L. The highest cesium-137 concentration was 115 pCi/L in 1984, but since 1995 the cesium-137 concentration has been near or below detection limits. The highest plutonium isotope concentrations were observed in the 1980s, when detection limits were higher than in recent years. In the late 1990s, the plutonium isotope concentrations were below detection limits.

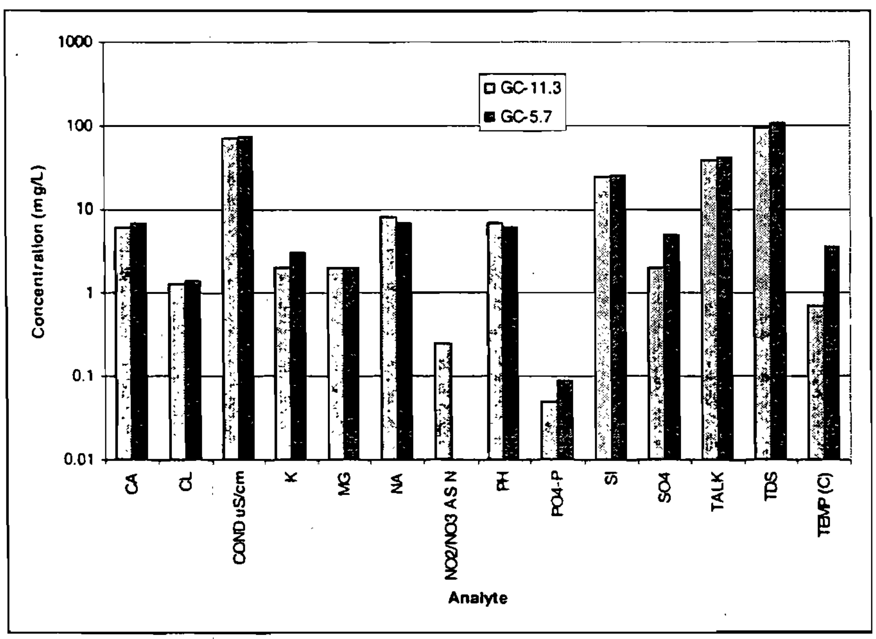
3.4.3.6.2 Other Surface Water Sampling

Personnel of the NMED Oversight Bureau conducted surface water sampling on February 26, 1997, at two locations in Guaje Canyon, Guaje Canyon Spring 5.7, and Guaje Canyon Spring 11.3 (Figure A-1). Guaje Canyon Spring 5.7 was located in middle Guaje Canyon and Guaje Canyon Spring 11.3 was located in upper Guaje Canyon downstream of Guaje Reservoir. Filtered surface water samples were collected and analyzed for general inorganic constituents, metals, and gross-alpha and –beta radioactivity. These data did not undergo validation review by the ER Project. Figure 3.4-23 shows the results of the analyses for general inorganic constituents. The TDSs of the samples were 96 and 110 mg/L and sodium was less than 10 mg/L. Gross alpha activity was less than 1 pCi/g; gross beta activity was 6.1 pCi/L at Guaje Canyon Spring 11.3 and 2.6 pCi/L at Guaje Canyon Spring 5.7. Metals detected in Guaje Canyon Spring 5.7 were aluminum (300 µg/L), iron (200 µg/L), and strontium (40 µg/L). Metals detected in Guaje Canyon Spring 11.3 were lithium (10 µg/L) and strontium (30 µg/L) (Yanicak 1998, 57583).



Source: Environmental Surveillance Reports, 1974, 1978–1999.
UF = unfiltered.

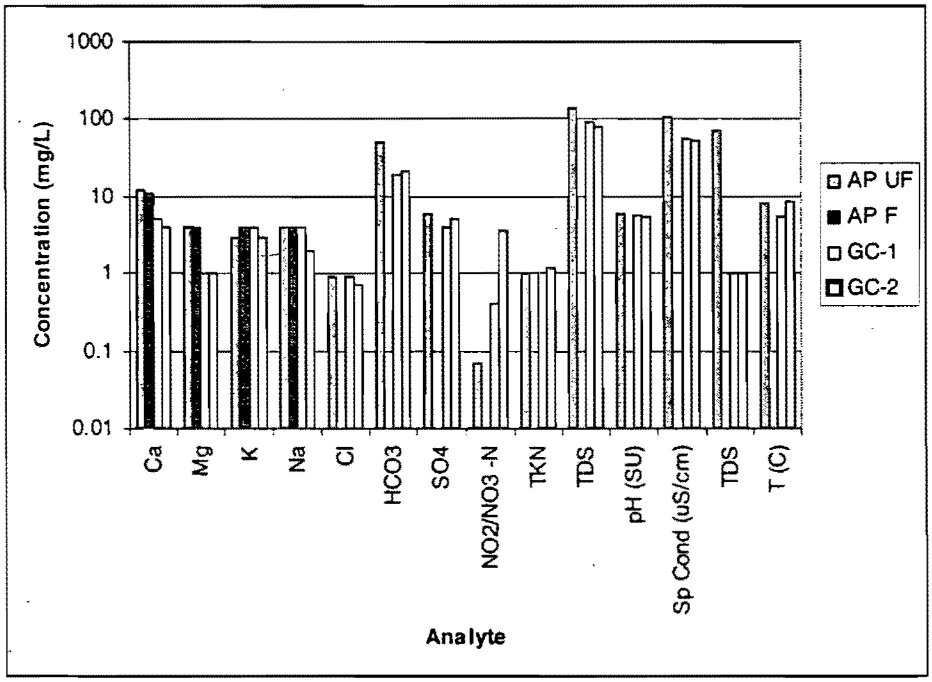
Figure 3.4-22. Summary of radionuclides in unfiltered surface water at the Guaje Canyon collection site, 1974, 1978–1999



Source: Yanicak 1998, 57583.

Figure 3.4-23. Results of NMED surface water sampling in Guaje Canyon, 1997

The NMED Oversight Bureau personnel collected samples from the two springs in Guaje Canyon and from Agua Piedra Spring in Agua Piedra Canyon in August 1997. The samples were analyzed for general inorganic constituents, metals, and selected radionuclides. Both filtered and unfiltered samples were collected from Agua Piedra Spring and unfiltered samples were collected from Guaje Canyon Spring 1 and Guaje Canyon Spring 2 (Yanicak 1998, 57583). These data did not undergo validation review by the ER Project. Figure 3.4-24 shows the results of the analyses for selected general inorganic constituents. Total suspended solids (TSS) in the samples were less than the detection limit of 20 mg/L. As a result, the filtered and unfiltered samples collected from Agua Piedra Spring were very similar in chemical composition. TDSs in Guaje Canyon Spring 1 and Guaje Canyon Spring 2 were less than 100 mg/L but the TDSs in Agua Piedra Spring were 140 mg/L. The concentration of bicarbonate (HCO_3) in Agua Piedra Spring was 50 mg/L, significantly higher than in Guaje Canyon Spring 1 and Guaje Canyon Spring 2, which contained 19 and 21 mg/L bicarbonate, respectively (Yanicak 1998, 57583).



Source: Yanicak 1998, 57583.
AP = Agua Piedra Spring, GC = Guaje Canyon spring.

Figure 3.4-24. Summary of general inorganic constituents in springs in Guaje Canyon, 1997

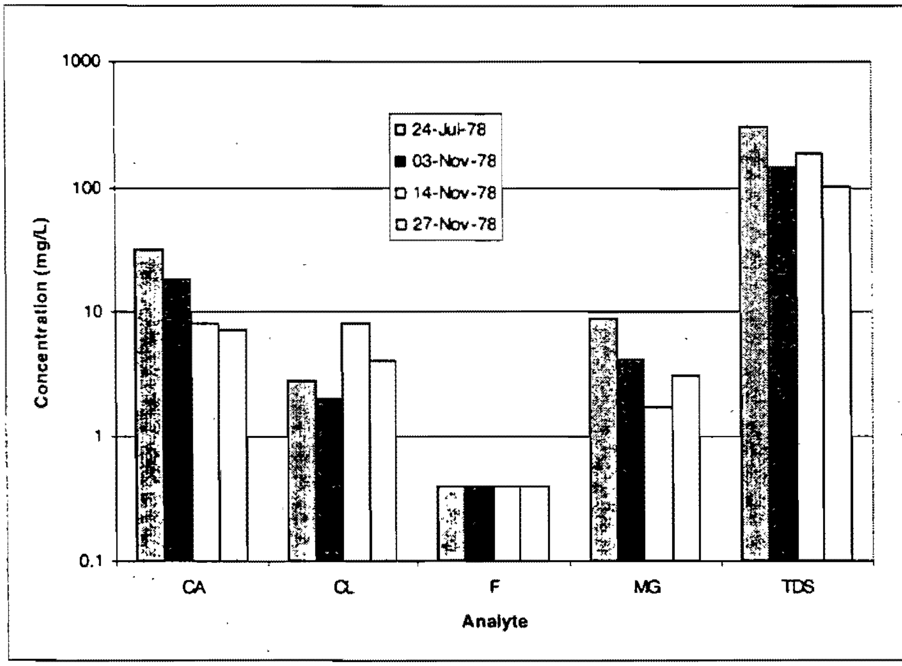
Agua Piedra Spring contained 0.12 µg/L uranium and gross alpha; gross beta activities were below detection limits. Guaje Canyon Spring 1 contained 0.074 pCi/L uranium-234, 0.013 pCi/L uranium-235, and 0.046 pCi/L uranium-238. Other radionuclides were not analyzed. Most trace metals were not observed in concentrations above the method detection limit (Yanicak 1998, 57583).

3.4.3.6.3 Environmental Surveillance Runoff Sampling

ESH-18 and its predecessors periodically have collected storm water runoff samples from Rendija Canyon, near the confluence with Guaje Canyon at municipal well G-6 and from Guaje Canyon near SR 502.

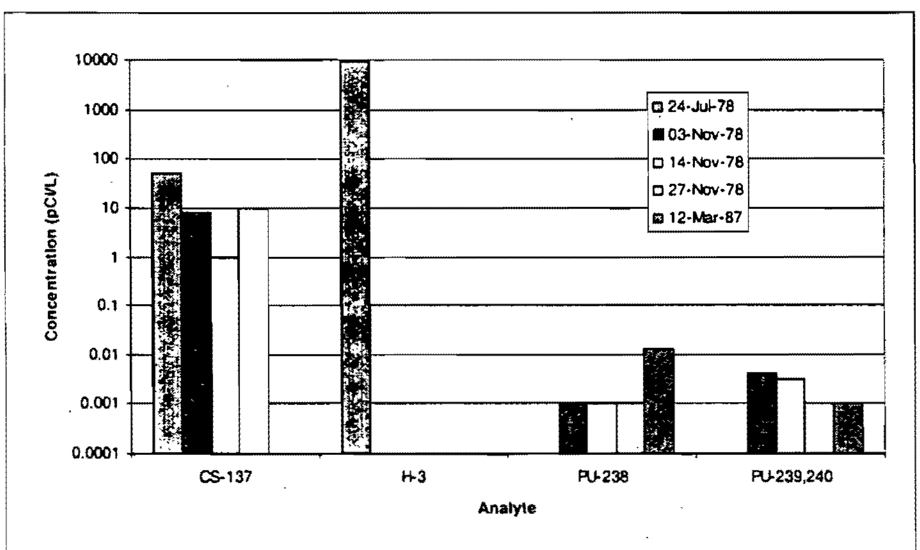
Rendija Canyon

Storm water runoff samples were collected from Rendija Canyon near well G-6 during four runoff events in July and November 1978. The samples were filtered; aliquots were analyzed for general inorganic constituents and radionuclides. Additionally, runoff samples were collected from Rendija Canyon in March 1987 and analyzed for plutonium-238 and plutonium-239/240. The summary of the results of the analyses of these samples is shown in Figures 3.4-25, 3.4-26, and 3.4-27. The highest TDS observed in the filtered samples was 300 mg/L. Tritium was measured in the July runoff event at 9300 pCi/L; tritium analyses were not performed on subsequent samples (ESG 1979, 05819).



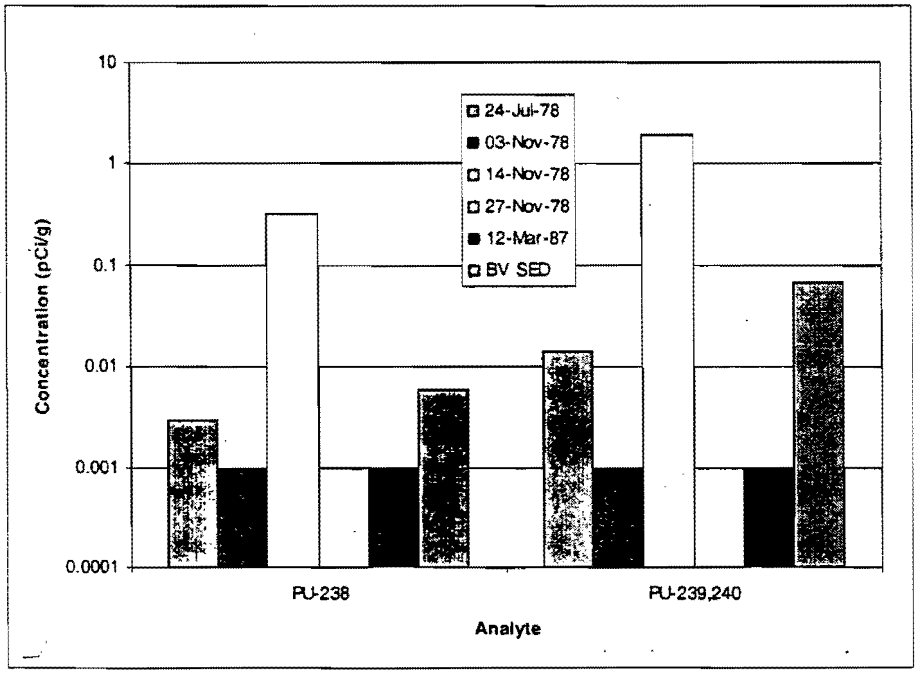
Source: ESG 1979, 05819.

Figure 3.4-25. Summary of general inorganic constituents in filtered storm water runoff in Rendija Canyon, 1978



Source: ESG 1979, 05819; ESG 1988, 6894.

Figure 3.4-26. Summary of radionuclides in filtered storm water collected in Rendija Canyon, 1978 and 1987



Source: ESG 1979, 05819; ESG 1988, 6894.

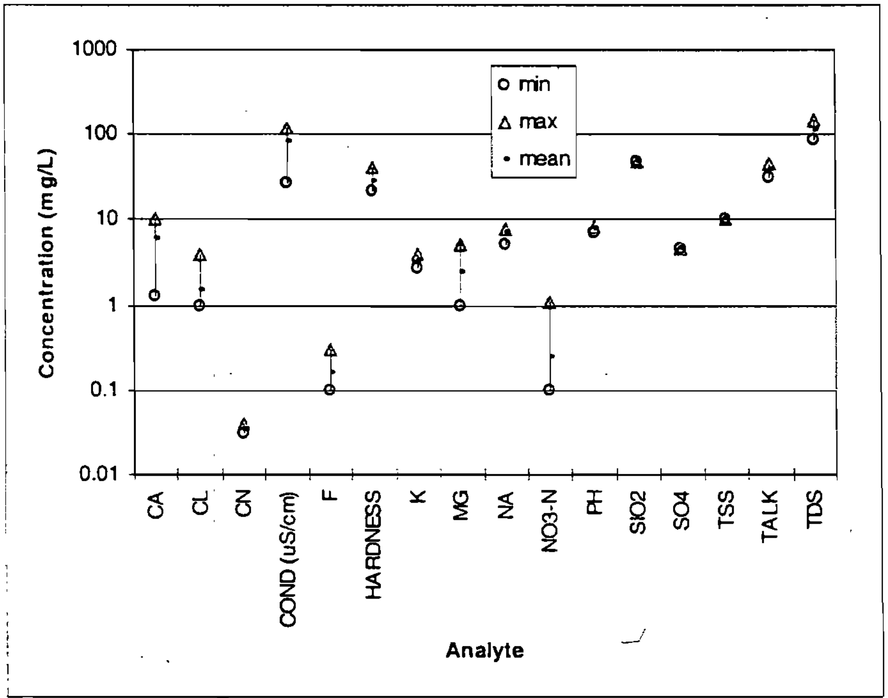
Figure 3.4-27. Summary of radionuclides in suspended sediment fraction of storm water runoff from Rendija Canyon, 1978 and 1987

The suspended sediment fraction of the samples was analyzed for plutonium-238 and plutonium-239/240 (Figure 3.4-27). The plutonium isotopes were measured in concentrations generally below the BVs for sediments, except for one runoff event in November 1978 when the suspended sediments yielded results of 0.32 pCi/g plutonium-238 and 1.93 pCi/g plutonium-239/240 (ESG 1979, 05819). No known Laboratory activities in the watershed involved radionuclides; the suspended sediment results may reflect regional fallout levels.

Guaje Canyon

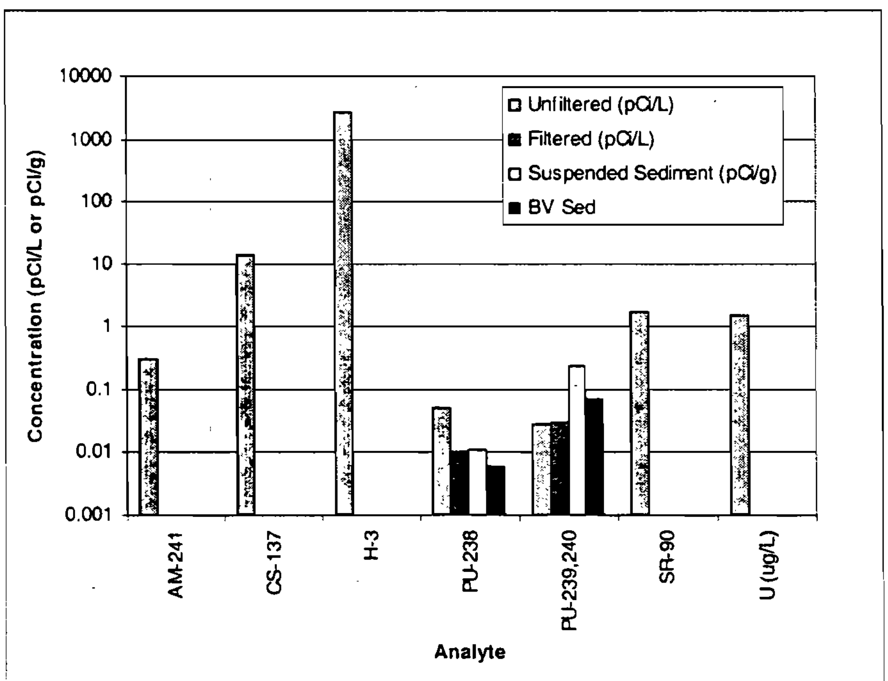
From 1973 to 1977 and in 1980 and 1987 storm water runoff samples were collected in Guaje Canyon at SR 502, above the confluence with Los Alamos Canyon. The samples were analyzed for radionuclides; from 1974 to 1980 they also were analyzed for general inorganic constituents. Figure 3.4-28 shows results of the analyses for general inorganic constituents in unfiltered samples. The TDS and hardness values were obtained from filtered samples. The TDS values ranged from 86 to 148 mg/L (Environmental Surveillance Reports, 1973–1977, 1980–1987).

From 1973 through 1980, unfiltered runoff samples collected in Guaje Canyon at SR 502 were analyzed for radionuclides. In 1987 runoff samples were collected during three separate runoff events; filtered samples were analyzed for radionuclides and the suspended sediment fractions of the samples were analyzed for plutonium isotopes. Figure 3.4-29 shows maximum concentrations of radionuclides measured in the runoff and the suspended sediment. Tritium values as high as 2600 pCi/L were measured in 1976. Maximum concentrations of plutonium-238 (0.011 pCi/g) and plutonium-239,240 (0.233 pCi/g) in the suspended sediment were above sediment BVs in 1987, although no known Laboratory activities involve these radionuclides in the watershed. No runoff samples were collected in Guaje Canyon at SR 502 from 1988 through 1999 (Environmental Surveillance Reports, 1973–1987).



Source: Environmental Surveillance Reports, 1973–1977, 1980–1987.

Figure 3.4-28. Summary of general inorganic constituents in unfiltered runoff from Guaje Canyon at SR 502



Source: Environmental Surveillance Reports, 1973–1987.

Figure 3.4-29. Maximum concentrations of radionuclides in runoff and suspended sediment collected in Guaje Canyon at SR 502, 1973–1987

3.4.3.7 Summary of Surface Water

The surface water hydrology of the north canyons is summarized below.

