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Los Alamos Area Office, MS A316
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505-667-7203/FAX 505-665-4504

Date: January 23, 1998
Refer to: EM/ER:98-020

Mr. Benito Garcia
NMED-HRMB
P.O. Box 26110
Santa Fe, NM 87502

SUBJECT: SUPPLEMENT TO RESPONSE TO REQUEST FOR SUPPLEMENTAL INFORMATION FOR THE CANYONS INVESTIGATION CORE WORK PLAN (FORMER OU 1049)

Dear Mr. Garcia:

On August 26, 1997, the New Mexico Environment Department sent to Los Alamos National Laboratory a request for supplemental information on the Core Document for Canyons Investigations. The Laboratory responded to that request on October 30, 1997 (reference EM/ER:97-438). In the response, the Laboratory promised to revise some text in the Core Document. The replacement pages are attached to this letter.

Locate your copy of the Core Document for Canyons Investigations and follow these instructions for inserting the replacement pages. Note the page number at the bottom of each page. The first digit refers to the chapter in the Core Document; Roman numerals refer to the annexes. Go to the appropriate chapter or annex and locate the page(s). Remove and recycle the old page(s) and insert the new page(s). Because of new page breaks, some of the new page numbers will be followed by a lower case letter, which allows succeeding page numbers to remain unchanged.

If you have any questions, please call Maureen Oakes at (505) 662-1815.

Sincerely,

Julie A. Canepa, Program Manager
LANL/ER Project

Sincerely,

Theodore J. Taylor, Program Manager
DOE/LAAO

JC/TT/ss

LANL
4 / 1049

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Attachment: Supplement to Response to Request for Supplemental Information for Canyons Investigation Core Work Plan (Former OU 1049)

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TABLE 1-1

OPERABLE UNIT 1049 CANYONS AND ASSOCIATED OPERABLE UNITS AND TECHNICAL AREAS

Canyon Groups	Associated Technical Areas	Associated Operable Units	Task/Site Work Plan Date[a]
Core Document	N/A[b]	N/A	April 1997
Group 1			
Los Alamos/DP	Former TA[c]: 1 Current TAs: 0, 2, 3, 21, 41, 43, 53, 62, 72, 73, 74	1071, 1078, 1098, 1100, 1106, 1111, 1114, 1136	November 1995
Pueblo/Acid	Former TAs: 1, 45 Current TAs: 0, 72, 73, 74	1071, 1078, 1079, 1100, 1106	
Group 2			
Mortandad and Sediment Traps	Current TAs: 3, 4, 5, 35, 42, 48, 50, 55, 59	1114, 1129, 1147	September 1997
Group 3			
Pajarito	Current TAs: 6, 7, 8, 9, 14, 18, 22, 23, 36, 40, 46, 50, 51, 54, 65, 66, 67, 69	1093, 1111, 1129, 1130, 1140, 1157	September 1998
Twomile	Current TAs: 3, 55, 58, 59, 64	1111, 1114, 1129	
Threemile	Current TAs: 14, 15, 18, 36, 67	1085, 1086, 1093, 1130	
Group 4			
Cañada del Buey	Current TAs: 5, 18, 46, 51, 52, 54	1129, 1140, 1148	September 1999
Sandia	Current TAs: 3, 53, 60, 61, 72	1100, 1114	
Group 6			
Water	Current TAs: 11, 16, 28, 36, 37, 49, 68, 71	1082, 1086, 1122, 1130, 1132, 1144	March 2000
Cañon de Valle	Current TAs: 9, 11, 14, 15, 16, 37, 67	1082, 1085, 1086, 1157	
Group 7			
Ancho	Current TAs: 33, 39, 49	1122, 1132, 1144	September 2000
Indio	Current TAs: 39, 49, 70	1132, 1144	
Chaquehui	Current TA: 33	1122	
Group 8			
Potrillo	Current TAs: 14, 15, 36, 67	1085, 1086, 1130	March 2001
Fence	Current TAs: 36, 68, 70, 71	1122, 1130	
Group 5			
Guaje	Current TAs: 74, residences	1071	June 2001
Bayo	Current TAs: 0, 10, 74, residences	1071, 1079	
Barrancas	Current TAs: 74, residences	1071	
Rendija	Current TAs: 0, 74, residences	1071	

a. Based on budgets
b. N/A = not applicable
c. TA = Technical Area

The Community Involvement and Outreach Office also distributes meeting notices and updates the ER Project mailing list, prepares information sheets summarizing completed and future activities, and provides public access to plans, reports, and other ER Project documents. These materials are available for public review between 8:00 a.m. and 5:00 p.m. on Laboratory business days in the Laboratory Community Reading Room at 1350 Central Avenue, Suite 101 in Los Alamos; at the public libraries in Española, Los Alamos, and Santa Fe; and at the San Ildefonso Pueblo Governor's Office.

1.4 Regulatory Requirements Governing the Work Plans

In March 1987 DOE established a national ER Program to address environmental cleanup requirements at its Defense Program facilities nationwide. DOE and the University of California (UC), which operates the Laboratory for DOE, are jointly responsible for implementing the DOE ER Program at the Laboratory. The Laboratory's ER Project is the organization responsible for that implementation, which must satisfy a number of regulatory mandates and meet internal requirements of DOE and the Laboratory.

1.4.1 Resource Conservation and Recovery Act Requirements

The Laboratory's Hazardous Waste Facility Permit under RCRA sets forth requirements that are implemented by the ER Project. The broad Permit was issued by EPA; its HSWA Module (EPA 1990, 1585), which gives specific requirements affecting the conduct of the ER Project, was issued by EPA because, at the time, NMED did not have authority to implement HSWA requirements. The HSWA Module became effective May 23, 1990, and is modified to reflect changes in the corrective action process at the Laboratory. The most recent Class III permit modification became effective May 19, 1994. Early in 1996, NMED received authority to implement HSWA and is now the administrative authority for the entire Permit.

The HSWA Module requires the Laboratory to prepare an IWP that contains the programmatic elements of an RFI work plan. The IWP (LANL 1996, 55574), which DOE/UC uses to guide and manage the ER Project, meets this requirement. The most recent revision of the IWP was submitted in December 1996. The IWP describes the DOE ER Program and its history at the Laboratory, describes current Laboratory conditions, identifies the Laboratory's potential release sites (PRSs) and their aggregation into field units, and presents the management and technical approaches for meeting the requirements of the HSWA Module. The IWP also contains the Schedule of Compliance for HSWA regulatory obligations. It should be noted that although the authority of RCRA and HSWA does not include radionuclide contaminants, DOE and the Laboratory have agreed to include them in the ER Project investigations; thus a PRS may be either a solid waste management unit (SWMU) (which is regulated under RCRA) or an area of concern (AOC) (which may contain contaminants not regulated under RCRA). Relevant information presented in the IWP will be cited but not repeated in this document.

The HSWA Module also requires the Laboratory to prepare RFI work plans for specific SWMU-based investigations and task/site work plans for investigations of the affected media of the canyon systems. Generic guidance for preparing RFI work plans is found in the proposed regulations of Subpart S of 40 CFR 264 (EPA 1990, 31277); specific requirements are described in the HSWA Module. EPA has provided specific guidance in Volume I of the interim final RFI guidance (EPA 1989, 8794). The HSWA Module sets out the scope of the RFI work plan, establishes the expected correspondence between the RFI tasks identified in EPA guidance documents (EPA 1989, 8794) and the equivalent ER Program tasks, and specifies the requirements to be fulfilled. These considerations are summarized in Table 1-2, which has been adapted from the HSWA Module, Section Q. Table 1-2 lists the major RFI tasks and subtasks defined by EPA and shows where the required subtasks are, or will be, discussed in the IWP, this core document, and the task/site work plan or SAPs.

TABLE 1-2

LOCATION OF DISCUSSIONS OF HSWA MODULE REQUIREMENTS

HSWA Module Requirements	IWP (1996)	Location in Core Document*
RFI Task I: Description of Current Conditions		
Facility Background	Chapter 2	Chapters 2 and 3
Nature and Extent of Contamination	Appendices A and B	Chapters 2 and 3
RFI Task II: RFI Workplan		
Data Collection Quality Assurance Plan	Chapter 4	Future SAPs
Data Management Plan	Chapter 5	Annex III (Records Management Plan)
Health and Safety Plan	Chapter 6	Annex II
Community Relations Plan	Chapter 7	Annex IV (Public Involvement Plan)
RFI Task III: Facility Investigation		
Environmental Setting		Chapter 3
Source Characterization		Chapters 2, 3, 4, and 5
Contamination Characterization		Chapters 2, 3, 4, and 5
Potential Receptor Identification		Chapter 6
RFI Task IV: Investigative Analysis		
Data Analysis		Chapters 5 and 6
Protection Standards		Chapter 6
RFI Task V: Reports		
Preliminary and Workplan	The IWP with annual update	Task/Site Work Plan and Future SAPs
Progress Draft and Final		Chapter 7 and Annex I

* The *Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon* (LANL 1995, 50290) included a SAP as Chapter 7, a project-specific quality assurance project plan as Annex II, and field and laboratory investigation method as Appendix C. Plans for subsequent canyons investigations will consist primarily of a SAP, incorporating this core document by reference for general background information, and providing canyon- or canyon aggregate-specific background information plus QA/QC procedures and field and laboratory investigation methods.

The IWP specifies that the ER Project's approach to the canyons investigations will comply with the HSWA Module and other regulatory obligations. This core document, and the subsequent SAPs, fulfill part of the requirements of the HSWA Module, Section I.5: Task/Site Work Plan, Canyon Systems (EPA 1990, 1585), which defines the requirement for canyons investigations. That section calls for one or more task/site work plans for studies to evaluate the potential impact of contaminants from SWMUs on the 15 (the Laboratory currently recognizes 19) major drainage areas or canyon systems at the Laboratory. It states that

> "The Permittee shall submit one or more Task/Site Workplans for studies to evaluate the 15 major drainage areas or Canyon systems at the facility. These studies must address each system as an integrated unit and evaluate them for potential impacts of contaminants from SWMUs. The plans must address the existence of contamination and the potential for movement or transport to or within Canyon watersheds and interactions with the alluvial aquifers and the main aquifer. The studies shall evaluate the potential for offsite exposure

through these pathways including the ground water and possible impacts on the Rio Grande."

The requirement to submit one or more task/site work plans for investigations to evaluate the 15 (currently the Laboratory considers 19 canyons) major canyon systems at the facility is addressed in part by this core document, which summarizes the general technical approach and site information that are applicable to all canyon systems. This HSWA Module requirement will be completed for each of the canyon systems by preparation of SAPs, tiered from this core document, that are specific to each canyon or canyon aggregate under investigation. SAPs will be prepared with input from NMED, EPA, DOE, and the Accord Pueblos. The remainder of the text of Section I.5 of the HSWA Module contains both requirements and criteria for the design of investigations. These requirements and the approaches to addressing them are discussed in detail in Section 5.2.1 in Chapter 5 of this core document.

Section Q of the HSWA Module, which describes the scope of work for RFIs at facilities, calls for comprehensive characterization of hydrogeological and geochemical properties relevant to contaminant migration in soils and sediments. The canyons are not PRSs in the sense of Section Q. They are natural environments containing contaminated media transported from nearby Laboratory PRSs, mostly located on adjacent mesa tops. Therefore, the canyon- or canyon aggregate-specific SAPs developed for investigations in each of the canyon systems are not RFI work plans in the typical sense; rather this core document and the SAPs are the plans for investigations designed to evaluate the role of canyons as collection points and transport pathways for contaminants derived from nearby SWMUs. Nevertheless, the canyons investigations described in this core document and in the SAPs for canyon- or canyon aggregate-specific investigations address the guidelines for conducting RFIs as outlined in Section Q. These guidelines include obtaining the following hydrogeological and geochemical information (adapted from the HSWA Module, Section Q, Table III.A [Environmental Setting]):

- geological and hydrogeological characteristics that affect groundwater flow and quality beneath the facilities;
- topographic features that might influence the groundwater flow system;
- representative, accurate classification and description of near-surface hydrogeological units that may be part of the migration pathways at the facility (that is, the water-bearing zones and any intervening unsaturated units);
- zones of near-surface fracturing or channeling in consolidated or unconsolidated deposits and zones of high or low permeability that might direct and restrict the flow of water and contaminants;
- representative description of water level or fluid pressure monitoring; and
- man-made influences that might affect the hydrogeology of the site.

Moreover, the canyon-specific requirements in Section I.5 of the HSWA Module for investigations to evaluate the potential for off-site exposure necessitates that much of the same information called for in facility-specific RFIs be obtained in canyons investigations as well. Investigations on the environmental setting will be performed as they relate to identified sources, pathways, and areas of release of hazardous constituents and their impact on the canyons. Sample collection targets areas likely to be affected by upstream releases; sample collection is not at random.

Sites to be investigated and evaluated by the ER Project are collectively referred to as potential release sites (PRS). A PRS may be a SWMU or an AOC. A SWMU is defined in the HSWA Module (EPA 1990, 1585) as "any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such

units include any area at or around a facility at which solid wastes have been routinely and systematically released." Radioactive materials and some hazardous substances (as defined under the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] and listed in 40 CFR 302 [EPA 1990, 0093]) are not included in the RCRA definitions of solid waste, hazardous waste, and hazardous constituents and are not subject to the provisions of the HSWA Module. However, the IWP (LANL 1996, 55574) indicates that the ER Project will address the potential release of radioactive and hazardous substances not regulated by RCRA. Any suspected release of a hazardous waste or hazardous waste constituent which is not directly associated with a SWMU is called an AOC. The different geologic media of the canyons system—sediments, groundwater-bearing zones, and contaminant source material—which lack SWMUs, are considered to be AOCs for purposes of the canyons investigations.

1.4.2 CERCLA, NEPA, and DOE Orders

Sections 1.2.1.3 and 1.2.1.4 of the IWP (LANL 1996, 55574) discuss the integration of the RCRA-based ER Project with applicable requirements of CERCLA and the National Environmental Policy Act. Additionally, the ER Project will comply with other applicable federal acts, state statutes, and DOE orders and policy statements. Chapter 5 of this document discusses further the regulatory basis and requirements for investigation of the canyon systems and the implementation of the general technical approach for addressing those requirements.

DOE orders applicable to the ER Project are identified in Annex I (Program Management Plan) of the 1993 version of the IWP (LANL 1993, 26077) (all annexes to the 1993 IWP are current with the 1996 IWP update but incorporated by reference in the latter; thus, reference is made to the 1993 IWP where the annexes are actually located). Compliance with the requirements of these orders is integral to all Laboratory operations and is ensured through the documented policies, planning, auditing, and work review procedures of the Laboratory.

1.4.3 Assessment of Natural Resource Damage

CERCLA Section 120 extends the liability for natural resource damage to federal facilities, which includes the Laboratory. The first part of a natural resource damage assessment is a preassessment screen as described at 43 CFR 11 (Department of the Interior 1993, 43390). The preassessment screen is used to determine whether a full natural resource damage assessment is appropriate and should be integrated with the CERCLA ecological assessment process for the canyons. The proposed RCRA Subpart S also requires that releases from SWMUs be addressed; specific methods to evaluate natural resource damage are currently being discussed by the ER Project, NMED, and EPA. Information gathered during ecological impact assessment activities in canyons investigations will create a baseline that will be used to assess the damage to natural resources. Any modifications of the general procedure will be described in investigation reports. This procedure is consistent with DOE guidance (DOE 1991, 8641). Natural resource damage assessment is not a direct regulatory requirement under this document. If ecological risk assessments are necessary, as required under RCRA and as performed under the CERCLA process, then the environmental impacts or damages will be evaluated through these existing programs. The need to integrate these requirements with natural resource damage assessments will be determined on a site-specific basis by the lead trustee (DOE).

1.5 Environmental Restoration Project Guidance

The IWP (LANL 1996, 55574) specifies the ER Project's technical and managerial approaches for compliance with the HSWA Module and other regulatory obligations. As illustrated in Table 1-2, the IWP has been prepared and is updated annually in accordance with the requirements of the HSWA Module. The IWP provides overall direction to the ER Project; specific guidance on the preparation of work plans for RFIs conducted under the project; detailed description of the facility (the Laboratory);

and programmatic-level plans for data collection QA, data management, health and safety, and public involvement. The IWP also contains the Schedule of Compliance for HSWA regulatory obligations.

Each work plan for PRS-based RFIs deals with the investigation of a specific operable unit and provides (with the guidance of the IWP and in accordance with the requirements of the HSWA Module) detail on that operable unit with respect to environmental setting, source and contaminant characterization, and identification of potential receptors. Each PRS-based RFI work plan also details the technical approach to investigation of the operable unit using the general approach of the IWP for guidance and includes operable unit-specific plans for data collection QA, data management, health and safety, and public involvement.

Each work plan for PRS-based RFIs uses the IWP for both guidance and as a referenceable source of information regarding the history of the Laboratory and its operations. Accordingly, reference to existing text in the IWP that describes programmatic-level issues and general facility history and status is made in this core document, in the subsequent canyon- or canyon aggregate-specific SAPs (which are focused on affected media and AOCs), and in every work plan for PRS-based RFIs.

The QAPP (LANL 1996, 53450) provides guidance on the procedures and methods employed to ensure that environmental data of the desired quality are available for the decision-making process. The QAPP addresses quality objectives for measurement data, as determined by the data quality objectives process, and the sampling and analysis procedures to be implemented to achieve the quality objectives. It discusses the QC requirements for the data collection process, including the need to define acceptance criteria for certain QC procedures and samples. It provides guidance for QA assessments and response actions. The QAPP also presents guidance on personnel training; sample handling and custody; and data management, review, validation, and verification. In addition to requirements for measurement data, the QAPP also provides guidance for using archived and nonmeasurement data. Wherever possible, the appropriate ER Project administrative and quality procedures and standard operating procedures to be used in conducting the investigation are cited in applicable sections of the QAPP. Each of the canyon- or canyon aggregate-specific SAPs will follow the QAPP guidance in specifying detailed QA/QC procedures for the investigation.

