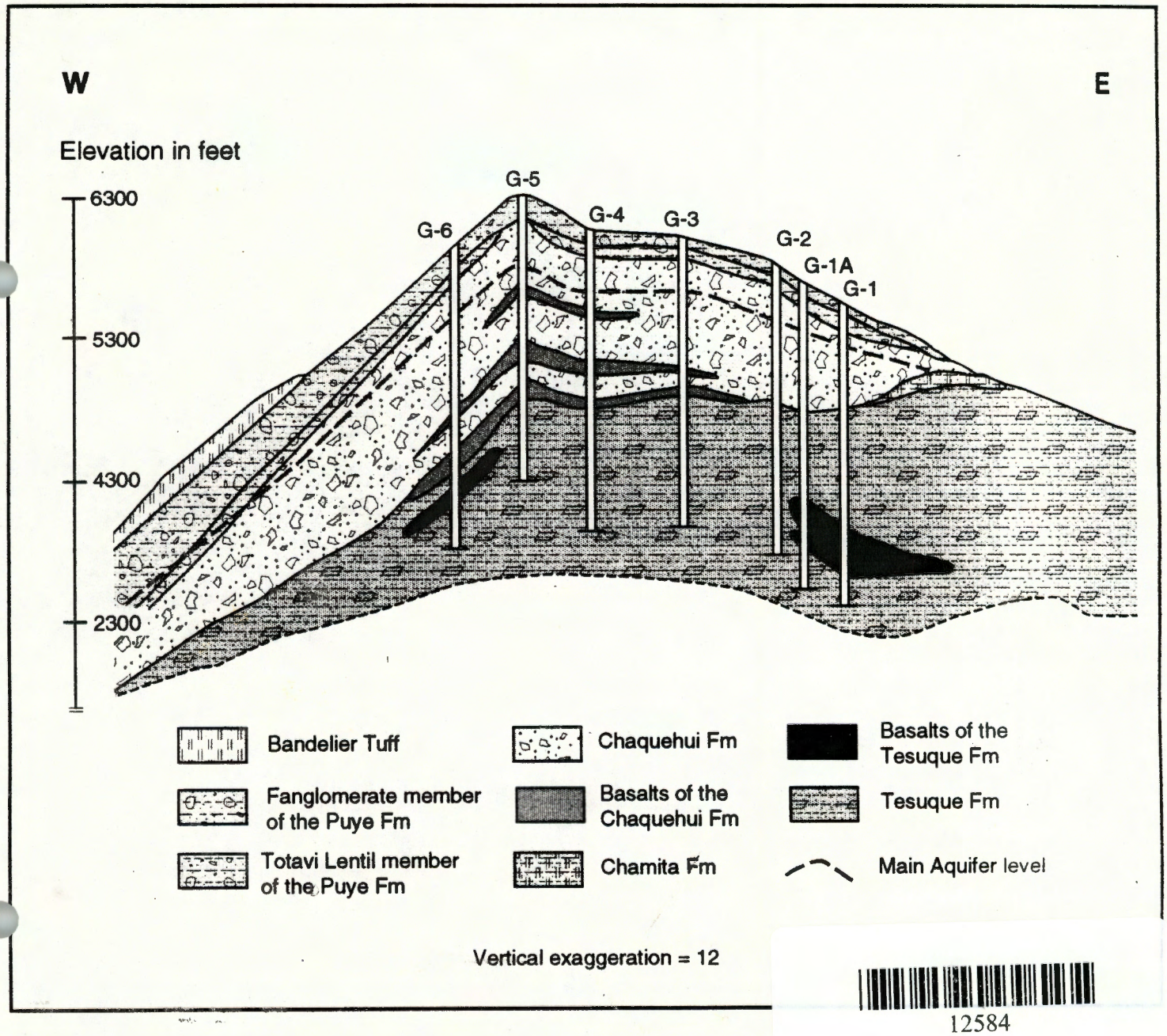
Groundwater Protection Management Program Plan

Los Alamos National Laboratory



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Los Alamos National Laboratory

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Executive Summary

The Groundwater Protection Management Program Plan (GWPMPP) provides a detailed framework for consolidating and coordinating groundwater protection activities at Los Alamos National Laboratory. The purpose of the plan is to monitor and protect the main aquifer underlying the Pajarito Plateau from contamination or other adverse impacts resulting from Laboratory operations, and to preserve the quality of water for Los Alamos and surrounding communities in northern New Mexico for future generations.

The GWPMPP addresses the following issues concerning the groundwater situation at the Laboratory: (1) hydrogeological characterization, (2) potential contamination, (3) groundwater monitoring network, (4) water supply, (5) information management, (6) quality assurance, and (7) regulatory compliance. These issues have been discussed in audits, reports, and assessments, and various deficiencies regarding current Laboratory operations have been identified. To remedy the problems, hydrologists, geologists, and consultants, as well as representatives of the New Mexico Environment Department and the Environmental Protection Agency, have examined these issues and have recommended solutions as they pertain to Laboratory operations.

Many of the deficiencies result from a lack of scientific data. Laboratory hydrologists do not have enough information to fully characterize the hydrogeology of the region or the contaminant flow from the technical area sites because the existing network of monitoring wells is not adequate. The primary solution to these problems, therefore, will be to expand the current groundwater monitoring network. By increasing the number of monitoring wells and boreholes and by constructing the wells at select locations across the Pajarito Plateau, hydrologists will be able to collect sufficient data to fully characterize the groundwater of the area. The GWPMPP includes a map of proposed well locations and rationale for each new site.

Other deficiencies involve the collection, dissemination, and accessibility of groundwater information. Groundwater efforts are currently spread among several organizations at the Laboratory; one organization often follows sampling procedures or well construction techniques that are sometimes different from another organization. To remedy these problems, the GWPMPP details the development of a computer database network to ensure that timely groundwater-related information will be accessible to internal and external organizations and other interested parties. Consistency of sampling procedures, well construction and abandonment techniques, and other procedures will also be implemented so that the sharing of groundwater-related information will be facilitated.

The GWPMPP also presents a business plan detailing the organizational hierarchy, roles and responsibilities, accountability and authority, funding allotments, and other financial considerations involved in implementing the plan. The core of the business plan is a prioritized list of groundwater activities, which ranks the activities according to their cost and overall importance. The final list of priorities, then, represents the best attempt to enhance Laboratory environmental operations within budgetary constraints.

In sum, the GWPMPP presents an organized approach to managing and protecting the groundwater in the Los Alamos area. Through a dynamic process of coordinating its activities, the Laboratory will use the plan as an effective guide in responding to changing environmental needs.

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Acronyms

AEA	Atomic Energy Act of 1954
AEC	Atomic Energy Commission
AIP	Agreement in Principle
ALARA	As Low As Reasonably Achievable
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CY	Calendar Year
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE/AL	DOE/Albuquerque Operations Office
DOE/HQ	DOE Headquarters
DOE/LAAO	DOE/Los Alamos Area Office
EPA	Environmental Protection Agency
ER	Environmental Restoration Program
ESH	Environment, Safety, and Health
FIMAD	Facility for Information Management, Analysis and Display
FY	Fiscal Year
GMP	Groundwater Monitoring Plan
GWPMP	Groundwater Protection Management Program
GWPMPP	Groundwater Protection Management Program Plan
HSWA	Hazardous and Solid Waste Amendments
HWTF	Hazardous Waste Treatment Facility
LAAO	Los Alamos Area Office
LANL	Los Alamos National Laboratory
LIPS	Laboratory Integration Prioritization System
MWDF	Mixed Waste Disposal Facility
NEPA	National Environmental Policy Act
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
NPDES	National Pollutant Discharge Elimination System

NRC	Nuclear Regulatory Commission
OB/OD	Open Burning / Open Detonation
PMC	Program Management Committee
QAP	Quality Assurance Plan
QAPP	Quality Assurance Program Plan
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedure
SPCC	Spill Prevention Control and Countermeasures
SWSC	Sanitary Wastewater Systems Consolidation
SWDA	Solid Waste Disposal Act
SWMU	Solid Waste Management Unit
SWPP	Storm Water Pollution Prevention
TA	Technical Area
TEGD	Technical Evaluation Guidance Document
TRC	Technical Review Committee
TSCA	Toxic Substances Control Act
UC	University of California
USGS	Unites States Geological Survey
WBS	Work Breakdown Structure
WSC	Waste Stream Identification and Characterization
WM	Waste Management

1.0 Introduction

1.1 Purpose and Scope

As a Department of Energy (DOE) facility, Los Alamos National Laboratory (LANL or Laboratory) is required to conduct its operations in an environmentally safe manner. DOE Order 5400.1 (DOE 1990) establishes environmental protection program requirements, authorities, and responsibilities for all DOE facilities. The goal of this order is to ensure that operations at DOE facilities comply with all applicable environmental laws and regulations, executive orders, and departmental policies.

In accordance with the requirements of Chapter III, Section 4a, of DOE Order 5400.1, the Laboratory has prepared this Groundwater Protection Management Program Plan (GWPMPP or Plan). The Order requires establishment of a groundwater protection management program which will provide: (1) documentation of the groundwater regime with respect to quantity and quality; (2) design and implementation of a groundwater monitoring program to support resource management and comply with applicable environmental laws and regulations; (3) a management program for groundwater protection and remediation, including specific Safe Drinking Water Act (SDWA), Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) actions; (4) a summary and identification of areas that may be contaminated with hazardous substances; (5) strategies for controlling sources of these contaminants; (6) a remedial action program that is part of the site CERCLA program required by DOE 5400.4; and (7) decontamination and decommissioning, and other remedial programs contained in DOE directives.

The GWPMPP has also been prepared to fulfill the requirements of Chapter IV, Section 9 of DOE Order 5400.1. This section requires development of a Groundwater Monitoring Plan (GMP) as a specific element of the GWPMPP. The GMP shall identify all DOE requirements and regulations applicable to groundwater protection and include monitoring strategies for sampling, analysis, and data management. The general requirements outlined in Section 9b include: (1) determination of baseline groundwater quality and quantity conditions; (2) demonstration of compliance with, and implementation of, all applicable regulations and DOE Orders; (3) providing data that will allow early detection of groundwater pollution or contamination; (4) providing a reporting mechanism for detection of groundwater pollution or contamination; (5) identifying existing and potential groundwater contamination sources and to maintain surveillance of these sources; and (6) providing data upon which decisions can be made concerning land disposal practices and the management and protection of groundwater resources.

Section 9c of Chapter IV requires that groundwater monitoring needs be determined by site-specific characteristics and, where appropriate, groundwater monitoring programs be designed and implemented in accordance with 40 CFR Part 264, Subpart F, or 40 CFR Part 265, Subpart F. The section also requires that monitoring for radionuclides be in accordance with DOE Orders in the 5400 series dealing with radiation protection of the public and the environment.

This Plan focuses on protection of groundwater resources in and around the Los Alamos area and ensures that all groundwater-related activities comply with the applicable federal, state, and local regulations. These regulations are described in Appendix A.

1.2 Laboratory Environmental Goals

The Laboratory's primary environmental goal is to protect the environment and public from possible adverse effects arising from the Laboratory's operations. As documented in the Laboratory's Environment, Safety, and Health Manual (LANL 1990), the Environment, Safety and Health Division (ESH) maintains a comprehensive program to provide oversight of environmental activities. Laboratory employees are required to observe environmental protection procedures and requirements as specified by their supervisors.

Director's Policy No. 104 (September 1991) states the following:

> Operations at the Laboratory shall be performed in a manner that protects the environment and addresses compliance with applicable federal, state, and local environmental protection regulations. Potential environmental degradation from previous laboratory operations will be identified and mitigated as part of a graded restoration program.

Appendix A lists the requirements of applicable environmental protection and restoration regulations pertaining to groundwater. It includes SDWA, CERCLA, RCRA, and the Hazardous and Solid Waste Amendments (HSWA).

1.3 GWPMP Mission and Objectives

The mission of the Groundwater Protection Management Program (GWPMP or Program) is to provide enhanced groundwater monitoring and program documentation in order to ensure long-term protection of the local and regional groundwater supply.

The specific Program objectives are to:

- Consolidate the activities of different LANL environmental groups to ensure a unified approach to groundwater protection and prevent duplication of effort.
- Establish an information system in which all groundwater-related data will be stored and which will be accessible to different LANL groups and outside customers.
- Address the requirements of the HSWA Permit, Module 8, Task III.
- Provide enhanced groundwater documentation to support a Laboratory-wide Environmental Impact Statement as requested by the DOE under the National Environmental Policy Act (NEPA).
- Maintain ongoing groundwater protection activities and address new issues of concern as they occur.

The purpose of this Plan is to implement these objectives. As such, the Plan will address issues of concern related to groundwater protection that exist at the Laboratory; define the management structure and fiscal organization of the Program; and establish an initial list of prioritized activities to be addressed for the purpose of expanded hydrologic knowledge and groundwater protection in the Los Alamos area.

2.0 Background

2.1 Historical Review

The Laboratory was established in 1943 as Project Y of the Manhattan Engineer District—the secret World War II effort to develop the world's first nuclear weapons. A physics professor at Berkeley, J. Robert Oppenheimer, was selected to head the effort. To keep the project developing in an academic atmosphere, the University of California (UC) was requested to manage the Laboratory.

In 27 months, Oppenheimer and his colleagues successfully completed their mission, and the war against Japan ended. After the war, Congress chose to sustain the Los Alamos site with continued funding. The Atomic Energy Commission (AEC) received control of the Laboratory from the Army and renewed the operating contract with UC. During subsequent years, the Laboratory continued to expand at a steady rate, first under the AEC and later under the Energy Research and Development Association. The Laboratory was designated a national laboratory and has operated under the (DOE) since 1978.

From its origins during World War II, the Laboratory has evolved into a large, multiprogram, multidisciplinary national laboratory. Table 2-1 shows the major milestones in scientific research that have been accomplished over the years at the Laboratory.

Table 2-1. Milestones in the History of Los Alamos National Laboratory

1943	The Los Alamos Laboratory, under the direction of J. Robert Oppenheimer, begins operation as Project Y of the Manhattan Project. The Bethe-Feynman formula, a simple method for calculating the yield of a fission bomb, is derived.
1944	The world's third nuclear reactor (a uranium-solution-fueled "Water Boiler" named LOPO) achieves criticality.
1945	The world's first nuclear bombs (Little Boy, a gun-type uranium bomb, and Fat Man, an implosion-type plutonium bomb) prove successful. Norris E. Bradbury is named second director of the Laboratory.
1946	The world's first plutonium-fueled nuclear reactor (Clementine) achieves criticality.
1947	The Monte Carlo technique for particle-transport computations is formulated.
1948	Helium-3 is first liquefied.
1951	First thermonuclear reaction is produced in the George shot of the Greenhouse test series.
1952	The MANIAC computer becomes operational. The first thermonuclear explosion is achieved by the Mike shot of the Ivy test series. The first facility for handling liquid hydrogen on a large scale becomes operational. Plutonium-244, plutonium-246, americium-246, einsteinium-253, and fermium-256 are discovered in the debris of the Mike shot.
1953	The Lady Godiva critical assembly achieves prompt criticality. The S_n, or discrete ordinates, method for solving neutron-transport problems is formulated.
1954	The first thermonuclear bomb containing solid fusion fuel is demonstrated in the Bravo shot of the Castle test series.
1955	The Rover Project to investigate nuclear-reactor-powered rockets is initiated.
1956	The neutrino is detected with the help of a recently developed liquid scintillator. The MANIAC II computer and the Omega West reactor become operational.
1957	The particle-in-cell (PIC) method for numerical fluid dynamics is invented.
1958	A helium-3 refrigerator providing temperatures below 0.45 Kelvin is developed.
1959	Plutonium-238 is used as a power source in space.
1960	The KIWI nuclear reactor for the Rover Project is operated at full power.
1961	The Stretch computer is developed in collaboration with IBM.

Table 2-1, Continued

1963	Satellite-borne sensors to verify adherence to the Limited Test Ban Treaty are developed. PHERMEX, the world's highest-intensity x-ray facility, is constructed.
1964	The world's highest-voltage Van de Graaff accelerator is completed.
1965	The Phoebus I-A Rover reactor is tested at full power.
1967	The side-coupled cavity is developed for the LAMPF linear accelerator.
1968	Funding for construction of LAMPF is approved by Congress and President Johnson.
1969	The ultra-high-temperature nuclear reactor (UHTREX) begins operation at 2400°F.
1970	Harold M. Agnew is named third director of the Laboratory.
1971	Naturally occurring plutonium-244 is isolated.
1972	LAMPF accelerates protons to design energy. Isotopes of uranium are separated by selective laser excitation of UF_6.
1974	Insensitive high explosives for use in nuclear weapons are developed. The Laboratory is named a national resource for stable isotopes.
1976	A portion of the Laboratory site is designated a national environmental research park.
1977	Fusion neutrons are detected in a plasma confined by radiation from a carbon-dioxide laser.
1978	The Hot Dry Rock Program is initiated (Fenton Hill).
1979	Donald M. Kerr is named fourth director of the Laboratory. Universality of the approach to chaos in deterministic systems is discovered.
1980	The University of California establishes a branch of the Institute of Geophysics and Planetary Physics. The center for Nonlinear Studies is established.
1981	The Center for Materials Sciences is established.
1982	The Laboratory is designated a national resource for flow cytometry. GenBank, the national database for nucleic-acid sequences, begins operation. A heavy-fermion superconductor is discovered.
1983	Congress approves long-term visits at LAMPF for citizens of the People's Republic of China.
1984	The radio-frequency quadrupole cavity is developed for a neutral-particle accelerator.
1985	A new technique (CORRTEX) is developed to verify yields of underground nuclear explosions.
1986	Siegfried S. Hecker is named fifth director of the Laboratory. The world's first high-temperature hot-dry-rock system is successfully tested.
1987	The first edition of nucleotide-sequence data for HIV samples is published.
1988	The Laboratory is designated as one of three national DOE centers for human genome studies. A new type of chemical bond is discovered in the binding of molecular hydrogen to the central metal atom in certain metal complexes.
1989	A beam of energetic neutral particles is created in space.
1990	Superconducting tapes and thin films are fabricated.
1991	The Laboratory is designated as one of two centers for research on high performance computing.
1993	Cross section for the scattering of electron neutrinos by electrons is determined experimentally.

2.2 Geography

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 (Figure 2-1). Most of the Laboratory and community developments are confined to mesa tops. The surrounding land is largely undeveloped with large tracts of land north, west, and south of the Laboratory site held by the Santa Fe National Forest, Bureau of Land

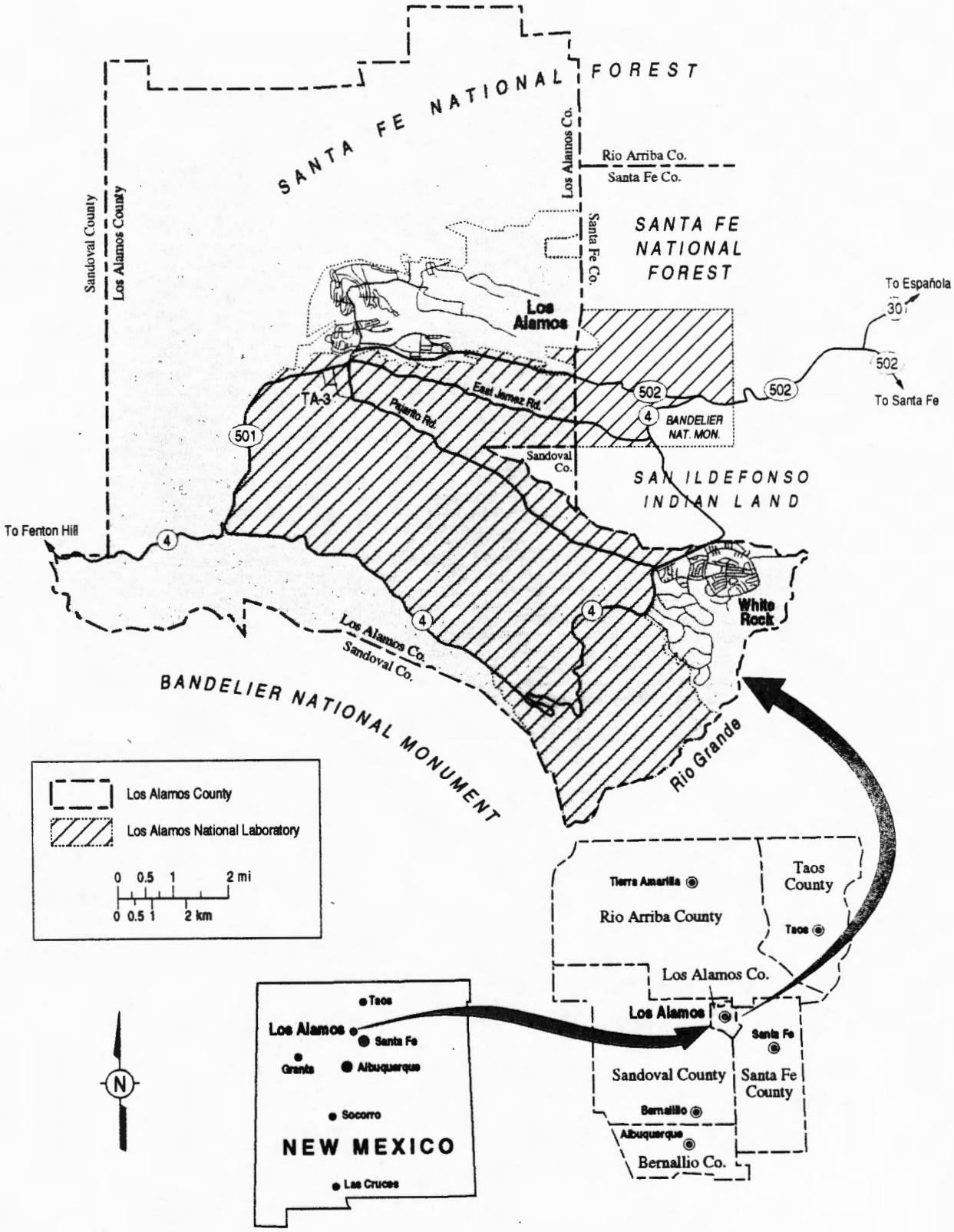

Figure 2-1. Regional location of Los Alamos.

Management, Bandelier National Monument, General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east.

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 (TAs) each of which has a specific research function or other use (Figure 2-2). The developed sites, however, 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.

2.3 Geology

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 intermittent streams. Mesa tops range in elevation from approximately 2,400 m (7,800 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 (Figure 2-3).

Most of the mesas in the Laboratory area are made up of the Bandelier Tuff Formation which consists of ash fall, ash fall pumice, and rhyolite tuff. The tuff, ranging from nonwelded to welded, is more than 300 m (1,000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of a series of major volcanic eruptions in the Jemez Mountains about 1.1 to 1.4 million years ago.

The tuff overlaps onto the Tschicoma Formation, which consists of older volcanic substances that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central and eastern edge along the Rio Grande. Totavi Formation sediments and Cerros del Rio basalts interfinger with the conglomerate. These formations overlay the sediments of the Tesuque and Chamita Formations, which make up the Santa Fe Group. The Santa Fe Group of sediments extends across the Rio Grande Valley and is more than 1,000 m (3,300 ft) thick. The Laboratory is bordered on the east by the Rio Grande, within the Rio Grande rift. Because the rift is slowly widening, the area experiences frequent but minor seismic disturbances.

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See Appendix B for a more technical discussion of the geology of the Pajarito plateau.

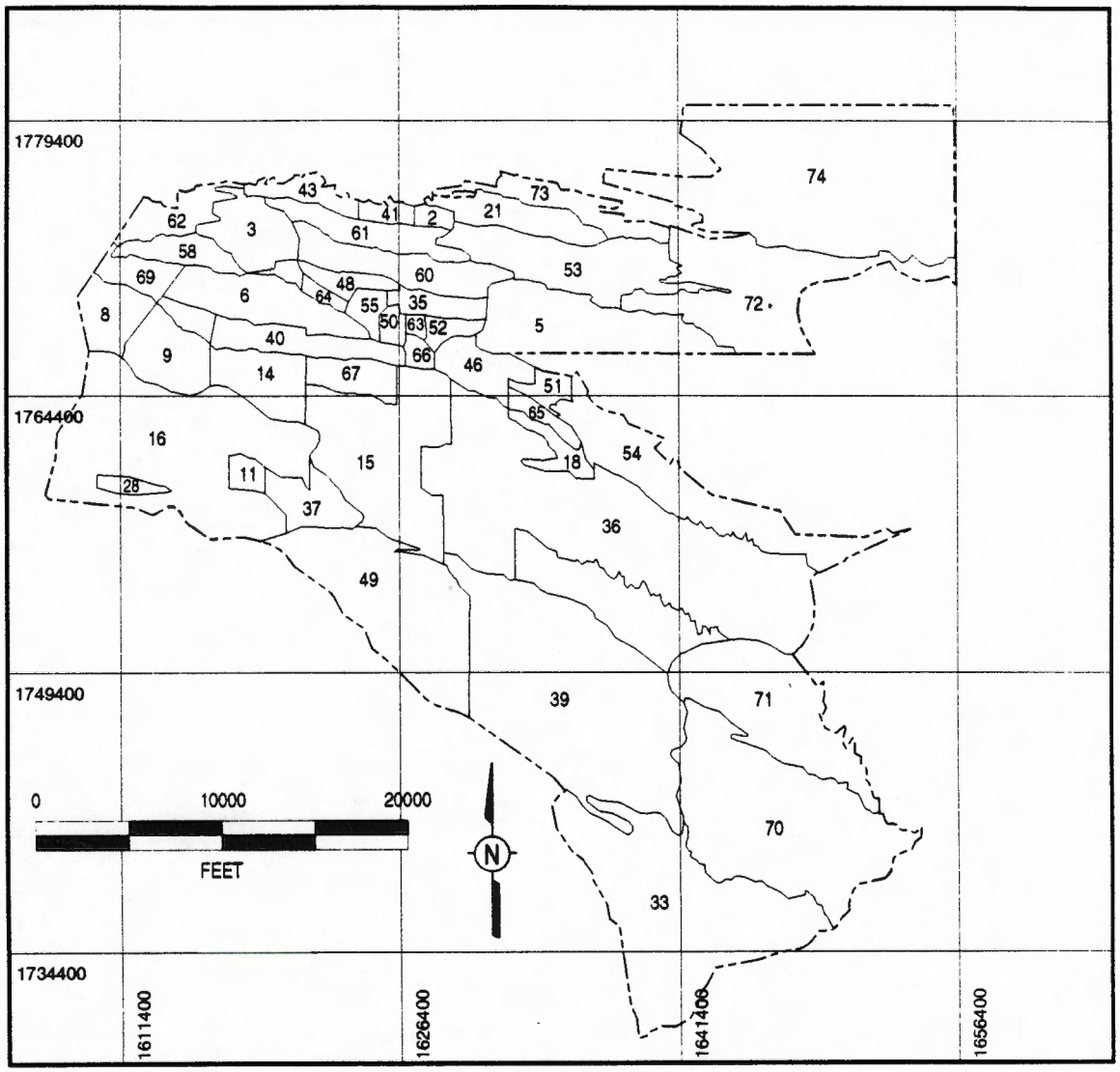
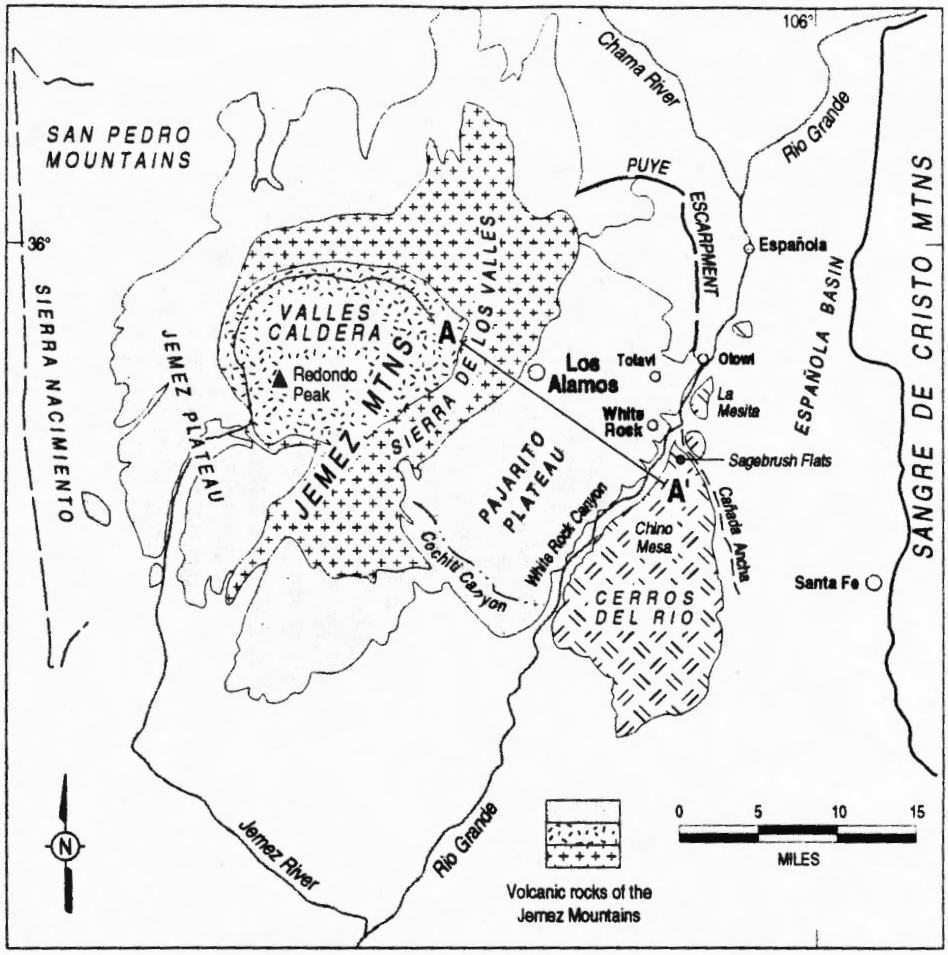


Figure 2-2. Technical areas at the Los Alamos National Laboratory



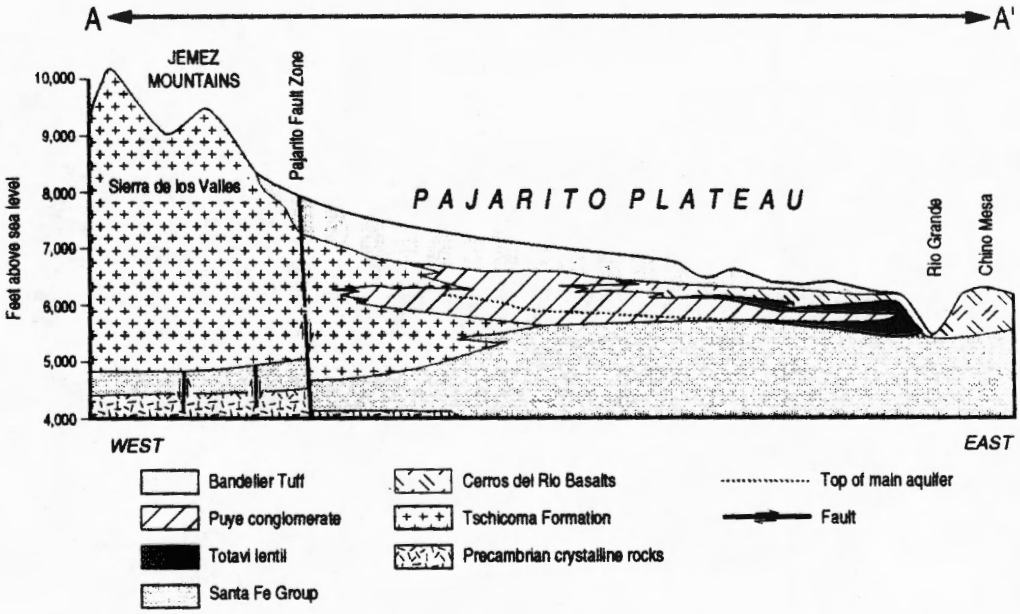


Figure 2-3. Geologic location and generalized cross section of Pajarito Plateau.

3.0 Summary of Hydrogeological Environment

3.1 Surface Water

Surface water occurs as ephemeral and interrupted streams in the Los Alamos region. Ephemeral reaches flow briefly in response to precipitation or snowmelt in the immediate locality. Intermittent reaches flow seasonally (e.g., during snowmelt in the spring), and perennial reaches flow continuously throughout the year.

Surface water occurs primarily as ephemeral reaches in all of the major canyons, including Guaje, Rendija, Barrancas, Bayo, Pueblo, Los Alamos, Sandia, Mortandad, Pajarito, and Water Canyons (Purtymun 1975). Figure 3-1 shows the major surface drainages in the Los Alamos area. Some reaches of these streams are intermittent during the spring and fall.

Perennial reaches in the Los Alamos region are few. Springs on the flanks of the Jemez Mountains supply base flow throughout the year to the upper reaches of Guaje, Los Alamos, Pajarito, and Water Canyons, and Canyon del Valle. The volume of flow, however, from these springs is insufficient to maintain surface flows across the Laboratory site before being depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande in some drainages. Effluents from sanitary sewage plants, industrial waste treatment facilities, and cooling-tower blowdown are released into some canyons at rates sufficient to maintain surface flows for varying distances. These discharges typically do not migrate across the eastern boundaries of the Laboratory.

3.2 Groundwater

Groundwater occurs in three modes in the Los Alamos area: (1) water perched in shallow alluvium in canyons, (2) water perched in volcanic sediments and basalts, and (3) water contained in the main aquifer. These three groundwater systems, depicted in Figure 3-2, are described below.

3.2.1 Perched Groundwater in Canyon Alluvium

Canyons of the plateau have alluvium deposits that range from 1 m (3 ft) to as much as 30 m (100 ft) in thickness. The composition of these deposits range from sands, gravels, pebbles, cobbles, and boulders in canyons that head on the flanks of the Jemez Mountains to clays, silts, sands, and gravels in canyons that head on the plateau. These alluvial layers are highly permeable, in contrast to the underlying volcanic tuff and sediments. As a result, storm runoff forms shallow alluvial groundwater zones that move down gradient within the alluvium. As the perched alluvial groundwater moves down the canyons, it is depleted by evapotranspiration and infiltration into the underlying volcanics (Purtymun et al. 1977).

3.2.2 Perched Groundwater in Volcanic Sediments and Basalts

Pueblo, Los Alamos, Sandia Canyons

In the Los Alamos area, perched zones occur in the conglomerates and basalts beneath the alluvium in the middle and lower reaches of Pueblo and Los Alamos Canyons and in the lower reach of Sandia Canyon. Studies suggest that infiltration of alluvial groundwater is the main source of recharge to the intermediate depth perched groundwater (Purtymun 1975; Abeele et al. 1981). Depth to perched water ranges from about 27 m (90 ft) in the midreach of Pueblo Canyon to about 140 m (450 ft) in lower Sandia Canyon. The vertical and lateral extent of these perched zones, the nature and extent of perching units, and the potential for migration of perched water to the main aquifer is not fully understood by investigators to date.

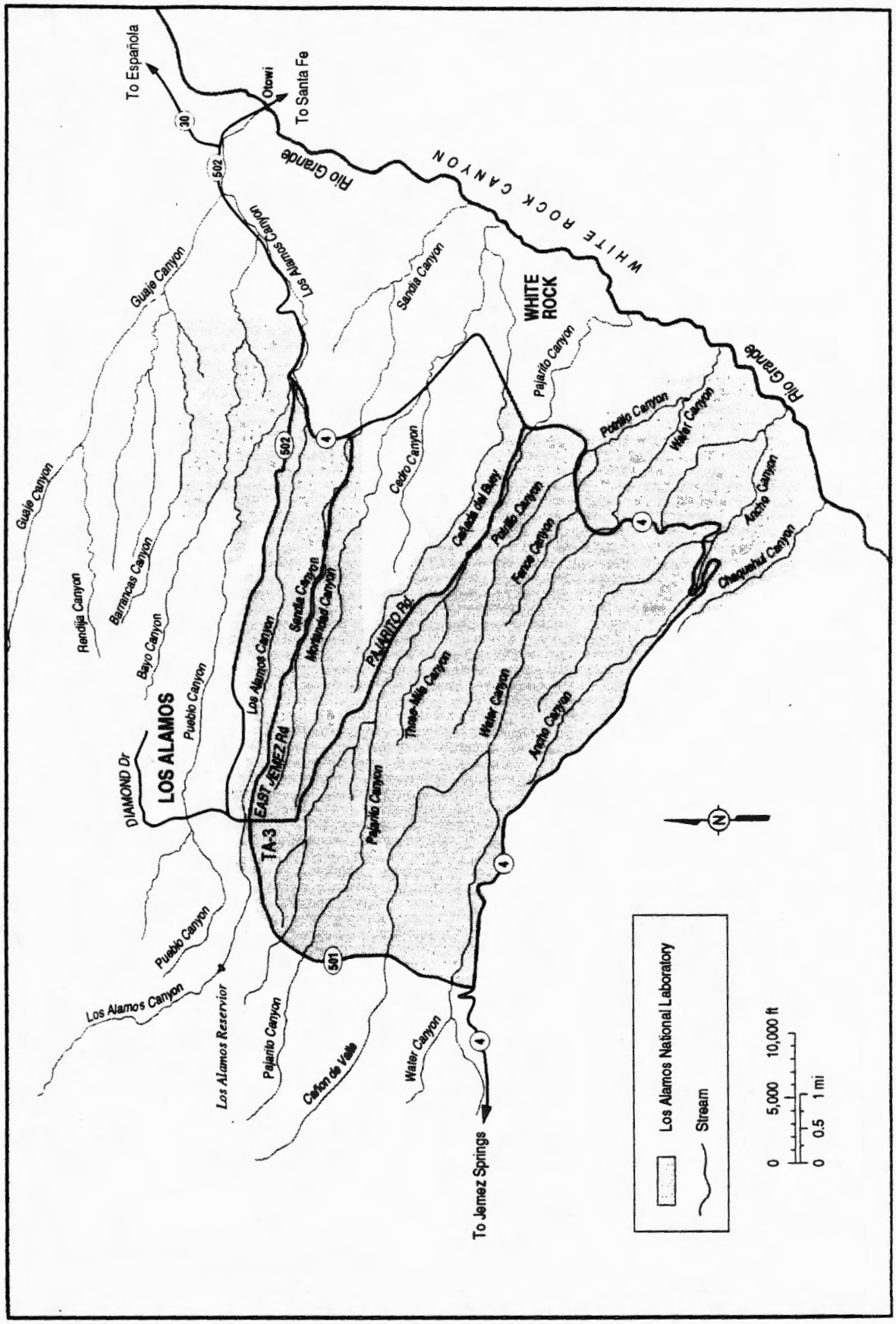


Figure 3-1. Major surface water drainages in the Los Alamos area.

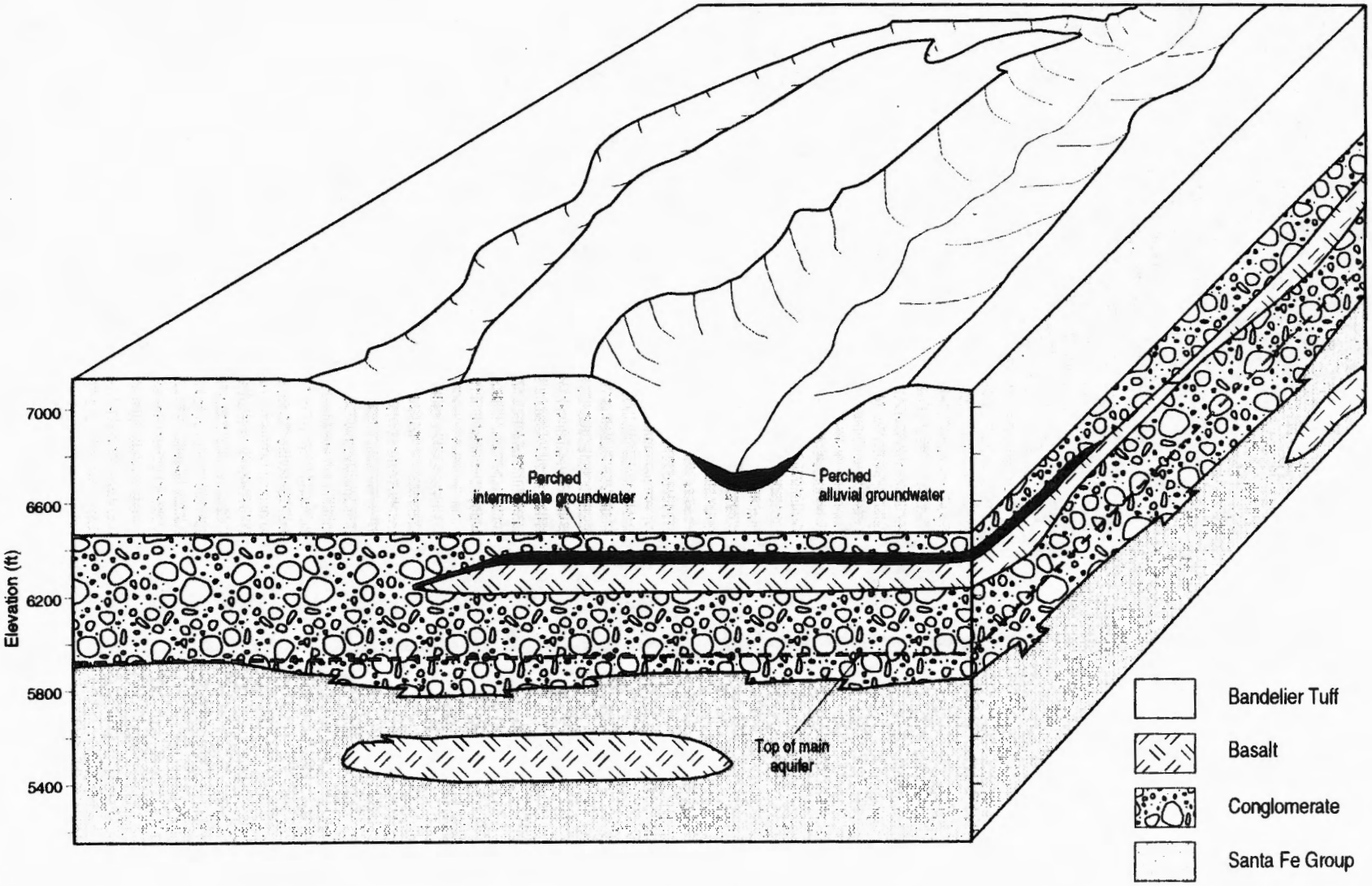


Figure 3-2. Conceptual illistration of geologic-hydrologic relationships in the Los Alamos area.

3.2.3 Main Aquifer

The main aquifer beneath the Pajarito Plateau serves as the municipal water supply for Los Alamos and the surrounding communities. The surface of the main aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Conglomerate beneath the central and western part of the plateau. The depths to water below the mesa tops range from 360 m (1,200 ft) along the western margin of the plateau to about 180 m (600 ft) at the eastern margin. The main aquifer is separated from the perched water in the alluvium and the perched water in the volcanics by 110 m (350 ft) to 190 m (620 ft) of tuff and volcanic sediments which impede the downward migration of surface and perched water. The main aquifer responds as an unconfined aquifer in the western part of the plateau but exhibits semiartesian to artesian conditions in the eastern part along the Rio Grande. Although the water level in some places is dropping approximately two feet per year, after more than forty years of use, the main aquifer shows little observed depletion of resources: the piezometric surface has not declined significantly and there are nearly complete water-level recoveries after the wells are shut down.

Assert that there is little depletion 5-19 says is unk ? prove it

The mechanism for recharge to the main aquifer is not well understood. Three hydrological models have been developed to show this mechanism. The first model, proposed by Conover et al. (1963) and Griggs (1964), presents data which support the concept that groundwater discharges from the Valles Caldera to the southwest away from the Los Alamos area, and that the Tschicoma Formation in the Jemez Mountains is completely impermeable to groundwater flow. In this model, Griggs (1964) suggests that the major source of recharge to the main aquifer is seepage from small streams and rivulets on the lower slopes of the Sierra del los Valles and on the western part of the Pajarito Plateau. A second recharge model, described in more recent Laboratory environment reports (Purtymun 1975; Purtymun et al. 1980; Purtymun et al. 1984), proposes the opposite in that the main aquifer is recharged primarily by the caldera through the Tschicoma Formation in the Jemez Mountains. In the third model, flow through the Tschicoma Formation from the Valles Caldera is considered likely; however, the major source of recharge is thought to be through the Sangre de Cristo Mountains (Figure 3-3).

See Appendix B for a more detailed discussion of the hydrogeology of the Los Alamos area.

~~GW Mining isn't the only issue.~~ We still don't know The influence of pumping on the g.w. flow regime
The text should mention that the influence of pumping on contaminant transport is still unknown

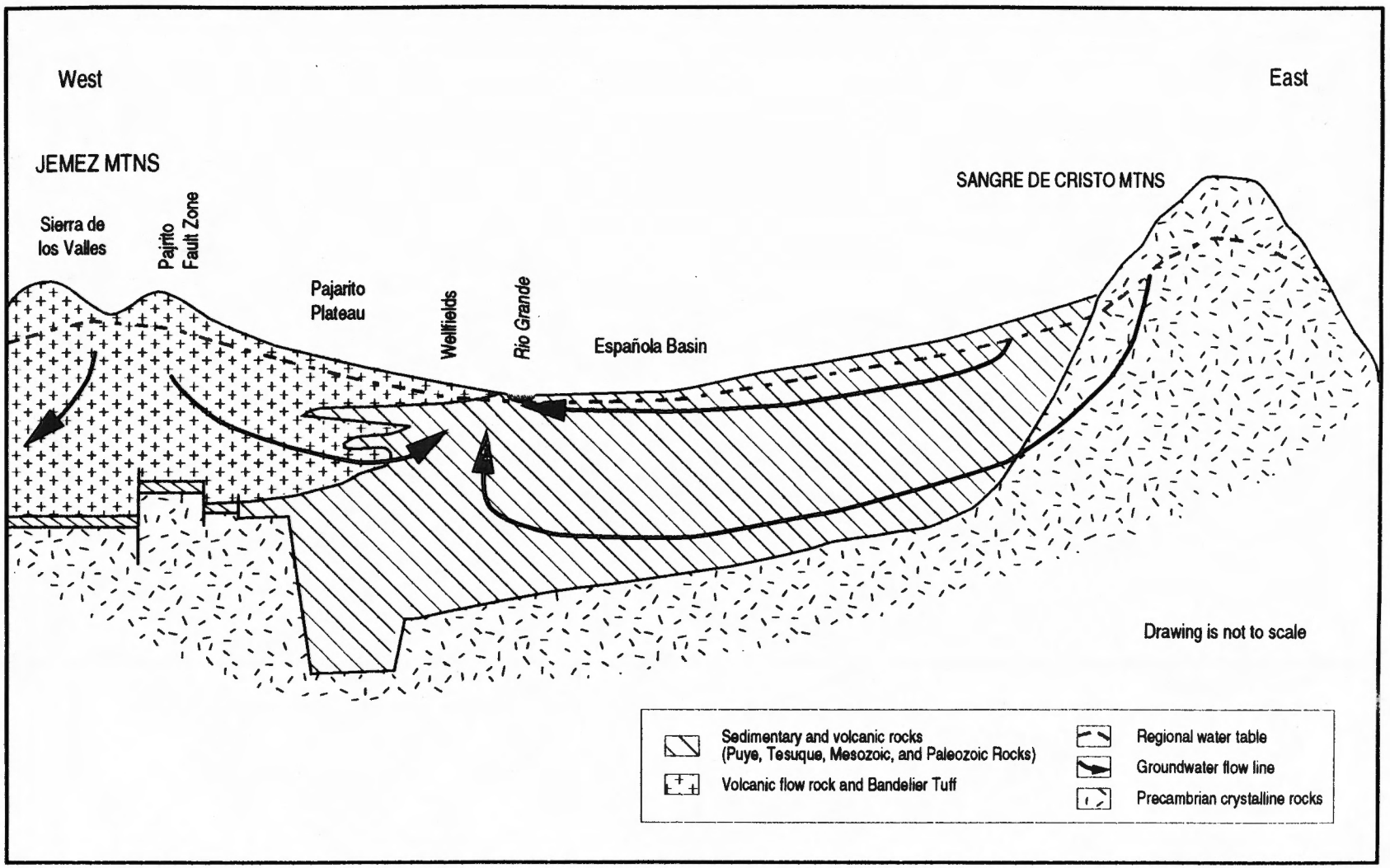


Figure 3-3. Conceptual model of regional groundwater flow paths (modified from Abeele 1981).

4.0 Groundwater Protection Efforts at LANL

4.1 Background

The protection of groundwater in the Los Alamos area has been of paramount importance since the end of World War II, when the AEC needed to develop a reliable water supply. Beginning in 1945, the United States Geological Survey (USGS) became extensively involved in overseeing and conducting various studies for the development of groundwater supplies. Special studies specifically designed to protect and monitor groundwater quality were initiated as joint efforts between the AEC, the Laboratory, and the USGS as early as 1949.

Groundwater monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the USGS to present efforts including the Environmental Restoration (ER) Project, the Decontamination and Decommissioning (D&D) Program, and emergency management and response programs. Other protection efforts include RCRA closures and compliance with the Laboratory's environmental permits (NPDES, RCRA part B, and HSWA).

To comply with the National Pollutant Discharge Elimination System (NPDES) permit, the Laboratory has four primary programs: the Sanitary Wastewater Systems Consolidation (SWSC) Project, the Storm Water Pollution Prevention (SWPP) 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 in order to detect any effects that Laboratory activities may have on the quality of the main aquifer. The current GWPMPP addresses environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations.

4.2 Protection Programs

4.2.1 Environmental Restoration Project

The ER Project was established at the Laboratory in 1987 by the DOE. The ER Project implements the DOE's policy to protect natural resources and restore those damaged by contamination from past and present releases of hazardous substances. The ER Project goals include (1) insurance that the environmental impacts of Laboratory activities are thoroughly investigated and that corrective actions are taken, (2) compliance with RCRA, CERCLA, NEPA, the Atomic Energy Act (AEA), and other applicable regulations and orders, and (3) provision of mechanisms through which interested parties can participate in the corrective action review process.

4.2.2 Decontamination and Decommissioning Program

The D&D Program at LANL was established in 1989 to manage nonoperational, contaminated facilities. The D&D Program responsibilities include assessment and cleanup of facilities and equipment not regulated under CERCLA or RCRA. The D&D Program 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.

4.2.3 RCRA Closures

RCRA mandates a program to regulate hazardous wastes from generation through disposal. The program emphasizes the reduction of hazardous waste volume and toxicity and requires treatment of hazardous waste prior to disposal. Several potential release sites and other areas of concern are subject to the corrective action requirements and the closure provision of RCRA.

All corrective measures conducted by LANL are to comply specifically with the RCRA regulation. LANL 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 1993). The ER Project is responsible for implementing corrective actions at RCRA-regulated land units and RCRA closures, if needed.

4.2.4 Emergency Management and Response

LANL 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.

4.2.5 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.

The Laboratory has established the SWSC Project to eliminate violations of the NPDES permit. A new, centralized, sanitary wastewater treatment plant was constructed at TA-46 to replace the TA-3 wastewater treatment plant and six smaller treatment facilities that consistently failed to meet NPDES discharge regulations. The new treatment plant will also eliminate approximately 30 septic tank systems, and result in a significant savings in operating and maintenance costs.

Storm water discharges associated with industrial activity and storm water discharges from construction sites fall under the NPDES regulations. Facilities covered by NPDES permits must develop SWPP plans. Each plan must identify potential sources of pollution that may reasonably be expected to affect the quality of storm water discharges. In addition, the plan must describe and ensure implementation of practices used to reduce the pollutants in storm water discharges at the facility and ensure compliance with the terms and conditions of the NPDES permit.

The WSC program was conducted during 1992 to verify that each waste stream is properly monitored under the outfall category for which it is permitted and to identify and eliminate noncomplying wastewater discharges. Action plans are developed and implemented through the WSC program to bring respective facilities into compliance with NPDES requirements.

The SPCC Plan is required by the CWA. It addresses facility improvements, operational procedures, and mechanisms for reporting hazardous substances and oil spills to the authorities. The SPCC program and LANL requires secondary containment for all above ground storage tanks. The program also provides spill control on drum and container storage, chemical

storage, and equipment containing oil. In 1989, eleven major sites were augmented with secondary containment facilities, and spill prevention and control training lectures were given to more than a dozen operating groups (LANL 1994).

4.2.6 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.

4.3 Monitoring Network

Groundwater protection activities at LANL include an extensive groundwater monitoring system for assessment of water quality and detection of contaminants in the water supply.

The existing groundwater monitoring network in the Los Alamos area consists of a variety of equipment including test wells, supply wells, gaging stations, observation wells, and other hydrogeologic devices located onsite and outside of the Laboratory boundaries. Scientists routinely sample and analyze wells and springs for radioactive and toxic constituents for basic water quality and resource depletion. (Results are published in the annual Environmental Surveillance Report and the annual Water Supply Report). Networks for the three principal sampling locations are summarized below.

4.3.1 Main Aquifer

The quality of water in the main aquifer is tested at various locations on at least an annual basis. Figure 4-1 shows the locations of main aquifer test wells, supply wells, observation wells, and springs in and around the Laboratory. Seven deep test wells and 10 supply wells are routinely sampled for radioactive and hazardous constituents as part of the annual Environmental Surveillance Group activities. Many of the springs near the Rio Grande are also sampled for the same radioactive and hazardous constituents. A list of the wells and springs sampled by the Environmental Surveillance Group is given in Table 4-1. Other wells and springs are known to exist around the Los Alamos area, yet information on locations, construction, and condition of wells is difficult to obtain. A preliminary list of known wells and springs and current data on them is given in Appendix E. The list includes initial information on well conditions and future plugging status. This list will be updated as information is obtained.

4.3.2 Perched Groundwater in Canyon Alluvium

Figure 4-2 shows the locations of many wells, borings, and auger holes completed into the alluvium. Perched alluvial groundwater zones are known to exist in four canyons (Pueblo, Los Alamos, and Mortandad Canyons, which are all radioactive effluent release areas, and Pajarito Canyon). Perched alluvial groundwater may exist in portions of Water, Sandia, and Potrillo Canyons and Canyon del Valle, however there are no boreholes or wells in likely locations in the canyons to confirm its presence. The perched alluvial groundwater zones are sampled by means of 27 shallow observation wells located within the Laboratory boundary, as previously listed in Table 4-1. Again, many other wells and boreholes to the alluvium are known to exist, and some of the data available on them is given in the preliminary well list in Appendix E.

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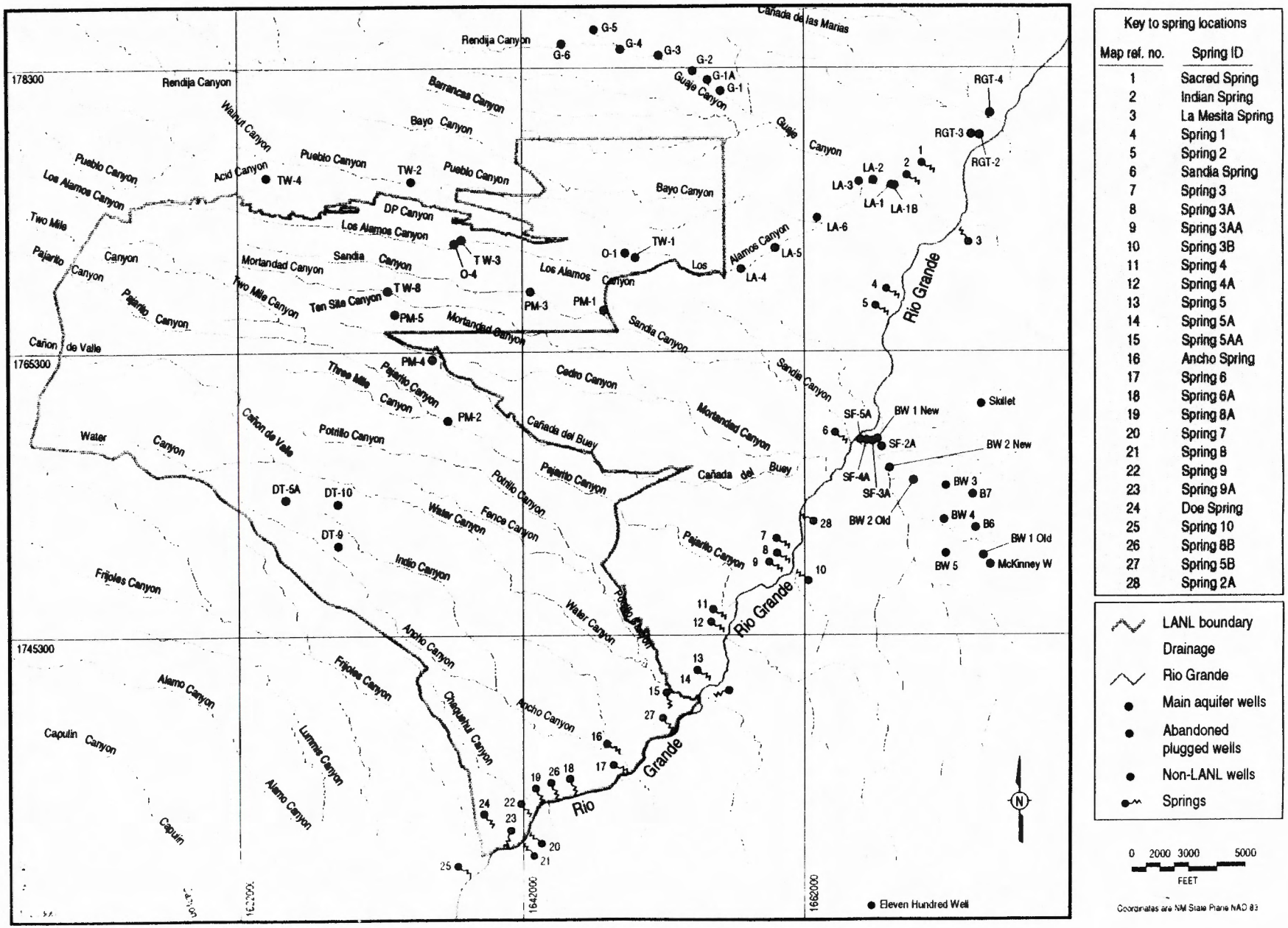

Figure 4-1. Main aquifer wells and springs.

Table 4-1. Environmental Surveillance Groundwater Monitoring Stations

Wells	X-Coordinate	Y-Coordinate	Elevation
Main			
DT-10	1628988	1754448	7019
DT-5A	1625309	1754789	7143
DT-9	1628993	1751492	6936
G-1	1656190	1783609	5973
G-1A	1655240	1784353	6014
G-2	1654210	1785123	6056
G-4	1648949	1786452	6229
G-5	1646949	1787907	6306
G-6	1644824	1786851	6422
PM-1	1647734	1768112	6520
PM-2	1636786	1760326	6715
PM-3	1642631	1769426	6640
PM-4	1635716	1764674	6920
PM-5	1633083	1767809	7095
TW-1	1650041	1772076	6369
TW-2	1634231	1777267	6648
TW-3	1637727	1773138	6595
TW-8	1632573	1769506	6877
Intermediate			
TW-1A	1650056	1772065	6369
TW-2A	1634184	1777288	6650
Alluvial			
APCO-1	1649209	1773020	6367
CDBO-6	1636209	1764759	6817
LAO-1	1629394	1773956	6836
LAO-2	1637607	1773095	6592
LAO-3	1638010	1773098	6578
LAO-4	1640751	1772729	6518
LAO-4.5	1643659	1772087	6451
LAO-C	1622157	1775249	7050
MCO-3	1627362	1770236	7052
MCO-4	1631214	1769787	6900
MCO-5	1632466	1769537	6848
MCO-6	1633635	1769012	6878
MCO-7	1634517	1768509	6827
MCO-7.5	1635454	1768440	6808
PCO-1	1637919	1759990	6687
PCO-2	1641700	1757442	6618
PCO-3	1646088	1755489	6546
Springs			
Main			
Ancho Spring	1646954	1737340	5700
Doe Spring	1642044	1733861	5600
Indian Spring	1666813	1777738	5640
La Mesita Spring	1672344	1771662	5580
Rio Spring 1	1669512	1771609	5615
Rio Spring 10	1638710	1728993	5360
Rio Spring 2	1669296	1771146	5600
Rio Spring 2A	1662671	1754880	5495
Rio Spring 3	1661314	1763673	5560
Rio Spring 3A	1661343	1753407	5560
Rio Spring 3AA	1661127	1751554	5560
Rio Spring 3B	1661589	1749996	5500
Rio Spring 4	1657432	1748409	5570

Table 4-1, Continued

Springs	X-Coordinate	Y-Coordinate	Elevation
Rio Spring 4A	1656148	1747876	5570
Rio Spring 5	1655484	1743048	5770
Rio Spring 5A	1655744	1741982	5395
Rio Spring 5AA	1651143	1742561	5760
Rio Spring 5B	1651079	1738170	5390
Rio Spring 6	1649191	1735678	5380
Rio Spring 6A	1647390	1734564	5375
Rio Spring 7	1645007	1733602	5370
Rio Spring 8	1644411	1733478	5370
Rio Spring 8A	1643417	1734019	5520
Rio Spring 8B	1643284	1733552	5480
Rio Spring 9	1642931	1733737	5485
Rio Spring 9A	1642651	1733468	5525
Sacred Spring	1670044	1780362	5640
Sandia Spring	1663244	1761562	5700
Intermediate			
Basalt Spring	1656544	1770762	6000
Alluvial			
Water Canyon Gallery	1604144	1762561	8000

4.3.3 Intermediate Depth Perched Groundwater

Perched groundwater systems of limited extent occur in the conglomerates and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. Samples are routinely obtained from two test wells and one spring. Figure 4-2 shows these locations.

4.4 Special Studies and Programs

In addition to overseeing the monitoring network, the Laboratory operates a number of special studies and programs related to groundwater protection. These programs include studies of the vadose zone, age-dating studies of the main aquifer, and groundwater quality studies at San Ildefonso Pueblo and in the vicinity of the Fenton Hill Geothermal Site. These programs are described below.

4.4.1 Vadose Zone Studies

The occurrence and movement of water in unsaturated conditions (vadose zone) has been studied at numerous locations within the Laboratory starting with special USGS studies in the 1950s. Knowledge of vadose zone processes is relevant to understanding the potential for downward movement of water that could constitute recharge to the main aquifer and provide a mechanism for downward migration of contaminants.

In general, the vadose zone studies show that there is less than 10% by volume of moisture content in the tuff beneath the mesa tops at depths greater than a few meters, the zone affected by seasonal moisture and evapotranspiration. This carries the implication that very little, if any, recharge from the mesas is able to reach the main aquifer (LANL 1993).

check this out

This does not rule out the possibility for preferential flow thru the tuff. What is the annual precip?
Ave. porosity for Tuff = 41% Ave K_{sat} for tuff = 0.2 m/day (Vertical)

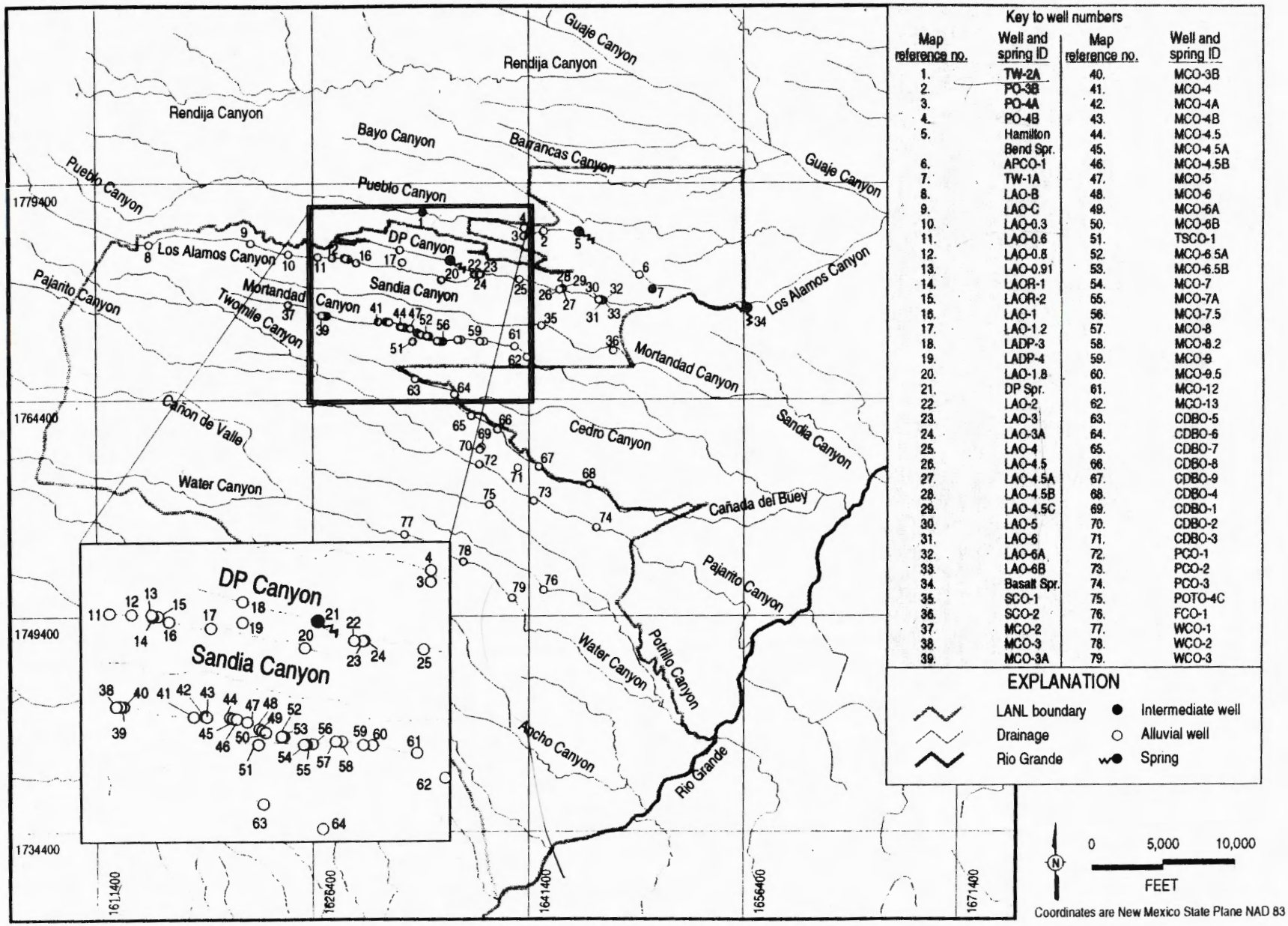

Figure 4-2. Alluvial and intermediate perched water wells and springs.

SWSC = Sanitary Wastewater Systems Consolidation

Canyons with alluvial aquifers are presumed to have greater potential for downward movement because there is a constant driving force. Since the mid 1980s, several studies have been conducted in canyons for RCRA compliance requirements to further define the occurrence of alluvial water and the potential for movement of water or contaminants.

In 1985, vadose zone characterization studies were completed for Areas G and L (Pajarito Canyon and Cañada del Buey). The results indicate that aqueous transport of contaminants through the tuff is not a viable mechanism for contaminant migration at either Area G or L (LANL 1993).

look this up check neglected to mention fractures, plant roots

A 1989 study in Sandia, Potrillo, Fence, and Water Canyons revealed no saturated conditions in the alluvium. In 1987, observation wells were installed in Cañon del Valle adjacent to an inactive waste disposal area. Monitoring of the wells revealed no saturation or evidence of leachate or seepage from the landfill to the alluvium.

In 1992, a study in Cañada del Buey was started to monitor conditions in and beneath the alluvium. The SWSC project in Cañada del Buey may at some time discharge treated effluent in the canyon drainage system. Five groundwater monitoring wells and two moisture level holes were installed within the upper and middle reaches of the drainage. Results of the study, under predischarge conditions, indicate that there is limited alluvial perched groundwater impact in Cañada del Buey. Along the drainage system, saturation was found within only a 0.8 km (0.5 mi) segment. The apparent source of saturation is purge water from the nearby municipal water supply well PM-4. The alluvium is dry upstream from this point of purge water entry. If effluents are eventually released into the drainage system, infiltration along the stream bottom will create a narrow ribbon of saturation within the alluvium and the weathered tuff that will be perched on the underlying unweathered Bandelier Tuff. Continued monitoring of these wells will further define the quality and extent of groundwater in the alluvium (LANL 1994).

What? What is the point here?

4.4.2 Age-of-Water and Recharge Source Studies

To better understand the nature of recharge to the main aquifer, researchers have performed age-dating measurements on selected water samples. This cooperative effort, involving several Laboratory divisions and staff from another DOE installation, uses geochemical techniques based on measurements of both radioactive and stable isotopes to help identify specific sources and estimate the age of water in the main aquifer. Preliminary interpretation of the data indicates that the water ranges in age from more than 1,000 years to more than 30,000 years.

check

4.4.3 Measurement of Barometric and Earth Tide Responses in Test Wells

In October 1992, the Laboratory began measuring and recording water level fluctuations at wells completed in the main aquifer. The data, which are recorded at hourly intervals using pressure transducers, suggest that the main aquifer adjacent to the Rio Grande responds like a confined aquifer to small barometric pressure and tidal perturbations. However, at locations farther to the west of this regional groundwater discharge area, the main aquifer apparently behaves like a phreatic aquifer in some locations and a confined to leaky-confined aquifer in other areas. Data from wells equipped with pressure transducers is given in the Environmental Surveillance Report for 1992 (LANL 1994) and suggest leaky-confined behavior as far west as TA-16. These new data collection and interpretation efforts will continue as part of the Groundwater Protection Management Program and will help to provide a more accurate characterization of the main aquifer.

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4.4.4 Environmental Studies at San Ildefonso Pueblo

The Laboratory conducts an ongoing environmental studies program at the San Ildefonso Pueblo. To document the potential impacts of Laboratory operations on lands belonging to the Pueblo, the DOE has entered into a memorandum of understanding with the Pueblo and the Bureau of Indian Affairs to conduct environmental sampling on Pueblo land. Part of the sampling program includes monitoring the water quality in five wells located on the Pueblo land and ensuring that the water is safe for consumption and has not been adversely impacted by Laboratory operations.

4.4.5 Studies of Surface Water Characteristics

The Laboratory is conducting ongoing studies of the surface water characteristics in the Los Alamos region (McLin 1991). These studies include Hydrologic Engineering Center (HEC) computer-based flood models, which project the effects of severe thunderstorms on all of the watersheds in the Los Alamos area. Different precipitation totals have been projected for 2-,5-, 10-, 25-, 50-, and 100-year storm events. The modeling effort predicts the effects of storm runoff on floodplain elevations within canyons and on different Laboratory facilities and structures.

4.4.6 Studies at Fenton Hill Geothermal Site

The Laboratory operates a program for extracting thermal energy from the hot dry rock geothermal reservoir at the Fenton Hill Geothermal Site (TA-57), which is located about 60 km (35 mi) west of Los Alamos (Figure 4-3). Two systems are located at the site. The first system contains two deep holes drilled into the dry Precambrian rock to a depth of about 3,040 m (10,000 ft). The two holes are connected by a large fracture that was induced by hydraulic pressurization. Water is circulated through this system to extract heat from the fractured areas in the granite. The second system uses a similar method and extracts heat from a depth of about 4,250 m (14,000 ft).

The Laboratory has conducted special studies of the chemical quality of surface water and groundwaters in the vicinity of the Fenton Hill since 1974. A preliminary study of the quality of water in the drainage area of the Jemez River and Rio Guadalupe established background data prior to any experiment. The data included chemical analyses from 17 surface water stations, 15 mineral and thermal springs, and 53 groundwater stations.

As a result of the preliminary study in 1974, the Laboratory established 13 surface and 20 groundwater stations to monitor the effects of Fenton Hill operations on the environment. Locations of groundwater sampling at wells and springs are given in Table 4-2 and shown in Figure 4-4. The chemical quality of the surface water and groundwater has been published in a series of yearly LANL reports entitled *Water Quality in the Vicinity of Fenton Hill* through 1988. After 1988, water quality data from Fenton Hill has been published in the Environmental Surveillance Reports. These reports show that the chemical quality of the samples has not changed significantly from average values taken since testing began. Although variations in chemical concentrations have occurred, these variations are within normal seasonal fluctuations (Purtymun et al. 1991).

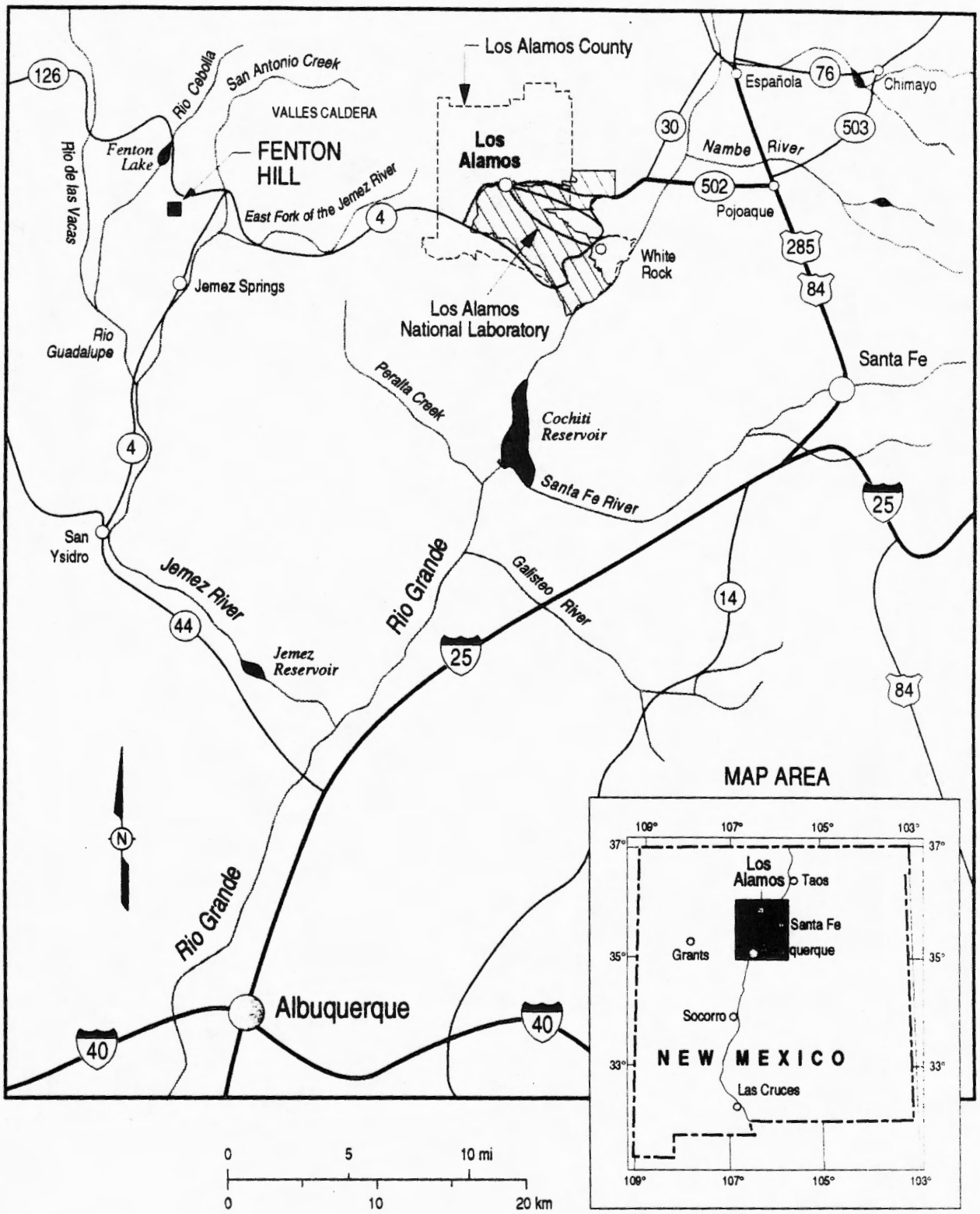


Figure 4-3. Regional location of Fenton Hill (TA-57).