- Natural streamflow in Bayo, Barrancas, and Rendija Canyons is ephemeral. A reach of upper Guaje Canyon has perennial flow from springs located in the upper reaches of the Canyon. The continuous flow combined with storm water runoff usually does not extend beyond the middle part of the canyon.
- NPDES outfalls in lower Rendija Canyon and lower Guaje Canyon discharge an unknown volume of water. Flow from the discharges infiltrates the alluvium.
- Storm water runoff samples collected in Rendija Canyon near well G-6 in 1978 contained tritium in a concentration of 9300 pCi/L. The suspended sediment fraction of a runoff sample contained 0.32 pCi/g plutonium-238 and 1.93 pCi/g plutonium-239/240, which is above sediment BVs.
- Surface water samples from Guaje Reservoir have contained cesium-137 at 6 pCi/L and tritium at 2400 pCi/L.
- Surface water samples from the Guaje Canyon site contained selenium in a concentration of 3 µg/L, above the NMWQCC wildlife habitat standard for 2 µg/L. During the early 1980s tritium concentrations ranged from 1000 to 2000 pCi/L, with the highest concentration 4500 pCi/L; however, since 1985 tritium has been measured at near-detection limits.
- Runoff samples collected from lower Guaje Canyon have contained tritium in concentrations as high as 2600 pCi/L in 1976. Maximum concentrations of plutonium-238 and plutonium-239,240 in suspended sediment were above sediment BVs in 1987, although the cause of these results is unknown.

3.4.4 Alluvial Groundwater

3.4.4.1 Alluvial Groundwater Investigations

Few investigations of alluvium and shallow groundwater have been conducted in the north canyons. Information regarding the alluvial zones is largely inferred from boreholes drilled in middle Bayo Canyon and middle and lower Guaje Canyon and from conceptual models describing the relation of surface water recharge to the presence of alluvial groundwater. No monitoring or groundwater investigations have been conducted in Barrancas or Rendija Canyons.

During periods of precipitation and increased runoff and streamflow, the surface waterfront advances downstream. As the surface water infiltrates the alluvial sediments, the alluvium may become locally saturated for short periods following these runoff events, but this saturation is not likely to persist.

Bayo Canyon

In 1956, a geologic survey was conducted in Bayo Canyon to assess the potential for contaminant migration pathways. The survey suggested that a possible hydraulic connection existed between Bayo Canyon and Pueblo Canyon in the vicinity of Hamilton Bend Spring and Otowi Seep. Water samples from Hamilton Bend Spring in Pueblo Canyon were often high in nitrates, and wastes from TA-10 in Bayo Canyon were treated with nitric acid (Abrahams 1956, 5319). However, investigations conducted in 1961, 1973, and 1974 (described below) determined that the migration of contaminants from TA-10 in Bayo

Canyon to Pueblo Canyon was unlikely, due to the limited quantity of surface water, and alluvial groundwater in Bayo Canyon was insufficient to move contaminants from the liquid waste disposal pit through the subsurface (Mayfield et al. 1979, 11717, pp. 13, 48, 49).

In 1961 four test holes, BCTH-1 through BCTH-4, were drilled at former TA-10 to determine if groundwater served as a migration pathway for contaminants from former firing sites in Bayo Canyon. The boreholes penetrated the alluvium into the underlying Puye Formation. Alluvial groundwater and significant moisture were not encountered (Mayfield et al. 1979, 11717, pp. 50, 51). Additional information on the test holes is found in Section 3.4.2.

Several subsurface investigations designed to determine nature and extent of contaminants at former TA-10 in Bayo Canyon have not encountered groundwater in the alluvium or the underlying formations. These investigations have included drilling approximately 14 boreholes in 1973 and 1974. Results of the investigations did not indicate the presence of groundwater or significant amounts of moisture in subsurface sediments. Borehole depths ranged from 8 ft (2.4 m) to 40 ft (12.2 m). Most boreholes were located within 250 ft (76 m) of the Bayo Canyon channel (Mayfield et al. 1979, 11717, pp. 47–59). Seven additional test holes were drilled in Bayo Canyon on November 12 and 13, 1980, to depths from 12 to 37 ft (3.6 to 11.2 m). The soil/tuff contact generally was encountered at depths of 6 to 27 ft (1.8 to 8.2 m). The bedrock beneath the streambed (Otowi Member of the Bandelier Tuff) usually was found to be weathered and some boreholes encountered pumice (Guaje Pumice Bed). No indications of moisture or groundwater were noted (Purtymun 1994, 58233, pp. 97-1, 97-2).

A total of 93 boreholes were drilled and sampled during the RFI at former TA-10 in Bayo Canyon from May to November 1994. The investigation was conducted to characterize the nature and extent of PRSs where potential subsurface contaminants may be a concern. Each borehole was drilled to a minimum depth of 50 ft (15.2 m). The alluvium in middle Bayo Canyon was approximately 20 to 40 ft (6 to 12 m) thick. Groundwater was not encountered in any of the boreholes. Damp alluvium and Bandelier Tuff were noted (LANL 1996, 54332, p. 9-13). These intermediate-depth boreholes are discussed in Section 3.4.2.

Guaje Canyon

In fall 1966, two shallow test holes were drilled in Guaje Canyon between the Rendija Canyon fault and the Guaje Mountain fault. The boreholes GCTH-1 and GCTH-2 were located approximately 3 mi (4.8 km) downstream of the Guaje Reservoir. GCTH-1, drilled near the intersection of the Guaje Pines Cemetery Road and Guaje Canyon road, encountered alluvium to the total depth of 23 ft (7 m). GCTH-2, drilled west of the Guaje Mountain fault to a total depth of 103 ft (31.4 m) encountered alluvium from 0 to 17 ft (5.2 m) and Puye Formation to total depth. Both boreholes were completed as 2-in.-diameter monitoring wells. The screened intervals of the wells are not known. Saturation in the boreholes was reported from the approximate level of the Guaje Canyon stream channel to total depth (Purtymun 1995, 45344, p. 299). Groundwater samples were not collected and the wells have not been monitored routinely.

In 1946 test wells were installed in lower Los Alamos and Guaje Canyons to determine if a water supply could be developed for Los Alamos. GT-4 was drilled in the lower reaches of Guaje Canyon at the confluence with Los Alamos Canyon at an elevation of 5675 ft (1730 m). The total depth of the well was 315 ft (96 m). Alluvium was encountered from surface to a depth of 54 ft (16.5 m) and the Santa Fe Group was encountered to the total depth of the test hole. Specific references to saturation within the alluvium were not noted. However, it was determined that the alluvium was too thin to support a municipal water supply (Purtymun 1995, 45344, pp. 245, 246).

Based on information from these investigations, shallow alluvial groundwater likely is present in the upper and middle reaches of Guaje Canyon, supported by infiltration from spring-fed surface water. Streamflow losses due to ET and infiltration and possible losses to geologic structures (faults) reduce the volume of surface water downstream. The saturated thickness of alluvial groundwater likely decreases downstream in the middle part of the canyon.

3.4.4.2 Relationship Between Alluvium and Bedrock Stratigraphic Units

Little information on the relationship of the alluvium to underlying formations, groundwater, or presence of potential contaminants is available for most parts of the north canyons and their tributaries. Subsurface investigations have been conducted in small sections of Bayo Canyon and Guaje Canyon.

Bayo Canyon

The alluvium in the Bayo Canyon floor ranges from a thin veneer to approximately 40 ft (12.2 m) deep near of the stream channel. Figure 3.4-30 is a cross section across Bayo Canyon at former TA-10 that shows the general relationship of the bedrock stratigraphic units identified from subsurface investigations. Because Bayo Canyon heads on the Pajarito Plateau, alluvium at TA-10 is derived entirely from the Tshirege and Otowi Members of the Bandelier Tuff. The alluvium thickens downstream and in the center of the modern drainage, indicating that a deeper inner canyon was cut in the Bandelier Tuff prior to the deposition of the alluvium. The poorly sorted, clay-rich sand and gravel alluvium overlies the Otowi Member of the Bandelier Tuff in the vicinity of the former TA-10. The Guaje Pumice Bed at the base of the Otowi Member was encountered in the RFI boreholes drilled at former TA-10. Generally, the Guaje pumice was in contact with the overlying alluvium. However, in some locations away from the center of the canyon, particularly in the southeast section of former TA-10, the Otowi Member was encountered beneath alluvium (see Figure 3.4-30). In the lower reaches of Bayo Canyon, the alluvium is underlain by the Puye Formation (Mayfield et al. 1979, 11717, p. 47).

The Puye Formation underlies the Guaje Pumice Bed in middle Bayo Canyon. The Puye Formation consists of fine- to coarse-grained sediments interbedded locally with thin tephras, axial river gravels, and lacustrine siltstone and clays. Several low-permeability paleosols have been observed in the upper portion of the Puye Formation that, if present, may serve locally as a layer that is impermeable to the infiltration of groundwater (LANL 1996, 54332, pp. 9–13; Broxton and Eller 1995, 1162).

The bedrock units in Bayo Canyon at the former TA-10 site dip southeast. If shallow alluvial groundwater were present and could come into contact with subsurface contaminants, the water may infiltrate bedrock units such as the Guaje Pumice Bed and continue down-dip in the bedrock units, potentially on a path not parallel to the canyon.

Guaje Canyon

The alluvium in upper and middle Guaje Canyon is derived from the Tschicoma Formation and the Bandelier Tuff, producing angular to sub-rounded clasts of Tschicoma Formation rocks with minerals derived from the Puye Formation. These minerals include feldspar, biotite, and other ferromagnesium minerals and quartz of the Tschicoma Formation. Quartz, sanidine, and silts and clays from the Bandelier Tuff are also present in the alluvium in Guaje Canyon.

In 1966 two shallow test holes were drilled in middle Guaje Canyon to evaluate subsurface conditions. GCTH-1 was drilled to 23 ft (7 m) into alluvium. GCTH-2 was drilled to 103 ft (31.4 m) in 17 ft (5.2 m) of alluvium underlain by the Puye conglomerate to the total depth of the borehole. Both units were saturated from the base of the borehole to near-stream level, indicating hydrologic communication between the alluvium and underlying Puye Formation at this location (Purtymun 1995, 45344, p. 299).

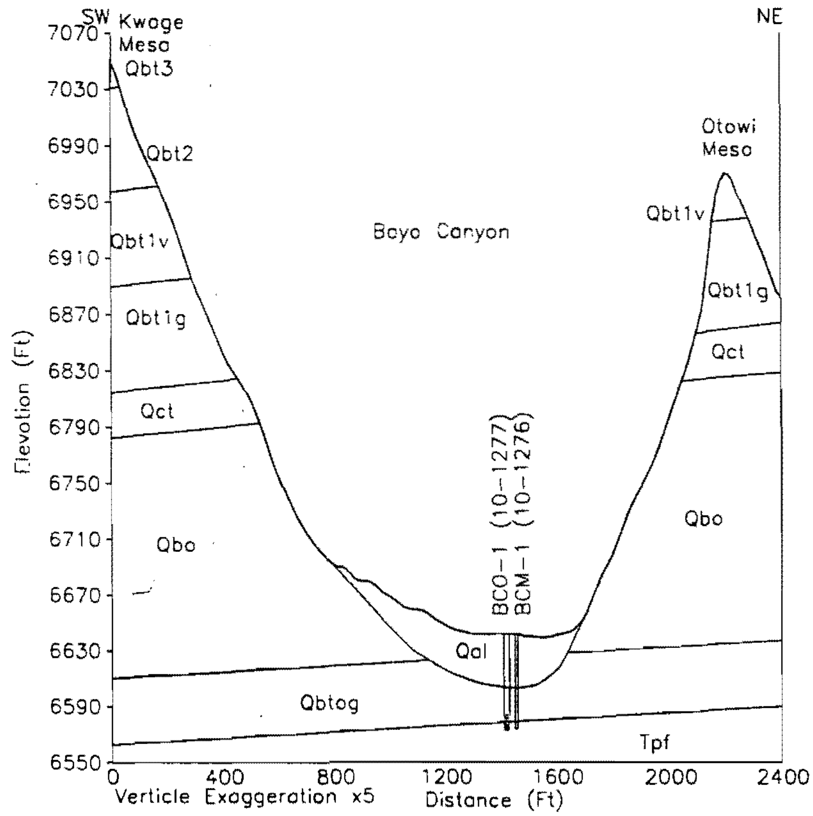


Figure 3.4-30. Cross section of Bayo Canyon at former TA-10 showing monitoring well locations

GCTH-2 was drilled in a structural basin located upstream from the GMFZ. The fault is down-thrown on the west and juxtaposes Puye Formation fanglomerate on the west against Tschicoma Formation dacite on the east. GCTH-2 encountered saturation throughout the alluvium and Puye Formation to total depth. At the time of the investigation, a small amount of water was observed emerging from the GMFZ and flowing for a short distance downstream before infiltrating the alluvium. Purtymun postulated that the Puye Formation in the small structural basin formed by the normal fault was saturated with water from the stream (see Figure 3.4-17). Relatively impermeable rocks of the Tschicoma Formation underlie the Puye Formation and are adjacent to the Puye Formation across the fault. Recharge from the stream infiltrates into the Puye Formation in the structural basin ("ponding") and then overflows at the fault into the stream channel, which is cut into the downstream Tschicoma Formation. The "pond" of groundwater in the structural basin adjacent to the fault also may provide recharge to the regional aquifer via the GMFZ (Purtymun 1975, 11787, p. 281).

Another small structural basin is formed where the Rendija Canyon fault crosses Guaje Canyon. A similar situation develops where a small structural basin of Puye Formation fanglomerates overlies less-permeable Tschicoma Formation dacite and is adjacent to the Tschicoma Formation across the fault (see Figure 3.4-17). No detailed information about saturation in this structural basin is available.

GT-4, drilled in 1946 in the lower reaches of Guaje Canyon near the confluence with Los Alamos Canyon, encountered alluvium from surface to a depth of 54 ft (16.5 m). The alluvium was underlain by the Santa

Fe Group to the total depth of the test hole (315 ft [96 m]). Alluvial groundwater was not noted (Purtymun 1995, 45344, pp. 245, 246).

Municipal water supply wells have been installed in the middle and lower reaches of Guaje Canyon. The alluvium is typically 12 to 17 ft (3.6 to 5.2 m) thick. The minimum thickness of 8 ft (2.4 m) was recorded at G-5, the furthest upstream well. The maximum thickness of alluvium (40 ft [12.2 m]) was reported at well G-6, located in Rendija Canyon approximately 0.8 mi (1.3 km) from the confluence with Guaje Canyon. Alluvial groundwater was not noted at well G-6. The alluvium in all wells is underlain by Puye Formation fanglomerate (Purtymun 1995, 45344, pp. 253, 259).

The Guaje Canyon water supply wells were installed at the edge of the canyon floor and may not have been located sufficiently near the center of the canyon to intersect alluvial groundwater, if present in the lower part of the canyon.

3.4.4.3 Summary of Alluvial Groundwater

Information about the alluvial groundwater in the north canyons is summarized below.

- Available data indicate no persistent alluvial groundwater in the north canyons downstream from PRSs.
- In upper Guaje Canyon surface water is likely a source of recharge to the alluvium and possibly to deeper units.
- There are no known alluvial groundwater discharge points in Bayo Canyon, Rendija Canyon, and Barrancas Canyon. Losses from ET and infiltration into deeper units are the likely sources of moisture loss in the alluvium and of any loss of alluvial groundwater. An unknown volume of infiltrated water may seep downward into subsurface units at locations upstream of PRSs.
- In Guaje Canyon, alluvial groundwater may discharge into deeper formations located in structural basins upstream from the Rendija Canyon fault and the Guaje Mountain fault.
- One intermediate-depth groundwater monitoring well and one subsurface moisture-monitoring well were installed in unsaturated material in Bayo Canyon in 1995. These wells initially were dry, and have not been monitored regularly since 1996. No monitoring wells have been installed in the lower reaches of Bayo Canyon.

3.4.5 Air Monitoring Investigations

3.4.5.1 Historical Monitoring

During 1950, an aerial study of air emissions from TA-10 in Bayo Canyon was conducted by the Air Force Research Laboratory. A Boeing B-17 was equipped with an ion-conductivity measuring device designed to correlate values in an attempt to measure the path of dust clouds containing active particulate and fall-out pattern following test shots from Bayo Canyon. Approximately seven flights were conducted with at least two flights tracking radioactive lanthanum (RaLa) shots from Bayo site. A later review of these investigations concluded that difficulties relating the Air Force Research Laboratory measurements with ionizing radiation were caused by variations from altitude and weather (Dummer 1996, 55951, p. 9).

The 1974 FUSRAP investigation included air sampling around former TA-10 in Bayo Canyon to ascertain if residual radionuclides from the former firing activities were a potential health concern. Airborne concentrations of strontium-90 and uranium were compared to that of other Northern New Mexico locations. The results did not reveal a statistically significant difference in concentrations (Mayfield et al. 1979, 11717, pp. 4, 11).

3.4.5.2 AIRNET Monitoring

The Laboratory operates a network of more than 50 environmental air monitoring stations ("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 (ESP 2000, 68661, p. 88). Particulate matter in the atmosphere primarily is caused by 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 generally are several orders of magnitude 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 (ESP 2000, 68661, pp. 88, 108).

AIRNET sampling locations are categorized as regional, pueblo, perimeter, quality assurance, technical area, or other on-site locations (ESP 2000, 68661, p. 88). The environmental surveillance program monitors one station within the Bayo Canyon watershed annually. The station is a perimeter sampling location at Barranca School (see Figure A-1) located at the head of the Bayo Canyon watershed. Air samples are analyzed for tritium; americium-241; plutonium-238; plutonium-239, 240; uranium-234; uranium-235; uranium-238; gamma spectroscopy; and gross alpha and beta radioactivity (ESP 2000, 68661, pp. 89-93, 140).

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 is located at http://www.esh.lanl.gov/~AirQuality/. The web site also includes follow-up information on investigations of higher-than-normal values.

3.4.5.3 TLDNET Monitoring

The Laboratory Air Quality Group (ESH-17) monitors for cosmic, gamma, and neutron radiation. These types of radioactivity are both naturally occurring and man-made. As the natural background radiation doses from terrestrial and cosmic sources are much larger than those from man-made sources, the man-made sources are difficult to distinguish from natural sources. As of 1999, the Laboratory's monitoring program included 97 thermoluminescent dosimeter (TLD) stations located on the Laboratory and at off-site regional stations to detect any impact from Laboratory operations. Monitoring locations have changed over the duration of the program. In 1999, the Laboratory monitored three locations in the Bayo Canyon watershed, all classified as perimeter locations. These stations are located at Barranca School (station #5), Cumbres (Middle) School (station #7), and at the end of Los Pueblos Street on Otowi Mesa (station #46). Two TLD monitoring stations are located in Pueblo Canyon; they are identified as "Bayo Canyon Well" and "Bayo Canyon."

In 1999, the annual dose recorded at Barranca School (#5) was 134 +/- 17 mrem, the dose at Cumbres School (#7) was 132 +/- 17 mrem, and the dose at the end of Los Pueblos Street (#46) was 153 +/- 20 mrem. The annual dose equivalents at the perimeter and regional stations ranged from 100 to 180 mrem. These dose rates are consistent with natural background measurements (ESP 2000 68661, pp. 100, 101, 130, 150).

3.4.5.4 NEWNET

Neighborhood Environmental Watch Network (NEWNET) is a Laboratory Nonproliferation and International Security Division program for radiological monitoring in local communities. The program establishes meteorological and external penetrating radiation monitoring stations in the local community and around radiological sources. The data include the current date, time, gross gamma radiation, wind direction, wind speed, barometric pressure, temperature, and humidity. Figure A-1 shows the locations of nearby NEWNET meteorological stations. The data are posted with at most a 24-hr delay on the World Wide Web at the NEWNET site at http://newnet.lanl.gov/ (ESG 2000, 68661, p. 107). NEWNET stations located nearest the north canyons are located at Los Alamos High School and at Eastgate near the Los Alamos Airport.

3.5 Biological Setting of the Northern Canyons

The general biological setting for the Los Alamos region and the canyons is discussed in Section 3.8 of the core document (LANL 1997, 62316). The unique aspects of the biological setting of the northern canyon systems are described here.

The biological assessments discussed below include fauna evaluations conducted in many TAs within the north canyons watershed areas (Dunham 1992, 31276; Banar 1996, 58192; Biggs and Cross 1995, 52028). This discussion also summarizes the threatened, endangered, and sensitive species that potentially are present, based on the habitats identified by these assessments.