1.6 Organization of This Document

This document contains seven chapters, four annexes, and three appendixes, as listed below.

Chapters

Chapter 1, this chapter, gives a brief introduction to the overall regulatory, operational, and environmental setting.

Chapter 2 provides background on the prehistoric and modern land uses within the investigation areas, including a discussion of general contaminant sources, and current environmental surveillance and protection programs.

Chapter 3 describes the environmental setting for the Pajarito Plateau.

Chapter 4 develops the conceptual model in and through the canyon systems and its implications in shaping the overall investigation efforts.

Chapter 5 describes the general technical approach that will be followed in the canyons investigations.

Chapter 6 explains the human health and ecological risk assessment considerations and approach for evaluating the data derived from canyons investigations.

Chapter 7 discusses reporting of findings of the investigations, and refinements to the conceptual model during the course of the investigations.

Annexes

Annex I presents a general project management plan for Field Unit 4 along with an implementation schedule for canyons investigations.

Annex II is the overall health and safety plan for Field Unit 4 field operations.

Annex III is a brief description of the records management plan.

Annex IV describes the general public involvement plan for obtaining and maintaining stakeholder interest and communication in canyons investigation activities.

Appendixes

Appendix A contains the fold-out color maps referenced in the text.

Appendix B contains the detailed plant and animal checklists used for ecological evaluations.

Appendix C lists the individuals who contributed to this document.

A list of acronyms precedes this introductory chapter. Definitions of unfamiliar terms can be found in the IWP (LANL 1993, 26078) and in the 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 length, area, and volume measurements.

REFERENCES FOR CHAPTER 1

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

Department of the Interior, October 1, 1993. "Natural Resource Damage Assessments" 43 CFR Part 11, Federal Register, Office of the Secretary, Washington, DC. **(Department of the Interior 1993, ER ID Number 43390)**

DOE (US Department of Energy), June 1991. "Natural Resource Trusteeship and Ecological Evaluation for Environmental Restoration at Department of Energy Facilities," DOE/EH-0192, National Technical Information Service, US Department of Commerce, 5285 Port Royal Road, Springfield, Virginia, 22161. **(DOE 1991, ER ID Number 8641)**

EPA (US Environmental Protection Agency), May 1989. "Interim Final RCRA Facility Investigation (RFI) Guidance, Vol. I of IV, Development of an RFI Work Plan and General Considerations for RCRA Facility Investigations," EPA/530-SW-89-031, OSWER Directive 9502.00-6D, Office of Solid Waste, Washington, DC. **(EPA 1989, ER ID Number 8794)**

EPA (US Environmental Protection Agency), March 29, 1990. "Hazardous Waste Management Systems; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions," final rule, Title 40 Parts 261, 264, 265, 268, 271, and 302, Federal Register, Vol. 55, No. 61, p. 11798. **(EPA 1990, ER ID Number 0093)**

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

EPA (US Environmental Protection Agency), July 27, 1990. "Corrective Action for Solid Waste Management Units (SWMUs) at Hazardous Waste Management Facilities," proposed rule, Title 40 Parts 264, 265, 270, and 271, Federal Register, Vol. 55, pp. 30798–30884. **(EPA 1990, ER ID Number 31277)**

LANL (Los Alamos National Laboratory), November 1993. "Installation Work Plan for Environmental Restoration," Revision 3, Vol. I, Los Alamos National Laboratory Report LA-UR-93-3987, Los Alamos, New Mexico. **(LANL 1993, ER ID Number 26077)**

LANL (Los Alamos National Laboratory), November 1993. "Installation Work Plan for Environmental Restoration," Revision 3, Vol. II, Los Alamos National Laboratory Report LA-UR-93-3987, Los Alamos, New Mexico. **(LANL 1993, ER ID Number 26078)**

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

LANL (Los Alamos National Laboratory), November 1995. "Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon," Los Alamos National Laboratory Report LA-UR-95-2053, Los Alamos, New Mexico. **(LANL 1995, ER ID Number 50290)**

2.0 BACKGROUND

This chapter describes the past uses of the canyon systems and adjacent areas, from prehistoric time to the present day. This chapter also discusses the environmental protection program and surface water, sediment and groundwater monitoring programs in operation at the Laboratory, and special studies conducted in support of those programs.

Each of the canyon- or canyon aggregate-specific sampling and analysis plans (SAPs) will include a discussion of canyon-specific information about the known contamination that has been released into the canyons under investigation. This discussion will cover the potential sources of past and current contamination (solid waste management units [SWMUs] and other potential release sites [PRSs] located adjacent to or within the canyons), and what is known of the nature and distribution of contamination in the canyons.

2.1 Description

The Laboratory is located in Los Alamos County in north-central New Mexico. It is situated approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (see Figure 1-1, Chapter 1 of this core document). Most of the Laboratory and community developments are confined to mesa tops, although some of the Laboratory technical areas have facilities located in canyon floors. The surrounding land is largely undeveloped with large tracts of land north, west, and south of the Laboratory held by the Santa Fe National Forest, United States (US) Bureau of Land Management, Bandelier National Monument, US General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east (LANL 1996, 55574).

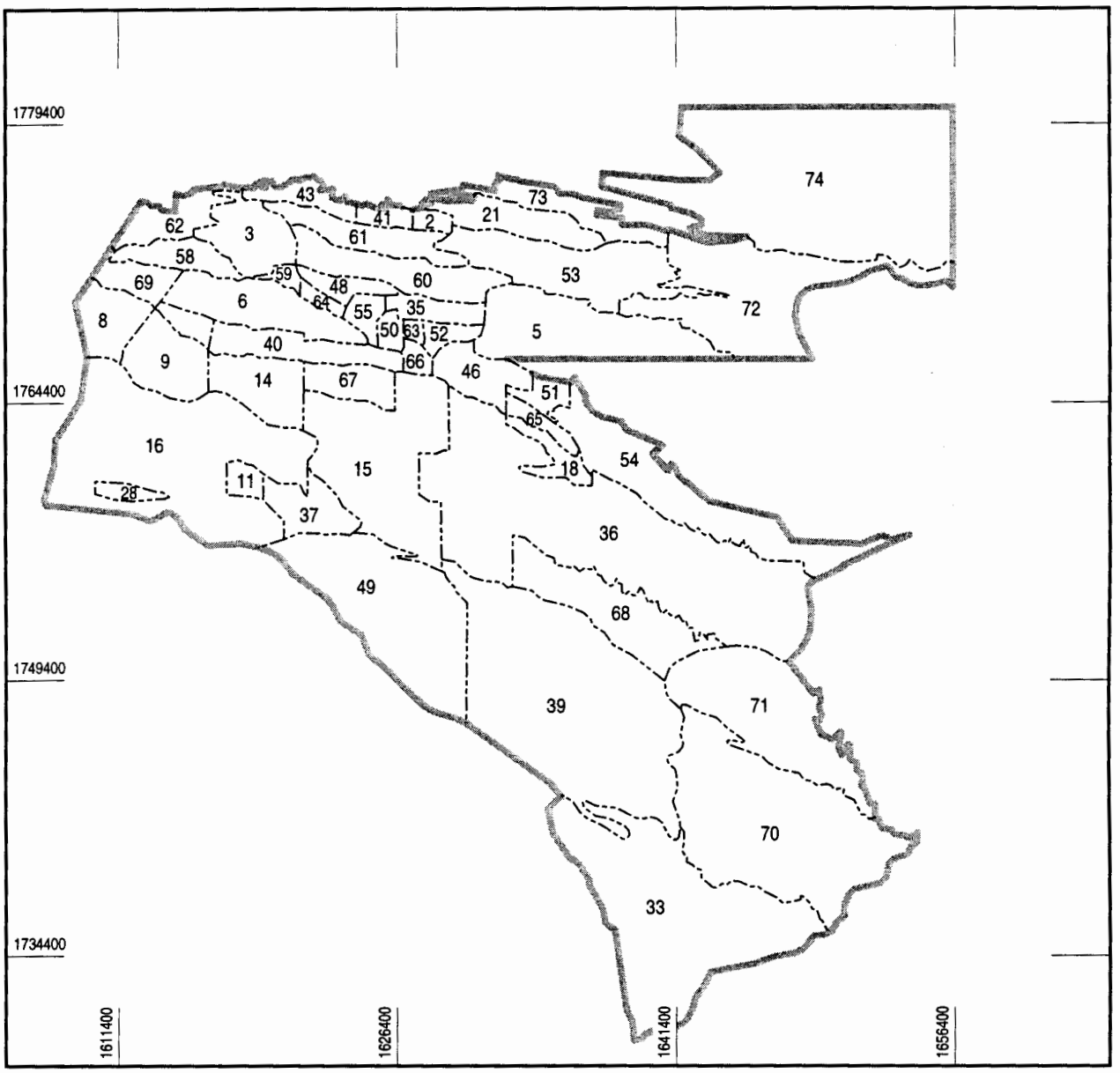
Laboratory land is used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way. The facility is divided into technical areas each of which has a specific research function or other use (Figure 2-1). However, the developed sites account for only a small part of the total land area. Most land provides isolation for security and safety purposes and is held in reserve for future use (LANL 1995, 50124).

2.1.1 Overview of the Area

The 111-km^2 (43-mi^2) Laboratory site and Los Alamos and White Rock communities are situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep, west-to-east-oriented canyons cut by ephemeral and intermittent streams. Mesa tops range in elevation from approximately 2,350 m (7,700 ft) on the flanks of the Jemez Mountains to about 1,900 m (6,200 ft) at their eastern termination above the Rio Grande Valley and White Rock Canyon (LANL 1996, 55574).

The mesas in the Laboratory area are made up of the Bandelier Tuff, which consists of ignimbrite and ash-fall and pumice-fall deposits. These tuff deposits are up to at least 250 m (820 ft) thick in the western part of the plateau and thin eastward to about 60 m (200 ft) or less above the Rio Grande (Broxton and Reneau 1996, 55429). The Bandelier Tuff was deposited as a result of a series of major volcanic eruptions in the Jemez Mountains about 1.2 and 1.6 million years ago (Izett and Obradovich 1994, 48817; Spell et al. 1996, 55542).

In the western portion of the Pajarito Plateau, the tuff overlies the Tschicoma Formation, which consists of older volcanic rocks that form the eastern Jemez Mountains. In the central and eastern parts of the plateau, the tuff is underlain by the fanglomerate of the Puye Formation and basaltic rocks of the Cerros del Rio volcanic field. Cerros del Rio basalts interfinger with the Puye Formation.



Source: LANL 1995, 50124

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0 10000 20000

FEET

Coordinates are NMSP NAD-83

N

Technical Area boundary

Laboratory boundary

Figure 2-1. Technical areas at the Los Alamos National Laboratory.

Conservation and Recovery Act (RCRA) closures and compliance with the Laboratory's environmental permits (the National Pollutant Discharge Elimination System [NPDES], and the RCRA Hazardous Waste Facility Permit with the Hazardous and Solid Waste Amendments [HSWA] Module VIII requirements for groundwater monitoring.) (LANL 1995, 50124).

To comply with the NPDES permit, the Laboratory has four primary programs: the Sanitary Wastewater Systems Consolidation (SWSC) Project, the Storm Water Pollution Prevention Plan, the Waste Stream Identification and Characterization (WSC) Program, and the Spill Prevention Control and Countermeasures (SPCC) Program.

The Laboratory also maintains a groundwater monitoring network to detect any effects that Laboratory activities may have on the quality of the regional aquifer. The Laboratory's Groundwater Protection Management Program Plan (GPMPP) addresses environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations (LANL 1995, 50124).

2.3.2 Protection Programs

2.3.2.1 Corrective Actions

The ER Project (established in 1987) implements the DOE's policy to protect natural resources and restore those damaged by contamination from past releases of hazardous substances and radionuclides. The ER Project goals include: (1) ensurance that the environmental impacts of Laboratory activities are thoroughly investigated and that corrective actions are taken; (2) compliance with RCRA, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Environmental Policy Act, the Atomic Energy Act, and other applicable regulations and orders; and (3) provision of mechanisms through which interested parties can participate in the corrective action review process (LANL 1995, 50124).

2.3.2.2 Decommissioning Project

The Decommissioning Project at the Laboratory was established in 1989 to remove nonoperational, contaminated facilities. The Decommissioning Project responsibilities include assessment and cleanup of facilities and equipment not regulated under CERCLA or RCRA. The Decommissioning Project has been integrated with the ER Project to enhance cleanup efforts. All activities are conducted in accordance with federal and state requirements and DOE orders applicable to nuclear facilities and other facilities that generate radioactive and hazardous materials and wastes (LANL 1995, 50124)

2.3.2.3 RCRA Closures

RCRA mandates a program to regulate hazardous wastes from generation through disposal. The program emphasizes the reduction of hazardous waste volume, mobility, and toxicity and requires treatment of hazardous waste before disposal. Contaminated PRSs may be subject to the corrective action requirements of RCRA. Recently active SWMUs managing hazardous wastes may be subject to the closure provisions of RCRA (LANL 1995, 50124).

All corrective actions conducted by the Laboratory are to comply specifically with the RCRA regulations. Laboratory sites are assessed and, if necessary, remediated by either voluntary corrective actions, corrective measures implementation, or RCRA closure. These activities ensure that releases are identified and either mitigated or eliminated (LANL 1996, 55574). The ER Project may be responsible for the implementation of corrective actions at PRSs and some SWMUs or the closure provisions of RCRA.

2.3.2.4 Emergency Management and Response

The Laboratory maintains an emergency management and response system that, through emergency planning, preparedness, and effective response capabilities, is capable of responding to and mitigating the potential consequences of emergencies (LANL 1995, 50124).

2.3.2.5 Compliance with the NPDES Permit

NPDES was established by the Clean Water Act (CWA) and requires permitting of all point-source effluent discharges into the nation's waters. The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Specific criteria for an effluent must be met before that effluent can be discharged into the environment. The Laboratory has two NPDES permits, one for Laboratory facilities and one for operations at the Fenton Hill hot-dry-rock geothermal facility (LANL 1995, 50124).

The Laboratory has established the SWSC Project and taken other actions to reduce the number of NPDES outfalls, correct deficiencies in outfalls, and improve compliance with the provisions of the NPDES permit. As part of the SWSC Project, a new, centralized, sanitary wastewater treatment plant was constructed at TA-46 to replace the TA-3 wastewater treatment plant and 6 smaller treatment facilities that consistently failed to meet NPDES discharge regulations. The new treatment plant will also eliminate the need for approximately 30 septic tank systems and result in a significant savings in operating and maintenance costs (LANL 1995, 50124).

2.3.2.6 Corrective Activities Program

The Corrective Activities Program includes activities designed to bring active or standby facilities into compliance with ambient air, water, and solid waste regulations and agreements. The program is responsible for compliance with CWA and other requirements for effluent discharge, including WSC and SPCC (LANL 1995, 50124).

2.3.3 Groundwater Monitoring

Groundwater protection activities at the Laboratory include installation of an extensive groundwater monitoring system for assessment of water quality (in conjunction with the Laboratory's Hydrogeologic Workplan [LANL 1996, 55430]).

The existing groundwater monitoring network in the Los Alamos area consists of a variety of supply wells, test wells, observation wells, and springs located on-site and outside the Laboratory boundary. Scientists routinely sample and analyze water from wells and springs for radioactive and toxic constituents, for basic water quality parameters, and for evidence of resource depletion. Results are published in the annual environmental surveillance report, for example, *Environmental Surveillance at Los Alamos during 1992* (Environmental Protection Group 1994, 35363) and the annual water supply report, for example, *Water Supply at Los Alamos during 1991* (Purtymun et al. 1994, 41290).

Information on groundwater monitoring and sampling requirements, design criteria, and sampling procedures and equipment can be found in the Groundwater Monitoring Plan, Appendix F of the GPMPP (LANL 1995, 50124), and the Hydrogeologic Workplan (LANL 1996, 55430). Monitoring networks for sampling the three principal groundwater-bearing zones present at the Laboratory—alluvial, intermediate perched zones, and the regional aquifer—are summarized below. A list of the monitoring stations used for environmental surveillance, the general locations, sampling rationale, and programmatic drivers is given in Table 2-2. Locations of monitoring wells are shown in Figure A-4 in Appendix A of this core document.