4.5 Reporting

The results of groundwater sampling and protection efforts at the Laboratory are published in the annual Environmental Surveillance Report and the annual Water Supply Report. These two reports are described below.

Table 4-2. Fenton Hill Water Sampling Locations and Elevations

Type	X-Coordinate	Y-Coordinate	Elevation
Wells			
FH-1 Supply	1515244.43	1775862.00	8675
FH-2 Observation	1515244.43	1775862.00	8692
Location 27	1524144.37	1773661.99	7650
Location 42	1521644.38	1772361.98	7840
Location 48	1524844.36	1771261.98	7630
Location 53	1529044.34	1776762.00	7835
Location 54	1528444.34	1776262.00	7795
Location 55	1528744.34	1776662.00	7805
Location 4	1522444.38	1773061.99	7760
Location 47	1524844.36	1770761.98	7640
Springs			
Location 6	1523844.37	1772861.99	7670
Location 31	1491144.57	1767261.98	7600
Location 39	1502144.50	1770361.99	7880
Location JF-1	1522544.37	1757561.93	6780
Location JF-5	1510844.41	1743661.89	6400
JS-2 -3	1509544.40	1735761.86	6220
JS-4 -5	1511044.40	1741161.88	6265
RV-2	1523244.39	1796862.07	8360
RV-4	1528044.34	1764761.96	7360
RV-5	1528544.33	1753961.92	7340

4.5.1 Annual Environmental Surveillance Report

The purpose of the Environmental Surveillance Report is to provide a comprehensive source of environmental data collected at the Laboratory. Since the early 1970s, the Laboratory has performed routine 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 which explain the groundwater monitoring and protection program at the Laboratory and the results of sampling that have occurred in the subject year.

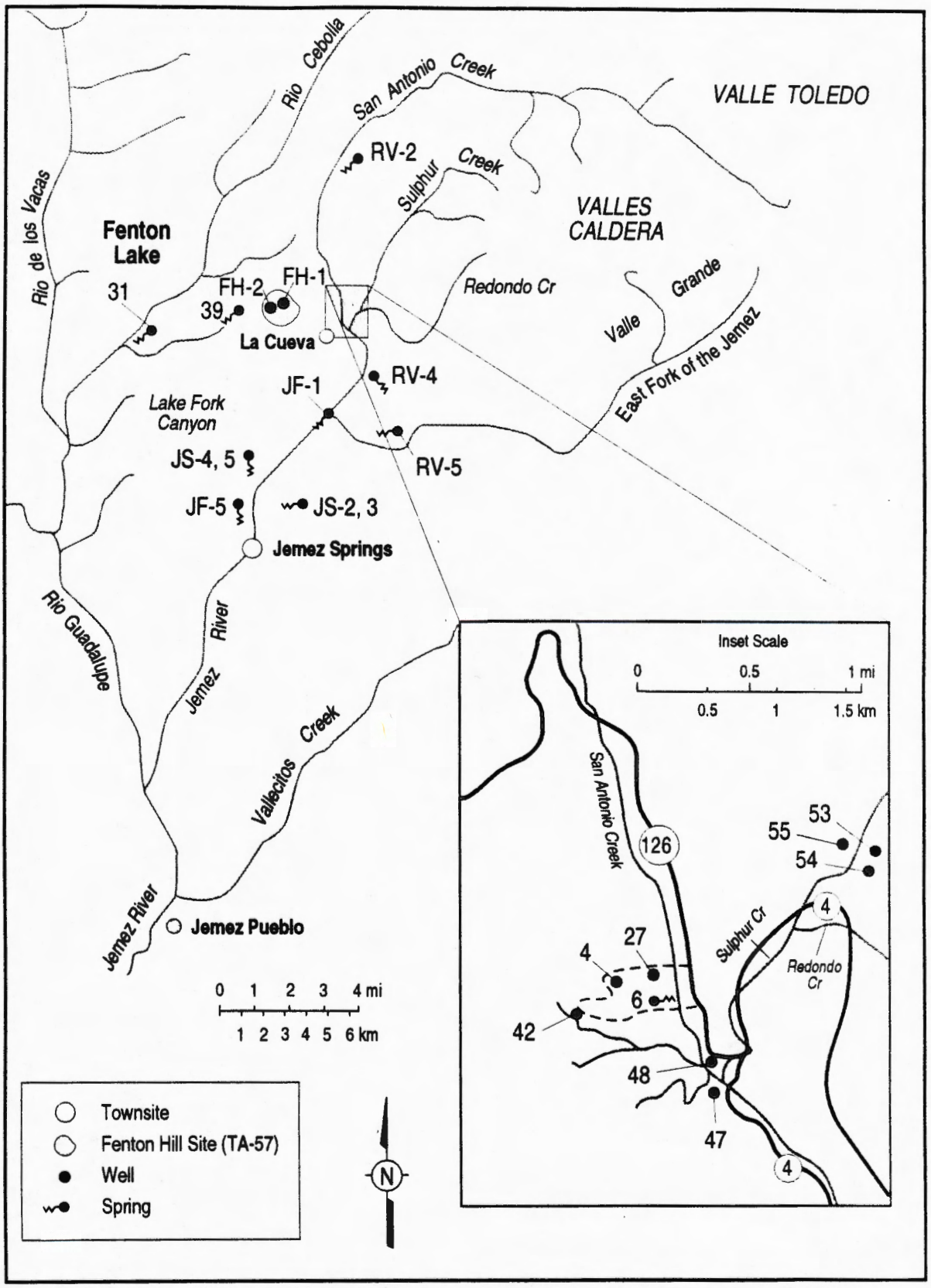


Figure 4-4. Surface water and groundwater sampling locations at Fenton Hill.

4.5.2 Annual Water Supply Report

The purpose of the Water Supply Report 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 main aquifer are provided as part of this report. Special studies and documentation of new supply wells are included as well as detailed records of pumping and water level measurements.

4.6 Conclusions

Environmental protection efforts at the Laboratory include the activities of several programs, many of which are under the Laboratory's ER Project. Remediation efforts conducted by these programs help to protect the groundwater supply.

The groundwater monitoring network at the Laboratory has been used for determining the quality of water in the main aquifer since immediately following World War II. However, because of its limited extent, questions are raised about the effectiveness of the network in detecting early stages of contamination. The controlled development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. Drawdowns are localized in the vicinity of the production wells and nearly complete recoveries are observed when wells are shut down for routine maintenance. What? !?

The history of Laboratory groundwater protection efforts, however, raises complex issues about the future viability of the groundwater monitoring network. These issues, which have been addressed in the *1991 LANL Self-Assessment*, the *1991 Tiger Team Assessment*, and in other reports and assessments (Appendix I), demonstrate the need for enhancing the current groundwater monitoring network. The issues and possible solutions are discussed in the next section.

5.0 Issues and Solutions

The following section discusses LANL's groundwater-related practices, policies, and procedures. The issues are divided into seven major categories: (1) hydrogeological characterization, (2) potential contamination, (3) groundwater monitoring network, (4) water supply, (5) information management, (6) quality assurance, and (7) regulatory compliance. Possible corrective actions and solutions follow each discussion of an issue.

A number of reports and assessments were used to prepare this section. The *1991 Tiger Team Assessment,* the *1991 LANL Self-Assessment,* the *1993 New Mexico Environment Department (NMED) Initial Assessment,* and the *Hydrogeologic Review for the Environmental Restoration Program at LANL* were all used as guides. These documents are reproduced in Appendix I, *Comments and Recommendations*, which has been formatted to include reference numbers in the right-hand margins. The numbers correspond to sections of the GWPMPP in which a particular issue is discussed.

5.1 Hydrogeological Characterization

5.1.1 Hydrogeological Characterization Issues

Recharge Mechanisms

The primary issue concerning hydrogeological characterization of the Pajarito Plateau is that the recharge mechanisms for the main aquifer are not well understood. The geologic setting is relatively complex, and researchers have considered several potential recharge areas to the main aquifer. These areas include the Valles Caldera, the canyon bottoms, the mesa tops, the Pajarito Fault Zone, other faults and fractures on the plateau, and the Sangre de Cristo Mountains (Stephens et al. 1993; Purtymun et al. 1994; Goff 1991). Studies of recharge to the main aquifer are complicated because of the numerous potential recharge sites and the lack of an extensive monitoring-well network. Preliminary studies provide some information on probable recharge areas.

The potentiometric surface of the main aquifer slopes downward toward the Rio Grande, leading some investigators to conclude that underflow from the Valles Caldera through the Tschicoma Formation is the primary recharge mechanism for the main aquifer. However, isotopic and geochemical studies show that the main aquifer waters near the Rio Grande differ from the waters in the Valles Caldera. Based on these studies, Stephens et al. (1993) concluded that underflow through the Tschicoma Formation is not likely to be the major source of recharge to the main aquifer.

Main aquifer waters have been dated using a ^{14}C method. The dating suggests that water in the aquifer is from 1,000 to 30,000 years old. But recent measurements of tritium in main aquifer waters at four locations (TW-1, -4, -8, and LA-1) by extremely low-detection-limit analytical methods suggest recharging within the last 40 years. Although mechanisms for recharge are not understood, the presence of tritium in the intermediate perched groundwater zone (TW-1A, TW-2A, LADP-3, and Basalt Spring [Stoker 1994]) indicates some degree of connectivity between the shallow and intermediate perched zones and the main aquifer.

^{14}C dating of gw limited to 200000 to 25000 yrs BP DIC with corrected ages of 30000 or 35000 yrs could actually be much younger.

Recharge to the main aquifer may be occurring through the canyon bottoms. A study in Mortandad Canyon determined that Laboratory-derived tritiated waters have infiltrated at least 60 m (200 ft) into the volcanic tuff (Stoker et al. 1991). Low-level tritium analysis of samples from a test well in Mortandad Canyon to the main aquifer clearly shows the presence of recent recharge (Stoker 1994). Vadose zone studies show that the moisture content of the tuff beneath

Need to look at: recharge, physical properties of main aquifer; define perched, shallow sat zones or aquifers

the canyons is greater than that beneath the mesa tops, and the depth to the main aquifer is several hundred feet less than on the mesa tops (LANL 1993). Also, because many of the canyons contain intermittent or ephemeral streams throughout the year, they are more likely to contribute some component of recharge to the main aquifer.

Stable isotopic studies ($\delta^{18}O$, $\delta^{2}H$) indicate that main aquifer waters represent meteoric waters and have recharge components from both high and low elevations (Goff 1991; Stephens et al. 1993). These data have been used to postulate that the Sangre de Cristo mountains may be the source for the waters in the eastern portion of the aquifer, along the west side of the Rio Grande.

None of the studies described above are conclusive, and additional investigations will be required to identify the recharge area(s). It is possible that recharge to the main aquifer is from multiple sources, and testing and evaluation should consider all of the potential recharge areas that have been proposed.

Hydrogeologic Data

Another issue concerning the main aquifer is the lack of hydrogeologic data. Not enough wells are completed to the main aquifer to understand local and regional hydrogeologic properties. The depth and continuity of the main aquifer is not well understood. Also, information is not available on the vertical stratification of the aquifer materials. Studies of the storage and transmissivity of the aquifer, as well as the physical characteristics of aquifer materials, need to be performed.

In sum, little data are available for characterizing recharge to and hydrogeology of the main aquifer. Much of the available data are suspect due to the age of the wells, the lack of information on well construction, and the lack of core samples for hydrologic property analyses or in-situ measurements. Stephens et al. (1993) suggest that the available data indicate that there may be multiple sources of recharge to the main aquifer. It is also possible that the recharge mechanisms operating today are different than those that were in place several thousand years ago when much of the main aquifer waters were introduced.

5.1.2 Hydrogeological Characterization Solutions

The primary solution to hydrogeological characterization problems is to construct a more extensive monitoring well network. Construction of monitoring wells in potential recharge areas will provide useful information in groundwater sampling and hydrologic testing and will help to determine if the sites are, in fact, recharge areas for the main aquifer.

more mw in potential recharge areas

The ESH Water Quality and Hydrology Group has proposed construction of 23 wells to the main aquifer, 14 wells to the intermediate perched groundwater zone, and 50 wells into the alluvium. Of the 23 wells to the main aquifer, one is a proposed ER Project well at TA-54, Area G. Of the 14 wells to the intermediate zone, one well in Los Alamos canyon at TA-2 is a proposed ER Project well. Information obtained from the drilling and sampling of these wells should provide increased knowledge of recharge through the plateau. Tables 5-1, 5-2, and 5-3 give the general locations and rationale for each of the proposed wells. Figures 5-1, 5-2, and 5-3 show the planned locations of the wells.

Drilling and sampling objectives for main, intermediate, and alluvial wells will be designed to provide as much multipurpose hydrogeologic data as reasonably possible. Proposed well locations were chosen to fill known geographic data gaps. Objectives for drilling and sampling differ for each well at each proposed location. The amount of hydrogeologic information varies

Want to fill in geographic gaps

Table 5-1. Proposed Main Aquifer Well Locations

Water Quality and Hydrology Group

Map Ref. Number	Well ID	Proposed Location	Rationale
1	*PLATS-1	Los Alamos Townsite	Hydrogeologic control, background water quality
2	PGC-1	Guaje Canyon near well field	Observation, RCRA compliance (top of aquifer)
3	PLAC-1	Upper Los Alamos Canyon near well H-19, TA-3	Hydrogeologic control, background water quality
4	PPFZ-1	East Pajarito Fault Zone, TA-8	Recharge information, Hydrogeological control near west boundary
5	PWC-1	Area P, upper Water Canyon near west boundary, TA-16	Hydrogeologic control in SW corner, RCRA compliance, answer questions left by drilling of SHB-3
6	PPC-1	Near new MWDF, Pajarito Canyon, TA-67	Hydrogeologic control, RCRA compliance for new facility, observation
7	PPC-2	Near new HWTF, Pajarito Canyon, TA-67	RCRA compliance for new facility, observation
8	PTSC-1	Near HWTF, Ten Site Canyon, TA-35	Address TA-35 and waste discharge from new facility
9	PPOC-1	Near OBOD area Potrillo Canyon, TA-15	Hydrogeologic control
10	PPC-3	Area J, Pajarito Canyon, TA-54	RCRA compliance, upgradient from Area L (chemical waste) and Area G (rad waste)
11	PMC-1	Near sediment traps, Mortandad Canyon, TA-5	RCRA compliance, downgradient from sediment traps
12	PSC-1	Near lagoons, Sandia Canyon, TA-53	Address discharge from lagoons, possible effect on intermediate groundwater
13	PPBC-1	Near well TW-1, Pueblo Canyon, TA-74	Check for tritium, replace TW-1
14	PLAC-2	In LA well field	Observation well near Rio Grande with controlled screen length
15	PPFZ-2	West of Pajarito Fault Zone	Hydrogeologic control west of boundary, recharge information
16	PPC-4	Area G, Pajarito Canyon, TA-54	RCRA compliance, downgradient of radioctive waste disposal area
17	PMC-2	In White Rock Townsite, Mortandad Canyon	Hydrogeologic control, downgradient of sediment traps, observation near Rio Grande
18	PCDB-1	Below White Rock, near Rio Grande and Cañada del Buey	Hydrogeologic control, observation near Rio Grande
19	PPOC-2	Near SR 4, Potrillo Canyon, TA-36	Address surface water loss questions
20	PWC-2	Water Canyon, TA-68	Address surface water loss questions
21	PAC-1	Below TA-33, Ancho Canyon, TA-70	Below TA-33 tritium release site
22	PBHQ-1	Near Bandelier HQ	Hydrogeologic control, observation
23	PBC-1	Bayo Canyon, TA-74	Hydrogeologic control, continuity of perched zone

Table 5-1, Continued

* Leading P = proposed, LATS = Los Alamos Townsite, GC = Guaje Canyon, LAC = Los Alamos Canyon, PFZ = Pajarito Fault Zone, WC = Water Canyon, PBC = Pueblo Canyon, TSC = Ten Site Canyon, SC = Sandia Canyon, MC = Mortandad Canyon, PC= Pajarito Canyon, POC = Potrillo Canyon, BC = Bayo Canyon, CDB = Cañada del Buey, BHQ = Bandelier Headquarters, AC = Ancho Canyon.

ER Project

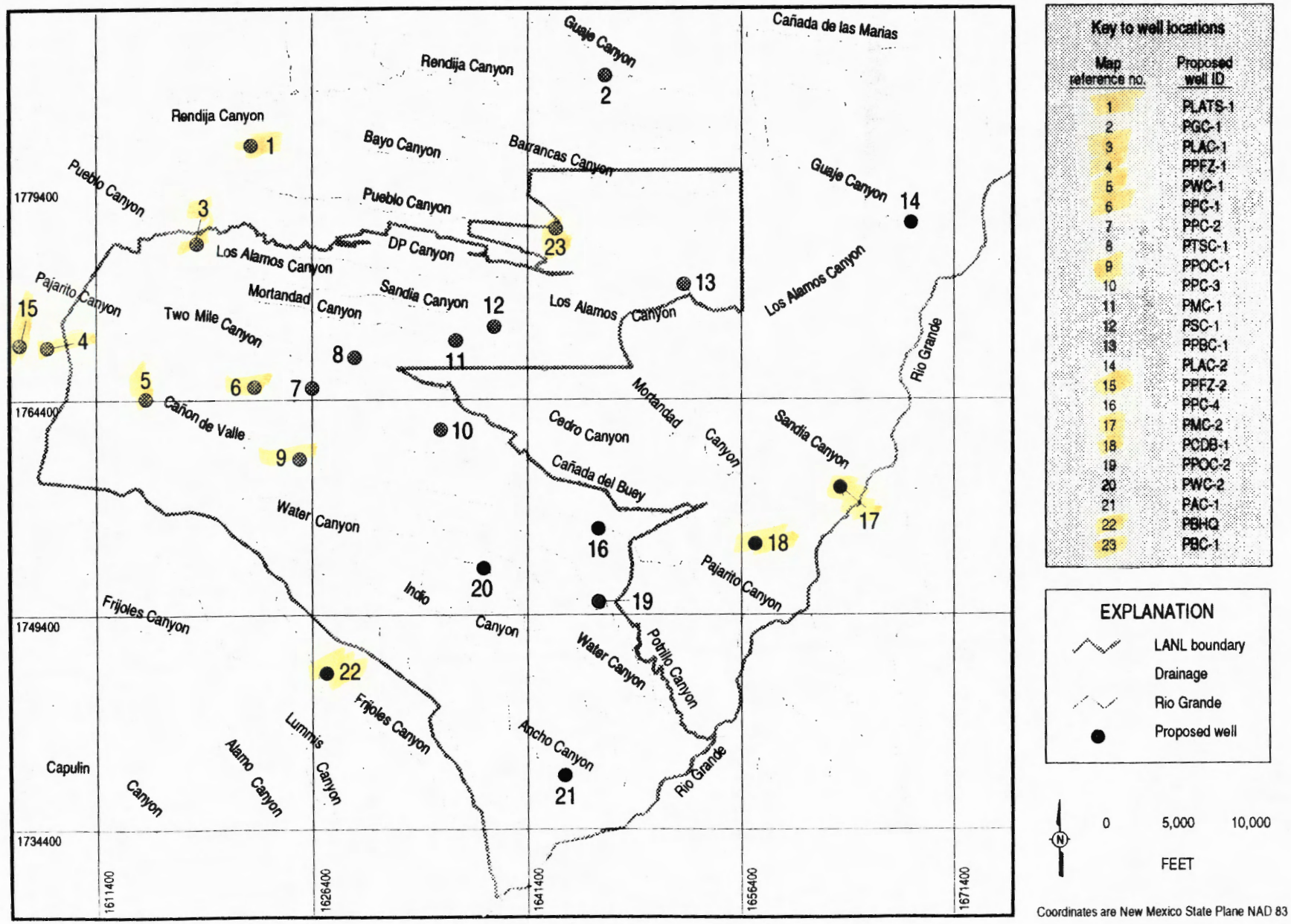
No. of Wells	Proposed Location	Drilling Date
6	Los Alamos/Pueblo Canyons	March 1996
6	Mortandad Canyon	March 1997
3	Pajarito Canyon	March 1999
3	Sandia Canyon/Cañada del Buey	March 2000

(The locations of these wells will be included in the RFI Work Plan for each of the canyons.)

across the facility and even over small distances. In some areas the shallow system may be intensely studied while the lower zones have relatively little information available. This variability of information means that the objectives of each well must be examined on a case-by-case basis. Objectives for each of the wells may include all or some of the following:

- Geohydrologic analyses of core samples (e.g., hydraulic conductivity, moisture content, moisture characteristic curve, specific particle density, air permeability, and unsaturated conductivity).
- Isotopic analyses and geochemical properties of core and aquifer water samples (e.g., $^{2}H/H$, $^{18}O/^{16}O$, stable and radioactive chlorine isotopes, tritium, and total organic carbon/dissolved organic carbon, cation exchange capacity, bromine, pH, and nitrogen).
- Total hole air flow anemometry.
- Borehole geophysics (e.g., epithermal neutron, gamma-gamma, natural gamma, spectral gamma, magnetic susceptibility, and electro-magnetic induction).
- Full suite of radiologic analyses for selected samples including groundwater.
- Full suite of geochemical analyses for selected water samples (e.g., Na, K, Mg, Ca, SO_4, HCO_3, Cl, alkalinity, Fe, Mn, Al, SiO_2, trichloroethene, trichloroethane, and other volatile and semi-volatile organics).
- Aquifer testing (e.g., testing of discrete water-bearing zones, pump tests, slug tests, etc.).
- Monitoring (sampling for geochemical, radiochemical, and isotopic constituents on a quarterly basis for a sufficient amount of time to determine if variations in quality exist, or monitoring to determine if fluctuations of the potentiometric surface exist).

Intermediate wells are proposed for the purpose of gathering unsaturated zone data, characterizing recharge and contaminant transport pathways, and determining extent and character of intermediate perched groundwater zones. Construction and completion of proposed wells will be dependent upon the main purpose of the well, information obtained during drilling, and whether groundwater is encountered.



= Wells to be installed for hydrogeologic control

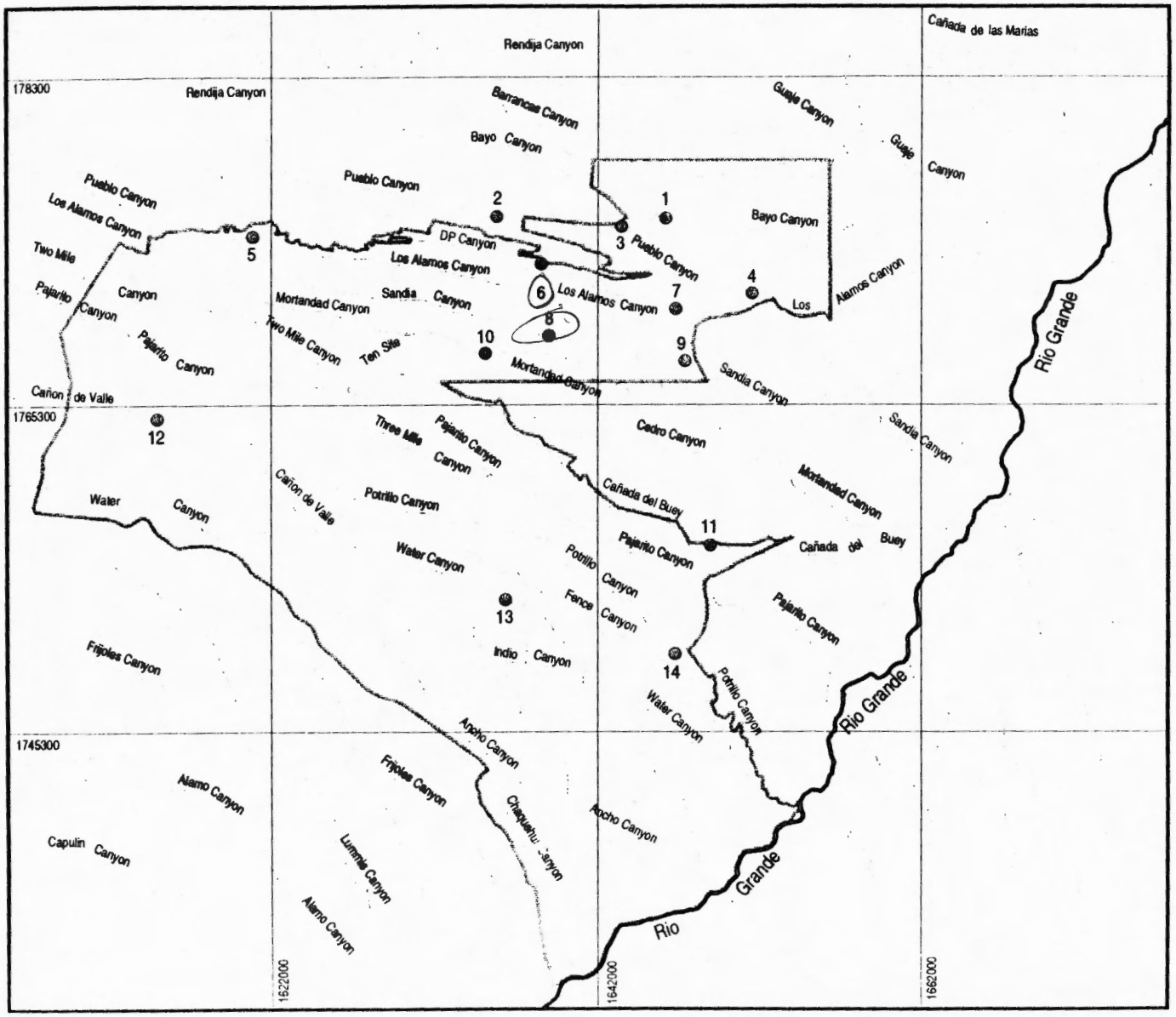
Figure 5-1. Proposed main aquifer well locations.

Table 5-2. Proposed Intermediate Well Locations

Map Ref. Number	Well ID	Proposed Location	Rationale
1	*PIBC-1	Middle Bayo Canyon, TA-74	To investigate continuity of perched zone geography
2	PIPBC-1	Near TW-1, Pueblo Canyon, TW-74	**Replacement for TW-1A geography
3	PIPBC-2	Near TW-2, Pueblo Canyon	**Replacement for TW-2A
4	PIPBC-3	Lower Pueblo Canyon, TA-74	Part of RFI Work Plan for OU 1098 - ER
5	PILC-1	Near TW-3 and O-4, Los Alamos Canyon, TA-73	Investigate perched groundwater encountered during drilling of O-4; near confluence of Los Alamos and DP Canyons source area + confluence
6	PILC-2	Upper Los Alamos Canyon, TA-43	Identification of source for water discovered in the Puye Formation and to further characterize the water possible source area
7	PILC-3	Middle Los Alamos Canyon, TA-72	**Replacement of LADP-3 geography
8	PISC-1	Middle Sandia Canyon, TA-72	Near proposed main aquifer well PSC-1 to address lagoon discharge effects on perched zone - source area
9	PISC-2	Near PM-1, Sandia Canyon, TA-72	Measure and sample perched groundwater encountered during drilling of PM-4 looking for known perched water
10	PIMC-1	Middle Mortandad Canyon, TA-5	Near proposed main aquifer well PMC-1 to address effects of sediment traps on possible perched groundwater possible source area geography
11	PIPC-1	Lower Pajarito Canyon, TA-54, near Area G	Near proposed main aquifer well PPC-4 to address possible presence of perched groundwater possible source area geography
12	PICDV-1	Upper Cañon de Valle, TA-16	Near proposed main aquifer well PWC-1 to answer questions left by drilling of SHB-3 and investigate possible perched groundwater geography maybe source area
13	PIWC-1	Upper Water Canyon, TA-68	Near proposed main aquifer well PWC-2 to answer water loss questions and investigate possible perched groundwater " "
14	PIPOC-1	Near confluence of Portrillo and Fence Canyons, TA-36	Near proposed main aquifer well PPOC-2 to answer water loss questions and investigate possible perched groundwater " " " "

* PI = proposed intermediate, PBC = Pueblo Canyon, LC = Los Alamos Canyon, SC = Sandia Canyon, MC = Mortandad Canyon, PC= Pajarito Canyon, CDV = Canyon de Valle, WC = Water Canyon, POC = Potrillo Canyon, BC = Bayo Canyon.

** Replacement of existing wells of inadequate construction with properly constructed wells that contain a good annular seal.



Key to well locations

Map reference no.	Proposed well ID
1	PIBC-1
2	PIPBC-1
3	PIPBC-2
4	PIPBC-3
5	PILC-1
6	PILC-2 Source Location for Pue?
7	PILC-3
8	PISC-1
9	PISC-2
10	PIMC-1
11	PIPC-1
12	PICDV-1
13	PIWC-1
14	PIPOC-1

EXPLANATION

- LANL boundary
- Drainage
- Rio Grande
- Proposed well

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Coordinates are New Mexico State Plane NAD 83

Figure 5-2. Proposed intermediate aquifer well locations.

Alluvial wells are proposed for the purpose of identifying and characterizing alluvial groundwater and for understanding connectivity between alluvial and intermediate zone groundwater. These wells are also proposed to evaluate the hydraulic relationship between water-bearing zones under the mesas and canyons. For these reasons, drilling and completion of alluvial wells is dependent on the information desired at each location. If groundwater is encountered, the well will be completed in accordance with National Environmental Protection Agency (EPA) guidelines (EPA Technical Enforcement Guidance Document [TEGD]), and applicable LANL Standard Operating Procedures (SOPs). A Well Completion Matrix presenting criteria from current and proposed LANL ER SOPs, New Mexico Monitoring Well Construction and Abandonment Well Standards, the HSWA permit and National EPA Guidelines is given in Appendix J.

Before any of the proposed wells, especially the alluvial wells, are drilled, the ER Project plans need to be assessed so as to minimize duplication of effort. Because ER activities mainly focus on the unsaturated and alluvial perched zones, proposed locations for the 50 alluvial aquifer wells are more likely to change than locations for main or intermediate wells in order to accommodate ER activities.

In addition to these Laboratory efforts, the USGS has proposed a study of groundwater recharge and flow system (Appendix G). The study will specifically target the question of recharge from the Sierra de los Valles to the west of the ? Laboratory and include several wells on either side of the Pajarito Fault Zone. The influence of the fault zone on surface-water flow will be monitored through the use of stream gaging stations above and below the fault zone. Downward migration of water will be monitored through well clusters. The estimated cost and duration of these proposed USGS activities is $2.24 million over six years.

USGS Proposal, ~~not~~ no plans on implementing?

Pajarito fault zone

Modeling

Information gathered from the installation of these monitoring wells will also help in the development of a more comprehensive hydrogeologic model of the Pajarito Plateau and the surrounding area. This modeling effort should include both basic water movement and contaminant transport in saturated and unsaturated zones. The model should be updated as new information is generated. All new wells installed should become part of the groundwater monitoring network and be sampled as part of the Laboratory's annual environmental surveillance activities. Piezometric surface maps should be generated from data collected and be updated as more information becomes available. Also, a geologic map at the water table might be helpful in understanding potential recharge pathways.

lets hope they do it.

they aren't planning to do this, are they

Suggestions

Other activities are suggested for further evaluation and characterization of recharge to the main aquifer. Sampling of perched waters beneath the canyon bottoms and within tuff units beneath the mesas would be useful for determining the potential for main aquifer recharge from perched water. Additional ^{14}C dating of water in the potential recharge areas, the main aquifer, perched zones, and seeps and springs would provide additional information on potential recharge rates and mechanisms. An evaluation of flow and infiltration from perennial and ephemeral streams will help assess whether the canyon bottoms are recharge areas.

Coordination of vadose zone studies conducted by different Laboratory groups and consolidation of the data generated would greatly augment the level of understanding of possible recharge though the vadose zone. The number of vadose zone studies are increasing but are being conducted over short intervals. Also, most of the study efforts do not extend below 45 to 60 m (150 to 200 ft), leaving a data gap between there and the top of the main

aquifer. An extended field program, one capable of spanning a time frame as long as a decade, is necessary to understand unsaturated flow conditions at Los Alamos. Coordination of these studies and consolidation of data is a planned activity of the GWPMP Program.

Table 5-3. Proposed Alluvial Well Locations

Map Ref. Number	Well ID	Proposed Location	Rationale
1	*PALC-1	Upper Los Alamos Canyon, TA-43	**Replace monitoring well LAO-C
2	PALC-2	Middle Los Alamos Canyon, TA-2 / TA-21	**Replace monitoring well LAO-1
3	PALC-3 through PALC-3E	Middle Los Alamos Canyon, TA-21	Transect consisting of 4 to 6 wells across the width of the Canyon for lateral control on extent of moisture across canyon and under mesa
4	PALC-4	Middle Los Alamos Canyon, TA-73	**Replace monitoring well LAO-2
5	PALC-5	Middle Los Alamos Canyon, TA-73	**Replace monitoring well LAO-3
6	PALC-6	Middle Los Alamos Canyon TA-73	**Replace monitoring well LAO-4
7	PALC-7	Middle Los Alamos Canyon TA-72	**Replace monitoring well LAO-4.5
8	PAPBC-1	Lower Pueblo Canyon TA-72	**Replace monitoring well APCO-1
9	PASC-1 through PASC-1E	Middle Sandia Canyon, TA-60	Transect consisting of 4 to 6 wells across the width of the Canyon for lateral control on extent of moisture across canyon and under mesa
10	PAMC-1	Upper Mortandad Canyon, TA-60	**Replace monitoring well MCO-3
11	PAMC-2 though PAMC-2E	Upper Mortandad Canyon, TA-60	Transect consisting of 4 to 6 wells across the width of the Canyon for lateral control on extent of moisture across canyon and under mesa
12	PAMC-3	Upper Mortandad Canyon, TA-60	**Replace monitoring well MCO-4
13	PAMC-4	Upper Mortandad Canyon, TA-5	**Replace monitoring well MCO-5
14	PAMC-5	Upper Mortandad Canyon, TA-5	**Replace monitoring well MCO-6
15	PAMC-6	Upper Mortandad Canyon, TA-5	**Replace monitoring well MCO-7
16	PAMC-7	Upper Mortandad Canyon, TA-5	**Replace monitoring well MCO-7.5
17	PACDB-1 though PACDB-1E	Upper Canada del Buey, TA-54	Transect consisting of 4 to 6 wells across the width of the Canyon for lateral control on extent of moisture across canyon and under mesa
18	PAPC-1	Upper Pajarito Canyon, TA-14	Investigate extent of saturated alluvium
19	PAPC-2	Upper Pajarito Canyon, TA-67	Investigate extent of saturated alluvium

majority of wells are placed to determine extent of alluvial aquifers

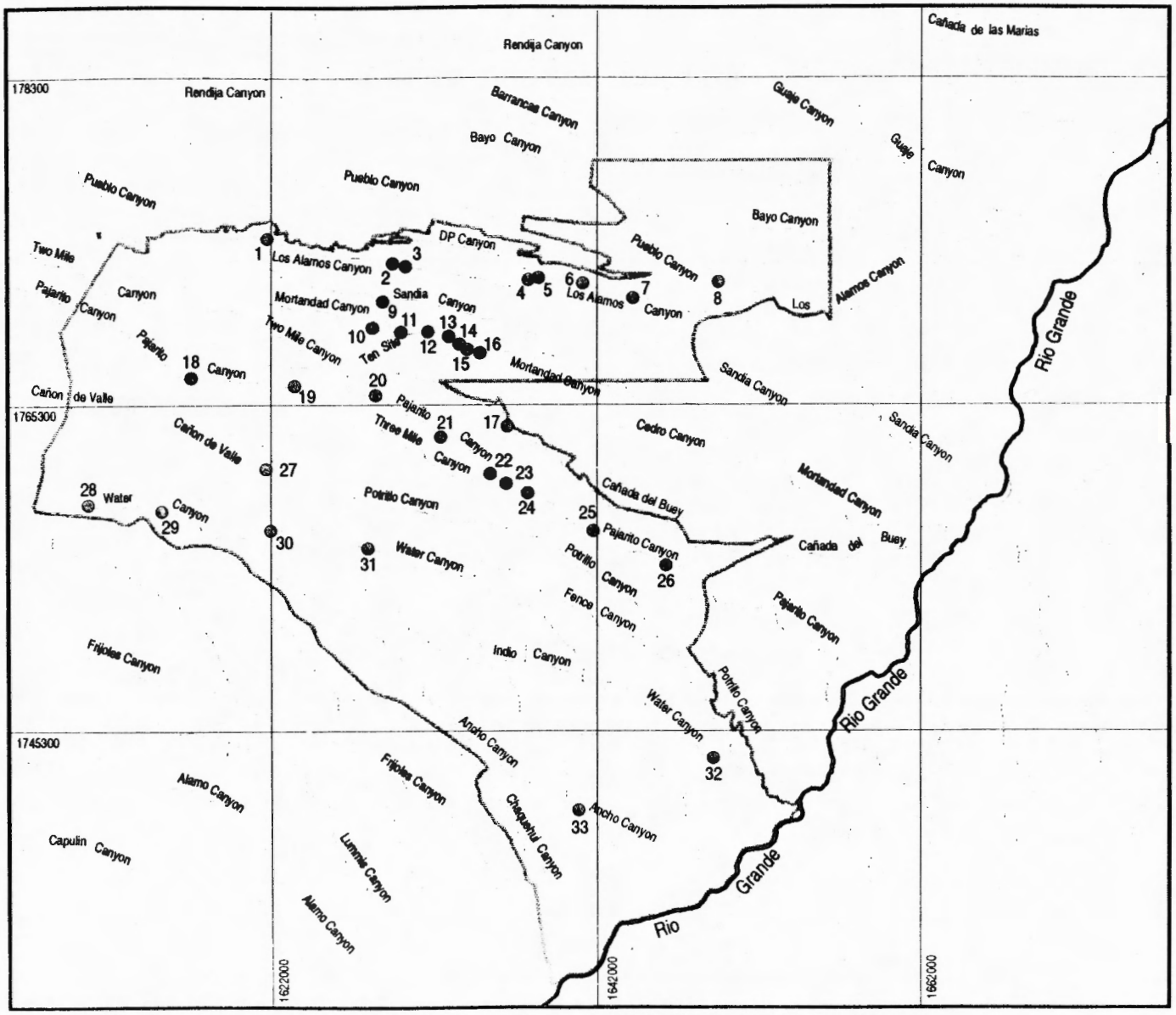
Table 5-3, Continued

20	PAPC-3	Middle Pajarito Canyon, TA-46	Investigate extent of saturated alluvium
21	PAPC-4	Middle Pajarito Canyon, TA-18	Investigate extent of saturated alluvium
22	PAPC-5 though PAPC-5E	Middle Pajarito Canyon, TA-18	Transect consisting of 4 to 6 wells across the width of the Canyon for lateral control on extent of moisture across canyon and under mesa
23	PAPC-6	Middle Pajarito Canyon, TA-36	Investigate extent of saturated alluvium
24	PAPC-7	Middle Pajarito Canyon, TA-36	**Replace monitoring well PCO-1
25	PAPC-8	Lower Pajarito Canyon, TA-36	**Replace monitoring well PCO-2
26	PAPC-9	Lower Pajarito Canyon, TA-36	**Replace monitoring well PCO-3
27	PACDV-1	Lower Cañon de Valle, TA-15	Investigate extent of saturated alluvium
28	PAWC-1	Upper Water Canyon, TA-28	Investigate extent of saturated alluvium
29	PAWC-2	Upper Water Canyon, TA-16	Investigate extent of saturated alluvium
30	PAWC-3	Upper Water Canyon, TA-37	Investigate extent of saturated alluvium
31	PAWC-4	Middle Water Canyon, TA-15	Investigate extent of saturated alluvium
32	PAWC-5	Lower Water Canyon, TA-71	Investigate extent of saturated alluvium
33	PAAC-1	Lower Ancho Canyon, TA-70, near State Road 4	AIP requested well to verify no perched water

* PA = Proposed Alluvial, LC = Los Alamos Canyon, PBC = Pueblo Canyon, SC = Sandia Canyon, MC = Mortandad Canyon, CDB = Cañada del Buey, PC = Pajarito Canyon, CDV = Cañon del Valle, WC = Water Canyon, and AC = Ancho Canyon.
** Replacement of existing inadequate well with a properly constructed well that contains an appropriate annular seal.

The ER Project is in the process of establishing a Framework Studies Program. This program would include input from the ESH Water Quality and Hydrology Group as well as others to help coordinate hydrologic investigations at the Laboratory. Since most of the vadose zone studies are currently being conducted through the ER Project, an effort should be made between the ER Project and the GWPMP Program to coordinate and expand these studies as needed to provide the necessary information. This information would satisfy the data needs for both hydrogeologic characterization and regulatory compliance.

Further collection and analyses of stable isotope data in the aquifer, potential recharge areas, and springs and seeps should be performed. In addition, stable isotope data should be collected for rainfall, ephemeral streams, and snowmelt. These data can provide valuable "fingerprints" of water types and can be used to evaluate recharge. In addition, paleotemperatures can be inferred from these data and may provide valuable information on recharge mechanisms (e.g., summer versus winter recharge).



Key to well locations

Map reference no.	Proposed well ID
1	PALC-1
2	PALC-3
3	PALC-3 through 3E
4	PALC-4
5	PALC-5
6	PALC-6
7	PALC-7
8	PAPBC-1
9	PASC-1 through 1E
10	PAMC-1
11	PAMC-2 through 2E
12	PAMC-3
13	PAMC-4
14	PAMC-5
15	PAMC-6
16	PAMC-7
17	PACDB-1 through 1E
18	PAPC-1
19	PAPC-2
20	PAPC-3
21	PAPC-4
22	PAPC-5 through 5E
23	PAPC-6
24	PAPC-7
25	PAPC-8
26	PAPC-9
27	PACDV-1
28	PAWC-1
29	PAWC-2
30	PAWC-3
31	PAWC-4
32	PAWC-5
33	PAAC-1

EXPLANATION

- LANL boundary
- Drainage
- Rio Grande
- Proposed well

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Coordinates are New Mexico State Plane NAD 83

Figure 5-3. Proposed alluvial aquifer well locations.

Groundwater chemistry should be analyzed to further evaluate recharge to the main aquifer. Chemical parameters may be used to estimate residence time for groundwater and to determine if any hazardous contaminants are present in potential recharge areas or the main aquifer. Care should be taken in using chemical parameters to "fingerprint" water because of the chemical transformations that can occur during groundwater movement.

5.2 Potential Contamination

5.2.1 Potential Contamination Issues

Recent analyses of low-level tritium in samples from various wells definitely show parts of the main aquifer have recent recharge (Stoker 1994). Although the exact recharge mechanism(s) has not been proven, possible transport pathways suggest that the contamination issue should address the possibility of (1) contaminants moving through the unsaturated (vadose) zone, (2) contaminants infiltrating areas of high fault or fracture density, and (3) contaminants infiltrating along well shafts or boreholes.

Potential Sources

Radioactive and hazardous waste has been generated and disposed at LANL since the Laboratory's inception in 1943 (Kelly 1975). Twenty-three Materials Disposal Areas were identified by Rogers (1977) and all such sites are considered potential sources of groundwater contamination. An extensive list of PRSs was identified early in the ER Project (see Appendix D). An additional possible source of groundwater contamination is the historic and current practice of discharging treated effluents in canyons near the northern boundary of the Laboratory. While all canyons have received some industrial and sanitary discharges, Los Alamos, Sandia, Mortandad, and Pueblo Canyons are particular areas of concern, because they are considered to be the most likely areas of potential recharge to the main aquifer.

Limited Current Information

The understanding of contaminant transport pathways is limited. Several reports (Purtymun 1984; Purtymun 1989; Purtymun and Stoker 1987; Devaurs and Purtymun 1985) describe the main aquifer as being isolated by a barrier of dry volcanic rock that inhibits infiltration or downward migration of moisture from the surface or from perched water zones. However, monitoring of the main aquifer has shown low levels of tritium in test wells 1, 1A, 2, 2A, 4, and 8, observation well LA-1, and former supply well LA-2. The transport pathways through the Bandelier Tuff have not yet been determined and could include saturated flow mechanisms as well as vapor phase migration through unsaturated geologic materials. Vapor phase migration through unsaturated tuff is supported by the finding of tritium down to 60 m (200 ft) below one mesa top at TA-33.

wells that had tritium

Acknowledge vapor phase transport

Plugging and Abandonment

One of the possible transport pathways is along the well bore of inadequately constructed or inappropriately designed wells. As mentioned before, many of the wells at the Laboratory were constructed as early as the 1940s. These wells may be in poor condition due to age or just be of an inappropriate construction for the type of monitoring which needs to be conducted at the Laboratory. Tritium has been detected in samples taken from observation well LA-1, test wells TW-1, -1A, -2, -2A, -4, and -8. In all of these cases, it is possible that tritiated waters from the surface have seeped along the well bore due to an inadequate seal. This may be because there was no seal installed or grouting emplaced during the cable tool drilling.

These wells need to be plugged and abandoned in accordance with the New Mexico Environment Department (NMED) and New Mexico State Engineer Office requirements to

insure that contaminant transport pathways to intermediate depth perched groundwater and the main aquifer are properly closed off. These plugging and abandonment procedures need to be applied to all wells that cannot be refurbished, as well as borings and coreholes that might present a pathway for contamination.

Monitoring Well Network

The location and distribution of monitoring wells are inadequate for assessing contaminant transport. Potential sources of contamination are often located in troublesome areas — zones of high fault or fracture density, near cliffs, and in canyon bottoms — in which few or no monitoring wells are located. For example, there are no monitoring wells completed in the zones of perched alluvial groundwater near the Los Alamos County Landfill.

Perched Zone Characterization

The understanding of contaminant transport pathways is essential for understanding canyon-specific perched water zones. For example, the Cerro Toledo alluvial deposit within the Bandelier Tuff ("epiclastic unit") outcrops near the confluence of Acid and Pueblo Canyons, and may serve as a pathway for discharges from the Larry Walkup Aquatic Center and a decommissioned radioactive waste treatment facility. The characterization of contaminant transport into perched zones in Los Alamos Canyon, which may ultimately outcrop as seeps and springs near the Rio Grande, is also not complete.

5.2.2 Potential Contamination Solutions

Main goal: more mw to understand Hydrogeology & transport modeling. Not concerned with detection prevention

The primary solution to understanding the extent of the effects of Laboratory activities on the main aquifer is to construct more monitoring wells (Figures 5-1, 5-2, and 5-3 are maps of the proposed well locations). Once constructed, the new monitoring wells should provide data for researchers to gain a better understanding of how contaminants are transported from discharge sites. The data will be used to model contaminant transport using hypothetical leaks or spills.

Fault Study

Analyses of subsurface data have shown that numerous faults cut across the Pajarito Plateau (Dransfield and Gardner 1985). The major fault zones within the Laboratory are shown in Figure 5-4. Although these fault zones have been identified, they have not been fully characterized as to their role in contaminant transport (i.e., they could act as either contaminant barriers or contaminant pathways). A site-wide study is needed to identify additional faults and fractures that may exist and to characterize their role in contaminant transport. This information is needed to support a contaminant transport model.

not sure what this involves

As previously mentioned, the USGS has proposed a study of groundwater recharge that includes characterization of the Pajarito Fault Zone. In addition to this the USGS has also proposed a study to collect, compile, and evaluate hydrologic data in and around the Los Alamos area. This data will be used for current and future studies, including groundwater flow and contaminant transport modeling. Estimated cost is about $1.7 M over five years.

another proposed USGS study

A special study of seeps and springs is being proposed for fiscal year 1995. This special study should help to characterize how contaminants travel downstream through the alluvium in select canyons to discharge points near the Rio Grande. This study should greatly assist in understanding contaminant transport along the shallow alluvial zones, and it should be among the highest priorities of the GWPMP.

proposed spring study

More special studies of the vadose zone are needed to characterize the contaminant pathways through unsaturated areas. These studies would provide a much better understanding of how tritium percolated to great depths beneath the perched water in Mortandad Canyon and the mesa at TA-33. These studies will also help to determine if tritium (and other contaminants)

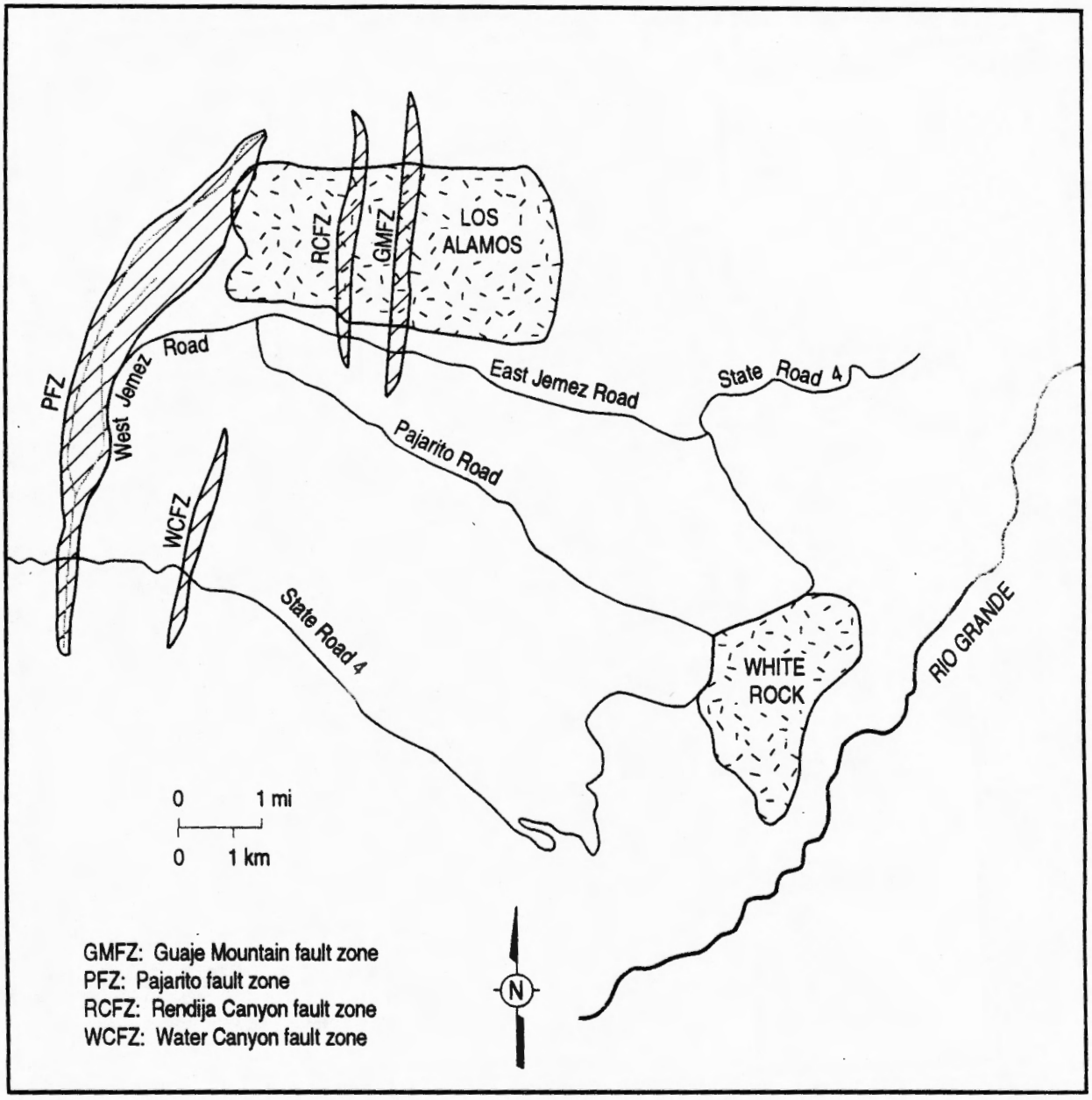

Figure 5-4. Major fault zones in the Los Alamos area

moves in the liquid or vapor phase. Additional sampling and analyses for tritium in the vadose zone, potential recharge areas, and the main aquifer waters are necessary to determine the significance of tritium in the main aquifer. tritium

Core samples collected during vadose zone studies should be analyzed for both naturally-occurring and anthropogenic isotopic tracers. This will provide an indication of infiltration rates and depths in the vadose zone, and help to determine hydrologic properties and whether vapor-phase transport of contaminants to the main aquifer is occurring. isotopic tracers

Additional sampling of groundwaters for low-level tritium analyses are being planned. Continuing discussions with the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez, and with the Pueblo Office of Environmental Protection are expected to lead to a major sampling effort. This sampling will include groundwater sources on and adjacent to the pueblos that have not previously been analyzed for low-level tritium. Most of the groundwater sources in the vicinity of Los Alamos will be resampled to add confidence to the validity of the measurements. actually in planning stage

Uranium and plutonium groundwater samples collected in 1994 are being analyzed by an extremely sensitive mass spectrometry technique to identify specific isotopes of uranium and plutonium. The ratios of uranium isotopes or merely the presence of some isotopes gives clear indication of the source (e.g., anthropogenic or natural). The analyses can also indicate the origin, such as atmospheric fallout or industrial effluent. Ur & Pu analyses

This information can also be used to resolve connectivity questions. Preliminary results indicate no detectable plutonium in any of the samples from the main aquifer as measured by low-level mass spectrometry. Measurements of samples from the shallow alluvium perched groundwater in Pueblo, Los Alamos, and Mortandad Canyons confirm previous measurements by other methods and demonstrate the usefulness of the isotopic ratios to clearly distinguish different sources. Extensive additional work using this analytic method is planned. How much volume is being pumped? too much to detect contam.

The Laboratory is currently in the process of developing standard procedures for well plugging and abandonment. A program specifically designed to address plugging of contaminant transport pathways (coreholes and borings) and abandonment of inadequate wells needs to be developed. This program would be responsible for implementing the plugging and abandonment SOPs. Initial funding has been requested for nine wells to be plugged and replaced over the next five years. Additional funding will be requested as plugging and abandonment needs arise. plugging

Plugging and abandonment activities should be prioritized. Plugging of a well should not be done until funding is available to replace that well. First priority should be given to those wells in which the presence of tritium or other contaminants is thought to be due to a leaking seal or inadequate well construction. This includes the test wells discussed above (TW-1, -1A, -2, -2A, -4, -8) and DT-5A in which lead was found at higher levels than earlier background concentrations. The Los Alamos well field was taken off line in 1991 and wells LA-1, -3, -4, and -6 were plugged in 1993 for this reason. Next priority should be given to wells, coreholes, and borings that are most likely to provide a contamination pathway to groundwater because of their location in areas that receive or have received liquid or solid waste. Final priority should be given to other wells that were constructed using cable tool drilling methods but are not located in areas that directly receive waste. This includes TW-3, DT-9, and -10. Table 5-4 is a prioritized list of wells to be plugged and abandoned, along with justification. A technical discussion of the plugging and abandonment procedures will be included upon completion of the Laboratory's plugging and abandonment SOP.

Table 5-4. Wells to be Plugged and Abandoned

Priority*	Well ID	Justification
1	TW-1A	Presence of tritium in well, inadequate well construction suspected
2	TW-2A	Presence of tritium in well, inadequate well construction suspected
3	LADP-3	Presence of tritium in well, inadequate well construction suspected
4	TW-2	Presence of tritium in well, inadequate well construction suspected
5	TW-1	Presence of tritium in well, inadequate well construction suspected
6	TW-4	Presence of tritium in well, inadequate well construction suspected
7	TW-8	Presence of tritium in well, inadequate well construction suspected
8	DT-5A	Presence of high Pb levels, inadequate well construction suspected
9	TW-3	Inadequate well construction suspected

* Priority subject to change upon collection of further information.

5.3 Groundwater Monitoring Network

5.3.1 Groundwater Monitoring Network Issues

Main Aquifer Monitoring Network

The main issue concerning the groundwater monitoring network is that the number and construction of wells used to characterize the hydrogeology in the Los Alamos region is insufficient. A total of 17 wells constitutes the network for monitoring the main aquifer within the Laboratory boundary — 10 supply wells and 7 monitoring wells. As shown earlier in the text (Figure 4-1), none of these wells are located at the eastern or western ends of the facility. This absence means that comprehensive data for water-level measurements, contaminant migration, and other parameters cannot be collected.

Shallow and Intermediate Monitoring Network

These issues also apply to the shallow and intermediate wells. Not enough wells are drilled into the perched alluvial zones (Figure 4-2) to characterize how surface-flow contaminants infiltrate the perched zones in some historically contaminated canyons. More wells are also needed at intermediate depths, where groundwater may occur, to characterize the connectivity between shallow, perched alluvial groundwater zones, and the intermediate groundwater zones. This lack of wells limits the understanding of how seeps and springs are recharged along the canyon bottoms.

Environmental Surveillance Monitoring

Another issue of concern is the effectiveness of environmental surveillance monitoring efforts at the Laboratory. There are not enough wells penetrating the main aquifer that are specifically

for monitoring purposes, and those that do exist are not appropriately distributed within the Laboratory boundary. Over half of the wells used for environmental surveillance monitoring at the Laboratory are also supply wells for Los Alamos County. The use of supply wells for monitoring purposes is a concern for a number of reasons. First, supply wells are screened over a much larger depth interval than monitoring wells. Secondly, the pumps are high capacity and produce water from a greater thickness of the water bearing zone. Lastly, the high flow rates and continued pumping of these wells induces a large component of dilution of any potential contaminants which might be introduced at the uppermost levels. As a result, water samples from supply wells do not provide the same quality of data as do samples from monitoring wells which produce from discrete intervals of the water bearing zone.

A routine environmental surveillance monitoring program is conducted at LANL. The details and structure of the Environmental Surveillance Program are outlined in the *Environmental Monitoring Plan* and the results of monitoring efforts are reported in the annual Environmental Surveillance Report. In some special cases, a well or spring may be sampled several times in one year for selected constituents. The Laboratory intends to review records to best understand where the monitoring frequency should be increased to more than annually. It is expected that the frequency of monitoring for new wells and some existing wells that are in probable contamination areas, or where contamination has already been found (e.g., tritium), or that exist as a transect or a well nest, may be sampled quarterly for a limited time to examine the variability of certain parameters.

Well Structure and Condition

The condition of many of the wells is another problem with the existing groundwater monitoring network. Many were constructed more than 40 years ago and do not meet current standards required by regulatory agencies. For example, the casing on older wells is inappropriate for the sampling of organics and trace metals; these older wells were not logged and cored according to contemporary standards. Many of the older wells are also not sealed properly to prevent contaminant infiltration along the casing.

Groundwater Monitoring Plan

In addition to these well problems, reviewers have identified deficiencies related to the Groundwater Monitoring Plan (Appendix F). Although the plan addresses frequencies, locations, and radioactive and hazardous constituents to be sampled, it needs to more fully address field SOPs. The Laboratory also needs to complete a full inventory and map of active, abandoned, or sampled wells on the Pajarito Plateau.

5.3.2 Groundwater Monitoring Network Solutions

A complete inventory of all wells, active, abandoned, or plugged, is in progress and should be completed early in 1995. As mentioned above, the Laboratory is expanding the groundwater monitoring network to include more wells in the vicinity of TA contamination areas (Figures 5-1, 5-2, and 5-3). Two intermediate-depth coreholes, and one monitoring well to the main aquifer, are being drilled near TA-54, Materials Disposal Area G. In addition, the following projects have been proposed and funded: two to six intermediate-depth core holes near TA-21, two intermediate-depth core holes near TA-2 and TA-41, and two intermediate-depth coreholes near TA-49. This program will help researchers to understand contaminant flow in the vicinity of these sites. Monitoring wells have been proposed for other historically contaminated areas as well.

All new monitoring wells will be included as part of the annual environmental surveillance activities at the Laboratory. The sampling frequencies for new wells should be determined individually based on the presence of certain radiochemical parameters. If theses parameters are present, the well may be sampled quarterly for these parameters. If, after sufficient time (e.g., three years), no significant variations in groundwater quality are noted, the sampling frequency for these parameters may be adjusted to an annual or other appropriate basis. Exceptions may include wells that are placed in known contamination areas or are part of a transect or well nest. In this case, quarterly sampling for certain parameters may be appropriate.

Sampling frequencies of existing wells may need to be altered on an individual basis. Wells that are located in probable contamination areas (e.g., locations where sources of contamination are nearby) will have their sampling frequencies increased to quarterly. Next priority for quarterly sampling are those wells which, from a review of existing data, show a variation in water quality. Priority will also be given to wells where contamination has already been detected or that are part of a transect or well nest. Many of the existing wells have shown no variation in groundwater quality during several years of sampling, therefore increased sampling of all wells within and around the Los Alamos area may not be appropriate at this time.

The expanded network will include more wells at the east and west ends of the facility (Figures 5-1, 5-2, and 5-3). The GWPMPP includes provisions for replacing or refurbishing old wells in the supply and monitoring-well network and outlines a drilling plan that will be implemented over a 5-year period. When complete, the expanded network will greatly assist hydrologists in understanding the mechanisms of recharge to the main aquifer. Sampling and monitoring of new wells will become part of the Environmental Surveillance Group's annual activities.

Two of the USGS proposals previously mentioned include the installation of monitoring wells around the Los Alamos area.

The Laboratory will consider the following factors in the construction of new wells:

MW Placement

- *Placement.* Monitoring wells should be placed in areas that are historically contaminated or that require greater hydrogeologic control. Laboratory environmental groups should concur on well placement, drilling methods, and construction techniques to reduce costs and duplication of effort.
- *Dedicated Equipment.* Monitoring wells should be outfitted with dedicated equipment. This equipment should include transducers, pumps, access tubes, and other devices that might become damaged if maintained as portable units. This would also eliminate the concern of cross-contamination.
- *Casing.* Monitoring wells should be constructed with casing materials that extend the lifetime of the well. Different casing materials (e.g., steel and plastic) should be examined in selecting the most appropriate material for a particular well.
- *Screened Intervals.* Monitoring wells should be constructed to monitor discrete hydrologic intervals. This technique should eliminate the problem of using supply wells for monitoring purposes; these are screened over too large an interval to collect accurate data. The EPA recommends a screen interval less than 15 feet to comply with RCRA.

A Well Completion Matrix presenting criteria from current and proposed LANL ER SOPs, New Mexico Monitoring Well Construction and Abandonment Well Standards, the HSWA permit and National EPA Guidelines is given in Appendix J.

The Groundwater Monitoring Plan (GMP) as it exists in the draft Environmental Monitoring Plan (LANL 1993a) has been approved by the DOE. As required by DOE Order 5400.1, the GMP will be updated and included as part of the GWPMPP. It is now included in the GWPMPP as Appendix F. Principal procedures and methodologies used to carry out the groundwater monitoring program are described in *Quality Assurance Project Plan: Water, Soil, Sediments, and Water Supply Monitoring at Los Alamos* (Stoker 1990) and in *Handbook for Sample Collection, Preservation, and Instrument Techniques* (Williams 1990). Currently, the Laboratory is developing a set of standard procedures for constructing, maintaining, and abandoning wells. In addition, the ESH Water Quality and Hydrology Group is developing a set of surface water and groundwater sampling procedures.

5.4 Water Supply

5.4.1 Water Supply Issues

Long-Term Usage

The main issue concerning water supply in Los Alamos is that the regional effects of supply-well pumping are uncertain. Laboratory hydrologists are uncertain whether the main aquifer is being depleted faster than it is being naturally recharged. An apparent 0.6 m (2 ft) per year water-level decline has been observed in some wells. Other supply wells, however, show no decline in water levels (Purtymun et al. 1994).

* effect of pumping unknown
this contradicts P. 3-4

Water Level Data

The problems associated with the monitoring-well network have already been described (Section 5.3.1). Water level measurements taken from pumping wells are questionable, and it is not possible to measure hydraulic gradients and direction of flow under pumping conditions. Data from test wells is sparse. Most of the main aquifer wells are located in the northeast portion of the facility or offsite to the north and east. Several test wells, DT-5A, -9, and -10, are located on mesas near the southwestern boundary of the Laboratory. This well arrangement does not provide adequate data for mapping the potentiometric surface and determining groundwater flow near the west and southeast portions of the Laboratory. This information is important for understanding how much water will be available for future Laboratory and townsite activities.

Previous Contamination

Another issue involves contamination observed in some supply wells. Noncoliform bacteria exist in some of the Laboratory's production wells, and high levels of naturally occurring arsenic were once found in a supply well (LA-6) in Los Alamos Canyon. The source of the bacteria and reasons for fluctuation in counts are unknown. Well LA-6 has since been plugged, and the LA Well Field has been replaced.

5.4.2 Water Supply Solutions

Recently the Laboratory has supplied all main aquifer test wells with continuously-recording pressure transducers to monitor changes in water level. This data will allow a better understanding of pumping effects on the aquifer and on the long-term water supply. Still more pumping and observation wells to the main aquifer need to be constructed to ensure a viable water supply for the Laboratory and townsite. The monitoring wells should be distributed

inside and outside laboratory boundaries in order to gain better potentiometric control and constructed with dedicated transducers or access ports for water-level measurements. Observation wells should be similarly equipped with dedicated transducers or access ports.

As previously discussed, the ESH Water Quality and Hydrology Group has proposed installing 23 monitoring wells to the main aquifer over the next five years, some of which are specifically intended to increase knowledge of the water supply, as well as monitor water quality (Figures 5-1, 5-2, and 5-3). The ER Project and Waste Management (WM) Program have also proposed the installation of wells strictly for monitoring purposes (Table 5-1).

ESH wants to use MWs for research + monitoring

A special study relating to long-range water supply for the Los Alamos area was completed in 1986 by the U.S. Corps of Engineers for the DOE. In this report, waters from the San Juan and Chama rivers were considered as a short-term supplement to the water supply. Other special studies are needed to answer questions pertaining to naturally occurring biological and mineral contaminants in the main aquifer wells.

5.5 Information Management

5.5.1 Information Management Issues

Central Database

The main issue concerning information management is that the Laboratory does not have a recognized, central database for storing hydrological, geological, water quality, and other related data. Each group uses its own unique manual or electronic method for storing basic groundwater data. Some groundwater information is obtainable by contacting a specific supplier or the Facility for Information Management, Analysis, & Display (FIMAD). However, greater centralization and coordination of this information management process is needed so that external and internal customers can access the relevant groundwater data.

Data Format

The process of centralizing information is complicated by other factors. Groundwater data conventions, such as units, labels, or qualifying remarks, are often unique to a particular LANL group, resulting in a lack of consistent data reporting. In addition, the use of different hardware and software applications throughout the Laboratory makes sharing, access, and integration of data difficult.

QA Procedure

Quality assurance of data is another issue concerning a central database. Different LANL groups use different methods for evaluating data quality, but centralization of data would require an approved and speedy method of data quality assurance. In addition, much of the historic data from Laboratory activities is contained in various publications and reports, many of which are out of print or unobtainable. These data need to be centralized so that interested parties, internal and external, can have access.

Timely Access to Data

Stakeholders and other groups outside of the Laboratory often do not have timely access to LANL database information. The turnaround time for many of the Laboratory environmental or groundwater reports is up to two years after the information was originally collected. Also, Laboratory groups do not have timely access to hydrogeologic data collected in the Los Alamos area by the NMED or USGS.

5.5.2 Information Management Solutions

The ER Project is in the initial stages of implementing a computer network database system. This database could serve as a central repository and archive for all groundwater-related data and provide appropriate access for internal and external customers. Presently, some water quality and hydrogeologic data is stored in the ORACLE and ARC/INFO databases through FIMAD. The computer database will be shared with the USGS and the NMED, who will supply hydrological data, well information, and other data to the database.

The following are suggested features of the database:

- *Dual system.* In the dual database system (shown in Figure 5-5) the rough data is first supplied to a draft database. After being reviewed, the data is then transferred to a quality-assured database accessible by customers.
- *Information management standards.* Standard nomenclature and units of measure should facilitate the transfer of information. Standard file formats (e.g., ASCII files) should be used for data that must be transferred electronically.
- *Quality assurance process.* The quality assurance process for groundwater data should be established and criteria developed. The quality assurance process needs to be timely, stepwise, and cumulative. The data should be qualified with remarks of validity by the source and users of the data, and then pass through a timely, formal process of approval before input to the quality-assured database. Criteria need to be developed for the quality and acceptance of the data.
- *Database content and access.* The database should incorporate data from all groundwater programs at LANL, including spatial data (mapping), relevant hydrogeologic data, well-completion information, results of chemical analyses, radiological data, and modeling data and results. The database should be accessible to Laboratory employees, universities, regulators, and stakeholders. Use of the database should facilitate communication and co-ordination of efforts between groups and individuals that are studying groundwater issues.

The FIMAD group is currently entering historical environmental surveillance, water quality, and other data from old or out-of-print LANL reports into the database where it can be accessed by interested groups or individuals.

5.6 Quality Assurance Plan

5.6.1 Quality Assurance Plan Issues

Quality Assurance Plan

A Quality Assurance Plan (QAP) needs to be developed for the GWPMP. A QAP is needed to provide a procedural framework for the program and to document program management activities. No method exists for planning management and group activities, monitoring progress of the program or projects, or defining roles and responsibilities of contributing Laboratory groups.

Laboratory-Wide SOPs

In addition to documenting management activities, the QAP needs to provide field SOPs. These procedures would describe methods for sampling, constructing wells, purging wells, maintaining and abandoning wells, and interpreting sampling data. Currently, each Laboratory group operates under its own unique set of procedures for field operations.

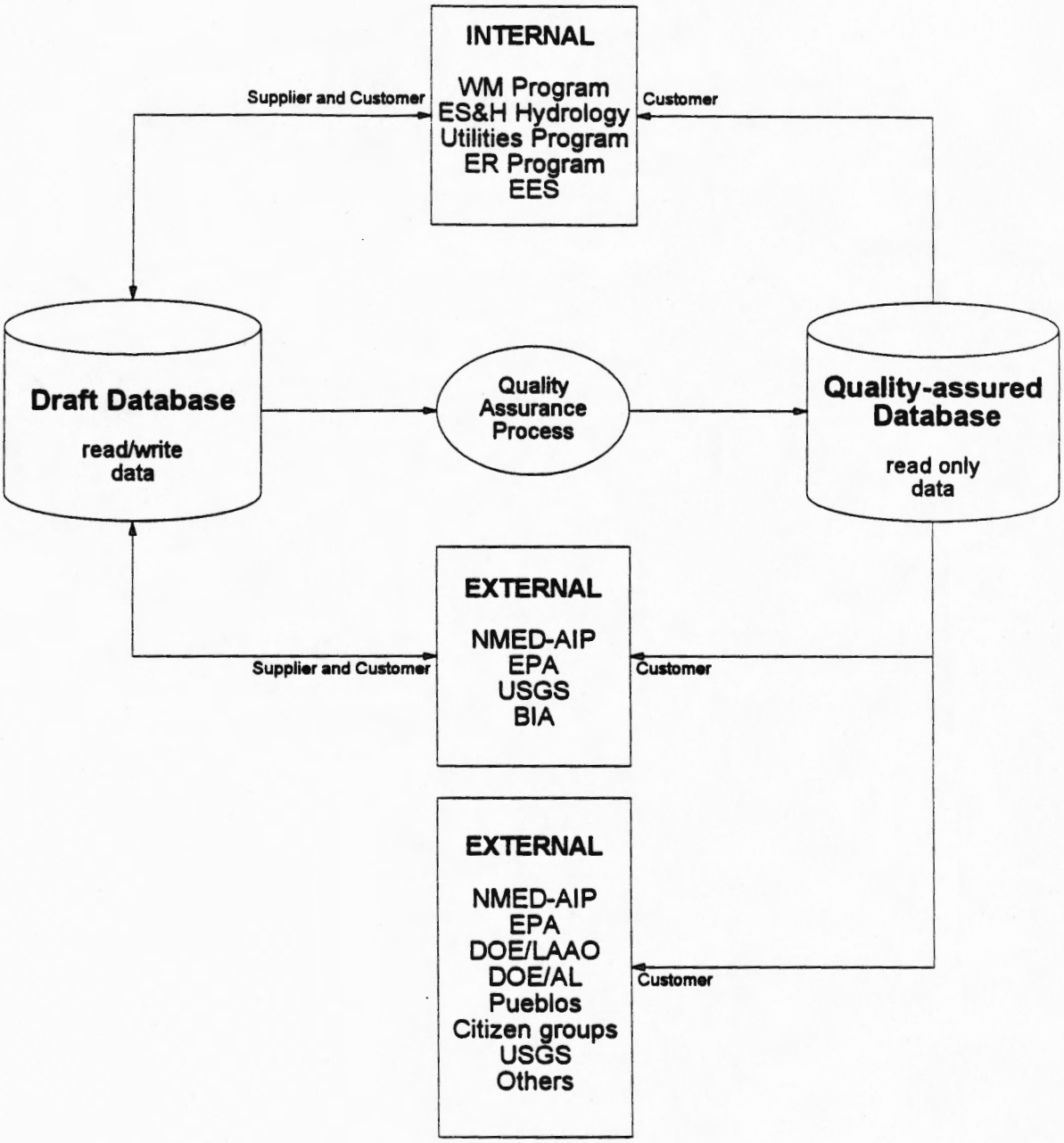

Figure 5-5 Structure of Dual Database System

Quality Assurance Officer

The GWPMP also lacks a Quality Assurance Officer to implement the QAP. Such a designated officer would be necessary to achieve quality technical performance and reliable data collection. In addition, the Quality Assurance Officer would ensure that all activities receive proper documentation for traceability and standard defensibility of data.

5.6.2 Quality Assurance Plan Solutions

A QAP will be implemented for the GWPMP. The QAP will be designed to comply with the requirements for structure and content of DOE Order 5700.6C, Quality Assurance, (DOE 1992). The QAP will integrate all management, technical, and quality aspects of the program to include planning, implementation, and assessment, and will document the sampling, monitoring, analysis, and reporting processes to ensure quality data.

The document will include four elements:

- *Program management.* This element states the program objective and goals, roles and responsibilities of participants, and program planning documentation requirements.
- *Measurement/data acquisition.* This element ensures that appropriate methods for sampling, analysis, data handling, and quality control are used and documented.
- *Assessment.* This element ensures the QAP is implemented as prescribed.
- *Data validation and usability.* This element ensures that data elements conform to specified criteria.

The QAP will ensure the collection and analysis of data that are valid, complete, traceable, and defensible. The following quality assurance documents are additional references for guidance and content in the preparation of the GWPMP QAP:

- 923-C006, QAPP/LANL, "QAPP for Technical Support Services to LANL Environmental Restoration Program."
- LA-UR-91-1844, "QAPP and QAPjP for the Environmental Restoration Program."

Standard operating procedures will be established for calibration and control of test and measurement equipment; handling, storage, shipping and preservation; inspection, test and operating status; and documentation. The SOPs for sampling and well drilling, maintenance, and abandonment are to be adapted from the ER SOPs. The following table is a partial listing of the applicable field SOPs.