Potentially threatened and endangered species in the canyon systems are listed in Table 3-6 of the core document (LANL 1997, 62316). Surveys conducted during the biological assessments discussed in Section 3.5.6.1.1 of this work plan did not confirm the presence of threatened, endangered, and sensitive species in the study areas. Preliminary risk assessments for the threatened Mexican spotted owl, the southwestern willow flycatcher, and the bald eagle have been completed. The results of the risk assessments determined that no unacceptable risks were present (Gallegos et al. 1997, 57915; Gallegos et al. 1997, 59790; Gonzales et al. 1998, 62349; Gonzales et al. 1998, 62350).

This section discusses the threatened, endangered, and sensitive species that potentially are present within the north canyons watersheds. The information is based on the habitats identified in the biological assessments conducted by the Laboratory Ecology Group (ESH-20) for the ER Project.

3.5.1 Bayo Canyon Biotic Environment

During 1991, field surveys were conducted in OU 1079 for compliance with the Federal Endangered Species Act of 1973; New Mexico's Wildlife Conservation Act; New Mexico Endangered Plant Species Act; US Department of Energy (DOE) Executive Order 11990, "Protection of Wetlands," and DOE Executive Order 11988, "Floodplain Management"; 10 CFR 1022, "Compliance with Floodplain/Wetlands Environmental Review Requirements"; and DOE Order 5400.1, "General Environmental Protection Program."

3.5.1.1 Flora

During August 1991, the Biological Resource Evaluation Team (BRET) of the Laboratory's Environmental Protection Group (EM-8) conducted field surveys for OU 1079, TAs-10, -31, -32, and -45. Vegetation ranged from a ponderosa pine-mixed conifer series in the western portions of the OU to a piñon-juniper series in the lower east portion of the OUs (Biggs 1993, 48979).

The steep-sided and narrow upper part of Bayo Canon is relatively moist and cool and supports a pine-fir (*Pinus ponderosa, Pseudotsuga menziesii, Abies concolor*) forest (Table 3.5-1). As the canyon widens into the section where the old TA-10 site was located, the pine-fir overstory thins and is restricted to the north-facing slope of Kwage Mesa. The canyon bottom supports many ponderosa pine trees (*Pinus ponderosa*) scattered throughout the old TA-10 site, except in the vicinity of the old firing sites, where all vegetation was removed during the period of active site operation. Ponderosa pine gives way to a piñon-juniper woodland (*Pinus edulis, Juniperus monosperma*) on the drier south-facing slope of Otowi Mesa (Ferenbaugh et al. 1982, 6293).

Table 3.5-1
Common Vegetative Species in Bayo Canyon

Scientific Name	Common Name
Grasses and Forbs	
Andropogon scoparius	Little bluestem
Bouteloua gracilis	Blue grama
Bromus tectorum	Cheatgrass
Koelaria cristata	Junegrass
Taraxicum officinale	Dandelion
Verascum thapsis	Woolly mullein
Shrubs and Subshrubs	
Artemesia tridentata	Big sagebrush
Atriplex canescens	Saltbush
Chrysothamnus nauseosus	Chamisa or rabbitbrush
Fallugia paradoxa	Apache plume
Forestiera neomexicana	New Mexico olive
Gutierrezia microcephala	Snakeweed
Prunus virginiana, var. *melancarpa*	Chokecherry
Quercus gambelii	Gambel oak
Quercus undulata	Scrub oak
Rhus trilobata	Squawbush
Robinia neomexicana	New Mexico locust
Disturbed-Habitat Plants	
Artemisia frigida	Wormwood
Chenopodium fremontii	Lambsquarters
Chrysopsis villosa	Goldenweed
Croton texensis	Doveweed
Cryptantha jamesii	James cryptantha

Table 3.5-1 (continued)
Common Vegetative Species in Bayo Canyon

Scientific Name	Common Name
Erodium cirdutarium	Filaree
Heliathus petiolaris	Prairie sunflower
Lupinus caudatus	Lupine
Mirabilis mulriflora	Wild four o'clock
Salsola iberica	Russian thistle or tumbleweed
Viguiera multiflora	Crownbeard

Source: Ferenbaugh et al. 1982, 6293, p. 31.

3.5.1.2 Fauna

The plant community type found west of the town site and extending into Bayo Canyon supports characteristic fauna such as mule deer, Abert's squirrel, Steller's jay, montane vole, deer mouse, and pipistrelle bat. Characteristic fauna in the north-facing slopes in upper Bayo Canyon include mule deer, red squirrel, and mountain cottontail.

Threatened and endangered animals that regionally nest or forage in the ponderosa pine forest habitats include the meadow jumping mouse, northern goshawk, and spotted bat (LANL 1995, 49974, pp. 7, 8).

3.5.1.3 Threatened and Endangered Species

Biological surveys did not find any threatened and endangered plant or animal species in Bayo Canyon (Biggs 1993, 48979). The spotted bat (*Euderma maculatum)*, a candidate for federal protection and a New Mexico-protected endangered species, may use the rocky cliffs as a roosting area. The northern goshawk *(Accipter gentillis)*, a candidate for federal protection, prefers ponderosa pine/oak and mixed conifer habitats, which occur on the north-facing slopes in the upper portion of the canyon. However, the goshawk tends to avoid humans, and its presence is unlikely because of the suburban areas on the mesa tops above the upper canyon. The Mexican spotted owl (*Strix occidentalis lucida)* nests in lower Pueblo Canyon and is expected to forage into middle Pueblo Canyon and possibly adjacent Bayo Canyon.

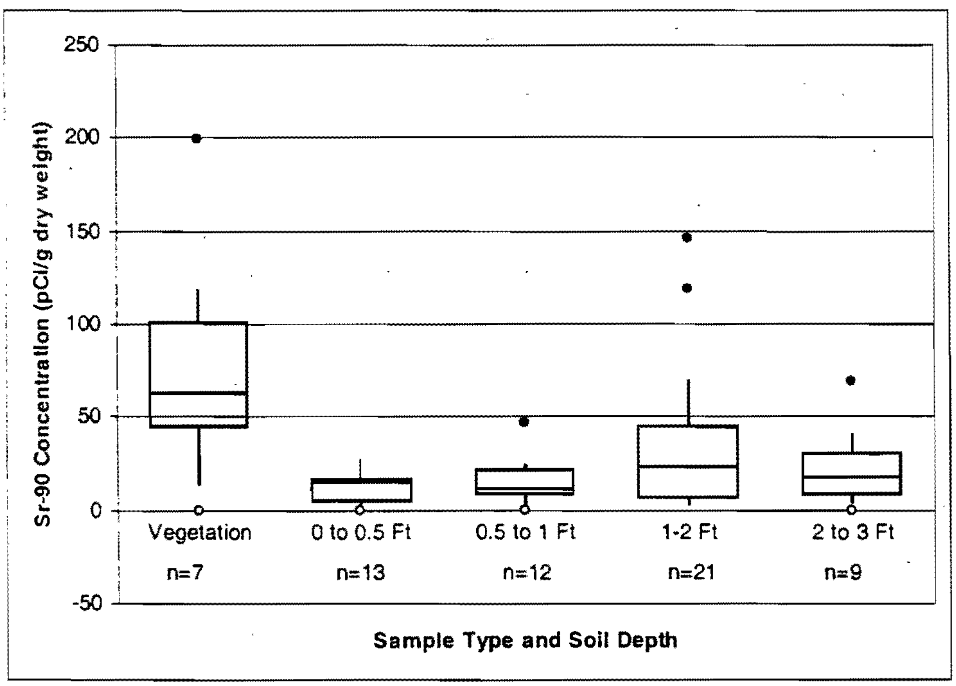
The Laboratory's BRET conducted Level 2 (habitat-evaluation) and Level 3 (species-specific) surveys during 1991 to provide information for a site characterization plan. The purpose of the field surveys was three-fold: to determine if species protected by the state or federal government were present before soil sampling took place; to determine if sensitive habitats were present; and to gather baseline data for future studies on plant and wildlife species in OU 1079. Information gathered from the field surveys was compared with habitat requirements of potentially occurring protected species (both threatened and endangered) (Biggs 1993, 48979).

After a search of the BRET threatened, endangered, and sensitive species database, and after consulting with state and federal agencies, several plant and wildlife species were listed as potentially occurring in the area. No protected species currently are known to use the areas of TA-10.

3.5.1.4 Radionuclide Concentrations in Biota

Chamisa (*Chrysothamnus nauseosus*) growing in a former liquid waste disposal site (PRS 10-007) in Bayo Canyon were collected and analyzed for strontium-90 and total uranium. The vegetation samples were ashed and the ash was analyzed. Surface soil samples also were collected from below (understory) and between (interspace) shrub canopies. Both chamisa plants growing at PRS 10-007 contained significantly higher concentrations of strontium-90 than a control plant. Top growth material from one plant contained 90,500 pCi/g strontium-90 in ash. Similarly, surface soil samples collected beneath and between plants contained strontium-90 concentrations above background levels and screening action levels. This may have occurred as a result of the chamisa plant's bringing strontium-90 from the subsurface and incorporating the radionuclide in the leaf material; leaf fall and plant litter may have contaminated the soil understory area followed by water and/or winds moving strontium-90 to the soil interspace area. Although some migration of strontium-90 in the surface soil has occurred at PRS 10-007, the concentration of strontium-90 in stream channel sediments collected downstream of former TA-10 at the Bayo Canyon-SR 502 intersection has been within regional background concentrations (Fresquez et al. 1995, 68471, p. 1).

Another investigation was conducted in 1996 and 1997 to address strontium-90 in vegetation at the former site of the central portion of TA-10 in Bayo Canyon. An interim action was planned to remediate chamisa plants containing elevated activity (LANL 1996, 55698, p. 1). However, the results of a radiation survey that was conducted to determine which chamisa plants should be removed indicated that several plant species in addition to chamisa contained elevated radioactivity. Other vegetation samples that contained elevated radioactivity included ponderosa pine, annuals, and grasses. Figure 3.5-1 shows the results of vegetation and soil sampling obtained during the investigation at former TA-10. Vegetation samples were dried and the dried material was submitted to a fixed laboratory for analyses. Soil samples were measured using a beta-gamma meter and the results were converted to concentration values using a conversion factor. Strontium-90 in seven vegetation samples ranged from 14 to 199 pCi/g dry weight, and strontium-90 in surface soil samples (0 to 0.5 ft [0 to 15 cm] depth) ranged from 2 to 27 pCi/g. Higher concentrations of strontium-90 were observed at depths of 1 to 2 ft (0.3 to 0.6 m) (LANL 1997, 56358, Table 1).



Source: LANL 1997, 56358, pp. 6–9.

Figure 3.5-1. Box plots showing strontium-90 concentrations in vegetation and soil samples at former TA-10

A risk assessment was developed from the characterization data obtained during the investigation. Pathways used in the assessment included (1) inhalation of resuspended dust and soil, (2) ingestion of soil, (3) ingestion of plant material, (4) ingestion of meat from animals that had foraged in the area, and (5) inhalation of wood smoke from firewood gathered at the site. Plant ingestion was the primary contributor (93%) to annual dose and ingestion of game meat was the second highest contributor (5%). The annual dose calculated from the plant ingestion scenario was less than 10 mrem/yr (LANL 1997, 56358, p. 11).

3.5.2 Rendija Canyon Biotic Environment

In 1991, the BRET conducted Level 2 (habitat evaluation) and Level 3 (species-specific) surveys to provide information for a site characterization plan. One purpose of the field surveys was to gather baseline data for future studies on plant and wildlife species in OU 1071 (Biggs 1996, 62928, p. 3). Surveys were conducted in Rendija Canyon as part of this assessment. The surveys were conducted for compliance with the Federal Endangered Species Act; the New Mexico Wildlife Conservation Act; the New Mexico Endangered Plant Species Act; DOE Executive Orders 11990, "Protection of Wetlands," and 11988, "Floodplain Management"; 10 CFR 1022; "Compliance with Floodplain/Wetlands Environmental Review Requirements"; and DOE Order 5400.1, "General Environmental Protection Program."

3.5.2.1 Flora

Several vegetation analyses and surveys have been conducted in portions of the canyons and mesa tops of OU 1071. These studies include a vegetation survey of Cabra Canyon, a tributary of Rendija Canyon; a winter plant survey of Cabra Canyon; a vegetation and ecological survey of the Pueblo Canyon-Los Alamos Canyon confluence; a vegetation survey of an old farm field in Rendija Canyon; and several smaller surveys in various scattered locations. These studies and surveys were conducted between 1980 and 1991 (Biggs 1996, 62928, p. 16).

The vegetation survey of Cabra Canyon was conducted to determine if any threatened, endangered, and sensitive plant species were present in an area proposed for disturbance and none was found (Biggs 1996, 62928, p. 18). Habitat at the Cabra Canyon site was not suitable for any federally proposed endangered or threatened plant species. It was noted that the site could be potential habitat for state-protected species if the site were not so disturbed (Biggs 1996, 62928, p. 19).

The old farm fields in Rendija Canyon were dominated by wormwood and brome grass and an open area near the canyon road was dominated by blue juniper, ponderosa pine, and cottonwood (Biggs 1996, 62928, p. 4). Vegetation transects in Rendija Canyon were established on the north- and east-facing slopes and along the canyon bottom where the terrain is relatively open (near the access road to the firing range and archery range) (Biggs 1996, 62928, p. 37). Ponderosa pine was the dominant overstory species in the canyon bottom, along the north-facing slope, and at the old field. Piñon pine was the dominant species along the east-facing slope. The diameter at breast height (DBH) of ponderosa pine along the north-facing slope was more than twice that of ponderosa pine in the canyon bottom (8.38 and 20.91 in., respectively). The old field consisted of a young ponderosa pine stand (DBH of 5 in.). Douglas fir was found only along the canyon bottom but is expected to also occur on the north-facing slope. Juniper was found in all areas but occurred most often along the north-facing slopes (Biggs 1996, 62928, pp. 37–38). A complete checklist of plant species identified during these surveys and of species identified in the most recent field surveys is given in Appendix A of the "Biological and Floodplain/Wetlands Assessment for Environmental Restoration Program, Operable Unit 1071, TAs-0, -19, -26, -73, and -74" (Biggs 1996, 62928).

3.5.2.2 Fauna

The biological assessments discussed above in Section 3.5.3.1 include fauna investigations for the technical areas located within the Rendija Canyon watershed for OU 1071 (Biggs 1996, 62928). The investigation conducted habitat evaluation surveys (Level 2) after searching a BRET database containing the habitat requirements for all state- and federally listed threatened, endangered, and sensitive plant and animal species known to occur within the boundaries of the Laboratory and the surrounding areas. The habitat information gathered during the field surveys was compared with the habitat requirements for each species of concern that was identified in the database search. If habitat requirements were not met for any species of concern, no further surveys were conducted. If habitat requirements were met, specific surveys for the species of concern were conducted.

Based on the results of the Level 2 survey, a Level 3 survey was conducted for the meadow jumping mouse in August 1991 along a portion of the stream channel in Rendija Canyon. The meadow jumping mouse inhabits meadows along streams or other similar water sources. No meadow jumping mice were found during the survey (Biggs 1996, 62928, p. 29). Although water was flowing through the canyon at the time of the survey, it was due to recent, heavy rainfall. This species is not expected to occur in the Rendija Canyon area, based on the results of this survey and the lack of a perennial flowing stream and associated suitable habitat (Biggs 1996, 62928, p. 4-5).

In summer 1992, an investigation was conducted to compare nocturnal, small-mammal communities at wet area created by wastewater outfalls with communities in naturally created wet and dry areas. Of the 13 locations chosen for sampling, 1 was in Rendija Canyon. Data were collected on-site type (dry, outfall, or natural), location, and species trapped, and the tag number of each individual captured was recorded. The site in Rendija Canyon was considered a dry area. One species of small mammal, the deer mouse, was captured in Rendija Canyon (Biggs and Raymer 1994, 56038, p. 8). The data were used to determine the mean number of species, percent capture rate, and species diversity. When data from each type of site were pooled, no significant differences were observed in these variables between dry, outfall, and natural location types (Biggs and Raymer 1994, 56038, p. 1).

3.5.2.3 Threatened and Endangered Species

A search of the database and consultation with state and federal agencies found that potential species of concern for the Rendija Canyon area (OU 1071) (based on habitat and known occurrences) are the northern goshawk, Mexican spotted owl, black hawk, bald eagle, Mississippi kite, broad-billed hummingbird, willow flycatcher, spotted bat, meadow jumping mouse, Say's pond snail, Wright's fishhook cactus, Santa Fe cholla, grama grass cactus, sessile-flowered false carrot, threadleaf horsebrush, Plank's catchfly, Santa Fe milk vetch, cyanic milk vetch, Taos milk vetch, tufted sand verbena, wood lily, checker lily, sandia alumroot, and Pagosa phlox (Biggs 1996, 62928, p. 4). Table 3.5-2 lists the occurrence potential of species likely to be found in Rendija Canyon. A habitat evaluation for OU 1071 and the middle part of Rendija Canyon found that two species appear to have at least a moderate potential for occurrence in the area: the spotted bat and the meadow jumping mouse.

3.5.3 Barrancas Canyon Biotic Environment

No specific biological studies have been conducted in Barrancas Canyon. A portion of Barrancas Canyon is located in TA-74 and can be partially grouped with OUs 1071 and 1079. See Section 3.5.1 for Bayo Canyon biotic environmental factors.

Table 3.5-2
Threatened, Endangered, and Sensitive Species Potentially Occurring in the Rendija Canyon Watershed

Scientific Name	Common Name	Legal Status	Potential for Occurrence
Wildlife			
Buteogallus anthracinus	Common black hawk	State protected	Low to none
Cyantyhs latirostris	Broad-billed hummingbird	State endangered	Low to none
Empidonax traillii	Willow flycatcher	Federal candidate	Low to none
Euderma maculatum	Spotted bat	Federal candidate/state threatened	Moderate to high
Haliaeetus leucocephalus	Bald eagle	Federally endangered	Low to none
Accipiter gentilis	Northern goshawk	Federal candidate	Low
Ictinia mississippiensis	Mississippi kite	State endangered	Low to none
Abronia bigelovii	Tufted sand verbena	Federal candidate/state sensitive	Low to none
Aletes sessiliflorus	Sessile-flowered false carrot	State sensitive	Low to none
Strix occidentalis lucida	Mexican spotted owl	Federal candidate	Low to none
Zapus hudsonius	Meadow jumping mouse	Federal candidate/state endangered	Moderate to high
Lymnaea captera	Say's pond snail	State endangered	Low to none
Astragalus cyaneus	Cyanic milk vetch	State sensitive	Low to none
Plants			
Astragalus feensis	Santa Fe milk vetch	State sensitive	Low to none
Astragalus Mathewsii	Mathew's woolly milk vetch	State sensitive	Low to none
Astragalus puniceus var. gertudis	Taos milk vetch	State sensitive	Low to none
Mammillaria wrightii	Wright fishhook cactus	State sensitive	Low to none
Opunita viridiflora	Santa Fe cholla	Federal candidate	Low to none
Phlox caryophylla	Pagosa phlox	State sensitive	Low to none
Silene plankii	Plank's catchfly	State sensitive	Low to none
Lilium philadelphicum var. *andium*	Wood lily	State endangered	Low to none
Fritillaria atropurpurea	Checker lily	State sensitive	Low to none
Heuchera pulchella	Sandia alumroot	State endangered	Low to none
Tetradymia filifolia	Threadleaf horsebrush	State sensitive	Low to none
Toumeya papyracantha	Gramma grass cactus	Federal candidate/state endangered	Low to none

Source: Biggs 1996, 62928, pp. 31, 32, Appendix C.

3.5.4 Guaje Canyon Biotic Environment

During the summers of 1993 and 1994, the BRET conducted baseline studies within two canyon systems, Los Alamos Canyon and Guaje Canyon. Biological data were collected within each canyon to provide background and baseline information for ecological risk models (Foxx 1995, 50039, p. vii).

3.5.4.1 Flora

Table 3.5-3 lists the dominant trees and shrubs in Guaje Canyon. Vegetation in upper Guaje Canyon is characterized by mixed conifer with aspen, and ponderosa pine. The National Wetlands Inventory (NWI) classifies this area as riverine, upper perennial, unconsolidated bottom, and permanently flooded (Foxx 1995, 50039, p. xiii).

The terrain in the mid-portion of Guaje Canyon is much like that in the upper portion. Although the canyon sides are not as steep as those in upper Guaje Canyon, the canyon bottom is narrow and is characterized by dense vegetation (mixed conifer with aspen). Water flow in the stream channel in middle Guaje Canyon is ephemeral. The NWI classifies this area similar to upper Guaje Canyon.

