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JUL 1997 RECEIVED

Date: July 7, 1997
Refer to: EM/ER:97-250

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

SUBJECT: FINAL RESPONSE TO THE NOD FOR LOS ALAMOS AND PUEBLO CANYONS WORK PLAN (FORMER OU 1049)

Dear Mr. Garcia:

Enclosed is a copy of the Los Alamos National Laboratory's Final Response to the Notice of Deficiency (NOD) for Los Alamos and Pueblo Canyons Resource Conservation and Recovery Act Facility Investigation Work Plan. To finalize the Laboratory's response to your Bureau's NOD comments on the Los Alamos and Pueblo Canyons Work Plan dated June 3, 1997, the enclosure contains new and/or revised document pages and instructions for replacing the pages in the original work plan.

Please note that in response to General Comments 5 and 6, which address present-day human health and ecological risk assessment issues, we have decided to incorporate Chapter 6 of the Core Document for Canyons Investigation by reference. This chapter is enclosed for your convenience. In addition, relative to the response to Specific Comment 12, the locations and numbers of regional aquifer wells (as well as alluvial and intermediate perched zone wells) are not finalized; these wells will be addressed after we have received final approval of the Hydrogeologic Work Plan from the New Mexico Environment Department.

If you have any questions regarding the final response to the NOD, please contact Allyn Pratt at (505) 667-4308 or Joe Mose at (505) 667-5808.

Sincerely,

Jorg Jansen, Program Manager
LANL/ER Project

Sincerely,

Theodore J. Taylor, Program Manager
DOE/LAAO

JJ/TT/rfr

Enclosures: (1) Final Response to the NOD for Los Alamos and Pueblo Canyon Work Plan (Former OU 1049)
(2) Certification

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TC

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CERTIFICATION

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

Document Title: Final Response to the NOD for Los Alamos and Pueblo Canyon Work Plan (Former OU 1049)

Name: _____ Date: 7-7-97

Jorg Jansen, Program Manager
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or

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6.0 RISK ASSESSMENT MODELS AND APPROACH

6.1 Introduction

This chapter presents the objectives, models, and approaches to the assessment of present-day human health and ecological risk used in the investigations to be conducted in the canyon systems.

Section 5.1.3 in Chapter 5 of this core document describes the site characterization approach to be used in these investigations. The approach attempts to take full advantage of data that are both extant and now being collected in the Environmental Restoration (ER) Project at nearby potential release sites of other operable units.

A preliminary list of potential contaminants based on a knowledge of past and present Laboratory operations and contaminant releases is included (Table 6-1) in this chapter. Those contaminants determined to be chemicals of potential concern (COPCs), as defined in Section 5.3.6 in Chapter 5 of this core document, will be retained in the analytical protocol for further investigations.

TABLE 6-1

POTENTIAL CONTAMINANTS FOR THE CANYON SYSTEMS BASED ON HISTORICAL INFORMATION

Acetone	Epoxy resins	Silver
Actinium	Ethanol	Sodium
Alcohol	Ethylene glycol	^{90}Sr
^{241}Am	Freon	^{99}Tc
Ammonium citrate (concentrated)	Fuel oil (No. 2)	Toluene
Barium	Gasoline	Trichloroethane
Benzene	High Explosives	Trichloroethylene
Beryllium	Kerosene	Tritium
Cadmium	Lead	Uranium (total)
^{137}Cs	Mercury	^{235}U
Chlorine (chloride)	Nitrates	^{238}U
Chromium (hexavalent)	Polychlorinated biphenyls	Waste oils
^{60}Co	^{238}Pu	Xylene isomers
Copper	$^{239,240}Pu$	
Diesel oil	Scintillation liquid	

Target human health risk values are commonly defined as an individual lifetime cancer risk greater than one in ten thousand to one in one million (10^{-4} to 10^{-6}) and a hazard index for noncarcinogens (defined as the sum of the ratios of the concentration of each contaminant to its toxicity value) of one (40 CFR 300.430[e] [2] [i] [A] [2]). The final definition of acceptable risk will be agreed upon after negotiations among the implementors (the Laboratory and the Department of Energy [DOE]), the regulators (the Environmental Protection Agency [EPA] and the New Mexico Environment Department [NMED]), Indian

Pueblos, and other stakeholders. Risk scenarios have been developed to define potential receptors and the pathways of exposure for the contaminants that may be present. An objective of this chapter is to develop those scenarios so that acceptable risk can be evaluated.

6.2 Technical Approach to Risk-Based Decision-Making

6.2.1 Overview

As described in Chapter 5 of this core document, sediment, water, and air particulate samples will be collected at selected locations in the canyon systems to provide data for the present-day human health and ecological risk assessment. Specific exposure areas for human health and ecological risk assessment have not been defined in the canyons, but are expected to range from several square feet to several square miles for different exposure pathways and scenarios. Because it is impossible to collect data at all locations where exposure is possible, a quantitative treatment of uncertainty associated with the spatial distribution of contaminants is an essential aspect of any quantitative risk assessment. Chapter 5 addresses the basic technical approach for collecting data to provide information on current contaminant distributions and concentrations in the canyons. In this section, the general methodology for using this information to quantify human health and ecological risk is presented.

The reference endpoints used to measure human health risk in the canyon systems are annual dose rate (radionuclides), lifetime incremental cancer risk (chemical carcinogens), and hazard quotient (noncarcinogens). The goal of the human health risk assessment is to determine the probability that concentrations of COPCs will result in risks exceeding target values for these endpoints in areas that could potentially correspond to exposure areas for one or more types of land use. To calculate such a probability, it is necessary to quantify the uncertainty associated with COPC distributions within the potential exposure areas. There are two major aspects of this uncertainty. The first is uncertainty associated with the spatial variability of COPCs within a defined geomorphic unit as measured by the field data. The second is uncertainty associated with the conceptual model of contaminant occurrence, transport, and exposure route (the conceptual model is discussed in Chapter 4 of this core document) (hereafter "the conceptual model"), which is the tool used for interpretation of the data.

The conceptual model contains hypotheses related to transport pathways and mechanisms of contaminant redistribution. While all of the hypotheses are expected to be tested during the canyons investigations, not all can be tested quantitatively. Those hypotheses of the conceptual model that will be quantified include: (1) that the distributions of COPCs within and among geomorphic units in a reach will show trends that can be used to minimize the number of samples collected; (2) that certain COPCs will be colocated in parts of the canyon systems and that a correlation between the concentrations can be developed and used to select sampling locations; (3) that COPC concentrations may generally decrease, but inventory may increase with distance from release sources in the upper reaches of the canyons; and (4) that variability in measured data is predictive of variability in unsampled areas. An additional parameter to be evaluated is the relation of readily-measured surface concentrations of COPCs to those at depth, which will be generally unknown at the start of the investigations.

The degree of uncertainty that is acceptable in the concentrations of COPCs is a function of the variability in concentrations, the target risk values, and the models and model parameters used to calculate risk. If preliminary remediation goals (PRGs) calculated for COPCs using the specific pathways and scenarios in Section 6.4 are either well above or well below the range of observed concentrations, a high degree of uncertainty in the variability may have a minimal impact on decision-making. For example, if the fifth and ninety-fifth percentiles of the distribution of a COPC are 0.1 and 100 ppm and, respectively, the PRG is

1,000 ppm, collecting additional data to improve confidence in the distribution may be unwarranted. Rather than attempting to specify an appropriate degree of probability in realizing a particular endpoint as the decision criterion, a cost-benefit approach to collecting additional samples will be used.

6.2.2 Uncertainty Analysis for the Distribution of Chemicals of Potential Concern

Specific methods for quantifying uncertainty in the spatial distributions of COPCs in the canyons investigations have not been finalized. The discussion here is intended to describe the general approach and techniques that will be employed.

Because exposure areas of interest differ greatly in size, data reflecting variability in distributions of a COPC must be evaluated over several spatial scales. For example, variability within and among geomorphic units is important for evaluating trends that may affect the number of samples required to achieve a given degree of certainty in the risk estimates, and variability at the high end of the observed range of the entire data set may be important to evaluate clustering of high contaminant concentrations. Figure 6-1 shows an example of the overlay of potential exposure areas associated with assessment endpoints of the American Indian exposure scenario with geomorphic units in a hypothetical canyon reach.

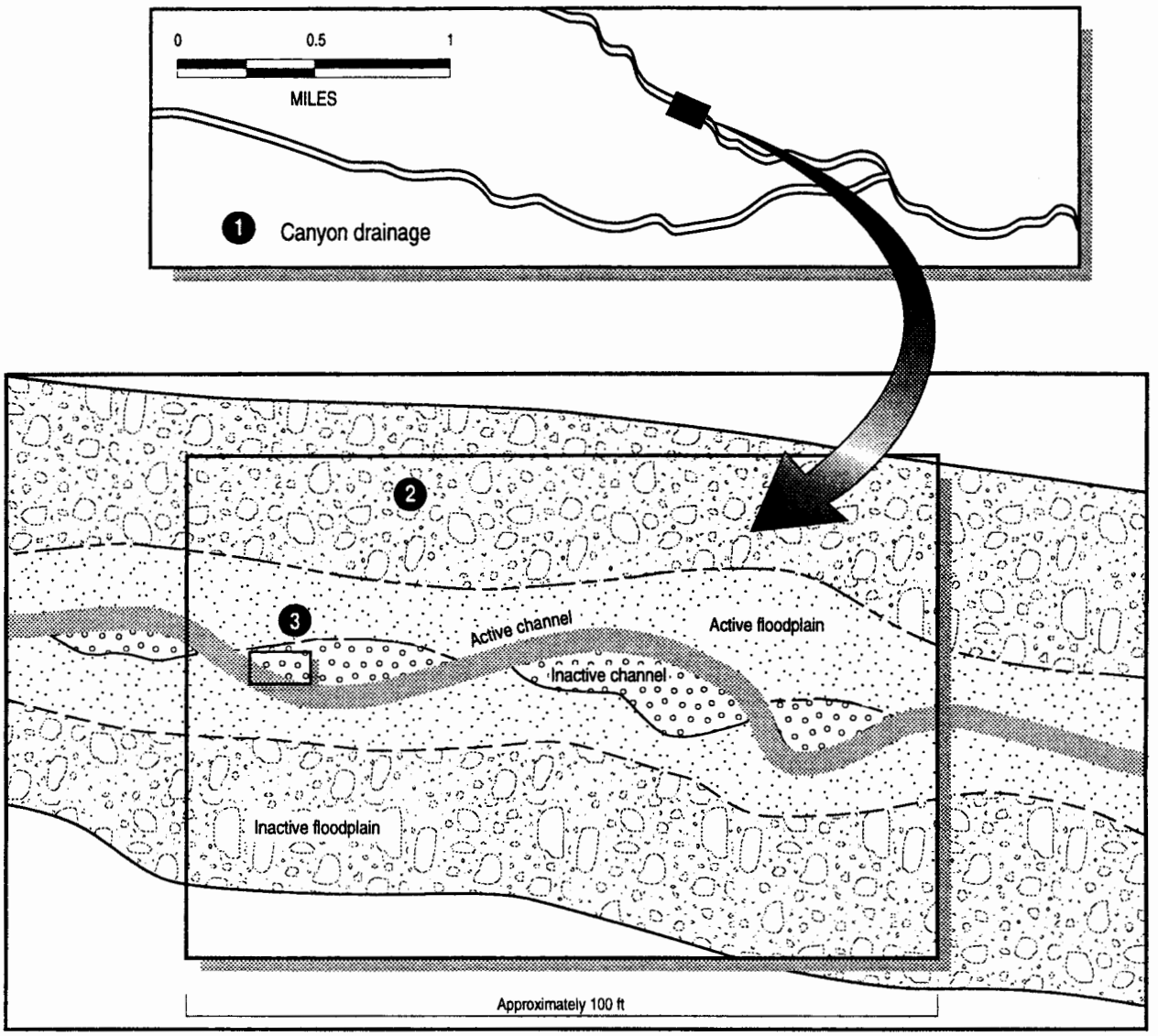
One technique for extracting the maximum amount of information regarding the spatial relationship among data points is described by Rautman (1993, 22936). The technique involves performing stochastic simulations of environmental concentrations based on limited sample data. One of the benefits of this approach is that geographic areas associated with the highest uncertainty relative to exceeding a risk level can be identified to assist in identifying locations for additional sampling and analyses. In addition, the simulations can be used to create probability maps of contaminant concentrations for similar purposes.

As additional data are collected, spatial distributions of COPCs will be revised and the ability to predict the expected value-of-information for later sampling activities will be improved. Although stochastic techniques may be employed to maximize the utility of the limited data set, the analytical data must also be used to quantify hypotheses of the conceptual model in order to develop defensible source term distributions with a limited number of samples. It is unlikely that sufficient data will be obtained to independently develop such source term distributions for every spatial scale of interest. Rather, a Bayesian statistical approach may be used with existing knowledge of contaminant distributions to create preliminary distributions that will be updated with data from additional samples. Initial hypotheses of contaminant concentration distributions can be developed from historical data and refined and validated with successive sampling.

Uncertainties associated with testing of conceptual model hypotheses, such as those identified in Section 6.2.1, may be defined individually to determine where model uncertainties are greatest. Monte Carlo methods might then be used to propagate uncertainty associated with selected tests by relating these terms in an equation whose sum is a source term for a particular exposure pathway. Additional sample collection can then be more properly focused to obtain data targeted to testing those hypotheses of the conceptual model associated with the highest degree of uncertainty.

6.2.3 Evaluation of Other Sources of Uncertainty

Uncertainty in the spatial distribution of COPCs will represent only part of the uncertainty in the final risk estimates. More difficult to quantify is the uncertainty associated with the accuracy of values calculated using transport and risk models of a particular form (these models are the quantitative, generally algebraic,



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1. Approximate canyon areas for activities including ranching, gathering wild plants, hunting, and collecting firewood.
2. Approximate area of a residential exposure unit encompassing house, small garden, and poultry enclosure.
3. Sediment trap, clay-sized particles; possible source term for exposure pathways such as ceremonial body painting and pottery making.

Figure 6-1. Spatial scale of selected exposure areas.

models that require a source term concentration as an input parameter). When assessing risk via indirect exposure pathways (i.e., when fate and transport modeling is performed), determination of model uncertainty is particularly important. Depending upon the particular pathways determined to be primary contributors to risk, and upon the estimated risk range relative to decision levels, treatment of model uncertainty may become key to the overall uncertainty analysis (International Atomic Energy Agency 1989, 54349; Cullen 1995, 54348). For indirect exposure pathways, both transport model uncertainty and uncertainty in the distribution of COPCs contribute to uncertainty in the exposure media source term for the risk assessment.

In general, uncertainty associated with the variability of human exposure factors such as exposure frequency and duration, body weight, and rates of ingestion and inhalation are minor compared to uncertainty in source term concentrations (International Atomic Energy Agency 1989, 54349). In the canyons present-day human health risk assessments, however, exposure factors associated with unique exposure pathways for American Indian use may contribute significantly to the overall uncertainty in risk estimates. Elicitation of exposure-related activity information from representatives of the Accord Pueblos is currently in progress to reduce uncertainty in these areas. Additionally, guidelines on the development of defensible parameter distributions based on these data, and data from the literature, will be followed to minimize the possibility that parameter distributions do not accurately reflect the state of knowledge for each parameter (Kaplan 1991, 54347; Lee and Wright 1994, 54346; Seiler and Alvarez 1996, 54345).

A prominent source of uncertainty in most human health and ecological risk assessments is the contaminant-specific toxicity value used to relate intake or dose to a particular adverse health effect. For a carcinogen, in particular, the dose-response function is itself the product of a particular model with associated uncertainties in both the dose-response model and the parameters used in the model. Although a quantitative treatment of uncertainty in both carcinogenic and noncarcinogenic toxicity values is possible, this source of uncertainty in the risk estimates is not unique to the canyons investigations and a large volume of literature exists on the subject. Present-day human health risk assessments in the canyons investigations will focus on providing information on the distributions of contaminant intake and exposure. Selected percentiles of these distributions will then be compared to appropriate toxicity values (slope factors, reference doses, and dose conversion factors), and other relevant toxicity information, and estimates of potential human health impacts will be provided. By keeping intake and exposure distributions separate from risk estimates, canyon-specific uncertainties in source term concentrations of COPCs, human exposure parameters, and model algorithms can be distinguished from toxicological uncertainties.

6.2.4 Application to Decision-making

Initial stages of the canyons investigations will have early estimations of model parameters and source-term uncertainties. The first evaluations will focus on the American Indian subsistence scenarios described in Section 6.5. Because this is a conservative and chronic exposure scenario, these analyses will serve as an indicator of any potential risk-based concern. Semiquantitative preliminary analyses for less conservative exposure scenarios that might have a higher probability of occurrence will also be examined at early stages to warn of any immediate health risks that might require interim measures. These scenarios may include recreational use, firewood collection, or pottery making, as appropriate. Ecological risk will be assessed by evaluating scenarios that are appropriate to ecological exposure units that include canyon ecosystems. As more data are collected, the ability to perform meaningful quantitative uncertainty analyses for exposure area source terms corresponding to the multiple exposure pathways discussed in Section 6.5 will improve, and assessments will begin to include distributions of contaminant intake and exposure based on the exposure scenarios defined for the canyons. Evaluation of risks, and/or

information on the probability of exceeding pathway and scenario-specific risk levels, will also incorporate a qualitative discussion of uncertainties introduced with the toxicity values for each COPC.

Risk information will be conveyed in the context of decision-making with an emphasis on incorporating the uncertainty analysis into selection of future activities (Finkel 1994, 54344). Recommendations for specific locations and types of samples to minimize uncertainty in the risk estimates will be provided, although a decision on *whether* to implement such recommendations may require input from other stakeholders.

As described in Section 6.5.4, risk estimates associated with American Indian uses will be focused primarily on providing exposure and risk information on a pathway- and activity-specific basis so that communities may appropriately manage potential impacts. Rules determining when sufficient information has been gathered will not be developed initially. A cost-benefit analysis with participation of all stakeholders may be an appropriate approach for determining when sufficient data have been gathered to address a particular assessment endpoint. To assist in this process, formal decision analysis methods can be employed to identify and rank decision options.

6.3 Identification of Chemicals of Potential Concern

6.3.1 Initial Sampling and Decision Criteria

The initial sampling in a given canyon and reach will identify and eliminate from further investigation those chemicals which are not considered to be of potential concern. The initial analyses will be used to focus additional sampling on a more limited analytical suite of COPCs as defined in Section 5.3.6 in Chapter 5 of this core document. The sampling will be stratified (in the statistical sense) according to recognized hydrogeological and geomorphologic units and considering geochemical characteristics of the contaminants (particularly mobility) that are described in Chapter 3 of this core document. A broad analytical suite is proposed initially because the number of potential contaminants in the source areas may be large, and large uncertainties remain as to whether these contaminants could reasonably be transported into the canyons, and whether depositional patterns are similar among the various contaminants.

6.3.2 Other Values Needed for Regulatory Compliance

For water sources in the canyon, canyon aggregate, or ecological exposure unit under investigation, the questions posed above regarding significant concentrations of contaminants and unacceptable risks may be simplified to: Are water sources contaminated above acceptable levels? To answer this question, results of analyses of water samples will be compared with federal maximum contaminant levels (MCLs) promulgated under the Safe Drinking Water Act (EPA 1994, 50118), the state drinking water standards (NMED 1995, 55501), the state groundwater standards (New Mexico Water Quality Control Commission Regulations 1995, 54406), or Indian Pueblo standards, as appropriate. In addition, the contribution to human health risk from COPCs identified in water sources will be evaluated for the appropriate exposure scenarios.

6.3.3 Potential Contaminants for the Canyons

Table 6-1 lists potential contaminants for the canyon systems. Existing data from previous sampling and analysis activities on mesa tops and canyons and the professional judgment of the canyons investigation technical team were used to identify this list of suspected contaminants. However, the list is not exhaustive, and the table contains some generic descriptions of classes of constituents. Table 6-2 lists

the suspected contaminants with federal and state MCLs and state groundwater standards. The chemical constituents listed in Table 6-2 guide, but do not limit, the selection of analytical protocols for initial groundwater sampling activities.

TABLE 6-2

EPA AND STATE MCLs AND STATE GROUNDWATER STANDARDS

COPCs	EPA MCLs[a] (mg/L)	NMED MCLs[b] (mg/L)	NMED Groundwater Standards[c] (mg/L)
Acetone	Not listed	Not listed	Not listed
Actinium isotopes	(d, e)	(f, g)	Not listed
Alcohol	Not listed	Not listed	Not listed
^{241}Am	(d)	(f)	Not listed
Barium	2	2	1.0
Benzene	0.005	0.005	0.01
Benzo[a]pyrene	0.0002	0.0002	0.0007
Beryllium	0.004	0.004	Not listed
Cadmium	0.005	0.005	0.01
^{137}Cs	(e)	(g)	Not listed
Chloride	250[h]	Not listed	250.0
Chromium[i]	0.1	0.1	0.05
^{60}Co	(e)	(g)	Not listed
Copper	1.3[j]	1.3[j]	1.0
Petroleum hydrocarbons	(k)	(k)	(l)
Ethylene glycol	Not listed	Not listed	Not listed
Fission products	(d, e)	(f, g)	Not listed
Other polynuclear aromatic hydrocarbons	Not listed	Not listed	(m)
Fluoride	4.0[h]	4.0	1.6
Freon 11 (CCl_3F)	Not listed	Not listed	(m)
Fuel oil No. 2	(k)	(k)	(l)
Gasoline	(k)	(k)	(l)
Kerosene	(k)	(k)	(l)
Lead	0.015[j]	0.015[j]	0.05
Mercury	0.002	0.002	0.002
Naphthalenes	Not listed	Not listed	0.03
PCBs	0.0005	0.0005	0.001
^{238}Pu	(d)	(f)	Not listed
$^{239,240}Pu$	(d)	(f)	Not listed
Silver	0.1[h]	Not listed	0.05

TABLE 6-2 (continued)

EPA AND STATE MCLs AND STATE GROUNDWATER STANDARDS

COPCs	EPA MCLs[a] (mg/L)	NMED MCLs[b] (mg/L)	NMED Groundwater Standards[c] (mg/L)
Sodium	Not listed	Not listed	Not listed
Strontium (stable)	Not listed	Not listed	Not listed
^{90}Sr	8 pCi/L	8 pCi/L	Not listed
Toluene	1	1	0.75
1,1,1-Trichloroethane	0.2	0.2	0.06
1,1,2-Trichloroethane	0.005	0.005	0.01
Trichloroethylene	0.005	0.005	0.1
Tritium	20,000 pCi/L	20,000 pCi/L	Not listed
Uranium	0.020[n]	(g)	5.0
^{235}U	(e)	(g)	Not listed
^{238}U	(e)	(g)	Not listed
Xylenes (total)	10	10	0.62
Gross-alpha particle radioactivity	15 pCi/L[d]	15 pCi/L[f]	Not listed
Beta particle and photon radioactivity	4 mrem/yr[e]	4 mrem/yr[g]	Not listed

a. MCL concentration from *Drinking Water Regulations and Health Advisories* (EPA 1996, 55500)

b. MCL concentration from *Drinking Water Regulations,* NMED Drinking Water Bureau (NMED 1995, 55501)

c. Human health and domestic water supply groundwater standard from *New Mexico Water Quality Control Commission Regulations,* NMED Water Quality Control Commission (1995, 54406); based on dissolved (i.e., filtered) portion except mercury

d. The EPA MCL for gross-alpha particle activity requires that the total of all alpha emitters (including ^{226}Ra but excluding ^{222}Rn and uranium) not exceed 15 pCi/L (EPA 1996, 55500).

e. The EPA MCL requires that the concentration of beta particle and photon radioactivity in drinking water not exceed an annual dose equivalent greater than 4 millirem per year. In addition, the sum of the annual dose equivalent of all beta particle and photon radioactivity shall not exceed 4 millirem per year (EPA 1996, 55500).

f. The NMED MCL for gross-alpha particle activity requires that the total of all alpha emitters (including ^{226}Ra but excluding ^{222}Rn and uranium) not exceed 15 pCi/L (NMED 1995, 55501).

g. The NMED MCL requires that the concentration of beta particle and photon radioactivity in drinking water not exceed an annual dose equivalent greater than 4 millirem per year. In addition, the sum of the annual dose equivalent of all beta particle and photon radioactivity shall not exceed 4 millirem per year (NMED 1995, 55501).

h. EPA secondary maximum contaminant level (SMCL) concentration from *Drinking Water Regulations and Health Advisories* (EPA 1996, 55500). SMCLs are unenforceable guidelines.

i. Chromium standards apply to the total of trivalent and hexavalent forms.

j. The EPA MCL is under review (EPA 1996, 55500). The number presented is the EPA action level. Although the EPA MCL is under review, the NMED Drinking Water Bureau has adopted the action level.

k. EPA and NMED MCLs are available for individual chemical constituents of petroleum products, but there are no MCLs for petroleum products.

l. Section 3103 of *New Mexico Water Quality Control Commission Regulations* (1995, 54406) states that non-aqueous phase liquid shall not be present floating atop of or immersed within groundwater, as can be reasonably measured. The standard for nonaqueous phase liquid applies to the total (i.e., nonfiltered) portion of the contaminants.

m. Polynuclear aromatic hydrocarbons are listed in the narrative standard for "toxic pollutant" in Section 1101(TT) of *New Mexico Water Quality Control Commission Regulations* (1995, 54406). Any water contaminant or combination of water contaminants listed in Section 1101(TT) creating a lifetime risk of more than one cancer per 100,000 exposed persons is a toxic pollutant.

n. Proposed EPA MCL (EPA 1996, 55500). Number presented is the EPA action level.

6.4 Conceptual Model for Human Exposure

6.4.1 Relation to Conceptual Model for Contaminant Occurrence, Transport, and Exposure Route

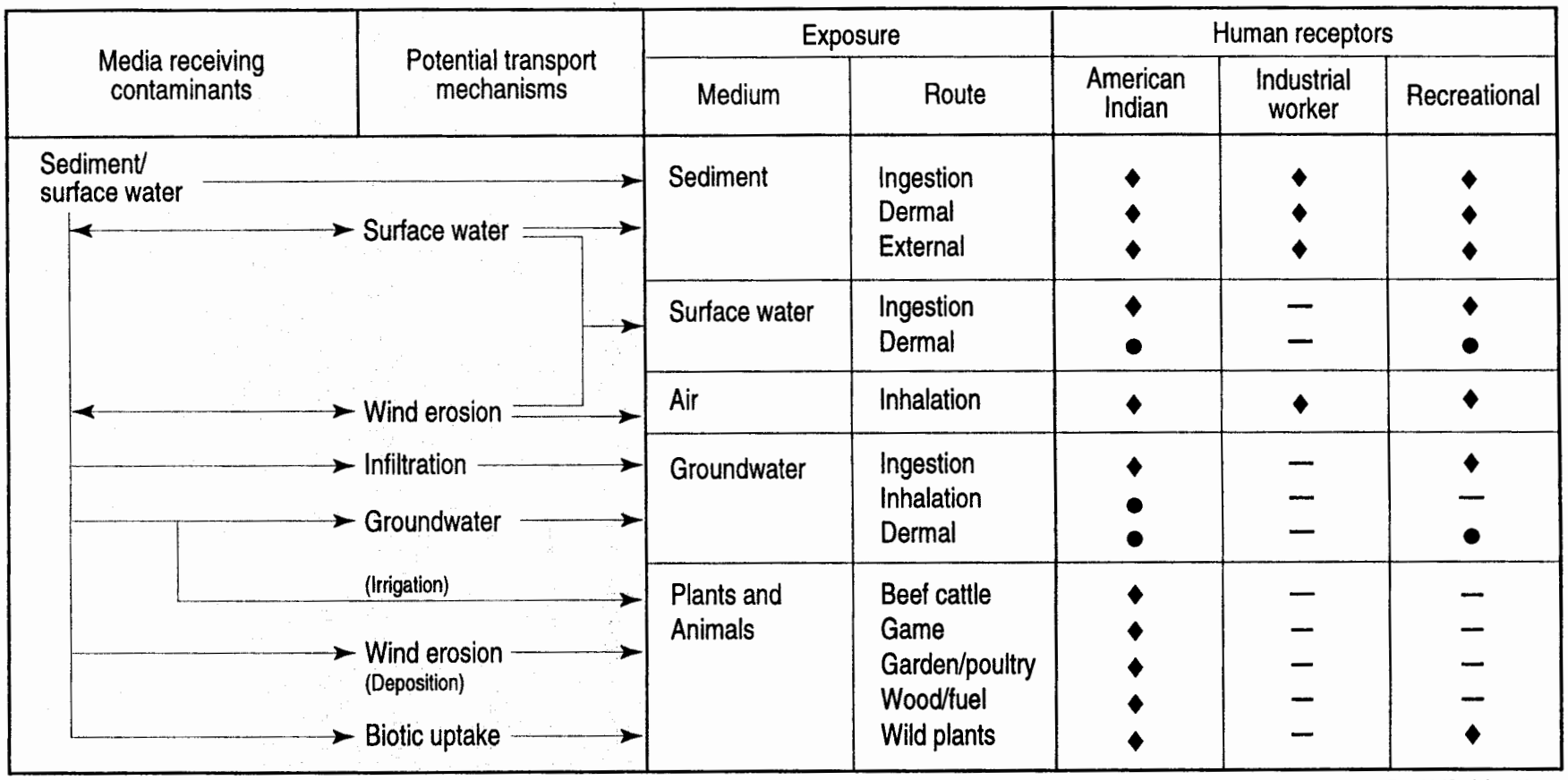
The conceptual model for human exposure, presented in Figure 6-2, identifies potentially contaminated media, release and transport mechanisms, and exposure media for COPCs. However, specific exposure scenarios and exposure routes evaluated in human health risk assessments will vary among individual canyons and canyon reaches. Conceptual exposure models are used to illustrate how constituents can move in the environment from contaminated media to receptors (the exposed population). The conceptual model presented in Figure 4-1 in Chapter 4 is formulated using available information about potential contaminants and the geochemical, geologic, geomorphologic, hydrogeologic, and biological environment. Both the exposure model and the conceptual model are used to identify appropriate media and locations for sampling and to determine if a risk to human health or the environment exists. These models will be updated iteratively as new data become available, and as parameters for the American Indian use scenario are defined.

The most current iteration of the conceptual model will be used in conjunction with available data to develop appropriate source terms for evaluating human health risks. Because canyon characterization is an iterative process of defining model uncertainties and further sampling to reduce those uncertainties, it will be necessary to evaluate and update risk predictions to adequately direct characterization activities. Early risk evaluations will be qualitative if data are insufficient to address given scenarios. These qualitative evaluations will be used to define uncertainties that need to be addressed in further investigations. As uncertainties are reduced, risk evaluations will be refined until quantitative evaluations can be performed with contaminant distributions extrapolated from available data using the refined conceptual model.

6.4.2 Potential Transport and Exposure Pathways

The primary sources of contaminant release into the canyon systems are the mesa-top activities of the Laboratory. Some releases occur within selected canyons as well. After constituents have been released into the canyon environment, they can potentially migrate via

- liquid and vapor infiltration into near-surface or subsurface soils;
- sediment transport in surface water;
- volatilization into ambient air;
- wind entrainment and deposition of contaminated dust onto surface soils and plants;
- rain splash transport of contaminated sediments onto plant surfaces;
- surface water overflow and subsequent runoff resulting in the contamination of sediments in drainage channels and, possibly, infiltration to deeper groundwater zones;
- uptake by animals from ingestion and inhalation of contaminated media;
- root uptake by plants from contaminated soils; and
- flow in alluvial or intermediate perched zone groundwater or the regional aquifer.



◆ Primary exposure pathway*

● Secondary exposure pathway* (quantitatively evaluated only if sample data or modeling indicate that significant exposure may occur)

— Pathway not evaluated

* Application of any particular pathway in the risk assessment for a specific canyon or canyon reach will depend on land use considerations, as discussed in Section 6.4.

Figure 6-2. Conceptual model for human exposure pathways.

Some or all of these transport pathways (the mechanisms and media by which contaminants are moved from their point of origin) and the related exposure pathways must be present for human exposure to contaminants to occur. The predominant pathways by which humans can be exposed to these transported contaminants are summarized in Figure 6-2. The most significant exposure pathways are expected to be ingestion of contaminated water from surface flow, springs, or the alluvial groundwater; inhalation or ingestion of contaminants in sediment suspended by wind; ingestion of contaminated plant or animal material; inhalation of smoke from the burning of contaminated wood; and external exposure to radiation from gamma-emitting radionuclides in sediments. Inhalation of volatile chemicals from sediments will not be evaluated because of the short residence time of these constituents in surface deposits. The exposure pathways for various land use scenarios are explained in greater detail in Section 6.5.