Table 5-5. Environmental Restoration (ER) Field Procedures

Procedure Numbers	Procedure
General Instructions	
LANL-ER-SOP-01.02,R0	Sample Containers and Preservation
LANL-ER-SOP-01.03,R1	Handling, Packaging, and Shipping of Samples
LANL-ER-SOP-01.04,R2	Sample Control and Field Documentation
LANL-ER-SOP-01.05,R2	Field Quality Control Samples
Drilling, Excavating, sampling and Logging	
LANL-ER-SOP-04.01,R2	Drilling Methods and Drill Site Management
Well Installation/Development And Water Sampling Techniques	
LANL-ER-SOP-05.01,R2	Monitor Well Construction
LANL-ER-SOP-05.02,R2	Well Development
Sampling Techniques	
LANL-ER-SOP-06.01,R0	Purging of Wells for Representative Sampling of Groundwater
LANL-ER-SOP-06.02,R0	Field Analytical Measurements of Groundwater Samples
LANL-ER-SOP-06.03,R0	Sampling for Volatile Organics
LANL-ER-SOP-06.04,R0	Sampling Commercial/Municipal/Domestic Wells
LANL-ER-SOP-06.05,R0	Soil Water Samples
Subsurface Hydrogeological Site Characterization	
LANL-ER-SOP-07.01,R0	Pressure Transducers
LANL-ER-SOP-07.02,R0	Fluid Level Measurements
LANL-ER-SOP-07.03,R0	Well Slug Tests
LANL-ER-SOP-07.04,R0	Aquifer Pumping Tests
Geotechnical Analysis	
LANL-ER-SOP-011.01,R0	Measurement of Bulk Density, Dry Density, Water Content, and Porosity in Soil
LANL-ER-SOP-011.02,R0	Particle Size Distribution of Soil/Rock Samples
LANL-ER-SOP-011.03,R0	Permeability of Granular Soils
LANL-ER-SOP-011.04,R0	Soil and Core pH
LANL-ER-SOP-011.05,R0	Total Organic Carbon
LANL-ER-SOP-011.06,R0	Cation-Exchange Capacity
Curatorial Management Activities	
LANL-ER-SOP-12.01,R0	Field Logging, Handling, and Documentation of Borehole Materials
LANL-ER-SOP-12-02,R0	Transportation, Receipt, and Admittance of Borehole Samples for the Sample Management Facility

5.7 Regulatory Compliance

5.7.1 Regulatory Compliance Issues

DOE Order 5400.1

In accordance with DOE Order 5400.1 (DOE 1990), the Laboratory is required to comply with all of the applicable federal, state, and local environmental regulations. The three primary regulatory drivers for the Laboratory's groundwater related activities are (1) RCRA, (2) HSWA, and (3) New Mexico Water Quality Control Commission (NMWQCC) regulations. (See Appendix A for other pertinent regulatory drivers.) The Laboratory's compliance with these three regulations is discussed below.

RCRA Permit

The RCRA permit requires the Laboratory to follow specific procedures in the handling, treatment, monitoring, and disposal of hazardous waste. RCRA was amended in 1984 with HSWA to include requirements for hazardous waste volume and toxicity reduction and to minimize the land disposal of hazardous waste.

HSWA Permit

The HSWA permit (Task III of Module VIII) requires the Laboratory to conduct a program to evaluate hydrogeologic conditions at the facility to supplement and verify existing information on the Laboratory's environmental setting. Because most of the wells completed in the main aquifer are located in the northeast and east section of the Laboratory, regional data for hydrogeologic characteristics affecting groundwater flow beneath the facility cannot be obtained. Many of the existing wells are used for water supply purposes and are therefore not adequate for obtaining hydrogeologic data required for compliance with this section of the HSWA permit (e.g., water-level measurements). Sufficient hydrogeologic data have not been collected to understand possible contaminant migration pathways through unconsolidated sand and gravel deposits, zones of fracturing or channeling, or zones of high or low permeability as required by the HSWA permit.

Anticipated Regulatory Requirements

The Laboratory also needs to comply with present and anticipated state regulatory requirements. Under the NMWQCC regulations, which pertain to industrial and municipal discharges onto or below the surface of the ground, the NMED can request a Groundwater Discharge Plan for new and existing facilities. The plan would require a site investigation, characterization of the waste stream, and justification that discharge activities will not degrade groundwater.

The Laboratory has two sanitary treatment facilities and over 100 industrial outfalls. A Groundwater Discharge Plan could be requested by the NMED for any of these facilities, and the Laboratory would need to comply within 120 days after the request.

In addition 10 CFR 834 is scheduled to become law. It is anticipated that the content will be similar to DOE Order 5400.1. Ninety days after the document is presented for public review, it could become law, and LANL will be required to be in compliance.

5.7.2 Regulatory Compliance Solutions

In order to fulfill the requirements of the RCRA and HSWA permits, the Laboratory needs to gather more comprehensive groundwater-related data. Wells completed to the main aquifer are needed to provide this hydrogeologic information and should be constructed for the specific purpose of monitoring and sample collecting or for aquifer test purposes. Other wells and

borings to intermediate or deep depths are needed for understanding hydrologic recharge and contaminant migration pathways through the various geologic formations and structures within and around the Laboratory boundary.

The Laboratory has two approved Groundwater Discharge Plans to meet NMWQCC regulations, one for TA-57 (Fenton Hill) and one for the TA-46 Sanitary Wastewater Treatment Plant which is the location for the SWCS Project (DOE 1992). The Laboratory should still be prepared to produce Groundwater Discharge Plans for discharges from other facilities as well as a Notice of Intent to Discharge for all new activities. Part A of the NMED Discharge Plan Application requires the following information:

- Location.
- Type of operation and type of treatment or storage.
- Quantity and quality of planned discharge.
- Locations of supply wells, monitoring wells, injection wells, seeps, springs, bodies of water or water courses within one mile radius.
- Depth to groundwater.
- Flooding potential and flooding protection measures.
- Geologic discription of discharge site.
- Actions for minimization of potential contaminant seepage.
- Proposed monitoring system.
- Contingency plan.

To comply with the NMWQCC regulations, the Laboratory needs to gather background information including site characterization, depth to groundwater, geologic stratigraphy, and the number of wells in the area. The Laboratory also needs to determine potential pathways through which effluent could enter the main aquifer or the intermediate and alluvial perched groundwater zones. This would require a hydrogeological study of known fractures and other potential recharge pathways to the main aquifer and intermediate perched groundwater zone. Because the regulations also protect surface waters that are fed by groundwater inflow, an investigation is needed to determine all new and existing discharge points for the alluvial and intermediate perched groundwater zones, the two zones most likely to be affected by Laboratory actions.

LANL needs to be prepared to comply with 10 CFR 834.

6.0 Business Plan

6.1 Introduction

This business plan provides a framework for the coordination of all Laboratory groundwater monitoring and protection activities. These activities are now spread among different organizations; in the future, a project leader will be responsible for coordinating the various activities. In addition, the business plan defines the roles and responsibilities of the contributing Laboratory organizations and provides a list of prioritized groundwater activities, cost estimates, and schedules for activity completion. The business plan will be further refined as the Program is developed and implemented.

6.2 Management Organization

The GWPMP Program has been established as an institutional program of the Laboratory residing within the ESH Division. The Project Leader for the GWPMP is assigned by the ESH-18 Group Leader (Water Quality and Hydrology Group) upon concurrence with the ESH Division Director. The Division Director delegates authority to the Project Leader, yet is still ultimately accountable for the actions of the Project Leader and Program activities. As shown in Figure 6-1, the Stakeholder Involvement Office of the Laboratory and the ESH Branch of DOE at the Los Alamos Area Office (LAAO) will interact with the Program through the ESH Division. Internal suppliers such as the Water Quality and Hydrology Group, the ER Project, the WM Program, Engineering, Earth and Environmental Sciences, and the Utilities Program will contribute monitoring wells, special studies, and other resources related to groundwater protection under their programs. External suppliers such as NMED and USGS will contribute the same. These activities will be coordinated through the GWPMP with the Water Quality and Hydrology Group providing primary program support. External customers include DOE/LAAO, DOE/Albuquerque, NMED, NMED-Agreement in Principal (AIP), EPA, USGS, pueblos, and other citizens groups.

6.2.1 Project Leader

The Project Leader will serve as the Laboratory's primary liaison for groundwater-related issues and provide the technical and professional leadership required for implementation of the program. He or she is appointed by the ESH Division Director through a nomination process and is accountable to the ESH-18 Group Leader and the ESH Division Director for project execution. The Project Leader will coordinate all Laboratory groundwater monitoring and protection activities, and will report directly to the ESH-18 Group Leader.

The Project Leader will be responsible for developing and implementing the GWPMP Plan. He or she will have the authority to appoint additional project leaders if needed and to allocate funds to capability organizations for execution of program activities. The Project Leader will serve as coordinator for all monitoring efforts and hydrogeologic studies related to groundwater protection at the Laboratory to ensure a unified approach and prevent duplication of effort among the different Laboratory programs. The Project Leader will prioritize and track groundwater activities, estimate costs, and provide schedules for completion of activities with input from contributing organizations. The Project Leader will be responsible for updating the Plan and serve as a focal point for consistency and quality of groundwater data and reports. The Project Leader will interact with internal Laboratory organizations and serve as the primary point of contact for DOE/LAAO, NMED-AIP, USGS, pueblos, and citizen groups on groundwater-related matters, including generating informative reports. The Project Leader will

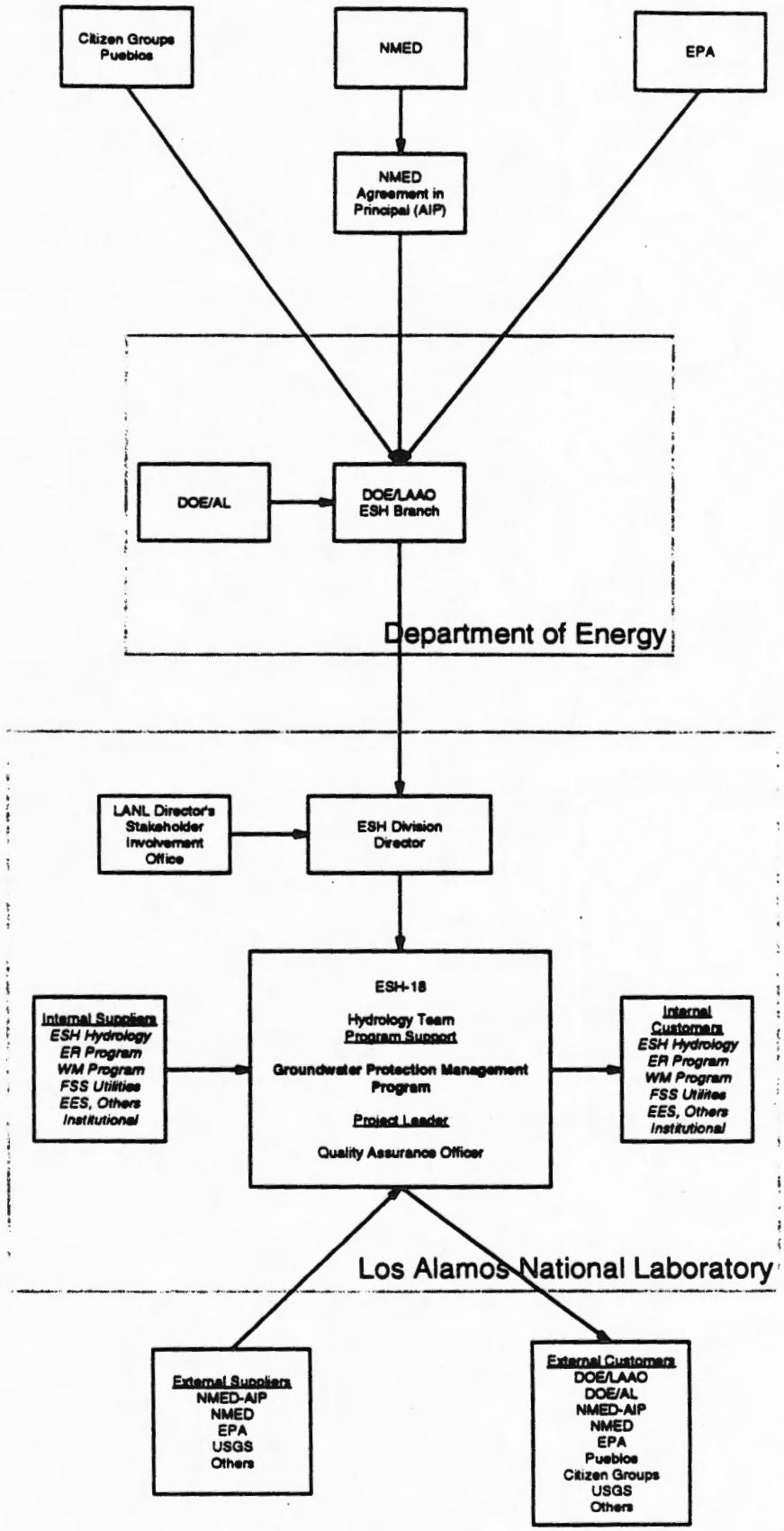

Figure 6-1 Organization Chart

determine program needs and be responsible for addressing those needs in order to ensure successful operation.

6.2.2 Water Quality and Hydrology Group (ESH Division)

The ESH Water Quality and Hydrology Group will serve as the home organization for the Project Leader and will provide primary support for the Program. The Group will assist the Project Leader in integrating contributions from the other Laboratory technical programs into a comprehensive groundwater monitoring, modeling, and characterization effort. The Water Quality and Hydrology Group will work with the Project Leader to prioritize and track groundwater activities, estimate resource requirements, and develop schedules for a coordinated Program. Existing groundwater monitoring programs conducted by the Water Quality and Hydrology Group as part of environmental surveillance activities will serve as the basis for the Program. As ER, WM, USGS and other monitoring wells are developed, these facilities will become a part of the Laboratory's routine monitoring program.

6.2.3 ER Project (EM Division)

The ER Project will provide a detailed compilation of ER-planned, scheduled, and funded activities that contribute information on site-specific groundwater conditions and to the general understanding of groundwater at the Laboratory. The ER Project will provide similar information from work plans that are now under development or in the approval process. ER Project staff will work with the Project Leader and other contributing Laboratory organizations to integrate studies and other activities that expand the usefulness of ER-generated information under the Program. ER Project staff will work with the Project Leader to expand the FIMAD mapping and geographic information system into an integrated Laboratory-wide system to support the Program.

6.2.4 WM Program (CST Division)

The WM Program will identify specific WM-planned, scheduled, and funded groundwater monitoring systems and site-specific groundwater studies for the Program. In addition, the WM Program will identify WM-related data needs which are required to support existing and proposed facilities (i.e., the Mixed Waste Disposal Facility [MWDF] and the Hazardous Waste Treatment Facility [HWTF]). The WM Program staff will work with the Project Leader and other contributing organizations to integrate studies and other activities into the Program.

6.2.5 Utilities Program (FSS Division)

The Utilities Program will provide water resources information for integration of Laboratory and Los Alamos County water supply data into the Program. The Utilities Program will provide the basic data required for water supply planning and hydrologic modeling to evaluate pumping effects on main aquifer and water rights. The Utilities Program will assist the Project Leader and other contributing Laboratory organizations in improving and automating hydrologic data collection from water supply wells.

6.2.6 Earth and Environmental Sciences (EES Division)

The EES staff will contribute and integrate groundwater information obtained from technical studies undertaken in behalf of ER and other programs. These studies include stable isotope recharge studies, geologic mapping, computer modeling, and other groundwater studies. The EES staff will assist the Project Leader and other contributing organizations to develop specific projects to be implemented by EES as part of the Program.

6.2.7 Other Laboratory Organizations

Other Laboratory organizations will contribute groundwater information collected under their programs to the Program.

6.3 Fiscal Organization

6.3.1 Coordination of Funding

Funding identified for groundwater protection activities under the current Environmental Surveillance Program, Tiger Team Action Plans, ESH 5-Year Plan, ER Project, WM Program, Utilities Program and other programs will be coordinated under the Program. A Project Control System and Work Breakdown Structure (WBS) will be utilized to identify and track contributions from each program involved in groundwater protection. An integrated approach will be used in order to avoid overlap and duplication of effort.

6.3.2 Environmental Surveillance Program

The indirect budget for FY95 for groundwater monitoring conducted by the ESH Water Quality and Hydrology Group under the Environmental Surveillance Program is $1500 K. Of this amount, approximately $200 K is dedicated to GWPMP management activities. Approximately $300 K is required for groundwater monitoring analytical work, and $200 K is to support existing activity levels. An additional $800 K is slated to support Tiger Team Action Plan activities. The $1500 K total represents the base funding for groundwater monitoring which will be coordinated under the Program. This funding source and others are shown in Table 6-1.

6.3.3 Tiger Team Action Plans

Many of the elements of the GWPMP are identified as planned actions under Tiger Team Action Plan C-EM-01 "Environmental Surveillance" and Action Plan C-EM-17 "Ground Water Discharge Plan Compliance" (Appendix I). These Action Plans were not funded in FY93 or in FY94. Funding for further development and implementation of these elements of the GWPMP Plan will be requested in FY95. Reprioritization will be requested in view of the recent discovery of low levels of tritium in the intermediate groundwater and main aquifer in Los Alamos Canyon. Work on these Action Plans will be coordinated under the Program.

6.3.4 ESH 5-Year Plan

Direct funding of some groundwater monitoring and related activities may be available in FY96 under the ESH 5-Year Plan. An initial request of $2 million per year in additional operating funds for groundwater protection and $5 million per year in line item funds for installation of new monitoring wells was included in the current ESH 5-Year Plan. Direct funding provided under the ESH 5-Year Plan will be coordinated and will support the Program.

6.3.5 ER Projects

Direct funding of groundwater monitoring and related activities provided by the ER Project will be coordinated under the Program.

6.3.6 WM Programs

Direct funding of groundwater monitoring and related activities provided by the WM Program will be coordinated under the Program.

Table 6-1. GWPMP Funding Sources

Tiger Team Action Plans **FY92 through FY2002**	C-EM-01 Environmental Surveillance - 11 year period (Includes all Environmental Surveillance activities)	$14,200 K	Requested
	C-EM-01 Environmental Surveillance 11 year period (Groundwater activities only)	$7,000 K	Requested
	C-EM-17 Groundwater Discharge Plan 4 year period (Groundwater activities only)	$1,600 K	Requested
	Total Tiger Team Groundwater Activities FY92 to FY02	**$8,600 K**	**Requested**
Indirect Budget FY95	Environmental Surveillance FY95 Base (Groundwater activities only)	$700 K	Requested
	C-EM-01 Environmental Surveillance (Groundwater activities only)	$300 K	Requested
	C-EM-17 Groundwater Discharge Plan (Groundwater activities only)	$500 K	Requested
	Total Groundwater Activities FY-95	**$1,500 K**	**Requested**
Direct Budget FY96 (ESH 5-year Plan)	ESH 5-Year Plan Core with Burden (Groundwater activities only)	$1,400K	Requested
	ESH 5-Year Plan Compliance (Groundwater activities only)	$2,000 K	Requested
	ESH 5-Year Plan Line Item (Install monitoring wells)	$5,000 K	Requested
	Total ESH 5-Year Plan (Groundwater Activities FY-96)	**$8,400 K**	**Requested**

6.4 Customers

The primary customers for the Program are external to the Laboratory and include the DOE/LAAO, DOE/AL, NMED, NMED-AIP, EPA, USGS, Pueblos, Citizen Groups, and other Stakeholders. The DOE/LAAO is the primary focus and audience for the Plan. Participation of the DOE/LAAO and NMED-AIP will be required during development and implementation of the Plan in order to produce an acceptable product.

Participation of stakeholder groups will be sought and facilitated through the Laboratory's Stakeholder Involvement Office. Communication with stakeholders during development and implementation of the Plan will be essential for public acceptance of the GWPMP as a viable means of protecting their groundwater interests. A training element will be required in the Program to properly present technical data in the context of general environmental protection.

The Program will be of particular benefit to internal customers including the Water Quality and Hydrology Group, ER Project, WM Program, Utilities Program and other contributing organizations. Groundwater data, special studies, and other information will be made readily accessible to these organizations, which should improve communication and reduce duplication of effort.

6.5 Cost and Duration Estimates

Table 6-2 shows costs based upon current budgets and anticipated costs of GWPMP activities. Additional groundwater protection activities in FY95 will depend upon allocation of indirect funding. Additional activities including installation of new monitoring wells in FY96 and beyond will depend upon allocation of direct funding under the ESH 5-year Plan. Contributions from the ER Project, WM Program, and other programs are being determined under the GWPMP Plan.

Table 6-3 shows costs based upon well drilling experience and projected costs for installing and equipping monitoring wells. This estimate includes costs for monitoring wells at new locations and replacement wells for existing wells which are deficient or improperly constructed for effective groundwater characterization. The estimated cost for new and replacement wells to completely upgrade the Laboratory's groundwater monitoring system is $25 million. This estimate includes two intermediate zone wells proposed by the ER Project.

Table 6-2. GWPMP Preliminary Cost Estimate

	1994	1995	1996	1997	1998	1999	2000	2001	2002
Operating Expenses	**705**	**1,500**	**3,400**	**3,400**	**3,400**	**3,400**	**3,400**	**3,400**	**3,400**
GWPMP Management									
Program Manager	50	125	250	250	250	250	250	250	250
GWPMP Plan Development	155	75							
Testing of Samples									
Existing Testing	300	300	300	300	300	300	300	300	300
Additional Testing			900	900	900	900	900	900	900
Environmental Surveillance Activities									
Existing Activity Level	200	200	400	400	400	400	400	400	400
Additional Support Act. (Sampling, Reporting, etc.)			300	300	300	300	300	300	300
* Tiger Team Action Plan Support Activities		800							
** GW Studies and Reporting			1,000	1,000	1,000	1,000	1,000	1,000	1,000
** Information System and Archiving			250	250	250	250	250	250	250
Line Item Costs			**5,000**	**5,000**	**5,000**	**5,000**	**5,000**		
Install 23 New Test Wells to Main Aquifer			3,680	3,680	3,680	3,680	3,680		
Remove Casing and Plug 9 Existing Wells			180	180	180	180	180		
Install 14 New Test Well to Intermediate Zone			840	840	840	840	840		
Install 50 New Test Wells to Shallow Alluvium			300	300	300	300	300		
Total	**705**	**1,500**	**8,400**	**8,400**	**8,400**	**8,400**	**8,400**	**3,400**	**3,400**

Notes: All years are fiscal years.
All costs are in thousand dollars.
Outyear costs do not include escalation or inflation.
1994 and 1995 costs are indirect costs.
1996 through 2002 costs are indirect dollars with burden included for existing activities.
* Not yet funded for Action Plans C-EM-01 and C-EM-17.
** These costs are estimates of required GWPMP and ESH-8 Hydrology Team enhanced activities.
Further funding may be required for as yet unidentified monitoring, testing, studies, reports, etc.

Table 6-3. Well Installation Cost Estimate

	Test Well at New Location	Test Well to Replace Deficient Test Well	Test Well to Replace Production Well	Extended Amount
Install New Test Wells to Main Aquifer (23 @ $800K each)	$4000K (5 Wells)**	$7200K (9 Wells)	$7200K (9 Wells)	18400K (23 Wells)
Plug Existing Deficient Test Wells (9 @ $100K each)				$900K (9 Wells)
Install New Test Wells to Intermediate Zone (14 @ $300K each)	$3600K (12 Wells)	$600K (2 wells)		$4200K (14 Wells)
Install New Test Wells in Shallow Alluvium (50 @ $30K each)	$600K (20 Wells)	$900K (30 Wells)		$1500K (50 Wells)
Total	**$8200K**	**$9600K**	**$7200K**	**$ 25000K**

Notes: All costs in thousand dollars.
Well installation includes design, drilling, development, casing, gravel pack, core, analysis, Pump and instrumentation.
Well plugging includes cutting and removal of casing and gravel pack, and grouting to prevent vertical movement of groundwater.
* Includes two wells proposed by the ER Program.
** Includes one well proposed by the ER Program for Area G.

6.6 Prioritization

6.6.1 Methodology

This section describes the methods used to develop a list of prioritized activities for the 1994 GWPMPP. First, Laboratory reviewers developed a comprehensive list of all of the groundwater-related issues. This process involved meeting with regulatory and other groups (NMED, NMED-AIP, EPA, and stakeholder groups), reviewing periodicals, and consulting hydrological experts. Second, the reviewers arranged the issues into logically related groups. For example, all of the issues concerning monitoring wells (condition, lack, and location of wells) were placed under a Groundwater Monitoring Network heading. These issues of concern have been previously discussed in detail in Section 5: Issues and Solutions. Next, the reviewers developed a list of activities to solve each of the issues discussed and assigned costs and schedules to each activity. The activites correspond to the discussion of solutions in Section 5. After analyzing the projected cost, time, and benefit of each activity, the reviewers assembled a final prioritized list.

The process was an informal one. Future GWPMPP managers may want to consider more structured methodologies. For example, the Laboratory has developed a software package called the Laboratory Integration Prioritization System (LIPS) that provides a formal process of determining priorities. LIPS is a risk-based prioritization system, which integrates and prioritizes the spending of Laboratory resources while considering the concerns of diverse

stakeholders. The system is based on the fundamental principles of decision analysis and uses multiattribute theory to quantify and compare the benefits of activities. The LIPS approach is a formal way of quantifying the benefits of proposed activities.

Whatever method is chosen, the manager must ensure that all participants agree to the ground-rules governing the process. That way, as priorities are chosen, the participants will understand the underlying methodology.

6.6.2 Prioritized List of Activities

Priority levels have been developed and assigned to each activity assuming that adequate resources are available to conduct this work. These priority levels are based on the following criteria:

- *Priority 1 Items*. These items represent the most important and most pressing activities identified by the Laboratory, the DOE, and the NMED to ensure the main aquifer is protected from contamination. Priority one items are scheduled to start immediately, assuming resources are available, with a goal of completion within 18 months.
- *Priority 2 Items*. These items represent significant groundwater-related activities that do not have the same urgency as priority one. Priority two items include projects that may already be underway or have a good likelihood of being funded for completion within a given duration. Priority two items are scheduled to start as soon as practical with a goal of completion or significant progress within five years.
- *Priority 3 Items*. These items represent long-term projects aimed primarily at extending the level of technical understanding of the regional groundwater system. These activities may not yet be funded or may require a phased approach for completion. Information gathered during the completion of higher priority projects will be use as a basis for completion of these longer term projects. Priority three items are scheduled to start within the next five years and show significant progress within 10 years.

Table 6-4 shows a prioritized list of proposed activities based on the needs identified by the Laboratory, DOE, and NMED. Each activity is assigned to one of the prioritization categories listed above. Section 5 page numbers are given to reference where each issue is described and solutions are discussed.

Figure 6-2 shows a preliminary 10-year schedule for completing the GWPMP activities.

Table 6-4. Prioritized List of Activities for the Section 5.0 Issues and Solutions

Issues	Solution/Activity		Activity Priority	GWPMPP Page
5.1 Hydrogeological Characterization				
• Hydrogeologic Data • Recharge Mechanisms	• Inventory existing data	• Compile existing hydrogeological data	1	5-2/5-12
		• Consolidate data in central database	2	
	• Study recharge pathways to main aquifer	• Initiate study of recharge from perched alluvial aquifer	1	5-2
		• Initiate study of recharge from intermediate aquifer	1	
		• Initiate study of recharge from mesa tops	1	
		• Initiate study of recharge from faults and fractures	1	
		• Determine recharge from regional sources	3	
	• Study seeps and springs	• Identify new seeps and springs	1	5-5
		• Survey new seeps and springs	1	
		• Sample all seeps and springs	1	
	• Study aqueous isotope geochemistry	• Sample wells	2	5-5
		• Sample seeps and springs	2	
	• Create hydrogeological information maps	• Construct piezometric surface map	1	5-5
		• Construct geologic map at piezometric surface	1	
	• Update hydrogeologic model		1	5-5
5.2 Potential Contamination				
• Potential Sources • Limited Current Information • Plugging and abandonment	• Study contaminant transport	• Study vadose zone pathways	2	5-7
		• Study fault and fracture pathways	2	
		• Study borehole contamination	2	
• Monitoring Well Network	• Study trace constituents in wells	• Evaluate historical well data	2	5-7
		• Perform trend analysis	2	
• Perched Zone Characterization	• Study trace constituents in seeps and springs		2	5-7
	• Develop plugging and abandonment program	• Develop plugging and abandonment SOPs	1	5-7
		• Plug and abandon nine wells already identified	1	
5.3 Groundwater Monitoring Network				
• Main Aquifer Monitoring Network	• Inventory all wells and borings	• Collect all well-related data	1	5-10

Table 6-4, Continued

• Shallow and Intermediate • Monitoring Network		• Construct map of all wells and borings • Evaluate monitoring network deficiencies	1 1	
• Environmental Surveillance Monitoring	• Develop drilling plan for new monitoring wells		1	5-10
• Condition of Wells • Groundwater Monitoring Plan	• Construct new monitoring wells		2	5-10
	• Environmental Surveillance Monitoring	• Include new wells in Environmental Surveillance Monitoring Plan	1	5-10
	• Update Groundwater Monitoring Plan (annually)		2	5-10
5.4 Water Supply				
• Usage • Water Level Data	• Construct or refurbish supply wells		3	5-11
• Previous Contamination	• Study origin of micro-biological constituents		3	5-12
5.5 Information Management				
• Central Database • Data Format • QA Procedure • Timely Access to Data	• Develop dual database system	• Consolidate newly collected hydrogeological and well-related data • Develop consistent database format • Establish mechanism for timely input of quality data. • Establish information transfer pathways for internal and external customers	1 1 1 1	5-12
5.6 Quality Assurance				
• Quality Assurance Plan • Laboratory-Wide SOP • QA Officer	• Develop a Quality Assurance Plan for field activities	• Develop SOPs for Well Installation • Develop SOPs for Water Sampling • Develop SOPs for Hydrogeological Site Characterization • Develop SOPs for Geotechnical Analysis • Develop SOPs for Curatorial Management Activities	1 1 1 1 1	5-15
	• Develop a Quality Assurance Plan for GWPMPP managerial activities	• Develop procedural framework for management activities • Develop documentation for management activities • Develop specific managerial roles and responsibilities	1 1 1	5-15

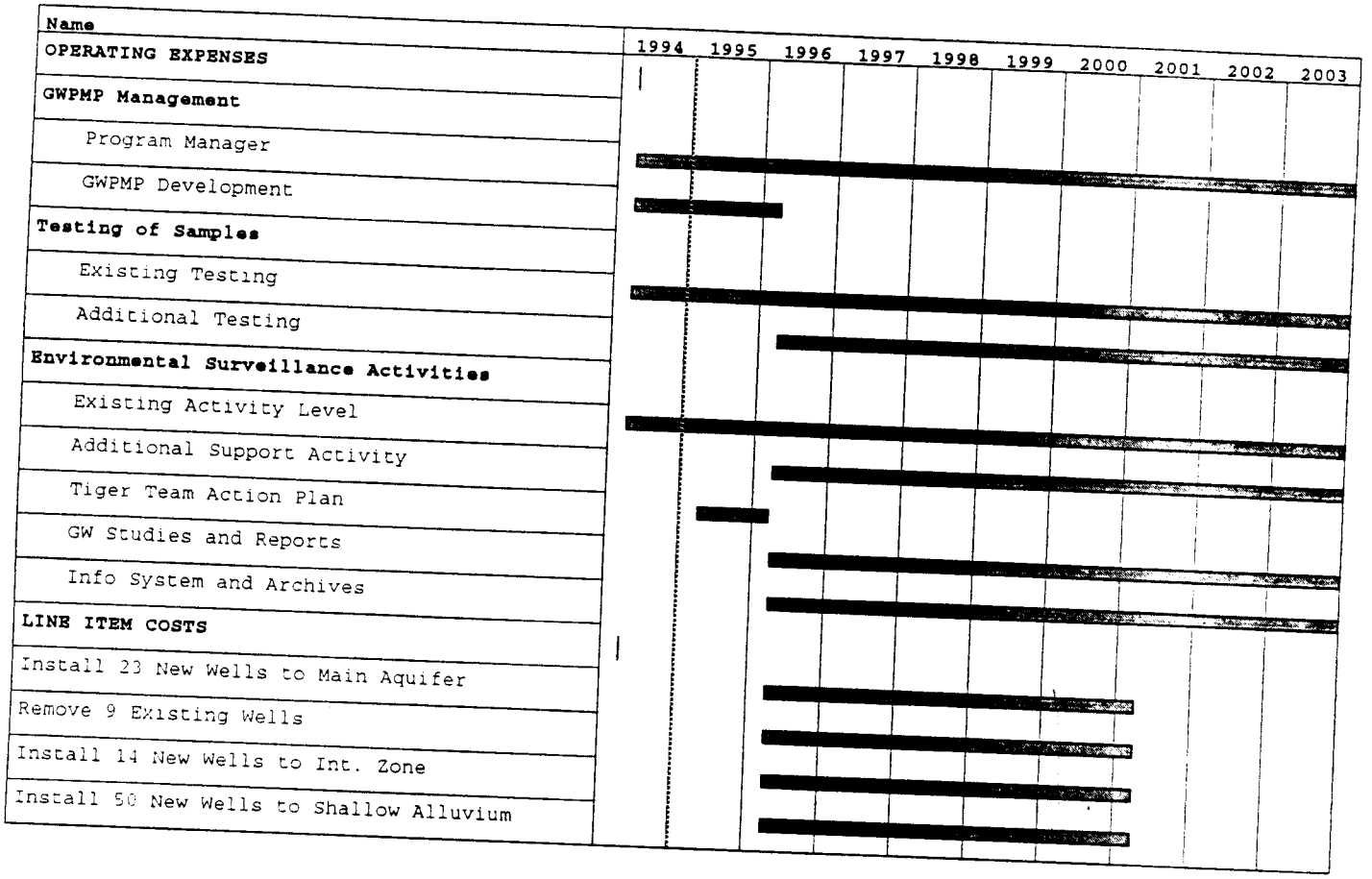

Figure 6-2 GWPMPP Preliminary 10-Year Schedule

6.7 Training Program

A training program will be implemented to familiarize Laboratory employees with the general purpose and structure of the Program. The training program will focus on Laboratory programs and external organizations that function as suppliers to or customers of the Program.

The training program should emphasize how the Program will benefit the Laboratory, the DOE, the state, and the pueblos and citizen groups. The training program will make clear the roles and responsibilities of the Laboratory programs with respect to the Program. It will also define the lines of communication between division and program leaders and the Project Leader, and between the Project Leader and the ESH Division Leader, DOE, the state, and pueblos and citizen groups. The training program will also specify the types of data needed from each program, the mechanism for transfer of information, and criteria for data quality assurance.

6.8 Problem Tracking Mechanism

New issues of concern related to groundwater will arise as the GWPMPP is implemented. A problem tracking mechanism will be developed to ensure that these new issues are addressed and measures are taken to mitigate circumstances that may lead to contamination of the main aquifer.

The Project Leader will be responsible for tracking the status of groundwater-related problems and invoking the necessary and appropriate actions for resolution. In addition, the Project Leader will ensure that all groundwater-related correspondence is "tracked"—that is, all queries receive consideration, follow-up actions, and replies. It will also be the Project Leader's responsibility to generate the appropriate status reports.

6.9 Performance Measures

Performance of the GWPMP must be measured and customer feedback provided in order to assure that an effective program is in place. The following performance measures will be used:

- Compliance with DOE Order 5400.1 "General Environmental Protection Program" and DOE Order 5480.1B "Environment, Safety, and Health Program for Department of Energy Operations."
- Compliance with NMWQCC Regulations Section 3-100 "Regulations for Discharge Onto or Below the Surface of the Ground." Although preparation of Groundwater Discharge Plans for individual laboratory facilities has not yet been required, the ability to comply will be used as a performance measure.
- Internal Customer Satisfaction (Water Quality and Hydrology Group, ER Project, WM Program, Utilities Program, and other programs). The following questions will be asked of customers: Was the GWPMP effective in coordinating groundwater protection activities at the Laboratory? Did the GWPMP help to improve communication and reduce duplication of effort among different programs? Was the GWPMP effective in complementing the programs of contributing organizations?
- External Customer Satisfaction (DOE/LAAO, NMED-AIP, pueblos and other stakeholders). The following question will be asked: Were previously noted deficiencies and unfunded activities properly addressed?

7.0 Implementation Plan

The following committees are responsible for providing guidance to Laboratory groups and assisting in the implementation of the GWPMP: (1) the Technical Review Committee, (2) the Program Management Committee, and (3) the Stakeholder Committee. A description of each committee, as well as various reporting requirements, is provided below.

7.1 Technical Review Committee

The Technical Review Committee (TRC) is responsible for evaluating the technical aspects of the GWPMP. The committee will review the list of prioritized activities in the plan and revise the list based on new or changing technical requirements. During this process, the TRC will solicit recommendations from the Program Management Committee, the Stakeholder Committee, and other LANL groups (i.e., Water Quality and Hydrology Group, ER project, WM Program, Utilities Program, and Earth and Environmental Sciences) and incorporate the groups' suggestions for revising technical goals and priorities. The GWPMP Project Leader will chair the TRC sessions. The members will meet regularly to review the list of priorities and will, at a minimum, consider the following issues:

1) *Current Status of Groundwater Activities.* The costs, schedules, and technical aspects of each of the prioritized activities will be evaluated. The technical effectiveness of various activities, such as sampling and testing, quality assurance of data, and monitoring well construction procedures, will also be determined. Based on this analysis, the TRC will assign priority one, two, or three to each activity.

2) *Alternatives to Activities.* Alternative technical activities will be considered for priorities that do not meet regulatory requirements, are not cost effective, or do not meet intended technical goals.

3) *New List of Priorities.* A revised list of priorities will be created at the completion of the re-evaluation process.

After making proposed changes to the list of priorities, the TRC will document the new list of priorities and send copies to the Program Management Committee, the Stakeholder Committee, and any internal or external customers. The TRC may use the LIPS method (described in Section 6.0 Business Plan) or some other method in developing changes to the list of priorities.

7.2 Program Management Committee

The Program Management Committee (PMC) is responsible for evaluating management issues related to the GWPMP. In particular, the PMC will consider fiscal, regulatory, and other management issues related to the development and implementation of the plan. The PMC will include members of the ER project, WM program, Water Quality and Hydrology Group, and DOE/LAAO. The GWPMP Project Leader will chair the PMC sessions. The members of the PMC will meet quarterly to discuss the following issues:

1) *Funding Issues.* The committee will consider the funding of activities that are underway or proposed. The committee will consider budgeted costs, actual costs, and cost and schedule variances for all groundwater-related activities. For activities that are running significant cost or schedule variances, the committee will consider alternative activities or action plans to salvage the projects.

2) *Regulatory Issues*. The committee will consider the existing and potential legal issues regarding compliance with federal, state, and local environmental regulations. At a minimum, the members will discuss the issues involving the RCRA and HSWA permits, NMWQCC regulations, and other regulations or permits (Appendix A) that affect Laboratory operations.

3) *Managerial Issues*. The committee will consider the effectiveness of management responsible for completing certain projects and consider who should be assigned to complete specific activities. Roles and responsibilities, schedules for completion, and effective ways of sharing or coordinating activities will be considered for these sessions.

After considering each of these issues, the PMC will work closely with the TRC to assist in assigning new lists of priorities. The PMC will provide input and documentation to the TRC concerning the status of each of these managerial issues so that priorities can be effectively assigned. Work Breakdown Structures shall be developed for each of the prioritized activities by the two committees as part of project planning. As WBSs are developed, relevant information will be included in the GWPMPP.

7.3 Stakeholder Committee

The Stakeholder Committee is responsible for providing groundwater-related information to the stakeholder groups. The DOE will chair the committee. The membership will include representatives from the pueblos, citizen groups, NMED, USGS, DOE/LAAO, LANL, and the EPA. The Stakeholder Committee will meet semi-annually to review the following issues:

1) The status of LANL groundwater monitoring and protection efforts.

2) Specific stakeholder interests involving groundwater protection.

3) Recommendations for prioritization of groundwater activities.

The Stakeholder Committee will provide the recommendations to the TRC concerning the list of priorities contained in the GWPMP. Recommended changes to the list of priorities, emergency remedial actions, or other stakeholder concerns will also be included in the report to the TRC.

7.4 Department of Energy Status Reports

The Project Leader will provide an annual status report to the DOE summarizing the groundwater protection activities in the GWPMPP. The report will include descriptions of TRC, PMC, and Stakeholder Committee meetings, and any recommended courses of action that were decided upon. An analysis of budgeted groundwater activities versus actual costs and schedules will also be provided. Cost and schedule variances will be justified with stated action plans to correct variances. In addition, discussions of pertinent regulatory compliance or managerial issues will be provided in this report.

7.5 GWPMP Updates

The Project Leader, TRC, and PMC will review and update the GWPMP on an annual basis. At a minimum, the revised GWPMP will include current hydrogeological data, status reports on issues and solutions, reports on newly identified activities with related cost and scheduling information, and a reprioritized list of issues.

Management reports will be generated from the information system. The reports will provide cumulative and project-specific information regarding project status, scheduling and costs; and newly planned projects and proposed costs. The information system and management reports will be continually updated to provide current and accurate information. The information system will be upgraded as needed to provide new and existing data fields in identified configurations.

7.6 Business Plan Schedule

Table 7-1 shows the primary milestones and target dates for implementing the GWPMP Business Plan. Those activities without target dates must be rescheduled for a later time.

Table 7-1. GWPMP Business Plan Schedule

Description	Target Date
Establish management organization for the GWPMP and define the Project Leader's role, home organization, and roles and responsibilities of groups	Completed
Provide initial funding for hiring Project Leader and for GWPMP Plan development ($205K Indirect Funding from ESH-DO)	Completed
Establish GWPMP as a Laboratory Institutional Program (Present Business Plan to ES&H Council)	Completed
Obtain DOE/LAAO approval of Business Plan	Completed
Appoint acting Project Leader for GWPMP	Completed
Hire Project Leader for GWPMP	April 1, 1995
Request Tiger Team Action Plan funding for groundwater protection activities in FY95	Completed
Request ES&H 5-Year Plan funding for groundwater protection activities in FY96	Completed
Complete update of GWPMP Plan	Completed
Begin implementation of GWPMP Plan through indirect funding	Completed
Begin enhanced sampling and monitoring through ES&H 5-Year Plan funding	October 1, 1995
Begin installation of new monitoring wells through ES&H 5-Year Plan funding	October 1, 1995

9.0 Glossary

Alluvial	Pertaining to or composed of alluvium (clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream), or deposited by a stream or running water.
Alluvial Perched Groundwater	This term is used to refer to the localized bodies of shallow groundwater that occur in the alluvial materials in the bottoms of the canyons cutting across the Pajarito Plateau. The alluvial is typically from 10 or 20 feet to over 100 feet wide. and from 10 to 40 or more feet thick. The water in the alluvium is perched on the underlying tuff or basalts and has a surface that fluctuates in elevation as a direct response to input or loss from stream channels. None of the water in the canyons within the Laboratory is used for municipal, industrial, or agricultural supply.
Aquifer	A body of rock that contains sufficient saturated permeable material to conduct water to yield economically significant quantities of water to wells and springs.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also know as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulation. A codification of all regulations developed and finalized by federal government agencies in the *Federal Register*.
COC	Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.
Confluence	A place of meeting of two or more streams; the point where the tributary joins the main stream.
Contamination	The deposition of unwanted radioactive or hazardous material on the surface of structures, areas, objects, or personnel.
Controlled Area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Continuous Stream	A stream that does not have interruption is space; it may be perennial, intermittent, or ephemeral, but it does not have wet and dry reaches.
Direct Runoff	The runoff reaching stream channels immediately after rainfall or snowmelting.
DOE	U.S. Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.
Downstream	Toward, at, or from a point near the mouth of a stream; in a direction toward which a stream (or glacier) is flowing.
EA	Environmental Assessment. A report that identifies potentially significant

	environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.
Effluent	A liquid discharged as a waste, such as contaminated water from a factory or the outflow from a sewage works; water discharged from a storm sewer or from land after irrigation.
EIS	Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.
Environmental Surveillance	The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media to determine environmental quality of an industry or community. It is commonly performed at sites containing nuclear facilities.
EPA	Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although State regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.
Ephemeral Stream	A stream or reach of a stream that flows briefly on in direct response to precipitation or snowmelt in the immediate locality; its channel bed is always above the water table of the region adjoining the stream.
Flow	Relative to streams, it is natural flow ensuing from the earth's hydrologic cycle, i.e., atmospheric precipitation resulting in surface and/or groundwater runoff. Natural in-stream flow may be interrupted or eliminated by dams and diversions.
Groundwater	That part of the subsurface water that is the zone of saturation, including underground streams.
Groundwater Runoff	The runoff that has entered the ground, become groundwater, and been discharged into a stream channel.
Hazardous Waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or EP-toxicity (yielding toxic constituents in a leaching test). In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term more generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.
Hazardous Waste	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expand the scope of hazardous waste

	regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous waster.
Hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
Intermittent Stream	A stream or reach of a stream that flows only at certain times of the year, such as when it receives water flow from springs or some surface source, melting snow, or localized precipitation.
Interrupted Stream	A stream that contains perennial reaches with intervening intermittent or ephemeral reaches.
NPDES	National Pollutant Discharge Elimination System. This federal regulation, under the Clean Water Act, requires permits for discharge into surface waterways.
Outfall	The vent or end of a drain, pipe, sewer, ditch, or other conduit that carries waste water, sewage, storm runoff, or other effluent into a stream.
Perched Groundwater	Unconfined groundwater separated from an underlying main body of groundwater by an unsaturated zone.
Perennial Stream	A stream or reach of a stream that flows continuously throughout the year in all years. Its upper surface, in general, is lower than the water table of the region adjoining the stream.
Piezometric Surface	This is also called potentiometric surface. This is the level to which water will rise in a well tightly cased into an aquifer.
QA	Quality assurance. The routine application of procedures within environmental monitoring and measurement to obtain required standards of performance. QA procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.
RCRA	Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.
Runoff	That part of precipitation appearing in surface streams. It is more restrictive than streamflow as it does not include stream channels affected by artificial diversions, storage, or other works of man.
SARA	Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title II of this act is also know as the Emergency Planning and Community Right-to-Know Act of 1986.
Snowmelt	The water resulting from the melting of snow.
Streamflow	A type of channel flow applied to that part of surface runoff traveling in a stream, whether or not it is affected by diversion or regulation.
Stream Channel	The hollow bed where a natural stream of water runs or may run; the long, narrow, sloping trough-like depression shaped by the concentrated

	flow of a stream and covered continuously or periodically by water.
Subsurface Water	Water in the lithosphere in solid, liquid, or gaseous form; includes all water beneath the land surface and beneath bodies of surface water.
Surface Runoff	The runoff that travels over the soil surface to the nearest surface stream; runoff that has not passed beneath the surface since precipitation.
SWMU	Solid Waste Management Unit. 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. Potential release sites include, for example, waste tanks, septic tanks, firing sites, burn sites, sumps, land fills (material disposal areas), outfall area, LANL canyons, and contaminated areas resulting from leaking product storage tanks (including petroleum).
Tritium	^{3}H. A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactivity decay makes it one of the least hazardous radionuclides.
Tuff	Rock of compacted volcanic ash and dust.
Vadose Zone	Also unsaturated zone or zone of aeration. The partially saturated or unsaturated region above the water table that does not yield water to wells. Water and/or gasses contained are usually under less than atmospheric pressure.
Water Rights	New Mexico water law is based on the doctrine of prior appropriation, and the rights to use water are established through the State Engineer's Office.
Water Table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well is screened in the unconfined aquifer and would fill with water.
Water Year	October through September.
Watershed	The region draining into a river, river system, or body of water.
Wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.

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APPENDIX A

DOE Orders and Regulatory Requirements

Regulations and DOE Orders

Atomic Energy Act

The Atomic Energy Act of 1954 (AEA), as amended, gives the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and the Environmental Protection Agency (EPA) the authority to establish standards and instructions (by rule, regulation, or order) to govern the possession and use of source, special nuclear, or by-product material to promote common defense and security; to protect health; and to minimize danger to life or property.

The DOE ensures that its facilities comply with the AEA requirements by issuing department orders concerning radioactive material and waste management. DOE departmental orders on radioactive material and waste management apply to all DOE elements, contractors, and subcontractors. The DOE is authorized by the AEA to control radioactive operations at DOE facilities. The DOE is responsible for keeping radionuclide emissions at its facilities as low as reasonably achievable (ALARA). The DOE has developed Derived Concentration Guides for comparison to measured radionuclide concentrations in air and water. The DOE assures that its operations are within its operating guidelines by requiring facilities to maintain radiation monitoring systems and to report the results in an annual summary report.

Clean Water Act and New Mexico Water Quality Act

The goal of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The regulations specify water quality standards and effluent limitations. To comply with the CWA, the Laboratory has two primary programs: the National Pollutant Discharge Elimination System (NPDES) permit program and the Spill Prevention Control and Countermeasures (SPCC) program. The Laboratory operates under two NPDES permits issued and enforce by EPA, Region 6. Through a joint federal and state agreement and grant, New Mexico acts as the agent for the EPA and performs compliance inspections and reporting. Other ongoing Laboratory compliance activities are management of the Federal Facility Compliance Agreement and construction of Sanitary Wastewater Systems Consolidation (SWSC) Project.

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) became law in 1976 as a means to regulate toxic waste disposal for the prevention of water and soil contamination due to poor disposal practices. Subtitle C of RCRA regulates hazardous waste from generation to disposal. RCRA was amended in 1984 by the Hazardous and Solid Waste Amendments (HSWA) to include requirements for hazardous waste volume and toxicity reduction, and to minimize the land disposal of hazardous waste. Under RCRA, the EPA has granted regulatory power to the states, including regulation of mixed wastes defined as RCRA regulated hazardous wastes with a radioactive component, but did not include granting regulatory power for the HSWA to the states.

New Mexico State authority for hazardous waste regulatory power comes from the Hazardous Waste Act and the Hazardous Waste Management Regulations. Through these, New Mexico

adopts the Codified Federal Regulations (40 CFR) pertaining to hazardous waste. Currently the state is operating under the 40 CFR of July 1990. However, the Laboratory's permitted hazardous waste units are operating under the July 1988 regulations that were in effect as of the November 1989 permit. Since 1989, the Laboratory has been operating under this RCRA permit issued jointly by the State of New Mexico and EPA.

Hazardous and Solid Waste Amendments

The HSWA portion of the RCRA permit was issued by EPA in March 1990. The permit sets conditions for the management of newly generated hazardous waste treatment and storage units, waste minimization land disposal restrictions, and corrective actions at solid waste management units. The Laboratory has submitted Part A of its permit application for mixed waste activities and Part B for three mixed waste management units as required by state regulations.

Task III of Module 8 of the HSWA permit requires that the permittee (a) collect information to supplement and verify existing information on the environmental setting at the facility, (b) collect analytical data to completely characterize wastes and areas where wastes have been placed, and (c) collect analytical data on groundwater, soils, surface water, sediments, and subsurface gas contamination to characterize contamination.

In accordance with Task III, Section A.1, the permittee is required to conduct a program to evaluate hydrogeologic conditions and to provide the following information:

- A description of regional and facility specific geologic and hydrogeologic characteristics affecting groundwater flow beneath the facility;
- An analysis of any topographic features that might influence the groundwater flow system;
- An analysis of fractures within the tuff, addressing tectonic trend fractures versus cooling fractures;
- Based on field data, tests, and cores, a representative and accurate classification and description of the hydrogeologic units which may be part of the migration pathways at the facility (e.g., the aquifers and any intervening saturated and unsaturated units);
- Based on field studies and cores, structural geology and hydrogeologic cross sections showing the extent (depth, thickness, lateral extent) of hydrogeologic units which may be part of the migration pathways identifying (1) unconsolidated sand and gravel deposits, (2) zones of fracturing or channeling in consolidated or unconsolidated deposits, and (3) zones of high permeability or low permeability that might direct and restrict the flow of contaminants;
- Based on data obtained from groundwater monitoring wells and piezometers installed upgradient and downgradient of the potential contaminant source, a representative description of water level or fluid pressure monitoring;
- A description of manmade influences that may affect the hydrogeology of the site; and

- Analysis of available geophysical information and remote sensing information such as infrared photography and Landsat imagery.

In accordance with Task III, Section A.2, the permittee is required to conduct a program to characterize soil conditions above the water table in the vicinity of a contaminant release and to provide the following information:

- Surface soil distribution;
- Soil profile, including ASTM classification of soils;
- Transects of soil stratigraphy;
- Saturated hydraulic conductivity;
- Porosity;
- Cation exchange capacity;
- Soil pH;
- Particle size distribution;
- Depth of water table;
- Moisture content;
- Effect of stratifications on unsaturated flow;
- Infiltration;
- Evapotranspiration;
- Residual concentration of contaminants in soil;
- Mineral and metal content;
- Trace element geochemistry as a means of differentiating units within the tuff; and
- Water balance scenarios.

Task III, Section C.1, requires the permittee to conduct a groundwater investigation to characterize any plumes of contamination at the facility. This investigation shall include the collection of sufficient data to define:

- A description of the extent of contamination;
- Rate and direction of contaminant movement;
- Concentration profiles of applicable constituents and radiochemical constituents in the plume;
- An evaluation of factors influencing plume migration; and
- An extrapolation of future contaminant movement.

Task III, Section C.2, states that the permittee is required to conduct an investigation characterizing the contamination of the soil above the water table in order to provide:

- A description of the extent of contamination;

- A description of contaminant and soil chemical properties within the contaminant source area and plume migration and transformation;
- Specific contaminant concentrations;
- Rate and direction of contaminant movement; and
- Worst case scenarios for future contaminant movement over the life of the contaminant.

The data shall include time and location of sampling, media sampled, concentrations found, conditions during sampling, and identity of the individuals performing the sampling and analysis.

New Mexico Water Quality Control Commission Regulations

The New Mexico Water Quality Control Commission (NMWQCC) regulations set quality standards for surface and groundwaters for protection of the public health or welfare, to enhance the quality of water, and to serve the purposes of the Water Quality Act. The NMWQCC publishes regulations to prevent or abate water pollution and to govern the disposal of septage and sludge.

The NMWQCC publishes regulations controlling discharges onto or below the surface of the ground for the purpose of protecting all groundwater of the state which has an existing concentration of 10,000 mg/L or less Total Dissolved Solids, for the present and potential future use as a domestic and agricultural water supply, and to protect those segments of surface waters which are gaining because of groundwater inflow, for uses designated in the New Mexico Water Quality Standards. The regulations are written so that in general:

- if the existing concentration of any water contaminant in groundwater is in conformance with the standard of Section 3-103 of these regulations, degradation of the groundwater up to the limit of the standard will be allowed; and
- if the existing concentration of any water contaminant in groundwater exceeds the standard of Section 3-103, no degradation of the groundwater beyond the existing concentration will be allowed.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) of 1974 as amended was established to provide safe drinking water to the public. Primary and secondary drinking water standards have been established for public water supply systems. The SDWA also provides for protection of underground sources of drinking water by controlling subsurface injection of potential contaminants. Regulations have been issued whereby states establish Underground Injection Control Programs to ensure that contaminants in water supplies do not exceed National Drinking Water Standards and to prevent endangerment of any underground source of drinking water. National Interim Primary Drinking Water Standards were adopted in 1975. Regulations covering radionuclides were added in 1976 while regulations covering trihalomethanes were prepared in 1977. Secondary regulations in 1979 established guidelines to states for the protection of the non-health-related qualities of drinking water. The New Mexico Water Supply Regulations implement the provisions of the SDWA.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) of 1969 requires federal agencies to consider the potential environmental impacts of proposed activities during the planning stages so that agencies' decisions reflect environmental values as well as cost and mission. Potential adverse impacts of proposed new projects are evaluated so that measures can be taken, if necessary, to lessen those impacts. An Environment, Safety, and Health questionnaire form developed by the Laboratory is used to provide initial information on environmental protection, industrial hygiene, radiation protection, and other safety and health compliance issues relative to a proposed project.

The issuance of Secretary of Energy Notice (SEN) 15 changed the DOE's requirements for compliance with NEPA. The SEN centralized all authority to approve NEPA documents at DOE Headquarters, required that each activity be presented as a unique event regardless of whether or not it duplicated an earlier event, discontinued the use of memorandums to document that a decision and a proposed activity would not cause a significant impact, and required that activities not falling into the remaining categorical exclusions be documented in an Environmental Assessment. New regulations for implementing NEPA were proposed in November 2, 1990, and these regulations will be implemented when final.

National Historic Preservation Act

The National Historic Preservation Act, Section 106, requires that Laboratory activities be evaluated in consultation with the State Historic Preservation Officer for possible effects to cultural or historic resources.

Endangered/Threatened/Protected Species and Floodplains/Wetlands Protection

The Laboratory must comply with the Endangered Species Act of 1973 as amended and with Executive Orders 11988 "Floodplain Management" and 11990 "Protection of Wetlands". These compliance activities involve review of proposed activities for potential impact on critical habitats, floodplains, and wetlands.

Comprehensive Environmental Response, Compensation, and Liability Act

Investigation and remediation of abandoned waste disposal sites are required by the Comprehensive Environmental Response, Compensation, and Liability Act of 1976 (CERCLA, the Superfund Act) and/or Section 3004 (u) of RCRA (Hazardous and Solid Waste Amendments Act of 1984 permit). The Laboratory's Environmental Restoration (ER) Program has begun an extensive investigation of abandoned solid waste management units (SWMU) within the facility and around the Los Alamos townsite. Although LANL is not listed by the EPA on the CERCLA National Priorities List (the most contaminated sites in the United States) and, therefore, not required by law to meet CERCLA cleanup standards, the ER Program voluntarily incorporates these standards during investigations and remediation of SWMUs. The Superfund Amendments and Reauthorization Act of 1986 (SARA) requires LANL to maintain an inventory list of hazardous materials and report certain spills of these materials to local agencies.

Emergency Planning and Community Right-to-Know

Title III, Section 313 of the Emergency Planning Community-Right-to-Know Act exempts facilities not meeting certain Standard Industrial Classification code criteria from reporting requirements. However, DOE policy requires the Laboratory to report releases under the remaining provisions of Secion 313. All research operations at the Laboratory are exempt under other provisions of the regulation; only one operation at the Laboratory has reported releases under SARA.

DOE Order 5400.1 General Environmental Protection Programs

DOE Order 5400.1 establishes environmental protection program requirements, authorization, and responsibilities for DOE operations to assure DOE facilities comply with applicable federal, state and local environmental regulations and laws, executive orders and internal department policies. The provisions of the Order apply to everyone within the DOE system including contractors and subcontractors. It is DOE's policy to conduct its operations in an environmentally safe manner. DOE is committed to ensuring that national environmental protection goals will be incorporated in the planning and implementation of DOE programs. In addition to conducting its operations in compliance with the applicable environmental regulations, statutes and standards, DOE is committed to good environmental management of its programs and facilities, to correct existing environmental problems, to minimize risks to the environment or public health, and to anticipate and address potential environmental problems before they pose a threat to the environment or public welfare.

DOE Order 5400.2A Environmental Compliance Issues Coordination

DOE Order 5400.2A establishes the requirements for coordination of significant environmental compliance issues to ensure timely development and consistent application of environmental policy and guidance. The provisions of this Order apply to everyone within the DOE system including contractors and subcontractors where DOE has authority to establish and enforce environmental protection, safety, and health protection requirements. Significant environmental compliance issues are those whose resolution has the potential of setting precedence, is controversial, and/or involves DOE Headquarters notification, concurrence, or approval. The coordination process is the method which ensures that significant environmental compliance issues are resolved or disseminated so that timely development and consistent application of environmental policy and guidance can be obtained.

DOE Order 5400.5 Radiation Protection of the Public and the Environment

DOE Order 5400.5 establishes standards and requirements for operations of the DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation. It is the policy of the DOE to implement legally applicable radiation protection standards and to consider recommendations by authoritative organizations (e.g., the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection). It is the policy of the DOE to adopt and implement standards generally consistent with those of the NRC for DOE facilities and activities not subject to licensing authority.

APPENDIX B

Hydrogeology of the Pajarito Plateau: Technical Review

HYDROGEOLOGIC BACKGROUND INFORMATION

(Excerpted from "Installation Work Plan for Environmental Restoration,")

2.6 Geologic and Hydrologic Setting

This summary of the hydrogeologic environment at the Laboratory and in the northern New Mexico region is intended to describe the major geologic, hydrologic, and hydrogeologic features and their conceptual interrelationships. It addresses the regional and installation-wide geologic setting and the hydrologic characteristics that affect surface water and groundwater occurrence and movement and their interactions as they relate to the potential for contaminant transport. The sources cited here and additional literature on the hydrology and geology of the Los Alamos region may be found in an annotated bibliography of geologic, hydrogeologic, and environmental studies related to solid waste management units at the Laboratory (LANL 1990, 0143). This bibliography was submitted to EPA in September 1990, and it and the literature it describes are available for review in the Laboratory's public reading room located at 1450 Central Avenue, Suite 101, in Los Alamos.

2.6.1 Geology

2.6.1.1 Regional Setting

The Laboratory is situated on the Pajarito Plateau on the east flank of the Jemez Mountains and on the west side of the Rio Grande valley (Figure 2-5). The Jemez Mountains are part of the Jemez volcanic field, which consists of some 432 mi^3 of volcanic rocks erupted from numerous vents, including a giant, multistage caldera (Gardner et al. 1986, 0310). The Jemez volcanic field occurs at the intersection of the Jemez lineament, a northeast-trending alignment of volcanic fields, and the Rio Grande rift, a major north-trending zone of extensional tectonics (Aldrich 1986, 0554).

Two major volcanic eruptions in the Jemez Mountains that occurred about 1.5 and 1.13 million years ago produced widespread and voluminous ash flow sheets: the Otowi and Tshirege members of the Bandelier Tuff (Smith and Bailey 1966, 0377; Spell et al. 1990, 0607). The morphology of the Pajarito Plateau is dominated by a gently eastward-sloping surface, formed on top of the Bandelier Tuff, which is dissected by numerous steep-sided canyons. The Otowi and Tshirege Members of the Bandelier Tuff were erupted concomitantly with the collapse of the Toledo and Valles calderas, respectively. Following formation of the calderas, volcanism continued with the extrusion of domes along ring fractures. The latest eruption in the Jemez Mountains occurred about 130,000 years ago, producing the El Cajete pumice and Banco Bonito rhyolite flow (Gardner et al. 1986, 0310; Self et al. 1988, 0500). Vestiges of volcanic activity continue today, as evidenced by solfataric and hot spring activity both within and outside of the Valles caldera (Goff et al. 1989, 0774). Studies of P-wave arrival time delays suggest the presence of partially molten rock beneath the Valles caldera, possibly the remnants of the cooling Bandelier magma chamber (Roberts et al. 1991, 0775).

The Pajarito Plateau is in the western part of the Española basin of the Rio Grande rift, a major tectonic feature of the western United States. The Española basin lacks distinct major faults on its eastern margin, but faults of major vertical offset may exist within the Precambrian rocks of the Sangre de Cristo uplift (Vernon and Riecker 1989, 0558; Biehler et al. 1991, 0528). The western margin is characterized by a prominent zone of major faults, which cuts Miocene to Quaternary rocks of the Jemez volcanic field (Smith et al. 1980, 0776; Gardner and Goff 1984, 0719; Goff et al. 1990, 0557). These border faults exerted strong control on the location and development of the volcanic field (Gardner and Goff 1984, 0719; Gardner et al. 1986, 0310).

Rocks formed before the rift developed are exposed around the margins of and underlie the Española basin. These rocks consist of Mississippian to Permian marine limestones, sandstones, and shales; Mesozoic marine to terrestrial sandstones and shales; and Eocene sandstones, shales, and freshwater limestones. Precambrian rocks—predominantly quartzite granitic gneiss and schist, and greenstone—are exposed in the cores of the flanking Sangre de Cristo, Nacimiento, and Brazos uplifts (Kelley 1978, 0641). The earliest sediments deposited in the Tertiary Española basin are those of the Abiquiu, Picuris,

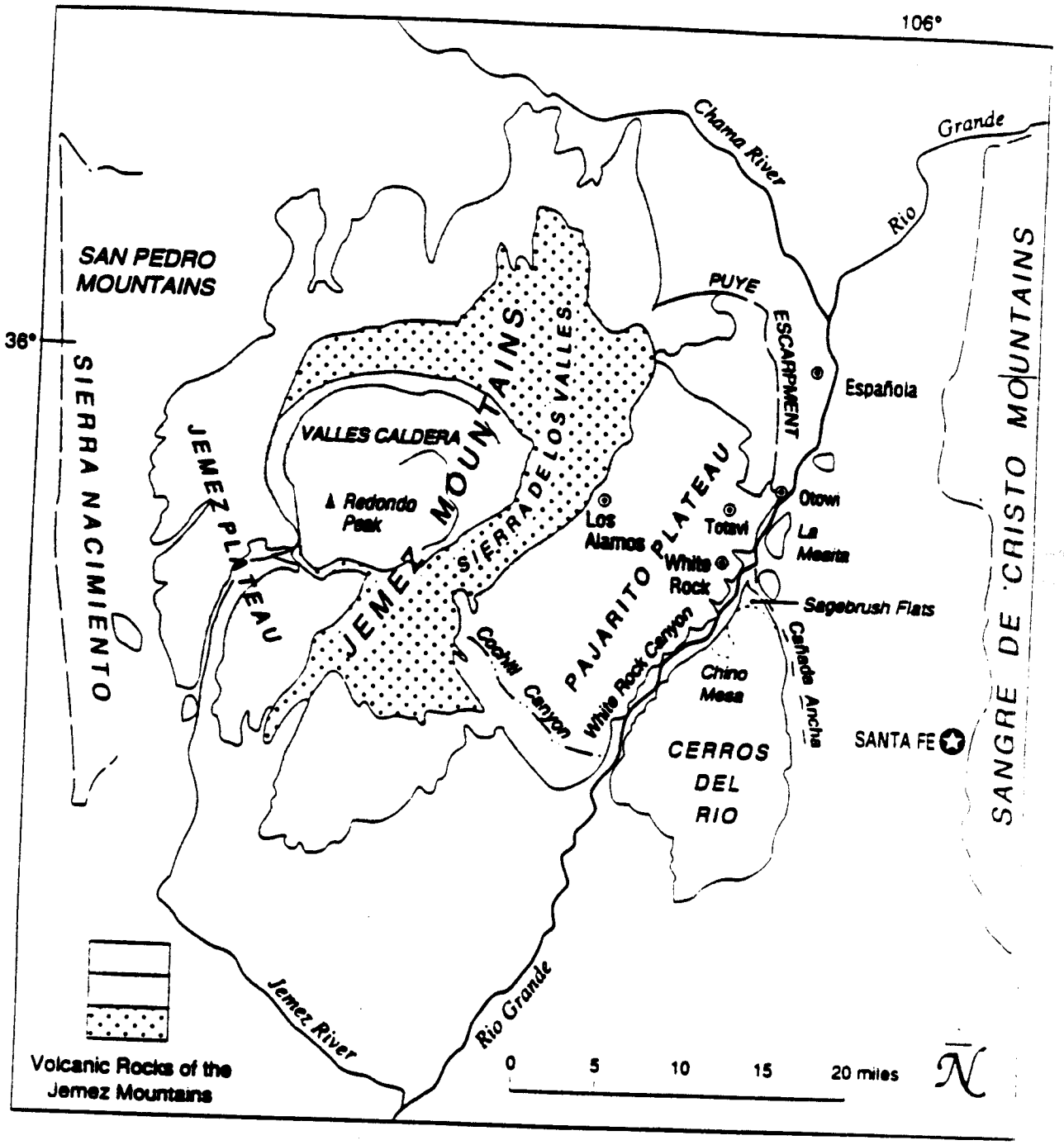

Figure 2-5. General geographic location map showing topographical features in the vicinity of Los Alamos.

0641). The earliest sediments deposited in the Tertiary Española basin are those of the Abiquiu, Picurís, and Los Piños formations, which consist of tuffaceous sandstones and volcaniclastic conglomerates derived largely from volcanic highlands to the north and northeast. These units range in age from about 28 to 17 million years old (Baldridge et al. 1980, 0527; May 1984, 0536; Ingersoll et al. 1990, 0533).

2.6.1.2 Stratigraphic Units

Beneath a veneer of soils and alluvial deposits, the mesas of the Pajarito Plateau are immediately underlain by the Bandelier Tuff of Pleistocene age, which is exposed in the canyon walls and is penetrated by numerous drill holes. Beneath the Bandelier Tuff, a sequence of interstratified sedimentary and volcanic rocks of Miocene to Pleistocene age occur, which have been penetrated by water supply wells and which have been studied where they outcrop in canyons on the margins of the Pajarito Plateau. These rock units include volcanic rocks of the Paliza Canyon Formation, Tschicoma Formation, and the Cerros del Rio volcanic field, and sedimentary deposits of the Puye Formation, the Totavi Formation, the Cochiti Formation, and the Santa Fe Group. These units are briefly discussed below. Figure 2-6 is a generalized geologic cross section from west to east of the Laboratory's geologic setting.

2.6.1.2.1 Santa Fe Group

The Santa Fe Group of Miocene and early Pliocene age (formed 18 to 4.5 million years ago) is a thick series of terrestrial conglomerates, sandstones, and mudstones, with minor limestones, evaporites, volcanic tuffs, and intercalated basalts. These rocks are the most extensive units filling the Rio Grande rift, and most production from water wells at Los Alamos is from the Santa Fe Group (Griggs and Hem 1964, 0313; Purtymun 1984, 0196). Sedimentary rocks usually dominate the Santa Fe Group, although basalts constitute up to 45% of the section penetrated by water supply wells at the Laboratory (Purtymun et al. 1984, 0713). In the Española basin and underlying the northern part of Los Alamos County, the Santa Fe Group is subdivided into two formations (Tesuque and Chamita formations) and several members, which reflects the diversity of the coalesced alluvial fans deposited in the Española basin (Galusha and Blick 1971, 0108; Ingersoll et al. 1990, 0533). Early investigators inferred that all Santa Fe Group rocks exposed around the flanks of the Pajarito Plateau and intersected by water wells beneath the plateau belonged to the Tesuque Formation (Griggs and Hem 1964, 0313; Cooper et al. 1965, 0495), although more recent investigations suggest that some of the upper Santa Fe Group in the vicinity of Los Alamos is instead Chamita Formation (Turbeville et al. 1989, 0221).

2.6.1.2.2 Keres Group

Two formations of the Keres Group (Bailey et al. 1969, 0019; Gardner et al. 1986, 0310), may be important in the pre-Bandelier Tuff subsurface in the southern parts of the Laboratory. These are the Paliza Canyon and Cochiti formations, each about 13 million to about 6 or 7 million years old. The St. Peter's Dome area lies about 3 mi from the southern boundary of the Laboratory and was a major center of Keres Group volcanism (Goff et al. 1990, 0557). Large volumes of Paliza Canyon andesite were erupted from the St. Peter's dome center and spread to the east and north. It appears that some of the volcanic units encountered in wells at TA-49 (Weir and Purtymun 1962, 0228) may be Paliza Canyon lavas that have been misidentified as Tschicoma and Cerros del Rio units, as discussed below.

Beneath the southern Pajarito Plateau, sedimentary deposits of the Cochiti Formation compose the Miocene basin fill and are therefore laterally equivalent to the sedimentary rocks of part of the Santa Fe Group and possibly also to those of the Puye Formation (Section 2.6.1.2.4) to the north (Gardner et al. 1986, 0310). The Cochiti Formation consists dominantly of basin fill gravels derived from the volcanic centers of the southern and central Jemez Mountains volcanic field. The transition between the Cochiti, Santa Fe, and Puye formations probably occurs somewhere beneath Los Alamos County, but it is very poorly defined.

2.6.1.2.3 Tschicoma Formation

The Tschicoma Formation consists of a sequence of dacitic domes and lavas that were erupted from vents in the central to northeastern Jemez Mountains between about 7 and 3 million years ago (Gardner et al. 1986, 0310). These volcanic rocks outcrop extensively in the mountains immediately west of the Laboratory and are reported in the subsurface beneath the western and southern part of the Laboratory (Weir and Purtymun 1962, 0228; Griggs and Hem 1964, 0313; Dransfield and Gardner 1985, 0082).

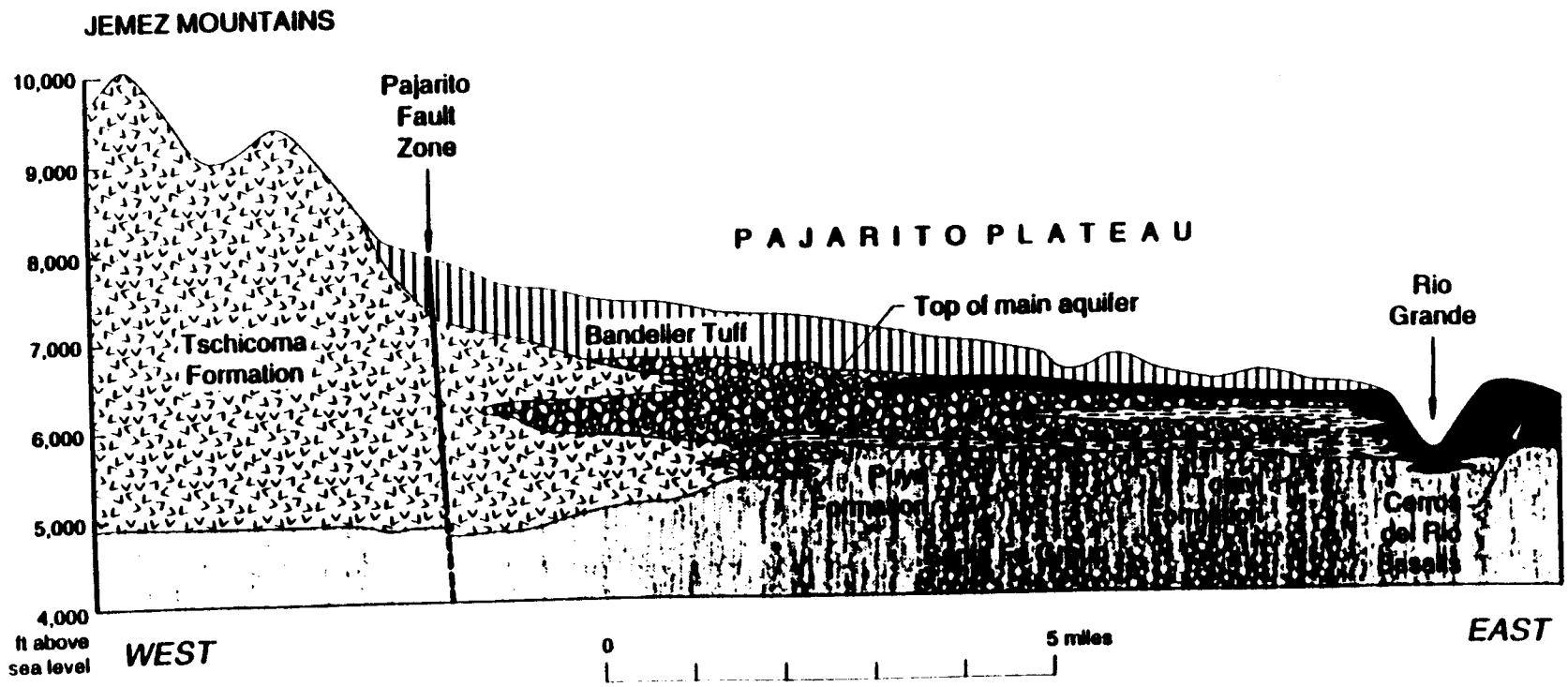

Figure 2-6. C[illegible]eralized geologic section showing stratigraphy and structure from the Sierra de Los Valles across the Pajarito Plateau to the Rio Grande.

2.6.1.2.4 Puye Formation

The Puye Formation consists of a Pliocene-to-Pleistocene fanglomerate that was shed eastward from Tschicoma volcanic centers in the northeastern Jemez volcanic field between about 4 and 1.7 million years ago. Earlier workers (e.g., Griggs and Hem 1964, 0313) included the Totavi Lentil, now considered a separate formation (Section 2.6.1.2.5), as part of the Puye Formation. Most of the Puye conglomerates contain cobbles of dacitic to andesitic composition in a volcanic sand matrix. The beds include stream flow deposits, debris flow deposits, volcanic ash and block flow deposits, and ash fall and pumice fall deposits (Waresback and Turbeville 1990, 0543). The Puye Formation is best exposed north of the Laboratory, but lithologically similar rocks have been penetrated in drill holes as far south as Frijoles Mesa (Weir and Purtymun 1962, 0228; Dransfield and Gardner 1985, 0082). Under parts of the Laboratory, the Puye Formation is interstratified with basalts of the Cerros del Rio volcanic field. In Los Alamos water supply wells, the top of the main aquifer is usually within the Puye Formation.