The lower section of Guaje Canyon is broader than the upper and middle sections. Where surveys were conducted in lower Guaje, the stream is ephemeral. The NWI classifies this area as riverine, intermittent, streambed, and seasonally flooded. Vegetation in lower Guaje Canyon is characterized by mixed conifer, ponderosa pine, and piñon-juniper (Foxx 1995, 50039, p. xiii).

For the canyon bottom and riparian vegetation, vegetation surveys along the stream channel and within the canyon bottom showed 126 species in Guaje Canyon. Understory species with the highest importance values were as follows: cutleaf coneflower, goosegrass, Richardson's geranium, and meadow horsetail (Foxx 1995, 50039, p. xvi).

Table 3.5-3
Dominant Trees and Shrubs of Guaje Canyon

Area of Canyon	Dominant Trees	Dominant Shrubs
Upper	Alder	Cliff bush
	New Mexico maple	Serviceberry
	Engelmann spruce	
	Ponderosa pine	
Middle	Alder	Serviceberry
	Water birch	Rose
	Aspen	
	Douglas fir	
Lower	New Mexico maple	Gooseberry
	Alder	Fendler
	Narrowleaf cottonwood	Barberry
	Ponderosa pine	

Source: Foxx 1995, 50039, p. xv.

3.5.4.2 Fauna

The Ecological Studies Team (EST) of the Laboratory's Ecology Group (ESH-20) collected aquatic samples from the streams within Guaje Canyon during two six-month sampling seasons in 1993 and 1994. The EST measured water quality parameters and collected aquatic macroinvertebrates from permanent sampling stations (Foxx 1995, 50039, p. 91). Over 35,000 individual aquatic invertebrates within 81 taxa in Guaje Canyon were collected, identified, and analyzed (Foxx 1995, 50039, p. xvii).

In 1993 and 1994, 6 plant litter samples were collected from below deciduous trees or shrubs in Guaje Canyon. Using standardized sorting and identification techniques, a total of 997 individual snails representing 8 families and 13 species were sorted and identified. Species richness and numbers of individuals varied greatly between samples (Foxx 1995, 50039, p. 195).

For two consecutive years (1993 and 1994), terrestrial arthropod studies were conducted in Guaje Canyon. More than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level (Foxx 1995, 50039, p. 225). The EST also conducted surveys of the birds in Guaje Canyon in 1993 and 1994. In 1993, they found 48 species and 669 birds and in 1994 the census revealed 42 species and 568 birds in Guaje Canyon.

In July and August 1993 and 1994, the BRET conducted field surveys in Guaje Canyon. Biological data were collected, including live-capture and release studies on rodent populations. The primary purpose of collecting small mammal data was to obtain sufficient information to estimate population size, density, and species diversity. The trapping sites were located in two habitat types: mixed conifer and ponderosa pine, and a transition zone of these two types. Deer mice were captured in all trapping locations. Shrews and voles were captured in the upper locations of the canyon and deer mice and a small number of harvest mice were captured in the ponderosa pine habitat of the lower portion of the canyon (Foxx 1995, 50039, p. 255).

Eleven small mammals were captured from Los Alamos and Guaje Canyons. Eight percent (8%) of the deer mice and four percent (4%) of the voles captured in Guaje and Los Alamos Canyons were positive for hantavirus. Three other species were questionably positive.

3.5.4.3 Threatened and Endangered Species

The BRET maintains a threatened, endangered, and sensitive database of all species that potentially occur in Los Alamos and surrounding counties. The threatened, endangered, and sensitive database search identified 23 species that might be present in Guaje Canyon. Four species (Mexican spotted owl, spotted bat, meadow jumping mouse, and Jemez Mountain salamander) have a high or high-to-moderate potential for actually occurring within Guaje Canyon. In addition, eight species were identified but more data were required to determine their presence in the canyon (Foxx 1995, 50039, p. 277). Threatened, endangered, and sensitive species that potentially occur in the Guaje Canyon watershed are listed in Table 3.5-4.

Table 3.5-4
Threatened, Endangered, and Sensitive Species Potentially Occurring in the Guaje Canyon Watershed

Common Name	Scientific Name	Legal Status	Potential for Occurrence
Western toad	*Bufo boreas*	State endangered	Low
Jemez Mountain salamander	*Plethodon neomxicanus*	State-endangered candidate for federal listing	Moderate to high
Mexican spotted owl	*Strix occidentalis lucida*	Federally threatened	Low
Northern goshawk	*Accipiter gentilis*	Federal candidate	Low
Common black hawk	*Buteogallus anthracinus*	State protected	Low to none
Bald eagle	*Haliaeetus leucocephalus*	Federally endangered	Low to none
Mississippi kite	*Ictinia mississippiensis*	State endangered	Low to none
Whooping crane	*Grus americana*	Federally endangered	Low
Least tern	*Sterna antillarum*	Federally endangered and state-endangered	Low
White-faced Ibis	*Plegadis chihi*	Candidate for federal listing	Low
Broad-billed hummingbird	*Cyantyhs latirostris*	State endangered	Low to none
Willow flycatcher	*Empidonax traillii*	Federal candidate	Low to none
Rio Grande silvery minnow	*Hybognathus amarus*	Federally proposed and state endangered	Low
Bluntnose shiner	*Notropis simus*	State endangered	Low
Pine marten	*Martes americana*	State endangered	Moderate
Spotted bat	*Euderma maculatum*	Federal candidate/state threatened	Moderate to high
Meadow jumping mouse	*Zapus hudsonius luteus*	Candidate for federal listing/state endangered	Moderate to high
Occult little brown bat	*Myotis lucfugus occultus*	Candidate for federal listing/state endangered	Moderate
Wood lily	*Lilium philadelphicum*	Candidate for federal listing/state endangered	Moderate
Helleborine orchid	*Epipactis gigantea*	State endangered	Moderate
Lilljeborg's pea-clam	*Pisidium lilljeborgi*	State endangered	Low to moderate
Say's pond snail	*Lymnaea caperata*	State endangered	Low

Source: Foxx 1995, 50039, p. 280; LANL 1997, 62316, p. 3-49.

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.

These 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 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 Waste 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.

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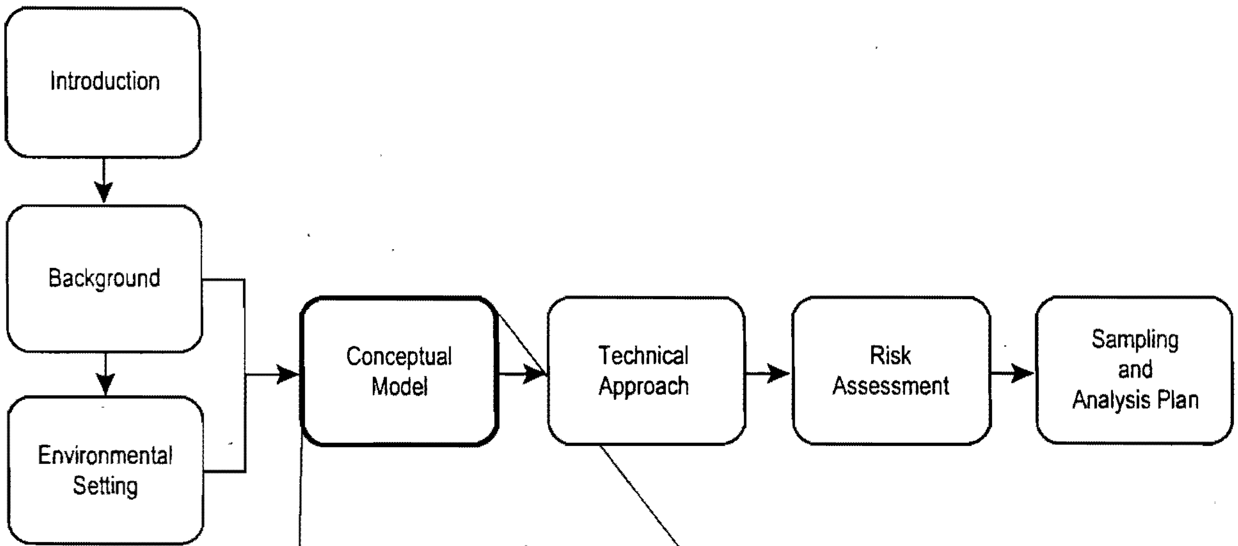
Chapter 4



Conceptual Model

- Sediment Transport Concepts
- Hydrologic Transport Concepts
- Geologic Concepts
- Biologic Transport Concepts

4.0 CONCEPTUAL MODEL

The conceptual model is a representation of site conditions that conveys what is known or suspected about the sources, releases and release mechanisms, fate and transport, exposure pathways, and potential receptors of site-specific contaminants. The conceptual model incorporates information available at any given time and evolves as more information becomes available. The conceptual model links existing knowledge of the north canyons systems (see Chapter 2 and Chapter 3 of this work plan) and the additional information needed to adequately understand the canyons systems. This chapter summarizes the significant geologic, hydrologic, and biological features, events, and processes operating in the Bayo, Barrancas, Rendija, and Guaje Canyons 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," "the core document") (LANL 1997, 62316); and
- the unique north canyons environmental factors and processes that need to be tested or confirmed.

The conceptual model is used to test hypotheses, support risk-based decision-making, and aid in the identification and design of potential remedial alternatives. The conceptual model is refined as new data become available until the model supports an appropriate remedial action decision (or no action). The concepts and the hypotheses presented in the conceptual model are tested by collecting new data and by interpreting the new data with existing information. The result will be an improved understanding of the canyons, 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 assessments of human health and ecological effects of current contaminant conditions and to project trends in 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 includes specific hypotheses regarding contaminant occurrence relevant to the north canyons. These site-specific concepts are in addition to general concepts included in the core document (LANL 1997, 62316) and have evolved as a result of information collected during the Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) activities conducted through March 2000, including work in other canyons (e.g., Katzman et al. 1999, 63915; Reneau et al., 1998, 59159; Reneau et al., 1998, 59160; Reneau et al., 1998, 59667).

Figure 4.1-1 shows the general model of the Pajarito Plateau and provides the background for specific descriptions in the conceptual model.

4.1 Conceptual Model of Sediment Transport

Most elements of the conceptual model for sediment transport processes in the north canyons are the same as those described in the core document (LANL 1997, 62316, p. 4-9) and are not repeated in this work plan. Section 3.4.1 of this work plan describes the information known about surface sediments. Section 3.4.2 of this work plan describes the information known about subsurface sediments.

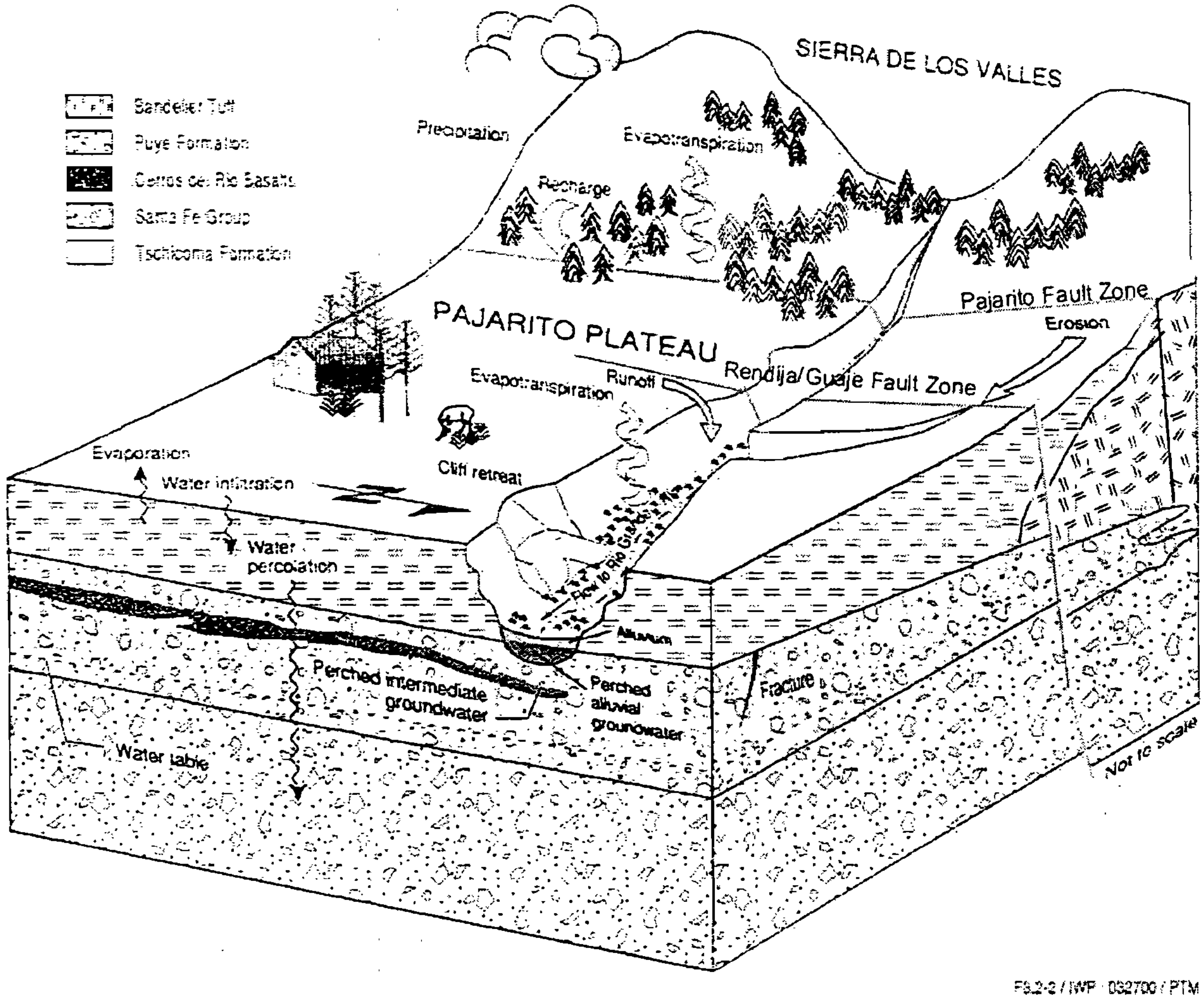


Figure 4.1-1. **General conceptual model of the Pajarito Plateau**

The sediments residing on the canyon floors will remain in place for varying lengths of time. The remobilization of sediments in geomorphic units by transport in storm water 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 and inhalation. Humans and animals could ingest unfiltered water from streamflow, runoff, and ponded water. Sediment material can be ingested 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 one pathway for radiological exposure to humans because dust can be raised high enough to be inhaled by humans.

Both present and future distributions of contaminants associated with sediment particles are strongly affected by sediment transport processes that occur during flood events. Sediments and associated contaminants can be deposited in different geomorphic units within the canyons, such as alluvium in channels and on floodplains, and alluvial fans along side drainages.

Current knowledge of potential contaminants in the north canyons sediments is summarized below and incorporated into the current conceptual model of contaminant occurrence in surface sediments. Additional investigations of surface sediments in discrete sections of the canyons are described in Chapter 7 of this work plan to further the understanding of contaminant occurrence and to refine the conceptual model.

4.1.1 Bayo Canyon

Potential contaminants in Bayo Canyon sediments are primarily associated with potential release sites (PRSs) at former Technical Area (TA) 10 in the middle part of the canyon, and possibly with PRS 00-011(d) near the canyon head. Significant information about historical activities is in Section 2.3.2. Information about contaminants in Bayo Canyon is provided in Section 3.4.1 and is summarized below.

- Former TA-10, located in the middle portion of Bayo Canyon, was used as a firing site and a radiochemistry laboratory from approximately 1944 through 1963. Former TA-10 was decontaminated and decommissioned (D&D) in the early 1960s, when all structures were removed and contamination was removed to a depth of about 20 ft (6 m).
- Contaminants and shrapnel were dispersed into middle Bayo Canyon as a result of the experimental detonations conducted during the 1940s and 1950s. Several shrapnel removal actions have been performed in Bayo Canyon (see Section 2.3.2). However, shrapnel fragments still present in middle Bayo Canyon could migrate down-canyon with sediments.
- Surface samples in upper Bayo Canyon near PRS 00-011(d) contained lead in concentrations up to 156 mg/kg, significantly above the sediment background value (BV), and one sample contained 300 mg/kg copper.
- Surface samples in middle Bayo Canyon at former TA-10 contained calcium, copper, nickel, uranium, and zinc in concentrations above sediment BVs. Metals found in concentrations significantly greater than sediment BVs were copper, nickel, and uranium.
- Surface samples in middle Bayo Canyon at former TA-10 contained elevated strontium-90 in concentrations up to 67 pCi/g. Subsurface samples at depths of 10 to 30 ft contain significantly higher concentrations of strontium-90, greater than 40,000 pCi/g at one location.
- High explosive (HE) compounds detected in Bayo Canyon surface samples are nitrobenzene, nitrotoluene, and dinitrotoluene.
- Strontium-90 present in the subsurface at former TA-10 may be brought to the surface by deep-rooted plants and deposited onto the surface as plant litter and organic debris.
- Contaminants at the surface at former TA-10 could be transported to the active stream channels by storm water runoff.
- The extent to which contaminants from former TA-10 have migrated downstream or have been deposited in active channel or floodplain sediments is not known.
- Active channel samples collected in lower Bayo Canyon at State Road (SR) 502 generally contained radionuclide concentrations below sediment BVs. Barium, cadmium, and thallium also were found in concentrations significantly above the sediment BV.

- Bayo Canyon receives runoff from urban areas that may affect the concentrations of metals (such as lead) and other chemicals in sediments, potentially creating an urban-related "baseline" that is greater than background levels.

Additional investigations of surface sediments in Bayo Canyon are needed to determine the nature and extent of contaminants that may have been transported downstream from PRS 00-011(d) and from former TA-10, and to evaluate potential human health or ecological effects. These investigations are discussed in Section 7.2.

4.1.2 Barrancas Canyon

Barrancas Canyon does not contain PRSs that are known to have contributed contaminants to surface sediments. Surface sediment samples collected from small side drainages in the Barrancas Canyon watershed in 1994 and 1995 contained copper and uranium above BVs. Two HE compounds (high melting explosive [HMX] and nitrobenzene) were detected in sediment samples collected from a side drainage to Barrancas Canyon immediately north of the former firing sites at TA-10. The presence of these HE compounds in the Barrancas Canyon watershed probably resulted from the experimental detonations conducted in Bayo Canyon during the 1940s and 1950s (see Section 2.3.2).

The presence of these contaminants in Barrancas Canyon warrants further investigation of the watershed to determine if the contaminants are present in the surface sediments and active channels. Investigations of surface sediments in Barrancas Canyon are needed to determine the nature and extent of contaminants that may have been dispersed into the watershed and transported downstream, and to evaluate potential human health or ecological effects. These planned investigations are discussed in Chapter 7.

4.1.3 Rendija Canyon

Potential contaminants in Rendija Canyon sediments are associated primarily with a former small-arms firing range (PRS 00-016), a former asphalt batch plant (PRS C-00-041) in the upper part of the canyon, and two former mortar impact areas, PRSs 00-011(a) and 00-011(e), in the middle part of the canyon. Significant information about surface sediments in Rendija Canyon is provided in Section 3.4.1 and is summarized below.

- Lead and other metals were found at PRS 00-016, the small arms firing range. The maximum lead concentration remaining after a voluntary corrective action (VCA) was 85.6 mg/kg. The maximum concentration remaining in the side drainage channel area north of the main cleanup site was 70.6 mg/kg. In the main cleanup areas, 15 of 41 samples were above the BV of 22.3 mg/kg, and 3 of 3 first-order-drainage samples were above BV. It is not known if there has been significant transport of metals downstream from this PRS.

- Asphalt was present along a tributary channel below the former asphalt batch plant, PRS C-0-041, which was the subject of a VCA cleanup. Sediment samples were not collected at the site or downstream after the VCA, and it is not known if the asphalt has affected downstream sediments.

- Ordnance and shrapnel present at two former mortar impact areas, PRSs 00-011(a) and 00-011(e), were cleaned up in 1993. Analyses of sediment samples collected along small drainage channels at PRS 00-011(a) found that 1 sample of the 17 collected was above the BV for lead; the maximum lead concentration was 29 mg/kg. Selenium was above BV (0.3 mg/kg) in 13 of 17 samples collected at PRS 00-011(a); the highest selenium concentration was 0.8 mg/kg.

It is not known if there has been significant transport of contaminants along the main Rendija Canyon channel downstream from these PRSs.