TABLE 2-2

CURRENT ENVIRONMENTAL SURVEILLANCE GROUNDWATER MONITORING WELLS

Station	Date Installed	East-West[a] Coordinate	North-South[a] Coordinate	Ground Elevation (ft MSL[b])	Casing Depth (ft)	Depth of Screened Interval (ft)	Purpose	Geologic Unit Screened/ Comments
Regional Aquifer Wells								
DT-10	1960	1628988	1754449	7020	1409	1080–1390	Test	Basalt, Puye Formation, Santa Fe Group
DT-5A	1960	1625310	1754789	7144	1821	1172–1392	Test	Basalt, Puye Formation, Santa Fe Group
DT-9	1960	1628994	1751493	6936	1501	1040–1500	Test	Totavi Lentil and Santa Fe Group
G-1	1950	1656191	1783609	5973	2000	282–1980	Supply	Santa Fe Group, Basalt
G-1A	1954	1655241	1784353	6014	1519	272–1513	Supply	Santa Fe Group, Basalt
G-2	1954	1654210	1785123	6056	1970	281–1960	Supply	Santa Fe Group
G-3	1951	1651676	1786218	6139	1792	441–1785	Supply	Santa Fe Group, Basalt/Off line
G-4	1951	1648949	1786452	6229	1930	426–1925	Supply	Santa Fe Group, Basalt
G-5	1951	1646950	1787907	6306	1840	462–1830	Supply	Santa Fe Group, Basalt
G-6	1964	1644824	1786851	6422	1530		Supply	Santa Fe Group
LA-1A	1946	1668082	1776927	5824	870	60–865	Observation	Alluvium, Santa Fe Group/ Plugged 1993
LA-1B	1960	1668248	1776952	5602	1750	326–1690	Observation	Santa Fe Group/No pump
LA-2	1946	1666924	1777219	5651	870	105–865	Supply	Santa Fe Group
LA-5	1948	1659826	1772533	5840	1750	440–1740	Observation	Santa Fe Group/No pump
O-1	1991	1649396	1772232	*6400.9*	2497	1017–2477	Supply	Santa Fe Group, Basalt/Off line
O-4	1991	1637337	1772995	*6639.0*	2596	1115–2596	Supply	Santa Fe Group, Basalt
PM-1	1965	1647734	1768112	*6513.2*	2499	945-2479	Supply	Santa Fe Group, Basalt
PM-2	1965	1636786	1760326	*6712.0*	2300	1001–2280	Supply	Puye Formation, Santa Fe Group, Basalt
PM-3	1966	1642631	1769426	*6610.9*	2552	956–2532	Supply	Santa Fe Group, Basalt
PM-4	1981	1635717	1764674	*6916.1*	2875	1260–2854	Supply	Puye Formation, Santa Fe Group, Basalt
PM-5	1982	1632110	1767790	*7094.0*	3093	1440–3072	Supply	Puye Formation, Basalt, Santa Fe Group
TW-1	1950	1650041	1772077	*6369.9*	642	632–642	Test	Puye Formation
TW-2	1949	1634231	1777268	*6646.4*	834	779–789	Test	Totavi Lentil
TW-3	1949	1637727	1773138	*6626.9*	815	805–815	Test	Totavi Lentil
TW-4	1950	1624048	1777680	*7242.7*	1205	1195–1205	Test	Tschicoma Formation
TW-8	1960	1632574	1769507	*6875.5*	1065	953–1065	Test	Puye Formation

a. Coordinates listed are based on the New Mexico planar coordinate system as used in the maps in Appendix A of this core document. All locations are shown in Figure A-4 of Appendix A. A more complete list of wells in the Los Alamos area is available in Appendix E of the GPMPP (LANL 1995, 50124). Locations of wells are updated continually as new wells are installed and other wells are abandoned and plugged.

b. MSL = mean sea level, the elevations in italics are either surveyed or they are taken from the Digital Elevation Model for the Laboratory; these elevations are considered to be of good quality. The remaining elevations are literature values, and they are of unknown quality.

TABLE 2-2 (continued)

CURRENT ENVIRONMENTAL SURVEILLANCE GROUNDWATER MONITORING WELLS

Station	Date Installed	East-West[a] Coordinate	North-South[a] Coordinate	Ground Elevation (ft MSL[b])	Casing Depth (ft)	Depth of Screened Interval (ft)	Purpose	Geologic Unit Screened/ Comments
Intermediate Perched Zone Wells								
TW-1A	1950	1650057	1772066	*6369.8*	225	215–225	Test	Basalt
TW-2A	1949	1634185	1777288	*6646.4*	132	127–132	Test	Puye Formation
Alluvial Groundwater Observation Wells								
APCO-1	1990	1649210	1773020	6368	19.7	4.7–14.7	Observation	Alluvium, Puye Formation/HSWA Spec Permit
CDBO-4	1985	1645475	1758547	6565	12	8–12	Observation	Alluvium, Bandelier Tuff
CDBO-5	1992	1633583	1765818	6879	17	7–17	Observation	Alluvium
CDBO-6	1992	1636209	1764760	6817	49	34–44	Observation	Band.Tuff/ Water from PM-4 pump start-up
CDBO-7	1992	1637400	1763301	6871	44	29–39	Observation	Band. Tuff/ Water from PM-4 pump start-up
CDBO-8	1992	1639294	1762366	6722	23	13–23	Observation	Alluvium, Bandelier Tuff
FCO-1	1989	1642412	1751182	6509	12.4	2.4-12.4	Observation	Alluvium, Bandelier Tuff/ Dry; HSWA Special Permit
LAO-0.3	1994	1624799	1774512	6968	8.33	5.9–10.9	Observation	Alluvium/TA-2/41 specific
LAO-0.6	1994	1626748	1774333	6910	10.54	8.0–13.0	Observation	Alluvium/TA-2/41 specific
LAO-0.7	1994						Observation	Alluvium/TA-2/41 specific
LAO-0.8	1994	1627700	1774275	6887	7.5	7.5–12.5	Observation	Alluvium/TA-2/41 specific
LAO-0.91	1994	1628654	1774207	6862	9.5	9.5–14.5	Observation	Alluvium/TA-2/41 specific
LAO-1	1966	1629395	1773956	6836	25.4	8–28	Observation	Alluvium, Band.Tuff (?)
LAO-2	1966	1637608	1773096	6593	29	12–32	Observation	Alluvium, Band.Tuff (?)
LAO-3	1966	1638011	1773098	6578	24	16–32	Observation	Bandelier Tuff (?)
LAO-3A	1989	1637981	1773100	6579	15	4.7–14.7	Observation	Alluvium
LAO-4	1966	1640752	1772729	6519	24	14–24	Observation	Bandelier Tuff (?)
LAO-4.5	1969	1643659	1772088	6452	40	10–40	Observation	Alluvium, Puye Formation (/)
LAO-4.5A	1989	1643500	1772052	6460	18.5	8.5–18.5	Observation	Basalt/Dry; HSWA Special Permit
LAO-4.5B	1989	1643512	1772055	6459	34.9	24.9–34.9	Observation	Puye Formation (/) Dry; HSWA Special Permit
LAO-4.5C	1989	1643547	1772077	6458	23.3	13.3–23.3	Observation	Alluvium, Puye Formation (/) Dry; HSWA Special Permit
LAO-6	1966	1646222	1771330	6395	16	6–16	Observation	Basalt/Dry
LAO-6A	1989	1646222	1771344	6396	14.2	4.2–14.2	Observation	Alluvium, Puye Formation (/) HSWA Special Permit
LAO-B	1994	1615149	1775170	7323	14.24	11.8–26.8	Observation	Alluvium/Background

a. Coordinates listed are based on the New Mexico planar coordinate system as used in the maps in Appendix A of this core document. All locations are shown in Figure A-4 of Appendix A. A more complete list of wells in the Los Alamos area is available in Appendix E of the GPMPP (LANL 1995, 50124). Locations of wells are updated continually as new wells are installed and other wells are abandoned and plugged.

b. MSL = mean sea level, the elevations in italics are either surveyed or they are taken from the Digital Elevation Model for the Laboratory; these elevations are considered to be of good quality. The remaining elevations are literature values, and they are of unknown quality.

TABLE 2-2 (continued)

CURRENT ENVIRONMENTAL SURVEILLANCE GROUNDWATER MONITORING WELLS

Station	Date Installed	East-West[a] Coordinate	North-South[a] Coordinate	Ground Elevation (ft MSL[b])	Casing Depth (ft)	Depth of Screened Interval (ft)	Purpose	Comments
LAO-C	1970	1622158	1775250	7050	12.2	3–13	Observation	Alluvium/Baseline well
MCO-3	1967	1627363	1770237	7053	12	2–12	Observation	Alluvium, Bandelier Tuff
MCO-4	1963	1631215	1769786	*6897.5*	19	14–19	Observation	Alluvium, Bandelier Tuff
MCO-4A	1989	1632028	1769700	*6886.6*	19.4	9.4–19.4	Observation	Alluvium, Bandelier Tuff/ HSWA Special Permit
MCO-4B	1990	1632036	1769695	*6886.7*	33.9	8.9–28.9	Observation	Alluvium, Bandelier Tuff/ HSWA Special Permit
MCO-5	1965	1632466	1769537	*6875.7*	46	21–46	Observation	Alluvium, Bandelier Tuff
MCO-6	1974	1633634	1769012	*6849.5*	47	27–47	Observation	Alluvium, Bandelier Tuff/ Replaces original MCO-6
MCO-6A	1989	1633633	1768961	*6849.7*	36	22.7–32.7	Observation	Alluvium, Bandelier Tuff/ HSWA Special Permit
MCO-6B	1990	1633630	1768982	*6850.3*	47.1	22–42	Observation	Alluvium, Bandelier Tuff/ HSWA Special Permit
MCO-7	1960	1634516	1768508	*6827.3*	69	39–69	Observation	Alluvium, Cerro Toledo interval
MCO-7.5	1961	1635463	1768496	*6808.9*	60	35–60	Observation	Alluvium, Bandelier Tuff
MCO-7A	1989	1634501	1768508	*6827.6*	44.8	34.8–44.8	Observation	Alluvium, Bandelier Tuff
MCO-8	1960	1636021	1768529	*6796.7*	84	64–84	Observation	Bandelier Tuff, Cerro Toledo interval/Out of service since 1977
PCO-1	1985	1637919	1759991	6687	12.3	4.3–12.3	Observation	Alluvium, Bandelier Tuff
PCO-2	1985	1641700	1757443	6618	9.5	1.5–9.5	Observation	Alluvium, Bandelier Tuff
PCO-3	1985	1646089	1755489	6547	17.7	5.7–17.7	Observation	Alluvium, Bandelier Tuff
SCO-1	1989	1642298	1769502	6619	19.3	9.3–19.3	Observation	Alluvium/Dry; HSWA Special Permit
SCO-2	1989	1647259	1767864	6501	19.4	9.4–19.4	Observation	Alluvium, Bandelier Tuff/ Dry; HSWA Special Permit
WCO-1	1989	1632759	1755069	6616	34.4	24.4–34.4	Observation	Alluvium (?), Bandelier Tuff/ Dry; HSWA Special Permit
WCO-2	1989	1636870	1753228	6625	23.5	13.5–23.5	Observation	Alluvium, Bandelier Tuff/ Dry; HSWA Special Permit
WCO-3	1989	1640213	1750620	6436	12.4	9–14	Observation	Alluvium, Basalt/Dry

a. Coordinates listed are based on the New Mexico planar coordinate system as used in the maps in Appendix A of this core document. All locations are shown in Figure A-4 of Appendix A. A more complete list of wells in the Los Alamos area is available in Appendix E of the GPMPP (LANL 1995, 50124). Locations of wells are updated continually as new wells are installed and other wells are abandoned and plugged.

b. MSL = mean sea level, the elevations in italics are either surveyed or they are taken from the Digital Elevation Model for the Laboratory; these elevations are considered to be of good quality. The remaining elevations are literature values, and they are of unknown quality.

Source: LANL 1995, 50124

2.3.3.1 Regional Aquifer Monitoring

Measurements of the quality of water in the regional aquifer are made at various locations in and around the Laboratory at least once a year. There are 8 deep test wells and 14 supply wells that belong to DOE. There are also several regional aquifer wells near the Rio Grande that do not belong to DOE. These wells are on San Ildefonso Pueblo land and are sampled under the memoranda of understanding (MOU) between the US Bureau of Indian Affairs (BIA), DOE, and the Laboratory. In addition there are many springs along the Rio Grande that are sampled. Springs are discussed in Section 2.3.3.4.

Deep test wells include TW-1 and TW-2 in Pueblo Canyon; TW-3 in Los Alamos Canyon; TW-4 near Acid Canyon; TW-8 in Mortandad Canyon; and DT-5A, DT-9, and DT-10 on Frijoles Mesa near the southwestern boundary of the Laboratory between Water Canyon and Ancho Canyon. Test wells TW-1, TW-2, TW-3, TW-4, and TW-8 are located in or near canyons that have received or are now receiving industrial effluents. The test wells were constructed between 1949 and 1960 using cable-tool drilling methods. All test wells are equipped with pumps and continuous recording transducers.

DOE supply wells include the Guaje well field, the Pajarito Mesa wells, and the Otowi well O-4. The Guaje wells are G-1, G-1A, G-2, G-4, and G-5 in Guaje Canyon and G-6 in Rendija Canyon. The Pajarito Mesa wells are PM-1 and PM-3 in Sandia Canyon, PM-2 in Pajarito Canyon, PM-4 in Cañada del Buey, and PM-5 between Cañada del Buey and Mortandad Canyon. Otowi well O-4 is in Los Alamos Canyon. These wells are also equipped with dedicated pumps and either continuous recording water-level transducers or airline recorders.

Two supply wells that are not currently being used to monitor the regional aquifer are Guaje well G-3 and Otowi well O-1. Well G-3 was taken off line in 1993 because of a decline in production and sand in the pump. Well O-1 does not have a turbine pump because the borehole was drilled too crookedly to allow for the installation of one.

The depth to water varies between wells that are located on canyon floors and those located on mesa tops. Depth to water also varies with location on the Pajarito Plateau, depending on how close to the mountains or to the eastern edge of the plateau the well is located.

Regional aquifer wells are sampled for standard analysis of 10 radiochemical constituents (^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, total uranium, ^{3}H, and gross-alpha, -beta, and -gamma radiation); metals (Ag, Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Tl, V, and Zn); general inorganic constituents (SiO_2, Ca, Mg, K, Na, CO_3, HCO_3, PO_4, SO_4, NO_3, CN, total dissolved solids, total hardness, total suspended solids, pH, and electrical conductance); and organic compounds (volatiles, semivolatiles, individual herbicides, pesticides, polychlorinated biphenyls [PCBs], and oils or solvents). Regional aquifer supply wells are sampled annually for radiochemical constituents, metals, and general inorganic constituent analyses, and triennially for organic compound analysis. Regional aquifer test wells are sampled annually for radiochemical and major constituent analyses and triennially for trace metal and organic compound analyses.

Regional aquifer wells on San Ildefonso Pueblo land that are sampled under the MOU include LA-1A, LA-1B, LA-2, LA-5. Residential or community wells sampled under the MOU include Otowi House well, Halladay House well, New Community well, Martinez House well, Sanchez House well, and Pajarito Well Pumps 1 and 2. Wells LA-1A and LA-1B are observation wells, whereas the others are supply wells for San Ildefonso Pueblo. No information is currently available on the construction of wells other than the LA-wells; thus they are not listed in Table 2-2. The wells to be sampled and analyzed are determined annually under the terms of the MOU. Wells chosen for sampling will vary from year to year. Other San Ildefonso Pueblo wells that are sometimes sampled for special studies are the Old Community well, Westside Artesian well, Eastside Artesian well, and Don Juan Playhouse well.

Regional aquifer springs sampled include 22 springs in White Rock Canyon and 6 springs on San Ildefonso Pueblo land near the confluence of Los Alamos Canyon with the Rio Grande. White Rock Canyon springs are sampled and analyzed annually for 7 radiochemical constituents (^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, tritium, total uranium, and gross-gamma activity) and general inorganic constituents, and triennially for metals. Selected springs are sampled and analyzed annually for PCBs.

TABLE 2-3

CURRENT SPRINGS SAMPLED IN THE ENVIRONMENTAL SURVEILLANCE PROGRAM

Spring	East-West Coordinate[a]	North-South Coordinate[a]	Elevation (ft MSL[b])	Source (Geologic Unit)
Alluvial				
Water Canyon Gallery	1604144	1762562	8000	Bandelier Tuff
Intermediate				
Basalt Spring	1656544	1770762	6000	Landslide blocks over Puye Formation
Regional Aquifer				
Ancho Spring	1645644	1739962	5700	Totavi Lentil
Doe Spring	1642325	1733598	5600	Cerros del Rio maar deposits
Indian Spring	1665944	1777262	5640	Santa Fe Group (?)
La Mesita Spring	1656544	1770762	5580	Santa Fe Group (?)
Rio Spring 1	1667928	1767857	5615	Unknown
Rio Spring 2	1667312	1766348	5600	Unknown
Rio Spring 2A	1662644	1754862	5495	Landslide blocks over Santa Fe Group
Rio Spring 3	1661487	1753562	5560	Landslide blocks
Rio Spring 3A	1661520	1753298	5560	Landslide blocks
Rio Spring 3AA	1661291	1751050	5560	Landslide blocks
Rio Spring 3B	1661354	1749814	5500	Unknown
Rio Spring 4	1656028	1747887	5570	Landslide blocks
Rio Spring 4A	1656144	1747862	5570	Landslide blocks
Rio Spring 5	1656056	1742541	5770	Unknown
Rio Spring 5A	1655365	1742005	5395	Unknown
Rio Spring 5AA	1651144	1742562	5760	Unknown
Rio Spring 5B	1561044	1738162	5390	Unknown
Rio Spring 6	1648882	1735517	5380	Unknown
Rio Spring 6A	1646562	1734272	5375	Unknown
Rio Spring 7	1645044	1733562	5370	Unknown
Rio Spring 8	1644444	1733462	5370	Unknown
Rio Spring 8A	1643818	1733508	5520	Cerros del Rio maar deposits
Rio Spring 8B	1643244	1733562	5480	Cerros del Rio maar deposits

a. Coordinates listed are based on the New Mexico planar coordinate system as used in the maps in Appendix A of this core document. All locations are shown in Figure A-4 of Appendix A.

b. MSL = mean sea level

TABLE 2-3 (continued)

CURRENT SPRINGS SAMPLED IN THE ENVIRONMENTAL SURVEILLANCE PROGRAM

Spring	East-West Coordinate[a]	North-South Coordinate[a]	Elevation (ft MSL[b])	Geologic Unit Spring Issuing From
Rio Spring 9	1643435	1733317	5485	Cerros del Rio maar deposits
Rio Spring 9A	1642742	1733147	5525	Cerros del Rio maar deposits
Rio Spring 10	1638023	1728162	5360	unknown
Sacred Spring	1670044	1780362	5640	Santa Fe Group
Sandia Spring	1663182	1761490	5700	Totavi Lentil
Other Springs (Occasional Sampling)				
American Spring	1601044	1760062	8280	Tschicoma Fm. /Bandelier Tuff contact
Apache Spring	1599144	1753662	8320	Bandelier Tuff
Armstead Spring	1599744	1762762	8216	Alluvium/Tschicoma contact
Bulldog Spring	1614970	1767245	~7450	Alluvium/Bandelier Tuff contact
Burning Ground Spring	1614275	1764630	~7500	Bandelier Tuff
Charlies Spring	1613350	1767790	~7500	Bandelier Tuff
DP Spring	1636615	1773713	~6900	Alluvium/Bandelier Tuff contact
Frijoles Spring 1	1592344	1759562	8430	Tschicoma Fm.
Guaje Spring 1	1600444	1797762	8850	Bandelier Tuff
Guaje Spring 2	1600444	1796062	8840	Bandelier Tuff
Hamilton Bend Spring	1642844	1776162	~6510	Alluvial Terrace
Homestead Spring	1614275	1768555	~7350	Bandelier Tuff
Los Alamos Spring	1657444	1770962	6000	Landslide Deposit
Otowi Seep	Unknown	Unknown		unknown
PC Spring	1601844	1773262	8660	Alluvium/Bandelier Tuff contact
Quemazon Spring	1603044	1788462	8660	Alluvium/Bandelier Tuff contact
Reservoir Spring	1605944	1778862	8000	Alluvium/Bandelier Tuff contact
Rio Spring 8B	1643244	1733562	5480	Cerros del Rio maar deposits
Rio Spring 9B	1642437	1732938	~6100	Cerros del Rio maar deposits
Skate Spring	1617130	1776080	~7200	unknown
Starmer Spring	1613260	1767830	~7500	Bandelier Tuff
SWSC Line Spring	1613905	1764760	~7450	Bandelier Tuff
TA-18 Spring	1634193	1760782	~6750	Colluvium/Bandelier Tuff contact
Valle Spring 1	1604144	1766462	8260	Alluvium/Bandelier Tuff contact
Valle Spring 2	1604344	1766582	8240	Alluvium/Bandelier Tuff contact

a. Coordinates listed are based on the New Mexico planar coordinate system as used in the maps in Appendix A of this core document. All locations are shown in Figure A-4 of Appendix A.

b. MSL = mean sea level

An intermediate perched groundwater zone in lower Los Alamos Canyon is regularly sampled at Basalt Spring. Although the main source of water for Basalt Spring is believed to be an intermediate perched

On-site sediment monitoring stations located in former radioactive effluent release areas include two stations within DP Canyon, six stations within Los Alamos Canyon, and seven stations within Mortandad Canyon (see Table 2-4). Eleven on-site sediment monitoring stations, included in the other canyons category, are listed in Table 2-4.