2.6.1.2.5 Totavi Formation

Immediately beneath the fanglomerates of the Puye Formation, unconformably overlying the Santa Fe Group, is a section of poorly consolidated fluvial gravels, which Griggs originally named the Totavi Lentil of the Puye Formation (Griggs and Hem 1964, 0313). The gravels contain clasts that differ lithologically from those in the Puye, including abundant well-rounded cobbles and boulders of quartzite, granite, and pegmatite that record a source area distant from the Jemez Mountains; this unit probably represents axial channel gravels of an ancestral Rio Grande. Recently, Waresback and Turbeville (1990, 0543) redefined these fluvial gravels as a separate formation, the Totavi Formation, which also includes lacustrine sediments that are complexly interstratified with the upper Puye Formation ("old alluvium" of Griggs and Hem 1964, 0313). In some water supply wells beneath the Laboratory, the Totavi was reported between the Santa Fe and the Puye, occurring at lower elevations in the eastern wells (Cooper et al. 1965, 0495; Purtymun et al. 1983, 0712; Purtymun et al. 1984, 0713). The presence of the Totavi at these levels suggests that Rio Grande River gravels were deposited on erosional surfaces, a setting analogous to Quaternary terraces of the Rio Grande in the Española basin described by Dethier et al. (1988, 0773), before deposition of the Puye fans, which unconformably overlie older formations.

2.6.1.2.6 Cerros del Rio Basalts

Basaltic flows, breccias, and scoria of the Cerros del Rio occur in the subsurface beneath much of the Pajarito Plateau (Dransfield and Gardner 1985, 0082) and outcrop in the east and southeast parts of Los Alamos County (Griggs and Hem, 1964, 0313). These volcanic rocks are associated with the Pliocene-to-Pleistocene Cerros del Rio basalt field, east of the Rio Grande, and rocks from this field have been dated at 4.6 to 2.0 million years old (Gardner et al. 1986, 0310). The youngest lava flows in this area occurred between the two Bandelier Tuff eruptions, 1.5 and 1.13 million years ago ("basaltic andesite of Tank Nineteen" described by Smith et al. 1970, 0776). Part of this volcanic field is also known as basaltic rocks of Chino Mesa (Griggs and Hem 1964, 0313). The top of the main aquifer beneath the Laboratory is locally within this section of basaltic rocks.

2.6.1.2.7 Otowi Member, Bandelier Tuff

The Otowi Member of the Bandelier Tuff underlies the Tshirege Member in the subsurface beneath much of the Pajarito Plateau and outcrops in many of the canyons (Griggs and Hem 1964, 0313). The Otowi Member is mostly a nonwelded ash flow tuff (ignimbrite) that was erupted from the Jemez Mountains 1.5 million years ago (Spell et al. 1990, 0607). It is highly porous and poorly indurated and is composed of multiple flow units. Where it outcrops, cooling joints are typically absent because of relatively low emplacement temperatures and the lack of induration. The Guaje Pumice Bed generally occurs at the base of the Otowi Member and consists of sorted pumice fragments that average 0.8 to 1.6 in. in size (Crowe et al. 1978, 0041).

2.6.1.2.8 Cerro Toledo Rhyolite and Interbedded Sediments

An interbedded sequence of rhyolitic tuffs and sediments commonly occurs between the Otowi and Tshirege members of the Bandelier Tuff. The rhyolitic tuffs were erupted between 1.5 and 1.2 million years ago, predominantly from the Cerro Toledo domes in the northeastern Jemez Mountains (Heiken et al. 1986, 0316). Beneath the Pajarito Plateau, the sediments are epiclastic sands and sandy gravels that lithologically resemble Puye Formation fanglomerates. At the Laboratory, deposits in this interval have sometimes been referred to as "Tsankawi pumice" or "Tsankawi member." These units may play an

important role in the migration of water in the subsurface beneath the Laboratory (Stoker et al. 1991, 0715).

2.6.1.2.9 Tshirege Member, Bandelier Tuff

The most widespread rock unit on the Pajarito Plateau is the Tshirege Member of the Bandelier Tuff (Griggs and Hem 1964, 0313), which was erupted from the Valles caldera in the Jemez Mountains about 1.13 million years ago (Spell et al. 1990, 0607). The Tshirege Member is composed of multiple flow units of crystal-rich ash-flow tuff (ignimbrite) and displays significant variations in welding and alteration, both in a single stratigraphic section and with varying distance from the caldera. Individual units tend to be more welded and thicker to the west. Flow units are locally separated by volcanic surge deposits of well-sorted, fine-grained, cross-bedded crystal and pumice fragments. Vapor phase alteration, caused by postemplacement cooling and migration of entrained magmatic gases, occurs in much of this unit. The base of the Tshirege Member is often marked by 1.5 to 10 ft of bedded, unconsolidated, pumice-rich ash fall tuff of the Tsankawi Pumice Bed (Bailey et al. 1969, 0019; Crowe et al. 1978, 0041). The Tsankawi Pumice Bed is generally poorly recognized in drill bit cuttings because rotary drills commonly grind the soft materials into dust.

The Tshirege Member has been subdivided into a sequence of mappable units based either on erosional characteristics (Weir and Purtymun 1962, 0228; Baltz et al. 1963, 0024; Purtymun and Kennedy 1971, 0200) or on primary cooling units (Crowe et al. 1978, 0041). These units have been correlated over large distances on the Pajarito Plateau. However, the boundaries between the units are not always distinct in the field and can be difficult to recognize in drill holes, causing investigators to place the contacts between units at different locations. Furthermore, in the absence of geologic mapping in the intervening areas, the validity of the correlations is uncertain.

Stratigraphic features in the tuff, such as volcanic surge deposits, may locally provide a preferential migration pathway for moisture and contaminants in the subsurface (Purtymun 1973, 0710; Crowe et al. 1978, 0041). Purtymun (1973, 0710) noted increased rates of vapor phase migration of tritium away from storage shafts at TA-54 along a stratigraphic boundary that includes surge layers. Individual flow units in the Tshirege Member contain vertical cooling joints that may or may not cross flow unit boundaries. In ash flow tuffs, cooling joint spacing varies primarily with the thickness of the unit, emplacement temperature, substrate temperature, and topography. Joint density tends to be greatest in welded tuff and least in nonwelded tuff. Hydraulic conductivities are generally greatest in the fractured, welded parts of ash flow tuffs and least in the nonwelded parts (Crowe et al. 1978, 0041).

2.6.1.2.10 Post-Bandelier Units

Stratigraphically overlying the Bandelier Tuff are discontinuous Quaternary alluvial units that occur as thin deposits (typically less than 15 ft thick) on mesa tops and as deposits in canyons. Alluvial fans consisting mostly of dacite debris are being shed over the Bandelier Tuff at the western boundary of the Laboratory. Well-sorted to poorly sorted sandy and gravelly alluvium occurs in the major drainages of the Pajarito Plateau, ranging up to at least 70 ft thick in some drill holes (Baltz et al. 1963, 0024). Additional, older alluvium occurs on stream terraces on the sides of the canyons, which can be buried by colluvial deposits from the canyon walls. The distribution of alluvial deposits on the mesas has not been mapped, but these deposits are most widespread on the western part of the Pajarito Plateau. Post-Bandelier alluvial units represent a range of ages from 1.1 million years ago to the present. Generally, alluvial units on the surface of the mesas are probably oldest, becoming inactive as drainages were incised into the plateau. Those units lowest in the drainages grade into the active alluvium along canyon bottoms.

The alluvial sediments in the canyon bottoms probably record a complex history of erosion and deposition, in part related to regional climatic changes. In Cabra Canyon, immediately north of Los Alamos, several cycles of erosion and deposition of sediment have occurred over the last 6,000 years, during which most of the previously stored sediment was eroded (Gardner et al. 1990, 0639). Similar cycles of erosion and deposition have been documented in many parts of the southwestern United States, and older alluvial units in the vicinity of Los Alamos may also record the effects of regional climatic changes (Dethier et al. 1988, 0773).

The mesas of the Pajarito Plateau are also covered in part by deposits of the El Cajete pumice, erupted from El Cajete crater in the Jemez Mountains. Deposits of pumice on the mesas have not been mapped, but at the Laboratory they are generally most common to the south, and the axis of the volcanic dispersal

plume is south of Los Alamos County. Available data suggest that the El Cajete pumice is 130,000 to 170,000 years old (Self et al. 1988, 0500).

2.6.1.3 Soils

A large variety of soils have developed on the Pajarito Plateau as the result of interactions of the underlying bedrock, slope, and climate (Nyhan et al. 1978, 0161). The mineral components of the soils are in large part derived from the Bandelier Tuff, but dacitic lavas of the Tschicoma Formation, basalts of the Cerros del Rio volcanic field, and sedimentary rocks of the Puye Formation are locally important. Alluvium derived from the Pajarito Plateau and from the east side of the Jemez Mountains contributes to soils in the canyons and also to those on some of the mesa tops. Layers of pumice derived from El Cajete in the Jemez Mountains and windblown sediment derived from other parts of New Mexico are also significant components of many soils on the Pajarito Plateau.

Soils formed on the tops of mesas on the Pajarito Plateau include the Carjo, Frijoles, Hackroy, Nyjack, Pogna, Prieta, Seaby, and Tocal series. These soils typically have loam or sandy loam surface horizons and clay or clay loam subsurface horizons. Some, including the Frijoles, Hackroy, and Seaby soils, contain abundant pumice. Others including the Prieta Soils, contain abundant wind-deposited sediment. Soils on the Mesas can vary widely in thickness and are typically thinnest near the edges of the mesas, where bedrock is often exposed. Soils formed from alluvial and colluvial deposits include the Potrillo, Puye, and Totavi series and are generally loose and sandy. The slopes between the mesa tops and canyon bottoms often consist of steep rock outcrops and patches of shallow, undeveloped colluvial soils. South-facing canyon walls are steep and usually have little or no soil material or vegetation; in contrast, the north-facing walls generally have areas of very shallow, dark-colored soils and are more heavily vegetated (Nyhan et al. 1978, 0161).

Soil-forming processes extend along fractures in bedrock, and coatings of clay and calcium carbonate on fractures record the transport of water to significant depths in the tuff. For example, at TA-54, Area G, calcium carbonate has been observed as deep as 39 ft and clay coatings as deep as 46 ft below the ground surface (Purtymun et al. 1978, 0207). Roots have also been observed at similar depths among fractures in core holes and pits, suggesting that these soil-forming processes continue at depth today.

2.6.1.4 Geologic Structure

As mentioned earlier, the Laboratory is on the Pajarito Plateau, which lies at the western margin of the Española basin of the Rio Grande rift, a major tectonic feature of the North American continent. The Pajarito fault system forms the western margin of the Española basin and exhibits Holocene movement and historic seismicity (Gardner and House 1987, 0110; Gardner et al. 1990, 0639; Gardner and House, in preparation, 0720). The fault system is made up of over 65 mi of mapped fault traces and connects with regional structures that extend at least as far as Cochiti to the south and Taos to the northeast (Gardner and House 1987, 0110).

Within Los Alamos County, the Pajarito fault system consists of three active, or potentially active, fault segments: the Frijoles Canyon, Rendija Canyon, and Guaje Mountain segments. The Frijoles Canyon fault segment is a zone of faulting over 0.25 mi in width, whose major scarp forms the western boundary of the Laboratory. Near the southwestern corner of the Laboratory, the major scarp of the Frijoles Canyon segment is over 410 ft high in rocks about 1 million years old. Movement on this fault segment is normal-oblique, and the fault's eastern side is relatively downdropped. Where exposed north of Los Alamos Canyon, the Rendija Canyon and Guaje Mountain faults are characterized by zones of gouge and breccia generally 100 to 150 ft wide. Both fault segments produce visible offsets of stratigraphic horizons and are dominantly normal-oblique faults whose west sides are downdropped. There are some indications of strike-slip movements on the Guaje Mountain fault segment (Wachs et al. 1988, 0502; Aldrich and Dethier 1990, 0017; Gardner et al. 1990, 0639). The youngest movements on the Guaje Mountain segment have been constrained to between roughly 4,000 and 6,000 years ago (Gardner et al. 1990, 0639). Displacement on the Guaje Mountain and Rendija Canyon faults apparently decreases south of Los Alamos Canyon, and narrow zones of faulting are replaced by wide (over 300 ft) zones of intense brecciation and fracturing superimposed on the network of cooling joints in the Bandelier Tuff (Vaniman and Wohletz 1990, 0541). In contrast to cooling joints, these tectonic fractures cross flow unit and lithologic unit boundaries; thus, tectonic fractures may provide more continuous and more deeply penetrating flow paths for groundwater migration than do cooling joints.

Dransfield and Gardner (1985, 0082) integrated a variety of data to produce structure contour and paleogeologic maps of the pre-Bandelier Tuff surface beneath the Pajarito Plateau. Their maps reveal

that subsurface rock units are cut by a series of down-to-the-west normal faults; the overlying Bandelier Tuff is not obviously displaced by these buried faults. However, where detailed fracture studies have been done on the plateau, they have shown that fracture abundances and apertures increase in the Bandelier Tuff over fault projections, which indicates the tectonic fracturing mentioned above (Vaniman and Wohletz 1990, 0541). In addition, small-scale offsets along fractures have been observed in various parts of the Laboratory, including Area G at TA-54 (Rogers 1977, 0216), that suggest additional unmapped fault zones. Unfortunately, detailed fracture studies on the Pajarito Plateau are few.

2.6.1.5 Seismicity and Volcanism

The Laboratory lies within a region that possesses a long and rich history of volcanic and tectonic activity that dates from the distant past into the Late Pleistocene and present, respectively. Volcanism began in the Jemez Mountains volcanic field more than 13 million years ago and continued without significant hiatus up through about 130,000 years ago (Gardner et al. 1986, 0310). Reports of questionable reliability describe what were apparently phreatic explosions and possible associated earthquakes within the volcanic field around 100 years ago (Santa Fe *Daily New Mexican* 1882, 0780). Regardless, given the long history of spatially focused, geologically continuous volcanic activity, future volcanism can be expected. Although volcanic activity directly affecting the Laboratory may prove unlikely, sufficient data to quantify the probabilities and nature of future volcanism are lacking.

Direct effects of future seismicity at the Laboratory are likely, although quantification of probabilities is not possible at present. Numerous small earthquakes are recorded in the Los Alamos area and northern New Mexico each year (Sanford 1979, 0540; Cash and Wolff 1984, 0530; Gardner and House 1987, 0110). Since establishment of the Laboratory, several earthquakes of Richter magnitude 3 to 4 have shaken Los Alamos (Gardner and House 1987, 0110). Recent work has shown that three fault segments in Los Alamos County are seismically active and that they are capable of generating large earthquakes of about 7 or more on the Richter scale (Gardner and House 1987, 0110; House and Cash 1988, 0132; Gardner et al. 1990, 0639; Gardner and House, in preparation, 0720). Unknown at this time is how frequently these large earthquakes occur and what their potential is for generating surface rupture and mass wasting (occurrences such as rockfalls and landslides, which are not caused primarily by the movement of water) within the confines of the Laboratory.

2.6.1.6 Geomorphic Processes

Significant geomorphic processes active on the Pajarito Plateau include (1) erosion of mesa top soils by run-off, (2) retreat of canyon walls by rockfall and landsliding, (3) colluvial transport on sloping portions of canyon walls, and (4) erosion and deposition of sediments by streams in the canyon bottoms. Few data exist on the rates of erosion sand landscape change caused by these different processes on the Pajarito Plateau. Estimates of long-term vertical erosion rates on mesa tops have been made based on stripping of overlying units (Purtymun and Kennedy 1971, 0200), but these estimates may be of limited value because the resistant, cliff-forming units may be eroded primarily by lateral cliff retreat rather than by vertical erosion. Erosion rates vary considerably on the mesa tops; the highest rates occur in and near drainage channels and in areas of locally steeper slope gradient, and the lowest rates occur on relatively gently sloping portions of the mesa tops removed from channels. Areas where run-off is concentrated by roads and other development are especially prone to accelerated erosion.

The rates and processes of erosion may differ significantly between the north and south slopes of canyons. Given current vegetation and climate, the more extensive exposures of bedrock on south-facing sides and greater soil cover on north-facing sides suggest that erosion rates of fine-grained material that can be transported by run-off are higher on the drier, less-vegetated, south-facing sides of canyons, although this material is largely retained on the north-facing slopes. However, no studies have been conducted to quantify the rates and processes of erosion on canyon sides.

Cliff faces retreat primarily by dislodgement of blocks bounded by joints and, to a lesser extent, by large-scale landsliding, including the formation of huge toreva blocks in White Rock Canyon. At present, the rates of cliff retreat have not been documented. Neither is it known to what extent cliff retreat rates may vary with climatic changes, with evolution of the canyons, or with proximity to side drainages.

Thicknesses, detailed stratigraphy, and ages of alluvium in canyon bottoms are, in general, poorly known, and therefore the rates of deposition, erosion, and transport of sediments through canyons are largely unknown. Available studies that have examined alluvial stratigraphy on the Pajarito Plateau

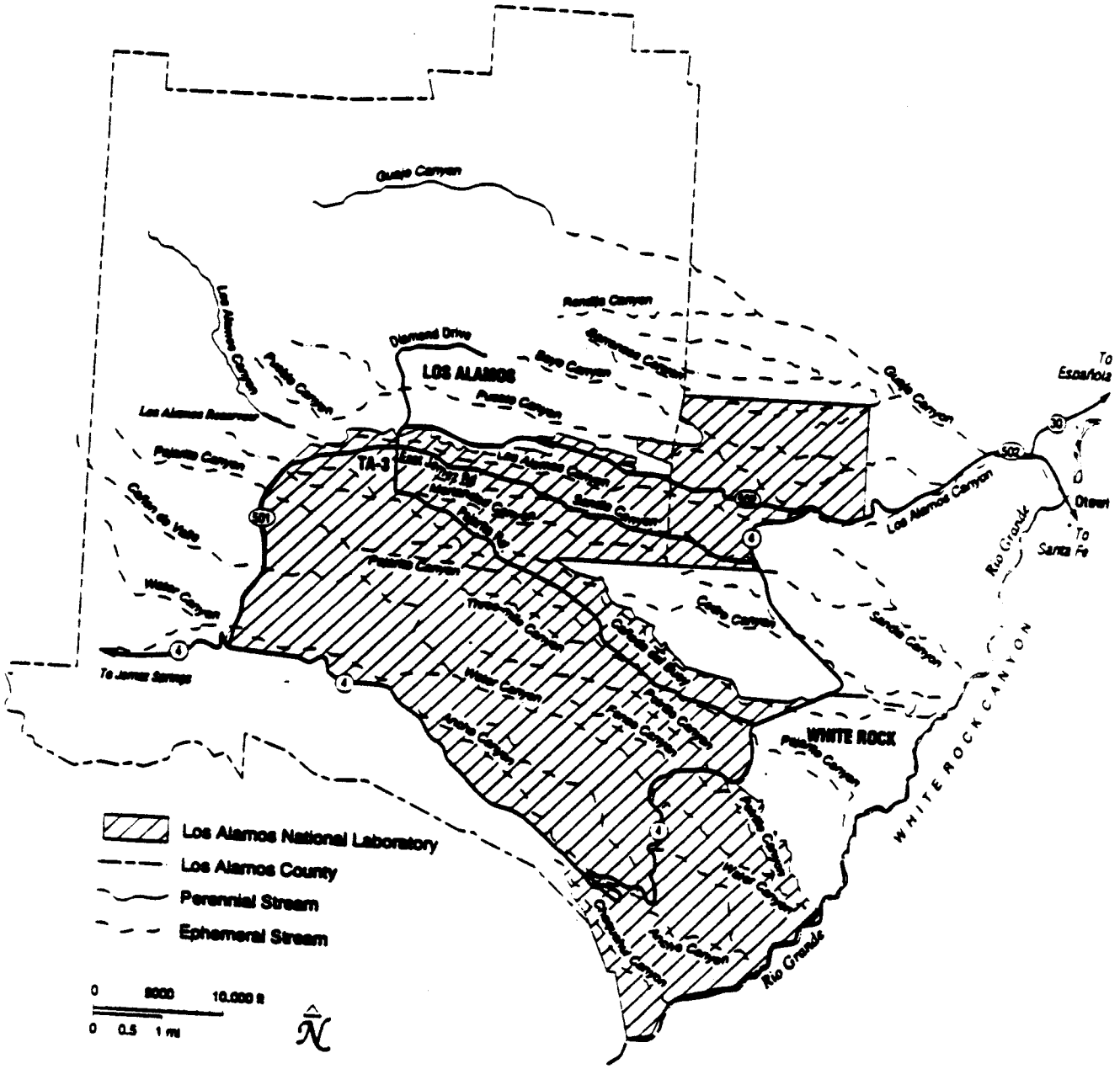

Figure 2-7. Location of the major surface water drainages in the Los Alamos area.

reveal multiple cycles of extensive erosion of sediment, followed by renewed deposition, in the past 6,000 years (Gardner et al. 1990, 0639). At Cabra Canyon, north of Los Alamos, the last few hundred years has been marked by the net accumulation of sediment in the canyon bottom (Gardner et al. 1990, 0639), but it is not known how long this sediment will stay in storage before being mobilized by floods and transported downcanyon. It is possible that these erosional cycles are climatically driven and regional in extent, but more extensive data from additional canyons are needed before this determination can be made. On a longer time scale, evidence from the adjacent Española basin does suggest a strong climatic control on periods of alluviation and canyon incision over the last million years (Dethier et al. 1988, 0773).

2.6.2 Hydrology

2.6.2.1 General Surface Water Conditions

The Rio Grande is the master stream in north-central New Mexico. All surface water drainage and groundwater discharge from the plateau ultimately arrives at the Rio Grande. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 14,300 mi^2 in southern Colorado and northern New Mexico. The discharge for the period of record has ranged from a minimum of 60 cubic feet per second (cfs) in 1902 to 24,400 cfs in 1920. The river transports about 1 million tons of suspended sediments past Otowi annually.

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, sediment retention, recreation, and fishery development. Flood flows are temporarily stored and released at safe rates. The dam is expected to trap at least 90% of the sediments carried by the Rio Grande.

Figure 2-7 shows the location of the major surface water drainages in the Los Alamos area. Los Alamos surface water occurs primarily as ephemeral streams in canyons cut into the Pajarito Plateau. Only four of the canyons contain perennial reaches inside Laboratory boundaries: Pajarito, Water, Ancho, and Chaquehui canyons. Of these four reaches, only Pajarito Canyon occurs upstream (to the west) of any Laboratory facilities or effluent discharge points. Other perennial reaches occur outside Laboratory lands in the drainage areas of Guaje, Los Alamos, Sandia, Pajarito, Water (and its tributary Cañon del Valle), Ancho, and Chaquehui canyons.

Within Laboratory boundaries, perennial reaches in the lower portions of Ancho and Chaquehui canyon are close enough to the Rio Grande that they extend to the Rio Grande without being depleted. In lower Water Canyon, the perennial reach is very short, extends into an intermittent reach that is also short, and does not extend to the Rio Grande. In Pajarito Canyon, about 1 mi east of State Road 501, a spring sometimes called Homestead Spring feeds a perennial reach a few hundred yards long, followed by an intermittent reach that flows varying distances, depending on climate conditions. The lower part of the DP Canyon also contains a short perennial reach sustained by discharge from DP Spring, but at present it is unknown whether the origin of the spring flow is natural or artificial.

Essentially all other reaches of canyons within the Laboratory boundary are ephemeral; that is, they flow naturally only briefly in response to precipitation or snowmelt in the immediate locality. Some other reaches are intermittent, especially those that flow during part of the year as the result of snowmelt. This snowmelt recharges the alluvial perched groundwater, and discharge from the perched systems supports intermittent stream flow for a somewhat longer period.

Springs between elevations 7,900 and 8,900 ft mean sea level on the flanks of the Jemez Mountains supply base flow throughout the year to the upper reaches of Cañon de Valle and in Guaje, Los Alamos, Pajarito, and Water canyons (Purtymun 1975, 0194). These springs discharge water perched in the Bandelier Tuff and Tschicoma Formation at rates from 2 to 135 gal./min (Abeele et al. 1981, 0009). The volume of flow from the springs is insufficient to maintain surface flow within more than the western third of the canyons before it is depleted by evaporation, transpiration, and infiltration into the underlying alluvium.

Eleven drainage areas, with a total area of 82 mi^2, pass through the Laboratory's eastern boundary. Run-off from heavy thunderstorms and heavy snow melt reaches the Rio Grande several times a year in some drainages. Los Alamos, Pajarito, and Water canyons have drainage areas at the east boundary of greater than 10 mi^2, Pueblo Canyon has 8 mi^2, and all the rest have less than 5 mi^2. Theoretical maximum flood peaks range from 25 cfs for a 2-year frequency to 686 cfs for a 50-year frequency (McLin 1992,

0825). The overall flooding risk to community and Laboratory buildings is low because nearly all the structures are located on the mesa tops, from which run-off drains rapidly into the deep canyons. Further discussion at natural surface flow characteristics by drainage may be found in LANL (1993).

Contaminants enter the surface water drainages by surface run-off, by liquid discharges, and occasionally by air deposition (Becker 1985, 0029; 1986, 0027). Run-off-derived contaminants are largely bound to sediments; their rate of down stream travel is governed by the scouring and carrying power of subsequent run-off events (Lane et al. 1985 0140). Given sufficient time, these sediments eventually will be moved across the Laboratory boundary.

Nearly every drainage has received liquid industrial or sanitary effluents discharged from the Laboratory. The effluent discharges determine the flow and water quality characteristics in drainages that contain little natural water. With travel downstream, most of the effluent-derived metals and radionuclides become sediment bound and remain near the surface of the stream channel; other contaminants, such as nitrate, are lost by evaporation or move downward into the alluvium. Detailed field investigations in Mortandad Canyon, for example, demonstrate that generally more than 99% of the total inventory of transuranic radioactivity discharged from the treatment plant effluents are associated with sediments in or immediately adjacent to the stream channel (Stoker et al, 1991, 0715).

In canyons that have received treated, low-level radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad canyons) concentrations of radioactivity in the alluvium are generally highest near the treated. effluent outfall and decrease downstream in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface run-off.

A study of transport of plutonium by snowmelt run-off was published in 1990 (Purtymun et al, 1990, 0215). The conclusions include the finding that most plutonium moved by run-off in Los Alamos and Pueblo canyons that reached the Rio Grande is transported with sediments—about 57% with suspended sediments and 40% with bed sediments. A total of about 600 mCi of plutonium was carried to the Rio Grande by five snowmelt run-off events studied during the year 1975 to 1986.

A regional plutonium analysis for the Rio Grande upstream of Elephant Butte Reservoir shows that fallout contributes about 90 percent of the total Plutonium amoving through the drainage system in any given year (Grat, 1993). The remaining 10 percent in from releases at Los Alamos. The contribution to the Plutonium budget from Los Alamos is associated with relatively coarse sediment that often behaves as bedload in the Rio Grande (Grant, 1993)

Environmental monitoring for chemical and radiochemical quality in surface water began with US Geological Survey investigations (Purtymun 1964, 0183; 1975, 0194; Purtymun and Kunkler 1967, 0202; Purtymun 1967, 0188) and have been continued by the Laboratory (ESG 1970-1990; Environmental Protection Group 1993, 0829).

2.6.2.3. General Groundwater Conditions

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

2.6.2.3.1 Perched Groundwater in Alluvium

Intermittent and ephemera streamflows in the canyons of the Pajarito Plateau have deposited alluvium that ranges in thickness to as much as 100 ft. The alluvium in 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 flank of the mountains. The alluvium in canyons that head on the plateau is comparatively more finely grained, consisting of clays, silts, sands, and gravels derived from the Bandelier Tuff. 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, 0009).

In contrast to the underlying volcanic tuff and sediments, the alluvium is quite permeable. Ephemeral run-off in some canyons infiltrates the alluvium until downward movement is impeded by the less permeable tuff and sediments, which results in a buildup of a shallow alluvial groundwater body. Depletion by evapotranspiration and movement into the underlying rocks limits the horizontal and

vertical extent of the alluvial water (Purtymun et al. 1977, 0206). The limited saturated thickness and extent of the alluvial groundwater preclude its use as a viable source of municipal and industrial supply to the community and the Laboratory. Lateral flow of the alluvial perched groundwaters is in an easterly, down-canyon direction. Tracer studies in Mortandad Canyon have shown that the velocity of water ranges from about 60 ft/day in the upper reach to about 7 ft/day in the lower reach of the canyon (Purtymun 1974, 0192).

The water quality in the alluvial perched groundwaters is variable, depending on the location and history of effluent descharges. In Mortandad Canyon, for example, Plutonium concentrations fluctuate up and down in response to variations in treatment plant effluent and storm run-off water, which cause some dilution of the shallow direct response to the average annual concentration of tritium in the TA-50 effluent with a log time of about 1 yr (Environmental Protection Group 1992, 0740).

Purtymun (1975, 0194; 1973, 0191) has written reviews of alluvial perched groundwaters by drainage area. The results of an extensive monitoring study of the alluvial perched groundwater in Mortandad Canyon are presented by Abrahams et al. (1962, 0231), Baltz et al, (1963, 0024), Purtymun (1973, 0191), Purtymun (1974, 0192), Purtymun et al, (1983, 02209), and Stoker et al, (1991, 0715).

2.6.2.3.2. Perched Water in Volcanic Sediments and Basalts

Perched water bodies occur in the conglomerates and basalts beneath the alluvium in the mid and lower reaches of Pueblo and Los Alamos canyons and in the lower reach of Sandia Canyon. Depth to perched water ranges from about 90 ft in the midreach of Pueblo Canyon to about 450 ft in lower Sandia. The vertical and lateral extent of the perched groundwaters, the nature and extent of perching units, and the potential for migration of perched water to the main aquifer is not fully understood by investigators to date. Only the body in lower Pueblo and Los Alamos canyons has been studied in some detail.

Patterns of chemical quality and water level measurements indicate that the lower perched groundwater in Pueblo Canyon is hydrologically connected to the stream in Pueblo Canyon (Abrahams and Purtymun 1966, 0014). Water from this perched groundwater discharges at the base of the basalt at Basalt Spring, which is off the Laboratory site in lower Los Alamos Canyon on the San Ildefonso Pueblo. The rate of movement of the perched groundwater in this vicinity has been estimateted at about 60ft/day or about 6 mo from recharge to discharge (Abrahams and Purtymun 1966, 0014).

Measurements of tritium in intermediate depth perched groundwater demonstrate that recharge to those depths has occurred during the last several decades. The levels of tritium in those locations are high enough that they are attributable to recharge of surface water contaminated by effluent or other releases from Laboratory operations.

intermediate well, high tritium, difficult to date ~~[illegible]~~ case!

The observations have been made at four locations in Pueblo and Los Alamos Canyons. Tritium has been observed in Test Well 2A in Pueblo Canyon at levels between 2000 and 3000 pCi/L for several years. Starting in 1991, low detection-limit of about 150 pCiL consistently in samples from Test Well 1A, located in lower Pueblo Canyon near its confluence with Los Alamos Canyon, and in Basalt Spring, located in los Alamos Canyon just downstream from its confluence with Pueblo Canyon.

The measurements at these three locations are consistent with previous understanding. The intermediate perched groundwater has long been known to be affected by effluents discharged into Pueblo Canyon, starting with measurements made by the USGS in the 1950s and 1960s (Abrahams, 1961).

The most recent observation of tritium in intermediate depth groundwater was made in Well LADP-3 completed in 1993 by the ER Program in the middle reach of Los Alamos Canyon about 1 mile downgradient from TA-2, the Omega Reactor site (Broxton et al., in preparation. Well LADP-3 encountered perched water at about 320 to 330 feet depth, just at the contact of the Otowi Tuff and the Puye Conglomerate. Samples of water from that well contained about 6000 pCi/l.

Some perched water occurs in volcanics on the flanks of the Jemez Mountains offsite to the west of the Laboratory. This water discharges in several springs (including American and Armistead springs) and provides flow for the gallery in Water Canyon. The gallery contributed to the Los Alamos water supply for 41 years, producing 23 to 96 million gallons annually.

2.6.2.3.3 Main Aquifer

Wells pumping
175 to 1400gpm

The main aquifer of the Los Alamos area is the only aquifer capable of large-scale municipal water supply (Purtymun 1984, 0196). In 1989, water for the Laboratory, the communities of Los Alamos and White Rock, and Bandelier National Monument was supplied from 11 deep wells in three well fields. The wells are located on the Pajarito Plateau and in Los Alamos and Guaje canyons east of the plateau. Municipal and industrial water supply during 1992 was 1.43 billion gallons, with individual well yields ranging from about 175 to 1,400 gpm (Stoker et al, 1992, 0826). Purtymun (1984, 0196) summarizes aquifer hydraulic characteristics as determined during aquifer tests or during periods of production of supply wells and test holes.

The surface of the main aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Conglomerate beneath the central and western part of the plateau. The depths to water below the mesa tops range from about 1,200 ft along the western margin of the plateau to about 600 ft at the eastern margin. The main aquifer is separated from the water in the alluvium and perched water in the volcanics by 350 to 620 ft of tuff and volcanic sediments (Environmental Protection Group 1993, 0829). The main aquifer exhibits artesian conditions in the eastern part along the Rio Grande (Purtymun 1984, 0196). Continuously recorded water level data collected in test wells since the fall of 1992 indicate that, throughout the plateau, the main aquifer responds to barometric and earth tide effects in the manner typical of confined aquifers.

The exact source of recharge to the main aquifer is unknown. Cushman (1965, 0042) suggested three sources of recharge: infiltration of run-off in canyons, underflow from the Valles Caldera through the Tschicoma Formation, and infiltration on mesas. However, a large quantity of hydrologic, structural, and geochemical data indicate that the caldera may not serve as an appreciable source of recharge to the main aquifer (Conover et al, 1963, 0246; Griggs and Hem 1964, 0313; Goff 1991, 1020). Furthermore, natural recharge through undisturbed Bandelier Tuff on the mesa tops is believed to be insignificant (Purtymun and Kennedy 1971, 0200; Kearl et al, 1986, 0135), and few or no data exist to support an evaluation of canyon run-off as a recharge source. It is inferred that major recharge of the main aquifer occurs from the west because the peizometric surface slopes downward to the east. Water level elevations suggest that groundwater flows from the Jemez Mountains east and east southeast toward the Rio Grande, where a part is discharged into the river through seeps and springs (Purtymun et al. 1980, 0208). Springs fed by the main aquifer discharge an estimated 4,300 to 5,000 acre-ft of water annually into White Rock Canyon along an 11-mi reach between Otowi Bridge at State Road 502 and the mouth of Rito de Frijoles (Cushman 1965, 0042).

The hydraulic gradient of the aquifer averages about 60 to 80 ft/mi within the Puye Conglomerate but increases to 80 to 100 ft/mi along the eastern edge of the plateau as the water in the aquifer enters the less permeable sediments of the Santa Fe Group. The rate of movement of water in the upper section of the aquifer varies, depending on the materials in the aquifer. Aquifer tests indicate that the movement ranges from 20 ft/yr in the Tesuque Formation to 345 ft/yr in the more permeable Puye Conglomerate (Purtymun 1984, 0196).

In an effort to better understand the nature of recharge to the main aquifer in the Los Alamos area, a series of isotope and age-dating measurements on selected water samples has been initiated by Laboratory and other DOE researchers. The study is attempting to apply a range of geochemical and geochronological techniques to help identify potential sources and ages of water in the main aquifer. Samples have been collected from the test wells and the water supply wells that penetrate the main aquifer. A variety of radioactive and stable isotope measurements are being utilized. At present a number of carbon - 14 measurements and low-level tritium measurements are available that permit some preliminary estimates of the age of the water in the main aquifer at various location..

"Age of water' means the time elapsed since the water, as precipitation, entered the ground to form recharge and became isolated from the atmosphere. The precipitation at the time of entry into the ground is assumed to have contained atmospheric equilibrium amounts of both tritium and carbon. Radioactive carbon - 14 is mainly from natural sources. Tritium is from both natural and fallout from atmospheric nuclear weapons testing.

Preliminary interpretation of the results off seven carbon - 14 analyses indicate that the minimum age of water in the main aquifer ranges from about a thousand years under the western portion of the Pajarito Plateau, increasing with eastern position, to about 30,000 years near the Rio Grande. These values are consistent with the general understanding of the Los Alamos main aquifer, based on physical and geologic conditions, indicating flow from west to east with major recharge occurring from the west.

Several measurements of tritium by extremely low detection limit analytical methods appear to show the presence of some recent recharge (meaning with the last 4 decades) in main aquifer water samples from 5 wells at certain locations near Los Alamos. Another 30 wells show no apparent influence of recent recharge to the main aquifer. The levels measured range from less than a percent to less than a hundredth of a percent of current drinking water standards, and are all less than levels that could be detected by the EPA - specified analytical methods normally used to determine compliance with drinking water regulations.

The first location is Test Well 1, located in Pueblo Canyon near the confluence with Los Alamos Canyon. Consistent analytical results indicate the tritium contamination does exist at this location, however the pathway mechanisms are not yet understood. This well has been suspected for several years of having a well-bore leakage or other communication from the surface is inferred from other types of data (Abrahams, 1961). One possible route of communication is along the ungrouted, ungrouted cable-tool installed casing. Another possibility is a downward movement through the rock beneath the canyon.

The second location is in Los Alamos Canyon near its confluence with the Rio Grande. An observation well (LA-1A), an old water supply well (LA-2), and a domestic well show the presence of tritium.

The third location is at Test Well 8 in Mortandad Canyon. Test Well 8 is located about a mile downstream of the outfall of the Laboratory's radioactive liquid waste treatment plant at TA-50. The well was sampled at the end of 1993 as part of the environmental surveillance program. The well was completed in 1960 to a depth of 1065 feet. The upper part of the well penetrates shallow alluvial perched groundwater in which contains the residual contaminants discharged by the TA-50 treatment plant. Tritium levels in the alluvial groundwater in the vicinity of Test Well 8 have been about 100,000 pCi/L in the last few years, ranging to as much as 1,000,000 pCi/L in the mid 1970s.

There are at least three possible pathways for the known source of tritium in Mortandad Canyon to be moving toward the main aquifer. There could be migration down the wellbore outside the steel casing as cable tool drilling does not include an annular seal. There could be saturated movement through fractures or faults. There could be movement in unsaturated flow through the vadose zone. Tritium is known to be migrating downward in the unsaturated zone beneath the alluvial perched groundwater in Mortandad Canyon based on measurement or cores collected to a depth of 100-200 feet at locations further west (Stoker et al. 1991).

2.6.2.4 Hydrologic Properties and Conditions of the Bandelier Tuff

At the central portion of the Laboratory, there is in excess of 1,000 ft of unsaturated volcanic tuff, sediments, and basalts of the Bandelier Tuff, the Puye Conglomerate, and the basaltic rocks of Chino Mesa. Numerous investigations focusing on hydrologic characterization of the upper 100 ft of the Bandelier Tuff have been conducted in the Los Alamos area since the 1950s (e.g., Abrahams et al, 1961, 0015; Weir and Purtymun 1962, 0228; Abrahams 1963, 0011; Purtymun and Koopman 1965, 0201; Purtymun and Kennedy 1971, 0200; Purtymun et al. 1978, 0207; Abeele et al. 1981, 0009; Kearl et al, 1986, 0135; Purtymun et al. 1989, 0214; Stoker et al. 1991, 0715). The vadose zone below about 100 ft has not been adequately characterized. (The vadose zone is the zone between the land surface and the main aquifer.

Most of the investigations of hydrogeologic properties of the Bandelier Tuff have been conducted on samples of crushed or disturbed tuff. Hydrologic property tests conducted since the mid-1980s largely have been on undisturbed cores (e.g., Kearl et al. 1986, 0135; Stoker et al. 1991, 0715). To aid the reader in evaluating the variability in hydraulic properties, a summary of hydraulic properties measured in undisturbed cores from the Bandelier Tuff is presented in Table 2-2.

Table 2-2 includes measured values for bulk density, porosity, and saturated hydraulic conductivity. The values for residual saturation, alpha, and N are the parameters for van Genuchten's formulation of the moisture characteristic curve (van Genuchten, 1980):

$$\theta\tilde{\theta} = \frac{\theta - \theta_r}{\theta_s - \theta_r} = \frac{1}{\left[1 + |\alpha h|^N\right]^M}$$

with $\underline{\theta}$ effective saturation,
θ volumetric moisture content,
θ_s saturated moisture content,
θ_r residual moisture content,
h suction
α, N van Genuchten fitting parameters
M = 1-1/N.

2.6.2.4.1 Effects of Physical characteristics

Physical characteristics of the tuff that affect fluid flow result primarily from the degree of welding and jointing. The degree of welding, which varies markedly within and between tuff units, influences the nature and variability of hydrologic characteristics. Welding results in increased density, decreased porosity, and decreased hydraulic conductivity of the rock matrix (Purtymun and Koopman 1965, 0201). However, welded tuffs tend to be more highly fractured (jointed) than nonwelded tuff, and the overall permeability of the welded tuff may be locally enhanced (Crowe et al, 1978, 0041).

2.6.2.4.2 Porosity

Porosity measurements by Abrahams (1963, 0011) range from 20% to 60% by volume, generally decreasing with increasing degree of welding. Measurements reported by IT Corporation (1987, 0327) are higher, from approximately 39% to 74%. A great deal of the high porosity occurs when pumic fragments are incorporated in the tuff. The higher povosities are comparable to those of the upper ranges found in fine clays. Such high porosities, are unusual for indurated materials. Extreme changes in porosity over a short vertical distance have been observed (Abrahams 1963, 0011).

2.6.2.4.3 Moisture Content

A number of hydraulic properties of the Bandelier Tuff vary with changing moisture content. The tuff is only partially saturated throughout the Laboratory, even beneath stream channels containing alluvial perched groundwater systems. The moisture contents of the tuff beneath mesa tops are very low, typically less than 5% by volume (Abrahams 1963, 0011). Abrahams shows that tuff moisture contents are higher beneath disturbed soils than beneath undisturbed soils and, generally, moisture content decreases with depth. At sites with relatively high near-surface moisture contents, the volumetric moisture content decreases rapidly with depth to less than 5% (Abrahams 1963, 0011). Moisture contents of the tuff beneath the canyon bottoms are considerably higher than those beneath the mesas, typically ranging from 20% to 50% by volume (Weir and Purtymun 1962, 0228); Stoker et al. 1991, 0715). Field studies in Mortandad, Sandia, and Potrillo canyons show that moisture content varies greatly with depth, depending on texture (Stoker et al. 1991, 0715; Environmental Protection Group 1993, 0829). Generally, moisture content decreases with depth below stream channels.

2.6.2.4.4. Moisture Characteristic Curves

The relationship between moisture content and soil-water potential had been obtained from more than 60 undisturbed mesa top and canyon bottom cores at (Rogers and Gallaher, in preparation). The data indicate los residual moisture contents (0 to 4%). Purtymun and Stoker (1987, 0204) indicate that at TA-49 specific retention (residual moisture content) ranged from 11% to 27%. Detailed analyses in Mortandad Canyon show that there are significant differences in moisture retention characteristics between and within formational units (Stoker et al. 1991, 0715). Abrahams (1963, 0011) determined the energy relationship with moisture content of a moderately welded tuff. The saturated moisture content of the tuff was about 41% by volume. When moisture contents are below about 4%, there is no movement of water; from about 4% to 8%, moisture is redistributed by diffusion; from about 8% to 23%, distribution is by gravity and capillarity; and above 23%, movement is by drainage from gravity (Abrahams 1963, 0011).

2.6.2.4.5 Hydraulic Conductivity

Hydraulic conductivity is the parameter that describes rate of flow of fluid through a porous medium in response to a hydraulic gradient; it is a function of both the fluid and the medium. Saturated hydraulic conductivities have been measured for tuff many times under laboratory and field conditions, with values

Table 2-2. Summary of Hydraulic Properties Data for Bandelier tuff Obtained Since 1984[1]

	Bulk Density (g/cm^2)	Saturated Moisture Content (%)	Saturation (%)	K_{sat} (cm/sec)	van Genuchten Parameters: Residual Saturation (%)[2]	α	N
			Tshirege Member				
Minimum	0.94	34.6	5.5	$5.6x^{10-6}$	0.0	.0011	1.152
Median	1.18	48.8	39.1	$1.1x^{10-4}$	2.3	.0056	1.696
Harmonic Mean				$5.8x^{10-5}$			
Maximum	1.49	74.2	91.5	$3.9x^{10-3}$	7.9	.2312	2.877
Number of Observations	43	63	34	85	32	32	32
			Tsankawi Pumice				
Miniumum	0.90	36.7	9.6	$4.7x^{10-5}$	0.0	.0005	1.106
Median	1.25	46.0	43.6	$6.8x^{10-4}$	0.23	0.187	1.481
Harmonic Mean				$1.7x^{10-4}$			
Maximum	1.60	65.6	99.4	$4.3x^{10-3}$	7.28	.0513	1.890
Number of Observation	18	12	12	9	9	9	9
			Otowi Member				
Minimum	1.49	59.0	53.3	$7.8x^{10-3}$	12.1	.0185	2.307
Median	1.18	44.0	28.3	$2.7x^{10-4}$	2.5	.0060	1.653
Harmonic Mean				$1.3x^{10-4}$			
Maximum	1.49	59.0	53.3	$7.8x^{10-3}$	12.1	.0185	2.307
Number of Observations	31	25	25	25	21	21	21

[1] Samples represent a compilation by D. Rogers and B. Gallaher (in preparation, xxx) of available hydraulic property determinations on undisturbed core samples taken between 1984 and 1992. Field and laboratory data from USGS work in the 1950s and 1960s and air/water injection tests conducted by Bendix Corporation in the mid-1980s (Kearl et al. 1986, 0135) are not included in the compliation because of concerns relating to the comparability of different measurement techniques.

[2] Most cores with $\theta_r > 10$ are omitted due to absence of thermocouple psychrometer measurements at high matric suctions.

ranging from 5.6 x 10-6 to 2.3 x 10-2 cm/s (0.054 to 6.5 ft/day), comparable to those of silty sand. In general, nonwelded tuff has greater saturated conductivity than welded tuff, and horizontal conductivities are greater than vertical conductivityies (Abrahams 1963, 0011). Unsaturated hydraulic conductivities may be many orders of magnitude lower, typically ranging from 10-6 to 10-11 cm/s (Stoker et al 1991, 0715; Rogers and Gallaher, in preparation), depending on in-situ moisture contents.

2.6.2.4.6 Joints

Joints formed by cooling of the ash flows or by later faulting typically divide the tuff into irregular blocks. The major joint sets are vertical or nearly vertical, with dips greater than 70°, and joint frequency increases with the degree of welding and approximately to faults (Vaniman and Vohlet, 1990). Joints and fractures in moderately welded tuffs generally terminate in nonwelded tuffs (Baltz et al. 1963, 0024). The joints are often vertically limited to a single ash flow or ash fall unit (Purtymun and Kennedy 1971, 0200). Joint apertures range from closed to open as much as 15 centimeters (Wohlet in preparation). The joints are commonly filled with caliche near the surface, grading downward to clay, and may be open to depths greater than 30 ft (Purtymun et al. 1978, 0207; Abeele et al. 1981, 0009). Examination of cores obtained from horizontal drilling beneath a water disposal site at TA-54 showed that about 80% of the joints were filled or plated with clay or secondary mineralization (Purtymun et al. 1978, 0207). Fracture opertures at TA-54 are typically small, with median values of about 3 mm; median fracture spacing is 1.9 to 4.0 feet (Reneav and Vaniman, in preparation). Reneau and Vaniman (in preparation) note the general absence of clay illuviation in any fractures to depths greater than 10 to 20 feet within an excauated pit at TA-54.

2.6.2.5 Movement of Moisture in the Bandelier Tuff

The movement of moisture in the Bandelier Tuff is governed by a complex interaction of many factors. Climatic and site-specific land use factors control the supply of moisture available for infiltration, and hydrogeological characteristics control the redistribution of moisture in the tuff.

Perhaps the most significant aspect of the tuff is its ability to imbibe water, ie, act as a sponge. Most of the pore spaces in the tuff are of capillary size and have a strong tendency to hold water against gravity by surface tension forces. Thus, a slug of water entering dry tuff is slowed or retained by capillary tension forces.

Water moves through the tuff in two ways: (1) by liquid and vapor movement through the pores of the tuff and (2) by movement through open, interconnected joints (Abrahams, 1963, 0011). When moisture content is low, movement in the vapor (gaseous) phase becomes more preponderant, and liquid movement through the rock matrix is extremely slow. Water entering open, interconnected joints might move rapidly downward through the joints; however, to maintain continuous flow through the fractures, it is likely that large volumes and a continuous supply of water are necessary because of the sponge effect of the adjacent tuff that forms the wall of the fracture. The existence of a low-permeability coating on the wall of the fracture, on the other hand, could increase the travel depth of water flowing through fractures (Thoma et al. 1992, 0826\7). If the joints are not continuous through contacts between subunits of the tuff, the water might be perched above the contact and would tend to move laterally, potentially to the walls of canyons.

These factors are discussed as they pertain to subsurface contaminant transport beneath the mesa tope and canyon bottoms.

2.6.2.5.1 Migration of Moisture Beneath Mesa Tops

The natural moisture content of the tuff forming the mesas between the canyons is generally less than 5% by volume at depths greater than a few tens of feet, the zone affected by seasonal inputs of moisture and evapotranspiration. Weir and Purtymun (1962, 0228) attributed the low moisture content to the protective cap of clay soil derived by weathering of the tuff near the surface, low rainfall, and high evapotranspiration. The existence of low moisture content is further supported historically by the absence of weathering below 10 m (Wheeler et al, 1977, 0828) and overall absence of perched water in the tuff at potential perching horizons.

Kearl et al. (1986, 0135) concluded that vapor phase transport is the predominant transport mechanism controlling the potential subsurface movement of contaminants beneath the mesa top at TA-54. They also conclude that there is no interconnection or movement of liquid water in the interval of Bandelier Tuff examined (upper 100 ft of Tshirege Member). Other laboratory analyses on cores of moderately welded tuff support the possibility of vapor phase dominance at most mesa top locations (Abrahams 1963, 0011).

> They did the all on cores. What about fractures?

From a waste containment perspective, the possibility of vapor phase dominance is significant; in extremely dry rock, only contaminants existing in a gaseous state, such as tritium or volatile organic solvents, migrate through the rock matrix. Other radionuclides and metals can be removed from their

Assuming const climate, etc

original location only under wetter conditions, when the uninterrupted movement of liquid water (i.e., capillarity) is more predominant.

recharge?

Few definitive field measurement techniques exist by which to quantify natural through mesa tops. One exception is the use of natural tracer profiles to infer recharge rates by comparison with analytical solute transport solutions. As an alternative, the flux of liquid water through the rock matrix that could eventually become recharge can be estimated as being approximately equal to the unsaturated hydraulic conductivity, inplicitity assuming that flow is downward and at steady state.

In-situ hydraulic conductivities for tuff beneath the mesa top Material Disposal Area L at TA-54 were computed by Rogers and Gallager (in preparation) from laboratory analyses of 5 undisturbed Bandelier Tuff cores obtained from 3 separate coreholes. Computed in-situ unsaturated hydraulic conductivities (i.e. fluxes) range from 3.0 x 10-12 to 1.5 x 10-8 cm/sec (3.7 x 10-5 to 1.9 x 10-1 ft/yr). For uniform flow through media with spatially varying hydraulic conductivity, the average hydraulic conductivity lies

The greatest concern about subsurface migration at mesa tops is the potential for a large volume of contaminants to be chronically released in the vicinity of open and interconnected joints, which could occur beneath a surface impoundment or a leaky chemical storage tank. The movement of water through joints would negate the protection provided to the groundwater when water moves only through pores in the tuff (Abrahams 1963, 0011).

Filled fractures strongly inhibit moisture movement. Open fractures are effective barriers to liquid phase unsaturated flow but may provide preferential flow paths for vapor transport or rapid movement of liquid under saturated or near-saturated conditions(Abeele et al. 1981, 0009). Roots have been found in joints to depths of at least 42 ft (Weir and Purtymun 1962, 0228), which suggests that joints may be important local infiltration pathways. Several fracture zones at TA-54 show an increase in moisture content relative to adjacent porous media (Kearl et al. 1986, 0135).

'Wicked' effect only works up to a point. pores become sat and flow continues

Although fractures have a local effect on infiltration in the upper portions of the mesas, it is less clear to what depth they play a role, for three key reasons. First, water passing through a fracture system has a tendency to be "wicked" into the adjacent rock matrix by capillary suction forces in the tuff, provided the fracture/rock interface is not sealed with material of low permeability (Thoma et al. 1992, 0827). Analytical and numerical modeling of TA-54 indicate that transient infiltration pulses in fractures likely affect only the very near surface before being imbibed into the adjacent tuff (Rosenberg et al. 1993). Second, most of the open fractures occur in the moderately welded to welded Tshirege Member of the Bandelier Tuff, and the underlying nonwelded Otowi Member is significantly less fractured (Baltz et al. 1963, 0024). Flow in the lower portions of the Bandelier Tuff, therefore, is far more likely to be dominated by the relatively slow process of capillarity.

Finally, although fractures may initially provide a pathway for movement of water into the mesas, they may later play a role in removing water (as water vapor) from within the mesa. Under low barometric pressure conditions, air transfers from the tuff to the atmosphere through boreholes (Purtymun et al. 1974, 0651). Barometric and air pressure variations along the canyon walls could cause the exchange of gas and water vapor between the atmosphere and the mesas, especially via interconnected fractures and joints, which are highly permeable to air. Air transfer has been documented in boreholes penetrating the tuff at TA-49 (Purtymun et al. 1974, 0651) and has been observed elsewhere on the plateau; however, studies at TA-54 have been inconclusive (Abeele et al, 1981, 0009); Kearl et al. 1986, 0135).

In conclusion, the combination of the Bandelier Tuff's low moisture content beneath the mesa tops, its associated hydraulic characteristics, and its thickness provides the main aquifer a substantial degree of protection from the mesa tops. At suspected waste sites at which contaminated liquids have not been disposed, the risks to the main aquifer are quite low. Detailed characterization of the subsurface probably is not warranted for most such sites. Site-specific conditions must always be considered, however, before making such a determination. At waste sites with large potential contaminant source terms, such as material disposal areas, phased subsurface investigations should be conducted to verity that the waste is sufficiently contained.

Waste disposal activities that chronically released large volumes and highly contaminated liquids or that contain volatile contaminants have the potential for migration within the mesas and should also be investigated for subsurface transport. Open fractures may be a key factor in determining whether contaminants migrate to deeper sections of the tuff or travel laterally to release areas on the mesa walls. All of these subsurface investigations should initially focus on the upper 100 to 200 ft of the vadose zone.

2.6.2.5.2 Migration of Moisture Beneath Canyon Bottoms

The canyons with alluvial perched groundwaters are presumed to present a greater potential for downward movement than do the mesa tops because there is a constant driving force and because the moisture content of the tuff below the saturated alluvium is significantly higher than that beneath the mesas. Additionally, the depth to the main aquifer in the canyons is several hundred feet less than from the adjacent mesa tops. The effect of this greater potential for fluid flow, through, is somewhat compensated by the general lack of highly concentrated contaminant sources in the canyon bottoms.

Recent investigations provide some important information on the movement of moisture and contaminants in the unsaturated tuff. The best field evidence that can be used to estimate potential downward rates of movement beneath canyon bottoms is obtained from corehole data collected by Stoker et al. (1991, 0715) in Mortandad Canyon. Because treated liquid radioactive effluents have been discharged to the canyon for almost 30 years, the radioactive constituents in effluent from the Laboratory serve as accurate tracers for fluid and contaminant migration studies.

The basic conclusions of the Mortandad study regarding the movement of radioactive contaminants below the alluvial perched groundwater are (1) soluble and particulate radioactive constituents have moved less than about 10 ft into the unsaturated zone beneath the alluvial perched groundwater; and (2) tritium, as tritiated water, has moved at least 150 ft below the alluvial perched groundwater to a total depth of 195 ft. Tritium concentrations in Corehole MCM-5.9 (the deepest corehole drilled so far in the canyon) decrease by a factor of about 100 between 150 and 195 ft, suggesting the possibility that tritium has not moved much deeper in the almost 30 years since effluents were first released from the TA-50 treatment plant (Stoker et al. 1991, 0715). The tritium data suggest a downward rate of movement of at least 6 ft/yr. However, this conclusion must be considered tentative until additional, deeper coreholes can confirm the pattern.

Recent drilling of characterization well LADP-3 in Los Alamos Canyon has shown that Laboratory-derived tritium has migrated to depths of at least 300 feet beneath the canyon bottom (Broxton et al., in preparation). Because the history of tritium releases to the canyon are uncertain, it is diffiuclt to calculate a downward rate of contaminant movement at this location.

Stoker et al. (1991, 0715) evaluated the moisture content in tuff beneath the alluvial perched groundwater in Mortandad Canyon. Most values for gravimetric moisture content in the Tshirege tuff beneath the alluvial perched groundwater ranged from 10% to 30%, corresponding to about 20% to 60% of saturation. Several peaks occurred at higher values, approaching 90% of saturation near the contact with or in the Tsankawi tuff and fluvial Cerro Toledo rhyolite deposits on the top of the Otowi member of the tuff at depths around 100 ft. In the Otowi tuff, the gravimetric moisture content decreased and leveled off at about 12% to 18%, which corresponds to 20% to 40% saturation. A similar pattern occurred in a corehole farther downstream in Mortandad Canyon past the end of the alluvial perched groundwater (Stoker et al. 1991, 0715) and also in Sandia and Potrillo canyons (Environmental Protection Group 1993, 0829).

Tuff beneath Mortandad canyon appears nearly saturate

The data suggest that there are complex variations in hydrologic properties in the layers from the base of the Tshirege through to the top of the Otowi tuff that significantly affect the movement of moisture in the unsaturated zone. There is also a suggestion that moisture conditions in the Otowi tuff become very uniform with only moderate differences in magnitude, depending on whether there are saturated conditions in overlying layers (Environmental Protection Group 1993, 0829). Additional field data and theoretical interpretation are required to confirm the patterns and quantify movement.

In contrast to those canyons with alluvial perched groundwater, rates of downward water movement beneath dry canyon bottoms are much slower, in some cases comparable to those estimated for mesa tops. For example, analysis of laboratory hydrologic data for undisturbed cores form Cañada del Buey indicates rates of movement between 0.2 and 0.003 ft/yr (Rogers and Gallaher, in preparation).

In summary, available data indicate that downward rates of contaminant movement beneath saturated canyon bottoms are at least an order of magnitude greater than those estimated for mesa tops. Drilling has confirmed that Laboratory-derived contaminants has percolated downward through Bandelier Tuff to depths exceeding 300 feet. The detection of tritium in main aquifer water samples from 5 wells raises the possibility of even deper percolation of contaminants in canyon bottoms. The downward movement beneath dry canyon bottoms is expected to be much less. However, because of the wide range of

percolation rates possible in canyon settings, wite-specific data must be collected to evaluate the significance of the groundwater pathway.

2.6.3 Special Studies

Two ongoing studies are of particular relevance to the ER Program; cover and stabilization pilot studies and geochemical studies of soils and Bandelier Tuff. The details of these studies are provide in Appendices C and D, respectively.

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APPENDIX C

Description of Technical Areas

Appendix C. Descriptions of Technical Areas

TA-2, Omega Site — The Omega West Reactor, an 8-MW nuclear research reactor, is located at TA-2. The reactor provides neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site — The main technical area of the Laboratory, TA-3 includes the Administration Building in which the Director's office and other administrative offices and laboratories for several divisions are located. Other buildings house the central computing facility, administrative offices, materials division, science museum, chemistry and materials science laboratories, physics laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, and the main cafeteria.

TA-6, Two-Mile Mesa South Site — Two-Mile Mesa Site is one of three sites (TA-22 and TA-40 are the other two) used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research conducted at this site includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-8, GT Site (or Anchor Site West) — Nondestructive testing is conducted at this site for the entire laboratory. The test facilities maintain capability in all modern nondestructive testing techniques to ensure the quality of material ranging from test weapons components to high-pressure dies and molds. The principal activities involve radiographic techniques (using x-ray machines to 1,000,000 V and a 24-MeV betatron), radioactive isotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East — At this site, the physical properties and feasibility of fabricating explosives are explored, and new organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site — The facilities at this site test explosive components and systems under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled andobserved remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site — This firing site is used for running various tests on relatively small explosive charges and for determining the impact of fragments.

TA-15, R Site — This site is the home of PHERMEX, a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for certain weapons development problems and tests. The site is also used for investigating how weapons function and systems behave in nonnuclear tests, principally by electronic recording means.

TA-16, S Site — The facilities at this site house the development, engineering design, pilot production, and environmental testing of nuclear weapons warhead systems. Other functions include stockpile production liaison; development and testing of high explosives, plastics, and adhesives; and research on process development for manufacture of items using these and other materials.

TA-18, Pajarito Laboratory Site — The fundamental behavior of nuclear chain reactions with simple low-power reactors called critical assemblies is studied here in buildings known as kivas. Experiments are operated by remote control and are observed by closed-circuit television. The reactors are used primarily to provide a controlled means of assembling a critical amount of fissionable materials to study the effects of various shapes, sizes, and configurations. The machines are also used to produce large quantities of fission neutrons for experimental purposes.

TA-21, DP Site — This site has two primary research areas: DP-West, a chemistry research facility, and DP-East, a research site for high-temperature chemistry and tritium.

TA-22, TD Site — See TA-6.

TA-28, Magazine Area A — The Laboratory uses this site as one of two storage areas for explosives.

TA-33, HP Site — A major high-pressure tritium-handling facility is located at HP Site. Laboratory and office space for the Geosciences Division's hot dry rock geothermal project is also located at this site.

TA-35, Ten Site — Nuclear safeguards research and development conducted here are concerned with nondestructive techniques for detecting, identifying, and analyzing fissionable isotopes. Research in reactor safety and laser fusion also occurs at this site.

TA-36, Kappa Site — Various explosive phenomena, such as detonation velocity, are investigated at Kappa Site.

TA-37, Magazine Area C — See TA-28.

TA-39, Ancho Canyon Site — Nonnuclear weapons behavior is studied here, primarily by photographic techniques. Various phenomenological aspects of explosives, interactions of explosives, and explosions involving other materials are also investigated at this site.

TA-40, DF Site — See TA-6.

TA-41, W Site — Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory — The Biomedical Research Group does research here in cellular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library, special counters used to measure radioactivity in humans and animals, and quarters for dogs, mice, and monkeys are also located in this building.

TA-46, WA Site — Applications for photochemistry, which include development of technology for laser isotope separation and laser enhancement of chemical processes, are investigated here. Solar energy research, particularly in the area of passive solar heating for residences, also occurs at this site.

TA-48, Radiochemistry Site — Using analytical and physical chemistry, scientists and technicians at this site study the nuclear properties of radioactive materials. Radioactive substances are measured in hot cells, which permit remote handling of radioactive materials.

TA-49, Frijoles Mesa — Frijoles Mesa has been used primarily as the site of underground hydronuclear experiments, conducted in 1960 and 1961, and as a buffer zone for nearby firing sites. The site is currently used for high-power microwave research and for training the Laboratory's hazardous devices team.

TA-50, Waste Management Site — Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for developing improved methods of solid waste treatment, and for containing the radioactive materials removed by treatment. Radioactive liquid waste from most technical areas is piped to this site for treatment.

TA-51, Environmental Research Site — Experiments conducted at this facility explore waste cover and stabilization alternatives, land reclamation, contaminant movement, and ecology.

TA-52, Reactor Development Site — A wide variety of activities related to nuclear reactor performance and safety is conducted at this site.

TA-53, Meson Physics Facility — The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, cancer treatment, materials studies, and isotope production. The Los Alamos Neutron Scattering Center and the proton storage ring are also located on this site.

TA-54, Waste Disposal Site — Solid radioactive and toxic wastes that meet regulatory acceptance criteria are disposed at this site.

TA-55, Plutonium-Processing Facilities — These facilities process plutonium and house research in plutonium metallurgy.

TA-57, Fenton Hill Site — The Laboratory's hot dry rock geothermal project is located at Fenton Hill, where scientists are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. After the water is heated, it is brought to the surface to drive electric generators.

TA-59, Environment, Safety, and Health Site — Occupational health and environmental science activities are conducted at this site.

TA-60, East Jemez Road — This area contains physical support facilities for the Laboratory, including the existing landfill.

TA-63, Pajarito Road Service Site — This area contains physical support facilities operated by World Services, Inc.

TA-74, Los Alamos Airport — This area contains the DOE-owned airport that serves the Laboratory.

APPENDIX D

List of Potential Release Sites

Potential Release Sites at Los Alamos National Laboratory

CODES AND ABBREVIATIONS USED FOR PRS DATA BASE

PRS Class Codes

HSWA	Listed in HSWA Module (one of the 605 SWMUs in the 1990 RCRA permit).
HSWA PM	Unit added in the permit modification proposed in February 1993.
RCRA	Unit regulated by RCRA; does not appear in 1990 HSWA Module.
RCRA PM	Unit regulated by RCRA; appears in 1990 HSWA Module but is one of 38 SWMUs deleted from the module by the permit modification proposed in March 1993.
AOC/PRS	Unit may not be a SWMU as defined by RCRA, but ER Program is investigating.

Abbreviations of Potential Contaminants

RAD	Possible radioactive waste.
HE	Possible high explosives.
HAZ CONST	Possible volatile organic compounds, semivolatile organic compounds, metals, etc.
OTHER	Non-RCRA constituents (e.g., asbestos, PCBs)

Codes for Potential Remedial Action

CARBC	Clean to acceptable risk-based criteria
ISIC	In-place stabilization; institutional controls
rec NFA	Recommended in RFI work plan for no further action
NFA	Likely that no further action will be recommended after site characterization.

CODES AND ABBREVIATIONS USED FOR PRS DATA BASE

PRS Class Codes

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ISIC	In-place stabilization; institutional controls
rec NFA	Recommended in RFI work plan for no further action
NFA	Likely that no further action will be recommended after site characterization.

22 for TA 0
16 for 73

PRS Data for Operable Unit 1071

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
0-003	0-003	0-003	0	HSWA	Container storage	Decommissioned	0		NFA
0-004	0-004	0-004	0	RCRA	Container storage	Active	0		NFA
0-005	0-005	0-005	0	HSWA	Landfill	Inactive	0		Rec NFA
0-007	73-001(a)	73-001(a)	73	007HSWA	Landfill	Inactive	1070	Rad, haz. const., HE, other	IS,IC
0-007	73-001(b)	73-001(b)	73	HSWA PM	Surface disposal site	Inactive	0	Hazardous const., other	CARBC
0-008	0-008	0-008	0	AOC/PRS	Surface disposal site	Inactive	0		Rec NFA
0-010	73-005	73-005	73	HSWA PM	Surface disposal site	Inactive	0		NFA
	0-010(a)	0-010(a)	0	AOC/PRS	Surface disposal site	Decommissioned	0		Rec NFA
		0-010(b)	0	AOC/PRS	Surface disposal site	Inactive	0		NFA
0-011(a)	0-011(a)	0-011(a)	0	HSWA PM	Mortar impact area	Inactive	0		NFA
0-011(b)	0-011(b)*								
0-011(c)	0-011(c)	0-011(c)	0	HSWA PM	Mortar impact area	Inactive	0		NFA
0-011(d)	0-011(d)	0-011(d)	0	HSWA PM	Mortar impact area	Inactive	0		NFA
0-011(e)	0-011(e)	0-011(e)	0	HSWA PM	Mortar impact area	Inactive	0		NFA
0-012	0-012	0-012	0	HSWA	Underground tank	Decommissioned	0		NFA
0-014	73-002	73-002	73	0-014HSWA	Incinerator & surface disposal	Inactive	800	Hazardous const.	CARBC
0-015(b)	0-015	0-015	0	AOC/PRS	Firing range	Active	0		Rec NFA
0-016	0-016	0-016	0	HSWA PM	Firing range	Inactive	100	Hazardous const.	CARBC
0-017	0-017	0-017	0	HSWA	Waste lines	Inactive	283	Rad, hazardous const.	CARBC
0-018(a)	deleted in 90 because it never received Lab waste								
0-018(b)	0-018(a)	0-018(a)	0	AOC/PRS	Wastewater treatment plant	Inactive	2800	Rad, hazardous const.	CARBC
0-018(c)	0-018(b)	0-018(b)	0	AOC/PRS	Wastewater treatment plant	Active	0		NFA
0-019	0-019	0-019	0	HSWA PM	Wastewater treatment plant	Decommissioned	0		NFA
0-020	73-003	73-003	73	AOC/PRS	Operational facility	Decommissioned	0		NFA
0-021(a)	73-004(a)	73-004(a)	73	HSWA PM	Septic tank	Inactive	0		NFA
0-021(b)	73-004(b)	73-004(b)	73	HSWA PM	Septic tank	Inactive	0		NFA
	0-024	0-024	0	AOC/PRS	Cistern	Inactive	0		NFA
	0-025	0-025	0	AOC/PRS	Landfill	Inactive	0		Rec NFA
	0-026	0-026	0	AOC/PRS	Landfill	Inactive	0		Rec NFA

*RFI states 0-011(b) & (e) are the same, therefore 0-011(b) was eliminated.