- Lead and other metals are expected to be present at the Los Alamos Sportsmen's Club (PRS 00-015), which is an active small arms firing range, although this site has not been investigated. Potential impacts on the main Rendija Canyon stream channel are unknown.
- Rendija Canyon receives runoff from urban areas that may affect the concentrations of metals (such as lead) and other chemicals in sediments, potentially creating an urban-related "baseline" that is greater than background levels.
- The Rendija Canyon watershed was heavily impacted by the Cerro Grande fire, increasing the magnitude and frequency of floods and changing the chemistry of sediment associated with the redistribution of ash.

Additional investigations of surface sediments in Rendija Canyon are needed to determine the nature and extent of contaminants that may have been transported downstream from PRSs in the watershed, and to evaluate their potential human health or ecological effects. These investigations will characterize lands in Rendija Canyon that are proposed for conveyance and transfer (see Chapter 7).

4.1.4 Guaje Canyon

One PRS associated with a polychlorinated biphenyl (PCB) spill is located in Guaje Canyon. Sediment and runoff samples have been collected as part of the Los Alamos National Laboratory (the Laboratory) environmental surveillance program. Significant information about surface sediments in Guaje Canyon is provided in Section 3.4.1 and is summarized below.

- An investigation of PRS 00-029(c) at Guaje well G-1 found a single sample with low levels of the PCB Aroclor-1260, at a concentration of 0.09 mg/kg. It is not known if there has been significant transport of PCBs downstream from this PRS although, because of the low levels of observed contaminant concentrations, this is considered unlikely.
- Sediment samples collected from Guaje Reservoir in 1999 contained americium-241, gross alpha, gross beta, and uranium in concentrations above the BV for sediments.
- Active channel sediment samples collected annually in lower Guaje Canyon at SR 502 since 1977 generally have been below BVs for radionuclides in sediments, although maximum values for plutonium-238, plutonium-239,240, strontium-90, and uranium at times have been above BVs. Most metals have been measured in concentrations below BVs; however, maximum values of silver, barium, and cadmium have been above BVs. No known sources for these analytes are associated with Laboratory activities in the Guaje Canyon watershed, and the meaning of these results is uncertain.
- Six sediment samples collected from 1973 through 1980 in Guaje Canyon near well G-4 contained gross gamma and strontium-90 in concentrations significantly above the sediment BV. No known sources for strontium-90 are associated with Laboratory activities in the Guaje Canyon watershed, and the meaning of these results is uncertain.
- The Guaje Canyon watershed was heavily impacted by the Cerro Grande fire, increasing the magnitude and frequency of floods and changing the chemistry of sediment associated with the redistribution of ash.

Additional investigations of surface sediments in Guaje Canyon are needed to determine the nature and extent of contaminants that may have been transported downstream from PRSs in this watershed, and to evaluate potential human health or ecological effects (see Chapter 7).

4.2 Hydrologic Transport Concepts

General hydrologic transport concepts are provided in the core document (LANL 1997, 62316, p. 4-9). The following descriptions highlight the most important elements of the conceptual model of hydrologic transport in the north canyons. Features and geographic locations discussed in this section are shown in Appendix A, Figure A-1, of this work plan. Figure 4.1-1 illustrates the major elements of the hydrologic conceptual model and the current hypotheses regarding connecting pathways and processes.

4.2.1 Streamflow and Runoff

The streamflow in Bayo, Barrancas, and Rendija Canyons is ephemeral from storm water runoff and snowmelt. Guaje Canyon contains a perennial reach of stream that extends from Guaje Canyon Springs 1 and 2 in the upper reaches of the canyon to about the Guaje Canyon Reservoir. During periods of heavy thunderstorms, runoff from the canyons extends to Los Alamos Canyon; however, there are currently no stream gaging stations in the north canyons so data pertaining to runoff volumes are not available.

The Cerro Grande fire in May 2000 significantly impacted upper and middle Rendija and Guaje Canyons. Temporary impacts of the fire include a reduction in soil infiltration capacity and a corresponding increase in the percentage of runoff from the watershed, the frequency of floods, peak discharges, and total runoff volume. It is estimated that runoff will return to normal in approximately 5 yr (BAER 2000, 68662).

4.2.2 Springs

Base flow in upper Guaje Canyon is maintained by two springs. The springs support perennial streamflow in upper Guaje Canyon that extends downstream for a distance. Early investigations of the Guaje springs estimated flow rates at 25 and 40 gal./min. Another spring is located in Aqua Piedra canyon, a tributary to Guaje Canyon. The flow rate, volume, and frequency of Aqua Piedra spring are not known.

4.2.3 Effluent Discharge

Currently, there are no outfalls or National Pollutant Discharge Elimination System (NPDES)-permitted discharges in Bayo and Barrancas Canyons. Outfalls associated with water supply wells in lower Rendija and Guaje Canyons occasionally discharge groundwater produced from the regional aquifer to the stream channel. Discharge rates and volumes are not known.

Effluent currently is not discharged into the north canyons. Before 1965 at former TA-10 in middle Bayo Canyon, radioactive liquid effluent was discharged into unlined pits and septic tank effluent may have been discharged to the channel. Water was trucked to the site. The site was abandoned and the area was cleaned up in 1965. Subsurface contaminants composed primarily of strontium-90 are present in the subsurface from about 10- to 30-ft (3 to 9 m) depth.

4.2.4 Mesa-Top Runoff

Bayo, Barrancas, and Rendija Canyons receive runoff and snowmelt from a portion of Los Alamos town site. Bayo and Barrancas Canyons receive runoff from North Mesa, Barranca Mesa, Otowi Mesa, and undeveloped Laboratory property at TA-74. Barrancas, Rendija, and Guaje Canyons receive most runoff from US Forest Service land. Rendija Canyon receives additional runoff and snowmelt from General Services Administration (GSA) land, which contains former firing sites and mortar impact areas.

4.2.5 Surface Water, Runoff, and Sediment Transport

The primary process that could redistribute contaminants in the north canyons system is sediment transport by storm water runoff. This general process is described in Chapter 4 of the core document (LANL 1997, 62316, p. 4-9). Land-use changes in the watersheds, such as development of residential areas, could impact runoff volumes, velocities, and water quality and cause accelerated erosion and/or redeposition of contaminants. Any contaminated sediment that is transported by storm water runoff (floods) either will be redeposited downstream in the active channel or in adjacent abandoned channels or floodplains, or transported to the Rio Grande. These same floods also erode uncontaminated sediment, causing general downstream dilution and decreases in contaminant concentrations.

Bayo Canyon

The streamflow in Bayo Canyon is entirely ephemeral from storm water runoff and snowmelt. During periods of heavy thunderstorms, runoff in Bayo Canyon occasionally may extend to Los Alamos Canyon. However, there are no stream gaging stations in Bayo Canyon so data for runoff volumes are not available. Runoff samples from Bayo Canyon have not been collected for analyses.

Barrancas Canyon

Barrancas Canyon and its three tributaries contain entirely ephemeral streams. During periods of heavy thunderstorms, runoff from Barrancas Canyon may discharge into Guaje Canyon. However, there are no stream gaging stations in Barrancas Canyon so data for runoff events are not available. Runoff samples from Bayo Canyon have not been collected for analyses.

Rendija Canyon

Rendija Canyon and its tributaries contain ephemeral streams. During periods of heavy thunderstorms runoff from Rendija Canyon may discharge into Guaje Canyon. However, there are no stream gaging stations in Rendija Canyon so data for runoff events are not available. Several storm water runoff samples collected from Rendija Canyon provided anomalous concentrations of certain radionuclides. Because no known Laboratory activities in the watershed involve radionuclides, the cause of these results is unknown.

Guaje Canyon

Guaje Canyon contains a perennial reach of stream in the upper part of the canyon that extends from Guaje Canyon Spring 1 and Guaje Canyon Spring 2 to about the Guaje Canyon Reservoir. Flow in downstream reaches is ephemeral. No gaging stations are located in Guaje Canyon so data for runoff events are not available. During periods of heavy storm water runoff, flow extends down the canyon to the confluence with Los Alamos Canyon. Several storm water runoff samples collected from Guaje Canyon provided anomalous concentrations of certain radionuclides. Because no known Laboratory activities in the watershed involve radionuclides, the cause of these results may be regional fallout.

Summary

Because continuous reaches of surface water are not present downstream of PRSs in any of the north canyons, no surface water investigations are planned unless persistent surface water (at least three continuous months of flow) is observed (see Section 7.3). Sampling of storm water runoff is part of investigations conducted under the Watershed Management Program Plan (LANL 1999, 62920). If persistent reaches of surface water (longer than 3 months) are observed in reaches of the canyons downstream of PRSs, sampling and characterization of the surface water will be performed.

4.2.6 Alluvial Groundwater

The presence and extent of the shallow alluvial groundwater in the northern canyons is not known. Currently no active monitor wells are screened in the alluvium in Bayo, Barrancas, Rendija, or Guaje Canyons. There are no known alluvial groundwater discharge points in the canyons. Losses from evapotranspiration and infiltration into deeper bedrock units are the likely sources of loss of alluvial groundwater, if present. An unknown volume of infiltrated water is hypothesized to seep downward into subsurface units through the base of the alluvium.

Bayo Canyon

The presence of alluvial groundwater in Bayo Canyon has not been documented. In 1994, 93 boreholes were drilled and sampled during the RFI field investigation at former TA-10. Groundwater was not encountered in any of the boreholes, although dampness at the base of the alluvium and at the contact between the Guaje Pumice Bed and the Puye Formation was noted (LANL 1996, 54332, p. 9-13).

Barrancas Canyon

No specific information is available about alluvial groundwater in Barrancas Canyon. Because Barrancas Canyon heads on the Pajarito Plateau and is a relatively small canyon, similar to Bayo Canyon, it may be assumed to have similar hydrologic characteristics as Bayo Canyon, and therefore to contain no alluvial groundwater.

Rendija Canyon

No specific information is available about alluvial groundwater in Rendija Canyon. Because of the limited extent of PRSs in the watershed and the absence of historic effluent releases, the potential for the occurrence of Laboratory-related contaminants in alluvial groundwater, if present, is expected to be low in this canyon.

Guaje Canyon

Surface water enters Guaje Canyon from springs, storm water runoff, snowmelt, and occasional discharges from outfalls associated with water supply wells. A body of alluvial groundwater is present in the upper and middle part of the canyon from about Guaje Reservoir downstream to the Guaje Mountain fault zone (GMFZ). Surface water below the reservoir appears to infiltrate into two structural basins formed by the Rendija Canyon fault zone (RCFZ) and the GMFZ. The fault zones may serve as conduits for the infiltration of alluvial groundwater to the regional aquifer. Some alluvial groundwater may discharge to the stream channel at the GMFZ and flow for a short distance downstream before infiltrating the alluvium. Because there are no PRSs upstream from this point, there is no potential for Laboratory-related contaminants in alluvial groundwater in this canyon.

Downstream of the GMFZ the presence and extent of alluvial groundwater in Guaje Canyon is not known. Surface water likely infiltrates the alluvium and may recharge a small body of perched alluvial groundwater in the lower reaches of the canyon, although no alluvial groundwater has been reported in any wells drilled in the lower canyon. There are no known alluvial groundwater discharge areas in lower Guaje Canyon.

Based on information from these investigations, shallow alluvial groundwater likely is present in the upper and middle reaches of Guaje Canyon, supported by infiltration from spring-fed surface water. Streamflow losses due to evapotranspiration and infiltration and possible losses to geologic structures (faults) reduce the volume of surface water downstream. The saturated thickness of alluvial groundwater likely decreases downstream in the middle part of the canyon. However, little information regarding the alluvial groundwater is available.

Summary

Because a significant body of alluvial groundwater downstream of PRSs in the north canyons is not likely, no alluvial groundwater investigations are planned.

4.3 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. Rendija Canyon and Guaje Canyon cross both the RCFZ and the GMFZ, and recharge from any alluvial groundwater to deeper zones of saturation most likely will be here.

4.4 Biological Transport Concepts

The biological transport conceptual model is presented in the core document (LANL 1997, 62316, p. 4-12). Significant information about biological contaminants in Bayo Canyon is provided in Section 3.5.1 and is summarized below.

- In 1994 a chamisa plant at PRS 10-007 in middle Bayo Canyon contained up to 90,500 pCi/g (ash) strontium-90.
- In 1996 strontium-90 in vegetation samples ranged from 14 to 199 pCi/g dry weight.
- Other vegetation samples that contained elevated radioactivity were ponderosa pine, annuals, and grasses.

In middle Bayo Canyon at former TA-10, contaminants such as strontium-90 present in subsurface sediments may be brought to the surface by deep-rooted plants such as chamisa. It is also possible that contaminants were present in the fill material used during D&D of the TA-10 site, which may be supported by the presence of contaminants in the 0- to 5-ft (0- to 1.5-m)-depth interval. Strontium is a biological analog for calcium. Consequently, radioactive strontium is commonly found in plant tissues where calcium is concentrated. Calcium, an essential macronutrient in plants, is found as a structural component in cell walls, and is also involved in the functioning of membranes. Unlike most nutrients, calcium typically is not retracted and conserved by plants prior to leaf senescence and abscission. Therefore, strontium-90 in plants either will be sequestered in woody material in the cell walls, or transported to the soil surface by leaf drop or needle cast. Exposures to other organisms typically involve consumption of leaves or plant litter. Human exposure through plant uptake is likely to come from edible plants or from burning contaminated wood.

The transport of strontium-90 from the subsurface into plants will result in eventual surface depositions through leaf fall, needle cast, and downed woody material. All these materials are then subject to decomposition processes that result in strontium-90 cycling analogous to calcium cycling. Thus, uptake of chemicals of potential concern (COPCs) into plants serves as a mechanism for bioturbation or redistribution of contaminants through the subsurface to the near surface soils. COPCs in the near-surface soils are available to a broader array of receptors.

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 Environmental Restoration (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 Waste 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.

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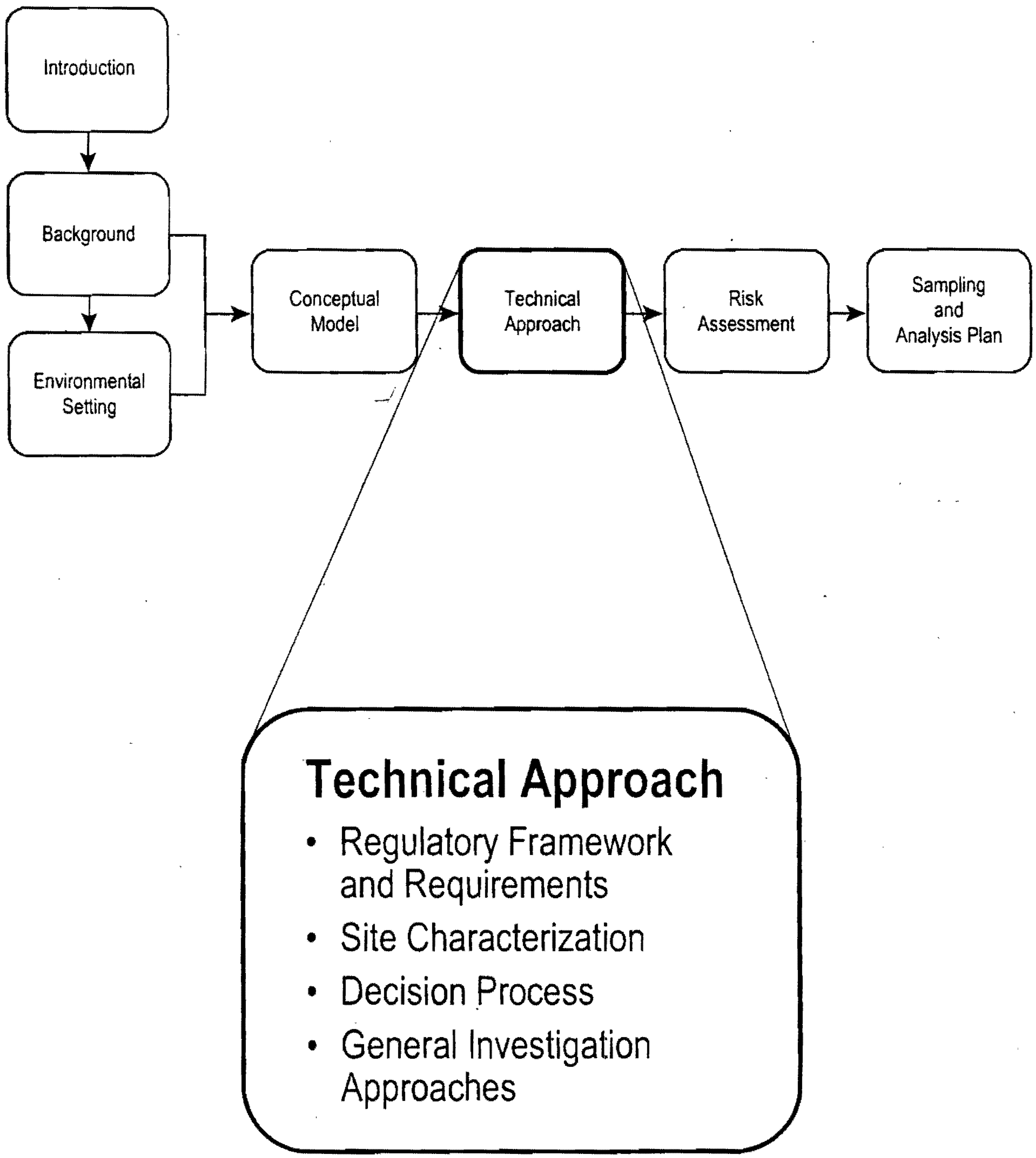
Reneau S., R. Ryti, M. Tardiff, and J. Linn, September 1998. "Evaluation of Sediment Contamination in Upper Los Alamos Canyon Reaches LA-1, LA-2, and LA-3," Los Alamos National Laboratory LA-UR-98-3974, Los Alamos, New Mexico. (Reneau et al. 1998, 59160)

Chapter 5



Introduction
Background
Environmental Setting
Conceptual Model
Technical Approach
Risk Assessment
Sampling and Analysis Plan
Technical Approach
• Regulatory Framework and Requirements
• Site Characterization
• Decision Process
• General Investigation Approaches

5.0 TECHNICAL APPROACH

The technical approach employed in the North Canyons investigations is identical to that described in Chapter 5 of the "Core Document for Canyons Investigations" (LANL 1997, 62316).

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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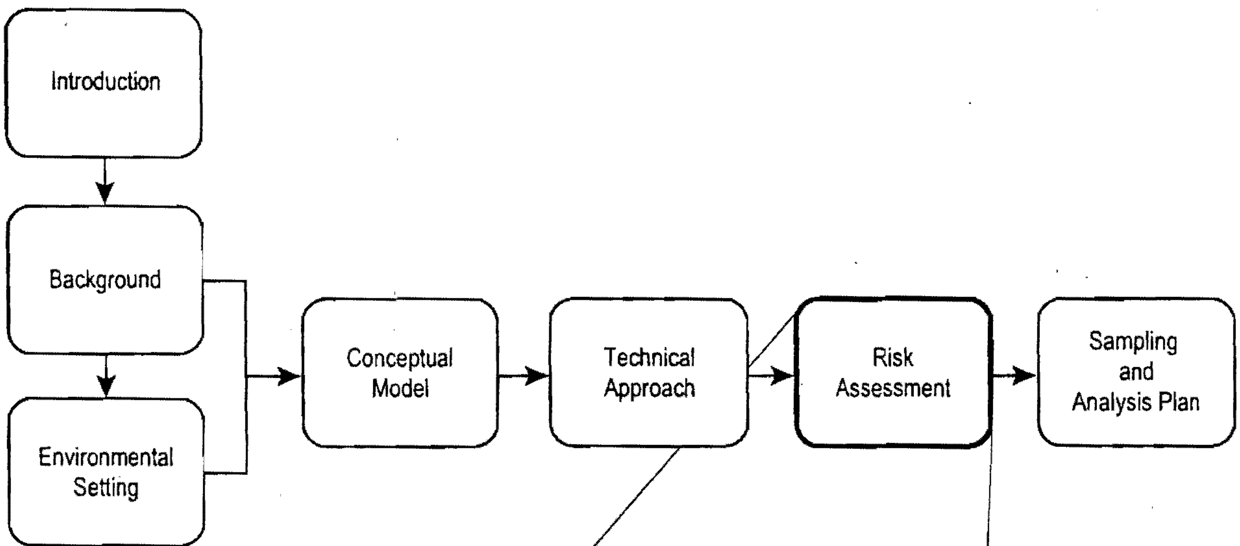
Chapter 6



Risk Assessment

- Interactive Decision Process
- Human Exposure Model
- Ecological Risk Model
- Potential Remedial Activities

6.0 RISK ASSESSMENT

The approach to risk assessment that will be employed in the north canyons investigations is related to that presented in Chapter 6 of the "Core Document for Canyons Investigations" (LANL 1997, 62316). However, the investigation outlined in this document will be modified to reflect Los Alamos National Laboratory's Environmental Restoration (ER) Project's evolving approach for risk assessment. The current approach to human health risk screening is described by Perona et al. (1998, 62049), and the approach to evaluating ecological effects is described in LANL (1999, 64783). Examples of the application of these approaches to evaluating the risk associated with sediment contamination are provided in existing canyon reports (e.g., Katzman et al. 1999, 63915; Reneau et al. 1998, 59159; Reneau et al. 1998, 59160; Reneau et al. 1998, 59667; Reneau et al. 2000, 66867).