Alluvial and intermediate perched zone groundwaters are known to be present in some canyon systems and may be found in others during the conduct of these investigations. Risk calculations for these investigations will incorporate contaminant concentrations found in these groundwaters as appropriate, based on quantity of water available (with respect to viability as a potential water supply), quality of the water, and the actual or potential for surface expression. The potential exists for migration of contaminants from the intermediate perched zones to the regional aquifer. Investigations of canyons or canyon aggregates will provide data needed to evaluate the level of risk from exposure to potentially contaminated groundwater from each of these sources.

6.5 Land Use Scenarios and Human Receptors for the Canyons

The canyon reaches will be viewed as indicators of the broader canyon system. For land use scenarios that assume use of entire canyons or sets of canyons, the data from individual reaches will be used to model appropriate source terms for risk in the geographic zone of interest for a scenario. Initially, risks will be modeled in a qualitative manner. As more data become available, the model of contaminant concentration and distribution will be refined iteratively and the risk estimates will be updated until sufficient data exist to evaluate a specific scenario with a degree of confidence acceptable to stakeholders. This determination will be based on uncertainties in the data, predicted spatial distributions of COPCs, and toxicity criteria, as discussed in Section 6.2.

Because the site characterization is seen as an iterative approach that will progressively refine estimates and reduce uncertainties in estimates of contaminant source terms, the canyons risk evaluation will use a probabilistic approach that allows incorporation of original uncertainties and update of those uncertainties as the evaluation proceeds. To illustrate, for scenarios where a very small region of contamination will be assumed to have a major impact, e.g., gathering of clays for use in ceremonial body painting, the maximum observed contaminant concentrations at these locations will be important. However, the potential distribution of these locations is expected to be revised as additional data allow uncertainty about the distribution and maximum contaminant concentrations to be reduced. For residential scenarios where utilization of broader areas of the canyons for longer periods of time will be important, data from reaches sampled and analyzed initially will be used to develop initial distributions of a generic residential site in the canyons, establishing a likely distribution for contaminant exposures. Again, as new data allow these distributions to be refined, the probable risk will be updated.

6.5.1 Development of Land Use Scenarios

Calculations of present-day human health risk in an area are affected by the assumptions made about how the area will be used. The selection of land use scenarios defines the population exposed (receptors), the mechanisms and media by which they are exposed (exposure pathways), and the parameters describing

how and to what extent they are exposed (exposure routes and uptake parameters). EPA Region VI staff have recommended in discussions regarding risk assessment that risk decisions be based on risk calculations consistent with "reasonable and likely" land use scenarios. The Laboratory has taken the position that many of its technical areas will continue to be used by the Laboratory for industrial purposes, although some sites may be released for residential or recreational purposes. Thus, risk scenarios appropriate to proposed land use will be considered.

An American Indian use scenario will also be developed and applied, where appropriate, to consider exposures by pathways specific to land uses by the neighboring Indian Pueblos. It is recognized that indigenous people may use the land in a manner that exposes them by pathways not commonly considered in traditional risk assessments. In the canyon systems, residential land use (and exposure) will be considered only within the framework of the American Indian use scenario. Residential land use will generally be considered possible in many of the same reaches where American Indian uses are feasible, if the canyon has a wide enough area above the 100 y floodplain to allow construction of permanent residences. Recreational use will generally be considered possible in all reaches of the canyon systems. Portions of the American Indian use scenario will be appropriate for evaluating recreational use in nearly all areas.

The following sections present the assumptions for three risk scenarios based on proposed land use scenarios: the continued-Laboratory-use scenario (with two potential receptors: construction workers and on-site workers); the recreational scenario (with two potential receptors: campers and trail users); and American Indian use (with five potential scenarios: residential, ranchers, hunters, traditional users, and users of the Rio Grande and Cochiti Lake). The exposure pathways discussed below under each land use scenario are preliminary and are subject to continuing negotiation with stakeholders. Both primary and secondary exposure pathways, as illustrated in Figure 6-2, are described.

The American Indian use scenarios are being developed with advice and input from the Accord Pueblos. Presented here is a first approximation of appropriate exposure pathways and land uses within canyons. Rather than grouping exposure pathways to define a scenario for the maximally exposed individual, the exposure pathways are presented separately to specify the appropriate data needed to support information about routes of exposure. Total exposure can then be calculated by summing contributions from all pertinent exposure pathways. This approach is intended to give extensive risk assessment information to the Indian Pueblos to enable them to understand and manage risks and impacts appropriately.

6.5.2 Continued Laboratory Use

Exposure pathways for workers are described below and summarized in Table 6-3.

6.5.2.1 Excavation and Construction Activities

Manual or mechanical movement of contaminated sediment during construction creates the following potential exposure pathways for on-site workers:

- inhalation of fugitive dust lofted by wind and construction activities (such as bulldozing) while operating in and adjacent to the construction site;
- ingestion of sediment or dust;

TABLE 6-3

EXPOSURE PATHWAYS FOR CONTINUED LABORATORY USE

Exposure Scenario		
Exposure Medium	**Construction Worker: Excavation and Building Activities**	**On-Site Worker: Office and Maintenance Activities**
Dust in air	INH[a]	INH
Sediment	D[b], E[c], ING[d]	D, E, ING

a. INH = inhalation
b. D = dermal contact
c. E = external radiation
d. ING = ingestion

- dermal contact with sediment; and
- external radiation by gamma-emitting radionuclides in sediment.

6.5.2.2 Office and Maintenance Activities

Office and maintenance workers at a site may be exposed to contaminants through the following exposure pathways:

- inhalation of fugitive dust suspended by wind in ambient air,
- ingestion of sediment or dust suspended by wind,
- dermal contact with sediment, and
- external radiation from gamma-emitting radionuclides in sediment.

6.5.3 Recreational Uses

Exposure pathways for recreational users are described below and summarized in Table 6-4.

6.5.3.1 Short-Term Camping

This land use scenario assumes that individuals camping in the canyons may be exposed to contaminants over a period of several weeks twice a year. Exposure pathways are as follows:

- inhalation of contaminants in fugitive dust suspended by wind in a camping area,
- incidental ingestion of sediment (such as deposition on hands and transfer to mouth while eating or drinking),
- ingestion of internally or externally contaminated edible plants (such as piñon nuts and berries) that are growing in a camping area,

TABLE 6-4

EXPOSURE PATHWAYS FOR RECREATIONAL USE

Exposure Scenario		
Exposure Medium	**Camper (Short-term)**	**Trail User**
Dust in air	INH[a]	INH
Sediment	D[b], E[c], ING[d]	D, E, ING
Groundwater and surface water	D, ING	D, ING
Plants and animals	ING	ING

a. INH = inhalation
b. D = dermal contact
c. E = external radiation
d. ING = ingestion

- ingestion of surface water or groundwater (water from seeps and springs used as drinking and/or cooking water),
- dermal contact with surface or groundwater (such as wash water),
- dermal contact with sediment (from bedroll or campfire area), and
- external radiation from gamma-emitting radionuclides in sediment in a camping area.

6.5.3.2 Trail User

This land use scenario assumes that individuals hiking in the canyons (but not camping overnight), bikers riding in the canyons, and horseback riders in the canyons may be exposed to contaminants for periods of less than a day for varying frequencies. Exposure pathways are as follows:

- inhalation of contaminants in fugitive dust suspended by wind while hiking or riding;
- incidental ingestion of sediment (such as deposition on hands and transfer to mouth while eating or drinking);
- ingestion of internally or externally contaminated edible plants (such as piñon nuts and berries) growing along the trail;
- ingestion of surface water or groundwater by drinking from a stream, seep, or spring;
- dermal contact with surface water (or groundwater as seeps or springs) while wading, swimming, or resting in wet areas;
- dermal contact with sediment while hiking or riding; and
- external radiation by gamma-emitting radionuclides in sediment while hiking or riding.

6.5.4 American Indian Uses

Representatives of neighboring Indian Pueblos emphasize that the residents want more detailed and specific information regarding risks so that they may become better informed and may manage risks and impacts appropriately for their communities. The following discussion of exposure pathways for a potential American Indian user of canyons is intended to provide more detailed information than is usually requested by interested members of the public (a typical risk assessment focuses on the maximally exposed individual to simplify the risk calculations as much as possible).

The difference between the typical scenario and calculations and the American Indian use scenario employed here is illustrated by the following example. Typically, risk calculations may indicate an insignificant contribution to overall dose from the hunting scenario (which primarily relates to elk, deer, and small game hunting) and discount the scenario from the detailed overall risk calculation as an insignificant source of exposure. Because for American Indians hunting is a traditional activity rather than a sport, and game meat supplies a larger than typical proportion of their diet, San Ildefonso Pueblo representatives have asked the Laboratory to monitor contamination levels in local elk. Existing data obtained from environmental surveillance reports on contaminant concentrations in elk tissue will be used where possible to calculate the contribution to human health risk from consumption of elk believed to have foraged in potentially contaminated canyon areas. Contaminant levels in elk, deer, and small game will be estimated as part of the ecological risk assessment as well, although the focus will be on a single species of the food chain. In addition, Indian Pueblo representatives will assist in identifying parameters used for risk calculations, including frequency and duration of activities that present potential exposures.

The scenarios detailed below have been submitted to the Accord Pueblos for their review, input, and concurrence on the appropriateness of each scenario. In addition, a work plan has been submitted to the Pueblos which is designed to train interviewers to survey Pueblo members to obtain data on appropriate parameters for these scenarios. Using Pueblo members as interviewers will allow cultural sensitivities to be protected in the process. The scenarios and exposure pathways are summarized in Table 6-5.

TABLE 6-5

EXPOSURE PATHWAYS FOR AMERICAN INDIAN USE

	Exposure Scenario				
Exposure Medium	**Residential**	**Ranching**	**Hunting**	**Traditional**	**Rio Grande and Cochiti Lake**
Dust in air	INH	INH		INH	
Sediments	D[a], E[b], ING	D, E, ING		D, E, ING	
Groundwater and surface water	D, ING[c], INH[d]	ING		D, ING	D, ING
Plants and animals	ING, INH	ING	ING	D, ING, INH	ING

a. D = dermal contact
b. E = external radiation
c. ING = ingestion
d. INH = inhalation

6.5.4.1 Residential

Members of established Indian Pueblo communities (such as Totavi) or potential new communities might be exposed to contaminants via pathways not commonly evaluated in traditional risk assessments. The American Indian residents may be exposed through the following exposure pathways:

- inhalation of contaminated smoke particles from the burning of contaminated wood for heating or cooking;
- inhalation of contaminants in dust while working in the field;
- inhalation of volatile organic compounds and tritium (in tritiated water vapor) with domestic use of groundwater;
- ingestion of groundwater for drinking;
- ingestion of surficially or internally contaminated corn and other fruits and vegetables grown on-site that may be irrigated with contaminated surface or groundwater;
- ingestion of wild foods (for example, piñon nuts, wild spinach, and tea herbs) that are harvested on-site;
- ingestion of contaminated eggs or poultry;
- incidental ingestion of, or dermal contact with, surface water or groundwater (in springs or seeps) by children while swimming or wading;
- incidental ingestion of, or dermal contact with, sediments during gardening, farming, traditional, or ceremonial activities;
- dermal contact with surface water that may be used to irrigate plants; and
- external radiation from gamma-emitting radionuclides in sediments.

6.5.4.2 Ranching

Ranchers who might run cattle in the canyon floor (especially lower Los Alamos Canyon and Pueblo Canyon) might be exposed to contaminants through the following exposure pathways:

- inhalation of contaminants in dust during ranching activities;
- ingestion of surface water or groundwater by drinking from a stream, seep, or spring;
- ingestion of meat from cattle that drink contaminated groundwater or surface water (such as in a stock pond or tank) or eat plants from contaminated areas;
- incidental ingestion of, or dermal contact with, sediments during ranching activities; and
- external radiation from gamma-emitting radionuclides in sediments during ranching activities.

6.5.4.3 Hunting

Hunters taking elk, deer, or other game (such as squirrels and rabbits) that have grazed in potentially contaminated areas may be exposed through the following exposure pathways:

- ingestion of meat distributed throughout the Indian Pueblo from game whose range includes contaminated regions and
- ingestion of game tissues at the site of the hunt or later.

Exposure pathways appropriate for the trail user are also relevant for hunting (see Table 6-4).

6.5.4.4 Traditional Uses

Traditional activities of Indian Pueblo communities may expose individuals to contaminants by the following exposure pathways:

- inhalation of particulates from the burning of contaminated wood in a kiva and from contaminated dust during ceremonial activities;
- incidental ingestion of sediments or dust or dermal contact with sediments during ceremonial and/or medicinal activities;
- ingestion, inhalation, or dermal contact of medicinal and ritual plants (roots or leaves) gathered from contaminated regions (plants may be brewed, burned, or used as a poultice on the skin surface);
- incidental ingestion of clay or dermal contact with clay during ceremonial body painting;
- infants' dermal contact with groundwater from springs used in naming ceremonies; and
- external radiation from sediments during ceremonial and/or medicinal activities.

Hunters and gatherers of ceremonial or medicinal plants may also be exposed through all the exposure pathways described for trail users (see Section 6.4.3.2).

6.5.4.5 Rio Grande and Cochiti Lake

American Indians use the Rio Grande and Cochiti Lake for several specific purposes that may expose them to contaminants through the following exposure pathways:

- ingestion of homegrown fruits and vegetables irrigated with surface water from the subject sources;
- ingestion of water during recreational or ceremonial use;
- ingestion of fish and other aquatic foods; and
- dermal contact with surface water while swimming, fishing, ceremonial washing, and conducting other water-related activities.

The sampling and analysis plans (SAPs) developed for investigations in each of the canyon systems may not support a full risk assessment of the Rio Grande and Cochiti Lake scenario. Data on contaminant concentrations in sediment and water collected in individual canyon systems may be used to estimate the degree to which canyons may contribute to the known contaminant levels in the Rio Grande.

6.5.4.6 Identifying Other American Indian Exposure Sources

The Laboratory risk assessment specialists are currently working with the Accord Pueblos to define the appropriate parameters (i.e., exposure frequency, duration, magnitude) for the American Indian use scenario. During this process, any additional concerns that arise will be incorporated into the risk evaluation. Out of respect for cultural sensitivities, some of these exposure sources may not be defined explicitly in the SAPs or in reports of risk evaluations. Efforts will be made to avoid mention of specific culturally sensitive activities presenting potential exposures, while incorporating the necessary exposure parameters. The Accord Pueblos will be asked to review the final scenario to ensure that cultural sensitivities are not infringed upon.

6.6 Ecological Risk Assessment

A Laboratory site-wide approach to ecological risk assessment is presently under development and will be based on the EPA framework for ecological risk assessment (EPA 1992, 48847; EPA 1994, 48846). The specific assessment end points, receptors, exposure units, exposure models, and risk assessment models will be determined by negotiations underway among the Laboratory, DOE, EPA, NMED, and the Accord Pueblos. The assessment of canyon ecosystems will be integrated with the Laboratory's site-wide approach.

Although assessments of present-day and future potential impacts to the canyon ecosystems are required by the HSWA Module (EPA 1990, 1585) and discussed in this core document (see Section 1.4.1), much of the work to define potential future impacts will be integrated into a broader program of studies, which is currently being defined by the ER Project in consultation with DOE, EPA, NMED, and tribal representatives from neighboring Indian Pueblos.

6.7 Description of Potential Remedial Activities

6.7.1 Cleanup Levels

At canyon locations where present-day risk assessment calculations show that risk to human health or the ecosystem may exceed acceptable values, risk-based cleanup levels will be calculated for contaminants of concern identified by the risk assessment. Target human health risk values are defined according to guidance discussed in Section 6.1. Final definitions of unacceptable risk to human health and the environment will be agreed on after negotiations with EPA, NMED, and the Accord Pueblos. Cleanup levels for nonradiological contaminants will be calculated using EPA equations and site-specific input parameters. RESRAD or a demonstrably equivalent code will be used to calculate cleanup levels for radionuclides in soils. The range of uncertainty in cleanup levels will be presented by basing the calculation on a reasonable maximally exposed individual and a best estimate of exposure identified in the appropriate land use scenarios. As discussed in Section 6.5.4, such a maximally exposed individual will not be defined for the American Indian use scenario.

6.7.2 Potential Remedial Actions

The Installation Work Plan (LANL 1996, 55574) describes the Laboratory's approach to the Resource Conservation and Recovery Act (RCRA) facility investigation, which focuses field investigations on determining whether a corrective measures study (CMS) is necessary and on supporting the performance of a CMS, the design and implementation of an accelerated cleanup, or a recommendation for no further action. The staged approach being employed for the canyons investigations encourages the identification of key data needs in each of the canyons or canyon aggregates under investigation as early in the process as possible to ensure that data collection is always directed toward providing information relevant to refining the conceptual model for contaminant transport and to selection of a remedial action.

The following sections provide a preliminary development and screening of remedial technologies and alternatives, but detailed screening and analysis are deferred until canyon-specific data are collected. Many of these remedial alternatives can be applied on a small scale to limited areas of contamination as voluntary corrective actions (VCAs). The ER Project has established criteria for distinguishing whether a contaminated site can be classified as a VCA (Glatzmaier and Fesmire 1995, 46071).

An example of possible VCAs in the canyons would be to excavate localized areas of high radionuclide concentrations (each less than one cubic yard, a volume that can be dealt with manually) that are identified during radiological surveys in the stream bottoms and overbank deposits. Any such areas located during the surveys could be containerized for sampling by a field team to determine storage or disposal requirements, and later removed and managed appropriately. Such an operation would be efficient, would remove concentrated gamma-emitting radionuclides from the canyon system, and would avoid the potential for these sources to be dispersed by floods.

Even though the nature and extent of potential contaminants present in the canyon systems will not be determined until investigations are completed, the following general response actions are believed to be technically feasible and appropriate:

- no action;
- institutional control (such as monitoring, fences, and deed restrictions);
- containment (for example, stabilizing eroding banks);
- treatment;
- removal (excavation to a RCRA mixed-waste or radioactive-waste landfill); and
- combinations of the above (for example, sediment traps whose contents are removed periodically).

This section does not give an all-inclusive list of potential remedial alternatives. It focuses on the most likely types of response actions for the canyon systems based on existing data. As additional data are collected during the canyons investigations, applicable remedial action methods will be re-evaluated. Technical options will be compared with respect to implementation, effectiveness, and cost, allowing informed decisions to be made in selecting remedial alternatives.

6.7.2.1 No Action

The no-action category means continuation of current practices. This category allows conditions and processes currently operating to continue.

The no-action alternative may be applicable if field investigation results indicate the following conditions in the canyon under investigation:

- no contaminants are present,
- contaminants are present but at concentrations below regulatory action levels, or
- present-day risk assessment demonstrates that the extent of contamination results in no risk or an acceptable risk under an appropriate exposure scenario, and
- prediction of future conditions based on a refined conceptual model or numerical models continue to indicate that contaminant concentrations are not likely to increase.

The no-action alternative also serves as a basis for comparison with other alternatives.

To undertake no action is to refrain from intervening in the fate and transport of contaminants. No action does not necessarily perpetuate the status quo because natural processes are changing the conditions. In this context, the no-action alternative is considered passive remediation, which recognizes the effects of natural processes such as dilution, biodegradation, volatilization, photolysis, leaching, radioactive decay, precipitation, and adsorption that reduce contaminant concentrations present in specific locations and environmental media.

The no-action alternative is likely to apply to most surface locations in the canyon systems because contaminant concentrations are expected to be below levels posing significant human or ecological risk (based on values measured during the FUSRAP [LANL 1981, 6059]). Based on results of hydrological, geochemical, and geological information available at this time, as discussed in Chapter 3 of this core document, large areas where buried soil contamination or groundwater contamination occur are also likely to pose either no risk or an acceptable risk due to the low contaminant concentrations, and may require no action.

6.7.2.2 Institutional Control

If field investigation results indicate that contaminants are present in concentrations above regulatory or risk-based levels at a given canyon location, other response actions or combinations of response actions (such as monitoring, fencing, or deed restrictions) may be required. For example, the area could be fenced and monitored to evaluate the migration of contaminants over time.

6.7.2.2.1 Monitoring

Monitoring involves no substantial action on contaminated media, but it does provide information about the status of contaminants and their movement through exposure pathways. In situations in which no other action is taken, monitoring can serve not only to document passive remediation but also to provide early warning if passive remediation fails to adequately protect human health and the environment. Also,

monitoring may be needed in situations in which containment, collection and removal, or treatment are undertaken. In these situations, the purpose of monitoring would be to document the effectiveness of the remedial actions and to provide early warning if the remedial action fails.

The monitoring approach applies to the alluvial groundwater, intermediate perched groundwater zones and surface drainage within the canyons. These systems have been and continue to be monitored to varying degrees.

6.7.2.2.2 Restricted Use

No remedial technology is required to implement restricted access (such as fencing or deed restrictions). Fences already exist in parts of several canyons. Also, most community developments near the Laboratory are confined to the mesa tops. The surrounding land is largely undeveloped; large tracts north, west, and south of the Laboratory boundaries are held by the Santa Fe National Forest, US Bureau of Land Management, Bandelier National Monument, US General Services Administration, and Los Alamos County. San Ildefonso Pueblo borders the Laboratory to the east. Because most of the surrounding land is controlled by federal government entities, land use restrictions have been applied and can continue to be enforced.

6.7.2.3 Containment

A likely remedial alternative for any contaminated sediments found in the canyon systems is believed to be containment followed by long-term monitoring.

Several remediation technologies can be considered for sediments, surface water, and groundwater. Sediment traps have been used in Mortandad Canyon to contain plutonium- and americium-contaminated sediments. Periodic removal of contaminated sediments is required for this containment technology. Permeable geochemical barriers can be designed to remove cations ($^{90}Sr^{2+}$ and $^{137}Cs^{+}$) and anions ($^{235}[UO_2][CO_3]_2^{2-}$ and $^{241}Am[CO_3]_2^{-}$) from surface water and groundwater. Groundwater pumping technologies can be applied to the alluvium to control groundwater flow. Application of pumping technology requires a thorough knowledge of the hydrodynamic properties of the alluvium where sufficient saturated thicknesses warrant use of this technology.

Additional containment alternatives (such as permeable berms, sediment traps, gabions, retaining walls, or levees) may be applicable to some locations within the canyon systems. These containment alternatives could be used in some locations to control or impede the erosion and transport of contaminated canyon sediments. However, additional site characterization data and better definition of potential migration pathways are required to determine whether these alternatives are appropriate and would merit further consideration. If applicable, the alternatives will be addressed during a CMS.

6.7.2.4 Treatment Technologies

Numerous technologies are associated with general response actions involving treatment of sediments or water, either *in situ* or combined with removal. Examples of *in situ* treatment technologies for contaminated sediments that may be applicable are contaminant coprecipitation, immobilization, soil flushing, vapor extraction, vitrification, and biological treatment. Possible groundwater treatments include anion and cation exchange techniques.

Insufficient data are available to determine which, if any, of these technologies may be applicable. As appropriate, treatment technologies will be evaluated during a CMS. Bench-scale and pilot studies will be used as needed to confirm the feasibility of various treatment technologies.

6.7.2.5 Removal

Removal would be followed by disposal, possibly after some treatment. Surface sediment contamination in the canyons could be remediated by removal. However, removal is not considered advantageous for areas of widespread low-level contamination because the ecological impact of disturbing large areas on the canyon floors would be substantial, and the potential is very high for mobilizing contaminants that are presently stable in sediment deposits. In addition, large volumes of material would likely be involved, which would overwhelm available facilities and require the development of new disposal sites.

6.7.2.6 Combined Technologies

Numerous possible combinations of temporary and/or permanent solutions can be envisioned. One combination with obvious potential application is the construction of sediment traps to capture contaminated sediment, which can then be removed, treated by soil washing techniques to reduce volume, and disposed of. Such sediment traps are already in operation in Mortandad Canyon; sediments are removed from these traps periodically.

Remediation efforts, if needed, will be coordinated with the Environmental Management Program and the Technology Development Program to ensure that applicable, cost-effective technologies will be used.

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ATTACHMENT I

INSTRUCTIONS FOR DOCUMENT REVISION

Action in Document:
Replace current Table of Contents with new Table of Contents attached.
Insert History in front of Executive Summary.

General Comments

(1) NMED COMMENT:
All references made to the Environmental Protection Agency (EPA) being the Administrative Authority (AA) should be replaced with the New Mexico Environment Department (NMED).

LANL RESPONSE:
All future Canyons RFI documents will refer to the New Mexico Environment Department as the Administrative Authority.

Action in Document:
Pages affected by the comment were ES-1, 1-2, and I-5. The entirety of the Executive Summary and Chapter 1 are to be replaced by response to NMED General Comment (3). Also, replace I-5 with I-5/I-6 attached.

(2) NMED COMMENT:
The Los Alamos National Laboratory (LANL) shall provide consistency within the report by employing the English unit measurement system in addition to references of the Metric System.

LANL RESPONSE:
As appropriate all future Canyons RFI documents will include both English and Metric unit measurements.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
N/A (new)		xxii/xxiii

(3) NMED COMMENT:
All references made to Task/Site Workplan should be replaced with RCRA Facility Investigation (RFI) Workplan.

LANL RESPONSE:
All future Canyons Workplans shall be referred to as RCRA Facility Investigation (RFI) Workplans.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
Executive Summary		Executive Summary
Chapter 1		Chapter 1
5-1		5-1/5-2

Pages in Current Document	with	Replacement Pages Attached
I-1		I-1/I-2
III-1/III-2		III-1/III-2
III-3		III-3/III-4
III-24		III-23/III-24
V-1		V-1/V-2

(4) NMED COMMENT:
A site map should be included within this Workplan which depicts all potential release sites (PRS) in relation to proposed sampling locations.

LANL RESPONSE:
A site map showing the locations all potential release sites within the Los Alamos and Pueblo Canyon drainage basins will be prepared.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
2-8		2-7/2-8 (a reference to Figure A-5 added)
N/A (new)		Figure A-5 in Appendix A

(5) NMED COMMENT:
Recreational land-use scenarios are proposed as exposure scenarios for determining human health risk for a majority of reaches within Pueblo and Los Alamos Canyons. Using a recreational land use scenario may allow concentrations of contaminants to remain at the site and thus hazardous constituents which have the potential to migrate off-site may pose an unacceptable risk using a residential land-use scenario. As noted in an Environmental Surveillance (ES) Report (1992), "Most of the residual radioactivity from these historical releases is now associated with the sediments in Pueblo Canyon with an estimated total inventory of about 600 mCi of plutonium (ESG 1981). About two-thirds (400 mCi) of this total are in the DOE-owned portion of lower Pueblo Canyon." This would suggest that additional source areas due to accumulation of sediments down canyon need to be considered. Concentrations of constituents of concern may increase down canyon as a result of potential "secondary" source areas. This information indicates sediment migration is of concern when assuming a recreational land-use scenario within one reach. LANL shall propose an acceptable solution to this situation.

LANL RESPONSE:
Initial evaluation of risks will be based on a Native American Pueblo subsistence scenario. This scenario is more conservative than EPA residential scenarios based on default assumptions, and will be used to identify any potential problems at an early stage. The iterative approach for the Canyon's investigation will result in a high degree of uncertainty after the initial sampling rounds, so not all scenarios will be used during the initial stages. Additional scenarios will be evaluated as areas of uncertainty are reduced with subsequent sampling rounds based on their importance for risk-based decision making. This approach is detailed more fully in the Canyon's Core Document.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
The entirety of Chapter 6		6-1/6-2

(6) NMED COMMENT:
The ecological risk model presented within Chapter 6 should be modified to reflect LANL's recent approach to ecological risk-assessment as described within the *Ecological Risk Assessment for LANL (1997)*.

LANL RESPONSE:
The ecological risk model will reflect the Laboratory's current ecological risk assessment approach (March 1997).

Action in Document:
Same as response to NMED General Comment (5).

(7) NMED COMMENT:
Numerous reaches within Los Alamos and Pueblo Canyons (e.g. DP Canyon/ Los Alamos Canyon confluence, Acid/Pueblo Canyon confluence, and upper Los Alamos Canyon (TA-2)) contain significant sediment contamination in need of stabilization. As noted by NMED DOE OB (Steve Yanicak to Court Fesmire dated May 6, 1996), contaminants found in sediments within the canyon bottom at TAs 2 and 41 need to be stabilized: "water levels within the alluvium could rise to a point at which ground water may come into contact with contaminates (e.g., ^{90}Sr) in the vadose zone, and therefore, introduce or re-mobilize" contaminants within sediments. Until appropriate final measures can be implemented, LANL shall develop stabilization measures for known areas of significant sediment contamination to prevent further migration of contamination.

LANL RESPONSE:
Stabilization and other interim measures will be implemented in areas that contain significant sediment contamination. The Laboratory will develop internal criteria for identifying triggers for interim actions and discuss these criteria with NMED. In addition, the Laboratory will evaluate the use of Best Management Practices for areas where contaminated sediments could be mobilized by releases of potable water to the canyon floor (e.g. TA-53 and Otowi-4 discharges). The locations and schedules for these actions will be identified in the Fiscal Year 98 Replan which will be completed in July of this year.

Action in Document:
Same as response to NMED General Comment (5). The language describing this commitment by the Laboratory is contained in that response.

(8) NMED COMMENT:
All schedules shall be modified to reflect the current status of activities and completion dates of specific tasks.

LANL RESPONSE:
Schedules in the Workplan will be modified to reflect the current status of activities, completion dates of specific tasks, and report dates. Schedules will be updated as part of the Fiscal Year 98 Replan which will be completed in July.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
Figure I-1		Figure I-1

Specific Comments

(1) NMED COMMENT:

Executive Summary, pg. ES-1(Response to Regulatory Requirements): The following sentence should be changed from, ~~"This site/site work plan satisfies the regulatory requirements of Module VIII, Sections I.5 and Q, tasks 1 through 5, of the HSWA Permit..."~~ to **"This RFI Workplan intends to satisfy a portion of the regulatory requirements of Module VIII, Sections I.5 and Q, tasks 1 through 5, of the HSWA Permit...".**

LANL RESPONSE:

Executive Summary, p. ES-1: The referenced sentence will be changed to "This RFI Workplan intends to satisfy a portion of the regulatory requirements of Module VIII, Sections I.5 and Q, tasks 1 through 5, of the HSWA Permit...".

Action in Document:

The only page in the current document affected is ES-1. The response to this comment is contained in the response to NMED General Comment (3).

(2) NMED COMMENT:

Table 1-2, Pg. 1-9: The schedule proposed for the submittal of all the remaining canyon Workplans is unacceptable. HRMB will initiate an agency permit modification to set a specific schedule of investigation for the 15 major canyons as a part of the HSWA Module. LANL shall resubmit a schedule which does not extend beyond the year 2000 for submitting all remaining canyon work plans.

LANL RESPONSE:

The schedule for completion of Canyon's SAPs will be modified to reflect the schedule below. This updated schedule will be incorporated in the Fiscal Year 98 Replan.

Action in Document:

The new Table 1-2 on page 1-9 is contained in the response to NMED General Comment (3).

(3) NMED COMMENT:

Section 2.5.5.1, pg. 2-22, par. 2: The following strikeout text should be replaced with the redline text; ~~"Two of the lagoons contain only sanitary waste..",~~ **"Two of the lagoons contain a mixture of industrial and sanitary waste..".**

LANL RESPONSE:

The sentence shall be modified to read "Two of the lagoons contain a mixture of industrial and sanitary waste".

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
2-22		2-21/2-22

(4) NMED COMMENT:

Section 3.6.3.2, pg. 3-42: The occurrence of intermediate perched ground water in Otowi-1 (Pueblo Canyon) and PM-1 (Sandia Canyon) should be noted in this section.

LANL RESPONSE:
The occurrence of intermediate perched water in Otowi-1 and PM-1 will be noted in this section.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
3-43		3-43/3-43a, 3-43b/3-44

(5) NMED COMMENT:
Table 3-17, pg. 3-82: The well logs for TW-2A do not indicate that ground water was encountered from the Cerros Del Rio Basalts. Please revise this table and associated narrative.

LANL RESPONSE:
The title to Table 3-17 on p.3-82 will be changed to read "Water-Quality Data from Intermediate Perched Zone Wells, Pueblo Canyon". Also, the section heading for section 3.7.5.2 will be changed to "Pueblo Canyon".