PRS . . . for
Operable Unit 1071

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
		0-035(a)	0	AOC/PRS	Surface disposal	Inactive	0		Rec NFA
	C-0-020	C-0-020	0	AOC/PRS	Mortar impact area	Inactive	0		NFA
19-001	19-001	19-001	19	HSWA	Septic system	Inactive	300	Hazardous const.	CARBC
19-002	19-002	19-002	19	HSWA PM	Surface disposal site	Inactive	74	Hazardous const.	CARBC
	19-003	19-003	19	HSWA PM	Septic tank	Inactive	0		NFA
	C-19-001	C-19-001	19	AOC/PRS	Soil contamination	Removed	0		NFA
26-001	26-001	26-001	26	HSWA PM	Surface disposal site	Inactive	111	Rad, hazardous const.	CARBC
26-002	26-002(a)	26-002(a)	26	HSWA PM	Tank and/or assoc. equip.	Decommissioned	50	Rad, hazardous const.	CARBC
	26-002(b)	26-002(b)	26	HSWA PM	Ind. or san. waste water treat.	Decommissioned	50	Rad, hazardous const.	CARBC
26-003	26-003	26-003	26	HSWA PM	Septic tank	Decommissioned	100	Rad, hazardous const.	CARBC
	73-001(c)	73-001(c)	73	HSWA PM	Landfill	Inactive	0	Hazardous const., HE	IS,IC
	73-001(d)	73-001(d)	73	HSWA PM	Landfill	Inactive	0	Hazardous const.	IS;IC
	73-004(c)	73-004(c)	73	HSWA PM	Septic tank	Inactive	0		NFA
	73-004(d)	73-004(d)	73	HSWA PM	Septic tank	Inactive	0		NFA
	73-006	73-006	73	HSWA PM	Ind. or san. waste water treat.	Inactive	0		NFA
	C-73-001	C-73-001	73	AOC/PRS	Underground tank	Decommissioned	0		Rec NFA
	C-73-002	C-73-002	73	AOC/PRS	Underground tank	Decommissioned	0		Rec NFA
	C-73-003	C-73-003	73	AOC/PRS	Underground tank	Decommissioned	0		Rec NFA
	C-73-004	C-73-004	73	AOC/PRS	Underground tank	Decommissioned	0		Rec NFA

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PRS Data for
Operable Unit 1078

988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
-004(a)	1-004(a)	1-004(a)	1	AOC/PRS	Incinerator	Decommissioned	0		Rec NFA
-004(b)	1-004(b)	1-004(b)	1	AOC/PRS	Incinerator	Decommissioned	0		Rec NFA
-005	1-005	1-005	1	AOC/PRS	Incinerator	Decommissioned	0		Rec NFA
	1-006(a)	1-006(a)	1	AOC/PRS	Drain lines & outfall	Inactive	0		NFA
	1-006(a)	1-006(b)	1	HSWA PM	Drain lines & outfall	Inactive	10	Rad, hazardous const.	CARBC
	1-006(a)	1-006(c)	1	HSWA PM	Drain lines and outfall	Inactive	10	Rad, hazardous const.	CARBC
	1-006(a)	1-006(d)	1	HSWA PM	Drain lines and outfall	Inactive	10	Rad, hazardous const.	CARBC
	1-006(a)	1-006(e)	1	AOC/PRS	Drain lines and outfall	Inactive	0		NFA
	1-006(b)	1-006(f)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(g)	1	AOC/PRS	Drain lines and outfall	Inactive	0		NFA
	1-006(b)	1-006(h)	1	HSWA PM	Drain lines and outfall	Inactive	10	Rad, hazardous const.	CARBC
	1-006(b)	1-006(i)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(j)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(k)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(l)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(m)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(n)	1	HSWA PM	Drain lines and outfall	Inactive	5	Rad, hazardous const.	CARBC
	1-006(b)	1-006(o)	1	HSWA PM	Drain lines and outfall	Inactive	5	Rad, hazardous const.	CARBC
	1-006(b)	1-006(p)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(q)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(r)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(s)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-006(b)	1-006(t)	1	AOC/PRS	Drain lines and outfall	Inactive	0		Rec NFA
	1-007(a)	1-007(a)	1	HSWA PM	Soil contamination area	Decommissioned	50	Rad, hazardous const.	CARBC
	1-007(a)	1-007(b)	1	HSWA PM	Soil contamination area	Decommissioned	50	Rad, hazardous const.	CARBC
	1-007(a)	1-007(c)	1	HSWA PM	Soil contamination area	Decommissioned	50	Rad, hazardous const.	CARBC
	1-007(b)	1-007(d)	1	HSWA PM	Soil contamination area	Decommissioned	5	Rad, hazardous const.	CARBC
	1-007(b)	1-007(e)	1	HSWA PM	Soil contamination area	Decommissioned	5	Rad, hazardous const.	CARBC
	1-007(b)	1-007(f)	1	AOC/PRS	Soil contamination area	Decommissioned	0		Rec NFA

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PRS Data
Operable Unit 1082

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
11-001(a)	11-001(a)	11-001(a)	11	HSWA	Firing site	Inactive	0		NFA
11-001(b)	11-001(b)	11-001(b)	11	HSWA	Firing site	Inactive	0		NFA
11-001(c)	11-001(c)	11-001(c)	11	HSWA	Firing site	Inactive	0		NFA
11-002	11-002	11-002	11	HSWA	Burn site	Active	0		NFA
11-003(a)	11-003(a)	11-003(a)	11	AOC/PRS	Mortar impact area	Inactive	0		NFA
11-003(b)	11-003(b)	11-003(b)	11	AOC/PRS	Firing range	Inactive	0		NFA
11-004(a)	11-004(a)	11-004(a)	11	HSWA	Drop tower	Active	20	Hazardous const.	Rec NFA
11-004(b)	11-004(b)	11-004(b)	11	HSWA	Drop tower	Active	4000	Rad, hazardous const., HE	CARBC
11-004(c)	11-004(c)	11-004(c)	11	HSWA	Drop tower	Active	4000	Rad, hazardous const., HE	CARBC
11-004(d)	11-004(d)	11-004(d)	11	HSWA	Drop tower	Active	4000	Rad, hazardous const., HE	CARBC
1-004(e)	11-004(e)	11-004(e)	11	HSWA	Drop tower	Active	4000	Rad, hazardous const., HE	CARBC
1-004(f)	11-004(f)	11-004(f)	11	AOC/PRS	Drop tower	Active	4000	Rad, hazardous const., HE	CARBC
1-005(a)	11-005(a)	11-005(a)	11	HSWA	Septic system	Active	4000	Rad, hazardous const., HE	CARBC
1-005(b)	11-005(b)	11-005(b)	11	HSWA	Septic system	Active	0		NFA
	11-005(c)	11-005(c)	11	HSWA PM	Ind. or san. wastewater treat.	Inactive	0		NFA
-006(a)	11-006(a)	11-006(a)	11	006HSWA	Sump	Active	0		NFA
-006(b)	11-006(b)	11-006(b)	11	HSWA PM	Tank and/or assoc. equip.	Active	1	Rad, haz. const., HE, other	CARBC
-006(c)	11-006(c)	11-006(c)	11	HSWA PM	Tank and/or assoc. equip.	Active	5	Rad, haz. const., HE, other	CARBC
-006(d)	11-006(d)	11-006(d)	11	HSWA PM	Tank and/or assoc. equip.	Active	5	Rad, haz. const., HE, other	CARBC
007	11-007	11-007	11	HSWA	Surface disposal	Inactive	5	Rad, haz. const., HE, other	CARBC
008	11-008	11-008	11	AOC/PRS	Surface disposal	Inactive	0		CARBC
009	11-009	11-009	11	HSWA	Material disposal area	Active	0		Rec NFA
010(a)	11-010(a)	11-010(a)	11	AOC/PRS	Container storage	Active	0		Rec NFA
010(b)	11-010(b)	11-010(b)	11	AOC/PRS	Container storage	Inactive	0		Rec NFA
	11-011(a)	11-011(a)	11	HSWA PM	Ind. or san. wastewater treat.	Active	0		Rec NFA
	11-011(b)	11-011(b)	11	HSWA PM	Ind. or san. wastewater treat.	Active	0		NFA
	11-011(c)	11-011(c)	11	HSWA PM	Ind. or san. wastewater treat.	Active	0		NFA
	11-011(d)	11-011(d)	11	HSWA PM	Ind. or san. wastewater treat.	Active	0		NFA
	11-012(a)	11-012(a)	11	AOC/PRS	Building	Removed	0		NFA

PRS Data for Operable Unit 1079

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (YD3)	Potential Contaminants	Potential Remediation
10-001(a)	10-001(a)	10-001(a)	10	HSWA	Firing Site	Decommissioned	162963	Rad, HE, hazardous const.	CARBC
10-001(b)	10-001(b)	10-001(b)	10	HSWA	Firing Site	Decommissioned	162963	Rad, HE, hazardous const.	CARBC
10-001(c)	10-001(c)	10-001(c)	10	HSWA	Firing Site	Decommissioned	162963	Rad, HE, hazardous const.	CARBC
0-001(d)	10-001(d)	10-001(d)	10	HSWA	Firing Site	Decommissioned	162963	Rad, HE, hazardous const.	CARBC
	10-001(e)	10-001(e)	10	AOC/PRS	Firing Site	Decommissioned	0		Rec NFA
0-002(a)	10-002(a)	10-002(a)	10	HSWA	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
0-002(b)	10-002(b)	10-002(b)	10	HSWA	Disposal pit	Decommissioned	56	Rad, hazardous const.	CARBC
0-003(a)	10-003(a)	10-003(a)	10	HSWA	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
0-003(b)	10-003(b)	10-003(b)	10	HSWA	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
0-003(c)	10-003(c)	10-003(c)	10	HSWA	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
	10-003(d)	10-003(d)	10	HSWA PM	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
	10-003(e)	10-003(e)	10	HSWA PM	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
	10-003(f)	10-003(f)	10	HSWA PM	Disposal pit	Decommissioned	30	Rad, hazardous const.	CARBC
-003(d)	10-003(g)	10-003(g)	10	HSWA	Manholes	Decommissioned	1	Rad, hazardous const.	CARBC
-003(e)	10-003(h)	10-003(h)	10	HSWA	Manholes	Decommissioned	1	Rad, hazardous const.	CARBC
-003(f)	10-003(i)	10-003(i)	10	HSWA	Septic tank	Decommissioned	1	Rad, hazardous const.	CARBC
	10-003(j)	10-003(j)	10	HSWA PM	Tank	Decommissioned	1	Rad, hazardous const.	CARBC
	10-003(k)	10-003(k)	10	HSWA PM	Tank	Decommissioned	1	Rad, hazardous const.	CARBC
	10-003(l)	10-003(l)	10	HSWA PM	Tank	Decommissioned	1	Rad, hazardous const.	CARBC
	10-003(m)	10-003(m)	10	HSWA PM	Waste line	Decommissioned	2	Rad, hazardous const.	CARBC
	10-003(n)	10-003(n)	10	HSWA PM	Leach field	Decommissioned	19	Rad, hazardous const.	CARBC
	10-003(o)	10-003(o)	10	HSWA PM	Leach field	Decommissioned	1	Rad, hazardous const.	CARBC
004(a)	10-004(a)	10-004(a)	10	HSWA	Septic system	Decommissioned	0		NFA
004(b)	10-004(b)	10-004(b)	10	HSWA	Septic system	Decommissioned	17	Rad, hazardous const.	CARBC
005	10-005	10-005	10	HSWA PM	Surface disposal	Decommissioned	4	Rad, hazardous const.	CARBC
006	10-006	10-006	10	HSWA	Burn site	Inactive	0		Rec NFA
007	10-007	10-007	10	HSWA PM	Landfill	Inactive	7407	Hazardous const.	CARBC
001	31-001	31-001	31	HSWA	Septic system	Decommissioned	0		NFA
	C 31 001	C 31 001	31	AOC/PRS	Buildings	Removed	0		Rec NFA

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1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
16-010(g)	16-010(g)	16-010(g)	16	HSWA	Waste water treatment facility	Active	0		Rec NFA
16-010(h)	16-010(h)	16-010(h)	16	HSWA	Burn site	Inactive	0		NFA
16-010(i)	16-010(i)	16-010(i)	16	HSWA	Burn site	Inactive	0		NFA
16-010(j)	16-010(j)	16-010(j)	16	RCRA PM	Burn site	Active	1	Hazardous const., HE	Def. D&D
6-010(k)	16-010(k)	16-010(k)	16	HSWA	Trough	Inactive	0		NFA
6-010(l)	16-010(l)	16-010(l)	16	HSWA	Trough	Inactive	0		NFA
6-010(m)	16-010(m)	16-010(m)	16	HSWA	Trough	Inactive	0		NFA
	16-010(n)	16-010(n)	16	HSWA PM	Trough	Inactive	0		NFA
6-011	16-011	16-011	16	RCRA	Incinerator	Inactive	10	Hazardous const., HE	Def. D&D
		*16-011(b) See notation at end of data base							
-012(a)	16-012(a)	16-012(a)	16	HSWA	Container storage	Active	0		Rec NFA
	16-012(a2)	16-012(a2)	16	AOC/PRS	Container storage	Active	0		Rec NFA
-012(b)	16-012(b)	16-012(b)	16	HSWA	Container storage	Active	0		Rec NFA
012(c)	16-012(c)	16-012(c)	16	HSWA	Container storage	Active	0		Rec NFA
012(d)	16-012(d)	16-012(d)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
012(e)	16-012(e)	16-012(e)	16	HSWA	Container storage	Active	0		Rec NFA
012(f)	16-012(f)	16-012(f)	16	HSWA	Container storage	Active	0		Rec NFA
012(g)	16-012(g)	16-012(g)	16	HSWA	Container storage	Active	0		Rec NFA
012(h)	16-012(h)	16-012(h)	16	HSWA	Container storage	Active	0		Rec NFA
12(i)	16-012(i)	16-012(i)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
12(j)	16-012(j)	16-012(j)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
12(k)	16-012(k)	16-012(k)	16	HSWA	Container storage	Active	0		Rec NFA
12(l)	16-012(l)	16-012(l)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
12(m)	16-012(m)	16-012(m)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
2(n)	16-012(n)	16-012(n)	16	RCRA PM	Satellite storage	Active	0		Rec NFA
2(o)	16-012(o)	16-012(o)	16	HSWA	Container storage	Active	0		Rec NFA
2(p)	16-012(p)	16-012(p)	16	RCRA PM	Container storage	Active	0		Rec NFA
2(q)	16-012(q)	16-012(q)	16	HSWA	Container storage	Active	0		Rec NFA
2(r)	16-012(r)	16-012(r)	16	HSWA	Container storage	Active	0		Rec NFA

8 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
003(m)	16-003(m)	16-003(m)	16	HSWA	Sump	Inactive	14	Hazardous const., HE	Def. D&D
003(n)	16-003(n)	16-003(n)	16	HSWA	Sump	Active	12	Rad, hazardous const., HE	Def. D&D
003(o)	16-003(o)	16-003(o)	16	HSWA	Sump	Active	16	Rad, hazardous const., HE	Def. D&D
003(p)	16-029(a)								
003(q)	16-029(b)								
03(r)	16-029(c)								
03(s)	16-029(d)								
03(t)	16-029(e)								
03(u)	16-029(f)								
03(v)	16-029(g)								
	16-003(p)	16-003(p)	16	AOC/PRS	Sump	Inactive	40	Rad, hazardous const., HE	CARBC
	16-003(q)	16-003(q)	16	AOC/PRS	Sump	Inactive	0		NFA
04(a)	16-004(a)	16-004(a)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
04(b)	16-004(b)	16-004(b)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
04(c)	16-004(c)	16-004(c)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
04(d)	16-004(d)	16-004(d)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
04(e)	16-004(e)	16-004(e)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
04(f)	16-004(f)	16-004(f)	16	HSWA	Waste water treatment facility	Inactive	0		NFA
	16-004misc				Unit does not exist				NFA
05(a)	16-005(a)	16-005(a)	16	HSWA PM	Septic tank	Decommissioned	10	Hazardous const., HE	CARBC
05(b)	16-005(b)	16-005(b)	16	HSWA PM	Septic tank	Decommissioned	0		NFA
05(c)	16-005(c)	16-005(c)	16	HSWA PM	Septic tank	Decommissioned	0		NFA
05(d)	16-005(d)	16-005(d)	16	HSWA PM	Septic tank	Decommissioned	3	Hazardous const., HE	CARBC
05(e)	16-005(e)	16-005(e)	16	HSWA PM	Septic tank	Decommissioned	2	Hazardous const., HE	CARBC
05(f)	16-005(f)	16-005(f)	16	HSWA PM	Septic tank	Decommissioned	2	Hazardous const., HE	CARBC
05(g)	16-005(f)	16-005(f)							
05(h)	16-005(f)	16-005(f)							
5(i)	16-005(g)	16-005(g)	16	HSWA PM	Burn Site	Active	1	Hazardous const., HE	Def. D&D
5(j)	16-005(h)	16-005(h)	16	HSWA PM	Septic tank	Decommissioned	0		NFA

PRS Data or Operable Unit 1082

1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
16-025(z)	16-025(z)	16	HSWA PM	Abandoned building & appurtenance	Decommissioned	100	Rad, hazardous const., HE	CARBC
16-026(a)	16-026(a)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(a2)	16-026(a2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(b)	16-026(b)	16	HSWA PM	Outfall	Inactive	10	Rad, hazardous const., HE	CARBC
16-026(b2)	16-026(b2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(c)	16-026(c)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(c2)	16-026(c2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(d)	16-026(d)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(d2)	16-026(d2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(e)	16-026(e)	16	HSWA PM	Outfall	Inactive	10	Hazardous const., HE	CARBC
16-026(e2)	16-026(e2)	16	HSWA PM	Outfall	Inactive	2	Hazardous const., HE	CARBC
16-026(f)	16-026(f)	16	HSWA PM	Outfall	Inactive	2	Hazardous const., HE	CARBC
16-026(f2)	16-026(f2)	16	HSWA PM	Outfall	Inactive	2	Rad, haz. const., HE	CARBC
16-026(g)	16-026(g)	16	HSWA PM	Outfall	Inactive	2	Hazardous const., HE	CARBC
16-026(g2)	16-026(g2)	16	HSWA PM	Outfall	Inactive	2	Hazardous const., HE	CARBC
16-026(h)	16-026(h)	16	HSWA PM	Outfall	Inactive	2	Hazardous const., HE	CARBC
16-026(h2)	16-026(h2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(i)	16-026(i)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(i2)	16-026(i2)	16	HSWA PM	Outfall	Inactive	0		Rec NFA
16-026(j)	16-026(j)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(j2)	16-026(j2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(k)	16-026(k)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(k2)	16-026(k2)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(l)	16-026(l)	16	HSWA PM	Outfall	Inactive	0		NFA
16-026(m)	16-026(m)	16	HSWA PM	Outfall	Inactive	2	Rad, hazardous const., HE	CARBC
16-026(n)	16-026(n)	16	HSWA PM	Outfall	Inactive	2	Rad, hazardous const., HE	CARBC
16-026(o)	16-026(o)	16	HSWA PM	Outfall	Inactive	2	Rad, hazardous const., HE	CARBC
16-026(p)	16-026(p)	16	HSWA PM	Outfall	Inactive	2	Rad, hazardous const., HE	CARBC
16-026(q)	16-026(q)	16	HSWA PM	Outfall	Decommissioned	2	Hazardous const., HE	CARBC

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	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	16-022(b)	16-022(b)	16	RCRA	Underground tank	Inactive	2	Hazardous const.	CARBC
(a)	16-023(a)	16-023(a)	16	AOC/PRS	Incinerator	Decommissioned	0		NFA
(b)	16-023(b)	16-023(b)	16	AOC/PRS	Incinerator	Decommissioned	0		NFA
	16-024(a)	16-024(a)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(b)	16-024(b)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(c)	16-024(c)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(d)	16-024(d)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(e)	16-024(e)	16	AOC/PRS	Operational facility	Decommissioned	25	HE	CARBC
	16-024(f)	16-024(f)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(g)	16-024(g)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(h)	16-024(h)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(i)	16-024(i)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(j)	16-024(j)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(k)	16-024(k)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(l)	16-024(l)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(m)	16-024(m)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(n)	16-024(n)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(o)	16-024(o)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(p)	16-024(p)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(q)	16-024(q)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(r)	16-024(r)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(s)	16-024(s)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(t)	16-024(t)	16	AOC/PRS	Operational facility	Inactive	0		NFA
	16-024(u)	16-024(u)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-024(v)	16-024(v)	16	AOC/PRS	Magazine	Decommissioned	0		NFA
	16-025(a)	16-025(a)	16	HSWA PM	Abandoned building & appurtenance	Decommissioned	5	Rad, HE	CARBC
	16-025(a2)	16-025(a2)	16	HSWA PM	Abandoned building & appurtenance	Decommissioned	10	Hazardous const., HE	CARBC
	16-025(b)	16-025(b)	16	HSWA PM	Abandoned building & appurtenance	Decommissioned	10	Rad, hazardous const., HE	CARBC
	16-025(b2)	16-025(b2)	16	HSWA PM	Abandoned building & appurtenance	Decommissioned	10	Rad, hazardous const., HE	CARBC

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1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
16-034(b)	16-034(b)	16	HSWA PM	Soil contamination area	Decommissioned	100	Hazardous const., HE	CARBC
16-034(c)	16-034(c)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(d)	16-034(d)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(e)	16-034(e)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(f)	16-034(f)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(g)	16-034(g)	16	HSWA PM	Soil contamination area	Inactive	0		NFA
16-034(h)	16-034(h)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(i)	16-034(i)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(j)	16-034(j)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(k)	16-034(k)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(l)	16-034(l)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(m)	16-034(m)	16	HSWA PM	Soil contamination area	Decommissioned	10	Hazardous const., HE	CARBC
16-034(n)	16-034(n)	16	HSWA PM	Soil contamination area	Decommissioned	0		NFA
16-034(o)	16-034(o)	16	HSWA PM	Soil contamination area	Decommissioned	100	Hazardous const., HE	CARBC
16-034(p)	16-034(p)	16	HSWA PM	Soil contamination area	Inactive	5	Hazardous const., HE	CARBC
16-035	16-035	16	HSWA PM	Soil contamination area	Inactive	0		NFA
16-036	16-036	16	HSWA PM	Soil contamination area	Inactive	150	Rad, hazardous const., HE	CARBC
16-037	16-037	16	AOC/PRS	Aboveground tank	Active	1	Hazardous const.	CARBC
C-16-001	C-16-001	16	AOC/PRS	Building	Removed	0		NFA
C-16-002	C-16-002	16	AOC/PRS	Building	Removed	0		NFA
C-16-003	C-16-003	16	AOC/PRS	Septic system	Removed	0		NFA
C-16-004	C-16-004	16	AOC/PRS	Building	Removed	0		NFA
C-16-005	C-16-005	16	AOC/PRS	Building	Decommissioned	50	Hazardous const., HE	CARBC
C-16-006	C-16-006	16	AOC/PRS	Building	Decommissioned	0		NFA
C-16-007	C-16-007	16	AOC/PRS	Building	Removed	0		NFA
C-16-008	C-16-008	16	AOC/PRS	Building	Removed	0		NFA
C-16-009	C-16-009	16	AOC/PRS	Building	Removed	0		NFA
C-16-010	C-16-010	16	AOC/PRS	Building	Removed	0		NFA
C-16-011	C-16-011	16	AOC/PRS	Building	Removed	0		NFA

PRS Data or Operable Unit 1082

988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	16-029(f2)	16-029(f2)	16	HSWA PM	Outfall	Decommissioned	11	Hazardous const., HE	CARBC
6-003(v)	16-029(g)	16-029(g)	16	003(v) HSWA	Sump	Active	12	Hazardous const.	Def. D&D
	16-029(g2)	16-029(g2)	16	HSWA PM	Pump pit	Decommissioned	0		NFA
	16-029(h)	16-029(h)	16	HSWA PM	Sump	Inactive	11	Rad, hazardous const., HE	CARBC
	16-029(h2)	16-029(h2)	16	AOC/PRS*	Drain line and outfall	Decommissioned	11	Hazardous const., HE	CARBC
	16-029(i)	16-029(i)	16	HSWA PM	Outfall	Inactive	11	Rad, hazardous const., HE	Def. D&D
	16-029(j)	16-029(j)	16	HSWA PM	Outfall	Inactive	11	Rad, hazardous const.,HE	CARBC
	16-029(k)	16-029(k)	16	HSWA PM	Sump	Inactive	11	Hazardous const., HE	CARBC
					*Subunit or ancillary unit to HSWA unit				
	16-029(l)	16-029(l)	16	HSWA PM	Sump	Inactive	11	Hazardous const., HE	CARBC
	16-029(m)	16-029(m)	16	AOC/PRS*	Sump	Decommissioned	12	Hazardous const., HE	CARBC
	16-029(n)	16-029(n)	16	AOC/PRS*	Sump	Decommissioned	12	Hazardous const., HE	CARBC
	16-029(o)	16-029(o)	16	AOC/PRS*	Sump	Decommissioned	12	Hazardous const., HE	CARBC
	16-029(p)	16-029(p)	16	AOC/PRS*	Sump	Decommissioned	12	Hazardous const., HE	CARBC
	16-029(q)	16-029(q)	16	HSWA PM	Sump	Inactive	13	Hazardous const., HE	CARBC
	16-029(r)	16-029(r)	16	AOC/PRS*	Outfall	Decommissioned	12	Hazardous const., HE	CARBC
	16-029(s)	16-029(s)	16	HSWA PM	Sump	Inactive	15	Hazardous const., HE	CARBC
	16-029(t)	16-029(t)	16	HSWA PM	Sump	Inactive	15	Hazardous const., HE	CARBC
	16-029(u)	16-029(u)	16	HSWA PM	Sump	Inactive	15	Hazardous const., HE	CARBC
	16-029(v)	16-029(v)	16	HSWA PM	Sump	Decommissioned	11	Hazardous const., HE	CARBC
	16-029(w)	16-029(w)	16	AOC/PRS*	Sump	Decommissioned	11	Hazardous const., HE	CARBC
	16-029(x)	16-029(x)	16	HSWA PM	Sump	Inactive	60	Hazardous const., HE	CARBC
	16-029(y)	16-029(y)	16	AOC/PRS*	Sump	Decommissioned	11	Rad, hazardous const., HE	CARBC
	16-029(z)	16-029(z)	16	AOC/PRS*	Sump	Decommissioned	11	Hazardous const., HE	CARBC
	16-030(a)	16-030(a)	16	HSWA PM	Ind. or san. waste water treatment	Active	0		NFA
	16-030(b)	16-030(b)	16	HSWA PM	Ind. or san. waste water treatment	Active	0		NFA
	16-030(c)	16-030(c)	16	HSWA PM	Ind. or san. waste water treatment	Active	0		NFA
	16-030(d)	16-030(d)	16	AOC/PRS	Outfall	Inactive	10	Rad, hazardous const., HE	CARBC
					*Subunit or ancillary unit to HSWA Unit				

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PRS Data for Operable Unit 1085

88 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
-001(a)	12-001(a)	12-001(a)	12	HSWA	Firing site	Inactive	10	Rad, hazardous const., HE	CARBC
-001(b)	12-001(b)	12-001(b)	12	HSWA	Firing site	Inactive	10	Rad, hazardous const., HE	CARBC
-002	12-002	12-002	12	HSWA PM	Open burning ground	Inactive	0		NFA
-003	12-003	12-003	12	AOC/PRS	Storage area	Inactive	0		NFA
-004(a)	12-004(a)	12-004(a)	12	AOC/PRS	Operational facility	Inactive	10	Rad, hazardous const., HE	CARBC
-004(b)	12-004(b)	12-004(b)	12	AOC/PRS	Operational facility	Inactive	1	Rad, hazardous const., HE	CARBC
	C-12-001	C-12-001	12	AOC/PRS	Building	Removed	10	Hazardous const., HE	CARBC
	C-12-002	C-12-002	12	AOC/PRS	Building	Removed	10	Hazardous const., HE	CARBC
	C-12-003	C-12-003	12	AOC/PRS	Building	Decommissioned	10	Hazardous const., HE	CARBC
	C-12-004	C-12-004	12	AOC/PRS	Building	Decommissioned	0	Hazardous const.	CARBC
	C-12-005	C-12-005	12	AOC/PRS	Building	Decommissioned	0	HE	CARBC
	C-12-006	C-12-006	12	AOC/PRS	Building	Inactive	0		NFA
-001(a)	14-001(a)	14-001(a)	14	AOC/PRS	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
-001(b)	14-001(b)	14-001(b)	14	AOC/PRS	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
-001(c)	14-001(c)	14-001(c)	14	AOC/PRS	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
-001(d)	14-001(d)	14-001(d)	14	AOC/PRS	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
-001(e)	14-001(e)	14-001(e)	14	AOC/PRS	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
-001(f)	14-001(f)	14-001(f)	14	AOC/PRS	Firing site	Active	2	Rad, hazardous const., HE	Def. D&D
-001(g)	14-001(g)	14-001(g)	14	AOC/PRS	Firing site	Active	3	Rad, hazardous const., HE	Def. D&D
-002(a)	14-002(a)	14-002(a)	14	HSWA	Firing site	Decommissioned	1	Rad, hazardous const., HE	Def. D&D
-002(b)	14-002(b)	14-002(b)	14	HSWA	Firing site	Decommissioned	1	Rad, hazardous const., HE	Def. D&D
-002(c)	14-002(c)	14-002(c)	14	HSWA	Building	Decommissioned	12	Rad, hazardous const., HE	CARBC
-002(d)	14-002(d)	14-002(d)	14	HSWA	Firing site	Decommissioned	12	Rad, hazardous const., HE	CARBC
-002(e)	14-002(e)	14-002(e)	14	HSWA	Firing site	Decommissioned	12	Rad, hazardous const., HE	CARBC
-002(f)	14-002(f)	14-002(f)	14	HSWA	Firing site	Decommissioned	1	Rad, hazardous const., HE	Def. D&D
-003	14-003	14-003	14	HSWA PM	Open burning ground	Inactive	10	Rad, hazardous const., HE	CARBC
-004(a)	14-004(a)	14-004(a)	14	AOC/PRS	Storage area	Active	1		NFA
-004(b)	14-004(b)	14-004(b)	14	HSWA	Storage area	Active	1		NFA
-004(c)	14-004(c)	14-004(c)	14	AOC/PRS	Storage area	Active	4		NFA

PRS Data or Operable Unit 1082

988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	C-16-041	C-16-041	16	AOC/PRS	Building	Removed	0		NFA
	C-16-042	C-16-042	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-043	C-16-043	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-044	C-16-044	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-045	C-16-045	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-046	C-16-046	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-047	C-16-047	16	AOC/PRS	Transport area	Removed	1	Hazardous const.	CARBC
	C-16-048	C-16-048	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-049	C-16-049	16	AOC/PRS	Building	Removed	0		NFA
	C-16-050	C-16-050	16	AOC/PRS	Building	Removed	0		NFA
	C-16-051	C-16-051	16	AOC/PRS	Transport area	Removed	1	Hazardous const.	CARBC
	C-16-052	C-16-052	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-053	C-16-053	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-054	C-16-054	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-055	C-16-055	16	AOC/PRS	Generation area	Removed	0		NFA
	C-16-056	C-16-056	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-057	C-16-057	16	AOC/PRS	Manhole	Removed	0		NFA
	C-16-058	C-16-058	16	AOC/PRS	Transport area	Removed	1	Hazardous const.	CARBC
	C-16-059	C-16-059	16	AOC/PRS	Generation area	Removed	0		NFA
	C-16-060	C-16-060	16	AOC/PRS	Building	Removed	75	Rad, hazardous const.	CARBC
	C-16-061	C-16-061	16	AOC/PRS	Building	Removed	0		NFA
	C-16-062	C-16-062	16	AOC/PRS	Generation area	Removed	0		NFA
	C-16-063	C-16-063	16	AOC/PRS	Generation area	Removed	0		NFA
	C-16-064	C-16-064	16	AOC/PRS	HE scrap pick-up	Removed	1	Hazardous const., HE	CARBC
	C-16-065	C-16-065	16	AOC/PRS	Storage area	Inactive	0		NFA
	C-16-066	C-16-066	16	AOC/PRS	Storage area	Removed	0		NFA
	C-16-067	C-16-067	16	AOC/PRS	Storage area	Removed	0		NFA
	C-16-068	C-16-068	16	AOC/PRS	Building	Removed	15	Hazardous const	CARBC
	C-16-069	C-16-069	16	AOC/PRS	Building	Removed	0		NFA

012(d)	15-014(k)	15-014(k)	15	012(d)HSWA	Outfall	Active	94	Hazardous const.	CARBC
012(e)	15-014(l)	15-014(l)	15	012(e)HSWA	Outfall	Active	0		Rec NFA
012(f)	15-014(i)	15-014(i)	15	012(f)HSWA	Outfall	Active	94	Hazardous const.	CARBC
012(g)	15-014(j)	15-014(j)	15	012(g)HSWA	Outfall	Active	94	Hazardous const.	CARBC
	15-013(a)	15-013(a)	15	AOC/PRS	Underground tank	Removed	0		Rec NFA
	15-013(b)	15-013(b)	15	AOC/PRS	Underground tank	Removed	0		Rec NFA
	15-014(a)	15-014(a)	15	HSWA PM	Ind. or san. waste water treat.	Active	940	Hazardous const.	CARBC
	15-014(b)	15-014(b)	15	HSWA PM	Ind. or san. waste water treat.	Active	94	Hazardous const.	CARBC
	15-014(c)	15-014(c)	15	HSWA PM	Ind. or san. waste water treat.	Active	0		Rec NFA
	15-014(d)	15-014(d)	15	HSWA PM	Ind. or san. waste water treat.	Active	0		Rec NFA
	15-014(e)	15-014(e)	15	HSWA PM	Ind. or san. waste water treat.	Active	0		Rec NFA
	15-014(f)	15-014(f)	15	HSWA PM	Ind. or san. waste water treat.	Active	0		Rec NFA
	15-014(g)	15-014(g)	15	HSWA PM	Ind. or san. waste water treat.	Active	0		Rec NFA
	15-014(h)	15-014(h)	15	AOC/PRS	Outfall	Active	94	Hazardous const.	CARBC
	C-15-001	C-15-001	15	AOC/PRS	Surface disposal	Inactive	19	Rad, hazardous const.	CARBC
	C-15-002	C-15-002	15	AOC/PRS	Surface disposal	Inactive	0		Rec NFA
	C-15-003	C-15-003	15	AOC/PRS	Surface disposal	Inactive	0		Rec NFA
	C-15-004	C-15-004	15	AOC/PRS	Transformers	Removed	0	Other	CARBC
	C-15-005	C-15-005	15	AOC/PRS	Laboratory and building	Removed	370	Rad, hazardous const.	CARBC
	C-15-006	C-15-006	15	AOC/PRS	Building	Removed	370	Hazardous const.	CARBC
	C-15-007	C-15-007	15	AOC/PRS	Non-intentional release	Inactive	4	Hazardous const.	CARBC
	C-15-008	C-15-008	15	AOC/PRS	Non-intentional release	Inactive	0		Rec NFA
	C-15-009	C-15-009	15	AOC/PRS	Underground tank	Inactive	0		Rec NFA
	C-15-010	C-15-010	15	AOC/PRS	Underground tank	Removed	74	Hazardous const.	CARBC
	C-15-011	C-15-011	15	AOC/PRS	Underground tank	Inactive	37	Hazardous const.	CARBC
	C-15-012	C-15-012	15	AOC/PRS	Underground tank	Active	0		Rec NFA
	C-15-013	C-15-013	15	AOC/PRS	Underground tank	Inactive	0		Rec NFA

PRS Data for Operable Unit 1086

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	15-001	15-001	15	AOC/PRS	Surface disposal	Active	93	Rad, hazardous const.	CARBC
	15-002	15-002	15	HSWA	Disposal pit and burn site	Inactive	4	Rad, hazardous const., HE	CARBC
	15-003	15-003	15	RCRA PM	Firing site	Active	24850	Hazardous const., HE	Del. D&D
(a)	15-004(a)	15-004(a)	15	HSWA PM	Firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(b)	15-004(a)	15-004(a)							
(c)	15-004(b)	15-004(b)	15	HSWA PM	Firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(d)	15-004(b)	15-004(b)							
(e)	15-004(c)	15-004(c)	15	0-004eHSWA	Firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(f)	15-004(d)	15-004(d)	15	HSWA PM	Firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(g)	15-004(e)	15-004(e)	15	AOC/PRS	Unit does not exist		0		Rec NFA
(h)	15-004(f)	15-004(f)	15	HSWA PM	Machine firing site	Inactive	10000	Rad, hazardous const., HE	CARBC
(i)	15-004(g)	15-004(g)	15	HSWA PM	Machine firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(j)	15-004(g)	15-004(g)							
(k)	15-004(h)	15-004(h)	15	AOC/PRS	Firing site	Inactive	100	Rad, hazardous const., HE	CARBC
(l)	15-004(c)	15-004(c)							
(m)	15-004(f)	15-004(f)							
(n)	15-004(g)	15-004(g)							
(o)	15-004(h)	15-004(h)							
	15-004(i)	15-004(i)	15	AOC/PRS	Detonation ground	Inactive	0		Rec NFA
(a)	15-005(a)	15-005(a)	15	AOC/PRS	Storage area	Active	1	Rad, hazardous const., HE	CARBC
(b)	15-005(b)	15-005(b)	15	AOC/PRS	Storage area	Active	1	Rad, hazardous const., HE	CARBC
(c)	15-005(c)	15-005(c)	15	AOC/PRS	Storage area	Active	1	Rad, hazardous const., HE	CARBC
	15-005(d)	15-005(d)	15	AOC/PRS	Storage area	Active	0		Rec NFA
(a)	15-006(a)	15-006(a)	15	HSWA	Firing site	Active	24850	Rad, hazardous const., HE	Del. D&D
(b)	15-006(b)	15-006(b)	15	HSWA	Firing site	Active	9308	Rad, hazardous const., HE	Del. D&D
(c)	15-006(c)	15-006(c)	15	HSWA	Firing site	Active	5236	Rad, hazardous const., HE	Del. D&D
(d)	15-006(d)	15-006(d)	15	HSWA	Firing site	Active	5236	Rad, hazardous const., HE	Del. D&D
	15-006(e)	15-006(e)	15	AOC/PRS	Not In TA-15		0		NFA
(a)	15-007(a)	15-007(a)	15	HSWA	Landfill MDA N	Inactive	2420	Rad, hazardous const., HE	IS.IC

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PRS Data for Operable Unit 1098

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
2-009(f)	2-009(c)	2-009(c)	2	AOC/PRS	Non-intentional release	Inactive	5000	Rad, hazardous const.	CARBC
2-009(g)	2-009(c)	2-009(c)	2	AOC/PRS	Non-intentional release	Inactive	5000	Rad, hazardous const.	CARBC
2-009(h)	2-009(c)	2-009(c)	2	AOC/PRS	Non-intentional release	Inactive	5000	Rad, hazardous const.	CARBC
2-009(i)	deleted, same as 2-003d						0		NFA
	2-009(d)	2-009(d)	2	AOC/PRS	Non-intentional release	Inactive	93	Rad, hazardous const.	CARBC
2-010	2-010	2-010	2	AOC/PRS	Building	Inactive/d	94	Rad, hazardous const.	CARBC
2-011	2-011(a)	2-011(a)	2	AOC/PRS	Storm drain and outfall	Active	228	Rad, hazardous const.	CARBC
	2-011(b)	2-011(b)	2	AOC/PRS	Storm drain and outfall	Active	1	Rad, hazardous const.	CARBC
	2-011(c)	2-011(c)	2	AOC/PRS	Storm drain and outfall	Active	1	Rad, hazardous const.	CARBC
	2-011(d)	2-011(d)	2	AOC/PRS	Storm drain and outfall	Active	37	Hazardous const.	CARBC
	2-011(e)	2-011(e)	2	AOC/PRS	Storm drain and outfall	Active	37	Hazardous const	CARBC
	2-012	2-012	2	AOC/PRS	Underground tank	Inactive	2	Hazardous const.	CARBC
	2-013	2-013	2	AOC/PRS	Storage area	Active	0		Rec NFA
-001	41-001	41-001	41	HSWA	Septic system	Inactive	2	Rad, hazardous const.	CARBC
-002(a)	41-002(a)	41-002(a)	41	HSWA	Waste water treatment facility	Active	25	Rad, hazardous const.	CARBC
-002(b)	41-002(b)	41-002(b)	41	HSWA	Waste water treatment facility	Active	42	Rad, hazardous const.	CARBC
-002(c)	41-002(c)	41-002(c)	41	HSWA	Waste water treatment facility	Active	17	Rad, hazardous const.	CARBC
-XXX	41-003	41-003	41	AOC/PRS	Sump	Active	1	Hazardous const.	CARBC
	41-004	41-004	41	AOC/PRS	Container storage	Active	0		Rec NFA
	C-41-001	C-41-001	41	AOC/PRS	Sump	Inactive	0		NFA
	C-41-002	C-41-002	41	AOC/PRS	Underground tank	Active	0		NFA
	C-41-003	C-41-003	41	AOC/PRS	Underground tank	Inactive	0		NFA
	C-41-004	C-41-004	41	AOC/PRS	Storm drains	Active	370	Hazardous const.	CARBC
	C-41-005	C-41-005	41	AOC/PRS	Underground tank	Inactive	10	Hazardous const.	CARBC

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PRS Data for Operable Unit 1093

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	18-010(c)	18-010(c)	18	AOC/PRS	Outfall	Active	0		NFA
	18-010(d)	18-010(d)	18	AOC/PRS	Outfall	Active	0		NFA
	18-010(e)	18-010(e)	18	AOC/PRS	Outfall	Active	0		NFA
	18-010(f)	18-010(f)	18	AOC/PRS	Outfall	Active	0		NFA
	18-011	18-011	18	AOC/PRS	Soil containment	Decommissioned	0		NFA
	18-012(a)	18-012(a)	18	HSWA PM	Ind. or san. waste water treat.	Active	0		NFA
	18-012(b)	18-012(b)	18	HSWA PM	Ind. or san. waste water treat.	Active	0		NFA
	18-012(c)	18-012(c)	18	AOC/PRS	Sump and drain lines	Active	0		NFA
	18-012(d)	18-012(d)	18	AOC/PRS	Drain line	Unknown	0		Rec NFA
	C-18-001	C-18-001	18	AOC/PRS	Laboratory	Decommissioned	0		Rec NFA
	C-18-002	C-18-002	18	AOC/PRS	Building	Removed	0		Rec NFA
	C-18-003	C-18-003	18	AOC/PRS	Storage area	Unknown	0		Rec NFA
1	27-001	27-001	27	HSWA	Buried naval guns	Unknown	0		NFA
2	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
2(a)	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
2(b)	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
2(c)	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
2(d)	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
2(e)	27-002	27-002	27	HSWA	Firing sites	Abandoned	0		NFA
3	27-003	27-003	27	HSWA	Bazooka impact area	Inactive	5556	HE	CARBC
	27-004	27-004	27	AOC/PRS	Building	Decommissioned	0		Rec NFA

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PRS Data for Operable Unit 1106

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	21-001	21-001	21	AOC/PRS	Container storage	Active	234	Rad, hazardous const.	CARBC
2	21-002(a)	21-002(a)	21	HSWA	Container storage	Inactive	0	Hazardous const.	CARBC
	21-002(b)	21-002(b)	21	AOC/PRS	Container storage	Inactive	80700	Hazardous const.	ISIC
1	21-003	21-003	21	RCRA PM	Container storage	Inactive	347	Hazardous const., other	CARBC
(a)	21-004(a)	21-004(a)	21	AOC/PRS	Aboveground tank	Active	1	Rad, hazardous const.	CARBC
(b)	21-004(b)	21-004(b)	21	HSWA PM	Tank and/or assoc. equipment	Active	25	Rad, hazardous const.	CARBC
(c)	21-004(c)	21-004(c)	21	HSWA PM	Tank and/or assoc. equipment	Active	25	Rad, hazardous const.	CARBC
	21-004(d)	21-004(d)	21	AOC/PRS	Outfall	Active	72	Rad, hazardous const.	CARBC
5	21-005	21-005	21	HSWA	Disposal pit	Decommissioned	0		NFA
6(a)	21-006(a)	21-006(a)	21	HSWA	Disposal pit	Inactive	242	Rad, hazardous const.	Def. D&D
6(b)	21-016(c)	21-016(c)	21	006b HSWA	Material disposal area	Inactive	2566	Rad, hazardous const.	CARBC
6(c)	21-006(b)	21-006(b)	21	006c HSWA	Disposal pit	Inactive	270	Rad, hazardous const.	Def. D&D
6(d)	21-006(c)	21-006(c)	21	006d HSWA	Disposal pit	Inactive	242	Rad, hazardous const.	Def. D&D
6(e)	21-006(d)	21-006(d)	21	006e HSWA	Disposal pit	Inactive	242	Rad, hazardous const.	Def. D&D
	21-006(e)	21-006(e)	21	HSWA PM	Surface disposal site	Inactive	242	Rad, hazardous const.	Def. D&D
	21-006(f)	21-006(f)	21	AOC/PRS	Disposal pit	Inactive	242	Rad, hazardous const.	Def. D&D
7	21-007	21-007	21	HSWA	Incinerators	Decommissioned	0		NFA
8	21-008	21-008	21	AOC/PRS	Incinerator	Decommissioned	0		NFA
9	21-009	21-009	21	AOC/PRS	Waste treatment lab	Decommissioned	0		NFA
0(a)	21-010(a)	21-010(a)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(b)	21-010(b)	21-010(b)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(c)	21-010(c)	21-010(c)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(d)	21-010(d)	21-010(d)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(e)	21-010(e)	21-010(e)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(f)	21-010(f)	21-010(f)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(g)	21-010(g)	21-010(g)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
0(h)	21-010(h)	21-010(h)	21	HSWA	Waste treatment facility	Decommissioned	0		NFA
1(a)	21-011(a)	21-011(a)	21	HSWA	Waste treatment facility	Active	21511	Rad, hazardous const.	ISIC
1(b)	21-011(b)	21-011(b)	21	HSWA	Sump	Active	34	Rad, hazardous const.	ISIC

PRS Data for Operable Unit 1100

#	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	53-001(n)	53-001(n)	53	RCRA	Storage area	Active	0		Rec NFA
	53-001(o)	53-001(o)	53	RCRA	Storage area	Active	0		Rec NFA
002(a)	53-002(a)	53-002(a)	53	RCRA PM	Disposal lagoon	Active	14974	Rad, hazardous const.	IS.1C
002(b)	53-002(b)	53-002(b)	53	RCRA PM	Disposal lagoon	Active	9733	Rad, hazardous const.	IS.1C
003	53-003	53-003	53	AOC/PRS	Septic tank	Active	0		Rec NFA
004	53-004	53-004	53	AOC/PRS	Operational facility	Active	0		Rec NFA
005	53-005	53-005	53	HSWA	Disposal pit	Decommissioned	5	Hazardous const., other	CARBC
006(a)	53-006(a)	53-006(a)	53	AOC/PRS	Underground tank	Inactive	8	Rad, hazardous const.	CARBC
006(b)	53-006(b)	53-006(b)	53	HSWA	Underground tank	Active	13	Rad, hazardous const.	CARBC
006(c)	53-006(c)	53-006(c)	53	HSWA	Underground tank	Active	13	Rad, hazardous const.	CARBC
006(d)	53-006(d)	53-006(d)	53	HSWA	Underground tank	Active	20	Rad, hazardous const.	CARBC
06(e)	53-006(e)	53-006(e)	53	HSWA	Underground tank	Active	20	Rad, hazardous const.	CARBC
	53-006(f)	53-006(f)	53	HSWA PM	Underground tank	Active	20	Rad, hazardous const.	CARBC
07(a)	53-007(a)	53-007(a)	53	HSWA	Aboveground tank	Active	20	Rad, hazardous const.	CARBC
07(b)	53-007(b)	53-007(b)	53	HSWA	Aboveground tanks (2)	Removed	0		Rec NFA
08	53-008	53-008	53	AOC/PRS	Storage area	Active	0		Rec NFA
09	53-009	53-009	53	AOC/PRS	Aboveground tanks (3)	Removed	3	Hazardous const.	CARBC
	53-010	53-010	53	AOC/PRS	Container storage	Decommissioned	35	Hazardous const.	CARBC
	53-011(a)	53-011(a)	53	AOC/PRS	Transformer	Active	0		Rec NFA
	53-011(b)	53-011(b)	53	AOC/PRS	Transformer	Active	0		Rec NFA
	53-011(c)	53-011(c)	53	AOC/PRS	Transformer	Active	0		Rec NFA
	53-011(d)	53-011(d)	53	AOC/PRS	Transformer	Active	0		Rec NFA
	53-011(e)	53-011(e)	53	AOC/PRS	Transformer	Active	0		Rec NFA
	53-012(a)	53-012(a)	53	AOC/PRS	Outfall	Active	0		Rec NFA
	53-012(b)	53-012(b)	53	AOC/PRS	Outfall	Active	0		Rec NFA
	53-012(c)	53-012(c)	53	AOC/PRS	Outfall	Active	0		Rec NFA
	53-012(d)	53-012(d)	53	AOC/PRS	Outfall	Active	0		Rec NFA
	53-012(e)	53-012(e)	53	AOC/PRS	Outfall	Active	0		Rec NFA
	53-012(f)	53-012(f)	53	AOC/PRS	Outfall	Active	0		Rec NFA

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PRS Data for Operable Unit 1106

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
a)	21-028(a)	21-028(a)	21	RCRA PM	Container storage	Active	0		Rec NFA
b)	21-028(b)	21-028(b)	21	RCRA PM	Container storage	Active	0		NFA
c)	21-028(c)	21-028(c)	21	RCRA PM	Container storage	Active	0		NFA
d)	21-028(d)	21-028(d)	21	RCRA PM	Container storage	Active	0		NFA
	21-028(e)	21-028(e)	21	RCRA PM	Container storage	Active	0		Rec NFA
	21-029	21-029	21	HSWA PM	Soil contamination area	Active	0		Rec NFA
	C-21-001	C-21-001	21	AOC/PRS	One-time spill	Removed	0		NFA
	C-21-002	C-21-002	21	AOC/PRS	Non-intentional release area	Removed	0		Rec NFA
	C-21-003	C-21-003	21	AOC/PRS	Non-intentional release area	Removed	0		Rec NFA
	C-21-004	C-21-004	21	AOC/PRS	Non-intentional release area	Removed	0		Rec NFA
	C-21-005	C-21-005	21	AOC/PRS	One-time spill	Removed	0		NFA
	C-21-006	C-21-006	21	AOC/PRS	Non-intentional release area	Removed	0		NFA
	C-21-007	C-21-007	21	AOC/PRS	Non-intentional release area	Active	0		NFA
	C-21-008	C-21-008	21	AOC/PRS	One-time spill	Removed	0		Rec NFA
	C-21-009	C-21-009	21	AOC/PRS	One-time spill	Removed	0		NFA
	C-21-010	C-21-010	21	AOC/PRS	Systematic leak	Removed	0		Rec NFA
	C-21-011	C-21-011	21	AOC/PRS	One-time spill	Removed	0		Rec NFA
	C-21-012	C-21-012	21	AOC/PRS	One-time spill	Removed	0		NFA
	C-21-013	C-21-013	21	AOC/PRS	Disposal pit	Inactive	0		Rec NFA
	C-21-014	C-21-014	21	AOC/PRS	Warehouse	Active	0		Rec NFA
	C-21-015	C-21-015	21	AOC/PRS	Building	Removed	0		Rec NFA
	C-21-016	C-21-016	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-017	C-21-017	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-018	C-21-018	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-019	C-21-019	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-020	C-21-020	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-021	C-21-021	21	AOC/PRS	Storage area	Removed	0		Rec NFA
	C-21-022	C-21-022	21	AOC/PRS	Laboratory	Removed	0		Rec NFA
	C-21-023	C-21-023	21	AOC/PRS	Laboratory	Removed	0		Rec NFA

PRS L...d for
Operable Unit 1106

88 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
-017(c)	21-017(c)	21-017(c)	21	HSWA	Material disposal area	Inactive	20186	Rad, hazardous const., othe	IS,IC
-018(a)	21-018(a)	21-018(a)	21	HSWA	Material disposal area	Inactive	241939	Rad, hazardous const.	IS,IC
-018(b)	21-018(b)	21-018(b)	21	HSWA	Material disposal area	Inactive	3573	Rad, hazardous const.	IS,IC
-019(a)	21-019(a)	21-019(a)	21	AOC/PRS	Filter system	Active	0		NFA
-019(b)	21-019(b)	21-019(b)	21	AOC/PRS	Filter system	Active	0		NFA
019(c)	21-019(c)	21-019(c)	21	AOC/PRS	Filter system	Active	0		NFA
019(d)	21-019(d)	21-019(d)	21	AOC/PRS	Filter system	Active	0		NFA
019(e)	21-019(e)	21-019(e)	21	AOC/PRS	Filter system	Active	0		NFA
019(f)	21-019(f)	21-019(f)	21	AOC/PRS	Filter system	Active	0		NFA
019(g)	21-019(g)	21-019(g)	21	AOC/PRS	Filter system	Active	0		NFA
019(h)	21-019(h)	21-019(h)	21	AOC/PRS	Filter system	Active	0		NFA
019(i)	21-019(i)	21-019(i)	21	AOC/PRS	Filter system	Active	0		NFA
019(j)	21-019(j)	21-019(j)	21	AOC/PRS	Filter system	Active	0		NFA
019(k)	21-019(k)	21-019(k)	21	AOC/PRS	Filter system	Inactive	0		NFA
019(l)	21-019(l)	21-019(l)	21	AOC/PRS	Filter system	Inactive	0		NFA
019(m)	21-019(m)	21-019(m)	21	AOC/PRS	Filter system	Active	0		NFA
20(a)	21-020(a)	21-020(a)	21	AOC/PRS	Filter system	Decommissioned	0		NFA
20(b)	21-020(b)	21-020(b)	21	AOC/PRS	Filter system	Decommissioned	0		NFA
21	21-021	21-021	21	HSWA	Systematic realease site	Active	0		NFA
22(a)	21-022(a)	21-022(a)	21	HSWA	Waste lines	Decommissioned	3	Rad, hazardous const.	IS,IC
22(b)	21-022(b)	21-022(b)	21	HSWA	Waste lines	Decommissioned	188	Rad, hazardous const.	IS,IC
22(c)	21-022(c)	21-022(c)	21	HSWA	Waste lines	Decommissioned	217	Rad, hazardous const.	IS,IC
22(d)	21-022(d)	21-022(d)	21	HSWA	Waste lines	Decommissioned	173	Rad, hazardous const.	IS,IC
22(e)	21-022(e)	21-022(e)	21	HSWA	Waste lines	Decommissioned	193	Rad, hazardous const.	IS,IC
22(f)	21-022(f)	21-022(f)	21	HSWA	Waste lines	Decommissioned	175	Rad, hazardous const.	IS,IC
22(g)	21-022(g)	21-022(g)	21	HSWA	Waste lines	Decommissioned	21	Rad, hazardous const.	IS,IC
22(h)	21-022(h)	21-022(h)	21	HSWA	Waste lines	Decommissioned	7	Rad, hazardous const.	IS,IC
	21-022(i)	21-022(i)	21	HSWA PM	Tank and/or assoc. equipment	Decommissioned	9	Rad, hazardous const.	IS,IC
	21-022(j)	21-022(j)	21	HSWA PM	Tank and/or assoc. equipment	Decommissioned	9	Rad, hazardous const.	Del. D&D

88 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
001(a)	6-001(a)	6-001(a)	6	HSWA	Septic system	Inactive	6	Rad, Hazardous const., HE	CARBC
001(b)	6-001(b)	6-001(b)	6	HSWA	Septic system	Inactive	5	Rad, Hazardous const., HE	CARBC
002	6-002	6-002	6	HSWA	Septic system	Decommissioned	6	Hazardous const., HE	CARBC
003(a)	6-003(a)	6-003(a)	6	HSWA PM	Firing site	Inactive	2327	Rad, hazardous const., HE	CARBC
003(b)	6-003(b)	6-003(b)	6	AOC/PRS	Firing site	Inactive	0		Rec NFA
003(c)	6-003(c)	6-003(c)	6	HSWA	Firing site	Inactive	7	Rad, hazardous const., HE	CARBC
003(d)	6-003(d)	6-003(d)	6	HSWA PM	Firing site	Inactive	101	Hazardous const., HE	CARBC
003(e)	6-003(e)	6-003(e)	6	HSWA PM	Firing site	Inactive	93	Hazardous const., HE	CARBC
		6-003(f)	6	HSWA PM	Firing site	Inactive	10	Rad, hazardous const., HE	CARBC
	C-6-002	6-003(g)	6	HSWA PM	Firing site & building	Inactive	37	Hazardous const., HE	CARBC
		6-003(h)	6	HSWA PM	Firing site	Inactive	100	Hazardous const., HE	CARBC
004	6-004	6-004	6	AOC/PRS	Sump	Nonexistent	0		Rec NFA
005	6-005	6-005	6	HSWA PM	Firing site	Decommissioned	96	Rad, hazardous const., HE	IS:1C
006	6-006	6-006	6	HSWA	Storage area	Inactive	222	Hazardous const., other	CARBC
007	6-007(a)	6-007(a)	6	007 HSWA	Material disposal area	Inactive	1222	Rad, hazardous const., HE	IS:1C
007	6-007(b)	6-007(b)	6	HSWA PM	Landfill	Inactive	622	Rad, hazardous const., HE	IS:1C
007	6-007(c)	6-007(c)	6	HSWA PM	Landfill	Inactive	8	Rad, hazardous const., HE	IS:1C
007	6-007(d)	6-007(d)	6	HSWA PM	Landfill	Inactive	1	Rad, hazardous const., HE	IS:1C
007	6-007(e)	6-007(e)	6	HSWA PM	Landfill	Inactive	44	Rad, hazardous const., HE	IS:1C
007	6-007(f)	6-007(f)	6	HSWA PM	Surface disposal	Inactive	2	Rad, hazardous const., HE	CARBC
	C-6-004	6-007(g)	6	HSWA PM	Building & surface disposal	Inactive	37	Rad, hazardous const., HE	CARBC
	6-008	6-008	6	AOC/PRS	Underground tank	Decommissioned	10	Rad, hazardous const., HE	CARBC
	C-6-001	C-6-001	6	AOC/PRS	Building	Removed	37	Hazardous const., HE	CARBC
	C-6-002	C-6-002	Renumbered 6-003(g)				0		NFA
	C-6-003	C-6-003	6	AOC/PRS	Building	Removed	370	Hazardous const., HE	CARBC
	C-6-004	C-6-004	Renumbered 6-007(g)				0		NFA
	C-6-005	C-6-005	6	AOC/PRS	Building	Removed	370	Hazardous const., HE	CARBC
	C-6-006	C-6-006	6	AOC/PRS	Building	Removed	370	Hazardous const., HE	CARBC
	C-6-007	C-6-007	6	AOC/PRS	Building	Removed	370	Hazardous const.	CARBC

PRS Data fpr
Operable Unit 1111

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	22-014(c)	22-014(c)	22	AOC/PRS	Unit does not exist				
22-006	22-015(a)	22-015(a)	22	006 HSWA	Drain lines and dry wells	Inactive	0		Rec NFA
22-007	22-015(b)	22-015(b)	22	007 HSWA	Sump and outfall	Inactive	52	Hazardous const.	CARBC
22-008	22-015(c)	22-015(c)	22	008 HSWA	Outfall	Inactive	2	Hazardous const., HE	CARBC
22-009	22-015(d)	22-015(d)	22	009 HSWA	Drain line and outfall	Inactive	1	Hazardous const.	CARBC
	22-015(e)	22-015(e)	22	HSWA PM	Ind. or san. waste water treat.	Inactive	2	Hazardous const., HE	CARBC
22-010(a)	22-016	22-016	22	010a HSWA	Septic system	Inactive	0	Hazardous const., HE	CARBC
22-010(b)	22-010(a)	22-010(a)	22	010b HSWA	Septic system	Inactive	17	Rad, hazardous const., HE	CARBC
22-010(c)	22-010(c)	22-010(c)	22	010c HSWA	Septic system	Inactive	7	Rad, hazardous const.	CARBC
22-011	22-011	22-011	22	HSWA	Disposal pit	Nonexistent	43	Rad, hazardous const., HE	CARBC
22-012	22-012	22-012	22	HSWA PM	Decontamination facility	Inactive	0		Rec NFA
2-013	22-013	22-013	22	RCRA	Aboveground tanks	Active	2	Hazardous const., HE	CARBC
0-001(a)	40-001(a)	40-001(a)	40	HSWA	Septic system	Nonexistent	0		Rec NFA
0-001(b)	40-001(b)	40-001(b)	40	HSWA	Septic system	Active	0		Rec NFA
0-001(c)	40-001(c)	40-001(c)	40	HSWA	Septic system	Active	6	Hazardous const., HE	CARBC
0-002(a)	40-002(a)	40-002(a)	40	RCRA	Storage area	Active	3	Hazardous const., HE	CARBC
0-002(b)	40-002(b)	40-002(b)	40	RCRA	Storage area	Active	0		Rec NFA
	40-002(c)	40-002(c)	40	RCRA	Storage area	Active	0		Rec NFA
-003(a)	40-003(a)	40-003(a)	40	RCRA	Firing site	Inactive	0		Rec NFA
-003(b)	40-003(b)	40-003(b)	40	RCRA	Firing site	Inactive	0		Rec NFA
-004	40-004	40-004	40	HSWA	Oper. release	Decommissioned	0		Rec NFA
005	40-005	40-005	40	HSWA	Sump	Active	10	Hazardous const.	CARBC
006(a)	40-006(a)	40-006(a)	40	HSWA	Firing site	Active	5	Hazardous const., HE	CARBC
006(b)	40-006(b)	40-006(b)	40	HSWA	Firing site	Active	3	Rad, hazardous const., HE	Def. D&D
006(c)	40-006(c)	40-006(c)	40	HSWA	Firing site	Active	1	Rad, hazardous const., HE	Def. D&D
007(a)	40-007(a)	40-007(a)	40	RCRA	Storage area	Active	1	Rad, hazardous const., HE	Def. D&D
007(b)	40-007(b)	40-007(b)	40	RCRA	Storage area	Active	26	Hazardous const., HE	Def. D&D
007(c)	40-007(c)	40-007(c)	40	RCRA	Storage area	Active	1	Hazardous const., HE	Def. D&D
007(d)	40-007(d)	40-007(d)	40	RCRA	Storage area	Active	17	Hazardous const., HE	Def. D&D
							15	Hazardous const., HE	Def. D&D

1988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
3-001(a)	3-001(a)	3-001(a)	3	HSWA	Satellite storage	Active	0		Rec NFA
3-001(b)	3-001(b)	3-001(b)	3	HSWA	Satellite storage	Active	0		Rec NFA
3-001(c)	3-001(c)	3-001(c)	3	HSWA	<90 day storage	Active	0		Rec NFA
3-001(d)	3-001(d)	3-001(d)	3	AOC/PRS	Satellite storage	Active	0		NFA
3-001(e)	3-001(e)	3-001(e)	3	AOC/PRS	<90 day storage	Active	0		NFA
3-001(f)	3-001(f)	3-001(f)	3	AOC/PRS	Satellite storage	Active	0		NFA
3-001(g)	60-001(a)								
3-001(h)	60-001(b)								
3-001(i)	3-001(g)	3-001(g)	3	AOC/PRS	Satellite storage	Active	0		NFA
3-001(j)	3-001(h)	3-001(h)	3	AOC/PRS	Satellite storage	Active	0		NFA
3-001(k)	3-001(i)	3-001(i)	3	AOC/PRS	Satellite storage	Decommissioned	1	Hazardous const.	CARBC
3-001(k)	3-056(b)								
3-001(l)	3-001(j)	3-001(j)	3	AOC/PRS	Satellite storage	Active	0		NFA
3-001(m)	3-001(k)	3-001(k)	3	001(m)HSWA	Satellite storage	Active	0		Rec NFA
3-001(n)	3-001(l)	3-001(l)	3	AOC/PRS	<90 day storage	Active	0		NFA
3-001(o)	3-001(m)	3-001(m)	3	AOC/PRS	Satellite storage	Active	1	Hazardous const.	CARBC
3-001(s)	3-056(d)								
3-001(t)	3-056(e)								
3-001(u)	3-056(h)								
	3-001(n)	3-001(n)	3	AOC/PRS	Satellite storage	Removed	0		NFA
	3-001(o)	3-001(o)	3	AOC/PRS	Satellite storage	Decommissioned	0		NFA
	3-001(p)	3-001(p)	3	AOC/PRS	Satellite storage	Active	0		Rec NFA
	3-001(q)	3-001(q)	3	AOC/PRS	Satellite storage	Removed	0		NFA
	3-001(r)	3-001(r)	3	AOC/PRS	Satellite storage	Active	0		Rec NFA
	3-001(s)	3-001(s)	3	AOC/PRS	Satellite storage	Active	0		NFA
	3-001(t)	3-001(t)	3	AOC/PRS	Satellite storage	Inactive	0		Rec NFA
	3-001(u)	3-001(u)	3	AOC/PRS	Satellite storage	Removed	0		NFA
	3-001(v)	3-001(v)	3	AOC/PRS	Satellite storage	Active	0		NFA
	3-001(w)	3-001(w)	3	AOC/PRS	Satellite storage	Active	0		NFA

PRS Data for Operable Unit 1114

88 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
008(a)	3-008(a)	3-008(a)	3	AOC/PRS	Firing site	Decommissioned	0		NFA
008(b)	3-008(b)	3-008(b)	3	AOC/PRS	Firing site	Decommissioned	0		NFA
009(a)	3-009(a)	3-009(a)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
009(b)	3-009(b)	3-009(b)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
009(c)	3-009(c)	3-009(c)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(d)	3-009(d)	3-009(d)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(e)	3-009(e)	3-009(e)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(f)	3-009(f)	3-009(f)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(g)	3-009(g)	3-009(g)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(h)	3-009(h)	3-009(h)	3	HSWA	Surface disposal	Inactive	0		Rec NFA
09(h)	60-002*				*part of 3-009(h) became 60-002				Rec NFA
	3-009(i)	3-009(i)	3	HSWA PM	Surface disposal site	Inactive	0		NFA
	3-009(j)	3-009(j)	3	HSWA PM	Surface disposal site	Inactive	0		NFA
10	3-010(a)	3-010(a)	3	010 HSWA	Systematic release site	Inactive	20	Rad, hazardous const.	CARBC
	3-010(b)	3-010(b)	3	AOC/PRS	Operational release	Inactive	0		Rec NFA
	3-010(c)	3-010(c)	3	AOC/PRS	Operational release	Inactive	0		Rec NFA
	3-010(d)	3-010(d)	3	AOC/PRS	Operational release	Inactive	0		Rec NFA
1	3-011	3-011	3	HSWA PM	Systematic product release	Inactive	0		NFA
2(a)	3-012(a)	3-012(a)	3	HSWA	One-time spill	Inactive	0		Rec NFA
2(b)	3-012(b)	3-012(b)	3	HSWA	Operational release and outfall	Inactive	150	Rad, hazardous const.	CARBC
3	3-013(a)	3-013(a)	3	013 HSWA	Operational release	Active	33	Hazardous const.	CARBC
3	3-013(b)	3-013(b)	3	013 HSWA	Operational release	Active	53	Hazardous const.	CARBC
3	3-013(c)	3-013(c)	3	HSWA PM	Operational release	Inactive	0		Rec NFA
	3-013(d)	3-013(d)	3	AOC/PRS	Operational release	Active	0		Rec NFA
	3-013(e)	3-013(e)	3	HSWA PM	Operational release	Active	0		Rec NFA
	3-013(f)	3-013(f)	3	AOC/PRS	Operational release	Inactive	0		Rec NFA
	3-013(g)	3-013(g)	3	HSWA PM	Operational release	Inactive	0		Rec NFA
	3-013(h)	3-013(h)	3	AOC/PRS	Operational release	Active	0		Rec NFA
4(a)	3-014(a)	3-014(a)	3	HSWA	Waste water treatment facility	Active	46	Rad, hazardous const	Def. D&D

PRS Data for Operable Unit 1114

988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
016(a)	3-016(a)	3-016(a)	3	AOC/PRS	Septic system	Active	0		NFA
016(b)	3-016(a)								
016(c)	60-006(a)								
016(d)	60-006(a)								
017(c)	3-016(b)	3-016(b)	3	AOC/PRS	Septic system	Active	0		NFA
017(a)	3-016(c)	3-016(c)	3	AOC/PRS	Septic system	Active	0		NFA
	3-016(d)	3-016(d)	3	AOC/PRS	Septic system	Active	0		NFA
	3-016(e)	3-016(e)	3	AOC/PRS	Septic system	Active	0		NFA
		3-016(f)	3	AOC/PRS	Septic system	Active	0		NFA
17(b)	61-004(a)								
17(c)	3-016(b)								
8	3-018	3-018	3	HSWA	Septic system	Inactive	0		Rec NFA
9	3-019	3-019	3	HSWA PM	Septic tank	Decommissioned	0		NFA
0	3-020(a)	3-020(a)	3	020 HSWA	Disposal pit	Inactive	0		Rec NFA
	3-020(b)	3-020(b)	3	HSWA PM	Surface disposal site	Inactive	0		Rec NFA
1	3-021	3-021	3	HSWA PM	Surface disposal site	Inactive	10	Hazardous const.	CARBC
2	3-022	3-022	3	AOC/PRS	Sump	Active	198	Hazardous const.	Def. D&D
3	3-023	3-023	3	AOC/PRS	Sump	Inactive	2	Hazardous const.	CARBC
	3-024	3-024	3	HSWA PM	Tank and/or assoc. equipment	Active	0		NFA
(a)	3-025(a)	3-025(a)	3	HSWA PM	Tank and/or assoc. equipment	Active	0		NFA
(b)	3-025(b)	3-025(b)	3	HSWA PM	Tank and/or assoc. equipment	Active	0		NFA
	3-025(c)	3-025(c)	3	AOC/PRS	Tank and/or assoc. equipment	Active	10	Rad, hazardous const.	Def. D&D
	3-026(a)	3-026(a)	3	AOC/PRS	Sump	Active	22	Hazardous const.	Def. D&D
	3-026(b)	3-026(b)	3	HSWA PM	Sumps	Active	8	Hazardous const.	Def. D&D
	3-026(c)	3-026(c)	3	HSWA PM	Tank and/or assoc. equipment	Active	0		NFA
	3-026(d)	3-026(d)	3	HSWA PM	Tank and/or assoc. equipment	Active	1	Hazardous const.	Def. D&D
a)	60-003								
b)	3-027	3-027	3	AOC/PRS	Separation site	Active	0		NFA
	3-028	3-028	3	HSWA	Surface impoundment	Active	0		Rec NFA

PRS Data for Operable Unit 1114

1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
3-038(e)	3-038(e)	3	AOC/PRS	Waste lines	Inactive	0		NFA
3-038(f)	3-038(f)	3	AOC/PRS	Waste lines	Inactive	0		NFA
3-039(a)	3-039(a)	3	039 HSWA	Silver recovery unit	Inactive	0		Rec NFA
3-039(b)	3-039(b)	3	AOC/PRS	Silver recovery unit	Active	0		Rec NFA
3-039(c)	3-039(c)	3	AOC/PRS	Silver recovery unit	Inactive	0		Rec NFA
3-039(d)	3-039(d)	3	AOC/PRS	Silver recovery unit	Active	0		Rec NFA
3-039(e)	3-039(e)	3	AOC/PRS	Silver recovery unit	Inactive	0		Rec NFA
3-040(a)	3-040(a)	3	AOC/PRS	Storage area	Active	0		NFA
3-040(b)	3-040(b)	3	AOC/PRS	Storage area	Decommissioned	0		NFA
3-041	3-041	3	AOC/PRS	Underground tank	Unused	0		NFA
3-042	3-042	3	AOC/PRS	Sump	Removed	1	Hazardous const.	CARBC
3-043(a)	3-043(a)	3	AOC/PRS	Aboveground tank	Removed	0		NFA
3-043(b)	3-043(b)	3	AOC/PRS	Aboveground tank	Removed	0		NFA
3-043(c)	3-043(c)	3	HSWA PM	Tank and/or assoc. equipment	Decommissioned	0		NFA
3-043(d)	3-043(d)	3	AOC/PRS	Aboveground tank	Decommissioned	0		NFA
a) 3-043(e)	3-043(e)	3	035(a)HSWA	Underground tank	Decommissioned	0		NFA
3-043(f)	3-043(f)	3	AOC/PRS	Aboveground tank	Decommissioned	0		NFA
3-043(g)	3-043(g)	3	AOC/PRS	Aboveground tank	Decommissioned	0		NFA
3-043(h)	3-043(h)	3	AOC/PRS	Aboveground tank	Decommissioned	0		NFA
3-043(i)	3-043(i)	3	AOC/PRS	Aboveground tank	Removed	0		NFA
3-044(a)	3-044(a)	3	044 HSWA	Container storage	Decommissioned	0		Rec NFA
3-044(b)	3-044(b)	3	AOC/PRS	Container storage	Decommissioned	0		Rec NFA
3-045(a)	3-045(a)	3	HSWA PM	Ind. or san. waste water treatm	Removed	100	Hazardous const.	CARBC
3-045(b)	3-045(b)	3	HSWA PM	Ind. or san. waste water treatm	Inactive	100	Hazardous const.	CARBC
3-045(c)	3-045(c)	3	HSWA PM	Ind. or san. waste water treatm	Inactive	100	Hazardous const.	CARBC
3-045(d)	3-045(d)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
3-045(e)	3-045(e)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
3-045(f)	3-045(f)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
3-045(g)	3-045(g)	3	HSWA PM	Ind. or san. waste water treatm	Decommissioned	0		NFA

PRS Data for Operable Unit 1114

88 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	3-051(c)	3-051(c)	3	AOC/PRS	Soil contamination	Active	0		NFA
	3-051(d)	3-051(d)	3	AOC/PRS	Soil contamination	Active	0		NFA
	3-052(a)	3-052(a)	3	HSWA PM	Ind. or san. waste water treatm	Active	26	Hazardous const.	CARBC
	3-052(b)	3-052(b)	3	AOC/PRS	Storm drainage	Active	20	Hazardous const.	CARBC
	3-052(c)	3-052(c)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
	3-052(d)	3-052(d)	3	AOC/PRS	Storm drainage	Active	0		NFA
	3-052(e)	3-052(e)	3	HSWA PM	Ind. or san. waste water treatm	Active	5	Hazardous const.	CARBC
	3-052(f)	3-052(f)	3	HSWA PM	Ind. or san. waste water treatm	Active	5	Hazardous const.	CARBC
	3-053	3-053	3	AOC/PRS	Operational facility	Active	14	Rad, hazardous const.	Def. D&D
	3-054(a)	3-054(a)	3	HSWA PM	Ind. or san. waste water treatm	Inactive	0		NFA
	3-054(b)	3-054(b)	3	HSWA PM	Ind. or san. waste water treatm	Active	5	Hazardous const.	CARBC
	3-054(c)	3-054(c)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
	3-054(d)	3-054(d)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
	3-054(e)	3-054(e)	3	HSWA PM	Ind. or san. waste water treatm	Active	5	Hazardous const.	CARBC
	3-055(a)	3-055(a)	3	HSWA PM	Ind. or san. waste water treatm	Inactive	0		NFA
	3-055(b)	3-055(b)	3	AOC/PRS	Outfall	Inactive	0		Rec NFA
	3-055(c)	3-055(c)	3	HSWA PM	Ind. or san. waste water treatm	Active	0		NFA
	3-055(d)	3-055(d)	3	HSWA PM	Ind. or san. waste water treatm	Inactive	0		NFA
1(p)	3-056(a)	3-056(a)	3	001(p)HSWA	Storage area	Active	23	Hazardous const.	Def. D&D
1(k)	3-056(b)	3-056(b)	3	AOC/PRS	Storage area	Active	0		Rec NFA
1(r)	3-056(c)	3-056(c)	3	001(r)HSWA	Storage area	Inactive	1	Hazardous const., other	CARBC
1(s)	3-056(d)	3-056(d)	3	HSWA PM	Container storage area	Active	0		NFA
1(t)	3-056(e)	3-056(e)	3	AOC/PRS	Storage area	Unknown	0		NFA
1(n)	3-056(f)	3-056(f)	3	AOC/PRS	Storage area	Unknown	0		NFA
	3-056(g)	3-056(g)	3	AOC/PRS	Storage area	Active	0		NFA
(u)	3-056(h)	3-056(h)	3	AOC/PRS	Storage area	Inactive	0		NFA
	3-056(i)	3-056(i)	3	AOC/PRS	Storage area	Unknown	0		NFA
	3-056(j)	3-056(j)	3	AOC/PRS	Storage area	Unknown	0		NFA
	3-056(k)	3-056(k)	3	AOC/PRS	Storage area	Unknown	0		NFA

PRS Data for
Operable Unit 1114

#	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
1	59-001	59-001	59	HSWA	Septic system	Decommissioned	0		Rec NFA
2	59-002	59-002	59	AOC/PRS	Container storage area	Active	0		Rec NFA
3	59-003	59-003	59	HSWA PM	Tank and/or assoc. equip.	Active	0		Rec NFA
	59-004	59-004	59	AOC/PRS	Outfall	Active	37	Rad, hazardous const.	CARBC
	C-59-001	C-59-001	59	AOC/PRS	Transformer	Active	0		NFA
g)	60-001(a)	60-001(a)	60	AOC/PRS	Storage area	Active	0		Rec NFA
h)	60-001(b)	60-001(b)	60	AOC/PRS	Storage area	Active	0		Rec NFA
	60-001(c)	60-001(c)	60	AOC/PRS	Storage area	Active	0		Rec NFA
	60-001(d)	60-001(d)	60	AOC/PRS	Storage area	Active	0		Rec NFA
h)	60-002	60-002	60	009(h)HSWA	Surface disposal	Active	0		Rec NFA
a)	60-003	60-003	60	AOC/PRS	Oil-water separator	Active	0		Rec NFA
a)	60-004(a)	60-004(a)	60	AOC/PRS	Storage area	Active	0		Rec NFA
b)	60-004(b)	60-004(b)	60	AOC/PRS	Storage area	Inactive	10	Hazardous const.	CARBC
c)	60-004(c)	60-004(c)	60	AOC/PRS	Storage area	Inactive	3	Hazardous const., other	CARBC
	60-004(d)	60-004(d)	60	AOC/PRS	Storage area	Inactive	10	Hazardous const.	CARBC
	60-004(e)	60-004(e)	60	AOC/PRS	Storage area	Active	10	Hazardous const., other	CARBC
a)	60-005(a)	60-005(a)	60	029(a)HSWA	Surface impoundment	Inactive	124	Rad, hazardous const.	CARBC
a)	60-005(b)	60-005(b)	60	AOC/PRS	Surface impoundment	Inactive	0		Rec NFA
c)	60-006(a)	60-006(a)	60	HSWA PM	Septic tank	Active	5	Hazardous const.	CARBC
	60-006(b)	60-006(b)	60	AOC/PRS	Septic system	Inactive	0		Rec NFA
	60-006(c)	60-006(c)	60	HSWA PM	Septic tank	Active	0		Rec NFA
	60-007(a)	60-007(a)	60	HSWA PM	Systematic or intent. prod. relea	Inactive	1	Hazardous const.	CARBC
	60-007(b)	60-007(b)	60	HSWA PM	Systematic or intent. prod. relea	Inactive	6	Hazardous const., other	CARBC
	C-60-001	C-60-001	60	AOC/PRS	Underground tank	Removed	0		NFA
	C-60-002	C-60-002	60	AOC/PRS	Underground tank	Removed	0		NFA
	C-60-003	C-60-003	60	AOC/PRS	One-time spill	Inactive	0		NFA
	C-60-004	C-60-004	60	AOC/PRS	Underground tank	Removed	0		NFA
	C-60-005	C-60-005	60	AOC/PRS	Storage area	Active	2	Hazardous const.	CARBC
(q)	61 001	61-001	61	AOC/PRS	Storage area	Active	0		Rec NFA

PRS Data for Operable Unit 1122

8 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
001(a)	33-001(a)	33-001(a)	33	HSWA	Material disposal area	Inactive	292	Rad, hazardous const.	CARBC
001(b)	33-001(b)	33-001(b)	33	HSWA	Material disposal area	Inactive	175	Rad, hazardous const.	CARBC
001(c)	33-001(c)	33-001(c)	33	HSWA	Material disposal area	Inactive	4	Rad, hazardous const.	CARBC
001(d)	33-001(d)	33-001(d)	33	HSWA	Material disposal area	Inactive	389	Rad, hazardous const.	CARBC
001(e)	33-001(e)	33-001(e)	33	HSWA	Material disposal area	Inactive	0		NFA
	33-001misc	33-001misc			Unit does not exist		0		NFA
002(a)	33-002(a)	33-002(a)	33	HSWA	Septic tank	Active	157	Rad, hazardous const.	CARBC
002(b)	33-002(b)	33-002(b)	33	HSWA	Sump	Inactive	203	Rad, hazardous const.	CARBC
002(c)	33-002(c)	33-002(c)	33	HSWA	Sump	Inactive	203	Rad, hazardous const.	CARBC
	33-002(d)	33-002(d)	33	HSWA PM	Drain line and outfall	Inactive	1	Rad, hazardous const.	CARBC
	33-002(e)	33-002(e)	33	HSWA PM	Drain line and outfall	Active	1	Rad, hazardous const.	CARBC
03(a)	33-003(a)	33-003(a)	33	HSWA	Material disposal area	Inactive	0		NFA
03(b)	33-003(b)	33-003(b)	33	HSWA	Material disposal area	Inactive	0		NFA
04(a)	33-004(a)	33-004(a)	33	HSWA	Septic system	Active	0		NFA
04(b)	33-004(b)	33-004(b)	33	HSWA	Septic system	Active	0		NFA
04(c)	33-004(c)	33-004(c)	33	HSWA	Septic system	Active	0		NFA
04(d)	33-004(d)	33-004(d)	33	HSWA	Septic system	Inactive	0		NFA
04(e)	33-004(e)	33-004(e)	33	HSWA	Seepage pit	Inactive	0		Rec NFA
04(f)	33-004(f)	33-004(f)	33	HSWA	Septic system	Inactive	0		Rec NFA
	33-004(g)	33-004(g)	33	HSWA PM	Outfall	Inactive	0		NFA
	33-004(h)	33-004(h)	33	HSWA PM	Outfall	Inactive	0		NFA
	33-004(i)	33-004(i)	33	HSWA PM	Outfall	Inactive	0		NFA
	33-004(j)	33-004(j)	33	HSWA PM	Outfall	Inactive	0		NFA
	33-004(k)	33-004(k)	33	HSWA PM	Outfall	Inactive	0		NFA
	33-004(l)	33-004(l)	33	AOC/PRS	Outfall	Inactive	0		Rec NFA
	33-004(m)	33-004(m)	33	HSWA PM	Septic system	Active	0		NFA
	33-004(n)	33-004(n)	33	AOC/PRS	Septic system	Inactive	0		Rec NFA
	33-004misc	33-004misc			Unit does not exist		0		NFA
5(a)	33-005(a)	33-005(a)	33	HSWA PM	Septic system	Decommissioned	0		NFA