Risk Assessment Related to Land Conveyance and Transfer

Input from San Ildefonso Pueblo concerning Native American land use will be incorporated, as available, into ER Project risk assessments. Native American land-use scenarios had not been developed for incorporation into risk assessments when this work plan was in preparation. However, these scenarios will be incorporated into future assessments when they become available.

References for Chapter 6

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Katzman, D., R. Ryti, M. Tardiff, and B. Hardesty, August 1999. "Evaluation of Sediment and Alluvial Groundwater in DP Canyon: Reaches DP-1, DP-2, DP-3, and DP-4," Los Alamos National Laboratory Report LA-UR-99-4238, Los Alamos, New Mexico. (Katzman et al. 1999, 63915)

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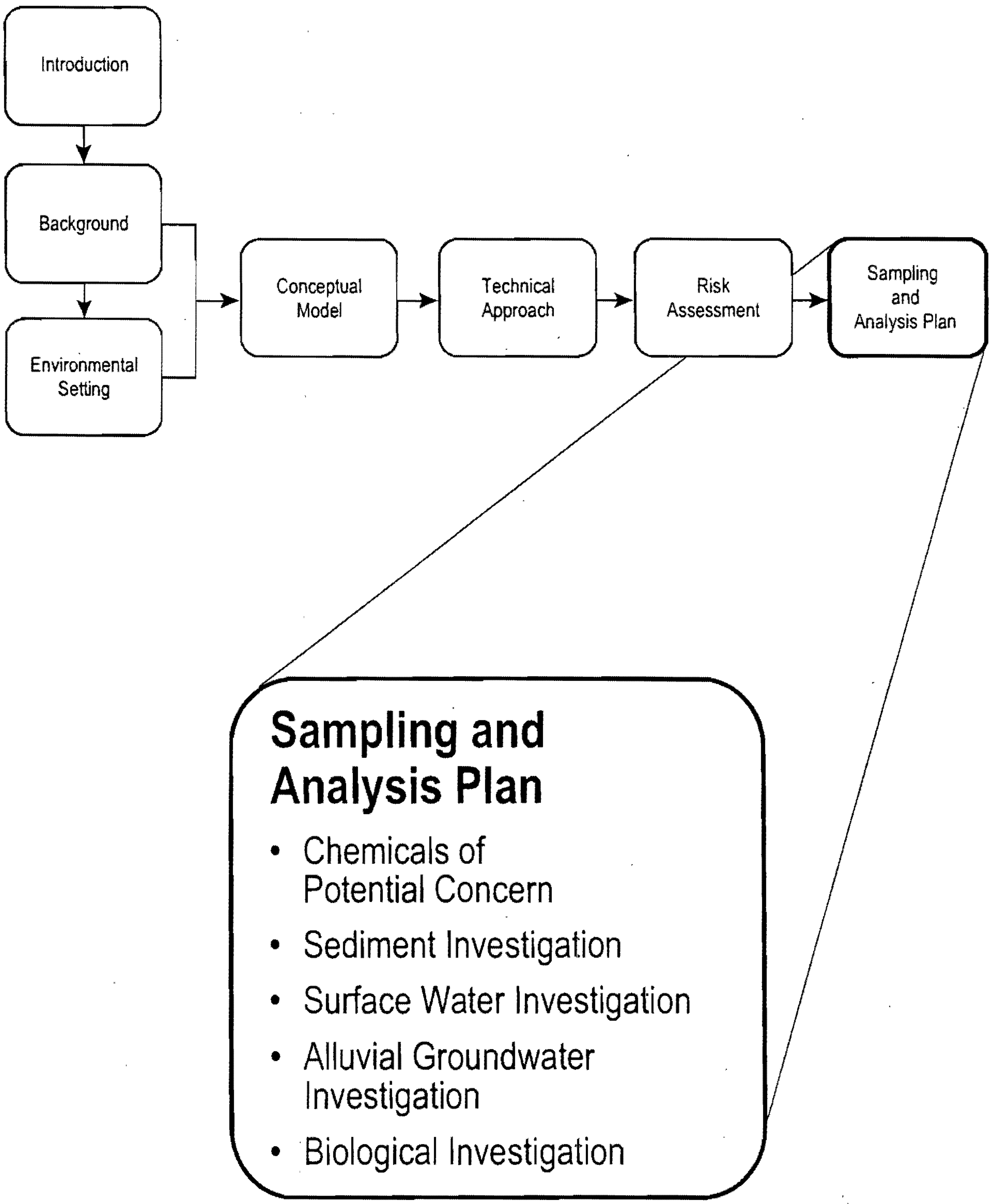
Chapter 7


Introduction
Background
Environmental Setting
Conceptual Model
Technical Approach
Risk Assessment
Sampling and Analysis Plan
Sampling and Analysis Plan
Chemicals of Potential Concern
Sediment Investigation
Surface Water Investigation
Alluvial Groundwater Investigation
Biological Investigation

7.0 SAMPLING AND ANALYSIS PLAN FOR THE NORTH CANYONS SYSTEMS

This chapter describes the rationale and plans for collecting and analyzing samples and field survey data that will be used to characterize the north canyons systems. These data will be used to support an evaluation of present-day risks to human health and the environment that are associated with Los Alamos National Laboratory ("the Laboratory")-derived contaminants within the north canyons system. These data also will be used to support an evaluation of the potential for future off-site exposure and impact on downstream lands, lands proposed for conveyance and transfer, and the Rio Grande. Evaluation of these risks and impacts requires testing and refining the conceptual model of occurrence, transport, and exposure route of contaminants in the north canyons systems ("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 ("the core document"), results of initial field surveys and sample analyses will be used to compare and reinterpret existing data to revise the conceptual model and develop subsequent sampling and analysis activities (LANL 1997, 62316).

Sampling and analysis plans (SAPs) presented in this chapter describe general approaches that will be followed and general areas to be sampled. Specific sampling locations will be defined based on data collected from the initial geomorphic characterization. For canyon reaches relevant to land transfer parcels, the Laboratory Environmental Restoration (ER) Project will consult with potential land transfer recipients to help focus sampling activities.

This chapter presents the plans for sampling and analyzing each medium that is considered a significant transport and exposure pathway (see Chapter 3 and Chapter 4 of this work plan). Each section will (1) state the objectives of the investigation of each medium; (2) discuss elements of the transport pathways and their importance; (3) identify issues that will 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, specific SAP objectives, and the data quality requirements for the investigations. Section 7.2 describes plans for sediment characterization. Section 7.3 describes plans for characterizing surface water. Section 7.4 describes plans for characterizing alluvial groundwater. Unlike previous canyon work plans, characterization of intermediate-depth groundwater and the regional aquifer are not included in this work plan. These activities now are considered part of the hydrogeologic work plan (LANL 1998, 59599) and are not addressed further in this document. Section 7.5 describes plans for biological sampling, which are part of an evaluation of the ecological and human health effects of Laboratory-derived contamination.

Table 7.0-1 lists known chemicals of potential concern (COPCs) in each of the north canyons and their potential original source areas. The table is based on the list of COPCs and on data collected from previous studies (summarized in Chapter 3 of this work plan) that show the occurrence of contaminants in the north canyons systems.

Table 7.0-2 shows the initial estimates of the numbers and types of samples that will be collected during the investigations. The numbers will be revised throughout the characterization process 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, 62316). Changes to the numbers of samples will be recorded and described in reports on these investigations.

Table 7.0-1
Chemicals of Potential Concern in the North Canyons and Source Areas

Known COPC	Source Area
Bayo Canyon	
Plutonium-238	Unknown, possibly in runoff
Plutonium-239,240	Unknown, possibly in runoff
Strontium-90	Former TA*-10
Uranium	Former TA-10
High explosive compounds	Former TA-10, PRS 0-011(d)
Volatile organic compounds	Former TA-10
Semivolatile organic compounds	Former TA-10
Barium	Former TA-10
Copper	Former TA-10, PRS 0-011(d)
Lead	PRS 0-011(d)
Shrapnel and other metals	Former TA-10
Barrancas Canyon	
High explosive compounds	Former TA-10
Copper, uranium, shrapnel	Former TA-10
Rendija Canyon	
Lead	PRS 0-016, 0-015, 0-011(a, e)
High explosive compounds	PRS 0-011(a, e)
Tritium	Unknown, possibly in runoff
Plutonium-238	Unknown, possibly in runoff
Plutonium-239,240	Unknown, possibly in runoff
Guaje Canyon	
Polychlorinated biphenyls	PRS 0-029(c)
Strontium-90	Unknown, possibly in runoff
Americium-241	Unknown, possibly in runoff
Plutonium-238	Unknown, possibly in runoff
Plutonium-239,240	Unknown, possibly in runoff
Uranium	Unknown, possibly in runoff
Barium	Unknown, possibly in runoff
Cadmium	Unknown, possibly in runoff
Silver	Unknown, possibly in runoff

Note: This table contains preliminary information from Resource Conservation and Recovery Act facility investigation (RFI) work plans, draft RFI reports, and other available reports.

* TA= technical area.

Table 7.0-2
Initial Estimates of Sample Collection and Analysis in the North Canyons

Sample Type	Estimated Number of Samples
Sediment[a,b]	
Full-suite[b] sediment	50–110 (5–11 per reach)
Limited-suite[c] sediment	TBD[d]
Key contaminants[e] sediment	TBD
Alluvial Groundwater and Surface Water	
Surface water – stream	0
Biological	
Plants	TBD
Animals	TBD

[a] Sediment samples will be collected to determine COPCs, to define contaminant concentrations and distributions, and to evaluate risk.
[b] Full-suite analyses will be used for all organic and inorganic chemicals and radionuclides, and for the determination of COPCs.
[c] Limited-suite analyses will be used for identified COPCs. (The collection of approximately 0 to 10 samples per reach is anticipated).
[d] TBD = to be determined.
[e] Sediment samples will be collected and analyzed for "key contaminants" (e.g., high explosives 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. (Approximately 0 to 50 samples per reach will be collected.)

7.1 Issues To Be Addressed

The general objectives for the canyons investigations discussed in the executive summary of the core document will be addressed in the investigations described in this work plan (LANL 1997, 62316). The following issues, which are of concern to the north canyons 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 alluvial groundwater, including risks from exposure to plant and animal tissues? This issue will be addressed quantitatively on-site and in selected off-site areas and will include present land use and potential future land-use scenarios, as appropriate.

2. What is the potential for human health or ecological effects (in the present as well as the future) as a result of migration of present-day contaminants? Stakeholder concerns indicate that the effect of contaminant migration on altering risk estimates needs to be evaluated with the present-day risk. Identification of historic trends in contaminant migration is a feasible approach.

7.1.1 Site Description

A detailed description of the north canyons is provided in Chapter 3 of this work plan.

7.1.2 Historical Data

Detailed discussions of historical uses, sources of environmental data, sources of potential contaminants, and current environmental conditions in the north canyons system are provided in Chapter 2 and Chapter 3 of this work plan.

The Laboratory primarily used Bayo Canyon for radiochemical processing, explosives testing, and liquid waste disposal at former Technical Area (TA) 10 from 1943 to about 1963 and as a mortar impact area at the head of the canyon at PRS 0-011(d). Except for a portion of the lower part of the canyon that was used as a buffer zone, the Laboratory has not utilized Barrancas Canyon. However, the canyon may have been impacted by explosives testing activities at former TA-10 in adjacent Bayo Canyon. Rendija Canyon was used as a mortar impact area at two sites [PRSs 0-011(a and e)]; as a small arms firing range at PRS 0-016; and as the site of an asphalt batch plant at PRS C-0-041. Rendija Canyon and Guaje Canyon contain water supply wells and support lift stations and pipelines associated with the Guaje well field. One PRS is present in Guaje Canyon, PRS 0-029(c), a polychlorinated biphenyl (PCB) site.

7.1.3 Regulatory Requirements

A summary of regulatory requirements for this work plan is presented in Section 1.4 of the core document (LANL 1997, 62316). The primary regulatory requirements are found in Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 1585; EPA 1994, 44146). The US Environmental Protection Agency (EPA) and the New Mexico Water Quality Control Commission (NMWQCC) 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 (EPA 1996, 55500; NMWQCC 1995, 50265; NMWQCC 1995, 54406). US Department of Energy (DOE) Order 5400.5, "Radiation Protection of the Public and the Environment," sets guidelines for radionuclide concentrations in water.

7.1.4 Overview of Information To Be Collected

To address the general objectives and the specific issues discussed in Section 7.1, the investigation will

- identify contaminant concentrations and distributions in (1) sediments and associated soils; (2) surface water, if present for 3 months or longer; and (3) selected plants and animals in the north canyons systems.

  The data collected will be sufficient to evaluate potential human health risks and ecological effects. 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.

- refine the conceptual model, which is discussed for the canyons in general in Chapter 4 of the core document and for the north canyons systems specifically in Chapter 4 of this work plan (LANL 1997, 62316).

  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 risks or ecological effects (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 (and if present, surface water) most important for addressing present-day human health risk or ecological effects and contaminant transport components of the conceptual model, including a variety of contaminant sources.

- identify contaminant transport pathways and improve understanding of transport mechanisms and predicting the potential for movement of present-day contaminants to off-site areas, including lands proposed for conveyance and transfer.
- identify health risks or effects on biological communities that inhabit or use the Rio Grande (now and in the future) as a result of transport of contaminants from the north canyons.
- identify remediation strategies for potential cleanup of specific areas in north canyons, as determined in these investigations.
- establish long-term monitoring needs and/or needs for institutional controls.

The following topics will be addressed in this chapter, which describes 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, 62316, pp. 5-3 et seq.) Specific decisions concerning north canyons 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 effects assessment to acceptable levels. The decisions focus 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.

Data collection activities are partly met by summarizing existing data (Chapter 3 of this work plan), using the data to develop preliminary parameter distributions where possible, and designing appropriate SAPs to iteratively reduce uncertainties in the parameters that contribute most to the uncertainty in contaminant assessment and transport evaluation. These latter parameters might include contaminant concentrations, hydrological connectivity and alluvial groundwater extent, alluvial groundwater geochemistry, particle size determination, 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.

7.2 Sediment Sampling and Analysis Plan

This section presents the SAP for investigating potentially contaminated sediment in the north canyons system. A minimum of ten canyon reaches or subreaches downstream of known Laboratory contaminant sources initially were 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. 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 yr) sediment transport processes.

7.2.1 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 the effects on 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 contaminants in sediments on off-site receptors and on lands proposed for conveyance and transfer, 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 or effects 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.

7.2.2 General Approach for Sediment Investigation

This investigation addresses the following issue: What is the nature and extent of potentially contaminated post-1942 sediment deposits within the canyons?

This investigation will

- 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 relative location to source terms and contaminant concentrations.

  Sediments deposited since 1942 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 investigation objectives listed in Section 7.2.1.

Full-suite, key-contaminant, and limited-suite analyses are discussed in Section 5.6.3 of the core document (LANL 1997, 62316) and summarized in Sections 7.2.3 and 7.2.5.1 of this work plan. These determinations 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 contaminants could have begun to be deposited in the canyons. 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 sampling of pre-1943 sediment may be needed to determine the presence and extent of contaminant concentrations.

Sampling largely will be restricted to the stream channel and its floodplain in the specified reaches in the north 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 7.2.5.1 for full-suite, key contaminant, and limited-suite analyses. If 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 Chapters 5 and 6 of the core document (LANL 1997, 62316). Additional data will be obtained if reduction in uncertainty potentially could change a risk-based decision as discussed in Chapter 6 of the core document.

- determine which contaminants are present in canyons 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,
    - sampling 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 sampling locations. 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 that exceed sediment background value (BV) (Ryti et al. 1998, 59730) and 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 Section 7.2.5.3.2 for BVs in sediments). Any contaminant identified at concentrations that exceed BVs 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 Chapters 5 and 6 of the core document (LANL 1997, 62316). 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.

7.2.3 Sampling and Analysis Plan for Sediment Investigation

The sediment investigation SAP follows the decision logic discussed in Chapter 5 of the core document (LANL 1997, 62316) and includes testing the conceptual model for the north canyons system (see 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 north canyons system downstream of known or potential contaminant sources. Field surveys and mapping, as well as sampling and analysis tasks, initially will concentrate on 10 reaches but may be expanded to include additional canyon reaches. Some reaches include multiple subreaches. The locations of the reaches are shown in Figure A-1, Appendix A, of this document. Table 7.2-1 summarizes the reaches and subreaches for which investigations are planned; Section 7.2.4 describes each reach.

Table 7.2-1
North Canyons Reaches to be Investigated

Canyon	Reach	Subreach	Priority Area No. of Reaches or Subreaches for Initial Characterization	Contingency Area No. of Possible Subreaches for Additional Characterization
Bayo	BY-1	None	1	
	BY-2	None	1	1
	BY-3	None	1	
Barrancas	BR-1	None	1	1
Rendija	R-1	R-1 North	1	
		R-1 South	1	
		R-1 East	1	
	R-2	None	1	
	R-3	None	1	1
Guaje	G-1	None	1	1
Total	**8**	**3**	**10**	**4**

Each reach may be either undivided, with a length of approximately 100 to 1000 m (328 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" is a specific area of a canyon that is treated as a single unit for sampling, analysis, and present-day human-health risk and ecosystem effects 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. Geomorphic characteristics generally are similar along the length of a reach or subreach. The regions of the main canyon and selected tributary canyons that will be investigated are shown in Figure A-1. The precise length and area of each canyon reach or subreach (1) will be defined by both the geomorphic survey and the results of sediment sampling and (2) will be designed to encompass local variability in geomorphic units and to constitute a reasonable area for use in the risk assessments. Initially some subreaches may be short (100 to 200 m [330 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 efficient collection of sediment data. The approach will be iterative to allow the expansion of specific reaches or subreaches to supplement the data set if significant contaminant concentrations are detected in these areas or other relevant areas.

The following criteria are used to select the reaches and subreaches.

- Areas are selected 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 potential source areas.
- Areas immediately upstream and downstream of drainage confluences are selected to allow better identification of significant contaminant sources and evaluation of contaminant concentrations.
- Areas with a variety of geomorphic characteristics are selected to allow better estimates of the total contaminant inventory in the canyon and of variations in contaminant distribution between reaches.
- Areas near institutional boundaries are selected to define contaminants that may migrate or have migrated off Laboratory property.

A sediment investigation strategy begins with a series of short subreaches, each approximately 100 to 200 m (110 to 220 yd) long located downstream of identified PRSs within the north canyons watershed. This planned strategy is intended to

- identify the PRSs that contribute significant amounts of contaminants to the stream channels,
- potentially eliminate parts of the watershed from further investigation, and
- narrow the analytical suite planned for each reach.

A second phase of investigation could expand the size of the key reaches or subreaches and add additional subreaches if necessary. Table 7.2-1 also lists "contingency" subreaches 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 concentrations of contaminants from upstream PRSs may not be sampled if significant contaminant levels are not found 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.

Supplemental investigations, such as field mapping and measuring the extent of specific deposits, may be conducted in areas between reaches to improve confidence in data extrapolated between reaches. Decisions to obtain such supplemental measurements between specific reaches will be made after reach data are evaluated and significant uncertainties are identified. Data collection from areas between reaches is not expected to be necessary where contaminant concentrations in adjacent sampled reaches are below levels that warrant remediation or other institutional actions. In contrast, if data from the sampled reaches indicate the need for remedial action, supplemental data on contaminant levels in the adjacent unsampled areas may be required.

Each reach or subreach will be used to address particular issues regarding potential contaminants in the canyon systems. The set of reaches and subreaches is intended to represent key aspects of the entire canyon system. Issues to be addressed by sampling in the individual reaches and subreaches are discussed in Section 7.2.4.