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
3-78 (section heading change)		3-77/3-78
3-82 (table title change)		3-81/3-81a, 3-81b/3-82

(6) NMED COMMENT:
Table 3-17, pg. 3-82: The well logs for TW-2, TW-3, and TW-4 do not indicate they were completed within the Santa Fe Group, but rather the Totavi Formation, Puye Formation and possibly the Tschicoma Formation. Please revise this table and associated narrative.

LANL RESPONSE:
The title to Table 3-18 on pp. 3-83 to 3-85 will be changed to read "Water-Quality Data from the Main Aquifer Wells, Los Alamos Canyon and Pueblo Canyon". Also, the text in section 3.7.6 will be modified to clarify that TW-1, TW-2, and TW-3 are completed in the Puye Formation (including the Totavi Lentil) in the upper part of the main aquifer, and that TW-4 is completed in the Tschicoma Formation.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
3-81 (clarification)		Replaced in response to NMED Specific Comment (5)
3-83, 3-84, 3-85 (table title change)		3-83/3-84, 3-85/3-86

(7) NMED COMMENT:
Section 3.7.6.1, pg. 3-86, par.6: The barometric pressure data for TW-1A and TW-1 may indicate a time-lag observation between these two points. It does not necessarily suggest that these two zones of saturation are hydraulically disconnected. This inference should be qualified.

LANL RESPONSE:
The sentence will be removed and replaced by "Water levels in TW-1 and TW-1A increased by 80 ft and 2 to 10 ft, respectively, following the drilling of Otowi-1 in 1990. The increase in water levels may be due to

lost fluid circulation in the Puye Formation during the drilling of Otowi-1. Water levels in both holes began to decline in 1992. Water levels in TW-1A began to stabilize by mid-1993 and since then the changes in water level are probably due to cyclical seasonal variations. Water levels in TW-1 stabilized in 1996 and now seem to be responding to seasonal variations. These synchronous changes in water levels along with similarities in above background tritium concentrations and major ion chemistry indicate that TW-1 and TW-1A are hydraulically connected (McLin, 1996)".

Action in Document:
Page 3-86 was affected by the comment, clarification of aquifer response data. Page 3-86 was replaced in response to NMED Specific Comment (6).

Also, replace reference pages 3-115/3-116 and 3-117/3-118, which include the reference to McLin 1996 in response to this comment, and the reference to Purtymun 1995 in response to NMED Specific Comment (4).

(8) NMED COMMENT:
Section 3.7.6.1, pg. 3-86, par.7: Within this paragraph, the reference made to Otowi-4 should be Otowi-1.

LANL RESPONSE:
The reference to Otowi-4 will be corrected to Otowi-1.

Action in Document:
The correction was made on page 3-86 and included in response to NMED Specific Comment (6).

(9) NMED COMMENT:
Section 6.3.2, pg. 6-8, par. 1: "Risk calculations for this investigation will incorporate contaminant levels found in the perched zones unless field investigations demonstrate that the perched zones are not usable for water supplies." As previously conveyed in a letter from NMED to DOE/LANL (Mr. Ed Kelley to Mr. G. Thomas Todd, dated July 24,1996), this approach is unacceptable. LANL shall remove this sentence from the Workplan.

LANL RESPONSE:
The sentence "Risk calculations for this investigation will incorporate contaminant levels found in the perched zones unless field investigations demonstrate that the perched zones are not useable for water supplies" shall be removed.

Action in Document:
This comment is addressed by response to NMED General Comment (5).

(10) NMED COMMENT:
Table 7-5, pg. 7-21: As indicated in Table 7-5, the total number of full-suite analyses samples to be taken for Reaches P1 - P4 is eight. However, the number of samples to be collected per reach is denoted as (4/reach). Please clarify the total number of samples taken.

LANL RESPONSE:
A minimum of four full-suite samples will be collected in each of two reaches in Pueblo Canyon. Upon implementing the plan in FY96, the Canyon's Technical Team actually collected 10 full-suite samples from reach P-4 and 7 full-suite samples from reach P-1.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
7-21		7-21/7-22

(11) NMED COMMENT:
Table 7-5, pg. 7-21: Although section 7.2.2.1.3 states, "Reach LA-4 may contain the highest concentrations of Laboratory-derived contaminants along lower Los Alamos Canyon", Table 7-5 indicates that Reach LA-4 samples will not be analyzed for a full-suite of organics, inorganics, and radionuclide constituents. LANL should provide an explanation of the sampling of reaches P-4 combined with LA-3 to justify the limited analysis of LA-4 within the text.

LANL RESPONSE:
Appropriate analyte suites for reaches not sampled for full-suite analyses will be determined by an evaluation of analytes above background in the closest upstream reach or reaches (e.g., analyte suite for LA-4 chosen based on analytes identified above background in reaches LA-3 and P-4).

Action in Document:
This comment is addressed on page 7-22 which was replaced in response to NMED Specific Comment (10).

(12) NMED COMMENT:
7.3.3, pg. 7-36: Regional aquifer wells should be included as part of this workplan in order to investigate known releases of hazardous constituents to ground water as described within NMED's *Hydrogeologic Evaluation of* LANL dated July 1996. The following locations should be investigated as described within the above-noted document: 1) Reach P-1 (immediately below the confluence of Acid/Pueblo Canyons), 2) Reach P-4 (immediately adjacent to POI-4), and 3) Reach LA-2 (immediately adjacent to LOAI-3.2). Specific single well aquifer characteristic testing should be performed as well as pumping of the regional aquifer wells, which are clustered with intermediate perched aquifer wells, to observe water-level measurements within P01-4 and LAOI-3.2.

LANL RESPONSE:
Characterization of perched zones and the regional aquifer below Los Alamos and Pueblo Canyons is now integrated with other Laboratory groundwater investigations as outlined in the Laboratory's Hydrogeologic Workplan. The groundwater investigations proposed in the Los Alamos and Pueblo Canyons Workplan will be modified to reflect the groundwater investigation approach in the Hydrogeologic Workplan after NMED completes its review and approves the Hydrogeologic Workplan.

All of the locations suggested for placement of characterization wells in the Notice of Deficiency are already targeted for regional aquifer wells in the Hydrogeologic Workplan. Specifically, the well near the confluence of Acid and Pueblo Canyon is R-2, the well near POI-4 is R-5, and the well in reach LA-2 is R-8. The general locations of these wells are shown in Fig. 4-2 and Appendix 6 of the Hydrogeologic Workplan. The exact locations of wells may change to reflect improvements in our understanding of the

hydrogeologic setting, and the NMED will be a participant in annual negotiations with the Laboratory and the DOE to decide the placement of wells.

Core samples will be collected from the intermediate zones to characterize hydrologic properties. Single well slug testing will be conducted in selected intermediate perched groundwater zones (generally 5 ft or greater in thickness). Because of the great thickness of unsaturated rocks separating the groundwater bodies, pumping the regional aquifer to observe water level fluctuations in intermediate-depth perched zones (e.g. in POI-4) does not appear to be a practical way of identifying interconnections. The interconnection between these groundwater bodies will be examined using water-level transducers to observe seasonal recharge effects and water-quality data to identify the presence of Laboratory derived contaminants and the geochemical signatures of the various modes of groundwater occurrences.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
7-35/7-36 (Hydrogeologic Workplan coordination change)		7-35/7-36, 7-36a/7-36b
7-93 (references added)		7-93/7-94

(13) NMED COMMENT:
7.3.3, pg. 7-36: This section lacks proposed aquifer testing for all concerned modes of ground water occurrence. LANL shall include aquifer testing for all newly constructed wells and provide the results within the RFI Report. Also, water-level measurements should be obtained quarterly for all newly installed wells and reported within the RFI Report.

LANL RESPONSE:
Aquifer testing for the intermediate zones shall be performed as described in #12 above. Single well tests either pumping or slug will be performed for the regional wells. Criteria will be developed and discussed with NMED and DOE on the hydrologic testing for the regional wells. Core samples will be collected and these can provide some information on hydrologic properties. Water level transducers will be installed in all regional aquifer wells. As described in the Hydrogeologic Workplan, the decision to install dedicated wells to intermediate-depth perched groundwater will be made after evaluating the perched groundwater bodies encountered during drilling of the regional aquifer wells. Transducers will be installed in any intermediate-depth wells that are installed.

Action in Document:
This comment is addressed on page 7-36 of the original; pages replaced in response to NMED Specific Comment (12).

(14) NMED COMMENT:
7.3.3.1.2, pg. 7-40: All water samples collected for compliance with RCRA and comparison with LANL SALs shall be collected as unfiltered samples. See letter from EPA to DOE\LANL (Mr. Honker to Mr. Vozella) dated May 16, 1995.

LANL RESPONSE:
Both filtered and unfiltered water samples will be collected and analyzed. Filtered samples, excluding total mercury, will be collected pursuant to State of New Mexico Water Quality Control Commission regulations. The US EPA (RCRA Ground Water Monitoring Technical Enforcement Guidance Document) recommends that filtered samples be collected in addition to unfiltered samples for metal-inorganic analyses. Unfiltered

samples will also be collected for volatile organic carbon and semi-volatile organic carbon analyses. The Laboratory is no longer using SALs for comparison to water samples.

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
7-39/7-40		7-39/7-40
7-70		7-69/7-70
7-76 through 7-82		7-75/7-76 through 7-81/7-82

(15) NMED COMMENT:
7. 7.3.3.1.5, pg. 7-64: The title to this section is misleading since the regional aquifer is found primarily within the Puye Formation and Totavi Lentil beneath LANL.

LANL RESPONSE:
The title to section 7.3.3.1.5 will be changed to "Main Aquifer Testing".

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
7-64		7-63/7-64
7-77		Addressed in response to NMED Specific Comment (14)

(16) NMED COMMENT:
7.3.3.1.5, pg. 7-67: In general, isotope data is the most indirect and inconclusive data to support hydraulic connection between various zones of saturation. Methods for investigating hydraulic connection include direct water-level measurement, aquifer characteristic testing, tracer tests, and isotope data. The first three methods listed are the most direct and conclusive. LANL shall supplement all water chemistry data used to support hydraulic connection inferences with water-level observation data where available.

LANL RESPONSE:
The Laboratory will supplement all water chemistry data used to support hydraulic connection inferences with water level observational data, field data (temperature, specific conductance, turbidity, and pH), and hydrologic properties where available.

Action in Document:
This comment is addressed in response to NMED Specific Comment (17) below.

(17) NMED COMMENT:
7.3.3.1.5, pg. 7-67; Water-level transducer data shall be collected and analyzed from POI-4, TW-1A, and TW-1 during the zonal sampling of Otowi-I. Pumping rates and water-levels observed within O-1 should be documented and reported within the RFI Report.

LANL RESPONSE:
Zonal sampling of the Otowi-1 municipal water supply well was completed between December 12, 1996 and January 10, 1997. The New Mexico Environment Department's Notice of Deficiency was dated March

17, 1997. Hence the zonal sampling at Otowi-1 had already been completed by the time this notice was received at the Laboratory. The new production pump was installed in Otowi-1 in March, 1997 and the well is no longer available for further zonal sampling.

Routine hourly water level measurements were collected at test wells TW-1 and TW-1A during the zonal sampling efforts at Otowi-1. However, no water levels were collected at well POI-4. During a previous 24-hour step-drawdown pump test at Otowi-1 conducted in 1990 (Purtymun et al., 1993), no water level declines were recorded in wells TW-1 or TW-1A. During this 1990 test, the Otowi-1 water production rate varied between 676 and 1375 gpm. Hence there was no reason to suspect that zonal sampling at 15 gpm would result in observable water level declines at TW-1, TW-1A, or POI-4. In addition, water levels in the Otowi-1 well were not recorded because of the low pumping rate required for the zonal sampling procedure.

Five separate 46-foot long zones were sampled over the screened interval in Otowi-1. A constant-length sampling interval was maintained with two K-packers separated by a 4-inch (ID) perforated pipe. A five-horsepower submersible pump was placed inside the 4-inch perforated pipe, and the entire assembly was lowered inside the 16-inch diameter wellbore using 2.375 inch drill pipe. Water was pumped to a 16,800 gallon holding tank before final discharge into the permitted NPDES outfall at the well-site. Individual water samples were collected at the wellhead through a small gate valve. A total of 100,320 gallons of water was pumped; the average pumping rate was approximately 15 gallons per minute (gpm).

Action in Document: Replace

Pages in Current Document	with	Replacement Pages Attached
7-67		7-67/7-68, 7-68a/7-68b
7-93		Addressed in response to NMED Specific Comment (12)

(18) NMED COMMENT:

7.3.3.1.5, pg. 7-67: Within the Workplan, 10 ft screen intervals are proposed for alluvial monitoring wells. Anticipated water-level fluctuations should be considered during the design of well construction for the alluvial monitoring wells. LANL shall propose screen lengths for all shallow perched "alluvial" monitoring wells to NMED for approval on a site-by-site basis. Twenty-foot screened intervals should be utilized for all other proposed monitoring wells (regional aquifer and intermediate perched ground water) unless data exists to justify the need for longer screened intervals.

LANL RESPONSE:

We agree that anticipated water-level fluctuations should be considered during the design of well construction for the alluvial monitoring wells. The Laboratory will propose screen lengths to NMED for approval on all alluvial monitoring wells on a case by case basis. The Laboratory will also propose screen lengths to NMED for approval on all regional aquifer wells on a case by case basis. Water-levels have declined as much as 100 ft in 40 years in the eastern part of the Laboratory, thus wells with 20 ft screens (presumably with 5 ft of screen above water and 15 ft below water) would be limited in their utility as potential monitoring wells. Screen lengths should be determined based on local trends of water level decline and the desired design life expectancy of the well.

Action in Document:

Response requires no change in the document.

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ENGLISH-METRIC UNIT CONVERSION TABLE

English	Multiply By	Metric
inches (in.)	25.4	millimeters (mm)
inches (in.)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square feet (ft^2)	9.290×10^{-2}	square meters (m^2)
square miles (mi^2)	2.589	square kilometers (km^2)
gallons (gal.)	3.785×10^{-3}	cubic meters (m^3)
gallons (gal.)	3.785	liters (L)
cubic yards (yd^3)	0.7646	cubic meters (m^3)

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A BRIEF HISTORY OF THE TASK/SITE WORK PLAN (RFI WORK PLAN) FOR OPERABLE UNIT 1049 LOS ALAMOS CANYON AND PUEBLO CANYON
July 1997

Record of Correspondence

Date	Recipient	Source	Subject
November 28, 1995	Mr. David Neleigh, EPA Region 6, NM Federal Facilities Section	Messrs. Theodore J. Taylor, Program Manager, LAAO and Jorg Jansen, Program Manager LANL/ER Project	Submittal of the Resource Conservation and Recovery Act Facility Investigation (RFI) Work Plan for Los Alamos and Pueblo Canyons
May 6, 1996	Mr. Court Fesmire, DOE/LAAO AIP	Mr. Steve Yanicak, NMED DOE Oversight Bureau	Review of LANL ER Project RFI Work Plan for Los Alamos and Pueblo Canyon, FU 4, Operable Unit 1049
September 9, 1996	Mr. Mat Johansen, DOE/LAAO AIP	Mr. Steve Yanicak, NMED DOE Oversight Bureau	Review of LANL's "Task/Site Workplan for Operable Unit 1049" dated November, 1995
March 17, 1997	Messrs. Theodore J. Taylor, Program Manager, LAAO and Jorg Jansen, Program Manager LANL/ER Project	Mr. Benito Garcia, NMED-HRMB	Notice of Deficiency for Los Alamos National Laboratory Operable Unit 1049: Los Alamos and Pueblo Canyon RFI Workplan Dated November 1995
April 18, 1997	Mr. Benito Garcia, NMED-HRMB	Messrs. Theodore J. Taylor, Program Manager, LAAO and Jorg Jansen, Program Manager LANL/ER Project	Response to NOD for Los Alamos and Pueblo Canyon Workplan (former Operable Unit 1049)
June 3, 1997	Messrs. Theodore J. Taylor, Program Manager, LAAO and Jorg Jansen, Program Manager LANL/ER Project	Mr. Robert S. "Stu" Dinwiddie, NMED, Manager, RCRA Permits Management Program	Approval of Los Alamos and Pueblo Canyon RFI Workplan (Operable Unit 1049) Los Alamos National Laboratory (LANL) EPA I.D. NM0890010515
June 11, 1997	Mr. Jorg Jansen, EM/ER, UC-LANL	Mr. Theodore J. Taylor, ER Program Manager, DOE/LAAO	Final RFI Workplan for Los Alamos and Pueblo Canyon (OU 1049)
July 7, 1997	Mr. Benito Garcia, NMED-HRMB	Jorg Jansen, Program Manager LANL/ER Project	Final RFI Work Plan for Los Alamos Canyon and Pueblo Canyon, Environmental Restoration Project

Supplemental Information

Preliminary comments on the work plan received May 6, 1996, and again September 9, 1996, by memoranda from Mr. Steve Yanicak were very helpful in alerting the technical team for the canyons investigations of some technical issues of concern to the New Mexico Environment Department (NMED); these technical concerns were addressed in preparation of subsequent plans for the canyons investigations, particularly the *Core Document for Canyons Investigations* (hereafter the "core document") discussed below.

The technical team conducted a pilot project in Los Alamos Canyon and Pueblo Canyon during the spring, summer, and autumn of 1996, which tested the feasibility of some aspects of the technical approach and the methodology for present-day human health risk assessments and projections of trends in risk proposed in the subject work plan.

The core document, which was prepared in June and July 1996 and reviewed and ready for submittal in July, was delayed to allow preparation of the *Hydrogeologic Workplan* describing the coordination among different technical groups and funding sources of groundwater investigations in general at the Laboratory. The *Hydrogeologic Workplan* was submitted to NMED (as Draft Revision 1.0) on December 6, 1996. The draft core document was subsequently revised to incorporate elements of the coordination with the *Hydrogeologic Workplan* and to incorporate lessons learned in the pilot project, including experience in conducting the rapidly-developing approaches to risk assessment using geostatistical tools to estimate uncertainty in risk assessment and reduce the uncertainty by further targeted sampling and analysis in the canyons.

Also during 1996, the Laboratory's Environmental Restoration Decision Support Council decided that the screening action levels (SALs) that had been used as the first test for contaminants of potential concern were not viable for this purpose. The use of SALs was discontinued in favor of an approach to identifying contaminants of potential concern using maximum contaminant levels, state and Pueblo standards, upper tolerance limits (UTLs) above background, and preliminary risk calculations using conservative exposure scenarios that is captured in the core document. In addition, the Laboratory's Ecological Risk Assessment Team continued to work on an approach to ecological risk assessment at the Laboratory, an interim version of which was contained in Chapter 6 of the subject work plan. A final version is not yet available. These issues were captured in the core document. The core document was submitted to NMED April 2, 1997.

A formal notice of deficiency (NOD) on the subject work plan was responded to by memorandum, with detailed Laboratory responses to each item of the NOD attached. The subject document was approved by letter with a request that a final work plan be submitted within 30 days of receipt. Because the Resource Conservation and Recovery Act facility investigation work plan for investigations in Mortandad Canyon was in preparation in an attempt to adhere to the scheduled target date for submittal (September 30, 1997), NMED granted an extension for submittal of the final version of the subject work plan.

The final version of the subject work plan was submitted on Monday, July 7, 1997. The form of the submittal was pages to be replaced in the original version. Those replacement pages address the NOD issues by modifications of the text of the original document according to the Laboratory's response dated April 18, 1997. Those responses incorporated the coordination with the *Hydrogeologic Workplan*, the changes in the use of SALs, the emerging methodology for both human health and ecological risk assessment discussed in the core document, and lessons learned in the pilot project, particularly those on the geostatistical methods used to guide additional sampling and analysis, also discussed in the core document. Thus, the final version of the subject work plan incorporates the core document by reference for the conduct of risk assessments, references the *Hydrogeologic Workplan* for coordination of the installation of some wells, and eliminates the use of SALs.

The preliminary schedule for implementing this work plan is shown in Figure I-1. This schedule has not been costed, and it represents the initial thinking of the technical team. Concurrent with the submission of this work plan, the FY96 budget (and out-year budget targets) are being developed by Congress and DOE. The activities and dates shown in Figure I-1 are all subject to change based on actual budgets for Field Unit 4.

The preliminary schedule includes a pilot study of one or two reaches for testing field characterization and data reduction tools and techniques. Also included are some alluvial and intermediate zone wells for pilot studies. Up to five alluvial and three intermediate zone wells may be funded in FY96. The schedule of deliverables for the canyons investigation will be defined in cooperation with both stakeholders and regulators at a future date.

Implementation of investigation activities is contingent upon regulatory review and approval of the Los Alamos Canyon and Pueblo Canyon work plan and upon the availability of funding. Schedules and costs will be updated through the DOE change-control process, as appropriate, with revisions submitted to the Administrative Authority for approval. The following assumptions were used to generate this schedule.

- Review and approval of the Los Alamos Canyon and Pueblo Canyon work plan and supporting project plans by regulatory agencies will be completed by March 1996.
- Certain tasks (for example, geomorphic mapping and the LAOI-B borehole) may be initiated before regulatory agencies grant final approval of the work plan.
- The schedule assumes that an adequate number of support personnel (such as environment, safety, and health technicians and trained drilling contractors) will be available.
- Regulatory agencies will provide approvals within the specified timelines.
- Investigation of the nine specified reaches will be sufficient for work plan goals and HSWA compliance.

2.3 RFI Reports

Results of field work will be presented in RFI reports. The RFI reports for Los Alamos Canyon and Pueblo Canyon will summarize all field work conducted during the investigation. As required by the HSWA Module, the Laboratory will submit RFI reports within 60 days of completion of investigations. As stated in Chapter 3 of the IWP (LANL 1995, 49822), the RFI reports will describe the procedures, methods, and results of field investigations and will include information on the type and extent of contamination, sources and migration pathways, and actual and potential receptors. The reports also will contain adequate information to support any remedial recommendations.

2.4 Budget

The schedule is based on constrained budgets for the first two years of the investigation and preliminary cost analysis, which is subject to significant uncertainties. The projected budget in FY96 is based on expected DOE funding levels and is subject to change depending on funding allocations. A change-control petition to DOE is required to augment these funding levels. Because DOE funding requests are set two years in advance, the first year in which the Los Alamos Canyon and Pueblo Canyon investigation is not constrained by previous budget estimates will be FY98. Funding requests for FY98 and beyond will reflect the cost and schedule that most efficiently complete the investigation. Uncertainties regarding the extent of ground water contamination, including the cost of drilling through potentially contaminated areas, could impact investigation costs substantially.

2.5 Organization and Responsibilities

The organizational structure for the ER Project is presented in Chapter 2 of the generic Quality Assurance Project Plan (LANL 1991, 0412). ER Project personnel authority and responsibilities are identified in this annex and in Figure I-2.

Records of qualifications and training of all field personnel working on the investigation for Los Alamos Canyon and Pueblo Canyon will be kept as ER records (see Chapter 5 of the IWP) (LANL 1995, 49822). Technical contributors to the Los Alamos Canyon and Pueblo Canyon work plan are listed in Appendix E of this work plan.

The responsibilities of the positions identified in Figure I-2 are summarized in the following sections.

2.5.1 Field Project Leader

Responsibilities of the field project leader are as follows:

- provides overall management for field unit activities, including strategic planning and budgeting;
- prepares monthly and quarterly reports for the ER Project manager;
- oversees subcontractors, as appropriate;
- coordinates with the technical team leader and conducts technical reviews of the milestones and final reports; and
- interfaces with the ER Project quality program project leader (QPPL) to resolve quality concerns and to coordinate with the quality assurance staff for audits.

2.5.2 Technical Team Members

Technical team members are responsible for providing technical input for their discipline throughout the RFI/CMS process. Technical team members have participated in the development of the Los Alamos Canyon and Pueblo Canyon work plan and the individual sampling and analysis plans and will continue to participate in the field work,

Executive Summary

Purpose

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI)work plan establishes the technical approach and methodology for environmental investigations of Los Alamos Canyon and Pueblo Canyon, two of the major drainage areas or canyon systems at Los Alamos National Laboratory (the Laboratory). Specifically, this investigation of Los Alamos Canyon and Pueblo Canyon evaluates the potential impacts of Laboratory-derived contaminants within the two canyon systems. The purpose of this investigation is to

- determine the potential for contaminant transport into or within Los Alamos Canyon and Pueblo Canyon watersheds;
- evaluate human health risks and ecological impacts associated with the presence of contaminants;
- refine conceptual models for contaminant transport;
- assess the potential for interconnections between ground water in alluvium, perched intermediate zones, and the main aquifer; and
- assess the projected impact that contaminants may have on off-site receptors and the Rio Grande.

This RFI work plan presents a technical approach that is significantly different from previous RFI work plans that investigated solid waste management units (SWMUs). This RFI work plan deals with the investigation of affected media within the canyon systems rather than the investigation of SWMUs. The technical approach and the sampling and analysis plans are designed to address the broad and far-reaching regulatory requirements contained in the Hazardous and Solid Waste Amendments (HSWA) Permit.

Response to Regulatory Requirements

This RFI work plan intends to satisfy a portion of the regulatory requirements of Module VIII, Sections I.5 and Q, tasks 1 through 5, of the HSWA Permit (May 19, 1994), which was issued by the Environmental Protection Agency (EPA) to address contamination problems specific to the Laboratory. NMED is the Administrative Authority for the HSWA Module. The satisfaction of these permit requirements is accomplished by the Laboratory Environmental Restoration (ER) Project. Because this RFI work plan identifies the canyons as ultimate transport pathways for contaminants migrating across and off the Laboratory, a distinction is created between the HSWA requirements for the canyon systems and the HSWA requirements for SWMUs. These canyon pathways cross American Indian, private, and public land and eventually contribute sediments, surface water, and ground water to the Rio Grande. Because the canyons and the associated transport processes are identified as the regulatory focus, the canyon investigations are different from SWMU-based investigations, both from a regulatory and a scientific perspective.

Background

Description of Field Unit 4

Field Unit 4, one of the five major field units in the ER Project, includes three operable units (OUs): OU 1098, OU 1129, and OU 1049. OU 1049 contains 19 canyon systems; two of these, Los Alamos Canyon and Pueblo Canyon, are the focus of this RFI work plan. The canyon systems were grouped for study using four criteria:

- potential for greatest risk to human health and the environment,
- amount of available data,
- presence of known contamination, and
- geographic proximity.

Los Alamos Canyon and Pueblo Canyon comprise about 18 miles of the 110 miles of canyon and drainage systems on property controlled by the Laboratory. Los Alamos Canyon and Pueblo Canyon were selected as the subjects for the first RFI work plan for two reasons: the considerable body of information available concerning the release of contaminants into these canyons and their proximity to populated areas.

Future RFI Work Plans

The Los Alamos Canyon and Pueblo Canyon RFI work plan is the first of eight planned RFI work plans. In FY96 an integrating RFI work plan that will act as an "umbrella" or core document will be developed. The additional seven work plans will be prepared in the following few years. These RFI work plans will address the remaining canyon systems of the Pajarito Plateau that may have been affected by Laboratory operations (see Table 1-2 in Chapter 1 of this RFI work plan). The core document, which will incorporate a significant amount of material from Chapters 1 through 5 of this RFI work plan, will be used as a tier document for the seven remaining RFI work plans. Each of the seven RFI work plans will have only an introduction, a chapter on the historical background, a short chapter describing the issues concerning the environmental setting of a specific canyon system, and a chapter describing the sampling and analysis plan and the quality assurance project plan. This approach is expected to effectively and efficiently satisfy the permit requirements.

Public Involvement

At the beginning of calendar year 1992, the ER Project established a public involvement effort. The ER Project Office schedules informal and formal meetings with the general public, the neighboring Indian Pueblos, and ER Project advisory groups. The purpose of these meetings is to involve these groups with the ER Project and its goals within the RCRA regulations. Activities undertaken for this RFI work plan include formal interactions with the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez, which have formal accords and agreements with the Department of Energy (DOE) and the Laboratory. (These Indian Pueblos are referred to as the Accord Pueblos in this RFI work plan.) These interactions result in suggested approaches for the RFI work plans. In addition, the ER Project has employed Indian Pueblo

members to work on the field characterization teams. The intent of these interactions is to provide avenues for the American Indian perspective to become an integral part of the preparation and execution of the canyons RFI work plans.

Conceptual Model and Technical Approach

One of the significant distinctions of this RFI work plan compared with an RFI SWMU-based work plan is the responsibility to investigate the canyons as an integrated natural system. The canyons that drain the Pajarito Plateau at the Laboratory are geologically and hydrologically diverse. This diversity and wide geographic extent caused the creation of a germane work plan methodology for these studies. This methodology is based on well-defined regulatory and broadly applicable technical issues that apply to the canyons investigations. Therefore, the canyon characterization activities are designed to collect data for a present-day snapshot of risk based on present-day contaminant levels, evaluate the potential impact of contaminant transport into and within the watersheds, and subsequently transition to a long-term monitoring program. The characterization study area is bounded by the western Laboratory border to the Rio Grande, the canyon floors laterally from the stream channel to the modern floodplain deposits, and the stream channel vertically to the deepest ground water bodies affected by regulatorially defined limits of contaminants. The characterization data is used to develop risk scenarios based on Laboratory use, recreational land use, traditional use by American Indians, and residential use at Totavi and Otowi Houses. Risk scenarios based on cumulative or dose release in future generations are recognized as possible products of these investigations but are not explicitly dealt with at this time. Refinement of the regulatory framework would need to provide more detailed guidance before future risk studies could be undertaken. Therefore, the technical approach is based primarily on satisfying the HSWA Module requirements in an efficient and technically defensible manner. To meet these objectives, the following two investigation paths are followed:

- sampling and analysis of surface sediments on the canyon floors to evaluate surface exposure pathways and
- sampling and analysis of surface and ground water to assess the transport pathways and potential impacts on the different zones of saturation.

For example, sediment sampling is largely restricted to post-1943 canyon deposits in both the active channels and the floodplains. Furthermore, RFI work plans will focus on identifying areas *most likely* to contain contaminants, determining the geomorphic settings where the greatest contaminant inventories could occur (post-1943 sediments), and assessing the susceptibility of the contaminants to redistribution in sediments and dust.

RFI work plans for ground water investigations will also focus on areas most likely to contain contaminants, such as the near-surface alluvial and intermediate perched zone ground waters. Results of these ground water investigations are also used for locating and designing ground water monitoring systems. Studies of the deep unsaturated zone and the main aquifer will be conducted if (1) the intermediate perched zones contain contaminants above maximum concentration limits for drinking water, (2) the data from nearby main aquifer wells indicate the presence of contaminants, or (3) the combined historical data and investigation results suggest that the alluvium, intermediate perched zones, and main aquifer are interconnected.

Sampling and Analysis Strategy

Chapter 7 of this RFI work plan contains the sampling and analysis plans for the first set of investigations to be conducted under this technical approach. The strategy is based on first understanding the nature of the contaminants present. This understanding is gained through a biased sample location selection strategy and broad-based analyses. After the lists of contaminants are defined, subsequent investigation will limit analyses to the limited suite of known contaminants. Because there is high probability that Laboratory-derived contamination is predominantly radioactive and that there are associated radioactive components in virtually all waste streams serving as canyon source terms, the initial sampling strategy relies heavily on the use of remote sensing radiological surveys and geomorphologic mapping to give a broad view of the distribution of contaminants within surface sediments. Discrete sampling points are identified based on radiological screening surveys and geomorphologic features. Locations of new wells are based on known or suspected hydrologic features. In all sampling, the selection criteria for location and analytical content are designed to develop the best possible data set at the most reasonable cost. The iterative portions of the technical approach will allow the investigators to tune the characterization requirements to observed conditions in the field. This approach will ultimately lead to a well-defined and quantitative understanding of the natural systems involved in canyon contaminant fate and transport.

Schedule and Reporting

Annex I of this RFI work plan contains a preliminary schedule for conducting the activities described in the sampling and analysis plans. This schedule is not currently supported by a firm budget commitment from DOE for ER Project activities and is subject to change when the final FY96 budget is determined. However, regardless of the level of the budget, Field Unit 4 personnel plan to conduct a pilot study for one or two of the reaches in Pueblo Canyon during FY96. Information gained from these pilot studies will help refine the manner in which the remaining studies are implemented.

The Laboratory, DOE, NMED, EPA, and the stakeholders have not produced a final definition of the types and schedule of reports for the efforts in this RFI work plan. Since the canyons contain no SWMUs, reporting schedules pertinent for HSWA permit modification are not directly applicable. Every effort is directed at creating an efficient schedule and communicative format for reporting the results of canyon investigations. Consistent with the technical approach, any results that indicate the need for an immediate mitigation remedial action will be communicated and initiated.