PRS Data for Operable Unit 1122

1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
33-015	33-015	33	HSWA PM	Incinerator	Inactive	0		NFA
33-016	33-016	33	HSWA PM	Sump	Inactive	0		NFA
33-017	33-017	33	HSWA	Operational release	Inactive	0		NFA
C-33-001	C-33-001	33	AOC/PRS	Transformer	Active	0		NFA
C-33-002	C-33-002	33	AOC/PRS	Transformer	Inactive	0		NFA

003(e)	35-003(e)	35-003(e)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(f)	35-003(f)	35-003(f)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(g)	35-003(g)	35-003(g)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(h)	35-003(h)	35-003(h)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const	CARBC
003(i)	35-003(i)	35-003(i)	35	HSWA	Waste water treatment facility	Removed	0		Rec NFA
003(j)	35-003(j)	35-003(j)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(k)	35-003(k)	35-003(k)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(l)	35-003(l)	35-003(l)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
003(m)	35-003(m)	35-003(m)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
03(n)	35-003(n)	35-003(n)	35	HSWA	Waste water treatment facility	Inactive	3800	Rad, Hazardous Const.	CARBC
03(o)	35-003(o)	35-003(o)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
03(p)	35-003(p)	35-003(p)	35	HSWA	Waste water treatment facility	Decommissioned	0		Rec NFA
03(q)	35-003(q)	35-003(q)	35	HSWA	Waste water treatment facility	Removed	3800	Rad, Hazardous Const.	CARBC
	35-003(r)	35-003(r)	35	AOC/PRS	Outfall	Inactive	3986	Rad, Hazardous Const.	CARBC
04(a)	35-004(a)	35-004(a)	35	HSWA PM	Storage areas	Active/Inactive	1	Hazardous Const.	CARBC
04(b)	35-004(b)	35-004(b)	35	HSWA PM	Storage areas	Active/Inactive	1	Hazardous Const.	CARBC
04(c)	35-004(c)	35-004(c)	35	HSWA PM	Storage areas	Active/Inactive	0		Rec NFA
04(d)	35-004(d)	35-004(d)	35	HSWA PM	Container storage area	Active	0		Rec NFA
04(e)	35-004(e)	35-004(e)	35	HSWA	Container storage area	Active	0		Rec NFA
04(f)	35-004(f)	35-004(f)	35	AOC/PRS	Container storage area	Inactive	0		Rec NFA
04(g)	35-004(g)	35-004(g)	35	HSWA PM	Container storage area	Active	1	Hazardous Const.	CARBC
04(h)	35-004(h)	35-004(h)	35	HSWA PM	Container storage area	Inactive	1	Hazardous Const.	CARBC
04(i)	35-004(i)	35-004(i)	35	AOC/PRS	Container storage area	Inactive	0		Rec NFA
04(j)	35-004(j)	35-004(j)	35	AOC/PRS	Container storage area	Active	0		Rec NFA
	35-004(k)	35-004(k)	35	AOC/PRS	Container storage area	Active	0		Rec NFA
	35-004(l)	35-004(l)	35	AOC/PRS	Container storage area	Inactive	0		Rec NFA
	35-004(m)	35-004(m)	35	AOC/PRS	Container storage area	Inactive	1	Hazardous Const.	CARBC
	35-004(n)	35-004(n)	35	AOC/PRS	Container storage area	Active	0		Rec NFA
	35-004(o)	35-004(o)	35	AOC/PRS	Container storage area	Active	0		Rec NFA
5(a)	35-005(a)	35-005(a)	35	RCRA	Surface impoundment	Decommissioned	0		Rec NFA
5(b)	35-005(b)	35-005(b)	35	RCRA	Surface impoundment	Decommissioned	0		Rec NFA

PRS Data for
Operable Unit 1129

)	35-015(b)	35-015(b)	35	HSWA	Waste oil treatment	Decommissioned	556	Hazardous Const.	CARBC
	35-016(a)	35-016(a)	35	HSWA PM	Drains and outfalls	Inactive	47	Hazardous Const.	CARBC
	35-016(b)	35-016(b)	35	AOC/PRS	Outfall	Active	47	Hazardous Const.	CARBC
	35-016(c)	35-016(c)	35	HSWA PM	Outfall	Inactive	47	Hazardous Const.	CARBC
	35-016(d)	35-016(d)	35	HSWA PM	Outfall	Inactive	47	Hazardous Const.	CARBC
	35-016(e)	35-016(e)	35	AOC/PRS	Outfall	Inactive	93	Hazardous Const.	CARBC
	35-016(f)	35-016(f)	35	AOC/PRS	Storm drain	Active	94	Hazardous Const.	CARBC
	35-016(g)	35-016(g)	35	AOC/PRS	Outfall	Active	93	Hazardous Const.	CARBC
	35-016(h)	35-016(h)	35	AOC/PRS	Storm drain	Active	101	Hazardous Const.	CARBC
	35-016(i)	35-016(i)	35	HSWA PM	Drains and outfalls	Active	94	Hazardous Const.	CARBC
	35-016(j)	35-016(j)	35	AOC/PRS	Storm drain	Active	48	Hazardous Const.	CARBC
	35-016(k)	35-016(k)	35	HSWA PM	Drains and outfalls	Inactive	46	Hazardous Const.	CARBC
	35-016(l)	35-016(l)	35	AOC/PRS	Storm drain	Active	48	Rad, Hazardous Const.	CARBC
	35-016(m)	35-016(m)	35	HSWA PM	Drains and outfalls	Inactive	93	Hazardous Const.	CARBC
	35-016(n)	35-016(n)	35	AOC/PRS	Storm drain	Active	48	Hazardous Const.	CARBC
	35-016(o)	35-016(o)	35	HSWA PM	Drains and outfalls	Active	96	Hazardous Const.	CARBC
	35-016(p)	35-016 (p)	35	HSWA PM	Outfall	Active	93	Hazardous Const.	CARBC
	35-016(q)	35-016(q)	35	HSWA PM	Drains and outfalls	Active	315	Rad, Hazardous Const.	CARBC
	35-017	35-017	35	AOC/PRS	Soil contamination from Reactor	Decommissioned	1157	Rad, Hazardous Const.	CARBC
	35-018(a)	35-018(a)	35	AOC/PRS	Transformer	Unknown	0		Rec NFA
	35-018(b)	35-018(b)	35	AOC/PRS	Transformer	Removed	0		Rec NFA
	C-35-001	C-35-001	35	AOC/PRS	Former underground storage tank	Removed	0		Rec NFA
	C-35-002	C-35-002	35	AOC/PRS	Former underground storage tank	Removed	0		Rec NFA
	C-35-003	C-35-003	35	AOC/PRS	Former underground storage tank	Removed	0		Rec NFA
	C-35-004	C-35-004	35	AOC/PRS	Oil spill	Cleaned	0		Rec NFA
	C-35-005	C-35-005	35	AOC/PRS	Oil spill	Cleaned	0		Rec NFA
	C-35-006	C-35-006	35	AOC/PRS	Organic spill	Removed	0		Rec NFA
	C-35-007	C-35-007	35	AOC/PRS	Unknown spill	Unknown	0	Rad, Hazardous Const., othe	CARBC
	C-35-008	C-35-008	35	AOC/PRS	Leaking transformer	Unknown	0		Rec NFA
a)	42-001(a)	42-001(a)	42	HSWA PM	Incinerator complex	Decommissioned	3161	Rad, Hazardous Const.	CARBC
b)	42-001(b)	42-001 (b)	42	HSWA PM	Incinerator complex	Decommissioned	14	Rad, Hazardous Const	CARBC

-001(b)	52-001(b)	52-001(b)	52	HSWA	Uthrex equip.	Decommissioned	0		Rec NFA
-001(c)	52-001(c)	52-001(c)	52	HSWA	Uthrex equip.	Decommissioned	0		Rec NFA
001(d)	52-001(d)	52-001(d)	52	HSWA	Uthrex equip.	Inactive	0		Rec NFA
002(a)	52-002(a)	52-002(a)	52	HSWA	Septic system	Active	14	Rad, hazardous const.	CARBC
002(c)	52-002(b)	52-002(b)	52	HSWA	Septic system	Active	0		Rec NFA
002(d)	52-002(c)	52-002(c)	52	HSWA	Septic system	Unknown	0		Rec NFA
002(e)	52-002(d)	52-002(d)	52	HSWA	Septic system	Unknown	0		Rec NFA
002(f)	52-002(e)	52-002(e)	52	HSWA	Septic system	Active	0		Rec NFA
002(h)	52-002(b)	52-002(b)	52	HSWA	Septic system	Active	0		Rec NFA
002(i)	52-002(b)	52-002(b)	52	HSWA	Septic system	Active	0		Rec NFA
002(j)	52-002(f)	52-002(f)	52	HSWA	Septic system	Active	0		Rec NFA
002(k)	63-001(b)	63-001(b)	52	HSWA	Septic system	Active	11	Hazardous Const.	CARBC
	52-002(g)	52-002(g)	52	HSWA PM	Septic system	Active	0		Rec NFA
03	52-003	52-003	52	HSWA PM	Waste treatment facility	Decommissioned	0		Rec NFA
04	52-004	52-004	52	HSWA PM	Evaporator	Inactive	0		Rec NFA
	C-52-001	C-52-001	52	AOC/PRS	Transformer	Active	0		Rec NFA
	C-52-002	C-52-002	52	AOC/PRS	Transformer	Active	0		Rec NFA
01	55-001	55-001	55	AOC/PRS	Cement plant	Active	0		Rec NFA
02	55-002(a)	55-002(a)	55	AOC/PRS	Rad waste storage area	Active	0		Rec NFA
02	55-002(b)	55-002(b)	55	AOC/PRS	Rad waste storage area	Active	0		Rec NFA
		55-002(c)	55	AOC/PRS	Rad waste storage area	Active	0		Rec NFA
03	55-003	55-003	55	AOC/PRS	Containment area	Active	0		Rec NFA
04	55-004	55-004	55	AOC/PRS	Evaporator	Active	0		Rec NFA
05	55-005	55-005	55	AOC/PRS	Filtration Unit	Active	0		Rec NFA
06	55-006	55-006	55	AOC/PRS	Glass Breaker	Active	0		Rec NFA
07	55-007	55-007	55	AOC/PRS	Thermal treatment unit	Active	0		Rec NFA
08	55-008	55-008	55	HSWA PM	Sumps and tanks	Active	0		Rec NFA
9(a)**					**Delisted in 1989				
9(b)**					**Delisted in 1989				
0	55 009	55 009	55	HSWA PM	Sumps and tanks	Unknown	0		Rec NFA
	55 010	55 010	55	AOC/PRS	Solvent spills	Inactive	1	Rad, Hazardous Const.	CARBC

PRS Data for Operable Unit 1130

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	36-001	36-001	36	HSWA	Material disposal area	Inactive	13777	Rad, hazardous const., HE	NFA
	36-002	36-002	36	HSWA	Sump	Active	1	Hazardous const., HE	CARBC
(a)	36-003(a)	36-003(a)	36	HSWA	Septic system	Active	1330	Rad, hazardous const.	IS:IC
(b)	36-003(b)	36-003(b)	36	HSWA	Septic system	Active	0		NFA
(c)	36-003(c)	36-003(c)	36	HSWA	Septic system	Active	0		rec NFA
	36-003(d)	36-003(d)	36	AOC/PRS	Septic system	Active	0		rec NFA
(a)	36-004(a)	36-004(a)	36	AOC/PRS	Firing site	Active	2327	Rad, hazardous const., HE	Def. D&D
(b)	36-004(b)	36-004(b)	36	AOC/PRS	Firing site	Active	2327	Rad, hazardous const., HE	Def. D&D
(c)	36-004(c)	36-004(c)	36	RCRA	Firing site	Active	20943	Rad, hazardous const., HE	Def. D&D
(d)	36-004(d)	36-004(d)	36	AOC/PRS	Firing site	Active	9493	Rad, hazardous const., HE	Def. D&D
(e)	36-004(e)	36-004(e)	36	AOC/PRS	Firing site	Inactive	2327	Rad, hazardous const., HE	Def. D&D
	36-004(f)	36-004(f)	36	AOC/PRS	Firing site	Active	20943	Rad, hazardous const., HE	Def. D&D
5	36-005	36-005	36	HSWA	Surface disposal site	Active	833	Rad, hazardous const.	CARBC
8	36-006	36-006	36	HSWA PM	Surface disposal site	Inactive	139	Hazardous const.	Def. D&D
7(a)	36-007(a)	36-007(a)	36	RCRA	Storage area	Active	0		rec NFA
7(b)	36-007(b)	36-007(b)	36	RCRA	Storage area	Active	0		rec NFA
7(c)	36-007(c)	36-007(c)	36	RCRA	Storage area	Active	0		rec NFA
7(d)	36-007(d)	36-007(d)	36	RCRA	Storage area	Active	0		rec NFA
7(e)	36-007(e)	36-007(e)	36	RCRA	Storage area	Active	8	Hazardous const., HE	rec NFA
7(f)	36-007(f)	36-007(f)	36	RCRA	Storage area	Inactive	8	Hazardous const., HE	rec NFA
8	36-004(c)	36-004(c)		Same as 36-004(c)			0		NFA
(g)	36-009*	27-003	27	Same as 27-003			0		NFA
	C-36-001	C-36-001	36	AOC/PRS	Containment vessel	Inactive	0		Def. D&D
	C-36-002	C-36-002	36	AOC/PRS	Surface disposal	Inactive	0		rec NFA
	C-36-003	C-36-003	36	AOC/PRS	Storm drainages	Active	0		NFA
	C-36-006(e)	C-36-006(e)	36	AOC/PRS	Firing site	Active	2300	Rad, hazardous const., HE	Def D&D

PRS Data for Operable Unit 1132

#	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
D2(g)	39-007(c)	39-007(c)	39	AOC/PRS	Storage area	Inactive	0		Rec NFA
D2(h)	39-007(d)	39-007(d)	39	AOC/PRS	Storage area	Inactive	0		NFA
	39-007(e)	39-007(e)	39	AOC/PRS	Storage area	Inactive	0		Rec NFA
	39-008	39-008	39	AOC/PRS	Firing range	Inactive	0		NFA
	39-009	39-009	39	AOC/PRS	Outfall	Active	0		Rec NFA
	C-39-001	C-39-001	39	AOC/PRS	One-time spill	Removed	0		NFA
	C-39-002	C-39-002	39	AOC/PRS	One-time spill	Removed	0		NFA

PRS Data for Operable Unit 1140

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	46-001	46-001	46	AOC/PRS	Aboveground tank	Inactive	0		Rec NFA
	46-002	46-002	46	HSWA	Surface impoundment	Active	378	Rad, haz. const., other	CARBC
(a)	46-003(a)	46-003(a)	46	HSWA	Septic system	Inactive	0		NFA
(b)	46-003(b)	46-003(b)	46	HSWA	Septic system	Inactive	0		NFA
(c)	46-003(c)	46-003(c)	46	HSWA	Septic system	Inactive	0		NFA
(d)	46-003(d)	46-003(d)	46	HSWA	Septic system	Inactive	7	Rad, haz. const., other	CARBC
(e)	46-003(e)	46-003(e)	46	HSWA	Septic system	Inactive	0		NFA
(f)	46-003(f)	46-003(f)	46	HSWA	Septic system	Inactive	0		NFA
(g)	46-003(g)	46-003(g)	46	HSWA	Septic system	Active	0		NFA
	46-003(h)	46-003(h)	46	HSWA PM	Operational release	Active	0		NFA
(a)	46-004(a)	46-004(a)	46	HSWA	Waste line	Inactive	0		Rec NFA
		46-004(a2)	46	HSWA PM	Outfall	Active	0		NFA
(b)	46-004(b)	46-004(b)	46	HSWA	Operational release	Inactive	0		Rec NFA
		46-004(b2)	46	HSWA PM	Operational release	Active	0		NFA
(c)	46-004(c)	46-004(c)	46	HSWA	Sump	Active	117	Rad, haz. const., other	CARBC
		46-004(c2)	46	HSWA PM	Outfall	Active	0		NFA
(d)	46-004(d)	46-004(d)	46	HSWA	Sump	Active	58	Rad, haz. const., other	CARBC
		46-004(d2)	46	HSWA PM	Stack emissions	Inactive	0		NFA
(e)	46-004(e)	46-004(e)	46	HSWA	Sump	Active	58	Rad, haz. const., other	CARBC
(f)	46-004(f)	46-004(f)	46	HSWA	Outfall	Active	0		NFA
(g)	46-004(g)	46-004(g)	46	HSWA	Outfall/Stack Emissions	Act./Inactive	0		NFA
(h)	46-004(h)	46-004(h)	46	HSWA	Outfall/Stack Emissions	Act./Inactive	0		NFA
	46-004(i)	46-004(i)	46	HSWA PM	Outfall	Inactive	0		Rec NFA
	46-004(j)	46-004(j)	46	HSWA PM	Outfall	Active	0		Rec NFA
	46-004(k)	46-004(k)	46	AOC/PRS	Outfall	Active	0		Rec NFA
	46-004(l)	46-004(l)	46	HSWA PM	Outfall	Inactive	0		Rec NFA
	46-004(m)	46-004(m)	46	HSWA PM	Outfall	Active	0		NFA
	46-004(n)	46-004(n)	46	AOC/PRS	Outfall	Inactive	0		Rec NFA
	46-004(o)	46-004(o)	46	AOC/PRS	Outfall	Active	0		Rec NFA

PRS . . for
Operable Unit 1140

#	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	46-009(b)	46-009(b)	46	HSWA PM	Surface disposal	Inactive	0		NFA
	46-010(a)	46-010(a)	46	AOC/PRS	Storage area	Active	0		Rec NFA
	46-010(b)	46-010(b)	46	AOC/PRS	Storage area	Inactive	0		Rec NFA
	46-010(c)	46-010(c)	46	AOC/PRS	Storage area	Active	0		Rec NFA
	46-010(d)	46-010(d)	46	HSWA PM	Operation release	Active	0		NFA
	46-010(e)	46-010(e)	46	AOC/PRS	Storage area	Active	0		Rec NFA
	46-010(f)	46-010(f)	46	AOC/PRS	Storage area	Active	0		Rec NFA
	46-010misc	46-010misc	46	AOC/PRS	Storage area	Inactive	0		Rec NFA
	C-46-001	C-46-001	46	AOC/PRS	One-time spill	Inactive	0		NFA
	C-46-002	C-46-002	46	AOC/PRS	Stack Emissions	Inactive	0		NFA
	C-46-003	C-46-003	46	AOC/PRS	Stack Emissions	Inactive	0		NFA

PRS Data for Operable Unit 1147

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
	50-001(a)	50-001(a)	50	001HSWA	Waste treatment facility	Active	10962	Rad, hazardous const.	CARBC
	50-001(b)	50-001(b)	50	AOC/PRS	Waste lines and manholes	Active	77	Rad, hazardous const.	CARBC
(a)	50-002(a)	50-002(a)	50	HSWA	Underground tanks	Active	954	Rad, hazardous const.	CARBC
(c)	50-002(b)	50-002(b)	50	002(c) HSWA	Underground tank	Active	15	Rad, hazardous const.	CARBC
(d)	50-002(c)	50-002(c)	50	002(d) HSWA	Underground tank	Active	15	Rad, hazardous const.	CARBC
	50-002(d)	50-002(d)	50	AOC/PRS	Underground tank	Active	34	Hazardous const.	CARBC
(a)	50-003(a)	50-003(a)	50	AOC/PRS	Storage area	Active	163	Rad, hazardous const.	Del D&D
(b)	50-003(b)	50-003(b)	50	RCRA	Storage area	Active	0		Rec NFa
(c)	50-003(c)	50-003(c)	50	RCRA	Storage area	Active	0		Rec NFA
(d)	50-003(d)	50-003(d)	50	RCRA	Storage area	Active	0		Rec NFA
(e)	50-003(e)	50-003(e)	50	RCRA	Storage area	Inactive	0		Rec NFA
	50-004(a)	50-004(a)	50	004HSWA	Waste lines	Decommissioned	4	Rad, hazardous const.	CARBC
(b)	50-004(b)	50-004(b)	50	002(b)HSWA	Underground tanks	Decommissioned	37	Rad, hazardous const.	CARBC
	50-004(c)	50-004(c)	50	HSWA PM	Waste lines	Decommissioned	26	Rad, hazardous const.	CARBC
	50-005	50-005	50	RCRA	Waste treatment facility	Active	0		Rec NFA
	50-006(a)	50-006(a)	50	006HSWA	Operational release	Active	86	Rad, hazardous const.	CARBC
	50-006(b)	50-006(b)	50	AOC/PRS	Operational release	Decommissioned	0		Rec NFA
	50-006(c)	50-006(c)	50	006HSWA	Operational release	Active	963	Rad, hazardous const.	CARBC
	50-006(d)	50-006(d)	50	006HSWA	Effluent discharge	Active	20575	Rad, hazardous const.	CARBC
	50-006(e)	50-006(e)	50	AOC/PRS	Aboveground tank	Decommissioned	0		Rec NFA
	50-007	50-007	50	RCRA	Incinerator	Active	0		NFA
	50-008	50-008	50	RCRA	Reduction site	Active	0		NFA
	50-009	50-009	50	HSWA	Material disposal area	Inactive	135185	Rad, hazardous const.	IS:IC
	50-010	50-010	50	AOC/PRS	Decontamination facility	Active	367	Rad, hazardous const.	Del D&D
1(a)	50-011(a)	50-011(a)	50	HSWA	Septic system	Decommissioned	22	Rad, hazardous const.	CARBC
1(b)	50-011(a)	50-011(a)	50	HSWA	Septic system	Decommissioned	22	Rad, hazardous const.	CARBC
1(c)	50-011(a)	50-011(a)	50	HSWA	Septic system	Decommissioned	22	Rad, hazardous const.	CARBC
	50-011(b)	50-011(b)	50	AOC/PRS	Septic system	Active	5	Rad, hazardous const.	Del D&D
	50-011misc.	50-011misc.			Does not exist		0		NFA

PRS Data for Operable Unit 1148

988 #	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
1-001	51-001	51-001	51	AOC/PRS	Septic system	Active	1	Hazardous const.	CARBC
-002(a)	51-002(a)	51-002(a)	51	AOC/PRS	Usage site	Active	0		Rec NFA
-002(b)	51-002(b)	51-002(b)	51	AOC/PRS	Usage site	Active	0		Rec NFA
	C-51-001	C-51-001	51	AOC/PRS	Storage area	Active	0		Rec NFA
	C-51-002	C-51-002	51	AOC/PRS	Buildings	Removed	0		Rec NFA
-001(a)	54-001(a)	54-001(a)	54	HSWA	Storage area	Active	15	Hazardous const.	Def. D&D
-001(b)	54-001(b)	54-001(b)	54	AOC/PRS	Storage area	Active	8	Hazardous const.	Def. D&D
-001(c)	54-001(c)	54-001(c)	54	HSWA	Storage area	Inactive	0		Rec NFA
-001(d)	54-001(d)	54-001(d)	54	AOC/PRS	Storage area	Active	59	Hazardous const., other	Def. D&D
-001(e)	54-001(e)	54-001(e)	54	AOC/PRS	Storage area	Active	111	Hazardous const.	Def. D&D
	54-001(f)	54-001(f)	54	AOC/PRS	Storage area	Active	0		Rec NFA
002	54-002	54-002	54	AOC/PRS	Storage area	Active	7	Hazardous const.	Def. D&D
003(a)	54-003(a)	54-003(a)			deleted in SWMU report, addressed as 54-014, 54-017, 54-018, and 54-019.				NFA
004	54-004	54-004	54	HSWA	Material disposal area, except sh. 9	Inactive	432	Rad, hazardous const., HE	IS,IC
005	54-005	54-005	54	HSWA	Material disposal area	Active	14154	Rad, haz. const., HE, other	IS,IC
006	54-006	54-006	54	HSWA	Material disposal area	Inactive	20067	Rad, haz. const., HE, other	IS,IC
007(a)	54-007(a)	54-007(a)	54	HSWA	Septic system	Active	40	Rad, hazardous const.	IS,IC
007(b)	54-007(b)	54-007(b)	54	HSWA	Septic system	Active	0		Rec NFA
007(c)	54-007(c)	54-007(c)	54	HSWA	Septic system	Active	36	Hazardous const.	CARBC
	54-007(d)	54-007(d)	54	AOC/PRS	Septic system	Active	14	Hazardous const.	CARBC
	54-007(e)	54-007(e)	54	AOC/PRS	Septic system	Active	22	Hazardous const.	CARBC
	54-007misc	54-007misc	54		Unit does not exist		0		NFA
008	54-008	54-008	54	AOC/PRS	Underground tank	Active	0		Rec NFA
009	54-009	54-009	54	RCRA PM	Aboveground tank	Active	6	Hazardous const.	Def. D&D
10	54-010	54-010	54	AOC/PRS	Underground tank	Active	0		Rec NFA
12	54-012(a)	54-012(a)	54	AOC/PRS	Reduction site	Active	1	Rad, hazardous const.	CARBC
	54-012(b)	54-012(b)	54	HSWA PM	Reduction site	Active	4	Hazardous const.	CARBC
13	54-013(a)	54-013(a)	54	013 HSWA	Decontamination facility	Inactive	0		Rec NFA
	54-013(b)	54-013(b)	54	HSWA PM	Disposal Pit	Inactive	56	Rad, hazardous const.	IS,IC

PRS Data for
Operable Unit 1154

	1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
(a)	57-001(a)	57-001(a)	57	AOC/PRS	Surface impoundment	Decommissioned	0		Rec NFA
(b)	57-001(b)	57-001(b)	57	AOC/PRS	Surface impoundment	Decommissioned	300		CARBC
(c)	57-001(c)	57-001(c)	57	AOC/PRS	Surface impoundment	Decommissioned	300		CARBC
	57-002	57-002	57	AOC/PRS	Landfill	Active	6667	Hazardous const.	CARBC
	57-003	57-003	57	AOC/PRS	Storage area	Active	0		Rec NFA
	57-004(a)	57-004(a)	57	AOC/PRS	Surface impoundment	Active	300		CARBC
	57-004(b)	57-004(b)	57	AOC/PRS	Surface impoundment	Active	356	Hazardous const.	Del. D&D
	57-005	57-005	57	AOC/PRS	Filter system	Active	0		Rec NFA

PRS Data for Operable Unit 1157

1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
C-8-001	C-8-001	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-002	C-8-002	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-003	C-8-003	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-004	C-8-004	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-005	C-8-005	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-006	C-8-006	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-007	C-8-007	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-008	C-8-008	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-009	C-8-009	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-010	C-8-010	8	AOC/PRS	Building	Removed	10	Hazardous const.	CARBC
C-8-011	C-8-011	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-012	C-8-012	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-013	C-8-013	8	AOC/PRS	Building	Removed	0		Rec NFA
C-8-014	C-8-014	8	AOC/PRS	Laboratory	Active	5	Hazardous const.	Def. D&D
C-8-015	C-8-015	8	AOC/PRS	Building	Inactive	0		Rec NFA
C-8-016	C-8-016	8	AOC/PRS	Building	Active	0		Rec NFA
C-8-017	C-8-017	8	AOC/PRS	Storage area	Active	0		Rec NFA
C-8-018	C-8-018	8	AOC/PRS	Storage area	Active	0		Rec NFA
C-8-019	C-8-019	8	AOC/PRS	Storage area	Active	0		Rec NFA
C-8-020	C-8-020	8	AOC/PRS	Disposal area	Inactive	0		Rec NFA
9-001(a)	9-001(a)	9	HSWA PM	Firing sites	Decommissioned	24	Rad, hazardous const., HE	CARBC
9-001(b)	9-001(b)	9	HSWA PM	Firing sites	Decommissioned	36	Rad, hazardous const., HE	CARBC
9-001(c)	9-001(c)	9	HSWA PM	Firing sites	Decommissioned	43	Rad, hazardous const., HE	CARBC
9-001(d)	9-001(d)	9	HSWA PM	Firing sites	Decommissioned	37	Rad, hazardous const., HE	CARBC
9-002	9-002	9	HSWA PM	Burn pit	Decommissioned	89	Rad, hazardous const., HE	CARBC
9-003(a)	9-003(a)	9	HSWA	Settling tank	Decommissioned	2	Rad, hazardous const., HE	CARBC
9-003(b)	9-003(b)	9	HSWA	Settling tank	Decommissioned	2	Rad, hazardous const., HE	CARBC
9-003(c)	9-003(c)	9	HSWA	Electric manhole	Decommissioned	0		Rec NFA
9-003(d)	9-003(d)	9	HSWA	Settling tank	Decommissioned	7	Hazardous const., HE	CARBC

PRS Data for Operable Unit 1157

1990 #	Current Yr	TA	Class	Site Type	Status	Waste Volume (Yd3)	Potential Contaminants	Potential Remediation
9-007	9-007	9	HSWA	Basket pit	Inactive	0		Rec NFA
9-008(a)	9-008(a)	9	AOC/PRS	Surface impoundment	Inactive	0		Rec NFA
9-008(b)	9-008(b)	9	008HSWA	Surface impoundment	Inactive	217	Rad	CARBC
9-009	9-009	9	HSWA	Surface impoundment	Inactive	627	Rad	CARBC
9-010(a)	9-010(a)	9	AOC/PRS	Storage area	Inactive	7	Hazardous const., HE	CARBC
9-010(b)	9-010(b)	9	AOC/PRS	Storage area	Removed	13	Hazardous const., HE	CARBC
9-010(c)	9-010(c)	9	AOC/PRS	Storage area	Inactive	0		Rec NFA
9-011(a)	9-011(a)	9	AOC/PRS	Storage area	Removed	0		Rec NFA
9-011(b)	9-011(b)	9	AOC/PRS	Storage area	Inactive	1	Hazardous const., HE	CARBC
9-011(c)	9-011(c)	9	AOC/PRS	Storage area	Inactive	1	Hazardous const., HE	CARBC
9-012	9-012	9	AOC/PRS	Disposal pit	Inactive	1111	Rad, hazardous const., HE	CARBC
9-013	9-013	9	009HSWA	Material disposal area	Inactive	576	Rad, haz. const., HE, other	IS:IC
9-014	9-014	9	AOC/PRS	Firing site	Decommissioned	70	Hazardous const., HE	CARBC
9-015	9-015	9	AOC/PRS	Manhole	Decommissioned	0		Rec NFA
9-016	9-016	9	AOC/PRS	Underground tank	Decommissioned	0		Rec NFA
C-9-001	C-9-001	9	AOC/PRS	Soil contamination	Active	370	Hazardous const.	CARBC
C-9-002	C-9-002	9	AOC/PRS	Buildings	Removed	0		Rec NFA
C-9-003	C-9-003	9	AOC/PRS	Buildings	Removed	0		Rec NFA
C-9-004	C-9-004	9	AOC/PRS	Building	Removed	0		Rec NFA
C-9-005	C-9-005	9	AOC/PRS	Building	Removed	0		Rec NFA
C-9-006	C-9-006	9	AOC/PRS	Buildings	Removed	0		Rec NFA
C-9-007	C-9-007	9	AOC/PRS	Building	Removed	0		Rec NFA
C-9-008	C-9-008	9	AOC/PRS	Underground tank	Removed	0		Rec NFA
C-9-009	C-9-009	9	AOC/PRS	Non-intentional release	Active	0		Rec NFA
C-9-010	C-9-010	9	AOC/PRS	Burn site	Inactive	0		Rec NFA
C-9-011	C-9-011	9	AOC/PRS	Burn site	Inactive	0		Rec NFA
69-001	69-001	69	HSWA PM	Incinerator and assoc. equip.	Inactive	1852	Hazardous const.	CARBC
69-002(a)	69-002(a)	69	AOC/PRS	Septic system	Active	0		Rec NFA
69-002(b)	69-002(b)	69	AOC/PRS	Septic system	Active	0		Rec NFA

APPENDIX E

Tables of Wells and Springs in the Los Alamos Area

Note: This is a preliminary effort to compile data on wells and springs in and around the Los Alamos National Laboratory. Existing information will be included as it is found. This table will be updated to include locations and information on new wells drilled and new springs discovered during the implementation of the Groundwater Protection Management Program.

Wells in Los Alamos and Surrounding Area

STATION	DATE INSTALLED	X-COORDINATE	Y-COORDINATE	ELEVATION	DEPTH CASE	SCREEN INTERVAL	PURPOSE	COMMENTS
Main								
BW-1new	1977	1667244	1759262	5500				
BW-1old	1971	1674752	1750944	5860				
BW-2 new	1977	1668044	1757062	5535				Flowing
BW-2 old		1669844	1756262	5620				
BW-3	1972	1670299	1756095	5620				
BW-4	1972	1672031	1753367	5650				Flowing
BW-5		1672116	1750941	5680				
BW-6	1972	1674202	1752890	5720				Flowing
BW-7	1972	1674157	1755217	5710				
DT-10	1960	1628968	1754449	7020	1409	1080-1390	Test	To be plugged
DT-5A	1960	1625310	1754789	7144	1821	1172-1392	Test	To be plugged
DT-9	1960	1628994	1751493	6936	1501	1040-1500	Test	To be plugged
Eleven Hundred	1952 ?	1666744	1726162	6636	1086		Stock	Also called Trick Well
G-1	1950	1656191	1783609	5973	2000	282-1980	Supply	
G-1A	1954	1655241	1784353	6014	1519	272-1513	Supply	
G-2	1954	1654210	1785123	6056	1970	281-1960	Supply	
G-3	1951	1651676	1786218	6139	1792	441-1785	Supply	Not on line
G-4	1951	1648949	1786452	6229	1930	426-1925	Supply	
G-5	1951	1646950	1787907	6306	1840	462-1830	Supply	
G-6	1964	1644824	1786851	6422	1530		Supply	
LA-1	1946	1668082	1776927	5624	870	60-865	Supply	Plugged 1993
LA-1B	1960	1668248	1776952	5602	1750	326-1690	Supply	No pump
LA-2	1946	1666924	1777219	5651	870	105-865	Supply	Pump
LA-3	1947	1665991	1777185	6578	870	105-865	Supply	Plugged 1993
LA-4	1948	1657448	1771233	5975	1964	754-1964	Supply	Plugged 1993
LA-5	1948	1659826	1772533	5840	1750	440-1740	Observation	No pump
LA-6	1948	1662882	1774593	5770	1490	420-1778	Supply	Plugged 1993
McKinney		1675247	1750237	6050				
O-1	1991	1649396	1772232	6396	2497	1017-2477	Supply	
O-4	1991	1637337	1772995	6627	2598	1115-2598	Supply	
PM-1	1965	1647734	1768112	6520	2499	945-2479	Supply	

STATION	DATE INSTALLED	X-COORDINATE	Y-COORDINATE	ELEVATION	DEPTH CASE	SCREEN INTERVAL	PURPOSE	COMMENTS
PM-2	1965	1636786	1760326	6715	2300	1001-2280	Supply	
PM-3	1966	1642631	1769426	6640	2552	956-2532	Supply	
PM-4	1981	1635717	1764674	6920	2875	1260-2854	Supply	
PM-5	1982	1633083	1767809	7095	3093	1440-3072	Supply	
RGT-2	1946	1674676	1780561	5525			Test Hole	Open hole
RGT-3	1946	1674074	1780579	5545			Test Hole	Open hole
RGT-4	1946	1675266	1781956	5537			Test Hole	Open hole
SF-2A	1986	1667580	1758621	5540	1872	1850-1860	Observation	
SF-3A	1987	1604344	1766562	5480	294	274-284	Observation	
SF-4A	1988	1567744	1780862	5470	280	260-270	Observation	
SF-5A	1988	1581244	1799062	5455	300	280-290	Observation	
Skillet	1972	1674657	1761459	5860	1700		Observation	Recorder 1972
TW-1	1950	1650041	1772077	6369	642	632-642	Test	To be plugged
TW-2	1949	1634231	1777268	6648	834	779-789	Test	Screen removed 1990; to be plugged
TW-3	1949	1637727	1773138	6595	815	805-815	Test	To be plugged
TW-4	1950	1624028	1777680	7256	1205	1195-1205	Test	To be plugged
TW-8	1960	1632574	1769507	6878	1065	953-1065	Test	To be plugged
Intermediate								
LADP-3	1993	1632989	1773469	6755	326	316-326	Test	To be plugged
LADP-4	1993	1775718	1633176	7051			Test	
TW-1A	1950	1650057	1772066	6369	225	215-225	Test	To be plugged
TW-2A	1949	1634185	1777288	6650	132	127-132	Test	To be plugged
Alluvial								
APCO-1	1990	1649210	1773020	6368	19.7	4.7-14.7	Observation	HSWA Special Permit
CDBO-1	1985	1637969	1760944	6758	13	5-13	Observation	
CDBO-2	1985	1638119	1761103	6748	12	6-18	Observation	
CDBO-3	1985	1640677	1759611	6670	12	2-12	Observation	
CDBO-4	1985	1645475	1758547	6565	12	8-12	Observation	
CDBO-5	1992	1633583	1765818	6879	17	7-17	Observation	
CDBO-6	1992	1636209	1764760	6817	49	34-44	Observation	Water from PM-4 pump startup
CDBO-7	1992	1637400	1763301	6871	44	29-39	Observation	Water from Pm-4 pump startup
CDBO-8	1992	1639294	1762366	6722	23	13-23	Observation	
CDBO-9	1992	1652119	1759703	6634	34	19-29	Observation	

STATION	DATE INSTALLED	X-COORDINATE	Y-COORDINATE	ELEVATION	DEPTH CASE	SCREEN INTERVAL	PURPOSE	COMMENTS
FCO-1	1989	1642412	1751182	6509	12.4	2.4-12.4	Observation	Dry, HSWA Special Permit
LAO-0.3	1994	1624799	1774512	6968	8.33	5.9-10.9	Observation	
LAO-0.6	1994	1626748	1774333	6910	10.54	8.0-13.0	Observation	
LAO-0.8	1994	1627700	1774275	6887	7.5	7.5-12.5	Observation	
LAO-0.91	1994	1628654	1774207	6862	9.5	9.5-14.5	Observation	
LAO-1	1966	1629395	1773956	6836	25.4	8-28	Observation	
LAO-1.2	1969	1632644	1773956	6740	18	8-18	Observation	
LAO-1.8	1969	1635446	1172661	6680	18	8-18	Observation	
LAO-2	1966	1637608	1773096	6593	29	12-32	Observation	
LAO-3	1966	1638011	1773098	6578	24	16-32	Observation	
LAO-3A	1989	1637981	1773100	6579	15	4.7-14.7	Observation	
LAO-4	1966	1640752	1772729	6519	24	14-24	Observation	
LAO-4.5	1969	1643659	1772088	6452	40	10-40	Observation	Obstruction in well
LAO-4.5A	1989	1643500	1772052	6460	18.5	8.5-18.5	Observation	Dry, HSWA Special Permit
LAO-4.5B	1989	1643512	1772055	6459	34.9	24.9-34.9	Observation	Dry, HSWA Special Permit
LAO-4.5C	1989	1643547	1772077	6458	23.3	13.3-23.3	Observation	HSWA Special Permit
LAO-5	1966	1646203	1771425	6395	25	5-25	Observation	Dry
LAO-6	1966	1646222	1771330	6395	16	6-16	Observation	Dry
LAO-6A	1989	1646222	1771344	6396	14.2	4.2-14.2	Observation	HSWA Special Permit
LAO-B	1994	1615149	1775170	7323	14.24	11.8-26.8	Observation	
LAO-C	1970	1622158	1775250	7050	12.2	3-13	Observation	
LAOR-1		1628595	1774282	6865			Observation	
LAOR-2		1628875	1774202	6853			Observation	
MCO-12	1971	1640444	1768162	6702	108	88-108	Observation	Replaces original MCO-12
MCO-13	1980	1641280	1767460	6674	107	87-107	Observation	Dry
MCO-2	1960	1634044	1768652	7133	9	2-9	Observation	Abandoned
MCO-3	1967	1627363	1770237	7053	12	2-12	Observation	
MCO-4	1963	1631214	1769788	6900	19	14-19	Observation	
MCO-4A	1989	1632029	1769700	6888	19.4	9.4-19.4	Observation	HSWA Special Permit
MCO-4B	1990	1632036	1769697	6888	33.9	8.9-28.9	Observation	HSWA Special Permit
MCO-5	1965	1632466	1769538	6848	46	21-46	Observation	
MCO-6	1974	1633635	1769013	6878	47	27-47	Observation	Replaces original MCO-6
MCO-6.5A	1961	1634144	1768762	6840	45	25-45	Observation	
MCO-6.5B	1961	1624144	1768762	6839	42	22-42	Observation	
MCO-6A	1989	1633633	1768962	6850	36	22.7-32.7	Observation	HSWA Special Permit

STATION	DATE INSTALLED	X-COORDINATE	Y-COORDINATE	ELEVATION	DEPTH CASE	SCREEN INTERVAL	PURPOSE	COMMENTS
MCO-6B	1990	1633631	1768984	6850	47.1	22-42	Observation	HSWA Special Permit
MCO-7	1960	1634518	1768510	6827	69	39-69	Observation	
MCO-7.5	1961	1635455	1768441	6808	60	35-60	Observation	
MCO-7A	1989	1634503	1768509	6828	44.8	34.8-44.8	Observation	HSWA Special Permit
MCO-8	1960	1636021	1768529	6796	84	64-84	Observation	Damaged beyond repair 1976
MCO-8.2	1961	1636044	1768562	6782	70	60-70	Observation	
MCO-9	1961	1638058	1768371	6747	55	45-55	Observation	Dry
MCO-9.5	1961	1628844	1768362	6740	46	26-46	Observation	Dry
PCO-1	1985	1637919	1759991	6687	12.3	4.3-12.3	Observation	
PCO-2	1985	1641700	1757443	6618	9.5	1.5-9.5	Observation	
PCO-3	1985	1646089	1755489	6547	17.7	5.7-17.7	Observation	
PO-3B	1956	1642444	1776062	6250	59	49-59	Observation	
PO-4A	1956	1641044	1775762	6524	21	12-21	Observation	
PO-4B	1956	1625444	1770162	6542	36	31-36	Observation	
POTO-4C	1989	1638644	1757062	6620	48	28-38	Observation	
SCO-1	1989	1642298	1769502	6619	19.3	9.3-19.3	Observation	Dry; HSWA Special Permit
SCO-2	1989	1647259	1767864	6501	19.4	9.4-19.4	Observation	Dry; HSWA Special Permit
SIMO-1	1990	1641799	1766653	6650	104	50-60	Observation	Dry
TSCO-1	1961	1633344	1768462	6857	35	15-35	Observation	
WCO-1	1989	1632759	1755069	6616	34.4	24.4-34.4	Observation	Dry; HSWA Special Permit
WCO-2	1989	1636870	1753228	6625	23.5	13.5-23.5	Observation	Dry, HSWA Special Permit
WCO-3	1989	1640213	1750620	6436	12.4	9-14	Observation	Dry
No map designation								
LAO-0.7							Observation	
MCO-4.9	1973	1632372	1769609	6880	30		Observation	
MT-1	1988	1635263	1768496	6812	69	39-59		Test
MT-2	1988	1636022	1768547	6797	64	44-54		Test
MT-3	1988	1635962	1768659	6797	74	44-64		Test
MT-4	1988	1636559	1768634	6785	74	54-64		Test
POTO-4A	1989	1638644	1757062	6620	174	154-164	Observation	
POTO-4B	1989	1638644	1757062	6620	99	79-89	Observation	
POTO-5A	1989	1638644	1757062	6620	77.5	57.5-67.5	Observation	
POTO-5B	1989	1638644	1757062	6620	27	7-17	Observation	
SF-2B	1986	1667580	1758621	5540	824	802-812	Observation	
SF-2C	1986	1667580	1758621	5540	356	324-334	Observation	

STATION	DATE INSTALLED	X-COORDINATE	Y-COORDINATE	ELEVATION	DEPTH CASE	SCREEN INTERVAL	PURPOSE	COMMENTS
SF-3B	1988	1587244	1778062	5480	169	149-159	Observation	
SF-3C	1988	1584244	1773062	5480	60	40-50	Observation	
SF-4B	1988	1571244	1788062	5470	110	110-120	Observation	Flowing
SF-4C	1988	1570244	1804062	5470	60	40-50	Observation	
SF-5B	1988	1584244	1794062	5455	160	140-150	Observation	
SF-5C	1988	1604144	1762562	5455	69	49-59	Observation	
Fenton Hill								
FH-1	1976	1515244	1775862	8690	450		Supply	
Location 27		1524144	1773862	7650			Observation	Artesian well overflow from tank
Location 4		1522444	1773062	7760			Observation	Hofheins, Community water source
Location 42		1521644	1772362	7840			Observation	Goldstone well
Location 47		1524844	1770762	7640			Observation	Lewis well
Location 48		1524844	1771262	7630			Observation	La Cueva lumber yard well
Location 53		1529044	1776762	7835			Observation	Crane, Sulphur Creek well
Location 54		1528444	1776262	7795			Observation	Hansen, Sulphur Creek well
Location 55		1528744	1776662	7805			Observation	Olsen, Sulphur Creek well
No map designation								
FH-2	1980	1515244	1775862	8691	450		Supply	
FH-3	1980	1515244	1775862	8692	460		Supply	

s in Los Alamos Area

STATION	DESCRIPTION	X-COORDINATE	Y-COORDINATE	ELEVATION
Alluvial				
Water Canyon Gallery	Flank of mountains	1604144	1762562	8000
Intermediate				
Basalt Spring	Lower LA Canyon	1658544	1770762	6000
Main				
Ancho Spring	Group I	1645644	1739962	5700
Doe Spring	Group II	1642325	1733598	5600
Indian Spring	Lower LA Canyon	1665944	1777262	5640
La Mesita Spring	Group IV	1658544	1770762	5580
Rio Spring 1	Group III	1667928	1767857	5615
Rio Spring 10	Group II	1638023	1728162	5360
Rio Spring 2	Group III	1667312	1766348	5600
Rio Spring 3	Group I	1661487	1753562	5560
Rio Spring 3A	Group I	1661520	1753298	5560
Rio Spring 3AA	Group I	1661291	1751050	5560
Rio Spring 3B	Group IV	1661354	1749814	5500
Rio Spring 4	Group I	1656028	1747887	5570
Rio Spring 4A	Group I	1656144	1747862	5570
Rio Spring 5	Group I	1656056	1742541	5770
Rio Spring 5A	Group II	1655365	1742005	5395
Rio Spring 5AA	Group I	1651144	1742562	5760
Rio Spring 6	Group II	1648882	1735517	5380
Rio Spring 6A	Group II	1646562	1734272	5375
Rio Spring 7	Group II	1645044	1733562	5370

STATION	DESCRIPTION	X-COORDINATE	Y-COORDINATE	ELEVATION
Rio Spring 8	Group II	1644444	1733462	5370
Rio Spring 8A	Group II	1643818	1733508	5520
Rio Spring 9	Group II	1643435	1733317	5485
Rio Spring 9A	Group II	1642742	1733147	5525
Sacred Spring	Lower LA Canyon	1670044	1780362	5640
Sandia Spring	Group I	1663182	1781490	5700
No map designation American Spring	Group I	1601044	1760062	8280
Apache Spring	Flank of mountains	1599144	1753662	8320
Armstead Spring	Flank of mountains	1599744	1762762	8216
DP Spring	Flank of mountains	1636615	1773713	8430
Frijoles Spring 1	Flank of mountains	1592344	1759562	8430
Frijoles Spring 2	Flank of mountains	1589344	1759362	8850
Guaje Spring 1	Flank of mountains	1600444	1797762	8840
Guaje Spring 2	Flank of mountains	1600444	1796062	6220
Hamilton Bend Spring	Fenton Hill	1642844	1776162	6265
JS-2,3	Fenton Hill	1509544	1735762	7600
JS-4,5	Fenton Hill	1511044	1741162	7880
Location 31	Fenton Hill	1491145	1767262	7670
Location 39	Fenton Hill	1502145	1770362	6780
Location 6	Fenton Hill	1523844	1772882	6400
Location JF-1 (Hot Spring)	Fenton Hill	1522544	1757562	6000
Location JF-5 (Hot Spring)	Fenton Hill	1510844	1743662	8660
Los Alamos Spring	Lower LA Canyon	1657444	1770962	8660
PC Spring	Flank of mountains	1601844	1773262	8000
Quemazon Spring	Flank of mountains	1603044	1788462	5495
Reservoir Spring	Flank of mountains	1605944	1778862	
Rio Spring 2A	Group IV	1662644	1754862	

STATION	DESCRIPTION	X-COORDINATE	Y-COORDINATE	ELEVATION
Rio Spring 5B	Group II	1651044	1738162	5390
Rio Spring 8B	Group II	1643244	1733562	5480
Rio Spring 9B	Group II	1642437	1732938	
RV-2 (Hot Spring)	Fenton Hill	1523244	1796862	8360
RV-4 (Hot Spring)	Fenton Hill	1528044	1764762	7360
RV-5 (Hot Spring)	Fenton Hill	1528544	1753962	7340
TA-18 Spring		1634193	1760782	
Valle Spring 1	Flank of mountains	1604144	1766462	8260
Valle Spring 2	Flank of mountains	1604344	1766562	8240
VG Spring 4		1587244	1778062	8600
VG Spring 5		1584244	1773062	8524
VG Spring 6		1567744	1780862	8640
VG Spring 7		1571244	1788062	8700
VT Spring 1		1570244	1804062	8570
VT Spring 2		1581244	1799062	8732
VT Spring 3		1584244	1794062	8868

APPENDIX F

Groundwater Monitoring Plan

APPENDIX F
ENVIRONMENTAL SURVEILLANCE
GROUNDWATER MONITORING PLAN

1.0 Introduction

This plan originally appeared as Chapter 8 of the 1993 Los Alamos National Laboratory Environmental Monitoring Plan.

This plan documents the scope of the groundwater monitoring program at the Laboratory. Groundwater may accumulate contaminants from discharges to surface water or from leakage of liquid effluent storage systems. Though hydrogeologic conditions at the Laboratory greatly protect the main aquifer from near-surface activities, groundwater monitoring is conducted to detect any threats to the resource.

1.1 Background

Groundwater resource management and protection at Los Alamos is focused on the main aquifer underlying the region. The aquifer has been of paramount importance to Los Alamos since the days of the post-World War II Manhattan Engineering District when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The USGS was extensively involved in overseeing and conducting various studies for development of groundwater supplies starting in 1945Ý46. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The long and comprehensive record of data indicates that DOE operations at the Los Alamos National Laboratory have not resulted in any contamination of the main aquifer. The controlled development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

Several hundred reports and articles document the program elements and the data germane to groundwater and the related Los Alamos environmental setting.

1.2 Project Description

The routine groundwater monitoring program consists of an annual sampling of a network of 65 fixed monitoring stations generally located within 6 km of the Laboratory. Monitoring of groundwater quality is conducted by sampling shallow and deep wells, and sampling natural groundwater discharge areas (springs).

Groundwaters are monitored to provide routine surveillance of Laboratory operations. Concentrations of radionuclides in water samples are compared with concentration guides derived from DOE's Radiation Protection Standards.

Routine chemical analyses of water samples include those inorganic constituents covered by State and Federal drinking water regulations. These analyses have been done for a number of years and are used as a screening tool to detect significant changes in the chemical quality of water. Additionally, analytical results are interpreted by comparison with drinking water standards.

Groundwater monitoring of the main aquifer at Los Alamos was implemented as an integral part of the comprehensive monitoring of shallow alluvial groundwater in canyons, surface water, soils, and sediments. These other media are indicators of potentials for groundwater contamination and document the range of possible pathways.

Groundwater resource monitoring also routinely documents conditions of the water supply wells and the main aquifer as part of the overall Groundwater Protection Management Program (LANL 1990). This information is documented in an annual series of reports providing detailed records of pumping and water-level measurements.

2.0 Rationale and Design Criteria

2.1 Siting of Sampling Locations

Groundwater sampling locations have been selected upon consideration of the probable mode of contaminant transport and contaminant source locations. Emphasis is placed on monitoring both the shallow (perched) aquifers and the deep main aquifer.

Although most facilities at the Laboratory are located upon mesa tops, the general location with the highest potential for groundwater contamination to occur is in the canyon bottoms. Waterborne contaminants are more likely to be present in the canyon bottoms because of the release of liquid effluents and the collection of snowmelt and summer runoff in the canyons. The potential for contaminants on the mesa tops to migrate downward under the influence of natural precipitation is greatly diminished by the thickness and extreme dryness of the underlying rock.

The groundwater sampling network is comprised of 17 shallow (perched aquifers) observation wells, 10 deep (main aquifer) test wells, 12 deep municipal supply wells and a gallery, and 28 springs. Sampling station locations are presented in Figure 1 and Table 1.

Sampling stations are grouped by hydrogeologic unit, as follows, beginning with the shallowest unit.

2.2 Sampling of Shallow Perched Alluvial Aquifers

Groundwater samples are collected from 17 wells completed in narrow perched aquifers found in alluvium within canyon bottoms. The aquifers are perched on the underlying Bandelier Tuff and recharged by the infiltration of liquid effluents and/or natural runoff.

2.2.1 Effluent Release Areas

As discussed in Section 7.2.1.3 of the Draft Environmental Monitoring Plan (EMP), the canyons that presently receive or have received treated industrial effluents are: Acid-Pueblo, DP-Los Alamos, Sandia, and Mortandad.

Groundwater in the alluvium of Pueblo Canyon is sampled at two observation wells. Water occurs seasonally in the alluvium dependent on the volume of surface flow from sanitary effluents and storm runoff. Hamilton Bend Springs discharges from alluvium in the lower reach of Pueblo Canyon and is dry part of the year (ESG 1981).

In Los Alamos Canyon, sampling stations consist of six observations wells completed into alluvium (about 6 m [20 ft] thick). Water levels decline in DP-Los Alamos Canyon during the winter and early summer as natural storm runoff is at a minimum (ESG 1981).

In Sandia Canyon, two monitoring holes in the lower canyon just west of State Road 4 indicated no perched water in the alluvium in this area.

Monitoring stations in Mortandad Canyon include six observation wells completed in the shallow alluvial aquifer. The wells in the lower reach of the canyon are dry. The top of the main aquifer is about 290 m (950 ft) below the perched aquifer (Purtymun 1974).

2.2.2 Non-effluent Release Areas

Three observation wells in Pajarito Canyon are used to monitor the perched water in the alluvium (thickness about 4 m [12 ft]). Water in the alluvium is perched on the underlying tuff and is recharged through storm runoff. The observation wells are utilized to determine if technical areas in the canyon or adjacent mesas (e.g., TA-54) are affecting the quality of shallow groundwater.

2.3 Sampling of Perched Groundwater in Basalts

Perched water in the basaltic rocks is sampled at Test Well 1A in Lower Pueblo Canyon and at Basalt Springs east in lower Los Alamos Canyon. Recharge to the perched aquifer in the basalt occurs near Hamilton Bend Springs and is mainly sanitary effluents from the Bayo Treatment Plant near Hamilton Bend Springs. Travel time from the recharge area near Hamilton Bend Spring to Test Well 1A is estimated to be one to two months and another two to three months to Basalt Springs.

2.4 Sampling of Perched Groundwater in Puye Conglomerate

Test Well TW-2A (drilled to a depth of 40.5 m [133 ft]), penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate. Aquifer tests indicate the perched aquifer is of limited extent. Water level measurements over a period of time indicate the perched aquifer is hydrologically connected to the stream in Pueblo Canyon.

2.5 Sampling of Main Aquifer

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply.

2.5.1 Test Wells

Seven test wells, originally drilled as hydrogeologic exploratory holes, are utilized as main aquifer monitor wells. These test wells are constructed to seal out all water above the main aquifer. Groundwater pumped from test wells is not used for municipal, industrial, or irrigation supply.

Test Wells 1 and 2 are in the lower and midreach of Pueblo Canyon. Depths to the top of the main aquifer are 181 to 231 m (594 and 758 ft), respectively. Test Well 3 is in the midreach of Los Alamos Canyon with a depth of 228 m (748 ft) to the top of the main aquifer. These wells are in canyons that have received (Pueblo Canyon) or are now receiving (Los Alamos Canyon) industrial effluents. Test Wells DT-5A, DT-9, and DT-10 are at the southern edge of the Laboratory. Depths to the top of the main aquifer are 359 and 332 m (1,180 and 1,090 ft), respectively. Test Well 8 is in the midreach of Mortandad Canyon, an area that receives industrial effluents. The top of the aquifer lies at about 295 m (968 ft).

2.5.2 Supply Wells

To supplement monitoring coverage provided by the dedicated monitoring (test) wells, municipal supply wells additionally are sampled. Water for the Laboratory and community is supplied from 12 deep wells in two well fields and one gallery. The gallery is west of the Laboratory on the flanks of the mountains. Locations of supply wells and gallery are found in Table 1.

The Guaje well field is composed of seven producing wells. Wells in the field range in depth from 463 to 610 m (1,530 to 2,000 ft). Movement of water in the upper 430 m (1,410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells. Wells range in depth from 701 to 942 m (2,300 to 3,090 ft). Movement of water in the upper 535 m (1,750 ft) of the aquifer is eastward at 29 m/yr (85 ft/yr).

A third well field, Otowi, is to be developed in the early 1990s to replace the capacity of the Los Alamos Well Field (retired in 1991) and to supplement the Guaje and Pajarito Fields.

The Water Canyon gallery collects spring discharge from a perched water zone in the volcanics on the flanks of the mountains west of Los Alamos and Pajarito Plateau. The canyon supplies a small but important part of the production with use of very little energy.

2.5.3 Sampling of Springs

As discussed in Section 1.2.3 of the EMP, a principal natural discharge area for the main aquifer is along White Rock Canyon, adjacent to the Rio Grande (Purtymun 1980). This area represents a major uncontrolled contaminant release zone, should the main aquifer become contaminated. Sampling of groundwater, therefore, is conducted at 22 stations in White Rock Canyon (Fig. 1, Table 1).

Table 1 Environmental Surveillance Groundwater Monitoring Stations

Wells	X-Coordinate	Y-Coordinate	Elevation
Main			
DT-10	1628988	1754448	7019
DT-5A	1625309	1754789	7143
DT-9	1628993	1751492	6936
G-1	1656190	1783609	5973
G-1A	1655240	1784353	6014
G-2	1654210	1785123	6056
G-4	1648949	1786452	6229
G-5	1646949	1787907	6306
G-6	1644824	1786851	6422
PM-1	1647734	1768112	6520
PM-2	1636786	1760326	6715
PM-3	1642631	1769426	6640
PM-4	1635716	1764674	6920
PM-5	1633083	1767809	7095
TW-1	1650041	1772076	6369
TW-2	1634231	1777267	6648
TW-3	1637727	1773138	6595
TW-8	1632573	1769506	6877
Intermediate			
TW-1A	1650056	1772065	6369
TW-2A	1634184	1777288	6650
Alluvial			
APCO-1	1649209	1773020	6367
CDBO-6	1636209	1764759	6817
LAO-1	1629394	1773956	6836
LAO-2	1637607	1773095	6592
LAO-3	1638010	1773098	6578
LAO-4	1640751	1772729	6518
LAO-4.5	1643659	1772087	6451
LAO-C	1622157	1775249	7050
MCO-3	1627362	1770236	7052
MCO-4	1631214	1769787	6900
MCO-5	1632466	1769537	6848
MCO-6	1633635	1769012	6878
MCO-7	1634517	1768509	6827
MCO-7.5	1635454	1768440	6808
PCO-1	1637919	1759990	6687
PCO-2	1641700	1757442	6618
PCO-3	1646088	1755489	6546

Table 1, Continued

Springs

Main			
Ancho Spring	1646954	1737340	5700
Doe Spring	1642044	1733861	5600
Indian Spring	1666813	1777738	5640
La Mesita Spring	1672344	1771662	5580
Rio Spring 1	1669512	1771609	5615
Rio Spring 10	1638710	1728993	5360
Rio Spring 2	1669296	1771146	5600
Rio Spring 2A	1662671	1754880	5495
Rio Spring 3	1661314	1763673	5560
Rio Spring 3A	1661343	1753407	5560
Rio Spring 3AA	1661127	1751554	5560
Rio Spring 3B	1661589	1749996	5500
Rio Spring 4	1657432	1748409	5570
Rio Spring 4A	1656148	1747876	5570
Rio Spring 5	1655484	1743048	5770
Rio Spring 5A	1655744	1741982	5395
Rio Spring 5AA	1651143	1742561	5760
Rio Spring 5B	1651079	1738170	5390
Rio Spring 6	1649191	1735678	5380
Rio Spring 6A	1647390	1734564	5375
Rio Spring 7	1645007	1733602	5370
Rio Spring 8	1644411	1733478	5370
Rio Spring 8A	1643417	1734019	5520
Rio Spring 8B	1643284	1733552	5480
Rio Spring 9	1642931	1733737	5485
Rio Spring 9A	1642651	1733468	5525
Sacred Spring	1670044	1780362	5640
Sandia Spring	1663244	1761562	5700
Intermediate			
Basalt Spring	1656544	1770762	6000
Alluvial			
Water Canyon Gallery	1604144	1762561	8000

The stations are composed of groups of main aquifer, intermediate, and alluvial springs in White Rock Canyon of the Rio Grande and around the Laboratory perimeter area. Most have similar aquifer-related chemical quality. Water from main springs is part of the main aquifer beneath the Pajarito Plateau (Purtymun 1980). Chemical quality of Spring 3B reflects local conditions in the aquifer discharging through a fault in volcanics. Discharge at these springs range from less than 1 L/sec (0.25 gal/sec) to 37 L/sec (10 gal/sec) (Purtymun, 1980).

Additional sampling of three other nearby springs is conducted. La Mesita Spring is east of the Rio Grande, while Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. The springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and form small seep areas. Total discharge at each spring is probably less than 1 L/sec (0.25 gal/sec).

2.6 Special Sampling

2.6.1 San Ildefonso Memorandum of Understanding

Groundwater monitoring is conducted on San Ildefonso Pueblo land as a part of a broader environmental monitoring program (see Section 7.2.1.4 of the EMP). In 1991, four wells on Pueblo land were sampled.

figure 1 map of sampling locations

2.6.2 Fenton Hill (TA-57)

The chemical quality of groundwaters in the vicinity of the Fenton Hill Geothermal Site has been monitored since the early 1970s. Groundwater stations include seven springs, and two wells (see Sec. 7.2.1.6 of EMP for map).

2.6.3 Cañada del Buey

In 1985, four monitoring wells were installed in Cañada del Buey for use in geohydrologic and environmental studies. To date, all the wells are dry. In addition to documenting the present condition of the canyon, the wells will monitor changes that occur after the new sewage treatment plant begins release of effluents to the drainage in 1993.

3.0 Extent and Frequency of Monitoring

3.1 Routine Annual Sampling

For consistency, water samples from a given station usually are collected in the same month from year to year. Samples are collected for the routine Environmental Surveillance Program according to the following schedule:

All Wells and Any Springs Within Effluent Release Areas	
Radiochemistry	Annual
Secondary Standards	Annual
Miscellaneous	Annual
Primary Standards	Every 3 Years
Organics	Every 3 Years
White Rock Canyon Springs	
Radiochemistry	Annual
Secondary Standards	Annual
Miscellaneous	Annual
PCBs	Annual

Water from wells, springs, and water supply (wells and distribution) are analyzed for Cs-137, Pu-238, Pu-239,240, total uranium H-3, and gross gamma activity. Water samples from former and active effluent release areas may also be analyzed for Am-241 and Sr-90. Water samples from supply wells and distribution are analyzed for gross alpha and gross beta radioactivity as well as Ra-226 if necessary.

Water from the stations is analyzed for the following inorganic constituents:

Primary Drinking Water Standards: Ag, As, Ba, Cd, Cn, Cr, F, Hg, N, Pb, and Se.

Secondary Standards: Cl, Cu, Fe, Mn, SO_4, Zn, TDS (total dissolved solids), and pH.

Miscellaneous chemicals: SiO_2, Ca, Mg, K, Na, CO_3, HCO_3, PO_4, total hardness, total suspended solids, and conductivity.

Organic analyses of water range from volatile to semivolatile organic compounds, the 129 priority pollutants, individual herbicides, pesticides, PCBs, oils, or solvents. Other samples are collected to monitor specific operations within the laboratory.

3.2 Special Sampling

To provide a more complete suite of chemical analyses for use in geochemical interpretation, during FY 1992 groundwaters additionally will be tested for aluminum, boron, lithium, organic carbon, strontium.

Groundwater sampling on San Ildefonso Pueblo land and at Fenton Hill typically occurs annually. In the most recent samplings, the samples were analyzed for the radiochemicals, primary and secondary standards, and miscellaneous chemicals listed in Section 3.1.

4.0 Procedures For Lab Analyses

Procedures for laboratory analyses are documented by EM-9's analytical procedures manual (Gautier 1992). These methods are based on EPA methods when available, or generally recognized and accepted institutions such as the American Public Health Association or American Society for Testing and Materials. In general, water samples are analyzed using EPA SW-846 (EPA 1987), with other methods specified in the LANL references.

5.0 Quality Assurance Requirements

The Quality Assurance Plan maintained by EM-8 details the process which will govern QA activities for groundwater monitoring (ESG 1987).

6.0 Program Implementation Procedures

6.1 Organizational Responsibility

The groundwater monitoring program is operated by a Environmental Management Technician under the supervision of Staff Members. All personnel are members of the Environmental Health Physics and Hydrology Section of EM-8.

The present line of supervision for the groundwater sampling program is:

EM-8 Group Leader
Section Leader
Project Leader
Staff Member
Staff Member
EM Technician

The Environmental Management Technician is responsible for the operation of the program. This includes sample collection, sample processing and submittal for chemical analysis, keeping a log, and maintaining the data files.

The Project Leader and Staff Members are responsible for preparation of summary data reports, the accuracy, precision, technical validity and overall quality of data and general functioning of the program. They prepare written reports giving the results of the groundwater sampling program, such as for the annual Environmental Surveillance Report.

The Group and Section Leaders are generally responsible for the quality of the work product, as they are for other environmental monitoring programs.

JCI's Utilities Department is the utility support contractor to the Los Alamos National Laboratory. JCI maintains and operates the water supply system, and routinely obtains groundwater level measurements from water supply wells.

6.2 Sampling Station Identification/Construction

Stations and samples are assigned a unique alphanumeric identifier to provide chain-of-custody control during the transfer of samples from the time of collection through analysis and reporting.

New monitoring wells are designed and installed according to the specifications of the RCRA Technical Enforcement Guidance Document (ASTM 1990), or the EPA-NWWA Handbook EPA600/4-89/034 (EPA 1989), or according to approved Laboratory Environmental Restoration Program SOPs. All monitoring wells will be abandoned according to the specifications of the New Mexico Environment Department and New Mexico State Engineer Office (NMEID 1990).

6.3 Field Procedures

All samples are collected and handled in accordance with approved Laboratory Environmental Restoration Program SOPs or approved EM-8 procedures. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer (a minimum of three casing volumes of standing water). Spring samples (groundwater) are collected at the discharge point. Fluid measurements of temperature, pH and specific conductance are made at each sampling site.

Duplicate samples, when needed, are collected independently at the same location and time by the method described above.

Before and after the groundwater well samples are collected, the pH, temperature and specific conductance are measured. Analyses are conducted for total recoverable metals and radiochemicals (see discussion in Section 7.8.5 of the EMP). Samples to be analyzed for radiochemicals and metals will be appropriately preserved. Samples for leachable constituents are preserved in the field and delivered to the laboratory as soon as possible in order to meet the holding time limits of the sample. Those samples are then filtered at the laboratory.

Details of container and preservation requirements, and identification of EPA methodology for each analysis are contained in the EM-9 publication "Handbook for Sample Collection, Preservation, and Instrumental Techniques" (Williams, 1990).

All samples are chilled at collection for transport to the EM-9 sample receiving room. Samples are maintained at a temperature of approximately 4°C.

If special equipment is used for collection of these samples, it is washed with a soap and water solution, followed by ethanol rinse if sampling for organics, and dried with paper towels. This is done before each sample is taken to reduce the potential for cross-contamination.

Collection of samples for chemical and radiochemical analyses follow a set procedure to ensure proper sample collection, documentation, submittal for chemical analyses, and posting of analytical results. Further details may be found in the water sampling quality assurance project plan maintained by EM-8. The procedures include:

- A pre-sampling conference is conducted with the EM-9 chemists to ensure use of proper sample containers, preservatives, and meeting holding times.
- All samples will be handled using chain-of-custody procedures both in the field and the laboratory.

- A minimum of 10% of all samples submitted for laboratory analysis will be for quality control purposes.
- Laboratory analytical results will be electronically transferred to EM-8 to minimize manual data transcription errors.

7.0 Preparation and Distribution of Reports

Analytical data are reviewed by project staff, compiled and tabulated for inclusion in the annual Environmental Surveillance Report or in publications associated with special studies. The annual surveillance report is reviewed internally within the EM-8 Group, EM Division Office, and Department of Energy offices in Los Alamos and Albuquerque. The review of the annual surveillance report provide internal quality control checks for the program.

8.0 Anticipated Modifications to Program

8.1 Equipment Improvements

During FY 1992 and 1993, quality control improvements are planned for the wells. The proposed improvements include:

- Dedicated (bladder) pumps will be installed in all wells that currently are sampled with bailers.
- All monitoring wells will be equipped with permanent identification markers and locking caps.
- Where possible, all test and municipal supply wells will be retrofitted with access ports to allow for accurate water level measurement and collection of non-aerated samples for volatile organic analyses.

8.2 Development of Surveillance Database and Report Writer

See discussion in Section 7.8.1 of EMP.

8.3 Establishment of Action/Alarm Levels

See discussion in Section 7.8.2 of EMP.

8.4 Establishment of Records Storage Procedures

See discussion in Section 7.8.4 of EMP.

8.5 Changes in Preservation and Filtration Procedures

See discussion in Section 7.8.5 of EMP.

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ASTM 1990: American Society for Testing and Materials, "Standard Guide for Design and Installation of Groundwater Monitoring Wells in Aquifers," ASTM D-5092-90 (1990).

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8.0 ENVIRONMENTAL SURVEILLANCE - GROUNDWATER

8.1 Introduction

The chapter documents the scope of the groundwater monitoring program at the Laboratory. Groundwater may accumulate contaminants from discharges to surface water or from leakage of liquid effluent storage systems. Though hydrogeologic conditions at the Laboratory greatly protect the main aquifer from near-surface activities, groundwater monitoring is conducted to detect any threats to the resource.

8.1.1 *Background*

Groundwater resource management and protection at Los Alamos is focused on the main aquifer underlying the region. The aquifer has been of paramount importance to Los Alamos since the days of the post-World War II Manhattan Engineering District when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The USGS was extensively involved in overseeing and conducting various studies for development of groundwater supplies starting in 1945–46. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The long and comprehensive record of data indicates that DOE operations at the Los Alamos National Laboratory have not resulted in any contamination of the main aquifer. The controlled development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

Several hundred reports and articles document the program elements and the data germane to groundwater and the related Los Alamos environmental setting.

8.1.2 *Project Description*

The routine groundwater monitoring program consists of an annual sampling of a network of 65 fixed monitoring stations generally located within 6 km of the Laboratory. Monitoring of groundwater quality is conducted by sampling shallow and deep wells, and sampling natural groundwater discharge areas (springs).

Groundwaters are monitored to provide routine surveillance of Laboratory operations. Concentrations of radionuclides in water samples are compared with concentration guides derived from DOE's Radiation Protection Standards.

Routine chemical analyses of water samples include those inorganic constituents covered by State and Federal drinking water regulations. These analyses have been done for a number of years and are used as a screening tool to detect significant changes in the chemical quality of water. Additionally, analytical results are interpreted by comparison with drinking water standards.

Groundwater monitoring of the main aquifer at Los Alamos was implemented as an integral part of the comprehensive monitoring of shallow alluvial groundwater in canyons, surface water, soils, and sediments. These other media are indicators of potentials for groundwater contamination and document the range of possible pathways.

Groundwater resource monitoring also routinely documents conditions of the water supply wells and the main aquifer as part of the overall Groundwater Protection Management Program (LANL 1990). This information is documented in an annual series of reports providing detailed records of pumping and water-level measurements.

Bend Springs. Travel time from the recharge area near Hamilton Bend Spring to Test Well 1A is estimated to be one to two months and another two to three months to Basalt Springs.

8.2.4 *Sampling of Perched Groundwater in Puye Conglomerate*

Test Well TW-2A (drilled to a depth of 40.5 m [133 ft]), penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate. Aquifer tests indicate the perched aquifer is of limited extent. Water level measurements over a period of time indicate the perched aquifer is hydrologically connected to the stream in Pueblo Canyon.

8.2.5 *Sampling of Main Aquifer*

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply.

8.2.5.1 *Test Wells*

Seven test wells, originally drilled as hydrogeologic exploratory holes, are utilized as main aquifer monitor wells. These test wells are constructed to seal out all water above the main aquifer. Groundwater pumped from test wells is not used for municipal, industrial, or irrigation supply.

Test Wells 1 and 2 are in the lower and midreach of Pueblo Canyon. Depths to the top of the main aquifer are 181 to 231 m (594 and 758 ft), respectively. Test Well 3 is in the midreach of Los Alamos Canyon with a depth of 228 m (748 ft) to the top of the main aquifer. These wells are in canyons that have received (Pueblo Canyon) or are now receiving (Los Alamos Canyon) industrial effluents. Test Wells DT-5A, DT-9, and DT-10 are at the southern edge of the Laboratory. Depths to the top of the main aquifer are 359 and 332 m (1,180 and 1,090 ft), respectively. Test Well 8 is in the midreach of Mortandad Canyon, an area that receives industrial effluents. The top of the aquifer lies at about 295 m (968 ft).

8.2.5.2 *Supply Wells*

To supplement monitoring coverage provided by the dedicated monitoring (test) wells, municipal supply wells additionally are sampled. Water for the Laboratory and community is supplied from 12 deep wells in two well fields and one gallery. The gallery is west of the Laboratory on the flanks of the mountains. Locations of supply wells and gallery are found in Table 8-1.

The Guaje well field is composed of seven producing wells. Wells in the field range in depth from 463 to 610 m (1,530 to 2,000 ft). Movement of water in the upper 430 m (1,410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells. Wells range in depth from 701 to 942 m (2,300 to 3,090 ft). Movement of water in the upper 535 m (1,750 ft) of the aquifer is eastward at 29 m/yr (85 ft/yr).

A third well field, Otowi, is to be developed in the early 1990s to replace the capacity of the Los Alamos Well Field (retired in 1991) and to supplement the Guaje and Pajarito Fields.

The Water Canyon gallery collects spring discharge from a perched water zone in the volcanics on the flanks of the mountains west of Los Alamos and Pajarito Plateau. The canyon supplies a small but important part of the production with use of very little energy.

8.2.5.3 *Sampling of Springs*

As discussed in Section 1.2.3, a principal natural discharge area for the main aquifer is along White Rock Canyon, adjacent to the Rio Grande (Purtymun 1980). This area represents a major uncontrolled contaminant release zone, should the main aquifer become contaminated. Sampling of groundwater, therefore, is conducted at 22 stations in White Rock Canyon (Fig. 8-1, Table 8-1).