In addition to the field survey and mapping tasks (described in Section 7.2.4), the sediment SAP includes three types of sampling tasks:

- collecting samples for "full-suite" analysis to analyze for the full suite of COPCs (organic and inorganic chemicals and radionuclides) (see Section 7.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of full-suite analysis)

  Purpose: to determine the COPCs and, if necessary, to define the limited suite of COPCs for subsequent sediment investigations

- collecting samples, if necessary, for "key contaminant" analysis (see Section 7.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of key contaminants) after conducting the initial sampling and analysis to determine the COPCs

  Purpose: to sample and analyze for one or more key contaminants to define vertical and horizontal variations in contaminant concentration and evaluate recent sediment transport processes

- collecting samples, if necessary, for "limited-suite" analysis (see Section 7.2.5.1 in this work plan and Chapter 5 of the core document for a discussion of limited-suite analysis) during subsequent sampling iterations

  Purpose: to analyze for the limited suite of COPCs to (1) define the degree of collocation between different contaminants and (2) perform the present-day risk assessment

The samples also will be analyzed for particle-size distribution to identify relationships between whole-sample contaminant concentrations and sediment particle-size distribution.

Section 7.2.5 describes the strategy and rationale for sample collection. The strategy for each sampling task will be based on the data collected during the initial field surveys and/or prior sampling. Requirements for additional data collection, including the selection of key contaminant or limited-suite analyses, will be based on the judgment of the technical team and through dialogue with the administrative authority. Some sampling also may address stakeholder concerns.

The products of a sediment investigation are

- data to support an assessment of the present-day risk to on-site (i.e., 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 risk estimate trends that are associated with existing contaminants in sediments that potentially could move downstream onto neighboring lands, lands proposed for conveyance and transfer, and the Rio Grande.

7.2.4 Canyon Reaches Planned for Investigation

This section describes each canyon reach planned for investigation and the significance of each reach in evaluating present-day risk and potential future trends in risk from exposure to Laboratory-derived contaminants. The reach locations are shown in Appendix A, Figure A-1. Ten reaches in the north canyons have been selected for the sediment investigation (see Table 7.2-1).

Reach BY-1: Upper Bayo Canyon

Reach BY-1 is located near the head of Bayo Canyon downstream of PRS 00-011(d) on Los Alamos County land. This reach will be investigated to evaluate potential contaminant movement from PRS 0-011(d). Potential contaminants associated with this PRS include high explosive (HE) compounds, metals (lead and copper), and possibly ordnance fragments. Reach BY-1 data will allow the determination of relative contaminant contributions from the PRS and from urban runoff into the canyon head.

Reach BY-2: Middle Bayo Canyon Downstream of Former TA-10

Reach BY-2 is located on Laboratory land downstream of former TA-10. This reach is located within TA-74 and is scheduled for transfer to the US Department of Interior in trust for San Ildefonso Pueblo. This reach will be investigated to evaluate contaminant concentrations in sediments downstream of former TA-10 and within the proposed TA-74 land conveyance and transfer parcel. Potential contaminants in this reach include strontium-90, volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals (copper, nickel, lead, and zinc), uranium, HE compounds, and shrapnel fragments.

Reach BY-2 has been shown to contain a low-to-moderate density of shrapnel fragments, ranging from 0 to 150 shrapnel pieces per 100-ft^2 (30-m^2) grid area (see Section 2.3.2.5.2). The entire length of the channel within TA-74, and downstream on San Ildefonso Pueblo land, will be surveyed visually for shrapnel fragments to determine the extent of shrapnel in the stream channel within the land transfer parcel. Sediment samples will be collected in Reach BY-2, and if significant concentrations of contaminants are found, a contingency reach may be sampled downstream of Reach BY-2 to determine the extent and distribution of contaminants.

Reach BY-3: Lower Bayo Canyon

Reach BY-3 is located on San Ildefonso Pueblo land downstream of TA-74. This reach will be investigated to evaluate the potential presence of contaminants from upstream PRSs and determine the contaminant inventory in this part of the canyon. COPCs identified in runoff in this part of the canyon include strontium-90, metals (barium, cadmium, and thallium), and HE compounds. Investigating Reach BY-3 will allow the evaluation of contaminants from upstream sources and the determination of the nature and concentrations of contaminants present in lower Bayo Canyon upstream of Los Alamos Canyon.

Reach BR-1: Middle Barrancas Canyon

Reach BR-1 is located in middle Barrancas Canyon downstream of side drainages that are located near firing sites at former TA-10 in Bayo Canyon. This reach will be investigated to evaluate the potential presence of contaminants that may have been dispersed during explosives testing in Bayo Canyon. Potential contaminants that have been identified during previous sampling in Barrancas Canyon include strontium-90, one metal (copper), and HE compounds. If significant concentrations of contaminants are found in Reach BR-1, a contingency reach may be sampled downstream of Reach BR-1 near the confluence with Guaje Canyon to determine contaminant extent and distribution.

Reach R-1: Upper Rendija Canyon

Reach R-1 is located in upper Rendija Canyon near PRSs 00-016 and C-00-041 on US Forest Service (USFS) land, and is composed of three subreaches. These subreaches will be investigated to evaluate the potential presence and extent of contaminants downstream from the PRSs in upper Rendija Canyon. Potential contaminants in these subreaches include metals (primarily lead), possibly HE compounds, and SVOCs. The subreaches are described below.

- Reach R-1 North is located in an unnamed tributary drainage to Rendija Canyon immediately downstream of a portion of PRS 00-016. This subreach will be investigated to evaluate the potential presence of contaminants in a side drainage downstream of the PRS.
- Reach R-1 South is located in the main drainage of Rendija Canyon immediately downstream of a portion of PRS 00-016. This subreach will be investigated to evaluate the potential presence of contaminants in the main drainage downstream of the PRS.
- Reach R-1 East is located in the main drainage of Rendija Canyon near the Rendija Canyon fault zone. This subreach is downstream of Reaches R-1 North and R-1 South and downstream of PRS C-00-041. This subreach will be investigated to evaluate potential contaminant migration further downstream from PRS 00-016 and from PRS C-00-041. Reach R-1 East will allow the determination of relative contaminant contributions from the different PRSs and the nature and concentrations of contaminants at the base of upper Rendija Canyon.

Reach R-2: "Thirty-Seven Millimeter Canyon"

Reach R-2 is located on General Services Administration (GSA) land in the lower part of "Thirty-Seven Millimeter Canyon" downstream of PRS 00-011(e). This reach will be investigated to evaluate the potential presence of contaminants downstream of the PRS. Potential contaminants in this reach include metals (primarily lead), HE compounds, and ordnance fragments.

Reach R-3: Middle Rendija Canyon

Reach R-3 is located in the main channel in middle Rendija Canyon downstream of PRS 00-011(a). This reach is located on GSA land just upstream of USFS land. This reach will be investigated to evaluate the potential presence of contaminants downstream of the PRS and potential contaminant contributions from other PRSs farther upstream. Potential contaminants in this reach include metals (primarily lead), HE compounds, and ordnance fragments. If significant contaminant concentrations are found in Reach R-3, a contingency reach may be sampled downstream of Reach R-3 near the confluence with Guaje Canyon to determine the extent and distribution of contaminants.

Reach G-1: Middle Guaje Canyon

Reach G-1 is located in middle Guaje Canyon downstream of PRS-00-029(c). This reach will be investigated to evaluate the potential presence of contaminants that may have been dispersed downstream from this PRS and potential contaminant contributions from other PRSs farther upstream. Potential contaminants that were identified during previous sampling at PRS-00-029(c) are PCBs. If significant contaminant concentrations are found in Reach G-1, a contingency reach may be sampled downstream of Reach G-1 near the confluence with Los Alamos Canyon to determine contaminant extent and distribution.

7.2.5 Sediment Sample Collection and Analysis

This section describes the planned sediment-sample collection process in the canyon reaches. Particular emphasis is given to the criteria for selecting sampling 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.

7.2.5.1 Sampling Design

Sediment samples from geomorphic units that potentially contain contaminants will be collected in each reach that will be investigated (see Section 7.2.4). Specific sampling locations in the initial sampling phases will be selected after the geomorphic survey is completed. Selection of sampling locations will consider the full range in age and particle-size characteristics of post-1942 sediments that are identified in the geomorphic survey (LANL 1997, 62316, pp. 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 from variable depths will be collected 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 be collected from a homogenous zone of 1 ft (0.30 m) or more of relatively uniform layers. Each sampling location will be marked, surveyed, and assigned a unique ER Project sample location identification number.

As explained in Section 7.2.3, three sampling tasks have been defined for the sediment investigation: full-suite COPC, key contaminant, and limited-suite COPC analyses. Field quality assurance (QA) samples, consisting of duplicates of a subset of sample layers, will be collected in accordance with the guidelines of the "Quality Assurance Project Plan Requirements for Sampling and Analysis" (LANL 1996, 53450).

Due to the scarcity of information available on contaminants in the north canyons system, the initial samples collected in each reach will be sent to an off-site laboratory for full-suite analyses, to ensure that no contaminants were overlooked during the historical analyses. An initial estimate of 5 to 10 samples will be collected from each reach or subreach; the actual location and number of samples collected will be determined by the technical team after results of the geomorphic surveys are available. Subsequent analyses may involve both limited-suite and key-contaminant analyses, depending on the results of the full-suite sampling.

After the initial phase of the investigation for each reach is completed, supplemental characterization may be required between some reaches to determine the extent of contaminant concentrations, and possibly to locate specific sites for corrective action. Activities in these areas could include geomorphic mapping and geomorphic characterization, sediment sampling and analyses, and data evaluation focused on identifying and mapping areas where contaminant concentrations exceed screening levels. Specific details of such supplemental investigations will be based on evaluation of data from the initial reaches.

7.2.5.1.1 Sample Collection for Full-Suite Analysis

The general approach discussed in Section 5.6.3.2 of the core document will be followed (LANL 1997, 62316). During the initial sampling task, sediment samples will be collected and analyzed for a full suite of potential contaminants to provide full characterization of the sediments and, if necessary, to define the limited-suite analyses for subsequent sampling and analysis tasks (see Section 7.2.5.1.3).

7.2.5.1.2 Sample Collection for Key-Contaminant Analysis

The analyte suite for key-contaminant-suite analyses will be determined by the technical team based on constituents identified at concentrations above background levels from the full-suite analyses. The selection of key contaminants allows analyses to be obtained from a large number of samples at a reasonable cost. The general approach discussed in Section 5.6.3.3 of the core document will be followed (LANL 1997, 62316). Key contaminant analyses are critical to the sediment investigations because those analytes are most important for evaluating risk.

7.2.5.1.3 Sample Collection for Limited-Suite Analysis

If necessary after the initial sampling event, additional samples may be collected for limited-suite analysis in reaches close to contaminant sources, to best characterize a range of contaminant concentrations. The general approach discussed in Section 5.6.3.4 of the core document will be followed (LANL 1997, 62316). Because the database on radionuclide, inorganic, and organic contaminants in the north canyons 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 contaminant occurrence and will be sufficient to develop a defensible, representative statistic for present-day risk assessment purposes. 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 effects assessments.

7.2.5.2 Sampling Methods

Sediment samples will be collected using the methods and most recent version of the ER Project standard operating procedure (SOP), LANL-ER-SOP-6.09, "Spade-and-Scoop Method for the Collection of Soil Samples." Sampling intervals will be determined in the field based on the judgment of field geologists. It is expected that a spade and scoop will be used to collect all sediment samples in this investigation. Near-surface samples will be collected from either stream bank exposures or shallow excavations of a selected homogenous thickness of sediment layers.

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 LANL-ER-SOP-

1.08, "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 LANL-ER-SOP-1.06, "Management of Environmental Restoration Project Wastes," and LANL-ER-SOP-1.10, "Waste Characterization."

7.2.5.3 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 contaminant distribution in the geomorphic strata, sample preparation methods will be 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 they are placed in a container. Gravelly samples will be sieved in the field to remove stones 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.

7.2.5.3.1 Organic Chemicals

The analytical suites and methods for analysis of organic chemicals are listed in Table 7.2-2. 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 EPA SW-846 protocols (EPA 1998, 64779). The detailed analyte lists, estimated quantitation limits (EQLs), required quality control (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 7.2-2
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 1998, 64779).

7.2.5.3.2 Inorganic Chemicals and Radionuclides

For inorganic chemicals the target analytes, conservative estimated detection limits (EDLs), analytical methods, and BVs in sediments are listed in Table 7.2-3. 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 following techniques: inductively coupled plasma emission spectroscopy (ICPES), electrothermal vapor atomic absorption, cold vapor atomic absorption (CVAA), and inductively coupled plasma mass spectrometry (ICPMS).

Table 7.2-3
Analytes, 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	0.4	0.83	ICPMS	SW-6020
Arsenic	2	3.98	ICPMS	SW-6020
Barium	20	127	ICPES	SW-6010B
Beryllium	0.6	1.31	ICPES	SW-6010B
Cadmium	0.2	0.4	ICPES or ICPMS	SW-6010B or SW-6020
Calcium	500	4420	ICPES	SW-6010B
Chromium	2	10.5	ICPES	SW-6010B
Cobalt	1.5	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-6020
Magnesium	1000	2370	ICPES	SW-6010B
Manganese	3	543	ICPES	SW-6010B
Mercury	0.1	0.1	CVAA	SW-7470A
Nickel	5.0	9.38	ICPES	SW-6010B
Potassium	500	2690	ICPES	SW-6010B
Selenium	0.3	0.3	ICPMS	SW-6020
Silver	0.5	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] Ryti et al. 1998, 59730.
[b] EPA SW-846 method (EPA 1998, 64779).

Table 7.2-4 lists radionuclide target analytes and their half-lives, detected emission, minimum detectable activities, analytical methods, and BVs in sediments. Before chemical separation and counting for alpha or high-energy beta emissions, samples will undergo a complete digestion or fusion procedure.

Strontium-90 will be measured by beta-counting 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 7.2-4
Analytes, Minimum Detectable Concentrations, and Analytical Methods for Radionuclides in Sediment Samples

Analyte	Half-Life (yr)	Detected Emission	Minimum Detectable Concentration (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	na[f]	GPC
Gross-beta	n/a	β	1.0	na	GPC
Gross-gamma	n/a	γ	2.0	na	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 7.2-5.
[d] n/a = not applicable.
[e] The minimum detectable concentration for cesium-137 is 0.2 pCi/g; the minimum detectable concentration for other analytes varies.
[f] na = 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 7.2-5) 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 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 usually are 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 to 40 pCi/g and is usually present in the gamma spectra of Laboratory soil and sediment 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 sediment samples.

Table 7.2-5
Analytes and Half-Lives of Radionuclides Measured Using Gamma Spectroscopy

Radionuclide	Half-Life	Emission
Th-232 Decay Series (thorium series)		
Lead-212	10.64 hr	β,γ
Thallium-208	3.053 min	β,γ
U-235 Decay Series (actinium series)		
Bismuth-211	2.14 min	α,β,γ
Thorium-227	18.72 days	α,γ
Uranium-235	7.04×10^8 yr	α,γ
U-238 Decay Series (uranium series)		
Bismuth-214	19.9 min	α,β,γ
Lead-214	26.8 min	β,γ
Thorium-234	24.10 days	β,γ
Activation Products (and their decay products)		
Americium-241	432.7 yr	α,γ
Cobalt-60	5.271 yr	β,γ
Protactinium-233	27.0 days	β,γ
Fission Products		
Cesium-134	2.065 yr	β,γ
Cesium-137	30.17 yr	β,γ
Europium-152	13.48 yr	β,γ
Ruthenium-106	372.6 days	β
Other		
Potassium-40	1.25×10^9 yr	β,γ

Radionuclide sample results will be reviewed against process knowledge and knowledge of waste streams that may have been released into the north canyons. Radionuclides detected in environmental media samples in concentrations above BVs will be included as COPCs. Detected radionuclides from gamma spectroscopy also include short-lived (less than 1 yr) 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 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.

7.2.5.3.3 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 support 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 described in LANL-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-sized 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.

7.3 Surface Water Sampling and Analysis Plan

This section presents the SAP for investigating surface water in the north canyons system. The ER Project strategy for characterizing surface water includes the sampling of persistent surface water that exists downstream of present or past Laboratory-impacted sites or PRSs for greater than 25% of a year. This approach provides data useful for assessing risk under conditions of potential chronic exposure. Persistent water may occur as baseflow within a channel or as pools that are sustained by periodic storm runoff or precipitation. No such surface water occurrences are known to exist in the north canyons.

Sampling of storm water runoff in canyons on and north of the Laboratory, including Guaje, Rendija, and Bayo Canyons, is conducted by the Laboratory's Water Quality and Hydrology Group (ESH-18) under the Watershed Management Program. Surface water investigations conducted for the north canyons for this SAP will be coordinated with the Watershed Management Program. All data available for storm water runoff will be used to evaluate historical and current fate and transport of contaminants during runoff events.

No natural perennial reaches occur downstream of Laboratory-affected property in the north canyons. A reach of spring-fed perennial flow occurs in upper Guaje Canyon, and a short perennial reach occurs in Agua Piedra Canyon (see Section 3.4.3.1.3 and Figure A-1). Surface water investigations are being conducted at the Guaje Canyon collection site as part of the Laboratory's environmental surveillance program (e.g., ESP 2000, 68661, pp. 222, 291).

7.3.1 Objective

A surface water investigation addresses the presence of Laboratory-derived contaminants in persistent surface water and evaluates the present and future potential for off-site exposures and impacts extending along the entire length of the north canyons to the Rio Grande.

More specifically, the objectives of this plan are to

- determine whether persistent surface water is present;
- characterize potential surface water contamination, if persistent surface water exists;

- evaluate temporal and spatial variability of contamination to represent conditions that could affect the contaminant concentration range; and
- evaluate the fate of contaminants that may be present in storm water runoff using data collected under the Watershed Management Program.

Results and observations from the surface water investigation will be evaluated with sediment data to refine the conceptual model for the interactions of each medium. At a minimum, a qualitative understanding will be developed of the relation between surface water and sediment. Understanding the interactions between surface water and sediment in the north canyons will support future environmental surveillance efforts. Integrating existing and new field-investigation data will provide a basis for understanding if surface water contaminant concentrations approach or exceed regulatory or risk-based thresholds. If the results indicate unacceptable present-day or potential future risks, a voluntary corrective action (VCA) or corrective measures study (CMS) may be required.

7.3.2 General Approach for Surface Water Investigation

This section briefly describes the general approach for the surface water investigation in the north canyons. The general approach will be to conduct site surveys to determine whether persistent surface water occurs within the north canyons and if present, collect data from representative locations for use in an assessment of risk from all relevant media.

Surface water investigations will focus on determining (1) whether persistent surface water is present in locations downstream of Laboratory PRSs; (2) the nature and extent of contaminants in surface water, if present; and (3) the risk posed by surface water contamination and other affected media in the north canyon system.

Field observations and data collected in this surface water investigation will be integrated with data from other previous and ongoing Laboratory studies, such as the Groundwater Protection Management Program Plan and the Watershed Management Plan, to improve understanding of the surface water hydrology of the Pajarito Plateau (LANL 1995, 50124; LANL 1999, 62920).

The investigation team will make recommendations regarding (1) corrective actions to alleviate significant surface water contaminants and (2) 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 is addressed by the investigation.

Issues

Does persistent surface water occur in the north canyons in areas downstream of Laboratory PRSs? If persistent surface water is identified, are any contaminants attributable to Laboratory-affected sites? What is the present-day risk posed by contaminants present in surface water in the north canyons system? How will that risk change with time?

Technical Approach

The technical approach stems first from determining whether persistent surface water is present in the north canyons in locations downstream of PRSs. If such occurrences are not identified, a surface water investigation will not be conducted. Surveys will be conducted during periods of the year (e.g., monsoon season and during the spring snowmelt season) when persistent surface occurrences are most likely. If persistent surface water is identified downstream of PRSs, the surface water will be characterized.

If characterization of surface water is appropriate, the following technical approach will be implemented.

- Samples will be collected either quarterly during a year or during seasons when water is present (assuming the water is present in a persistent manner) from all selected locations within the watershed in a "snapshot" manner (i.e., from multiple locations in a watershed within a short period of time).
- Field observations will be conducted to document the extent, duration, and availability of surface water.

Because no surface water BVs are available, screening will be conducted by initially comparing the results to applicable state water quality standards. The data then will be evaluated in a risk context in combination with results of the sediment investigation using appropriate land-use assumptions. Ecological-effects evaluations may require toxicity bioassays of aquatic species and/or observations of their population abundance and diversity.

Data collection will include measurements of surface water quality that include field-measured parameters (e.g., pH, conductivity, temperature, pooled-water area and depth, streamflow, and spring discharge rates) and laboratory-measured geochemistry.