Sediments from natural drainages around two on-site radioactive solid waste management areas, TA-49 and TA-54, are sampled and analyzed to monitor for transport of radioactivity from surface contamination. The sediment sampling locations at these areas are shown in Figure A-4 of Appendix A of this core document but are not listed in Table 2-4 because they are devoted to technical-area-specific monitoring. In 1960, a surface contamination incident occurred at TA-49 which resulted in erosional transport of radioactively contaminated soil. Eleven on-site sediment sampling locations were established in 1972 to monitor surface sediment in a natural drainage leading away from TA-49. An additional location was added in 1981 as the drainage channel changed. Nine sediment sampling locations were established in 1982 outside the perimeter fence at TA-54, Area G, to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area.

2.3.5.2 Geomorphic Studies

Several geomorphic studies have been completed within discrete segments of several canyons. These studies have contributed significantly to the general understanding of the age of sedimentary deposits in the canyons (Drake and Inoué 1993, 53456; Drakos and Inoué 1994, 48850; Reneau 1995, 50143; Reneau et al. 1996, 55539). Data indicate that sedimentary deposits and geomorphic surfaces in the canyons are generally less than 10,000 years old and include post-1942 historical deposits (Reneau et al. 1996, 55539).

A geomorphic study completed in 1991 (Graf 1994, 55536) provides a historic perspective for evaluating the contributions of plutonium from Los Alamos Canyon to the Rio Grande. The study used historic aerial photography and hydrologic data to evaluate the movement and deposition of sediment over time. Several conclusions were made regarding the regional balance of deposited plutonium in the sediment from 1948 to 1985, accounting for both worldwide fallout and the Laboratory contribution from Los Alamos Canyon to the northern Rio Grande.

- Worldwide fallout accounts for more than 90% of the plutonium in the Rio Grande system; the Laboratory contributes slightly less than 10%.
- Approximately half the total plutonium in the Rio Grande system resides in sediment along the Rio Grande; the remainder is stored in sediments in the Elephant Butte Reservoir.
- Most of the Laboratory contributions remain stored in sediment along the Rio Grande between the mouth of Los Alamos Canyon and Peña Blanca (just downstream from Cochiti Dam). Since 1973 when Cochiti Dam was completed, the downstream movement has ended in Cochiti Reservoir.

The geomorphic study identified locations where sediments had been deposited during specific periods. A sediment sample was collected from a floodplain near Buckman (near Cañada Ancha and east of the mouth of Sandia Canyon) that was hydrologically active between 1941 and 1968. The sample was collected specifically for the analysis of plutonium isotopes by high-sensitivity mass spectrometry. The ratio of ^{239}Pu to ^{240}Pu in the sample indicated that the plutonium consisted of an equal mixture of worldwide fallout and Laboratory-produced material transported through Acid Canyon, Pueblo Canyon, and Los Alamos Canyon. The total activity of the two plutonium isotopes (0.017 pCi/g) was less than the average value for fallout in northern New Mexico (0.023 pCi/g) (Purtymun et al. 1987, 6687). Thus, only the isotopic ratio, not an elevated concentration, identified the contribution as being from historic Laboratory releases.

2.3.6 Surface Water Monitoring

Since 1945, water-quality data have been collected and published. The USGS monitored the effects of releases of radioactive effluents and conducted geohydrological studies in the Los Alamos area for the AEC from 1949 through 1969. Results of these studies are available in a series of reports and publications (references compiled for use in the ER Project in Bennett [1990, 7507]). Starting in 1970, the Laboratory initiated a formal environmental monitoring program. This monitoring program, which is now required by DOE Order 5400.1 (DOE 1988, 0075), continues under the direction of the Laboratory's ESH Division.

The surface water sampling locations are generally collocated with the sediment sampling locations discussed in the previous section, and the rationale for location is similar. Table D-10 in *Environmental Surveillance at Los Alamos during 1991* (Environmental Protection Group 1993, 23249) (see Table 2-5) lists 10 perimeter surface water monitoring stations, and 12 on-site surface water monitoring stations as shown in Figure A-4 in Appendix A of this core document.

Chemical analyses include major ions (calcium, sodium, magnesium, potassium, chloride, sulfate, fluoride, and bicarbonate); radionuclides (tritium, ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{234}U, ^{235}U, ^{238}U, and gross-alpha and -beta); and trace elements. Results of chemical analyses, generally obtained on unfiltered water samples from these monitoring stations, are tabulated in Laboratory reports of special studies and in the annual environmental surveillance reports. Analyses of these unfiltered water samples are not directly comparable to New Mexico Water Control Commission standards, which are largely based on filtered water samples. References to the annual environmental surveillance reports and reports of numerous special studies are contained in Chapter 3 of this core document.

2.3.7 Reporting

The results of groundwater, surface water, sediment and soil sampling, analysis and protection efforts at the Laboratory are published in the annual environmental surveillance reports and the annual water supply reports. These two reports are described below.

2.3.7.1 Annual Environmental Surveillance Reports

The purpose of the environmental surveillance reports is to provide a comprehensive source of environmental data collected at the Laboratory. Since the early 1970s, the Laboratory has routinely collected and analyzed samples of air, water, soil, and foodstuffs throughout the Los Alamos area to determine any levels of contamination. The data collected in this program are published annually in the environmental surveillance report for distribution to the public and to local, state, and federal agencies. Included in the report are sections that explain the groundwater monitoring and protection program at the Laboratory and the results of sampling that have occurred in the subject year (LANL 1995, 50124).

2.3.7.2 Annual Water Supply Reports

The purpose of the water supply reports is to ensure a continuing historical record and to provide guidance for the management of water resources in long-range planning for the water supply system. The report publishes data on the amount of water supplied in the Los Alamos area, the conditions of the water supply wells, and the hydrologic conditions of the regional aquifer. Special studies and documentation of new supply wells are included as well as detailed records of pumping and water level measurements (LANL 1995, 50124).

Surface water flows provide the primary mechanism for redistributing and transporting contaminants that remain from early Laboratory operations and discharges from currently operating facilities. The primary mechanisms that affect mobilization of contaminants within the various canyons include sediment transport, contaminant dissolution and desorption, runoff, infiltration, and percolation. Effluent-supported flow from Laboratory and Los Alamos County sanitary wastewater treatment plants located in some of the canyons also affects the mobilization of contaminants.

Aspects of surface water hydrology that are relevant to potentially contaminated areas include

- areas and pathways of surface water runoff and sediment deposition;
- rates of soil erosion, contaminant dissolution and desorption, transport, and sedimentation;
- locations and sizes of areas of disturbed and undisturbed surface soils;
- relationships between infiltration and runoff;
- presence and effectiveness of adsorptive media in retarding infiltration of water-borne contaminants; and
- fate of infiltrating water.

The hydrology of the canyon systems is thoroughly discussed in Section 2.1.3 of the Hydrogeologic Workplan (LANL 1996, 55430); Section 2.4.2 of the IWP (Revision 6) (LANL 1996, 55574); and Section 2.6.2 of the IWP (Revision 3) (LANL 1993, 26078). The discussion in this section elaborates on surface water as a contaminant transport pathway within the various canyons of the Pajarito Plateau.

3.5.1 Surface Drainages

The Rio Grande is the master stream in north-central New Mexico. Much of the surface water flow and groundwater discharge from the Pajarito Plateau canyon systems ultimately arrives at the Rio Grande.

3.5.1.1 Rio Grande

The Rio Grande at Otowi has a drainage area of 14,300 mi^2 (37,037 km^2)in southern Colorado and northern New Mexico. The instantaneous discharge for the period of record has ranged from a low of 60 cubic feet per second (cfs) (1.70 m^3/sec) measured in 1902 to a high of 24,400 cfs (691 m^3/sec) measured in 1920. The river transports about 1 million tons of suspended sediments past Otowi annually (Graf 1993, 23521).

Essentially all Rio Grande flow downstream of the Laboratory passes through Cochiti Reservoir, which began filling in 1976. It is designed to provide flood control, recreation, and fishing development. The dam is expected to trap at least 90% of the sediments carried by the Rio Grande (Graf 1993, 23521). Before 1976, sediments transported by the Rio Grande collected in Elephant Butte Reservoir, which was built in 1916.

3.5.1.2 Descriptions of Canyon Streams

Section 3.1 describes the locations and general topography of the canyons, and Table 3-1 summarizes elevation, watershed area, and channel length information. Figure A-1 in Appendix A of this core document shows watershed boundaries.

Most surface water in canyons on the Pajarito Plateau occurs as ephemeral (flowing in response to precipitation), intermittent (flowing in response to availability of snowmelt or groundwater discharge), or interrupted (alternating perennial, ephemeral, and intermittent stretches) streams. Currently, only seven of the canyons are known to contain perennial (flowing continuously) reaches within Laboratory boundaries (Pajarito Canyon, Twomile Canyon, Threemile Canyon, Cañon de Valle, Sandia Canyon, Ancho Canyon, and Chaquehui Canyon).

Figure A-4 in Appendix A of this core document shows the location of canyons, springs, and other features mentioned in this section. Sections 2.6.2.2.1 through 2.6.2.2.10 of the IWP (Revision 3) (LANL 1993, 26078) provide the basis for the brief description of surface water occurrence in each canyon. Canyons systems and their surface water characterization are described from north to south in the following paragraphs.

Guaje Canyon contains an interrupted stream. It has a perennial reach extending from springs located upstream of Guaje Reservoir to some distance downstream of the reservoir and an intermittent reach downstream to the confluence with Los Alamos Canyon. Rendija Canyon, Barrancas Canyon, and Bayo Canyon contain ephemeral streams with no springs or perennial reaches. Snowmelt runoff from all four canyons does not reach the Rio Grande.

The stream in Pueblo Canyon is mostly ephemeral, but it has a short intermittent reach downstream of Acid Canyon, which is fed by water emerging from alluvium. Continuous, effluent-supported flow occurs in the lower reach of Pueblo Canyon because it receives discharge from the Los Alamos County Sewage Treatment Plant (STP) located between Pueblo Canyon and Bayo Canyon. This flow continues into the lower reach of Los Alamos Canyon. Snowmelt runoff from the upper reaches of Pueblo Canyon occasionally extends downstream as far as the Los Alamos townsite, but normally does not reach Laboratory property.

Los Alamos Canyon contains an interrupted stream. Several perennial springs are present in the upper reaches of Los Alamos Canyon and in its main tributary, Quemazon Canyon. These upper reaches are perennial from the springs to within a few hundred yards of Los Alamos Reservoir. Below the reservoir, flow is seasonally variable, controlled by releases from the reservoir. In lower Los Alamos Canyon during most of the year, surface water flow results from discharge from the Los Alamos County STP. This flow combines with perennial flow from Basalt Spring on San Ildefonso Pueblo land and often extends to the Rio Grande.

Sandia Canyon contains an ephemeral stream within Laboratory boundaries and has neither perennial springs nor perennial reaches. A significant effluent-supported flow arising from the major discharge of treated sanitary sewage effluent occurs in Sandia Canyon and typically extends approximately 2.5 to 3 mi (4.0 to 4.8 km) downstream. Approximately 3 mi (4.8 km) east of the Laboratory boundary, a perennial spring, known as Sandia Spring, flows for a few hundred yards. This flow does not normally reach the Rio Grande. Significant snowmelt runoff does not occur within Sandia Canyon.

Mortandad Canyon contains a stream that is entirely ephemeral; neither perennial springs nor perennial reaches occur in this canyon. Surface water flows from the National Pollutant Discharge Elimination System-permitted outfall of the Laboratory's Radioactive Liquid Waste Treatment Plant at TA-50 and from cooling tower outfalls; surface flow typically extends approximately a mile downstream of the TA-50 outfall. Significant snowmelt runoff does not occur within Mortandad Canyon. Cañada del Buey joins Mortandad Canyon about 0.5 mi (0.8 km) upstream from the confluence of Mortandad Canyon with the Rio Grande. Cañada del Buey contains a stream that is entirely ephemeral. The Los Alamos County-operated sanitary wastewater treatment plant in White Rock discharges into Cañada del Buey at a point about 0.5 mi (0.8 km) east of the Laboratory boundary. This discharge results in effluent-supported flow that regularly extends to the Rio Grande.

Pajarito Canyon contains an interrupted stream fed by several perennial springs in the upper reaches of Pajarito Canyon. Perennial flow is followed by an intermittent reach to within approximately 0.5 mi (0.8 km) west of the Laboratory boundary. Pajarito Canyon then has an ephemeral reach extending downstream to a point approximately 1 mi (1.6 km) east of the Laboratory's west boundary. At this point, Homestead Spring supports another perennial reach for at least several hundred yards, followed by an intermittent and/or ephemeral reach that may extend to near the confluence with Threemile Canyon.

Both Twomile Canyon and Threemile Canyon contain ephemeral and/or intermittent streams. East of the confluence with Threemile Canyon, Pajarito Canyon is ephemeral across Laboratory land to a point approximately 0.4 mi (0.64 km) upstream from its confluence with the Rio Grande. Pajarito Spring is located at that point and supports perennial flow to the confluence with the Rio Grande. In most years, snowmelt extends onto Laboratory land down to or below the confluence with Threemile Canyon. Snowmelt runoff occasionally extends downstream as far as the Rio Grande.

Potrillo Canyon and Fence Canyon contain streams that are entirely ephemeral with no perennial springs or perennial reaches. No significant snowmelt runoff occurs within either of these canyons.

Water Canyon contains an interrupted stream fed by several perennial springs in the upper reaches of Water Canyon, including Armstead Spring, American Spring, and other springs in the upper reaches of Cañon de Valle. These springs support perennial reaches followed by intermittent reaches limited to the area west of the Laboratory boundary. Water Canyon and its major tributary, Cañon de Valle, are ephemeral from the western Laboratory boundary across Laboratory land to a point below the confluence with Potrillo Canyon. Snowmelt runoff in Water Canyon seldom extends downstream as far as the eastern Laboratory boundary; however, occasionally it extends to the Rio Grande.

Ancho Canyon contains a stream that is ephemeral within Laboratory boundaries to a point approximately 0.8 mi (1.3 km) upstream from its confluence with the Rio Grande. At this point, a perennial spring, known as Ancho Spring, supports a perennial flow to the Rio Grande. Ancho Canyon has no significant snowmelt runoff.

Chaquehui Canyon contains a stream that is ephemeral to a point approximately 0.5 mi (0.8 km) upstream from its confluence with the Rio Grande. A perennial spring, known as Doe Spring, is located at that point and supports perennial flow for a short distance, followed by a short intermittent reach. Spring 9 and Spring 9A, located about 0.25 mi (0.4 km) upstream from the confluence with the Rio Grande, support perennial flow again. Perennial flow occurs from these two springs to the Rio Grande. No significant snowmelt runoff occurs in Chaquehui Canyon.

3.5.2 Normal Seasonal Runoff

Runoff from summer storms on the Pajarito Plateau typically reaches a maximum discharge in less than 2 hours after rainfall ceases and generally has a duration of less than 24 hours (Purtymun et al. 1990, 6992). A high discharge rate results in large masses of suspended and bedload sediments being carried for long distances, occasionally to the Rio Grande. The most extensive studies of thunderstorm runoff were conducted in the Los Alamos Canyon/Pueblo Canyon system, specifically in DP Canyon. In 1967, 23 runoff events were measured. These events carried a total of 88,000 kg (194,260 lb) of sediments in 36,800 m^3 (1,299,400 ft^3) of water (Purtymun and Johansen 1974, 11835).

Spring snowmelt runoff is generally of low discharge lasting several weeks to several months and, in some of the canyons, occasionally reaches the Rio Grande. For example, between 1975 and 1986 snowmelt reached the Rio Grande a total of 205 days, occurring in only 5 of those years and averaging approximately 41 days per year or approximately 4.7% of the total number of days in the 12-year period (McLin 1992, 12014).