Structure of the Work Plan

This RFI work plan contains seven chapters, five annexes, and five appendixes, as listed below.

Chapters

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

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

Chapter 3 describes the environmental setting for Los Alamos Canyon and Pueblo Canyon and summarizes available data germane to the current investigation.

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

Chapter 5 describes the technical approach that will be followed during execution of this RFI work plan.

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

Chapter 7 contains the sampling and analysis plans for the initial characterization efforts in the two canyons and describes more fully the implementation of the reach concept for understanding the natural systems. Elements of the quality assurance project plan are also found in this chapter.

Annexes

Annex I presents a general project management plan for Field Unit 4 along with an implementation schedule for the investigation work.

Annex II contains other elements of the quality assurance project plan, including analytical tables.

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

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

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

Appendixes

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

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

Appendix C summarizes the human health risk assessment calculations.

Appendix D describes the various field and laboratory investigation methods likely to be employed.

Appendix E lists the individuals who contributed to this RFI work plan.

1.0 INTRODUCTION

1.1 Purpose

This RFI work plan discusses investigations to be conducted in Los Alamos Canyon and Pueblo Canyon as part of the Environmental Restoration (ER) Project for Operable Unit (OU) 1049, the canyons OU at Los Alamos National Laboratory (the Laboratory). The investigation includes evaluation of the effects of past and current releases into tributaries to the canyons; past releases into Acid Canyon, a tributary to Pueblo Canyon; and past and current releases into DP Canyon, a tributary to Los Alamos Canyon.

This is one of eight RFI work plans that will describe ER work for all the canyons that were part of historical operations at the Laboratory or now cross property controlled by the Laboratory. This RFI work plan meets the requirements of the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA), and related Department of Energy (DOE) orders. Also, it describes the field sampling plans to meet those requirements and other commitments to external stakeholders. This introductory chapter gives a brief summary of regulatory requirements, describes Los Alamos Canyon and Pueblo Canyon, and explains the structure of this RFI work plan.

1.2 Public Participation

Regulations issued pursuant to HSWA address public participation in the corrective action process. In addition, through the Community Involvement and Outreach Office, the Laboratory is providing a variety of opportunities for public participation. These opportunities include meetings held as needed to disseminate information, to discuss significant milestones, and to solicit informal public review of this and the other draft work plans. The ER Project staff will also discuss this work plan at meetings of community organizations. The Community Involvement and Outreach Office also distributes meeting notices and updates the ER Project mailing list, prepares information sheets summarizing completed and future activities, and provides public access to plans, reports, and other ER Project documents. These materials are available for public review between 8:00 a.m. and 5:00 p.m. on Laboratory business days in the Laboratory Community Reading Room at 1350 Central Avenue, Suite 101 in Los Alamos; at the public libraries in Española, Los Alamos, and Santa Fe; and at the San Ildefonso Pueblo Governor's Office.

1.3 Regulatory Requirements Governing the Work Plan

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

1.3.1 Resource Conservation and Recovery Act Requirements

The Laboratory's operating permit under RCRA sets forth requirements that are implemented by the ER Project. The RCRA Part B Operating Permit, issued by EPA, and its HSWA Module VIII (hereafter referred to as the HSWA Module) give specific require-

HSWA Module VIII (hereafter referred to as the HSWA Module) give specific requirements affecting the conduct of the ER Project (EPA 1990, 1585). The HSWA Module became effective May 23, 1990, and is updated to reflect changes in the status of the operating permit. The most recent update became effective May 19, 1994. NMED is the Administrative Authority for the HSWA Module.

The HSWA Module requires the Laboratory to prepare an installation-wide work plan that contains the programmatic elements of a RCRA facility investigation (RFI) work plan. The Laboratory-wide Installation Work Plan (IWP) (LANL 1995, 49822), which DOE/UC uses to guide and manage the ER Project, meets this requirement. The most recent revision of the IWP was submitted to EPA in February 1995. The IWP describes the DOE ER Program and its history at the Laboratory, describes current Laboratory conditions, identifies the Laboratory's potential release sites (PRSs) and their aggregation into field units, and presents the management and technical approaches for meeting the requirements of the HSWA Module. Relevant information presented in the IWP will be cited but not repeated in this RFI work plan.

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

This RFI work plan fulfills part of the requirements of the HSWA Module, Section I.5: Task/Site Work Plan, Canyon Systems (EPA 1990, 1585). That section calls for one or more task/site work plans for studies to evaluate the potential impact of contaminants from solid waste management units (SWMUs) on the 15 (the Laboratory currently recognizes 19) major drainage areas or canyon systems at the Laboratory. It states that

> The Permittee shall submit one or more Task/Site Workplans for studies to evaluate the 15 major drainage areas or Canyon systems at the facility. These studies must address each system as an integrated unit and evaluate them for potential impacts of contaminants from SWMUs [Solid Waste Management Units]. The plans must address the existence of contamination and the potential for movement or transport to or within Canyon watersheds and interactions with the alluvial aquifers and the main aquifer. The studies shall evaluate the potential for offsite exposure through these pathways including the ground water and possible impacts on the Rio Grande.

This RFI work plan addresses these concerns for Los Alamos Canyon and Pueblo Canyon. RFI work plans for the remaining canyons and a core plan will be prepared later, with input from EPA, the New Mexico Environment Department, DOE, and the Indian Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez, which have formal accords and agreements with DOE and the Laboratory. These four Indian Pueblos are referred to as the "Accord Pueblos" in this work plan.

TABLE 1-1

LOCATION OF DISCUSSIONS OF HSWA MODULE REQUIREMENTS

HSWA Module Requirements	IWP (1995)	Location in RFI Work Plan
RFI Task I: Description of Current Conditions		
Facility Background	Chapter 2	Chapters 2 and 3
Nature and Extent of Contamination	Appendices A and B	Chapters 2, 3, and 7
RFI Task II: RFI Workplan		
Data Collection Quality Assurance Plan	Chapter 4	Annex II
Data Management Plan	Chapter 5	Annex IV
Health and Safety Plan	Chapter 6	Annex III
Community Relations Plan (Public Involvement Plan)	Chapter 7	Annex V
RFI Task III: Facility Investigation		
Environmental Setting		Chapter 3
Source Characterization		Chapters 2, 3, 4, and 7
Contamination Characterization		Chapters 2, 3, 4, and 7
Potential Receptor Identification		Chapter 6
RFI Task IV: Investigative Analysis		
Data Analysis		Chapter 6
Protection Standards		Chapter 6
RFI Task V: Reports		
Preliminary and Workplan	The IWP with annual update	RFI Work Plan
Progress Draft and Final		

PRSs. A PRS may be a SWMU or an area of concern (AOC). A SWMU is defined in the HSWA Module as "any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released." Radioactive materials and some hazardous substances (as defined under the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] and listed in 40 CFR 302 [EPA 1990, 0093]) are not included in the RCRA definitions of solid waste, hazardous waste, and hazardous constituents and are not subject to the provisions of the HSWA Module. However, the IWP (LANL 1995, 49822) indicates that the ER Project will address the potential release of radioactive and hazardous substances not regulated by RCRA.

the potential release of radioactive and hazardous substances not regulated by RCRA. Sites that potentially contain hazardous substances but not hazardous wastes or hazardous constituents as defined by RCRA are called AOCs. The different geologic media of the canyons system—sediments, aquifers, and parent material—are categorized as AOCs.

The investigation of Los Alamos Canyon and Pueblo Canyon is required by the HSWA Module to ensure that the transport of contaminants released into the canyons will not adversely affect human health or the environment either on or off Laboratory property.

1.3.2 CERCLA, NEPA, and DOE Orders

Sections 1.2.1.3 and 1.2.1.4 of the IWP (LANL 1995, 49822) discuss the integration of the RCRA-based ER Project with applicable requirements of CERCLA and the National Environmental Policy Act (NEPA). Additionally, the ER Project will comply with other applicable federal acts, state statutes, and DOE orders and policy statements. Chapter 5 of this RFI work plan discusses further the regulatory basis and requirements for investigation of the canyons system and the implementation of the technical approach for addressing those requirements.

DOE orders applicable to the ER Project are identified in Annex I (Program Management Plan) of the 1993 version of the IWP (LANL 1993, 26077) (all annexes to the 1993 IWP are current with the 1995 IWP update). Compliance with the requirements of these orders is integral to all Laboratory operations and is ensured through the documented policies, planning, auditing, and work review procedures of the Laboratory.

1.3.3 Assessment of Natural Resource Damage

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

1.4 Environmental Restoration Project Guidance

The IWP (LANL 1995, 49822) specifies the ER Project's technical and managerial approaches for compliance with the HSWA Module and other regulatory obligations.

As illustrated in Table 1-1, the IWP has been prepared and is updated annually in accordance with the requirements of the HSWA Module. The IWP provides overall direction to the ER Project; specific guidance on the preparation of work plans for RFIs conducted under the project; detailed description of the facility (the Laboratory); and programmatic-level plans for data collection quality assurance, data management, health and safety, and public involvement.

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

Each PRS-based RFI work plan uses the IWP for both guidance and as a referenceable source of information regarding the history of the Laboratory and its operations. Accordingly, reference is made in the canyons RFI work plans (which are focussed on affected media and AOCs) and in every PRS-based RFI work plan to existing text in the IWP that describes programmatic-level issues and general facility history and status.

The ER Project Quality Assurance Project Plan (QAPP, formerly referred to as the QAPjP) (see Chapter 4 of the IWP [LANL 1995, 49822]) discusses the procedures and methods employed to ensure that environmental data of the desired quality are available for the decision-making process. The QAPP addresses quality objectives for measurement data, as determined by the data quality objectives process, and the sampling and analysis procedures to be implemented to achieve the quality objectives. It discusses the quality control (QC) requirements for the data collection process, including the need to define acceptance criteria for certain QC procedures and samples. It outlines the procedures for quality assurance assessments and response actions. The QAPP also presents the requirements for personnel training; sample handling and custody; and data management, review, validation, and verification. In addition to requirements for measurement data, the QAPP also addresses requirements for using archived and nonmeasurement data. Wherever possible, the appropriate ER Project administrative and quality procedures and standard operating procedures to be used in conducting the investigation are cited in applicable sections of Chapter 4 of the IWP.

1.5 Description of the Canyons Operable Unit

1.5.1 General Setting

Los Alamos County is situated on the Pajarito Plateau, a region 5 to 6 miles wide and 6500 to 7600 ft above sea level, between the 10,500-ft-high Jemez Mountains to the west and the 5500-ft-high Rio Grande Valley to the east (Figure 1-1). The plateau is cut by many deep canyons that run generally west-northwest to east-southeast from the mountains to the Rio Grande. Developments within Los Alamos County include the Los Alamos and White Rock residential areas and the Laboratory technical areas. The Los Alamos townsite and most of the Laboratory technical areas occupy relatively flat mesa tops situated between the canyons. A more in-depth description of the regional geologic and hydrologic setting is found in Chapter 3 of this RFI work plan and in Chapter 2 of the IWP (LANL 1995, 49822).

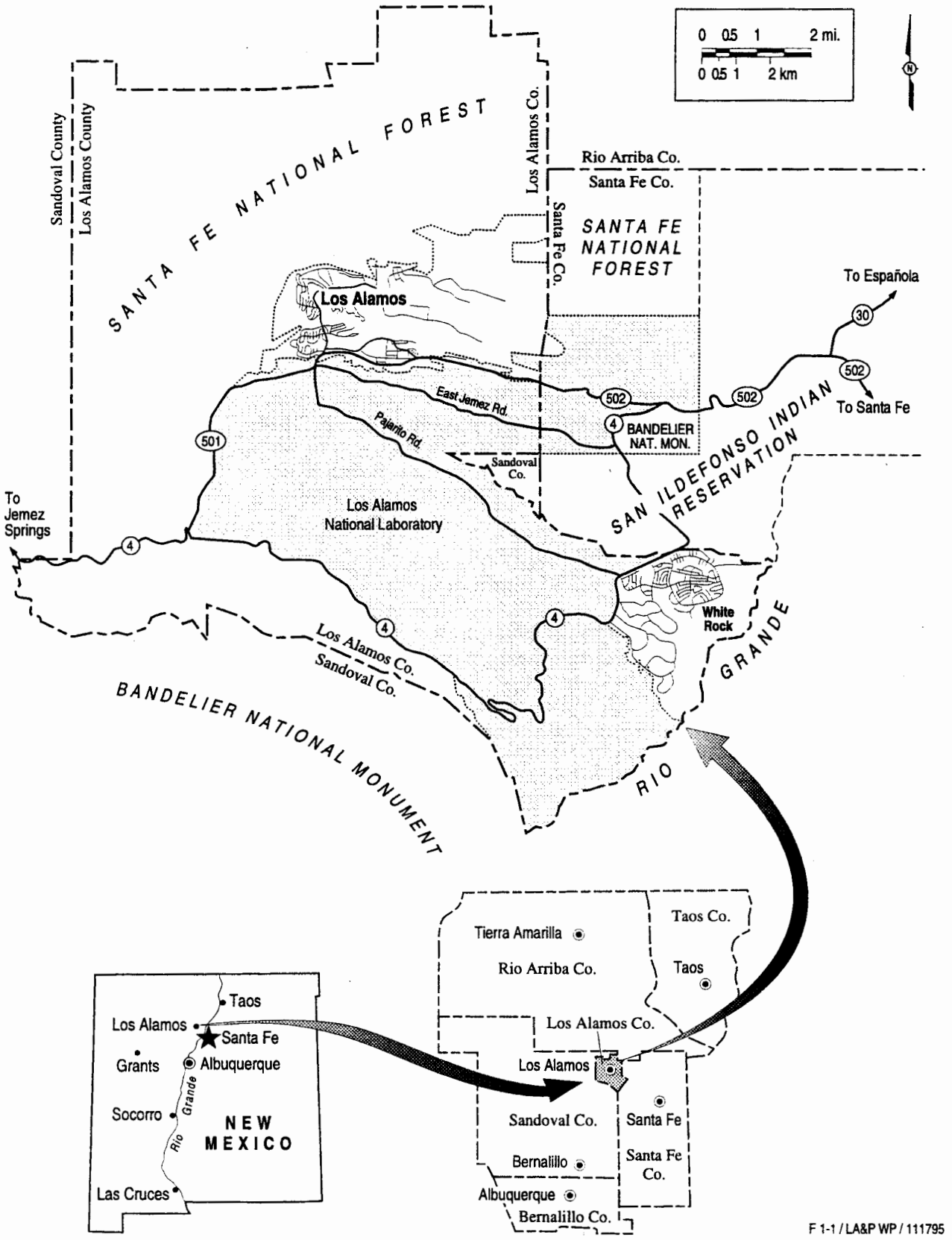


Figure 1-1. Location map of Los Alamos National Laboratory.

Nineteen significant canyon systems drain the surface water from the Laboratory sites located on the Pajarito Plateau (Figure 1-2). Most of the reaches of these canyons within the Laboratory boundaries are ephemeral. Runoff flows naturally but briefly in response to precipitation events, mostly summer thunderstorms and spring snowmelt. During these events the runoff drains rapidly from the mesa tops into these deep canyon systems. Essentially all the surface water discharge that leaves the Laboratory site moves through these canyons and occasionally reaches the Rio Grande. From there the water flows downstream to Cochiti Lake.

Carried by storm event runoff, contamination from mesa-top PRSs has the potential to enter surface water drainages. Runoff-derived contamination entering these canyon drainages is mainly bound to the sediments; more soluble contaminants tend to remain in solution (see Chapter 3 of this RFI work plan). The rate of sediment (affected media) transport by storm events is governed by the energy or carrying power of the specific event. It is expected that given sufficient storm events, over time these sediments will eventually be moved across the Laboratory boundary to the Rio Grande (LANL 1993, 26077).

Environmental monitoring for chemical and radiochemical quality of surface water, ground water, and sediments began with the United States Geological Survey in 1945 (Purtymun 1964, 11822; Purtymun 1975, 11787; Purtymun and Kunkler 1967, 11782; Purtymun 1967, 8987). To date, the Laboratory has continued these investigations. Groups from the Laboratory's Environment, Safety, and Health Division perform environmental monitoring across the Laboratory site and in nearby areas (Environmental Protection Group 1993, 23249).

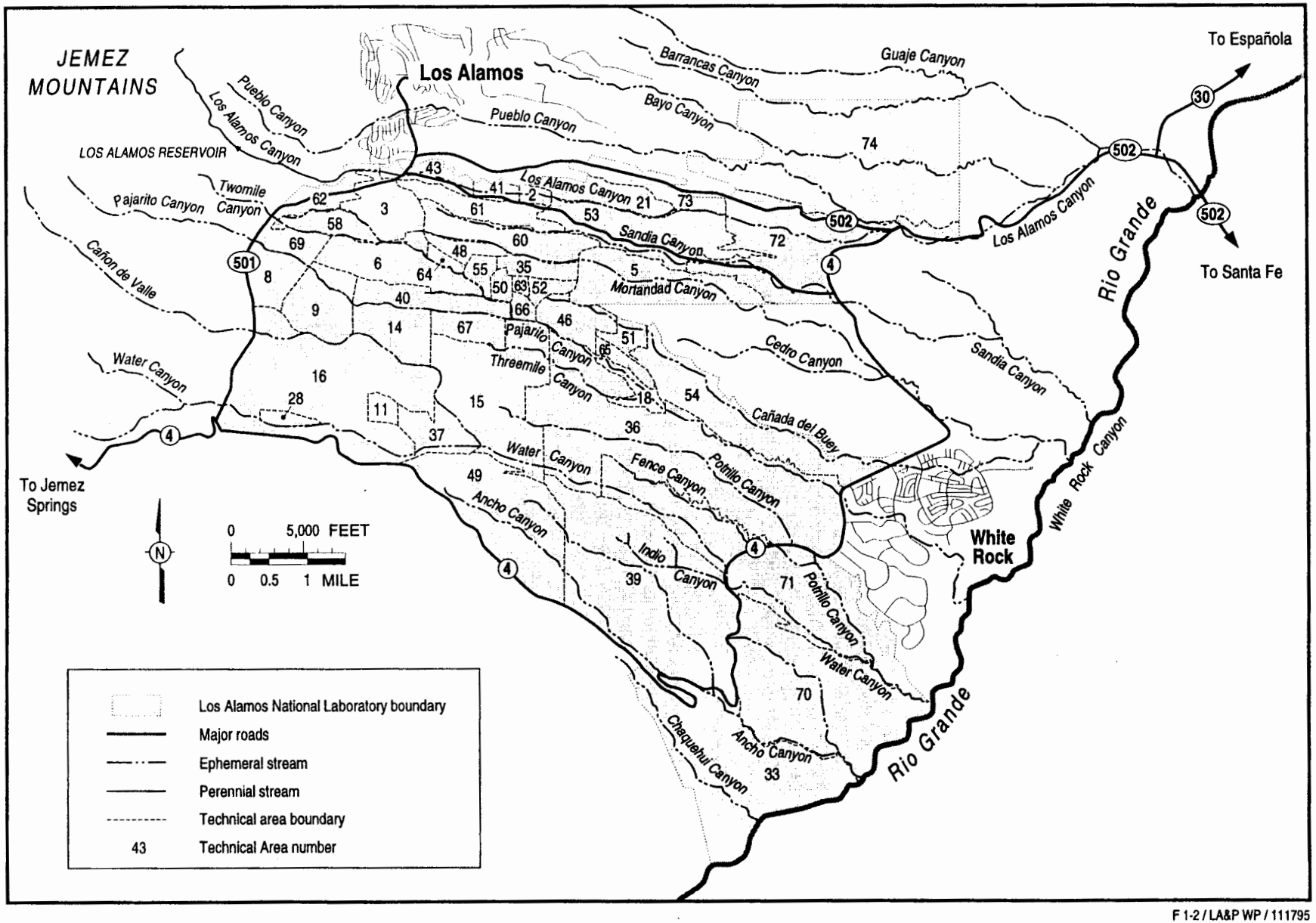
This RFI work plan addresses potential contaminant contributions from SWMUs (PRSs) located adjacent to Los Alamos Canyon and Pueblo Canyon, which may have resulted in releases into these two canyons. Operable units under investigation and the technical areas (TAs) included in them that may affect (or may have affected) Los Alamos Canyon and Pueblo Canyon include OU 1078 (former TA-1), OU 1079 (former TA-45), OU 1098 (TAs -2 and -41), OU 1100 (TA-53), OU 1106 (TA-21), OU 1111 (TA-62), OU 1114 (TA-3), and OU 1136 (TA-43) (Figure 1-2).

1.5.2 RFI Work Plans

The current scheme is to consolidate the studies of these 19 canyon systems into 8 RFI work plans (Table 1-2) and a core document. This consolidation is based on geographic proximity, similarity of discharges and potential resulting contamination, and economic efficiency.

The core RFI work plan is intended to be a tiered document that provides text common to all RFI work plans for the introduction, background (historical) information, environmental setting, conceptual model, technical approach, and risk assessment chapters. The core document is in effect the parent document for the eight RFI work plans. The individual RFI work plans will provide detail specific to the canyon(s) being investigated in the environmental setting and the canyon-specific sampling and analysis plans that are appended to the core document.

Because of scheduling constraints, this Los Alamos Canyon and Pueblo Canyon RFI work plan was developed ahead of the core document. This RFI work plan contains all the sections found in an RFI work plan. The majority of the text in this RFI work plan and the associated knowledge will be used to create the core document. Future canyon-specific RFI work plans will contain only a brief introduction, a short discussion of



F 1-2 / LA&P WP / 111795

Figure 1-2. Major surface water drainages in the Los Alamos area.

TABLE 1-2

OPERABLE UNIT 1049
CANYONS AND ASSOCIATED OPERABLE UNITS AND TECHNICAL AREAS

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

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

the canyon's history and environmental setting, and a comprehensive sampling and analysis plan.

1.6 Organization of This RFI Work Plan

Following this introductory chapter, Chapter 2 provides background information on Los Alamos Canyon and Pueblo Canyon, including a description and history of the area and of the potential sources of contamination; Chapter 3 describes the environmental setting; Chapter 4 contains the conceptual model of contaminant transport within the two canyons; Chapter 5 describes the technical approach to the investigation and numerical models that may be used to evaluate transport and assess current and potential future exposure and impact; Chapter 6 describes human health and ecological risk and impact assessment considerations; and Chapter 7 contains the field investigation objectives and sampling and analysis plans based on data describing the known nature and extent of contamination.

A list of acronyms precedes Chapter 1. Definitions of unfamiliar terms can be found in the IWP (LANL 1993, 26078) and in the *Glossary of Geology* (Bates and Jackson 1987, 50287).

1.7 Units of Measurement

The units of measurement used in this document are expressed in both English and metric units, depending on which unit is commonly used in the field being discussed. For example, English units are used in text pertaining to engineering, and metric units are often used in discussions of geology, geochemistry, and hydrology. When information is derived from some other published report, the units are consistent with those used in that report. An English-Metric conversion table is provided with the Acronyms and Abbreviations on page xxii.

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Purtymun, W. D., August 1964. "Progress Report on the Hydrology of Mortandad Canyon, Disposal System for Treated Low-Level Liquid Radioactive Wastes; July 1961 to June 1963," US Geological Survey Administrative Release, Albuquerque, New Mexico. **(Purtymun 1964, ER ID Number 11822)**

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Purtymun, W. D., and J. L. Kunkler, March 1967. "The Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, July 1965 through June 1966," US Geological Survey Administrative Release, Albuquerque, New Mexico. **(Purtymun and Kunkler 1967, ER ID Number 11782)**

5.0 TECHNICAL APPROACH

This chapter describes the technical approach for conducting investigations in Los Alamos Canyon and Pueblo Canyon. The only solid waste management units (SWMUs) located within the area covered by this investigation are the SWMUs in Technical Area (TA) -2 and TA-41 (which are being studied in the Resource Conservation and Recovery Act [RCRA] facility investigation [RFI] for Operable Unit 1098). Because those SWMUs are contained in another operable unit, their investigations are addressed in another work plan. Consequently, the technical approach for this work plan is focused on general characterization of the canyon floors and refinement of the conceptual models of contaminant transport pathways (discussed in Chapter 4 of this work plan) to evaluate present-day risk and potential future impacts from Laboratory-derived contaminants.

5.1 Summary of Canyons Investigations Technical Approach

5.1.1 Regulatory Framework for Canyons Investigations

The Installation Work Plan (LANL 1995, 49822) specifies that the Environmental Restoration (ER) Project's technical approach in the canyons investigations will comply with the Hazardous and Solid Waste Amendments (HSWA) Module VIII of the RCRA Part B Operating Permit (EPA 1990, 1585 with modifications dated April 19, 1994) and other regulatory obligations. The requirements for the canyons investigations are defined in Section I.5 of the HSWA Module, which states the following.

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

The requirement to submit one or more RFI work plans for investigations to evaluate the 15 (currently the Laboratory considers 19 canyons) major drainage areas or canyon systems at the facility is addressed in part by this work plan, which is the first of a series. Chapter 1 of this work plan discusses the canyons to be studied and the subsequent documents that will address investigations of other canyons systems or groups of systems, including all those required in the operating permit. The remainder of the text of Section I.5 of the HSWA Module contains both requirements and criteria for the design of investigations. These requirements are discussed in detail in Section 5.2.1.

Section Q of the HSWA Module, which describes the scope of work for RFIs, calls for comprehensive characterization of hydrogeological and geochemical properties relevant to contaminant migration in soils and sediments. The canyons are not facilities in the sense of Section Q. They are natural environments containing contaminated media transported from nearby Laboratory facilities, mostly located on adjacent mesa tops. This work plan is not an RFI work plan in the typical sense; rather it is a work plan that describes investigations of the role of canyons as collection points and transport pathways for contaminants derived from nearby SWMUs. Nevertheless, this work plan follows the guidelines for conducting RFIs as outlined in Section Q. These guide-

lines include obtaining the following hydrogeological and geochemical information (adapted from Section Q, Table III.A [Environmental Setting]):

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

Moreover, the canyon-specific requirements in Section I.5 of the HSWA Module for investigations to evaluate the potential for off-site exposure necessitates that much of the same information called for in facility-specific RFIs be obtained in the canyons investigation as well.

5.1.2 Purpose of the Investigation

The purposes of this investigation are

1. to determine to what extent portions of Los Alamos Canyon and Pueblo Canyon have been or are likely to be affected by the combined releases, in the past and in the immediate future, from all sites that could contribute residual contamination to them and
2. to re-examine contaminant transport mechanisms, refine the conceptual model, and project future impacts of the contaminants in the affected media that may result from future transport of the contaminants to other locations and other media.

The investigation supports an integrated assessment of the present-day risk to human health from Laboratory-derived contaminants, and an evaluation of the potential for transport, through all accessible pathways, to cause unacceptable off-site impacts in the future.

As described in Section 5.1.4, risk assessment calculations will be performed using present-day contamination levels and exposure scenarios that are applicable today and in the foreseeable future. These calculations are referred to as a present-day risk assessment to distinguish them from the more qualitative evaluations of the potential for future off-site exposure and impacts.

1.0 INTRODUCTION

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

2.0 TECHNICAL APPROACH

The approach used for the Los Alamos Canyon and Pueblo Canyon investigation is based on the ER Project's overall technical approach as described in Chapter 3 of the IWP (LANL 1995, 49822). The technical approach for the Los Alamos Canyon and Pueblo Canyon investigation is described in Chapter 5 of this work plan and is illustrated in Figure 5-1. The general philosophy is to develop and iteratively refine the conceptual model through carefully planned stages of investigation and data interpretation. The data gathered and the subsequent interpretation will be used to define the nature and extent of contamination and the likelihood for contaminant migration in Los Alamos Canyon and Pueblo Canyon.

The technical objectives of the Los Alamos Canyon and Pueblo Canyon investigation, as presented in Chapter 5 of this work plan, are as follows:

- to determine to what extent portions of Los Alamos Canyon and Pueblo Canyon have been or are likely to be affected by the combined releases (in the past and in the immediate future) from all sites that could contribute residual contamination to them and

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

2.1 Technical Implementation Rationale

The scheduling of the investigations is based on the following rationale and priorities, as illustrated in Figure I-1

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

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1.0 INTRODUCTION

This annex contains the Health and Safety (H&S) Plan (hereafter referred to as this H&S plan), which has been developed for the Resource Conservation and Recovery Act (RCRA) RFI investigation for Los Alamos Canyon and Pueblo Canyon. This H&S plan provides the framework within which personal protection will be provided during the implementation of the Los Alamos Canyon and Pueblo Canyon investigation. Site-specific H&S plans will be prepared before beginning any field task. Site-specific H&S plans also will describe the specific measures to be taken for personal protection during implementation of the task and will define individual responsibilities, which are outlined in this H&S plan. Overall health and safety policy for the Environmental Restoration (ER) Project is provided in Chapter 6 of the Installation Work Plan (IWP) (LANL 1995, 49822).

As field investigation progresses, measures for personal protection may be identified that are more effective than those identified in this annex. Deviations from this H&S plan will be documented in the pertinent site-specific H&S plan along with the reasons for that deviation. As changes are required, this H&S plan will be updated.

This H&S plan includes an assessment of potential hazards, justification for personal protection requirements, and site-specific emergency response procedures. A copy of this H&S plan will be kept on-site at all times.

The specific purpose of this annex is to establish guidelines for field workers involved in the Los Alamos Canyon and Pueblo Canyon investigation. A new H&S plan must be initiated for any corrective actions. In addition to general guidance in the IWP, the following regulations and standards were used to develop the procedures set forth in this plan: Laboratory policies, *ES&H Program Documents*, DOE orders, Occupational Safety and Health Administration (OSHA) regulations, National Institute for Occupational Health (NIOSH) standards, American Conference of Governmental Industrial Hygienists (ACGIH) recommendations, Nuclear Regulatory Commission regulations, and Environmental Protection Agency (EPA) guidance. Applicable state and local regulations also will be followed.

The responsibilities of workers with regard to health and safety as described herein do not distinguish whether Laboratory employees or subcontractors are implementing this H&S plan. If it is necessary to modify this H&S plan for implementation, EPA will be notified of any modifications.

Detailed background information, including descriptions of specific site hazards, for the Los Alamos Canyon and Pueblo Canyon investigation is contained in Chapter 2 of this work plan. Detailed maps showing the locations of access roads, topography, and other health and safety related features are contained in Figures A-3 and A-4 in Appendix A of this work plan.

2.0 FIELD UNIT WORK ORGANIZATION

The following information describes policies and standards set forth in this H&S plan, including specific lines of responsibility, standards and regulations, and requirements for audits and variances of health and safety policies.

2.1 General Responsibilities

General RFI investigation responsibilities are outlined in Chapter 6 of the IWP (LANL 1995, 49822). Listed below are specific responsibilities for workers involved in the investigation for the Los Alamos Canyon and Pueblo Canyon.

2.2 Individual Responsibilities

Within line management of the ER Project, certain Laboratory employees and subcontractors have specific health and safety responsibilities. Figure III-1 shows a field work organization chart with line organization responsibilities. Other organizational charts pertinent to the Los Alamos Canyon and Pueblo Canyon investigation are presented in Annex I of this work plan.