Table 8-1. Locations of Ground Water Sampling Stations

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]	Type[b]
Perimeter Springs				
La Mesita Spring	N080	E550	10	GWD
Sacred Spring	N170	E540	11	GWD
Indian Spring	N140	E530	12	GWD
White Rock Canyon Stations				
Group I				
Sandia Spring	S030	E470	13	SWR
Spring 3	S110	E450	14	SWR
Spring 3A	S120	E445	15	SWR
Spring 3AA	S140	E440	16	SWR
Spring 4	S170	E110	17	SWR
Spring 4A	S150	E395	18	SWR
Spring 5	S220	E390	19	SWR
Spring 5AA	S240	E360	20	SWR
Ancho Spring	S280	E305	21	SWR
Group II				
Spring 5A	S230	E390	22	SWR
Spring 5B	S275	E355	96	SWR
Spring 6	S300	E330	23	SWR
Spring 6A	S310	E310	24	SWR
Spring 7	S330	E295	25	SWR
Spring 8	S335	E285	26	SWR
Spring 8A	S315	E280	27	SWR
Spring 8B	S310	E285	97	SWR
Spring 9	S270	E270	28	SWR
Spring 9A	S325	E265	29	SWR
Doe Spring	S320	E250	30	SWR
Spring 10	S370	E230	31	SWR
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR
Spring 2A	S105	E475	95	SWR
Group IV				
Spring 3B	S150	E465	34	SWR
Test Wells				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD

The stations are composed of four groups of springs. Three groups (Group I, II, and III) have similar aquifer-related chemical quality. Water from these springs is part of the main aquifer beneath the Pajarito Plateau (Purtymun 1980). Chemical quality of Spring 3B (Group IV) reflects local conditions in the aquifer discharging through a fault in volcanics. Discharge at these springs range from less than 1 L/sec (0.25 gal/sec) to 37 L/sec (10 gal/sec) (Purtymun, 1980).

Additional sampling of three other nearby springs is conducted. La Mesita Spring is east of the Rio Grande, while Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. The springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and form small seep areas. Total discharge at each spring is probably less than 1 L/sec (0.25 gal/sec).

8.2.6 *Special Sampling*

8.2.6.1 *San Ildefonso Memorandum of Understanding*

Groundwater monitoring is conducted on San Ildefonso Pueblo land as a part of a broader environmental monitoring program (see Section 7.2.1.4). In 1991, four wells on Pueblo land were sampled.

8.2.6.2 *Fenton Hill (TA-57)*

The chemical quality of groundwaters in the vicinity of the Fenton Hill Geothermal Site has been monitored since the early 1970s. Groundwater stations include seven springs, and two wells (see Sec. 7.2.1.6 for map).

8.2.6.3 *Cañada del Buey*

In 1985, four monitoring wells were installed in Cañada del Buey for use in geohydrologic and environmental studies. To date, all the wells are dry. In addition to documenting the present condition of the canyon, the wells will monitor changes that occur after the new sewage treatment plant begins release of effluents to the drainage in 1993.

8.3 Extent and Frequency of Monitoring

8.3.1 *Routine Annual Sampling*

For consistency, water samples from a given station usually are collected in the same month from year to year. Samples are collected for the routine Environmental Surveillance Program according to the following schedule:

All Wells and Any Springs Within Effluent Release Areas	
Radiochemistry	Annual
Secondary Standards	Annual
Miscellaneous	Annual
Primary Standards	Every 3 Years
Organics	Every 3 Years
White Rock Canyon Springs	
Radiochemistry	Annual
Secondary Standards	Annual
Miscellaneous	Annual
PCBs	Annual

Water from wells, springs, and water supply (wells and distribution) are analyzed for Cs-137, Pu-238, Pu-239,240, total uranium H-3, and gross gamma activity. Water samples from former and active

The Environmental Management Technician is responsible for the operation of the program. This includes sample collection, sample processing and submittal for chemical analysis, keeping a log, and maintaining the data files.

The Project Leader and Staff Members are responsible for preparation of summary data reports, the accuracy, precision, technical validity and overall quality of data and general functioning of the program. They prepare written reports giving the results of the groundwater sampling program, such as for the annual Environmental Surveillance Report.

The Group and Section Leaders are generally responsible for the quality of the work product, as they are for other environmental monitoring programs.

JCI's Utilities Department is the utility support contractor to the Los Alamos National Laboratory. JCI maintains and operates the water supply system, and routinely obtains groundwater level measurements from water supply wells.

8.6.2 *Sampling Station Identification/Construction*

Stations and samples are assigned a unique alphanumeric identifier to provide chain-of-custody control during the transfer of samples from the time of collection through analysis and reporting.

New monitoring wells are designed and installed according to the specifications of the RCRA Technical Enforcement Guidance Document (ASTM 1990), or the EPA-NWWA Handbook EPA600/4-89/034 (EPA 1989), or according to approved Laboratory Environmental Restoration Program SOPs. All monitoring wells will be abandoned according to the specifications of the New Mexico Environment Department and New Mexico State Engineer Office (NMEID 1990).

8.6.3 *Field Procedures*

All samples are collected and handled in accordance with approved Laboratory Environmental Restoration Program SOPs or approved EM-8 procedures. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer (a minimum of three casing volumes of standing water). Spring samples (groundwater) are collected at the discharge point. Fluid measurements of temperature, pH and specific conductance are made at each sampling site.

Duplicate samples, when needed, are collected independently at the same location and time by the method described above.

Before and after the groundwater well samples are collected, the pH, temperature and specific conductance are measured. Analyses are conducted for total recoverable metals and radiochemicals (see discussion in Section 7.8.5). Samples to be analyzed for radiochemicals and metals will be appropriately preserved. Samples for leachable constituents are preserved in the field and delivered to the laboratory as soon as possible in order to meet the holding time limits of the sample. Those samples are then filtered at the laboratory.

Details of container and preservation requirements, and identification of EPA methodology for each analysis are contained in the EM-9 publication "Handbook for Sample Collection, Preservation, and Instrumental Techniques" (Williams, 1990).

All samples are chilled at collection for transport to the EM-9 sample receiving room. Samples are maintained at a temperature of approximately 4 °C.

If special equipment is used for collection of these samples, it is washed with a soap and water solution, followed by ethanol rinse if sampling for organics, and dried with paper towels. This is done before each sample is taken to reduce the potential for cross-contamination.

Collection of samples for chemical and radiochemical analyses follow a set procedure to ensure proper sample collection, documentation, submittal for chemical analyses, and posting of analytical results.

REFERENCES

ASTM 1990: American Society for Testing and Materials, "Standard Guide for Design and Installation of Groundwater Monitoring Wells in Aquifers," ASTM D-5092-90 (1990).

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APPENDIX G

USGS Proposals

August 1994

Proposal NM94-N

Evaluation, compilation, and collection, of hydrologic data in and around the Los Alamos National Laboratory, New Mexico

Prepared by David W. Wilkins

Introduction:

Los Alamos National Laboratory (LANL) is in the Espanola Basin. The Espanola Basin is a north-south trending basin with the northern boundary at a constriction to the Rio Grande near Embudo, New Mexico. The basin is about 45 miles long with the southern boundary at White Rock Canyon, east of Los Alamos. The Sangre de Cristo Mountains form the east boundary and the Jemez Mountains form the west boundary (fig. 1). The basin in the Basin and Range Province situated between the eastern and western prongs of the Southern Rocky Mountains.

LANL is located on the east flank of the Jemez Mountains near the west side of the Rio Grande depression in north central New Mexico. The Jemez mountains are described as volcanic pile that rests on and rises above a zone of faults at the western edge of the Rio Grande depression (Griggs, 1964). LANL is located on the Pajarito Plateau (fig. 1) which is a topographic high that slopes gently eastward to the Rio Grande. The west boundary of the Pajarito Plateau is the Sierra de los Valles.

The Tschicoma Formation of Pliocene age and the Bandelier Tuff of Pleistocene age are major volcanic units in the area. The Tschicoma Formation forms the mountains of the Sierra de los Valles, between the Valles Caldera and the Pajarito Plateau, and is present beneath the surface of the western edge of the plateau. The Tschicoma Formation is overlain by the Bandelier Tuff along the flanks of the mountains. The Bandelier Tuff is a series of ash flows and ash falls of rhyolitic tuff that caps the Pajarito Plateau and overlies the Puye Formation and basaltic rocks of Chino Mesa in the central and eastern edge of the plateau (Purtymun and Johansen, 1974).

The Santa Fe Group comprises the Tesuque and the Puye Formations and the basaltic rocks of Chino Mesa. The Tesuque Formation consists of friable to moderately well cemented siltstone and sandstone with lenses of conglomerate and clay and some interbedded basalt flows. The Puye Formation is a poorly consolidated conglomerate channel-fill deposit overlain by a fanglomerate composed of volcanic debris. The basaltic rocks of Chino Mesa consist of basalt and basalt breccia that overlie the Puye along the Rio Grande and interfingers with the conglomerate to the west beneath the Pajarito Plateau (Purtymun and Cooper, 1969).

The Pajarito Fault Zone lies near the western edge of the Pajarito Plateau. South of the LANL area the Bandelier Tuff on the east side of the fault is downthrown about 300 feet in relation to the tuff on the west side of the fault. To the north the fault splits into two smaller subparallel faults, both downthrown to the east. Kelley, (1978) shows a fault zone throughout the Espanola Basin. The

shows locations of wells in the general area of the Espanola Basin. The density of wells in the area of LANL show that ground-water data collection are minimal in the LANL area because of the lack of wells that are measured or sampled. Figure 2 shows the location of stream gages that collect stage-discharge and water quality data in and around the LANL area. The area near LANL has restricted opportunities for data collection.

Objectives:

Objectives of the proposed study were selected to meet the needs defined in the "Problem" section of the proposal. The overall objective of this proposal is to evaluate the need for specific hydrologic data and compile, collect, and store the needed data in a USGS designed and operated comprehensive data base.

Specific objectives of the proposed study are:

1. Populate the USGS National Water Information System (NWIS) data base with existing hydrologic data in and around LANL.

2. Establish communications between LANL computer systems and the USGS compute. system.

3. Evaluate current and future hydrologic data needs at LANL.

4. Establish a plan for the installation of monitoring wells and surface flow gaging stations at LANL.

5. Install test and observation wells and surface flow gaging stations at LANL

6. Evaluate the need for and frequency of ground- and surface-water data collection adjacent to LANL.

7. Establish a data collection net work and collection schedule for sites adjacent to LANL.

8. Collect data from the selected sites for the schedule selected adjacent to LANL.

Purpose:

The purpose of the proposed study is to develop and maintain a comprehensive hydrologic data base that will be used by LANL scientists to store and retrieve data. An evaluation of the hydrologic data needs, both for current and for future needs, will be made resulting in a data collection plan that will supply the kinds and amounts of data needed for current and future studies, including ground-water flow and ground-water transport models.

Scope:

This proposed study will encompass most of the Espanola Basin. Existing data will be compiled

term data collection needs and the existing data collection networks will be made. This evaluation will done by LANL staff, determined by the Environment Protection Group, USGS staff, and state or local government agency staff suggested by LANL or the USGS. The purpose of the evaluation will be to determine the short- and long-term hydrologic data needs of LANL in the context of current and future studies in and around LANL. For example, a ground-water flow model of LANL and adjacent area is likely to be developed as will be a ground-water transport model, the data collection network evaluation will consider these probable projects and compare data that are in the data base and current data collection at LANL to data that will be needed to develop and calibrate these two types of models. For each probable hydrologic investigation that might be conducted in or around LANL an evaluation of the data needs will be made.

USGS staff will compile information from the evaluations. A USGS Open-File Report will be prepared that describes the suggested hydrologic investigation, the data needs for that investigation, and the short- and long-term data needs of each probable project. The report will also contain a summary of the available data, the data currently being collected, and suggestions for future data collection (type, location, and frequency).

For those sites that are necessary to be established within the next 4 years (Federal fiscal years 1996-1999), both ground and surface water, a plan will be developed for the establishment and operation of each site. Specific drilling date, drilling procedures, construction, testing, finishing, and data collection at each test and observation well site will be established. For surface-water sites location, type of control, type of data to be collected, and data collection frequency will be detailed. This information will be included in the Open-File Report mentioned above.

Data collection from existing sites at LANL will continue by the LANL department that has been collecting the data. If there are sites that are not being used for data collection but the evaluation results in conclusions that data should be collected at these sites then LANL or USGS staff will begin data collection from that site. These data will be entered into the data base quarterly.

From 1996 through 1998 the recommended ground- and surface-water sites will be constructed and operated. For each well drilled, tested, and finished a USGS Open-File Report will be completed. The report will contain descriptions of the drilling operation, geologists descriptions of the cuttings or of any core that might have been collected from the hole, geophysical logs, aquifer test procedures and results of the aquifer tests, and descriptions of the data collection methods.

USGS or LANL staff will collect the specified data from each of the wells that were drilled. The data will be collected at a frequency chosen by the evaluation group. All data will be entered into the data base on a quarterly basis and will be available to LANL staff through the communication link with the USGS computer. Each year, starting the fourth year, an Open-File Data Report will be prepared that summarizes the ground-water data collected from all observation wells in the network for the previous water year (October-September. Surface-water sites and the data collected at each of those sites will be included in the USGS Annual Report for New Mexico.

From figure 1 it can be seen that there are many wells adjacent to LANL. Most of these wells are not measured for depth to water or are not sampled for water quality determinations on a regular basis. Figure 2 shows the location and type of surface-water data collected in and adjacent to

taking place from all sites on and adjacent to LANL. The annual data report will be prepared.

Project Costs:

Costs for the investigation are for federal fiscal years-October through September. Costs include all manpower, equipment, and travel. For the first two years the cost estimates are based on specific tasks and costs of completing those task. For years 3 through 5 the number of wells to be drilled or the number of surface-water sites to be installed are unknown. Contract costs have been estimated that will be used to drill wells or establish surface-water gages. It is also assumed that drilling will require the manpower, travel, and transportation costs shown.

Specific costs and needed funding for drilling and surface gage installation can be better estimated once the data needs at LANL have been evaluated and a plan for installation of the needed sites developed. By the end of the second year detailed costs for the agreed upon work will be made. These estimates will be presented to LANL and the project agreement amended as needed.

Fiscal year 1995	
Labor	$170,500
Travel	3,400
Transportation	2,500
Totals	$176,400
Fiscal year 1996	
Labor	$146,300
Travel	3,100
Transportation	3,800
Printing	6,500
Supplies	1,100
Equipment	4,300
ADR Rentall	1,000
Total	$166,100
Fiscal year 1997*	
Labor	$188,900
Travel	30,400
Transportation	9,500
Communications	1,300
Contracts	254,000
Supplies	41,400
Equipment	7,800
ADR Rental	5,600
Geophysical logging	10,000
Total	$548,900
Fiscal year 1998*	
Labor	$206,000
Travel	34,400

Manpower:

All work for this project will be supplied by the U.S. Geological Survey. Drill crews are supplied by the Geologic Division. The New Mexico District currently has the manpower required for this project and will consist of:

Project Supervisor	GS 13
Project Chief	GS 11
Hydrologic Technician	GS 7
Hydrologic Technician	GS 9
Instrumentation Technician	GS 11
Drilling Technician	GS 7

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Federal Year	1995				1996				1997				1998				1999			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Data collection on LANL							X	X	X	X	X	X	X	X	X	X	X	X	X	X
Entry of LANL data							X	X	X	X	X	X	X	X	X	X	X	X	X	
Installation of data collection sites									X	X	X	X	X	X	X	X				
Well installation Open-File Reports													X							
Preperation of data site information adjacent to LANL									X								X			
Evaluation of data collection needs adjecent to LANL										X										
Field check candidate data collection sites											X									
Final selection of data collection sites adjacent to LANL												X								
Data collection adjacent to LANL												X	X	X	X	X	X	X	X	X
Entry of data adjacent to LANL													X	X	X	X	X	X	X	X
Prepare annual data report													X				X			

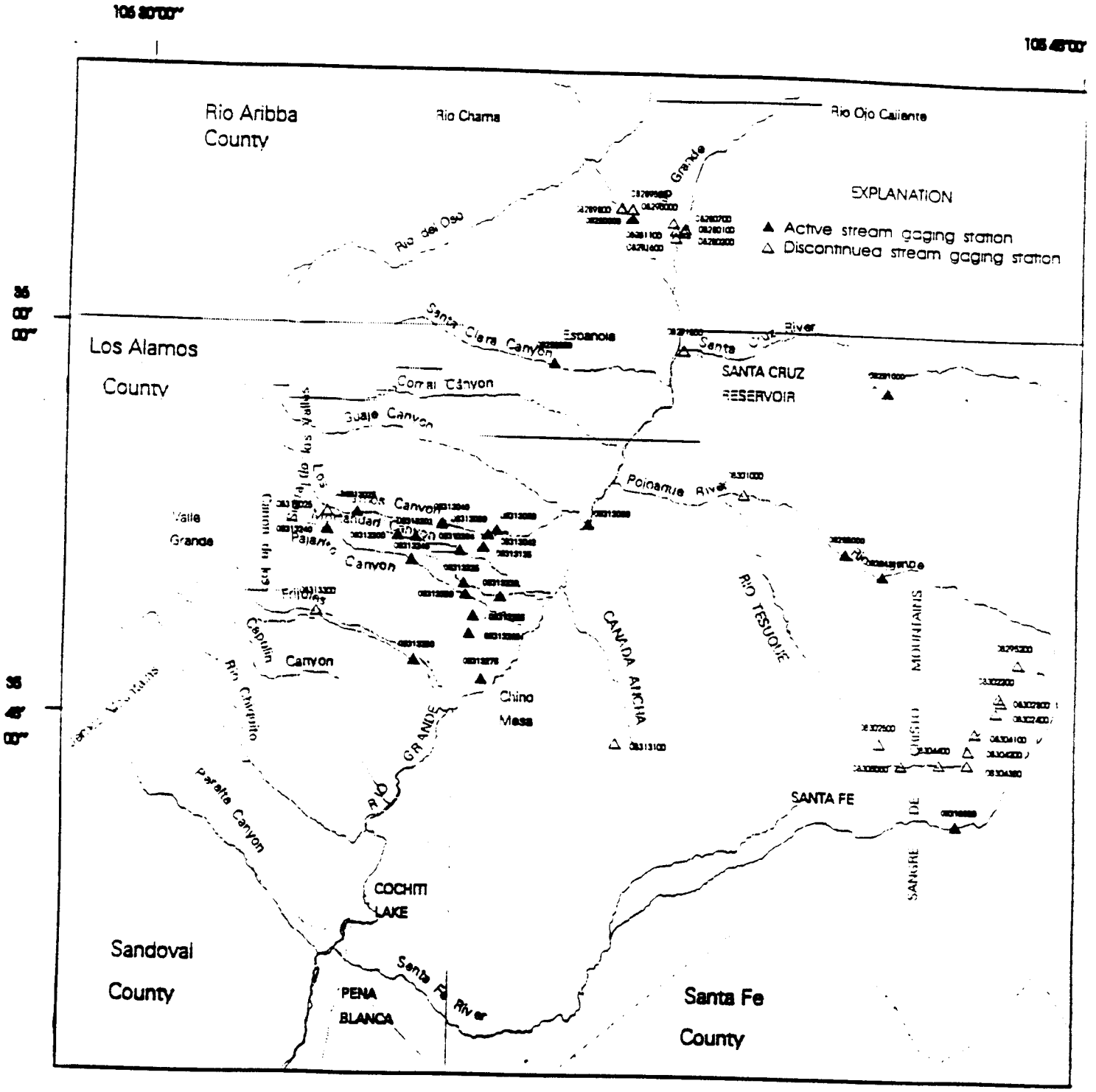

Figure 2.–Surface-water gage locations on and adjacent of Los Alamos National Laboratory

Proposal NM93C
Revised July 1994

Ground-water Recharge and Flow System determination west of the Los Alamos National Laboratory area, Los Alamos County, New Mexico

Prepared by David W. Wilkins

Introduction:

Los Alamos National Laboratory (LANL) is located on the east flank of the Jemez Mountains near the west side of the Rio Grande in north central New Mexico (fig. 1). The Jemez mountains are described as volcanic pile that rests on and rises above a zone of faults at the western edge of the Rio Grande depression (Griggs, 1964). LANL is located on the Pajarito Plateau (fig. 1) which is a topographic high that slopes gently eastward to the Rio Grande. The west boundary of the Pajarito Plateau is the Sierra de los Valles.

The Tschicoma Formation of Pliocene age and the Bandelier Tuff of Pleistocene age are major volcanic units in the area. The Tschicoma Formation forms the mountains of the Sierra de los Valles, between the Valles Caldera and the Pajarito Plateau, and is present beneath the surface of the western edge of the plateau. The formation is composed of latite, quartz-latite flows, and pyroclastic rocks. The Tschicoma Formation is overlain by the Bandelier Tuff along the flanks of the mountains. The Bandelier Tuff is a series of ash flows and ash falls of rhyolitic tuff and caps the Pajarito Plateau and overlies the Puye Formation and basaltic rocks of Chino Mesa in the central and eastern edge of the plateau (Purtymun and Johansen, 1974).

The plateau is formed by rocks of the Santa Fe Group of middle (?) Miocene to Pleistocene (?) age and volcanic rocks of Pliocene and Pleistocene age (Griggs, 1964, fig. 8). The Santa Fe Group comprises the Tesuque and the Puye Formations and the basaltic rocks of Chino Mesa. The Tesuque Formation consists of friable to moderately well cemented siltstone and sandstone with lenses of conglomerate and clay and some interbedded basalt flows. The Puye Formation is a poorly consolidated conglomerate channel-fill deposit overlain by a fanglomerate composed of volcanic debris. The basaltic rocks of Chino Mesa consist of basalt and basalt breccia that overlie the Puye along the Rio Grande and interfingers with the conglomerate to the west beneath the Pajarito Plateau (Purtymun and Cooper, 1969). The Bandelier Tuff overlies the Tesuque Formation in the study area. It is the Tewa Group of the Jemez volcanic dome (Kelley, 1978) that resulted from the products of the explosion and subsequent eruptions of the Valles caldera west of the Sierra de los Valles.

The Pajarito Fault Zone lies near the western edge of the Pajarito Plateau. South of the LANL area the Bandelier Tuff on the east side of the fault is downthrown about 300 feet in relation to the tuff on the west side of the fault. To the north the fault splits into two smaller subparallel faults, both downthrown to the east. Displacement decreases northward until both faults die out. The fault

supplied by interstices, faults, and fractures need to be known

The city of Los Alamos and LANL have grown over the last twenty years and more production wells have been drilled on the plateau. During the operation of LANL, hazardous materials have been disposed of in sediments of the plateau. Current government regulations require documentation of locations of disposal sites, types of materials in the disposal sites, and impact of disposed materials on the ground and on surface and ground water; and eventually clean up of contaminated sites. Before impacts on the hydrologic system can be determined and contaminated ground water cleaned up, the ground-water flow system must be known. Purtymun and Johansen (1974) show a water-level contour map that indicates direction of flow. There are no contours west of Los Alamos indicating a lack of ground-water flow information on the western edge of the plateau and the Sierra de los Valles. This area is hydrologically important because it is a possible recharge area for the plateau.

Objectives:

Specific objectives of this study are:

1. Determine recharge areas of the aquifer system

2. Determine the influence of the Pajarito Fault zone on the surface- and ground-water flow systems

3. Determine hydrologic characteristics of faults and fractures in the Tschicoma Formation, Bandelier Tuff, and Rocks of Chino Mesa that overly the local aquifer system

4. Create a ground-water monitoring network that can be used for future definition of the flow system and to determine the flow system of the local aquifer system.

Approach:

To determine the influence of surface flows on recharge areas and the influence of the Pajarito Fault zone on the surface- and ground-water systems eight surface-water stations will be installed on two major drainages that head in the Sierra de los Valles and flow onto the Pajarito Plateau. These drainages may be the Los Alamos and Guaje. The drainages and sites for the gages will be determined in consultation with staff of LANL Two gages will be installed above the Pajarito Fault and two below the fault in each drainage. The purpose of each set of gages, in a drainage, is to determine the gain or loss of surface flow for the selected reaches of the channel. Data from gages immediately upstream and downstream of the fault will be used to determine the influence of the fault on surface-water flow. Data from gages defining reaches upstream and downstream of the fault will be used in establishing infiltration rates in the Tschicoma Formation and the Bandelier Tuff in the arroyo channels.

To assist in determining the recharge areas for the aquifer system, the influence of the Pajarito Fault zone, hydrologic characteristics of faults and fractures in the formations overlying the Tesu-

tures in the unsaturated zone and fracture strike, dip, and size In conjunction with the televiewer logs a temperature-fluid conductance log will be run. This log will be used to determine if water is flowing into the borehole through fractures or faults. Inflowing water from fractures or faults may have a different temperature or fluid conductance than the fluid in the borehole. An attempt will be made to remove the drilling mud and replaced with a less dense fluid, if the hole will stay open. Replacing the dense drilling mud might allow water to flow from fractures and faults into the well bore. Several passes using the temperature-fluid conductance log will be made. These data will allow an estimate of ground-water flow, if any, through fractures and faults that might be recharging the local aquifer system. A statistical evaluation of the occurrence, strike, dip, and frequency of fractures and faults will be done. This evaluation will consider the regional stress field and may result in information about the orientation of faults and fractures that will most likely transmit water.

Each well will be cased with 4-inch steel casing. All wells will be cemented from the bottom of the hole to 5 feet below the bottom of the screened interval. Each well will have 10 feet of screen installed at the bottom of the well above 20 feet of blank casing that will be a trap for sediment and particulates. Each well will be gravel packed from five feet below the screened interval to 10 feet above the top of the screen. The remainder of the annular space to land surface will be cemented. Drillers logs will be recorded during drilling. Caliper, resistivity, temperature, neutron, gamma, and gamma-gamma logs will be run after drilling but before completion and development in all deep holes

If data collected from the 8 wells installed for this project indicate that recharge to the local aquifer system is from west of the Sierra de los Valles then deep wells should be drilled on the west side of Pajarito Mountain, in or near the Valles Caldera. At least 2 wells should be drilled into the local aquifer system so horizontal gradients can be determined.These wells will be about 5,000 feet deep and penetrate the Tesuque Formation. Water-level data from these wells will be used to determine ground-water gradients between wells in the caldera and the next well or wells to the east. The depth of these holes may require a large commercial drill rig. Since the drilling of these wells is not determined to be necessary the specifications for the holes and the costs will not be included in this proposal.

Duration of the Project:

The project is designed for six years. The attached work plan shows beginning and ending times for specific tasks and the length of time required to complete a specific task. Monitoring is a long-term task but it is not shown beyond the fifth year. In general terms, the first year of the project will be used to select sites and install and operate eight stream-gaging stations. During the second year four wells will be cored and drilled in the floodplain of the selected drainage. Borehole geophysical logs will be run and analyzed. In the third year five wells will be cored and drilled. One well will be drilled west of Pajarito Mountain and four on the plateau east of Pajarito Mountain. In all holes borehole geophysical logs will be run and analyzed. Data collection will start in the first year and continue through the fifth year. The last year is for report preparation and publication. Water-level data collection is expected to continue indefinitely. Long-term stream-gage operation may not be necessary depending on the need for long-term data. The decision to continue gage

Project Costs:

Costs for the investigation are for federal fiscal years-October through September. Costs include all manpower, equipment, travel, well drilling, gage installation, and training.

Fiscal year 1995

Personnel	$63,300
Surface water gage construction and operation	$111,800
Travel	$3,300
Total	$178,400

Fiscal year 1996

Personnel	$126,000
Drilling four wells	$346,500
Surface water gage operation	$68,400
Travel	$21,200
Vehicles	$5,700
Recorder purchase and rental	$6,300
Vehicles	$5,700
Total	$579,800

Fiscal year 1997

Personnel	$137,300
Drilling four wells	$363,000
Surface water gage operation	$70,800
Travel	$23,500
Vehicles	$6,400
Recorder Purchase and rental	$9,600
Total	$610,600

Fiscal year 1998

Personnel	$124,800
Surface water gage operation	$79,600
Travel	$8,700
Vehicles	$2,500
Recorder rental	$6,100
Total	$221,700

Fiscal year 1999

Personnel	$246,000
Surface water gage operation	$86,400
Travel	$6,600
Vehicles	$3,400
Recorder rental	$6,400
Total	$348,800

with sections of the Jemez Caldera and the Lucero Uplift: New Mexico Geological Society Twelfth Field Conference.

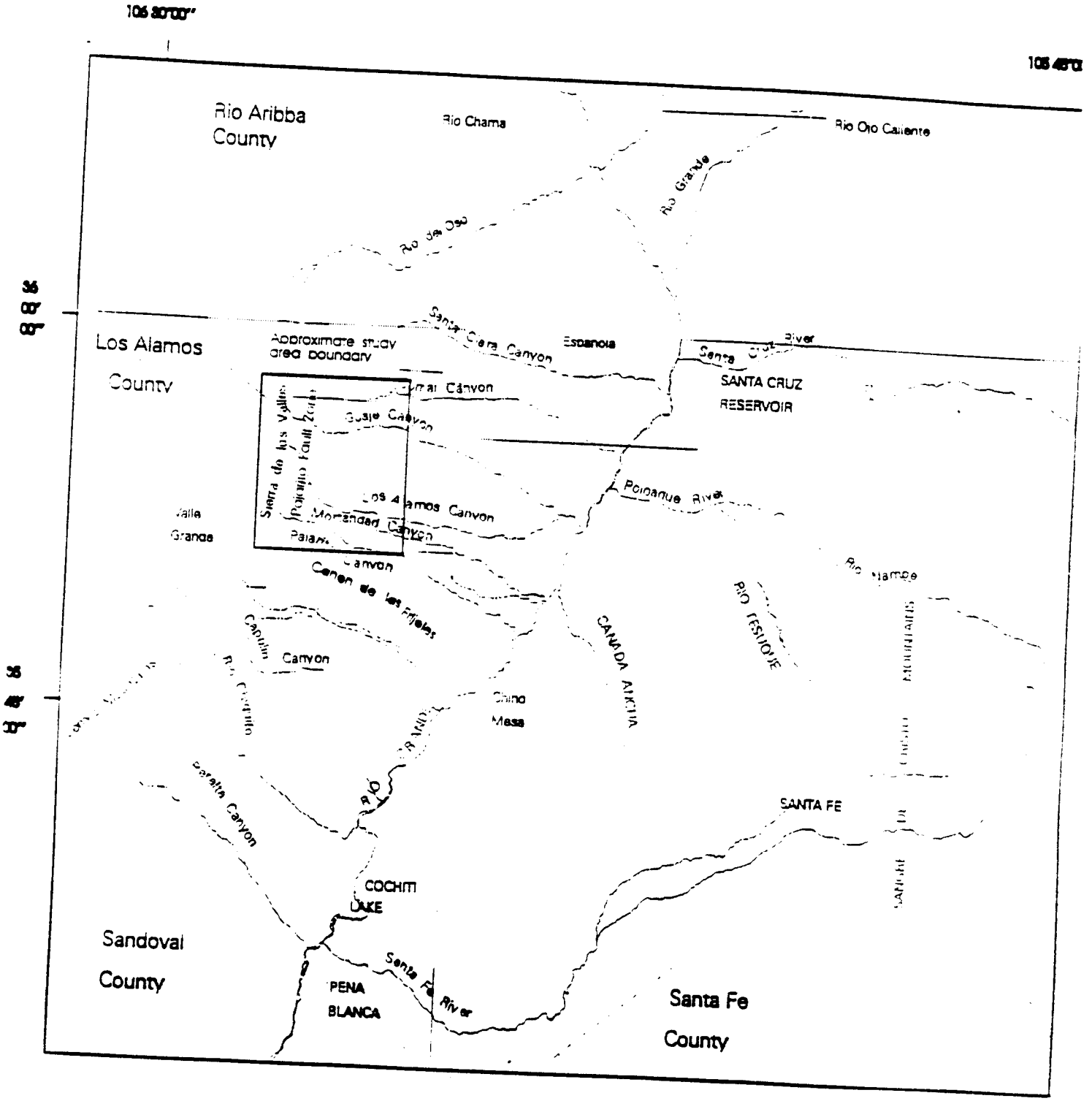

Figure 1.—Approximate study area and geographic features

PRELIMINARY ESTIMATION OF GROUND-WATER-FLOW PATH LINES IN THE MAIN AQUIFER, LOS ALAMOS COUNTY, NORTH CENTRAL NEW MEXICO

Proposal by Peter F. Frenzel

INTRODUCTION

Los Alamos, is located in north-central New Mexico, on the Pajarito Plateau in the Espanola Basin. The Pajarito Plateau (fig. 1) is a topographic high that slopes gently eastward to the Rio Grande. The Pajarito Plateau is on the eastern slope of the Jemez mountains which are described as volcanic pile that rests on and rises above a zone of faults at the western edge of the Rio Grande depression (Griggs, 1964). Los Alamos, Santa Fe, and other communities in the area use ground water from the Santa Fe Group sediments that fill the Espanola Basin. The Espanola Basin is one of a series of grabens and structural basins along the length of the Rio Grande from its headwaters in Colorado through New Mexico and Texas. Research at Los Alamos National Laboratory (LANL) is the main activity at Los Alamos. LANL is a Federally-owned (Department of Energy) facility that is operated under contract by the University of California. LANL developed the atomic bomb and has engaged in related or similar research for the past 50 years. Laboratory wastes are stored or buried near the lab. Wise and effective management of radioactive substances has long been a concern of LANL. This proposal is concerned with ground-water-flow path lines which would be useful for development of a chemical transport model.

GEOLOGY AND HYDROLOGY

The Espanola Basin is a north- to northwest-trending and plunging, asymmetric faulted synclinal sag (Baltz, 1978, p. 213). The basin is filled to an unknown depth with semiconsolidated to unconsolidated Tertiary and Quaternary sediments of the Santa Fe Group. The Santa Fe Group in the Espanola Basin is comprised of Tesuque, Puye, and Ancha Formations of Tertiary age (Manley, 1978, p. 202).

The Tesuque Formation of the Santa Fe Group is the principal aquifer in the Espanola Basin. The Tesuque Formation was deposited mainly as coalescing alluvial-fan deposits derived from the highlands to the north and east. In the eastern half of the basin, the Tesuque dips westward between 4 and 10 degrees as measured in outcrops. Dip in the western part of the basin is generally unknown because the Tesuque is overlain by the Puye Formation of the Santa Fe Group.

The Tertiary Puye Formation of the Santa Fe Group (Griggs, 1964, p. 28; Purtymun and Johansen, 1974, p. 347-349) is younger than the Tesuque Formation and is present on the western side of the Rio Grande. The formation consists mainly of gray sand and small pebbles derived from rocks varying in composition from basaltic to rhyolitic that were associated with the volcanics of the Jemez Mountains. The deposits form high-terraced escarpments deeply incised by east-west-trending washes extending from the Jemez Mountains to the Rio Grande. In Los Alamos, wells have penetrated water in the Puye Formations as well as in the underlying Tesuque Formation. The Puye and Tesuque Formations are hydraulically connected.

The Ancha Formation of the Santa Fe Group (Spiegel and Baldwin, 1963, p. 45) is a Tertiary high pediment gravel deposited unconformably on the Tesuque Formation in the southern part of the Espanola Basin. The Ancha Formation is mainl south and west of Santa Fe and under the city itself. The Ancha is coarser than the Tesuque, bu is mainly unsaturated except in the southern part of the basin.

The Tschicoma Formation of Pliocene age and the Bandelier Tuff of Pleistocene age are major volcanic units in the Pajarito Plateau. The Tschicoma Formation is approximately the same age as the Puye Formation (Kelley, 1978). The Tschicoma forms the mountains west of Los Alamos and is present beneath the surface of the western edge of the Pajarito Plateau. The Tschicoma is composed of latite, quartz-latite flows, and pyroclastic rocks.

The Bandelier Tuff overlies the Tschicoma Formation along the flanks of the mountains and overlies the Puye Formation and basaltic rocks in the central and eastern edge of the Pajarito Plateau. The Bandelier is a series of ash flows and ash falls of rhyolitic tuff and caps the Pajarito Plateau (Purtymun and Johansen, 1974). The Bandelier Tuff and possibly the eastern edge of the underlying Tschicoma Formation generally occupy the unsaturated zone at Los Alamos.

The Pajarito Fault Zone lies near the western edge of the Pajarito Plateau. South of the LANL area the east side of the fault is downthrown about 300 feet in relation to the west side of the fault. To the north, the fault splits into two smaller subparallel faults, both downthrown to the east. Displacement decreases northward until both faults die out. The downthrown block is to the east from the southern boundary of the basin to the Chama River. The downthrown block and dip are to the west north of the Chama River. Although the Pajarito Fault Zone has been considered to be the western boundary of the Espanola basin by Hearne, McAda and Wasiolek, and Finch and Fleming, the possible westward extent of the Tesuque Formation, and its hydraulic continuity westward beyond the Pajarito Fault zone is unknown.

Water supply in the Espanola Basin is from surface and ground water. Most irrigation is from surface water and most domestic, municipal and industrial supplies are from ground water withdrawn from the Santa Fe Group sediments. However, Santa Fe is partly supplied from surface flows of the Santa Fe River. Los Alamos is supplied mainly by ground water with some irrigation of ornamentals supplied from surface flows of several canyons. Smaller communities and individual supplies in the Espanola Basin depend on ground water except for agricultural irrigation.

In the Pajarito Plateau area, several aquifers have been identified. The main aquifer, is more or less continuous with water-bearing sediments elsewhere in the Espanola Basin. Additionally, perched aquifers have been identified in the Tschicoma and Puye Formations, in the basaltic rocks of Chino Mesa, and in the Bandelier Tuff (Griggs, 1964, p. 102). Ground water in the alluvium of canyons on the Pajarito Plateau also is perched to some extent (Baltz, Abrahams, and Purtymun, 1963). The degree of hydraulic connection through a zone that is mostly unsaturated between the perched aquifers and the main aquifer generally is unknown. The main aquifer is composed of the Tesuque Formation and the lower part of the Puye Formation. The upper surface of the main aquifer rises westward from the Rio Grande through the Tesuque into the lower part of the Puye Formation beneath the central and western parts of the plateau. The water is unconfined in the western edge of the plateau and becomes semi-confined as water in the aquifer moves below the

OBJECTIVE

- To estimate ground-water-flow path lines in the main aquifer of the Pajarito Plateau.

PURPOSE AND SCOPE

The purpose of this study will be to estimate ground-water-flow path lines using a ground water flow model that can be revised as easily as possible to account for new data. The area modeled will include enough of the central and southern Espanola Basin to avoid artificial boundary effects in the Pajarito Plateau area. Although the purpose of the flow model is to estimate paths of ground-water flow, the data necessary to define path lines accurately enough for a transport model probably does not yet exist. Therefore, the path lines estimated are termed "preliminary". The model will become obsolete as additional data are collected and concepts of the ground-water system change. Although the model will be made as easily-modified as possible, data and new concepts that may be brought forth after the first 24 months of this study may not be included in the final product. Although the model will be constructed with the idea of providing a basis for a solute transport model, this model will be limited to ground-water flow below the water table in the main aquifer, and will treat flow in the vadose zone only as a boundary condition.

APPROACH

In general, path lines will be estimated from a finite-difference ground-water flow model using MODFLOW (McDonald and Harbaugh, 1988) and MODPATH (Pollack, 1989). The approach will be made in 3 steps. The first step will be to study the geologic and hydrologic literature of the Espanola Basin, and compile existing data. The second step will be to assemble a geographic information system data base. The third step will be to calibrate a ground-water flow model and estimate the path lines.

The first step will begin with the literature review. The literature review will include selected literature that could lead to conclusions about ground-water path lines in the main aquifer of the Pajarito Plateau, and might include several disciplines. The review will concentrate on gathering information about the study area that will lead to development of a ground-water flow model, not on theoretical considerations of path-line calculation. The area of the Pajarito Plateau will be emphasized with a lesser degree of emphasis on more distant parts of the Espanola Basin. Part of the first step will be to locate and compile existing data that were not compiled by previous projects. Existing stress data might include ground-water pumpage, the fate of Santa Fe and Los Alamos public supply water (irrigation, private disposal systems, public disposal effluent locations and rates), and possibly other hydrologic features such as water impounded in Cochiti Reservoir which occasionally backs up onto an area of the Espanola Basin. Existing hydrogeologic data might include lithologic well logs and estimated hydraulic conductivities. Other existing data relating to path lines might include ground-water age, altitude of recharge, penetration of tracers into the aquifer system, degree of saturation, surface geophysics, borehole geophysics, fracture studies, and water-bearing characteristics of cores. The literature review will be preserved as an annotated bibliography and published as an Open File Report. Annotations will relate to the determination of path lines and will not necessarily indicate the full content of the literature reviewed. Part of the first step will be development of the conceptual model, which will be modified throughout the project, preserved as the geohydrology section of the model report, and published by the end of the project.

MANPOWER, COSTS, AND WORKPLAN

The total duration of the investigation is 45 months: 3 years for the study with 9 additional months for final report preparation. Costs are almost entirely to cover salaries for personnel, and are concentrated in the first 3 years of the investigation. Manpower is available within the New Mexico district and consists of the project chief (GS-12), a consulting modeling and GIS expert (GS-13), a computer specialist (GS-11), and a student helper (GS-4). The project chief will be 80 percent available the first year and 100 percent available for the remainder of the project.

Costs in dollars*

Fiscal year 1995	
Personnel	$140,000
Vehicle**	5,700
Copy/purchase documents	1,300
Total	$147,000
Fiscal year 1996	
Personnel	$171,000
Vehicle**	1,000
Printing of bibliography	8,500
Total	$180,500
Fiscal year 1997	
Personnel	$175,000
Vehicle**	1,000
Total	$176,000
Fiscal year 1998	
Personnel	$76,000
Vehicle**	300
Printing of model reports	19,000
Total	$95,300
Project total	$598,800

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APPENDIX H

Annotated Bibliography of Geologic, Hydrogeologic, and Environmental Studies Relevant to Solid Waste Management Units at Los Alamos National Laboratory

LA-UR-90-3216

Los Alamos National Laboratory

Environmental Restoration

A Department of Energy environmental clean up program

Annotated Bibliography of Geologic, Hydrogeologic, and Environmental Studies Relevant to Solid Waste Management Units at Los Alamos National Laboratory

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APPENDIX I

Comments and Recommendations

Attached are the Tiger Team Assessment, the LANL Self-Assessment, the New Mexico Environmental Division (NMED) Initial Assessment, and the Hydrogeologic Review for the Environmental Restoration Program at LANL. The structure of the documents has been reformatted so that section numbers could be placed in the right-hand margin. These section numbers correspond the sections of the Plan where the mentioned concern has been addressed. Some of the comments and recommendations do not necessarily pertain to groundwater protection or the GWPMP. These are referenced as not applicable (NA).

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3.2.4 Ground Water

Statement addressed in Section:

Ground water occurs in two principal subsurface regimes at Los Alamos: 1) perched water in relatively shallow (10-100 ft) alluvial canyon bottoms across the Laboratory or in basalts in the northeastern portion, and 2) the main aquifer in deep sediments (800-1200 ft below the mesa tops) underlying the more recent volcanic rocks that make up the entire Pajarito Plateau. The deep main aquifer is the source of the municipal and industrial water supply for the entire Laboratory and Los Alamos County.

The several hundred feet of dry volcanic rock provide protection for the main aquifer from surface infiltration or downward migration of moisture from the perched water in canyon alluvium. Extensive monitoring of the main aquifer since the late 1940s has never shown any contamination attributable to Laboratory operations. Not enough is yet known about the fundamental processes controlling movement of water or contaminants through the unsaturated zone to completely understand whether contamination could ever reach the main aquifer.

Several of the canyon-bottom shallow alluvial aquifers contain contamination, both radiological and nonradiological, from discharge of both untreated (during early years) and treated (continuing to present) Laboratory effluents. These situations have been and continue to be monitored by an ongoing routine surveillance program that has evolved from the initial monitoring provided to the U.S Atomic Energy Commission by the U.S Geological Survey starting in 1946 and continuing until the early 1970s when taken over by Laboratory staff. The potential for recharge to the main aquifer from such alluvial perched water is not fully studied. Tritium contamination has been found to depths of about 200 ft (the greatest depth of core samples taken to date) in the unsaturated zone below Mortandad Canyon, the canyon that receives effluent from the radioactive liquid waste treatment plant at TA-50. The tritium concentration in moisture extracted from the tuff was less than 10 percent of the DOE's Derived Concentration Guide for Tritium in water. In addition, continued sampling of the water of the deep aquifer, located 950 feet beneath the canyon, has not detected any impact of Laboratory operations on water quality in the aquifer and with no resultant radiation dose to users of this water. New special studies being implemented under auspices of the Environmental Restoration (ER) Program are beginning to contribute significant additional understanding to mechanisms by which the main aquifer may be recharged by alluvial perched water.

In addition to the environmental quality aspects of contaminant migration, the main aquifer is also monitored for resource management as the source of water supply. Water levels, pumping drawdown, total production and pumping rates, and other hydrologic data related to well performance are documented and evaluated routinely. This evaluation provides the basis for determining requirements for well maintenance, sighting of new wells, and planning for the reliability of future water supply. The data also provide the basis for compliance reporting to the New Mexico State Engineer Office in relation to the legal water rights owned by DOE.

The major deficiency related to ground water is that there is not enough basic detailed information available to fully understand the complex hydrogeologic setting of the Pajarito Plateau on which the Laboratory is located. The deficiencies in understanding relate to both the water quality and resource management issues. The available information is inadequate to meet the requirements of DOE Order 5400.1 for the Ground Water Protection Management Program Plan. Fundamental research is necessary in basic geology, unsaturated zone geology and hydrology, and saturated zone geology and hydrology. An independent panel of experts is reviewing the current state of hydrogeologic knowledge to recommend research priorities for the Laboratory. 5.1.2

Ground water monitoring facilities, equipment, and documentation are inadequate and do not satisfy the Ground Water Protection Management Program Plan. No significant numerical modeling capability is in place to routinely model the unsaturated zone or saturated zone of the aquifers at the Laboratory. 5.3.2 5.1.2

The Laboratory has not prepared ground water discharge plans for discharges from existing facilities. A request for such plans is anticipated from NMED. These plans would be required within 120 days after a request by NMED, which I s insufficient time for meeting this requirement. In addition, the Laboratory has not prepared a Notice of Intent to Discharge and a Ground Water Discharge Plan for the new SWSC Project, which must be approved before discharge begins in July 1992. 5.7.2 Done

DOE owns the water supply system for the Laboratory and Los Alamos County, including the wells, booster pump stations, transmission lines, and storage tanks. The Laboratory provides oversight of the water supply system. JCI provides the day-to-day operation and maintenance of the system. DOE sells water to Los Alamos County, which operates and maintains the distribution systems at Los Alamos Townsite and White Rock.

The Laboratory is responsible for meeting the monitoring and oversight requirements of the Safe Drinking Water Act (SDWA) for the system. Samples are collected by the Laboratory and tested for chemical quality and radioactivity by the state Laboratory Division (SLD). JCI collects and tests samples for bacteriological quality (coliform bacteria) in their laboratory, which is certified by the SLD. Sampling and test results for bacteriological and chemical quality, and for radioactivity, meet the requirements of the SDWA.

Programs to ensure that the water supply is not contaminated from external sources at the Laboratory are inadequate. A cross-connection control program inside buildings is needed to ensure against contamination of the potable supply from an industrial or waste water source. A survey of all water fountains and potable drinking water outlets for lead is needed NA

to ensure that elevated levels of lead are not originating from lead-lined water fountains or building plumbing. A plan to improve the bacteriological quality of the water supply at the Laboratory along dead-end and stagnant lines is also needed. This plan would include control of noncoliform bacteria, which is recommended to ensure against contamination but is not required under the SDWA.

No mechanisms, legal or related to infrastructure, are yet in place to provide for additional water pumpage for reliable future water in conformance with regulations of the New Mexico State Engineer Office. Additional efforts are needed to ensure continuing adequate water supply for the Laboratory and Los Alamos County.

GW. 1 Quality Control Regulations

Performance Objective: The Laboratory must comply with New Mexico Water Quality Control Commission Regulations related to ground water and other ground water requirements.

Finding/GW.1-1: The Laboratory is not in a position to provide a 120 day period response as required by NMED for preparation of a Laboratory-wide Ground Water Discharge Plan. 5.7.2

Discussion: Under the regulations of the New Mexico Water Quality Control Commission, a Ground Water Discharge Plan may be requested at any time for the continued operation of any one or all of the 9 sanitary treatment facilities and over 100 industrial outfalls. A Ground Water Discharge Plan would be required within 120 days after notification from NMED. A Laboratory-wide Ground Water Discharge Plan is needed to meet New Mexico Water Quality Control Commission regulations in a timely manner.

Finding/GW. 1-2: A Notice of Intent to Discharge and a Ground Water Discharge Plan have not been prepared to meet the July 1992 SWSC Project to allow for discharge from the new SWSC Project. 5.7.2

Discussion: The new SWSC sanitary treatment plant is included in the Laboratory's new NPDES permit. A Notice of Intent to Discharge and a Ground Water Discharge Plan are needed as soon as possible to satisfy New Mexico Water Quality Control Commission Regulations. The WQ&T Section of EM-8 has collected ground water discharge information for the plan and a draft Notice of Intent has been prepared. The new SWSC Project will not begin operation until these items are completed.

Finding/GW. 1-3 A Ground Water Discharge plan regarding sanitary sludge disposal has not been initiated for TA-54, Area G in response to a potential request for such a plan by NMED.. 5.7.2

Discussion: Under New Mexico Water Quality Control Commission regulation, a Ground Water Discharge Plan may be requested at any time by the NMED for continued disposal of sanitary sludge at TA-54, Area G a Ground Water Discharge Plan would be required within 120 days after notification from NMED. A Ground Water Discharge Plan for TA-54, Area G. relating to sanitary sludge disposal is needed to meet New Mexico Water Quality Control Commission regulations in a timely manner.

Finding/GW.1-4: A Ground Water Discharge Plan has not been initiated for the TA-53 lagoons in response to a potential request by NMED. Done

Discussion: Under the New Mexico Water Quality Control Commission regulations, a Ground Water Discharge Plan may be requested at any time by NMED for continued use of these lagoons. Liners do not exist for the two sanitary lagoons. The TA-53 lagoons were included in Part A (Mixed-Waste Section) of the Laboratory's RCRA Permit in January 1991. A Ground Water Discharge Plan for the TA-53 lagoons should be initiated to meet New Mexico Water Quality Control Commission regulations. The 120 day period allowed for preparation of a Ground Water Discharge Plan for the TA-53 lagoons is not adequate for completion of such a plan.

GW .2 Implementation of Ground Water Protection Programs

Performance Objective: The Laboratory should implement all provisions of the Ground Water Protection Management Program Plan (GWPMPP) as required by the DOE Order 5400.1, and its implementation guidance provided by DOE.

Finding/GW. 2-1: Sufficient detailed information is not available on the hydrogeology of the Pajarito Plateau to meet all the requirements of DOE Order 5400.1 and the GWPMPP guidance. Furthermore, a plan to acquire the necessary information does not exist. 5.1.2

Discussion: The large area encompassed by the Laboratory and its location on the very complex geologic setting of the Pajarito Plateau present an extremely challenging setting. A complete understanding of the sources, occurrence, and movement of water in both saturated and unsaturated conditions is essential to evaluating the present and potential impacts of waste management and water resources for water supply purposes. Fundamental information is not available on the basic geology and hydrology to adequately address the requirements of the DOE GWPMPP guidance or the requirements of RCRA Corrective Action studies

Major deficiencies in information can be found in the following areas taken from the DOE GWPMPP guidance and the DOE ground water check list in Section 11 of the DOE *Environmental Audit Manual:*

- **Basic Geology:** Basic geology of the Laboratory area includes structural features, stratigraphy, fracture and fault zones (knowledge of both the Pajarito fault zone on the western margin of the plateau and the plateau itself where faults and fractures may control erosional patterns and potential infiltration zones are crucial to understanding ground water recharge), geomorphology, seismic history, and geochemistry.

- **Saturated Zone Geology and Hydrology:** Information on recharge of the main aquifer and lithology is incomplete; knowledge of the upper surface of the main aquifer, especially toward the west, is incomplete; temporal variation of the ground water surface is not well described; information is lacking on vertical and horizontal permeability variation, horizontal and vertical pore-water velocities, pore-water flow gradients, the extent of phreatic versus confined zones, geologic structure beneath the Bandelier tuff, spatial variations of natural ground water quality, and areal continuity of data.

- **Unsaturated or Vadose Zone Geology and Hydrology:** The areal variation in lithology is incompletely described; infiltration rate and vertical permeability are known only for a few select locations, the geologic structure and thickness of strata lack detail, unsaturated moisture characteristics have been measured for only two basic locations (TA-54 and Mortandad Canyon) within the Laboratory; unsaturated hydrologic property measurements are lacking for the Otowi and Guaje Members of the Bandelier tuff, the Chino Mesa Basalts, the Puye Conglomerate, and the unsaturated portions of the Santa Fe Group sediments.

Finding/GW.2-2: Ground water monitoring facilities, equipment, documentation, and procedural improvements needed to satisfy the GWPMPP guidance have not been completed. 5.3.2

Discussion: A large number of improvements need to be made in the Laboratory ground water monitoring for compliance with the recommendations of the DOE GWPMPP guidance. The following paragraphs highlight the most important items:

- Additional ground water monitoring wells to the main aquifer are needed to provide better areal coverage, especially in the western and southeastern portions of the Laboratory. All possible test wells to the main aquifer need to be equipped with access tubes or transducers to provide more extensive capability to measure the peizometric surface. Water-level measurements need to be made at least annually, and in some areas possibly more frequently to establish the appropriate interval for detecting significant changes in gradient. Annual potentiometric surface maps need to be prepared. 5.3.2

- The complete inventory and comprehensive map of all known monitoring and production wells, including all known abandoned holes and "similar holes in the ground," need to be completed. The inventory needs to identify availability of as-built and development records and the existence or availability of geologic and geophysical logs. 5.3.2 5.6.2

- Procedures and methodology need to be more completely documented. Such things as purging methods, water-level measurement protocols, well maintenance, pump tests, well abandonment, well security, details of sampling protocols (frequency, custody records, and analyses for each well), details of interpretation (data base, statistical comparisons, and trends) need to be specified appropriately for specific Laboratory conditions. 5.6.2

- All monitoring wells, test wells, and test holes (in addition to those used as part of the routine monitoring program) need to be equipped with locking security caps, marked with permanent stamped labels, and surveyed to 0.01 ft elevation and 0.5 ft New Mexico State Plane coordinates to permit mapping on the Laboratory graphic information system. 5.3.2

GW.3 Ground Water Monitoring Program

Performance Objective: The Laboratory should be conducting a comprehensive ground water monitoring program in accordance with the provisions for ground water monitoring as required by DOE Order 5400.1, and the General Environmental Protection Program, including the requirements for procedural documentation. Routine environmental monitoring of ground water for contamination from Laboratory operations should be implemented to address all issues and requirements of relevant DOE Orders and directives (e.g., DOE Order 5400.1 DOE Order 5820.2A, and DOE Order 5400.5), including the requirements for complete procedural documentation.

Findings/GW. 3-1: The documentation of procedural aspects of the ground water monitoring component of the EMP is not adequate, and the Ground Water Monitoring Plan required by DOE Order 5400.1 is not completed or implemented. 5.3.2 5.6.2

Discussion: While the overall ground water sampling water sampling component of the routine Environmental Surveillance Program at the Laboratory is considered appropriate and in accordance with

GW.3 Ground Water Monitoring Program

Performance Objective: The Laboratory should be conducting a comprehensive ground water monitoring program in accordance with the provisions for ground water monitoring as required by DOE Order 5400.1, and the General Environmental Protection Program, including the requirements for procedural documentation. Routine environmental monitoring of ground water for contamination from Laboratory operations should be implemented to address all issues and requirements of relevant DOE Orders and directives (e.g., DOE Order 5400.1 DOE Order 5820.2A, and DOE Order 5400.5), including the requirements for complete procedural documentation.

Findings/GW. 3-1: The documentation of procedural aspects of the ground water monitoring component of the EMP is not adequate, and the Ground Water Monitoring Plan required by DOE Order 5400.1 is not completed or implemented.

Discussion: While the overall ground water sampling water sampling component of the routine Environmental Surveillance Program at the Laboratory is considered appropriate and in accordance with DOE guidance (e.g. DOE/EH-0173T, and DOE/EP-0023), documentation of procedural aspects for citing of sampling locations, sampling techniques, data handling (including data basing) and QA are incomplete in relation to the requirements of DOE Order 5400.1 (Chapter IV Sections 4 and 9.A and 9.B). The general Environment Monitoring Plan (EMP) and the separately identifiable Ground Water Monitoring Plan (which becomes a component of both the EMP and the GWPMPP) are required to be in place by November 9, 1991. The existing QA program plans do not completely meet the requirements of the more recent DOE Orders and directives for extent of documentation and do not fully address QA aspects. 5.3.2 5.6.2

Findings/GW. 3-2: No significant numerical modeling capability is in place to routinely model either the unsaturated zone or saturated zone at the Laboratory.

Discussion: Inadequate physical data is available to support a comprehensive modeling effort. Basic physical processes are not fully understood. This includes both basic water movement as well as potential transport of contaminants. 5.1.2

The Laboratory has premier computing capabilities, and the Laboratory staff has developed state of the art general models, specifically TRACR3D, to address such problems under specific funding for other DOE programs, e.g., Yucca Mountain.

GW. 4 Safe Drinking Water Regulations

Performance Objective: The Laboratory must comply with the SDWA and New Mexico regulations governing water supplies.

Finding/GW.4-1: The cross-connection control program, wellhead inspection program, and program for disinfection of lines after construction are not current and formalized for compliance with the SDWA.

Discussion: Formal procedures and QA for these programs are required to properly document that the work being performed by JCI Health, Safety, and Environment Department, in behalf of the WQ&T Section of EM-8, meets regulatory requirements and environmental standards 5.3.2 5.6.2

Finding/GW.4-2: Sampling procedures, QA and SOPs including worker protection, are not current for the SDWA Program.

Discussion: Formal procedures for SDWA sampling and QA are required. Formal procedures for SDWA record keeping are also needed to properly document routine SDWA activities. These activities include sampling and testing, as well as programs required to protect the water supply such as cross-connection controls, wellhead inspection, and disinfection of lines. A formalized notification procedure for violations of the SDWA is also needed. 5.6.2

Finding/GW. 4-3: No plan exists for improved microbiological quality of the Los Alamos water supply system.

Discussion: Growths of biofilms of flavobacterium and other noncoliform bacteria have been experienced in the Los Alamos water system. These growths represent a deterioration of microbiological water quality in sections of the system in which flows are limited. Preparation of a plan to improve microbiological water quality at the wellheads and throughout the system is needed to control potential contamination and potential growths of disease-causing organisms. 5.4.2

Finding/GW. 4-4: There has not been a Laboratory-wide survey of plumbing inside buildings to identify cross connections and to ensure against contamination.

Discussion: A survey of the potable water supply inside buildings for cross connections is needed to ensure against contamination. The new Mexico regulations governing water supply require the use of backflow prevention devices and stipulate that there shall be no piping arrangement or connection that allows an unsafe substance to enter a public water supply. A Backflow Prevention Device Test Program is in place at the Laboratory, but a formal cross-connection control survey inside buildings also is needed to ensure compliance with state regulations.

NA

Finding/GW. 4-5: A systematic survey to identify potential elevated levels of lead in drinking water from water fountains and other outlets has not been conducted.

Discussion: Certain models of water fountains were manufactured using lead solder and tanks. Lead from these sources can reach into the drinking water. A Laboratory-wide survey, which includes sampling, is needed to identify and remove older water fountains and other potable water outlets that could produce elevated levels of lead in drinking water.

Selected water fountains at the Laboratory have been sampled for lead and have been found to exceed proposed new lead limits for drinking water. Levels over the current drinking water standard for lead (0.05 mg/l) have not been found. A Laboratory-wide inventory and sampling of water fountains are needed to ensure against elevated levels of lead and to provide a data base for action when proposed new lead limits are implemented by EPA and NMED.

NA

GW.5 New Mexico State Engineer Water Rights Regulations

Performance Objective: The Laboratory must operate and manage the water supply system in conformance with the New Mexico State Engineer Office (NMSEO) regulations on water rights.

Findings/GS. 5-1: Under the permit for NMSEO, there are no mechanisms, legal or infrastructure, in place to provide for additional water pumpage when the demand increases above the legal water rights limit.

Discussion: The DOE-owned wellfields that supply water for the Laboratory and the community are being pumped at 95 percent to 98 percent of the annual legal water rights maximum under the permit from the NMSEO. Several possible approaches would permit either greater pumpage or use of the additional San Juan-Chama water that was contracted for by DOE. These include establishing return flow credits for effluents, and devising a method to divert the San Juan-Chama water from the Rio Grande when released from upstream reservoirs. Additionally, replacement wells are needed to ensure current capacity as older wells lose yield or fail. Lead times for providing such mechanisms may well be much longer than the potential demand increase that could result from a hot dry summer, for example. Higher priority efforts to ensure adequate water supply in future years are essential to meet commitments to Los Alamos County and the needs of the Laboratory.

To be addressed

Tiger Team Assessment of the
Los Alamos National Laboratory
November 91

3.5.3.2 Compliance Findings

FINDING GW/CF-1 **Groundwater Protection Management Program Plan**

Performance Objective

DOE Order 5400.1, "General Environmental Protection Program," Chapter III. Section 4.a.. required that a Ground Water Protection Management Program Plan (GWPMPP) be completed by May 1990. Elements of the GWPMPP include documentation of the ground water regime with respect to quantity and quality; design and implementation of a monitoring program; a management program for ground water protection and remediation; a summary of areas that may be contaminated; strategies for controlling sources of these contaminants; a remedial action program that is part of the site resource Conservation and Recovery Act program; decontamination and decommission programs; and other remedial programs contained in DOE directives.

Finding

The LANL GWPMPP does not fully meet the requirements of DOE 5400.1

Discussion

LANL's GWPMPP (GW-87) does not fully meet the requirements and lacks specific information and reviews as required by DOE Order 5400.1. Information deficiencies include the following:

1.	The GWPMPP does not include an adequate Groundwater Monitoring Plan (GMP) according to the criteria in DOE Order 5400.1 (see Finding GW/CF-2).	5.3
2.	The GWPMPP does not adequately define the relation between the recharge and baseline water quality and quantity of the main aquifer.	5.1.2
3	There is no written, formal relationship between the groups within the Environmental Management Division to implement specific sections within the GWPMPP (e.g., underground storage tank management programs).	6.2
4.	There is no description of training, other than for safety and health that is expected for new and existing employees, to further the goals of the ground water program.	6.7
5.	The GWPMPP lacks documentation of both quality and quantification of the TA-57 (Fenton Hill) perched ground water regime.	4.3.5

LAAO could not provide documentation indicating that they approved or reviewed the GWPMPP initially or annually, as required by DOE Order 5400.1. The Environmental Protection Group (EM-8) indicated that the document was sent to LAAO for review on April 27, 1991; however, EM-8 did not receive any comments from LAAO (I-GW-95).

This finding was partially identified in the LANL Self-Assessment.

FINDING GW/CF-2 **Sitewide Hydrogeological Monitoring Well Network**

Performance Objective

DOE Order 5400.1 "General Environmental Protection Program." Chapter III, Section 4. a., requires preparation of a GWPMPP by May 1990, Specific elements of the GWPMPP include the "documentation of the ground water regime with respect to quality and quantity, design and
implementation of a monitoring program, a management program for ground water protection and remediation, a summary of areas that may be contaminated, and strategies for controlling sources of these contaminants."

DOE Order 5400.1, Chapter IV. Section 9 requires that a Ground Water Monitoring Plan (GMP) be developed and implemented as a specific element of the GWPMPP by November 9, 1991. The GMP specifies "Ground Water that is or could be affected by DOE activities shall be monitored to determine and document the effects of operations on ground water quality and quantity." The GMP must address regulations and requirements applicable to ground water protection and monitoring, sampling strategies, sampling and analysis plans, and data management.

DOE Order 5400.1 Chapter II. Section 10. "Ground Water Protection," states "The Ground Water Protection Program," should be summarized, including a review of the monitoring program that describes the number of wells."

Finding

LANL's sitewide hydrogeological ground water monitoring well network will not be extensive enough to be able to characterize the impact of DOE operations on ground water quality by November 9, 1991, as required by DOE Order 5400.1.

Discussion

The existing ground water monitoring well network at LANL was largely developed by the U.S. Geological Survey prior to 1960 without a GMP. It is not adequate to determine the complex hydrogeologic conditions of the Pajarito Plateau. The LANL GMP, as required by DOE Order 5400.1, is being drafted, but will not be available for review by November 9, 1991.

The well network monitors the main aquifer and perched alluvial aquifers in the Canyons. The following deficiencies regarding the main aquifer monitoring well network on-site have been identified:

1. The 11-well onsite well monitoring network includes no wells on the western perimeter of the site and the western side of the Pajarito fault zone. Site baseline measurements, and the means of detecting migrating contamination from offsite locations, are lacking due to the absence of wells on the western perimeter. The effect of faults on ground water recharge and directional flow, potential infiltration zones, and seismic history on both sides of the fault zone cannot be accurately determined because of the lack of wells. 5.1.2 5.3.2

2. Five of the 11 onsite monitoring wells are also potable production wells. When these wells are pumped for drinking water purposes, significant cones of depression are created, giving rise to inaccurate measurements for monitoring purposes both in depth to ground water and generalized ground water flow direction. This results in inaccurate measurement of peizometric surfaces on a major portion of the monitoring network. Accurate peizometric surface measurements are essential for determining generalized ground water flow direction. 5.1.2

3. All of the potable production wells and only one of the remaining six onsite monitoring wells have access for depth-to-ground water peizometric surface measurements. 5.3.1

4. Only the 5 potable production wells are sampled for bacteria. Noncoliform (anaerobic) bacteria counts fluctuate randomly at these wells and were observed to increase during some runoff events, especially at Pajarito Well No. PM-2 (I-GW-12). The wells also contain free floating, nontoxic, edible mineral oil, a standard result of lubricating the line shaft turbines. Neither the source of the bacteria nor the environmental consequences of the mineral oil in the well bores is understood by LANL. 5.4.2

The following deficiencies of the perched hydrogeological monitoring well network located in the shallow alluvium have been identified:

1. There are no monitoring wells located in the perched alluvial water located adjacent to the Los Alamos County Landfill to monitor for potential ground water contamination (I-GW-17). The landfill is located on a zone of intense fracturing (I-GW-73). The possibility exists for contaminant migration to the ground water located in the perched alluvial water. 5.2 5.4.2

2. LANL's characterization of surface flow contaminants infiltrating into perched aquifer zones in Los Alamos Canyon, which ultimately outcrop as seeps and springs at the confluence of the Rio Grande, is not complete (I-GW-54). The understanding of contaminant transport pathway mechanisms is essential for understanding canyon-specific perched aquifer systems. 5.2.2

3. LANL has not adequately characterized the seep-spring recharge mechanism located in the Santa Fe Group (I-GW-54). A through understanding of the seep-spring recharge mechanism is required part for adequate comprehension of the sitewide hydrologic regime. 5.2.2

LANL has no standard operating procedures for borehole drilling, well construction, disposal of borehole cuttings and drilling fluids, well inspection and maintenance, and well abandonment. Further, LANL does not have a monitoring well inventory program that lists inactive or properly abandoned monitoring wells, piezometers, neutron moisture probe access tubes, or boreholes. Best management practice would suggest the need for standard operating procedures and an inventory to track and manage the well network. 5.6.2 5.3.2 5.5.2

This finding was fully identified in the LANL Self-Assessment.

FINDING GW/CF-3:

Groundwater Sampling Procedures

Performance Objective

DOE Order 5400.1, "General Environmental Protection Program," Chapter IV, "Environmental Monitoring Requirements," requires that a Quality Assurance Program (QAP) consistent with DOE Order 5700.6B, "Quality Assurance," be implemented by November 9, 1991. It also states that the QAP shall include chain-of custody procedures.

DOE Order 5400.1 further states that "Test Method for Evaluating Solid Waste, Physical/Chemical Methods" (SW-846) should be used as a reference for environmental monitoring.

OSWER 9950.1, "Ground Water Monitoring Technical Enforcement Guidance Document," discusses specific procedures for sample collection, including Section 4.2.2, "Sample Withdrawal"; Section 4.3.3, "Special Handling Requirements"; and Section 4.4, "Chain-of Custody.".

LANL's Water, Soil, Sediments, and Water Supply Monitoring Quality Assurance Project Plan (QAPP) (revised January 10, 1990) specifies the procedures to be used in conducting ground water sampling and analysis at the monitoring wells, springs, and sediment sampling locations.

Finding

LANL ground water sampling procedures are not consistent with DOE Orders and guidance documents.

Discussion

Sampling procedures outlined in OSWER 9950.1, "Groundwater Monitoring Technical Enforcement Guidance Document," and DOE Order 5400.1 requirements for chain-of-custody are not incorporated into the Environmental Protection Group's (EM-8's) Water, Soil, Sediments, and Water Supply Monitoring QAPP. In addition, EM-8 does not follow required sampling procedures as contained in the QAPP.

The following deficiencies are present in the QAPP:

1. The QAPP does not contain formal chain-of-custody procedures. Section 5.2 of the QAPP states, "The analytical request form serves as an informal chain-of-custody for the samples," This chain-of-custody is prepared in the field. 5.6.2

2. Section 6 of the QAPP specifies "equipment used in routing collection of water, soils, and sediment requires no calibration." Calibration is necessary for standardization and equipment checks.

3. Section 4.6.1 of the QAPP specifies sample acidification prior to filtration for all chemical analysis, which is opposite of OSWER 9950.1 requirements for metal analysis. However, the procedure was consistent with the requirements for the radiochemistry samples as specified in Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (DOE/EH-0173T).

4. Section 4.6.3 of the QAPP does not directly address sample collection techniques to minimize agitation and aeration.

5. The QAPP manual does not address field decontamination procedures for sampling equipment.

6. The QAPP manual does not directly address the need for refrigeration for sulfate, nitrate, and semi-volatile organic compounds. Although the information is incorporated by reference in LANL Report No. LA-11738, the requirements should be in a form that is easily accessible during sampling.

7. The QAPP manual does not adequately address well purging requirements.

The Environmental Subteam observed three sampling events (October 1, 7-9, and 17, 1991) conducted by LANL. During the sampling events, there was an overall lack of formality, and inadequate field sampling protocols. Sample collection lacked consistency. The following deficiencies in field sampling methods were noted:

1. No environmental chain-of-custody form was used in the field on October 1, 199 (I-GW-32). No environmental chain-of-custody forms were used in the field during the second sampling event, but were generated later at the laboratory, according to EM-8 staff (GW-89). Environmental chain-of-custody forms were used in the field on October 17, 1991. However, the forms were not properly completed. The EPA SW-846 document states, "The

possession and handling of samples should be traceable from time of collection through analysis and final disposition" (GW-147).

2. The pH, temperature, and specific conductivity meters were field checked for accuracy only at the beginning of the sampling event on October 1, 1991 (I-GW-30). Accuracy should be checked at the beginning and end of each sampling event. The two types of pH paper were not checked for accuracy to a known standard prior to the October 7-9, 1991, sampling event. In response to Tiger Team observations, the pH, temperature, and specific conductivity meters were field checked for accuracy at the beginning and end of the sampling event on October 17, 1991 (I-GW-79).

3. Ground Water samples collected on October 1, 7-9, 17, 1991, were not filtered prior to being preserved with an acidic solution as specified in OSWER 9950.1. However, radiochemistry samples were preserved in accordance with DOE/EH-0173T.

4. Ground Water sample containers for the October 1, 1991, sampling event were acidified (e.g., preserved) in a radiological laboratory prior to field sampling (I-GW-31). Given the possibility for radiological cross-contamination, sample containers should not be acidified in locations that could impact analytical integrity of the sample.

5. During the October 1, 1991, sampling event, the sampling port of the production well emitted an aerated ground water sample which is not acceptable for volatile organic compound analyses or semi-volatile organic compound analyses (I-GW-26).

6. Sample containers for parameters other than volatile organic compound analyses were not preserved on ice for transport to the laboratory during the October 1, 1991, sample event (I-GW-30). No samples were preserved on ice for transport to the laboratory for October 7-9, 1991 sampling event (I-GW-55). However, samples were preserved on ice for transport to the laboratory during the October 17, 1991, sampling event (I-GW-76).

7. Tygon sampling tubes and sediment sampling scoops were not properly decontaminated between sampling stations during the October 7-9, 1991, sampling event (I-GW-55).

8. The purging of ground water monitoring well MCO-5 during the October 17, 1991, sampling event was not based on an appropriate calculation of well-bore volume (I-GW-76). This resulted in analysis of well-bore water rather than ground water.

9. Two of the three temperature probes were broken on the October 7-9, 1991, sampling event (I-GW-53). The lack of functioning thermometers could result in a lack of quality data,

This funding was fully identified in the LANL Self-Assessment.

3.5.3.2 Best Management Practice Findings

FINDING GW/BMPF-1: **Closure and Protection of Wells and Boreholes**

Performance Objective

DOE Order 5400.1, "General Environmental Protection Program," Section 5.a., "Policy" requires that DOE "minimize risks to the environment or public health, and anticipate and address potential environmental problems before they pose a threat to the quality of the environment or public welfare."

The 1986 RCRA Ground Water Monitoring Technical Guidance Document (TEGD) suggests that locking caps should be placed on wells to prevent tampering and ground water contamination. Additionally, the TEGD states that when wells are no longer operable, or give false ground water analytical data, they should be decommissioned and sealed.

The New Mexico Environment Department (NMED) has issued procedures to be used for plugging and abandonment of monitoring wells installed after January 1, 1991. These are best management practices for wells installed before that date.

Finding

Abandoned or inactive monitoring wells, peizometers, neutron moisture probe access tubes, and boreholes are not adequately closed or sealed to protect the environment. 5.3.2

Discussion

LANL has not developed procedures or criteria for determining when wells should be decommissioned or in what manner they will be abandoned. There are several monitoring wells, peizometers, neutron moisture probe access tubes, and boreholes which are not properly secured nor protected. However, best management practices suggest that these should be plugged and sealed as suggested by the NMED: otherwise, they present a potential pathway for ground water contamination.

1. A new monitoring well, MCO-5.1., has no locking cap. The polyvinyl chloride casing is not protected against potential vandalism to the well bore or aquifer (I-GW-23).

2. A monitoring well (TW-2B) that was partially installed in 1947, was observed to be inadequately secured (I-GW-24). Both the production tubing and the annulus between the well casing and the production tubing were open ended. The potential to introduce contaminants to the well bore and perched aquifer exists since it is not plugged and sealed.

3. An older U.S. Geological Survey monitoring well (LAO-5), located in the perched alluvial, was observed to be missing a lock (I-GW-25).

4. At various locations throughout Mortandad Canyon, piezometers and neutron moisture probe access tubes were observed without caps or locks (I-GW-77).

5. LANL has no procedures for placing permanent identification placards on ground water monitoring wells (1/22).

This finding was fully identified in the LANL Self-assessments

FINDING GW/BMPF-3: **Groundwater Discharge Plan**

Performance Objective

New Mexico Water Quality Regulation (NMQR), Section 3-104, states that no person shall cause or allow effluent or leachate to discharge so that it may move directly or indirectly into ground water without a Groundwater Discharge Plan approved by the Director of the New Mexico Water Environment Department (NMED).

NMWQR, Section 3-106, requires that for discharges existing prior to March 1977, a Groundwater Discharge Plan shall be submitted within 120 days of receipt of notice from NMED that a plan is required. For discharges initiated subsequent to March 1977, a Notice of Intent must be submitted to NMED, which will determine whether a discharge plan is required.

NMED has not yet notified LANL that Groundwater Discharge Plans are required. However, as a best management practice, LANL should initiate Groundwater Discharge Plans to ensure compliance with anticipated NMWQR requests.

Finding

LANL has not initiated preparation of Groundwater Discharge Plans to ensure compliance with anticipated NMWQR requirements. 5.7.2

Discussion

LANL has indicated that a request is anticipated from NMWQCC for Groundwater Discharge Plans for some or all for the 9 sanitary treatment facilities and approximately 100 industrial outfalls. LANL has also indicated that they would be unable to meet the 120-day schedule for either a sitewide plan or site-specific plans if a request were made at the present time. LANL has currently identified the potential need for plans for continued disposal of sanitary sludge at TA-54, Area G, and for discharges from the unlined sanitary lagoons at TA-53. LANL has also identified the need for a Laboratory-wide Ground Water Discharge Plan to meet potential NMWQCC requests. However, drafting of the plans has not been initiated, and there is currently no program in place to draft the plans.