Because of relatively low flow rates, effluent from the Los Alamos County STP located between Pueblo Canyon and Bayo Canyon provides a minor sediment transport mechanism, but effluent from the plant results in flow through the lower part of Pueblo Canyon into lower Los Alamos Canyon during most of the year. This flow transports some of the contaminated sediments from Pueblo Canyon into Los Alamos Canyon on San Ildefonso Pueblo land. The amounts of plutonium transported were estimated at approximately 3 to 4 mCi in 1990 and 4 to 6 mCi in 1991 (Environmental Protection Group 1992, 7004; Environmental Protection Group 1993, 23249). These annual amounts are roughly 20 to 30 times the amount carried from Pueblo Canyon into Los Alamos Canyon during four spring runoff events measured in 1975, 1979, 1985, and 1986 (Apt and Lee 1976, 5559; ESG 1980, 5961; ESG 1986, 6626; ESG 1987, 6678).

3.5.3 Flooding Potential

The climate and topography in the region of the Laboratory are conducive to short-term, high-intensity storms and rapid associated runoff. In the location standards for treatment, storage, and disposal (TSD) facilities and TSD permitting requirements under RCRA (at 40 CFR 264.18[b] and 40 CFR 270.14 [b] [11] [iii] respectively) (EPA 1994, 50122; EPA 1994, 50116), the Environmental Protection Agency (EPA) requires that the potential impacts on Laboratory facilities be evaluated for floods that might result from these storms. The Laboratory recently performed an evaluation of the estimated 100-year storms and resultant floodplain elevations for the watersheds that drain the Laboratory area (McLin 1992, 12014). For this study, researchers used the US Army Corps of Engineers computer-based flood hydrograph packages, HEC-1 (Army Corps of Engineers 1990, 44017) and HEC-2 (Army Corps of Engineers 1990, 44018), to perform the floodplain hydrologic simulations. A 6-hour storm was modeled for all the major canyons within the canyon systems. Parameter inputs (such as precipitation, surface runoff, and initial soil moisture content) were selected to represent a reasonable worst-case scenario and thus present a conservative estimate of a 100-year flood event in the various canyons (McLin 1992, 12014). A summary of the results of this study is presented in Sections 2.6.2.2.1 through 2.6.2.2.10 of the 1993 IWP (LANL 1993, 26078).

3.5.4 Infiltration

The primary mechanism of contaminant transfer between the surface and the underlying groundwater-bearing zones is infiltration of surface water carrying colloidal and dissolved contaminants. The potential for significant infiltration exists, given both the presence of coarse-grained sediments in most parts of the canyon systems and the high vertical hydraulic gradients beneath canyon streams. The surface water infiltration pathways within the canyon systems include native or disturbed soils; unconsolidated alluvium; Bandelier Tuff, Puye Formation, and basalt; faults and fracture systems; and cooling joints.

Infiltration of surface water into the alluvium commonly occurs throughout the canyon systems where alluvium is present. Limited geochemical evidence indicates infiltration of water below the alluvium at some locations discussed in the following section.

3.6.1.1 Porosity

The rocks of the Bandelier Tuff tend to have relatively high porosities, ranging from 30 to 63 vol % on tuff samples collected within the Laboratory boundaries. Porosity values are lower in more densely welded tuff (see Section 2.4.2.3.2 of the IWP [Revision 6] [LANL 1996, 55574]). The effective porosity (interconnected or fluid accessible porosity) ranges from 18 to 52 vol % (Stephens and Associates 1991, 27618; Stoker et al. 1991, 7530).

3.6.1.2 Moisture Content

Moisture content of the Otowi Member of the Bandelier Tuff has been measured in three boreholes (one borehole in Sandia Canyon and two boreholes in Mortandad Canyon) to assess the movement of water through the unsaturated zone. The moisture content of the Otowi Member in these boreholes is moderate to high, generally ranging from 20 to 40 vol % (Stephens and Associates 1991, 27618; Stoker et al. 1991, 7530). These values are considerably higher than those typically reported for the mesa tops and in some cases approach full saturation (Weir and Purtymun 1962, 11890; Section 2.4.2.3.3 of the IWP [Revision 6] [LANL 1996, 55574]). In contrast, moisture contents on the upper Otowi Member range from 8 to 13% in the mesa-top borehole 49-2-700-1 at TA-49. Results of this investigation suggest that greater infiltration of water occurs beneath the canyon floors than through the mesa tops.

3.6.1.3 Hydraulic Conductivity

Hydraulic conductivity is a measure of the potential for fluid flow within a porous solid material. Saturated cores of the Otowi Member of the Bandelier Tuff have hydraulic conductivities that range from 8.3×10^{-6} to 7.8×10^{-3} cm/s. The hydraulic conductivity varies with moisture content; values for unsaturated tuff are two to five orders of magnitude lower than those for saturated tuff (5.6×10^{-8} to 5.6×10^{-11} cm/s for welded tuff and 3.1×10^{-6} to 3.3×10^{-9} cm/s for nonwelded tuff) (Stoker et al. 1991, 7530; Section 2.4.2.3.5 of the IWP [Revision 6] [LANL 1996, 55574]).

The variation in hydraulic properties with water content is described by the moisture characteristic curve, which relates water content of the solid phase to suction, tension, or negative pressure head. The moisture characteristic curve is also used to determine the relative hydraulic conductivity, which can be used to calculate water flux at water contents below full saturation (see Section 2.4.2.3.4 of the IWP [Revision 6] [LANL 1996, 55574]). Numerous moisture characteristic curves have been determined on crushed Bandelier Tuff. A limited amount of *in situ* moisture characteristic data are available, particularly for the low water contents generally found in the Bandelier Tuff (Abeele 1984, 6520).

3.6.2 Groundwater Zones

Groundwater occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in some of the larger canyons, (2) intermediate perched zone groundwater (a perched groundwater body lies above a less permeable layer and is separated from the underlying aquifer by an unsaturated zone), and (3) the regional aquifer.

3.6.2.1 Alluvial Groundwater

Surface water infiltration creates saturated zones in the alluvium of some of the canyons within the canyon systems. The thickness of the alluvium within a given canyon ranges from several feet to as much as 100 ft (30.5 m). The alluvium in those canyons that head on the Jemez Mountains is

generally composed of sands, gravels, pebbles, cobbles, and boulders derived from the Tschicoma Formation and Bandelier Tuff on the flanks of the mountains. The alluvium in the canyons that head on the plateau is comparatively more finely grained, consisting of sands, silts, gravels, and clays derived from the Bandelier Tuff and local soils (see Section 2.6.2.3.1 of the IWP [Revision 3] [LANL 1993, 26078]). Saturated hydraulic conductivity of the alluvium typically ranges from 10^{-2} cm/s for a sand to 10^{-4} cm/s for a silty sand (Abeele et al. 1981, 6273).

In contrast to the underlying volcanic tuff and sediments, the alluvium is quite permeable. Surface water infiltrates the alluvium until downward movement is impeded by the less permeable tuff and sediments of the unsaturated stratum, which results in accumulation of water in a shallow alluvial groundwater zone. Partial depletion by evapotranspiration, movement into the underlying geologic formations, and the limited lateral extent and thickness of the alluvium precludes its use as a reliable and continuous water supply; however, occasional use by humans is possible where water quality permits. The alluvial groundwaters flow laterally in an easterly, down-canyon direction. Tracer studies in Mortandad Canyon have shown that the velocity of alluvial groundwater varies from approximately 60 ft (18.3 m) per day in the upper reach to approximately 7 ft (2.1 m) per day in the lower reach of the canyon (Purtymun 1974, 5476). Purtymun (1975, 11787; 1973, 4971) has summarized the occurrence of alluvial groundwaters by drainage area.

The quality of the alluvial groundwaters of the canyon systems is variable depending on the location and history of any effluent discharges. Contaminants in soils, sediments, and surface waters enter the alluvium and migrate downgradient. Rates of contaminant migration differ with contaminant due to differing adsorption and precipitation reactions that occur along the transport pathway. The saturated alluvium is of interest because

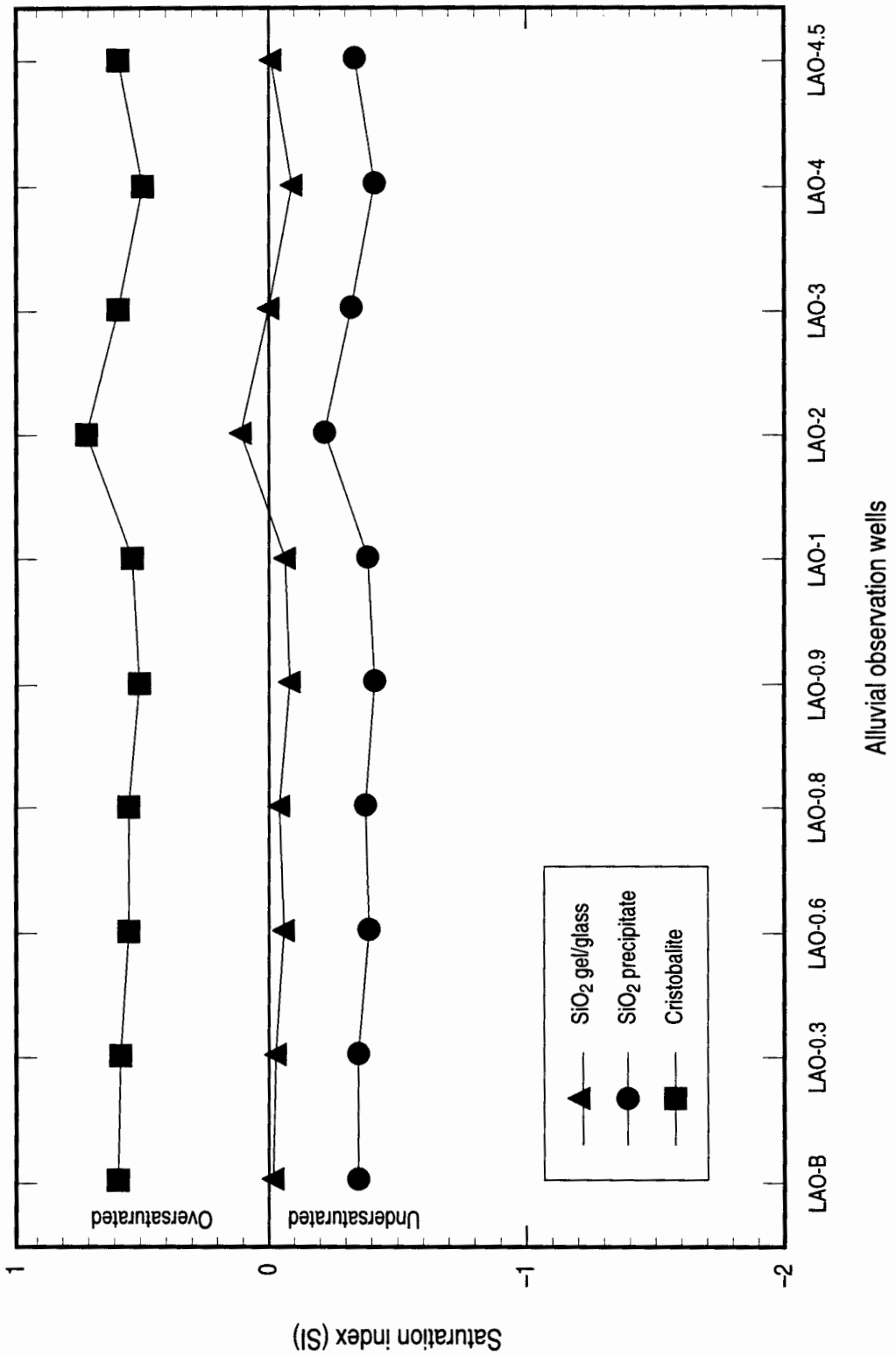
- surface water (and any contaminants) that recharges alluvium will migrate downgradient, be available for uptake by plants, and possibly become available locally at discharge points downgradient for consumption by animals and humans (see Appendix K of the IWP [Revision 3] [LANL 1993, 26078]) and

- the alluvial groundwater that recharges the underlying Bandelier Tuff may contaminate the intermediate perched zones and the much deeper regional aquifer within the Santa Fe Group.

3.6.2.2 Intermediate Perched Groundwater Zones

Saturated conditions are known to exist within the canyon systems at depths between the alluvium and the regional aquifer in the Guaje Pumice Bed, Cerros del Rio basalts, and the Puye Formation in the middle and lower reaches of Pueblo Canyon and Los Alamos Canyon and in the lower reach of Sandia Canyon. Depth to perched water ranges from approximately 90 ft (27 m) in the middle reach of Pueblo Canyon to approximately 450 ft (137 m) in lower Sandia Canyon. The vertical and lateral extent of the perched groundwaters, the nature and extent of the perching units, and the potential for migration of perched water to the regional aquifer are not fully understood. It is also not known whether the perched groundwater systems are hydraulically interconnected.

Perched groundwater also occurs in the Bandelier Tuff and the Tschicoma Formation on the eastern flank of the Jemez Mountains and on the west side of the Laboratory. These perched waters discharge to several springs (including American Spring and Armstead Spring) and provide flow for the gallery in Water Canyon (see Section 2.6.2.3.2 of the IWP [Revision 3] [LANL 1993, 26078]).



F3-12 / CORE DOC / 032197

Figure 3-12. Saturation indices for silica minerals in alluvial groundwater in upper Los Alamos Canyon.

of the water, and geochemical interactions between the water and the aquifer matrix. The TDS concentrations of groundwater samples collected from the regional aquifer are generally less than the TDS of those collected from the intermediate perched zone in Los Alamos Canyon and Pueblo Canyon. The average background TDS in groundwater in the Guaje Pumice Bed in LAOI-1.1A during 1994 and 1995 was 166 mg/L (Longmire et al. 1996, 54168). From 1984 to 1988, the average TDS concentration in groundwater samples collected from TW-3, located below the confluence of Los Alamos Canyon and DP Canyon, was 129 ± 49 mg/L. Calcium tends to be the predominant cation, and bicarbonate is the dominant anion. However, at depth within the regional aquifer, sodium is the dominant cation in groundwater, which suggests that cation exchange processes are occurring and affecting the composition of the water. The increasing bicarbonate concentrations in successively deeper saturated zones is due probably to the presence of calcite ($CaCO_3$) in the Santa Fe Group and possibly due to the oxidation of natural organic matter to CO_2 (Drever 1988, 49933). Filtered groundwater samples collected from TW-3 are a calcium-sodium-bicarbonate type (Blake et al. 1995, 49931). Results of speciation calculations using MINTEQA2 (Allison et al. 1991, 49930) suggest that TW-3 groundwater is in equilibrium with calcite and that dissolved concentrations of calcium and bicarbonate are controlled by this equilibrium.

Several factors contribute to variations in chemistry of the groundwater in the Santa Fe Group. Production wells have screened intervals over hundreds of feet, and groundwater samples probably reflect contributions from different zones of the regional aquifer. In addition, unfiltered samples, which contain both dissolved constituents and constituents sorbed on suspended matter, were probably collected from the supply wells. Therefore, inferences about geochemical interactions of water and sediment based on analyses of these water samples are more ambiguous than similar inferences would be for analyses of samples from more restricted zones of saturation and analyses of only filtered samples. Analyses of filtered water samples from the regional aquifer and other water-bearing zones will be used as input to geochemical modeling to quantitatively address natural water composition and rock/water interactions influencing the fate and transport of contaminants.

3.7.5.2 Low-Level Tritium Analyses and Age Estimates

Tritium is present in contemporary precipitation on the Pajarito Plateau at levels ranging from 21 to 450 pCi/L (Adams et al. 1995, 47192). These levels reflect input from airborne releases, from atmospheric nuclear testing, and from cosmic ray production in the upper atmosphere (ESG 1971–1995; Purtymun et al. 1987, 6687). Tritium in groundwater may result from recharge of these rainwaters to the alluvium and intermediate perched zones. Flow to deeper aquifers (such as the regional aquifer) would have to be very rapid for this tritium (which has a half-life of 12.33 years) to reach the water table.

Activities of tritium in the groundwater samples collected from selected production wells in Los Alamos Canyon range from 0.58 ± 0.29 pCi/L to about 63.0 ± 2.2 pCi/L. On May 12, 1993, a sample with tritium activity of 63 pCi/L or 19.7 tritium units was collected from former water supply well LA-1 (Blake et al. 1995, 49931, Table 4, p. 28). These activities are lower than most of the range for tritium in contemporary precipitation cited above. Higher activities of tritium (700 pCi/L) were present in the atmosphere in northern New Mexico during 1962 and 1963, when tritium from atmospheric testing reached its peak (Environmental Protection Group 1993, 23249). The presence of tritium in the regional aquifer might indicate recharge by very young (approximately 30 to 50 years) water. However, samples from most of the regional aquifer production wells show such low values of tritium that they cannot contain any significant component of young water. Thus, the groundwater in the regional aquifer is generally older than the period of atmospheric nuclear testing.

3.7.5.3 Carbon-14 Age Estimates

The isotope ^{14}C decays to ^{14}N by emission of a beta particle; it has a half-life of 5730 years. Therefore, ^{14}C can be used to date materials with ages of a few hundred to tens of thousands of years. Most of the ^{14}C in the air is produced by cosmic rays in the upper atmosphere and mixes rapidly throughout the atmosphere. Measurements of ^{14}C in waters may be used to infer the time since the water last reached equilibrium with the surface air.

The maximum possible age is determined from the measured ratio of ^{14}C to common carbon, which gives an age based on the radioactive decay of ^{14}C. This value is commonly greater than the actual age because the carbon concentration in the infiltrating water is diluted by the dissolution of older (even completely nonradioactive) carbonate minerals or organic material. Estimating this dilution effect requires measurement of other carbon isotopes and assumptions about mixing. Calculating a minimum age based on the estimated dilution can lead to very young or negative ages if the carbon geochemistry is not well characterized. It is also possible that ^{14}C from other sources such as laboratory effluents or atmospheric nuclear testing (the so-called Bomb Pulse carbon) could raise the amount of ^{14}C in a sample and lead to an inferred age that is very young or even negative.