2.2.1 Deputy Directors

The deputy directors of the Environmental Management (EM) Program and the Environment, Safety, and Health (ESH) Division are responsible for ensuring that programmatic health and safety concerns are addressed. They also are responsible for promoting a comprehensive health and safety program that covers special areas such as

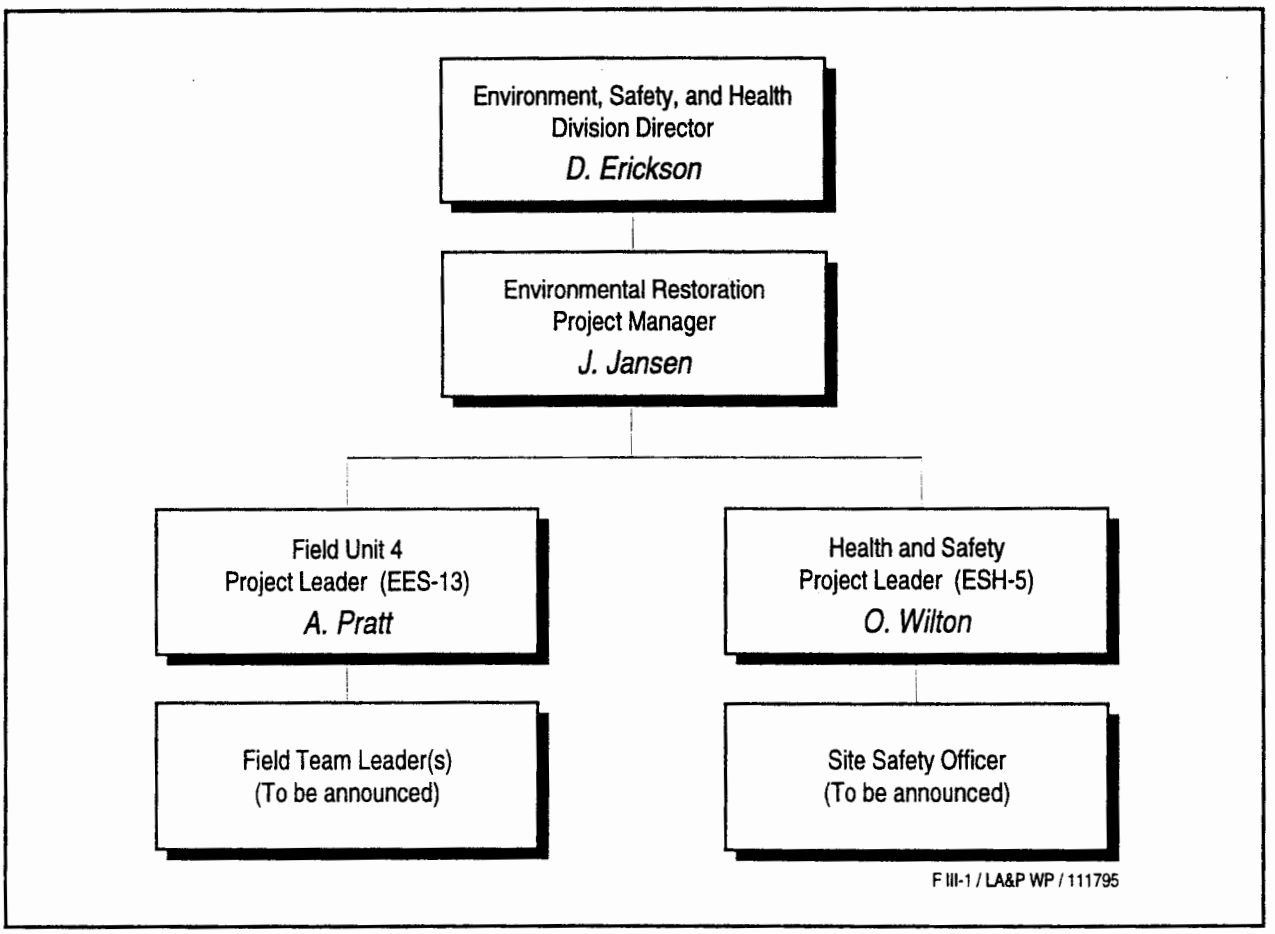


Figure III-1. Field work organization chart.

radiation protection, occupational medicine, industrial safety, industrial hygiene, criticality safety, waste management, and environmental protection and preservation.

2.2.2 Environmental Restoration Project Manager

The ER Project manager is responsible for the overall health and safety program for ER Project activities. The project manager ensures that the health and safety programs are established, implemented, and supported.

2.2.3 Field Unit Health and Safety Representative

The field unit health and safety representative is responsible for updating and implementing the ER Project Health and Safety Plan (Section 6.3.2 of Chapter 6 of the IWP) (LANL 1995, 49822) and for reviewing operable unit H&S plans. The field unit health and safety representative also is responsible for interfacing and coordinating with Laboratory personnel to use resources appropriate for the ER Project health and safety program, and to ensure ER Project compliance with all applicable health and safety policies and regulations. In conjunction with the field team manager, the field unit health and safety representative oversees day-to-day health and safety activities in the field.

2.2.4 Field Project Leader

The field project leader (FPL) is responsible for the RCRA investigations in Los Alamos Canyon and Pueblo Canyon. Specific health and safety responsibilities include

- prepare, review, implement, and revise RFI investigation health and safety documents and
- interface with the field unit health and safety representative to resolve health and safety concerns.

2.2.5 Field Team Leader

The field team leader is responsible for implementing the sampling and analysis plan, this H&S plan, and the quality assurance project plan for the Los Alamos Canyon and Pueblo Canyon investigation. Other health and safety responsibilities include

- ensuring the health and safety of the field team members;
- assigning a site safety officer to ensure compliance with this H&S plan;
- knowing emergency response procedures and notification requirements and their implementation;
- acting as a backup to the site safety officer in the event of an emergency;
- coordinating field activities with Laboratory personnel and subcontractors, as needed;

- reading and complying with this H&S plan; and
- ensuring day-to-day compliance with the health and safety procedures set forth in this H&S plan.

2.2.6 Site Safety Officer

In addition to the responsibilities outlined in Section 6.3.2.3.1 in Chapter 6 of the IWP (LANL 1995, 49822), the following responsibilities specific to the Los Alamos Canyon and Pueblo Canyon investigation also will apply to the site safety officer:

- reading and enforcing this H&S plan;
- evaluating the potential hazards that may exist in either Los Alamos Canyon or Pueblo Canyon;
- being informed about the results of sample analysis pertaining to health and safety as the investigation and remediation work progresses;
- concurring with the field team leader about the location of exclusion area boundaries;
- presenting safety briefings to workers;
- determining protective clothing requirements for workers;
- determining personal dosimetry requirements for workers;
- maintaining a current list of telephone numbers for emergency situations;
- having an operating radio transmitter and receiver in case telephone service is not available;
- maintaining an up-to-date copy of this H&S plan;
- maintaining an up-to-date copy of the emergency plan and procedures for the investigation;
- establishing the safety requirements to be followed by visitors;
- providing visitors with a safety briefing;
- maintaining a logbook of workers and visitors within the exclusion area at a site;
- determining whether workers can perform their jobs safely under prevailing weather conditions;
- taking control of an emergency situation;
- ensuring that all workers have been trained in the appropriate safety procedures and have read and understood this H&S

3.5.4.2 Trench Protection

Trench boxes and trench shields have been developed for trench operations where benching, sloping, and shoring are not feasible. A trench box or shield is a box constructed from a strong metal or wood that is wide enough for workers to move around inside and perform their duties. OSHA regulations specify criteria for the trench box to be considered safe. The trench box is placed in the trench and attached to a backhoe so that it may be pulled along as the work progresses. This type of system is used often in the installation of water systems. The walls of the trench may not be viewed from the box, and protection is voided when workers leave the box.

3.5.4.3 Fire Protection

A fire extinguisher is classed by the type of fire it is designed to extinguish. However, a fire extinguisher may be effective for more than one class of fire.

- Class A - ordinary combustible materials (wood, paper, and textiles)
- Class B - flammable liquids (oil, grease, and paint)
- Class C - electrical fires
- Class D - metals capable of rapid oxidation (magnesium, sodium, zinc, aluminum, uranium, and zirconium)

3.5.4.4 Other Safety Equipment

In addition to the personal protective devices described above, other safety equipment may be used as needed. Laboratory Administrative Requirement 12-2, "Seat Belts," (available on-line) will be followed. Warming and cooling equipment may be necessary to minimize stress from climatic conditions. Emergency equipment will also be necessary for immediate response and emergency treatment. Additionally, the location of such equipment must be clearly marked, and workers should know the location and be trained in its use.

3.5.5 General Safety Practices and Mitigation Measures

Some hazards can be minimized by implementing specific safety procedures, work practices, special equipment, worker training, and emergency response equipment in case of an accident. Sections 6.9 and 6.10 in Chapter 6 of the IWP (LANL 1995, 49822) discuss some of these practices. The following routine measures will be taken.

- Daily planning and/or preactivity meetings will be held for all workers involved in field activities. These meetings will discuss health and safety concerns and refresh workers on the emergency response plans.
- Control zones will be established for safety as well as contamination and decontamination procedures. The type and size of the control zones will depend on the type of field activity to be conducted. The level of protection will be based on site-specific RFI investigation areas. For informational and medical support, control zones will have maps posted that identify direct routes to administrative and medical facilities.

- If troublesome levels of dust are generated during augering or drilling activities, water may be used to suppress dust for the protection of field workers.

- The buddy system will be employed as a general practice.

3.6 Site Access Control

3.6.1 Restricted Access and Exclusion Zones

Restricted access or exclusion zones will be established before work begins at contaminated sites to protect workers from unnecessary exposure to toxic materials and to prevent the spread of contamination. A general description of exclusion zones is found in Section 6.5 in Chapter 6 of the IWP (LANL 1995, 49822).

3.6.2 Decontamination

Workers, equipment, and vehicles that have been located in contaminated areas may carry residual contamination. Although protective clothing, respirators, and good work practices can help reduce contamination, decontamination may be necessary to prevent exposure of workers and the inadvertent spread of contaminants.

Vehicles and equipment that are suspected of being contaminated will be cleaned with high-pressure steam or equally effective systems. Vehicles and equipment suspected of being contaminated with alpha contamination will be screened with alpha survey instruments before being released from the site.

Worker decontamination can be performed in all levels of protection. Disposable protective equipment does not need to be decontaminated but should be disposed of as a hazardous waste. Reusable protective equipment must be decontaminated using a soap and water wash and two successive rinses. Visual inspections of the equipment will help determine the effectiveness of the decontamination process. As with the equipment, workers will be screened with an alpha scintillometer when working with or near alpha-contaminated material. ER Project SOPs, established to guide the decontamination process, will be maintained on-site and will be followed at all times. Worker decontamination procedures are specified in the ER Project HASP. Laboratory Administrative Requirements for Waste Management are 10-1, "Radioactive Liquid Waste," 10-2, "Low-Level Radioactive Solid Waste," 10-3, "Hazardous and Mixed Waste," and 10-5, "Transuranic (TRU) Solid Waste," which are available on-line.

In addition to the following list, Section 6.8 in Chapter 6 of the IWP (LANL 1995, 49822) contains information on decontamination.

- The level of decontamination required will depend on the nature and magnitude of contamination and the type of protective clothing worn. Disposable clothing (for example, Tyvek) will not be washed because water may transport contamination through the paper garment to the skin.

- Waste water and materials used during decontamination will be contained for appropriate disposal. Arrangements will be made with the Laboratory for acquisition and disposal of drums containing soapy water, rinse water, methanol, and trash.

1.0 OVERVIEW OF PUBLIC INVOLVEMENT PLAN

The Public Involvement Plan specific to the Los Alamos Canyon and Pueblo Canyon RFI investigation follows the directives, goals, and regulatory requirements set forth in Chapter 7 of the Installation Work Plan for the Environmental Restoration (ER) Project (LANL 1995, 49822) and the "Plan for Increasing Public Participation in Cleanup Decisions for the Los Alamos National Laboratory" (Working Group and Lefkoff 1995, 44013), which was developed with public input.

This Public Involvement Plan was developed specifically to provide an avenue for meaningful public participation in making recommendations for cleanup decisions at the Laboratory. In addition, recommendations were made to develop effective communications between the neighboring communities (including the Pueblos) and the ER Project staff during the investigation, characterization, and cleanup activities at the Laboratory.

The Laboratory, as a hazardous waste treatment, storage, and disposal facility, operates under a Resource Conservation and Recovery Act permit issued by the New Mexico Environment Department. Module VIII of this permit, the Hazardous and Solid Waste Amendments (HSWA) Module, issued by the Environmental Protection Agency (EPA 1990, 1585), governs all environmental restoration activities. The HSWA Module requires the ER Project to perform certain activities for public involvement, such as

* establishing a mailing list of interested parties;
* creating fact sheets, news releases, work plans, final reports, newsletters, and quarterly technical reports;
* creating a public information repository and reading room for ER Project materials;
* conducting informational meetings for the public;
* conducting tours and briefings; and
* establishing procedures for immediate notification of neighboring Pueblos or other affected parties if a newly discovered off-site release could impact them.

Although the ER Project public involvement effort has implemented these activities since 1991, beginning in 1994 the ER Project has expanded its effort to develop a more broad-based approach for outreach to other northern New Mexico communities. This effort is supported by the following goals:

* broaden the base of involved individuals and groups;
* begin to build trust by focusing on personal contact, dialogue, and mutual education;
* obtain meaningful public input on decisions regarding cleanup issues; and
* learn a better, more cost-effective way of involving the public early in major activities of the ER Project.

To accomplish those goals, the following objectives have been established:

- make information readily available and give to the public the information it needs to understand environmental restoration cleanup issues and provide the ER Project with recommendations;
- respond to requests for information as soon as possible;
- increase contacts with the public in ways that encourage interaction, such as establishing dialogues with members of community organizations;
- use community leaders, as well as Laboratory and ER Project representatives who live in the neighboring communities, as community contacts;
- involve the public in the cleanup process before decisions are made;
- treat the public as equals;
- ask for assistance from community members and use them as experts on their community's concerns and needs;
- develop alternatives for determining cleanup levels and site prioritization; and
- evaluate the effectiveness and efficiency of each of the public participation activities.

2.0 PUBLIC INVOLVEMENT ACTIVITIES

2.1 Information Sheets

The Community Involvement and Outreach Office staff will prepare information sheets for the Los Alamos Canyon and Pueblo Canyon activities and update the sheets whenever new information becomes available. Information sheets will be reviewed by ER Project staff and informally reviewed by members of the public before they are completed.

2.2 Dissemination of Information

Information on Los Alamos Canyon and Pueblo Canyon will be distributed via the existing mailing list of approximately 2000 individuals and organizations. In addition, information materials will be available at the Laboratory Community Reading Room (1350 Central Avenue in Los Alamos) and in the information repositories at the public libraries of Santa Fe, Española, and Los Alamos. The Governor's Office at San Ildefonso Pueblo will also have information available to Pueblo members. Anyone who would like more information about the ER Project can call 1-800-357-8301.

Ashley Pond who established the Los Alamos Ranch School (Foxx and Tierney 1984, 5950). Dr. J. Robert Oppenheimer and General Leslie R. Groves (commanding officer of the Manhattan Project) decided that the Pajarito Plateau was ideal for the final research, design, and assembly facility for the Manhattan Project. Condemnation proceedings for the Los Alamos Ranch School began in November 1942; in February 1943 it closed (Graf 1993, 23251).

2.2.3 Los Alamos National Laboratory Operational Use

Extensive archival searches, examination of aerial photographs, and interviews with many former Laboratory employees have established that the Laboratory has used the land in Los Alamos Canyon and Pueblo Canyon continuously since the mid-1940s.

Use of the canyons system at the Laboratory began at a small branch of Pueblo Canyon known as Acid Canyon where radioactive liquid wastes from Manhattan Engineer District/Atomic Energy Commission operations were discharged between late 1943 or early 1944 and June 1964. Initially, wastes were untreated. A treatment plant (at former TA-45) on the rim of Acid Canyon was constructed and began operation in April 1951 providing chemical treatment (which was developmental for the times) for reduction of radionuclide concentrations. The treatment plant was decommissioned in late 1966, and decontamination work at the site and in Acid Canyon began in 1967. By June 1967, the treatment plant and Acid Canyon were deemed sufficiently free of contamination to be released from Atomic Energy Commission control without restrictions. The treatment plant site and a portion of Pueblo Canyon were transferred to Los Alamos County by quitclaim deed on July 1, 1967 (LANL 1981, 6059). Additional decontamination work was performed in 1982 (see Section 2.5.4 for more details).

Los Alamos Canyon and Pueblo Canyon continue to receive discharges of treated wastewater, both industrial and domestic, to the present day. The history of waste treatment and discharges and the potential contamination resulting from them are discussed in greater detail in this chapter.

These and other uses of the canyons and adjacent mesas, and potential resulting contamination, are discussed further in Sections 2.4 and 2.5.

2.2.4 Current Recreational Use

Los Alamos Canyon is a popular recreational area for local residents. Camping and picnic areas are located near Los Alamos Reservoir, and the reservoir itself is used for fishing and some swimming. The Los Alamos County Ice Rink is located in TA-62 west of TA-43.

In addition to joggers, hikers, and bird watchers who frequent the area, Pueblo Canyon is often visited by those people who are interested in the numerous archeological sites within the canyon.

2.3 Environmental Monitoring

The Environmental Surveillance Group (ESG) at the Laboratory has conducted environmental monitoring in Los Alamos Canyon and Pueblo Canyon since 1966. Results of this monitoring are reported in the Laboratory's annual environmental surveillance reports and other special reports (ESG 1990, 6995; Elder and Knoell 1986, 6670; Montoya 1991, 6997). These reports provide the basis for the following discussion.

During the past several decades, data have been collected from seven alluvial monitoring wells located in Los Alamos Canyon: LAO-C, LAO-1, LAO-2, LAO-3, LAO-4, LAO-4.5, and LAO-5. The results, especially during the last decade, confirm contamination of the shallow alluvial ground water, primarily with low to moderate levels of tritium, ^{137}Cs, and ^{90}Sr (ESG 1990, 6995). The chemical composition of water from these wells is discussed in detail in Section 4.4.3 of the *RFI Work Plan for Operable Unit 1098* (LANL 1993, 21404). These wells and the contamination data are discussed in greater detail in Chapter 3 of this work plan.

Measurable surface sediment contamination by radionuclides has been found within the Los Alamos Canyon creek channel west of the confluence with Pueblo Canyon at state road 4 (LANL 1993, 21404; LANL 1991, 7528; LANL 1991, 7529; LANL 1991, 7680; LANL 1981, 6059). Radionuclide contamination above background levels has been observed in surface sediment samples taken west of TA-41 and in surface sediment and shallow (alluvial) ground water samples taken east of TA-2. These data and the recent Environmental Restoration (ER) Project work (which is the source of the data) are discussed at greater length in Chapter 3 of this work plan. Near-surface, low-level radionuclide releases occurred within TA-2 and TA-21 (LANL 1993, 21404; LANL 1991, 7529); individual sediment samples have shown concentrations (expressed as activities per unit mass of sediment) of ^{137}Cs that exceed the screening action level (SAL) of 4 pCi/g (LANL 1993, 21404). This contamination is attributable primarily to TA-2 but also to TA-21 (LANL 1993, 21404; LANL 1991, 7528; LANL 1991, 7529; LANL 1991, 7680; LANL 1981, 6059).

Previous studies indicate that most radionuclides (excluding ^{90}Sr) are transported on suspended sediments and in the bedload (LANL 1981, 6059). These sediments are transported during storm flows. Therefore, contaminant distributions like those described above may be expected to vary substantially spatially as well as temporally. Additional discussion of the nature of this surface contamination in Los Alamos Canyon is provided in the *RFI Work Plan for Operable Unit 1098* (LANL 1993, 21404) and in Chapter 3 of this work plan.

2.4 Internal Sources of Potential Contamination—Los Alamos Canyon

This section discusses the sources of potential contamination that originated from activities conducted within Los Alamos Canyon. No similar sources exist in Pueblo Canyon. Sources of potential contamination originating from SWMUs on the mesa tops or from other canyons are discussed in Section 2.5. The activities that directly contaminated Los Alamos Canyon occurred at the two technical areas located within the canyon: TA-2 and TA-41. The locations of these technical areas are shown in Figure 2-2. The locations of PRSs (SWMUs and AOCs) discussed herein are shown in Figure A-5 in Appendix A of this work plan.

TA-2 and TA-41 have been used continuously since 1943. TA-2 has housed a series of research nuclear reactors; TA-41 is used for weapons development and long-term studies of weapon subsystems. The most probable contaminants from these activities are radiological and chemical constituents including uranium, plutonium, tritium, ^{90}Sr, ^{137}Cs, other fission products, chromium, mercury, acids, and solvents.

2.4.1 Technical Area 2

TA-2 has been used to house a series of small research reactors (Bunker 1983, 44020). The first three reactors at TA-2, including the first water boiler reactor, were homogeneous, liquid-fueled systems that were operated in succession. They were fueled by aqueous uranyl solutions enriched with ^{235}U. The last of the liquid-fueled reactors was deactivated in 1974.

MAP/OTHER

(See Non-Scanned Objects for Location and Description)

6.0 RISK ASSESSMENT MODELS AND APPROACH

The approach to assessment of present-day human health and ecological risk and the projection of future trends in risk is provided in Chapter 6 of the *Core Document for Canyons Investigations* (LANL 1997, 55622).

Comprehensive plant and animal inventories are required by the Federal Endangered Species Act of 1973; the New Mexico Wildlife Conservation Act; Executive Order 11990, entitled "Protection of Wetlands"; Executive Order 11988, entitled "Floodplain Management"; 10 CFR 1022; DOE Compliance with Floodplain/Wetlands Environmental Review Requirements (DOE 1979); and DOE Order 5400.1, entitled "General Environmental Protection Program" (DOE 1988). The required inventories have been performed for the Los Alamos Canyon and Pueblo Canyon watersheds, and the habitat description will be included in the ecological RFI report prepared for the Ecological Exposure Unit in which these canyons are located.

The Laboratory is developing a new approach for ecological risk assessment in cooperation with EPA Region 6 and NMED. Further discussion of ecological risk assessment methodology will be deferred until the Ecological Exposure Unit methodology that is being developed has been approved by the regulators (LANL 1997, 56024).

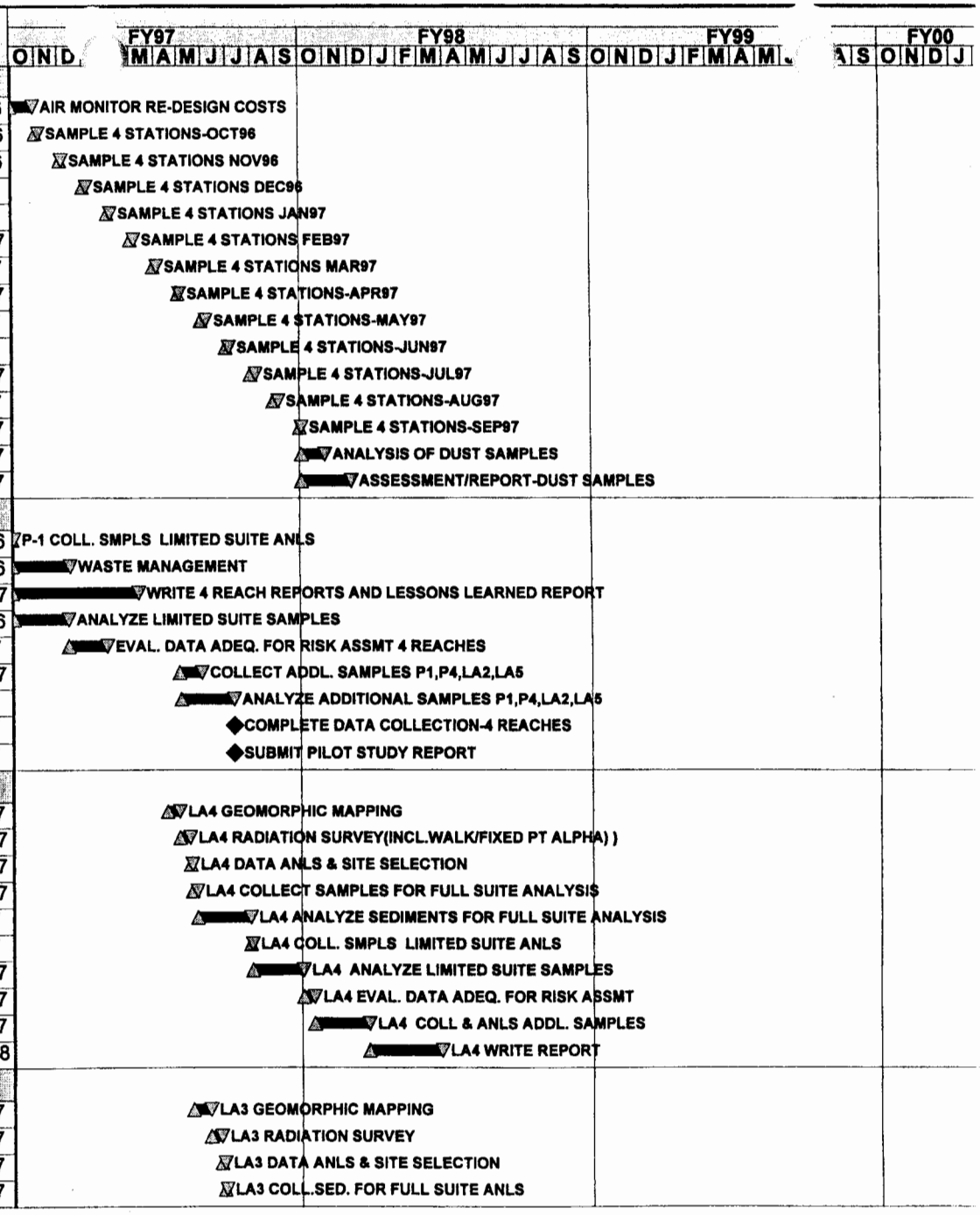
In addition to the potential remedial actions discussed in Chapter 6 of the core document, stabilization and other interim measures will be implemented in areas that contain significant contamination as they are found. The Laboratory will develop internal criteria for signalling interim actions and discuss these criteria with NMED. The Laboratory will also evaluate the use of Best Management Practices for areas where contaminated sediments could be mobilized by discharges of potable water to the canyon floor such as at TA-53 and supply well Otowi-4.

References for Chapter 6

LANL (Los Alamos National Laboratory), March 14, 1997. "Ecological Risk Assessment Methodology for Los Alamos National Laboratory," (draft), Ecological Risk Assessment Team, Environmental Science Group, Los Alamos National Laboratory, Los Alamos, New Mexico. **(LANL 1997, ER ID Number 56024)**

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

Activity description	Orig dur	Early Start	Early Finish
DUST STATIONS			
AIR MONITOR RE-DESIGN COSTS	20	01OCT96	29OCT96
SAMPLE 4 STATIONS-OCT96	3	31OCT96*	04NOV96
SAMPLE 4 STATIONS NOV96	3	02DEC96*	04DEC96
SAMPLE 4 STATIONS DEC96	3	31DEC96*	03JAN97
SAMPLE 4 STATIONS JAN97	3	31JAN97*	04FEB97
SAMPLE 4 STATIONS FEB97	3	28FEB97*	04MAR97
SAMPLE 4 STATIONS MAR97	3	31MAR97*	02APR97
SAMPLE 4 STATIONS-APR97	3	30APR97*	02MAY97
SAMPLE 4 STATIONS-MAY97	3	30MAY97*	03JUN97
SAMPLE 4 STATIONS-JUN97	3	30JUN97*	02JUL97
SAMPLE 4 STATIONS-JUL97	3	31JUL97*	04AUG97
SAMPLE 4 STATIONS-AUG97	3	29AUG97*	03SEP97
SAMPLE 4 STATIONS-SEP97	3	30SEP97*	02OCT97
ANALYSIS OF DUST SAMPLES	20	03OCT97	31OCT97
ASSESSMENT/REPORT-DUST SAMPLES	40	03OCT97	03DEC97
REACH P-1,P-4,LA-2,LA-5 LOS ALAMOS/PUEBLO CANYON			
P-1 COLL. SMPLS LIMITED SUITE ANLS	2	01OCT96*	02OCT96
WASTE MANAGEMENT	50	01OCT96	13DEC96
WRITE 4 REACH REPORTS AND LESSONS LEARNED	106	01OCT96	10MAR97
ANALYZE LIMITED SUITE SAMPLES	45	03OCT96	10DEC96
EVAL. DATA ADEQ. FOR RISK ASSMT 4 REACHES	32	11DEC96	29JAN97
COLLECT ADDL. SAMPLES P1,P4,LA2,LA5	20	01MAY97*	29MAY97
ANALYZE ADDITIONAL SAMPLES P1,P4,LA2,LA5	45	02MAY97	07JUL97
COMPLETE DATA COLLECTION-4 REACHES	0		07JUL97
SUBMIT PILOT STUDY REPORT	0		07JUL97
REACH LA-4, LOS ALAMOS CANYON			
LA4 GEOMORPHIC MAPPING	10	15APR97*	28APR97
LA4 RADIATION SURVEY(INCL.WALK/FIXED PT ALPHA)	10	29APR97	12MAY97
LA4 DATA ANLS & SITE SELECTION	3	13MAY97	15MAY97
LA4 COLLECT SAMPLES FOR FULL SUITE ANALYSIS	5	16MAY97	22MAY97
LA4 ANALYZE SEDIMENTS FOR FULL SUITE ANALYSIS	45	23MAY97	28JUL97
LA4 COLL. SMPLS LIMITED SUITE ANLS	2	29JUL97	30JUL97
LA4 ANALYZE LIMITED SUITE SAMPLES	45	31JUL97	02OCT97
LA4 EVAL. DATA ADEQ. FOR RISK ASSMT	8	03OCT97	15OCT97
LA4 COLL & ANLS ADDL. SAMPLES	45	16OCT97	22DEC97
LA4 WRITE REPORT	60	23DEC97	23MAR98
REACH LA-3, LOS ALAMOS CANYON			
LA3 GEOMORPHIC MAPPING	15	15MAY97*	05JUN97
LA3 RADIATION SURVEY	10	06JUN97	19JUN97
LA3 DATA ANLS & SITE SELECTION	3	20JUN97	24JUN97
LA3 COLL.SED. FOR FULL SUITE ANLS	2	25JUN97	26JUN97