For initial planning use, the investigation will be limited to specific locations within boundaries of the north canyons investigation. Surface water samples will be collected at the upstream perennial reach in Guaje Canyon and at surface water collection sites where persistent surface water is identified. Data needed to evaluate the present-day human health and ecological effects will be collected during a single, 1-yr field investigation and should reflect system variability during the investigation period. 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, 62316).

7.3.3 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, 62316). The SAP is designed to be flexible; objectives and approaches will be refined and modified as new data are obtained. Revisions or refinements to the conceptual model (see Chapter 4 of this work plan) will be based on integrating results from all investigation components as well as an integration and further interpretive analysis of data from previous and ongoing Laboratory studies (see Chapters 2 and 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.

Additional stream gaging stations are planned for Guaje Canyon and Rendija Canyon (LANL 1999, 62920, p. 6-10). The Water Quality and Hydrology Group (ESH-18) personnel will monitor these stations and the data will be published in the annual surface water data reports (e.g., Shaull et al. 2000, 66648) and the annual environmental surveillance reports. These data will be available to support the evaluation of surface water in north canyons. Table 7.3-1 lists the planned gaging stations.

Table 7.3-1
Planned Surface Water Gaging Stations in the North Canyons

Designation	Description
Not available	Permanent station for flow gaging, sampling, and water-quality parameter measurement with continuous data-recording capability. Planned location is Guaje Canyon above the confluence with Rendija Canyon.
Not available	Permanent station for flow gaging, sampling, and water-quality parameter measurement with continuous data-recording capability. Planned location is Rendija Canyon above the confluence with Guaje Canyon.
Not available	Permanent station for flow gaging, sampling, and water-quality parameter measurement with continuous data-recording capability. Planned location is Guaje Canyon above the confluence with Los Alamos Canyon.

Source: LANL 1999, 62920.

7.3.4 Surface Water Sampling and Analysis

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.

7.3.4.1 Surface Water Sampling

All surface water samples will be collected and handled in accordance with the most recent version of LANL-ER-SOP-6.13, "Surface Water Sampling."

Surface water collection sites will be designated if areas with persistent surface water are identified. Surface water samples will be collected for analysis on a quarterly basis for 1 yr or at appropriate times when surface water is present. The number of sample sites will be based on the location and number of persistent surface water sites identified.

Samples will be collected in the middle of the stream to provide representative surface water chemical data for the location. Duplicate surface water samples will be collected as appropriate. Both filtered and unfiltered samples will be collected for each analyte as appropriate. Comparing these data will permit an evaluation of chemical concentrations in solution versus constituents adsorbed onto solid fractions in the water.

7.3.4.2 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. Specific conductance, turbidity, pH, temperature, and dissolved oxygen will be measured in the field at the time of sampling. Each sample will be analyzed for the parameters listed in Table 7.3-2.

Analytical Methods

Surface water samples collected according to the strategy outlined in Section 7.3.4.1 will be analyzed for the suite of constituents listed in Table 7.3-2. All analyses for organic chemicals will be performed in accordance with EPA SW-846 protocols (EPA 1998, 64779) or 40 CFR 136 methods (LANL 1997, 62316, p. 6-6). The detailed analyte lists, EQLs, minimum detectable concentrations, 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 7.3-2
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	Semivolatile organic compounds
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 the presence of contaminants. Table 7.3-3 lists target analytes, conservative EDLs, and analytical methods for inorganic chemicals. 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 1998, 64779), 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 7.3-3
Estimated Detection Limits and
Analytical Methods for Inorganic Chemicals in Surface Water 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	ICPMS	SW-6020
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	ICPMS	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	ICPMS	SW-6020
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 (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.

* EPA SW-846 method or equivalent (EPA 1998, 64779).

The target analytes and their half-lives, detected emissions, minimum detectable concentrations, and analytical methods for radionuclides are listed in Table 7.3-4. 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 7.3-4
Minimum Detectable Concentration 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]	2.411×10^4	α	0.05	α-spectrometry
Strontium-90	28.7	β	1.0	Gas proportional counter (GPC)
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	n/a[c]	γ	10^f	γ-spectroscopy

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] n/a = not applicable.

Surface water samples will also be analyzed for organics and stable and radiogenic isotopes using the methods listed in Table 7.3-5.

Table 7.3-6 lists the field measurements that will be made at the time of sample collection.

7.4 Alluvial Groundwater Sampling and Analysis Plan

No alluvial groundwater is known or suspected to occur in significant quantities downstream of Laboratory-affected portions of the north canyons. Therefore, no alluvial groundwater monitor wells are planned.

7.5 Biological Sampling and Analysis Plan

Vegetation in middle Bayo Canyon at a portion of the former TA-10 site has been found to contain elevated concentrations of strontium-90 and possibly other contaminants. Vegetation sampling included in this work plan will be used as an indicator for the possible transport and uptake of strontium-90 in lower Bayo Canyon within the proposed TA-74 land transfer parcel. Because part of the TA-74 land transfer parcel is proposed for transfer to the US Department of Interior in trust for San Ildefonso Pueblo, the ER Project will consult San Ildefonso Pueblo prior to conducting biota sampling.

Table 7.3-5
Analytical Methods for Organics and Radiogenic Isotopes in Surface Water Samples

Analyte	Analytical Method
Stable and Radiogenic Isotopes[a]	
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[d]/WRI[e] 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 1998, 64779.
[c] EPA 1983, 56406.
[d] USGS = US Geological Survey.
[e] WRI= Water resource investigation.

Table 7.3-6
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.

The results of the investigation will be incorporated into human health risk assessments and ecological-effects assessments, as appropriate. Vegetation sampling will occur in conjunction with Phase II activities, and sampling activities will be triggered if concentrations of strontium-90 are measured above BVs in sediment samples collected during Phase I. If other COPCs readily taken up by plants (e.g., tritium or zinc) are identified during Phase I sampling, these analytes will be added to the vegetation sampling suite. The potential for plant uptake of various COPCs will be assessed by reviewing the plant transfer factors listed in the ecorisk database (LANL 1998-2000, Records Package 186).

Other biological data needs may be identified during the sampling and assessment of sediment and surface water. As discussed in the core document (LANL 1997, 62316), the approach for evaluating ecological effects is being developed with the NMED, DOE, Laboratory ER Project, and EPA. Based on the results of this process, additional biological sampling for the north canyons will be developed, as necessary, to be consistent with the final technical approach.

7.5.1 Objectives

The objectives of the vegetation sampling are summarized as follows:

- determine the extent of Laboratory-derived contaminants, particularly strontium-90, in vegetation in Bayo Canyon downstream of former TA-10 and within the proposed TA-74 land transfer parcel;
- evaluate the present-day risk to human health and potential effects on ecological receptors from contaminated vegetation; and
- collect vegetation data in conjunction with sediment samples to evaluate and refine the contaminant transport components of the conceptual model.

The following sections present the preliminary vegetation investigation SAP and describe the technical approach adopted to achieve these objectives.

7.5.2 General Approach for Vegetation Sampling

This section describes the general approach for the vegetation sampling and analysis. Vegetation samples will be collected coincident with sediment samples at locations where contaminant concentrations are expected to be highest. Vegetation samples will be collected with sediment samples in reach BY-2, which is located in the proposed TA-74 land transfer parcel in lower Bayo Canyon downstream of the former TA-10 site. Prior to conducting biota sampling, the ER Project will consult with San Ildefonso Pueblo to help focus sampling activities.

This investigation addresses the following issue: What is the nature and extent of strontium-90 and other contaminants readily assimilated by vegetation in Bayo Canyon downstream of the former TA-10?

If strontium-90 is detected above BVs in sediments downstream of TA-10, uptake into plants rooted in these sediments is considered likely. The type of plants rooted in these sediments will be important to the consideration of health or ecological effects. For example, if pines are found to be rooted in strontium-90-bearing sediments, exposure to wood smoke could be considered. However, if only herbaceous annual plants are rooted in contaminated sediments, exposure to wildlife or cultural uses of these plants would be of concern. Seasonal uptake differences also are more important for annual plants than woody plants.

This investigation will include the following activity:

- Determine the concentrations of strontium-90 in selected plant species.

  The following will be used to help enable this determination:

  - Phase I sediment sampling results to select COPCs for vegetation sampling (currently assumed to be only strontium-90),
  - locations of plants relative to contaminated sediments,

- timing of vegetation sampling (e.g., towards the end of the growing season for annual plants),
- concentrations of strontium-90 in each plant sample compared to sediment samples, and
- comparison of concentrations in the vegetation sample with reference area samples.

The results of the geomorphic mapping described in Section 7.2 will form part of the basis for selecting locations of plants to be sampled for laboratory analysis. Samples will be selected to represent the canyon floor area and will be biased to sample the areas with the greatest volume of potentially contaminated sediments and vegetation. The timing of plant sampling will be important to providing valid data for comparison to published plant uptake factors and for use in human health and ecological assessments. Every effort will be made to collect samples from the time of year with greatest contaminant concentrations. For most plants, this is expected to be the end of the growing season. An exception would be samples collected from woody portions of plants or trees where the timing of sampling woody material is less critical.

Phase I sediment samples will help determine which, if any, analytes should be included in vegetation sampling. Analytes identified as COPCs in sediment and that have plant transfer factors greater than 1.0 (based on the current Ecorisk Database, LANL 1998-2000, Record Package 186) will be included in the vegetation-sampling suite.

Results will be compared with published concentrations of strontium-90 obtained from reference locations in northern New Mexico (e.g., Gonzales et al. 2000, 69697) to determine if strontium-90 is present above background levels.

7.5.3 Sampling and Analysis Plan for Vegetation Investigation

Vegetation sampling will be conducted concurrently with Phase II sediment sampling in Reach BY-2, if necessary. Preliminary surveys described in Section 7.2 will be conducted prior to sampling.

The sampling strategy includes the following:

- identifying the COPCs for vegetation sampling based on the Phase I sediment results (analytes identified as COPCs in sediment that have plant transfer factors greater than 1.0 will be included in the vegetation sampling suite);
- identifying the area where vegetation could take up contaminants through root uptake (assuming that foliar uptake is unimportant), and
- for planning purposes, assuming that 12 samples of plant material will be collected and analyzed for strontium-90.

The field investigation will include

- a description of the vegetation at the site and
- sampling of selected vegetation.

Sampling Design

Each sample location will be marked, surveyed, and assigned a unique ER Project sampling location identification number. All samples will be field-screened using hand-held instruments at the point of collection for gross radioactivity.

Sampling Methods

Vegetation samples will be collected using the methods and procedures developed by the Laboratory's Ecology Group (ESH-20). Species sampled will be determined in the field based on the judgments of the sampling team. Most samples will be collected by cutting the vegetation and storing samples in zip-lock bags.

All samples will be collected using the most recent versions of 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 LANL-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 LANL-ER-SOP-1.06, "Management of Environmental Restoration Project Wastes," and LANL-ER-SOP-1.10, "Waste Characterization."

Analytical Methods

The analytical suite for vegetation samples includes strontium-90. All analyses will be performed in accordance with EPA SW-846 protocols (EPA 1998, 64779). The detailed analyte lists, 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.

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 Waste 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.

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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, 54406)

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Appendix A

Figure A-1. Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon Watersheds

Media Place Holder Target

This target represents media that was not microfilmed. The original media can be obtained through the Records Processing Facility.

ER ID # 71060

Box # 291

Record Type: DRAWING / MAP

Date: —

Symbol: FIMAD PLOT ID 109808

Subject:

FIGURE A-1. Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon Watersheds

106

Figure A-1.
Bayo Canyon, Barrancas Canyon, Rendija Canyon, and Guaje Canyon Watersheds

Appendix B

Status of PRSs

Table B-1
PRSs in the Bayo Canyon Watershed

PRS Number	PRS Name	HSWA	Consolidation Unit	NFA Proposed	NFA Criterion[a]	NFA Proposal Date	NFA Status
00-008	Surface disposal site	No	None	Yes	2	03/27/1995	DOE concurrence of proposal for NFA.
00-011(d)	Mortar impact area	Yes	None	Yes	5	03/01/1994	Proposed in RFI report.
00-025	Landfill	No	n/a[b]	Yes	1	03/27/1995	DOE concurrence of proposal for NFA.
00-026	Landfill	Yes	None	Yes	5	06/19/2000	DOE concurrence of proposal for NFA.
00-028(b)	Effluent discharge, ball fields (active)	Yes	00-028(a)-00	Yes	5	07/22/1996	Site proposed in work plan or RFI report that received an NOD or disapproval letter from AA.[c]
10-001(a)	Firing site (inactive)	Yes	10-001(a)-99	Yes	5	09/08/1995	NFA proposed in work plan or RFI report that received an NOD or disapproval letter from AA.
10-001(a)-99	Firing site consolidation unit	Yes	10-001(a)-99	Yes	5	9/8/95	NFA proposed in work plan or RFI report that received an NOD or disapproval letter from AA.
10-001(b)	Firing site (inactive)	Yes	10-001(a)-99	Yes	5	09/08/1995	NFA proposed in work plan or RFI report that received an NOD or disapproval letter from AA.
10-001(c)	Firing site (inactive)	Yes	10-001(a)-99	Yes	5	09/08/1995	NFA proposed in work plan or RFI report that received an NOD or disapproval letter from AA.
10-001(d)	Firing site (inactive)	Yes	10-001(a)-99	Yes	5	09/08/1995	NFA proposed in work plan or RFI report that received an NOD or disapproval letter from AA.
10-001(e)	Detonation test area - doesn't exist	No	None	Yes	1	03/27/1995	DOE concurrence of proposal for NFA.
10-002(a)	Disposal pit	Yes	10-002(a)-99	Yes	5	06/03/1996	Proposed in RFI report.
10-002(a)-99	Waste Water Treatment Plant	Yes	10-00(a)-99	No	n/a	n/a	n/a
10-002(b)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(a)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(b)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(c)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(d)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.

Table B-1 (continued)
PRSs in the Bayo Canyon Watershed

PRS Number	PRS Name	HSWA	Consolidation Unit	NFA Proposed	NFA Criterion[a]	NFA Proposal Date	NFA Status
10-003(e)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(f)	Disposal pit	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(g)	Manholes	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(h)	Manholes	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(i)	Septic tank	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(j)	Tank	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(k)	Tank	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(l)	Tank	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(m)	Waste line	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(n)	Leach field	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-003(o)	Leach field	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-004(a)	Septic system	Yes	None	Yes	5	06/03/1996	Proposed in RFI report.
10-004(b)	Septic system	Yes	10-002(a)-99	Yes	5	06/03/1996	Proposed in RFI report.
10-005	Surface disposal	Yes	10-001(a)-99	Yes	5	06/03/1996	Proposed in RFI report.
10-006	Burn site - doesn't exist	Yes	None	Yes	1	03/27/1995	Proposed in permit modification.
10-007	Landfill	Yes	10-002(a)-99	No	n/a	n/a	Rad/other components must be addressed.
10-008	Tree rimmed firing point, Bayo Canyon (inactive)	No	10-001(a)-99	Yes	5	09/30/1997	Proposed in RFI report.
10-009	Former Bayo landfill	No	None	No	n/a	n/a	Nothing submitted for NFA.
C-10-001	Surface soil, 2 10 x 10 ft plots, Bayo Canyon	No	None	Yes	5	09/15/1995	Cleanup report submitted.

[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] n/a = not applicable.
[c] AA = administrative authority.

Table B-2
PRSs in the Rendija Canyon Watershed

PRS Number	PRS Name	HSWA	Consolidation Unit	NFA Proposed	NFA Criterion[a]	NFA Proposal Date	NFA Status
00-011(a)	Mortar impact area	Yes	None	Yes	5	03/01/1994	Proposed in RFI report.
00-011(c)	Mortar impact area	Yes	None	Yes	5	03/01/1994	Proposed in RFI report.
00-011(e)	Mortar impact area	Yes	None	Yes	5	03/01/1994	Proposed in RFI report.
00-015	Firing range, Rendija Canyon (active)	No	None	Yes	4	03/27/1995	Final DOE approval of NFA.
00-016	Firing range (inactive)	Yes	None	Yes	5	06/19/2000	Proposed in Class III permit modification.
00-024	Cistern - never located	No	None	Yes	1	03/27/1995	DOE concurrence of proposal for NFA.
00-028(a)	Effluent discharge, golf course (active)	Yes	00-028(a)-00	Yes	5	07/22/1996	Sites proposed in RFI report that received an NOD or disapproval letter from AA.[b]
00-028(b)	Effluent discharge, ball fields (active)	Yes	00-028(a)-00	Yes	5	07/22/1996	Sites proposed in RFI report that received an NOD or disapproval letter from AA.
00-040	Underground tank - new AOC	No	None	Yes	4	03/27/1995	DOE concurrence of proposal for NFA.
C-00-020	Mortar impact area	No	None	Yes	5	03/01/1994	Proposed in RFI report.
C-00-041	Asphalt and tar remnant site	No	None	Yes	5	09/15/1995	Cleanup report submitted.

[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-3
PRSs in the Guaje Canyon Watershed

PRS Number	PRS Name	HSWA	Consolidation Unit	NFA Proposed	NFA Criterion[a]	NFA Proposal Date	NFA Status
00-029(c)	Transformer - PCB only site	No	None	Yes	5	09/30/1996	AOC proposed for NFA in permit modification 9/96.

[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)

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

List of Contributors

Name and Affiliation	Education and Expertise	Function
Michelle Benak (SAIC)	B.S. Environmental Geology; 8 yr experience in environmental characterization, sampling, and monitoring	Provided research and developed historical descriptions
Michael Dale (NMED DOE OB)	M.S. Geology with emphasis on hydrogeology; 9 yr experience	Provided oversight for hydrologic processes
Bob Enz (DOE)		DOE liaison
Philip Fresquez (ESH-20)	Ph.D. Environmental Soil and Plant Science; 22 yr experience in site characterization, reclamation, and monitoring and surveillance	Biological assessment support
Catherine Goetz (SAIC)	B.S. Geology; 16 yr experience in field investigations and geologic and scientific research	Provided research and developed environmental descriptions
Penelope Gomez (ESH-18)	M.S. Computer Information Systems/B.S. Environmental Engineering; 4 yr experience in data/database management	Environmental Surveillance database support
Bill Hardesty (EES-9)	B.S. Chemistry; 6 yr experience data validation, data QA/QC, and data reporting; currently an ER Project data steward	ER database support
Marcia Jones (EES-10)	12 yr experience in the geographical information system specializing in cartography	Produced large maps
Danny Katzman (EES-9)	M.S. Geology; 16 yr experience in geologic and geomorphic investigations, RCRA site characterization and remediation, and project management	Canyons technical team leader for surface water and historical data support
Richard Koch (SAIC)	M.S. Geology; 26 yr 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
Patrick Longmire (EES-6)	Ph.D. Aqueous Geochemistry; 22 yr experience in field hydrogeochemistry and soil chemistry regulatory oversight, the UMTRA project, and RCRA/CERCLA remediation	Technical lead for aqueous geochemistry
Pamela Maestas (Neptune & Co., Inc.)	B.A. Human Resources Management; 5 yr experience as electronic publications specialist	Electronic publications specialist
Kenneth Mullen (ESH-18)	Ph.D. Analytical Chemistry; 20 yr experience in environmental monitoring	Environmental surveillance database support
Allyn Pratt (EES-9)	B.S. Environmental Science/M.B.A.; 22 yr experience in natural resource management, project management, and environmental management	Canyons Focus Area team leader
Steven Reneau (EES-9)	Ph.D. Geology; 22 yr experience in geosciences; 10 yr at the Laboratory, including 8 yr evaluating surface transport of contaminants for the Environmental Restoration Project	Canyons Focus Area technical lead for geomorphology

Name and Affiliation	Education and Expertise	Function
David Rogers (ESH-18)	Ph.D. Earth Sciences (Hydrogeology); 28 yr experience in geosciences including 11 yr as a geophysicist; 7 yr experience in hydrological investigations, modeling of groundwater flow and contaminant transport, and geochemistry	Technical support
Randall Ryti (Neptune & Co., Inc.)	Ph.D. Biology; 15 yr experience in analysis and assessment of natural systems and risk assessment	Risk assessment support
Michael Saladen (ESH-18)	15 yr experience in emergency response and reporting, environmental permitting and regulatory compliance	NPDES outfall status data
William Stone (EES-6)	Ph.D. Geology; 30 yr experience in hydrogeology, including university teaching and hydrogeologic investigations	Technical lead for hydrology
Mark Tardiff (Neptune & Co)	M.S. Ecology; 25 yr experience in contaminant transport dynamics, natural systems analysis, and risk assessment	Risk assessment support
Jan Torline (IM-1)	B.S. Journalism; 12 yr experience writing/editing DOE environmental remediation/restoration documentation	Technical editor

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