About 25 analyses of ^{14}C activity in groundwater samples collected from the regional aquifer (Santa Fe Group) in the Los Alamos vicinity have been completed. Measurements of ^{14}C indicate that groundwater in the Santa Fe Group may have maximum ages ranging from a few thousand years in the central and western part of the Pajarito Plateau up to as much as 40,000 years at the Rio Grande in Los Alamos Canyon. Deep flow paths characterized by long residence times may account for the old ages of groundwater. However, the flow paths within the regional aquifer are heterogeneous and complex; they are not well understood. The large screen lengths within the wells, the vertical gradients, and the chemical heterogeneity influence the ^{14}C age dates obtained from the regional aquifer. The ages of the water samples represent average ages for the screened interval of each well, which may include mixing of waters from one or more production zones, and not the average age for the entire saturated thickness of the regional aquifer. These results are preliminary; an improved understanding of the carbonate geochemistry of the regional aquifer and more detailed ^{14}C analyses in the future should improve the delineation of age of the regional aquifer water.

3.8 Biological Setting

3.8.1 Regional Vegetation

Northern New Mexico's semiarid environment supports diverse plant communities whose distribution is largely determined by elevation. Generally, arid-climate vegetation dominates at low elevations, and vegetation adapted to more consistent moisture grows at higher elevations. The varied topography and vertical relief of the Jemez Mountains and the Pajarito Plateau support an especially rich and diverse subset of the regional vegetation. Vegetation types are classified into two main groups: wetland and upland. Most of the streams in Los Alamos County are ephemeral and do not support wetland vegetation. However, perennial flows from springs, Laboratory facilities, and Los Alamos County facilities create a few permanent or near-permanent streams in some canyons. These streams are discussed in Section 3.8.4. The major vegetation in the canyons is subdivided into several plant communities, all of which are upland communities.

The Plains and Great Basin Riparian-Deciduous Forest community grows at the lowest elevations in Los Alamos County along the Rio Grande floodplain, about 5,000 ft (1,524 m) above sea level. The trees that characterize this vegetation type, such as cottonwood, willow, non-native salt cedar, and Russian olive, are restricted to areas where water is available at or near the ground surface throughout the year.

Above the Rio Grande floodplain at elevations ranging from about 5,600 to 6,200 ft (1,707 to 1,890 m), one-seed juniper becomes the most common overstory species. This species is often intermixed with lesser amounts of piñon. Both of these tree species, typical of the Great Basin Conifer Woodland community, are tolerant of a relatively dry climate. Together they form an open piñon-juniper woodland at elevations of about 6,200 to 6,900 ft (1,890 to 2,103 m) on the Pajarito Plateau.

As the elevation increases toward the Jemez Mountains, the Great Basin Conifer Woodland community gradually grades into the Rocky Mountain Montane Conifer Forest community where increased precipitation allows ponderosa pine to become a dominant species at about 6,900 to 7,500 ft (2,103 to 2,286 m). White fir and Douglas fir grow along the north-facing slopes at intermediate elevations. These species are often intermixed with ponderosa pine and form a mixed-conifer community. Species of the Rocky Mountain Subalpine Conifer Forest and Woodland community occur along the extreme western edge of Los Alamos County and are more prevalent at the higher elevations of the Jemez Mountains.

3.8.2 Previous Studies

Before 1994 investigators completed several site-specific studies within or near the canyon systems. During those investigations, researchers obtained information on threatened, endangered, or sensitive species and baseline ecological data.

3.8.2.1 Plants

Several investigators surveyed the vegetation in or near the canyon systems. Table B-1 in Appendix B of this core document contains a checklist of plant species that were identified during those surveys and lists the surveys used to prepare the checklist. A number of native plants from northern New Mexico have historically been used or continue to be used by American Indians for food and beverages; medicine; smoking or chewing; construction materials; or for coloring, tanning, and soap making. A partial listing of these species that may be exposure pathways for adjacent Indian Pueblos is presented in Table 3-5.

3.8.2.1.1 Vegetation Overstory of the Canyons

Portions of the canyon systems are located primarily within a ponderosa pine community. Other overstory species found in these canyons are one-seed juniper, Gambel oak, Douglas fir, white fir, Engleman spruce, Rocky Mountain maple, thinleaf alder, water birch, New Mexican olive, and Rio Grande cottonwood. The common midstory species are Gambel oak, Fendler's rose, piñon pine, and willow. Shrub layer dominance depends on topography and elevation and can include skunkbrush sumac, big sagebrush, rubber rabbit brush, willow, chokecherry, and Gambel oak.

3.8.2.1.2 Vegetation Understory of the Canyons

The understory of Los Alamos Canyon and Pueblo Canyon is predominately blue grama grass, brome grass, and cheat grass. In the upper portions of the canyons, other understory species include cutleaf coneflower, wild strawberry, and James geranium. In the middle portions of the canyons, other understory species include redtop (a grass), raspberry, mountain muhly, bluegrass, sedge, western wheatgrass, dropseed, and needle grass. In the lower portions of the canyons, other understory species include rushes, bluegrass, Fendler's rose, western wheatgrass, dropseed, and needle grass. Open meadows are dominated by bluegrass, tarragon, and trailing fleabane. Forbs such as golden aster, tarragon, and horseweed reside in the middle and lower portions of the canyons. Along the stream channels, stinging nettle dominates a plant assemblage composed of sweetclover, horseweed, and raspberry.

3.8.2.2 Wildlife

3.8.2.2.1 Invertebrates

Terrestrial Invertebrates

At least 164 families of terrestrial arthropods have been identified on Laboratory property. Most of these families are very likely to inhabit the canyon systems (see Table B-2 in Appendix B of this core document).

4.0 CONCEPTUAL MODEL

4.1 Introduction

This chapter summarizes the significant geologic, hydrologic, and biological features, events, and processes operating in the canyon systems that could reasonably affect estimates of human and ecological risk from Laboratory-derived contaminants. This chapter places these features, events, and processes within a conceptual framework that is intended to support a credible human health risk assessment for current contamination conditions and to project trends of possible future impacts. The human health risks will be evaluated, as needed, for Laboratory personnel working in the canyons and for the public occupying the canyons for a variety of purposes. In addition, impacts to the ecological system will be assessed.

The conduct of canyon investigations will involve working with the neighboring Indian Pueblos (Cochiti, Jemez, San Ildefonso, and Santa Clara) to define and evaluate impacts associated with cultural activities and resources valued by the American Indian population. This commitment fulfills part of the Laboratory's responsibility for stakeholder involvement. The approach to evaluating present-day risks is iterative, and this conceptual model does not yet fully reflect American Indian concerns. Section 4.3 discusses how the conceptual model will be revised to reflect investigation data as well as changing risk assessment objectives.

4.1.1 Purpose

The purpose of the conceptual model of contaminant occurrence, transport, and exposure route (hereafter "the conceptual model") is to incorporate known significant features, events, and processes into a comprehensive view of contaminant occurrence and transport that is then used to guide the development of the technical rationale for investigations and evaluations. The conceptual model also articulates the major assumptions (all subject to testing in the canyons investigations), the features that may need to be described more completely and accurately, and the models of processes that may need to be refined to adequately evaluate human and ecological risk. The conceptual model description helps identify the investigations needed to refine impact assessments. Sampling and analysis plans (SAPs) for canyons investigations will be designed to test major assumptions of the conceptual model. Field investigations, laboratory analyses of samples, and data assessments (discussed in Chapter 5 and Chapter 6 of this core document) will enable iterative refinement of the conceptual model, making it progressively more detailed and specific to individual canyons and reaches within canyons.

4.1.2 Relationship of the Conceptual Model to Impact Assessment

The conceptual model describes the potential pathways by which contaminants could be transported from Laboratory sources to potential receptors. It identifies connections among these transport pathways and connections among transport pathways and exposure pathways to humans, other animals, and plants.

The distinction between pathways for long-distance transport and pathways for exposure is important because some media can serve as both, and confusion can arise from the overlap. For example, wind transport is not considered to be a major route for dispersal of contamination (despite the fact that wind can transport contaminated dust from source areas) because the source of fine particulates which can be suspended by wind is limited on the surficial soils of the canyons. Moreover, canyon sediments can be relatively moist and vegetated, which reduces the potential for wind suspension; the sustained high winds needed to cause substantial transport do not normally occur. On the other hand, the inhalation of wind-suspended localized sediment that has been transported by streams is considered to be a significant pathway of exposure to humans. By contrast, surface water during floods can transport large amounts of contaminated sediments downstream. Thus, surface water is considered to be an important transport pathway, whereas wind

is considered to be primarily an exposure pathway. However, definition of both pathways is necessary to determine future impact.

The exposure pathways are part of the human health and ecological risk assessment models described in Chapter 6 of this core document. The selection of potential receptors and exposure pathways defines the structure and assumptions of the assessment models. The conceptual model discussed in this chapter addresses the exposure pathways selected for consideration in the assessment models described in Chapter 6.

The potential human and ecological exposure scenarios for the canyon systems include the following:

- use by Laboratory workers engaged in occupational activities;
- recreational use;
- use by the American Indian population for residential, cultural, and religious purposes, and for farming, ranching, and hunting; and
- habitation by the local biological community, taking into consideration the effects of human occupation.

The approach to exposure is a modular one and assumes that scenarios are not exclusive; individuals and populations may have time-apportioned activities associated with any of the three exposure scenarios (American Indian, Laboratory worker, and recreational). For example, a given individual may be a member of San Ildefonso Pueblo, work at the Laboratory, and engage in hiking activities in the canyons. Exposure results will be presented in a modular fashion for specific activities and times. Therefore, activities can be aggregated as appropriate to predict potential exposures for individuals or populations engaged in such multiple activities. Chapter 6 describes these exposure scenarios in detail.

Chapter 5 and Section 6.2 of Chapter 6 discuss the methods for interpreting data, including application of recently developed techniques for analysis of spatial uncertainty, that will be used in testing hypotheses of the conceptual model, as well as risk-based decision making.

4.1.3 Development of the Generic Conceptual Model

A generic conceptual model was developed from the conceptual model in the *Task/Site Work Plan for Operable Unit 1049: Los Alamos Canyon and Pueblo Canyon* (LANL 1995, 50290) because these canyon systems are considered representative of the range of features, events, and processes occurring in the canyon systems of the Pajarito Plateau. Also, these two canyons are currently the focus of ongoing canyons investigations, and new data from these investigations will be used to make initial refinements in the conceptual model. The conceptual model is illustrated in Figure 4-1, which shows Pueblo Canyon and upper Los Alamos Canyon. Key elements of the conceptual model, including descriptions of contaminant transport pathways and mechanisms, are described in Table 4-1.

The conceptual model identifies potential sources of contamination, relevant pathways for transport, and likely pathways for exposure based on current knowledge of the distribution of contaminants in and adjacent to the canyons system. The transport pathway descriptions include the predominant release mechanisms, transport processes, and the contaminated media for each transport pathway. The conceptual model includes those elements that are likely to influence decisions about remediation in the canyon environment. Application of the conceptual model in risk-based decision making is addressed in Section 6.2 of Chapter 6 of this core document.

TABLE 4-1 (continued)

ELEMENTS OF THE CONCEPTUAL MODEL FOR THE CANYON SYSTEMS

Transport Pathway/Mechanism	Concepts/Hypotheses
	Channel incision, lateral bank erosion, and sediment redistribution will be most active during large floods that may have return periods of years to decades in different canyon reaches.
Groundwater transport	
Alluvial groundwater	Maximum concentrations of contaminants are initially associated with alluvial groundwater close to potential source areas.
	Dilution and attenuation by geochemical processes lead to decreased contaminant concentrations (relative to mobile or conservative species such as chloride and tritium) downgradient within a water-bearing zone.
	Alluvial groundwater is present in portions of Los Alamos Canyon, Pueblo Canyon, Pajarito Canyon, and Mortandad Canyon. In addition, alluvial groundwater may be present in portions of Potrillo Canyon, Water Canyon, Sandia Canyon, and Cañon de Valle.
	Alluvium is more permeable than underlying bedrock units; surface water infiltrates alluvium until downward movement is impeded by less permeable tuffs and sediments, at which point shallow alluvial groundwater accumulates.
	The thickness and longitudinal extent of the alluvial saturated zones vary seasonally, with maximums occurring during spring snowmelt and summer storms.
	Water in the alluvium will flow down the canyon; flow processes can be approximated by a homogeneous porous medium model.
	The rate of contaminant migration (except tritium) in alluvial groundwater is retarded relative to the water flow rate primarily by sorption onto mineral, organic, or organic-coated mineral particles in the alluvium.
	Water in the alluvium enters the underlying rock units; the migration process and rate depends on the properties of the interface between the two units.
	Recharge to intermediate zones of perched groundwater occurs in most canyons primarily from the alluvium.
Infiltration and vadose zone flow and transport	Dissolved contaminants infiltrate alluvium more readily than contaminants adsorbed onto sediment particles.
	Transport of normally insoluble or strongly sorbed contaminants in the unsaturated zone can occur by movement of colloidal-size suspended solids. Nonsorbing species (for example, tritium or anionic species) migrate in solution.
	The rates of liquid infiltration into and percolation through tuff and underlying bedrock units depends primarily on the unsaturated hydraulic properties of the rock units.
	Steady-state liquid flow at depth can be very slow in unsaturated tuff and other bedrock units.
	Joints and fractures in bedrock can provide additional pathways for relatively rapid infiltration, transient flow, and lateral transport in the subsurface.
	Fractures contribute to liquid flow and transport at moisture contents above some critical value. Below this value, flow in the rock matrix will predominate.
	The rate of contaminant migration through the vadose zone varies and may be retarded by mineral precipitation and sorption onto mineral grains in the bedrock units, especially the Bandelier Tuff.

TABLE 4-1 (continued)

ELEMENTS OF THE CONCEPTUAL MODEL FOR THE CANYON SYSTEMS

Transport Pathway/Mechanism	Concepts/Hypotheses
Perched groundwater at depth	Intermediate-depth groundwater may be more common in the canyon systems with large watersheds, particularly those that receive snowmelt and storm runoff from headwaters in the Sierra de los Valles. The lateral extent and hydraulic continuity of such perched groundwater zones are not known.
	Perched zones are found in areas where a sufficient water source is present to maintain saturation in deeper geologic units.
	Studies in Los Alamos Canyon and Pueblo Canyon indicate that perched zones in these canyons are hydrologically connected to alluvial groundwater systems.
	In addition to alluvial groundwater from canyon floors, deeper perched zones may receive recharge from watersheds west of the Laboratory.
	Intermediate perched systems have not been observed to extend laterally beneath mesas. However, lateral spreading of perched water may occur downgradient if the canyon course and the dip of the perched zone do not coincide.
	A contrast in hydraulic properties between layers can divert flow laterally and cause zones of perched groundwater to develop near stratigraphic contacts, such as the contact between subunits of the Tshirege Member or between the Guaje Pumice Bed and the underlying Puye Formation or Cerros del Rio basalts. Flow directions in these perched systems will be controlled by the dips of the stratigraphic contacts.
	Laterally diverted groundwater flow can return to the surface in springs or seeps.
	Steady-state conditions can adequately describe groundwater flow in the intermediate perched zones, although some non-steady-state rapid responses have been seen where these zones approach the alluvium or the surface.
	Contaminant concentrations in alluvial and intermediate perched groundwaters are expected to decrease with depth because of dilution and geochemical attenuation along vertical flow paths.
Vapor transport	Vapor-phase transport is important only for tritium and volatile organic compounds.
	Vapor-phase transport is controlled primarily by the vapor pressure of the contaminant and the porosity, permeability, moisture content, and moisture characteristic properties of the unsaturated medium (soil, sediment, or rock).
	Exchange of pore gas with the atmosphere (a significant mechanism for tritium release) is controlled by temperature gradients and atmospheric pressure variations.
	Fractures in bedrock can facilitate gas exchange between rock and the atmosphere. In certain environments water vapor exchange can be a significant component of overall water flux.
Regional aquifer and saturated zone flow and transport	Numerous permeable units in the Puye Formation, the Tshicoma Formation, and the Santa Fe Group comprise the regional aquifer.
	Water in the regional aquifer moves generally eastward from the Jemez Mountains toward the Rio Grande under natural gradients.

TABLE 4-1 (continued)

ELEMENTS OF THE CONCEPTUAL MODEL FOR THE CANYON SYSTEMS

Transport Pathway/Mechanism	Concepts/Hypotheses
	The hydraulic gradient of the regional aquifer averages about 60 to 80 ft/mi within the Puye Formation and increases to 80 to 100 ft/mi along the eastern edge of the plateau as groundwater enters the less permeable sediments of the Santa Fe Group.
	Based on aquifer tests, the rate of groundwater movement in the regional aquifer ranges from 20 ft/y in the Tesuque Formation to 345 ft/y in the more permeable Puye Formation.
	The regional aquifer is recharged in part from the west, probably from the Jemez Mountains, with possible contributions from fault and fracture zones on the Pajarito Plateau and, at some locations, from alluvial groundwater and intermediate-depth perched groundwater. Natural recharge through undisturbed Bandelier Tuff on the mesa tops is believed to be insignificant.
	A portion of the regional aquifer discharges into the Rio Grande through springs and seeps. Springs fed by the regional aquifer discharge an estimated 4,300 to 5,000 acre-ft of water annually to the portion of the Rio Grande adjacent to the Laboratory.
	Contamination of the regional aquifer has occurred near the Rio Grande and elsewhere through infiltration below low-elevation canyon floors, recharge on the Pajarito Plateau, or poorly constructed wells.
	The regional aquifer in the Los Alamos area is the only aquifer capable of producing a large-scale municipal water supply.
	The regional aquifer exhibits artesian conditions in the eastern part of the Pajarito Plateau near the Rio Grande; recharge for this portion of the aquifer may originate in the Sangre de Cristo Mountains.
	If present, Laboratory-derived contaminants in the regional aquifer will tend to be highly diluted compared with potential recharge sources such as contaminated alluvial groundwater.
Atmospheric transport pathways/mechanisms	
Wind-borne dust	Entrainment is limited to contaminants in surface sediments.
	Entrainment, dispersal, and deposition are controlled by sediment properties, surface roughness, vegetative cover, terrain, moisture content, and other climatic factors.
	Entrainment, dispersal, and deposition are affected by wind speed, stability of the wind direction, and precipitation.
Gas/vapor dispersion	Gas exchange between the subsurface and the atmosphere provides the release mechanism for volatile contaminants.
	Gas exchange between the rock or soil and the atmosphere is a function of temperature and pressure gradients.
	Fractures can facilitate gas exchange between rock and the atmosphere.
	Atmospheric conditions affecting vapor dispersal include wind speed, stability of the wind direction, and precipitation.
Biological pathways - transport and exposure	
Plant uptake	The ability of plants to absorb contaminants depends on soil and water chemistry, soil microflora activities, contaminant characteristics, climatic conditions, and the characteristics of individual plant species.