Project Start	01OCT89
Project Finish	29DEC05
Data Date	01OCT96
Run Date	03JUL97

Early Bar
Progress Bar
Critical Activity

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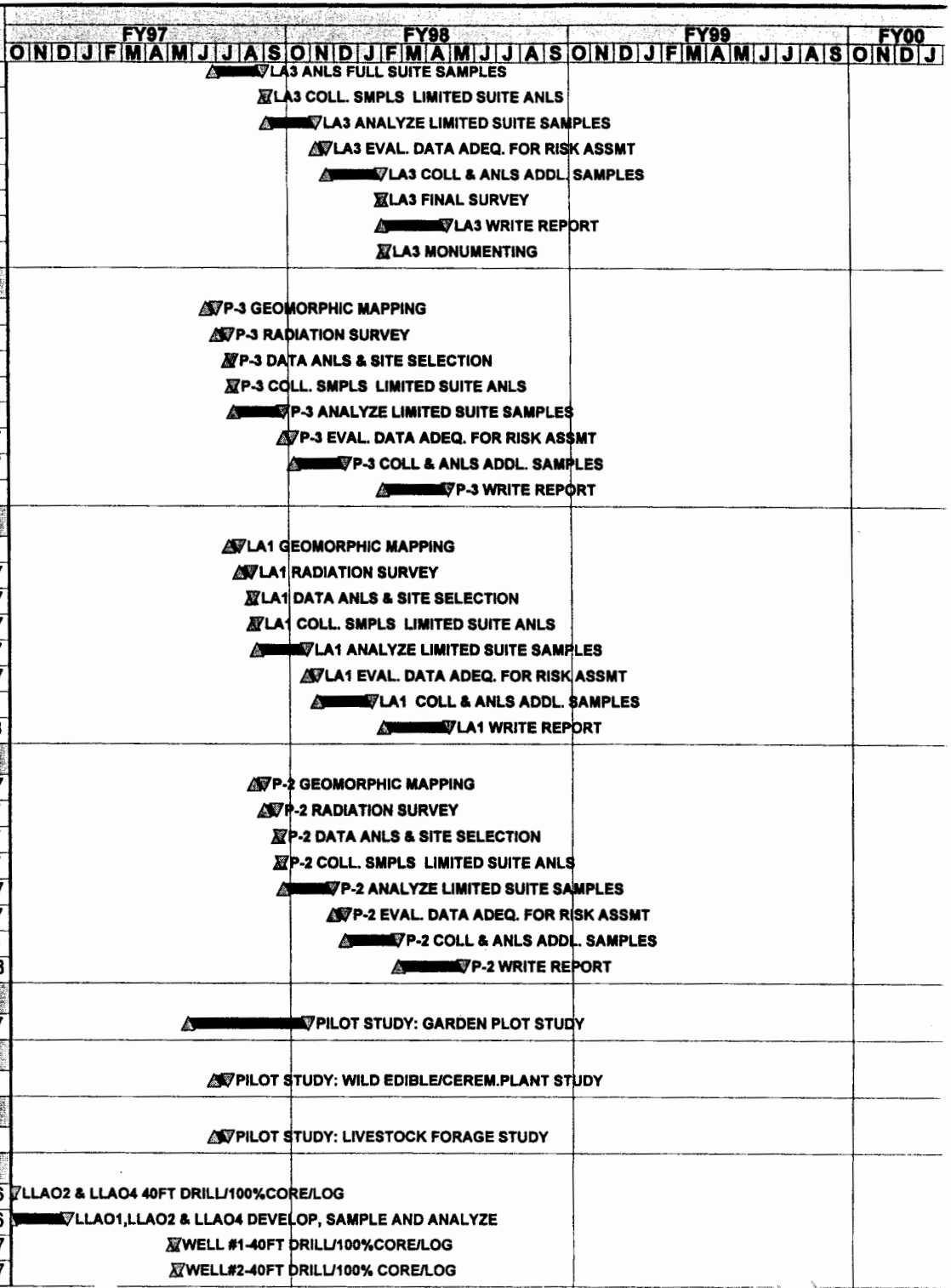
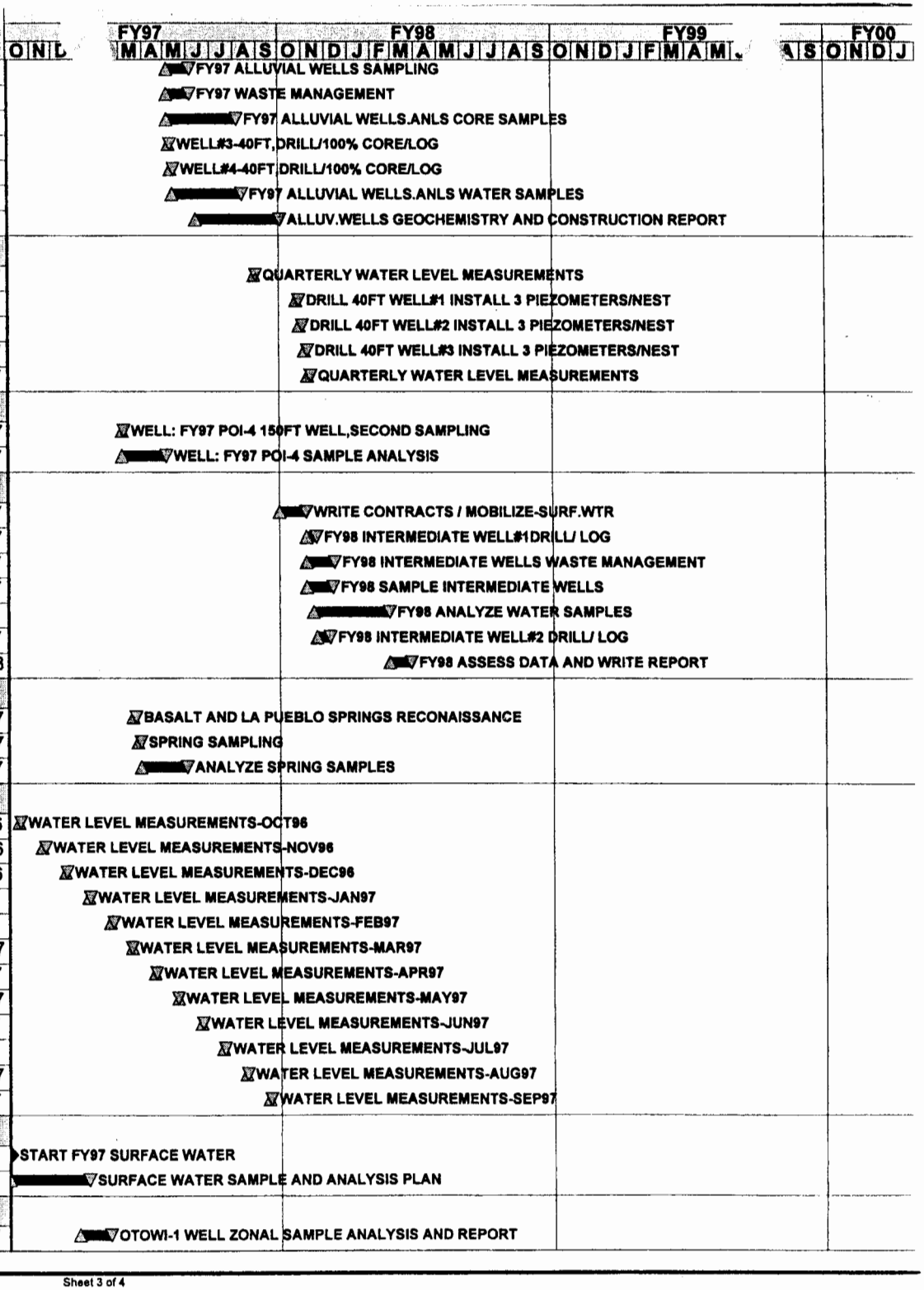
Figure I-1
Schedule for Los Alamos and Pueblo Canyon Field Work

Activity description	Orig dur	Early Start	Early Finish
LA3 ANLS FULL SUITE SAMPLES	45	27JUN97	29AUG97
LA3 COLL. SMPLS LIMITED SUITE ANLS	2	02SEP97	03SEP97
LA3 ANALYZE LIMITED SUITE SAMPLES	45	04SEP97	06NOV97
LA3 EVAL. DATA ADEQ. FOR RISK ASSMT	8	07NOV97	19NOV97
LA3 COLL & ANLS ADDL. SAMPLES	45	20NOV97	29JAN98
LA3 FINAL SURVEY	1	30JAN98	30JAN98
LA3 WRITE REPORT	60	30JAN98	24APR98
LA3 MONUMENTING	2	02FEB98	03FEB98
REACH P-3, PUEBLO CANYON			
P-3 GEOMORPHIC MAPPING	10	16JUN97*	27JUN97
P-3 RADIATION SURVEY	10	30JUN97	14JUL97
P-3 DATA ANLS & SITE SELECTION	3	15JUL97	17JUL97
P-3 COLL. SMPLS LIMITED SUITE ANLS	2	18JUL97	21JUL97
P-3 ANALYZE LIMITED SUITE SAMPLES	45	22JUL97	23SEP97
P-3 EVAL. DATA ADEQ. FOR RISK ASSMT	8	24SEP97	03OCT97
P-3 COLL & ANLS ADDL. SAMPLES	45	06OCT97	11DEC97
P-3 WRITE REPORT	60	30JAN98	24APR98
REACH LA-1, LOS ALAMOS CANYON			
LA1 GEOMORPHIC MAPPING	10	15JUL97*	28JUL97
LA1 RADIATION SURVEY	10	29JUL97	11AUG97
LA1 DATA ANLS & SITE SELECTION	3	12AUG97	14AUG97
LA1 COLL. SMPLS LIMITED SUITE ANLS	2	15AUG97	18AUG97
LA1 ANALYZE LIMITED SUITE SAMPLES	45	19AUG97	22OCT97
LA1 EVAL. DATA ADEQ. FOR RISK ASSMT	8	23OCT97	03NOV97
LA1 COLL & ANLS ADDL. SAMPLES	45	04NOV97	13JAN98
LA1 WRITE REPORT	60	30JAN98	24APR98
REACH P-2, PUEBLO CANYON			
P-2 GEOMORPHIC MAPPING	10	15AUG97*	28AUG97
P-2 RADIATION SURVEY	10	29AUG97*	12SEP97
P-2 DATA ANLS & SITE SELECTION	3	15SEP97	17SEP97
P-2 COLL. SMPLS LIMITED SUITE ANLS	2	18SEP97	19SEP97
P-2 ANALYZE LIMITED SUITE SAMPLES	45	22SEP97	25NOV97
P-2 EVAL. DATA ADEQ. FOR RISK ASSMT	8	26NOV97	09DEC97
P-2 COLL & ANLS ADDL. SAMPLES	45	10DEC97	17FEB98
P-2 WRITE REPORT	60	18FEB98	12MAY98
GARDEN PLOT STUDY			
PILOT STUDY: GARDEN PLOT STUDY	109	19MAY97*	22OCT97
WILD EDIBLE/CEREMONIAL PLANT STUDY			
PILOT STUDY: WILD EDIBLE/CEREM.PLANT STUDY	13	23JUN97*	10JUL97
LIVESTOCK FORAGE STUDY			
PILOT STUDY: LIVESTOCK FORAGE STUDY	13	23JUN97*	10JUL97
ALLUVIAL WELLS			
LLAO2 & LLAO4 40FT DRILL/100%CORE/LOG	4	01OCT96	04OCT96
LLAO1,LLAO2 & LLAO4 DEVELOP, SAMPLE AND	49	02OCT96	13DEC96
WELL #1-40FT DRILL/100%CORE/LOG	2	01MAY97*	02MAY97
WELL#2-40FT DRILL/100% CORE/LOG	2	05MAY97	06MAY97



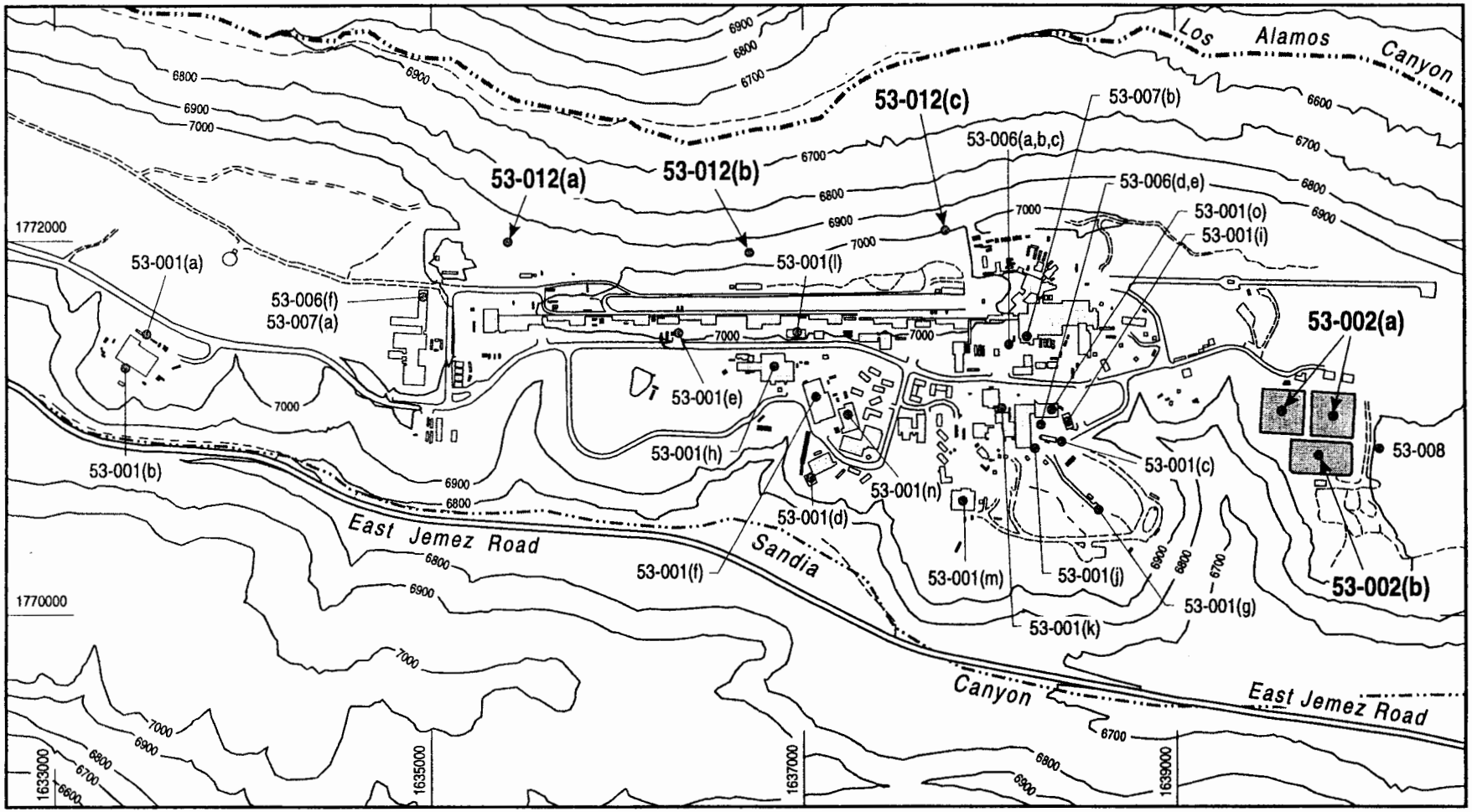
Activity description	Orig dur	Early Start	Early Finish
FY97 ALLUVIAL WELLS SAMPLING	22	05MAY97	04JUN97
FY97 WASTE MANAGEMENT	22	05MAY97	04JUN97
FY97 ALLUVIAL WELLS.ANLS CORE SAMPLES	65	05MAY97	05AUG97
WELL#3-40FT,DRILL/100% CORE/LOG	2	07MAY97	08MAY97
WELL#4-40FT,DRILL/100% CORE/LOG	2	09MAY97	12MAY97
FY97 ALLUVIAL WELLS.ANLS WATER SAMPLES	65	12MAY97	12AUG97
ALLUV.WELLS GEOCHEMISTRY AND CONSTRUCTION	80	11JUN97	02OCT97
ALLUVIAL WELLS: PIEZOMETER NESTS			
QUARTERLY WATER LEVEL MEASUREMENTS	2	28AUG97*	29AUG97
DRILL 40FT WELL#1 INSTALL 3 PIEZOMETERS/NEST	4	22OCT97	27OCT97
DRILL 40FT WELL#2 INSTALL 3 PIEZOMETERS/NEST	4	28OCT97	31OCT97
DRILL 40FT WELL#3 INSTALL 3 PIEZOMETERS/NEST	4	03NOV97	06NOV97
QUARTERLY WATER LEVEL MEASUREMENTS	2	07NOV97*	11NOV97
INTERMEDIATE WELLS-FY97			
WELL: FY97 POI-4 150FT WELL,SECOND SAMPLING	2	03MAR97*	04MAR97
WELL: FY97 POI-4 SAMPLE ANALYSIS	45	03MAR97	02MAY97
INTERMEDIATE WELLS - FY98-01			
WRITE CONTRACTS / MOBILIZE-SURF.WTR	23	01OCT97*	03NOV97
FY98 INTERMEDIATE WELL#1DRILL/ LOG	10	04NOV97	18NOV97
FY98 INTERMEDIATE WELLS WASTE MANAGEMENT	25	04NOV97	11DEC97
FY98 SAMPLE INTERMEDIATE WELLS	22	06NOV97	10DEC97
FY98 ANALYZE WATER SAMPLES	65	14NOV97	23FEB98
FY98 INTERMEDIATE WELL#2 DRILL/ LOG	10	19NOV97	04DEC97
FY98 ASSESS DATA AND WRITE REPORT	20	24FEB98	23MAR98
SPRINGS RECONNAISSANCE LOS ALAMOS/PUEBLO-FY97			
BASALT AND LA PUEBLO SPRINGS RECONAISSANCE	5	17MAR97*	21MAR97
SPRING SAMPLING	3	24MAR97	26MAR97
ANALYZE SPRING SAMPLES	45	27MAR97	29MAY97
WATER LEVEL MEASUREMENTS			
WATER LEVEL MEASUREMENTS-OCT96	2	15OCT96*	16OCT96
WATER LEVEL MEASUREMENTS-NOV96	2	15NOV96*	18NOV96
WATER LEVEL MEASUREMENTS-DEC96	2	16DEC96*	17DEC96
WATER LEVEL MEASUREMENTS-JAN97	2	15JAN97*	16JAN97
WATER LEVEL MEASUREMENTS-FEB97	2	14FEB97*	18FEB97
WATER LEVEL MEASUREMENTS-MAR97	1	14MAR97*	14MAR97
WATER LEVEL MEASUREMENTS-APR97	1	15APR97*	15APR97
WATER LEVEL MEASUREMENTS-MAY97	1	15MAY97*	15MAY97
WATER LEVEL MEASUREMENTS-JUN97	1	16JUN97*	16JUN97
WATER LEVEL MEASUREMENTS-JUL97	1	15JUL97*	15JUL97
WATER LEVEL MEASUREMENTS-AUG97	1	15AUG97*	15AUG97
WATER LEVEL MEASUREMENTS-SEP97	1	15SEP97*	15SEP97
SURFACE WATER-FY97			
START FY97 SURFACE WATER	0	01OCT96*	
SURFACE WATER SAMPLE AND ANALYSIS PLAN	69	01OCT96	15JAN97
MAIN AQUIFER			
OTOWI-1 WELL ZONAL SAMPLE ANALYSIS AND	30	02JAN97*	13FEB97



Activity description	Orig dur	Early Start	Early Finish
CHARACTERIZATION REPORTS			
WRITE SUMMARY REPORT FOR LA AND PUEBLO	250	30SEP97*	30SEP98

FY97 O N D J F M A M J J A S | FY98 O N D J F M A M J J A S | FY99 O N D J F M A M J J A S | FY00 O N D J

WRITE SUMMARY REPORT FOR LA AND PUEBLO C/



Source: FIMAD G103873 06 Oct 95

F 2-7 / LA&P WP / 112595

Building or structure
Surface impoundment
Paved road
Potential release site (PRS)
Ephemeral stream
Unimproved road or trail
100-ft contour intervals

N

0 500 1000
FEET
Coordinates are NMSP NAD-83

Figure 2-7. Location of TA-53 relative to Los Alamos Canyon.

2.5.5.1 Direct Disposal into Los Alamos Canyon

Known and potential discharges into Los Alamos Canyon come from the drains and outfalls (SWMU Nos. 53-012[a through c]) and from waste-treatment lagoons (SWMU Nos. 53-002[a and b]) (LANL 1990, 7511). The drain lines to the outfalls serve cooling towers for the injector, the acceleration area, and the beam stop. The SWMU report (LANL 1990, 7511) indicates that 140,000 gal. of water per day was discharged into Los Alamos Canyon when the facility was in full operation. It is not known whether radionuclides (from potential leakage from heat exchangers or neutron activation products) released in this cooling water reached the stream in Los Alamos Canyon.

Two of the lagoons contain a mixture of industrial and sanitary waste (SWMU No. 53-002[a]) and discharge from an outfall permitted under NPDES (number 095). The third lagoon (SWMU No. 53-002[b]) receives radioactive waste and does not have an outfall. The sludge has never been removed from these lagoons. The SWMU report states that all sludge samples from the lagoons indicate contamination with a variety of short-lived radionuclides (with half-lives less than six years and most less than three years) and tritium.

2.5.5.2 Mesa-Top Contamination

Most of the other types of SWMUs at TA-53 have the potential to release contaminants into Los Alamos Canyon, although that potential should be reduced by remedial activities conducted by Field Unit 2. The SWMU report (LANL 1990, 7511) lists the likely contaminants in each SWMU type and provides the basis for the following discussion.

Waste storage areas (SWMU No. 53-001) contain (or have contained) solvents (in liquid form and absorbed on rags), contaminated oils, Freon and other organic chemicals, low-level radioactive waste, photographic chemicals, epoxy resins, solid wastes, lead, cadmium, and radionuclide-contaminated oil mixed with vermiculite.

The underground storage tanks (SWMU No. 53-006) contain (or have contained) resins or water contaminated with short-lived radionuclides and possibly contaminated with acids and organic chemicals. The aboveground storage tanks (SWMU No. 53-007) contain mixed waste, solvents, and organic chemicals (including some carcinogens). However, the SWMU report is not specific. The boneyard (SWMU No. 53-008) contains locked trailers, drums, steel shielding blocks, concrete, radioactively contaminated or activated equipment, and general debris. Radionuclides are the expected contaminants. Other SWMU types are not known to have released any contaminants, or they have been remedied by prior actions (LANL 1990, 7511).

(LANL 1995, 49822). These systems occur at depths of less than 350 ft between TA-2 and the confluence of DP Canyon with Los Alamos Canyon. A chemically distinct perched water zone was noted at a depth of 317 ft in the uppermost portion of the Puye Formation in borehole LAOI(A)-1.1. Perched water is found at a depth of 117 ft in TW-2A in the middle reach of Pueblo Canyon and at approximately 253 ft in supply well Otowi-4 in the middle reach of Los Alamos Canyon (Purtymun and Stoker 1988, 6879). The perching may be caused by a 5- to 10-ft-thick clay layer in the upper fanglomerate section of the Puye Formation. Perched water was also encountered in the boreholes for Otowi-1 in lower Pueblo Canyon at 183 ft in the fanglomerate member of the Puye Formation, and for PM-1 in Sandia Canyon at 450 ft in the Cerros del Rio basalt (Purtymun 1995, 45344).

The borehole for TW-1A was drilled to a depth of 225 ft and penetrated an intermediate perched zone within the Cerros del Rio basalts in Pueblo Canyon. Water infiltrating from the alluvium recharges perched water in the Cerros del Rio basalt interbedded with the Puye Formation under middle and lower Pueblo Canyon (LANL 1981, 6059). This body of perched ground water occurs at depths of 121 ft in TW-2A in middle Pueblo Canyon and at depths of about 160 to 230 ft in TW-1A in lower Pueblo Canyon.

Within the fractured basalts and the Puye Formation, ground water movement is probably to the east/southeast. Some of this ground water discharges at Basalt Spring in lower Los Alamos Canyon about 0.6 mi below its confluence with Pueblo Canyon.

This perched water is monitored by ground water samples collected from TW-1A and from the discharge at Basalt Spring in lower Los Alamos Canyon. Nonradioactive contaminants (including chloride and nitrate) have been detected in water samples collected from Basalt Spring (see Section 3.7.3.3) (Environmental Protection Group 1994, 35363). The most likely source of these contaminants is the Los Alamos County sewage treatment plant. More recently, low-detection-limit measurements of tritium and ^{14}C have shown the presence of Laboratory contaminants in samples of the intermediate perched zone ground water collected from TW-1A and Basalt Spring.

3.6.4 Main Aquifer

The main aquifer occurs in the sediments of the Santa Fe Group at a depth of approximately 800 ft below the floor of Los Alamos Canyon in TW-3 and in supply well Otowi 4 (Figure 3-12), both located at the confluence of DP Canyon with Los Alamos Canyon (at the east end of TA-21).

Ground-water-level measurements taken in deep observation wells located on the Pajarito Plateau indicate that the elevation of the potentiometric surface of the main aquifer rises westward from the Rio Grande through the Santa Fe Group and the lower part of the volcanic and sedimentary rock units beneath the central and western part of the Pajarito Plateau (Purtymun and Johansen 1974, 11835) (Figure 3-16). The hydraulic gradient indicates that ground water moves eastward toward the Rio Grande, where part of it discharges into the Rio Grande through seeps and springs (LANL 1995, 49822; Purtymun et al. 1980, 6048).

The primary recharge area to the main aquifer is apparently located to the west in the flanks of the Sierra de los Valles, but neither the locations nor the major mechanisms of recharge are known. Recharge to the main aquifer may occur within Los Alamos Canyon in areas where bedrock units such as the Otowi Member of the Bandelier Tuff, Guaje Pumice Bed, Puye Formation, and the Santa Fe Group consist of coarse-grained

materials. Coarse-grained materials are found especially in lower Los Alamos Canyon. Fractured Cerros del Rio basalt may also provide recharge pathways. Other possible zones of recharge include the Guaje Mountain, Rendija Canyon, and Pajarito fault zones, and possibly the other fault zones.

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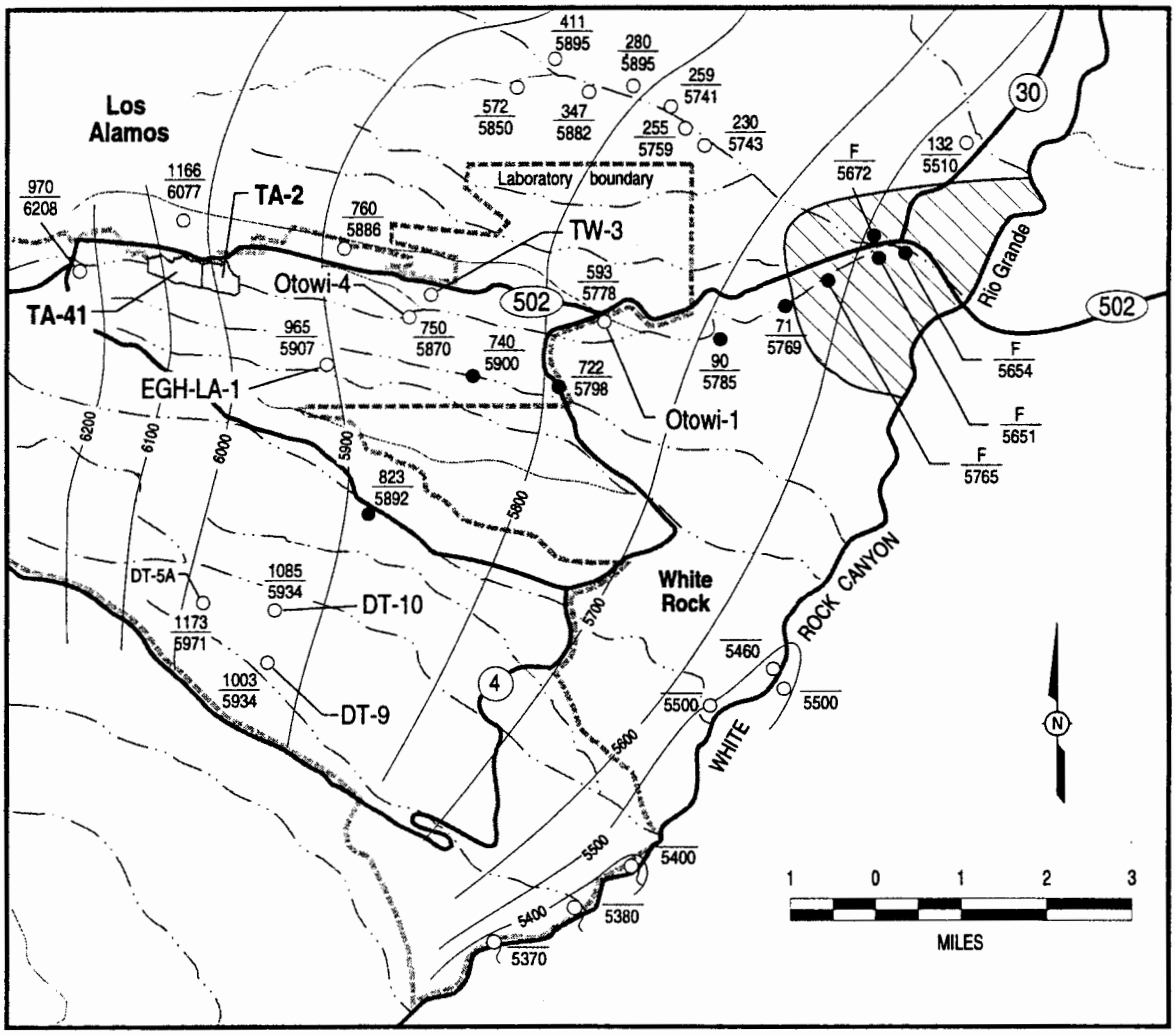

Source: Purtymun and Johanson 1974, 11835

F 3-16 / LA&P WP / 11 2595

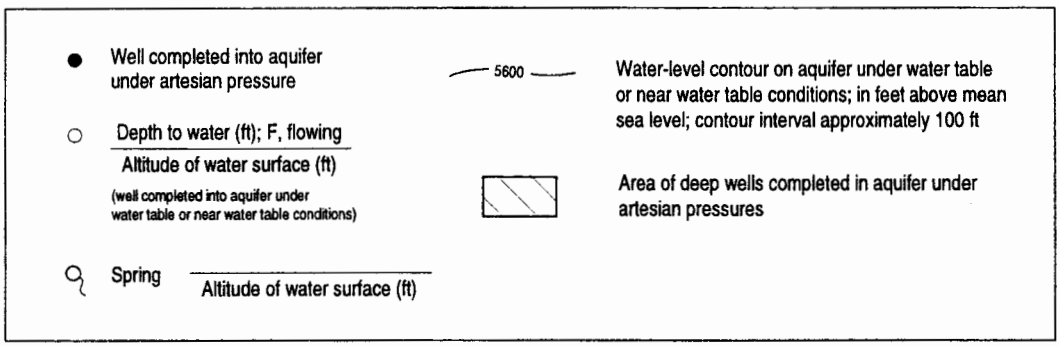

Figure 3-16. Generalized water-level contours and piezometric surface contours of the main aquifer.

TABLE 3-15

TOTAL PLUTONIUM IN WATER FROM THE ALLUVIUM ACID CANYON AND PUEBLO CANYON 1954 THROUGH 1965[a]

Station	1954	1955	1956	1957	1958	1959
AC[b]-3	828	468	—[c]	—	5.3	2.9
AC-4	342	34	—	—	1.9	42
AC-5	198	554	—	—	4.9	—
PC[d]-1	3.6	1.4	1.8	0.7	<0.5	<0.5
PC-2	21	6.3	5.8	1.8	<0.5	10.9
PC-3	6.3	2.7	1.8	0.9	1.3	<0.5
PC-4	7.7	3.2	5.8	0.9	0.5	<0.5
PC-5	6.8	—	—	—	0.5	0.5
PC-6	8.6	3.6	3.6	1.8	1.8	<0.5
PC-7	14	5.8	3.2	1.8	<0.5	<0.5
PC-8	5.4	—	—	0.9	<0.5	<0.5
PC-9	8.6	—	3.2	2.7	0.7	<0.5
PC-10	—	—	—	<0.5	<0.5	<0.5
PC-11	—	—	—	—	—	<0.5
PO[e]-1A	—	—	—	2.7	1.9	<0.5
PO-4A	—	—	—	1.5	<0.5	<0.5
PO-4B	—	—	—	—	<0.5	<0.5
Hamilton Bend Spring	4.5	11.7	2.7	0.6	<0.5	<0.5
Otowi Seep	9.9	—	2.7	—	<0.5	<0.5
	1960	**1961**	**1962**	**1963**	**1964**	**1965**
AC-3	<0.5	—	14.6	18.2	—	—
AC-4	4.0	1.3	—	—	—	—
AC-5	<0.5	—	—	—	—	—
PC-1	—	—	—	—	—	—
PC-2	—	—	—	—	—	—
PC-3	<0.5	<0.5	—	—	—	—
PC-4	—	—	<0.5	<0.5	—	—
PC-5	—	—	—	—	—	—
PC-6	<0.5	<0.5	<0.5	0.9	0.8	—
PC-7	—	—	—	—	—	—
PC-8	—	—	—	—	—	—
PC-9	—	—	<0.5	<0.5	<0.5	—
PC-10	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PC-11	<0.5	2.7	<0.5	<0.5	0.9	<0.5
PO-1A	<0.5	—	—	—	<0.5	—
PO-4A	<0.5	—	—	—	<0.5	<0.5
PO-4B	<0.5	—	—	—	—	<0.5
Hamilton Bend Spring	<0.5	0.5	<0.5	1.0	0.9	—
Otowi Seep	<0.5	—	3.8	<0.5	0.8	<0.5

a. Average of a number of analyses in pCi/L
b. AC = alluvial observation well in Acid Canyon
c. — means not analyzed.
d. PC = alluvial observation well in Pueblo Canyon
e. PO = alluvial observation well in Pueblo Canyon

(LANL 1981, 6059)

(828 pCi/L) was observed in 1954 at observation well AC-3. The pH of that ground water sample in 1954 was 10.4. At this high pH the plutonium was probably complexed with carbonate, possibly forming a soluble anion.

3.7.5 Intermediate Perched Zone

Four observation wells are completed in intermediate perched zones within the Guaje Pumice Bed, Puye Formation, and interbedded basalt flows within Los Alamos Canyon and Pueblo Canyon. Observation wells LADP-3 and LAOI(A)-1.1 (located in upper Los Alamos Canyon) are completed in the Guaje Pumice Bed, and TW-1A and TW-2A (located in Pueblo Canyon) are completed in the Puye Formation and interbedded basalt flows.

3.7.5.1 Guaje Pumice Bed—Los Alamos Canyon

Observation wells LADP-3 and LAOI(A)-1.1 (Figure A-2 in Appendix A of this work plan) are completed in an intermediate-depth saturated zone of variable thickness in the Guaje Pumice Bed in upper Los Alamos Canyon. At observation well LADP-3, a saturated thickness of 5 ft occurs at a depth of 325 ft. At observation well LAOI(A)-1.1, a saturated thickness of 22 ft occurs at a depth of 295 ft. The stratigraphy encountered in the boreholes for these wells was discussed in Section 3.6.3.1.

In May 1995, tritium activity measured in observation well LAOI(A)-1.1 was 2.0 pCi/L, and the concentration of chloride was 1.01 mg/L. These latter analytical results suggest that observation well LAOI(A)-1.1 could serve as a background observation well for the Guaje Pumice Bed in upper Los Alamos Canyon.