LANL has also identified the need for a Ground Water Discharge Plan for the new Sanitary Treatment Plant at TA-46 and has initiated drafting of the Notice of Intent, but has not initiated drafting of the Discharge plan so as to ensure compliance with the required schedule.

This finding was fully identified in the LANL Self-Assessment.

Hydrogeologic Review for the Environmental Restoration Program at Los Alamos National Laboratory

SUMMARY OF COMMENTS ON ISSUES IDENTIFIED BY THE ER PROGRAM

The following is a brief summary of the panel's comments on issues identified by the ER staff. Detailed comments by each reviewer are provided in Section 6.

ISSUE 1: *Do we have enough hydrogeological data at LANL to defensibly answer pertinent hydrogeological questions related to the ER site cleanups (e.g., stabilization in place)?*

5.1.2

There is considerable uncertainty in several aspects of hydrogeology which needs to be addressed. However, at a few sites such as Mortandad Canyon and TA-54, sufficient hydrogeological data may already be available to support some ER program decisions. Primary areas of concern include the importance of vapor and liquid transport on mesa tops, characterization of perched aquifers, and radionuclide uptake by vegetation.

ISSUE 2: *Is there adequate flow and transport data to defend calculation of the subsurface pathway?*

5.1.2

Data may be sufficient only at sites that have been characterized, such as TA-54 and Mortandad Canyon. Even at these sites there is uncertainty in the spatial extent of contamination, hydraulic properties, and transport processes such as colloidal mechanisms. Moreover, the quality of the existing water chemistry data base which could be used to evaluate pathways is considered deficient in several aspects (Section 2.3).

ISSUE 3: *Do we know enough about the role of fractures?*

5.2.2

The panel is somewhat divided on this question. On one hand, some geologic evidence suggests that fractures lack connectivity over great depths and fractures may provide capillary barriers to unsaturated flow. On the other, roots and weathering patterns suggest that some fractures on mesa tops may be preferential paths for infiltration. Our primary concern for liquid flow in fractures is in canyon bottoms where fractures in bedrock may intersect perched alluvial aquifers. There are few field data on the role of fractures, but there is also very little one can do to adequately and quantitatively characterize variably saturated fracture flow and transport coefficients. At small site scales, the role of fractures as transport pathways and their connections to regional pathway will likely have to be addressed for each site individually.

ISSUE 4: *Can we defensibly model LANL hydrogeology using a porous continuum model?*

To be addressed

Much of the experimental and environmental monitoring data suggests that a porous media flow model would be appropriate. However, porous media models should be used to predict observed behavior in order to validate the models and to confirm the validity of the porous media approach.

ISSUE 5: *Are we sufficiently certain of ground water flow direction regionally that we can know ground water flow direction at a specific OU? Additionally, is there any reason to believe that there are local ground water gradients?*

5.1.2

Generally sufficient data exist to establish that regional flow is to the east. Local effects undoubtedly occur near the well fields, and it is possible that small perturbations may occur in the main aquifer beneath perched aquifers or other potential recharge areas. Additional information is required to monitor horizontal and vertical pathways and to confirm sources of recharge. Mapping details of drawdown and "zones of capture" around the well fields would add to the knowledge base.

ISSUE 6: *Can we defensibly state there is no connection between any perched zones and the main aquifer?*

5.1.2

Existing data are insufficient to state that no perched water percolates to the main aquifer. In fact, recent work at Montandad Canyon shows that vertical transport has occurred in the Bandelier Tuff to at least 150 ft (46) beneath the perched alluvial aquifer. Little is known of vapor phase transport in these areas.

ISSUE 7: *Do we know enough about gas exchange between the subsurface and atmosphere as a potential contaminant transport pathway?*

To be addressed

Gas exchange has been observed near open shafts and boreholes. Density driven gas phase transport of chlorinated solvents, for example, may also be important, but has not been documented in the field at LANL. The importance of gas transport and the characterization of gas transport pathways requires additional study.

ISSUE 8: *Do we know enough that modeling as a homogeneous, steady state system adequately defines the system? Alternatively, do we know enough to model as a nonhomogeneous, transient system?*

To be addressed

Except for scoping calculations, field observations and model studies show that some degree of heterogeneity will need to be incorporated into the conceptual models of flow and transport in the vadose zone, in the perched aquifers, and in the main aquifer. Transient effects will need to be considered to simulate transport at lease within perched alluvial aquifers, and in pumping scenarios for the main aquifer.

Available data are scarce, and details of experimental procedures need to be published. A model study using existing sorption data underestimated observed radionuclide transport. Available data do not appear to be sufficient to defend ER objectives.

Initial Assessment of the Ground Water Monitoring Program at Los Alamos National Laboratory, New Mexico

POTENTIAL GROUND WATER POLLUTION SOURCES

DOCUMENTATION

Radioactive and hazardous waste has been generated and disposed of at LANL since the Lab's inception in 1943 (Kelly, 1975). Twenty-three Materials Disposal Areas (A, B, C, D, E, F, G, H, J, K, L, M, N, P, Q, R, S, T, U, V, W, X, and Y: Figure 4) were identified by Rogers (1977). All such sites are considered potential sources of ground water contamination. Some of these disposal sites have been characterized in considerable detail by previous workers. Kelly (1975) summarized burial conditions and environmental monitoring at eight of these Areas (A, B, C, D, E, F, G, and T) in conjunction with an evaluation of monitoring efforts at LANL. Rogers (1977) made an invaluable and exhaustive two-volume compilation of the history and environmental settings of the same Areas covered by Kelly. Volume I includes background (historical) information on the site, the geologic and hydrologic setting, type of waste involved, and the mode of disposal. Volume II consists of Appendices including a list of photos, slides and engineering drawings, the Lab's solid Radwaste management policy, the guidelines for disposal pit construction, and records of disposal in Tech Area 54, Area G shafts.

Waste disposal sites were identified by LANL (DOE 1987) as part of the Comprehensive Environmental Assessment and Response Program (CEARP), under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund). A Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA), conducted by A. T. Kearney (1987) for the Lab. provided additional information on Solid Waste Management Units (SWMUs) at LANL. In 1988, draft SWMU report, providing "reasonably available" information, as submitted to the Environmental Protection Agency (EPA), pursuant to Title 40, Code of Federal Regulations, Part 270.14d (40 CFR270.14d). The 1988 draft SWMU report was revised by International Corporation under contract to LANL and includes an update on SWMU's identified at the Lab (IT Corporation, 1990). The 1990 report identifies 537 SWMU's located in 50 active and formal TA's. As of this writing, the number of potentially contaminated sites recognized is approximately 2,000. Many of these are minor and LANL estimates that 90-95 percent of these will be handled under Voluntary Corrective Actions or No Further Action proposals.

An additional possible source of ground water contamination is the historic and current practice of discharging liquid waste (NPDES-permitted) in canyons near the northern boundary of the Lab. According to the latest Surveillance Report (for 1990: Environmental Protection Group, 1992), four areas have received industrial or sanitary effluents: DP-Los Alamos (DP-LA), Sandia, Mortandad, and Acid-Pueblo Canyons.

DP-LA Canyon received treated industrial (including radioactive) and sanitary effluent between 1952 and 1984. The effluent, together with natural runoff, resulted in a shallow body of perched ground water in the alluvium of LA Canyon. Sandia Canyon received cooling tower blowdown and treated sanitary effluent from TA-3. The stream in the canyon is perennial for a short distance downstream of the outfall in the upper canyon. No perched ground water has been identified in the alluvium of the lower canyon. Mortandad Canyon receives radioactive liquid waste from TA-50. This maintains a perched ground water body in the alluvium on the canyon floor Purtymun (1974) found this water moves at a rate ranging from 59 ft/d in upper reach to 7 ft/d in the lower reach of the canyon. Elevated NO_3 Pu, and tritium (^3H) have been identified in Mortandad Canyon. Acid-Pueblo Canyon received radioactive effluent from 1944 to 1964 and receives treated sanitary effluent from the Los Alamos County Bayo Canyon sewage treatment plant. In 1990, the sewage effluent produced flow in lower Pueblo Canyon and into Los Alamos Canyon for most of the year. However, subsequent sampling in the canyon indicated that Pu values were below detection and ^3H content was at background level, which is very near its detection limit.

CONCERNS/RECOMMENDATIONS

At this is the initial review of the ground water program at LANL, this report primarily addresses basic concerns regarding potential sources of ground water contamination:

1. Regarding location of potential sources of ground water contamination, the 1990 Environmental Surveillance Report contains no map of known disposal areas. Evaluation of monitoring efforts at LANL would be greatly facilitated if the major disposal areas (not individual SWMU's) were generally indicated (along with monitoring sites and water level contours) on a single map in future Environmental Surveillance Reports. This would likely require a larger plate (preferably at a scale of 1:24,000) folded in a pocked at the back of the report.

To be addressed

2. A biannual update on disposal activity at all these areas should be prepared. Such reports should cover the same topics addressed by Rogers (1977).

To be addressed

3. It is a cause for concern that a large number of the potential sources of contamination are located in the vicinity of high fault/fracture density (Wachs and others, 1988), near cliffs, and in canyon bottoms.

5.2.2

Subsequent assessment reports by the NMED will address site-specific concerns.

CONCEPTUAL HYDROGEOLOGIC MODEL

PREVIOUS WORK

Oversight at LANL is facilitated by the existence of a sizable body of reference materials and the availability of most of them in LANL's Environmental Restoration Program Records Processing Facility in Los Alamos. The citations below are not intended to be exhaustive, but rather to indicate representative important works.

Major sources of geologic information on the Pajarito Plateau include reports by Theis and others (1950), Griggs (1964), Purtymun (1966), Smith and others (1970), Crowe and others (1978), and Kelley (1978). Most of these include mapping. The most detailed (1 inch = 400 ft), and only Lab-wide geologic map is unpublished (Rogers 1981).

Numerous published works report on various aspects of the hydrologic system associated with the Pajarito Plateau. Many of these reports treat the system strictly from a water-supply point of view (Theis and Conover, 1962; Griggs, 1964; Cushman, 1965; Cooper and Purtymun, 1965; Purtymun and Cooper, 1965, 1969; Cushman Purtymun, 1975; Purtymun and others, 1980; Purtymun, 1984; Purtymun and Stoker, 1988). The water supply at Los Alamos has been carefully documented in a series of annual reports by Purtymun, and Purtymun and others dating back to 1972 (Purtymun 1984). Modeling of the ground water system near Santa Fe by McAda and Wasiolak (1988) includes the Los Alamos area.

Some reports, however, do focus on hydrogeologic considerations in radwaste disposal or monitoring at the Lab (Weir and others, 1962; Weir and Purtymun, 1962; John and others, 1966; Purtymun, 1966, 1073a. b; Devaurs, 1895; Purtymun and others, 1974, 1989; Anonymous, 1990; Penrose and others, 1990; Stoker and others, 1991). The spread of radioactive contamination in specific canyons or Tech Areas was addressed by Baltz and others (1963). Purtymun (1974), Devaurs and Purtymun (1985), Purtymun and Stoker, and Stoker and others (1991).

LANL's CONCEPTUAL MODEL

As many of the reports listed above were done by or for the Lab, they are the basis for LANL's conceptualization of the regional hydrologic system. The key elements, as summarized in the 1990 Surveillance Report, are as follows.

1. Ground water occurs in three situations:

   a) perched water in alluvium in canyons

   b) perched water in basalts and sedimentary units of the Puye Conglomerate, and,

   c) beneath the regional water table in the main aquifer.

2. The alluvium on canyon floors is recharged by surface water runoff.

3. The main aquifer consists of the Tesuque Formation and the lower parts of the overlying and intertonguing Tschicoma Formation (in the western part of the Pajarito Plateau), and the Tesuque Formation and overlying Puye Conglomerate (in the central and eastern parts of the Pajarito Plateau).

4. Water in the main aquifer is separated from that in the shallow alluvium and other perched systems by 250 - 620 ft of unsaturated tuff and sediments.

5. There is little or no recharge of the main aquifer from the mesas, the shallow alluvium, or other perched ground water.

6. The main aquifer is recharged in the Valle caldera, west of the Laboratory.

7. Ground water in the main aquifer flows easterly until discharging to the Rio Grande.

LANL's conceptual hydrogeologic model is shown diagrammatically in Figure 5.

Site specifies studies undertaken by the Lab have added to the understanding of the relationship of the complete hydrologic system. For example, the study of Mortandad Canyon by Stoker and others (1991) enhanced the conceptualization of the so-called "shallow alluvium aquifer."

1. Saturation is confined to a relatively thin zone, extending 5 - 20 ft above the contact of the alluvium with the underlying Tshirege Member of the Bandelier Tuff.

2. The area of saturated alluvium extends from the treatment plant (TA-50) outfalls SWMU 50 - 051 to a point approximately 2 miles down canyon.

3. Thickness of the saturated zone decreases towards the canyon margins.

4. Since 1960, the saturated portion of the alluvium aquifer has neither changed significantly in size nor moved down canyon (eastward).

Reportedly, tritium was found at a depth of approximately 200 ft within the Bandelier Tuff. Other radionuclides had apparently moved only a few feet beneath the alluvial aquifer. No organic contaminants were detected above, in, or below the perched water in the alluvium.

ONCERNS/RECOMMENDATIONS

Again, as this is the initial assessment, the focus is on very basic questions. The adequacy of the monitoring network at LANL depends to a very large extent on the accuracy of the conceptual hydrogeologic model upon which it is based. In his evaluation of environmental monitoring at LANL, Kelly (1975) concluded that further hydrogeologic data were needed to design an effective monitoring system. Although some progress has been made in this area, there are still concerns about LANL's conceptual model, the hydrogeologic data base, and the presentation of surveillance information.

1. The recharge area(s) for the main aquifer under the Pajarito Plateau has not been clearly identified. Most RCRA operating permits, closure plans, and annual surveillance reports state that "major recharge to the main aquifer is from the intermountain basin of the Valle Caldera in the Jemez Mountains west of Los Alamos" following Purtymun (1974). The water level map published by the lab does suggest a recharge area to the west. The Pajarito fault zone at the west edge of the plateau could provide a pathway for some of this recharge. However, stable-isotope data suggest that some component of recharge occurs at elevations higher than available in the Jemez Mountains (Goff and Sayer, 1980). The Sangre de Cristo Mountains have been suggested at the site of these higher elevations. Further work is needed on this manner. 5.1.2

2. Maps published by the Lab show that the main aquifer is generally unconfined, except in a wedge-shaped area near the central part of Los Alamos County. Since unconfined conditions suggest connection with the surface (i.e, atmospheric conditions occur at the water table), the common contention in operating permits and work plans, that the Bandelier Tuff is an impermeable barrier to recharge, does not seem to be valid over most of the plateau. Further work is needed to resolve this issue. 3.2.3

3. Perched water beneath the Bandelier Tuff suggests that there is recharge through the tuff. Various methods of determining recharge (e.g. chloride mass balance, chlorine 36, etc.) may prove useful in answering this question. 5.1.2

4. TW-1 is deep ground water observation well that shows a 50 ft water mound. TW-1A is completed in perched water above the screened interval of TW-1. The perched water from TW-1A and the alluvial water in this area have similar chemistry, different from that in TW-1. This situation raises questions concerning the effectiveness of the Bandelier Tuff as a barrier to vertical migration and needs to be investigated. 5.1.2

5. If ^3H has penetrated at least 200 ft beneath the alluvium aquifer in Mortandad Canyon, it seems possible that it could ultimately reach the main aquifer. 5.2.2

6. As asked by LANL hydrologists, is 200 ft the true maximum depth of ^3H percolation, or is that merely the deepest it can be detected, owing to dilution? Furthermore, did the ^3H move in the liquid or vapor phase, and which phase is most common at the Lab? 5.2.2

7. What is the cause and fate of disappearing streams in canyons (for example, Potrillo Canyon)? A study of hydrogeologic conditions at such sites (water table depth, thickness/character of the alluvium, etc) would be useful. 5.1.2

8. An alluvial deposit within the Cerro Toledo interval of the Bandelier Tuff, lithologically similar to the Puye Conglomerate, and known informally as the "epiclastic unit", crops out in various places on the plateau. LANL has reported that, where unsaturated, this unit may serve as a capillary barrier to vertical migration 5.2.1

of contaminants or recharge, but that it has been observed to be as much as 90 percent saturated, locally. Of particular concern is an outcrop of the epiclastic unit in a cliff near the confluence of Pueblo and Acid canyons. In this position it lies down canyon of both the Larry Walkup Center, which discharges approximately 800,000 gallons of chlorinated water annually, and the decommissioned untreated liquid radwaste facility (SWMU 1-00). Thus, the potential role of the "Epiclastic Unit" as a pathway for contaminant transport should be investigated.

9. The hydraulic properties of all aquifers should be characterized in the field through properly designed pumping tests, using appropriately constructed and placed wells. Such tests should include wells on both sides of major faults in order to better define the role of these structures as conducts, barriers, or inconsequential. 5.1.2 5.3

10. Water level maps for the shallow, perched systems should be contoured separately from those for the deep (main) aquifer. 5.1.2

11. An approximate geologic map at the water table should be constructed from available subsurface data, and appropriate hydraulic conductivity's should be assigned to each unit in order to show the contaminant-transport capacity across the area. 5.1.2

12. Once such a map is available, modeling of the ground water flow system should be undertaken. This would be an excellent way of testing the conceptual model, as well as the assumed hydrologic properties of materials underlying the Pajarito Plateau. 5.1.2

13. Eventually, contaminant transport should also be modeled. This could initially be done with hypothetical leaks or spills, then modified for actual excursions. Such models could show directions, rates, and concentrations that might be expected from a most conservative scenario. Results would be ideal for presentations to the public, the Pueblos, etc. 5.2.2

14. No water-level map is provided with the 1990 surveillance report. Such maps normally accompany monitoring reports and provide essential information on the hydrologic system. In fact, it is difficult to interpret water quality data, let alone evaluate the monitoring network, without such maps. As noted above, page-size versions will probably not suffice; a 1:24.000 map, including major disposal areas and monitoring sites would be ideal (folded in a pocked at the back of the report). If digitized, it should be a simple matter to update such a map for subsequent annual reports. NA

15. Previously published water level maps essentially depict pre-development conditions; no impacts of pumping at production wells (i.e. cones of depression) are indicated (Figure 6). Yet, water level changes (i.e. drawdown values) are regularly given in the annual reports on the water supply at LANL. Modeling by McAda and Wasiolak (1988) predicts significant cones of depression in the future as well. As ground water flow is toward such depressions, their position and extent are critical to both designing and evaluating the monitoring network. Water level maps for the Lab should include these features. 5.1.2

16. Water-level maps commonly used for closure plan. RCRA Facility Investigation (RFI) Work Plans, operating permit applications, etc., all include data collected over 10 years ago at TA-40 in wells DT-5A, DT-9 and DT-10. This gives a false impression of the water level in the southwestern part of the Pajarito Plateau. It is understood that this is, in part, because there is no access port for water level measurement at these wells. This should be remedied such that water levels can be monitored on a regular basis. 5.3.2

GROUND WATER MONITORING NETWORK

WELLS/SPRINGS USED

The 1990 Surveillance Report identifies 43 ground water monitoring wells (Figure 7). Of these, 26 are deep and target the main aquifer, whereas, 17 are shallow and monitor perched water in the alluvium. Of the 26 are deep wells, 19 are water supply sells; the remaining 7 are test wells. The supply wells used for monitoring include 7 in the Guaje well field, 6 in the Los Alamos well field, and 6 in the Pajarito well field. None of the shallow wells are water supply wells. In addition to these wells, ground water is also monitored by means of 33 springs that primarily discharge along the eastern edge of the plateau in White Rock Canyon.

PARAMETERS MONITORED

Different sites are analyzed for slightly different lists of parameters. According to Appendix G of the 1990 Surveillance Report, springs in White Rock Canyon are monitored for 16 non radioactive parameters (SiO_2, Ca, Mg, K, Na, CO_3, HCO_3, P, SO_4, Cl, F, NO_3-N, TDS, hardness, pH, specific conductance), 6 radiochemical parameters (^{3}H, ^{137}Cs, total U, ^{238}Pu, $^{239,240}Pu$, gross gamma).and trace metals (Ag, Al, As, Ba, Cd, Cr, F, Hg, NO_3-N, Pb, Se, Cl, Cu, Fe, Mn,Ni, P, Sb, Se, Sr, Tl, U, V, Zn). Ground water in supply wells and the water distribution system at LANL is monitored for 6 radiochemical parameters (gross alpha, gross, beta, ^{3}H, ^{238}Pu, $^{239,240}Pu$ and total U). 18 EPA

primary/secondary standards (Ag, As, Ba, Cd, Cr, F, Hg, NO_3-N, Pb, Se, Cl, Cu, Fe, Mn, SO_4, Zn, TDS, pH), and 20 other parameters (Al, SiO_2, Ca, Mg, K, Na, CO_3, HCO_3, P, SO_4, Cl, F, NO_3-N, TDS, hardness, pH, specific conductance, B, Mo, Sr, V, Be, Ni, Sb, Tl, NO_3-N). Ground waters are also monitored for organic compounds: 68 volatiles, 71 semi-volatiles, 19 pesticides, 2 herbicides, and 4 PCB's.

CONCERNS/RECOMMENDATIONS

1. It is understood that the monitoring plan for the Lab is currently being revised. Inclusion of a table, in both the plan and future surveillance reports, giving sites, parameters monitored and frequency of monitoring, would be most helpful in our oversight effort. — Table 5.1

2. As in all monitoring networks, existing wells are employed where possible because drilling new ones is expensive. However, the large number of water-supply wells used for monitoring at LANL is a concern. Wells constructed for supply have large screened intervals in order to maximize water production. By contrast, water-level or water quality wells are usually screened over a narrow interval to provide information for a more discrete portion(s) of the aquifer. Properly constructed monitoring wells should be installed to replace, or at least supplement/verify, data from the supply wells currently used. — 5.3.2

3. There are relatively few monitoring wells/sites in view of the size of the area encompassed by the Lab. This may result from the conceptual notion long held by the Lab that, due to the depth water table, and presumed impermeability of the volcanic tuff at the surface, the main aquifer is not at risk and need not be monitored, other than at the supply wells. Not only would more wells better cover the area and, if properly constructed, better monitor the aquifers, but they would provide an excellent test of this hydraulic isolation hypothesis. Lower Los Alamos Canyon is one such area that should have a more extensive monitoring system in place. — 5.3.2

4. The density of wells/sites is also unrealistic. There are many wells in some areas and few to none in others. A more uniform spacing of wells is desirable and should be established. New wells should be strategically located with respect to historically contaminated areas of the plateau or to enhance depiction of the water table. A partial solution to this is to not use all wells in the well fields. A representative well should be selected, an alternate designated, and the others ignored, as far as regional surveillance is concerned. This would prevent the misconception that the relatively large of "monitoring wells" actually represents an adequate regional surveillance system. — 5.3.2

5. The wells drilled under the Hazardous Solid Waste Amendment (HSWA) permit requirements are not currently included in the Environmental Surveillance network, but should be. — 5.3.2

6. As noted above, the map of monitoring wells/sites in the surveillance reports should also show the major disposal areas (not every SWMU) that are being monitored, and contours that represent recent water level information. — To be addressed

7. The classification of monitoring sites should be reconsidered and standardized. The designation of springs is not consistent; sometimes they are denoted as surface water and sometimes as ground water. Ground water is preferable inasmuch as springs are outcrops of the water table or the potentiometric surface. — 5.12

8. Spring-sampling stations are inadequately marked in the field. They should be identified by as permanent a monument as possible, to avoid major deviation in a sampling point over time. A written description of sampling points should also be on file. — 5.1.2

9. The organization of the surveillance reports is somewhat confusing. the following would be helpful for the oversight effort: — NA

   a) field identification of sites should be the same as maps identification. Site identification numbers, as used on figures and maps, should appear in the first column;

   b) presentation of a summary table with sampling frequency and parameters monitored for each site (water level, major ions, radionuclides, etc; quarterly, annually, etc);and

   c) listing the standards for all parameters, for easy reference. LANL projects, understood to be underway or planned, will greatly enhance our conceptualization of the hydrogeologic system.

SUMMARY

Current monitoring efforts at LANL go far beyond those of just a few years ago, and surveillance reports regularly present more than was previously know. However, a number of general and specific inadequacies are recognized, based on our initial assessment. The following are largely summarized from the sections entitled "Concerns/Recommendations" above. However this list is not all inclusive and the concerns/recommendations listed above should be consulted for details.

1. Potential Contamination Sources

a) Biannual reports on waste-disposal activities at all sites should be prepared. **To be addressed**

b) General waste-disposal areas (not individual SWMU's) should be shown on maps of monitoring wells/sites, together with the regional water-level contours, so that adequacy of the surveillance network may be better evaluated. **To be addressed**

2. Conceptual Hydrogeologic Model

a) Questions concerning recharge, confined/unconfined conditions of the aquifer, and permeability of the Bandelier Tuff should be resolved. Appropriate tests should be designed and conducted (chloride, isotopes, paired piezometers, pumping tests, etc). 5.1.2

b) A water-level map, depicting current conditions (drawdown around supply wells), should be included with surveillance reports.

c) Ground water flow and contaminant-transport modeling should be undertaken to test LANL's conceptual hydrogeologic model. 5.1.2

5.2.2

3. Ground Water Monitoring Network

a) The monitoring plan should be revised as soon as possible, focusing on clearly stated objectives. 5.3

b) The number and location of monitoring wells should reflect the number and location of major waste disposal areas; this does not mean a well or series of wells is needed at each SWMU, but rather there should be enough wells to intercept any possible contamination. 5.3.2

c) The location of future monitoring wells should be based on the location of the potential sources of contamination, transport pathways, and the regional flow system as indicated by a current water-level map that includes drawdown due to pumping of production wells. Some additional monitoring wells may be needed merely to better depict the water table. 5.3.2

d) New wells should be constructed to monitor discrete hydrologic interval(s) (production wells are screened over too large an interval). 5.3.2

We would be glad to clarify or discuss our position/recommendations on any of the issues addressed herein at any time. Inquiries may be directed 827-2434 or 665-7130.

ACKNOWLEDGMENTS -- Cooperation of various LANL and DOE personnel during our investigation, through tours and interviews, is greatly appreciated. Discussions with John Hawley (NM Bureau of Mines and mineral Resources) and Margaret Anne Rogers (MARA, Inc.) were most helpful.

Action Plan No.: C-EM-01

Title: Environmental Surveillance

Category: X Environmental ___ Safety & Health ___ Management & Organization

LANL: Net Benefit to Cost Index - 2

Tiger Team Concerns(s) or Finding(s):

A/CF-4 LANL has not implemented an ambient air sampling program with all the elements required by DOE 5400. 1, DOE 5400.5, and DOE/EH-0173T.

SW/CF-6 Surface water effluent monitoring and environmental surveillance programs which meet the goals and objectives of DOE 5400.1 will not be implemented by November 9, 1991.

GW/CF-4 Environmental surveillance of soil, sediment, and biota at LANL does not fully satisfy the DOE 5400.1 requirements for the Environmental Surveillance Program, and there is no overall plan in place to meet those requirements by the implementation date of November 9, 1991.

GW/BMPF-1 Abandoned or inactive monitoring wells, piezometers, neutron moisture probe access tubes, and boreholes are not adequately closed or sealed to protect the environment.

QA/CF-9 LANL is not consistently documenting and implementing a chain of custody for their field sampling activities.

RAD/CF-1 LANL has not implemented some required elements of an environmental TLD monitoring program.

RAD/CF-13 LANL has not implemented a program to provide complete radiological monitoring and surveillance at inactive waste sites.

RAD/BMPF-1 LANL's ASERs are not prepared in accordance with the guidance provided in DOE 5400.1.

GW/CF-1 The LANL GPMPP does not fully meet the requirements of DOE 5400.1

GW/CF-3 LANL ground water sampling procedures are not consistent with DOE Orders and guidance documents.

GW/CF-2 LANL's sitewide hydrogeological ground water monitoring well network will not be extensive enough to be able to characterize the impact of DOE operations on ground water quality by November 9, 1991, as required by DOE 5400.1.

RAD/CF-2 LANL will not be able to complete and implement an Environmental Monitoring Plan (EMP) by November 9, 1991, as required by DOE 5400.1.

Code: X Compliance ___ Best Management Practice _ Safety & Health Category

Compliance Protocol: DOE 5400.1, DOE 5400.5, DOE 5480.19, DOE 5480.20, DOE 5700.6B, DOE 5820.2A, DOE/AL 5700.6B, DOE/EH-0173T, NRC REG Guide 8.25, EPA OSWER 9950.1, 40 CFR 262.11, 40 CFR 264.13, 40 CFR 265.13, Los Alamos RCRA Part B Permit, New Mexico Environment Department Monitor Well Construction and Abandonment Guidelines, New Mexico State Engineer Office Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico

ADS Number: N/A **DOE Priority No.:** 2

Root Cause: Until recently, the Laboratory did not ensure sufficient priority and resources were applied to the rapidly changing requirements in the environmental area.

Response: Many of the deficiencies in the environmental surveillance program were addressed in the Laboratory's Environmental Monitoring Plan (EMP) which includes sub-section for an upgraded Ground Water Monitoring Plan. It was drafted and submitted to DOE in November 1991 and amended in January 1992. Modifications common to all the surveillance programs include the development of formal Quality Assurance/Quality Control (QA/QC) programs and of detailed sampling protocols for field measurement, sample collection and preservation, equipment decontamination, instrument calibration, and data handling. Use of field chain of custody procedures has been implemented by all of the Laboratory surveillance programs, and a formal standard operating procedure for chain of custody is being prepared.

The Los Alamos National Laboratory has initiated a waste stream characterization (WSC) program to ensure that all point source discharges to the environment, resulting from Laboratory operations, are identified in the Laboratory's NPDES permit. A compliance schedule for the WSC program was incorporated into an Administrative Order (AO), in conjunction with the Federal Facility Compliance Agreement (FFCA), issued by the U.S. Environmental Protection Agency (EPA). The WSC program includes a survey to identify building drains and document the source of each waste stream and includes locating potential unpermitted discharges. As unidentified waste streams and unpermitted discharges are discovered, the Laboratory will submit a proposed compliance schedule to the Environmental Protection Agency for correcting the deficiencies. This schedule will be incorporated into the AO and FFCA. Information gathered during the WSC program will be incorporated into the NPDES permit.

New tritium and particulate air samplers have been ordered to replace all the existing samplers in the monitoring network, and 8 samplers have been relocated to minimize localized air circulation effects. The new samplers will be calibrated to standards imposed by the National Institute of Standards and Technology; they will minimize potential errors associated with air leakage and changeout procedures; they will be placed in a secure housing to minimize weather effects and tampering; and they will be calibrated every 6 months as recommended by the Nuclear Regulatory Commission Guide 8.25. New elemental tritium gas samplers have been purchased and will be installed during spring 1992. A computerized relational data base management system has been developed to store, tabulate, and statistically analyze air monitoring results. The system was developed and verified in accordance with DOE 1330.1C and is operated per DOE 1360.2. Programmatic revisions to the radiological ambient air program have been incorporated into the Environmental Monitoring Plan and include formal sampling and QA/QC procedures, requirements for management oversight, equipment calibrations and audits, commitment to perform particle-size measurements, and adoption of biweekly sampling once resources become available. Negotiations are ongoing between the Laboratory, DOE, and Environmental Protection agency (EPA) to modify the radiological stack monitoring program.

Dedicated pumps have been purchased for installation in all of the shallow ground water monitoring wells. Well abandonment procedures have been adopted. Initial planning and implementation of hydrologic condition and main aquifer recharge studies has begun and includes the installation of some stream flow gauging facilities and 20-30 additional deep and shallow investigatory and monitoring wells. Preliminary age dating of the main aquifer has been performed, recharge source characterization studies using stable isotopes are under way, and Laboratory analysis of drilling cores is being performed to characterize the vadose zone. Contracts have been issued for additional stream gauging and for assistance in developing sediment transport models for the canyons. The liquid effluent monitoring program has significantly increased the sampling frequency from a few times per year to weekly. Special intensive studies have been designed for CY91 to determine compliance with New Mexico Water Quality Standards.

Sampling of elk was conducted during FY91 and cattle sampling is to be performed during FY92; the feasibility of sampling other wildlife species identified by the Tiger Team is being studied by the Laboratory, as these species do not contribute to direct internal radiation exposure to man. A new staff member was hired by the Environmental Protection Group (EM-8) to manage the inactive waste sites monitoring program. The Laboratory is preparing the Annual Site Environmental Report (ASER) for CY91 to follow the suggested format in DOE 5400.1, Attachment II.

Also please see C-EM-05 (NPDES Waste Stream Characterization), C-RP-13 (Radioactive Air Emissions Management Program), and C-EM-26 (Risk Management) for information/interrelated actions.

★ **LANL is committed to (1) supporting the FY 92 through FY 94 schedules in this action plan with the existing budget resources that are depicted in the funding matrix of this plan, and (2) the FY 95 through FY 02 schedules with the developed budget requirements that are represented in the funding matrix of this plan; however, these FY 95 - FY 02 schedules and budget requirements are contingent upon receipt of requested additional resources. (Also see Section 2.0 (2.7) - Financial/Resource Assumptions.)**

Planned Actions:

		Start Date	End Date	LANL Responsible Organization
0.	Please see the RESPONSE section of this action plan for additional information or actions already taken and please note dates for planned actions scheduled to be completed subsequently.			
1.	Design and implement the schedule for hydrologic condition and aquifer recharge studies. (Completion of Planned Action 1 completes Findings GW/CF-1 and GW/CF-2.)	10/1991	01/1999	EM

2.	Revise and implement the Environmental Monitoring Plan and a chain of custody procedure to upgrade effluent monitoring and environmental surveillance programs for ambient air, radiological air emissions, ground water, surface water, soil, sediment, biota, environmental thermoluminescent dosimeter (TLD), and inactive waste sites as detailed in the Environmental Monitoring Plan. Revision of the EMP will include (in addition to a chain of custody procedure) SOPs (as needed) and QA/QC plans. (Completion of Planned Actions 1 and 2 completes Findings GW/CF-3, QA/CF-9, RAD/CF-2, and SW/CF-6.)	02/1992	09/1993	EM
3.	Continue the development and incremental implementation of the expanded monitoring programs of vegetation, biota, sediment, soil, ground water, surface water, environmental thermoluminescent dosimeter (TLD), and inactive waste sites as detailed in the Environmental Monitoring Plan. (Completion of Planned Actions 1 through 3 completes Findings GW/CF-4, RAD/CF-1, and RAD/CF-13.)	02/1992	02/2002	EM
3.1	Prepare Inactive Waste Site (IWS) surveillance reports encompassing CY '89, '90, '91.			
3.2	Complete SOP for annual IWS surveillance activities, including perimeter radiological surveys, and intensive soil and vegetation surveys.			
4.	Prepare and submit the 1991 Annual Site Environmental Report in DOE format; evaluate feasibility of including current bee and honey sample results.	03/1992	02/1993	EM
5.	Establish procedures to ensure that bee and honey sample results are included in the current year's Annual Site Environmental Report. (Completion of Planned Actions 1 through 5 completes Finding RAD/BMPF-1.)	08/1992	12/1992	EM
6.	Continue dialogue between DOE Headquarters, DOE Albuquerque Field Office, DOE Los Alamos Area Office, and the Laboratory to resolve management issues relating to inactive waste sites monitoring program, including resources and administrative ownership of sites. (See Action Plan C-DOE-85 Management of Transferred Inactive Waste Sites, regarding DOE dialog regarding ownership of IWSs.)	03/1992	06/1993	EM

7.	Revise the Ground Water Protection Management Program Plan to include the following: (1) the upgraded Ground Water Monitoring Plan, which is a subsection of the Environmental Monitoring Plan; (2) a better definition of group responsibilities and professional training requirements; and (3) a description of the Fenton Hill ground water.	09/1993	06/1994	EM
8.	Install required new monitoring wells, inventory abandoned bore holes and wells, and complete monitoring facility improvements to include installation of well protective covers and plugging of decommissioned boreholes. (Completion of Planned Actions 1 through 8 completes Finding GW/BMPF-1.)	04/1992	04/1999	EM
8.1	Inventory bore holes and wells.	04/1992	06/1993	EM
8.2	Install protective covers and plug decommissioned bore holes.	04/1992	12/1993	EM
8.3	Initiate funds request, receive funds and install new monitoring wells. (Completion of new monitoring wells installation will occur three years after receipt of funding).	04/1992	04/1999	EM
9.	Develop and implement environmental training programs for radiological ambient air monitoring.	11/1991	11/1993	EM
10.	Upgrade tritium and particulate sampling systems and begin expanded sampling program. (Completion of Planned Actions 1 through 10 completes Finding A/CF-4.)	01/1992	11/1997	EM

Within 30 days subsequent to the completion of a planned action that completes a concern(s) / finding(s) the Laboratory will submit a Certificate of Completion to DOE to formally initiate the closure of the concern(s) / finding(s).

Action Plan: C-EM-01 ($k)

PSO: Institutional (Allocated To DP - 50%, EW - 9%, ER - 12%, NE - 3%, OFA/WFO - 19%, All Other - 7%)					
FISCAL YEAR	OPERATING	INCREMENTAL	CAPITAL EQUIPMENT	CONSTRUCTION	FY TOTAL
1992	813.7	350.0	66.6	.0	1230.3
1993	2913.2	.0	.0	.0	2913.2
1994	2505.4	.0	.0	.0	2505.4
1995	2022.7	748.8	.0	.0	2771.5
1996	187.8	616.7	.0	.0	804.5
1997	187.8	616.7	.0	.0	804.5
1998	.0	624.1	.0	.0	624.1
1999	.0	624.1	.0	.0	624.1
2000	.0	624.1	.0	.0	624.1
2001	.0	624.1	.0	.0	624.1
2002	.0	624.1	.0	.0	624.1
ACTION PLAN TOTAL	8630.6	5452.7	66.6	.0	14149.9

Reference Information: (1) C-DOE-85 (Management of Transferred Inactive Waste Sites). (2) C-EM-05 (NPDES Waste Stream Characterization). (3) C-RP-13 (Radioactive Air Emissions Management Program). (4) C-EM-26 (Risk Management).

Action Assigned To:

Organization:	EM-DO	**Author:**	Bruce Gallaher
Contact:	Tom Gunderson	**Organization:**	EM-8
Phone:	665-3778	**Author's Phone:**	667-3040
FAX:	665-3811	**FAX:**	667-0486

Action Plan No.: C-EM-17

Title: Ground Water Discharge Plan Compliance

Category: X Environmental ___ Safety & Health ___ Management & Organization

LANL: Net Benefit to Cost Index - 2

Tiger Team Concern(s) or Finding(s):

GW/BMPF-3 LANL has not initiated preparation of Ground Water Discharge Plans to ensure compliance with anticipated NMWQR requirements.

Code: X Compliance ___ Best Management Practice _ Safety & Health Category

Compliance Protocol: New Mexico Water Quality Control Commission (NMWQCC) Regulations, Sections 3-104 and 3-106

ADS Number: N/A **DOE Priority No.:** 3

Root Cause: Los Alamos National Laboratory has not considered preparation of Ground Water Discharge Plans to be a high priority in the past because the main aquifer in the Los Alamos area is located 600-1200 feet below the surface and has not been affected by surface discharges.

Response: The NMWQCC regulations provide that, unless exempted under the regulations, all direct or indirect discharges of effluent or leachate must be made pursuant to a discharge plan approved by the New Mexico Environment Department (NMED). Owners of discharges which were in existence prior to the effective date of the regulations in 1977 must submit discharge plans only if required by written notice from the NMED. Most of the point source discharges at the Laboratory were in existence prior to 1977. It is possible that the pre-1977 discharges will be called in for discharge plans at the discretion of the NMED. Also, there may be post-1977 discharges that require discharge plans. The Laboratory will not be in a position to meet the 120-day deadline required for submittal of a ground water discharge plan under the NMWQCC regulations unless discharge plan work begins before NMED notification.

A discharge plan is nearing completion for the new sanitary wastewater systems consolidation (SWSC) project treatment plant. This project is designed to meet all NMWQCC numerical standards at the outfall except for possible exceedance of the nitrogen standard during extremely cold weather. The discharge plan for the SWSC project addresses monitoring and contingency plans. The sludge generated at the SWSC plant will be used as a soil amendment on a forest land application site. The site selection process is under way. When a site is selected, a discharge plan will be prepared for the sludge operation. Again, the primary limiting contaminant is expected to be nitrogen.

All of the NPDES permitted outfalls have gone through a process of notification to the NMED. To date, the NMED has not required discharge plans to be prepared for any of the NPDES outfalls. One outfall serving the Fenton Hill hot dry Rock geothermal research site has been included under the discharge plan requirement by the New Mexico Oil Conservation Division. This site is currently operated under an approved ground water discharge plan.

★ LANL is committed to (1) supporting the FY 92 through FY 94 schedules in this action plan with the existing budget resources that are depicted in the funding matrix of this plan, and (2) the FY 95 through FY 02 schedules with the developed budget requirements that are represented in the funding matrix of this plan; however, these FY 95 - FY 02 schedules and budget requirements are contingent upon receipt of requested additional resources. (Also see Section 2.0 (2.7) - Financial/Resource Assumptions.)

Planned Actions:

		Start Date	End Date	LANL Responsible Organization
0.	Please see the RESPONSE section of this action plan for additional information or actions already taken and please note dates for planned actions scheduled to be completed subsequently.			
1.	Complete preparation of ground water discharge plan for SWSC project.	06/1991	06/1992	EM
2.	Select site for proposed new sludge disposal area.	04/1992	06/1992	ENG
3.	Complete preparation of ground water discharge plan for new sludge disposal area.	07/1992	12/1992	EM
4.	Establish procedures to inventory, rank, and prioritize other discharges that may require inclusion in a Laboratory-wide discharge plan.	10/1992	09/1993	EM
5.	Collect preliminary data and prepare hydrogeologic information on high-priority discharges (See Planned Action 4, above).	04/1993	09/1993	EM
6.	Obtain consultant services and complete ground water discharge plan covering high-priority discharges.	10/1993	09/1994	EM

7.	Obtain additional consultant services and complete the comprehensive Laboratory-wide ground water discharge plan for the entire Laboratory. (Completion of Planned Actions 1 through 7 completes Finding GW/BMPF-3.)	10/1994	09/1996	EM

Within 30 days subsequent to the completion of a planned action that completes a concern(s) / finding(s) the Laboratory will submit a Certificate of Completion to DOE to formally initiate the closure of the concern(s) / finding(s).

Action Plan: C-EM-17 ($k)

PSO: Institutional (Allocated To DP - 50%, EW - 9%, ER - 12%, NE - 3%, OFA/WFO - 19%, All Other - 7%)

FISCAL YEAR	OPERATING	INCREMENTAL	CAPITAL EQUIPMENT	CONSTRUCTION	FY TOTAL
1992	49.8	.0	.0	.0	49.8
1993	141.6	.0	.0	.0	141.6
1994	336.8	.0	.0	.0	336.8
1995	266.9	437.8	.0	.0	404.7
1996	.0	688.9	.0	.0	688.9
1997	.0	.0	.0	.0	.0
1998	.0	.0	.0	.0	.0
1999	.0	.0	.0	.0	.0
2000	.0	.0	.0	.0	.0
2001	.0	.0	.0	.0	.0
2002	.0	.0	.0	.0	.0
ACTION PLAN TOTAL	795.1	826.7	.0	.0	1621.8

Reference Information: None

Action Assigned To:

Organization:	EM-DO	**Author:**	Steve Rae
Contact:	Tom Gunderson	**Organization:**	EM-8
Phone:	665-3778	**Author's Phone:**	665-1859
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APPENDIX J

Monitoring Well Design and Completion Matrix

MONITORING WELL DESIGN AND COMPLETION MATRIX

PREPARED BY :
JON C. NEWSOM
EES-4, SUBSURFACE TECHNICAL TEAM
10/27/94

CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
WELL ABANDONMENT	OVER-REAM CASING AND REMOVE IF POSSIBLE. PUMP GROUT WITH TREMIE PIPE BOTTOM TO SURFACE IN ONE MONOLITHIC EFFORT. WHERE A PROPER SURFACE SEAL HAS BEEN SET AND OVER-REAMING IS NOT PRACTICAL : RIP THE SCREEN AND CASING WITH PERFORATOR AND PUMP GROUT FROM BOTTOM TO SURFACE IN ONE EFFORT.	OVER-REAM CASING AND REMOVE IF POSSIBLE. PUMP GROUT WITH TREMIE PIPE BOTTOM TO SURFACE IN ONE MONOLITHIC EFFORT. WHERE A PROPER SURFACE SEAL HAS BEEN SET AND OVER-REAMING IS NOT PRACTICAL : RIP THE SCREEN AND CASING WITH PERFORATOR AND PUMP GROUT FROM BOTTOM TO SURFACE IN ONE EFFORT.	REMOVE CASING WHERE POSSIBLE. CUT CASING AT GROUND SURFACE. USE EXPANDING GROUT OR FILL WITH BENTONITE PELLETS FROM BOTTOM TO SURFACE.	NOT MENTIONED.	
PROTECTIVE SURFACE CASING / SHROUD	STEEL POST, 5' MINIMUM LENGTH, 1.5' TO 3.0' ABOVE GROUND, 8" OD FOR 4" WELLS AND 6" OD FOR 2" WELLS, LOCKING CAPS, LOCK, WHETHER-PROOF	STEEL POST, 5' MINIMUM LENGTH, 1.5' TO 3.0' ABOVE GROUND, 8" OD FOR 4" WELLS AND 6" OD FOR 2" WELLS, LOCKING CAPS, LOCK, WHETHER-PROOF	LOCKING CAP , LARGE ENOUGH TO ALLOW REMOVAL OF PVC CASING CAP		
CASING MATERIALS, CONDITIONS	PVC, STAINLESS STEEL, OR IN SOME CASES NON STAINLESS STEEL WELL CASING, WHERE DESIGN DICTATES	PVC	SCHEDULE 40 OR HEAVIER PVC, MINIMUM 2" ID	INERT MATERIALS , FLUSH JOINT, INTERNAL UPSET OR, THREADED, NO GLUE, SCREWS, OR RIVETS	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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10/27/94

CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
SURFACE PAD AROUND CASING	MINIMUM: 24' X 24' X 6" THICK, CEMENT, PLACED AROUND CASING, SLOPED DOWNWARD FROM CASING FOR RUNOFF.	24' X 24' X 4" THICK, CEMENT, PLACED AROUND CASING, SLOPED DOWNWARD FROM CASING FOR RUNOFF.	24' X 24' X 6" THICK, CEMENT, PLACED AROUND CASING, SLOPED DOWNWARD FROM CASING FOR RUNOFF.	NOT MENTIONED	
WELL PROTECTIVE GUARD POSTS	3' OR LARGER STEEL PIPE. MINIMUM 4' ABOVE GROUND, 2' BELOW GROUND. 3 POST RADIALLY LOCATED 4' AROUND THE WELL. CEMENTED INSIDE `6" HOLE. MAY NOT BE REQUIRED IN AREAS OF ZERO TRAFFIC.	3' OR LARGER STEEL PIPE OR TEE BAR POST. MINIMUM 4' ABOVE GROUND, 2' BELOW GROUND. 3 POST RADIALLY LOCATED 4' AROUND THE WELL. CEMENTED IN PLACE.	NOT MENTIONED	NOT MENTIONED	
ANNULAR WELL SEAL MINIMUM WIDTH (BETWEEN CASING OD AND WELL BORE)	2" OR LARGER PER SIDE, 4" OR LARGER TOTAL	2" OR LARGER PER SIDE, 4" OR LARGER TOTAL	2" OR LARGER PER SIDE, 4" OR LARGER TOTAL	3" OR LARGER PER SIDE, 6" OR LARGER TOTAL	2" OR LARGER PER SIDE, 4" OR LARGER TOTAL
ANNULAR WELL SEAL SURFACE TO MINIMUM DEPTH.	PORTLAND CEMENT TYPE I-II, WITH 2% TO 5% BENTONITE ADDED. MINIMUM DEPTH IF PLACED ABOVE BENTONITE SEAL IS 10'. WAIT 48 HOURS ADD MORE AT SURFACE.	GROUT WITH SMALL % BENTONITE. WAIT 48 HR. ADD MORE AT SURFACE.	CEMENT WITH 2% TO 8% BENTONITE. MINIMUM DEPTH IS 10' FROM SURFACE.	GROUT (PRESUMED TO MEAN CEMENT) PLACED WITH TREMIE IF DEEPER THAN 5'.	

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ANNULAR WELL SEAL MATERIALS (BELOW MINIMUM DEPTH SURFACE SEAL) GENERALLY BETWEEN 10' FROM SURFACE AND 2' ABOVE SCREEN.	HIGH SOLIDS CONTENT BENTONITE SLURRY GROUT, DRY GRANULAR BENTONITE CHIPS, OR PORTLAND TYPE I-II CEMENT WITH 2% TO 5% BENTONITE. NOTE* PLACE AND HYDRATE 2 ' THICK CHIP OR PELLET SEAL ABOVE FILTER PACK BEFORE PLACING GROUT. *NOTE. HEAT AND HIGH HYDROSTATIC PRESSURES CAUSED BY CEMENT CAN COLLAPSE PVC PIPE.	HIGH SOLIDS BENTONITE SLURRY GROUT, PORTLAND CEMENT, OR BENTONITE PELLETS. PLACE A 2' THICK SEAL ABOVE FILTER PACK, HYDRATE FOR 24 HOURS BEFORE ADDING ANY LIQUID GROUT.	CAN USE DRILL CUTTINGS, CLEAN SANDY CLAY, OR TIGHTER SOIL TO WITHIN 10' OF SURFACE.	GROUT (PRESUMED BENTONITE OR CEMENT) IF BENTONITE HYDRATE A MINIMUM TIME OF 12 HOURS BEFORE ADDING SURFACE SEAL PLACE WITH TREMIE.	
CENTRALIZERS: QUANTITY, SPACING	PLACE ONE AT BOTTOM OF SCREEN, ONE AT TOP OF SCREEN, AND SPACE ADDITIONAL ONES EVERY 50 ' UNLESS PLACING THROUGH HOLLOW STEM AUGERS OR THROUGH ODEX CASING, WHERE FEWER ARE REQUIRED.	EVERY 20' IF PLACED WITHOUT AUGERS. MAY NOT BE APPLICABLE IF PLACED THROUGH AUGERS. USE MECHANICAL FASTENERS, SPACE AT 90 DEG. AND 120 DEG.	ONE AT TOP OF SCREEN AND ONE AT BOTTOM OF SCREEN.	NOT MENTIONED	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
FILTER PACK, MATERIAL, MINIMUM/MAXIMUM COVERAGE	WASHED WELL ROUNDED COLORADO SILICA. SIZED TO PASS 10% OR LESS THROUGH THE SCREEN SLOTS. PLACE 2' ABOVE SCREENED INTERVAL. PLACE 2' BELOW SCREENED INTERVAL IF ABOVE A BENTONITE SEAL.	INERT SILICA, SIZED TO PASS 10% OR LESS THROUGH THE SCREEN SLOTS. PLACE 2' ABOVE THE SCREEN, PLACE 2' BELOW THE SCREEN IF A BENTONITE SEAL HAS BEEN PLACED BELOW THE SCREEN INTERVAL. FILTER PACK TO BE PLACED WITH TREMIE PIPE IF 30' OR DEEPER.	PLACE 2' TO 5' MAXIMUM ABOVE THE THE SCREEN. PLACE 1' OR GREATER BELOW THE SCREENED INTERVAL IF ABOVE A BENTONITE SEAL. PLACE 2' OR GREATER IF ABOVE AN ARTESIAN ZONE.	PLACE 2' ABOVE THE SCREENED INTERVAL. DO NOT PLACE ACROSS CLAY ZONES.	
SCREEN: MATERIAL, MINIMUM/ MAXIMUM LENGTH	PVC, STAINLESS STEEL, OTHER INERT MATERIALS. COVERAGE TO BE DETERMINED AS PART OF INDIVIDUAL WELL DESIGN. GENERALLY THE SCREENED INTERVAL WILL BE BETWEEN 5' AND 25'. A BOTTOM CAP IS REQUIRED AND A SHORT BLANK SECTION MAY BE USED.	DETERMINED ON A WELL TO WELL BASIS FOR BETTER WELL DESIGN. SCREEN TO COVER ONLY ONE PRODUCING ZONE.	**PVC (ASSUMED), 20' MINIMUM LENGTH** **TOP OF SCREEN MUST BE 5' ABOVE WATER TABLE.** MUST BE MACHINE SLOTTED (NOT DONE WITH A HACKSAW).	(PVC ASSUMED) 10' MAXIMUM LENGTH. DO NOT PLACE ACROSS A CLAY ZONE.	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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10/27/94

CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
DEVELOPMENT	USE A SURGE PLUG TO PURGE FINE SANDS AND DRILLING CONTAMINATES FROM WELL. USE A BAILER AND OR SUBMERSIBLE PUMP TO REMOVE SUFFICIENT BOREHOLE FLUIDS TO ACHIEVE TURBIDITY MEASUREMENTS AS REQUIRED BY THE HSWA PERMIT.	NOT MENTIONED	DEVELOP SO THAT WELL WATER FLOWS FREELY AND THAT ALL SEDIMENT HAS BEEN REMOVED.	PURGE THE WELL UNTIL CONTAMINATES INTRODUCED DURING DRILLING CAN BE ASSURED OF BEING REMOVED. DEVELOPMENT SHALL INCLUDE THE USE OF A SURGE PLUG, AND EITHER BAILING OR PUMPING UNTIL NEPHELOMETRIC TURGIDITY UNITS (N.T.U.) CAN BE CONSISTENTLY MEASURED AT FIVE (5) OR LESS, IF POSSIBLE.	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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10/27/94

CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
WELLS 300' OR DEEPER	300' OR GREATER AND NOT TO THE MAIN AQUIFER: GROUT IN A SURFACE CASING. DEPTH OF THIS CASING SHOULD EXTEND BEYOND SHALLOW AQUIFERS. 300' OR GREATER AND INTO THE MAIN AQUIFER THAT ENCOUNTERS A PERCHED AQUIFER: SET A CONDUCTOR PIPE TO THE TOP OF THE MAIN AQUIFER (FROM SURFACE TO MAIN AQUIFER) TO ISOLATE THE PERCHED AQUIFER FROM THE MAIN AQUIFER.	NOT MENTIONED	NOT MENTIONED	300' OR GREATER AND NOT TO THE MAIN AQUIFER: GROUT IN A SURFACE CASING.(DEPTH OF THIS CASING IS NOT SPECIFIED). 300' OR GREATER AND INTO THE MAIN AQUIFER THAT ENCOUNTERS A PERCHED AQUIFER: SET A CONDUCTOR PIPE TO THE TOP OF THE MAIN AQUIFER (FROM SURFACE TO MAIN AQUIFER) TO ISOLATE THE PERCHED AQUIFER FROM THE MAIN AQUIFER.	
SHALLOW ALLUVIUM PERCHED AQUIFER MONITORING HOLES	DESIGN MAY VARY SIGNIFICANTLY IN VERY SHALLOW HOLES WHERE NEAR SURFACE WATERS ARE TO BE MONITORED A 24" MINIMUM CEMENT GROUT SEAL MAY BE USED.	DESIGN MAY VARY SIGNIFICANTLY	NOT MENTIONED	NOT MENTIONED	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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10/27/94

CATEGORY	PROPOSED LANL ER SOP SOP- 5.01, R1	PRESENT LANL ER SOP SOP-5.01, R0	NEW MEXICO MONITORING WELL CONSTRUCTION AND ABANDONMENT WELL STANDARDS	HSWA PERMIT 8/15/92	NATIONAL EPA GUIDELINES
WELL POINTS AND PIEZOMETERS	DESIGN MAY VARY SIGNIFICANTLY. PROVIDE A SURFACE SEAL WHICH PREVENTS SURFACE WATER FROM ENTERING THE WELL.	DESIGN MAY VARY SIGNIFICANTLY.	NOT MENTIONED	NOT MENTIONED.	
DOCUMENTATION				WITHIN 30 DAYS OF INSTALLATION OF WELLS, SUBMIT A MAP TO THE ADMINISTRATIVE AUTHORITY WHICH DELINEATES THE KNOWN EXTENT OF THE PERCHED GROUND WATER AT THE FACILITY. WITHIN 90 DAYS THE PERMITTEE SHALL SAMPLE EACH WELL FOR CERTAIN CONSTITUENTS AND ANALYTICAL RESULTS SENT TO THE AD. AUTHORITY. OTHER ONGOING MONITORING PROGRAM REPORTS.	

MONITORING WELL DESIGN AND COMPLETION MATRIX

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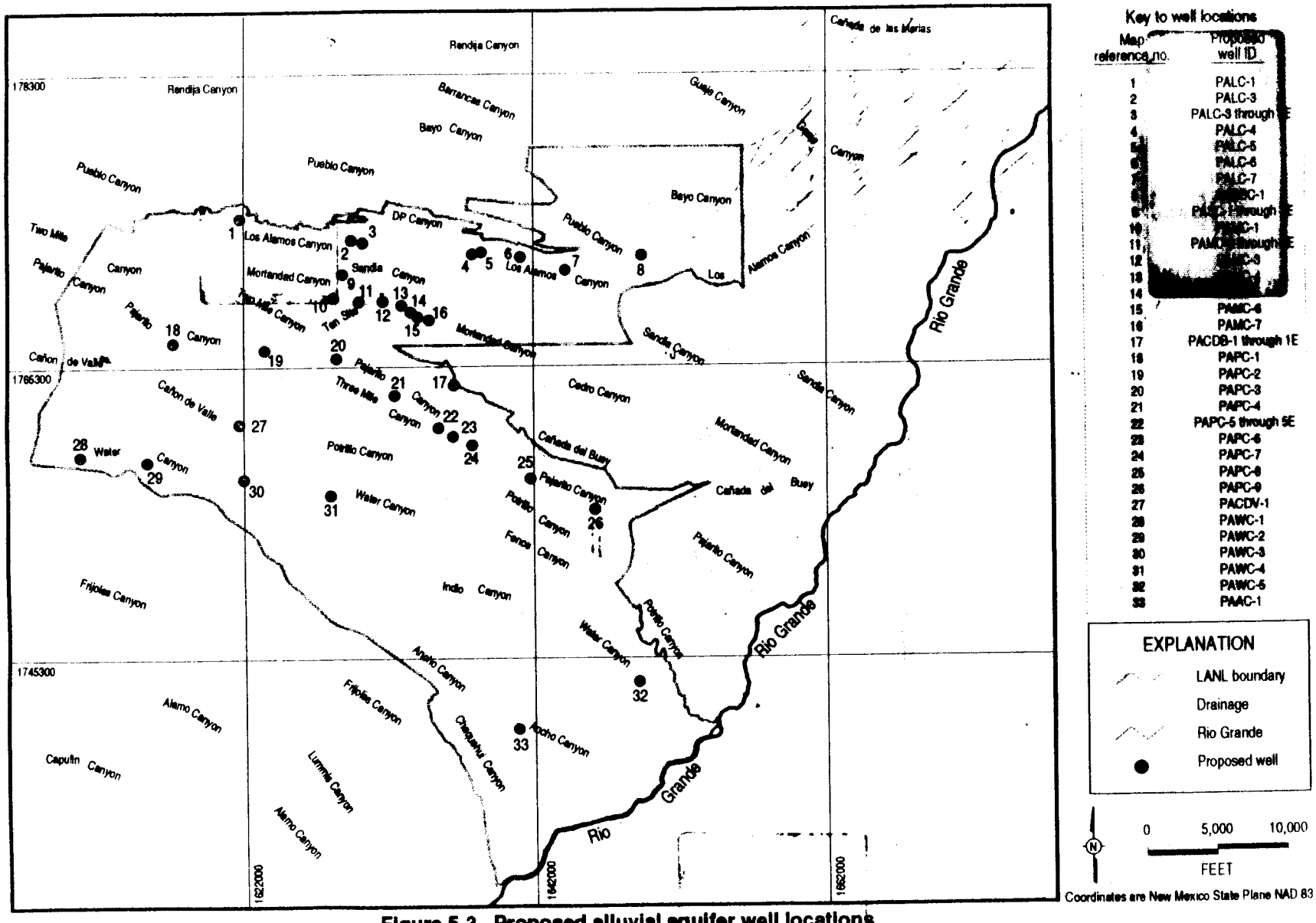

Figure 5-3. Proposed alluvial aquifer well locations.

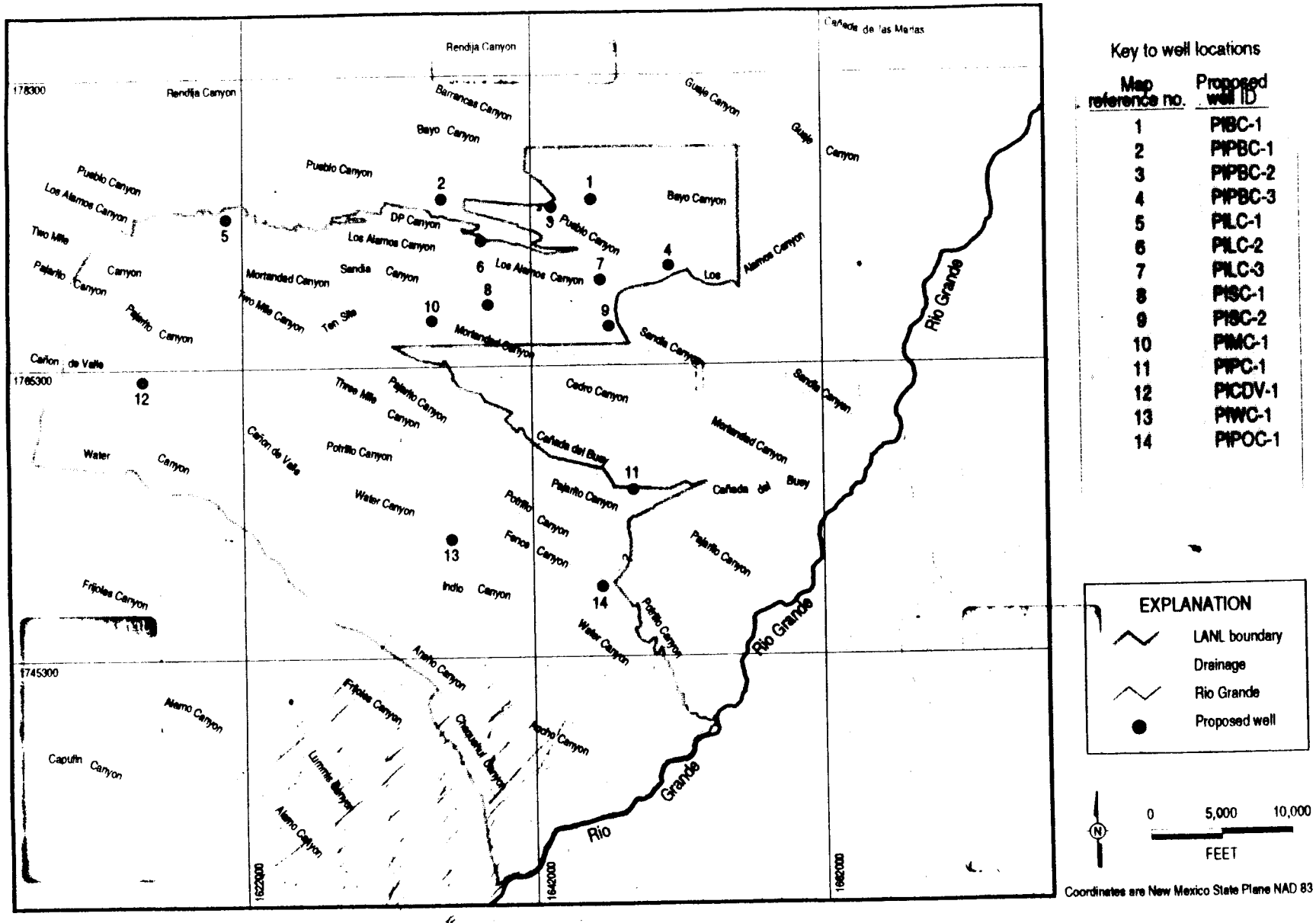

Figure 5-2. Proposed intermediate aquifer well locations.

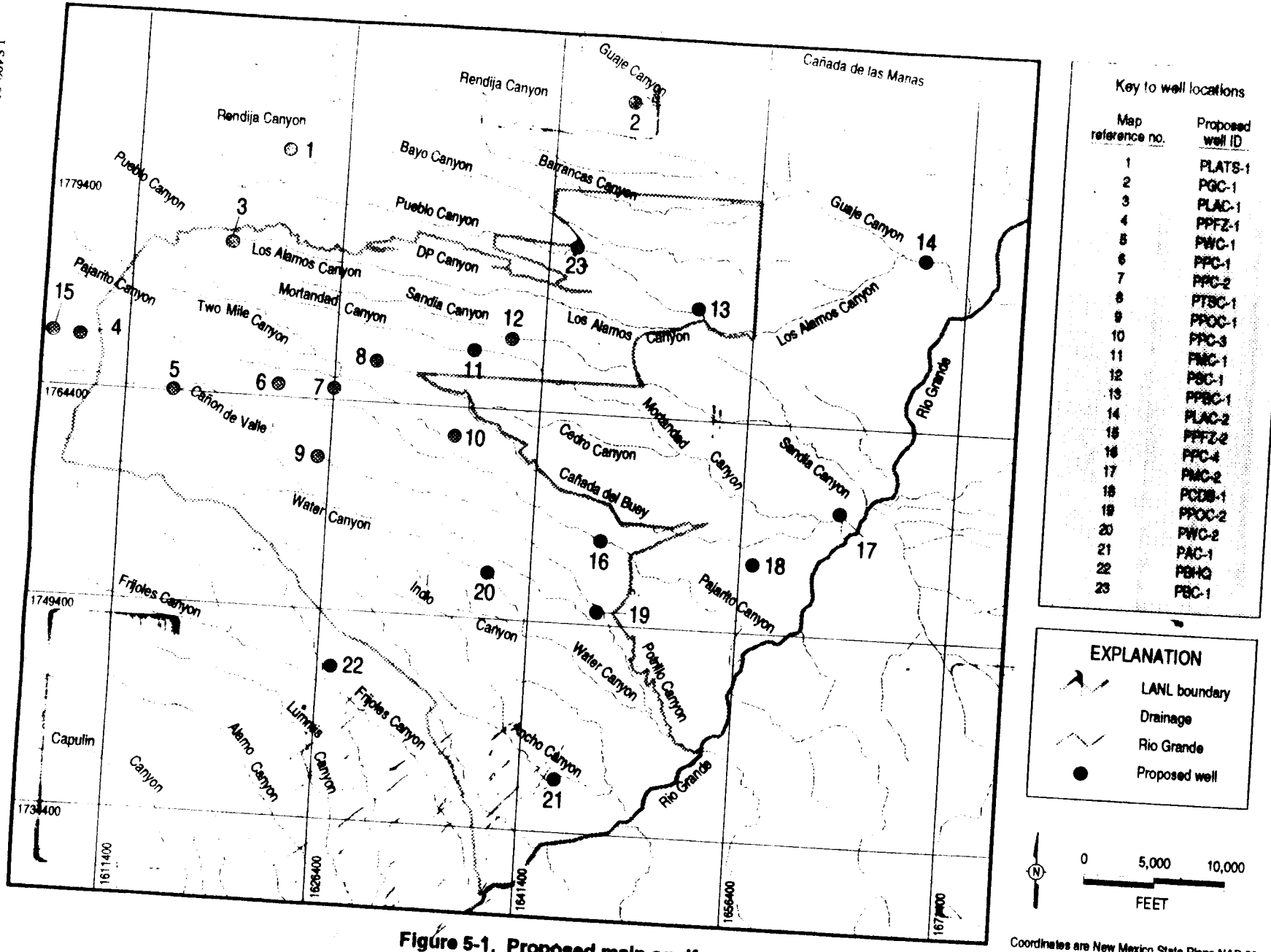

Figure 5-1. Proposed main aquifer well locations.

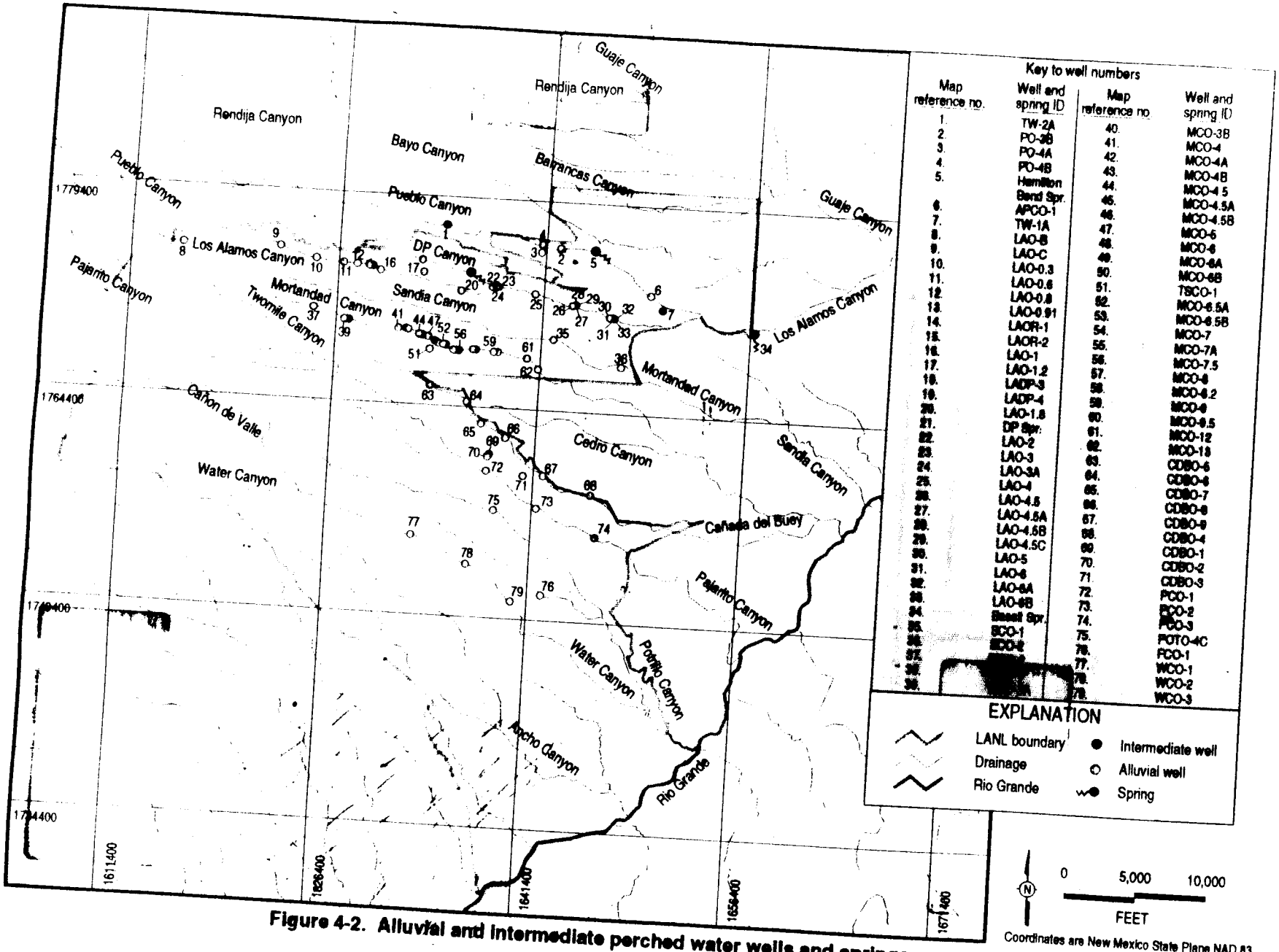

Figure 4-2. Alluvial and intermediate perched water wells and springs.

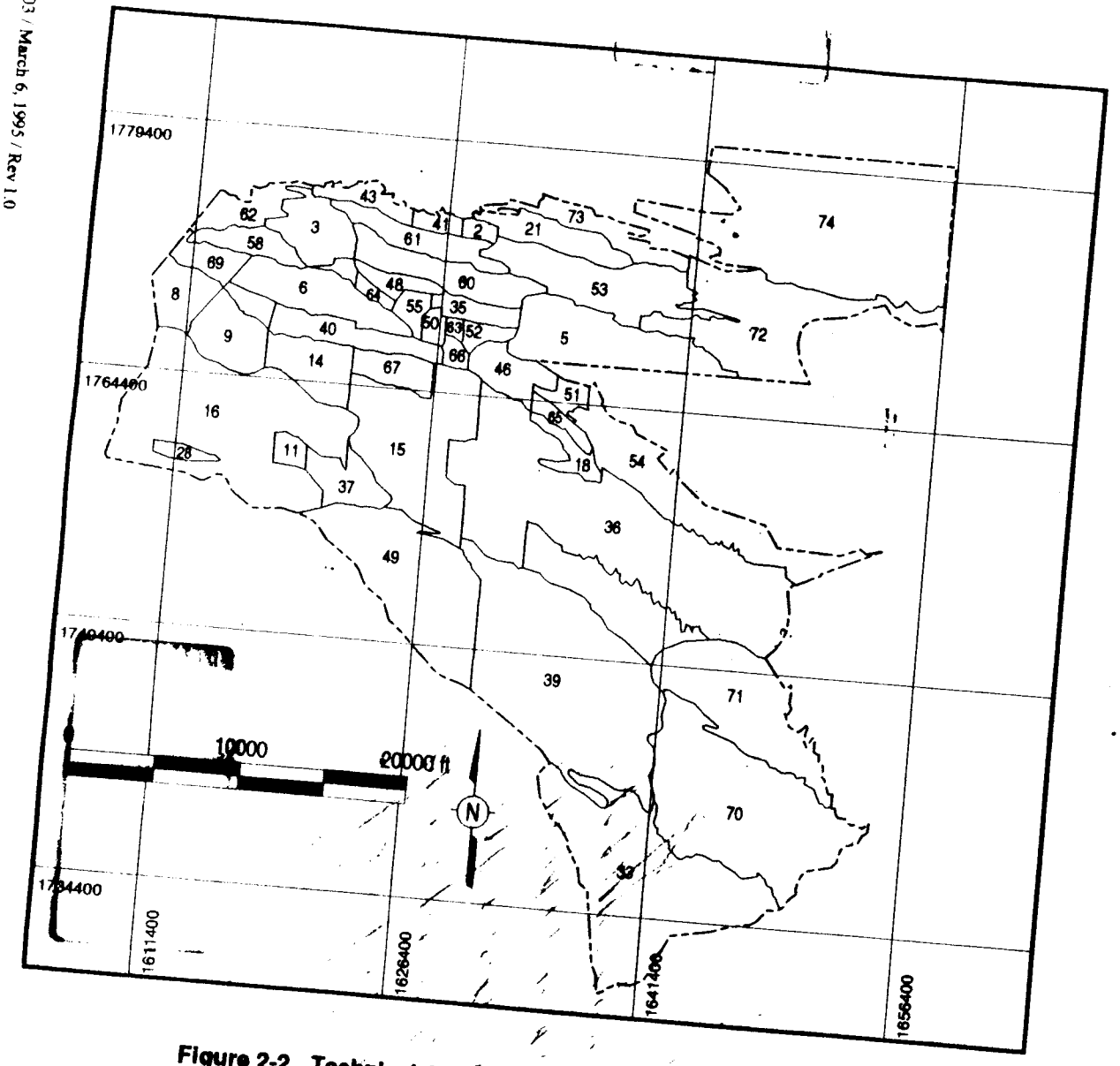

Figure 2-2. Technical Areas at the Los Alamos National Laboratory