TABLE 4-1 (continued)

ELEMENTS OF THE CONCEPTUAL MODEL FOR THE CANYON SYSTEMS

Transport Pathway/Mechanism	Concepts/Hypotheses
	Contaminants in the rooting zone can be assimilated into the roots and redistributed throughout plant tissues. The rooting zone can include alluvial groundwater.
	Contaminants in plant tissues can be redistributed by herbivore feeding and by erosional transport of dying leaves, branches, stems, and roots.
	Certain contaminants, such as tritium, can be transpired to the atmosphere.
	Plant surfaces such as stems and leaves can be contaminated by resuspension of contaminated soil by wind or rain splash.
Animal uptake	Animals can ingest contaminants by consuming water from streams or wells (for example, stock tanks).
	Animals consume leaves, stems, roots, and plant products (such as nectar) and any contaminants they contain. Certain contaminants can be progressively concentrated in the food chain through bioaccumulation.
	Animals also consume contaminants that adhere to the surfaces of plant tissues. Predatory animals ingest contaminants that are in or on their prey.
	Animals can ingest soil intentionally or incidentally while grooming.
	Animals can inhale contaminants absorbed to airborne particles.
	Animals can absorb contaminants through abraded or injured skin while bathing or swimming in contaminated water.
	Animal behavior patterns and the elimination of feces and urine can disperse contaminants away from source areas.
	Humans and other animals can consume the flesh from contaminated animals that have moved away from contaminated areas.
	Behavior can decrease the degree of exposure to environmental contaminants because food or water might not be obtained from a single site, or behavior might cause animals to be exposed to multiple, antagonistic contaminants.
Bioturbation	Burrowing invertebrates (such as earthworms) and vertebrates (such as pocket gophers) redistribute contaminants vertically and horizontally.
	Large, hoofed animals can alter the characteristics of the plant cover and the soil surface.
Biotic/abiotic interaction	Vegetative cover affects erosion by both water and wind. Animal feeding behaviors affect vegetative cover.
	Disturbance of the soil surface by vertebrates also affects the rates of erosion processes.

The remainder of this chapter discusses the elements of this conceptual model in detail and the process by which revisions to it will be made as new data are acquired and the knowledge and concerns of stakeholders are addressed.

4.2 Contaminant Transport Conceptual Model

This discussion is organized around the major transport processes of the conceptual model, starting with the processes having the greatest ability to disperse and transport contaminants and finishing with the processes having the least ability, as follows:

5.3.4 Perform Field and Analytical Work

Characterization of contamination in the canyon systems poses unique challenges. For example, low levels of contaminants in sediments are irregularly distributed over large areas of the canyon floors. These contaminants are periodically redistributed by runoff from storm events resulting in contaminant distributions that vary significantly in both space and time.

5.3.4.1 Focused Sampling Strategy

One approach to characterization of such a large and dynamic system would be to collect samples at fixed intervals over the entire area. This approach is discounted because large portions of the canyons are likely to be uncontaminated, and indiscriminate systematic sampling of all areas is inefficient.

The alternative approach adopted here is a *focused* sampling strategy designed to maximize the information obtained to address the objectives by

1. concentrating sediment sampling and surface water and groundwater characterization activities in reaches of canyons where prior data suggest that human health risk assessments may be warranted, or are key to verifying or refining the conceptual model;
2. identifying COPCs, as defined in Section 5.3.6, in an initial sampling and analysis task wherein the analytical protocol is broad (also known as the "full-suite analyses");
3. limiting the analytical suite for subsequent samples to contaminants known to be present and to solutes that influence contaminant mobility, as identified in the initial sampling task;
4. collecting data (including screening data) to test the components and hypotheses of the conceptual model; and
5. using statistical and numerical techniques to quantify uncertainty in contaminant distributions.

The sampling strategy will be flexible to reflect new field data as they are received. Measurement and analysis options and the number and location of sampling sites can be modified on the basis of field information. The success of such a strategy depends on timely analysis and integration of data to ensure that each input is evaluated sufficiently and in time to allow for resampling if necessary. The conceptual model is thereby adjusted continually on the basis of discovery in the field.

The thorough examination of existing information and the conceptual model enables focused sampling to address uncertainties in both contaminant distribution and transport processes. This approach avoids the collection of large quantities of data that may be irrelevant to the objectives. Reexamination of the conceptual model and of the rationale for characterization will keep sampling focused on critical data needs throughout the investigations.

5.3.4.2 Assess Data Quality

The assessment of the data quality consists of a comparison of the data collected with the objectives outlined under the DQO process. The process is relatively automatic where well-specified quantitative objectives are defined. For those aspects of the investigations for which quantitative decision criteria and limits on decision errors cannot be developed (e.g., where even the conceptual model is uncertain, and the study is exploratory in nature), the assessment will rely on expert judgment. These judgments will be documented, and subsequent decisions will be quantified where possible.

Data collected in the canyons investigations are intended to serve the dual objectives of conducting a present-day human health risk assessment as warranted by the contaminant concentrations and testing and refining the conceptual model. To meet the former objective, data must be sufficient in number and quality to establish a statistical model for the data set and confidence intervals on measure(s) of central tendency in the data set (see also Section 6.2 and Section 6.4.1 in Chapter 6 of this core document for discussion of data use in present-day human health risk assessments and the iterative process for reducing uncertainties in the spatial distribution of data). Data used to address the latter objective also lend themselves to statistical evaluation but do not need to achieve the same standards as data used for present-day human health risk assessment.

5.3.5 Perform Data Assessment

Data assessment at this stage includes comparisons with background data sets (sediment and water), evaluation of potential risk, and identification of spatial and temporal variations in contaminant concentrations.

5.3.6 Decision Point Number 2

Are COPCs Present?

COPCs are broadly defined for the canyons investigations as chemicals selected for additional (limited-suite) analyses on the basis of existing sample data (generally, full-suite analyses and historical data) and the assessment of data described in Section 5.3.5. COPCs will vary among reaches depending upon the nature of contaminant releases into the canyon at and upstream of the reach. In addition, COPCs may vary among risk assessment endpoints due to variability in the size of exposure areas and types of exposure media. Because multiple risk assessment endpoints exist, an analytical datum may be evaluated in several groupings, or decision sets, and chemicals may be identified as COPCs for certain endpoints but not others.

If no COPCs are found to be present, no further action will be recommended as discussed in Section 5.2.4.1. If COPCs are found to be present, the conceptual model will be refined as described below, and the assessment will continue.

5.3.7 Decision Point Number 3

Are uncertainties acceptable to evaluate conceptual model?

After evaluating the data set, the technical team will judge whether the remaining uncertainties in the data are acceptable for evaluating the conceptual model. Data will be evaluated for their utility in answering questions such as distributions within geomorphic units at surface and at depth, collocation of contaminants, and geochemical characteristics of contaminant binding. Statistical evaluations will be used to determine the degree of reduction in uncertainty (e.g., reduction in measurements of variance) to be gained by the collection and analysis of additional samples. These evaluations will form the basis for additional sampling and analysis needs requested by the technical team to address remaining uncertainties in the model for a given reach. Because of cost, time, and effectiveness, it may be more prudent to perform remedial actions rather that perform further characterization. Therefore, best management practices and remedial actions may be initiated in lieu of further data collection.

If reduction in uncertainties is considered necessary to answer investigation questions (the "No" path at decision point number 3) and uncertainties can be reduced significantly by collecting and analyzing more samples, then a strategy for additional data collection will be developed.

If uncertainties are acceptable and/or no reduction in uncertainty can be reasonably achieved (the "Yes" path at decision point number 3), the existing level will be deemed "acceptable," and the conceptual model will be refined as required by the data.

5.3.8 Refine Conceptual Model

The objective of this step is to refine the conceptual model and associated assessments of impacts using analysis and interpretation of the available field and analytical data, particularly as it applies to previously identified uncertainties in the model. Refinements may include improved descriptions of horizontal and vertical distributions of contaminants, improved estimates of contaminant concentrations and inventories, and improved descriptions of significant transport processes and time-dependent variations in contamination.

From this step, the investigation process divides into one path leading to the assessment of present-day risk and the second to the assessment of projected risk.

5.3.8.1 Evaluate Estimated Risk

The present-day human health risk will be evaluated using the refined conceptual model and the initial data on COPC concentrations. Contaminant concentrations that exceed background levels will be evaluated in deterministic risk models using maximum observed concentrations and conservative upper-bound parameter estimates to determine which contaminants and exposure pathways present potential human health risks. Those contaminants that present risk exceeding levels of concern in deterministic evaluation will then be evaluated using Monte Carlo techniques based on contaminant concentrations weighted by volume of exposure medium. These simulations will partially provide the basis for defining uncertainties to be addressed in subsequent sampling and analysis (see Section 6.2 and Section 6.4.1 in Chapter 6 of this core document for details).

The first evaluations will focus on the American Indian subsistence scenarios described in Section 6.5 in Chapter 6 of this core document. This special population will serve as an indicator of any potential risk-based concern. The term "American Indian land use scenario" is used to encompass a number of activities consistent with subsistence-based use of the canyons ecosystem by American Indians. Specific activities (including farming, ranching, hunting, and the use of plant, animal, and mineral resources for artistic, ceremonial, and medicinal purposes) are described in Section 6.5.4 of this core document. Exposure assessment activities within a scenario will generally proceed on an activity-specific basis so that individual or population exposures may be aggregated across activities as necessary to address stakeholder concerns.

Therefore, rather than one representative child and adult American Indian exposure scenario, a variety of potential exposure scenarios and their contributing activities will be evaluated. These exposures will include evaluations of both children and adults. The specific components representing a reasonable maximum exposure evaluation for regulatory purposes will be derived in consultation with NMED and will be identified as such in the report. Additional exposure evaluations will also be included to address concerns of the Accord Pueblos.

As human health risk assessment models and parameters are defined, and as additional data on patterns of contaminant distribution are obtained, the human health risk process will be made more selective. This process will eliminate the additional collection of data for analytes that have concentrations above background levels but below levels of potential concern.

5.3.8.1.1 Decision Point Number 4

Are the data uncertainties acceptable for risk assessment?

At this step, a judgment is made as to whether the available data and the uncertainties in the data at appropriate spatial scales (see Section 6.2 and Section 6.4.1 in Chapter 6 of this core document) for risk assessment will enable a defensible assessment of the present-day human health risk.

prospective long-term order of well installation. However, it is technically prudent to perform the activities in an annual iterative process of data collection, review, and reassessment to take full advantage of all new information and data before locating and installing subsequent wells. This approach will ensure that characterization activities and well installation are optimized. The need for installation of subsequent wells (alluvial, intermediate perched zone, or regional aquifer wells) will always depend on data and information gained from the previously installed wells and on the interpretation of the data from those wells.

5.7.6 Expected Results of Groundwater Investigations

The expected outcomes of the activities described in the Hydrogeologic Workplan (LANL 1996, 55430) are

- refined understanding of the hydrogeologic framework at the facility, including recharge areas, hydraulic interconnections, aquifer geochemistry, flow paths, and flow rates, which are synthesized by modeling simulations;
- information sufficient either to design and implement a detection monitoring program that meets applicable requirements and/or to demonstrate that monitoring requirements can be waived; and
- defined areas of existing or potential groundwater contamination and the potential pathways of contaminant transport from the surface to the regional aquifer, with predictions of directions and rates of movement and risk based on modeling simulations.

As a result of this characterization effort, if it is determined that enhanced groundwater monitoring is necessary, an interdisciplinary Laboratory group will develop a proposed amendment to the Groundwater Monitoring Plan for submittal to the appropriate regulatory agency(ies).

5.8 General Technical Approach for Surface Water Investigations

Surface water investigations in the canyons are presently being developed as part of the Laboratory's Watershed Management Program Plan (WMPP). The WMPP will provide a detailed framework for integrating and coordinating surface watershed activities at the Laboratory. No canyon surface water sampling is planned until the WMPP is completed.

The specific WMPP objectives are to

- integrate the activities of different Laboratory organizations to ensure a unified approach to surface water protection and to prevent duplication of effort;
- establish an information system in which all surface water-related data will be stored and which will be accessible to Laboratory organizations and stakeholders;
- address the requirements of the HSWA Module, the Clean Water Act, and other relevant federal and state environmental requirements;
- provide enhanced surface water documentation to support Laboratory-wide environmental impact statement development, as requested by the Site-Wide Environmental Impact Statement Project Office or DOE in accordance with the requirements of the National Environmental Policy Act; and
- maintain ongoing surface water protection activities and address new issues as they occur.

The WMPP will describe a program that has the following goals:

- document the surface water resource with respect to quantity and quality;
- design and implement a surface water monitoring program to support resource management concepts and comply with applicable environmental laws and regulations;
- implement a management program for surface water protection and contamination abatement, which includes specific Clean Water Act and New Mexico Water Quality Act requirements and other relevant regulatory requirements;
- summarize and identify watershed areas that may not meet New Mexico Water Quality Standards or other regulatory requirements;
- develop strategies for controlling sources of surface water contaminants and/or excessive erosion and sedimentation;
- integrate relevant aspects of Laboratory programs described in the GPMPP, the Threatened and Endangered Species Habitat Management Plan, and the Natural Resources Management Program Plan; and
- develop a watershed management work plan.

5.9 General Technical Approach for Biological Investigations

The objective of biological investigations in the canyons systems is to assess the impact of Laboratory-derived contaminants on environmental and human receptors. The objective will be achieved by examining the three components of the ecosystem summarized below.

- Ecosystem receptors (including selected species and biological communities) which are likely to be affected by Laboratory-derived contaminants will be studied. The selected species include threatened or endangered species, or surrogates for these species if examination risks further threat. The biological communities to be studied represent broad units of the ecosystem and include the aquatic, soil, plant, and animal communities.
- Wetlands, which are a critical regulated environment, will be included in the biological investigation. Wetlands are a sensitive habitat for many species, and their evaluation is integral with the aquatic community evaluation.
- The potential impact on human receptors of Laboratory-derived contaminants in plants and animals that are either part of the diet of or used in American Indian tribal ceremonies will be assessed.

For aspects of biological investigations that address ecological questions, the final approach to ecological investigations at the Laboratory, as approved by NMED, will be followed. For biological investigations that address biota as a vector for human exposure, data needs will be determined by (1) identification and quantification of major uncertainties, (2) development of protocols to obtain necessary data either through the ER Project or from other biological sampling programs, and (3) discussion and agreement with NMED on final protocols if implemented by the ER Project or on appropriate confidence bounds for data from other sources.

5.9.1 Ecosystem Receptors

An integrated ecological risk investigation approach for the ER Project is presently under development, and it will be implemented after DOE, regulator, and stakeholder approval. The first two objectives described above will be addressed by the Laboratory-wide ecological risk

investigations. The third objective will be addressed as part of canyons investigations, and the data will support human health risk for scenarios related to American Indian use. These data will also be used as a source for future site-wide ecological risk investigations. The appropriate level of detail for ecological risk assessments has not yet been determined.

Environmental sampling to evaluate exposure to ecological risk receptors will not be proposed until the assessment endpoints (see Chapter 6 of this core document for details on assessment endpoints) and their exposure units have been agreed upon with the regulators, with appropriate input from stakeholders. Negotiations are underway between the Laboratory, DOE, EPA, NMED, and the Accord Pueblos to define the assessment endpoints, exposure units, exposure models, and risk models. In addition, Laboratory personnel and subcontractors have worked and will continue to work with the Accord Pueblos to help define appropriate risk scenarios for the American Indian population in the vicinity of Los Alamos Canyon and Pueblo Canyon. When an agreement has been reached, a preliminary assessment using available data will be conducted to assess uncertainties and identify sensitive parameters in the models. The canyon- or canyon aggregate-specific SAPs will focus on collecting data for the most sensitive and uncertain parameters identified for the ecological risk assessment.

The sediment, groundwater, and surface water investigations described above will provide important data for the ecological risk assessment. For example, hydrogeologic and geomorphic units are natural sources of environmental heterogeneity within exposure units and they may form natural boundaries between some exposure units. Therefore, mapping and characterizing heterogeneous units will provide essential data to ecological exposure assessments.

5.9.2 Wetlands Investigation

Because stream flow occurs seasonally for extended periods of time, or even continuously in some canyon reaches, identifiable wetlands are present in some canyon systems. An inventory of wetlands is in preparation by the Environmental Assessments and Resource Evaluations group (ESH-20) as part of an ongoing survey of the canyons of the Pajarito Plateau. Until the wetlands have been delineated, discrete sampling in the investigations will be limited.