In April 1995, a ground water sample collected from observation well LADP-3 had 1472 ± 38 pCi/L of tritium (Table 3-16). Tritium activities and chloride concentrations (21.7 mg/L) in observation well LADP-3 suggest that recent water derived from the alluvium is recharging the Guaje Pumice Bed in upper Los Alamos Canyon (Broxton et al. 1995, 50119) (Figure 3-29). The Omega West Reactor is the most reasonable source of tritium in observation well LADP-3, and the elevated chloride concentrations probably are derived from road salt. Low-level ^{137}Cs and plutonium isotopes were not detected in observation well LADP-3, and ^{137}Cs was not detected in observation well LAOI(A)-1.1 (data not shown in Table 3-16). Recharge from the alluvium to the Guaje Pumice Bed probably is occurring between observation wells LAOI(A)-1.1 and LADP-3 (Figure 3-29).

3.7.5.2 Pueblo Canyon

Water infiltrating from the alluvium recharges the intermediate perched zone within the Cerros del Rio basalts and the Puye Formation under the middle reach of Pueblo Canyon (LANL 1981, 6059). In Pueblo Canyon ground water probably moves eastward in the fractured, interbedded Cerros del Rio basalts and the Puye Formation. Some of the ground water discharges from Basalt Spring in lower Los Alamos Canyon approximately 0.6 mi below its confluence with Pueblo Canyon. Samples of ground water from TW-2A have chemical compositions reflecting the characteristics of the alluvial ground water in the middle reach of Pueblo Canyon. Tritium has been detected in TW-2A. Other radionuclides have not been detected, except one anomalous value for plutonium in 1992, which exceeded the DOE derived concentration guide for

drinking water (Environmental Protection Group 1994, 35363). This value has not been confirmed or rejected as a valid indication of contamination. The results of prior analyses were very much lower.

Ground water quality in the intermediate perched zone is monitored by samples collected from TW-1A, TW-2A (Table 3-17), and the discharge at Basalt Spring (Tables 3-10 A, B, and C). Ground water samples collected from TW-2A have chemical compositions reflecting a contribution from alluvial ground water in middle to lower Pueblo Canyon. The Los Alamos County sewage treatment plant is the most likely source of the constituents observed in TW-1A and Basalt Spring.

Tritium and total plutonium (^{238}Pu and $^{239,240}Pu$) have been detected in TW-2A (Environmental Protection Group 1994, 35363). More recently, low-detection-limit measurements of tritium and ^{14}C (see Table 3-19 in Section 3.7.6.2) have indicated the possible presence of Laboratory contaminants in samples collected from TW-1A and TW-2A. Measurements of ^{14}C in ground water samples collected from TW-1A show the presence of recent surface contamination because the ^{14}C activity is much higher than that found in atmospheric precipitation.

In summary, analytical results of ground water samples collected from the three intermediate perched zone observation wells (TW-1A, TW-2A, and LADP-3) and Basalt Spring that contain tritium, chloride, and other solutes demonstrate recent recharge from the alluvium to the intermediate perched zone in Pueblo Canyon and Los Alamos Canyon. The analytical results for TW-1A, TW-2A, and Basalt Spring are consistent with previous analytical data collected by the USGS in the 1960s. Results of chemical analyses from observation well LAOI(A)-1.1 did not confirm elevated concentrations of chloride and activities of tritium; the ground water chemistry of this well probably represents background conditions within the Guaje Pumice Bed.

3.7.6 Main Aquifer

In Los Alamos Canyon and Pueblo Canyon, Test Well LA-1A and supply wells Otowi 4, LA-1B, LA-2, LA-3, LA-4, LA-5, and LA-6 are completed in the Santa Fe Group; TW-1, TW-2, and TW-3 are completed in the Puye Formation (including the Totavi Lentil) in the upper part of the main aquifer; TW-4 is completed in the Tschicoma Formation. Most of the discussion of the hydrochemistry of the test wells is referenced to water-quality data collected from TW-3 (Table 3-18) because this test well probably represents uncontaminated conditions within the main aquifer of the Laboratory. Analyses of ground water samples collected from TW-1 and TW-2 show the presence of contaminants (chloride, nitrate, and tritium), which may be the result of contaminant migration through bedrock from the intermediate perched zones to the main aquifer or contaminant migration along improperly sealed boreholes of wells completed in the 1940s.

3.7.6.1 General Chemistry

Beneath Los Alamos Canyon, the ground water of the main aquifer is characterized by more alkaline pH values (8.1 to 8.2) than those measured on ground water samples collected from the alluvium (7.0 to 7.3) and from the intermediate perched zones (7.3 to 7.7) (Environmental Protection Group 1994, 35363). The TDS concentrations of ground water samples collected from the main aquifer (Table 3-18) are generally less than the TDS of those collected from the alluvium (Tables 3-10 A, B, and C) and intermediate perched zone (Table 3-16) in Los Alamos Canyon and Pueblo Canyon.

From 1984 to 1988, the average TDS concentration in ground water samples collected from TW-3, located below the confluence of Los Alamos Canyon and DP Canyon, was 129 ± 49 mg/L. Calcium tends to be the predominant cation, and bicarbonate is the dominant anion. The increasing bicarbonate concentrations in successively deeper saturated zones is probably due to both the presence of calcite ($CaCO_3$) and possibly through the oxidation of natural organic matter to CO_2 (Drever 1988, 49933). Ground water samples collected from TW-3 are dissolved calcium-sodium-bicarbonate solutions (Environmental Protection Group 1994, 35363). Results of speciation

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TABLE 3-17

WATER-QUALITY DATA FROM INTERMEDIATE PERCHED ZONE WELLS PUEBLO CANYON

Element/Parameter	TW[a]-1A	TW-2A
pH (field)	7.7	7.3
Total dissolved solids (mg/L)	266	196
Radiochemical (pCi/L)		
^{90}Sr	0.6 (0.9)[b]	0.0 (0.9)[b]
^{137}Cs	1.2 (1.2)	3.0 (13)
^{238}Pu	0.00 (0.03)	0.019 (0.03)
$^{239,240}Pu$	0.043 (0.023)	1.28 (0.091)
^{241}Am	N/A[c]	0.011 (0.03)
Gross-alpha	2 (1)	2 (1)
Gross-beta	6 (1)	7 (1)
Gross-gamma	110 (100)	110 (100)
Major Constituents (mg/L)		
SiO_2	35	62
Ca	33	38
Mg	8.6	7.3
K	7	4
Na	59	24
Cl	49	41
F	0.9	0.2
CO_3	<1	<1
HCO_3	108	86
PO_4-P	4.1	0.1
SO_4	31	26
NO_3-N	1.82	3.21
CN	<0.01	<0.01
Trace Metals (mg/L)		
Ag	<0.03	<0.03
Al	0.23	<0.02
As	<0.002	<0.002
B	0.23	0.127
Ba	0.03	0.03
Be	<0.002	<0.002
Cd	<0.01	<0.01
Cr	<0.02	<0.02
Co	0.009	<0.004
Cu	<0.03	<0.03
Fe	57.4	0.97
Hg	0.0007	<0.0001
Total uranium (µg/L)	0.3 (0.2)	0.4 (0.2)

a. TW = test well
b. Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.
c. N/A means analysis not performed, lost, or not completed.

(Blake et al. 1995, 49931; Environmental Protection Group 1994, 35363; Environmental Protection Group 1993, 23249)

TABLE 3-18

WATER-QUALITY DATA FROM THE MAIN AQUIFER WELLS LOS ALAMOS CANYON AND PUEBLO CANYON

Element/Parameter	LA-A[a]	LA-1B[a]	LA-2[a]
pH (field)	7.2	7	8.1
Total dissolved solids (mg/L)	141.7	632.4	194.9
Radiochemical (pCi/L)			
^{90}Sr	N/A[b]	N/A	N/A
^{137}Cs	N/A	229 (120)[c]	40 (92)
^{238}Pu	N/A	0.008 (0.012)	0.000 (0.010)
$^{239,240}Pu$	N/A	0.008 (0.010)	-0.005 (0.009)
^{241}Am	N/A	N/A	N/A
Gross-alpha	N/A	30 (7)	6 (2)
Gross-beta	N/A	3 (1)	2 (0)
Gross-gamma	N/A	-0.0 (70)	0 (70)
Major Constituents (mg/L)			
SiO_2	6.4	38.9	30.8
Ca	3.71	7.1	10.7
Mg	0.03	0.31	0.14
K	1.63	2.51	1.54
Na	37.2	166	33.1
Cl	7.74	18.6	2.58
F	0.29	2.87	0.61
CO_3	7	11.1	6.9
HCO_3	67.7	346	88
PO_4-P	<0.02	<0.02	<0.02
SO_4	8.95	35.5	7.5
NO_3-N	0.04	2.26	2.06
CN	N/A	<0.01	<0.01
Trace Metals (mg/L)			
Ag	<0.001	<0.001	<0.001
Al	<0.1	<0.1	<0.1
As	<0.05	<0.05	<0.05
B	0.13	0.38	0.08
Ba	<0.01	0.04	0.08
Be	N/A	N/A	N/A
Cd	<0.001	<0.001	<0.001
Cr	<0.002	0.027	0.011
Co	<0.002	<0.002	<0.002
Cu	<0.002	<0.002	<0.002
Fe	0.33	0.01	0.01
Hg	N/A	<0.0002	<0.0002
Total uranium (µg/L)	N/A	6.0	6.1

a. Former supply well
b. N/A means analysis not performed, lost, or not completed.
c. Radioactivity counting uncertainties (± standard deviation) are shown in parentheses.

(Blake et al. 1995, 49931; Evironmental Protection Group 1994, 35363; Environmental Protection Group 1993, 23249)

TABLE 3-18 (continued)

WATER-QUALITY DATA FROM THE MAIN AQUIFER WELLS LOS ALAMOS CANYON AND PUEBLO CANYON

Element/Parameter	LA-5[a]	Otowi 4[a]	TW-1[b]
pH (field)	8.1	7	8.1
Total dissolved solids (mg/L)	183	308.2	290
Radiochemical (pCi/L)			
^{90}Sr	N/A[c]	N/A	0.2 (1.0)[d]
^{137}Cs	74 (81)	N/A	1.1 (1.3)
^{238}Pu	0.038 (0.014)	-0.006 (0.030)	0.005 (0.030)
$^{239,240}Pu$	0.010 (0.010)	0.006 (0.020)	0.013 (0.020)
^{241}Am	N/A	N/A	0.000 (0.030)
Gross-alpha	0 (1)	3 (1)	2 (1)
Gross-beta	2 (0)	5 (1)	6 (1)
Gross-gamma	80 (70)	110 (100)	160 (100)
Major Constituents (mg/L)			
SiO_2	38.7	105	56
Ca	19.5	21	49
Mg	0.76	8.06	9.7
K	2.49	3.56	4
Na	15.8	21	16
Cl	3.22	7.03	30
F	0.44	0.28	0.4
CO_3	0	0	3
HCO_3	93.5	137	97
PO_4-P	<0.02	<0.02	0.2
SO_4	5.63	5.05	22
NO_3-N	1.75	<0.02	6.45
CN	<0.01	N/A	<0.01
Trace Metals (mg/L)			
Ag	<0.001	<0.001	<0.03
Al	<0.1	<0.1	<0.02
As	0.05	<0.05	<0.002
B	0.04	<0.05	0.066
Ba	0.06	0.05	0.08
Be	N/A	<0.001	<0.002
Cd	<0.001	<0.001	<0.01
Cr	0.008	0.007	<0.02
Co	<0.002	<0.002	<0.004
Cu	<0.002	0.004	<0.03
Fe	0.03	<0.01	0.77
Hg	<0.0002	<0.0002	0.0007
Total uranium (µg/L)	1.0	<1	2.7 (0.3)

a. Current minor supply well (see text)
b. Test well
c. N/A means analysis not performed, lost, or not completed.
d. Radioactive counting uncertainties (± 1 standard deviation) are shown in parentheses.

(Blake et al. 1995, 49931; Environmental Protection Group 1994, 35363; Environmental Protection Group 1993, 23249)

TABLE 3-18 (continued)

WATER-QUALITY DATA FROM THE MAIN AQUIFER WELLS LOS ALAMOS CANYON AND PUEBLO CANYON

Element/Parameter	TW-2[a]	TW-3[a]	TW-4[a]
pH (field)	8.2	N/A[b]	8.7
Total dissolved solids (mg/L)	114	255.6	121.3
Radiochemical (pCi/L)			
^{90}Sr	0.7 (0.8)[c]	0.2 (0.8)	0.2 (0.7)
^{137}Cs	0.7 (1.0)	1.7 (1.2)	N/A
^{238}Pu	0.00 (0.010)	-0.025 (0.030)	0.005 (0.030)
$^{239,240}Pu$	0.043 (0.023)	0.005 (0.020)	0.063 (0.020)
^{241}Am	0.020 (0.030)	0.039 (0.030)	0.025 (0.030)
Gross-alpha	0 (0)	1 (1)	0 (1)
Gross-beta	3 (1)	3 (0)	3 (1)
Gross-gamma	40 (100)	-110 (100)	40 (90)
Major Constituents (mg/L)			
SiO_2	59	79.6	6
Ca	12	17.6	11.6
Mg	3	5.15	3.82
K	1	2.33	3.42
Na	13	12.2	12.8
Cl	3	3.06	3.24
F	0.5	0.41	0.26
CO_3	<1	0	3.2
HCO_3	59	99.2	73.4
PO_4-P	0.4	0.04	<0.02
SO_4	3	3	2.56
NO_3-N	0.17	2.61	0.02
CN	<0.01	N/A	N/A
Trace Metals (mg/L)			
Ag	<0.03	<0.001	<0.001
Al	<0.02	<0.1	<0.1
As	<0.002	<0.05	<0.05
B	0.023	0.03	0.06
Ba	0.02	0.03	0.06
Be	<0.002	<0.001	<0.001
Cd	<0.01	<0.001	<0.001
Cr	<0.02	0.003	<0.002
Co	<0.004	<0.002	<0.002
Cu	<0.03	0.002	0.003
Fe	2.58	0.002	0.03
Hg	<0.0001	0.03	<0.002
Total uranium (µg/L)	<0.2(0.0)	<2.0	<1.0

a. Test well
b. N/A means analysis not performed, lost, or not completed.
c. Radioactivity counting uncertainties (± 1 standard deviation) are shown in parentheses.

(Blake et al. 1995, 49931; Environmental Protection Group 1994, 35363; Environmental Protection Group 1995, 50285)

calculations using MINTEQA2 (Allison et al. 1991, 49930) suggest that TW-3 ground water is in equilibrium with calcite and that dissolved concentrations of calcium and bicarbonate are controlled by this equilibrium.

Concentrations of chloride are less than 8 mg/L at TW-3 (Table 3-18) (Environmental Protection Group 1994, 35363). These concentrations suggest that this well does not contain significant amounts of alluvial and Guaje Pumice Bed ground water, which are characterized by elevated concentrations of chloride in upper Los Alamos Canyon.

TW-1 is located west of TW-1A in Pueblo Canyon (see Figure A-2 in Appendix A of this work plan) and is completed in the Santa Fe Group at a total depth of 642 ft (Purtymun 1995, 45344). Unusually high water levels observed in 1991 at TW-1 (main aquifer) and water-quality data collected over several decades from this well suggest a downward communication of ground water from the intermediate perched zone (identified in TW-1A) to the main aquifer.

Figures 3-30 and 3-31 show distributions of nitrate and chloride, respectively, over time in TW-1A and TW-1. The similarity in the patterns of nitrate and chloride in both wells suggests hydraulic connection between the wells possibly through fractured rock. Under near neutral pH conditions, both of these anions are mobile. If leakage from TW-1A to the Santa Fe Group is occurring, chemical mixing between the two aquifers would be expected. This mixing would produce similar concentrations of these two anions in both wells continuously over time.

Figure 3-32 shows activities of tritium in TW-1A and TW-1. Tritium activities are higher in TW-1 than in TW-1A, the reverse of the pattern of nitrate and chloride concentrations in the two wells. The reason for the difference is unknown.

Water levels in TW-1 and TW-1A increased by 80 ft and 2 to 10 ft, respectively, following the installation of Otowi-1 in 1990. The increase in water levels may be due to lost fluid circulation in the Puye Formation during drilling of the borehole for Otowi-1. Water levels in both wells began to decline in 1992. Water levels in TW-1A began to stabilized by mid-1993 and since then the changes in water levels are probably due to seasonal variations. Water levels in TW-1 stabilized in 1996 and now seem to be responding to seasonal variations. These synchronous changes in water levels along with similarities in above background tritium concentrations and major ion chemistry indicate that TW-1 and TW-1A are hydraulically connected (McLin 1996, 56025).

These data suggest that the elevated concentrations of nitrate and chloride, and the above-background tritium levels (from recent, low-detection-limit analyses) observed in TW-1 may be the result of ground water migrating through pores and fractures (especially the latter) characteristic of the Cerros del Rio basalt and the Puye Formation. Another hypothesis that may account for the contaminant distributions in TW-1 is that fluid movement along the ungrouted, cable-tool casings at TW-1 provides a conduit for ground water flow. A third hypothesis, related also to the unusually high water levels in TW-1A noted above, is leakage from the drilling for supply well Otowi-1, located about 600 ft west of TW-1A and TW-1.

Results of chemical analyses of ground water samples collected from former supply wells LA-1A, LA-1B, LA-2, LA-3, LA-4, LA-5, and LA-6 from 1962 to 1993 show that sodium and bicarbonate are the predominant ions. Concentrations of sodium and bicarbonate typically range from 15 to 300 mg/L and from 70 to 300 mg/L, respectively. Concentrations of calcium generally range from 3 to 30 mg/L. Nitrate concentrations, typically range from 0.2 to 10 mg/L.

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TABLE 7-5

SUMMARY OF SEDIMENT SAMPLE COLLECTION DESIGN

Location	No. of Samples[a]	Analysis
Pueblo Canyon		
Upper canyon	8	Full-suite analyses for organic, inorganic, and radionuclide constituents; determination of background concentrations
Reaches P-1 and P-4	8[b] (4/reach)	Full-suite analyses for organic, inorganic, and radionuclide constituents; determination of COPCs[c]
Reaches P-1 through P-4	48[b] (12/reach, 4/geomorphic unit[d])	Limited-suite analyses for identified COPCs; representative statistic used for risk assessment
Reaches P-1 through P-4	To be determined[e]	Limited-suite analyses for key contaminants; description of transport mechanisms and assessment of projected impact
Los Alamos Canyon		
Upper canyon	8	Full-suite analyses for organic, inorganic, and radionuclide constituents; determination of background concentrations
Reaches LA-2, LA-3, and LA-5	12[b] (4/reach)	Full-suite analyses for organic, inorganic and radionuclide constituents; determination of COPCs
Reaches LA-1 through LA-5	60[b] (12 / reach, 4/geomorphic unit[d])	Limited-suite analyses for identified COPCs; representative statistic used for risk assessment
Reaches LA-1 through LA-5	To be determined[e]	Limited-suite analyses for key contaminants; description of transport mechanisms and assessment of projected impact

a. Surface sediment samples will be collected at depths of 0 to 1 ft.
b. A minimum of four samples for full-suite analysis will be collected in each of two reaches in Pueblo Canyon. Sufficient samples will be collected and analyzed to arrive at a reliable representative statistic for the contaminant concentrations. [Note: Upon implementing this plan in FY96, 10 samples were collected and analyzed from reach P-4 and 7 from reach P-1.
c. COPC = chemical of potential concern
d. Additional samples may be collected if geomorphic units are subdivided to a more detailed level of identification, based on field surveys and judgment of field geologist.
e. The number of samples collected in this sampling task will be decided based on results of earlier sampling events.

7.2.4.1.1 Background Sample Collection

To prepare a data set of background constituent concentrations, background samples will be collected from areas upstream of the known Laboratory contaminant source areas. The background samples will be analyzed for the full suites of analytes defined in Section 7.2.4.3. Full-suite analyses are needed to establish background levels for all possible contaminants and to identify Laboratory-derived contaminants from Los Alamos townsite-derived contaminants.

At least two areas, one each in Los Alamos Canyon and Pueblo Canyon, will be selected in canyon reaches judged to be unaffected by Laboratory discharges. A minimum of eight sediment samples will be collected from each area, with three samples collected from the active channel and five samples collected from the floodplain. Samples collected from the active channel are expected to be dominated by coarse sediments and will not be size-sorted before analysis. Samples collected from the floodplain will exhibit a wide range of sediment particle sizes, and before analysis will be size-sorted into two aliquots: less than 125-µm and greater than 125-µm diameter. The two aliquots will undergo separate chemical analysis to evaluate the dependence of constituent concentrations on particle size. After the preliminary data set is evaluated, the technical team will decide the need for additional samples to develop a representative statistic for the background constituent distribution.

It is expected that the sediments in those reaches of Los Alamos Canyon and Pueblo Canyon that lie upstream of the Laboratory boundary will have a higher proportion of Tschicoma dacite and a smaller proportion of Bandelier Tuff than the sediments in downstream reaches. Therefore, the chemical composition of background samples collected upstream may not be entirely comparable to the background chemical composition in downstream reaches, as they represent a dacite-rich end member of the sediment geochemistry. Where possible, sediment samples will be collected from inactive (pre-1943) floodplains in the downstream reaches and analyzed to evaluate the comparability to the background chemical composition data set. In some reaches proposed for investigation, it may not be possible to obtain samples representative of a tuff-rich end member because of widespread contaminated sediments. Instead, the background chemical composition data sets available for other canyons on the Pajarito Plateau dominated by Bandelier Tuff (for example, Indio and Ancho Canyons) may be suitable.

7.2.4.1.2 Sample Collection for Full-Suite Analysis

Sediment samples will be collected and analyzed for a full suite of COPCs to define the limited suite of COPCs for subsequent sampling and analysis tasks. Constituent concentrations will be compared to the background data set to identify the COPCs that may pose potential human health or ecological risks. The results of the full-suite analyses will also be used to evaluate the comparability and representativeness of data collected in previous investigations. Full analytical suites for organic, inorganic, and radionuclide constituents are defined in Section 7.2.4.3.

Sediment samples for full-suite analysis will be collected from the canyon reaches closest to known source areas, from reaches immediately upstream of the eastern Laboratory boundary and from the reach at the confluence of Los Alamos Canyon system with the Rio Grande: specifically, reaches P-1 and P-4 in Pueblo Canyon and reaches LA-2, LA-3, and LA-5 in Los Alamos Canyon. Appropriate analyte suites for reaches not sampled for full-suite analyses will be determined by an evaluation of analytes above background in the closest upstream reach or reaches (for example, the analyte suite for reach LA-4 will be chosen based on analytes identified above background in reaches LA-3 and P-4).

A minimum of four samples will be collected in each of the five reaches at locations where the highest radioactivity (alpha, beta, or gamma) is measured in the radiological survey. If numerous locations with elevated radioactivity are found in a reach, the technical team may decide to increase the number of samples collected for full-suite analysis to adequately characterize the nature of contamination. All full-suite analytical measurements planned are critical to the sediment investigation.

The key hypotheses of the current conceptual model for contaminant transport that will be tested during the ground water investigation are summarized as follows.

- Maximum concentrations of contaminants may be associated with alluvial ground water close to potential source areas.
- Dilution and attenuation by geochemical processes will decrease downgradient contaminant concentrations downgradient within a water-bearing zone.
- Alluvial water-bearing zones are sources of recharge to intermediate perched zones.
- For many chemical species, attenuation will decrease contaminant concentrations in ground water as it migrates through the unsaturated zone toward intermediate perched zones.
- Intermediate perched zones may receive some recharge from uncontaminated watersheds west of the Laboratory. Contaminant concentrations in water entering these perched zones are diluted.
- Intermediate perched zones occur within with major canyon systems, particularly those that head in the Jemez Mountains. These zones are believed to be narrow and ribbon-like rather than laterally extensive. However, some lateral spreading may occur downgradient, if the canyon course and the dip of the perched zone do not coincide.
- In addition to proximity to major canyons, the location of intermediate perched zones is controlled by hydrogeologic characteristics of subsurface units (for example, in permeable beds above clay-rich layers).
- Intermediate perched zone and alluvial ground water may be minor sources of recharge to the main aquifer.
- If present, Laboratory-derived contaminants in the main aquifer are likely to vary in concentration. The contaminant concentrations are probably below maximum contaminant levels (MCLs) for drinking water because (1) the large volume of water in the main aquifer dilutes contaminant concentrations in recharge, and (2) contaminant concentrations in alluvial and intermediate perched zone ground water are expected to decrease with increasing depth due to dilution and geochemical attenuation along vertical migration pathways.

The general approach used for the ground water investigation is as follows.

- Investigations in alluvium will focus on determining the continuity of alluvial water-bearing zones, the potential for recharge from the alluvium to deeper zones, and the nature of contamination.

- Investigating the intermediate perched zones will focus on determining the occurrence of ground water, interconnection with alluvial ground water, the nature and extent of contamination and hydrogeologic features controlling contaminant distribution.

- Main aquifer studies will be pursued as described in the Hydrogeologic Workplan (LANL 1996, 55430).

- Additional criteria that will be considered in deciding whether to pursue studies in the main aquifer include emergence of evidence for connections between the main aquifer and intermediate perched zones or development of other evidence requiring major revision to the conceptual model of the main aquifer.

- Wells completed in the main aquifer will be sampled for low-level tritium and other chemical species to determine whether the main aquifer is affected by Laboratory-derived contaminants. These samples will also test the hypothesis of mixing of young water (derived from shallow sources) with old water (main aquifer) in lower Los Alamos Canyon.

- Recommendations will be made about corrective measures to ground water bodies and monitoring strategies for use by the Laboratory's Water Quality and Hydrology group (ESH-18).

- Data collected in this ground water investigation will be used with data from other previous and ongoing Laboratory studies to improve the conceptual model of the hydrogeology of the Pajarito Plateau.

Proposed alluvial wells and proposed intermediate perched zone wells are described in Table 7-11 and Table 7-12 respectively. Locations are shown in Figures 7-14, 7-15, and 7-16. The surface and ground water sample collection is summarized in Table 7-13 in Section 7.3.3.1.

Note: Characterization of intermediate perched zones and the main (regional) aquifer below Los Alamos Canyon and Pueblo Canyon will be integrated with other Laboratory investigations as detailed in the Hydrogeologic Workplan (LANL 1996, 55430). The ground water investigations proposed in this work plan will be modified to reflect the approach in the Hydrogeologic Workplan after NMED completes its review and approves the Hydrogeologic Workplan. Specifically, a well near the confluence of Acid Canyon and Pueblo Canyon (R-2), a well near POI-4 (R-5), and a well in reach LA-2 (R-8) are proposed. The general locations of these wells are shown in Figure 4-2 and Appendix 6 of the Hydrogeologic Workplan. The exact locations of wells may change to reflect refinement of the understanding of the hydrogeologic setting, and the NMED will be a participant in annual negotiations with the Laboratory and DOE to decide the placement of wells.

Core samples will be collected from any intermediate perched zones encountered to characterize hydrologic properties. Single well slug testing will be conducted in selected intermediate perched zones (generally 5 ft or greater in thickness). Because of the great thickness of unsaturated rocks separating the ground water bodies, pumping the regional aquifer to observe water level fluctuations in intermediate perched zones (for example, POI-4) does not appear to be a practical way of identifying interconnections. Interconnections will be examined using water-level transducers to observe seasonal recharge effects and water-quality data to identify the presence of Laboratory-derived contaminants and the geochemical signatures of the various modes of ground water occurrences. As described in the Hydrogeologic Workplan, the decision to install dedicated wells to intermediate perched zones will be made after evaluating the zones encountered during drilling for the main (regional) aquifer wells. Transducers will be installed in any intermediate perched zone wells that are installed.

7.3.3 Ground Water Sample Collection and Analysis

This section describes the sampling design for collecting surface water and ground water (alluvial, intermediate perched zone, and main aquifer) samples and borehole core samples. Particular emphasis is given to the criteria for selecting the locations of the proposed new wells. The methods for sample collection and for chemical, radiochemical, and geotechnical analyses are also provided in this section.

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TABLE 7-13

SUMMARY OF SURFACE WATER AND GROUND WATER SAMPLE COLLECTION DESIGN

Hydrological Zone	No. of Wells	Sampling Frequency	Annual No. of Samples
Pueblo Canyon			
Surface water		Once per quarter per reach[a]	16
Alluvial, background wells[b]	2	Once per quarter	8
Alluvial, observation wells[b]	7	At completion and six months	14
Intermediate-perched, observation wells[b]	2	At completion and six months	4
Los Alamos Canyon			
Surface water		Once per quarter per reach	20
Alluvial, observation wells[b]	7	At completion and at six months	14
Intermediate-perched, observation wells[b]	7[c]	At completion and at six months	14

a. If surface water is present, samples will be collected in each of the nine canyon reaches (four in Pueblo Canyon, five in Los Alamos Canyon) described in Section 7.2.2.1. Numbers of samples are the most that will be collected if water is available.

b. At a minimum, one core sample will be collected above and below each major hydrogeological contact. Additional samples may be collected at the judgement of the field geologist.

c. Includes two intermediate perched zone observation wells in Sandia Canyon

Table 7-13 summarizes the surface water and ground water sample collection design. The sampling strategy for each of the hydrologic zones is described in detail in the following sections, as is the strategy for the collection of borehole core samples. Where new wells are proposed, the rationale for the well location is discussed in terms of a specific issue to be addressed, as well as the approach taken to address the issue.

7.3.3.1.1 Surface Water Sampling

Surface water in stream channels of the canyons consists—most of the time—of water that recharged the alluvium previously and re-emerges from it, normally at a location downgradient of the point of recharge. In this respect, surface water is in hydraulic connection with ground water in the alluvium. The few times when the two are not in hydraulic connection occur during periods of low precipitation when the alluvium is largely dewatered and the depth to ground water increases. Because the surface water is so closely linked to the alluvial water system (both chemically and hydraulically over short periods), information about contamination in the surface waters is important to gaining a complete understanding of the operation of the connected systems.

Surface water samples will be collected on a quarterly basis for one year, from each of the nine canyon reaches in Los Alamos and Pueblo Canyons as described in Section 7.2.2.1. Surface water samples will also be collected on a quarterly basis at Basalt Spring (see Figure A-2 in Appendix A of this work plan) and any other springs or seeps identified in the canyons. The number and location of the surface water samples will be determined in the field based on the availability of water at the time of sample collection. Surface water samples will be collected in the middle of the stream to provide representative surface water chemical data for each reach or spring. Both filtered (0.45 μm) and unfiltered samples will be collected and analyzed. Surface water samples will undergo the same chemical analyses as alluvial ground water samples, as described in Section 7.3.4.3. The analytical data will be supplemented by the unfil-

tered surface water samples collected of environmental monitoring by the Laboratory's Water Quality and Hydrology group (ESH-18).

7.3.3.1.2 Alluvial Ground Water Sampling

The HSWA Module requires that this work plan investigate the potential for movement or transport of contaminants within canyon watersheds and interactions with alluvial ground water and other ground water. Three characteristics of ground water in the alluvium are relevant to these requirements for investigation.

- Continuity

  The alluvium is generally continuously saturated in two or more zones of variable thickness extending most of the length of Los Alamos Canyon from Sierra de Los Valles to the Rio Grande. The alluvium in Pueblo Canyon contains zones of saturation of variable thickness and extent.

- Potential Recharge to Deeper Ground Water

  The alluvial ground water in Los Alamos Canyon may provide a source of recharge to saturated zones in the Guaje Pumice Bed, the Puye Formation, the Cerros del Rio basalt, and the Santa Fe Group. A similar situation exists in at least some reaches of Pueblo Canyon.

- Levels of Contamination

  The highest measured levels of contaminants (including tritium, plutonium isotopes, ^{90}Sr, ^{137}Cs, and nitrate) and most likely the highest inventories of these contaminants in ground water occur in the alluvium in Los Alamos Canyon and Pueblo Canyon, based on Laboratory monitoring data (LANL 1981, 6059; ESG 1967–1994).

The sampling and analysis plan for alluvial ground water in Los Alamos Canyon and Pueblo Canyon addresses a set of specific issues relevant to understanding aspects of each of these three characteristics of the alluvium. These issues are discussed in the succeeding sections for each of the major canyon reaches.

Ground water sampling will be conducted in existing and new wells. Ground water will be sampled from most wells two times, once during relatively high surface water flow and again at relatively low (or no) surface water flow. The movement of ground water in the alluvium is rapid enough to respond to seasonal variations in stream flow, resulting in detectable changes in the ground water quality (ESG 1970–1994). The purpose of the two samples is to define the effect on contaminant concentrations of seasonal variation in surface water flow. Background observation wells will be sampled quarterly for one year to refine understanding of the seasonal variation.

Existing wells, which are already sampled for environmental monitoring, may be resampled one time for chemical analysis described in Section 7.3.3.3. These wells include LA-1A, LA-1B, LA-2, LA-5, TW-1, TW-1A, TW-2, TW-2A, TW-3, TW-4, Otowi-1, and Otowi House.

Both filtered (0.45 μm) and unfiltered samples will be collected and analyzed. Analyses of these samples will be supplemented by analyses of unfiltered samples collected for environmental monitoring by the Laboratory's Water Quality and Hydrology group (ESH-18).

Rotary drilling with wire-line coring systems—capable of providing HX- or CP-size cores—will probably be employed for intermediate-depth coring to as great a depth as possible. In general, the core barrel will be lined to facilitate sample handling and containment at the surface. Several forms of rotary wire-line systems may be used including a punch core, a modified pitcher barrel, and a conventional rotary wire-line system. Fluids to be circulated in the rotary systems may include air, water, and inert gases (for example, argon) but generally, air will be used as the circulating fluid. Sidewall cross-contamination will be minimized by using conventional circulation (through the bit). In general, circulation fluids will be air filtered through a high-efficiency particulate air system or an air mist using deionized water. An inert gas may be introduced to those environments where the redox potential is a significant concern. The appropriate circulation fluid will be selected based on the target analytes, target sample depth, and site-specific borehole conditions. Steps to avoid introducing muds, special polymers, and other proprietary constituents will be taken and such drilling materials will be used only after field personnel have determined that the hole cannot be advanced without the special additives. Borehole particulate and gaseous tracers will be used, as appropriate, to help determine sample integrity and overall adequacy of the sampling program.

Intermediate perched zone wells will be installed with a minimum 4-in.-diameter casing. A surface casing extending below the alluvium will be grouted in place before advancing the borehole into bedrock. Special precautions will be taken to provide proper annular seal for boreholes and wells approaching or greater than 300 ft depth in conformance with the HSWA Module requirements to prevent potential downward migration of contaminated water.

Well completion will depend upon the hydrogeologic conditions encountered at the target horizon. If perched ground water is found, the well will be completed with a 10-ft stainless steel screen and stainless steel casing to the boundary of the perched zone. From the perched zone boundary to the surface, an alternate casing such as standard steel or PVC may be used with a dielectric to minimize cost. A permanent ground water pump suitable for sample collection may be installed.

7.3.3.3 Analytical Methods

This section describes the methods for analyzing ground water samples for organic, inorganic, and radionuclide constituents, and describes the methods for analyzing borehole core samples for inorganic and radionuclide constituents and geotechnical parameters. Analysis of ground water and borehole samples has two purposes: (1) to detect and measure Laboratory-derived COPCs, and (2) to obtain information about the baseline geochemistry of the water-bearing zones.

7.3.3.3.1 Analysis of Ground Water Samples

Ground water samples collected according to the strategy outlined in Section 7.3.3.1 will initially undergo full-suite analyses for organic, inorganic, and radionuclide constituents at an ER Project-approved fixed-site laboratory. The analytical suites and methods for analysis of organic constituents are listed in Table 7-7 (Section 7.2.4.3). The analytical suites include SVOCs, organochlorine pesticides, PCBs, and VOCs. All analyses for organic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31733). The detailed analyte lists, EQLs, required QC procedures,

and the acceptance criteria are found in the ER Project analytical services statement of work (LANL 1995, 49738). The first sample collected from each alluvial and intermediate perched zone well and at each surface water sampling location will undergo analysis for the full suite of organic constituents. If organic constituents are identified as COPCs for a particular sampling location, all subsequent samples from that location will be analyzed for organic COPCs. Any organic compound reported to be below the method detection limit will be excluded from subsequent limited-suite analyses.

All water samples collected over a one-year sampling period will be analyzed for inorganic constituents in order to identify COPCs and to obtain a better understanding of the baseline geochemistry of surface water and ground water. The target analytes, EDLs, and analytical methods for inorganic constituents are listed in Table 7-15. Both filtered (0.45 μm) and unfiltered samples for inorganic analyses will be collected and analyzed. Analyses of these samples will be supplemented by analyses of unfiltered samples collected for environmental monitoring by the Laboratory's Water Quality and Hydrology group (ESH-18). Measurements for inorganic constituents include analyses for 26 dissolved metals, major anions (bromide, chloride, fluoride, nitrate, and sulfate), minor anions (chlorate, nitrite, and phosphate), dissolved silica, and total cyanide. All analyses for inorganic constituents will be performed according to EPA SW-846 protocols (EPA 1986, 31732) or EPA standard methods for chemical analysis of water. The required QC procedures and acceptance criteria for the metals and total cyanide analyses are found in the ER Project analytical services statement of work (LANL 1995, 49738).

The target analytes and their half-lives, detected emission, EQLs, and analytical methods for radionuclide constituents are listed in Table 7-16. In addition to measurements of gross-alpha, -beta, and -gamma radioactivity, the radionuclide analytes include ^{241}Am, tritium, ^{90}Sr, ^{99}Tc, and isotopes of plutonium, thorium, and uranium. The analyses for low-detection-limit tritium and ^{236}U will help identify whether recent recharge to an aquifer has occurred. The analyte list for the gamma spectroscopy analysis given in Table 7-10 (Section 7.2.4.3) includes long-lived activation and fission products, as well as their shorter-lived daughter products. The shorter-lived daughter products are included in the analyte list to verify the presence of the longer-lived parents. The shorter-lived radionuclides (half-life less than 180 days) are not considered to be COPCs. The required QC procedures and acceptance criteria for the radiochemical analyses are found in the ER Project analytical services statement of work (LANL 1995, 49738).

Water samples will also be analyzed for the additional parameters listed in Table 7-17. To better understand the nature of recharge to an aquifer, analysis for ^{14}C and stable isotope ratios deuterium/hydrogen and ^{18}O/^{16}O will be performed to estimate the age of water and to help identify specific sources of recharge. Analyses for ^{13}C and dissolved organic carbon (humic acids) will be performed to provide better understanding of the baseline organic geochemistry of the ground water. The field measurements listed in Table 7-18, which include alkalinity, dissolved oxygen, pH, specific conductance, temperature, and turbidity, will be made at the time of sample collection.

7.3.3.3.2 Analysis of Borehole Core Samples

Borehole core samples collected according to the criteria outlined in Section 7.3.3.1.4 will undergo analysis for inorganic constituents and the radionuclide constituents listed in Tables 7-9 and 7-10 (Section 7.2.4.3) at an ER Project-approved fixed-site laboratory. The purpose of the analyses is to identify COPCs and to obtain a better understanding of the baseline geochemistry of the water-bearing zones. The target analytes, EDLs, and analytical methods for inorganic constituents are listed in Table 7-19.

TABLE 7-20

GEOTECHNICAL, GEOCHEMICAL, HYDROLOGIC, AND GEOPHYSICAL ANALYSES OF BOREHOLE CORE SAMPLES

Analysis	Analytical Method
Geotechnical analyses	
Bulk density, dry density	ASTM[a] D-4531-86
Distribution coefficient (K_d)	Batch Method
Porosity (total and effective)	API[b] Method 40, Section 3.58
Soil classification	ASTM D-2488
Geochemical analyses	
Mineralogical composition	X-ray diffraction, electron microprobe[c]
Hydrologic analyses	
Moisture content (gravimetric and volumetric)	ASTM D-4531-86
Moisture potential	Pressure plate extractor (or other techniques)
Saturated hydraulic conductivity	ASTM D-2434-68
Geophysical analyses	
Lithological logging	TBD[d]
Natural gamma logging	TBD
Neutron moisture logging	TBD

a. ASTM = American Society for Testing and Materials
b. API = American Petroleum Institute
c. Geochemical analyses are described in the LANL-ER-SOPs-09 series.
d. TBD = to be determined

7.3.4 Reconciliation with Data Quality Objectives

This section describes the data quality objectives process (EPA 1994, 35363) as completed for the surface and ground water sampling and analysis portion of this chapter.

7.3.4.1 Alluvial Ground Water Data Quality Objectives

1. State the problem

> What is the present-day risk posed by contaminants migrating in the alluvial ground water in Los Alamos Canyon and Pueblo Canyon? Will that risk change with time?

2. Identify the decision(s)

    - What is the areal extent of the alluvial ground water?
    - Are there or could there be contaminant levels above the MCLs or UTLs above background?
    - Is there a process or pathway for exposure?

3. Identify inputs to decision(s)

    - Moisture content/saturation, water levels, saturated thickness, temporal variations
    - Analyses of core and/or water samples for geochemical parameters and species, including contamination indicators, temporal water quality variations, and a validated conceptual model of ground water chemistry
    - Hydrologic properties, geologic structure, hydraulic gradients and predicted flow directions, land-use scenarios, spring-discharge information, current/planned well-withdrawal points, and a validated conceptual model of the hydrologic system

4. Define the study boundaries

    - Spatial

      For initial planning use, the study will be limited by the boundaries for the Los Alamos Canyon and Pueblo Canyon investigation.

    - Temporal

      Two sampling events approximately six months apart

      Quarterly spring flow measurements

      Chemical indicators sufficient to determine seasonal effects

      Quarterly sampling of background wells

    - Interpretive Study

      The data needed to evaluate potential future impacts from contaminant transport within or outside of the Laboratory boundary must provide adequate validation of models of saturated zone and geochemical-transport properties to indicate that potential future impacts of contaminants are not substantially larger than present-day risks.

    - Risk Assessment Study

      The data needed to evaluate the present-day risk should be collected as part of a single field program. Any major delay

(more than three years from start to finish) could make it difficult to evaluate potential interannual variations in separate elements of the risk assessment.

Because the field data will be collected in the first three years of the field investigation program, it is anticipated that the present-day risk assessment investigations will be completed in the fourth year (see Chapter 6 of this work plan, Section 6.1).

5. Develop a decision rule

Present-day risk assessment investigations will consider alluvial ground water if the following conditions are found:

- sufficient saturated thickness exists and persists over time for the water-bearing zone to qualify as an aquifer;
- contaminant concentrations are above UTLs above background or MCLs, or trends in concentration of contaminants suggest that they may exceed UTLs above background or MCLs in the future; and
- existing, or reasonably likely future land uses could lead to significant exposure.

6. Specify limits or uncertainty

Decisions depend on the professional judgment of the geochemist, hydrogeologist, geologist, risk assessor, and statistician. At this point, the conceptual model is not certain enough to allow formulation of statistical decision criteria. A broad range of issues have been defined that, depending upon the outcome of the field investigation, would contribute confidence to future decisions about the presence of any significant risk from alluvial ground water transport pathways.

Table 7-21 shows the relationship between the data quality objectives laid out above and the issues listed in Section 7.3.3.1.2.

7.3.4.2 Data Quality Objectives for Intermediate Perched Zone and Main Aquifer Ground Waters

1. State the problem

Does the potential exist for contaminants to move to intermediate perched zones and the main aquifer and pose a potential risk?

2. Identify the decision(s)

- Are intermediate perched zone and main aquifer ground waters present?

TABLE 7-21

RELATIONSHIP OF ALLUVIAL GROUND WATER ISSUES TO DATA QUALITY OBJECTIVE DECISIONS

Alluvial Ground Water Sampling and Analysis Issues[a]	Related DQO[b] Decision(s)
Issue No. 1: What is the background/baseline chemical composition of the alluvial ground water?	Decision No. 3: Is there a process or pathway for exposure?
Issue No. 2: Is alluvial ground water continuous in middle Pueblo Canyon, and is there present or likely future contamination?	Decisions No. 1, No. 2, and No. 3: What is the areal extent of alluvial ground water? Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 3: What is the lateral and vertical extent of the alluvial ground water and the degree of contamination in lower Pueblo Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 4: . How significant is percolation from the alluvium through bedrock to deeper horizons?	Decisions No. 1, No. 2, and No. 3: What is the areal extent of alluvial ground water? Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 5: How is the composition of alluvial ground water affected by discharges from TA-21 and TA-53, and by anthropogenic disturbance?	Decision No. 2: Are there or could there be contaminant levels above the UTLs above background?
Issue No. 6: To what extent does alluvial ground water mix with ground water in underlying rock units between wells LAO-3 and LAO-5?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 7: How much deep percolation occurs beneath the upper Los Alamos Canyon alluvium?	Decisions No. 1, No. 2, and No. 3: Does intermediate ground water exist? Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure.
Issue No. 8: What is the lateral and vertical extend, and the degree of contamination of alluvial ground water in lower Los Alamos Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 9: How much deep percolation occurs beneath the alluvium in lower Los Alamos Canyon?	Decisions No. 1, No. 2, and No. 3: Does intermediate ground water exist? Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 10: What is the extent and impact of the hydrocarbon plume near Totavi on the alluvial ground water in lower Los Alamos Canyon?	Decisions No. 2 and No. 3: Are there or could there be contamination levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 11: How much infiltration of potentially contaminated surface water occurs to the alluvium and the main aquifer adjacent to the Rio Grande?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?

a. See Section 7.3.3.1.2
b. DQO = data quality objective

- Are there or could there be contaminant levels at or above the UTLs above background or MCLs?
- Is there a process or pathway for exposure?

3. Identify inputs to decision(s)

- Moisture content/saturation, water levels, saturated thickness, temporal variations
- Analyses of core and/or water samples for geochemical parameters and species including contamination indicators, temporal water quality variations, and a validated conceptual model of aquifer chemistry
- Hydrologic properties, geologic structure, hydraulic gradients and predicted flow directions, land-use scenarios, spring-discharge information, current/planned well-withdrawal points, validated conceptual model of hydrologic system.

4. Define the study boundaries

- Spatial

For initial planning use, the study will be limited by the boundaries for the Los Alamos Canyon and Pueblo Canyon investigation. Portions of Sandia Canyon are also included in this investigation. Decisions 1 and 3 may require extension of the study area east and south of the limits of the canyons and possibly deeper toward the main aquifer, depending upon the actual observations.

- Temporal

–Field Study

Monthly ground water levels for one year

Monthly spring-flow measurements

Chemical indicators sufficient to determine seasonal effects

–Interpretive Study

The data needed to evaluate potential impacts from contaminant transport within or outside of the Laboratory boundary must provide adequate validation of models of aquifer distribution and transport properties to indicate that future impacts of transported contaminants are not substantially larger than present risks.

–Risk Assessment Study

These data needed to evaluate the present-day risk should be collected as part of a single field program. Any major delay (more than three years from start to finish) could make it difficult to evaluate potential interannual variations in separate elements of the risk assessment. Otherwise, the present-day risk can be evaluated at any time, once the data are collected.

Because the field data will be collected in the first three years of the program, it is anticipated that present-day risk assessment investigations will be completed in the fourth year.

5. Develop a decision rule

Present-day risk assessment investigations will consider intermediate perched zone and main aquifer ground water if the following conditions are found:

- sufficient saturated thickness exists and persists over time to qualify as an aquifer;
- contaminant concentrations are above UTLs above background or MCLs, or trends in concentration of contaminants suggest that they may exceed UTLs above background or MCLs in the future; and
- existing or reasonably likely future land uses could lead to significant exposure.

6. Specify limits or uncertainty

Professional judgments of a hydrogeologist, geologist, geochemist, risk assessor, and statistician are needed. At this point, the conceptual model is not certain enough to allow formulation of statistical decision criteria. We have defined a broad range of issues that, depending upon the outcome of the field investigation, would contribute confidence to future decisions about the presence of any significant risk from deep ground water transport pathways.

Table 7-22 shows the relationship between the data quality objectives laid out above and the issues listed in Sections 7.3.3.1.3 and 7.3.3.1.5.

TABLE 7- 22

RELATIONSHIP OF INTERMEDIATE AND MAIN AQUIFER ISSUES TO DATA QUALITY OBJECTIVE DECISIONS

Intermediate Perched Zone Sampling and Analysis Issues[a]	Related DQO[b] Decision(s)
Issue No. 1: Is an intermediate perched zone beneath Los Alamos Canyon connected to the discharge at Basalt Spring?	Decision No. 3: Is there a process or pathway for exposure?
Issue No. 2: How, and to what extent, are contaminants transported from surface water and alluvial ground water to the intermediate perched zone in lower Pueblo Canyon and to Basalt Spring?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 3: Is intermediate perched water flowing southeastward toward Sandia Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 4: Does an intermediate perched zone exist in Los Alamos Canyon between DP Canyon and state route 4, and is it contaminated?	Decisions No. 1 and No. 2: Does intermediate ground water exist? Are there or could there be contaminant levels above the UTLs above background?
Issue No. 5: How and where is contamination transferred from the alluvium to the intermediate perched zone in the Guaje Pumice Bed east of TA-2?	Decision No. 2: Are there or could there be contaminant levels above the UTLs above background?
Issue No. 6: How is ground water perched in the Puye Formation in the vicinity of well LAOI(A)-1.1?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 7: Does an intermediate perched zone exist east of well TW-2A, and how is it recharged?	Decisions No. 1, No. 2, and No. 3: Does intermediate ground water exist? Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure.
Issue No. 8: What is the source of recharge for the intermediate perched zone in upper Los Alamos Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 9: Does the intermediate perched zone that discharges from Basalt Spring extend further east?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 1: Are the ^{14}C minimum age estimates for TW-2, TW-3, and TW-4 true indications of young water?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure
Issue No. 2: Do low-detection limit measurements of tritium in wells TW-2, TW-3, TW-4, and LA-5 indicate contamination of either the well bore or the main aquifer?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 3: Is tritium present in the main aquifer in lower Pueblo Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 4: What is the source of tritium-contaminated recharge to the main aquifer in the vicinity of wells LA-2 and LA-1A?	Decision No. 2: Are there or could there be contaminant levels above the UTLs above background?

a. See Section 7.3.3.1.3
b. DQO = data quality objective

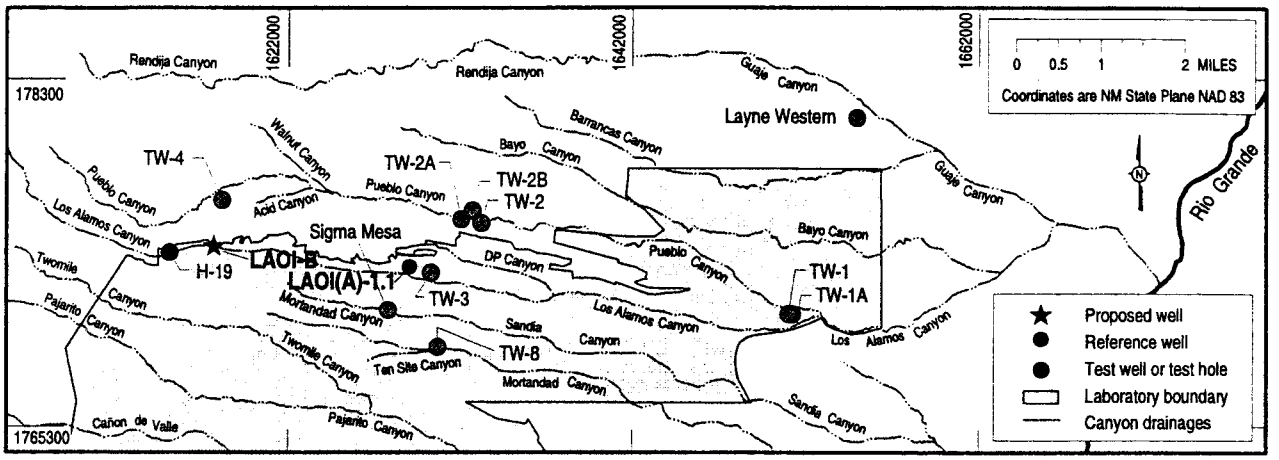
TABLE 7- 22 (continued)

RELATIONSHIP OF INTERMEDIATE AND MAIN AQUIFER ISSUES TO DATA QUALITY OBJECTIVE DECISIONS

Intermediate Perched Zone Sampling and Analysis Issues[a]	Related DQO[b] Decision(s)
Issue No. 1: Are the ^{14}C minimum age estimates for TW-2, TW-3, and TW-4 true indications of young water?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure
Issue No. 2: Do low-detection limit measurements of tritium in wells TW-2, TW-3, TW-4, and LA-5 indicate contamination of either the well bore or the main aquifer?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 3: Is tritium present in the main aquifer in lower Pueblo Canyon?	Decisions No. 2 and No. 3: Are there or could there be contaminant levels above the UTLs above background? Is there a process or pathway for exposure?
Issue No. 4: What is the source of tritium-contaminated recharge to the main aquifer in the vicinity of wells LA-2 and LA-1A?	Decision No. 2: Are there or could there be contaminant levels above the UTLs above background?

a. See Section 7.3.3.1.3
b. DQO = data quality objective

Well LAOI-B (LA Canyon, vicinity of H-19)



F 7-24 / LA&P WP / 111595

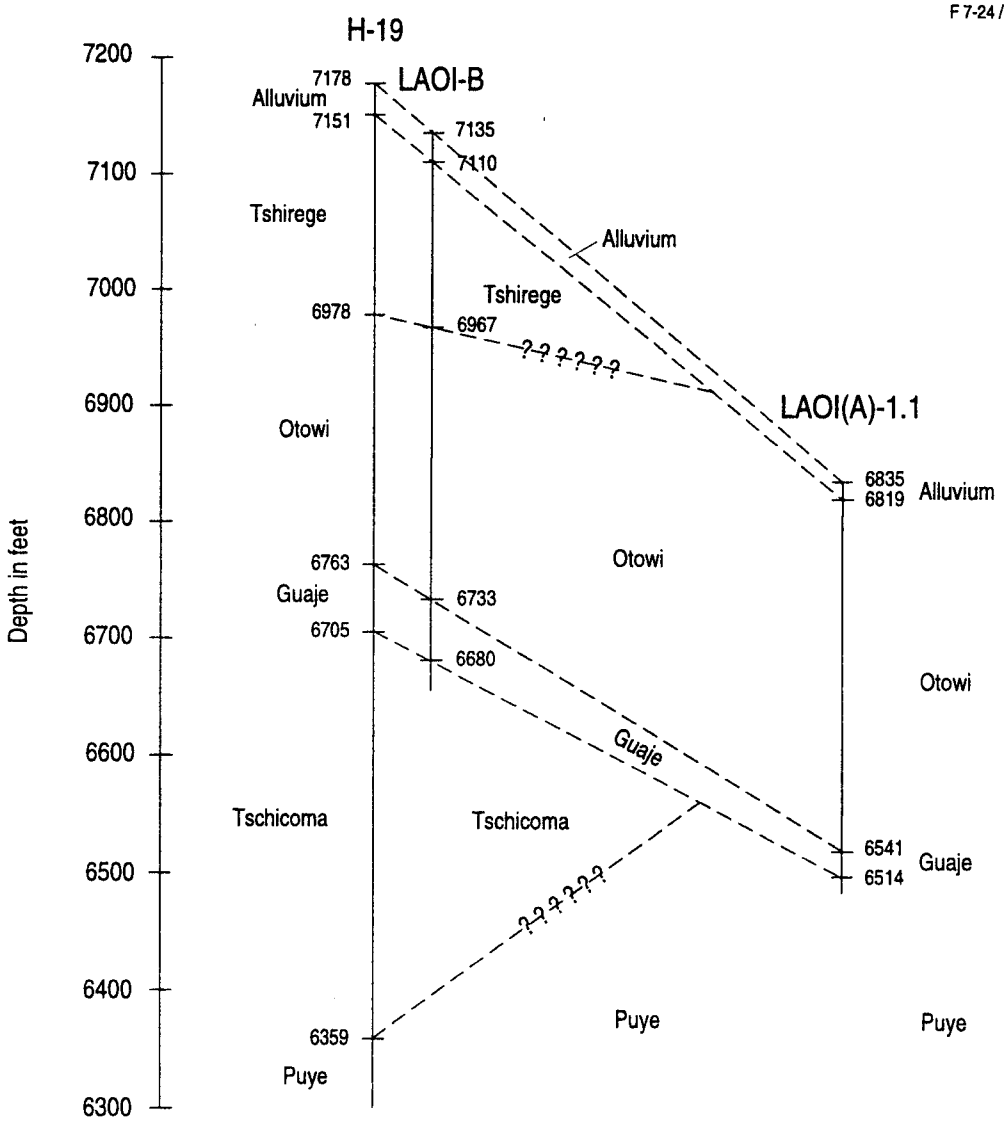


Figure 7-24. Expected stratigraphic section for proposed intermediate perched zone well LAOI-B.

7.3.3.1.4 Intermediate-Depth Borehole Characterization

For each of the intermediate-depth boreholes, the characterization approach includes a systematic set of steps to be completed. These steps are described in this section.

1. Construct a detailed lithologic log during drilling.

A lithologic log will be prepared from cores (when taken), cuttings, and drilling-performance data. The technical team will save, with appropriate packaging and storage, some cuttings and/or cores for possible future mineralogical, chemical, or hydrologic analyses.

2. Run a geophysical logging suite.

Geophysical logs will be run generally only in the intermediate perched zone boreholes, although compact neutron moisture log tools can be run in shallower holes if a small, truck-mounted rig is available. For the intermediate-depth boreholes, natural gamma, neutron moisture, and density logs may be collected, if the drilling method and the hole stability permit. Other geophysical logs may be considered if (in the opinion of the technical team) they satisfy a particular need in a given location.

3. Collect cores at selected intervals.

At least one interval of core will be collected (depending on the number and types of analyses to be performed) in each hydrogeologic unit and immediately above and below each major hydrogeologic contact.

7.3.3.1.5 Main Aquifer Sampling

The main aquifer will be included in the initial characterization efforts by sampling from and taking other measurements in existing wells completed in the main aquifer. These efforts will attempt to

- add greater confidence to the present understanding of the conceptual model and
- confirm or clarify existing questionable or uncertain data.

The focus of the main aquifer testing is to identify possible locations for downward movement of potentially contaminated ground water and to pick appropriate locations for investigating main aquifer conditions with new wells. The characterization effort for the main aquifer will initially center on reevaluating information from existing wells completed in the main aquifer and on selective resampling and analysis of those wells.

The following are the major components of the main aquifer testing.

- Resampling of LA-1B, LA-2, and LA-5 for low-detection-limit tritium, organic compounds, major and minor ions, trace elements, stable isotopes, ^{90}Sr, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and field-measured parameters.

Approach

The opportunity to sample the new supply well Otowi-1, near the confluence of Pueblo Canyon and Los Alamos Canyon, may take place in 1996. This well will be sampled at the earliest possible time when construction is underway to equip and connect the well to the Los Alamos County water supply. A small submersible pump will be temporarily installed with swab plates to restrict the zone of pumping and to collect samples from different levels in the screened section of the well. This well will be sampled for major and minor ions, neutral species, trace elements, organic compounds, low-detection-level tritium, ^{14}C, ^{90}Sr, ^{137}Cs, ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, stable isotopes, and field-measured parameters as described in Section 7.3.3.3 plus temperature, specific conductance, turbidity, and pH to support inferences regarding hydraulic interconnections. Results of the analyses will provide direct input into risk assessment data and should help clarify the possible recharge sources and vertical structure of the main aquifer to a depth of more than 2500 ft.

Zonal sampling of the Otowi-1 municipal water supply well will be conducted prior to installation of the new pump as noted above. Routine hourly water level measurements will be collected at test wells TW-1 and TW-1A during pumping at 15 gpm at Otowi-1. However, no water levels will be collected at well POI-4 because during a previous 24-hour step-drawdown pump test at Otowi-1 conducted in 1990 (Purtymun et al. 1993, 15371), no water level declines were recorded in wells TW-1 or TW-1A. During this 1990 test, the Otowi-1 water production rate varied between 676 and 1375 gpm. Hence there is no reason to expect that zonal sampling at 15 gpm would result in observable water level declines at TW-1, TW-1A, or POI-4. Moreover, declines in water levels in Otowi-1 are not expected because of the low pumping rates required for the zonal sampling procedure.

Five separate 46-ft-long zones will be sampled over the screened interval in Otowi-1. A constant-length sampling interval will be maintained with two K-packers separated by a 4-in. (ID) perforated pipe. A five-horsepower submersible pump will be placed inside the 4-in. perforated pipe, and the entire assembly lowered inside the 16-in.-diameter wellbore using 2.375 in. drill pipe. Water will be pumped to a 16,800 gallon holding tank before final discharge into the permitted NPDES outfall at the well-site. Individual water samples will be collected at the wellhead through a small gate valve.

TABLE 7-14

GROUND WATER AND BOREHOLE CORE SAMPLING METHODS REQUIREMENTS

Activity	LANL-ER-SOP No.
Surface water sampling	06.13
Monitor well construction	05.01
Well development	05.02
Purging of wells for representative sampling	06.01
Pressure transducer measurements	07.01
Fluid level measurements	07.02
Drilling methods and drill-site management	04.01
General borehole logging	04.04
Core-barrel sampling for subsurface earth materials	06.26
Field logging, handling, and documentation of borehole samples	12.01

7.3.3.2 Sampling Methods

Well construction activities will be completed, to the extent possible, in accordance with procedures outlined in LAN-ER-SOP-05.01, "Monitor Well Construction," NMED Well Construction and Abandonment Guidelines, and well construction requirements specified in Section C(1) of the HSWA Module. A well design and completion matrix addressing these procedural requirements can be found in Appendix J of the proposed GWPMP document. Well development will follow the procedures outlined in LANL-ER-SOP-05.02, "Well Development." Water level readings in the new wells will be performed in accordance with LANL-ER-SOP-07.02, "Fluid Level Measurements." Drilling methods (hollow-stem augering and rotary drilling) are described in LANL-ER-SOP-04.01, "Drilling Methods and Drill Site Management." Specific methods for the alluvial and intermediate-depth borehole drilling are described in the following sections. Surface water, ground water, and borehole core samples will be collected according to the ER Project SOPs listed in Table 7-14.

All samples will be collected using the applicable ER Project SOPs for the collection, preservation, identification, storage, transport, and documentation of environmental samples, as described in Section 4.4. in Chapter 4 of the IWP (LANL 1995, 49822). Decontamination of sampling equipment will be performed in accordance with LANL-ER-SOP-01.08, "Field Decontamination of Drilling and Sampling Equipment." Wash water and other wastes generated during the sampling operation will be managed and disposed of in accordance with LANL-ER-AP-05.3, "Management of ER Program Wastes."

7.3.3.2.1 Alluvial Borehole Drilling

The drilling objective will be to penetrate the base of the alluvium and the saturated zone of bedrock. Boreholes will be cored approximately 5 ft into the unsaturated zone of underlying bedrock. The purpose of the core is to sample and characterize the possible zones of perching for the alluvial ground water. At a minimum, one core sample will be collected above and below each major hydrological contact. Shallow boreholes will be completed as alluvial observation wells with 2-in.-diameter polyvinyl chloride (PVC), or suitable equivalent casing and screen. These wells will contain a 10-ft screen placed at the water table (top of the screen at the water table) to account for variations in saturated thickness.

Subsurface investigations will use drilling techniques that are dependent upon the type and quantity of sample material required, the planned borehole total depth (TD), the constituents of interest, type of contamination controls, and rigor associated with maintenance of the sample integrity. Hollow-stem augers and rotary systems are the two primary forms of drilling routinely used at the Laboratory. Alluvial boreholes will be advanced using hollow-stem augers wherever possible to ensure that the water table interval and the base of the alluvium can be identified precisely.

Hollow-stem augers with 5-ft-long, split-barrel samplers are used routinely for drilling and sampling (coring) to depths of up to 250 ft below ground surface in volcanic tuff. They can be used to obtain HX- or CP-size (variable-diameter) core material for radiochemical and chemical analysis. Fluid circulation is not required to drill and sample with a hollow-stem auger—a significant advantage over most conventional rotary applications. In some cases, deionized water may be introduced directly to the borehole with a decontaminated, stainless steel dart bailer system. The disadvantages to the system are its depth limitation (may be less than 250 ft if basalts are encountered), rate of penetration, disturbance to core material associated with the sampling process, and generation of relatively large volumes of "cutting" materials that may include contaminants at some sites.

7.3.3.2.2 Intermediate-Depth Borehole Drilling

It may be possible to use hollow-stem augers in drilling some intermediate-depth wells. Experience shows that penetration of the Otowi Member of the Bandelier Tuff can be achieved to depths up to approximately 250 ft. However, the Puye Formation, and especially the Cerros del Rio basalts, will require rotary drilling methods. Also, drilling and sampling operations to depths greater than 250 ft (in volcanic tuff) will generally utilize a rotary drilling strategy. Before drilling each well, the depth and target formation will be reviewed, in consultation with the drilling organization, to determine which method is appropriate for different segments of the borehole.

Rotary systems can drill larger-diameter deeper boreholes than hollow-stem auger equipment. In general, rotary applications have a greater rate of penetration than hollow-stem auger tools and can be used to collect core from hard-rock systems. The disadvantage of rotary systems is the need to circulate a fluid in the borehole. The fluid can impact sample quality.

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