The biological evaluation of wetlands will be performed in collaboration with a US Fish and Wildlife Service investigation of water quality in the canyon systems of the Pajarito Plateau. Sediment and water sampling will be deferred to the Fish and Wildlife Service investigation, although sediment and surface water samples collected in the concurrent investigations described in this chapter will be used to plan future sampling efforts.

5.9.3 Biological System Contributors to Human-Health Risk

Exposure pathways for assessing human-health risk include the ingestion of fish, wildlife, native plants, and domesticated plants (see Section 6.5 in Chapter 6 of this core document). Sampling in canyons is proposed to determine the bioconcentration and potential impact of native plants, garden produce, game animals, and domestic livestock on human exposure.

American Indian populations gather wild edible plants and other plants used for ceremonial purposes. The Indian Pueblo representatives will be consulted to define significant species routinely gathered in each canyon. Because of the ceremonial significance of some of these species, sampling will be conducted by Accord Pueblo representatives. Exact sampling locations may not be disclosed. Detailed information on specific species and usage will be collected by tribal members and transmitted to the technical team in summary form to preserve cultural sensitivities.

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7.0 REPORTING

Over the course of the canyons investigations, the Field Unit 4 team and the technical team will progressively refine the conceptual model for contaminant occurrence and transport (hereafter "the conceptual model") discussed in Chapter 4 of this core document; modify and improve the methods for geomorphic surveys, field contaminant surveys, groundwater characterization, assessment of contaminant mobility in the subsurface, and sample collection and analysis; and report findings of the individual canyon or canyon aggregate investigations with respect to contaminant occurrence and distribution and present-day human health risk assessments. The procedures for making these adjustments to the conceptual model and field and laboratory methods, and for reporting findings of individual canyon or canyon aggregate investigations will be reports as discussed briefly in this chapter.

Consistent with the general strategy of using this core document as an upper level umbrella description of the overall canyon systems and technical approach to the investigations, each canyon- or canyon aggregate-specific sampling and analysis plan (SAP) and each report will incorporate this core document by reference, and each report of investigations will reference the specific SAP for the investigations. This strategy of tiering the relevant documents will enable SAPs and reports to be focused, brief, communicative, easily prepared, and easily reviewed.

Administrative authority (AA) involvement at critical decision points during investigations is essential for the successful implementation of the iterative investigations proposed for the canyon systems. Significant modifications to the scope of work and critical decision points will be communicated to the AA through phone calls, letters, faxes, and e-mail. Anticipated modifications to the scope of work will also be addressed in the monthly Environmental Restoration Project progress reports. Significant modifications to the scope of work for any work plan will be provided to the AA for approval.

7.1 Sampling and Analysis Plans

SAPs will be prepared for investigations in each of the canyons or canyon aggregates as discussed in Chapter 1 of this core document. Each SAP will incorporate this core document by reference for most of the general information regarding the regulatory and programmatic framework for the investigation, the historical background of the area, the regional environmental setting, the conceptual model, the overall technical approach, and present-day human health risk assessment and ecological impact assessment approaches.

Each successive canyon- or canyon aggregate-specific SAP will provide specific information on historical background including observed and potential contaminants as well as contaminant sources for the specific canyon system, environmental setting including the geomorphology of the canyon(s) and the state of knowledge of groundwater bearing zones present and extent of known Laboratory-derived contamination in water and sediments, geochemistry of groundwater, and specific hypotheses of the most recent refinement of the conceptual model to be tested in the investigation. Each successive SAP will incorporate lessons learned from previous canyons investigations regarding field and laboratory methods, borehole advancement and well installation techniques, and the site characterization approach. The technical approach taken in each successive investigation, while following the general approach discussed in Chapter 5 of this core document, is expected to be modified from the previous investigation to incorporate progressive refinements to the conceptual model.

In accordance with the guidelines provided in "Quality Assurance Project Plan Requirements for Sampling and Analysis" (LANL 1996, 53450), each SAP will describe field and laboratory methods and quality assurance procedures to be used in the investigation.

7.2 Field Unit 4 Reports

A report will be prepared at the conclusion of investigations in each canyon or canyon aggregate. This document will summarize the results of the investigations, integrate all surface and subsurface data into a refined conceptual model, present estimates of transport rates of contaminants in the surface and subsurface, define present-day and future impact of contaminants on the Rio Grande, make recommendations to optimize Laboratory monitoring of contaminants in the canyon(s) system.

Reports are planned 60 days after all relevant data for an investigation are received. Tentatively, the reports will be prepared in the following format.

Abstract

Introduction—investigation objectives and approach

Methods—summarize field, analytical, and computational methods

Results—present the data

Discussion—discuss what was learned and conclusions drawn from investigation

Conclusions—highlight major conclusions, make recommendations for future SAPs, and suggest refinements to the conceptual model

1.0 INTRODUCTION

This annex addresses the project management plan requirements of the Hazardous and Solid Waste Amendments (HSWA) Module (Task II, p. 39) of the Laboratory's Resource Conservation and Recovery Act (RCRA) Part B Permit (EPA 1990, 1585) and presents the technical approach, management structure, schedule, budget, and reporting milestones for implementing the canyon systems investigations as set forth in this document. The project management plan for the canyon systems investigations is an extension of the Environmental Restoration (ER) Project Program Management Plan given in Annex I of the Installation Work Plan (IWP) (LANL 1993, 26077) and contains no significant departures from the IWP guidelines.

2.0 TECHNICAL APPROACH

The approach used for the canyon systems investigations is based on the ER Project's overall technical approach as described in Chapter 3 of the IWP (LANL 1996, 55574). The technical approach for the canyon systems investigations is described in Chapter 5 of this core document and is illustrated in Figure 5-1 of that chapter. The general philosophy is to develop and iteratively refine the conceptual model for contaminant occurrence and transport (hereafter the conceptual model) as discussed in Chapter 4 of this core document through carefully planned stages of investigation and data interpretation. The data gathered and the subsequent interpretation will be used to define the nature and extent of contamination and the likelihood for contaminant migration in canyon systems.

The technical objectives of the canyon systems investigations, as presented in Chapter 5 of this core document, are as follows:

- to determine to what extent portions of the canyon systems have been or are likely to be affected by the combined releases from all sites that contribute contamination to them and

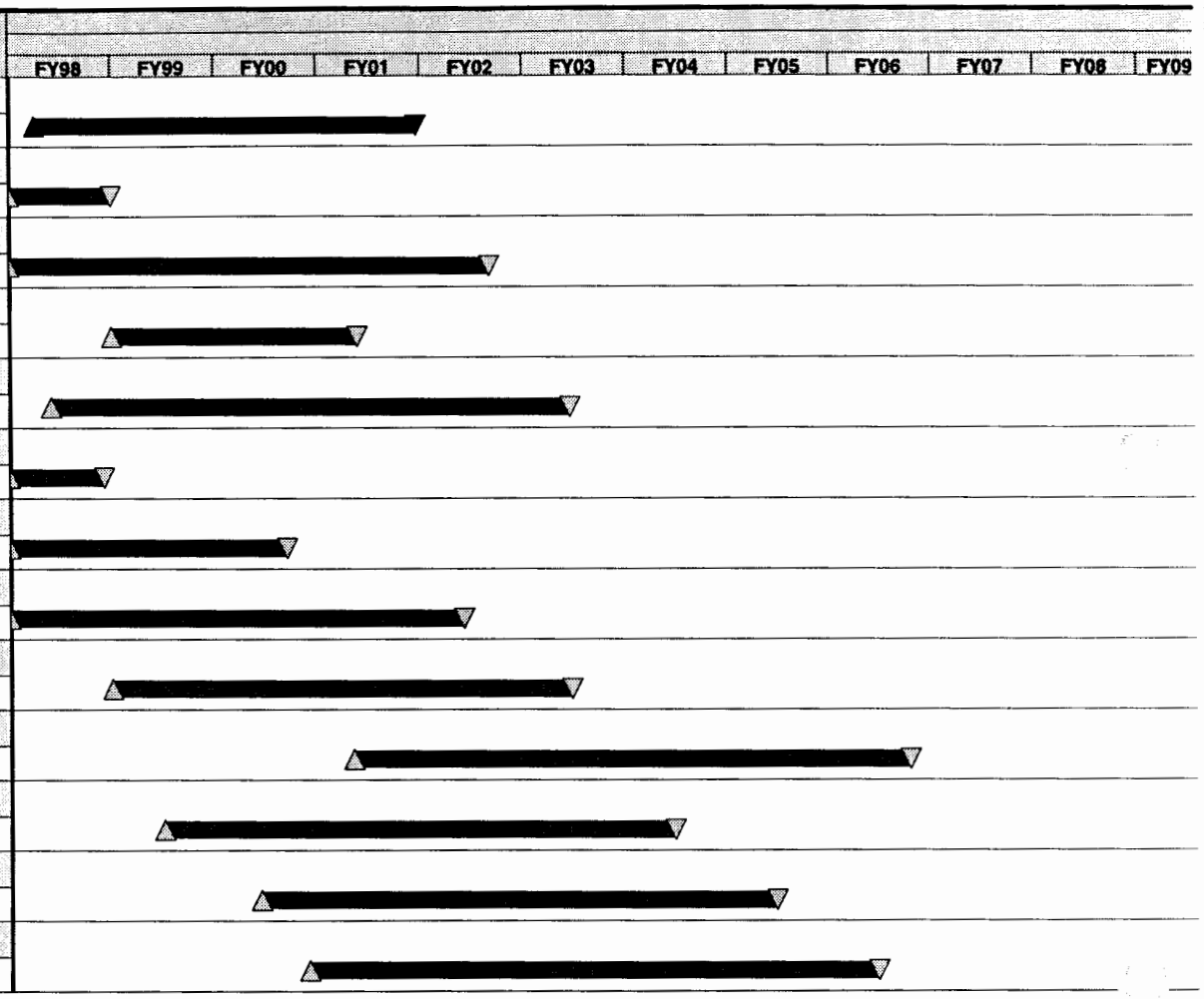
- to reexamine contaminant transport mechanisms, refine the conceptual model, and project future impacts of the contaminants in the affected media that may result from future transport of the contaminants to other locations and other media. The investigations also are intended to support an integrated assessment of the present-day impact (including human health risk) from Laboratory-derived contaminants and an evaluation of the potential for transport (through all accessible pathways) to cause off-site impacts in the future.

2.1 Technical Implementation Rationale

The scheduling of the investigations in canyons or canyon aggregates as discussed in Chapter 1 of this core document is based on the following rationale and priorities, as illustrated in Figure I-1 of this Annex.

Two relatively independent investigation paths are part of the schedule logic and the investigation rationale. These include (1) sampling and analysis of surface sediments and (2) sampling and analysis of surface water and groundwater.

Activity Description	Orig Dur	Early Start	Early Finish
+ ARCH AND BIO SURVEYS			
	928	02JAN98	19SEP01
+ CANYONS CHARACTERIZATION(MISC)			
	249	01OCT97	30SEP98
+ DEEP WELLS			
	1,160	01OCT97	31MAY02
+ INTERMEDIATE WELLS			
	588	01OCT98	14FEB01
+ ALLUVIAL WELLS			
	1,254	02MAR98	13MAR03
+ LOS ALAMOS/PUEBLO CANYONS			
	230	01OCT97	02SEP98
+ MORTANDAD CANYON			
	673	01OCT97	15JUN00
+ PAJARITO,TWO & THREE MILE CANYON			
	1,097	01OCT97	04MAR02
+ SANDIA & CANADA DEL BUEY CANYONS			
	1,109	01OCT98	20MAR03
+ GUAJE,BAYO,BARRANCAS & RENDIJA CANYONS			
	1,361	01FEB01	14JUL06
+ WATER & CANON DEL VALLE CANYONS			
	1,238	01APR99	22MAR04
+ ANCHO,INDIO & CHAQUEHUI CANYONS			
	1,251	15MAR00	23MAR05
+ POTRILLO & FENCE CANYONS			
	1,381	01SEP00	22MAR06



Project Start	01OCT89
Project Finish	09FEB07
Data Date	01OCT97
Run Date	29OCT97

Early Bar
Progress Bar
Critical Activity

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9873

Sheet 1 of 1

Figure I-1
FY98 Estimated Schedule for
Implementing Canyons Investigations

2.1.1 Sampling and Analysis of Surface Sediments

An appropriate number of reaches downstream of known Laboratory sources of contamination, as discussed in Chapter 5 of this core document, and described in detail in each of the canyon- or canyon aggregate-specific sampling and analysis plans (SAPs), will be characterized to

- determine the nature, extent, and transport of Laboratory-derived contamination in the appropriate canyons,
- evaluate present-day risk to human health and ecosystems from contaminated sediments,
- collect data to evaluate and refine the conceptual, and
- assess the projected impact of contaminated sediments on groundwaters, off-site receptors, and the Rio Grande.

The initial stages of each of the investigations include contamination and geomorphic surveys to provide information about the distribution and geomorphic controls on contaminants across the canyon floors, the heterogeneity of contaminant distribution within geomorphic units, the locations and extents of areas containing elevated contaminant concentrations that may be candidates for further investigations, and the distribution of contaminants in the subsurface. Concurrent with the mapping and survey activities, background samples (if required as noted in Section 5.6.3.1 in Chapter 5 of this core document) will be collected upstream of known Laboratory source areas to determine background concentrations of potential contaminants in sediments in the canyon systems.

Based on initial mapping and survey activities, sites will be selected for collecting and analyzing sediment samples for a full suite of potential contaminants. Results of analysis for the full suite of potential contaminants will be used to define the limited suite of chemicals of potential concern for subsequent sampling and analysis tasks. Limited suite analyses will be performed on sediments and used for determining the heterogeneity of contaminants in geomorphic units and for conducting human health and ecological risk assessments. Additional sediment samples may be analyzed for a more restricted suite of key contaminants to provide additional information about contaminant distributions and to address hypotheses related to contaminant transport mechanisms derived from the conceptual model.

2.1.2 Sampling and Analysis of Surface Water and Groundwater

The strategy for sampling surface water and groundwater will focus on characterizing the hydrology and geochemistry of the canyon systems individually and on characterizing the nature and extent of Laboratory-derived contaminants in groundwater-bearing zones. These investigations have three components that can be conducted separately:

- surface water sampling and analysis,
- alluvial groundwater sampling and analysis, and
- intermediate perched zone and regional aquifer groundwater sampling and analysis.

Though conducted separately, the results from all three components of the sampling and analysis activities will contribute to an improved understanding of the canyon systems both individually and as an integrated hydrologic system. Groundwater investigations conducted in the canyons will be integrated hydrologic system. Groundwater investigations conducted in the canyons will be

integrated with work conducted under the Hydrogeologic Workplan (LANL 1996, 55430) as discussed in Section 5.7 in Chapter 5 of this core document.

The construction of new wells, collection of borehole core samples during drilling for new wells, and periodic sampling of groundwater in existing and new wells during the canyons investigations will be coordinated with the work described in the Hydrogeologic Workplan and will be discussed in each of the canyon- or canyon aggregate-specific SAPs. Sampling of the regional aquifer is limited to existing wells during the initial stages of each of the investigations. The SAPs are designed to be flexible, and the objectives and approaches will be continually refined and modified as new data are obtained.

2.1.3 Priorities

The management priorities that form the rationale for the sequence of activities described above have the following aspects:

- Investigations in Field Unit 4 are derived largely from requirements in the HSWA Module VIII of the RCRA Part B Operating Permit (EPA 1990, 1585). In this sense, the SAPs are not facilities-based RCRA facility investigation (RFI) work plans like other ER investigations at the Laboratory. Rather, priorities in these SAPs reflect the need to characterize the present-day human health and ecological risks and the projected impacts of affected media downgradient of Laboratory source areas.

- The canyon systems have the potential for residential use as well as frequent casual recreational use; thus they represent a potential source of public exposure to Laboratory-derived contaminants.

- Surface sediments are likely to contain the largest inventory of contaminants and represent the source material most likely to lead to human and ecological exposure. Furthermore, transport of these sediments by erosion processes represents the dominant contaminant transport mechanism in the canyon systems.

- Potential for contamination of the hydrologic system beneath the canyon systems is a major concern of regulators and stakeholders.

- A large volume of data on contaminants is available for some of the canyons. That data can be used to guide the planning for sampling and analysis in each canyon or canyon aggregate to achieve the investigation objectives expeditiously.

2.1.4 Quality Assurance

In accordance with the requirements of the ER "Quality Assurance Project Plan Requirements for Sampling and Analysis Plans" (hereafter the "QAPP") (LANL 1996, 53450), each of the canyon- or canyon aggregate-specific SAPs will contain a thorough description of the quality assurance (QA)/quality control procedures and the field and laboratory investigation methods to be used in each investigation. The guidance found in the QAPP will be used to prepare these portions of each SAP.

2.2 Schedule

General schedule requirements for the Laboratory's ER Project are described in Annex I of the IWP (LANL 1993, 26077). A projected RFI/corrective measures study (CMS) schedule for the RFI/CMS process for

2.4 Indian Pueblo Interaction

The interactions with the Indian Pueblos will be closely coordinated between the field project leader and the Community Involvement and Outreach Office, and the Community Involvement and Outreach Office.

2.5 Tours of the Canyon Systems Sites

It will be helpful to the public to see the actual cleanup sites associated with the canyon systems. Tours will be scheduled as potential release sites are scheduled for corrective action, during public meetings, or at the specific request of the public. For these activities, ER Project personnel will take into consideration times convenient for the public such as late afternoons, evenings, and weekends.

2.6 Responses to Inquiries

Inquiries about the canyon systems activities may be directed to the

- Field Unit 4 field project leader, Allyn Pratt, at 505-667-4308 or
- Community Involvement and Outreach staff at 1-800-357-8301.

A specific briefing may also be held upon request.

2.7 Monthly Progress Tracking System

As the canyon- or canyon aggregate-specific sampling and analysis plans are implemented, the ER Project will document technical progress in monthly progress reports. These reports will be available at the Laboratory Community Reading Room.

REFERENCES FOR ANNEX IV

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

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